Base Load Power Hub (BLPH)

INSTALLATION, OPERATING AND MAINTENANCE MANUAL - 66kV GS LCP

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HYOSUNG HEAVY INDUSTRIES

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1	Cover	X							
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3	Revision / Change Log	X							
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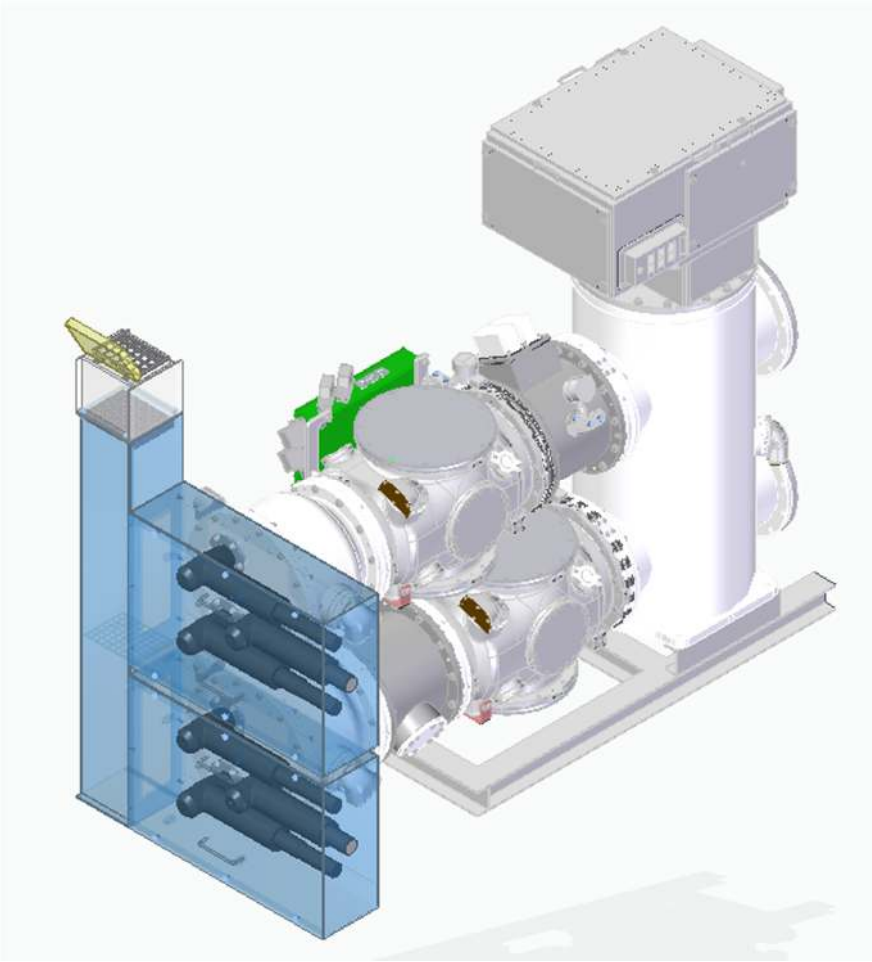
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INSTALLATION, OPERATION AND MAINTENANCE MANUAL

THE MAIN DEVICE FOR LOCAL CONTROL PANEL FOR 72.5KV GIS



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Install, Operation & Maintenance Manual

Intelligent Merging Unit 2

Preface

Introduction

This Manual and the explanatory document for the operation of IM2 or related service provide the entire information on the safe handling, commissioning and testing of IM2.

The use should be familiar with the contents of this manual and read the relevant information carefully before carrying out work on IM2.

Safety

Proper and safer operation of IM2 depend on proper transportation and handling, proper storage, installation and commissioning, and careful operation, maintenance and service. For this reason, only qualified personnel may work on or operate IM2.

Requirements for eligible employee

- Be sure to be proficient in installation, commissioning and operation of IM2 and system to which IM2 is connected.
- Be sure to be able to perform switching works safely pursuant to the approved safety engineering practices.
- Be sure to have authority to supply and disconnect power to/from IM2, and to detach, ground and label IM2.
- Be sure to complete training on management and use of safe equipment according to safety engineering.
- Be sure to complete training on emergency procedures.

Caution

- Be sure to ground the terminal of IM2 safely.
- Be sure to install IM2 an environment free from abnormal vibration within the ambient environment specified in the specification.
- Be sure to apply AC voltage and current, or power to IM2.
- Be sure to carefully check the supply voltage when connecting the output contact of IM2 to the external circuit.
- Be sure to use the linking cables carefully without applying excessive force.

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1. Introduction

1.1. Overview

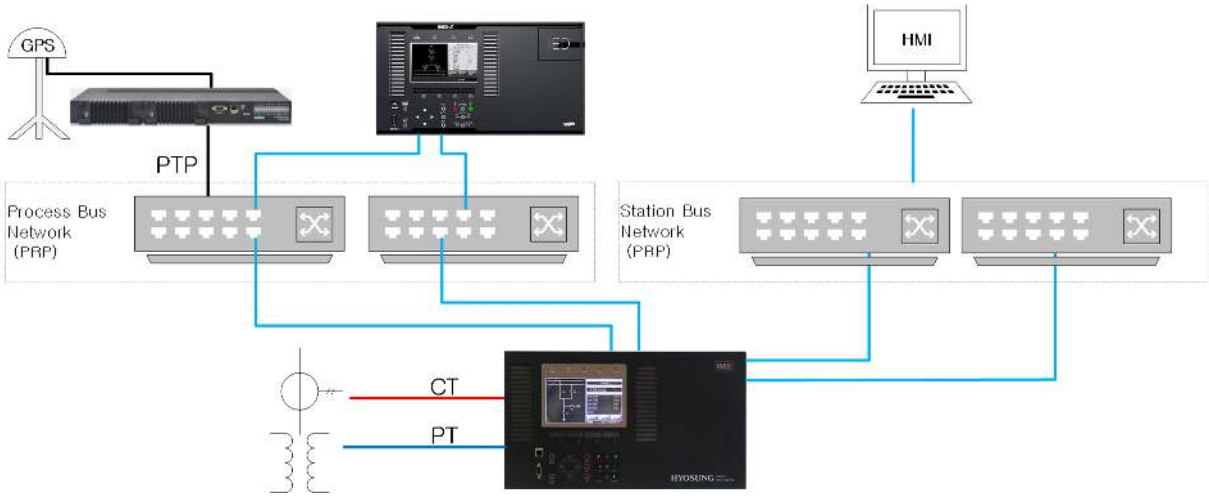
- Intelligent Merging Unit 2 ("IM2") is an equipment for digital substations that receives analogue output from instrumental transformers and transmits the sampled values.
- IM2 for CT/PT receives analog signals from the conventional potential and/or current instrument transformers and transmits the sampled value packets.
- IM2 for LPIT receives the optical output digital signal of the secondary converter (SC) connected to Low Power Instrumental Transformer ("LPIT") such as Rogowski Coil and Capacitive Voltage Divider, and transmits the sampled value packets.
- IM2's sampling clock synchronization offers 2 methods: IEEE 1588v2 PTP and 1PPS. It processes PTP packets coming through the Process Bus Network for synchronizing clock, or receives 1PPS signal to synchronize with the Grand Master Time, and then maintain synchronization difference within ±2μsec, the allowable value according to IEC 61869-9.
- IM2 transmits the sampled value according to IEC 61850-9-2 standard, uses 4PT and 4CT data set defined in the IEC 61850-9-2LE guide, and supports the sampling rate defined in IEC 61850-9-2LE, as well as the sampling rate of 5760(60Hz), 4800(60Hz), 4800(50Hz), 4000(50Hz) for protection, and 15360(60Hz), 14400(60Hz), 14400(50Hz), 12800(50Hz) for measurement as defined in IEC 61869-9.
-

1.1.1. Features

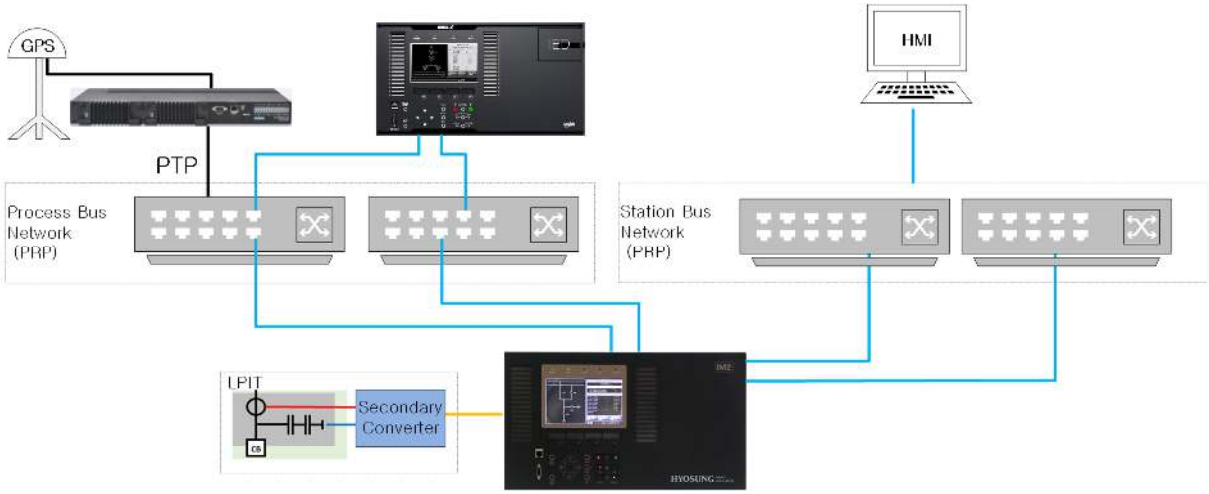
- Process voltage and current signals using 24-bit high-precision, high-resolution ADC
- Process outputs from the Secondary Converter for LPIT
- Be capable of using 50/60Hz and support 80, 96 samples/cycle for protection and 80, 96, 240, 256, 288 samples/cycle for measurement
- Configure the sampled data compatible with IEC 61850-9-2LE and IEC 61869-9
- Be able to transmit up to 8 Sampled Value streams (8 Sampled Value Control Block (SVCB))
  - 4 streams for protection, 4 streams for measurement
- Support the lossless redundancy protocol, HSR/PRP
- Support the IEC61850 Report function/ & GOOSE transmitting/receiving through the Process Bus network
  - A total of 15 GOOSE Control Blocks (GOCB) (recommended)
- Support the function of the global clock synchronization
  - IEEE 1588v2 PTP
  - 1PPS BNC port
  - 1PPS jitter < ±2μsec

1.2. Connection Diagram

- The followings are configuration diagrams showing the general connection of IM2.



<Connection diagram example for using conventional CP/PT>



<Connection diagram example for using LPIT>

- IM2 for CT/PT is connected with CTs, PTs analog signal lines. Maximum 32 lines are connected, including maximum 12 voltages and maximum 20 currents.
- IM2 for LPIT is connected through the Secondary Converters to LPITs. Maximum 16 SCs can be connected to IM2 for LPIT, through 1 optical cable per 1 SC.
- IM2's Station/Process Bus communication ports are connected to network switching hubs that provides redundancy protocol, HSR/PRP, via optical cables, respectively. When using PTP

for clock synchronization, it can be used without additional connection. However, when IM2 is going to use PPS signal for synchronization, it may be needed to be connected to a PPS output device via a BNC cable.

- IED connected to Process Bus network that receives the Sampled Value can perform the functions of protection and measurement, using the sampled values transmitted by IM2.

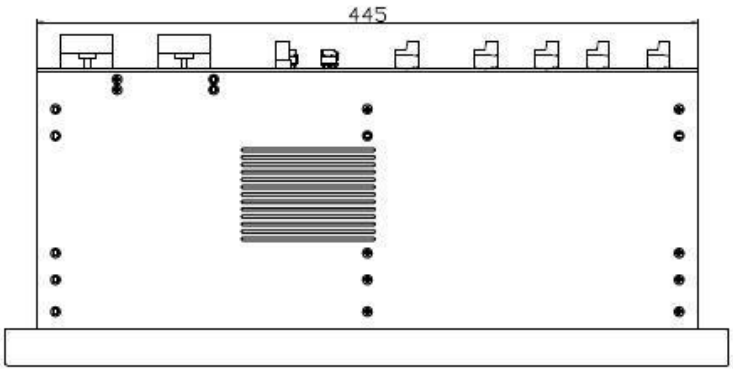
1.3. Specifications

Classification	Item	Specifications	Note
Condition of Use	Ambient temperature	-40℃ ~ +70℃	
	Relative humidity	Below 95%	
	Altitude	Below 1,000m	
Rating	Frequency	50/60Hz	
	Current	1A, 5A	
	Line voltage	100, 110, 115, 120, 200, 230V	
	Power	DC 125V (100~250V) AC 220V (100~240V) 50/60Hz	
Appearance of Product	Dimension (W x H x D)	487 x 263 x 223mm 487 x 263 x 219mm	for CT/PT for LPIT
	Type	Stand-Alone Type	
	Weight	Below 13kg Below 10kg	for CT/PT for LPIT
	Material	Aluminum	

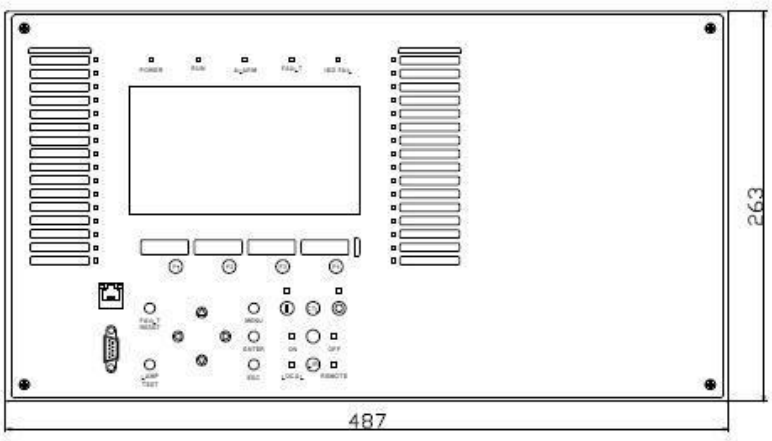
2. Appearance and Wiring

2.1. Appearance

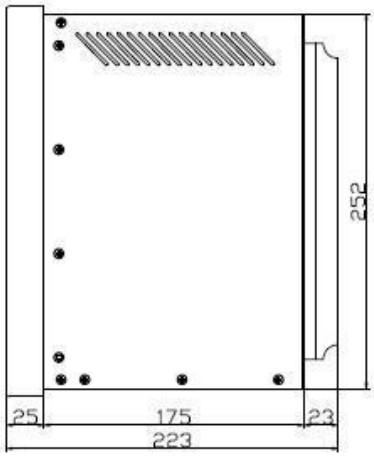
- The enclosure of IM2 is made of a fully-sealed aluminum metal case structure so as not to be affected by external interference.



Top view

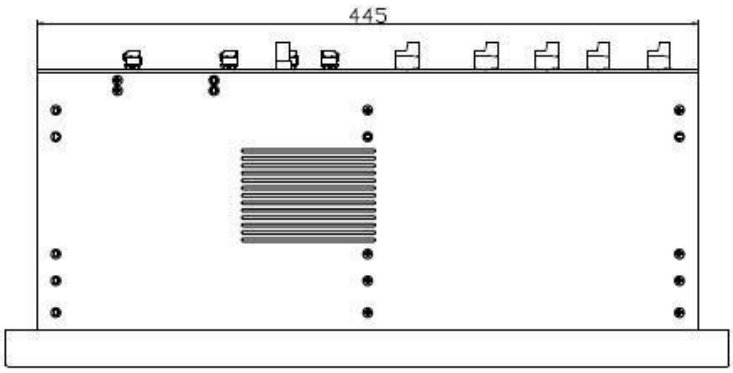


Front view

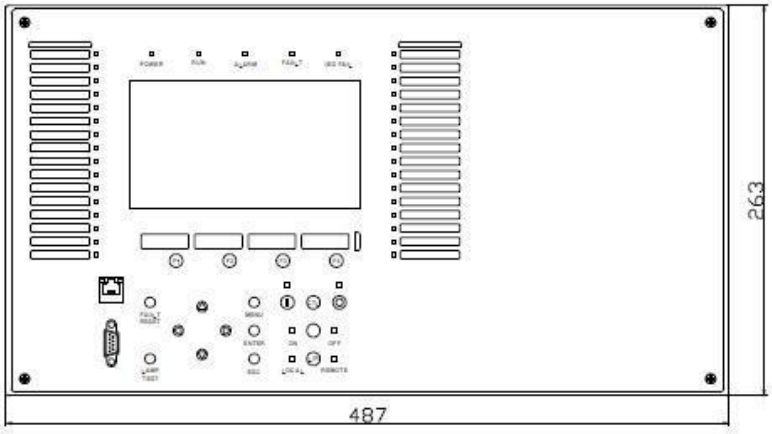


Side view

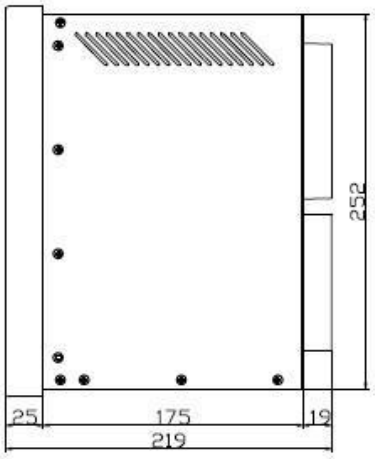
<Appearance of IM2 for CT/PT>



Top view



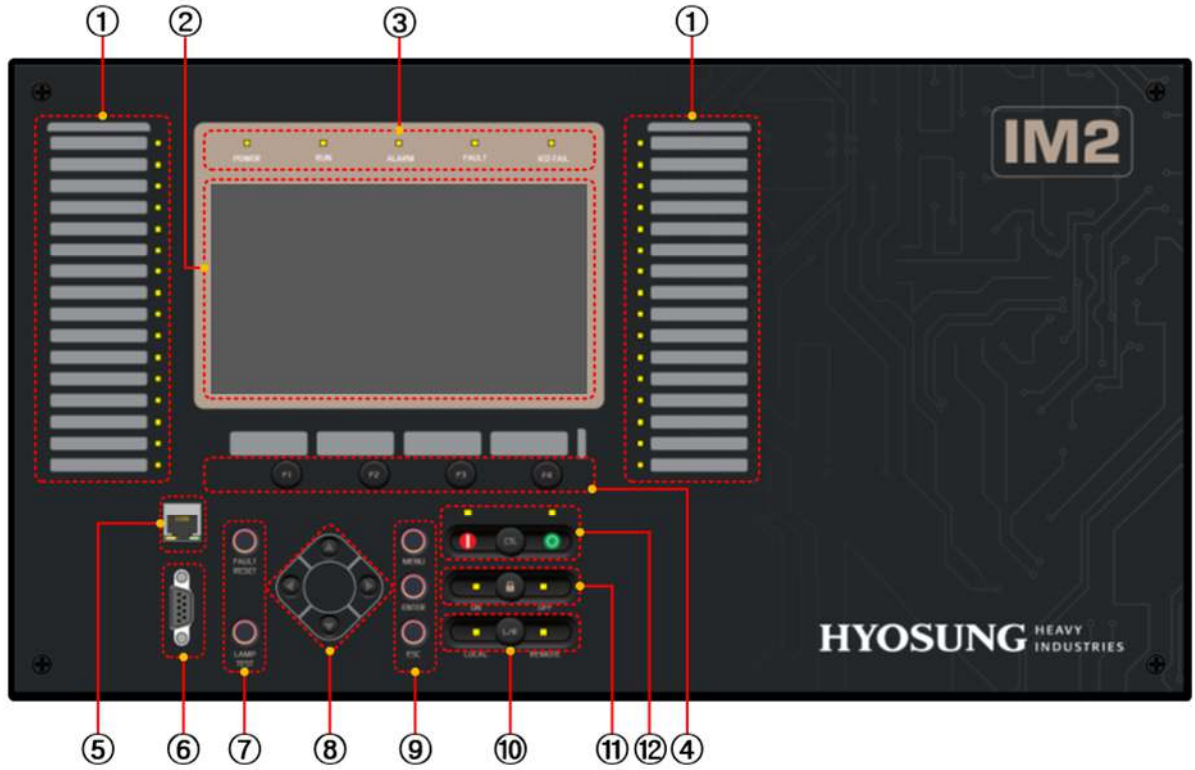
Front view



Side view

<Appearance of IM2 for LPIT>

2.1.1. Front Side



<Front Side of IM2 HMI>

- The description of the front side is as follows.

① LED for displaying the operational status

② TFT color graphic LCD (7") that can confirm and change the operational status and the set value

③ LED(Power) for displaying system status

④ Function button

⑤ Ethernet communication port

⑥ Console for connecting the operating software

⑦ Buttons for initializing LED status, and for testing LED

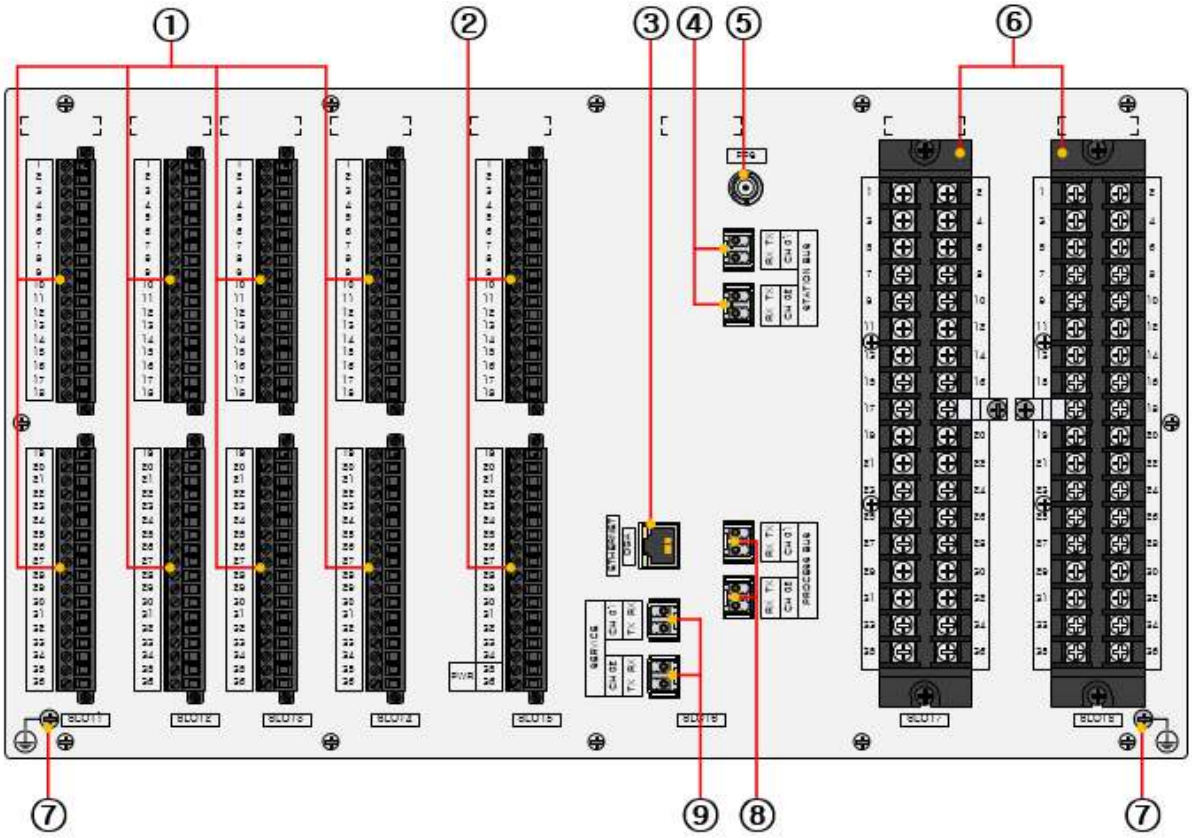
⑧ , ⑨ Buttons to move upward and downward, to select or cancel item in the menu

⑩ A button and status LED for local/remote operation

⑪ A button and status LED for operating to turn on/off interlock

⑫ A button and status LED to control device

2.1.2. Back Side (CT/PT)

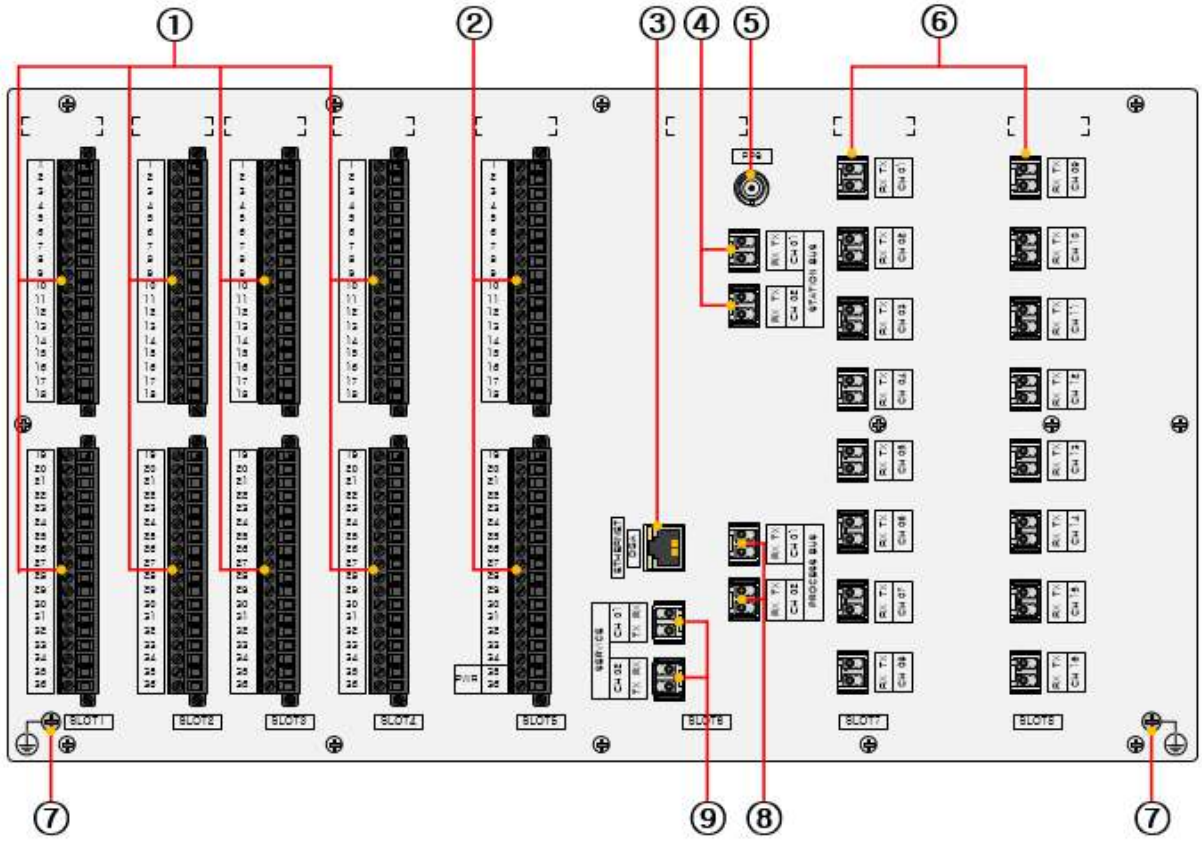


<Back side of IM2 for CT/PT>

- The back side of IM2 for CT/PT is configured as follows.

① Contact input/output terminal block
② Contact input and power input terminal block
③ Ethernet and DGA port
④ IEC 61850 Station Bus communication port (Optical)
⑤ 1PPS clock synchronization input port
⑥ Voltage/current input terminal block
⑦ Ground
⑧ IEC 61850 Process Bus communication port (Optical)
⑨ Service communication port (Optical)

2.1.3. Back Side (LPIT)

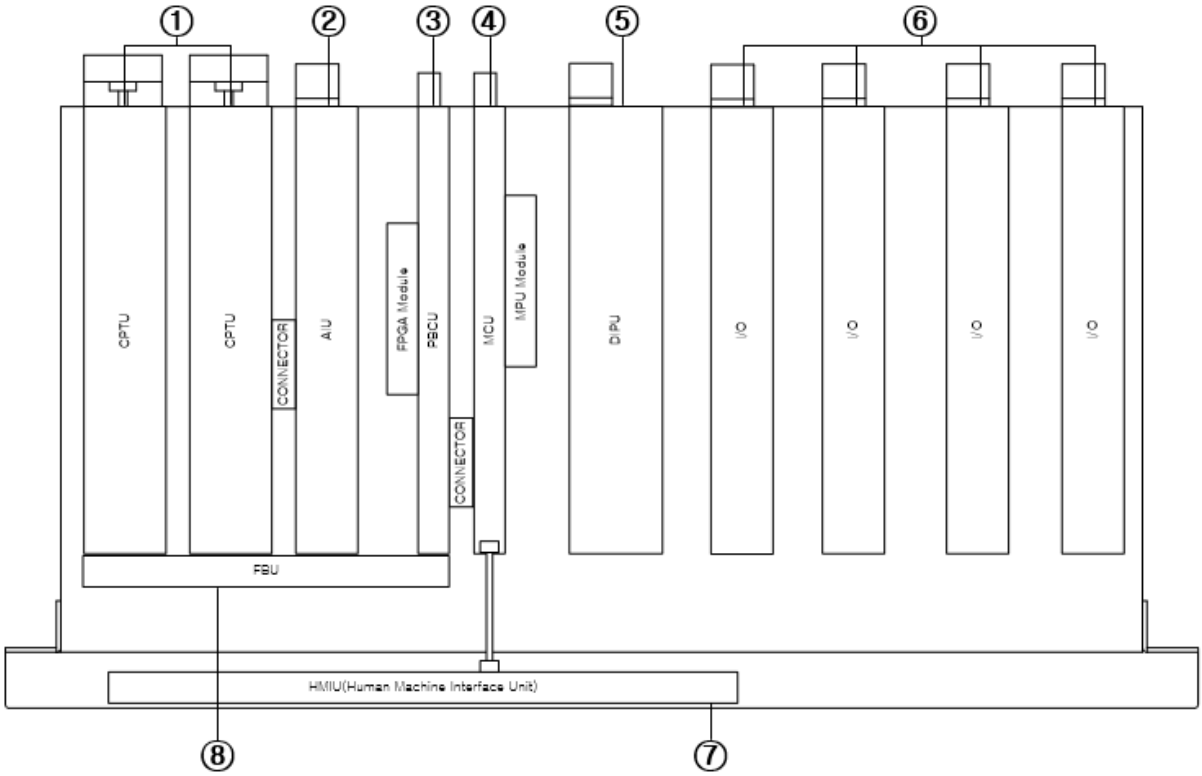


<Back side of IM2 for LPIT>

- The back side of IM2 for LPIT is configured as follows.

① Contact intput/output terminal block
② Contact input and power input terminal block
③ Ethernet and DGA port
④ IEC 61850 Station Bus communication port (Optical)
⑤ 1PPS clock synchronization input port
⑥ S/C Unit communication port (Optical)
⑦ Ground
⑧ IEC 61850 Process Bus communication port (Optical)
⑨ Service communication port (Optical)

2.1.4. Module mounting positions (for CT/PT)



<Module mounting positions>

- Modules of CPTU, AIU and PBCU are connected by FBU module, and MCU board and modules of HMIU, DIPU, I/O(DAIU, DOU, DIU) are connected via cable.

① **CPTU** module is divided into two types. CPTU-A is a module that provides input of 12 currents (CT) and 4 voltages (PT), and carries out function of inputting analog data. CPTU-B is a module that provides input of 8 currents (CT) and 8 voltages (PT), and carries out function of inputting analog data.

② **AIU** carries out digital conversion of the input analog data.

③ **PBCU** carries out function of converting the measure data into SV(Sampled Value), and then transmitting it.

④ **MCU** is a module where MPU, DSP and memory are positioned, and carries out functions of performing protection logic and processing HMI.

⑤ **DIPU** is a module that provides 26 contact input points, and carries out monitoring function, receives power and then supplies power used by each module.

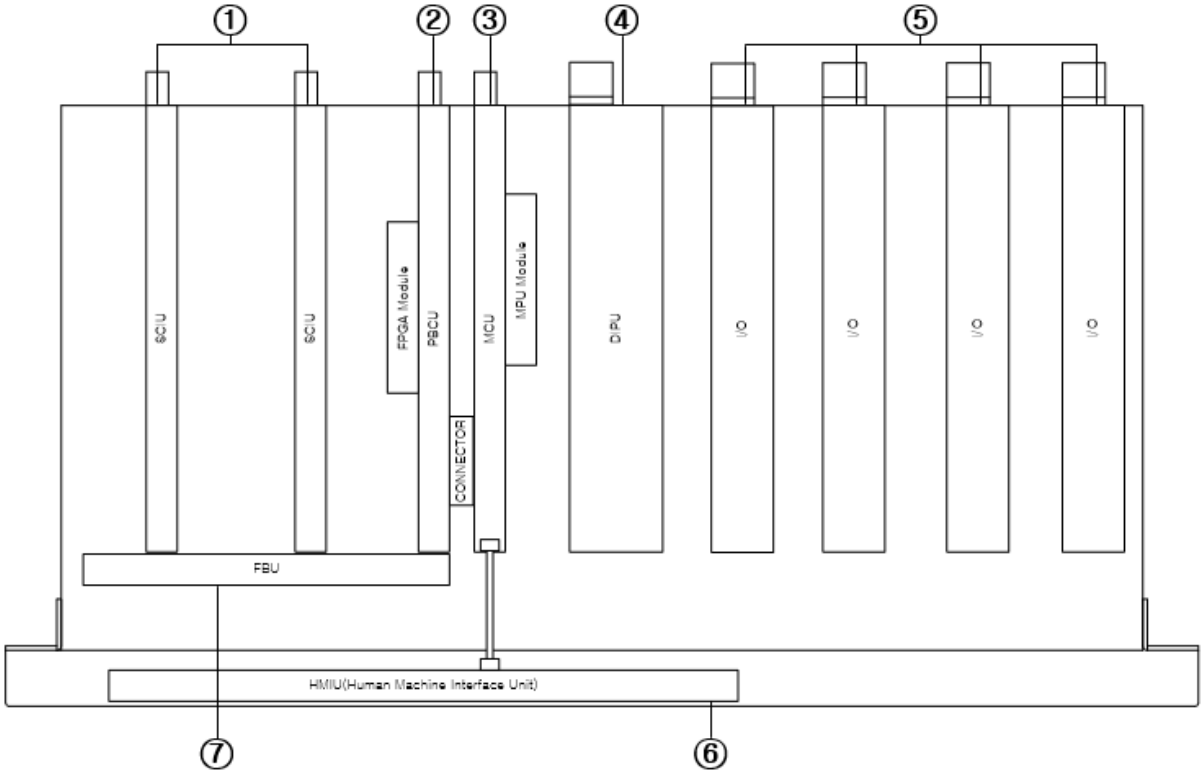
⑥ **I/O** modules have three types

- **DAIU** is a module that provides 16 contact input points as well as input of 6 TDs and 2 RTDs, and carries out monitoring and measurement functions.
- **DOU** is a module that provides 17 contact output points for each module and is responsible for the control function.
- **DIU** is a module that provides 28 contact input points, and carries out monitoring function.

⑦ **HMIU** is an operator interface module that provides information to the operator via LCD and LED as well as receives input from the operator via button and touch screen, and carries out functions of setting and displaying.

⑧ **FBU** carries out interface function that connects AIU and PBCU module.

2.1.5. Module mounting positions (for LPIT)



<Module mounting positions>

- SICU and PBCU modules are connected by FBU module, and MCU board and modules of HMIU, DIPU, I/O(DAIU, DOU, DIU) are connected via cable.

① **SCIU** carries out function for inputting communication data of S/C(Secondary Converter) Unit.

② **PBCU** carries out functions of converting measurement data into SV(Sampled Value) and transmitting it.

③ **MCU** is a module where MPU, DSP and memory are positioned, and carries out functions of performing logic and processing HMI.

④ **DIPU** is a module that provides 26 contact input points, carries out a monitoring function, and receives and provides power used by each module.

⑤ **I/O** board has three types.

- **DAIU** is a module that provides 16 contact input points, 6 TD input and 2 RTD inputs, and carries out functions of monitoring and measurement.
- **DOU** is a module that provides 17 contact output points for each module and is responsible for the control function.
- **DIU** is a module that provides 28 contact input points, and carries out a monitoring function.

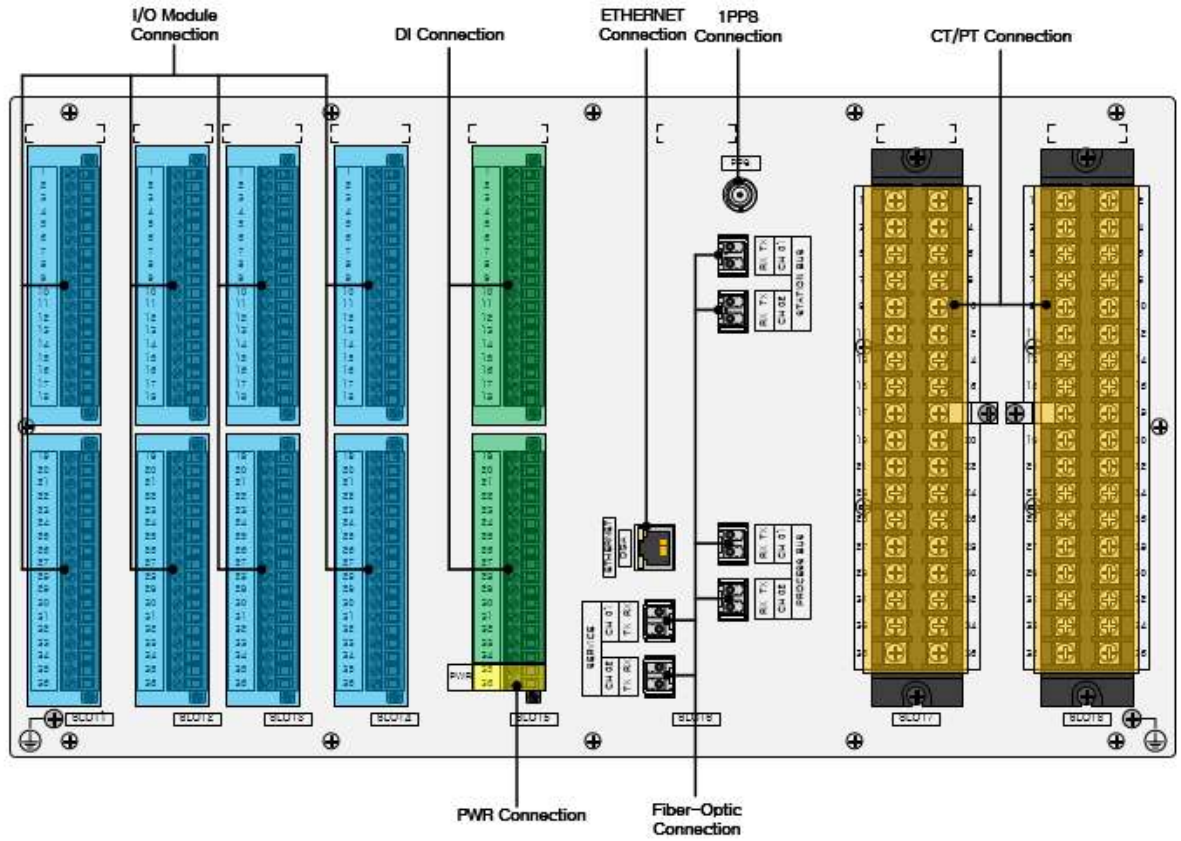
⑥ **HMIU** is an operator interface module that provides information to the operator via LCD and LED, and receives input from the operator via button and touch screen, and carries out functions of setting and displaying.

⑦ **FBU** carries out interface function that connects AIU and PBCU module.

2.2. Connection

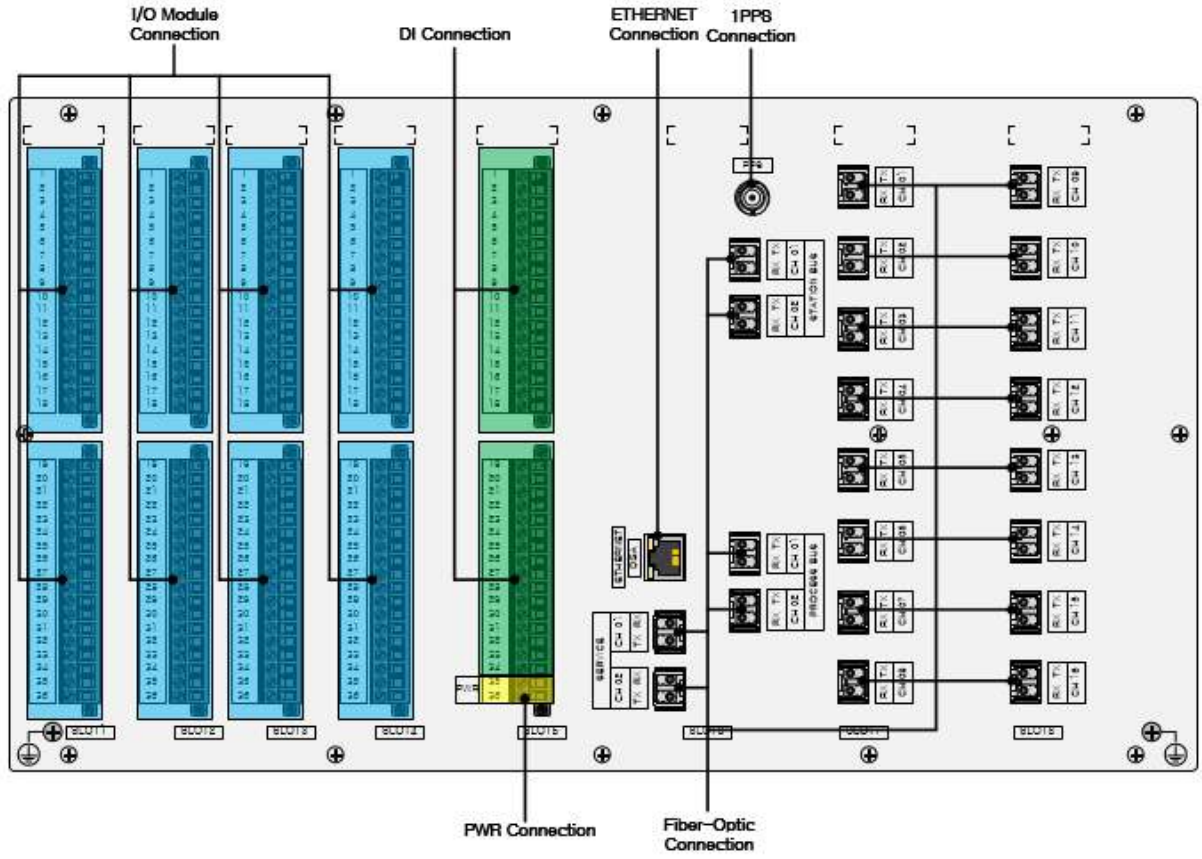
- IM2 has terminal blocks in the rear side to enable rear wiring, and is connected to the outside through the terminal block. Wiring should be made in a structure that is completely in contact with each other and does not come loose.

2.2.1. Connection Positions (for CT/PT)



<Connection positions of IM2 for CT/PT>

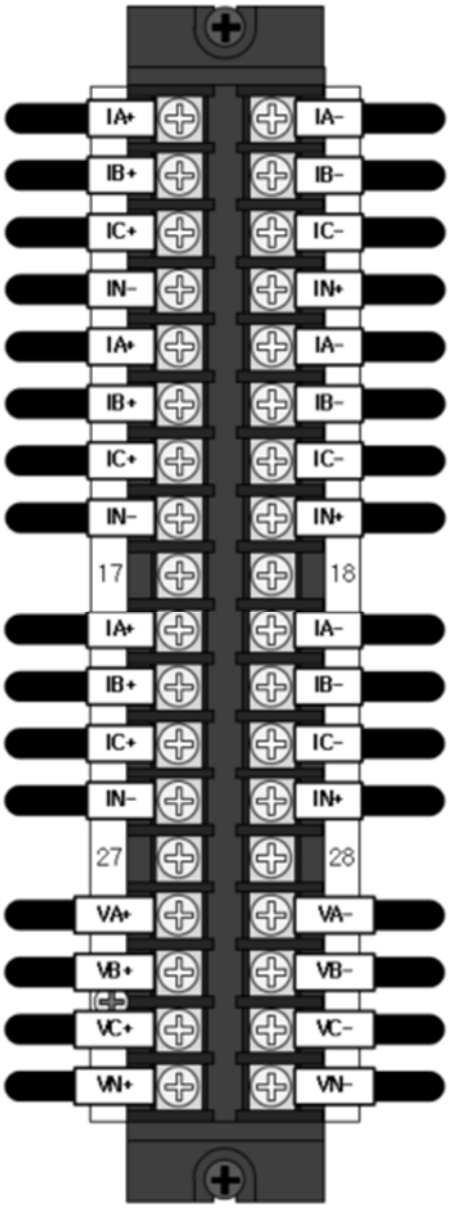
2.2.2. Connection Positions (for LPIT)



<Connection positions of IM2 for LPIT>

2.2.3. How to connect

2.2.3.1. CPTU-A Connection



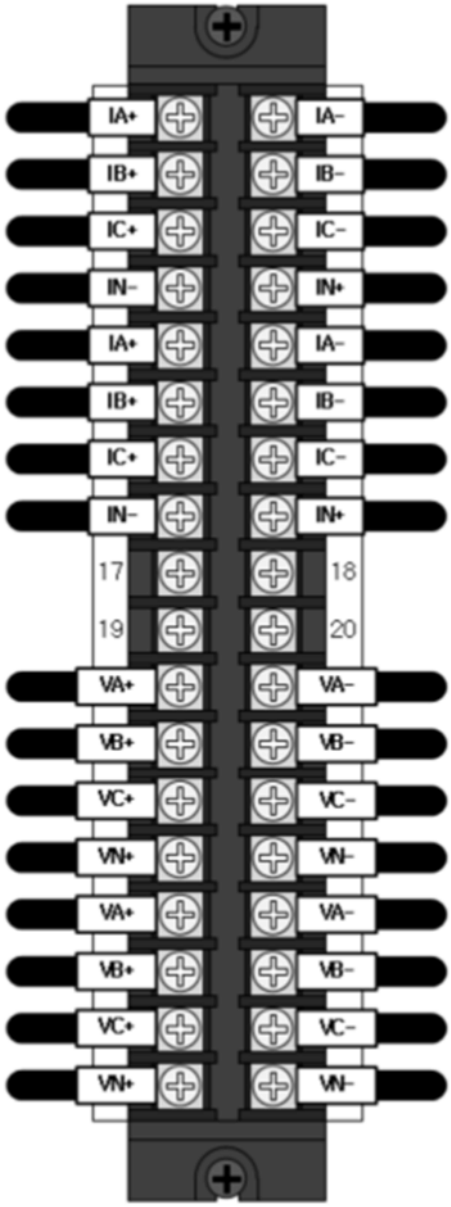
<CPTU-A cnnection>

- CT connection uses #1~#16 and #19~#26 of the CPTU-A terminal block, and the current input connection should be made as +/- pairs.
- PT connection uses #29~36 of the CPTU-A terminal block, and the input connection should be made as +/- pairs.

- Terminal block for CPTU-A connection is configured as follows.

CPTU-A	Function	CPTU-A	Function	Components
1	IA1+	2	IA1-	CT
3	IB1+	4	IB1-	
5	IC1+	6	IC1-	
7	IN1-	8	IN1+	
9	IA2+	10	IA2-	
11	IB2+	12	IB2-	
13	IC2+	14	IC2-	
15	IN2-	16	IN2+	
17	-	18	-	NC
19	IA3+	20	IA3-	CT
21	IB3+	22	IB3-	
23	IC3+	24	IC3-	
25	IN3-	26	IN3+	
27		28		NC
29	VA1+	30	VA1-	PT
31	VB1+	32	VB1-	
33	VC1+	34	VC1-	
35	VN1+	36	VN1-	

2.2.3.2. CPTU-B Connection



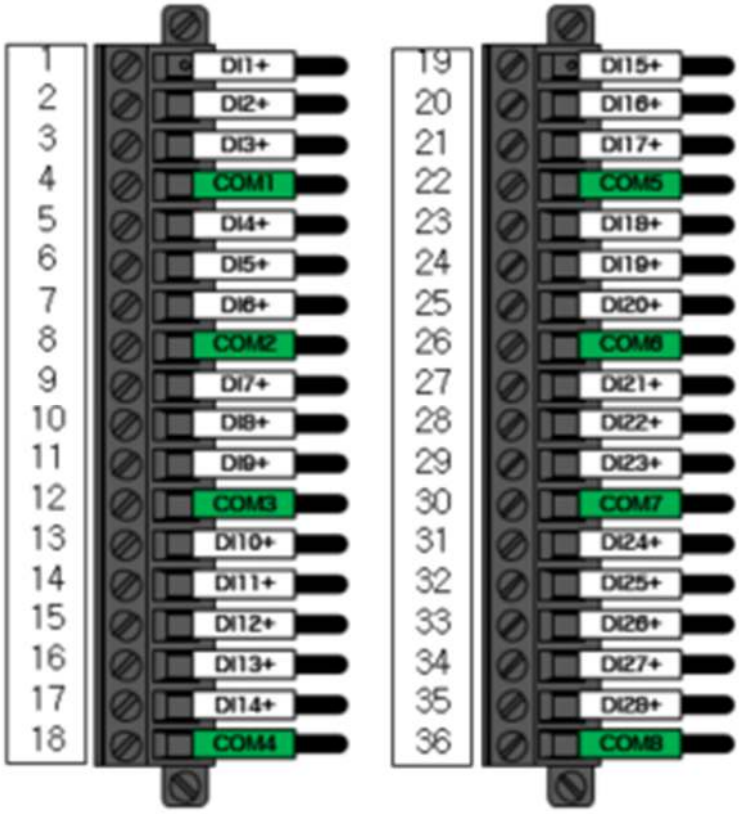
<CPTU-B Connection>

- CT connection uses #1~#16 of the CPTU-B terminal block, and the current input connection should be made as +/- pairs.
- PT connection uses #21~#36 of the CPTU-B terminal block, and the input connection should be made as +/- pairs.

- Terminal block for CPTU-B connection is configured as follows.

CPTU-B	Function	CPTU-B	Function	Components
1	IA1+	2	IA1-	CT
3	IB1+	4	IB1-	
5	IC1+	6	IC1-	
7	IN1-	8	IN1+	
9	IA2+	10	IA2-	
11	IB2+	12	IB2-	
13	IC2+	14	IC2-	
15	IN2-	16	IN2+	
17	-	18	-	NC
19	-	20	-	
21	VA1+	22	VA1-	PT
23	VB1+	24	VB1-	
25	VC1+	26	VC1-	
27	VN1+	28	VN1-	
29	VA2+	30	VA2-	
31	VB2+	32	VB2-	
33	VC2+	34	VC2-	
35	VN2+	36	VN2-	

2.2.3.3. Connection of DIU



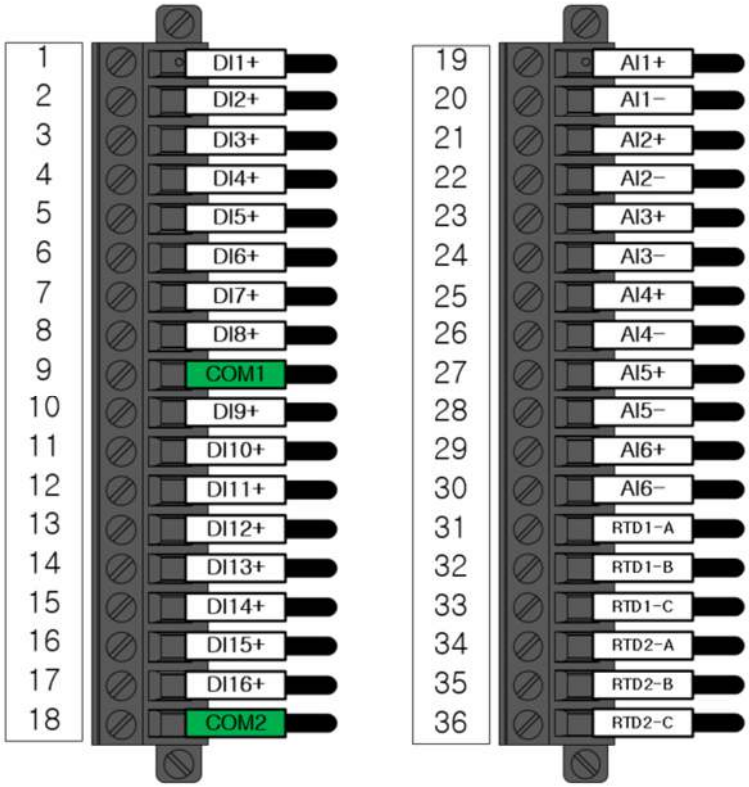
< DIU connection>

- Connection of contact inputs in DIU uses #1~#36 of each terminal block, and is made so that 3 points or 5 points of each terminal block share one COM.

- The configuration for connecting the contact DIU terminal block is as follows.

DIU	Function	DIU	Function
1	DI1+	19	DI15+
2	DI2+	20	DI16+
3	DI3+	21	DI17+
4	DI1,2,3-	22	DI15,16,17-
5	DI4+	23	DI18+
6	DI5+	24	DI19+
7	DI6+	25	DI20+
8	DI4,5,6-	26	DI18,19,20-
9	DI7+	27	DI21+
10	DI8+	28	DI22+
11	DI9+	29	DI23+
12	DI7,8,9-	30	DI21,22,23-
13	DI10+	31	DI24+
14	DI11+	32	DI25+
15	DI12+	33	DI26+
16	DI13+	34	DI27+
17	DI14+	35	DI28+
18	DI10,11, 12,13,14-	36	DI24,25, 26,27,28-

2.2.3.4. Connection of DAIU



<DAIU connection>

- Connection of contact inputs in DIU uses #1~18 of each terminal block, and is made so that 8 points of each terminal block share one COM.

- The configuration for connecting the contact DIU terminal block is as follows.

DAIU	Function
1	DI1+
2	DI2+
3	DI3+
4	DI4+
5	DI5+
6	DI6+
7	DI7+
8	DI8+
9	DI1,2,3,4,5,6,7,8-
10	DI9+
11	DI10+
12	DI11+
13	DI12+
14	DI13+
15	DI14+
16	D15+
17	D16+
18	DI9,10,11,12,13,14,15,16-

- Connection of AI in DIU uses #19~#30 of each terminal block, and the connection should be made as +/- pairs.

- The configuration for connecting the contact AI terminal block is as follows.

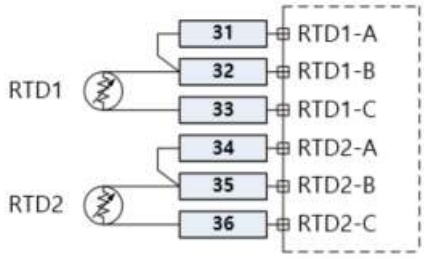
DAIU	Function
19	AI1+
20	AI1-
21	AI2+
22	AI2-
23	AI3+
24	AI3-
25	AI4+
26	AI4-
27	AI5+
28	AI5-
29	AI6+
30	AI6-

- Connection of RTD in DIU uses #31~#36 of each terminal block. #31~#33 are RTD1 [A.B.C], #34~36 are RTD2 [A,B,C] and they are connected as 2-wire or 3-wire connections.

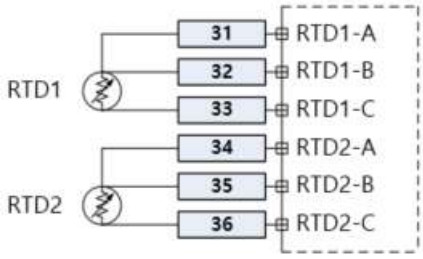
- The configuration for connecting the RTD terminal block is as follows.

DAIU	Function
31	RTD1-A
32	RTD1-B
33	RTD1-C
34	RTD2-A
35	RTD2-B
36	RTD2-C

- The configuration for connecting the RTD sensors is as follows.

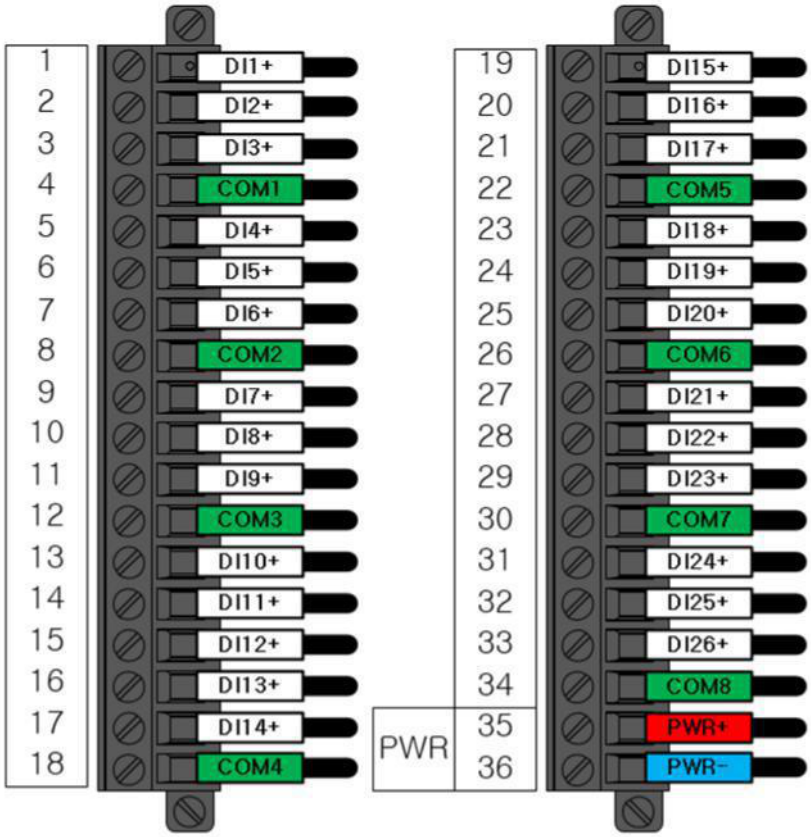


2-wire



3-wire

2.2.3.5. Connection of DIPU



< DIPU connection >

- Connection of contact input in DIPU uses #1~#36 of each terminal block, and is made so that 3 points or 5 points of each terminal block share one COM.

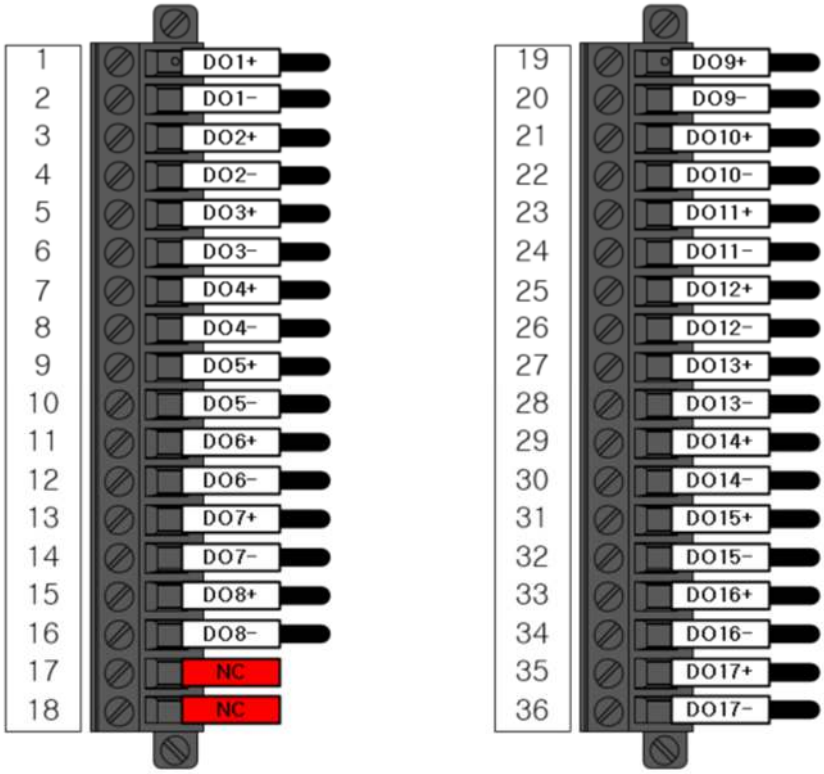
- The configuration for connecting the DIPU terminal block is as follows.

DIPU	Function	DIPU	Function
1	DI1+	19	DI15+
2	DI2+	20	DI16+
3	DI3+	21	DI17+
4	DI1,2,3-	22	DI15,16,17-
5	DI4+	23	DI18+
6	DI5+	24	DI19+
7	DI6+	25	DI20+
8	DI4,5,6-	26	DI18,19,20-
9	DI7+	27	DI21+
10	DI8+	28	DI22+
11	DI9+	29	DI23+
12	DI7,8,9-	30	DI21,22,23-
13	DI10+	31	DI24+
14	DI11+	32	DI25+
15	DI12+	33	DI26+
16	DI13+	34	D24,25,26-
17	DI14+		
18	DI10,11, 12,13,14-		

- DIPU can be used with AC and DC power supply.
- The configuration for connecting the power supply terminal block is as follows.

DIPU	Function	
35	DC125V+	AC220(L)
36	DC125V -	AC220(N)

2.2.3.6. Connection of DOU



<DOU Connection>

- Connection of AI in DOU uses #1~36 of each terminal block, and the connection is made so that there are input as +/- pairs.
- output # 35~36 point out of contacts of DOU terminal blocks are used as the basic B contact.

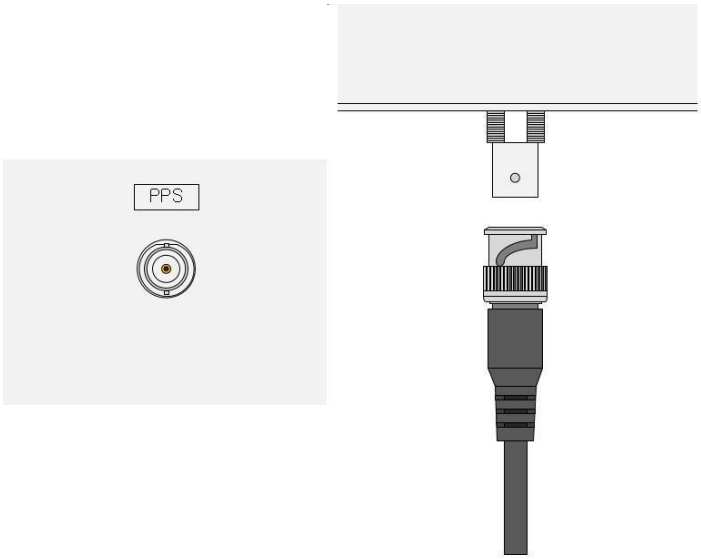
Be sure to check the status of the contact point B before connecting the contact output terminal block.

- The configuration for connecting the power supply terminal block is as follows.

DOU	Function	Contact
1	DO1+	
2	DO1-	
3	DO2+	
4	DO2-	
5	DO3+	
6	DO3-	
7	DO4+	
8	DO4-	
9	DO5+	
10	DO5-	
11	DO6+	
12	DO6-	
13	DO7+	
14	DO7-	
15	DO8+	
16	DO8-	
17	-	
18	-	

DOU	Function	Contact
19	DO9+	
20	DO9-	
21	DO10+	
22	DO10-	
23	DO11+	
24	DO11-	
25	DO12+	
26	DO12-	
27	DO13+	
28	DO13-	
29	DO14+	
30	DO14-	
31	DO15+	
32	DO15-	
33	DO16+	
34	DO16-	
35	DO17+	B contact
36	DO17-	

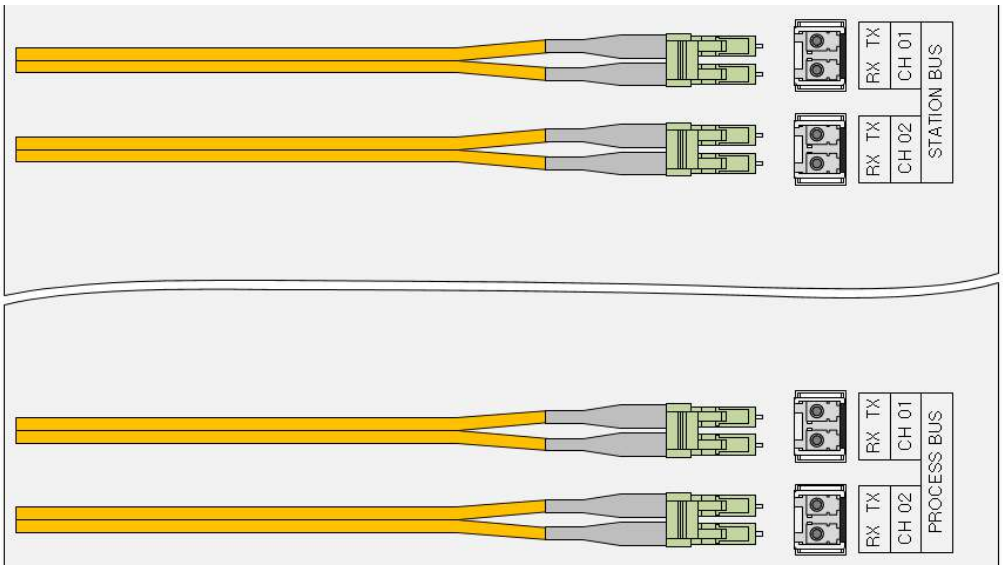
2.2.3.7. 1PPS Connection



<PPS connection>

- 1PPS input cable is connected to 1PPS input port, using BNC cable.

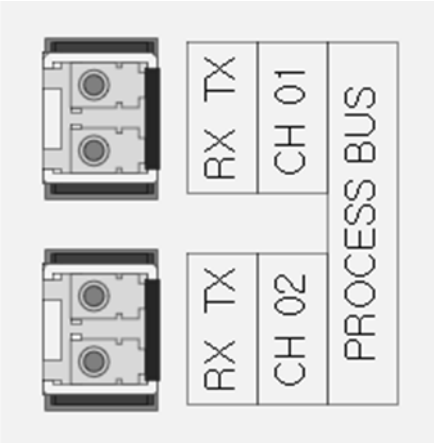
2.2.3.8. Fiber-Optic Connection



<Fiber-optic connection>

- The optical port for connecting STATION BUS terminal (IEC 61850) and PROCESS BUS terminal consists of 2 channels (redundancy), respectively, and the optical cables are connected to CH 01 and CH 02 ports.

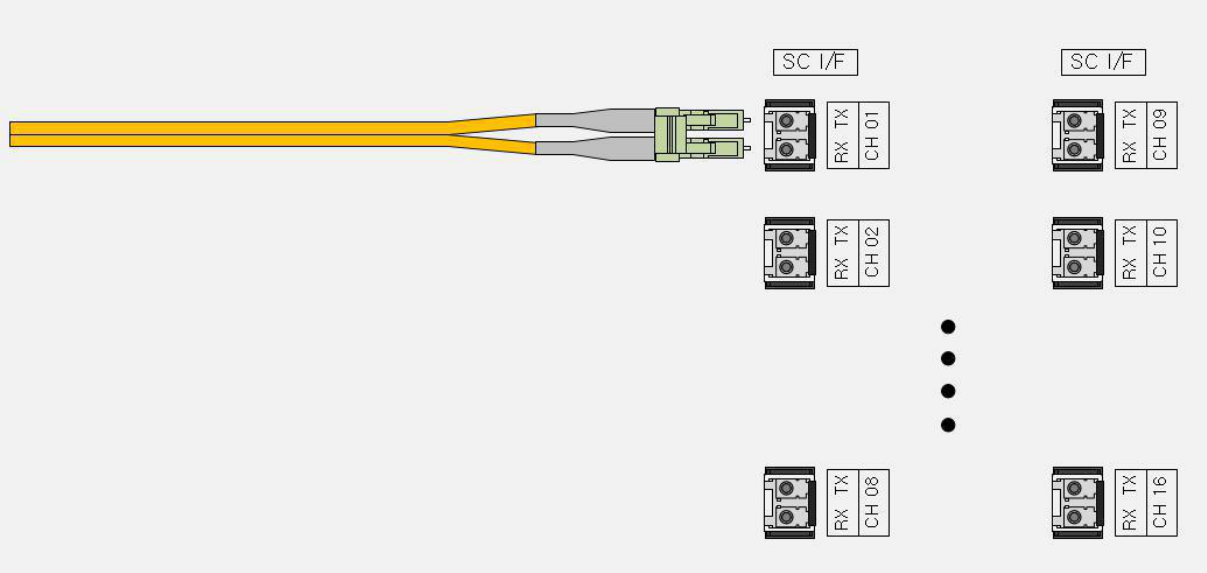
- SFP Specification

Classification	Description
Number of Port	2 (physical) / 1 (HSR/PRP redundant)
Figure	Rear 

Classification	Description		
Characteristics	Glass optical fiber		
Connector type	2 x duplex LC		
	Select option		
	100Base-FX	1000Base-SX 1	1000Base-SX 2
Fiber type	Multi mode (50/125μm and 62.5/125μm optical cable)		
Transmission distance	2km	550m	2km
Wave length	1310nm	850nm	1310nm
Max. Data Rate	100 Mbps	1000 Mbps	1000 Mbps
Operating Temperature	-40 ~ 85℃		
Storage Temperature	-40 ~ 85℃		
Protocol	IEC 61850-9-2LE, IEC 61869-9, limited IEC 61850-8-1 IEEE1588v2		

Do not replace SFP modules supplied by the manufacturer arbitrarily

2.2.3.9. Fiber-Optic Connection for Secondary Converter in the IM2 for LPIT



<Fiber-optic connection to SCs in IM2 for LPIT>

- Optical port for connecting Secondary Converter Unit communication consists of a total of 16 channels, and optical cable is connected as LC to ST type between Secondary Converter unit and IM2.

- SFP Specification

Classification	Description
Number of Port	8 (physical)
Characteristics	Glass optical fiber
Connector type	duplex LC
Fiber type	Multi mode (62.5 μm/125 μm optical cable)
Transmission distance	Maximum 2km
Wave length	850nm
Bit Rate	DC-50 MHz

Classification	Description
Operating Temperature	-40 ~ 85℃
Storage Temperature	-40 ~ 85℃
Protocol	Manufacturer's own protocol



Do not replace SFP modules supplied by the manufacturer arbitrarily

2.2.3.10. Wiring Feature

- Wiring cables used on the back side should be cables equal to or higher than the following standards.
  - Vinyl chloride insulated cable less than 450/750V that meets KSC C IEC 60227-3(2005) or IEEE 383
  - Cables for AC current circuit: copper cable of 2.5㎟ or thicker
  - Cable for power and ground-related circuit: copper cable of 2.5㎟ or thicker
  - Cable for optical communication: Multi-mode, 1310nm
  - Cable for other circuits: copper cable of 1.5㎟ or thicker
  - Treatment of wiring end: Be sure to use the ring-shaped solderless terminals with appropriate dimensions or sleeve-type solderless terminal, and mark bands and colors should be attached to facilitate wiring inspection. However, the solderless terminals must be certified by an authorized agency or conform to KSC 2620 standard.

3. Operation

3.1. Wired-X

The operating software for IM2 is installed on a Windows OS-based PC to connect to IM2 via TCP/IP over Ethernet communication service ports located at the front and the rear of IM2. The communication between the operating software and IM2 is based on request-response scheme.



<Operating software and IM2>

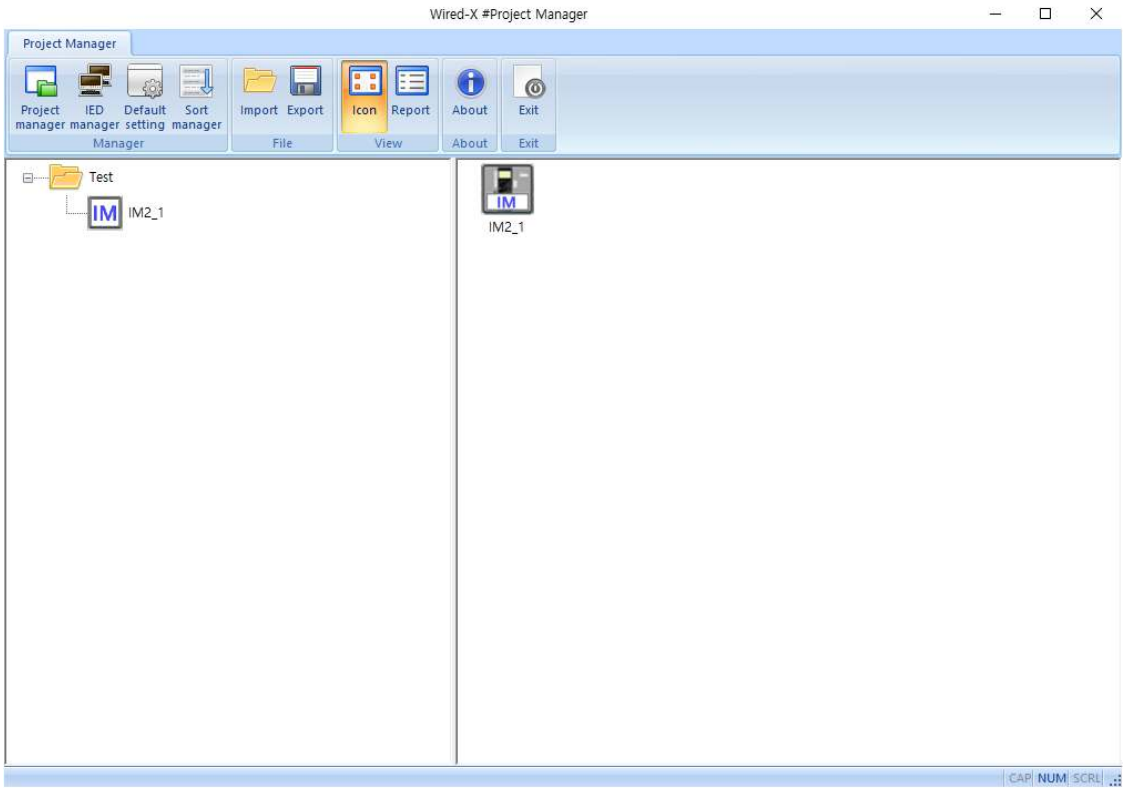
3.1.1. Software Components

Operating software consists of the following modules.

Software module	Details
Project Manager	Project management, device management
Device Manager	Device communication, event, setting, status management
IEC 61850 engineering tool	Management of IEC 61850 engineering files

1) Project Manager

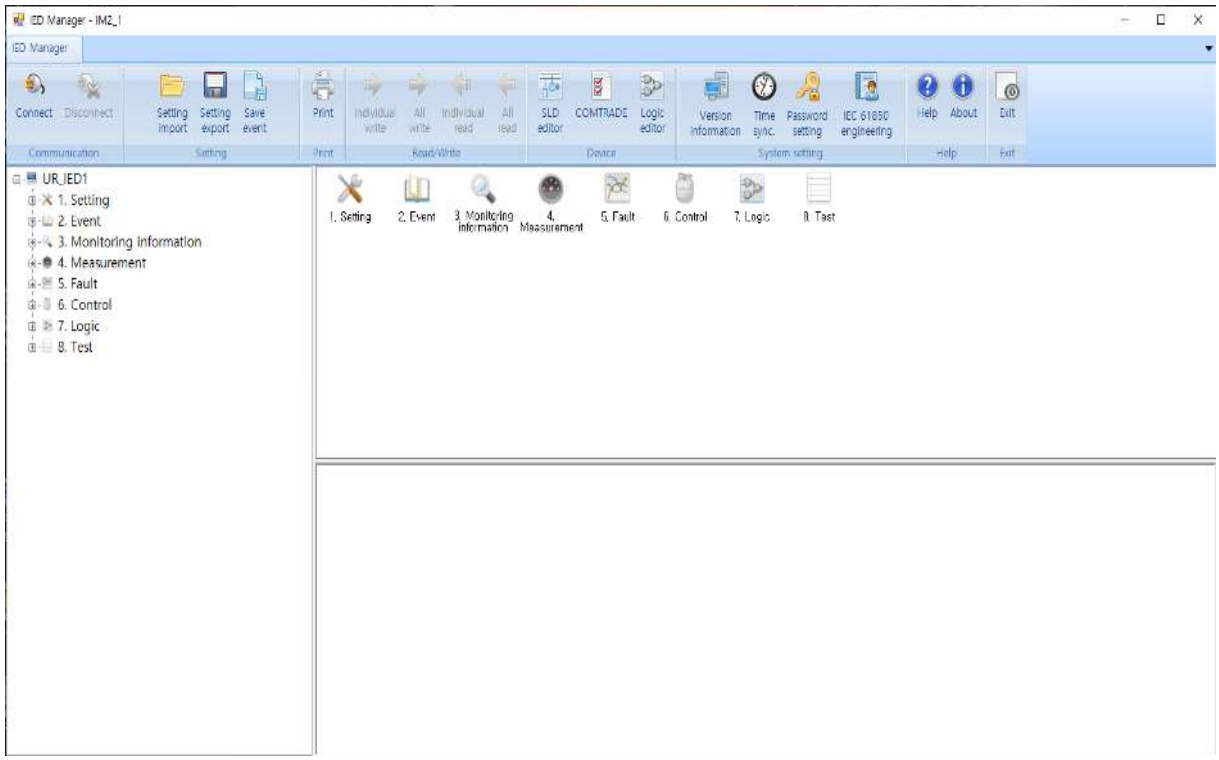
This is the window screen when the operating software is initially run, creating projects and managing devices to be used in the project by device model. Folders where data are saved, communication methods, communication settings for each device model can be managed.



<Project manager window>

2) Device Manager

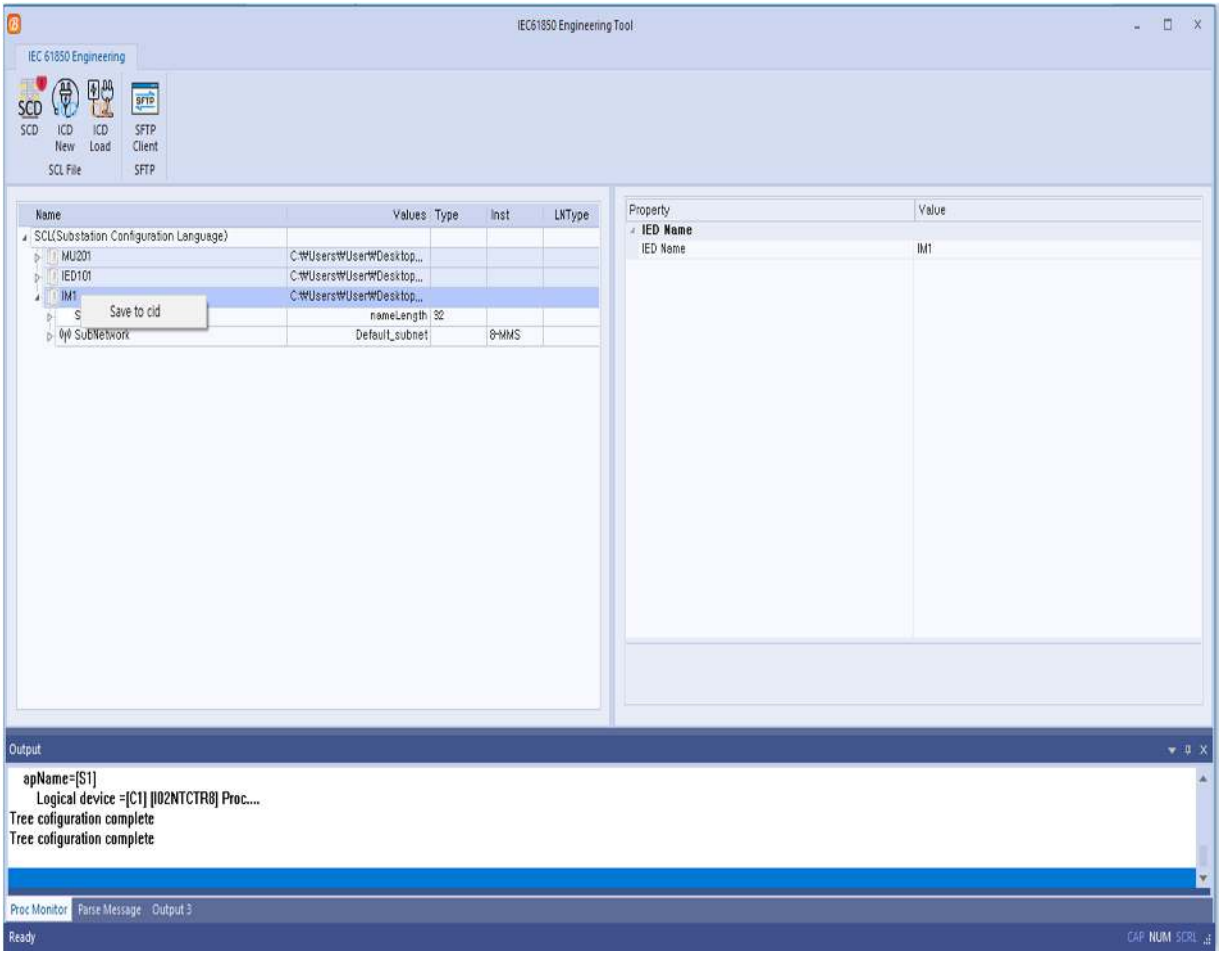
The following is the Device Manager screen which appears after the connection to a device registered in the project created in the Project Manager is completed. Functions of transmitting and receiving the setting, event and history data with the device are provided. IEC 61850 engineering tool can be launched in the device manager screen.



<Device manager window>

3) IEC 61850 engineering tool

IEC 61850 engineering tool is a tool launched in the device manager, which functions to export .ICD files of devices, or import .SDC files to export .CID files. Also, it functions to upload/download the engineering files on/from devices via FTP.



<Window of IEC 61850 engineering tool>

3.1.2. Software Installation

1) Supporting Operating Systems

• Windows XP

• Windows Server 2003, 2008, 2019 Standard

• Windows Vista

• Windows 7

• Windows 8

• Windows 10

• Windows 11

2) PC requirements

• CPU: 1.5GHz or higher

• RAM: 1GB or greater

• HDD: available space of 30GB or more

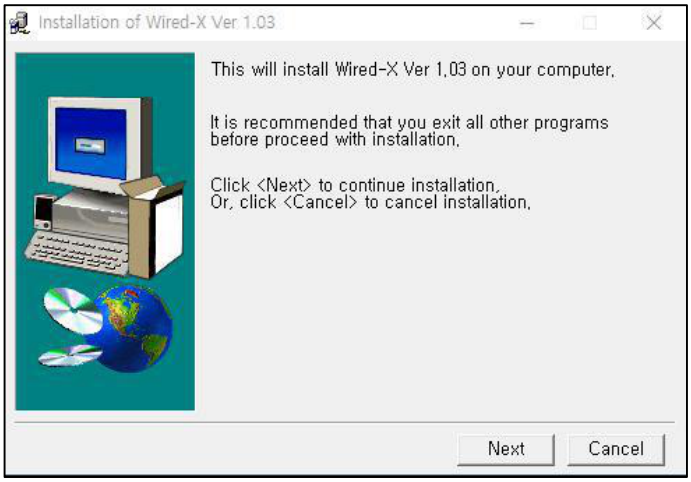
• Ethernet port

3) Installation

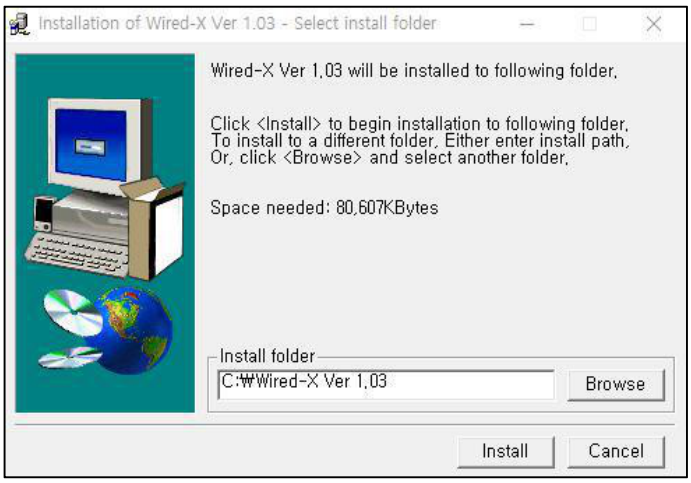
• Run "Wired-X Setup.exe" 

to start the installation.

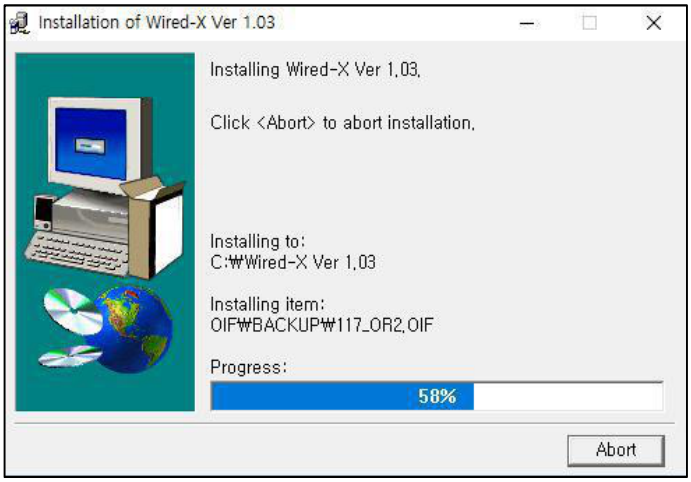
• Click the "Next" button.



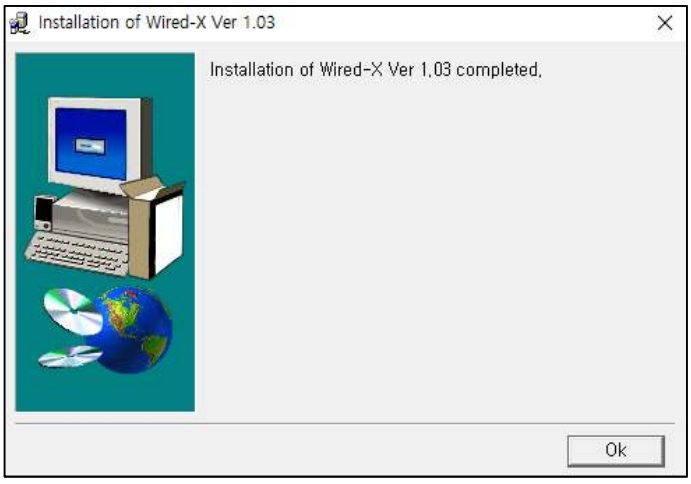
• Designate the "installation folder" and click the "Install" button.



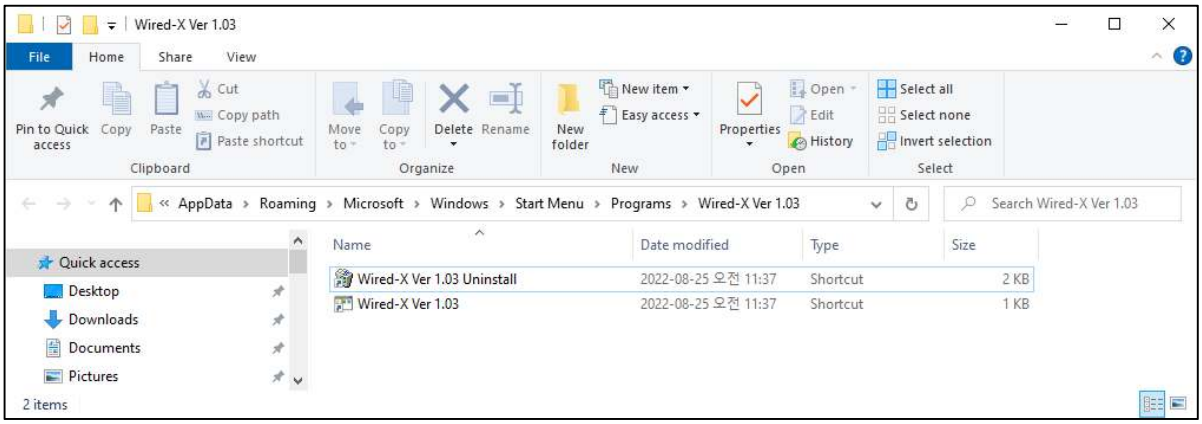
• Installation is proceeded.



• When the installation is completed, click “Ok” button.



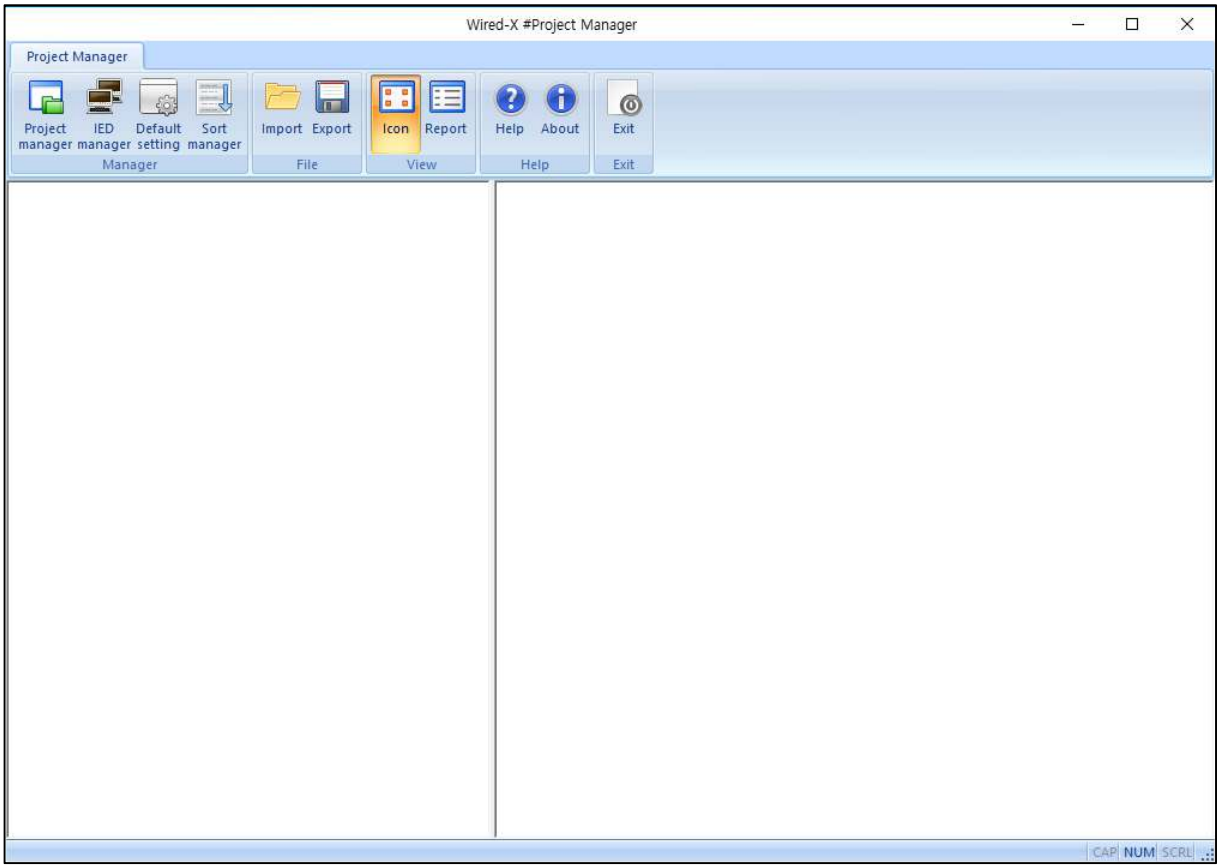
• When the installation is completed normally, the following icons are generated.



<Icons generated >

3.1.3. Running the Software

After the installation is completed, the operating software can be launched by double-clicking  icon. Below is the first screen that appears when the operating software is launched. When first launched, nothing is displayed on the screen. Project registration and device registration step should be first executed in order to being ready to make a connection to a device.

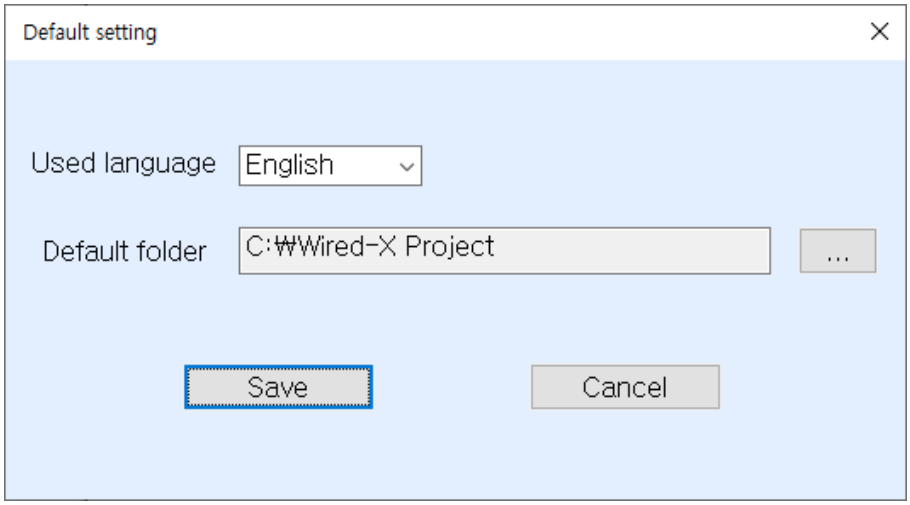


<Initial screen of the operating software (Project Manager)>

3.1.4. Environment Setting for Software

1) Save Path Setting

Set up a “default folder” that saves information on all devices to which the operating software is connected. Be sure to set up before registering project or devices. Click  icon on the toolbar.



<Default setting>

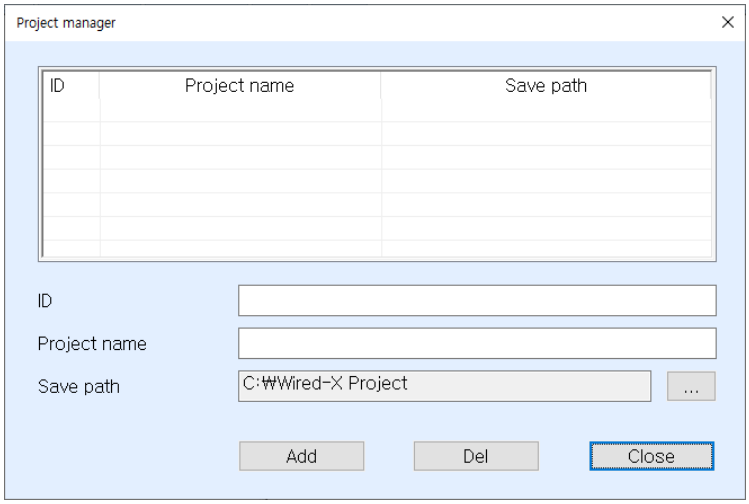
The language used in the software can be changed between “Korean” and “English”. Click "..." button to select the path of default folder. The default path is "C:\Wired-X Project".

After selecting the desired folder, click "OK" button and then click “Save” button on the previous screen to complete the change of the “default folder”. The change of language takes effect after restarting the program. The information on all devices connected to and managed by the operating software is saved in the set “default folder”.

2) Registration of Project

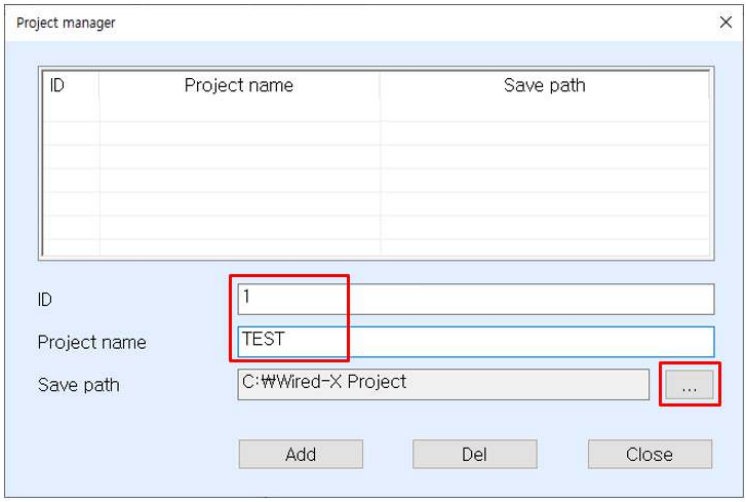
Be sure to register project in order to classify devices connected to and managed by the operating software into project units. For example, one substation can be a project.

First, click  icon on the toolbar.



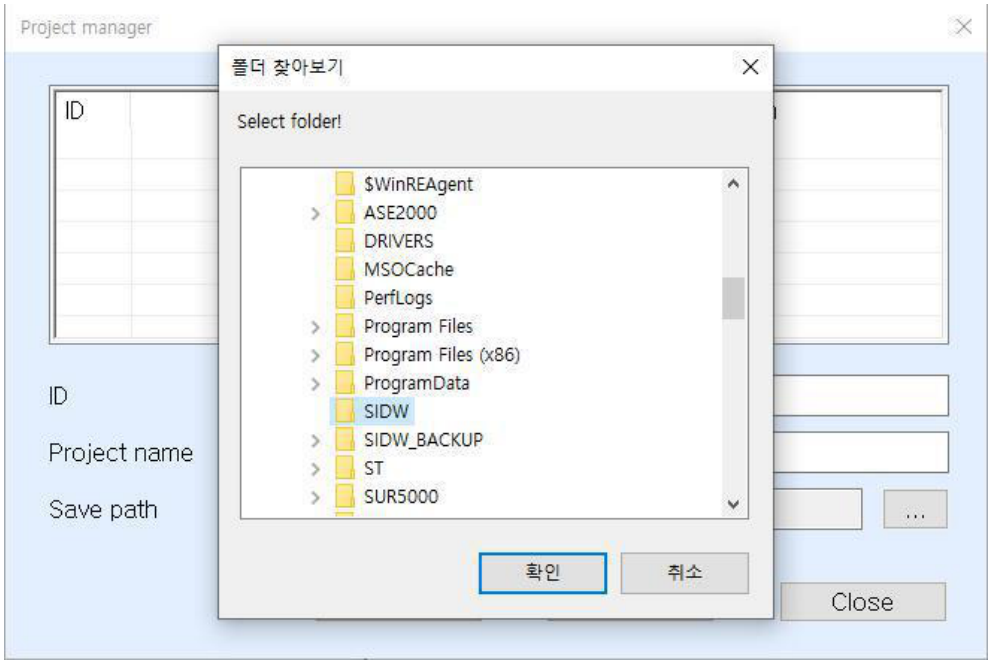
<Project Manager window>

Register projects on the window of Project Manager. Items to be registered are "Project ID", "Project Name", and "Save Path". For "Project ID", enter a numerical value that is distinct from other projects, and for “Project Name”, enter a distinguishable name (e.g., substation name). For "Save Path", select the folder where the project is saved. Check the items for registering project.



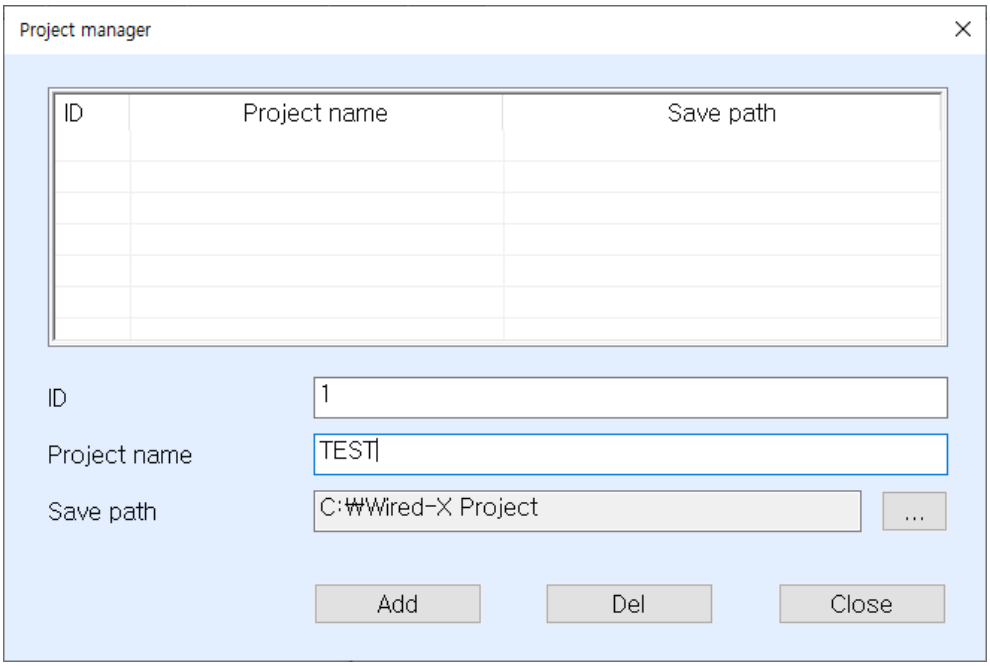
<Window for registering projects>

Select a folder where project will be saved.



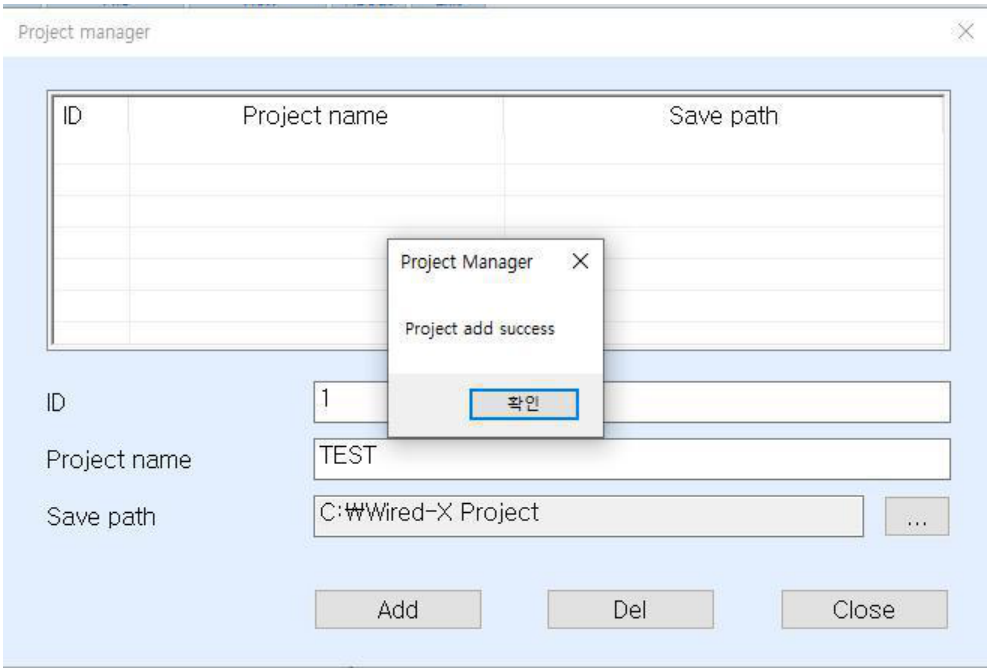
<Window for selecting save path>

Check the input items and then click “Add” button to register the project.



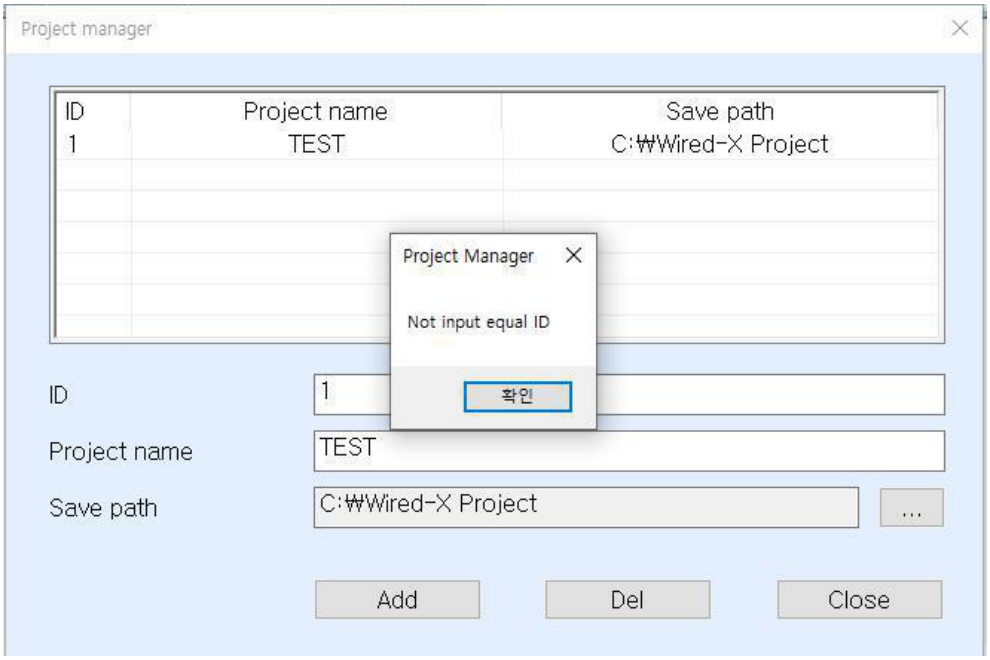
<Window for entering project items>

The added project details will be updated in the upper list.



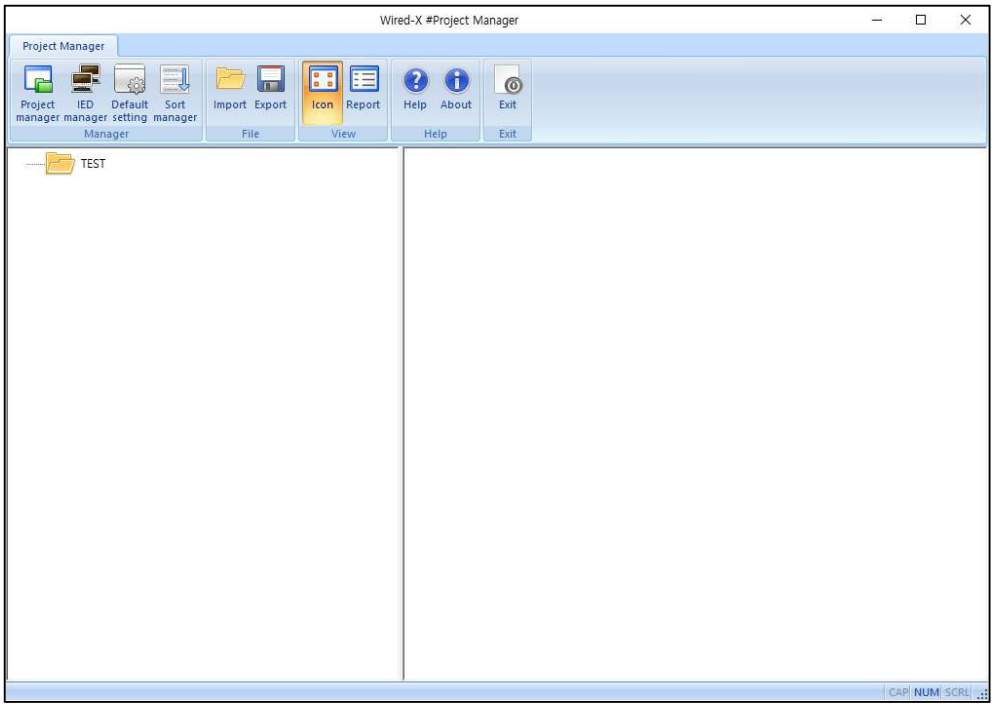
<Window that displays message of 'Project add success'>

If the ID is same as the existing value, project registration will fail.



<Window that displays error message when inputting an existing ID>

After the registration process is finished, the name of the registered project is generated in the tree on the left side of the initial screen.

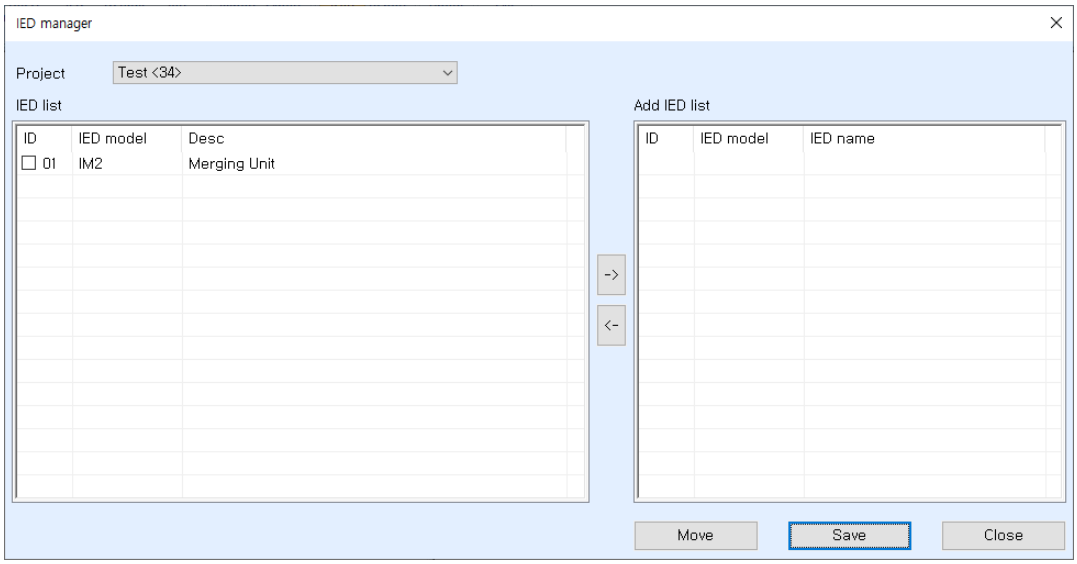


<window for checking the registered projects>

3) Registration of Devices

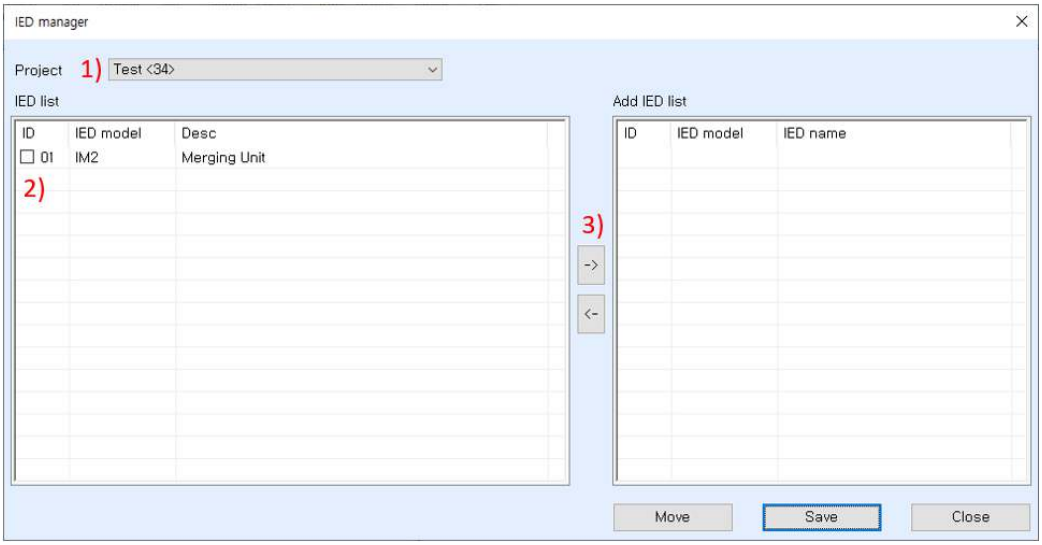
After a project is successfully registered, it is necessary to register devices for the project. For example, the IM2 devices installed in one substation can be the devices for the project.

Click  icon on the toolbar.

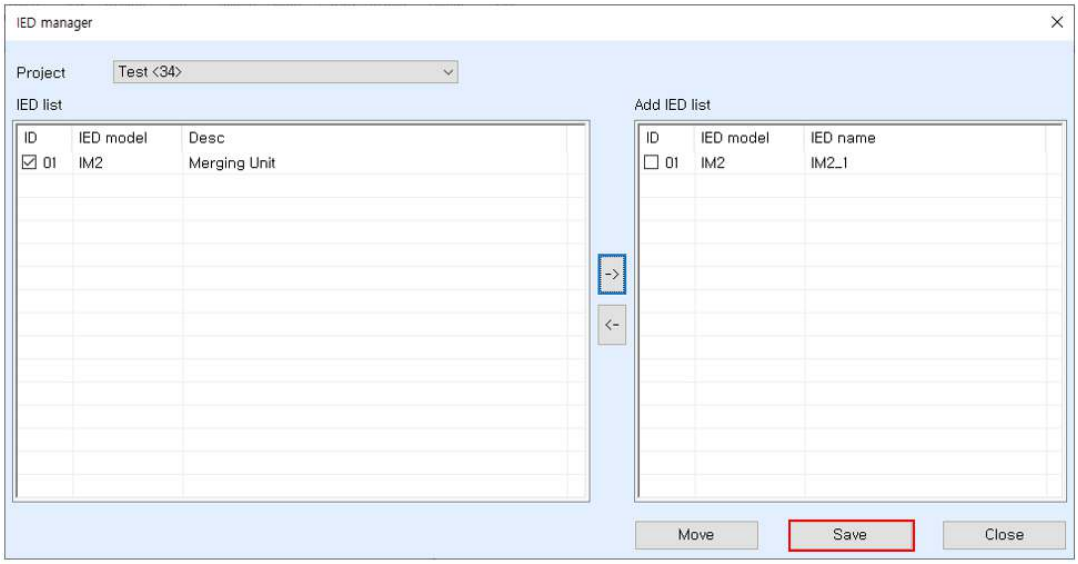


<Manager window>

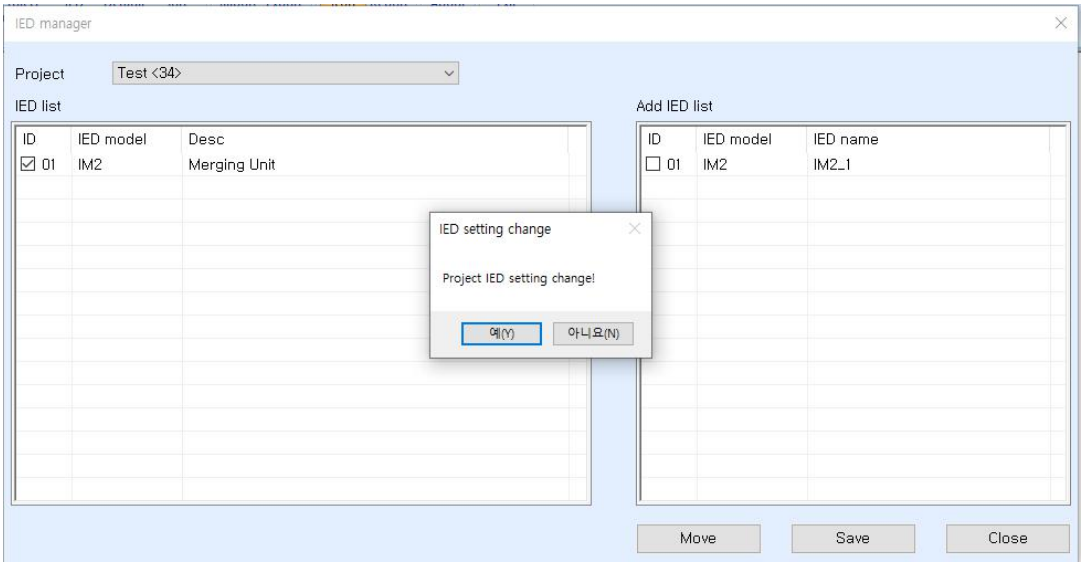
Select "Project", and then select “Device Model” to register from “Device List” on the left (multiple selections are possible), and click “-->” button to update “Registered List of Devices” on the right. Click “Save” button to complete the registration of device.



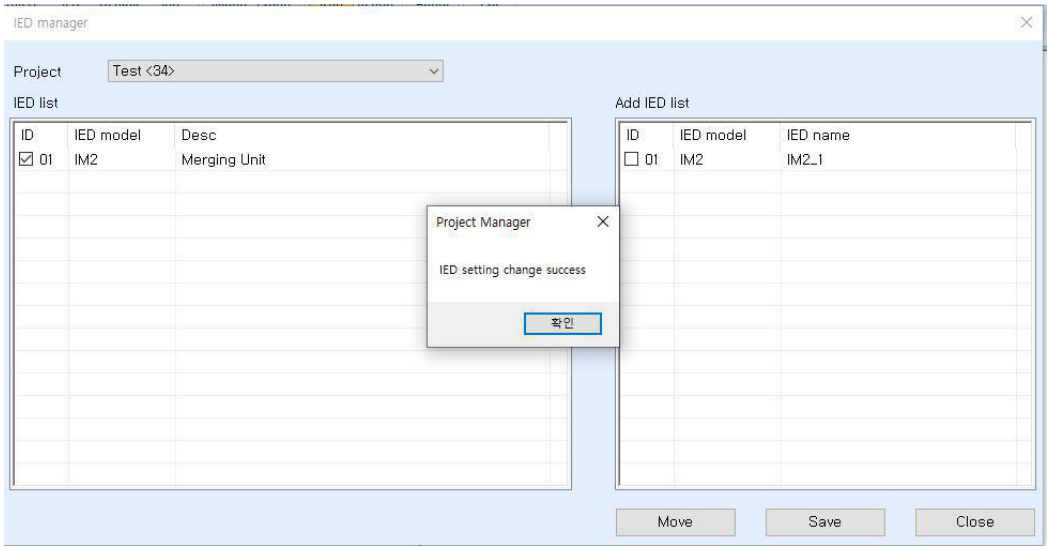
<Device registration procedure 1 – selection of item>



<Device registration procedure 2 – Save>

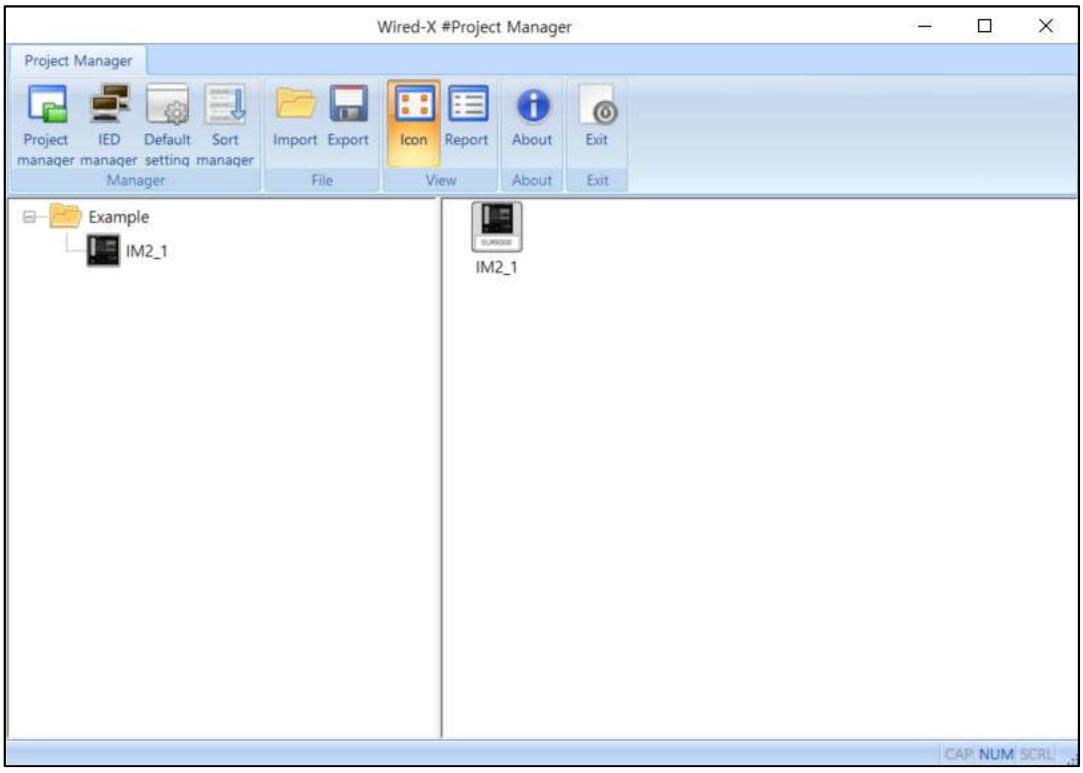


<Device registration procedure 3 – Check setting>



<Device registration procedure 4 – Setting completed>

When the device is registered normally and the above window is closed, the registered device is displayed below the corresponding project item on the left list as follows, and is also displayed in the right side of the screen if the project is selected.

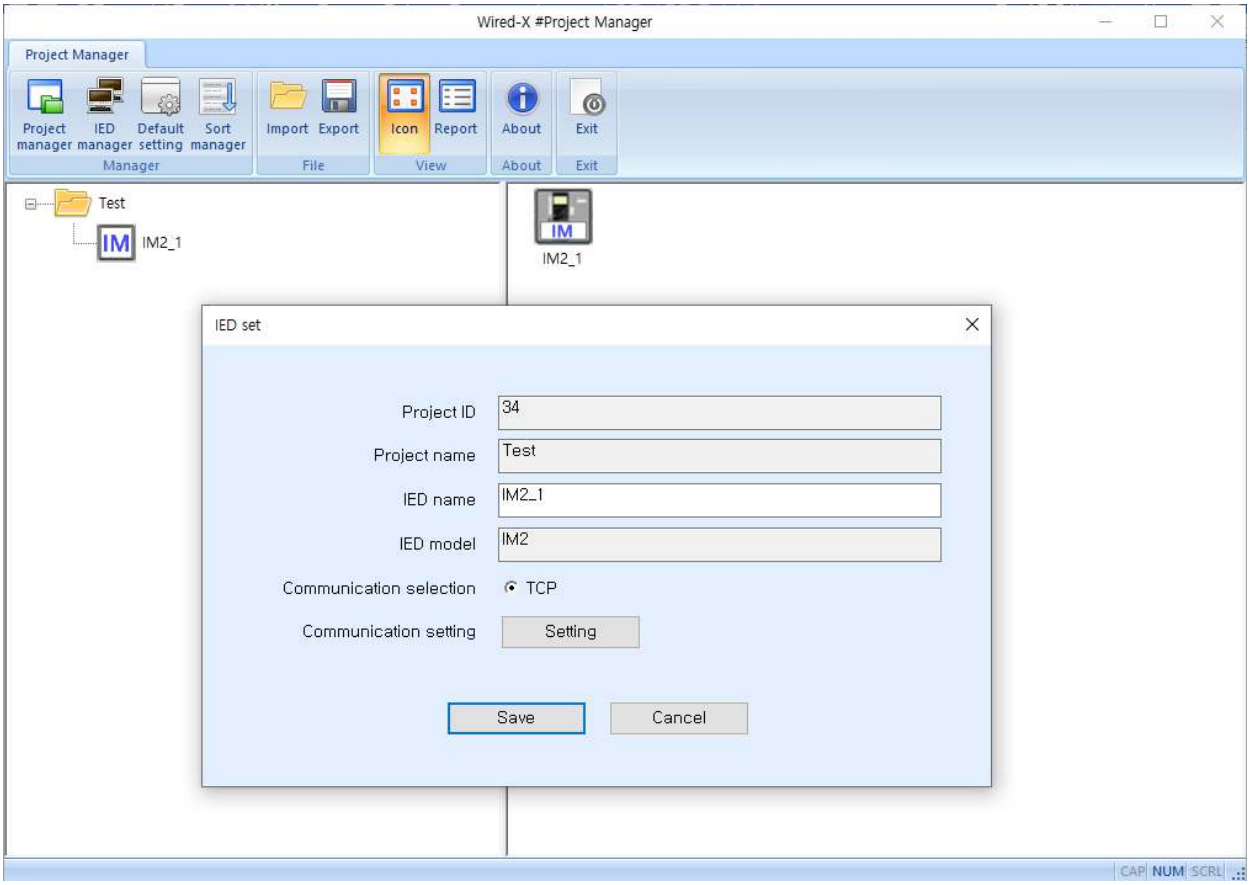


<Result of registering the device>

3.1.5. Connection to Software

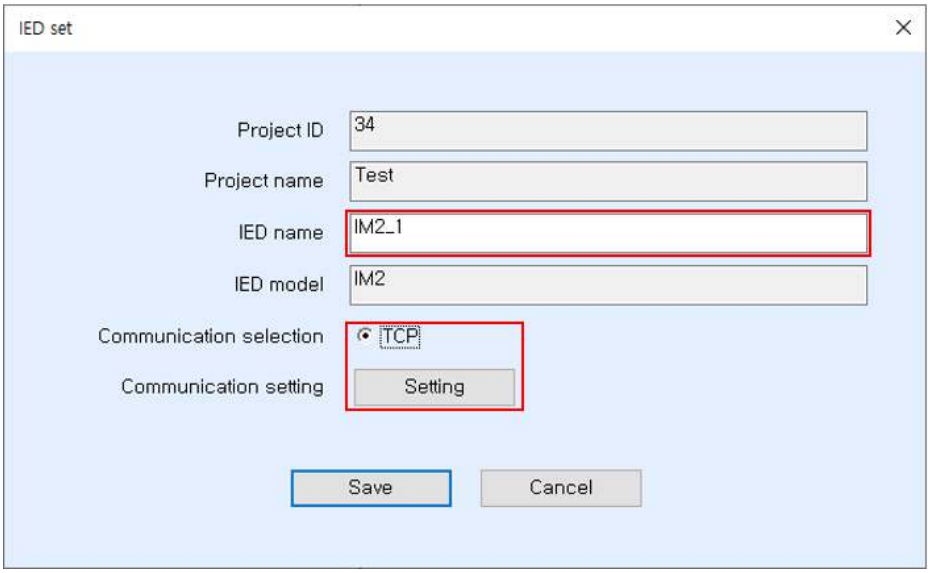
1) Setting of Connection

In order to connect the operating software to the registered device, the communication scheme and related parameters should be set up. Select the device to connect in the left or right side of the screen, click the right button on the mouse to display a window for “Device setting”.

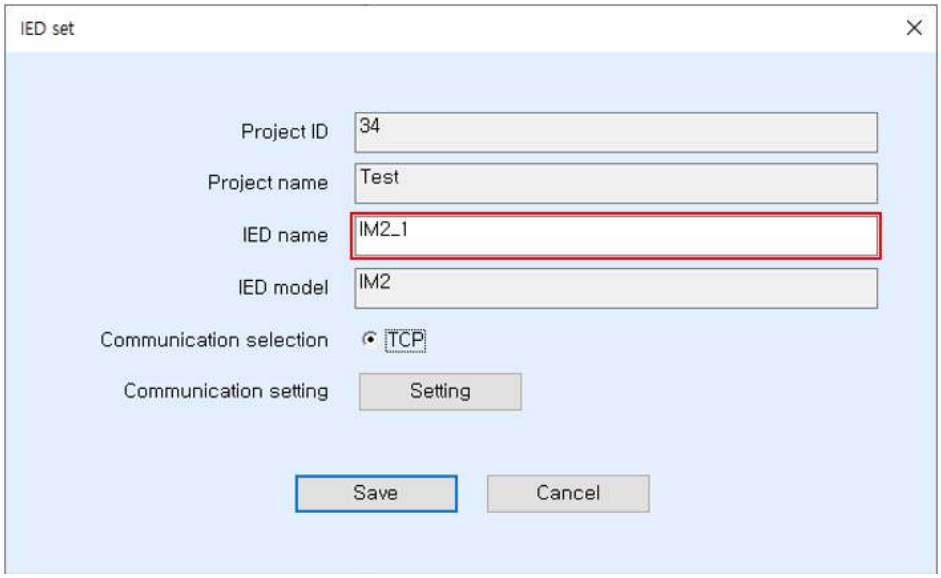


<Window for device setting>

In the above screen, “Device name”, “Communication selection” and “Communication setting” can be modified. The initial value of "Device name" is entered as the same string with the “Device model” at the time of registration, and the operator can change it. “Communication selection” is an item to select how to communicate with the device, and in such case, the setting items on the window of “Communication setting” varies depending on the selected communication scheme.

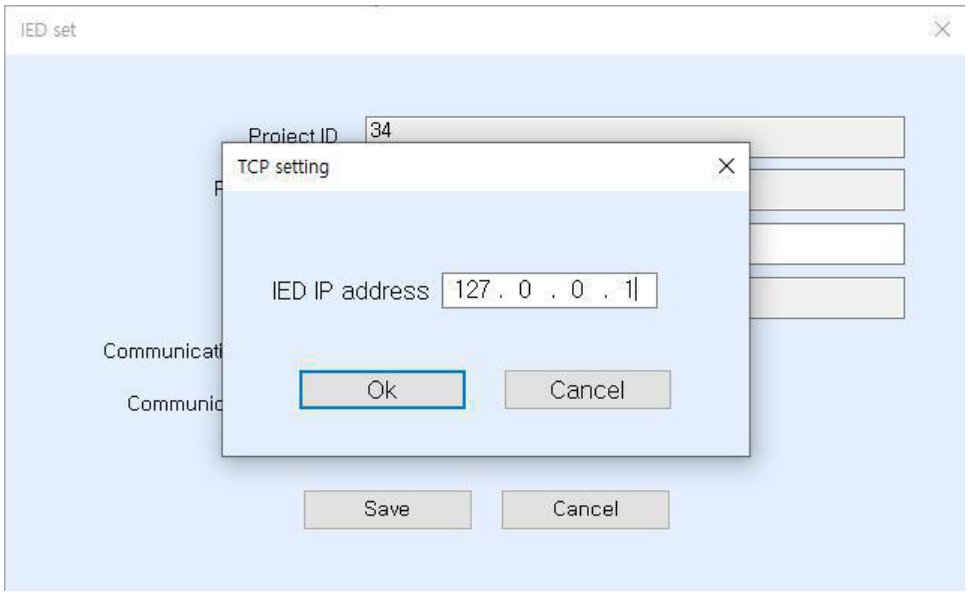


<Device setting – modifiable items>



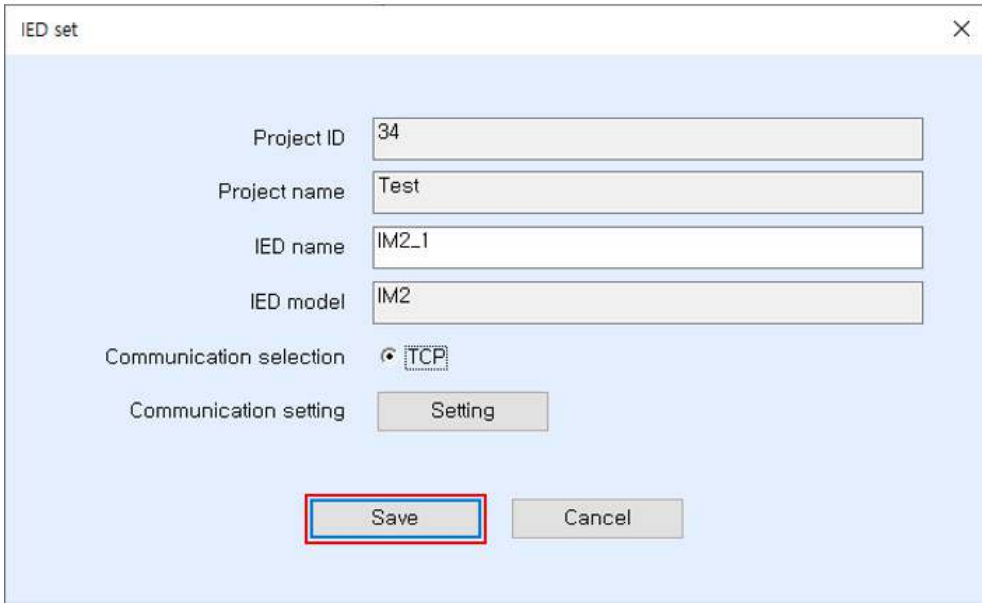
<Device name setting>

For the communication scheme, only TCP/IP is supported by IM2. In the communication setting window, the IP address of the device to connect should be correctly set. Click "OK" button after setting.



<Device setting – setting of TCP communication>

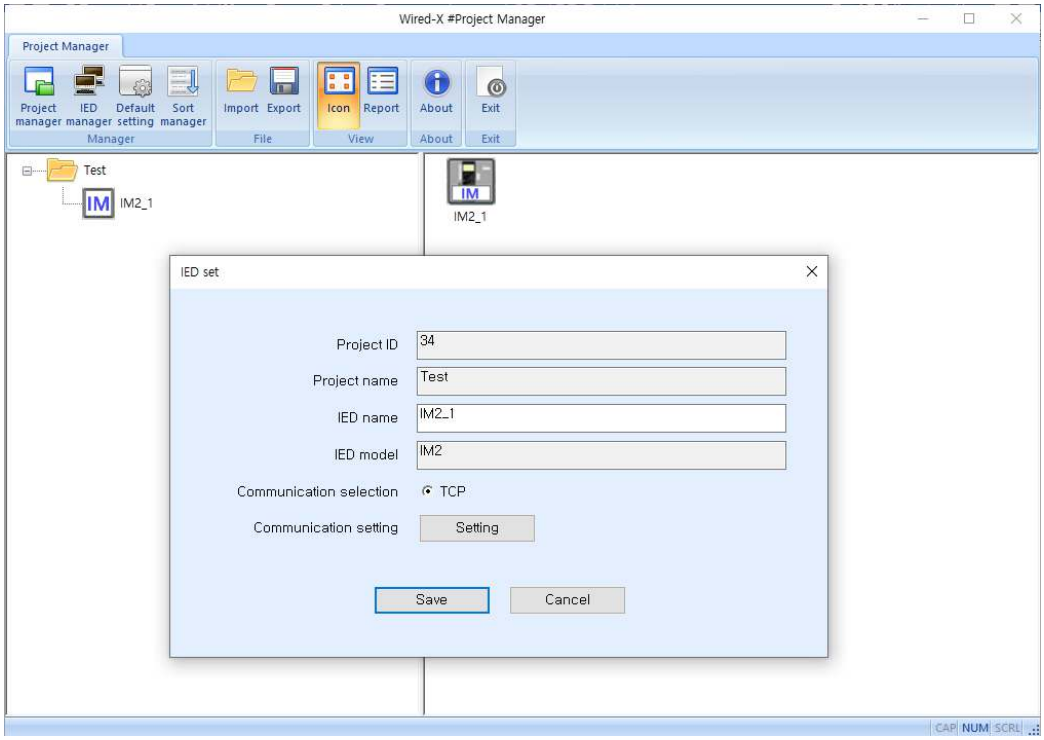
Check the set items after setting, and then click "Save" button.



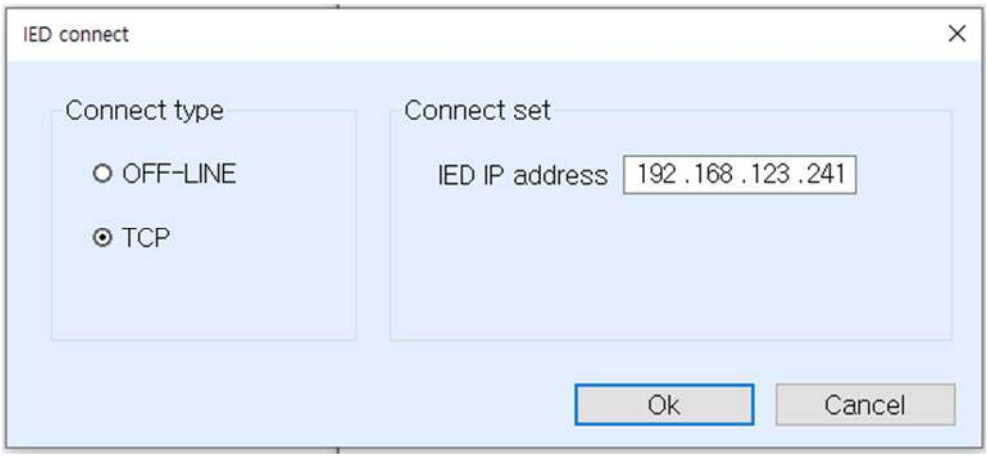
<Device setting completed>

2) Connection

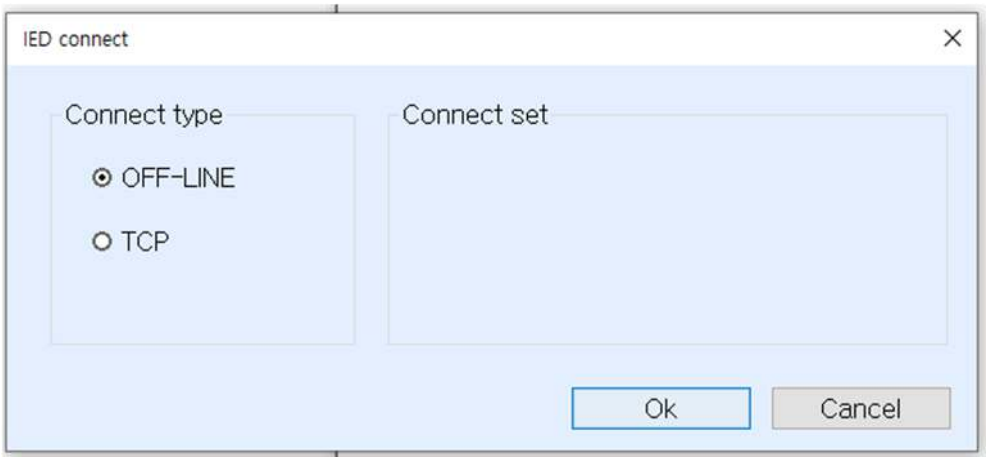
After setting communication parameters, double-click the device to be connected. Then, a window for device connection will be displayed.



<1st step of device connection – select and double-click the device>



<2nd step of device connection – TCP selected>

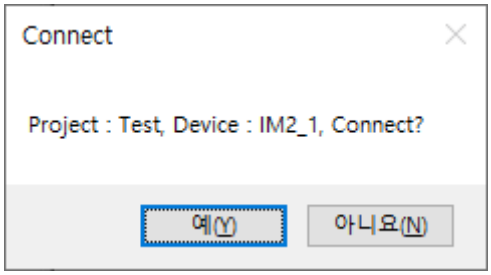


<2nd step of device connection – off-line selected>

The connection type can be reselected in the above window. For the connection type designated in the left side of the above window, the detailed information for the type should be set in the right side of the window.

If "OFF-LINE" mode is selected, the Wired-X operates, without connecting to the device, with the information which is pre-set in the software. The values can be modified and saved also in the "OFF-LINE" mode, and it is possible to connect to the device again via TCP and read/write the values from/to the device.

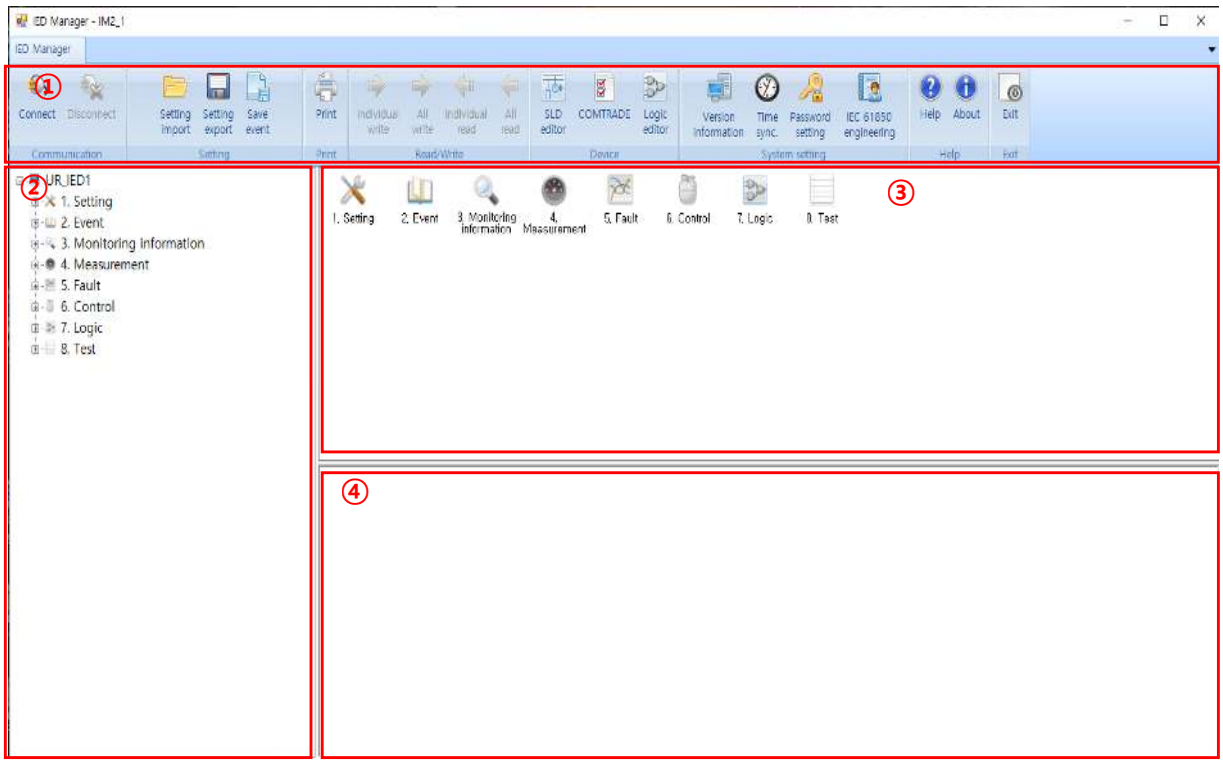
Check "Connection type", and "Connection settings", and then click "OK" button to display the confirmation window, and then click "Yes" button to connect to the device.



<3rd step of device connection – confirmation window>

When connected to the device, the software automatically reads data from the device. If the

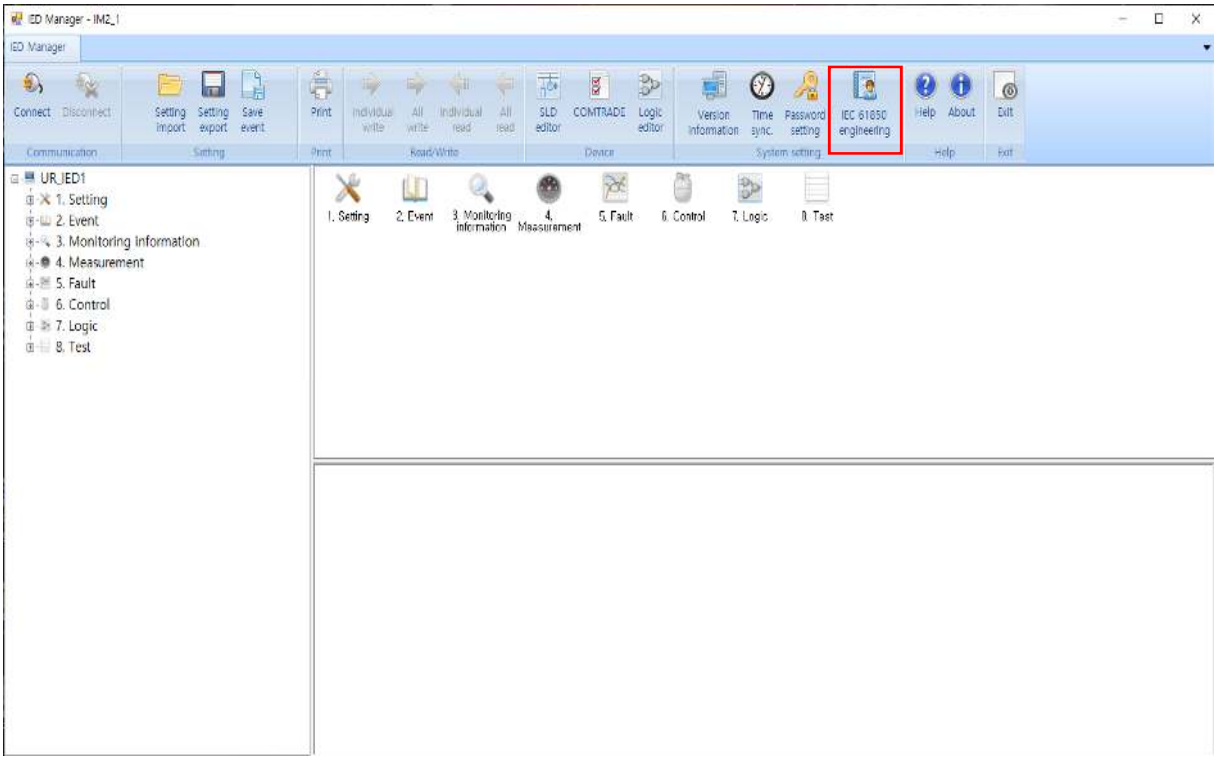
software failed to connect with the device due to some reason, a communication error message is displayed and the connection trial is terminated. If a communication error message is displayed, check the device settings again and proceed to try connection. When the connection and data synchronization with the device are completed successfully, the initial screen of the Device Manager is displayed. Device Manager view is consist of 4 area (①Main Tool Bar, ②Tree View, Detail Information View, ④Log view)



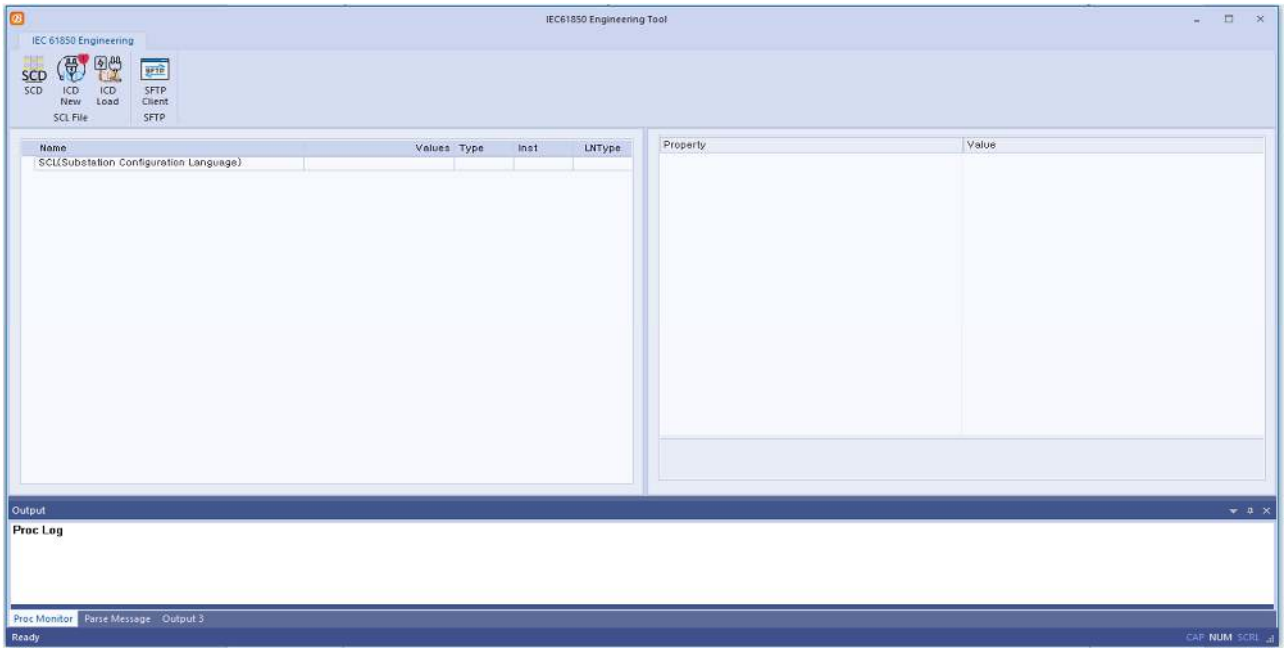
<Screen layout of the Device Manager>

3.1.6. Running IEC 61850 Engineering Tool

1) Running IEC61850 Engineering Tool on Wired-X



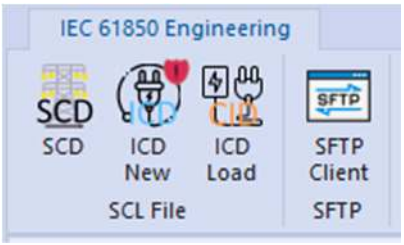
<IEC 61850 Engineering Tool Run Button>



<IEC61850 Engineering Tool>

2) Basic Menu and Tools for IEC61850 Engineering Tool

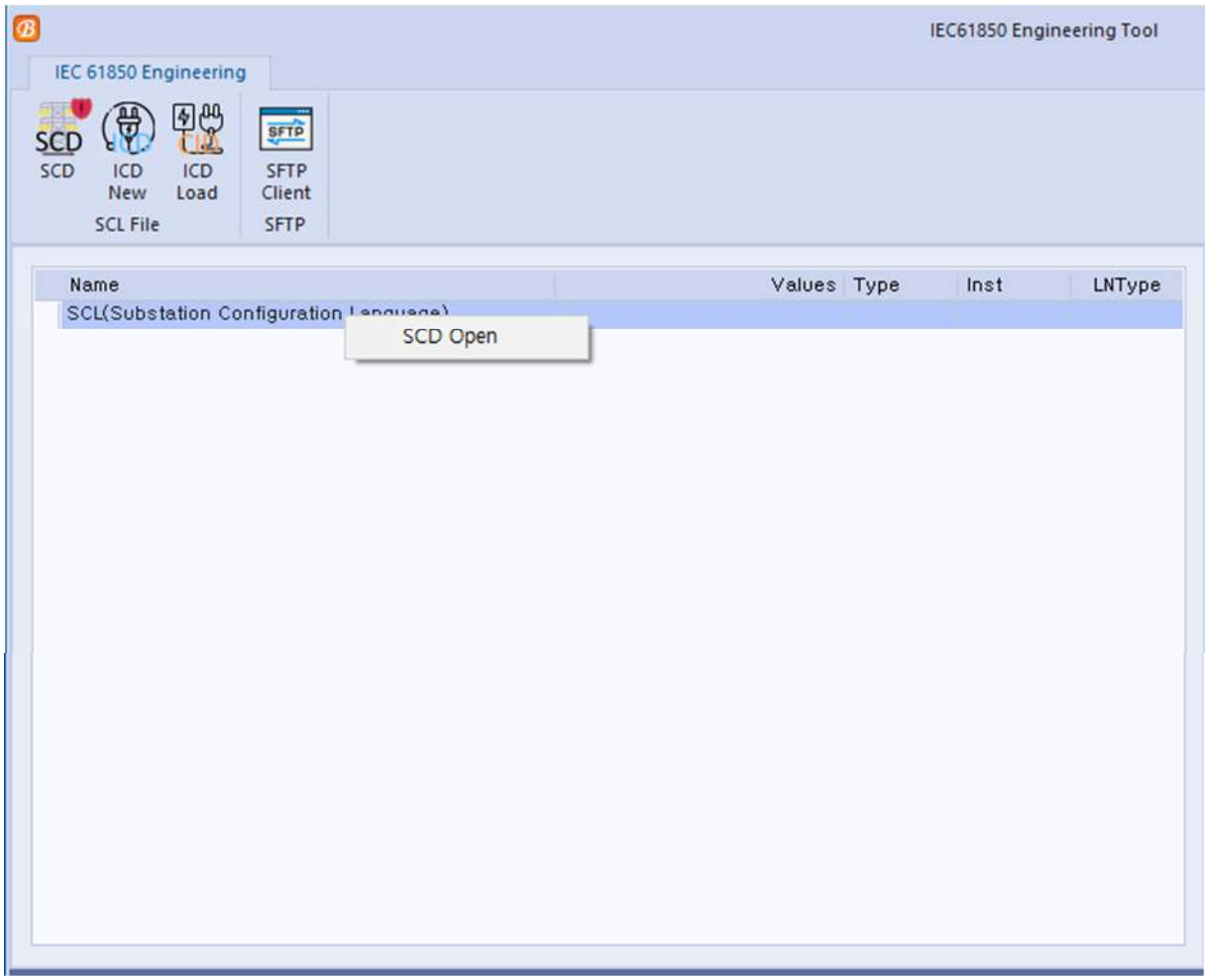
Reading SCL and Connecting to SFTP can be found under the SCL File Menu.



<SCL File Menu>

3) Opening SCD File

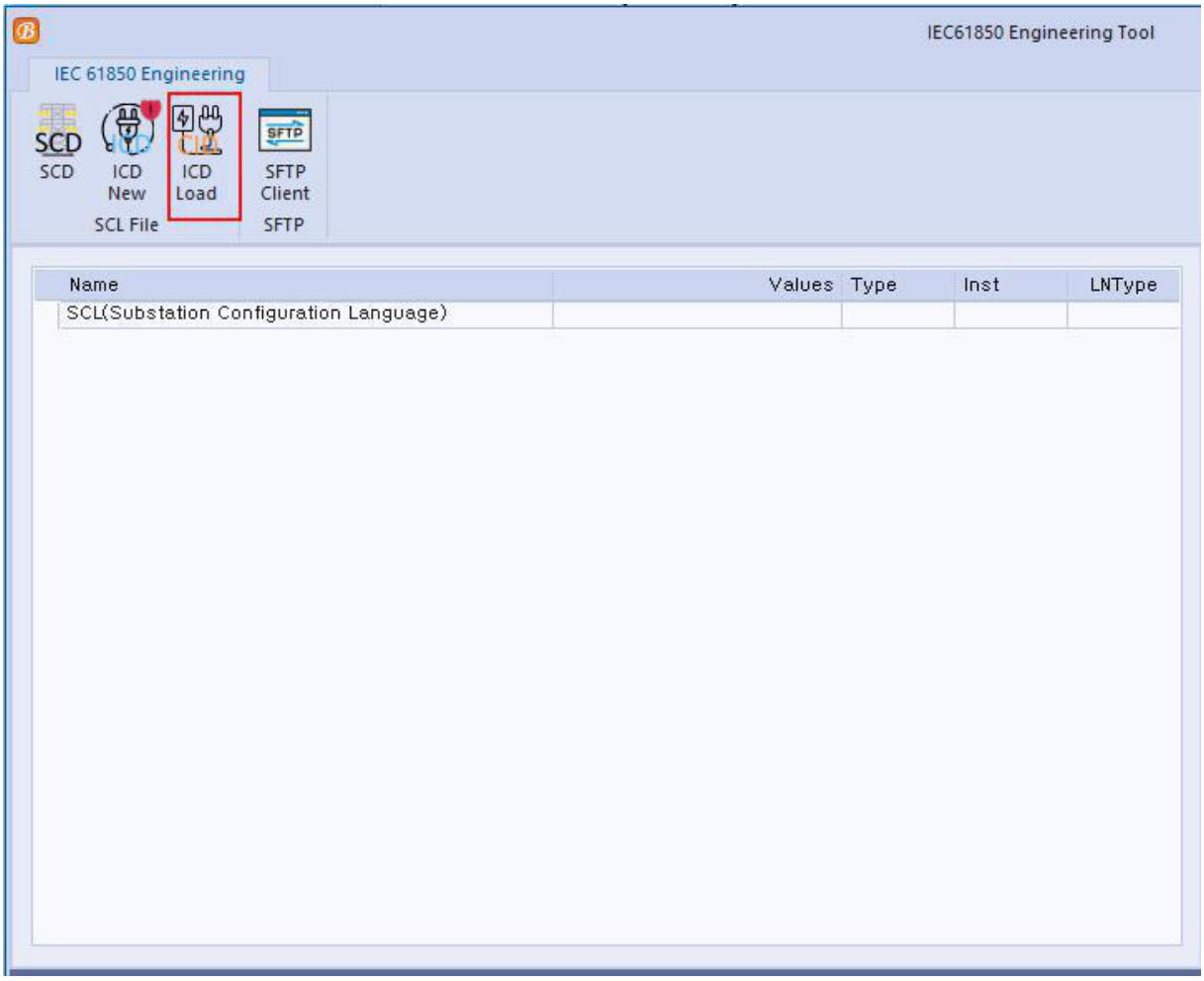
Click SCD under SCL File Menu, and right click on SCL to open.



<SCD File Open>

4) Loading ICD File

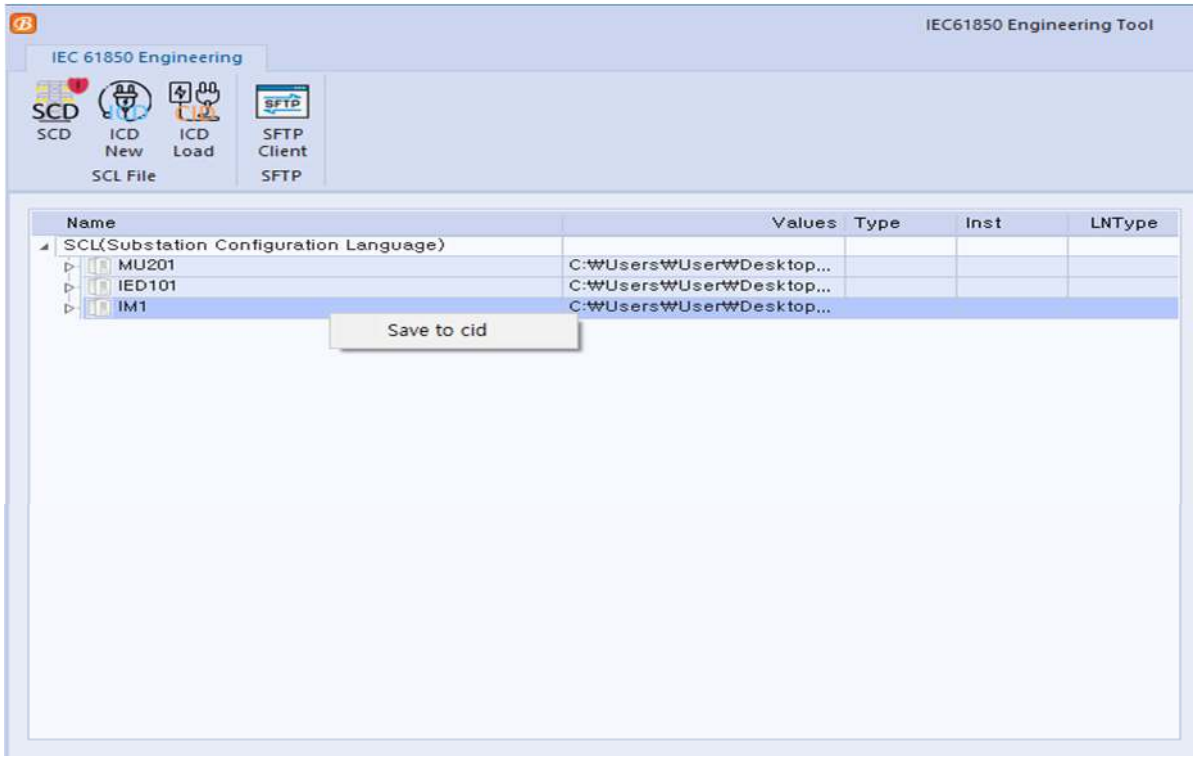
Click ICD Load under SCL File menu to load ICD File.



<Loading ICD File>

5) Exporting CID File

To export CID file, opening the SCD file and click on "Save to cid".

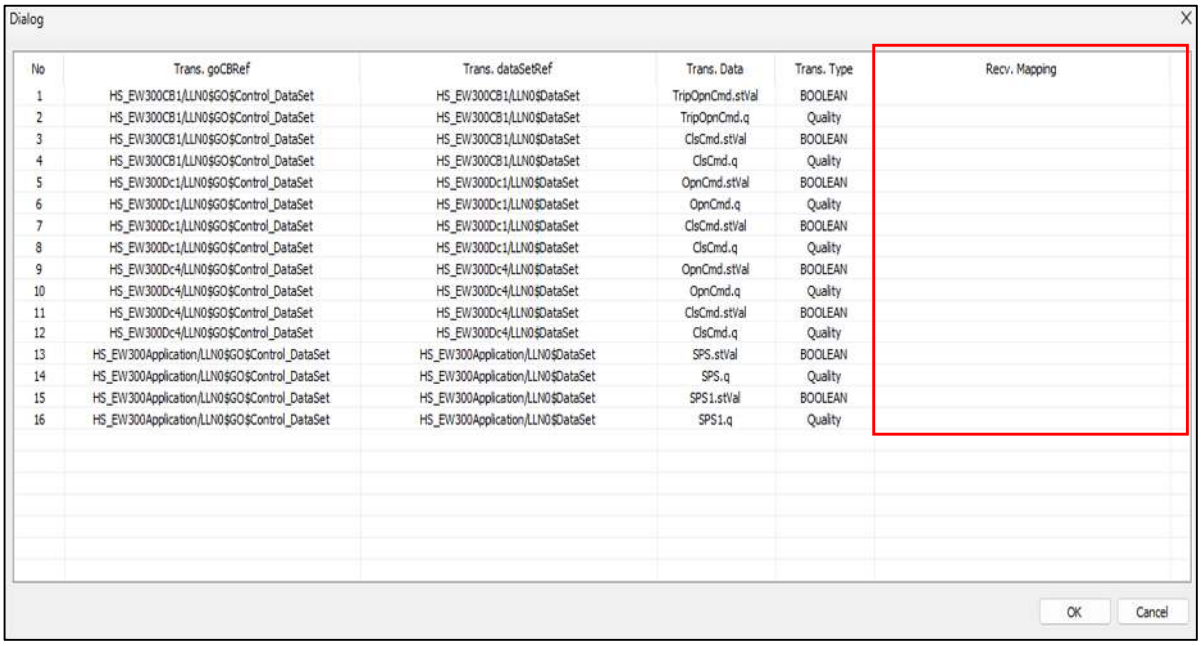


<Exporting CID File>

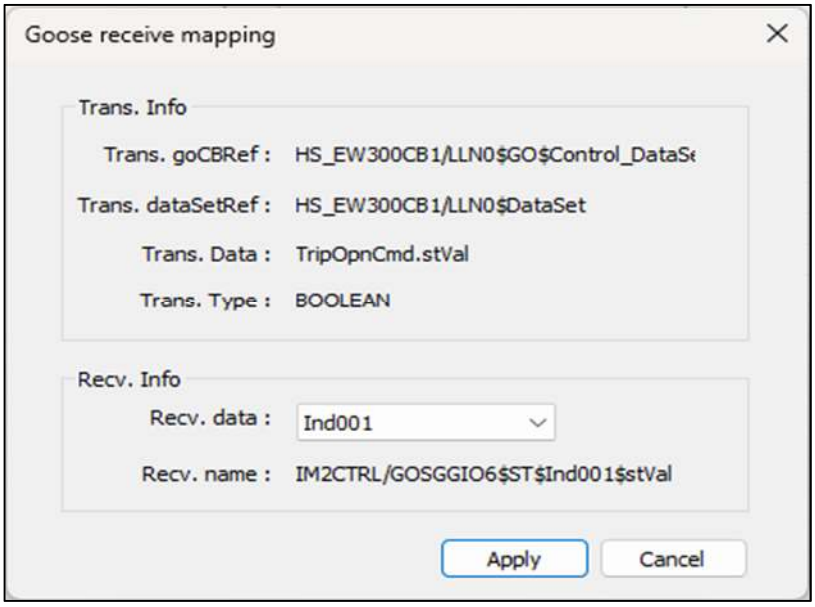
If GOOSE receive has not been mapped to IM2 in the SCD file, a window will appear, prompting you to specify the location for saving the CID file.

If you have configured the IM2 to receive GOOSE in the SCD, the GOOSE detailed mapping window will appear automatically. This is because the SCT usually only progresses the mapping to the LN level. To map to the DA level for the IM2 to receive GOOSE, follow this process.

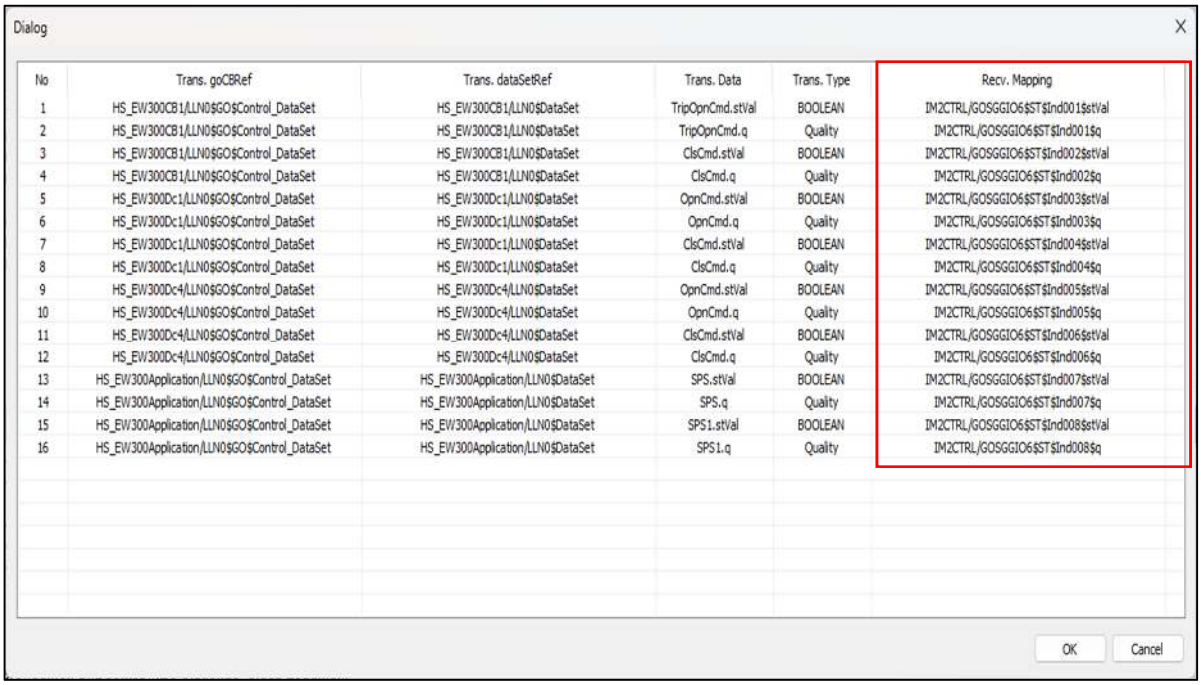
A window like the one below will pop up, and you can see that the "Recv. Mapping" column on the left is empty.



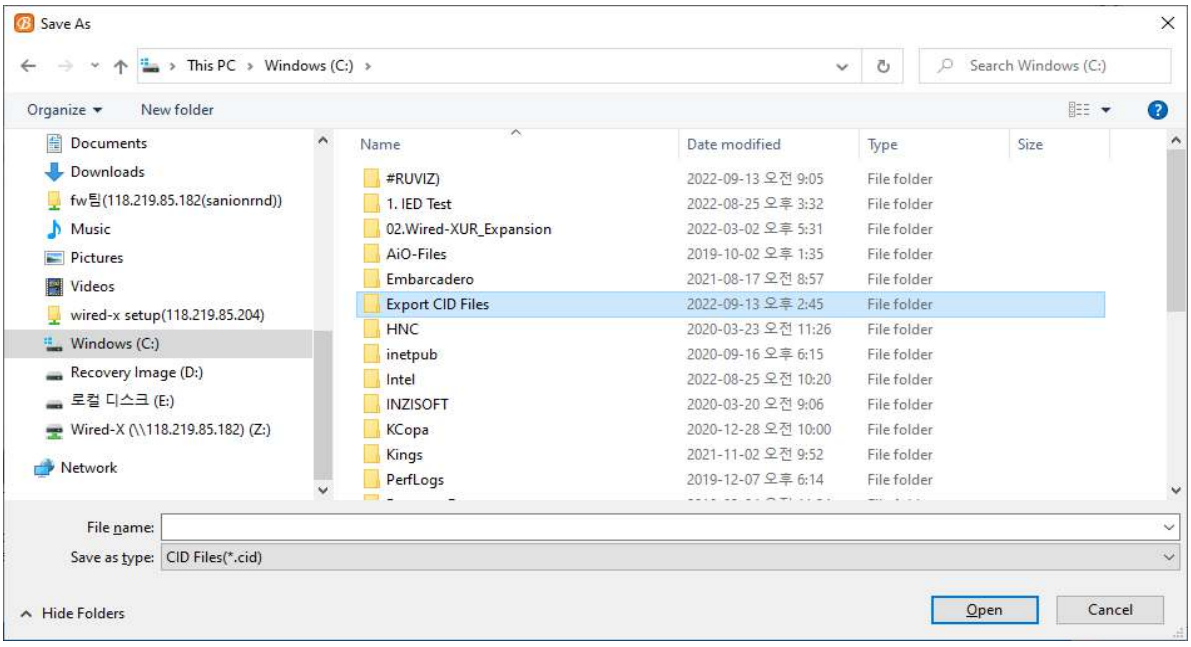
Referring to the GOOSE transmit value on the right, select and assign the value to the desired DA on IM2's GGIO6. In general, it is important to note whether it is a single point or double point.



After completing all the GOOSE incoming mappings, the status displayed below should indicate completion.



Clicking the "ok" button will prompt a window to appear, asking where to save the CID file.



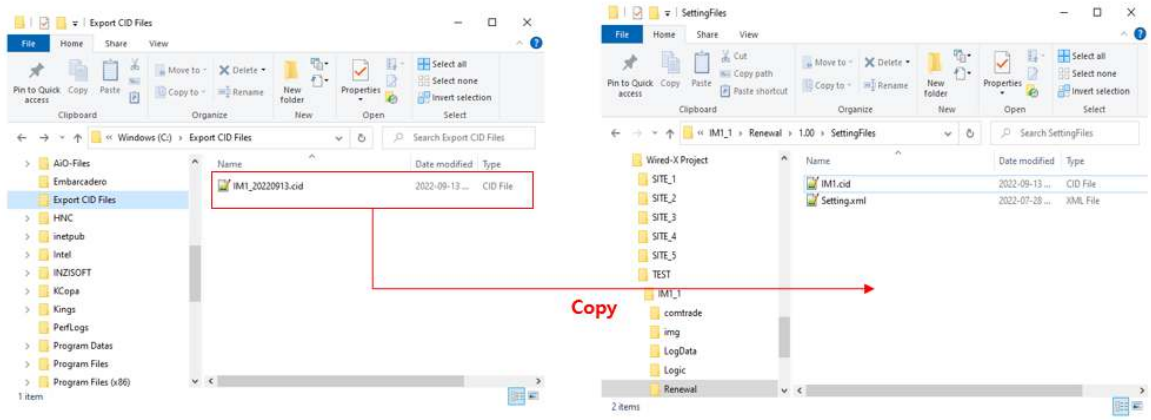
Finally, update the extracted CID file in the IM2 CID file management folder.

CID file management folder is as follows.

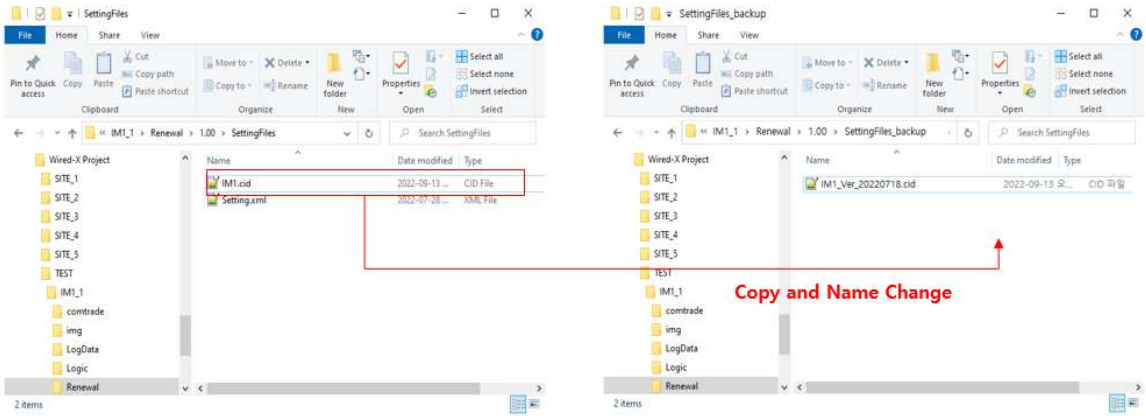
: Project create folder\Device name\Renewal\version\SettingFiles

Ex. C:\Wired-X Project\IM2 Test Project\IM2_1\Renewal\1.00\SettingFiles

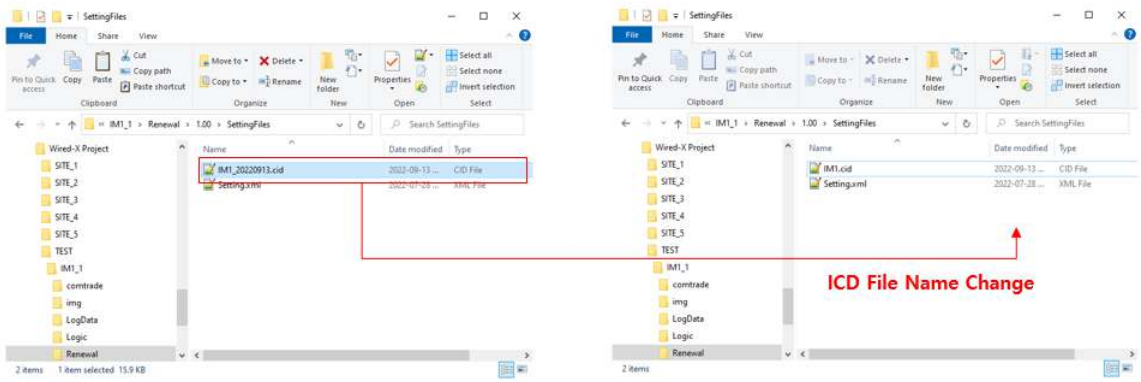
Step1. Copy the extracted CID file to the IM2 CID file management folder.



Step2. Copy the old CID file to the IM2 CID file backup folder and change the CID file name according to your history management rules.



Step3. Delete the old CID file and rename the CID file to be updated to “IM2.cid”. The deleted CID file cannot be recovered. Please must be back up your old CID file before proceeding.

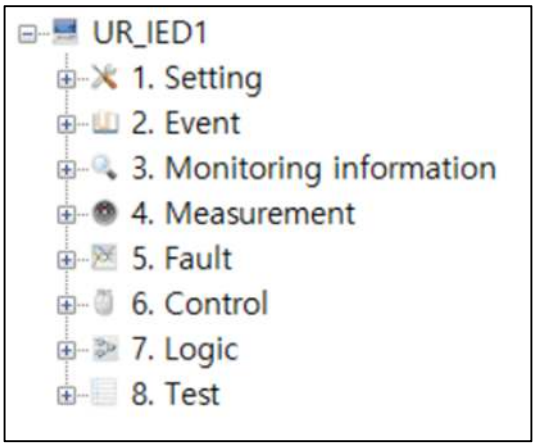

IM1_20220913.cid
Setting.xml
IM1.cid
Setting.xml
ICD File Name Change

3.2. Wired-X Menus and Settings

A description of Wired-X's menu organization and the settings available through Wired-X.

3.2.1. Menus on Wired-X

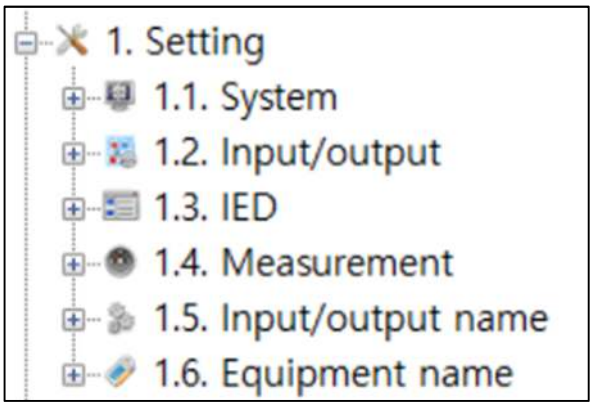
The menu organization and brief description of Wired-X is shown below.



Item	Description
1. Setting	Provide settings for IM2
2. Event	Viewing events recorded in IM2
3. Monitoring information	Check IM2's various monitoring information
4. Measurement	View the IM2's measurement information
5. Fault	Check the COMTRADE recorded in IM2
6. Control	Provide device control over Wired-X
7. Logic	Downloading and uploading user logic
8. Test	Provide simulated tests

3.2.2. Wired-X : Setting

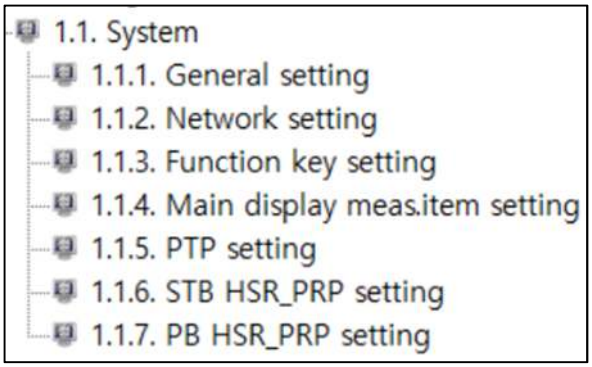
The settings menu is divided into six sections, each of which is briefly described below.



Item	Description
1. System	General system settings for IM2
2. Input/output	Provides a mapping of physical and logical elements
3. IED	Operation related settings for IM2
4. Measurement	Select measurement sets that are displayed on the main display and "4.Measurement" on Wired-X
5. Input/output name	Modify Input/output point name
6. Equipment name	Modify the name displayed on the main display

3.2.2.1. Wired-X : Setting – System

The system menu is divided into seven sections, each of which is described below.



"General setting" allows you to set general settings for IM2. The items and their values are described below.

Item	Value
Station bus time sync	PB Sync : synchronized time to PB bus time SNTP : synchronized time to SNTP server
Process bus time sync	PTP : synchronized time to PTP server PPS : synchronized internal PPS to external PPS input
Local time offset hour	-24 ~ 24 : UTC time
Local time offset minute	0 ~ 59 : UTC time
Language	English / Korean
LCD backlight time	1 ~ 180 minute
Measurement angle display	Negative / Positive
Wired-X connection port	Front port / Back port
SLD display	IEC symbol / LED symbol
SLD open LED location	Left / Right

※ SNTP and PTP cannot be used at the same time.

Network setting allows IM2 to set the IP, subnet, and gateway address of the network port, and the items are as follows.

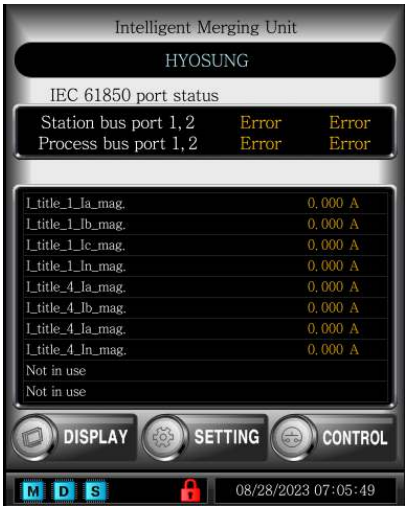
Item		Current value	New value
Service port	IP address	10,10,10,12	
	Subnet mask	255,255,255,0	
	Default gateway	10,10,10,1	
SNTP server	IP address	203,248,240,140	
	Subnet mask	255,255,255,0	
	Default gateway	203,248,240,1	
Station bus port	IP address	10,10,10,51	
	Subnet mask	255,255,255,0	
	Default gateway	0,0,0,0	
Process bus port	IP address	192,168,37,242	
	Subnet mask	255,255,255,0	
	Default gateway	192,168,37,1	

Station & Process bus port are set by CID file.

"Function key setting" allows you to set shortcut keys from F1 to F4, and switches the screen directly to the set page.

Item	Current value	New value
F1	Control event	
F2	Counter status	
F3	Process bus GOOSE publisher	
F4	PTP information	

"Main display meas. Item setting" is a menu to set the measurement items to be displayed on the main LCD display shown below. Up to 10 items can be set in total.



Item	Current value	New value
Measurement item 1	I_title_1/Ia_mag	
Measurement item 2	I_title_1/Ib_mag	
Measurement item 3	I_title_1/Ic_mag	
Measurement item 4	I_title_1/In_mag	
Measurement item 5	I_title_4/Ia_mag	
Measurement item 6	I_title_4/Ib_mag	
Measurement item 7	I_title_4/Ia_mag	
Measurement item 8	I_title_4/In_mag	
Measurement item 9	Not in use	
Measurement item 10	Not in use	

"PTP settings" allows you to modify settings related to PTP and includes the following items.

Item	Current value	New value
Delay mechanisim	P2P	
Transper mode	L2	
Slave only in use	In use	
Priority 1	128	
Priority 2	128	
Domain number	0	
Clock class	255	
Clock accuracy	25ns under	
Anounce message period	2 Sec	
Sync message period	1 MSG every sec	
Delay request period	1 MSG every sec	
PDelay request period	1 MSG every sec	
Announce timeout	3 sec	
Sync timeout	2 sec	
Transper-Receive time diff.	0 ns	
Egress latency	0 ns	
Ingress latency	0 ns	

It is recommended to use the default values. If needed, PTP specialist may change the settings as the network requirement.

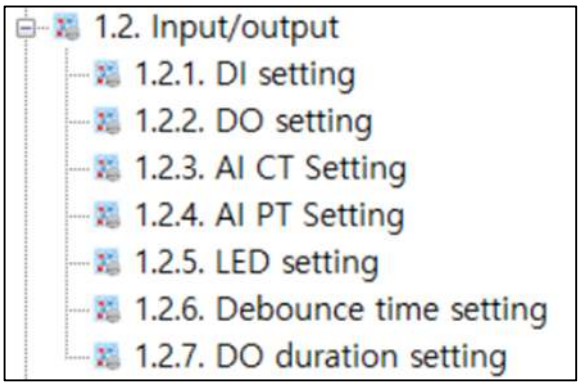
"STB HSR_PRP setting" and “PB HSR_PRP setting” allow you to modify settings related to HSR/PRP and includes the following items.

Item	Current value	New value
PRP in use	In use	
PRP mode	Duplicate discard	
HSR in use	Not in use	
HSR mode	Mode H	
HSR interface	HSR-SAN	
Rsdbox LAN ID	A	
Own net ID	0	
Port A speed	1000 Mbps	
Port B speed	1000 Mbps	

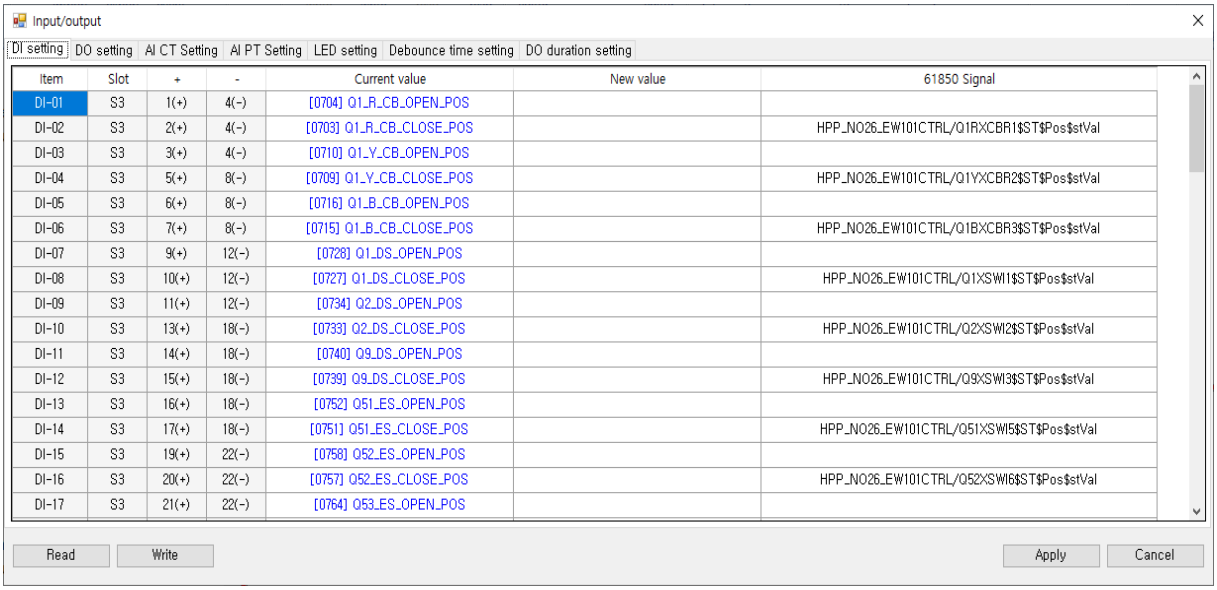
It is recommended to use the default values. If needed, HSR/PRP specialist may change the settings as the network requirement.

3.2.2.2. Wired-X : Setting – Input/output

The Input/out menu is divided into seven sections, each of which is described below.



The "DI setting" allows you to map the inputs of the DI module to internal points. If the internal points related to IEC 61850 signal, it shows on the column



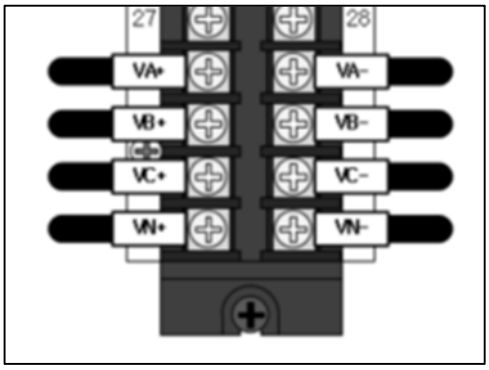
"DO setting" allows you to map the internal points to outputs of the DO module.



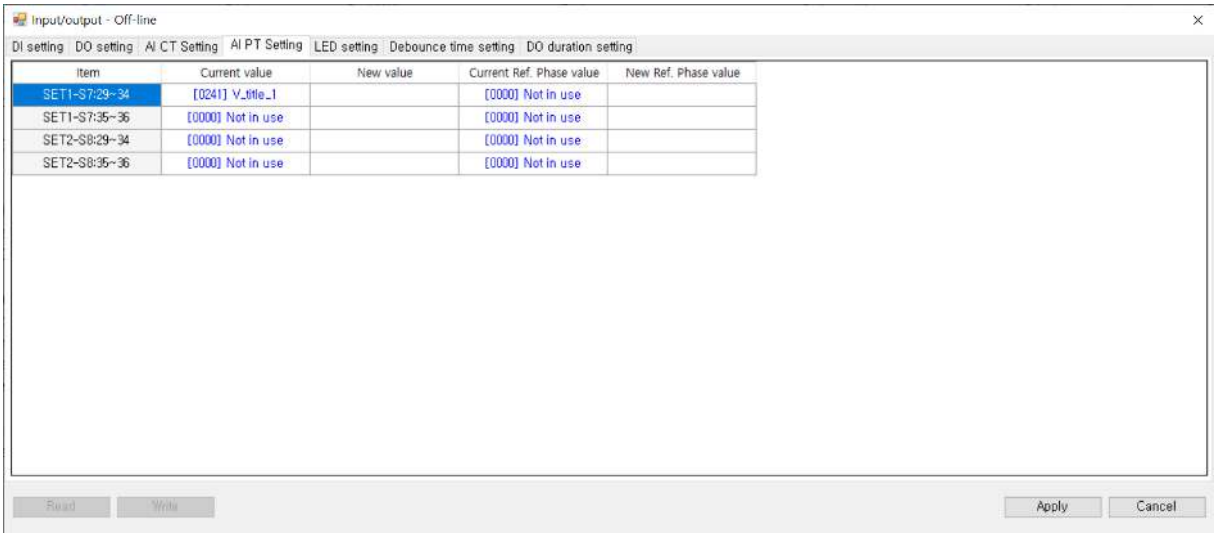
"AI CT setting" allows you to assign current inputs of CPT module to internal current set. Also, a user can set N phase as calculated (3I0) or measured (Y-Connection). The user may select reference angle of phase for display, otherwise the angle of A phase in internal voltage set #1 is the default angle.



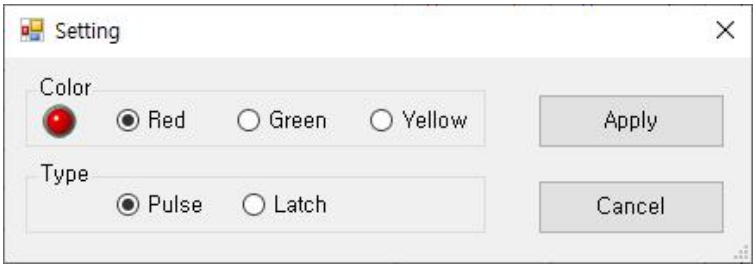
"AI PT setting" allows you to assign voltage inputs of CPT module to internal voltage set. N phase is calculated, therefore VN terminal can be assigned independently from VA,VB,VC.

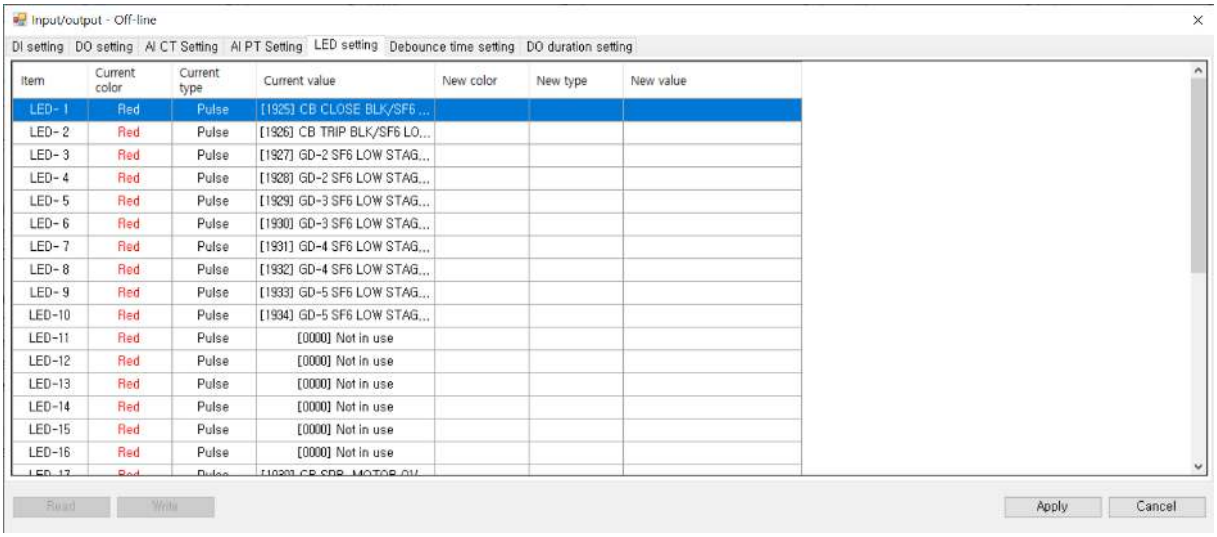


The user may select reference angle of phase for display, otherwise the angle of A phase in internal voltage set #1 is the default angle.

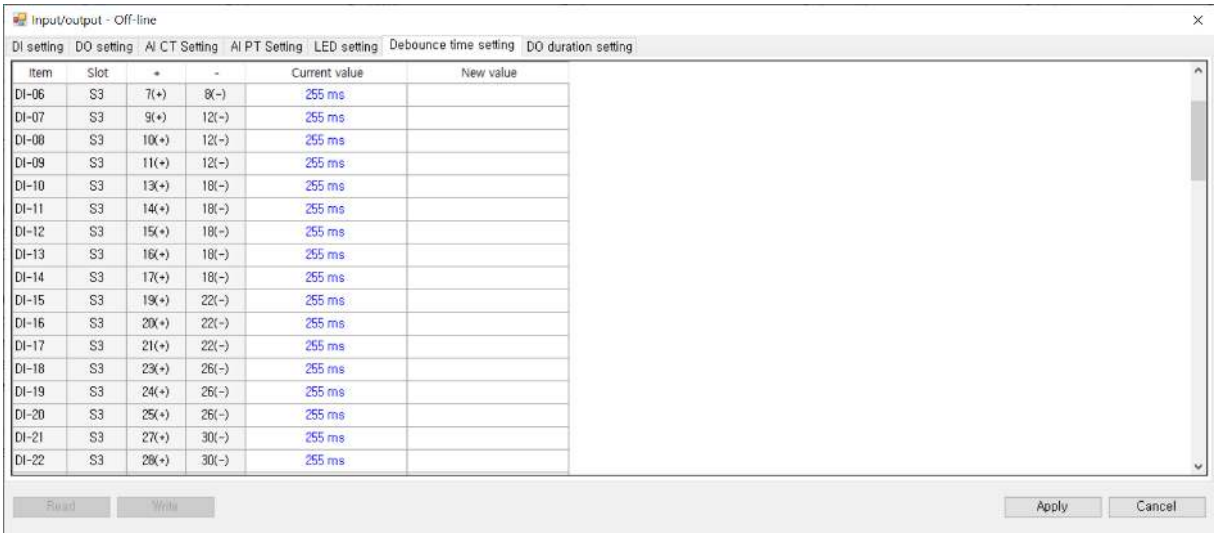


"LED setting" allows you to assign internal points to 32 LEDs. Red, green and yellow colors are provided. Pulse and latch types are provided.



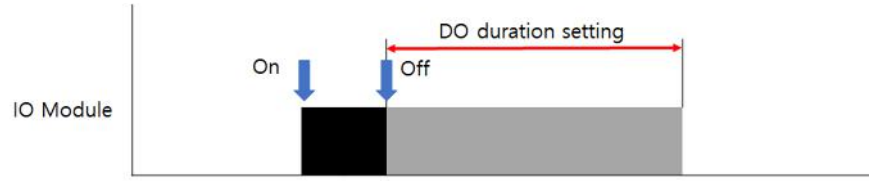


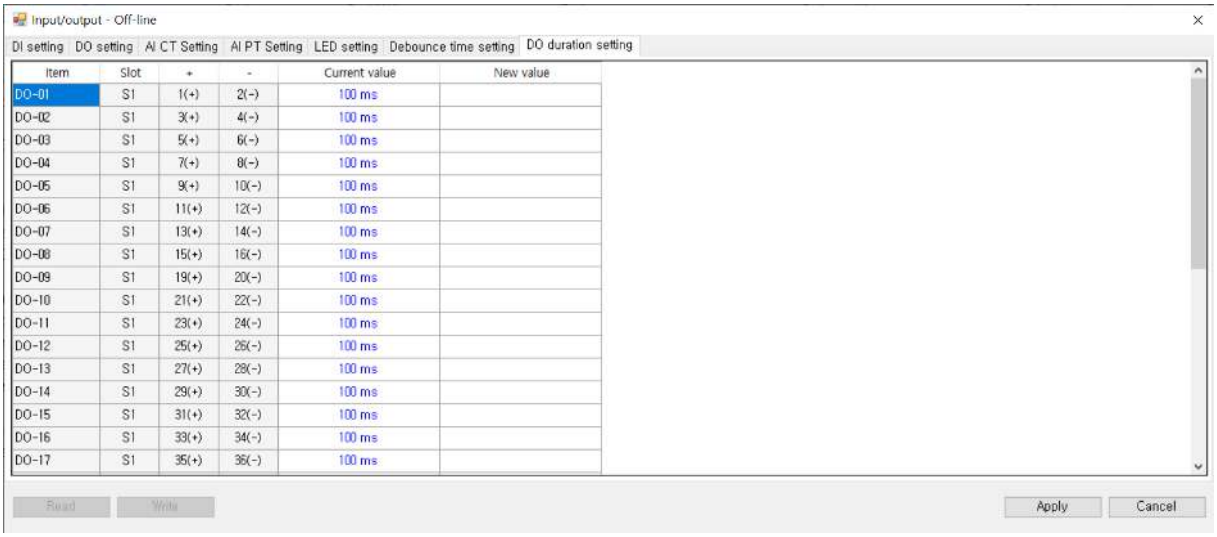
"Debounce setting" sets the debounce value to prevent mechanical chattering of the DI module inputs. Setting range is 1 ~ 255msec.



"DO duration setting" allows the output of the DO module to be maintained for a set amount of time after the internal point is turned off. Setting range is 1 ~ 10,000msec.

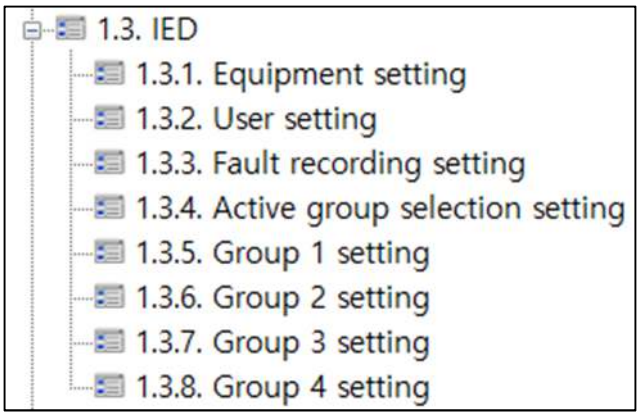
A pictorial representation of the description is shown below.





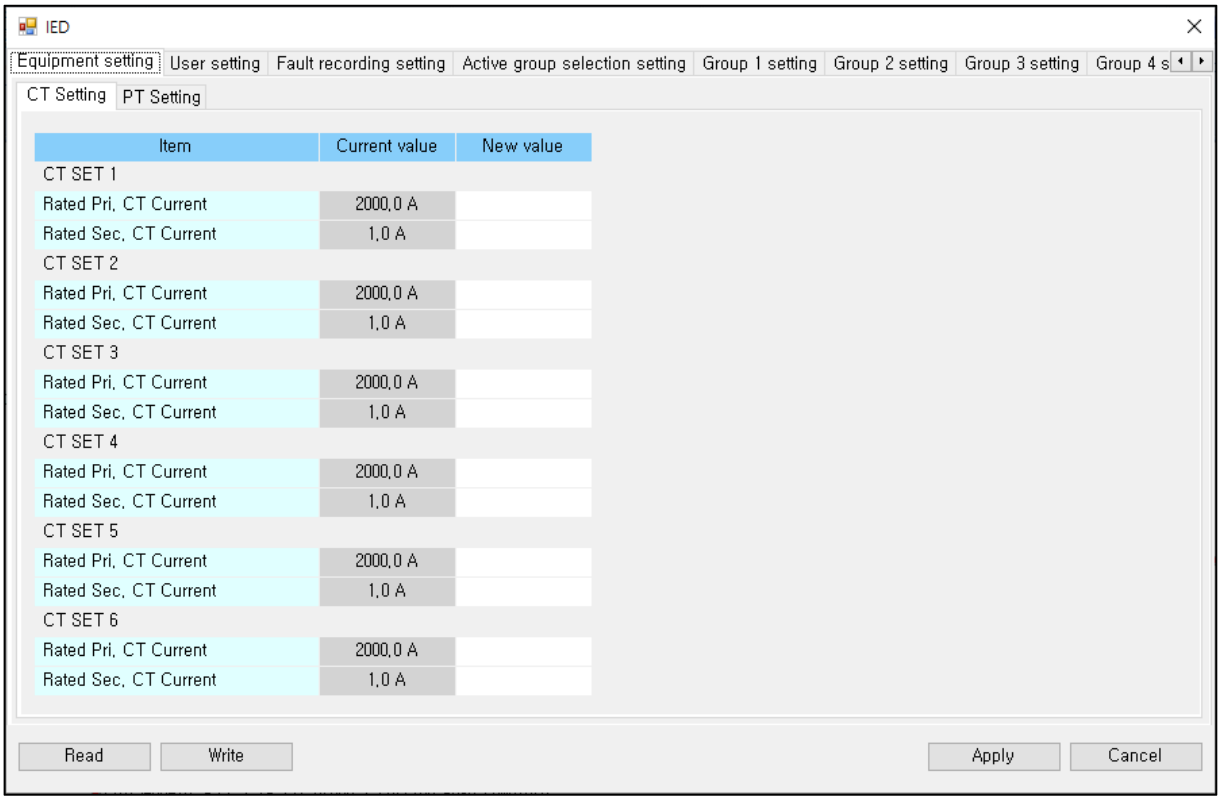
3.2.2.3. Wired-X : Setting – IED

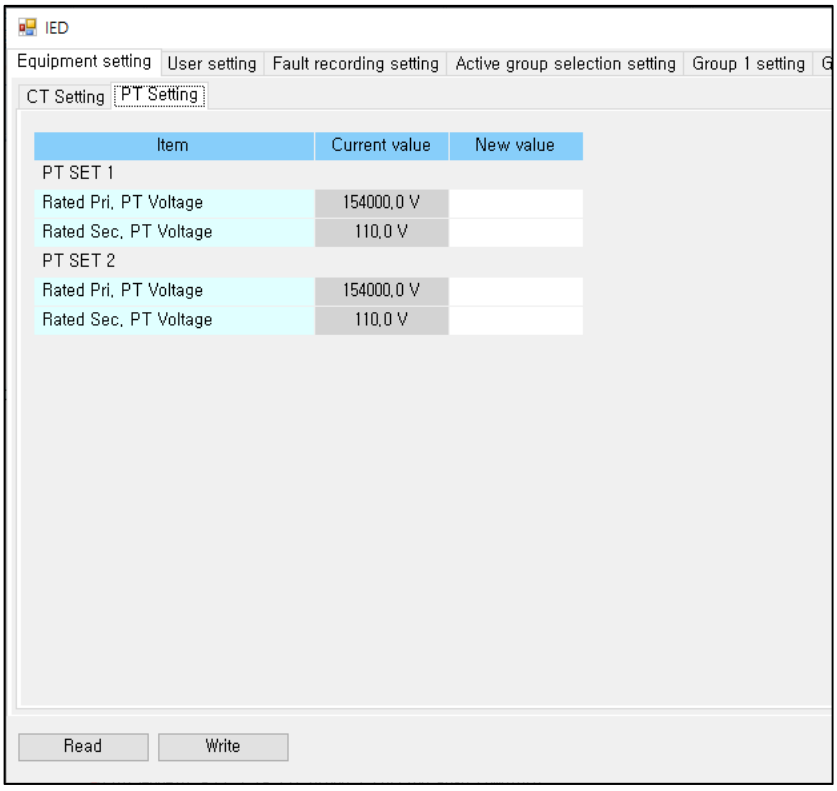
The IED menu is divided into eight sections, each of which is described below.



User setting, Active group selection setting, Group 1~4 setting are emptied in factory settings. The above settings may be configured by the manufacturer to suit the site logic upon reasonable request of the site user.

"Equipment setting" sets CT/PT primary and secondary ratio that are used in the measurement display


IED
Equipment setting
User setting
Fault recording setting
Active group selection setting
Group 1 setting
Group 2 setting
Group 3 setting
Group 4 s
CT Setting
PT Setting
Item
Current value
New value
CT SET 1
Rated Pri. CT Current
2000,0 A
Rated Sec. CT Current
1,0 A
CT SET 2
Rated Pri. CT Current
2000,0 A
Rated Sec. CT Current
1,0 A
CT SET 3
Rated Pri. CT Current
2000,0 A
Rated Sec. CT Current
1,0 A
CT SET 4
Rated Pri. CT Current
2000,0 A
Rated Sec. CT Current
1,0 A
CT SET 5
Rated Pri. CT Current
2000,0 A
Rated Sec. CT Current
1,0 A
CT SET 6
Rated Pri. CT Current
2000,0 A
Rated Sec. CT Current
1,0 A
Read
Write
Apply
Cancel


IED
Equipment setting
User setting
Fault recording setting
Active group selection setting
Group 1 setting
G
CT Setting
PT Setting
Item
Current value
New value
PT SET 1
Rated Pri. PT Voltage
154000,0 V
Rated Sec. PT Voltage
110,0 V
PT SET 2
Rated Pri. PT Voltage
154000,0 V
Rated Sec. PT Voltage
110,0 V
Read
Write

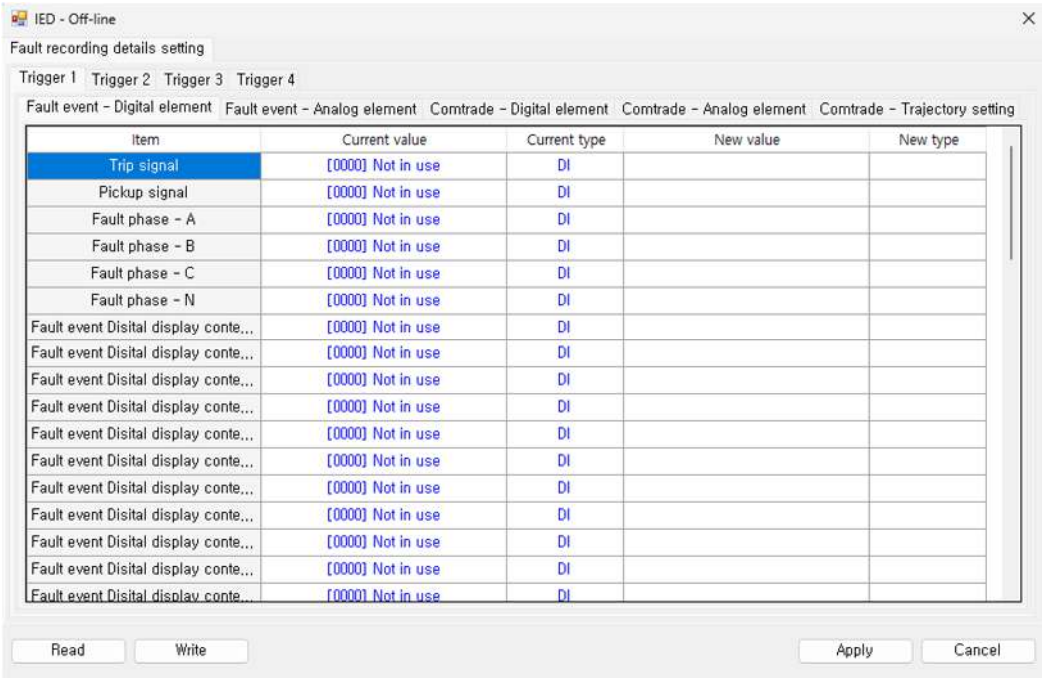
In "Fault recording setting", user can set whether to enable, how to record, and how long to record.

Item	Description
Record use	In use / Not in use
Record type	Internally, recording is triggered on the rising edge of the Trip and Pickup signals. Trip : Triggered only on rising edge of the trip signal. One COMTRADE file is generated. Pickup & Trip : Trip is same as the above. Pickup is only generated when the pickup signal has been maintained until "pickup after time". All conditions met two COMTRADE files are generated.
Record sampling	4.0K (50Hz) / 4.8K (60Hz). Not settable. Display only
Prev-pickup save time	Record time before the rising edge of pickup signal
After-pickup save time	Record time after the rising edge of pickup signal
Prev-trip save time	Record time before the rising edge of trip signal
Atfer-trip save time	Record time before the rising edge of trip signal

Maximum recording time is 10 seconds (10000 ms) fixed. IM2 can record 32 channels, CT & PT depending on the ordering code, and assigned DI, DO binary points from the Logic Editor. The maximum number of DAT files that can be stored is 64 fixed. If the saving DAT exceeds the maximum number, the oldest DAT files are deleted automatically.

Input Signal to triggering fault record

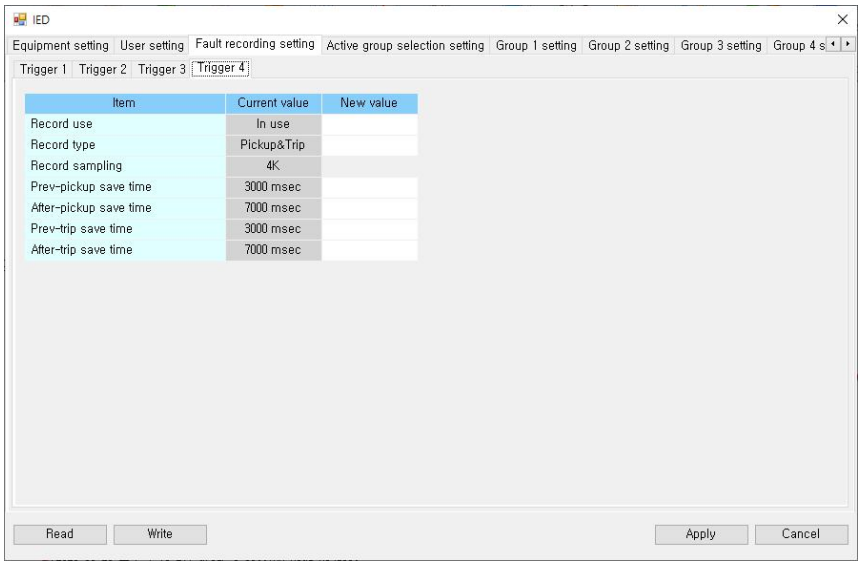
- Triggering points can be recorded by external signals. It can be set from “1.7.1. Fault recording details settings” as below. External signals can be the protection signals from other devices or the DI signals.



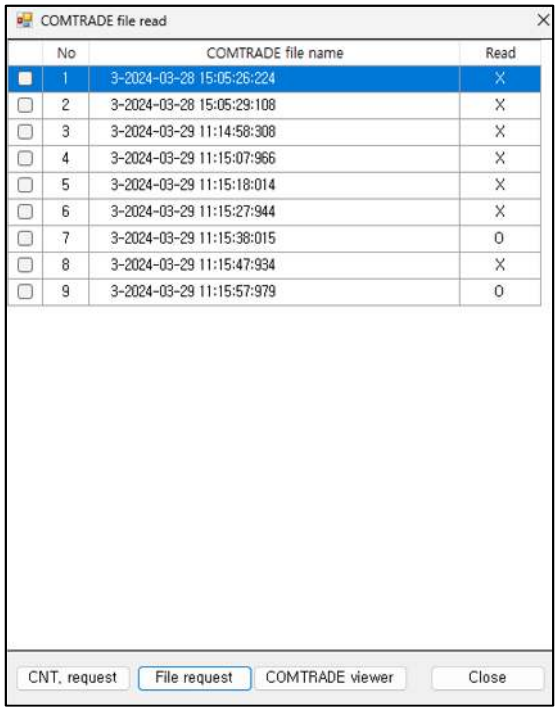
Output Signals from the fault record

- When the fault recording is done, the alarm will be shown at the front LCD as a popup screen.

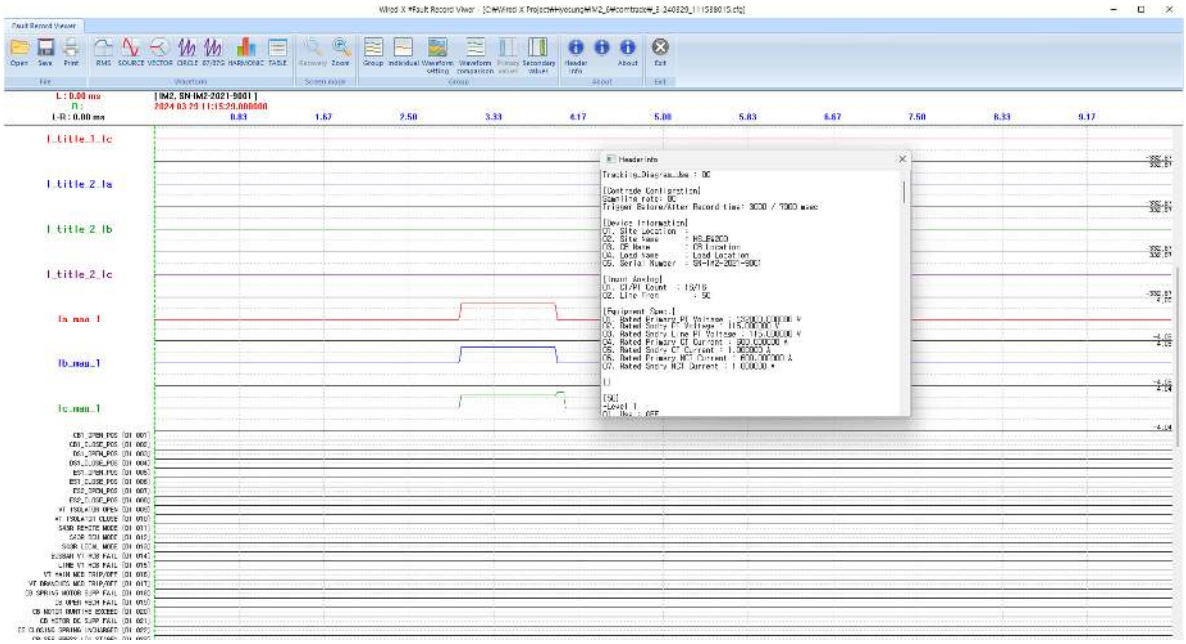
The triggering settings can be done in Wired-X as follows. It can be set in LCD also.



The details of the COMTRADE file can be analyzed in “COMTRADE” at the top of the menu. The list of COMTRADE files in the selected IM2 is shown as below.



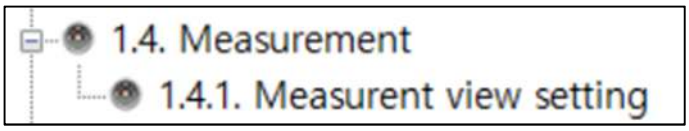
Click on the COMTRADE viewer to see the result and analysis screen from Wired-X as below.

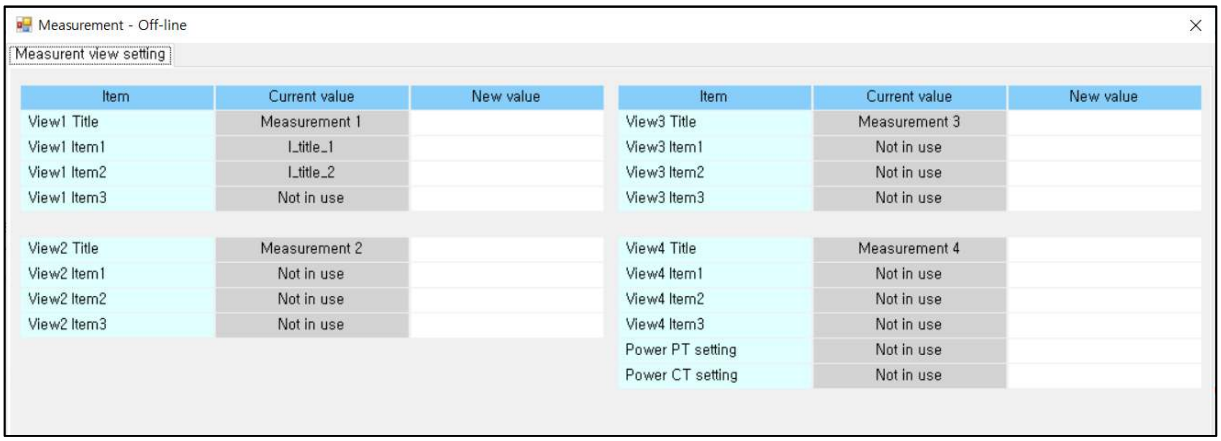


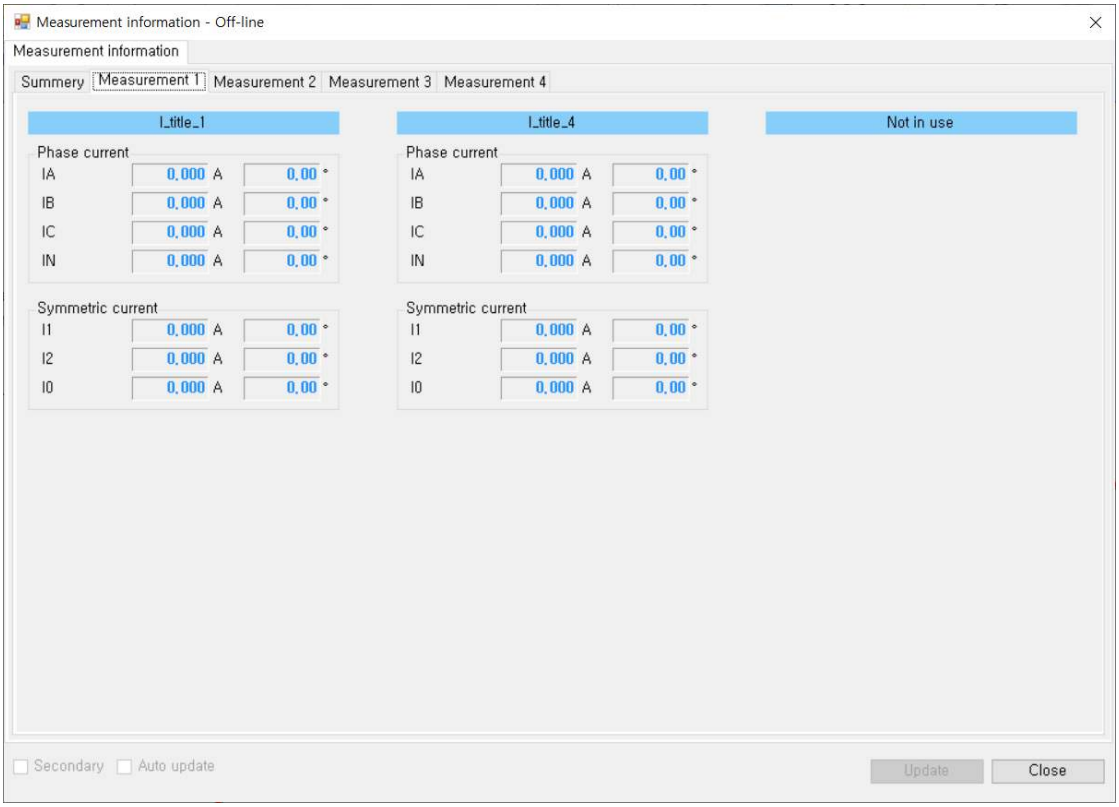
It includes analog data and DI/DO points.

3.2.2.4. Wired-X : Setting – Measurement

Select CT or PT set that will displayed on LCD & Wired-X measurement window or screen. A user may select maximum 3 sets in one window

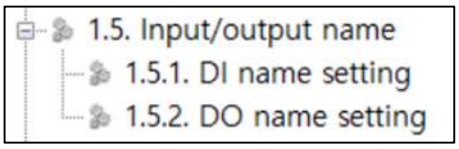


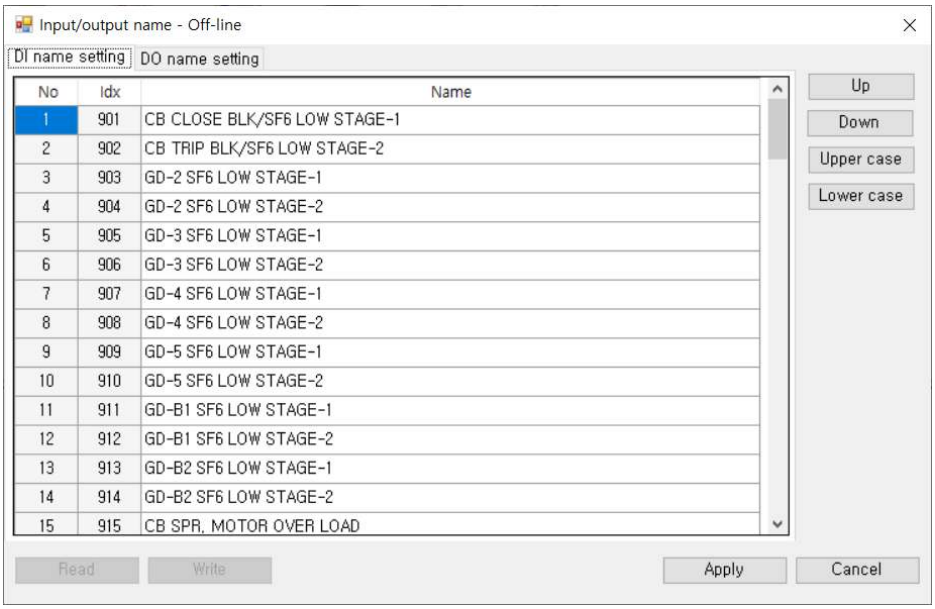


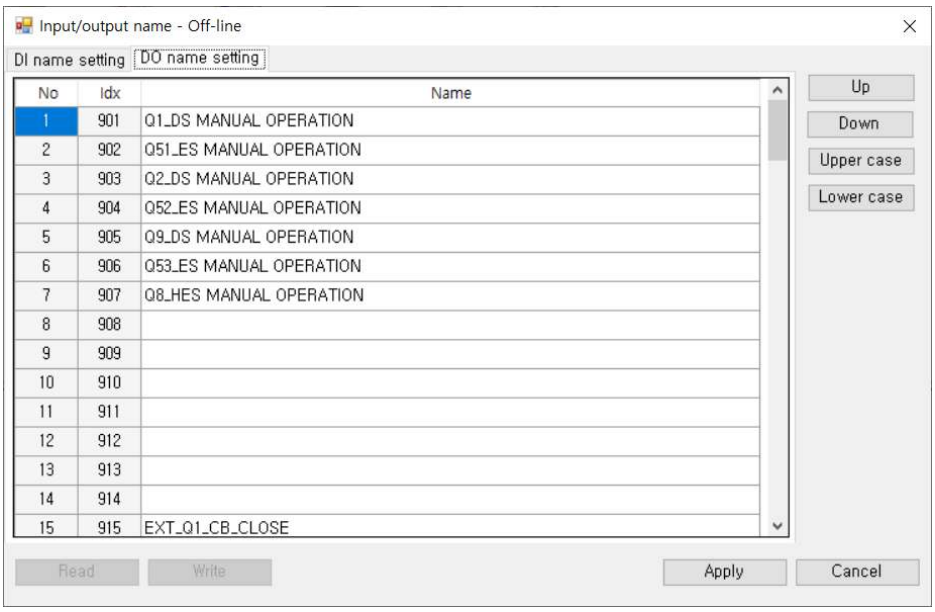


3.2.2.5. Wired-X : Setting – Input/output name

DI/DO name is set as shown in approved drawing by default. However, a user may change the name as below

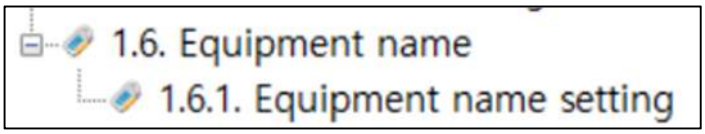


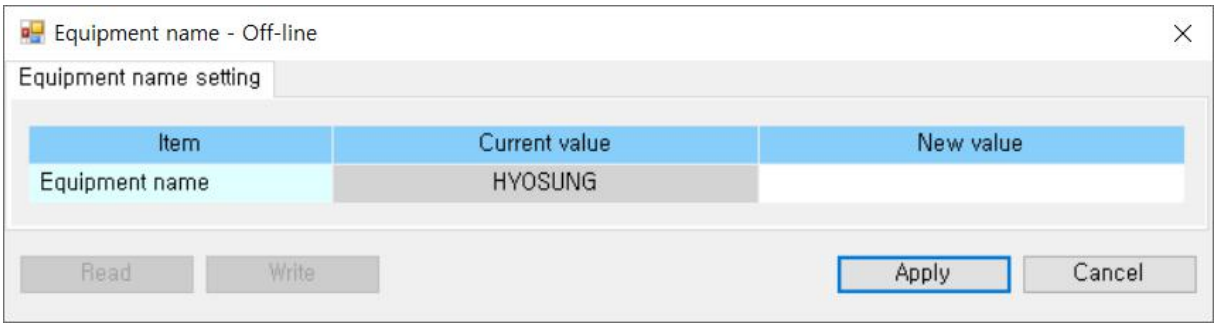




3.2.2.6. Wired-X : Setting – Equipment name

Use this setting to modify the IM2 name that will appear on the main home display.

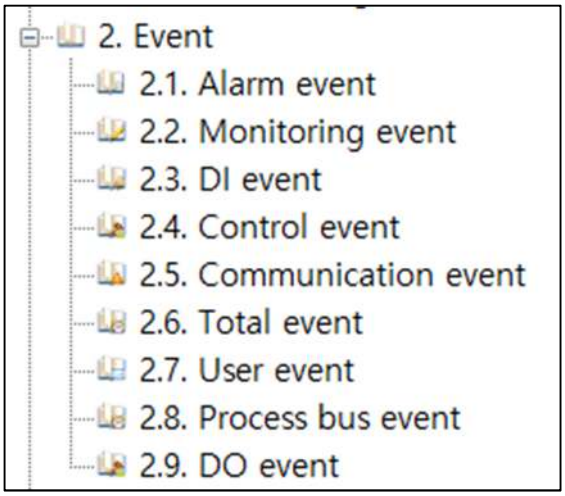






3.2.3. Wired-X : Event

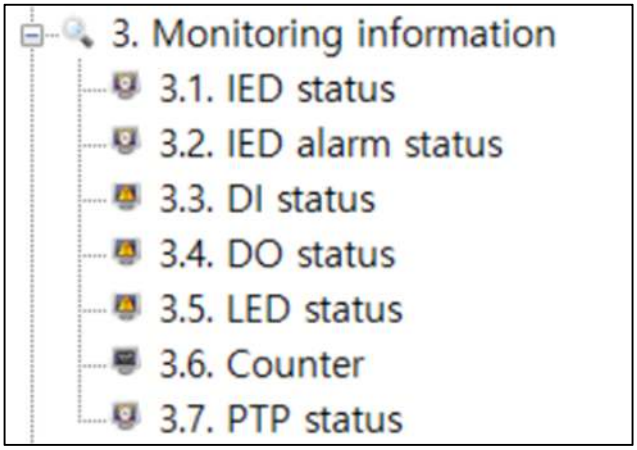
Before accessing the events recorded in IM2 using this menu, you must first read all events in IM2 through the "All read" button. There are a total of nine events, which are described below.



Event	Description
Alarm	Events logged when an alarm situation occurs in IM2
Monitoring	Events recorded by IM2's self-supervision
DI	Record event when DI status changed
Control	Record event when control happens
Communication	Internal/external communication event (Including 61850)
Total	Show all events in recorded order
User	User logic/setting related event
Process bus	Process bus related event
DO	Record event when DO status changed

3.2.4. Wired-X : Monitoring information

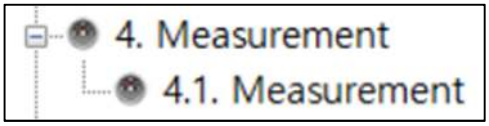
This menu enables you to monitor the up-to-date status of IM2 and the input/output status of DI/DO modules.



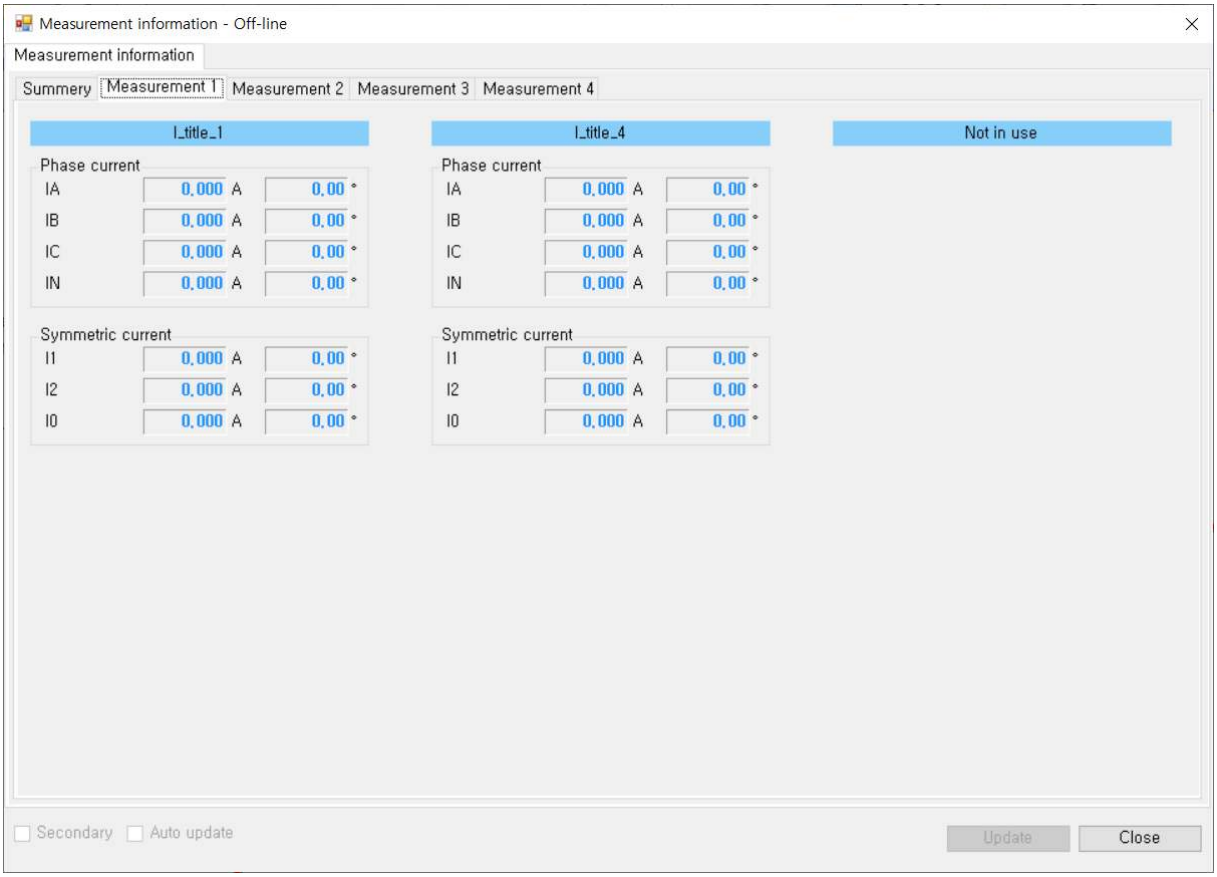
Item	Description
IED status	Shows the main status of IM2
IED alarm status	Shows the status related to the IM2 alarm (related to the Alarm LED).
DI status	Real-time input status of each terminal on the DI module
DO status	Real-time output status of each terminal on the DO module
LED status	Real-time status of each LED on the front panel
Counter	Show recorded counters of IED reset, LED reset, IED fault
PTP status	Shows real-time PTP-related status.

3.2.5. Wired-X : Measurement

The measurement sets that you configure in "view settings" will be visible on one tab. A maximum of three sets can be displayed on the tab.

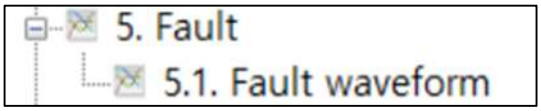


For a voltage set, the magnitude and phase of each phase, the magnitude and phase of the symmetry component, the magnitude and phase of the line to line voltage, and the frequency processed by phase A are displayed.

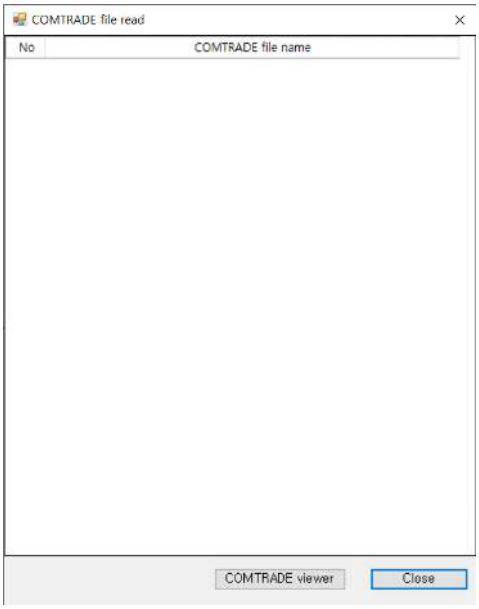


3.2.6. Wired-X : Fault

You can view the COMTRADE file stored in your PC folder via Wired-X.



Select the COMTRADE file you want to view and click the "COMTRADE viewer" button.

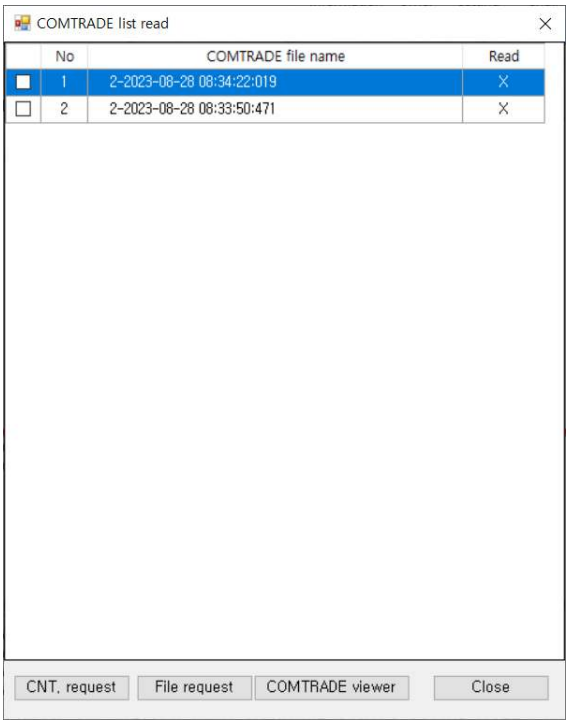


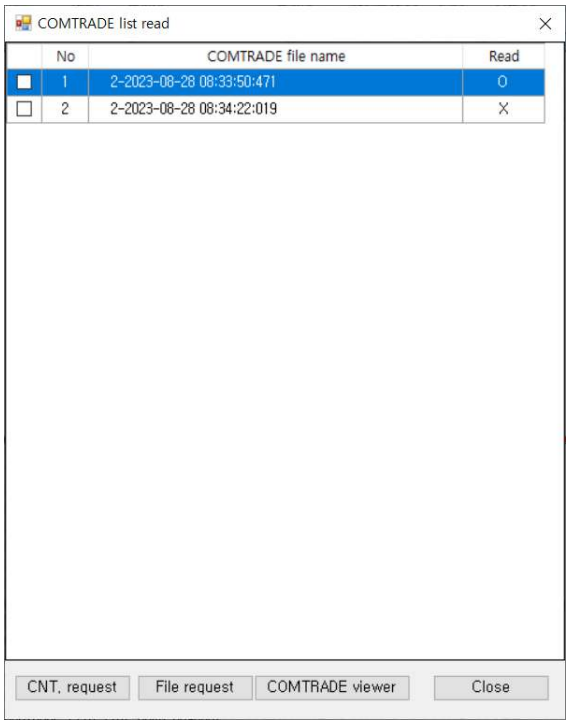
To import a COMTRADE file recorded in IM2, follow the procedure below. A user may access by clicking 

located at toolbar. Read file from COMTRADE by clicking "CNT.Request".

Click File request after selecting COMTRADE file to transfer IM2 → Wired-X

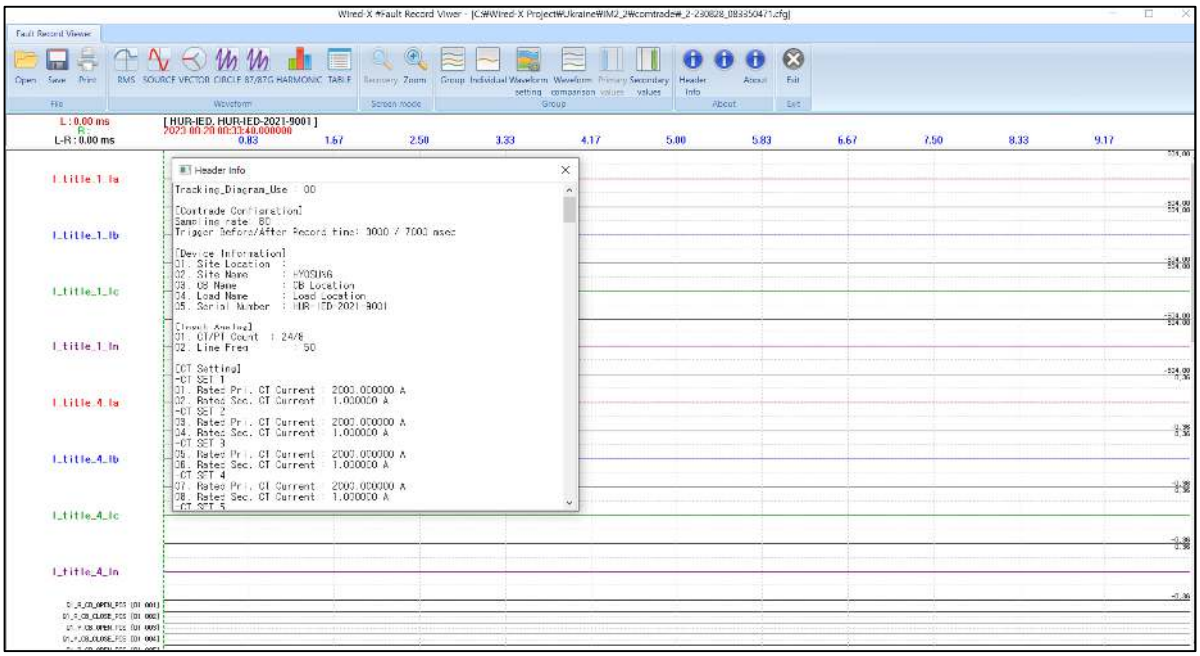
The file already read, is marked as 'O' on Read column. Already read data can be read again in offline mode





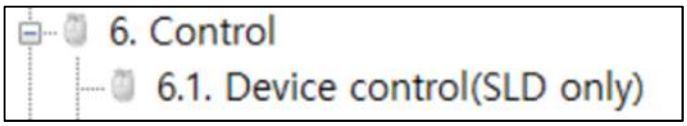
The user may check individual file by entering COMTRADE viewer.

AI CT, AI PT, DI, and DO are displayed by default.

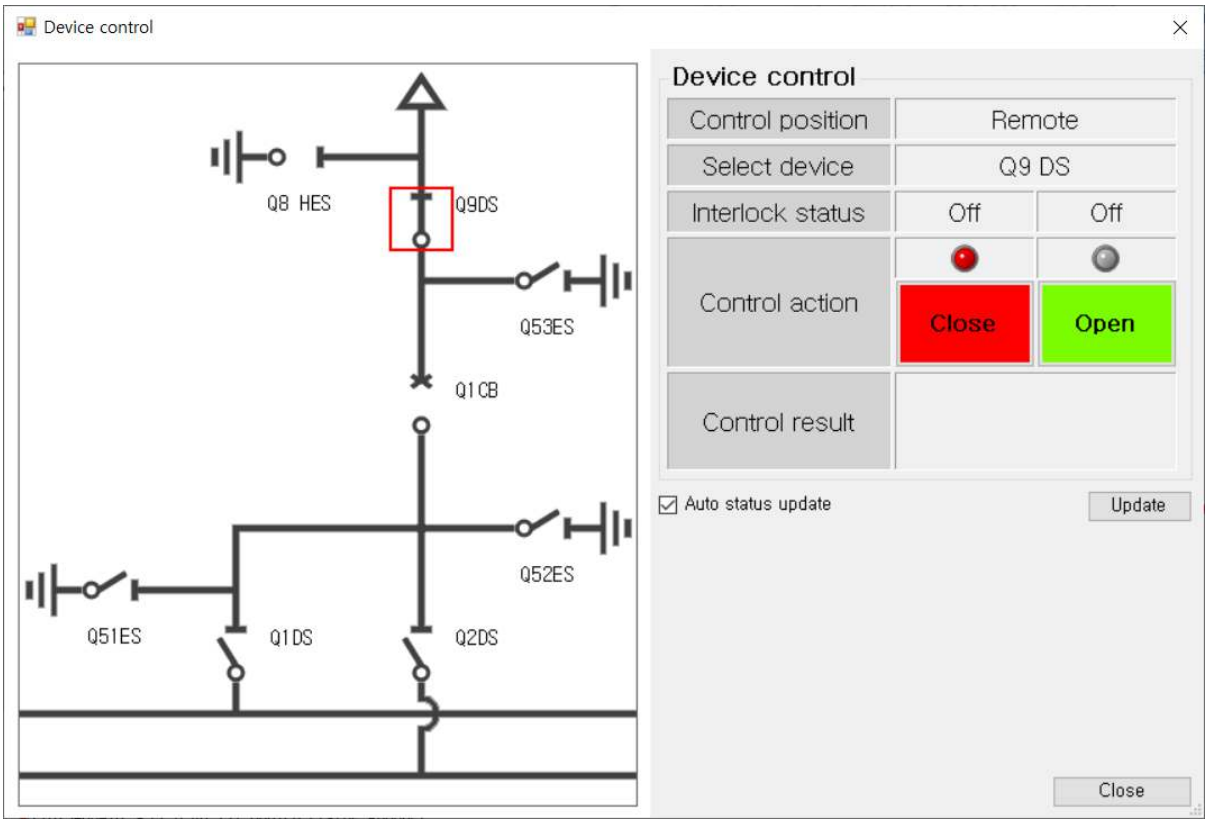


3.2.7. Wired-X : Control

IM2 controls connected devices such as CB, ES, DS.

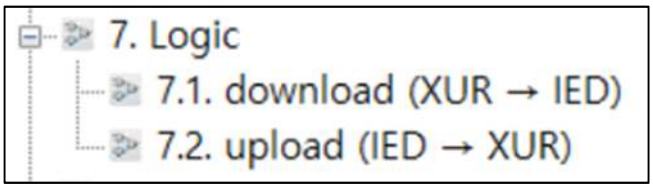


The source of control can be 61850 control service, Wired-X, LCD and external connected DI point. Control command will be processed correctly, if all the conditions are fulfilled.



This is covered in more detail in “4.3 Function of CB/DS/ES control in SLD”

3.2.8. Wired-X : Logic

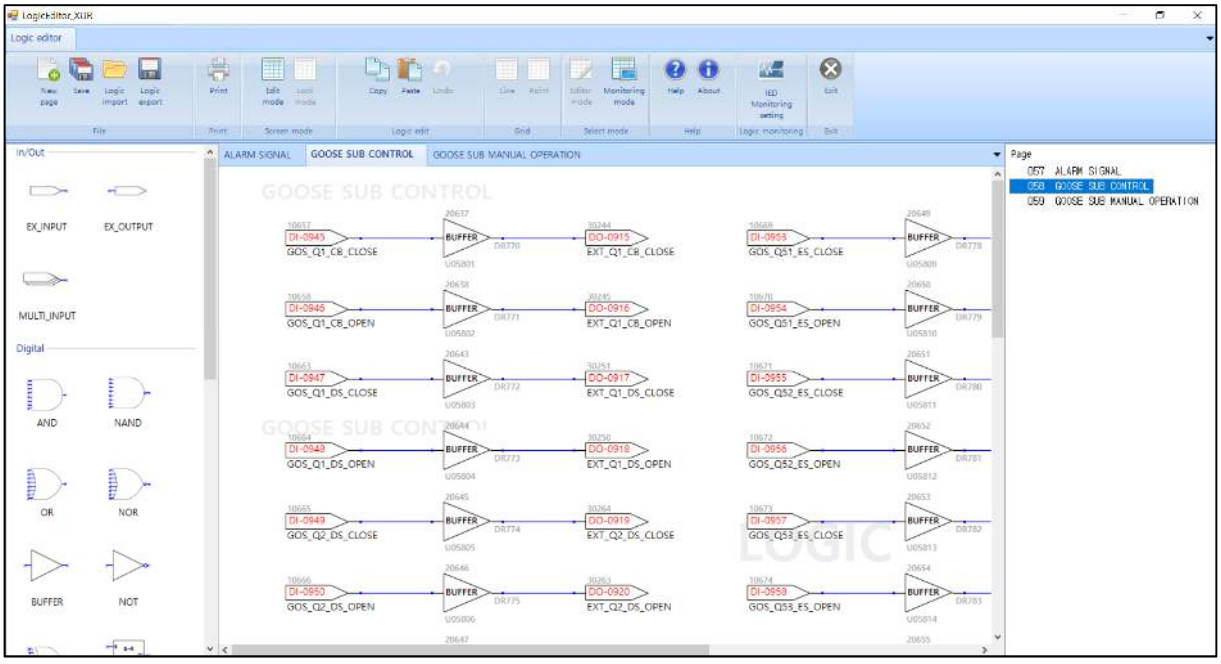


Upload/Download pre-structured logic from a manufacturer.

A user may execute the logic editor by pressing 

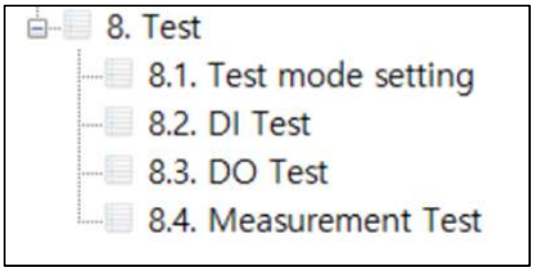
button on the toolbar

In general, the user may use GOOSE subscription data to design the logic.



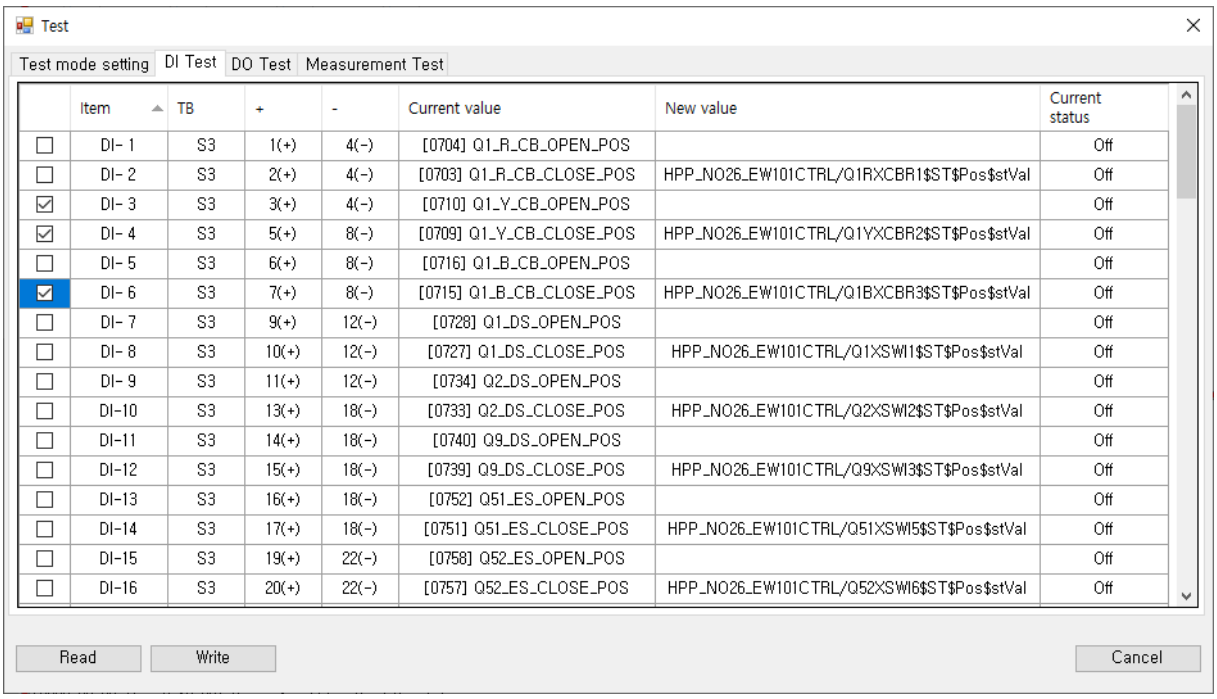
3.2.9. Wired-X : Test

A user can test DI, DO, SV without physical source connected to IM2.

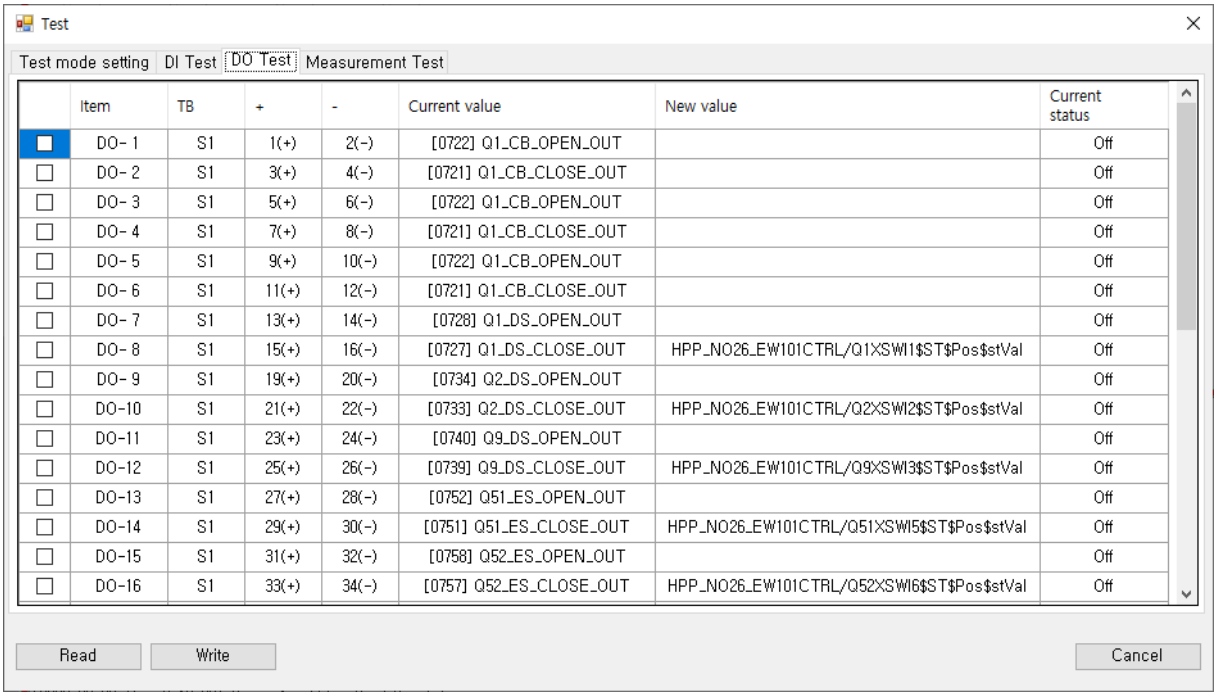


Item	Description
Test mode setting	Choose whether you want to test DI, DO, and SV. When test mode is activated, the selected test values are used for input and output, while the actual DI/DO/AI inputs and outputs are ignored.
DI Test	Select a point to test as if the input were coming in virtually
DO Test	Outputs to the selected DO terminal.
Measurement Test	Used when exporting a virtual SV.

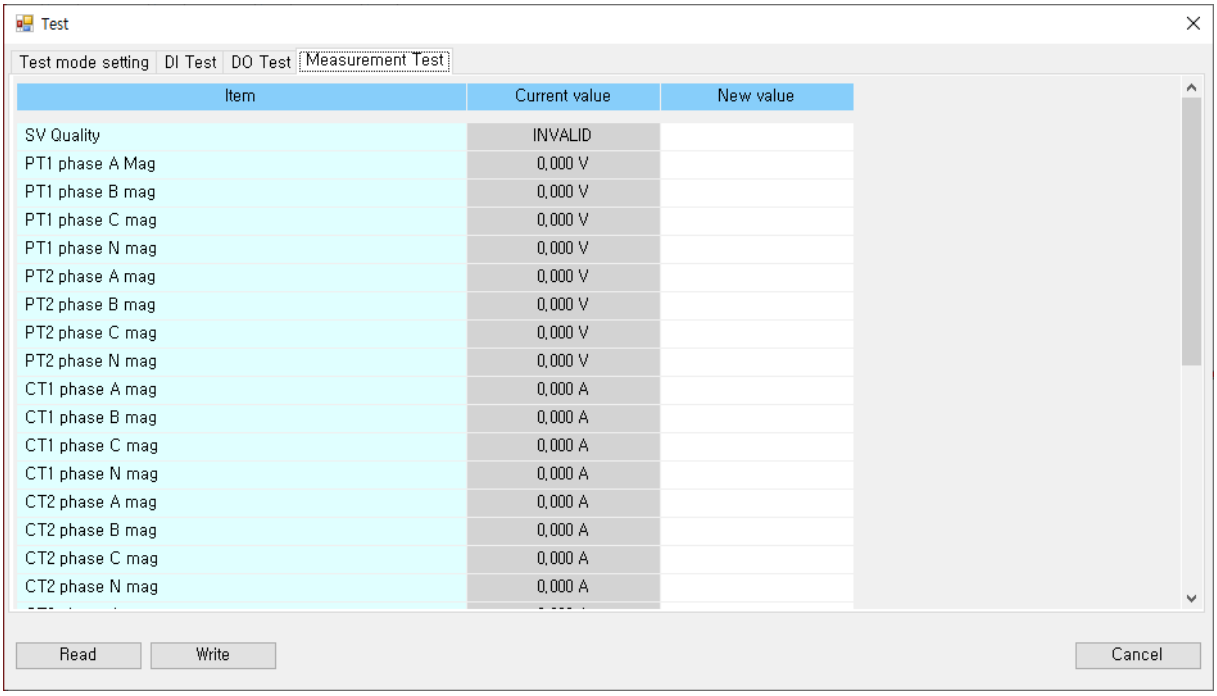
In DI Test mode, Select and configure testing DI and press “write” button.



In DO Test mode, Select and configure testing DO and press “write” button



In SV Test mode, Select and configure SV simulation test and press “write” button.



3.3. HMI Configuration

3.3.1. Overview

- HMI carries out functions of mutual information exchange between the operator and IED. It also operates so that the operator can easily recognize the operating state of IM2, and change the operating value and set value with a simple manipulation. The features of HMI are as follows.

1. The use of LCD and touch screen allows to display and process various information.

2. 4 LEDs for displaying system status and 32 LEDs for displaying operation status provide necessary information to the operator.

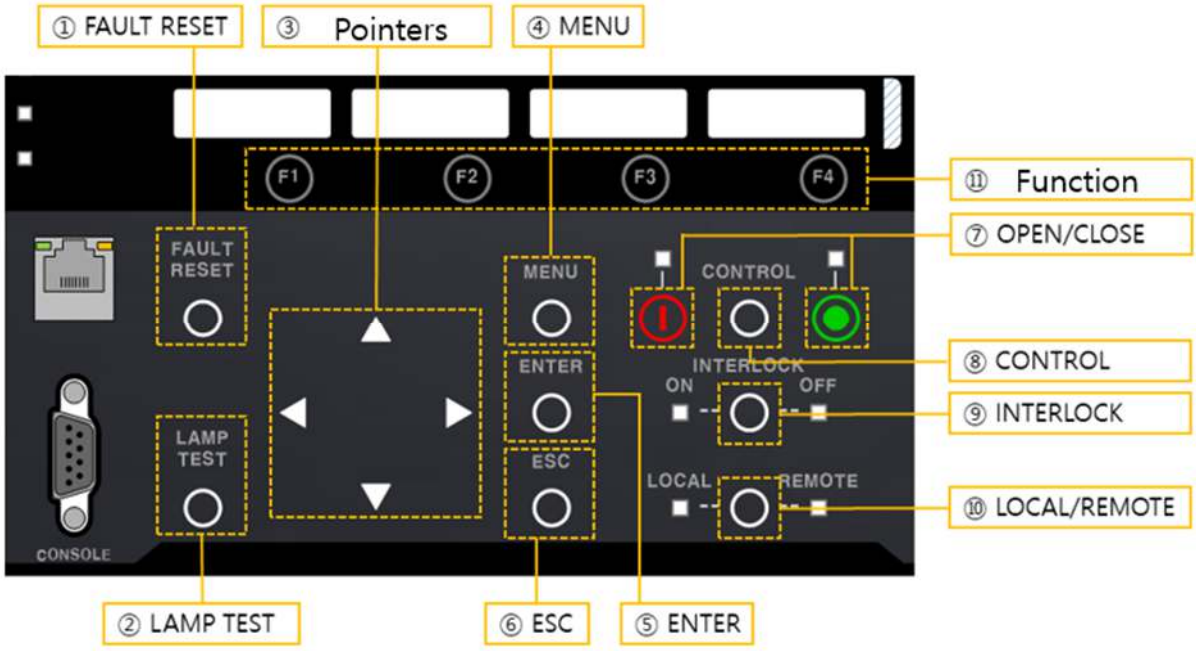
3. Simple manipulation allows the operator to carry out functions, such as setting and controlling IED.

4. The operator can conveniently check information and change settings on PC (operating software), using the communication port on the front.

3.3.2. Input Device

- Input device consists of a total of 18 buttons, including 4 function buttons, a button to move direction (up, down, left and right), interlock button, local/remote button and FAULT RESET button.

- Input device is configured as follows.



① FAULT RESET : a button to reset LED

② LAMP TEST : a button to test the operation of LED

③ A button to move up, down, left and right

④ MENU : a button to run menu

⑤ ENTER : a button to start the operation

⑥ ESC : a button to cancel the operation

⑦ OPEN/CLOSE : a button to run control devices at the control menu

⑧ CONTROL : a button that must be selected before operating the control device

⑨ INTERLOCK : a button to change the status of using(On)/not using (Off) interlock

⑩ LOCAL/REMOTE : a button to change Local or Remote status

⑪ Function Button : a shortcut button to move to a specific screen

- A more detailed description of button function is as follows.

① FAULT RESET

- [FAULT] The user can return LED and the operational status of LED to "Off". However, if the current operational status of LED is 'True', it does not change to 'Off'.

② LAMP TEST

- The user can run 'On/Off' of all LEDs, and check the normal status of each LED.

③ Button to move up, down, left and right

- Up/Down
  1. The user can move the cursor for selecting item up and down on a screen where the menu can be selected.
  2. During the control operation, The user can move the selected relaying element.
- Left/Right
  3. The user can move the cursor for selecting item left and right on a screen where the menu can be selected.
  4. During the control operation, You can move the selected relaying element.
  5. If the menu items consist of two or more pages, the user can move to the previous or next page.

④ MENU

- When the main menu is running, the user can move to the submenu.
- When the submenu is running, the user can move to the display, setting, and control menu in sequence.

⑤ ENTER

- The user can run the active menu or item.
- When the user intend to change the set value, the user can apply the input value.

⑥ ESC

- When the submenu is running, the user can move to the previous menu.
- When the highest menu is running, the user can move to the main screen.
- When a pop-up window is displayed, the user can close the pop-up window.
- If an item is selected on the fault event page, the user can deselect the item.

⑦ OPEN/CLOSE

- The user can run OPEN/CLOSE control operation for the selected object to be controlled.

⑧ CONTROL

- This is a button to select a control operation. Be sure to press this button first before pressing OPEN/CLOSE button in order to run the control operation.

⑨ INTERLOCK

- A User can control after selecting a device on the Control> Device Control screen.
- The user can select whether to run Interlock.
  1. When ‘not in use’(Off), the user can forcibly release the Interlock to control devices.
  2. When ‘in use’ (On), the user can activate the Interlock logic to control devices.
- Change of Interlock status
  3. Change of ‘not in use’ (Off): The user can change ‘in use’ (On) to ‘not in use’ (Off) only in the state of ‘Local', and change to ‘not in use’ (Off) only while the button is pressed.
  4. Change of ‘in use’ (On): When the button is pressed and then released, ‘not in use’ (Off) is maintained according to the set delay time of returning the set IED Interlock key, and then becomes ‘in use’ (On) automatically.
  5. However, When 'Local' status is changed to 'Remote' status, the Interlock status is automatically changed to ‘in use’ (On).

⑩ LOCAL/REMOTE

- This button assigns the position where the operator sets or controls IED.
  1. When 'Local' is selected, the user can run the setting and controlling operation in front of the IED.
  2. When 'Remote' is selected, the user can run the setting and controlling operation, using the upper-level commands or communication.

⑪ Function Buttons (F1, F2, F3, F4)

- The user can run functions set by the operator for each button.

• Display

- LED for displaying system status

◆ The types, colors and functions of LEDs for displaying system status are as shown in the table below.

Item	Color	Function
POWER	Green	LED indicating DC power is in a normal state
RUN	Green	LED indicating that power is applied and the CPU of the IED is operating normally. When IED is in normal operation, LED turns on, and when IED software or the front HMI does not operate normally, LED turns off. Also, in the event of IED_FAIL, LED turns off.
ALARM	Red	LED indicating that an abnormality has occurred in the device, and such abnormality is detected by the constant monitoring function. In the event of IED_ALARM, it turns on in red, and in the event of IED_LOCK, it blinks in red. When returning to a normal state, LED turns off.
FAULT	Red	LED indicating that a fault has been detected and protective action has been performed. If the fault is cleared, be sure to use [FAULT RESET] button on the front to turn off the light.

■ LED indicating the operational status

A total of 32 LEDs displaying the operational status are provided, and it is possible to set items the operator wants to display on each LED. It is also possible to set the operational properties of LED for each items to be displayed, such as color and display type.

■ LCD and touch screen

LCD and touch screen provides an operator interface, such as checking the set value and operational status, and changing the set value.

3.4. HMI Features

3.4.1. Functions displaying information on the operational status

- IM2 stores various information on operational state, which can be checked in the display menu.
- Up to 2000 items of event on fault, self-monitoring and control are saved, and the non-volatile memory inside the IM2 allow to store them permanently. However, since there is a limit to the number of storage and they are managed in the order of the latest record, the information on the oldest event is deleted when any events occur in excess of the maximum number.
- Up to 64 fault waveforms are stored in 4K/4.8K rate, which is identical to the samples used for protection per cycle. They are saved in the form of COMTRADE file, so the user can transmit them to the higher-level system, including the operating system of substation and SCADA, and analyze them using the operating software.
- It is possible to save fault waveform of 10 seconds long.
- The set values are saved in the nonvolatile memory inside the IM2, and therefore, preserved permanently. Data loss and damage are prevented by the use of 2 nonvolatile memories to save the set value in duplicate.
- In order to check whether all items, such as the set value related to the function, are normal during operation, the constant monitoring function checks whether the data is normal.

3.4.2. Function for Verifying Passwords

- In order for the operator to run the operation of each menu, the operator must have the authority to run such operation. Therefore, be sure to go through procedures for verifying passwords in order to check the authority before running the setting and control menus.
- The operator's authority is divided into 4 levels in total as shown below: display, setting, control and admin.

  - display authority : Information on setting and operational status inside the IM2 can be checked.
  - setting authority : All items can be set (including display authority)
  - control authority : CB, etc. can be controlled (including display authority).
  - admin authority : All items can be set and controlled.

- Password for each authority can be changed at the menu of 'setting'.

3.4.3. Operator's setting function

- The operator can set items, including time, network, the use of contract input/output, factors, holding time of controlled output and debouncing time.
- The set value of factors are individually managed in for set groups, and the group selected according to the operators' settings is applied to the operation of the factors.
- The operator's setting is possible even during normal operation of IM2, and is reflected in the operation of IM2 immediately after change.

3.4.4. Alarm for occurrence of fault event

- When a fault event occurs, the status is displayed on IM2 so that the operator can know the occurrence of a fault. The [FAULT] LED on the front is turned on, a pop-up window containing the fault details is displayed on the front LCD, and then the tray icon for occurrence of fault event on the status bar turns on.
- If the user select the 'Check' button after checking information of the pop-up window, the pop-up window disappears and the IM2's HMI function can be used normally.
- The tray icon for occurrence of fault event on the status bar turns on in the event of a fault event, and it turns off when the operator checks the fault event history in the display menu.
- In the event of a fault event, the screen is as follow.



3.4.5. Communication Port

Communication ports are provided that allow an operator to acquire data or enter information using a PC in which the operating software is installed. The role of the communication port is as follows.

- When the communication port is connected to the PC in which the operating software is installed, and acquires data of IM2, it supports the operator to easily analyze the IM2 monitoring information, or measurement data and fault information data via the operating software.
- The operator can easily enter the set value for IM2, transmit it to IM2 for application via the operating software.
- The operating software allows to acquire COMTRADE file containing the fault record from IM2, and then to analyze the fault.
- It is possible to connect the front communication port to the PC on the spot in order to update IM2 software.

4. Function

4.1. Setting standards of equipment

IM2 sets the rated voltage and current of the power system in which IM2 is installed. The equipment that sets the rating includes the bus PT, line PT, phase CT and N-phase CT.

Items set	Unit	Min.	Max.	Step	Default value
Rated Primary PT Voltage	V	1	2000	1	154000
Rated Secondary PT Voltage	V	1	1000	1	110
Rated Secondary Line PT Voltage	V	1	1000	1	110
Rated Primary CT Current	A	100	10000	1	2000
Rated Secondary CT Current	A	1	100	1	5
Rated Primary NCT Current	A	100	10000	1	2000
Rated Secondary NCT Current	A	1	100	1	5

4.2. Function of saving fault record

IM2 has a function to save the voltage, current signal input to IM2, and the operational result of internal logic as the fault record when internal function works. The setting items for the function of saving fault record are as shown in the table below.

Items set	Unit	Min.	Max.	Step	Default value
Use or not to use	-	Off	On	-	Off
Mode of saving fault waveform	-	Trip	Trip & pickup	-	Trip
Record Sampling	-	-	-	-	4K
Saved length of waveform before pickup occurs	msec	1	10000	1	3000
Saved length of waveform after pickup occurs	msec	1	10000	1	7000
Saved length of waveform before trip occurs	msec	1	10000	1	3000
Saved length of waveform after trip occurs	msec	1	10000	1	7000

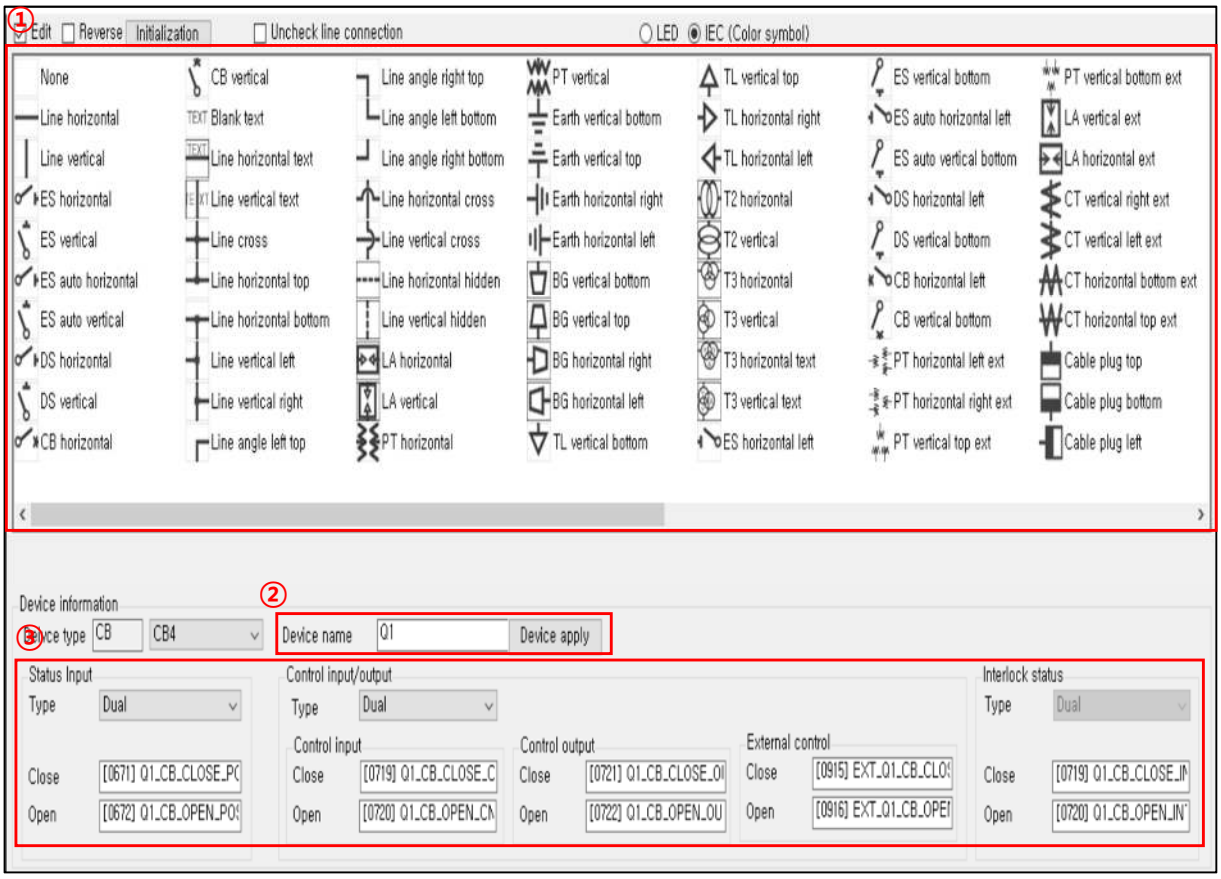
IM2 internally performs 80 samplings per cycle in order to carry out sampled value generation, therefor fault record sampling is fixed to 80 samples/cycle (=4K sample/sec(50Hz), =4.8K sample/sec(60Hz)).

4.3. Function of CB/DS/ES control in SLD

IM2 has a function to control an equipment such as CB, DS and ES in Single Line Diagram.



Wired-X provides a single line diagram editor, and a user can draw or edit SLD through the SLD editor as shown below. However, user generally do not need to modify SLD as they are designed/tested to match the approved drawings upon delivery. If you want to make a modification, please contact the manufacturer first.



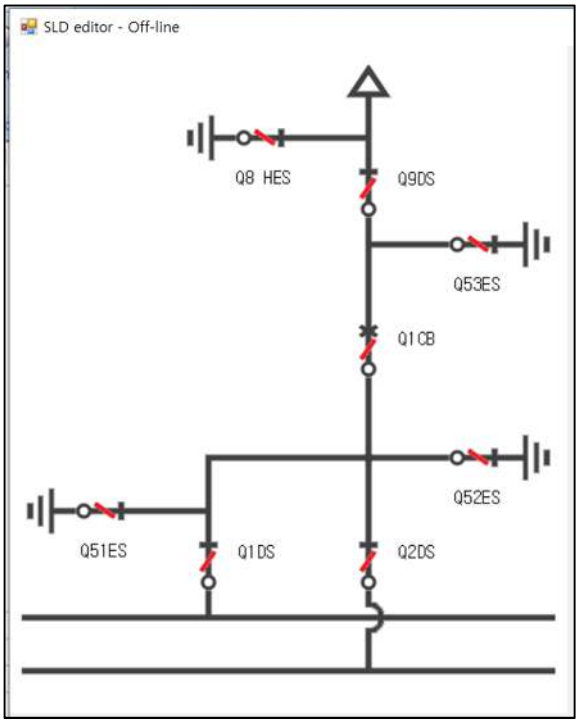
① Available Symbols for SLD

② Device name as it appears on the schematic

③ Assigning points for control in SLD. ***This setting is critical and may not function properly***

if altered. Please contact the manufacturer before making any adjustments..

Below is an example of a single line diagram implemented through the Single Line Diagram Editor. A single line diagram can contain up to 4 CB symbols, 4 DS symbols, and 4 ES symbols.



- The real-time status of the current device is displayed on a single line diagram.
- The operator can change symbols indicated on the single line diagram according to the settings, and the status of the device is displayed differently according to the symbol.
- The status of the device is displayed as follows.

	The state of Open input	The state of Close input	IEC Symbol	LED Symbol
1	Off	Off		
2	On	Off		
3	Off	On		
4	On	On		

4.3.1. Control related conditions

The following conditions must be met for the control output to function properly.

- Local/Remote status
- Interlock status
- Position status /Command input
- Control output point and whether to assign a DO

Control depends on local/remote status to determine which sources are controllable, as shown below.

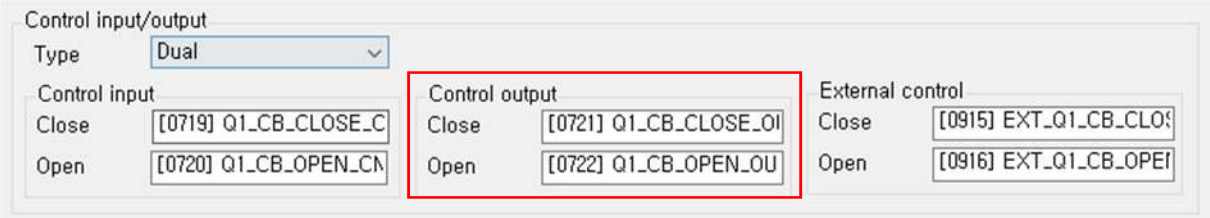
	Controllable source
Local	LCD touch panel, Button
Remote	Control input : 61850 Control Service, Wired-X External control : Internal digital points assigned to a GOOSE or DI

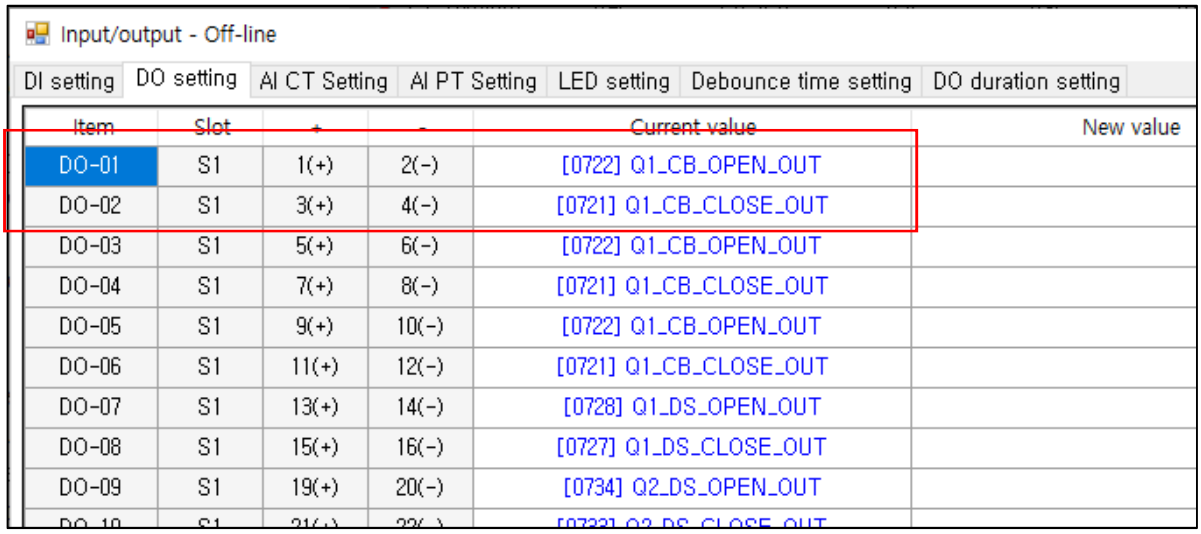
Obviously, you can't control the LCD touch panel or buttons in the Remote state, and vice versa. Check the local/remote status before executing the control action.

The Interlock status is an input that blocks the control output, preventing output when on and allowing output when off.

The position of the device and the command input must always be opposite. If a command identical to the device's position is given, no output is produced. Ex) open output occurs on close position, no output occurs on , and a failure event occurs on OPEN.

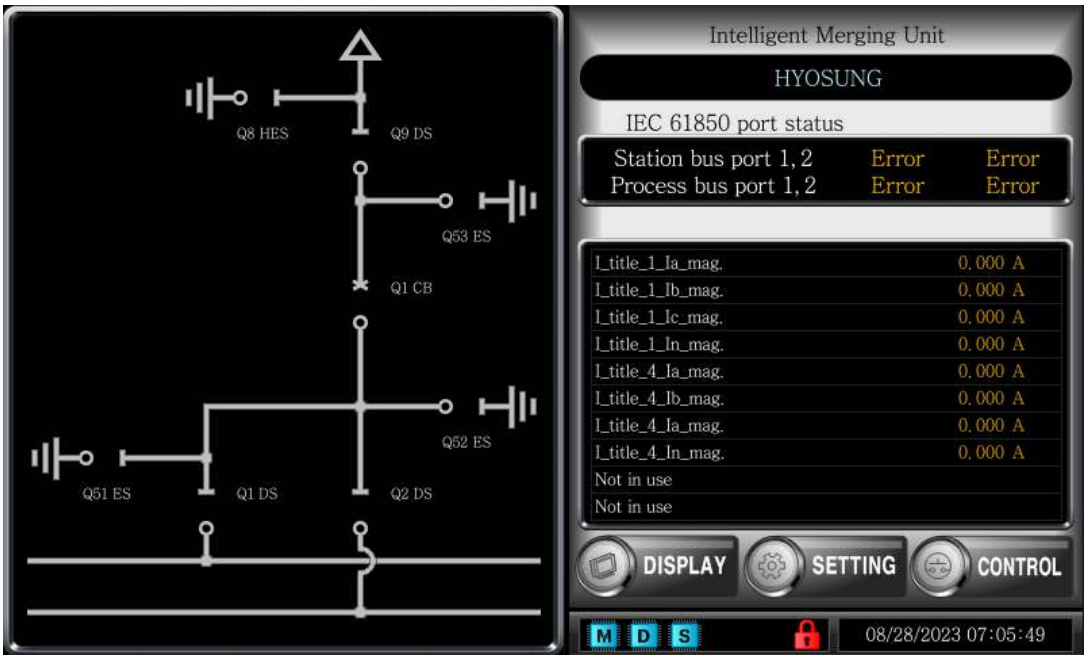
The control output point must be assigned to a DO on the DOU module. DO settings can be checked at 1.2.2 “DO setting”



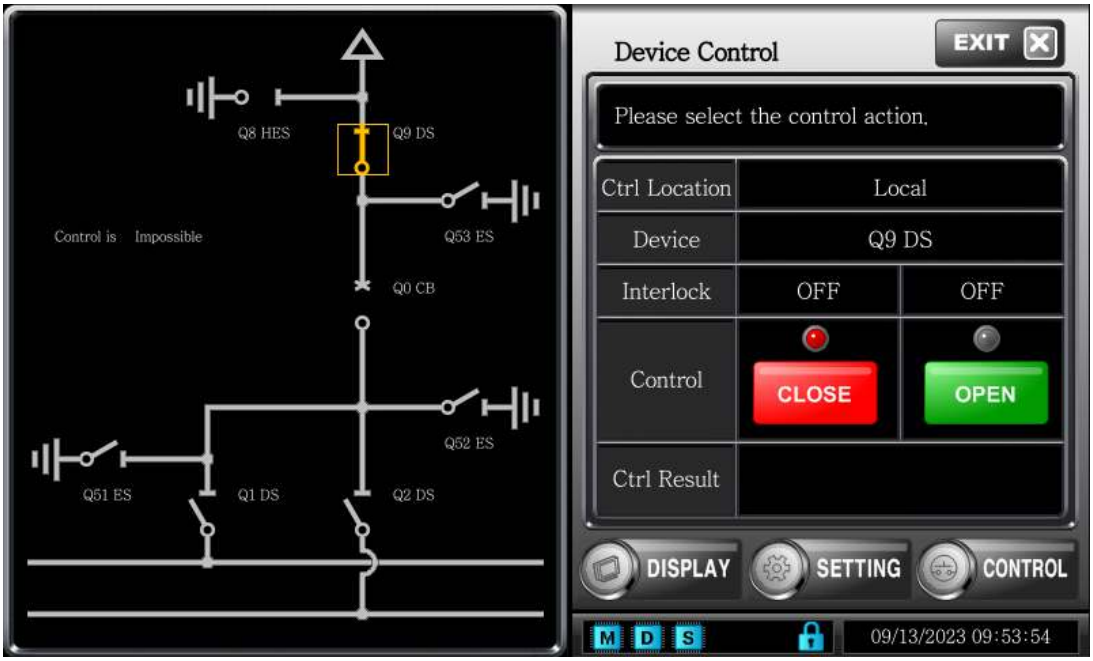


4.3.2. How to control CB/DS/ES in SLD

The conditions necessary for the control to operate have been verified, and now we will proceed to explain the actual method of operation. The IM2 can be operated in two ways: through the LCD or Wired-X. First, let's explain how to operate on the LCD.



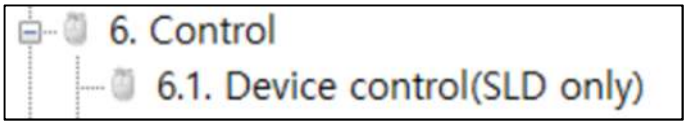
When the device in the SLD is tapped on the Main Home screen like the above picture, a password prompt will appear. After entering the correct password, you will be directed to the control screen displayed below.

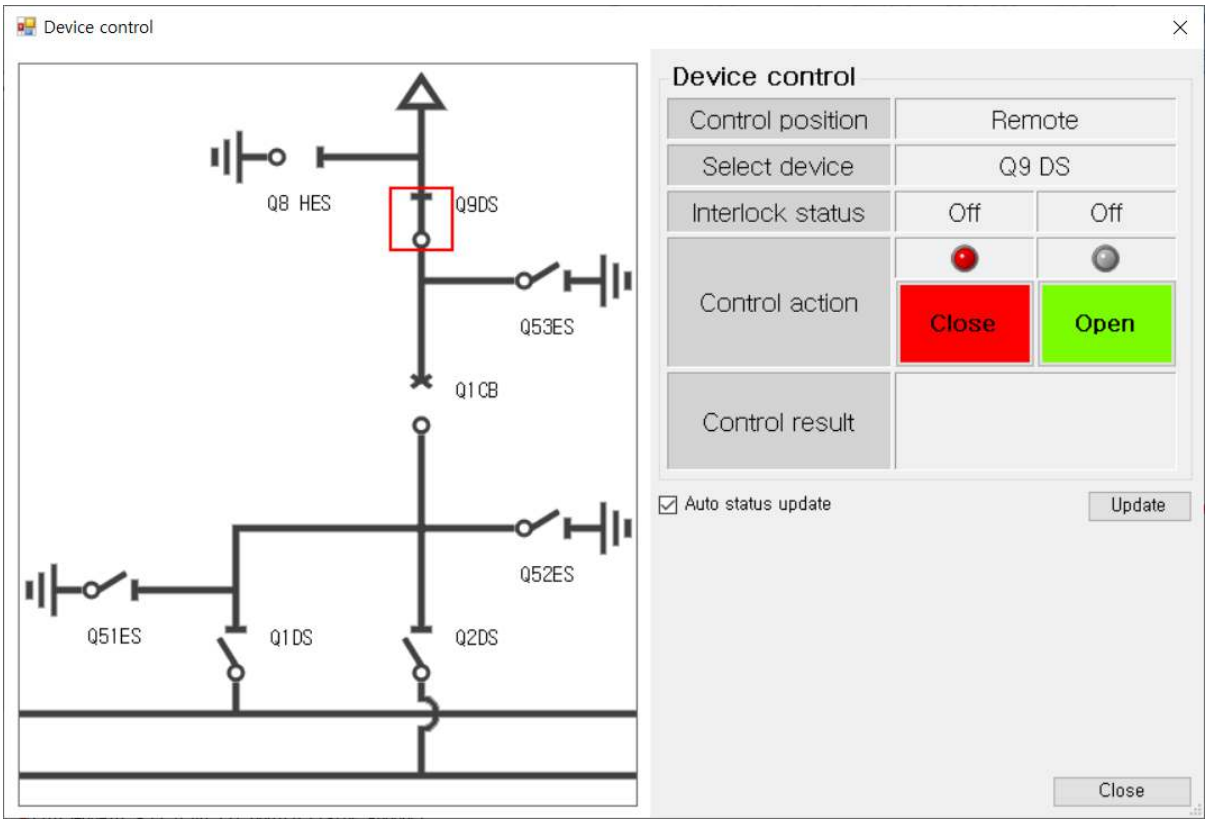


In the previous descriptions, you can see that after checking the control condition and issuing the control command, it works normally. To summarize the control conditions using the LCD/Button, we have the following:

Item	Condition
Ctrl Location	Local
Interlock	OFF
Device's Position	Open or Close

Similarly, Wired-X can control through "6. Control" after connecting to IM2 through Wired-X.





The control conditions using Wired-X are as follows

Item	Condition
Ctrl Location	Remote
Interlock	OFF
Device's Position	Open or Close

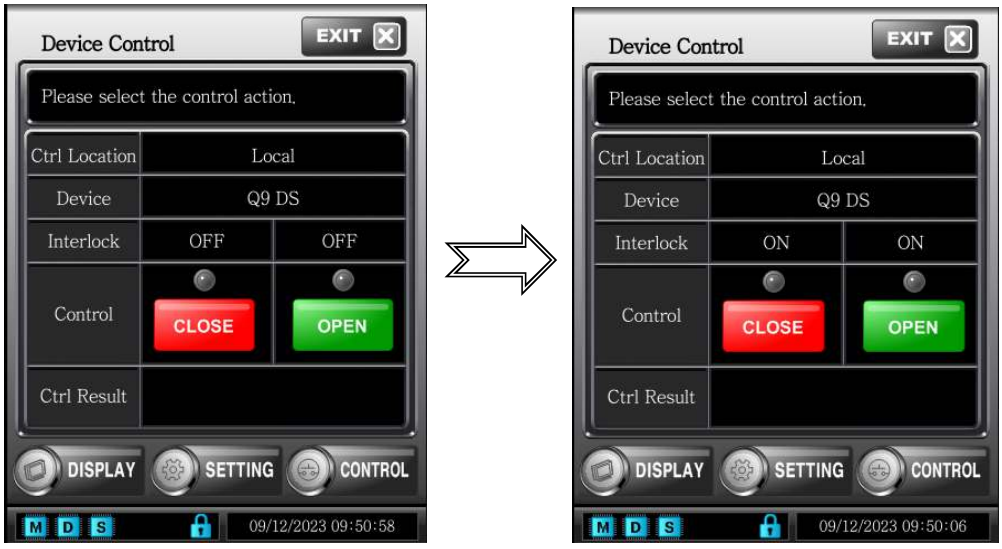
4.3.3. How to take control of CB/DS/ES in an Emergency

During an emergency, it may be necessary to take control of a device to prevent further damage. This behavior is only possible on-site in Local mode. To do so, follow these steps:

1. Select a device in SLD and enter password.
2. Press and hold "Lock" button over 3 seconds. (Releasing the button, it will revert after 3 seconds)



3. Check interlock status and confirm "OFF" to "ON".



5. Alarm & Self-Monitoring

5.1. Overview

- If the ARM lamp of this device is lit, be sure to check whether this device is free from error. Therefore, the automatic monitoring function is very important to check the status of this device in the course of startup and normal operation. A fatal error detected during automatic monitoring means that this device will be blocked and out of service. Accordingly, the power of this device must be turned off/on in order to make this device work again, or otherwise this device must be replaced.

5.2. How to classify alarms and check events

5.2.1. Description of alarm events

Alarm LED is lit upon occurrence of alarm event, and divided into [alarm element for locking the operation] and [alarm element for unlocking the operation].
When [alarm element for locking the operation] event occurs, the logic function does not work, and be sure to check it promptly and take actions because there may be problems with IM2's own hardware.

5.2.2. How to check upon occurrence of alarm event

Select "Display>Event>Alarm Event" to check the event.

5.2.3. Alarm Table

IM2 Alarm & Fail LED work in the following situations.

Status	Alarm LED	Fail LED
Operation alarm	blinking	Turn on
Non-operation alarm	Turn on	OFF
Normal & other alarm	OFF	OFF

5.2.4. How to check and inspect when alarm LED on the front of IED is turned on

1) How to check and take actions when 'Alarm event for locking the operation' occurs

- This is the case where IM2_LOCK or IM2_FAIL occurs, and if problems inside IM2 occurs, ALARM LED blinks every 1 second, and IM2 FAIL LED is turned on.

NO.	Occurrence of event	Confirmations and checklist
1	Abnormality in external power	This is an event of monitoring the control power. As this works when DC is not more than 90V and not less than 140V, be sure to check whether the power is DC 125V at the input terminal of the control power.
2	Abnormality in DSP Core	This is an event that occurs when IED's internal circuit is abnormal. When checking this event, be sure to contact the maker.
3	Abnormality in the set value	
4	DSP's failure to receive the initially set value	
5	Abnormality in measurement circuit	
6	Abnormality in ADC	
7	Abnormality in internal power	

2) How to check and take action upon occurrence of alarm event 'unlocked operation'

- This the case where IM2_ALARM elements work, and if the logic element is not locked, ALARM LED is turned on.

NO.	Event checking	Confirmations and checklist
1	Abnormality in IEC 61850 communication ※ *When IEC 61850 function is applied*	Be sure to check whether the connection of 61850 port and the optical distributor's cable linked to the rear of IM2 is normal, and whether the cables are connected mutually crosswise.
2		Be sure to check whether IEC 61850 IP for connecting to IM2 from HMI and clients is properly set. Be sure to check at "Setting>System>Network setting >IEC61850 port".
3	Abnormality in DI circuit	It operates when the state is changes more than 40 times within 1 second, so be sure to check the connection bolts on the rear of IM2 are loose.

4	Abnormality in DO circuit	This is an event that occurs when IED's internal circuit is abnormal. When checking this event, be sure to contact the maker.
5	Abnormality in DO contact	
7	Abnormality in the set value of MPU	
8	Abnormality in IEC 61850 communication process ※ *When IEC 61850 function is applied*	
9	Abnormality in IM2 event information	

3) How to check and inspect when an equipment is not controlled

NO.	Confirmations and checklist
1	If an equipment is controlled at the site, be sure to check whether the control position is in the state of the site, and whether it is in the remote state when the equipment is controlled at a higher level, such as HMI.
2	The same control is not executed.. e.g.) When the state of inputting contact is in the state of 'CB close', 'CB close' is not controlled.
3	If the state of inputting the contact of an equipment to be controlled is not input, the equipment is not controlled. In other words, if the state of the equipment is recognized as abnormal, the equipment is not controlled. e.g.) 'CB close' can be controlled only when the state of inputting the contact is in the state of 'CB open'.
4	Be sure to check whether the interlock logic for controlling the device is applied. (Be sure to check at 'Display-Logic-Interlock) If the output of interlock logic for controlling the device is "0", the device is not controlled, so the device must be controlled after configuring the output of interlock logic as "1".

4) How to check and inspect when the connection to Wired-X communication fails

NO.	Item	Confirmations and checklist
1	When connecting to Console (serial) communication	Be sure to check whether COM port of the operator's PC matches with the Wired-X Com port. The user can check the COM port number at "My Computer>Hardware> Device Admin>Port". (How to check may vary depending on the operating system.)
2	When connecting to Ethernet communication	Be sure to check whether IP entered in IM2 is properly set. The user can check IP at "Settings>System>Network setting>Ethernet Console port".
3		Be sure to check whether the communication cable is properly connected to Ethernet port on the front of IM2.
4		Be sure to run 'Ping Test' to check whether IP assigned to IED is being used by other equipment. The user can check on the operator's PC at 'Start>Run> Enter CMD> Enter ping IP'
5		Be sure to check whether the access is blocked by the firewall on the operator's PC.

6. Display

6.1. Main Screen



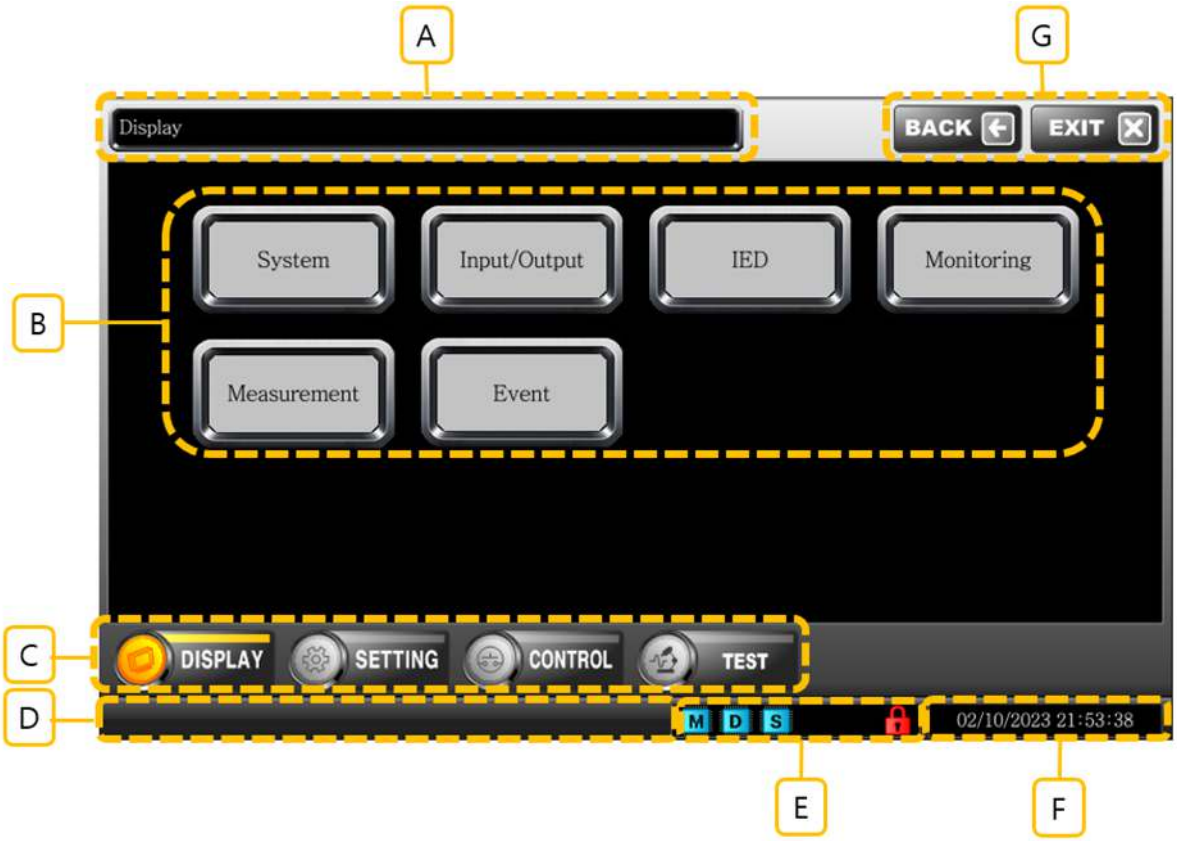
- The main screen displays product name, the state of IEC 61850 port, time and measurement information. The user can move to Display/Settings/Control Tab on the main screen. the mark 'lock' at the bottom of the screen indicates 'Remote/Local mode and Lock/Unlock status. The settings can be changed, using buttons on the front of IM2 (10,11). The icon, 'lock' is displayed in blue for Local mode, and in red for Remote mode, and the set value can be changed only in Local mode.

A. Single Line Diagram	: Single line diagram and equipment status are displayed.
B. Device name	: IED name
C. Facility name	: Facility name
D. the state of IEC 61850 communication	: the state of 2 ports on IEC 61850 is displayed. ※ The user can use it when applying IEC 61850.
E. Measurement data	: Key information on measurement is displayed.
F. Menu category	: All menus are classified and displayed depending on function

G. Time display	: information on current time is displayed
H. Tray icon	: The status of IED operation is displayed simply For details, see [Tray Icon] below.

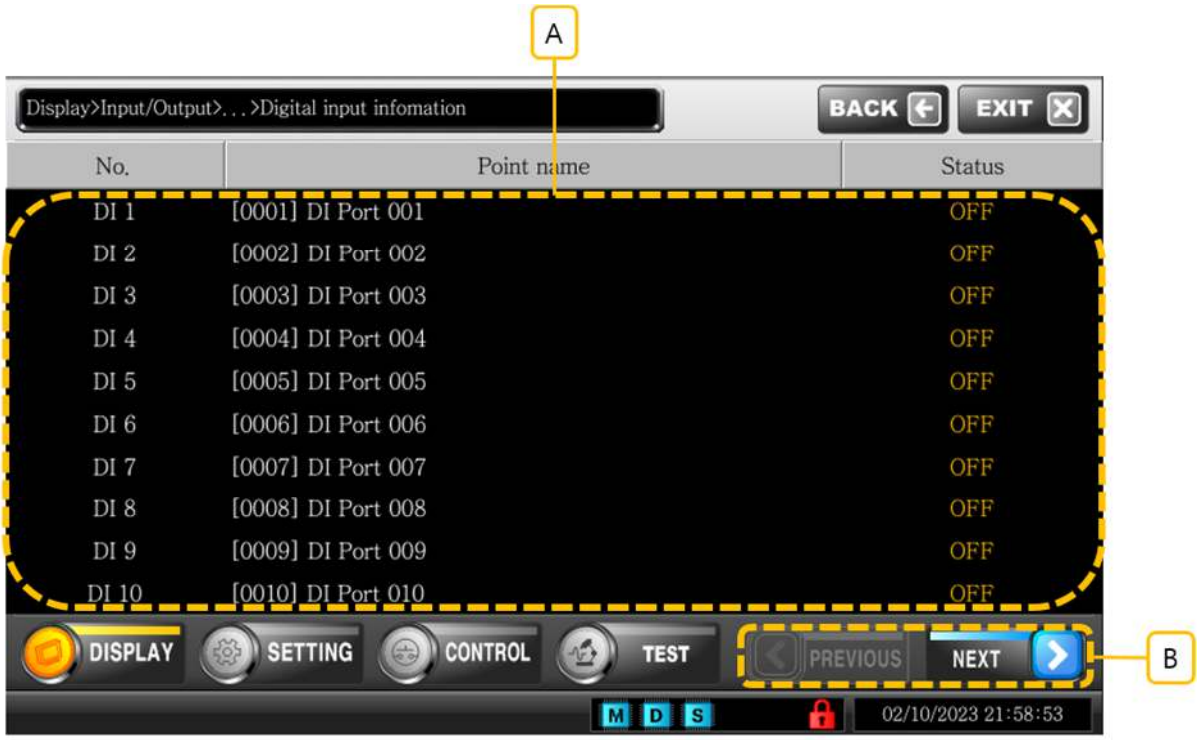
6.1.1. Screen for selecting menu

- The configuration and meaning of the screen for selecting the detailed menu, such as display, setting and control, are as follows. The figure below is the screen for setting menu.



A.	Display of menu path	: displaying the path of the currently running menu
B.	Detailed menu	: displaying the detailed menu belonging to the menu
C.	Menu category	: Classifying and displaying all menus according to the operation
D.	Display of status	: displaying information on status
E.	Tray icon	: simply displaying the status of IED operation
F.	Display of time	: displaying information on the current time
G.	Moving backward /End button	: moving to the previous menu or main menu

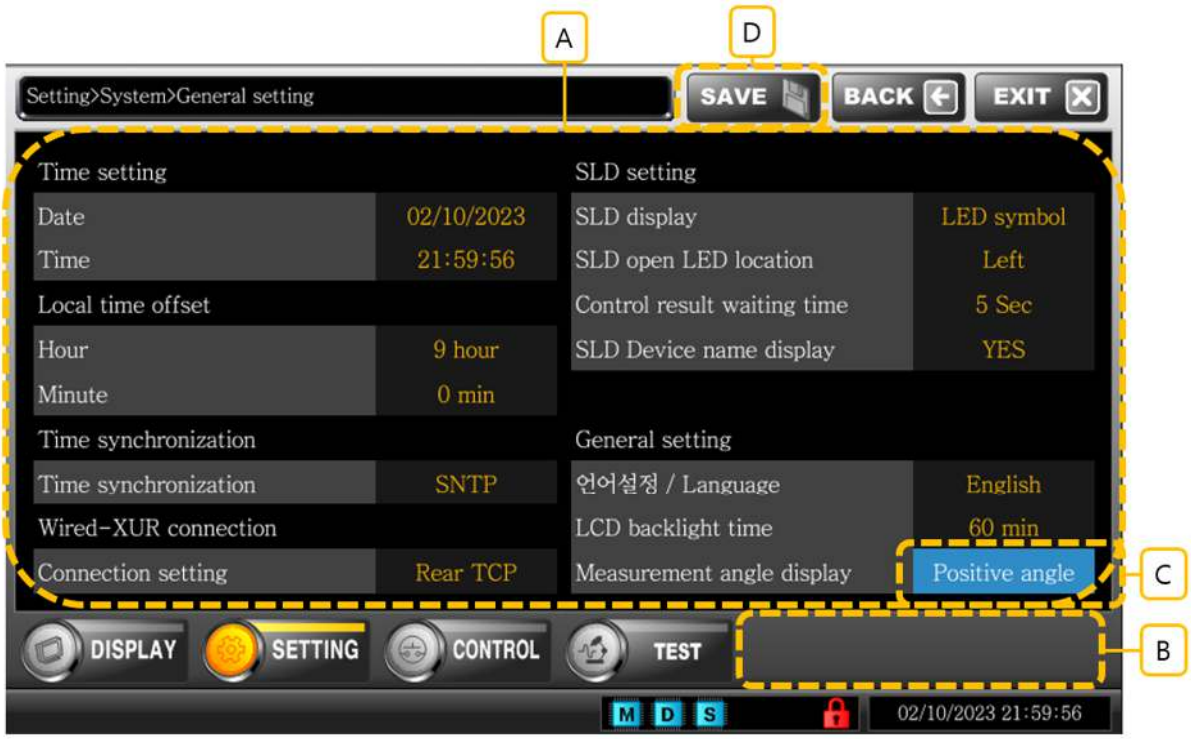
6.1.2. Screen of Display Menu



A. Detailed data : displaying the detailed data belonging to the menu

B. previous/next button : If there are 2 pages or more, a button to move page

6.1.3. Screen of menu set



A. Items set : settable items belonging to the menu

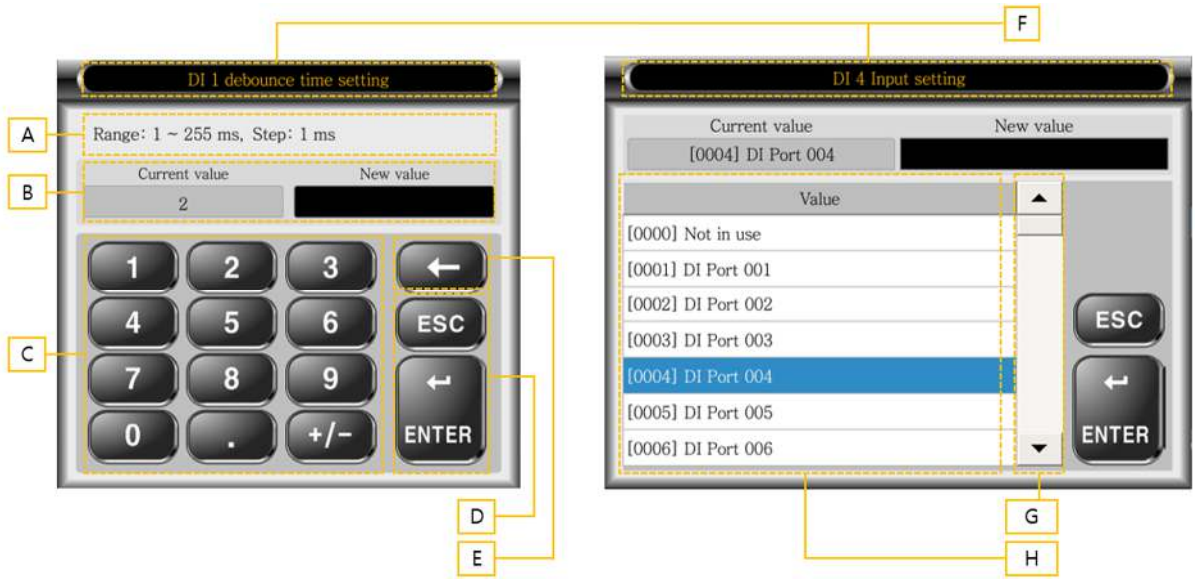
B. Previous/Next button : If there are more than 2 pages of data, a button to move page

C. Activation of menu set : Element to select and classify for running item

D. Save button : a button to save and apply the set value changed by the operator

6.1.4. Screen of pop-up window

- Pop-up windows displayed during the operation of menu is largely divided into a window with a button for entering numbers, and a window with a set list.



A.	Displaying the settable range	: Displaying the settable range, such as Min., Max. Step of the item
B.	Displaying the set value	: Displaying the existing set value and new set value entered by the operator
C.	Button to enter numbers	: Number button used to enter the set value
D.	Cancel/Confirm button	: 'Confirm' button to cancel the changed setting or to apply new input value
E.	Button to cancel input	: Button to cancel the input of new set value one by one
F.	Name of the set item	: Displaying the name of the set item
G.	Up/Down scroll	: a button to move to the previous/next item in the set list
H.	List set	: Displaying the list for the operator to select the settable item

6.1.5. Tray Icon

- Types and meanings of icons displayed on HMI are as follows.



A. MPU : Display whether MPU is normal or abnormal
- M : MPU is normal
- M : MPU processor is abnormal
- M : MPU is abnormal (None-Lock alarm)
- M : MPU is abnormal (Lock alarm)

B. DSP : Display whether DSP is normal or abnormal
- D : DSP is normal
- D : DSP processor is abnormal
- D : DSP is abnormal (None-Lock alarm)
- D : DSP is abnormal (Lock alarm)

C. IEC 61850 (STB) : Display whether IEC 61850(STB) is normal or abnormal
- S : IEC 61850 is normal
- S : IEC 61850 processor is abnormal
- S : IEC 61850 communication is abnormal
- S : IEC 61850 communication is abnormal

※ It is possible to use when applying IEC 61850.

D. Displaying fault waveform : the state of saving fault waveform
- : completing to record fault waveform

E. Interlock : Display the status of Interlock
- : Remote/ Locked
- : Local / Unlocked
- : Local / Locked

6.1.6. LED operation

- LED repeats the following process sequentially. In terms of LED display for each type, it checks and displays the data on 32 setting elements of LED individually.
- Check the displaying items set on the LED: The user can check the displaying items on LED set by the operator, and operate the LED according to the set type and color.
  1. Monitoring of the value of LED setting elements: The user can monitor data in real time, and reflect them in LED display as soon as they are changed..
  2. LED display: There is a difference in the display method for each type of LED setting. The details of the display method for each type are as follow.

Type	How to display
Pulse	It is displayed in real time according to the status value. If 'True', it is on, and if 'False', it is Off.
Latch	It monitors the status value in real time, and if 'True', LED is turned on, but even if it is changed to 'False', LED is not turned off. If the status is 'False', The user can turn off LED, using [FAULT RESET] button on the front.

6.1.7. LCD operation

- LCD repeats the following functions in order.
  1. Input on LCD: The image and status values are displayed on the LCD. The image and data name displayed on the LCD are updated only when the power is turned on for the first time or when the menu is shifted, and various status are updated and displayed ever 200ms, and the measured values are displayed every 3 second. Therefore, the operator can check the status change inside the IED in real time.
  2. Input on screen touch: The operator's screen touch is monitored, and the corresponding operation is performed. When the position, where the touch screen is pressed, is the menu button, the LCD of the selected button is changed, and when it is the button related to the saving of the settings, the changed set value is reflected inside the IED.
  3. LCD backlight: To protect the LCD, if there is no input on LCD touch or button for a set time, the LCD backlight is turned off. The backlight time can be set by the operator, and the backlight turns on again when the screen is touched or a button on the front is pressed.

6.1.8. Menu List on the Display

- The display function does not require a separate password.. That is, all operators can use the display function.
- The status of IED operation and monitoring elements are displayed, and the value set and measured by the operator can be checked..
- The menu tree on the display is as follows.

Menu on the display	Sub-menu	Sub-sub menu
System	Version information	
	General setting	
	Network information	
	Function button setting	
	Setting of measurement on the main screen	
	Board information	
	PBCU system information	
	PTP information	
	HSR/PRP information	
Input/ Output	Information on contact point	Information on input of contact point
		Information on output of contact point
	GOOSE information	Station/Process Bus GOOSE subscriber
		Station/Process Bus GOOSE publisher
		Station/Process Bus GOOSE control block
	LED information	
	Information on debouncing time	
	Information on duration of controlled output	
	Information on type of contact output	
IED (inclusion is undecided.)	Information on logic elements	
	Information on machine dimensions	
	Information on elements of saving fault record	
	Information on the set groups	
Monitoring	Status of IED operation	
	Status of IED alarm	

	Status of counter	
	Status of PBCU system	
	PTP status	
	HSR/PRP status	
Measurement (Information will be added after installing functions later)	Measurement information	Voltage: 1~3 Set
		Current: 1~3 Set
		Current: 4~5 Set
		Comprehensive information
		Information on user's measurement 1
		Information on user's measurement 2
	Transducer information	
	RTD information	
	Information on measurement inside IED	
	Electric energy	
Event	Alarm event	
	Monitoring event	
	Contact input event	
	Control event	
	Communication event	
	Fault event	
	Setting event	

6.2. Menu on the Display

6.2.1. How to run menu on the Display

1) "Move" while running the main menu on the LCD

① When moving from the main menu, which is the initial screen of IM2, to the menu on the Display, touch the "Display" button on the LCD to move to the top menu of the Display.

② Go to the menu of "Version Information" to check the information on IM2 version. The position of the menu of "Version Information" can be checked, referring to the menu structure of the upper Display. The menu of "Version Information" is positioned at 'Display> System>Version Information'.

③ Touch "System" button out of the buttons of the detailed menu displayed on the top menu on the display to move to the "System" menu.



④ Touch "Version Information" button out of the detailed menu buttons belonging to the System menu and go to the menu of "Version Information".

⑤ The data of [Version Information] menu are displayed on the LCD. The path of the currently running menu can be checked in the part of displaying title at the top.



※ STB of F/W version can be used when IEC 61850 is applied.

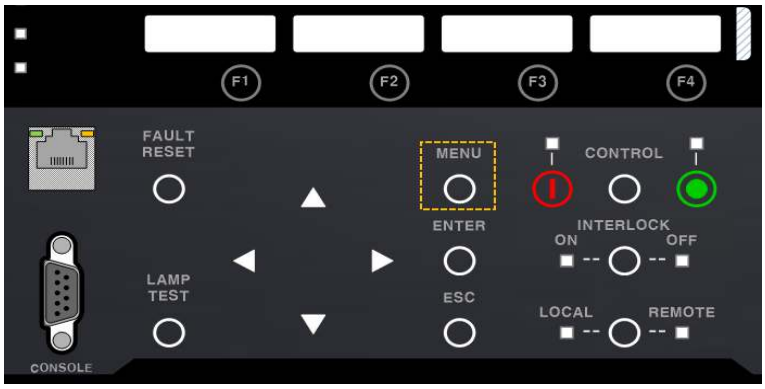
2) 'Move" while setting, controlling LCD and running test menu

① When moving to the menu on the display while other menu is running, touch "Display" menu on the LCD to go to the top menu on the display.

② Moving in the top menu on the display is the same as moving the above 'moving while the main menu on the LCD is running'.

3) Move using the front buttons

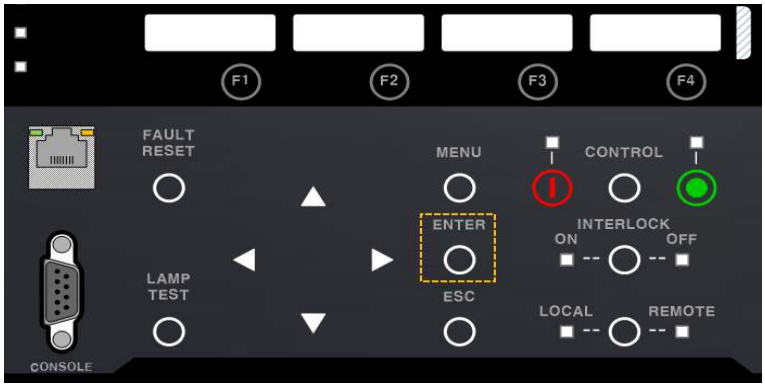
① When moving from the main menu, which is the initial screen of IM2, to the menu on the display, press the "Menu" button on the front of IM2 to go to the top menu on the display.



② To check information on IM2 version, go to the menu of "Version Information". The menu of "Version Information" is positioned at "Display>System>Version Information".

③ Use "Up, Down, Left, Right" button on the top menu of the Display to go to the "System" button among the buttons of the detailed menu. The movement of button can be checked by the indication of button selection.

④ When the button selection is activated, press "Enter" button to run the menu of "System".



⑤ Also use "Up, Down, Left, Right" menu in the "System" menu to go to "Version Information" button out of detailed menus. When the button selection is activated, press "Enter" button to run the menu of "Version Information".

⑥ The data of "Version Information" menu is displayed on the LCD.

⑦ When moving to the Display menu while other menus are running, Press "Menu" button on the front of IM2 to run. Pressing "Menu" button switches from the currently running menu to the next menu in the order of "Display" – "Setting" – "Control".

6.3. System

6.3.1. Version Information

- IM2 information and each version, including product name and model name of IM2, are displayed.

Item	Data
Product information	Product name
	Model name
	Product number
Firmware version	MPU
	DSP
	STB
Hardware version	Hardware

6.3.2. General Information

- Information is displayed, including Language of IM2, LCD backlighting time and clock synchronization.
- The generally set items are displayed as follows.

Item	Data
Time setting	Date
	Time
Offset of local time	Hour
	Minute
Clock synchronization	
How to access Wired_X	
Setting of single line diagram	Display of singled line diagram
	LED position for opening single line diagram
	Waiting time for the result of control
	Displaying the name of device on the single line diagram
General settings	Language setting / Language
	LCD backlight setting
	Displaying measurement phase

6.3.3. Information on network settings

- Communication network address of IM2 is displayed.
- IP addresses of Ethernet console port and SNTP server on the back of IED set by the operator are displayed, respectively.
- Network setting items are displayed as follows.

Item	Data
Ethernet console port	IP address
	Subnet mask
	Default gateway
SNTP server	IP address
	Subnet mask
	Default gateway
IEC 61850 port	IP address
	Subnet mask
	Default gateway

※ The settings of IEC 61850 port (IP address, subnet mask, default gateway) are applied to CID(Configured IED Description) files.

6.3.4. Information on settings of function buttons

- The operating elements of the total 4 function buttons of IM2 are displayed.

Item	Data
Settings of function button	Function button 1
	Function button 2
	Function button 3
	Function button 4

6.3.5. Information on measurement settings on the main screen

- Information on measurement items on the main screen of IM2 is displayed.
- The main screen displays up to 10 Measurement Items.

Item	Data
Measurement settings on the main screen	Measurement Item 1
	Measurement Item 2
	Measurement Item 3

	Measurement Item 4
	Measurement Item 5
	Measurement Item 6
	Measurement Item 7
	Measurement Item 8
	Measurement Item 9
	Measurement Item 10

6.3.6. Board Information

- Information on the type of AI board and IO board used by IM2 is displayed.
- Information on up to 2 AI boards and 5 IO boards is displayed.

Item	Data
AI Board	Board A
	Board B
IO Board	Board 1
	Board 2
	Board 3
	Board 4
	Board 5

6.3.7. Information on PBCU system

- Settings of clock synchronization and power of PBCU at IM2 can be checked.

Item	Data
Process Bus Live Config	PBCU On/Off
Process Bus Time Sync Mode	PTP /Local Time(RTC)
Process Bus Clock Sync Mode	PTP/PPS/GPS

6.3.8. Information on STB Time system

- Settings of clock synchronization of STB at IM2 can be checked.

Item	Data
Station Bus Time Sync Mode	SNTP/Internal Clock (PBCU)

6.3.9. PTP information

- Settings and status of PTP of IM2 can be checked.

Item	Data
Master offset	-
Path delay	-
Ingress time	-
Initial delay	-
Cumulative scaled rate offset	-
UTC offset	-
Local clock id	-
Current clock id	-
Current clock status	-
Delay Mechanism	Auto/E2E/P2P
Network Transport	UDS/UDP IPv4/UDP IPv6/IEEE 802.3/DEVICENET/CONTROLNET/PROFINET
Timestamping	Software/Hardware/Legacy H/W/One Step/P2P 1 Step
Slave Only	Enable/Disable
Priority 1	0~255
Priority 2	0~255
Domain Number	Default/ALTERNATE 1,2,3
Clock Class	0~255
Clock Accuracy	Unknown Accuracy/Within 25ns ~ >10s
Announce message period	(1 msg every 1/2/4/8 sec) / (2/4/8/16/32/64 msg every sec)
Sync. Message period	(1 msg every 1/2/4/8 sec) / (2/4/8/16/32/64 msg every sec)

Delay request message period	(1 msg every 1/2/4/8 sec) / (2/4/8/16/32/64 msg every sec)
PDelay request message period	(1 msg every 1/2/4/8 sec) / (2/4/8/16/32/64 msg every sec)
Announce receipt timeout	2~255
Sync Receipt timeout	0~255
Delay asymmetry	-2^{31}~2^{31}
Egress latency	-2^{31}~2^{31}
Ingress latency	-2^{31}~2^{31}

6.3.10. HSR/PRP Information

- The settings of communication redundancy of IM2 (HSR/PRP) are displayed.

Item	Data
Redundancy Mode	HSR/PRP
HSR Work Mode	Mode H/N/T/U
PRP Work Mode	Duplicate Discard/Duplicate Accept
HSR Ring Interface	HSR-SAN/HSR-HSR/HSR-PRP
Redundancy A Port Speed	100/1000
Redundancy B Port Speed	100/1000

6.4. Input / Output

- Analog and digital information output/input in/from the corresponding IM2 are set in the screen below.



6.4.1. Information on contact input

- The operating value of the contact input of IM2 is displayed in real time.
- It is possible to check the status of contact input as many as the number of the mounted pointers, and the operating elements set by the operator are displayed on each number of physical point.
- Items of displaying information on contact input are as follows.

Item	Status	
Number	-	-
Point name	unused	The set point name
Status	Off	On

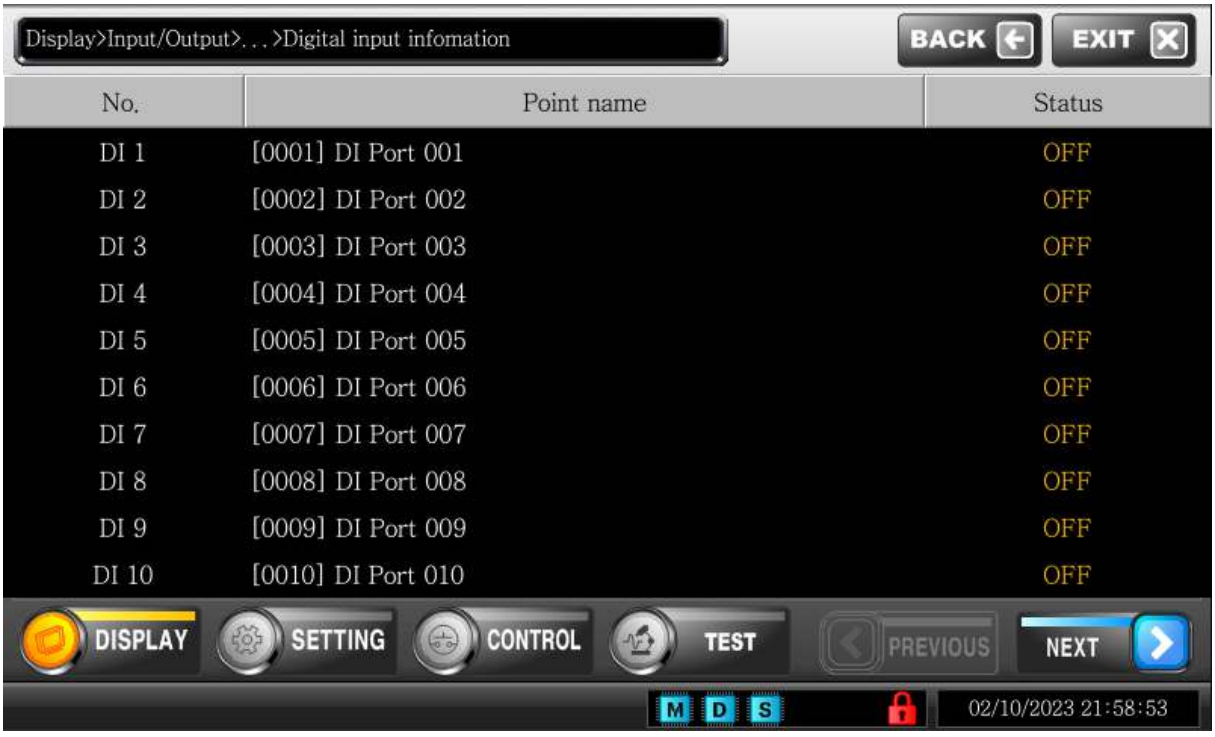
6.4.2. Information on contact output

- The operating value of the contact output of IM2 is displayed in real time.

- It is possible to check the status of contact output as many as the number of the mounted pointers, and the operating elements set by the operator are displayed on each number of physical point.
- Items of displaying information on contact output are as follows.

Item	Status	
Number	-	-
Point name	unused	Name of the set point
Type of contact	Contact A	Contact B
Controlled output	OFF	ON
Status of contact	OFF	ON

- The screen displaying information on contact input/output is configured as follows.



6.4.3. GOOSE Information

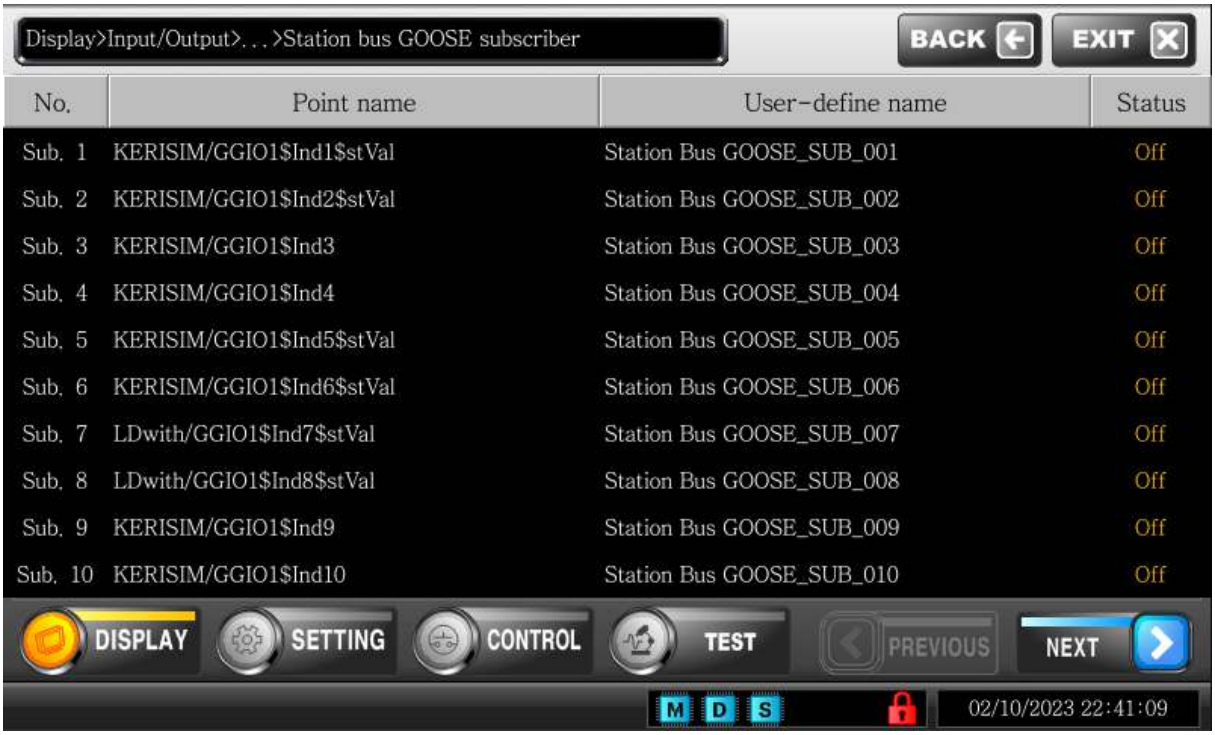
- The status of GOOSE publisher and subscriber is displayed.
- The operator can check the status of input and output of GOOSE messages in real time, and the use of each GOOSE control block.
- Items of GOOSE subscriber and publisher that can display status correspond to the elements

defined in the CID file for IEC 61850 communication.

- The point of GOOSE subscriber and publisher can additionally define "the User-defined names" via the operating software, and When a user defines 'the User-defined name", an operator can check the set point name and user-defined name together.
- It shows information on GOOSE subscriber and publisher of Station/Process Bus, respectively. The configuration of GOOSE status display in Station and Process bus is the same, so Station bus GOOSE display is shown as a representative.

Item	Data
Station/Process Bus GOOSE subscriber	Point number
	Point name
	User-defined name
	Status
Station/Process Bus GOOSE publisher	Point number
	GoCB number
	Point name
	User-defined name
	Status
Station/Process Bus GOOSE control block	Point number
	In use or not in use
	Status
	Test mode

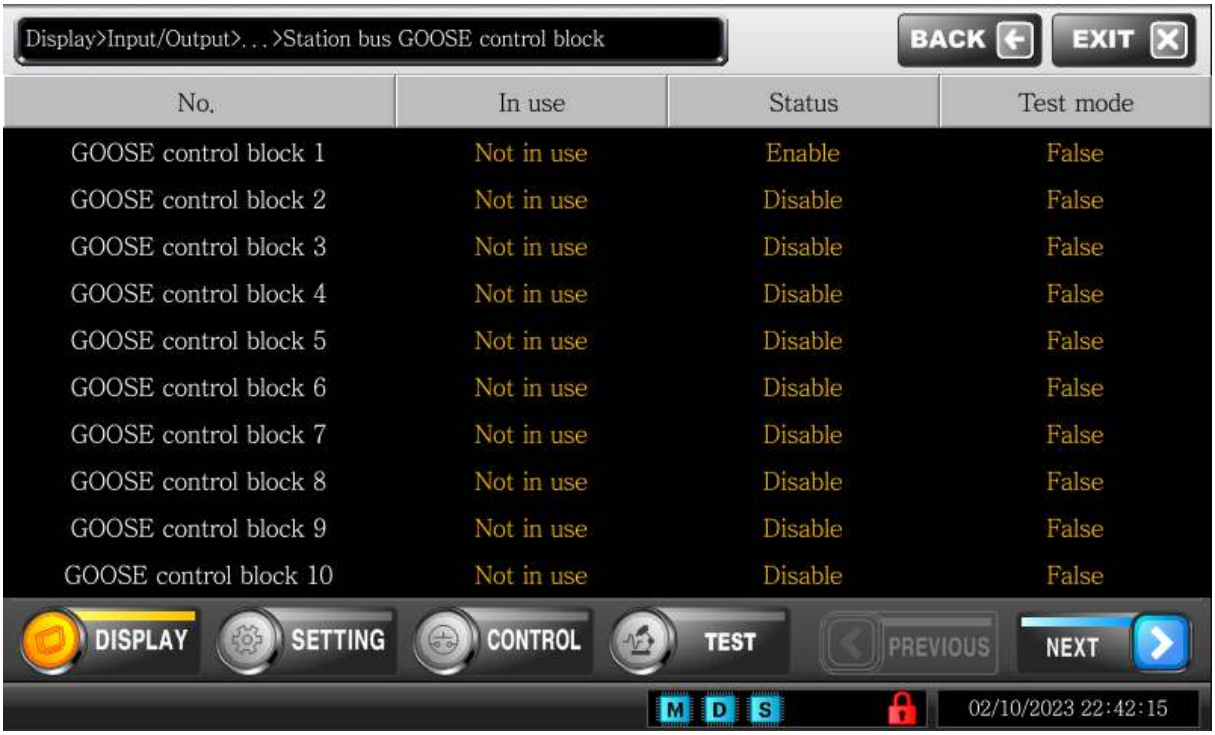
- The screen displaying GOOSE subscriber is configured as follows.



- GoCB number means the control block number to which the corresponding publisher point is transmitted, and GOOSE message is transmitted only when the setting of GOOSE control block is 'Enable'.
- The screen displaying GOOSE publisher is configured as follows.



- It shows the use and condition of GOOSE CB and test mode.

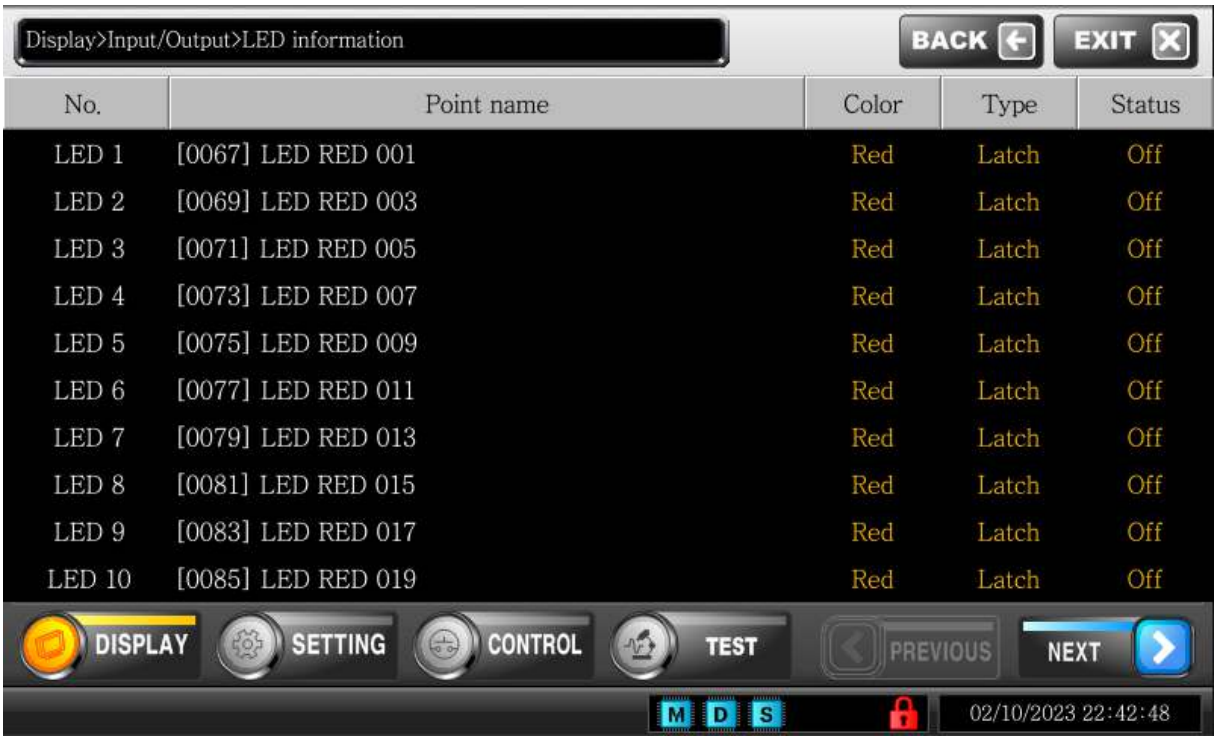


6.4.4. LED information

- It displays the monitoring elements and attributes of LED set using the front LCD and operating software. It displays the set value of each of the total 32 LEDs so that the operator can recognize them.
- The following Items are displayed.

Item	Status		
LED number	-	-	-
Point name	unused	Name of the set point	-
Color	Red	Green	Yellow
Type	PULSE	LATCH	-
Status	OFF	ON	

- LED operation by type
  - Operation when the type is PULSE: When LED monitoring element is turned on, and LED is turned on, and when LED monitoring element is turned off, LED is turned off .
  - Operation when the type is LATCH: When LED monitoring element is turned on, LED is turned on, and even when LED monitoring element is turned off, LED is not turned off. LED is turned out only when pressing “FAULT RESET” button on the front of HMI.
- LED information screen is configured as follows. When LED is set to ‘unused’, information on color and type is not displayed.



6.4.5. Information on Debounce Time

- With respect to the input contact, the debounce time for the input signal is displayed for each input contact.
- The input contact is 54 points, and the debounce time can be set in unit of 1ms from 1ms to 255ms.

6.4.6. Information on duration of control output

- When the output contact is operated, the output duration of each contact is displayed for each output contact.
- The output contact is 66 points, and the duration of the control output can be set in unit of 1ms from 1ms to 10000ms.

6.4.7. Information on the type of contact output

- When the output contact is operated, the type of contact is displayed for each output contact.
- The output contact is 66 points and the type of contact can be set to Latch and Pulse.

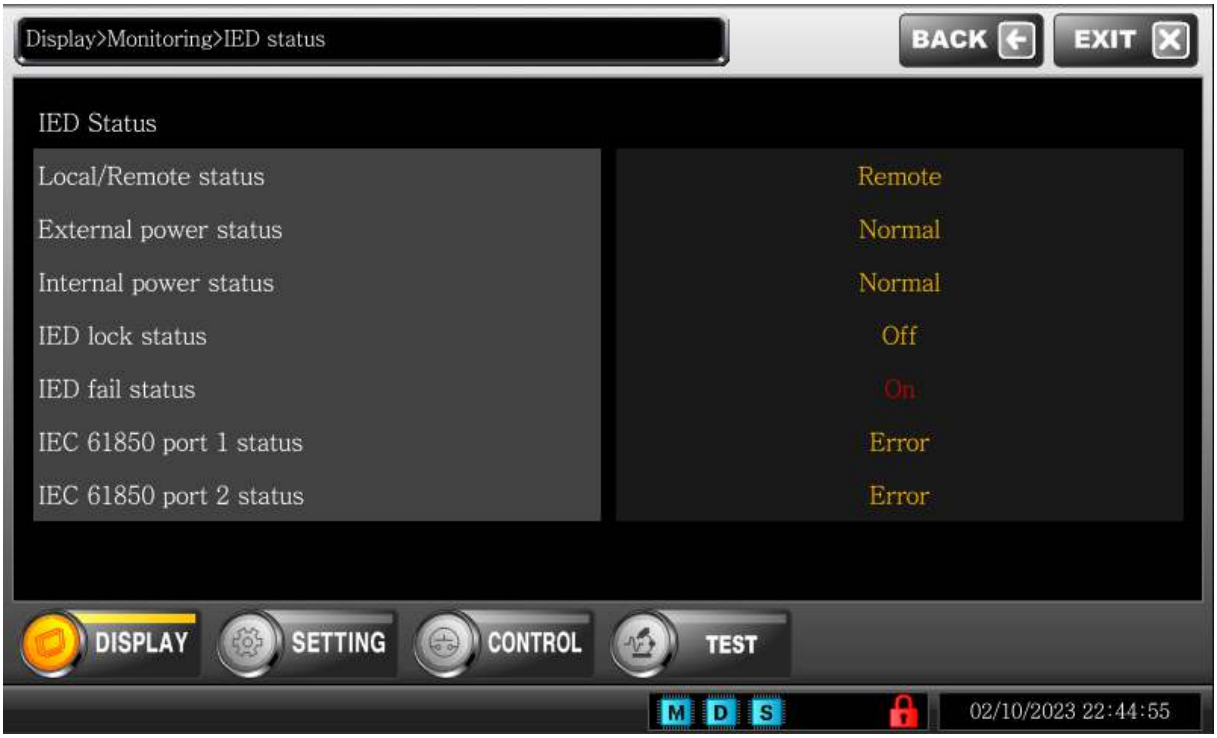
6.5. Monitoring

6.5.1. Operation Status of IED

- The operation status of IM2 is monitored in real time to check for its abnormalities.
- The operation status of IM2 displays the items below.

Item	Status	
Status of Local/Remote	Remote	Local
Status of input power	Normal	abnormal
Status of internal power	Normal	abnormal
Status of IED lock	Normal	abnormal
Status of abnormalities in IED	Normal	abnormal
Status of IEC 61850 port 1	Normal	abnormal
Status of IEC 61850 port 2	Normal	Abnormal

- The screen of IM2 operation status is configured as follows.

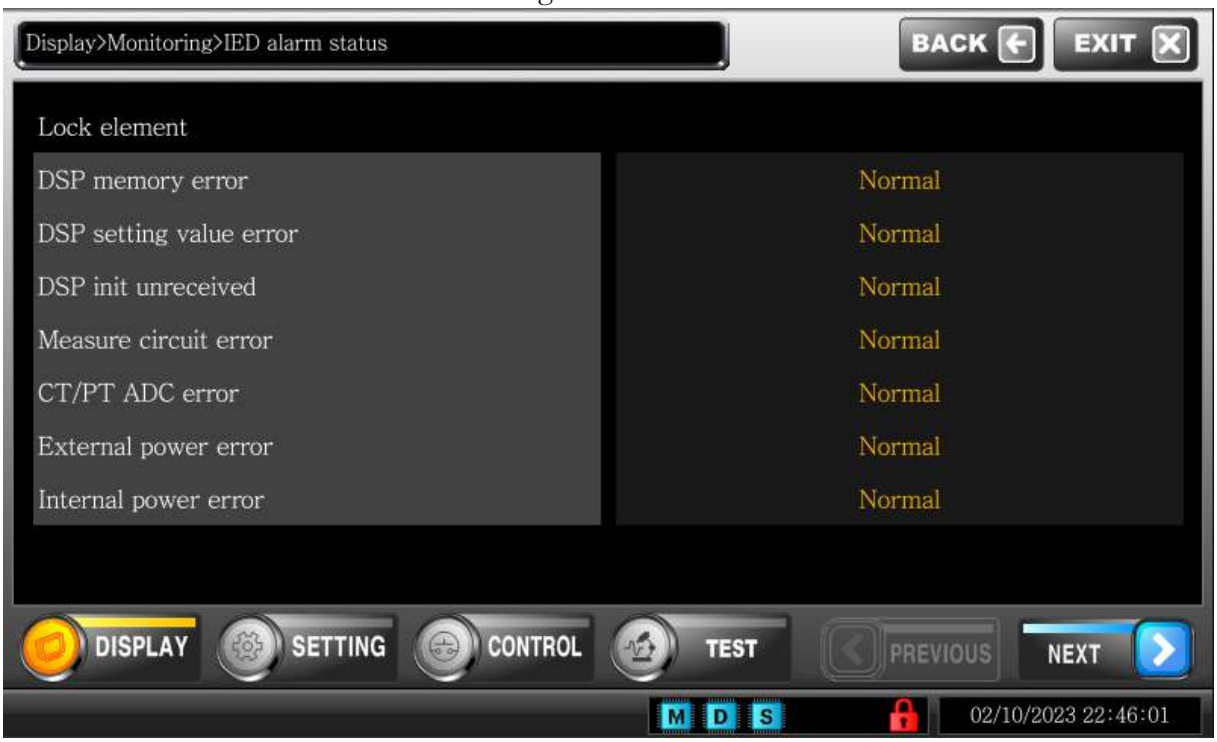


6.5.2. Alarm status of IM2

- The alarm status of IM2 is displayed in real time to determine the cause of status.

Alarm element for locking operation	Alarm element for 'not locking' operation
DSP memory is abnormal	DI circuit is abnormal
Set value of DSP is abnormal	DO circuit is abnormal
Initial set value of DSP is not received	DO contact is abnormal
Measurement circuit is abnormal	MPU event information is abnormal
CT/PT ADC is abnormal	The set value of MPU is abnormal
Input power is abnormal	IEC 61850 communication is abnormal
Internal power is abnormal	MPU processor is abnormal
-	DSP processor is abnormal
-	SMO processor is abnormal
-	STB processor is abnormal

- The screen of IM2 alarm status is configured as follows.

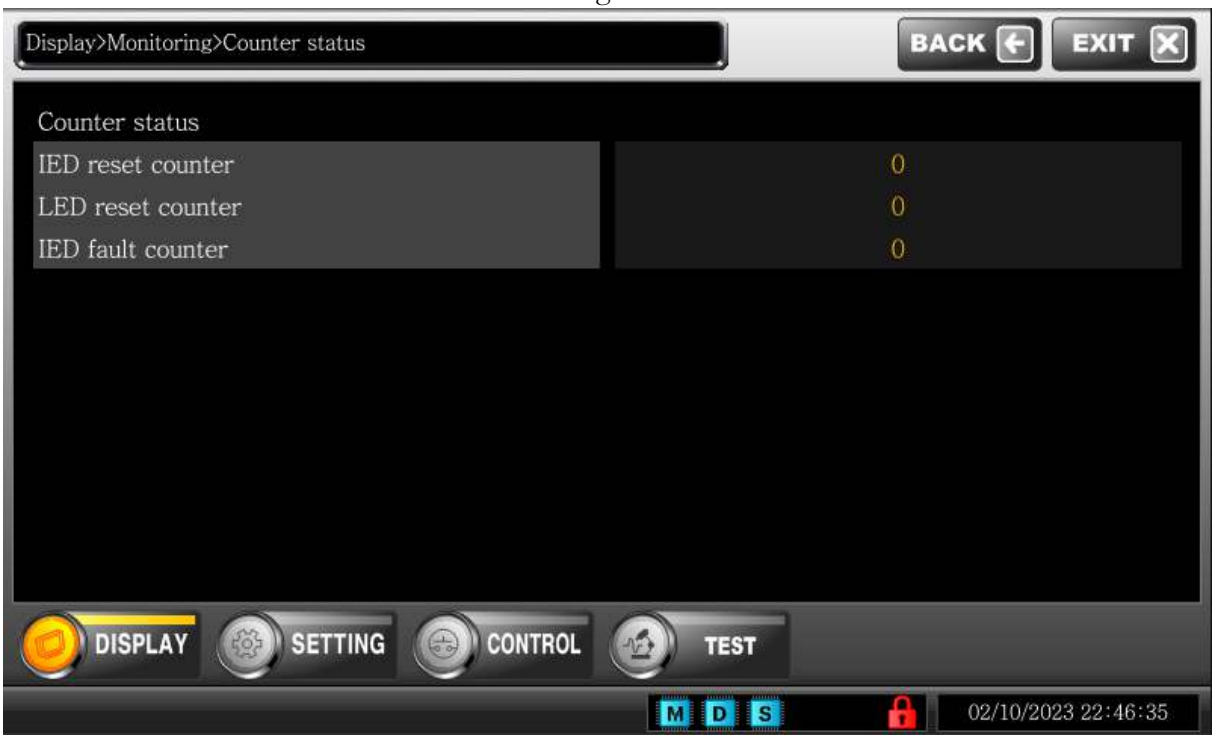


6.5.3. Status of Counter

- It displays the reset counter value of IM2. When IM2's internal reset and LED reset is operated, or failure occurs, each counter value increases.
- The status of counter displays the following items.

Item	Description
IM2 reset counter	The number of times IM2's own system has been rebooted is displayed
LED reset counter	The number of times the LED status has been initialized is displayed, using "Fault Reset" button on the front of HMI.
Counter for the occurrence of failure in IM2	The number of failures is displayed.

- The screen for the status of counter is configured as follows.



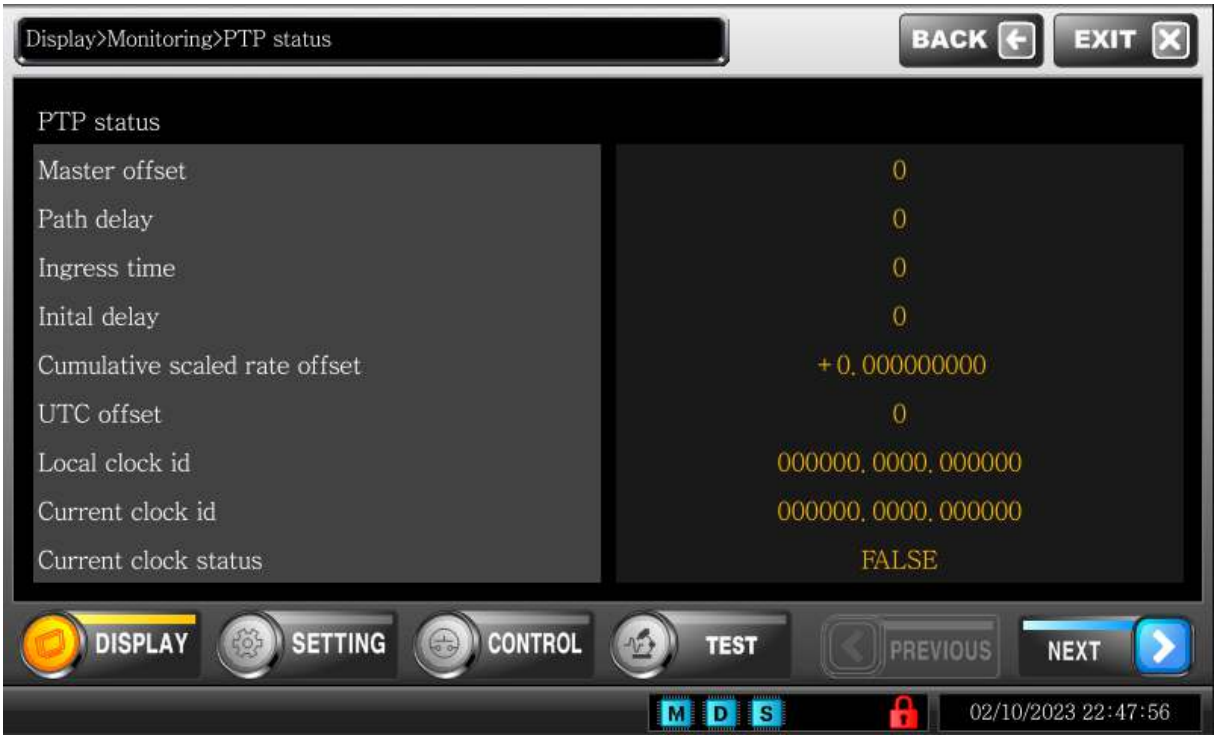
6.5.4. Status of PBCU System

- It displays the status of PBCU system.



6.5.5. PTP Status

- It displays the status and settings of PTP connected to IM2.






Display>Monitoring>PTP status
BACK
EXIT
PTP status
Announce message period
1 msg every 8 sec
Sync. message period
1 msg every 8 sec
Delay request message period
1 msg every 8 sec
Pdelay request message period
1 msg every 8 sec
Announce receipt timeout
0
Sync. receipt timeout
0
Delay asymmetry
0
Egress latency
0
Ingress latency
0
DISPLAY
SETTING
CONTROL
TEST
PREVIOUS
NEXT
M
D
S
02/10/2023 22:48:56

6.5.6. HSR/PRP Status

- It displays HSR/PRP status of IM2.



6.6. Event

6.6.1. Alarm event

- Alarm event consists of items that stop the operation of IED and the user must check, out of elements that monitor the abnormal operation of IED.
- It saves up to 2000 events, and if more than 2000 events occur, the latest event replaces the oldest event and is saved.
- The user can check in order of the latest history.
- Upon occurrence of alarm event, "ALARM" LED on the front is turned on and ALARM Data is transmitted to the upper level.
- Events include data of occurrence time for each item, event type and detailed items.

Items to be displayed	Description
Time	Event occurrence time: "YYYY/MM/DD hh:mm:ss:ms"
Type	Type of distinguishing alarm events is displayed.
Detailed Item	Detailed description according to the status that each type may have is displayed.

- For detailed items for alarm events, refer to "XI.2.A. Alarm Event".

6.6.2. Monitoring Event

- The monitoring event saves the unusual state that occurred during the operation of IM2.
- It saves up to 2000 events, and if more than 2000 events occur, the latest event replaces the oldest event and is saved.
- The user can check in order of the latest history.
- Events include information on the occurrence time and event type for each item.

Item	Description
Time	Event occurrence time: "YYYY/MM/DD hh:mm:ss:ms"
Type	Item of event occurrence
Detailed Item	Detailed description according to the status that each type may have is displayed.

- For more details for monitoring event, refer to "XI.2.B. Monitoring Event".

6.6.3. Contact input event

- The contact input event monitors and save the status of changes in contact input point of IM2.
- Individual monitoring of the contact input point is performed, including the time of change in status, element name for the physical contact point set by the operator, and data on the status of contact input point.
- The time of change in status is monitored and saved in unit of 1ms.
- It saves up to 2000 events, and if more than 2000 events occur, the latest event replaces the oldest event and is saved.
- The user can check in order of the latest history.
- One contact input event includes time, the name of contact input point, and information on the status of operation.

Item to be displayed	Description
Time	Event occurrence time: "YYYY/MM/DD hh:mm:ss:ms"
Point name	The element of DI operation point is displayed. The number of operated contact point and the operating element name set at the corresponding contact point are displayed.
Operation	The status of the input contact point is displayed. On(1) / Off(0)

6.6.4. Control Event

- Control event saves all control history according to the control command received from IM2.
- It saves up to 2000 events, and if more than 2000 events occur, the latest event replaces the oldest event and is saved.
- The user can check in order of the latest history.
- One control event includes a total of 5 information: the occurrence time, position, type, object, and result of control.

Item	Description	Data
Time	Event occurrence time:	"YYYY/MM/DD hh:mm:ss:ms"
Type of control	Where the operator issued the control command	Input element (LCD, PC, 61850)
Name of control point	DO object operated by the operator	Output element
Result	Result of control action	Success
		Fail - Interlock
		Fail - Timeout

6.6.5. Communication event

- Communication event saves the CAN communication status between boards, and the history on the status of connection to the operating program.
- It saves up to 2000 events, and if more than 2000 events occur, the latest event replaces the oldest event and is saved.
- The operator can check in order of the latest history.
- One communication event includes the occurrence time, event item and detailed item.
- Event items that can save using communication event are as follows.

Item	Data
Abnormal CAN communication occurs	CAN BUS ID
Abnormal CAN communication is released.	CAN BUS ID
Abnormal PCIF communication occurs	-
Abnormal PCIF communication is released.	-
Abnormal ADC SPI communication occurs.	ADC ID
Abnormal ADC SPI communication is released.	ADC ID
Connection to Wired-X	Access IP
Disconnection from Wired-X	Access IP

6.6.6. User event

- IM2 saves fault events when it detects faults in the system.
- It saves up to 2000 events, and if more than 2000 events occur, the latest event replaces the oldest event and is saved.
- The operator can check in order of the latest history.
- Events include information on occurrence time for each item.
- Running the menu of fault event displays a list of fault events first, and selecting an item in the displayed list displays information on the detailed event of the selected item.

6.6.7. Setting event

- If the settings in operation is changed in IM2, it saves the setting event.
- It saves up to 2000 events, and if more than 2000 events occur, the latest event replaces the oldest event and is saved.
- The operator can check in order of the latest history.
- The event items that can be saved as the setting events are as follows.

Item to be displayed	Description
Time	Event occurrence time: "YYYY/MM/DD hh:mm:ss:ms"
Control	Position of the set change
Setting	Name of the set change
previous/changed set value	Changed value

7. Setting

7.1. Overview

- Changing the setting of IM2 affects critical operations of device, such as transmission of the sampled value, so it is recommended to set it only when it is not in operation. In addition, the setting function should be used after fully understanding the user manual.
- The current value can be checked and changed for all setting items.
- The setting function can be run only by the operator who has setting authority or admin authority. That is, a password corresponding to the authority must be entered.
- There are a settable range and unit for each item in order to prevent malfunction of IM2, and the value set by the operator is constantly monitored, but if the corresponding condition is not met, it is not applied to the internal operation of IM2.
- The set value is saved in the non-volatile memory inside IED, and can be permanently preserved.
- Saving the set value is possible only when the current status of IM2 is 'Local'.
- As soon as the operator changes and saves the set value, it is reflected in the internal operation of IM2.
- The status of IM2 must be returned to 'Remote' after the operator completes to change the set value.
- The menu tree for setting is as follows.

Menu for setting	Sub menu	Sub-sub menu
System	General setting	
	Network setting	
	Function button setting	
	Measurement setting of main screen	
	Correction of touch screen	
	Board setting	
	PBCU system setting	
	PTP setting	
	HSR/PRP setting	
Input/ Output	Contact setting	Setting of contact input
		Setting of contact output
	GOOSE setting	Setting the use of Station/Process Bus GoCB
		Setting the test mode of Station/Process Bus GoCB

	LED setting	Setting of LED output
		Setting of LED color
		Setting of LED type
	Debounce setting	
	Setting of duration of control output	
	Setting the type of contact output	
Password	Password setting	

7.2. How to set

7.2.1. Items for setting numeric input

① When moving from the main menu, which is the initial screen of IM2, to the setting menu, touch the "Setting Menu" button on the LCD to go to the top setting menu.

② Enter password using the number button on the pop-up window for entering password, and then touch "Confirm" button.

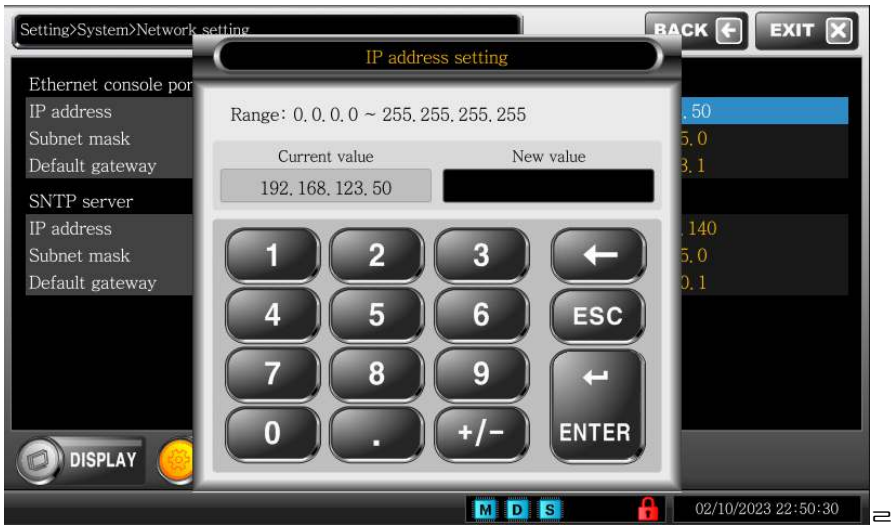
③ If the user move to the setting menu while other menu is running, touch "Setting" button on the LCD to go to the top setting menu.

④ For example, the user need to go to "Network Setting" menu to set up the device network. For checking the position of "Network Setting" menu, refer to the structure of the upper setting menu. "Network Setting" menu is positioned at 'Setting>System>Network Setting'.

⑤ Touch "System" button in the detailed menu displayed in the setting menu.

⑥ Touch "Network Setting" button to move, out of the detailed menus displayed in the system menu.

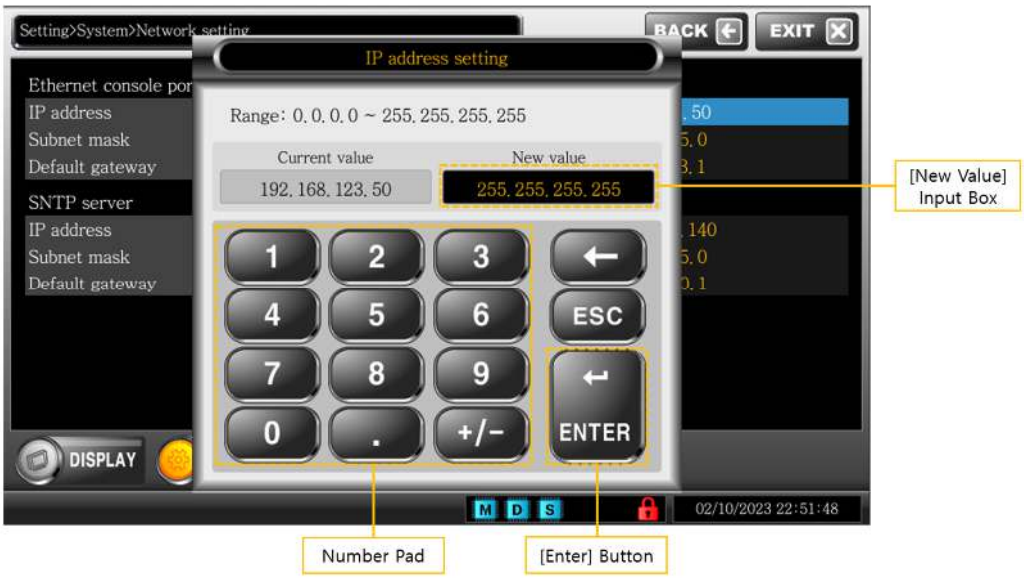
⑦ When the user touch "IP address" item out of items for setting device network, the pop-up window for setting IP address will appear.



⑧ Enter the IP addresses of device network in order from the beginning, using the number button. For example, if the user set the IP of '255.255.255.255', enter the number using the number button '2', '5', '5' and then press '.' button to go to the next input of number, and thereafter, press the number button. Enter the next numbers in the same way.

⑨ The entered setting value can be checked in the part of displaying the new setting value on the

pop-up window. Touch "Confirm" button after checking whether the entered setting value is correct.



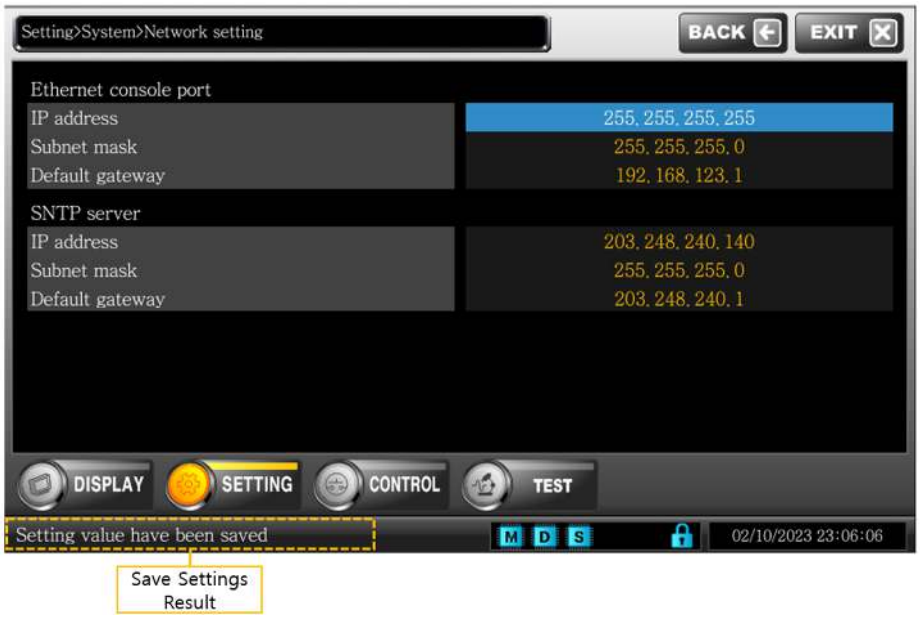
⑩ The newly entered setting value is reflected and displayed in the "Network Setting" menu.

⑪ After completing to change the setting item, be sure to touch "Save" button at the top of the menu.

⑫ In order to prevent the erroneous operation of the reflected setting value, be sure to check once again on the pop-up window whether it is saved or not.



⑬ If the user touch “Save” button to save, the user can check the saving result in the status bar at the bottom.



⑭ If the user touch “Cancel” button, the saving is cancelled and the next operation is waited.

⑮ If the operator changes the set value, touch “Back” or “End” button to check whether the changed setting value is saved, and then move to “Back” or “End”.

7.2.2. Items for selecting the setting list

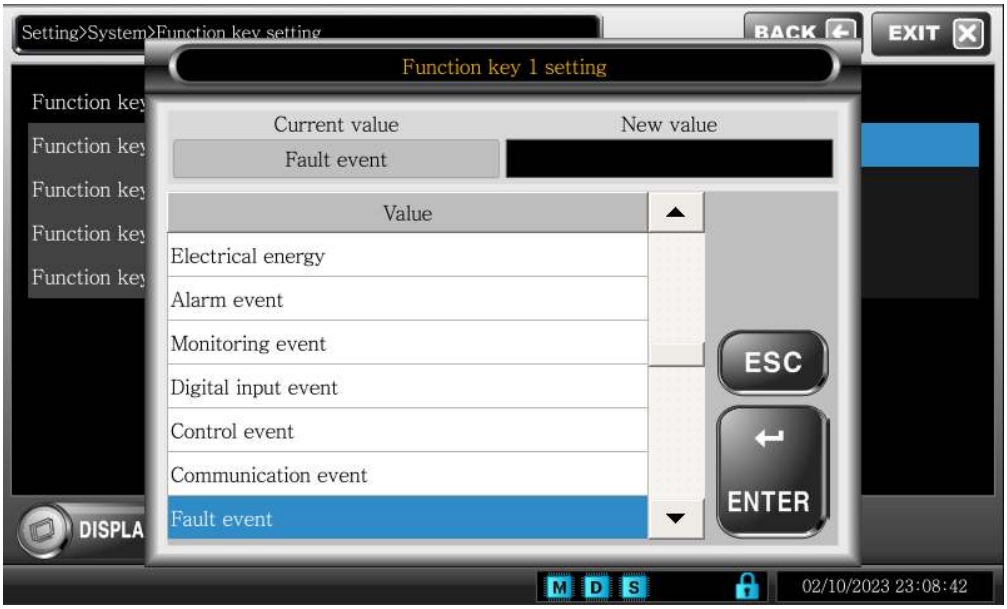
① Move to the setting menu. “How to move” is the same as the method mentioned in the upper level ‘A) the setting of numeric input’.

② For example, in order to set the function button, the user need to go to “Setting of Function Button” menu. To check the position of “Setting of Function Button” menu, refer to the structure of the upper setting menu. “Setting of Function Button” menu is positioned at ‘Setting>System>Setting of Function Button’.

③ Touch “System” button among the detailed menus displayed in the setting menu.

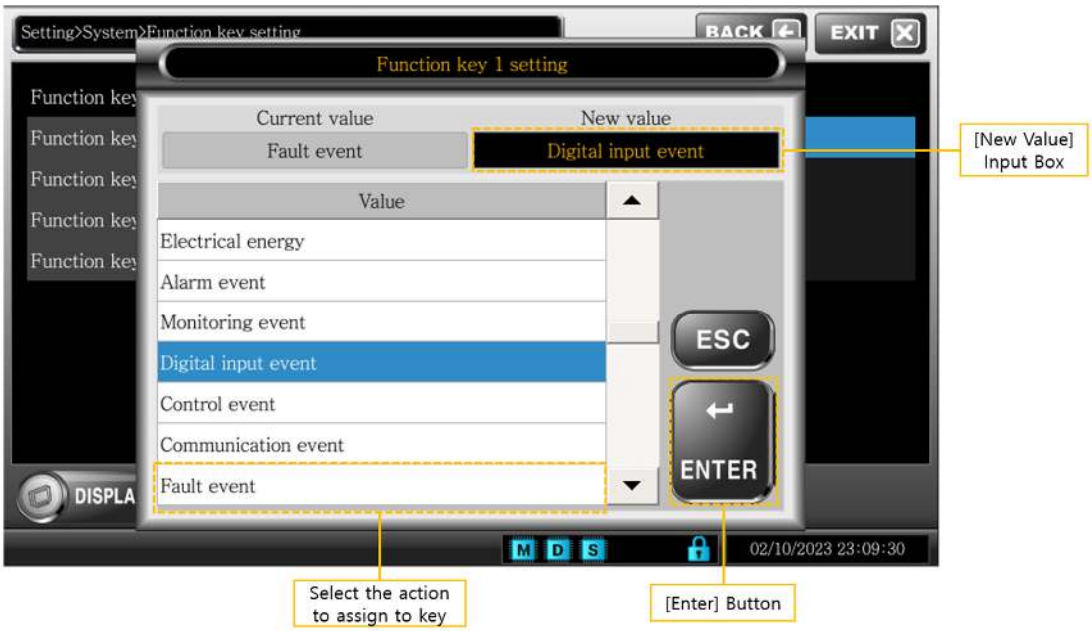
④ Touch the relevant button to move, following the path from “System” menu to “Setting of Function Button” menu.

⑤ If the user touch Item “Function Button 2” out of Item for setting the function button, a pop-up window for setting appears.



⑥ The setting list is displayed on the pop-up window, and if the user touch the right scroll “Up/Down” button, the displayed list page moves.

⑦ If the user select a changed Item, the selected item will be activated. The selected setting value can be checked in the part of displaying the new setting value on the pop-up window. Be sure to check whether it is entered correctly, and then touch “Confirm” button.



⑧ The newly entered setting value is reflected and displayed in the "Setting of Function Button".

⑨ When the user complete to change the setting Item, be sure to touch "Save" button at the top of the menu.

⑩ To prevent erroneous operation of the reflected setting value, be sure to check once again on the pop-up window for checking 'Save" whether it is saved or not.

⑪ When the user touch "Confirm" button to save, the user can check the saving result in the status bar at the bottom.

7.2.3. System Menu

1) General Settings

- General settings allow the operator to set language, backlighting time, and how to synchronize clock and how to display the single line diagram.
- Date and Time: The current date and time of IED can be set.
  - Set Year (YYYY)/Month(MM)/Day (DD), Hour (hh):Minute (mm):Second (ss).
- Offset hour and minute of local time: It is the offset time to apply the time of each country to the received world standard time in synchronizing clock, etc., and basically set to "+9:00" in order to display the Korean standard time. The offset time must be changed depending on the state in which the clock synchronization system is built.
- Clock synchronization: It sets a method for synchronizing the time of IM2. The RTC clock synchronization method is used unless the setting is changed separately.
  - For clock synchronization, the user can select SNTP using server IP or clock synchronization using GPS.
- Setting of connection to Wired-X: It sets how to connect to Wired-X.
  - Wired-X can be selected as the connection method using TCP on the front/rear side, or using RS232C on the rear side.
- Display of single line diagram: If IEC symbol or LED symbol is set, the display of single line diagram on the main screen and the control screen. are changed.
- LED position for opening the single line diagram: It sets LED position for opening the single line diagram.
  - LED symbol is selected for displaying the single line diagram, and the function to change LED position of 'Open' (green)/Closed (red) is set to 'Left', 'Green (open)' is displayed at the left top of device (CB, DS, ES) symbol, and 'Red (closed)' is displayed at the right. If this function is set to 'Right', 'Red (closed)' is displayed at the left top of device (CB, DS, ES) symbol and 'Red (closed)' is displayed at the right.
- Waiting time for control result: It sets the waiting time for checking and running the result.
  - It sets time for checking the changed time of contact for checking the control result.
  - The settable range is from 1 to 60Sec, which can be set in a unit of 1Sec, and the default value is set to 5 Sec.
- Display of devices on the single line diagram: It sets whether the name of device is displayed on the single line diagram.
- Language setting/Language: It is possible to select language displayed on HMI, depending on the operator's convenience.

- LCD backlight time: It sets the time to turning off LCD backlight when the user does not touch or input on HMI LCD. If the user does not touch or input on LCD or button while setting "Backlight time", LCD backlight is turned off. When the front LCD is turned off, the screen and interlock return to the initial mode, and in such case, when selecting input of LCD touch or button, LCD backlight is turned on. However, the LCD backlight is not turned off in the state of 'Local'.
- Display of measurement phase: It sets how to display the phase value of measurement. If it is set to 'Negative angle', the phase value is displayed as ∠-359.99~∠0, and if it is set to 'Positive angle', the phase value is displayed as ∠0~∠359.99.

2) Network settings

- It can set communication port related to network communication of IM2, and information on access to network for external devices.
- It can set Ethernet console port on the front of IM2 and network of SNTP server (IP address, subnet mast, default gateway).

3) Setting the function button

- It sets whether to use a total of 4 function buttons, and their operation elements.
- It sets operation elements of each function button so that the operator can perform his/her desired function with the simple pressing of button on the front.

4) Setting the measurement on the main screen

- It sets whether to use a total of 10 measurement items, and measurement elements.
- Variable setting of items for displaying measurement can be set.
- If the user set measurement elements to be displayed on the main screen, they appear on the main screen in order.

5) Calibration of touch screen

- This is a menu to calibrate LCD touch screen, and calibrating the touch screen is in order of "Left_Top", "Right_Top", "Right_Bottom", "Left_Bottom", "Center", which is carried out, touching the center of the cross mark on the screen.

6) Board setting

- It sets the types on A and B of AI board connected to IM2.

7) Setting the PBCU system

- It can set the status and clock synchronization of PBCU.

8) PTP Setting

- For normal PTP synchronization, the following IM2 PTP settings must be compatible with PTP settings of devices connected to the starters.

9) HSR/PRP Setting

- Communication redundancy (HSR/PRP) can be set as follows. For normal operation, it must be set in the same way as devices connected to the same network.

7.2.4. Input/ Output Menu

1) Setting of contact input

- It sets the operation elements to be used for each contact point of input.
- Input contact can be set as many as the number of the mounted points, and the same operation elements cannot be set in duplicate.

2) Setting of contact output

- It sets the operation elements to be used for each contact point of output.
- Output contact can be set as many as the number of the mounted points, and the same operation elements can be set in duplicate.

※ Of elements to set the contact output in the table of the set value, some elements **must be assigned to contact B among DO points.**

3) Setting of whether to use GoCB

- In order to transmit IM2's information to GOOSE, the operator must set whether to use GOOSE control block as "Enable".
- The usable GOOSE control block is 'item in GOOSE control block' defined in the CID file for IEC 61850 communication, and can be activated in the menu to set whether to use it or not.
- Up to 15 GOOSE control blocks can be set.
- If the state of GOOSE control block is set to 'Enable', GOOSE information is transmitted to the corresponding GOOSE control block.

4) Setting of GoCB test mode

- It is set when transmitting IM2's information to GOOSE in the state of test mode.
- If the test mode for GOOSE control block is set to 'True', Test bit is set and transmitted at the time of transmitting GOOSE.
- The usable GOOSE control block is 'item in GOOSE control block' defined in the CID file for IEC 61850 communication, and can be activated in the menu to set the test mode.
- GOOSE control block is up to 20, and the test mode therefor can be set.
- Be sure not to change the test mode for GOOSE control block while IM2 is in operation.

5) Setting of LED output

- It sets monitoring elements to be applied to LED on the front of IM2 that displays a total of 32 operating status.
- It has information on color and type to be displayed on LED for each monitoring element, and information on LED setting can be checked at 'Display>Input/Output>LED Information'.

6) Setting of LED color

- It sets colors to be applied to LED on the front of IM2 that displays a total of 32 operating status.
- It has information on color and type to be displayed on LED for each monitoring element, and information on LED setting can be checked at 'Display>Input/Output>LED Information'.

7) Setting of LED type

- It sets types to be applied to LED on the front of IM2 that displays a total of 32 operating status.
- It has information on color and type to be displayed on LED for each monitoring element, and information on LED setting can be checked at 'Display>Input/Output>LED Information'.

8) Setting of debounce time

- With respect to the input contact, the debounce time for the input signal can be set for each input contact.

9) Setting the duration of control output

- When the output contact operates, the duration of contact output can be set for each contact output.
- If the output element is Pulse type, this duration is applied as the time when the output contact is maintained as 1.
- If the output element is Latch type, this duration is applied as the time when the output contact is maintained as 1 after the element is released.

10) Setting the type of contact output

- The set value can be set to Latch and Pulse, and its initial value is Latch.

11) Password setting

- If provide a function to set a password for each authority, such as setting, control and admin.
- Passwords are classified (setting, control, admin) in the same way as the classification of authority, and can be set after going through the procedures for verifying the password for the authority (a function that allows the user to change the password only if the password is the same when entering the existing password before changing the password).
- A password consists of four digits.
- When entering a password, numbers are not displayed, and the input value is displayed as '*'.
- If the user forgets the password after specifying it, the user should contact a manufacturer to set the password again after resetting the system.

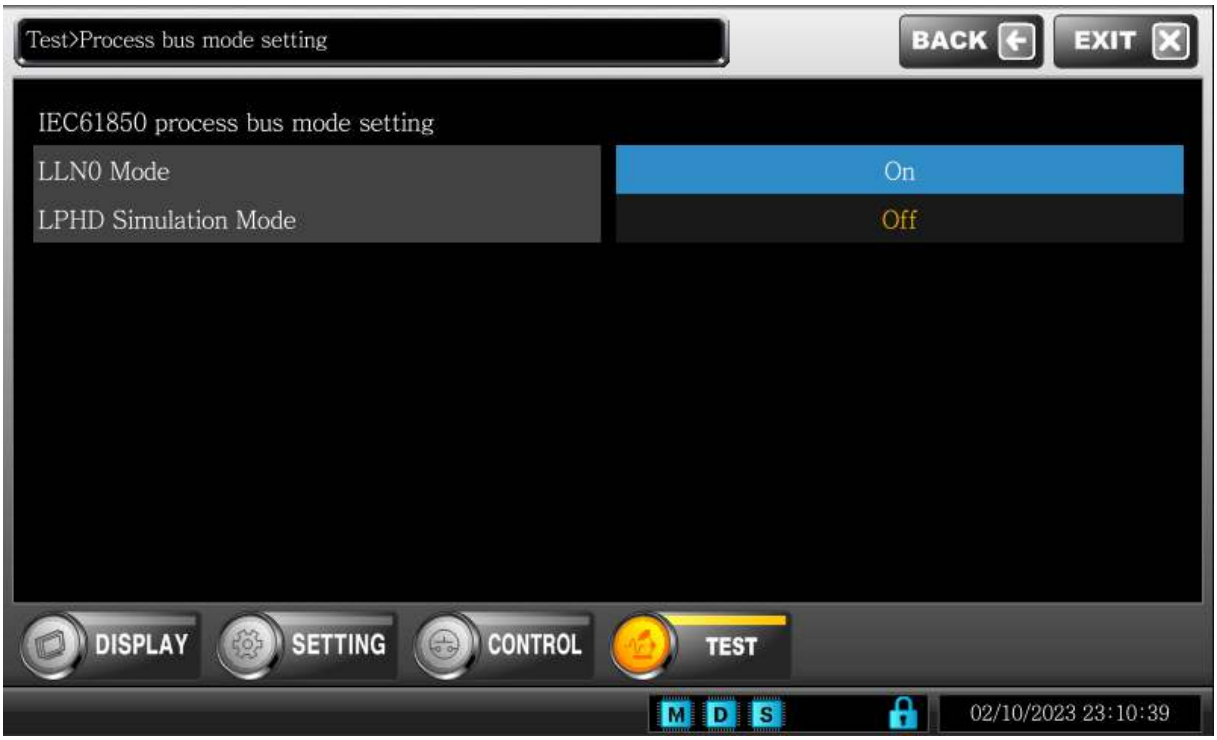
7.3. Test

7.3.1. Outline

- In order to enter the test tab, the user should set any tab (display, setting, control) on the main screen to enter, and can see it at the bottom. In the test tab, the user can change the mode of LLN0 and LPHD according to IEC 61850 standard for each Station/Process bus.



- The contents of Station bus and Process Bus are the same as below. When LPHD mode is turned on, the simulated measurement information is updated instead of the measurement values. GOOSE, SV and MMS Report are transmitted or stopped depending on LLN0 value.


Test>Process bus mode setting
BACK
EXIT
IEC61850 process bus mode setting
LLN0 Mode
On
LPHD Simulation Mode
Off
DISPLAY
SETTING
CONTROL
TEST
M D S
02/10/2023 23:10:39

8. Installation

8.1. Overview

IM2 must be shipped, stored and installed carefully. Be sure to select an installation place where can easily connect to the communication and access the HMI on the front of IM2. Be sure to check whether the external wiring is properly connected and correctly disconnected to IM2, and pay special attention to grounding. Strictly observe the applicable guidelines contained in this Section.

8.2. Safety Guideline

Hardware of IM2 can be replaced only by the trained personnel. Always comply with the basic preventive measures to avoid damage caused by electrostatic discharge when handling IM2.

In some cases, the settings must be changed and applied as required by the engineering configuration after replacement. Therefore, the responsible personnel must be familiar with the setting of device.

8.3. Installation position and ambient conditions

IM2 must not be exposed to excessive air pollution (dust, toxic substances). In addition, be sure to avoid severe vibration, extreme temperature change, high humidity, high amplitudes and short rise time, and strong induced magnetic fields as much as possible. Excessively high temperature may materially reduce the operating life of IM2.

8.4. Conditions of cable connection

Cables of 20M or shorter must be used to obtain the precision provided by IM2. Precision is not guaranteed for cables longer than 20M.

9. Maintenance

9.1. Overview

IM2 provides alarms and events for problems occurred during filed operation, and describes countermeasures for the alarms.

If you make an mistake in settings and IM2 fails to function correctly, we will demonstrate how to restore your settings.

Once you are satisfied with the modifications you have made to the settings and IM2 is functioning correctly, I will demonstrate how to back up those settings.

9.2. Countermeasures taken when ARM LED is turned on

The situations in which ARM LED is turned on are described in the table below, and the countermeasures can be taken as follows. In addition, a temporary network failure may be the main cause, so it may be necessary to power off/on or reset the network switch device connected to IM2.

Alarm Information	Alarm details	Troubleshooting
PTP master clock synchronization fail	PTP Fail : 1. The PTP master is not on the network. 2. Network DELAY MECHANISM is not identical to each other.	This is an alarm that occurs when the Grand Master device and PTP are not synchronized. Be sure to check whether the status and setting information of the network and the Grand Master match the device.
HSR/PRP switch Port N link down	Sampled value transport Network N port link down.	This is an alarm that occurs when a redundant port link is down. Be sure to check the status of network.
IEC61850 port link down	Communication Port all link down.	This is an alarm that occurs when all links of the redundant ports are down. Be sure to check the network status, the speed of SFP (optical module) and whether HSR/PRP matches the mode of network configuration.

Alarm Information	Alarm details	Troubleshooting
Internal power abnormality occur	Internal power anomaly detection	This is an event that occurs when the internal circuit is abnormal. Be sure to contact the maker after checking.
ADC(N) power abnormality occur	ADC(N) reference power anomaly detection	This is an event that occurs when the internal circuit is abnormal. Be sure to contact the maker after checking.
ADC(N) status abnormality occur	ADC(N) channel status anomaly detection	This is an abnormality in internal circuit or problems with ADC. Be sure contact the maker.
External Power abnormality occur	External input power anomaly detection	This is an alarm caused by an abnormality in external power. Be sure to check the external power and contact the maker.
PPS Input abnormality occur	No 1PPS input	Be sure to check the PPS Input entered from the outside and whether a rising edge occurs every second using an oscilloscope, etc.
DPLL Synchronization Fail	Detects when the external global sync signal and internal PLL signal are out of sync.	This is an alarm that occurs when there is no input of PTP or PPS from the outside. Be sure to contact the maker. If an external global synchronizer exist, it is an internal logic problem.

<Information, type and explanation on alarm>

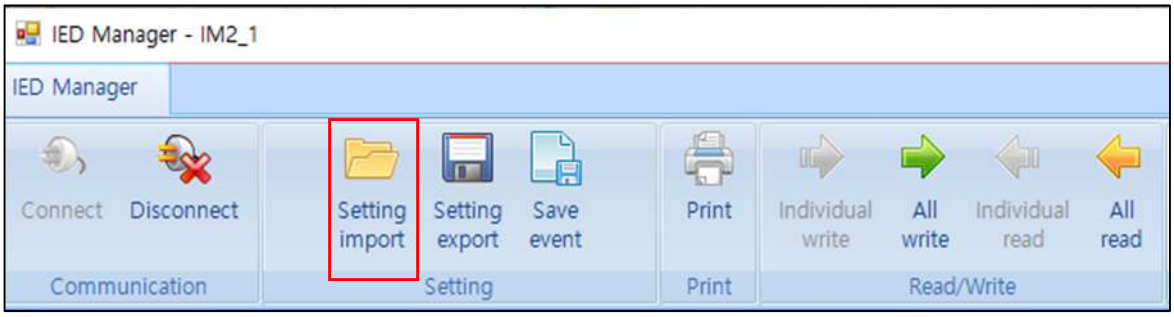
9.3. Countermeasures taken when COMM LED is turned off

Lights-out of COMM LED occurs when all links of redundancy (HSR/PRP) are down, so it is required to check the status of communication. Be sure to check whether the network status, the speed of SFP (optical module) matches the speed of network configuration, as well as whether the speed of HSR/PRP port is set to the same speed as the SFP, or whether the mode of network configuration is the same as the device setting.

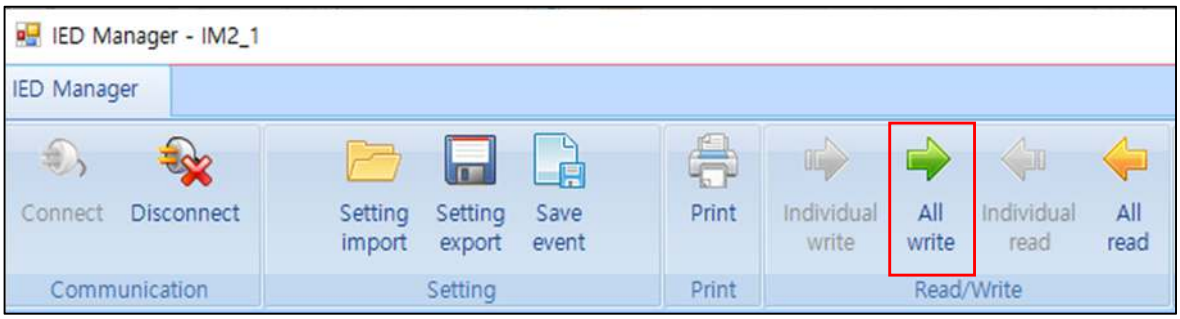
- If the network configuration is HSR, the device setting is also HSR, and if the network configuration is PRP, the device setting is also PRP.
- If the network configuration is 100Mbit/s, the speeds of SFP and Redundancy Port are also set to 100Mbit/s.

9.4. Recovery / Restore

If the IM2 is in operation and user change the settings incorrectly, causing the IM2 to behave abnormally, you can recover the IM2 to its previous settings or to the settings it had when it was shipped. (When restoring to the settings provided at delivery, any settings that have changed since delivery will need to be re-set by the user.)



Launch Wired-X and connect the IM2. Click the "Setting import" button to select a working setting file or the setting file provided at delivery, and the settings from the file will be loaded into Wired-X. (If the loaded Wired-X settings differ from the current Wired-X settings, they will be highlighted in red.)

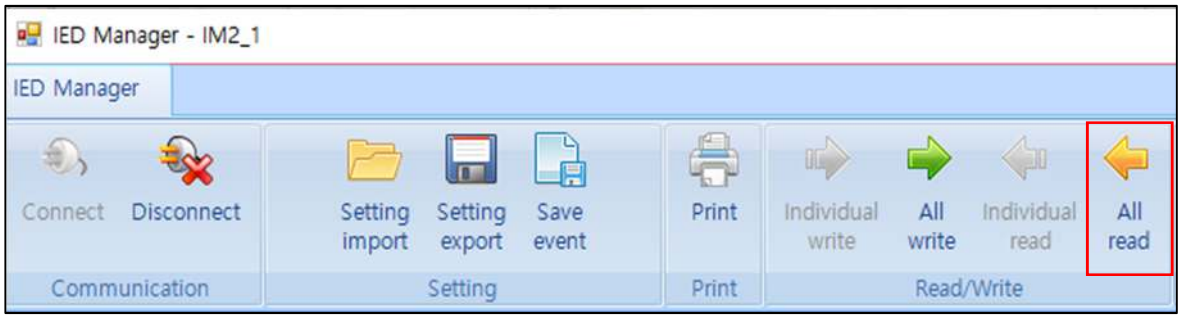


Then, press the "All write" button to download the settings from the Wired-X to the IM2, and complete the recovery process.

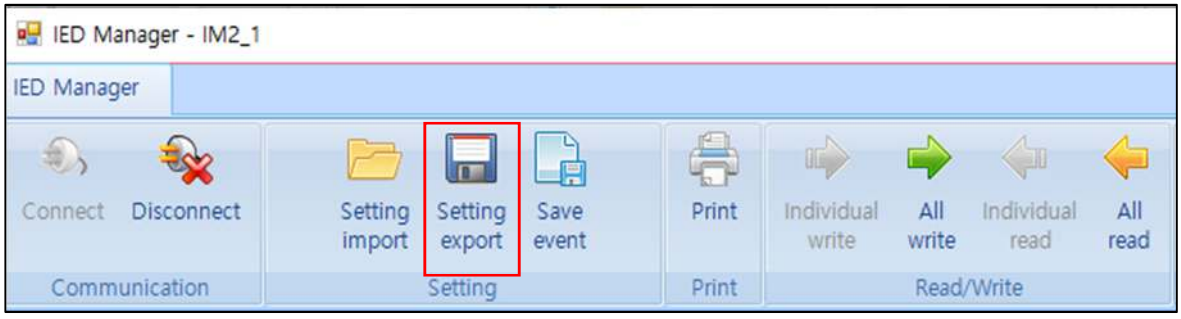
9.5. Backup

You'll often change settings while running IM2. Once you have verified that IM2 is working properly with the settings you have changed, it is recommended that you back up those settings.

Firstly press the "All read" button to upload the settings from the IM2 to the Wired-X.



After pressing the "export settings" button, you will be prompted for the name and path of the file to be saved. Specify the name and path and Wired-X's settings will be saved as a file.



10. Appendix

10.1. Abbreviation

Abbreviation	Explanation
AI	Analog Input
AT	Analog Terminal
BFI	Break Failure Initiation
BRCB	Buffered Report Control Block
CB	Circuit Breaker
CB	Control Block
CBO	Check Before Operating
CID	Configured IED Description
COS	Change Of Status
CPT-AI	Current/Potential Transformer – Analog Input
CPU	Central Processing Unit
CT	Current Transformer
DI	Digital Input
IM2	Intelligent Merging Unit 2
DO	Digital Output
DPRAM	Dual-Port Random Access Memory
DS	Disconnecting Switch
DPC	Controllable Double Point
DSP	Digital Signal Processor
DT	Digital Terminal
EEPROM	Electrically Erasable Programmable Read-Only Memory
ES	Earth Switch
FA	Frame Address
FB	Function Block
FG	Frame Ground
FPGA	Field Programmable Gate Array
FT	Frame Time
FTP	File Transfer Protocol
GCB	GOOSE Control Block
GOOSE	Generic Object Oriented Substation Event
HMI	Human Machine Interface
HOC	High-set Over Current
HPI	Host-Port Interface
ICD	IED Capability Description
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device

LCD	Liquid Crystal Display
LD	Logical Device
LED	Light Emitting Diode
LN	Logical Node
MMS	Manufacturing Message Specification
MPU	Micro Processor Unit
PC	Personal Computer
RCB	Report Control Block
REF	Restricted Earth Fault
RTC	Real Time Clock
SBO	Select Before Operating
SCADA	Supervisory Control And Data Acquisition
SCD	Substation Configuration Description
SCL	Substation Configuration Language
SDRAM	Synchronous Dynamic Random Access Memory
SLD	Single Line Diagram
SMPS	Switching-Mode Power Supply
SMPU	Signal Main Processor Unit
SNTP	Simple Network Time Protocol
SPC	Controllable Single Point
SOE	Sequence Of Events
STB	STation Bus
URCB	Unbuffered Report Control Block
UTC	Universal Time Coordinated

10.2. Tables & Lists

- Time setting

Item	Unit	Min.	Max.	Step	Initial value
Year	-	2000	2099	1	-
Month	-	1	12	1	-
Day	-	1	31	1	-
Hour	-	0	23	1	-
Minute	-	0	59	1	-
Second	-	0	59	1	-

- General settings

Item	Unit	Min.	Max.	Step	Initial value
Date	-	-	-	-	-
Time	-	-	-	-	-
Offset hour of local time	hour	-24	24	1	9
Offset minute of local time	min	0	59	1	0
Setting of access to Wired-X	-	Front TCP	Rear RS232C	-	Rear TCP
Display of single line diagram	-	IEC symbol	LED symbol	-	LED symbol
LED position for opening the single line diagram	-	Left	Right	-	Left
Waiting time for control result	Sec	1	60	1	5
Display of device name on the single line diagram	-	Not displayed	displayed	-	Displayed
Language setting/ Language	-	Korean	English	-	Korean
LCD backlight time	Sec	0	3600	1	60
Display of measurement phase	-	Negative angle	Positive angle	-	Negative angle

- Ethernet Console Port

Item	Unit	Min.	Max.	Step	Initial value
IP Address	-	0.0.0.0	255.255.255.255	1	0.0.0.0
Subnet mask	-	0.0.0.0	255.255.255.255	1	255.255.255.0
Default gateway	-	0.0.0.0	255.255.255.255	1	0.0.0.0

- Setting of function button

Index	Element	Default setting
0	unused	
1	Version information	

2	Information on general settings	
3	Information on network settings	
4	Information on function button settings	
5	Information on measurement settings on the main screen	
6	Board information	
7	Contact information	F4
8	Information on input of contact	
9	Information on output of contact	
10	GOOSE information	
11	GOOSE subscriber	
12	GOOSE publisher	
13	GOOSE control block	
14	LED information	
15	Information on debouncing time	
16	Information on duration of control output	
17	Information on the type of contact output	
18	Information on logic element	F3
19	Information on dimension of machine	
20	Information on element for saving fault record	
21	Information on the set groups	
22	Status of IED operation	
23	Status of IED alarm	
24	Status of counter	
25	Measurement information	
26	Voltage: 1~3 Set	
27	Current: 1~3 Set	
28	Current: 4~5 Set	
29	Comprehensive information	F2
30	Information on measurement of users 1	
31	Information on measurement of users 2	
32	Transducer information	
33	RTD information	
34	Information on measurement inside IED	
35	Electrical energy	
36	Alarm event	
37	Monitoring event	
38	Contact input event	
39	Control event	
40	Communication event	
41	Fault event	F1
42	Setting event	
43	General settings	
44	Network setting	
45	Function button setting	
46	Measurement setting of main screen	
47	Correction of touch screen	

48	Board setting	
49	Contact setting	
50	Contact input setting	
51	Contact output setting	
52	GOOSE setting	
53	Setting the use of GoCB	
54	Setting the test mode of GoCB	
55	LED setting	
56	LED output setting	
57	LED color setting	
58	LED type setting	
59	Debounce time setting	
60	Setting the duration of control output	
61	Setting the type of contact output	
62	Logic element setting	
63	Setting the dimension of facility	
64	Fault record setting	
65	Setting the change in the set group	
66	Group 1 setting	
67	Group 2 setting	
68	Group 3 setting	
69	Group 4 setting	
70	Transducer setting	
71	RTD setting	
72	Measurement element setting	
73	Setting the calculation of power	
74	User measurement setting	
75	Password setting	
76	Device control (dedicated to single line diagram)	
77	Control of other facilities	

- Board setting

Item	Unit	Min.	Max.	Step	Initial value
AI board A	-	Disconnect	8PT/8CT	-	Disconnect
AI board B	-	Disconnect	8PT/8CT	-	Disconnect

- PTP setting

Index	Element	Default setting
0	Delay Mechanism	Auto/E2E/P2P
1	Network Transport	UDS/UDP IPv4/UDP IPv6/IEEE 802.3/DEVICENET/CONTROLNET/PROFINET
2	Timestamping	Software/Hardware/Legacy H/W/One Step/P2P 1

		Step
3	Slave Only	Enable/Disable
4	Priority 1	0~255
5	Priority 2	0~255
6	Domain Number	Default/ALTERNATE 1,2,3
7	Clock Class	0~255
8	Clock Accuracy	Unknown Accuracy/Within 25ns ~ >10s
9	Announce message period	(1 msg every 1/2/4/8 sec) / (2/4/8/16/32/64 msg every sec)
10	Sync. Message period	(1 msg every 1/2/4/8 sec) / (2/4/8/16/32/64 msg every sec)
11	Delay request message period	(1 msg every 1/2/4/8 sec) / (2/4/8/16/32/64 msg every sec)
12	PDelay request message period	(1 msg every 1/2/4/8 sec) / (2/4/8/16/32/64 msg every sec)
13	Announce receipt timeout	2~255
14	Sync Receipt timeout	0~255
15	Delay asymmetry	-2^{31}~2^{31}
16	Egress latency	-2^{31}~2^{31}
17	Ingress latency	-2^{31}~2^{31}

- HSR/PRP setting

Index	Element	Possible selection
0	Redundancy Mode	HSR/PRP
1	HSR Work Mode	Mode H/N/T/U
2	PRP Work Mode	Duplicate Discard/Duplicate Accept
3	HSR Ring Interface	HSR-SAN/HSR-HSR/HSR-PRP
4	Redundancy A Port Speed	100/1000
5	Redundancy B Port Speed	100/1000
6	Redundancy Mode	HSR/PRP

- Setting the use of GoCB

Item	Unit	Min.	Max.	Step	Initial value
GOOSE control block 1 ~ 20	-	unused	used	-	unused

- Setting the test mode of GoCB

Item	Unit	Min.	Max.	Step	Initial value
GOOSE control block 1 ~ 20	-	False	True	-	False

- Setting list of color and type for each LED monitoring element

Item	Unit	Min.	Max.	Step	Initial value
Color	-	Red	Yellow	-	See the list
Type	-	Pulse	Latch	-	See the list

- Debounce time setting

Item	Unit	Min.	Max.	Step	Initial value
1~54	ms	1	255	1	1

- Setting the duration of control output

Item	Unit	Min.	Max.	Step	Initial value
)O 1~2	ms	0	10000	1	0
)O 3~16	ms	0	10000	1	0
)O 17~18	ms	0	10000	1	0
)O 19~21	ms	0	10000	1	0
)O 22~28	ms	0	10000	1	0

- Information on the dimension of IM2

setting Item	Unit	Min.	Max.	Step	Initial value
Reference capacity	MVA	10	10000	1	60
Line voltage	kV	1	2000	1	154
1st rated current of CT	A	1	50000	1	1200
2nd rated current of CT	A	1	500	1	5
1st rated line voltage of PT	V	1000	60000	1	22900
2nd rated line voltage of PT	V	1	1000	1	110

- Change in group setting

setting Item	Unit	Min.	Max.	Step	Initial value
Current group	-	Group 1	Group 4	-	Group 1

- Setting the saving element of fault record

setting Item	Unit	Min.	Max.	Step	Initial value
Used or not	-	unused	used	-	unused
Mode to save fault waveform	-	Trip	Pickup & Trip	-	Trip
Sampling of fault waveform	Sample	1/4	1	-	1
Saved length of waveform before pickup occurs	msec	1	10000	1	200
Saved length of waveform after pickup occurs	msec	1	10000	1	800
Saved length of waveform before trip occurs	msec	1	10000	1	200
Saved length of waveform after trip occurs	msec	1	10000	1	800

*The maximum saved length of fault record is 10000ms.

- Password setting

Item	Unit	Min.	Max.	Step	Initial value
Setting authority	-	0	9999	1	0
Control authority	-	0	9999	1	0
Admin authority	-	0	9999	1	0

- Alarm event

Index	Type	Data
1	Occurrence of fault trip	Information on fault
2	Pickup Occurrence of fault pickup	Information on the relevant Pickup COMTRADE
3	Occurrence of alarm elements of locking the operation	DSP memory is abnormal
		DSP setting value is abnormal
		Initial setting value of DSP is not received
		Measurement circuit is abnormal
		ADC is abnormal
		External power is abnormal
		Internal power is abnormal
4	Release of alarm elements of locking the operation	DSP memory is abnormal
		DSP setting value is abnormal
		Measurement circuit is abnormal
		ADC is abnormal
		External power is abnormal
		Internal power is abnormal
5	Occurrence of alarm elements of not locking the operation	DI circuit is abnormal
		DO circuit abnormal
		DO contact is abnormal

		MPU event information is abnormal
		MPU setting value is abnormal
		IEC 61850 communication is abnormal ※ when applying the relevant function
		MPU processor is abnormal
		DSP processor is abnormal
		SMO processor is abnormal
		STB processor is abnormal
6	Release of alarm elements of not locking the operation	DI circuit is abnormal
		DO circuit is abnormal
		DO contact is abnormal
		MPU event information is abnormal
		MPU setting value is abnormal
		IEC 61850 communication is abnormal ※ when applying the relevant function
		MPU processor is abnormal
		DSP processor is abnormal
		SMO processor is abnormal
		STB processor is abnormal

- Monitoring events

Index	Item to be displayed	Status
1	Occurrence of abnormality in measurement circuit	-
2	Recovery of abnormality in measurement circuit	-
3	Occurrence of abnormality in ADC Ref 2.5V	ADC number
4	Recovery of abnormality in ADC Ref 2.5V	ADC number
5	Occurrence of abnormality in ADC Ref voltage	5V
6	Recovery of abnormality in ADC Ref voltage	5V
7	Occurrence of abnormality in ADC Factor	Gain, Offset, Phase
8	Recovery of abnormality in ADC Factor	Gain, Offset, Phase
9	Occurrence of abnormality in Logic Solver	-
10	Recovery of abnormality in Logic Solver	-
11	Occurrence of abnormality in Logic Data	-
12	Recovery of abnormality in Logic Data	-
13	Occurrence of monitoring text event	
14	Occurrence of abnormality in Processor	MPU, DSP, SMO, STB
15	Recovery of abnormality in Processor	MPU, DSP, SMO, STB
16	Occurrence of abnormality in Mem IF	MPU, DSP, SMO, STB

17	Recovery of abnormality in Mem IF	MPU, DSP, SMO, STB
18	Occurrence of abnormality in Task	IO, MAIN, CRM, HMI
19	Recovery of abnormality in Task	IO, MAIN, CRM, HMI
20	Occurrence of abnormality in the range of setting value	-
21	Recovery of abnormality in the range of setting value	-
22	Occurrence of abnormality in setting value of CRC	RAM, original data, backup, initialization
23	Recovery of abnormality in setting value of CRC	-
24	Occurrence of abnormality in initial event of CRC	-
25	Occurrence of abnormality in the initial COMTRADE CRC	CFG, DAT, HDR
26	Occurrence of abnormality in the initial setting value	original data, backup, initialization
27	Recovery of abnormality in the initial setting value	-
28	Rebooting of DSP Core	-
29	Occurrence of abnormality in IO board	-
30	Recovery of abnormality in IO board	-
31	IED Power off	-
32	IED Power on	-
33	Update of IO board	
34	Change in IO board CAN ID	
35	Occurrence of abnormality in setting value of IO board	-
36	Recovery of abnormality in setting value of IO board	-
37	Rebooting of IO board	-
38	Occurrence of abnormality in external power	Over 140V, below 90V ※ *Configurable when ordering*
39	Termination of abnormality in external power	
40	Occurrence of abnormality in IO board I2C	
41	Termination of abnormality in IO board I2C	
42	Successful update of IO board	
43	Failed update of IO board	
44	Failure in updating IO board	
45	Occurrence of DI Lock	DI number
46	Release of DI Lock	DI number
47	Occurrence of abnormality in DO Select	DO number

48	Release of abnormality in DO Select	DO number
49	Occurrence of abnormality in DO Operate	DO number
50	Recovery of abnormality in DO Operate	DO number
51	Occurrence of abnormality in DO TCS	-
52	Recovery of abnormality in DO TCS	-
53	Occurrence of abnormality in DO contact	DO number
54	Recovery of abnormality in DO contact	DO number
55	Occurrence of abnormality in DO circuit	DO number
56	Recovery of abnormality in DO circuit	DO number
57	Occurrence of abnormality in trip coil of IO board	-
58	Recovery of abnormality in trip coil of IO board	-
59	Occurrence of abnormality in ADC interrupt	
60	Termination of abnormality in ADC interrupt	

- User event

• The elements recorded as fault events are variable, and may be selected and used out of the input and output elements. The followings show the event items set to the transformer properly as examples.

Element	Value		Element	Value
Pickup	Occurrence / -			
Trip	Occurrence / -			
Fault in A phase	Occurrence / -			
Fault in B phase	Occurrence / -			
Fault in C phase	Occurrence / -			
Fault in N phase	Occurrence / -			

SIEMENS

SIPROTEC 5

Transformer Differential Protection

7UT82, 7UT85, 7UT86, 7UT87

V9.70 and higher

Manual

Preface

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Appendix A

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C53000-G5040-C016-M

NOTE

For your own safety, observe the warnings and safety instructions contained in this document, if available.

Disclaimer of Liability

Subject to changes and errors. The information given in this document only contains general descriptions and/or performance features which may not always specifically reflect those described, or which may undergo modification in the course of further development of the products. The requested performance features are binding only when they are expressly agreed upon in the concluded contract.

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Preface

Purpose of the Manual

This manual describes the functions for transformer protection.

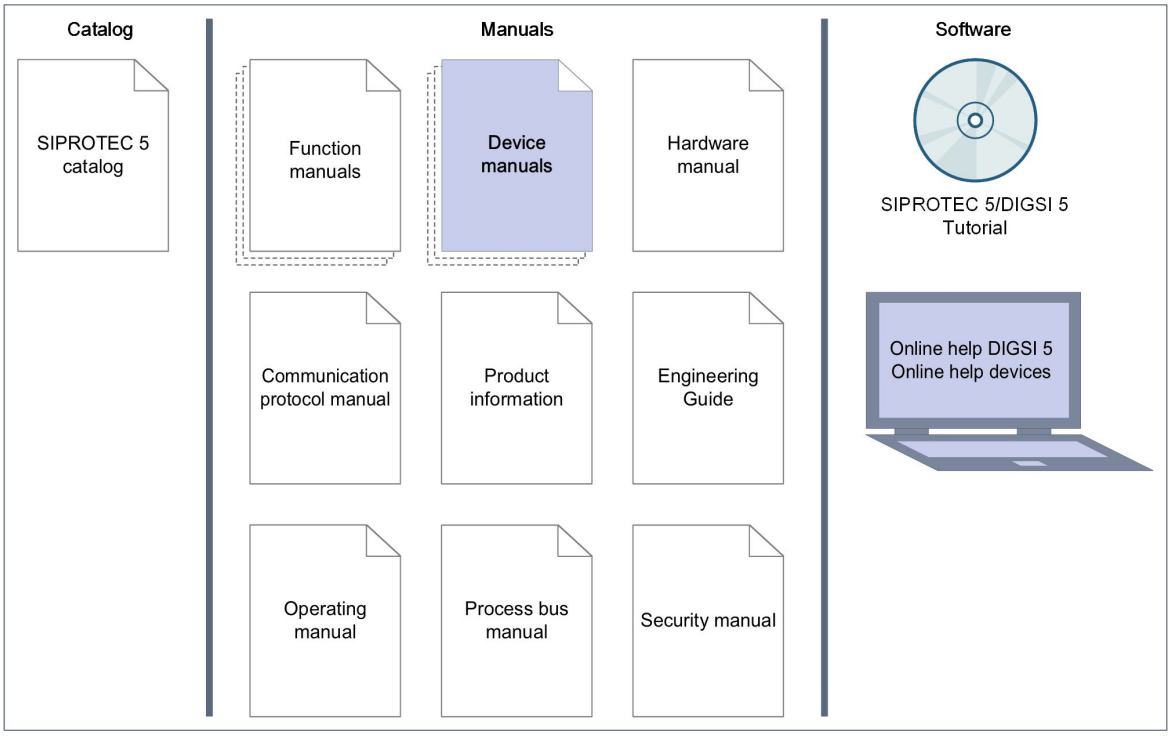
Target Audience

Protection system engineers, commissioning engineers, persons entrusted with the setting, testing and maintenance of automation, selective protection and control equipment, and operational crew in electrical installations and power plants.

Scope

This manual applies to the SIPROTEC 5 device family.

Further Documentation



[dw_product-overview_SIP5_device-manual, 5, en_US]

- Device manuals
  Each Device manual describes the functions and applications of a specific SIPROTEC 5 device. The printed manual and the online help for the device have the same informational structure.
- Hardware manual
  The Hardware manual describes the hardware building blocks and device combinations of the SIPROTEC 5 device family.

- Operating manual

  The Operating manual describes the basic principles and procedures for operating and assembling the devices of the SIPROTEC 5 range.

- Communication protocol manual

  The Communication protocol manual contains a description of the protocols for communication within the SIPROTEC 5 device family and to higher-level network control centers.

- Security manual

  The Security manual describes the security features of the SIPROTEC 5 devices and DIGSI 5.

- Process bus manual

  The process bus manual describes the functions and applications specific for process bus in SIPROTEC 5.

- Product information

  The Product information includes general information about device installation, technical data, limiting values for input and output modules, and conditions when preparing for operation. This document is provided with each SIPROTEC 5 device.

- Engineering Guide

  The Engineering Guide describes the essential steps when engineering with DIGSI 5. In addition, the Engineering Guide shows you how to load a planned configuration to a SIPROTEC 5 device and update the functionality of the SIPROTEC 5 device.

- DIGSI 5 online help

  The DIGSI 5 online help contains a help package for DIGSI 5 and CFC.

  The help package for DIGSI 5 includes a description of the basic operation of software, the DIGSI principles and editors. The help package for CFC includes an introduction to CFC programming, basic examples of working with CFC, and a reference chapter with all the CFC blocks available for the SIPROTEC 5 range.

- SIPROTEC 5/DIGSI 5 Tutorial

  The tutorial on the DVD contains brief information about important product features, more detailed information about the individual technical areas, as well as operating sequences with tasks based on practical operation and a brief explanation.

- SIPROTEC 5 catalog

  The SIPROTEC 5 catalog describes the system features and the devices of SIPROTEC 5.

Indication of Conformity

CE

This product complies with the directive of the Council of the European Communities on harmonization of the laws of the Member States concerning electromagnetic compatibility (EMC Directive 2014/30/EU), restriction on usage of hazardous substances in electrical and electronic equipment (RoHS Directive 2011/65/EU), and electrical equipment for use within specified voltage limits (Low Voltage Directive 2014/35/EU).

This conformity has been proved by tests performed according to the Council Directive in accordance with the product standard EN 60255-26 (for EMC directive), the standard EN IEC 63000 (for RoHS directive), and with the product standard EN 60255-27 (for Low Voltage Directive) by Siemens.

The device is designed and manufactured for application in an industrial environment.

The product conforms with the international standards of IEC 60255 and the German standard VDE 0435.

Standards

IEEE Std C 37.90

The technical data of the product is approved in accordance with UL.

For more information about the UL database, see *ul.com*

You can find the product with the **UL File Number E194016**.



IND. CONT. EQ.
69CA

Additional Support

For questions about the system, contact your Siemens sales partner.

Customer Support Center

Our Customer Support Center provides a 24-hour service.

Siemens Electrification & Automation
Global Support
Single entry point
Phone: +49 9131 1743072
E-mail: *support.ea.si@siemens.com*

Training Courses

Inquiries regarding individual training courses should be addressed to our Training Center:

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Siemens Power Academy TD
Humboldtstraße 59
90459 Nuremberg
Germany

Phone: +49 911 9582 7100
E-mail: *poweracademy@siemens.com*
Internet: *www.siemens.com/poweracademy*

Notes on Safety

This document is not a complete index of all safety measures required for operation of the equipment (module or device). However, it comprises important information that must be followed for personal safety, as well as to avoid material damage. Information is highlighted and illustrated as follows according to the degree of danger:



DANGER

DANGER means that death or severe injury **will** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid death or severe injuries.



WARNING

WARNING means that death or severe injury **may** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid death or severe injuries.



CAUTION

CAUTION means that medium-severe or slight injuries **can** occur if the specified measures are not taken.

✧ Comply with all instructions, in order to avoid moderate or minor injuries.

NOTICE

NOTICE means that property damage **can** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid property damage.

NOTE

Important information about the product, product handling or a certain section of the documentation which must be given attention.

Qualified Electrical Engineering Personnel

Only qualified electrical engineering personnel may commission and operate the equipment (module, device) described in this document. Qualified electrical engineering personnel in the sense of this document are people who can demonstrate technical qualifications as electrical technicians. These persons may commission, isolate, ground and label devices, systems and circuits according to the standards of safety engineering.

Proper Use

The equipment (device, module) may be used only for such applications as set out in the catalogs and the technical description, and only in combination with third-party equipment recommended and approved by Siemens.

Problem-free and safe operation of the product depends on the following:

- Proper transport
- Proper storage, setup and installation
- Proper operation and maintenance

When electrical equipment is operated, hazardous voltages are inevitably present in certain parts. If proper action is not taken, death, severe injury or property damage can result:

- The equipment must be grounded at the grounding terminal before any connections are made.
- All circuit components connected to the power supply may be subject to dangerous voltage.
- Hazardous voltages may be present in equipment even after the supply voltage has been disconnected (capacitors can still be charged).
- Operation of equipment with exposed current-transformer circuits is prohibited. Before disconnecting the equipment, ensure that the current-transformer circuits are short-circuited.
- The limiting values stated in the document must not be exceeded. This must also be considered during testing and commissioning.

Selection of Used Symbols on the Device

Nr.	Symbol	Beschreibung
1		Direct current, IEC 60417, 5031
2		Alternating current, IEC 60417, 5032
3		Direct and alternating current, IEC 60417, 5033
4		Earth (ground) terminal, IEC 60417, 5017
5		Protective conductor terminal, IEC 60417, 5019

Nr.	Symbol	Beschreibung
6		Caution, risk of electric shock
7		Caution, risk of danger, ISO 7000, 0434
8		Protective insulation, IEC 60417, 5172, safety class II devices
9		Guideline 2002/96/EC for electrical and electronic devices
10		Guideline for the Eurasian market
11		Mandatory conformity mark for electronics and electrotechnical products in Morocco
12		Extra low voltage (ELV), IEC 60417, 5180, Safety Class III devices

OpenSSL

This product includes software developed by the OpenSSL Project for use in OpenSSL Toolkit (*http://www.openssl.org/*).

This product includes software written by Tim Hudson (*tjh@cryptsoft.com*).

This product includes cryptographic software written by Eric Young (*eay@cryptsoft.com*).

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1 Introduction

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1.1 General

The digital multifunctional protection and bay controllers of the SIPROTEC 5 device series are fitted with a powerful microprocessor. As a result, all tasks, from acquiring measurands to entering commands in the circuit breaker, are processed digitally.

Analog Inputs

The measuring inputs transform the currents and voltages sent by the instrument transformers and adapt them to the internal processing level of the device. A SIPROTEC 5 device consists of inputs for measuring current and voltage. The current inputs are intended for the detection of phase currents and ground current. The ground current can be detected sensitively using a core balance current transformer. In addition, phase currents can be detected very sensitively for a particularly precise measurement. The voltage inputs detect the measuring voltage of device functions requiring voltage measured values.

The analog values are digitized in the microprocessor for data processing.

Microprocessor System

All device functions are processed in the microprocessor system.

This includes, for example:

- Filtering and preparation of the measurands
- Constant monitoring of the measurands
- Monitoring of the pickup conditions for the individual protection functions
- Querying of limiting values and time sequences
- Control of signals for logic functions
- Control of open and close commands
- Recording of indications, fault data, and fault values for fault analysis
- Administration of the operating system and its functions, for example data storage, real-time clock, communication, interfaces
- External distribution of information

Binary Inputs and Outputs

Using the binary inputs and outputs, the device receives information from the system or from other devices (such as locking commands). The most important outputs include the commands to the switching devices and the indications for remote signaling of important events and states.

Front Elements

For devices with an integrated or offset operation panel, LEDs and an LC display on the front provide information on the device function and report events, states, and measured values. In conjunction with the LC display, the integrated keypad enables on-site operation of the device. All device information such as setting parameters, operating and fault indications or measured values can be displayed, and setting parameters changed. In addition, system equipment can be controlled via the user interface of the device.

Serial Interfaces

The serial interface in the front panel enables communication with a personal computer when using the DIGSI operating program. As a result, the operation of all device functions is possible. Additional interfaces on the rear are used to implement various communication protocols.

Power Supply

The individual functional units of the device are powered by an internal power supply. Brief interruptions in the supply voltage, which can occur during short circuits in the system auxiliary voltage supply, are bridged by capacitor storage (see also the Technical Data).

1.2 Properties of SIPROTEC 5

The SIPROTEC 5devices at the bay level are compact and can be installed directly in medium and high-voltage switchgear. They are characterized by comprehensive integration of protection and control functions.

General Properties

- Powerful microprocessor
- Fully digital measured-value processing and control, from sampling and digitizing of measurands to closing and tripping decisions for the circuit breaker
- Complete galvanic and interference-free isolation of the internal processing circuits from the system measuring, control, and supply circuits through instrument transformers, binary input and output modules, and DC and AC voltage converters
- Easy operation using an integrated operator and display panel, or using a connected personal computer with user interface
- Continuous display of measured and metered values at the front
- Storage of min/max measured values (slave pointer function) and storage of long-term average values
- Storage of fault indications for system incidents (faults in system) with real-time assignment and instantaneous values for fault recording
- Continuous monitoring of the measurands as well as the device hardware and software
- Communication with central control and storage devices possible via the device interface
- Battery-buffered, synchronizable clock

Modular Concept

The SIPROTEC 5 modular concept ensures the consistency and integrity of all functionalities across the entire device series. Significant features here include:

- Modular system design in hardware, software, and communication
- Functional integration of various applications, such as protection, control, and fault recorder
- The same expansion and communication modules for all devices in the family
- Innovative terminal technology with easy assembly and interchangeability and the highest possible degree of safety
- The same functions can be configured individually across the entire family of devices
- Ability to upgrade with innovations possible at all times through libraries
- Open, scalable architecture for IT integration and new functions
- Multi-layered security mechanisms in all links of the security chain
- Self-monitoring routines for reliable localization and indication of device faults
- Automatic logging of access attempts and security-critical operations on the devices and systems

Redundant Communication

SIPROTEC 5devices maintain full communication redundancy:

- Multiple redundant communication interfaces
- Redundant and independent protocols to control centers possible (such as IEC 60870-5-103 and IEC 61850, either single or redundant)
- Redundant time synchronization (such as IRIG B, SNTP or IEEE 1588).

1.3 Overview of Transformer Protection Devices

The protected object can be a power transformer in multi-winding design as well as an auto transformer. The main protection functions supplement the transformer differential protection by the restricted ground-fault protection. In addition more supplemental protection functions can be activated.

The protection device classification is oriented to the basic design of the protected object. The simplest design is a two-winding transformer with different vector group. The design can also be the simplest form of the auto transformer. After that comes the three-winding transformer with different vector-group design. The design can also be an auto transformer with stabilizing winding. The last groups are multi-winding transformers, which are often found with converter applications (for example high-voltage direct-current transmission).

An important differentiating characteristic of the devices is the ability to process the number of windings (in the following called transformer sides) and the number of measuring points. For the transformer sides, the 7UT8x offers greater flexibility. In this way, you can expand 7UT85 (two-winding transformer) to up to 3 transformer sides, and the 7UT86 (three-winding transformer) to up to 4 transformer sides using function points, if necessary. This allows greater flexibility for plant expansions or for spare parts stocking.

The following table gives you a rough overview of the 4 classes of the transformer differential protection devices.

Table 1-1 Classification of the Devices

7	UT		Essential Differentiating Characteristics
7	UT	82	Two-winding transformer (2 sides and maximum 2 measuring points)
7	UT	85	Two-winding transformer (3 sides of which 2 are free of charge and a maximum of 5 measuring points)
7	UT	86	Three-winding transformer (4 sides of which 3 are free of charge and a maximum of 7 measuring points)
7	UT	87	Multi-winding transformer (5 sides and maximum 20 measuring points)

With 7UT87, there is a special feature. Due to the maximum number of 5 sides, the simultaneous protection of 2 transformers (for example from 2 two-winding transformers) is possible through one device. More information on possibilities for use can be found in the device catalog or the application templates in chapter *4 Applications*.

Typical properties of the 4 device types are presented in the following table:

Table 1-2 Overview of the Available Measuring Points

Device	Measuring Points
7UT82	Two 1-phase current measuring points (1ph I) Two 3-phase current measuring points (3ph I)
7UT85	Five 3-phase current measuring points (3ph I) Five 1-phase current measuring points (1ph I) Five 3-phase voltage measuring points (3ph V) Five 1-phase voltage measuring points (1ph V)
7UT86	Seven 3-phase current measuring points (3ph I) Seven 1-phase current measuring points (1ph I) Seven 3-phase voltage measuring points (3ph V) Seven 1-phase voltage measuring points (1ph V)
7UT87	Twenty 3-phase current measuring points (3ph I) Twenty 1-phase current measuring points (1ph I) Twenty 3-phase voltage measuring points (3ph V) Twenty 1-phase voltage measuring points (1ph V)

Table 1-3 Properties – 7UT82

Short description	Differential protection for two-winding transformers for all voltage levels
Main protection function	1 differential protection function (standard transformer) with additional stabilization; up to 2 restricted ground-fault protection functions
Inputs and outputs	1 predefined standard variable with 8 current transformers, 7 binary inputs, 6 binary outputs
Width of housing	1/3 × 19 inches

Table 1-4 Properties – 7UT85

Short description	Differential protection for two-winding transformers for all voltage levels
Main protection function	1 differential protection function (standard or auto transformer) with additional stabilization; up to 2 restricted ground-fault protection functions
Inputs and outputs Hardware flexibility	2 predefined standard variants with 8 current transformers, 7 to 19 binary inputs, 7 to 23 binary outputs Flexible adaptable and expandable I/O quantity structure of the modular SIPROTEC 5 module
Width of housing	1/3 × 19 inches to 1/1 × 19 inches

Table 1-5 Properties – 7UT86

Short description	Differential protection for three-winding transformers for all voltage levels
Main protection function	1 differential protection function (standard) with additional stabilization; up to 3 restricted ground-fault protection functions. For auto transformer applications 2 differential protection functions can be processed in an auto transformer function group.
Inputs and outputs Hardware flexibility	2 predefined standard variants with 12 current transformers, 4 voltage transformers, 11 to 23 binary inputs, 19 to 34 binary outputs Flexible adaptable and expandable I/O quantity structure of the modular SIPROTEC 5 module
Width of housing	1/2 × 19 inches to 1/1 × 19 inches

Table 1-6 Properties – 7UT87

Short description	Differential protection for multi-winding transformers for all voltage levels
Main protection function	Up to 3 differential protection functions with additional stabilization (in different transformer function groups); up to 5 restricted ground-fault protection functions. For auto transformer applications 2 differential protection functions can be processed in an auto transformer function group.
Inputs and outputs Hardware flexibility	2 predefined standard variants with 20 current transformers, 4 voltage transformers, 15 to 27 binary inputs, 22 to 38 binary outputs Flexible adaptable and expandable I/O quantity structure of the modular SIPROTEC 5 module
Width of housing	2/3 × 19 inches to 1/1 × 19 inches

The important functional properties of the devices are:

- Transformer protection for two-winding, three-winding, and multi-winding transformers with versatile, additional protection functions
- Universal usability of the permissible measuring points
- Applicable from average up to extra-high voltage
- Protection from standard power transformers and auto transformers

- Typical properties of a transformer differential protection, such as flexible adaptation to the transformer vector group, command of closing and overexcitation processes, reliable behavior in current-transformer saturation with different degrees of saturation
- Increased sensitivity with near-neutral-point ground faults through a separate restricted ground-fault protection
- Voltage controller for the control and regulation of motor-operated tap changers
- Additional current and voltage inputs can be supplements for standard protection functions, such as overcurrent, voltage frequency, etc.
- In the standard design 2 communication modules are pluggable, as well as different logs are usable (IEC 61850, IEC 60870-5-103, DNP3 (serial+IP), Modbus RTU Slave)
- Performance automation with CFC (Continuous Function Chart)
- Secure serial protection data communication, also over great distances and all available physical media (optical fibers, two-wire connections and communication networks)
- Measurement of all relevant operating variables
- Powerful fault recording
- Consistent monitoring concept
- Auxiliary functions for simple tests and commissioning

2 Basic Structure of the Function

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2.1 Embedding of Functions in the Device

General

SIPROTEC 5 devices offer great flexibility in the handling of functions. Functions can be individually loaded into the device. Additionally, it is possible to copy functions within a device or between devices. The necessary integration of functions in the device is illustrated by the following example.



NOTE

The availability of certain settings and setting options depends on the device type and the functions available on the device!

EXAMPLE

A 1 1/2 circuit-breaker layout of the 7SA86 distance protection device serves as an example. The following protection functions are required for implementation (simplified and reduced):

- Distance protection (21)
- Overcurrent protection, phases (51)
- Circuit-breaker failure protection (50BF), for circuit breakers 1 and 2
- Basic functionality (for example handling of tripping)

Several predefined function packages that are tailored to specific applications exist for each device family. A predefined functional scope is called an **application template**. The existing application templates are offered for selection automatically when you create a new device in DIGSI 5.

EXAMPLE

When creating the device in DIGSI 5, you must select the appropriate application template. In the example, select the application template **DIS overhead line, grounded systems, 1 1/2 circuit-breaker layout**. This application template covers the required functional scope. Selecting this application template determines the preconfigured functional scope. This can be changed as necessary (see *2.2 Application Templates/Adaptation of Functional Scope*).

Function Groups (FG)

Functions are arranged in function groups. This simplifies handling of functions (adding and copying). The function groups are assigned to primary objects, such as a line, transformer, or circuit breaker.

The function groups bundle functions with regard to the following basic tasks:

- Assignment of functions to currentand/or voltage transformers (assignment of functions to the measuring points and thus to the protected object)
- Exchange of information between function groups

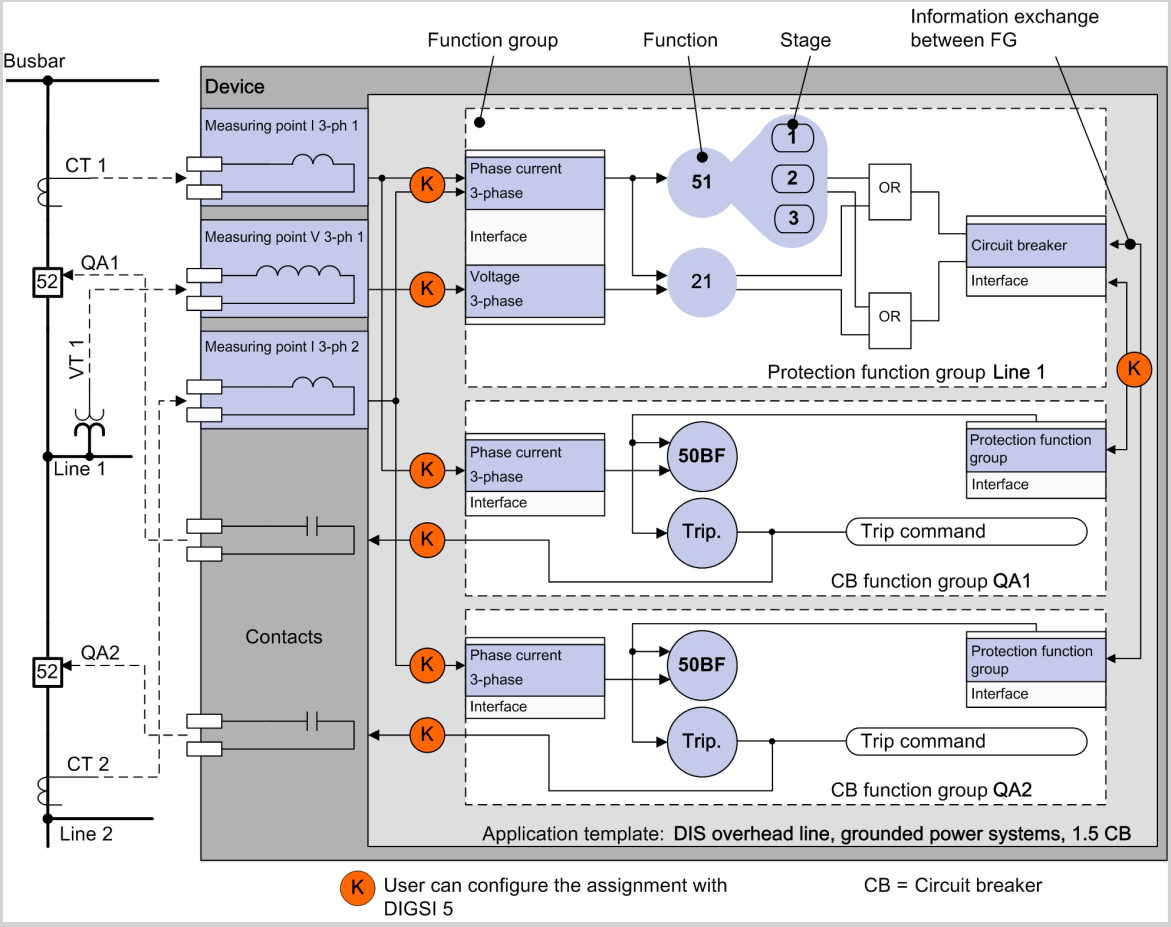
When a function is copied into a function group, it automatically works with the measuring points assigned to the function group. Their output signals are also automatically included in the configured interfaces of the function group.

EXAMPLE

The selected application template **DIS overhead line, grounded systems, 1 1/2 circuit-breaker layout** comprises 3 function groups:

- Protection function group **Line 1**
- Circuit-breaker function group **QA 1**
- Circuit-breaker function group **QA 2**

The following figure shows the embedding of functions via function groups.



[dw_eifkfg, 1, en_US]

Figure 2-1 Embedding the Functions via Function Groups

Depending on the type of device, there are different types of function groups:

- Protection function groups
- Circuit-breaker function groups

Protection function groups bundle functions that are assigned to one protected object – for example to the line. Depending on the device type and nature of the protected object, there are different types of protection function groups (for example line, voltage/current 3-phase, transformer, motor, generator).

Circuit-breaker function groups bundle functions assigned to the local switches – for example, circuit breakers and disconnectors (such as processing of tripping, circuit-breaker failure protection).

The number and type of function groups differ in the respective application templates, depending on the type of the device and application. You can add, copy, or even delete function groups for a specific application. You can also adapt the functional scope within a function group according to the use case. For detailed information on this, refer to the DIGSI 5 Online Help manual.

Interface Between Function Group and Measuring Point

The function groups receive the measurands of the current and voltage transformers from measuring points. For this, the function groups are connected to 1 or more measuring points.

The number of measuring points and the assignment of function groups to the measuring points are preset by the selected application template in accordance with the specific application. Therefore, this specifies which measuring point(s) and the corresponding measurands have to be used by which function within the function group.

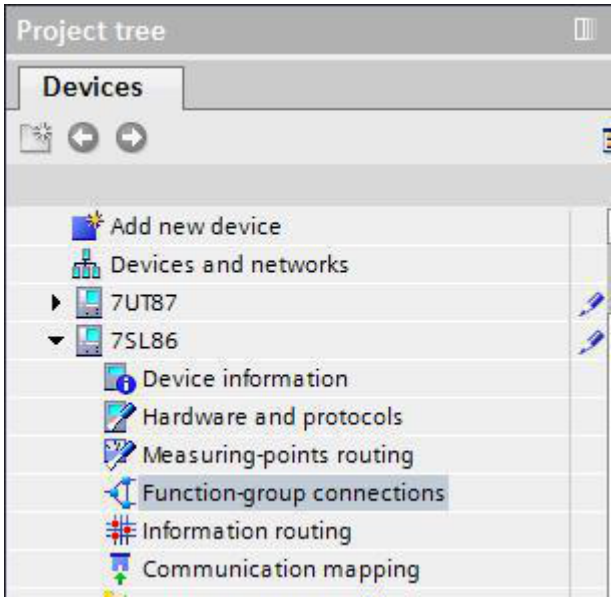
EXAMPLE

The measuring points are assigned to the function groups in the application template in *Figure 2-1* as follows:

- The protection function group **Line** is assigned to the measuring points **I-3ph 1**, **I-3ph 2**, and **V-3ph 1**. The function group therefore receives the measured values from the current transformers 1 and 2, as well as from the voltage transformer 1. The currents of measuring points **I-3ph 1** and **I-3ph 2** are geometrically added, for a feeder-related processing.
- The circuit-breaker function group **QA1** is assigned to the measuring point **I-3ph 1** and receives the measured values from current transformer 1.
- The circuit-breaker function group **QA2** is assigned to the measuring point **I-3ph 2** and receives the measured values from current transformer 2.

You can change the assignment on demand, that is, function groups can be assigned to any available measuring points of the device.

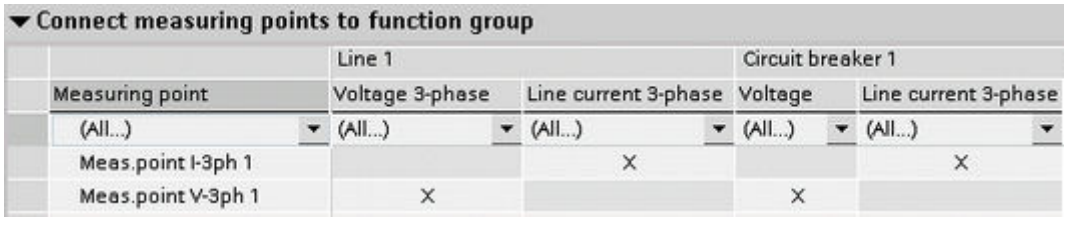
To check or change the assignment of measuring points to the function groups, double-click **Function-group connections** in the DIGSI 5 project tree.



[sc_fgverb, 1, en_US]

Figure 2-2 Project Tree in DIGSI 5 (Detail)

The window for routing of the measuring points opens in the working area (see the following figure, does not correspond to the example).



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Figure 2-3 Connecting Measuring Points and Function Groups

Interface Between Protection and Circuit-Breaker Function Groups

The protection function group(s) is/are connected to one or several circuit-breaker function groups. This connection generally determines:

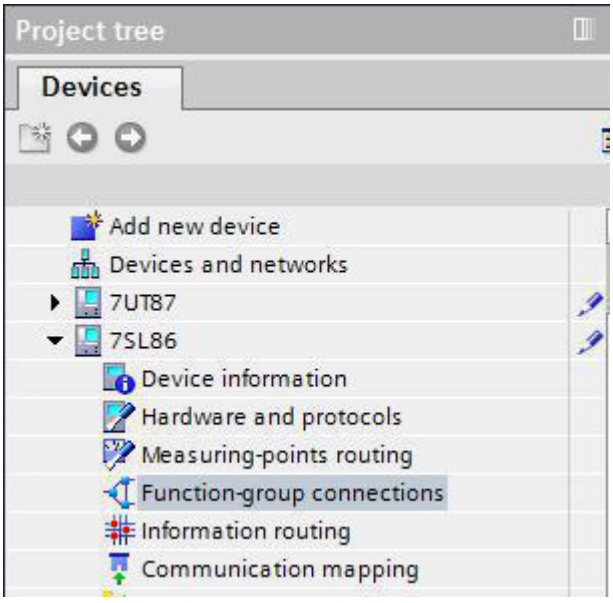
- Which circuit breaker(s) is/are started by the protection functions of the protection FG.
- Starting the **Circuit-breaker failure protection** function (if available in the Circuit-breaker function group) through the protection functions of the connected protection function group
- Starting the **Automatic reclosing** function (AREC, if available in the Circuit-breaker function group) through the protection functions of the connected protection function group

Besides the general assignment of the protection function group(s) to the circuit-breaker function groups, you can also configure the interface for specific functionalities in detail. Further information on this is included later. *Figure 2-6* shows how to reach the detail configuration. *Figure 2-7* shows the possible assignments in detail.

These definitions are also set appropriately for the specific application by the selected application template.

You can change this connection, if needed. That is, the protection function groups can be assigned to the circuit-breaker function groups as desired.

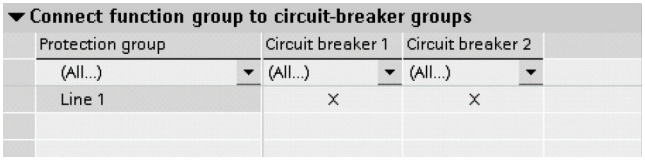
To check or change the assignment of the protection function groups to the Circuit-breaker function groups, double-click **Function group connections** in the DIGSI 5 project tree → **Name of device**.



[sc_fgverb, 1, en_US]

Figure 2-4 Project Tree in DIGSI 5 (Detail)

The window for general routing of the function groups opens in the working area.

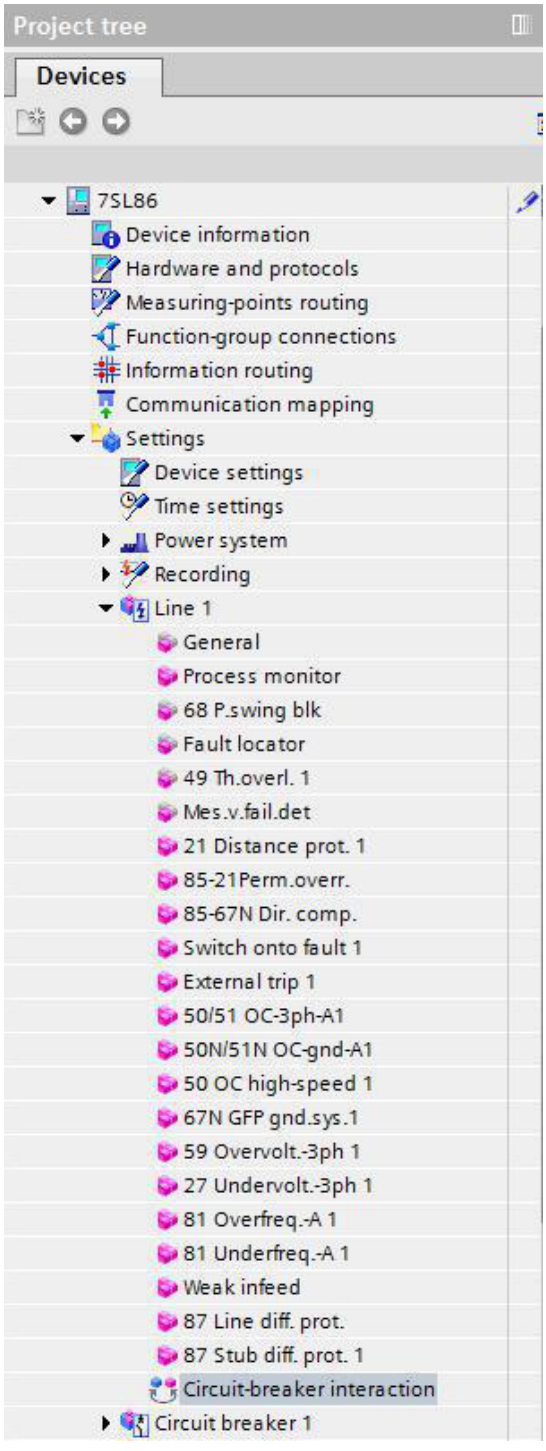


[scfgcols-220211-01.tif, 1, en_US]

Figure 2-5 Connection of Protection Function Group with Circuit-Breaker Function Group

Besides the general assignment of the protection function group(s) to the circuit-breaker function groups, you can also configure the interface for specific functionalities in detail. Proceed as follows:

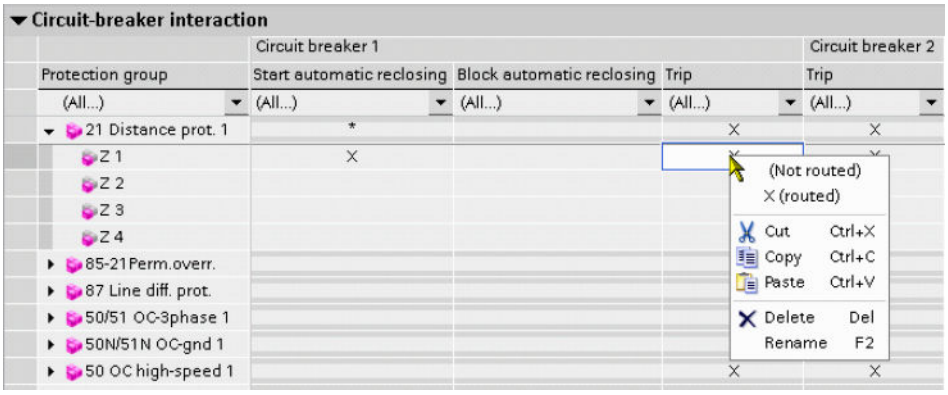
- Open the SIPROTEC 5 device folder in the DIGSI 5 project tree.
- Open the function settings folder in the DIGSI 5 project tree.
- Open the appropriate protection function group in the DIGSI 5 project tree, for example **Line 1**.



[sclsinta-190214-01, 1, en_US]

Figure 2-6 Project Tree in DIGSI 5 (Detail)

- Double-click **Circuit-breaker interaction** (see *Figure 2-6*).
- The window for the detailed configuration of the interface between the protection function group and the **Circuit-breaker** function group(s) opens in the working area.
- In this view, configure the interface via the context menu (right mouse button), see *Figure 2-7*.



[sc_detail, 1, en_US]

Figure 2-7 Detail Configuration of the Interface Between the Protection Function Group and the Circuit-Breaker Function Groups

In the detail configuration of the interface, you define:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the Automatic reclosing function
- Which protection functions block the Automatic reclosing function
- Which protection functions start the Circuit-breaker failure protection function

Functions (FN), Tripping Stages/Function Blocks (FB)

As already illustrated in *Figure 2-1*, functions are assigned to the protected objects or other primary objects via function groups.

Functions can be further subdivided. For example, protection functions often consist of multiple protection stages (for example, the Overcurrent-protection function). Other functions can contain one or more function blocks.

Each stage, each function block, and each function (without stages/function blocks) can be individually switched into specific operating modes (for example, switch on/off). This is termed function control and is explained in *2.3 Function Control*.

To adjust the functionality to the specific application, functions, stages, and function blocks can be added, copied, and deleted (see *2.2 Application Templates/Adaptation of Functional Scope*).

2.2 Application Templates/Adaptation of Functional Scope

Application Template

The application template defines the preconfigured functional scope of the device for a specific use case. A certain number of application templates is predefined for each device type. DIGSI 5 automatically offers the application templates for selection when a new device is installed. The available application templates with the respective functional scope are described in more detail in *4 Applications*.

The selection of the application template first predefines which function groups and functions are present in the device (see also *Figure 2-1* in *2.1 Embedding of Functions in the Device*).

You can adjust the functional scope to your specific application.

Adjusting the Functional Scope

Adjust the functional scope based on the selected application template. You can add, copy or delete functions, tripping stages, function blocks, or complete function groups.

In the DIGSI 5 project tree, this can be done via the following Editors:

- Single-line configuration
- Information routing
- Function settings

Siemens recommends the **Single-line configuration** Editor to adjust the functional scope.

Complete missing functionalities from the Global DIGSI 5 Library. Then, the default settings of the added functionality are active. You can copy within a device and between devices as well. Settings and routings are also copied when you copy functionalities.



NOTE

If you delete a parameterized function group, function, or stage from the device, all settings and routings will be lost. The function group, function, or tripping stage can be added again, but then the default settings are active.

In most cases, the adaptation of the functional scope consists of adding and deleting functions, stages, and function blocks. As previously described, the functions, tripping stages, and function blocks automatically connect themselves to the measuring points assigned to the function group.

In few cases, it may be necessary to add a protection or circuit-breaker function group. These newly added function groups do not contain (protection) functions. You must individually load the (protection) functions for your specific application. You must also connect the protection or circuit-breaker function group to one or more measuring points (see *2.1 Embedding of Functions in the Device*). You must connect newly added protection function groups to a circuit-breaker function group (see *2.1 Embedding of Functions in the Device*).

Functions, tripping stages, function blocks, and function groups can be added up to a certain maximum number. The maximum number can be found in the respective function and function-group descriptions.

Function Points

Function points (FP) are assigned to specific functions, but not to other functions. You can find more detailed information in the description of application templates, in *4 Applications*.

The device is supplied with the acquired function-point credit. Functions with function points can be loaded into the device only within the available function-point credit. The functional scope cannot be loaded into the device if the required number of points of the functional scope is higher than the function-point credit. You must either delete functions or upgrade the function-point credit of the device.

In addition to function-point classes (10, 20, 30, 40, 50, 75, 100 to 1400) beginning with firmware version V09.20, any function-point values in the range from 0 to 5000 are supported as a credit in the device. Thus, the precise function-point credit required can be loaded into the device by the Function-Point Manager. Alternatively, you can order classless devices with 0 points (new option beginning with V09.20) or class-bound with the required function-point class.

Extending the Function-Point Credit

You can reorder function points if the function-point credit for the device is not enough or if you have ordered a classless device with 0 points. Proceed as follows:

- Determine the function-point requirement of certain functions, for example, with DIGSI 5 or the SIPROTEC 5 Configurator.
- Create a signed license file for your device with the SIPROTEC Function-Point Manager at *www.siprotec-function-point-manager.siemens.com* or order the license file from your sales partner.
- Once you have ordered the license file using the Function-Point Manager, you can download it from there directly.
- Once you have ordered the license file from your sales partner, you will receive it by e-mail or to download.
- Use DIGSI 5 to load the signed license file onto your device. The procedure is described in the Online Help of DIGSI 5.

2.3 Function Control

Function control is used for:

- Functions that do not contain stages or function blocks
- Stages within functions
- Function blocks within functions

NOTE

Simplifying **functions** and **function control** will be discussed in the following. The description also applies to tripping stage control and function block control.

Functions can be switched to different operating modes. You use the parameter **Mode** to define whether you want a function to run (***on***) or not (***off***). In addition, you can temporarily block a function. For the purpose of commissioning, you can switch it into test mode (parameter **Mode** = ***test***).

Devices with the activated IEC 61850 allow you to switch the operating mode by using the logical node zero **LLN0**. Depending on the option **LDevice Mod controllable**[1] in DIGSI 5 under **Settings** > **Device settings**, the logical devices (as well as the child logical devices and logical nodes) can be set to one of the following operating modes:

- ***On***
- ***Off***
- ***Test***
- ***Relay blocked***
- ***Test/Relay blk.***

The following table describes the relationship between the LLN0 and the setting **LDevice Mod controllable**.

LLN0.Mod	Setting LDevice Mod controllable	
	Deactivated	Activated
Application/LLN0.Mod	Controllable	Controllable
Logical device/LLN0.Mod	Status only	Controllable
Child logical device/LLN0.Mod	Status only	Controllable
Logical node/LLN0.Mod	Status only	Controllable
_:51 Mode (controllable) of an individual tripping stage of a protection function	Controllable	Controllable

With the setting **LDevice Mod controllable** being activated, the behavior of a logical device (as well as the child logical devices and logical nodes) can be controlled also by the parameter **SetMod** (**SetMod** = ***on***: behavior = on; **SetMod** = ***off***: behavior = off) of the LLN0.

The function shows the current status – such as an *Alarm* – via the *Health* signal.

For more details, refer to the Application Notes *SIPROTEC 5 IEC 61850 Mod/Beh*.

The following explains the different operating modes and mechanisms and how you set the functions into these modes. The function control is shown in *Figure 2-8*. It is standardized for all functions. Therefore, this control is not discussed further in the individual function descriptions.

1 This parameter is only applicable if IEC 61850 is active.

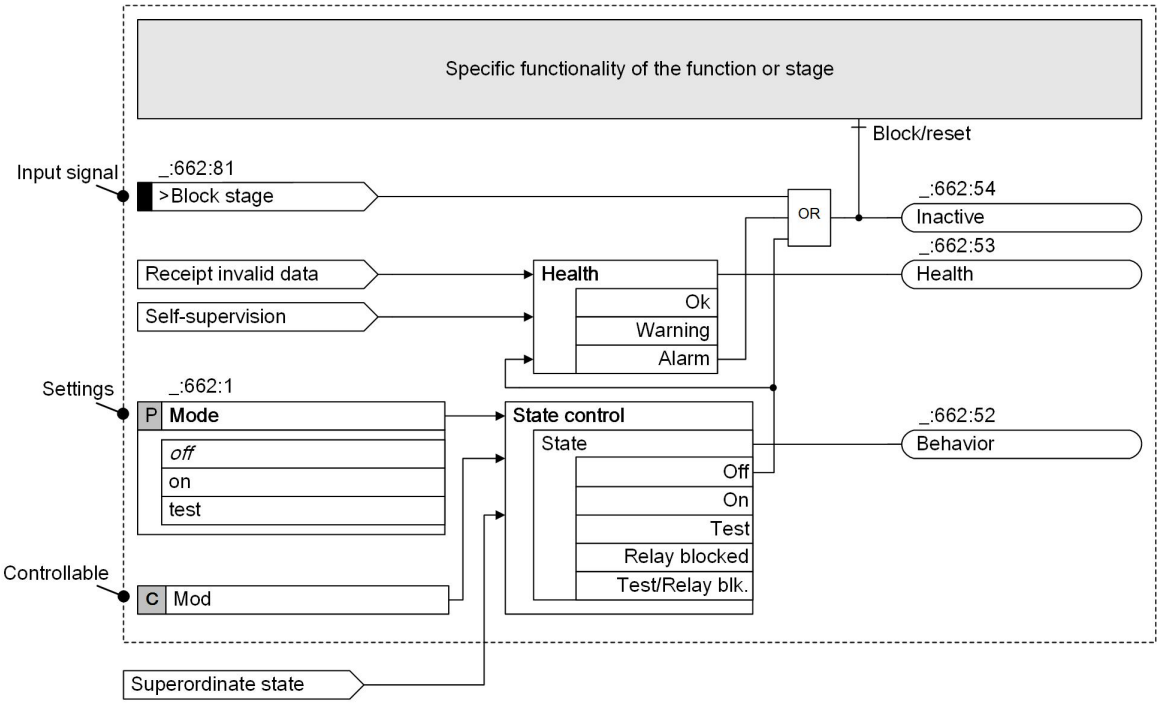


Figure 2-8 General Control of a Function

State Control

You can control the state of a function via the parameter **Mode**, the controllable **Mod** and the input **Superordinate state**.

The superordinate state is also influenced by the state of the superordinate logical devices (LD) of the IEC 61850 structure.

You set the specified operating state of the function via the parameter **Mode**. You can set the function mode to ***on***, ***off*** and ***test***. The operating principle is described in *Table 2-2*. You can set the parameter **Mode** via:

- DIGSI 5
- On-site operation at the device
- Browser-based user interface
- Certain systems control protocols (IEC 61850, IEC 60870-5-103)

You can also set the set point operating state of the function through the controllable **Mod**. You can set the function mode to ***On***, ***Off***, ***Test***, ***Relay blocked*** and ***Test/Relay blk.***. The operating principle is described in *Table 2-2*. You can set the controllable **Mod** via:

- IEC 61850-8-1
- CFC

The **superordinate state** can accept the values ***On***, ***Relay blocked*** ***Test*** and ***Test/Relay blk.***.

The state of the function resulting from the parameter **Mode**, the controllable **Mod** and the **Superordinate state** is shown in the following table. The resulting state of the function results from the combination of all sources (parameters **Mode**, Controllable **Mod** and **Superordinate state**). For simplicity, the table represents only the combination of 2 sources.

Table 2-1 Resulting State of the Function

Inputs		State of the Function
Source A	Source N	
On	On	On
On	Off	Off
On	Test	Test[2]
On	Relay blocked	Relay blocked
On	Test/Relay blk.	Test/Relay blk.
Test	On	Test[2]
Test	Off	Off
Test	Test	Test[2]
Test	Relay blocked	Test/Relay blk.
Test	Test/Relay blk.	Test/Relay blk.
Off	On	Off
Off	Off	Off
Off	Test	Off
Off	Relay blocked	Off
Off	Test/Relay blk.	Off
Relay blocked	On	Relay blocked
Relay blocked	Off	Off
Relay blocked	Test	Test/Relay blk.
Relay blocked	Relay blocked	Relay blocked
Relay blocked	Test/Relay blk.	Test/Relay blk.
Test/Relay blk.	On	Test/Relay blk.
Test/Relay blk.	Off	Off
Test/Relay blk.	Test	Test/Relay blk.
Test/Relay blk.	Relay blocked	Test/Relay blk.
Test/Relay blk.	Test/Relay blk.	Test/Relay blk.



NOTE

The browser-based user interface shows an easy-to-read list of the states of all functions if they deviate from the state ***On***.

The following table describes the possible states of a function:

2 With the parameter **(_:151) Oper.bin.outp. under test**, you define whether functions in test mode can activate relay outputs. If the parameter **(_:151) Oper.bin.outp. under test** and the test mode are activated for the entire device, all functions – including the relay outputs – are in **Test** state. If the parameter **(_:151) Oper.bin.outp. under test** is not active and the test mode is activated for the entire device, all functions – except the relay outputs – are in **Test** state. The relay outputs adopt the **Test/Relay blk.** state.

Table 2-2 Possible States of a Function

State of the Function	Explanation
On	The function is activated and operating as defined. The prerequisite is that the health of the function is ***OK***.
Relay blocked	The function is activated and operating as defined. The prerequisite is that the health of the function is ***OK***. All outputs of indications of this function to relays are blocked. **Note:** Logics outside this function block, for example, superordinate group indications, are not affected by the blocking. Their output to a relay still leads to an activation.
Off	The function is turned off. It does not create any information. The health of a disabled function always has the value ***OK***.

<table>
<tr><th>State of the Function</th><th colspan="2">Explanation</th></tr>
<tr><td>Test</td><td colspan="2">The function is set to test mode. This state supports the commissioning. All outgoing information from the function (indications and, if present, measured values) is provided with a test bit. This test bit significantly influences the further processing of the information, depending on the target.
When leaving the state Test, functions that process measured values are briefly reset for ~500 ms and blocked internally. This state is documented by the message Inactive and other function-specific messages, where appropriate.</td></tr>
<tr><td></td><td>Target of the Information</td><td>Processing</td></tr>
<tr><td></td><td>Log</td><td>The indication is labeled as Test in the log.</td></tr>
<tr><td></td><td>Binary output</td><td>An indication routed to binary outputs does not control the switching contact, unless the behavior of the binary output is in test state.</td></tr>
<tr><td></td><td>Light-emitting diode (LED)</td><td>An indication routed to the LED triggers the LED (normal processing)</td></tr>
<tr><td></td><td>CFC</td><td>Here, the behavior depends on the state of the CFC chart.
• CFC chart itself is not in test state:
The CFC chart is not triggered by a status change of information with a set test bit. The initial state of the information (state before test bit was set) is not processed during execution of the CFC chart.
• CFC chart itself is in test state:
The CFC chart continues to process the information (indication or measured value) normally. The CFC outgoing information is provided with a test bit. The definitions in this table apply to its continued processing.
A CFC chart can be set to the test state by switching the entire device to test mode or by using the CFC block CHART_STATE to switch a single CFC chart to Test mode.</td></tr>
<tr><td></td><td>Protocol</td><td>Indication and measured value are transmitted with set test bit, provided that the protocol supports this functionality.
If an object is transmitted as a GOOSE message, the test bit is set spontaneously and the GOOSE message is transmitted immediately. The receiver of the GOOSE message is automatically notified of transmitter test mode.
If an object is transmitted via the protection interface, the test bit is not transmitted. The Test state must also be transmitted as information for this state to be taken into account in the application on the receiver side. You must route the Test signal in the DIGSI 5 project tree → Device → Communication routing.
The test mode of the differential protection is dealt with separately in the application.</td></tr>
<tr><td>Test/Relay blk.</td><td colspan="2">The function works as described under Test. All output information (indications) of this function which is routed to a relay is blocked.
All output information from the function (indications and, if available, measured values) is provided with a test bit. This test bit significantly influences the further processing of the information, depending on the target.
Logics outside this function block, for example, superordinate group indications, are not affected by the blocking. If the state of these functions allows the processing of indications with a test bit (target function in the state Test or Test/Relay blk.), the output information routed to a relay continues to the control of the relays.</td></tr>
</table>

Health

Health signals if a selected function can perform its designated functionality. If so, the health is *OK*. In case the functionality is only possible in a limited way or not at all, due to state or problems within the device, the health will signal *Warning* (limited functionality) or *Alarm* (no functionality).

Internal self-monitoring can cause functions to assume the health state *Alarm* (see *8 Supervision Functions*). If a function assumes the health state *Alarm*, it is no longer active (indication *not active* is generated).

Only a few functions can signal the health state *Warning*. The health state *Warning* results from function-specific supervision and - where it occurs - it is explained in the function description. If a function assumes the *Warning* status, it will remain active, that is, the function can continue to work in a conditional manner and trip in the case of a protection function.

Not Active

The indication *Inactive* signals that a function is currently not working. The indication *Inactive* is active in the following cases:

- Function is disabled
- The function is in the health state *Alarm*
- Function is blocked by an input signal (see *Figure 2-8*)
- All protection-function steps are disabled via the *Enable protection* controllable (state = false). The indication *Protection inactive* is active.
- The function is briefly *Inactive* when exiting the state **Test**.

Blocking of the Operate Indication, No Fault Recording at Pickup

With the parameter **Blk. Op. Ind. & Fault Rec.** , you define whether a function works as a protection or a monitoring function. Further, you use this to determine the type and scope of the logging (see following table).

Parameter Value	Description
No	The function works as a protection function. It generates an operate indication and starts fault recording with pickup. During fault recording, a fault is created and logged as a fault record in the fault log.
Yes	The function works as a supervision function. The logic runs normally, but without creating the operate indication. The time-out indication is still generated and can be processed further if necessary. No fault recording starts with pickup.



NOTE

With the IEC 61850 structure editor, you can assign the logical nodes (LN) of the stages of a function to different logical devices (LD).

Always assign all LNs of a function to the same LD.

2.4 Text Structure and Reference Number for Settings and Indications

Each parameter and each indication has a unique reference number within every SIPROTEC 5 device. The reference number gives you a clear reference, for example, between an indication entry in the buffer of the device and the corresponding description in the manual. You can find the reference numbers in this document, for example, in the application and setting notes, in the logic diagrams, and in the parameter and information lists.

In order to form unique texts and reference numbers, each function group, function, function block/stage, and indication or parameter has a text and a number. This means that structured overall texts and numbers are created.

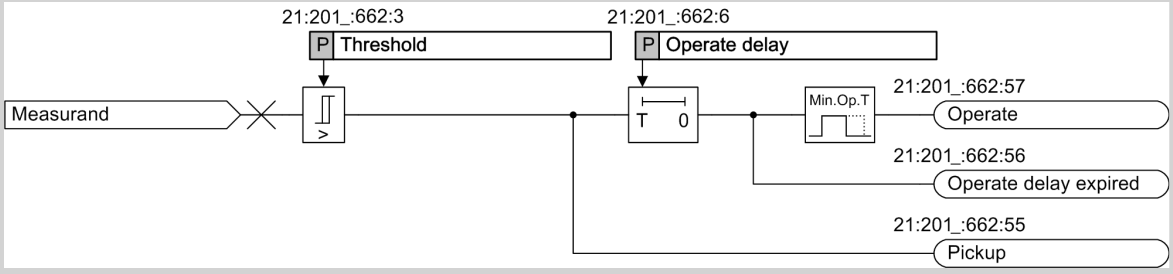
The structure of the texts and reference numbers follows the already shown in *Figure 2-1*, hierarchy:

- Function group:Function:Stage/Function Block:Indication
- Function group:Function:Stage/Function Block:Parameter

The colon serves as a structure element to separate the hierarchy levels. Depending on the functionality, not all hierarchy levels are always available. Function Group and Stage/Function block are optional. Since the function groups, functions as well as tripping stages/function blocks of the same type can be created multiple times, a so-called instance number is added to these elements.

EXAMPLE

The structure of the text and reference number is shown in the protection-function group **Line** as an example of the parameter **`Threshold value`** and the indication **`Pickup`** of the 2nd definite-time overcurrent protection stage of the function **Overcurrent protection, phases** (see *Figure 2-9*). Only one function and one function group exist in the device. The representation of the stage is simplified.



[lo_stuumz_1_en_US]

Figure 2-9 Stage of the Overcurrent Protection Function, Phases (without Representation of Stage Control)

The following table shows the texts and numbers of the hierarchy elements concerned:

	Name	Number of the Type	Instance Number
Protection function group	Line	2	1
Function	Overcurrent 3ph	20	1
Stage	Definite-time overcurrent protection	66	2
Settings	Threshold value	3	–
Indication	Pickup	55	–

The instance numbers arise as follows:

- Function group: Line **1**
  1 instance, because only one **Line** function group exists in the device
- Function: Overcurrent 3ph **1**
  1 instance, because only one **Overcurrent 3ph** function exists in the **Line** function group

- Stage: Definite-time overcurrent protection **2**

  2 instances, because 2 definite-time overcurrent protection stages exist in the **Overcurrent 3ph** function (here the 2nd instance as an example)

This results in the following texts and numbers (including the instance numbers):

Parameter:	**Number**
Line 1:Overcurrent 3-ph 1:Definite-time overcurrent protection 2:Threshold value	21:201:662:3
Indication:	**Number**
Line 1:Overcurrent 3-ph 1:Definite-time overcurrent protection 2:Pickup	21:201:662:55

The structure is simplified accordingly for parameters and indications with fewer hierarchy levels.

2.5 Information Lists

For the function groups, functions, and function blocks, settings and miscellaneous signals are defined that are shown in the settings and information lists.

The information lists merge the signals. The data type of the information may differ. Possible data types are ENS, ACD, ACT, SPS and MV.

One type is assigned to the individual data types. The following table shows the possible types:

Type	Meaning
I	**I**nput – input signal
O	**O**utput – output signal
C	**C**ontrollable – control signal

EXAMPLE:

The following table shows the types for some data types as examples:

Data Type	Type
ENS	O
ACD	O
ACT	O
SPS	I or O
SPC	C
MV	O

For further information, refer to *3.8.2 Basic Data Types*.

3 System Functions

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3.1 Indications

3.1.1 General

During operation, indications deliver information about operational states. These include:

- Measured data
- Power-system data
- Device supervisions
- Device functions
- Function procedures during testing and commissioning of the device

In addition, indications give an overview of important fault events after a failure in the system. All indications are furnished with a time stamp at the time of their occurrence.

Indications are saved in logs inside the device and are available for later analyses. The following number of indications are saved at least in the respective buffer (depending on the scope of the indications):

- Operational log 2000 indications
- Fault log 1000 indications
- Switching-device log 2000 indications
- Ground-fault log 100 indications
- User-defined log 200 indications
- Motor-starting log 200 indications

If the maximum capacity of the user-defined log or of the operational log is exhausted, the newest entries overwrite the oldest entries. If the maximum capacity of the fault log or of the ground-fault log is reached, the number of the last fault is output via the signal **Fault recording buffer is full**. You can route this signal in the information routing. If indications in the information routing of DIGSI 5 are routed to a log, then they are also saved. During a supply-voltage failure, recorded data are securely held by means of battery buffering or storage in the flash memory. You can read and analyze the log from the device with DIGSI 5. The device display and navigation using keys allow you to read and analyze the logs on site.

Indications can be output spontaneously via the communication interfaces of the device and through external request via general interrogation. In DIGSI 5, indications can be tracked spontaneously duringonline mode in a special indication window. Indications can be made accessible to higher-level control systems through mapping on various communication protocols.



NOTE

All indications are assigned to certain device functions. The text of each indication contains the corresponding function designation. You can find explanations of the meaning of indications in the corresponding device functions. However, you can also define indications yourself and group them into your own function blocks. These can be set by binary inputs or CFC logic.

Reading Indications

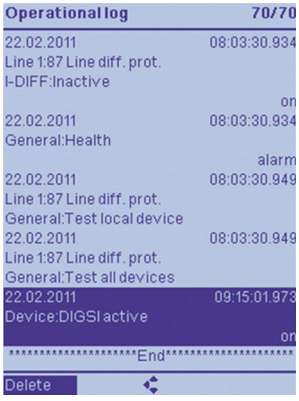
To read the indications of your SIPROTEC 5 device you can use the on-site operation panel of the device or a PC on which you have installed DIGSI 5. The subsequent section describes the general procedure.

3.1.2 Reading Indications on the On-Site Operation Panel

Procedure

The menus of the logs begin with a header and 2 numbers at the top right corner of the display. The number after the slash signifies the number of indications that are available. The number before the slash indicates

how many indications have just been selected or shown. The end of the indication list is closed with the entry ***END***.



[sc_oprlog, 1, en_US]

Figure 3-1 On-Site Display of an Indication List (Example: Operational Indications)

Menu Path	Log
Main menu → Indications →	Operational log Fault log Switch. device log Ground-fault log Setting-history log User log 1 User log 2 Motor-starting log Com supervision log
Main Menu → Test & Diagnosis → Log →	Device diagnosis Security log Communication log

To reach the desired log from the main menu, use the navigation keys of the on-site operation panel.

✧ Navigate inside the log using the navigation keys (top/bottom). You will find the most current indication at the top of the list. The selected indication is shown with a dark background.

Which indications can be shown in the selected log depends on the assignments in the DIGSI 5 information routing matrix or is predefined. Every indication contains date, time, and its state as additional information.

You will find information about this in chapter *3.1.5.1 General*.

In some logs, you are given the option of deleting the entire indication list by softkey in the footer of the display. To learn more about this, read chapter *3.1.6 Saving and Deleting the Logs*.

NOTE

No password entry is necessary to read indications from the device.

3.1.3 Reading Indications from the PC with DIGSI 5

Procedure

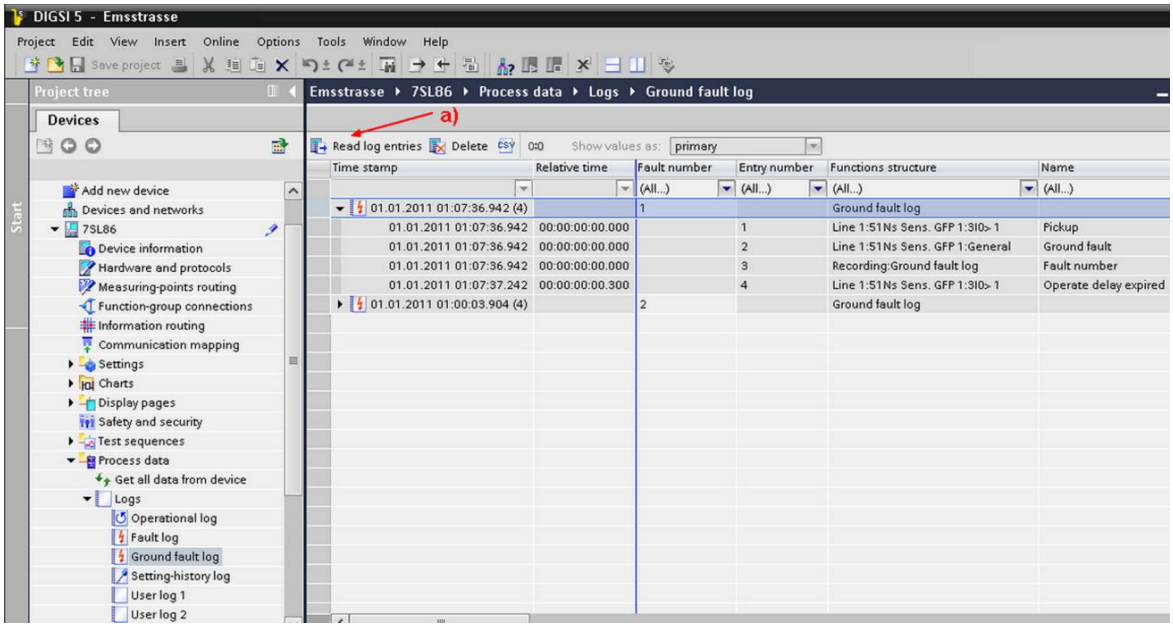
Menu Path (Project)	Log
Project → Device → Process data → Log →	Operational log Fault log Switch. device log Ground-fault log Setting-history log User log 1 User log 2 Motor-starting log Com supervision log
Online access → Device → Device information → **Logs** tab →	Device-diagnosis log Security indications
Online access → Device → Test suite → Communication module → Hardware[3]	Communication log

To read the indications with DIGSI 5 your PC must be connected via the **USB user interface** of the on-site operation panel or via an **Ethernet interface** of the device. You can establish a direct connection to your PC via the Ethernet interfaces. It is also possible to access all connected SIPROTEC 5 devices via a data network from your DIGSI 5 PC.

✧ You reach the desired logs of the SIPROTEC 5 device using the project-tree window. If you have not created the device within a project, you can also do this via the **Online access** menu item.

After selecting the desired log, you are shown the last state of the log loaded from the device. To update, it is necessary to synchronize with the log in the device.

✧ Synchronize the log. For this purpose, click the appropriate button in the headline of the log (see the ground-fault indications example in *Figure 3-2* a)).



[sc_grfimd, 1, en_US]

Figure 3-2 DIGSI 5 Display of an Indication List (Example of Ground-Fault Log)

3 There may potentially be several communication modules to select from

You will find additional information about deleting and saving logs in chapter *3.1.6 Saving and Deleting the Logs*.

Which indications can be shown in the selected log depends on the assignments in the DIGSI 5 information routing matrix or is predefined. You will find information about this in chapter *3.1.5.1 General*.

Setting Relative Time Reference

✧ Reference the display of log entries, if needed, to the real time of a specific entry. In this way, you determine a relative time for all other indications. The real-time stamps of events remain unaffected.

3.1.4 Displaying Indications

Displayed indications are supplemented in DIGSI 5 and on the on-site operation panel with the following information:

Table 3-1 Overview of Additional Information

Indications in	DIGSI 5 Information	Device Display Information
Log for operational indications and log for user-defined and switching-device indications	Time stamp (date and time), Relative time, Entry number, Function structure, Name, Value, Quality, Cause, Number	Time stamp (date and time), Function structure, Name, Value
Log for fault indications	Time stamp (date and time), Relative time, Fault number, Entry number, Function structure, Name, Value, Quality, Cause, Number	Time stamp (date and time), Fault number, Value
Log for motor-starting indications	Time stamp (date and time), Motor-starting time, Starting current, Starting voltage, Starting duration	Time stamp (date and time), Function structure, Name, Value

Indications in	DIGSI 5 Information	Device Display Information
Log for ground-fault indications	Time stamp (date and time), Relative time, Fault number, Entry number, Function structure, Name, Value, Indication number, Quality, Cause, Number	Time stamp (date and time), Fault number, Value
Log for parameter changes	Time stamp (date and time), Relative time, Entry number, Function structure, Name, Value, Quality, Cause, Number	Time stamp (date and time), Function structure, Name, Value
Spontaneous indication window (DIGSI 5)	Time stamp (date and time), Relative time, Indication, Value, Quality, Additional Information	Time stamp (date and time), Fault number, Value
Log for safety indications[4]	Time stamp (date and time), Indication number, Indication	Time stamp (date and time), Indication
Log for device-diagnostic indications[4]	Time stamp (date and time), Indication number, Indication	Time stamp (date and time), Indication
Log for communication indications[4]	Time stamp (date and time), Indication number, Indication	Time stamp (date and time), Indication
Log for communication supervision (GOOSE)	Time stamp (date and time), Relative time, Entry number, Function structure, Name, Value, Quality, Cause, Number	Time stamp (date and time), Function structure, Name, Value

4 Only online access

Overview of Displayed Quality Attributes

If values are shown on the device display or in DIGSI, the following quality attributes are different for measured values and metered values.

Table 3-2 Measured Values

IEC 61850				Device Display/ DIGSI	Description
Detail Quality	Validity				
	Good	Invalid	Questionable		
–	X			Value	The measured value is valid.
Failure		X		Fault	The device is defective. Contact Support.
Inaccurate			X	---	The measured value was not calculated (for example, the angle between current and voltage if 1 of the 2 variables is missing).
Bad Reference			X	≈ Value	The measured value can be inaccurate (for example, outside the frequency-tracking range).
Out of Range			X	> Value	The measured value exceeds the measuring range.

Table 3-3 Metered Values

IEC 61850			Device Display/ DIGSI	Description
Validity				
Good	Invalid	Questionable		
X			Value	The metered value is invalid.
	X		---	The metered value was not calculated.
		X	≈ Value	The metered value has no reference.

Indication Columns

The following table shows the meaning of the individual columns in the log:

Indication Column	Meaning
Time stamp	Time stamp of the indication in device time using the local time zone of the device or the query time for the motor log
Relative time	Relative time to a reference entry
Error number	Number of the error that occurred in the device. This number increments continuously.
Entry number	Entry identification of buffer entries. This identification displays the sequence of buffer entries.
Indication number	Number of the indication that occurred in the device. This number increments continuously and is necessary for an analysis by Siemens.
Indication	Indication text
Function structure	Path of the signal with the signal name
Name	Signal name
Value	Current state of the command. Also pay attention to the value quality to check whether the value is up to date.

Indication Column	Meaning
Quality	The quality of the value shows the source of the value and whether the value is up to date.
Cause	Additional information such as the cause and validity
Number	DIGSI address of the signal
Motor startup time	Time of motor starting
Starting current	Current needed by the motor to start up
Starting voltage	Voltage needed by the motor to start up
Start duration	Time needed by the motor to start up

3.1.5 Logs

3.1.5.1 General

Indications are saved in logs inside the device and are available for later analyses. Different logs allow categorization of indication logging based on operating states (for example, operational and fault logs) and based on fields of application.

Table 3-4 Log Overview

Log	Logging
Operational log	Operational indications
Fault log	Fault indications
Switching-device log	Switching operation and circuit-breaker statistics
Ground-fault log	Ground-fault indications
Setting-history log	Setting changes
User-defined log	User-defined indication scope
Security log	Access with safety relevance
Device-diagnosis log	Error of the device (software, hardware) and the connection circuits
Communication log	Status of communication interfaces
Motor-starting log	Information on the motor starting
Communication-supervision log	Communication supervision (GOOSE)

Log Management

Logs have a ring structure and are automatically managed. If the maximum capacity of a log is exhausted, the oldest entries disappear before the newest entries. If the maximum capacity of the fault or ground-fault log is reached, the number of the last fault is output via the signal **Fault recording buffer is full**. You can route this signal in the information routing. If indications in the information routing of DIGSI 5 are routed to a log, then they are also saved. During a supply-voltage failure, recorded data are securely held by means of battery buffering or storage in the flash memory. You can read and analyze the log from the device with DIGSI 5. The device display and the navigation allow you to read and evaluate the logs on site using keys.

Configurability of Logs

The indication capacity to be recorded in configurable logs (for example, ground-fault log) is laid down in columns of the information routing (matrix) of DIGSI 5 specifically defined for this purpose.

Procedure

To reach the information routing of your SIPROTEC 5 device, use the project-tree window. Access is only through the project:

- Open the information routing.
  Project → Device → **Information routing**

- Select the appropriate routing column.
  Destination → Logs → Column **Ground-fault log (G)**

The routing of the selected indication is done via right click.

- Select one of the options in the list box shown:
  - Routed (X)
  - Unrouted

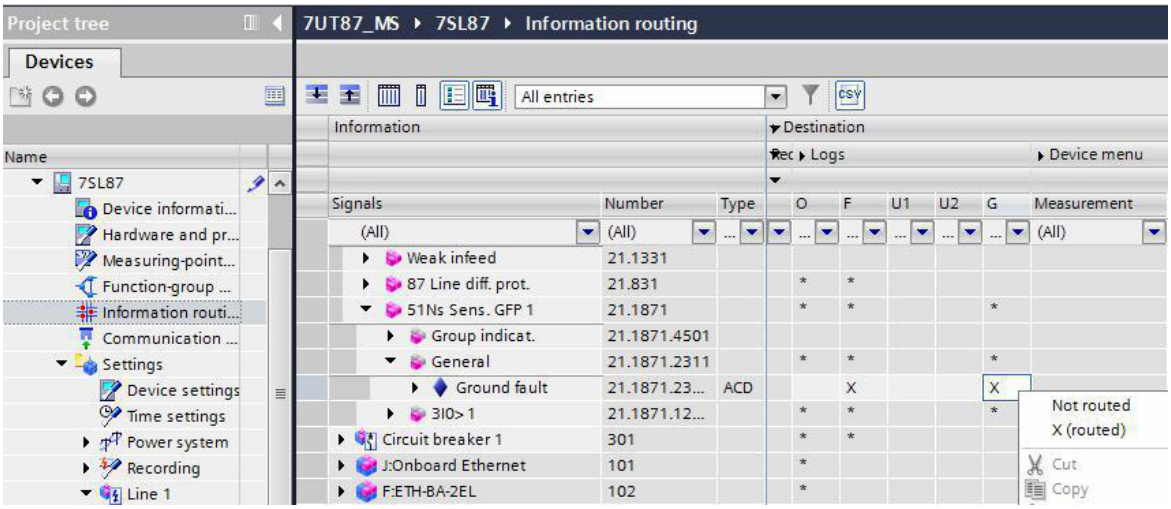


Figure 3-3 Indication Configuration in DIGSI 5 (Example: Ground-Fault Log, Column G)

For non-configurable logs (for example, setting-history logs) scope and type of logged indications are described separately (see following chapter about logs).

3.1.5.2 Operational Log

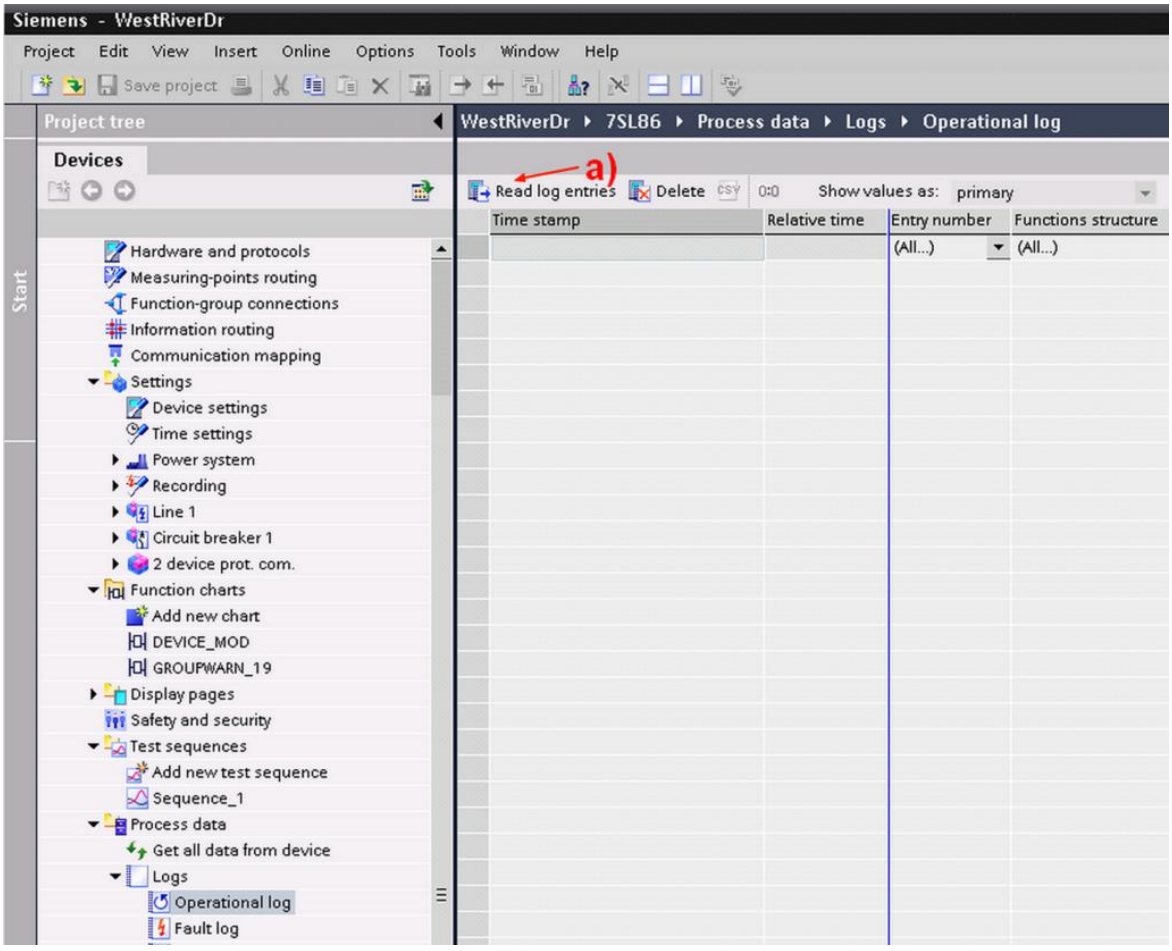
Operational indications are information that the device generates during operation. This includes information about:

- State of device functions
- Measured data
- Power-system data

Exceeding or dropping below limiting values is output as an operational indication. Short circuits in the network are indicated as an operational indication **Fault** with sequential fault number. For detailed information about the recording of system incidents, refer to the description of the fault log (chapter *3.1.5.3 Fault Log*). Up to 2000 indications can be stored in the operational log.

Reading from the PC with DIGSI 5

- To reach the operational log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process Data → Log → **Operational log**
- The status of the operational log last loaded from the device is shown to you. To update (synchronization with the device), click the button **Read log entries** in the headline of the indication list (*Figure 3-4* a)).

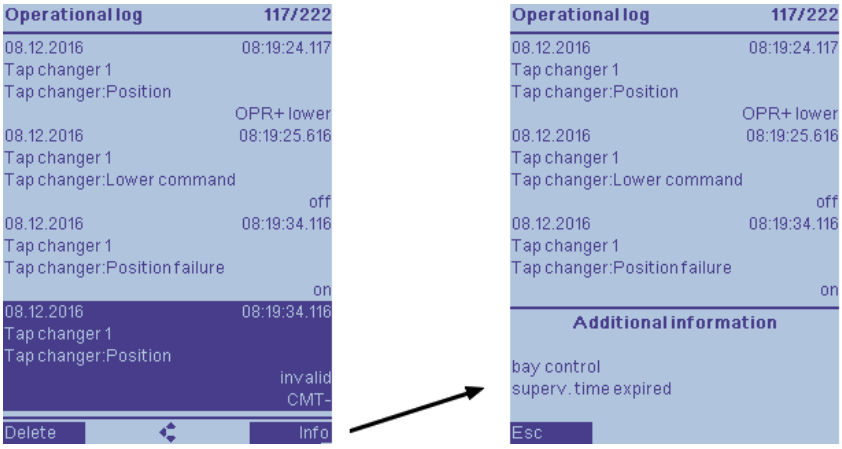


[sc_betrmd, 1, en_US]

Figure 3-4 Reading the Operational Log with DIGSI 5

Reading on the Device via the On-Site Operation Panel

- To reach the operational log via the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Indications → **Operational log**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.
- Using the **Info** softkey, you can retrieve auxiliary information on the entry depending on the context.



[sc_operlog1_2, en_US]

Figure 3-5 On-Site Display of an Indication List (Example: Operational Indications)

Deletability

The operational log of your SIPROTEC 5 device can be deleted. This is done usually after testing or commissioning the device. To know more about this, read chapter *3.1.6 Saving and Deleting the Logs*.

Configurability

The indication scope of the operational log is configured in a specifically defined column of the information routing (matrix) of DIGSI 5:

Target → Log → **Operational log** column

Selected application templates and functions from the library bring with them a predefined set of operational indications which you can adjust individually at any time.

3.1.5.3 Fault Log

Fault indications are events which arise during a fault. They are logged in the fault log with real-time stamp and relative-time stamp (reference point: fault occurrence) . Faults are numbered consecutively in rising order. With fault recording engaged, a corresponding fault record with the same number exists for every fault logged in the fault log. A maximum of 128 fault logs can be stored. A maximum of 1000 indications can be recorded in each fault log.

Fault Definition

In general, a fault is started by the raising pickup of a protection function and ends with the cleared pickup after the trip command.

When using an automatic reclosing function, the complete reclosing cycle (successful or unsuccessful) is preferably integrated into the fault. If evolving faults appear within reclosing cycles, the entire clearing process is logged under one fault number even in multiple pickup cycles. Without automatic reclosing function every pickup is also recorded as its own fault.

User-defined configuration of a fault is also possible.

NOTE

The definition of the fault is done through settings of the fault recording (see Device manual). Events are logged in the fault log even when fault recording is switched off.

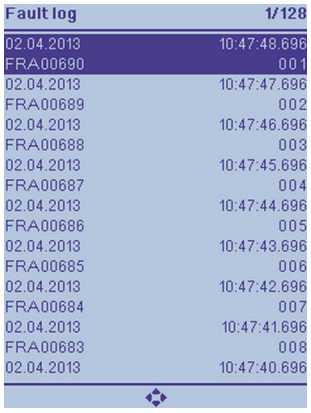
Apart from the recording of fault indications in the fault log, spontaneous display of fault indications of the last fault on the device display is also done. You will find details about this in chapter *3.1.8 Spontaneous Fault Display on the On-Site Operation Panel*.

Deletability

The fault log of your SIPROTEC 5 device can be deleted. For more details about this, refer to chapter *3.1.6 Saving and Deleting the Logs*.

Reading on the Device through the On-Site Operation Panel

- To reach the fault log from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Indications → **Fault logs**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.



[sc_faullg, 1, en_US]

Figure 3-6 Reading the Fault Log on the On-Site Operation Panel of the Device

Configurability

The indication scope of the fault log is configured in a specifically defined column of the information routing (matrix) of DIGSI 5:

Target → Log → **Fault log** column

Selected application templates and functions from the library already bring a predefined set of operational indications with them which you can adjust individually at any time.

The operational measured values and the measured values of the fundamental components and symmetrical components (see Device Manual) are calculated every 9 cycles (at 50 Hz, this is every 180 ms). However, this can mean that the data are not synchronized with the sampled values of the analog channels. The recording of these measured values can be used to analyze the slowly changing processes.

3.1.5.4 Ground-Fault Log

Ground-fault indications are events which arise during a ground fault. They are logged in the ground-fault log with real-time stamp and relative-time stamp (reference point: ground-fault occurrence). Ground faults are numbered consecutively in rising order. A maximum of 10 ground-fault logs are stored, and for each ground-fault log it is guaranteed that at least 100 indications are recorded.

The following functions can start the logging of a ground fault with the raising ground-fault indication:

- **Directional sensitive ground-fault protection for deleted and isolated systems** (67Ns)
- **Sensitive ground current protection with I0** (50Ns/51Ns)
- **Intermittent ground-fault protection**

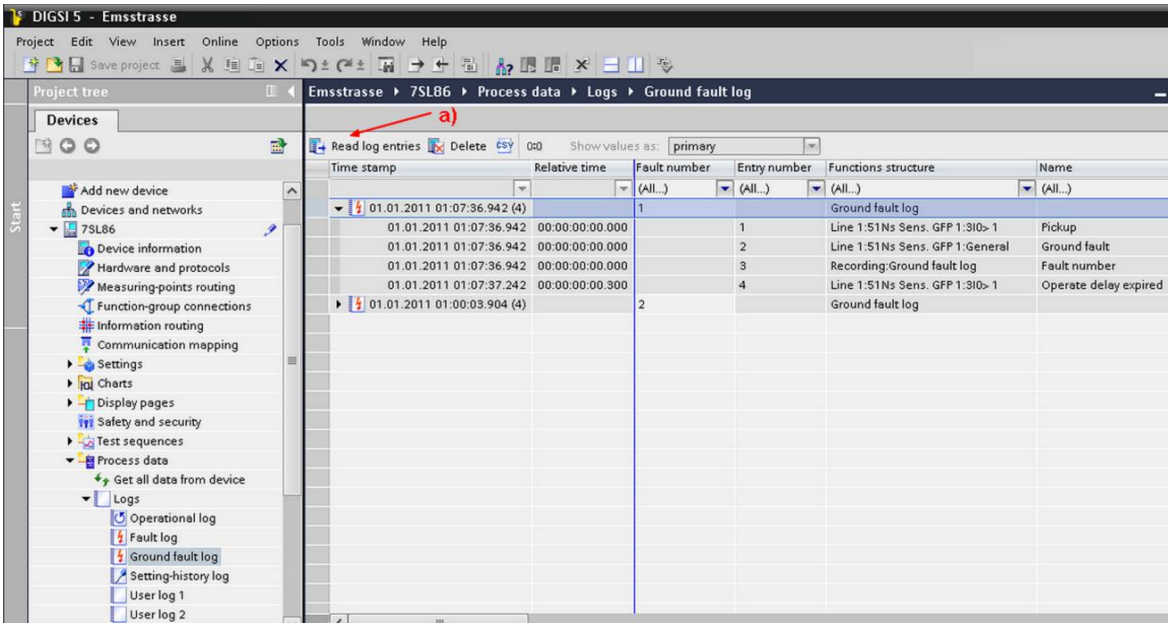
The logging ends with the clearing ground-fault indication.

Reading from the PC with DIGSI 5

- To reach the ground-fault log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process data → Logs → **Ground-fault log**

The status of the device-diagnosis log last loaded from the ground-fault log is shown to you.

- To update (synchronization with the device) click the button **Read log entries** in the headline of the indication list (*Figure 3-7* a)).

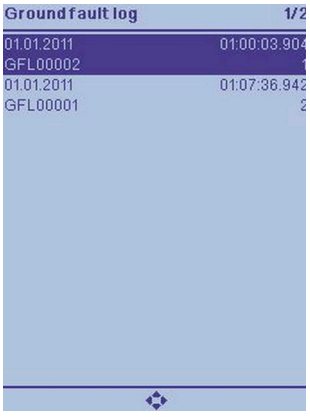


[sc_grflmd, 1, en_US]

Figure 3-7 Reading the Ground-Fault Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the ground-fault log from the main menu, use the navigation keys of the on-site operation panel.
  Main menu → Indications → **Ground-fault indication**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.



[scgfllg1-191012-01.tif, 1, en_US]

Figure 3-8 Reading the Ground-Fault Log on the On-Site Operation Panel of the Device

Deletability

The ground-fault log of your SIPROTEC 5 device can be deleted. Read details about this in chapter *3.1.6 Saving and Deleting the Logs*.

Configurability

The indication scope of the ground-fault log is configured in a specifically defined column of the information routing (matrix) of DIGSI 5:

Target → Log → Column **Ground-fault log**

Selected application templates and functions from the library already bring a predefined set of operational indications with them which you can adjust individually at any time.

3.1.5.5 Setting-History Log

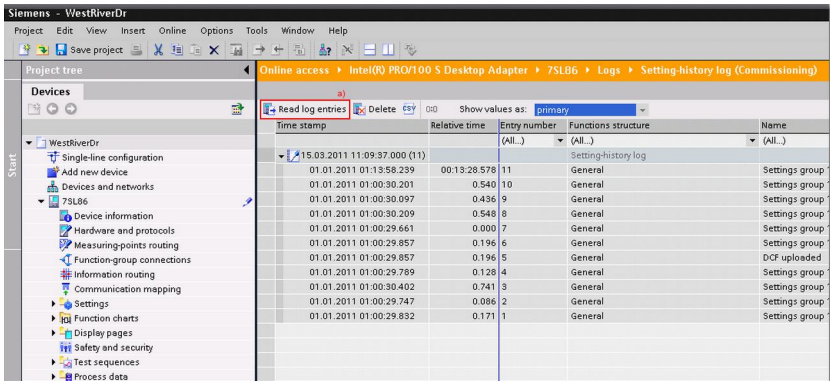
All individual setting changes and the downloaded files of entire parameter sets are recorded in the log for setting changes. This enables you to determine setting changes made are associated with events logged (for example faults). On the other hand, it is possible to obtain verification with fault analyses, for example, that the current status of all settings truly corresponds to their status at the time of the fault. Up to 200 indications can be stored in the setting-history log.

Reading from the PC with DIGSI 5

- To reach the log for setting changes of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process data → Log → **Setting changes**

The status of the setting-history log last loaded from the device is shown to you.

- To update (synchronization with the device), click the **Read log entries** button in the headline of the indication list (*Figure 3-9*).



[sc_paramd, 1, en_US]

Figure 3-9 Reading the Setting-History Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the setting-history log from the main menu, use the navigation keys of the on-site operation panel.
  Main menu → Indications → **Setting changes**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.



[sc_hislog, 1, en_US]

Figure 3-10 Reading the Setting-History Log on the On-Site Operation Panel of the Device

Indication Categories in the Setting-History Log

For this log, there is selected information that is stored in case of successful as well as unsuccessful setting changes. The following list gives you an overview of this information.

Table 3-5 Overview of Indication Types

Displayed Information	Explanation
Selection edit+	Selection of settings group to be edited
Cancelation+	Cancelling of all changes successful
SG activation+	SG activation via command successful
SG activation-	SG activation via command failed
Set+	Parameter value was changed
Confirmation+	Confirmation of change successful
Confirmation-	Confirmation of change failed
DCF uploaded	DCF loaded into device
SG 1	Settings group 1
SG 2	Settings group 2
SG 3	Settings group 3
SG 4	Settings group 4
SG 5	Settings group 5
SG 6	Settings group 6
SG 7	Settings group 7
SG 8	Settings group 8

NOTE

- The logged indications are preconfigured and cannot be changed!
- The log, which is organized as a ring buffer, cannot be deleted by the user!
- If you want to archive security-relevant information of the device without loss of information, you must regularly read this log.
- You cannot route additional indication objects to the setting-history log.

3.1.5.6 User Log

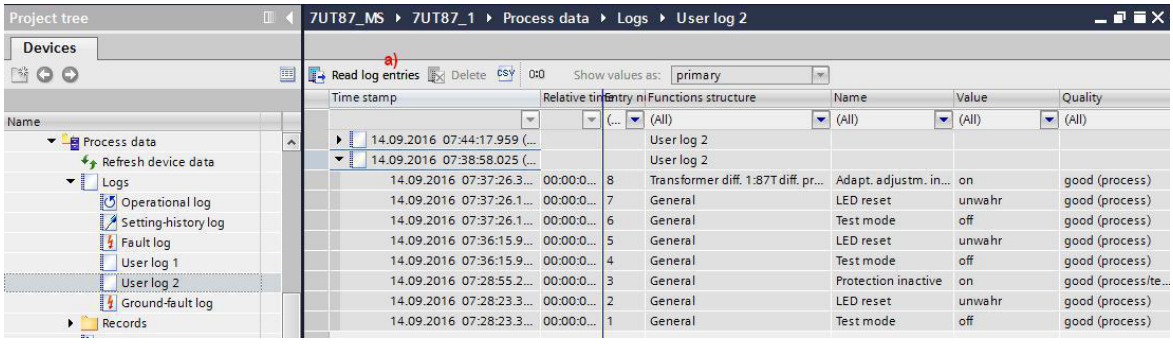
With the user-defined log (up to 2), you have the possibility of individual indication logging parallel to the operational log. This is helpful, for example, in special monitoring tasks but also in the classification into different areas of responsibility of the logs. Up to 200 indications can be stored in the user-defined log.

Reading from the PC with DIGSI 5

- To reach the user-defined log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process Data → Log → **User log 1/2**

The status of the user-defined log last loaded from the device is shown to you.

- To update (synchronization with the device), click the **Read log entries** button in the headline of the indication list (*Figure 3-11* a)).

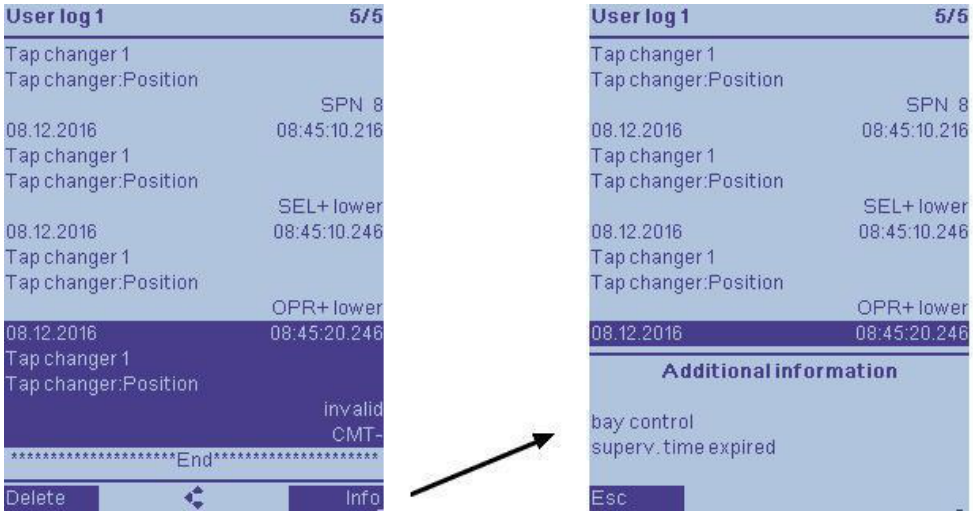


[sc_application_md, 2, en_US]

Figure 3-11 Reading the User-Defined Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach user-specific logs from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Indications → **User-defined log 1/2**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.
- Using the **Info** softkey, you can retrieve auxiliary information on the entry depending on the context.



[sc_userlog1, 1, en_US]

Figure 3-12 Reading the User-Defined Log on the On-Site Operation Panel of the Device

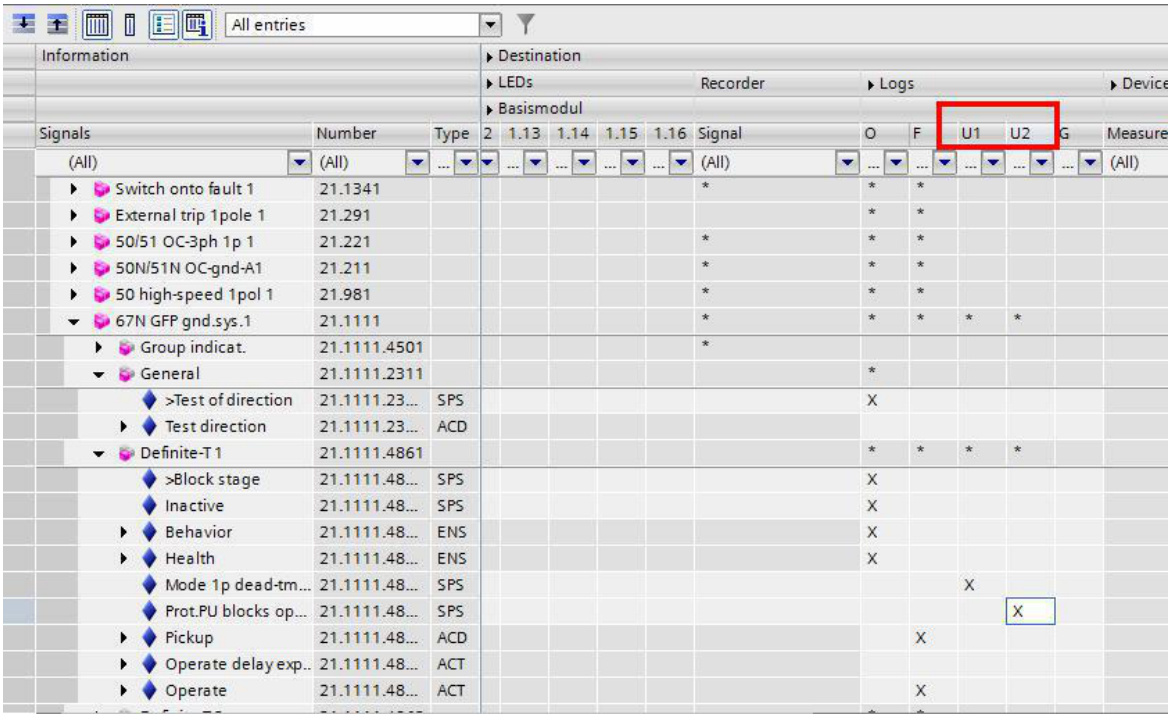
Deletability

The user-defined log of your SIPROTEC 5 device can be deleted. You will find details about this in chapter *3.1.6 Saving and Deleting the Logs*.

Configuration of a User-Defined Log

The indication capacity of a created user-defined log can be configured freely in the associated column of the information routing (matrix) of DIGSI 5:

Target → Log → U1 or U2



[sc_diu1u2, 1, en_US]

Figure 3-13 Indication Configuration in DIGSI 5 (Example: User-Defined Log U1/2)

3.1.5.7 Communication Log

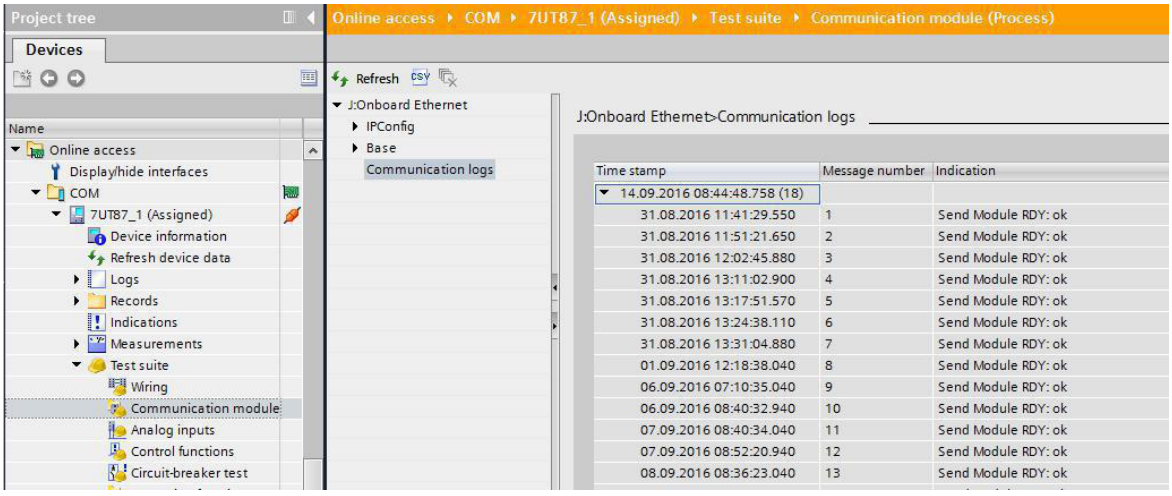
The logging of the respective status such as ensuing faults, test and diagnosis operation, and communication capacity utilizations is done for all hardware-based configured communication interfaces. Up to 500 indications can be stored in the communication log. Logging occurs separately for each communication port of the configured communication modules.

Reading from the PC with DIGSI 5

- Use the project-tree window to reach the communication logs of your SIPROTEC 5 device.
  Online access → Device → Test suite → Communication module
- Then select:
  J:Onboard Ethernet → **Communication log**

The communication log is shown to you in the state last loaded from the device.

- Before this, refresh the contents by clicking the update arrows in the headline.

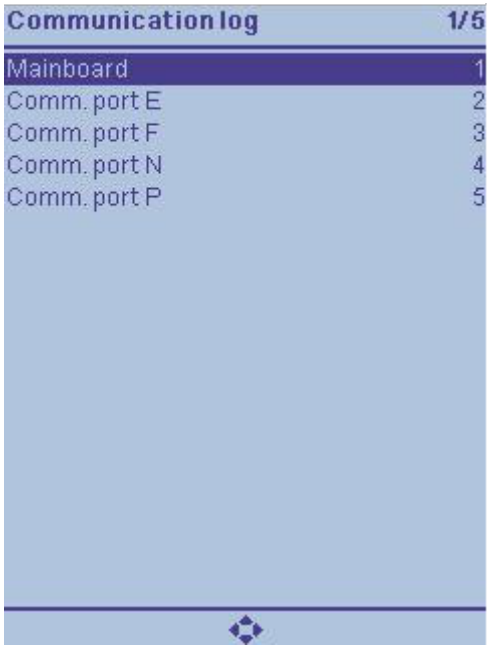


[sc_compuf, 2, en_US]

Figure 3-14 Reading the Communication Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the communication log from the main menu, use the navigation keys on the on-site operation panel.
  Main Menu → Test & Diagnosis → Logs → **Communication logs**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.



[sc_commlg, 1, en_US]

Figure 3-15 Reading the Communication Log on the On-Site Operation Panel of the Device

Deletability

The communication logs of your SIPROTEC 5 device can be deleted. Read details about this in chapter *3.1.6 Saving and Deleting the Logs*.

Configurability

The communication logs are not freely configurable. The entries are preconfigured.

3.1.5.8 Communication-Supervision Log

The communication-supervision log is used to log communication events.
The following events are currently logged:

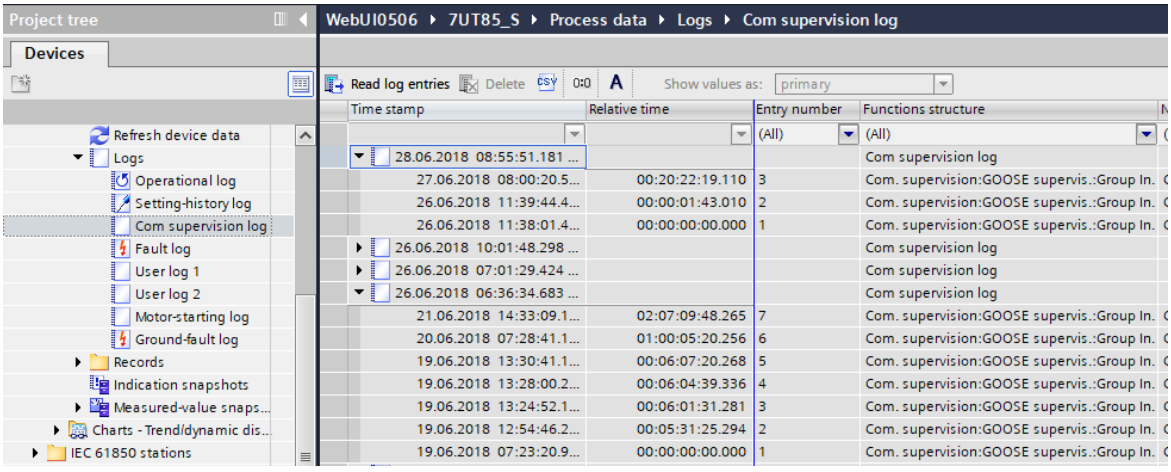
- Status for each GOOSE subscription (if configured)
  A log is kept of whether the GOOSE subscription has received valid messages or not.
- Aggregated status for all GOOSE subscriptions
  The status is **TRUE** if at least one GOOSE subscription does not receive any valid message.
- Subscriber in simulation mode
  GOOSE messages are processed with a simulation flag. The status is **TRUE** if at least one GOOSE subscription processes simulated messages.

Reading from the PC with DIGSI 5

- To reach the communication-supervision log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process data → Logs → **Com supervision log**

The status of the communication-supervision log last loaded from the device is shown.

- To update (synchronization with the device), click the button **Read log entries** in the headline of the indication list.

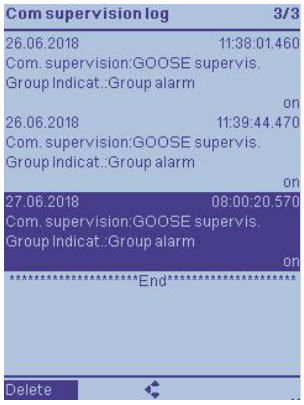


[sc_comsuperv, 1, en_US]

Figure 3-16 Reading the Communication-Supervision Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the communication-supervision log from the main menu, use the navigation keys on the on-site operation panel.
  Main menu → Logs → **Com supervision log**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.



[sc_comsupervlg, 1, en_US]

Figure 3-17 Reading the Communication-Supervision Log on the On-Site Operation Panel of the Device

Deletability

The communication-supervision log of your SIPROTEC 5 device can be deleted. Read details about this in chapter *3.1.6 Saving and Deleting the Logs*.

Configurability

The communication-supervision log cannot be freely configured. The entries are preconfigured.

3.1.5.9 Security Log

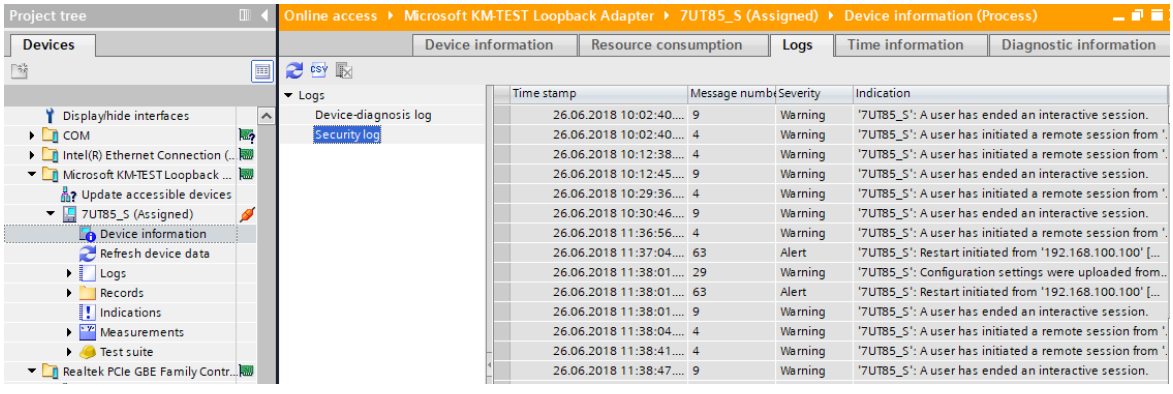
Access to areas of the device with restricted access rights is recorded in the security log. Unsuccessful and unauthorized access attempts are also recorded. Up to 2048 indications can be stored in the security log.

Reading from the PC with DIGSI 5

- To reach the security log of your SIPROTEC 5 device, use the project-tree window. The device must be in Online access.
  Project → Online access → Device → Device Information → **Logs** tab → Security logs

The state of the security log last loaded from the device is displayed.

- Before this, refresh the contents by clicking the update arrows in the headline.

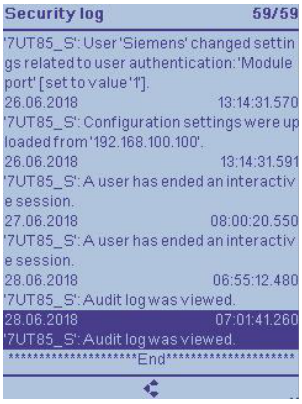


[sc_secmld, 2, en_US]

Figure 3-18 Reading the Security Indications with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the security log from the main menu, use the navigation keys of the on-site operation panel.
  Main menu → Test & Diagnosis → Logs → **Security log**
- You can navigate on the on-site operation panel using the navigation keys (top/bottom) inside the displayed indication list.



[sc_seclog, 1, en_US]

Figure 3-19 Reading the Security Log on the On-Site Operation Panel of the Device

NOTE

- The logged indications are preconfigured and cannot be changed!
- This log, which is organized as a ring buffer, cannot be deleted by the user!
- If you want to archive security-relevant information of the device without loss of information, you must regularly read this log.

3.1.5.10 Device-Diagnosis Log

Concrete take-action instructions are logged and displayed in the device-diagnosis log for the following items:

- Required maintenance (for example, battery supervision)
- Identified hardware defects
- Compatibility problems

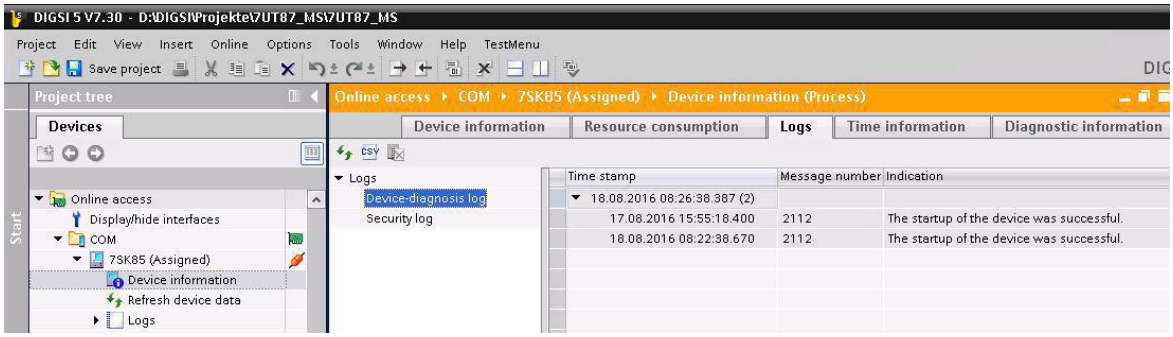
Up to 500 indications can be stored in the device-diagnosis log. In normal operation of the device, it is sufficient for diagnostic purposes to follow the entries of the operational log. This specific significance is assumed by the device-diagnosis log when the device is no longer ready for operation due to hardware defect or compatibility problems and the fallback system is active.

Reading from the PC with DIGSI 5 in Normal Operation

- To reach the device-diagnosis log of your SIPROTEC 5 device, use the project-tree window.
  Project → Online access → Device → Device information → **Logs** tab → Device-diagnosis log

The status of the device-diagnosis log last loaded from the device is shown to you.

- Before this, refresh the contents by clicking the update arrows in the headline.



[sc_devdia, 1, en_US]

Figure 3-20 Reading the Device-Diagnosis Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel in Normal Operation

- To reach the diagnosis log from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Test & Diagnosis → Logs → **Device diagnosis**
- You can navigate on the on-site operation panel using the navigation keys (top/bottom) inside the displayed indication list.



[sc_devdia_01, 1, en_US]

Figure 3-21 Reading the Device-Diagnosis Log on the On-Site Operation Panel of the Device

NOTE

- The device-diagnosis log cannot be deleted!
- The logged indications are preconfigured and cannot be changed!

3.1.5.11 Motor-Starting Log

The motor-starting log records the starting current, starting voltage and the start duration each time a motor starts. The motor-starting current and the motor-starting voltage are displayed as primary values. Up to 200 indications can be stored in the motor-starting log.

Measurement of the motor statistics starts when the motor state changes to ***Start***. Measurement of the motor starting time ends as soon as the motor state changes to ***Standstill*** or ***Running***. The motor state is obtained from the **Motor-state detection** function.

No entry is recorded in the motor-starting log if the motor state changes to ***Start*** and the current drops below the motor starting current within 500 ms.

Table 3-6 Motor-Starting Log

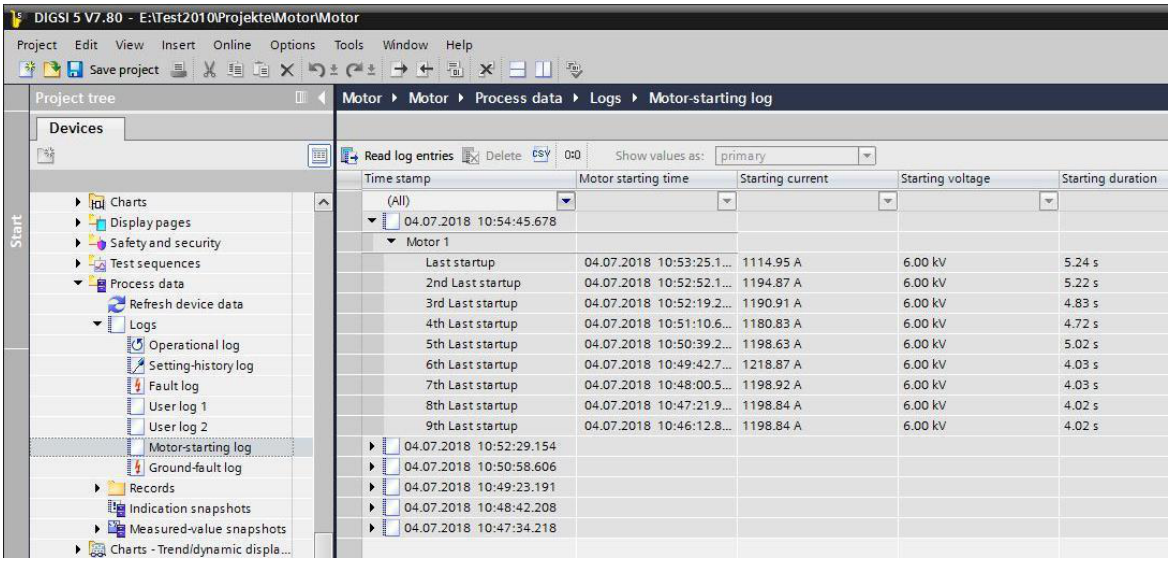
Measured Values		Primary
Start duration	Motor starting time	s
Starting current	Motor-starting current (primary)	A (or kA)
Starting voltage	Motor-starting voltage (primary)	V (or kV)

Reading from the PC with DIGSI 5

- Use the project-tree window to reach the motor-starting log of your SIPROTEC 5 device.
  Project → Device → Process data → Logs → **Motor-starting log**

The state of the motor-starting log last loaded from the device is shown to you.

- To update (synchronization with the device), click the **Read log entries** button in the headline of the indication list (*Figure 3-22*).



[scmotmlp-160713-01, 2, en_US]

Figure 3-22 Reading the Motor-Starting Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the motor-starting log from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Indications → **Motor-starting log**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.



[ScMotLog-280618, 1, en_US]

Figure 3-23 Reading the Motor-Starting Log on the On-Site Operation Panel of the Device

Deletability

The motor-starting log of your SIPROTEC 5 device can be deleted. Read details about this in chapter *3.1.6 Saving and Deleting the Logs*.

Configurability

The motor-starting log is only present in the **Motor** function group. There is no column for the motor-starting log in the DIGSI information routing. The entries in the motor-starting log are preconfigured and cannot be changed.

3.1.6 Saving and Deleting the Logs

Deleting the logs of the device in the operating state is unnecessary. If storage capacity is no longer sufficient for new indications, the oldest indications are automatically overwritten with new incoming events. In order for the memory to contain information about the new faults in the future, for example, after a revision of the system, a deletion of the log makes sense. Resetting the logs is done separately for the various logs.

NOTE

Before you delete the content of a log on your SIPROTEC 5 device, save the log with DIGSI 5 on the hard disk drive of your PC.

NOTE

Not all logs of your SIPROTEC 5 device can be deleted. These limitations apply especially to logs with relevance for security and after-sales (security log, device-diagnosis log, setting-history log).

NOTE

If you delete any files directly from the fault log or fault record, the error number for new fault records continues incrementing up to the maximum number 2^32. It does not reset to 0.

If you initialize flash partitioning of the fault log and fault record, the error number for new fault records resets to 0.

NOTE

If the device executes an initial start, for example after an update of the device software, the following logs are automatically deleted:

- Operational log
- Fault log
- Switching-device log
- Ground-fault log
- Setting-history log
- User-defined log
- Motor-starting log
- Communication-supervision log

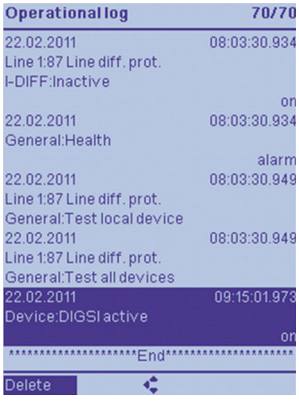
Back up the deletable logs using DIGSI 5.

NOTE

If a ground fault is currently active, the ground-fault log cannot be deleted.

Deleting Logs on the On-Site Operation Panel

- To reach the selected log from the main menu, use the navigation keys of the on-site operation panel (example operational log):
  Main menu → Logs → **Operational log**



[sc_oprlog, 1, en_US]

Figure 3-24 Deleting the Operational Log on the On-Site Operation Panel

- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.
- The option to delete the entire log is offered to you in the footer of the display at the bottom left. Use the softkeys below under the display to activate the command prompts. Confirm the request to **Delete**.
- After being requested, enter the password and confirm with **Enter**.
- After being requested, confirm the **Deletion of all entries** with **Ok**.

Deleting Logs from the PC with DIGSI 5

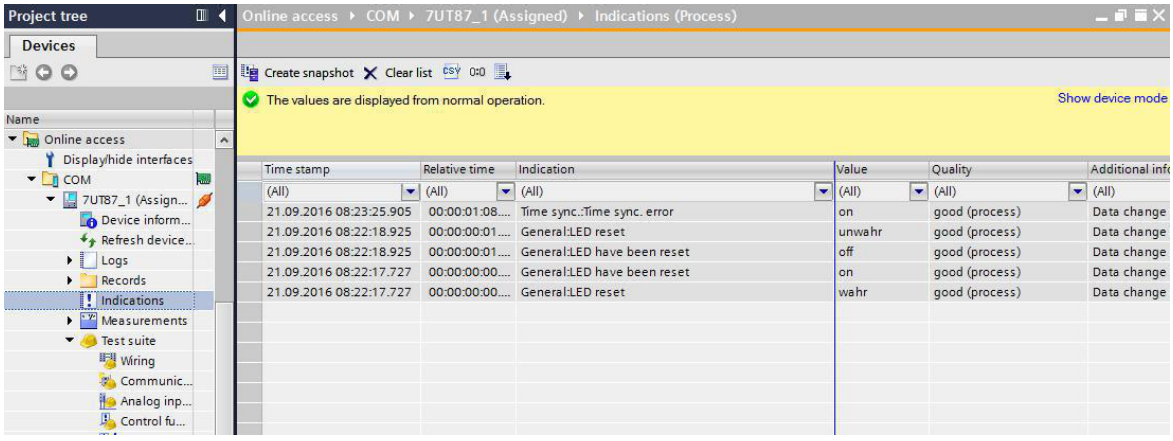
- To reach the selected log of your SIPROTEC 5 device, use the project-tree window (for example operational log).
  Project → Device → Process data → Logs → **Operational log**

3.1.7 Spontaneous Indication Display in DIGSI 5

With DIGSI 5 you have the possibility of displaying all currently transmitted indications of the selected device in a special indication window.

Procedure

- Call up the spontaneous indications of your selected device in the navigation window under Online access.
- Click **Indications** in the path:
  Online access → Interface → Device → **Indications**
- The raising indications appear immediately without you having to wait for a cyclical update or initiate the manual update.



[sc_spnmld, 2, en_US]

Figure 3-25 Displaying Spontaneous Device Indications in DIGSI 5

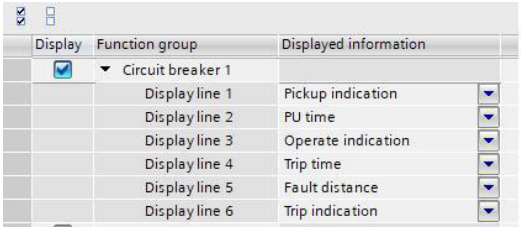
3.1.8 Spontaneous Fault Display on the On-Site Operation Panel

After a fault, the most important data of the last fault can be displayed automatically on the device display without further operational measures. In SIPROTEC 5 devices, protected objects and even circuit breakers can be freely created and configured depending on the application (even several instances). In DIGSI 5, several spontaneous fault displays can be configured, depending on the application, with each individual one being assigned a particular circuit breaker. These displays remain stored in the device until they are manually confirmed or released by LED reset.

Configuration of a Spontaneous Fault Display with DIGSI 5

- To reach the **Fault-display configuration** of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Display pages → **Fault-display configuration**

- In the main window, all configured circuit breakers are displayed. A list of a maximum of 6 configurable display lines is offered for each circuit breaker. The activation of a spontaneous fault display occurs for each circuit breaker by selection via checkmark in the column **Display**.
- With the parameter **(_:139) Fault-display** (under Device → Parameter → Device settings) you determine whether spontaneous fault displays should be shown for each pickup or only pickups with the trip command.



[sc_konstf, 2, en_US]

Figure 3-26 Configuration of the Spontaneous Fault Display on the Device

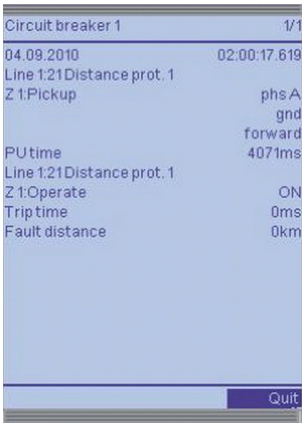
For every display line the following display options can be selected:

Table 3-7 Overview of Display Options

Displayed Information	Explanation
Pickup indication	Display of the first function stage picked up in a fault, as needed with auxiliary information (phases, ground, direction)
PU time	Display of the entire pickup duration of the fault
Operate indication	Display of the first function stage triggered in a fault, as needed with auxiliary information (phases)
Trip time	Display of the operate time related to the beginning of the fault (pickup start)
Fault distance	Display of the measured fault-location distance
Operate result indication	Display of the control or switching device triggered in a fault, with auxiliary information (phases) where necessary

Acknowledgment of the Spontaneous Fault Display on the Device

After faults, the last occurred fault is always displayed to you. In cases where more than one circuit breaker is configured, several stored fault displays can be present after faults, with the latest being displayed. These displays remain stored in the device until manual acknowledgment or release by LED reset.



[sc_stfanz, 1, en_US]

Figure 3-27 Spontaneous Fault Display on the Device

Method 1: Manual acknowledgment

- Press the softkey button **Quit** in the base bar of the display. The display is irretrievably closed. Repeat this step until no further spontaneous fault displays appear.
- After completion of all confirmations the last display view is showed before the faults.

Method 2: Acknowledgment via LED reset

- An LED reset (device) causes the reset of all stored LEDs and binary output contacts of the device and also to the confirmation of all fault displays stored in the display.

You can find more details on the topic of LED reset in chapter *3.1.9 Stored Indications in the SIPROTEC 5 Device*

3.1.9 Stored Indications in the SIPROTEC 5 Device

In your SIPROTEC 5 device, you can also configure indications as **stored**. This type of configuration can be used for LEDs as well as for output contacts. The configured output (LED or contact) is activated until it is acknowledged. Acknowledgment occurs via:

- On-site operation panel
- DIGSI 5
- Binary input
- Protocol of substation automation technology

Configuration of Stored Indications with DIGSI 5

In the **Information Routing** of each device set up in DIGSI 5, you can route binary signals, among others, to LEDs and output contacts.

- To do this, proceed in the project tree to:
  Project → Device → **Information routing**
- Right-click the routing field of your binary indication in the desired LED or binary output column in the routing range of the targets.

You are offered the following options:

Table 3-8 Overview of Routing Options

Routing Options		LEDs	BOs	BIs	Description
H	(active)			X	The signal is routed as active with voltage.
L	(active)			X	The signal is routed as active without voltage.
V	(unlatched)	X	X		The signal is routed as unlatched. Activation and reset of the output (LED, BO) occurs automatically via the binary-signal value.
G	(latched)	X	X		The binary signal is latched when the output (LED) is activated. To reset, a targeted confirmation must occur.

Routing Options		LEDs	BOs	BIs	Description
NT	(conditioned latching)	X			Fault indications are stored during control of the output (LED) as a function of the parameter **(_:91:139) Fault-display**. In the event of a new fault, the previously stored states are reset. • If the fault gets terminated via a trip command from the assigned circuit breaker, the status of an indication remains as latched with the setting option ***with trip***. Without a trip command, the status is displayed before the fault (if necessary, the status of the last fault) is restored. • With the setting option ***with pickup*** the current indication image of a pickup gets stored. The image comprises all indications of functions that are effective in the event of tripping on the same circuit breaker, like the picked up function.
TL	(stored only with tripping)		X		Routing option TL (tripping stored) is only possible for the switching object circuit breaker. The output is saved with protection tripping. The contact remains activated until acknowledged. Control commands are not affected. A control command is pending above the parameterized command period until feedback has been successfully received. **Note**: You can realize the functionality of the **Lockout** (ANSI 86) by storing the output relay with the routing option TL.

3.1.10 Application Mode/Test Mode and Influence of Indications on Substation Automation Technology

With the controllable *Application mode* = ***Test*** or ***Test/Relay blk.***, you switch on or off the test mode for the entire device.

For further information, refer to *11.2 Enabling/Disabling the Application/Test Mode for the Entire Device*.

If the test mode of the device or of individual functions is switched on, the SIPROTEC 5 device marks indications sent to substation automation technology station control system with an additional test bit. This test bit makes it possible to determine that an indication was set during a test.

3.1.11 Resetting Stored Indications of the Function Group

You can configure indications of individual functions as "stored" in a function group. This type of configuration can be used for LEDs as well as for output contacts. The configured output (LED or contact) is activated until it is acknowledged.

The protection and the circuit-breaker function groups contain the block **Reset LED FG**. The block **Reset LED FG** is visible only in the Information routing under the corresponding function group in DIGSI 5. You use the binary input signal *>Reset LED* to reset the stored LEDs in the respective function group. The configured outputs (contacts) are not reset.

3.2 Measured-Value Acquisition

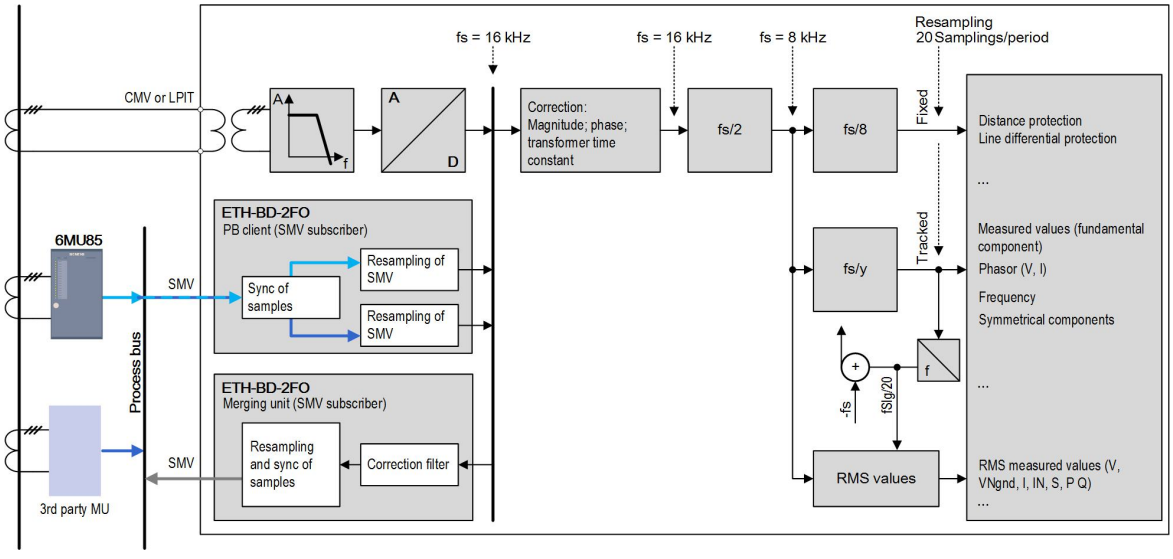
Basic Principle

SIPROTEC 5 devices are equipped with a powerful measured-value acquisition function. In addition to a high sampling frequency, they have a high measurand resolution. This ensures a high degree of measuring accuracy across a wide dynamic range. The 24-bit sigma/delta analog-digital converter represents the core of measured-value acquisition. In addition, the oversampling function supports the high measurand resolution. Depending on the requirements of the individual method of measurement, the sampling frequency is reduced (**Downsampling**).

In digital systems, deviations from the rated frequency lead to additional errors. In order to avoid this, 2 algorithm-dependent processes are used in all SIPROTEC 5 devices:

- Sampling-frequency tracking:
  The analog input channels are scanned for valid signals in cycles. The current power frequency is determined and the required sampling frequency is defined by using a **resampling algorithm**. The tracking is effective in the frequency range between 10 Hz and 90 Hz.
- Fixed sampling frequency – correction of the filter coefficients:
  This method operates in a limited frequency range (f_{rated} +/- 5 Hz). The power frequency is determined and, depending on the degree of the frequency deviation, the filter coefficients are corrected.

The following figure shows the basics of dealing with sampled values (SAV) in the measured-value acquisition chain. *Figure 3-28* shows to whom the various sampling frequencies are made available. In order to limit the bandwidth of the input signals, a low-pass filter (anti-aliasing filter to maintain the sampling theorem) is installed downstream. After sampling, the current input channels are adjusted. Meaning that magnitude, phase, and transformer time constant are corrected. The compensation is designed to ensure that the current transformer terminal blocks can be exchanged randomly between the devices.



[dw_meserf, 2, en_US]

Figure 3-28 Measured-Value Acquisition Chain

f_a	Sampling frequency
SMV	Sampled measured value
CMV	Conventional measured value
LPIT	Low-power instrument transformer

The internal sampling frequency of the SIPROTEC 5 devices is fixed at 16 kHz (sampling rate: 320 samplings per 50 Hz cycle). All current and voltage inputs are sampled. If magnitude, phase, and transformer time

constant are corrected, the sampling frequency is reduced to 8 kHz (160 samplings per 50-Hz cycle). This is the basic sampling frequency to which various processes, such as fault recording, RMS measured values, refer. For the RMS measurement, the measured-value window is adjusted on the basis of the power frequency. For numerous measurement and protection applications , 20 samplings per cycle are sufficient (if f_{rated} = 50 Hz): sampling every 1 ms, at f_{rated} = 60 Hz: sampling every 0.833 ms). This sampling rate is an adequate compromise between accuracy and the parallel processing of the functions (multi-functionality).

The 20 samplings per cycle will be made available to the algorithms processed in the function groups in 2 variants:

- Fixed (not resampled)
- Resampled (frequency range from 10 Hz to 90 Hz)

Depending on the algorithms (see function descriptions), the respective data flow is considered. A higher sampling frequency is used for selected methods of measurement. You can find detailed information in the corresponding function description.



NOTE

The **Power-system data** (starting in *6.1 Power-System Data*) contain the measuring points for current and voltage. Each measuring point has its own parameters.

3.3 Sampling-Frequency Tracking and Frequency Tracking Groups

3.3.1 Overview

Starting from platform version V07.80, you can merge measuring points into **Frequency tracking groups** in SIPROTEC 5 devices. The device operates with a maximum of 6 **Frequency tracking groups**.

The chapter *3.3.2 Sampling-Frequency Tracking* provides the necessary hints on the operating principle of sampling-frequency tracking and its application.

The chapter *3.3.3 Frequency Tracking Groups* describes the principle and application of frequency tracking groups.

3.3.2 Sampling-Frequency Tracking

SIPROTEC 5 devices are equipped with powerful sampling-frequency tracking as explained in *3.2 Measured-Value Acquisition* . This ensures high measuring accuracy over a wide frequency operating range (10 Hz to 90 Hz).

To determine the actual sampling frequency, the voltage and current measuring points are checked for valid input signals, the actual power frequency is determined and the tracking frequency (sampling frequency = 20 · tracking frequency) is adapted. The method is implemented in such a way that the number of samplings per actual power frequency or the frequency of the system is always constant. The number of samplings is 20 per cycle, as described in *3.2 Measured-Value Acquisition* .

During engineering, you set the parameters specifying which measuring points are used for frequency tracking. All 3-phase voltage and current measuring points and 1-phase voltage and current measuring points are allowed.



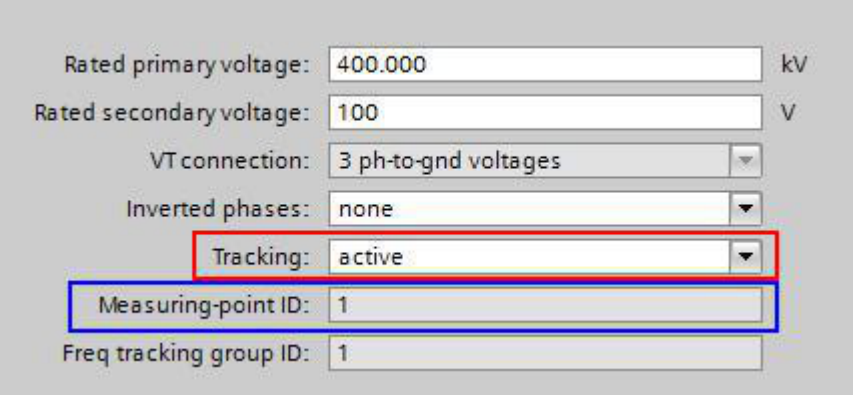
NOTE

Using a measuring point for sampling-frequency tracking requires this measuring point to be suitable for reliably determining the power frequency. This is the case, as long as the measuring point has been connected to the power system and the rated voltages and currents are measured. If the measured values for the rated voltages and currents are unavailable, sampling-frequency tracking must be switched off for this measuring point.

Examples of these kind of conditions are as follows:

- 1-phase measuring points: Measuring points that measure zero-sequence voltages or zero-sequence currents must not be used for frequency tracking.
- 3-phase measuring points: Measuring points that measure unbalanced currents and voltages for a capacitor bank must not be used for frequency tracking.

The following figure shows where you set the parameters for the corresponding measuring point and activate sampling-frequency tracking in the DIGSI 5 project tree under **Settings** → **Power-system data**.



[sc_MP_Powersys trackfreq, 1, en_US]

Figure 3-29 Using the Measuring Point to Determine the Sampling Frequency

If the parameter **Tracking** = ***active***, the measuring point is used to determine the actual tracking frequency. If the parameter **Tracking** is set to ***active*** for several measuring points, the ID of the measuring point determines the sequence in which these are checked for valid input signals. The algorithm starts with the lowest ID number, as follows:

- First, the 3-phase measuring points are scanned. If no valid voltage is found, the selected current measuring points are next. In this case, the following sequence applies:

  3-phase voltage measuring point → 3-phase current measuring point → 1-phase voltage measuring point → 1-phase current measuring point

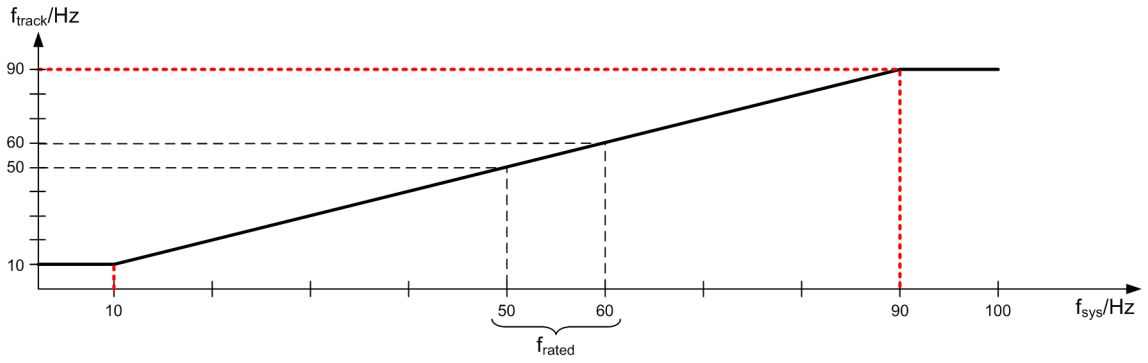
  If a trigger signal comes from a current measuring point, the voltage measuring points are still continuously scanned for valid voltages and switched immediately if a voltage is found.
- If the true RMS value is greater than 2.5 % of the set secondary device rated value, a measuring point is valid. For example, this is 2.5 V at 100 V, 25 mA at 1 A or 125 mA at 5 A.
- A 3-phase measuring point is scanned in the sequence of phase A → phase B → phase C.
  In the case of the voltage measuring points, the phase-to-phase voltage V_{AB}, V_{BC}, and V_{CA} is always used for evaluation. The phase-to-phase voltage is calculated in the event of a phase-to-ground connection.
- The tracking frequency is tracked using different interval steps. If the tracking frequency deviates only slightly from the measured frequency, the frequency is tracked using small steps of 0.010 Hz. In the case of greater deviations, the interval is 1 Hz. To react faster in the event of larger deviations, for example in switchover conditions, tracking occurs in 5-Hz steps. When switching on measurands immediately the measured tracking frequency is used.
- If no tracking frequency can be determined, the appropriate rated frequency of the electrical power system is used as the tracking frequency. This case occurs before the measurands are switched on, after they are switched off or when the device is powered on. If the measurands are switched on, the starting frequency is the set power frequency, for example 50 Hz or 60 Hz. Since rated-frequency input variables can be assumed for most applications, the measuring algorithms start with the fixed sampling frequency, for example, 1 kHz for 50 Hz and 1.2 kHz for 60 Hz.

Figure 3-30 shows the behavior of sampling-frequency tracking across the frequency band and at the frequency limits.

The x-axis shows the actual power frequency (f_{sys}) and the y-axis shows the set tracking frequency (f_{track}). Between 10 Hz and 90 Hz, the relationship is linear. If the actual power frequency is less than 10 Hz, the tracking frequency is kept at 10 Hz. In this case, sampling occurs at 20 · 10 Hz = 200 Hz. If the power frequency is greater than 90 Hz, the tracking frequency is kept constant at 90 Hz.

If the frequency is outside the frequency operating range (10 Hz to 90 Hz), frequency tracking generates the indication ***Freq. out of range***. The individual protection functions evaluate this indication. If an overfunction can occur, the protection functions are blocked internally to avoid a failure.

You can find more detailed information on the behavior of the protection functions in *12 Technical Data*.



[dw_working-area_sampling-frequency-tracking, 2, en_US]

Figure 3-30 Operating Range of Sampling-Frequency Tracking

Siemens recommends routing the calculated power frequency (f_{sys}) and the determined tracking frequency (f_{track}) as a measured value trace in the fault record. In this way, you can document the behavior of the device in transient conditions. The following figure shows that you find the both measured values in the information routing under **Power-system data → General**:

Information			S	Destination		
			BO	LED	Recorder	
Signals	Number	Type				Signal
(All)	(All)	...				(All)
General	91					
Device	4171					
Alarm handling	5971					
Time managem.	8821					
Time sync.	8851					
Res. bin. out.	4711					
LED not in FG	7411					
Power system	11					*
General	11.2311					*
>Phs-rotation reversal	11.2311.500	SPS				
>Invert Phases	11.2311.501	SPS				
Phase sequence ABC	11.2311.319	SPS				
Phase sequence ACB	11.2311.320	SPS				
Freq.out of oper.range	11.2311.321	SPS				
f sys	11.2311.322	MV				X
f track	11.2311.323	MV				X

[sc_rout meas freq, 1, en_US]

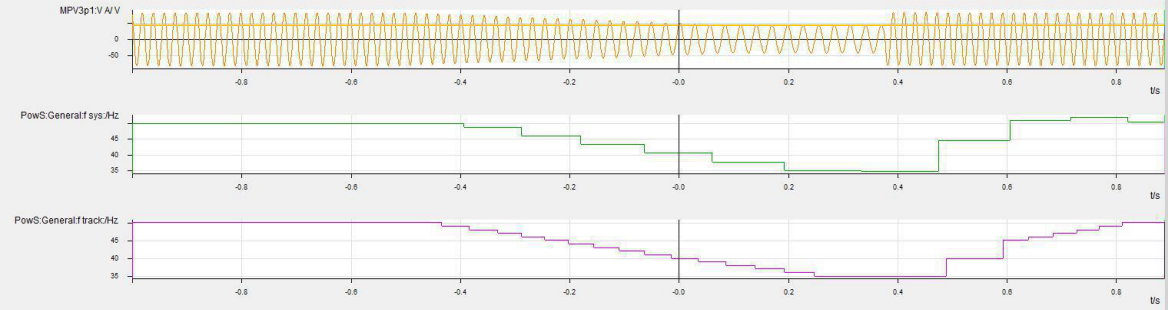
Figure 3-31 Routing of the Frequency Measured Values

EXAMPLE:

Figure 3-32 shows the behavior of sampling-frequency tracking using an example.

The voltage was reduced linearly from 57.7 V (100 V phase-to-phase) to 35 V (60.6 V phase-to-phase) and, at the same time, the frequency was reduced from 50 Hz to 35 Hz, for example motor coasting down. Then, an abrupt switch to the rated values of 57.7 V at 50 Hz was made.

The upper trace shows the power-system voltage on 1 phase (A) as an example. The center trace is the calculated power frequency and the lower trace is the determined tracking frequency. If you multiply the determined tracking frequency of the lower trace by 20, you can determine the sampling frequency.



[sc_example freqtrack, 1, en_US]

Figure 3-32 Example of Frequency Tracking and Reaction to a Step Change in the Input Variable

3.3.3 Frequency Tracking Groups

In the SIPROTEC 5 devices before platform version V07.80, sampling-frequency tracking applies to the entire device. This means that the 1st valid measuring point, for example, a 3-phase voltage measuring point, determines the selected tracking frequency based on the detected frequency.

If all measuring points in a system are galvanically coupled to each other, the power frequency is identical for all measuring points.

There are problems with electrical power system states or system states where galvanic separation is possible and measuring points of the separated system parts are connected to the SIPROTEC 5 device. For these problematic electrical power system states or system states, different frequencies are possible for a limited time. Depending on the measuring point set for tracking, the device selects which frequency to use. As a result, measuring errors and a failure of protection functions are possible.

Starting with platform version V7.80, you can assign the measuring points to different frequency tracking groups. This ensures high flexibility and high measuring accuracy for a variety of applications. In this case, every frequency tracking group specifies its own sampling frequency. In the case of galvanic separation and different system frequencies, different sampling frequencies arise as a result. This occurs temporarily in systems with rotating machines, for example. A way to achieve galvanic separation is to use an open circuit breaker.

NOTE

In the measured-value acquisition chain in *Figure 3-28* in the chapter *3.2 Measured-Value Acquisition* , only the data stream designated as tracked is adapted. The data stream represented as fixed derives its sampling frequency exclusively from the set rated frequency. In this case, the constant sampling frequency of 1 kHz at f_{rated} = 50 Hz and 1.2 kHz at f_{rated} = 60 Hz is used. This applies to every measuring point, regardless of the frequency tracking group to which it is assigned.

EXAMPLE:

Figure 3-33 shows an example for the necessity of frequency tracking groups. The generator circuit breaker (GCB) and the high-voltage circuit breaker (HVCB) are the galvanic disconnection points. In this way, different switching states are possible. The device uses current measuring points (CTs 1 to 6) and voltage measuring points (VTs 1 to 4) located on different sides of the circuit breakers. In addition, it is assumed that the generator is started using a starting-frequency converter. In a gas-turbine application, the starting-frequency converter accelerates the generator from 0 Hz to about 70 % of the rated speed (roughly 35 Hz at f_{rated} = 50 Hz). After this, the gas turbine is fired up and brings the generator to the rated speed. Then, the voltage is built up to the rated voltage and synchronized. During this start-up operation, the GCB is open and the HVCB is closed. As a result, the measuring points VT 1, CTs 1, 2, 4 have a frequency that deviates from

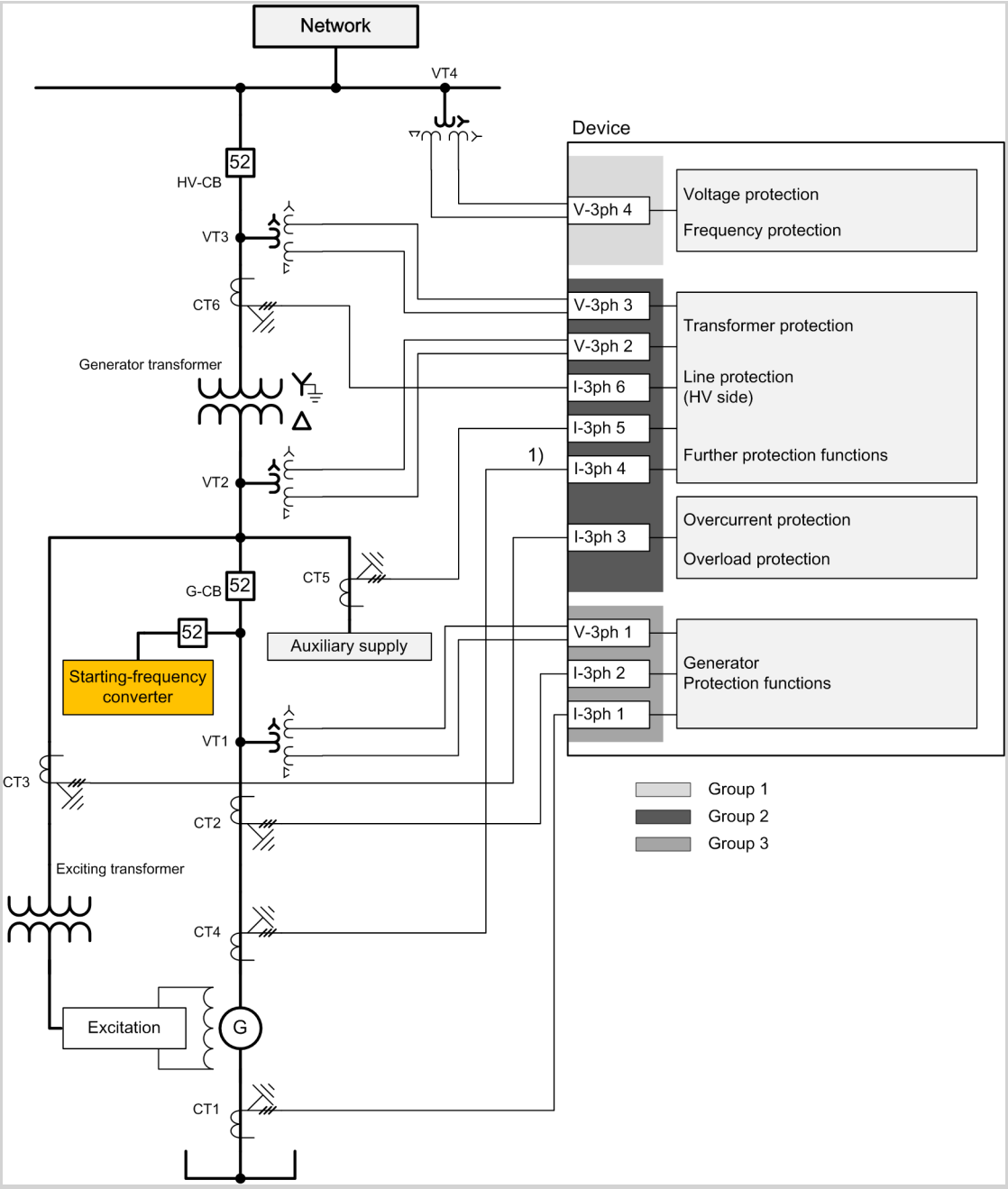
the other measuring points during start-up operation. The other measuring points are usually at the rated frequency due of the connection to the power system.

Furthermore, protection tripping can result in a switching state where the HVCB is open and the GCB remains closed. In this case, the generator and a generator transformer can assume a frequency that deviates from the power frequency. In the event of load shedding, the generator accelerates before the speed controller intervenes. This is particularly pronounced in hydro generators.

An evaluation of the individual scenarios shows that different frequencies can occur at the different measuring points for a limited time. For this reason, 3 frequency tracking groups are necessary in this example. These groups are marked with different colors in the following figure.

NOTE

The measuring point (CT 4) marked with 1) in the following figure will be discussed later.



[dw_example_frequency-tracking-groups, 1, en_US]

Figure 3-33 Example of the Necessity of Frequency Tracking Groups

To strike a balance between application flexibility and the required computing power, the number of additional frequency tracking groups was limited to 5. Together with the basic functionality, a total of 6 frequency tracking groups are possible.

If you wish to use frequency tracking groups, use the following engineering recommendations. Before starting work, make sure you know how many frequency tracking groups are needed. Select only the required number.

If you start with an application template that you have expanded by the necessary measuring points, you must load the necessary number of additional frequency tracking groups from the Global DIGSI 5 Library into the **Power system** folder.



[sc_loading freq group, 1, en_US]

Figure 3-34 Loading the Required Frequency Tracking Groups

If you instantiate an additional frequency tracking group, the system automatically assigns the ID of the frequency tracking group in DIGSI using consecutive numbers. As the device already has 1 frequency tracking group, the ID numbering for additional frequency tracking groups starts with 2.



[sc_ID freqgroup, 1, en_US]

Figure 3-35 ID of the Frequency Tracking Group

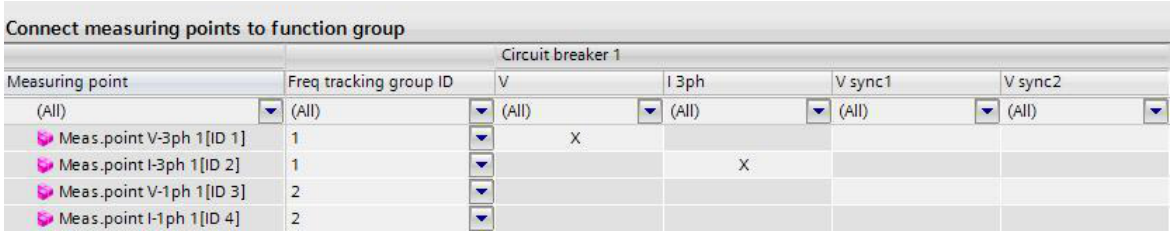
NOTE

If you have activated several frequency tracking groups during engineering and you then delete a frequency tracking group again later, the assigned ID is also deleted. All other frequency tracking groups retain their assigned IDs.

Try to avoid discontinuities by deleting the frequency tracking group with the highest ID if possible.

You will find the frequency measured values and the indications of the corresponding frequency tracking group in the routing matrix (see *Figure 3-31*).

Assign the measuring points to the frequency tracking groups in the **Function-group connections** Editor. As soon as you have instantiated another frequency tracking group from the Global DIGSI 5 Library, the additional column **Frequency tracking group ID** appears in the routing matrix. In this column, you select the number of the corresponding frequency tracking group for each measuring point using the list box.



[sc_routing MP to freqgroup, 1, en_US]

Figure 3-36 Assignment of the Measuring Point to the Frequency Tracking Group

NOTE

Keep the following in mind when assigning the measuring points to the frequency tracking groups:

- The function groups (FGs) can operate only with 1 frequency tracking group.
- This applies also to interconnections between the function groups as for the **Transformer differential protection**.

  In the case of the **Transformer differential protection**, the **Transformer side** FG is interconnected with the **Transformer** FG and all **Transformer side** FGs of one transformer must operate in the same frequency tracking group.

  The same applies when the neutral-point current is measured using a 1-phase function group.

There are also exceptions such as the FG **Circuit breaker** (see chapter *5.9 Function-Group Type Circuit Breaker*). The voltage measured values are processed by the **Synchronization function** which operates only with a fixed sampling frequency. In this way, voltage measuring points from different frequency tracking groups can be connected.

The cited rules are checked using scripts and infractions reported during engineering.

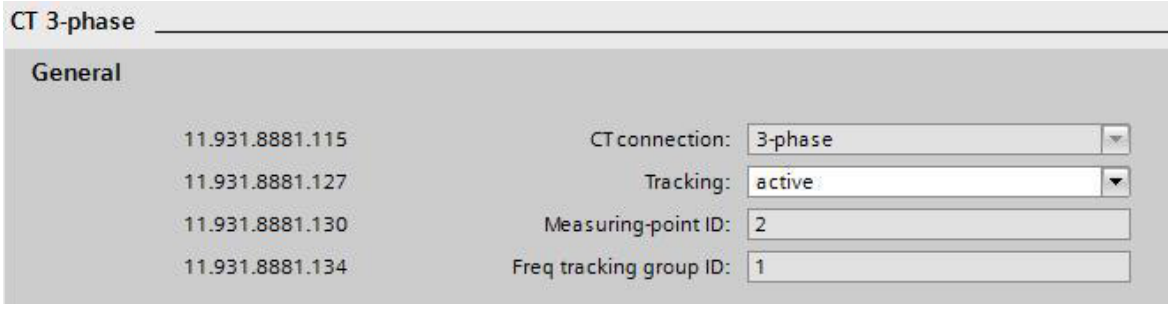
Now, you can select the measuring points to be used to determine the tracking frequency for the appropriate frequency tracking group as explained in chapter *3.3.2 Sampling-Frequency Tracking*. If possible, use at least 1 voltage measuring point and 1 current measuring point. Give preference to 3-phase measuring points.

When the tracking frequency has been determined, all measuring points of the frequency tracking group are set to this frequency and the tracked sampling frequency is adapted.

NOTE

As described in the chapter *3.2 Measured-Value Acquisition* , the measured-value current with fixed sampling frequency is unaffected by this.

To avoid errors, the ID of the measuring point and the ID of the assigned frequency tracking group are displayed in the setting sheet of the measuring points in DIGSI 5 (see *Figure 3-37*).



[sc_MP additional setting freqgroup, 1, en_US]

Figure 3-37 Example: Settings of the 3-Phase Current Measuring Point; Additional Display of the ID for the Frequency Tracking Group

In addition, the ID of the frequency tracking group is displayed in the function group in the **General** block (see *Figure 3-38*). Here, you can also check the consistency.

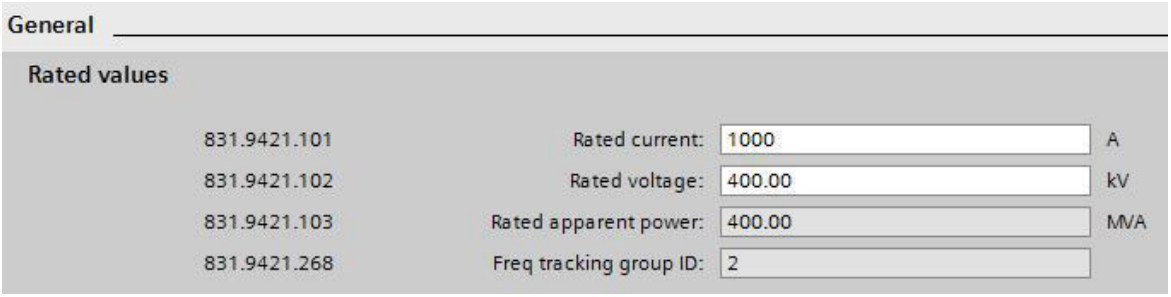


Figure 3-38 Display of the ID for the Frequency Tracking Group in the Block **General** of the Function Group

A special feature is explained using *Figure 3-33* as an example.

The measuring point marked in *Figure 3-33* with **1)** uses a current transformer that is located on the generator side but is used by the transformer differential protection. As a result, this current transformer must be assigned to the frequency tracking group 2 in accordance with the rules above. Since the generator is started using a starting-frequency converter in the application example, the frequency at this measuring point deviates from the frequency at the other measuring points of group 2. For this reason, the measuring point with CT 4 must **not** be used to determine the tracking frequency.

Depending on the application, the current of the CT 4 acts as a disturbance variable when forming the Kirchhoff's current law. As a rule, this current is not particularly strong (< 15 % of I_{rated}) so that the disturbance effect remains small. If required, you must set the differential protection to be less sensitive. Decide this for the specific application.

The following table shows the possible assignment of measuring points used to determine the tracked sampling frequency for the example. For this purpose, the parameter **`Tracking`** = ***`active`*** in the corresponding measuring point:

Frequency Tracking Group	1	2	3
Recommended measuring points for tracking	VT 4	VT 3 VT 2 CT 5	VT 1 CT 1

3.3.4 Frequency Tracking Groups – Interpretation of Measured Values

If you use frequency tracking groups, you must keep in mind special features when interpreting the measured values. The measuring points of a frequency tracking group are to be treated as decoupled for measurement purposes. This means that the complex measured values of a single function group, like phasor measured values, always match. Since phase A of the 1st measuring point is always assumed to be the reference value when representing the measured value, the phasor measured values cannot be compared between frequency tracking groups. This also applies if all measuring points are galvanically connected to one another.

NOTE

When selecting the reference variable, a voltage measuring point always takes precedence over a current measuring point. If the frequency tracking group does not contain a voltage measuring point, the 1st current measuring point is used.

EXAMPLE:

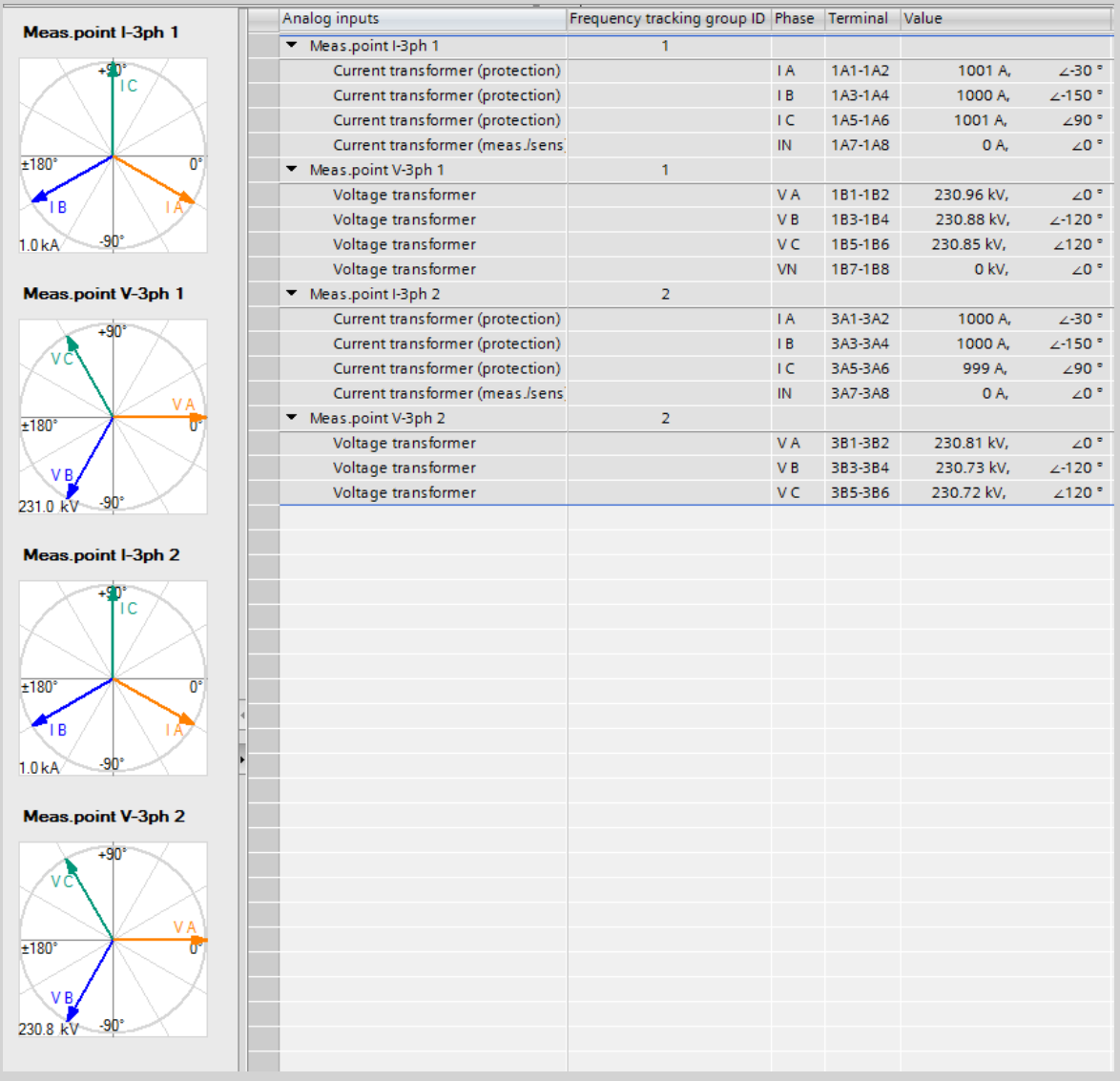
Figure 3-39 shows an example of the phasor representation of the analog measured values of the measuring points.

The phasor representation of the analog measured values of the measuring points can be found in the DIGSI 5 project tree under **Online access** → **Device** → **Test suite** → **Analog inputs**.

Each of the 2 frequency tracking groups contains one 3-phase voltage measuring point **V-3ph** and one 3-phase current measuring point **I-3ph**.

Frequency tracking group **1** contains the measuring points **V-3ph 1** and **I-3ph 1**, frequency tracking group **2** contains the measuring points **V-3ph 2** and **I-3ph 2**. The frequencies between the frequency tracking groups differ by 0.5 Hz. A phase displacement of -30° is set between the voltage and the current.

In *Figure 3-39*, you can see that the fundamental RMS measured values are identical. The phasor measured angles are shown as decoupled (see Phase angle). In this case, V_A is the reference value in the corresponding frequency tracking group. With decoupled sampling-frequency tracking, the measurement of the measurands is exact, even with a different system frequency.



Analog inputs	Frequency tracking group ID	Phase	Terminal	Value	
Meas.point I-3ph 1	1				
Current transformer (protection)		I A	1A1-1A2	1001 A,	∠-30 °
Current transformer (protection)		I B	1A3-1A4	1000 A,	∠-150 °
Current transformer (protection)		I C	1A5-1A6	1001 A,	∠90 °
Current transformer (meas./sens		IN	1A7-1A8	0 A,	∠0 °
Meas.point V-3ph 1	1				
Voltage transformer		V A	1B1-1B2	230.96 kV,	∠0 °
Voltage transformer		V B	1B3-1B4	230.88 kV,	∠-120 °
Voltage transformer		V C	1B5-1B6	230.85 kV,	∠120 °
Voltage transformer		VN	1B7-1B8	0 kV,	∠0 °
Meas.point I-3ph 2	2				
Current transformer (protection)		I A	3A1-3A2	1000 A,	∠-30 °
Current transformer (protection)		I B	3A3-3A4	1000 A,	∠-150 °
Current transformer (protection)		I C	3A5-3A6	999 A,	∠90 °
Current transformer (meas./sens		IN	3A7-3A8	0 A,	∠0 °
Meas.point V-3ph 2	2				
Voltage transformer		V A	3B1-3B2	230.81 kV,	∠0 °
Voltage transformer		V B	3B3-3B4	230.73 kV,	∠-120 °
Voltage transformer		V C	3B5-3B6	230.72 kV,	∠120 °

[sc_measured_val_DIGSI, 1, en_US]

Figure 3-39 DIGSI Online Mode: Phasor Representation of the Measuring Points with 2 Frequency Tracking Groups and a Different Frequency

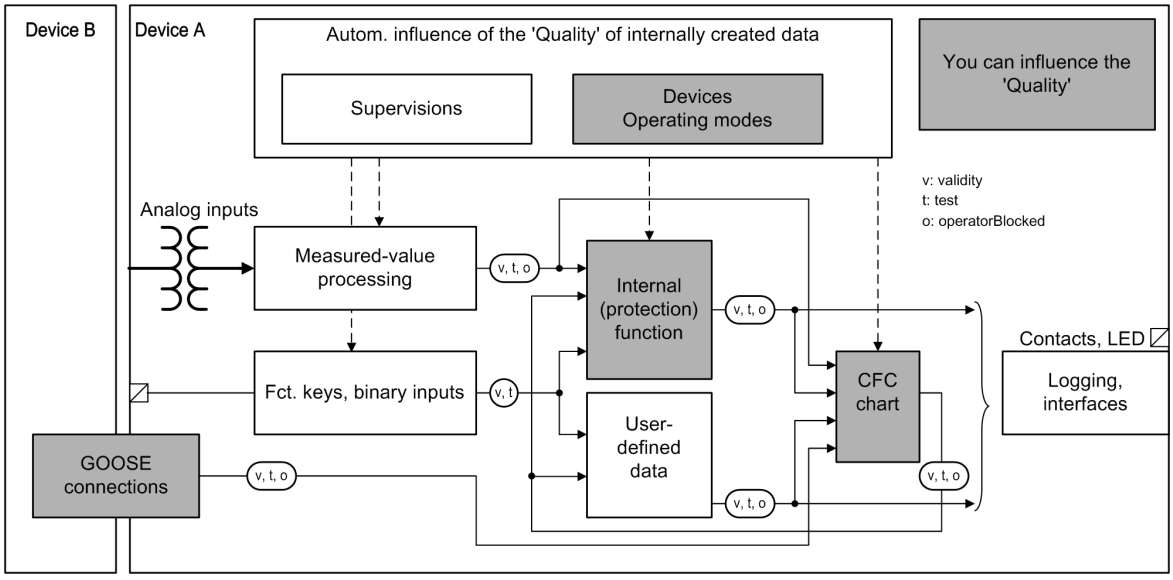
If the circuit breaker in a system is closed, the measuring points are galvanically connected to one another. If you want to compare the phasor variables of all measuring points to one another when using frequency tracking groups, Siemens recommends starting a fault record. Evaluate the fault record using SIGRA in the **Phasor representation** mode. The comparison is possible here because sampled values that are not frequency-tracked are used in the fault record. If the frequency deviates from the rated frequency, the measured values differ slightly.

3.4 Processing Quality Attributes

3.4.1 Overview

The IEC 61850 standard defines certain quality attributes for data objects (DO), the so-called Quality. The SIPROTEC 5 system automatically processes some of these quality attributes. In order to handle different applications, you can influence certain quality attributes and also the values of the data objects depending on these quality attributes. This is how you can ensure the necessary functionality.

The following figure describes roughly the general data flow within a SIPROTEC 5 device. The following figure also shows at which points the quality can be influenced. The building blocks presented in the figure are described in more detail in the following.



[lo_quali1, 2, en_US]

Figure 3-40 Data Flow within a SIPROTEC 5 Device

Supported Quality Attributes

The following quality attributes are automatically processed within the SIPROTEC 5 system.

- **Validity** using the values *good* or *invalid*

  The **Validity** quality attribute shows if an object transferred via a GOOSE message is received (valid, invalid) or not received (invalid). The *invalid* state can be suppressed in the receiver device by also setting a substitute value for the object that is not received (see *3.4.2 Quality Processing/Affected by the User for Received GOOSE Values*). The substitute value is forwarded to the functions.

  If the device receives one of these values, it is replaced by the *invalid* value and thus processed further as *invalid*.

  If one of the detailed quality attributes (detailQual) has the value *TRUE*, then **Validity** is set to the *invalid* value, unless this was already done at the transmitter end.

- **Test** using the values *TRUE*, *FALSE*

  The **Test** quality attribute indicates to the receiver device that the object received via a GOOSE message was created under test conditions and not operating conditions.

- **OperatorBlocked** using the values *TRUE*, *FALSE*

  The **OperatorBlocked** quality attribute indicates whether an object transferred via GOOSE message originates from a device that is in a *functional logoff* state. When the sending device is switched off, the object is no longer being received and assumes the *invalid* state. However, since the **OperatorBlocked** quality was previously identified on the receiver device, the object can be treated differently at the receiving end (see *3.4.2 Quality Processing/Affected by the User for Received GOOSE Values*). At the receiving end, the object may be treated like a dropped signal.

- **Source** using the values *process*, *substituted*

  The **Source** quality attribute indicates whether the object was updated in the sending device.

  You can find more detailed information in *3.9.2 Acquisition Blocking and Manual Updating*.

Influencing Quality by the Operating Modes

In addition to the normal operation, the device also supports further operating modes that influence quality:

- **Test mode of the device**

  You can switch the entire device to test mode. In this case, all data objects generated in the device (state values and measured values) receive the quality attribute **Test** = *TRUE*.

  The CFC charts are also in test mode and all output data receive the quality attribute **Test** = *TRUE*.

- **Test mode for individual functions, stages, or function blocks**

  You can switch individual functions, stages, or function blocks into test mode. In this case, all data objects generated by the function, stage, or function block (state values and measured values) receive the quality attribute **Test** = *True*.

- **Functional logoff of the device**

  If you take the device out of operation and want to isolate it from the supply voltage, you can functionally log off the device ahead of time. Once you functionally log off the device, all data objects generated in the device (state values and measured values) receive the quality attribute **OperatorBlocked** = *TRUE*. This also applies to the output from CFC charts.

  If objects are transferred via a GOOSE message, the receiver devices can assess the quality. The receiver device detects a functional logoff of the transmitting device. After shutting down the sending device, the receiver device identifies that the sending device has been logged off operationally and did not fail. Now the receiving objects can automatically be set to defined states (see chapter *3.4.2 Quality Processing/Affected by the User for Received GOOSE Values*).

- **Switching off individual functions, stages, or function blocks**

  You can switch off individual functions, stages, or function blocks. In this case, all data objects generated by the function, stage, or function block (state values or measured values) receive the device-internal quality attribute **Off**. The states of the inputs and measured values remain unchanged in this case; input changes are not processed. As the quality attribute **Off** is not provided for in communication protocol IEC 61850, the data objects are transferred with the quality attribute *Invalid*.

Influencing the Quality through Hardware Supervision

Supervision functions monitor the device hardware (see *8.4 Supervision of the Device Hardware*). If the supervision functions identify failures in the data acquisition of the device, then all recorded data will receive the quality attribute **Validity** = *invalid*.

Influencing the Quality through Voltage-Transformer Circuit Breakers

If tripping of the voltage-transformer circuit breaker is detected (see *8.3.4 Voltage-Transformer Circuit Breaker*), all recorded data will receive the quality attribute **Validity** = *invalid*.

Influencing the Quality by the User

You can influence the processing of data and their quality differently. In DIGSI 5, this is possible at the following 3 locations:

- In the **Information routing** editor for external signals from GOOSE connections
- In the CFC chart
- In the **Information routing** editor for binary input signals of device-internal functions

The following chapters describe in more detail the options regarding this influence as well as the automatic quality processing.

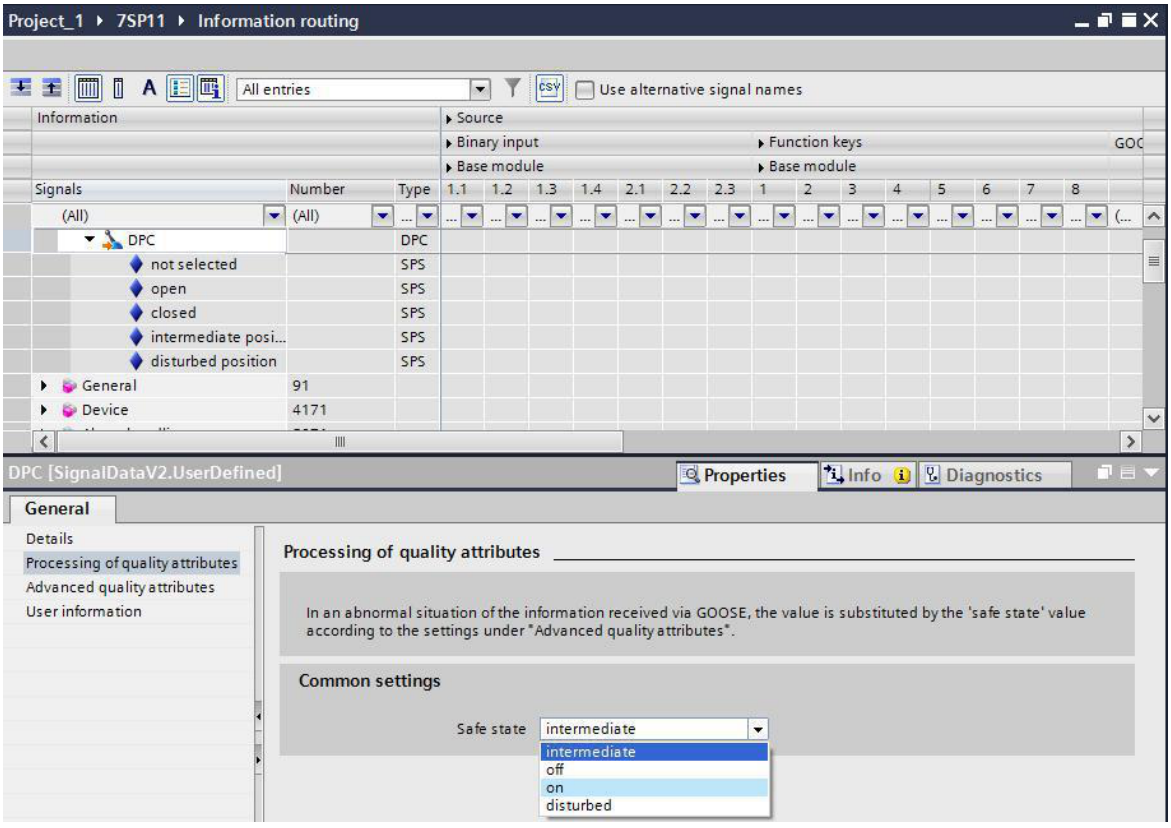
If a GOOSE connection is the data source of a binary input signal of a device-internal function, you can influence processing of the quality at 2 locations: at the GOOSE connection and at the input signal of the function. This is based on the following: A GOOSE date can be distributed within the receiving device to several functions. The GOOSE connection setting (influence) affects all functions. However, if different functions require customized settings, these are then set directly at the binary input signal of the function.

3.4.2 Quality Processing/Affected by the User for Received GOOSE Values

The properties of quality processing have changed with the introduction of GOOSE Later Binding. You can find information about the former quality processing in *Previous Quality Processing/Affected by the User for Received GOOSE Values, Page 122*.

In the **Information Routing** Editor, you can influence the data value and quality of all data types. The following figure shows the possible influence using the example of a DPC data type. All setting options are effective for the device receiving the data.

- In the DIGSI 5 project tree, double-click **Information Routing**.
- Select either the desired signal in the **External Signals** group or the signal of a function activated via the GOOSE column.
- Open the **Properties** window and select the **Processing Quality Attributes** sheet.



[sc_LB_GOOSE_2, 2, en_US]

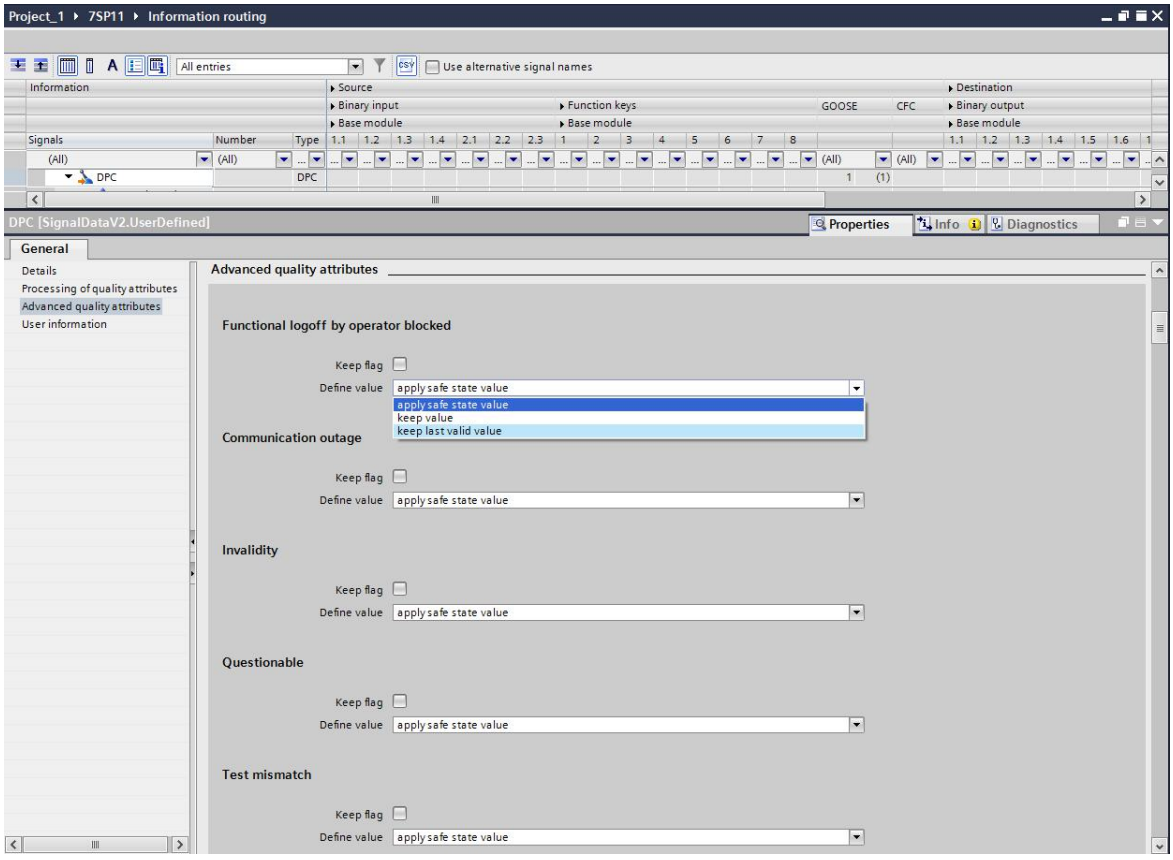
Figure 3-41 Influence Option When Linking a DPC Type Data Object

Depending on the selected data type of the object, various selection options are offered to you for the **Safe state** item in the **Common settings** section. At this point, you select the manually updated values that allow a safe operating state as soon as the data access via the communication path is disturbed.

- Select the property for the selected data object.

You can also set the **Advanced quality attributes** of the data object for GOOSE Later Binding.
The following figure shows the advanced quality attributes using the example of a DPC data type.

- Open the **Properties** window and select the **Advanced quality attributes** sheet.



[sc_LB_GOOSE_1, 2, en_US]

Figure 3-42 Advanced Quality Attributes for GOOSE Later Binding

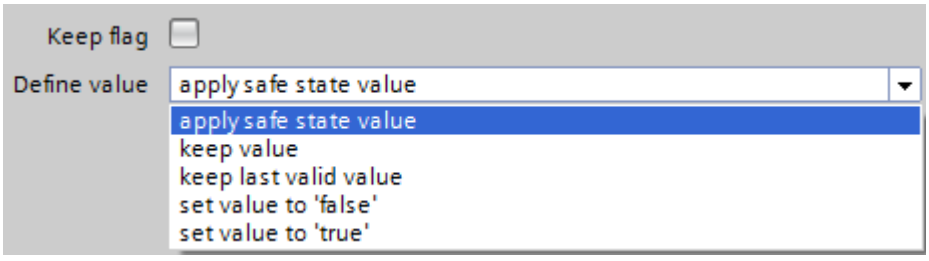
With the following advanced quality attributes, you can filter the transmitted GOOSE indications and check and set their quality. The values that have been adapted, if necessary, are forwarded to the receiver.

For the tests, you can select from the following setting options depending on the data type.

Table 3-9 Value Definitions

Setting Value	Description
Apply safe state value	The value configured in the **Safe state** is forwarded as valid to the application as soon as communication disturbance occurs.
Keep value	The disturbed quality attribute is overwritten with *good* and the received value is forwarded as valid to the application. If no value was received, the output value is assumed being in safe state.
Keep last valid value	If an invalid quality attribute is received, the last valid value is forwarded to the application. If no value has yet been received, the output value is assumed being in safe state.
Set value to "false"	Applies only to Boolean communication objects. Every invalid quality attribute causes the valid value *false* to be forwarded to the application.
Set value to "true"	Applies only to Boolean communication objects. Every invalid quality attribute causes the valid value *true* to be forwarded to the application.

These settings of the **Advanced quality attributes** apply to the advanced quality attributes listed below. The selection can vary depending on the data type.



[sc_LB_GOOSE_3, 2, en_US]

Figure 3-43 Value Definition of a Data Object of the SPS Type

You can also forward the quality attributes unchanged. To do this, you must mark the **Keep flag** check box.

NOTE

By default, the ***Keep flag*** checkbox is disabled when the signal is routed to the LED or the binary output.

Functional Logoff by Operator Blocked

You have set the *Operation mode* to *Device logoff* = *true* in the transmitting device. As a result, every indication issued from the functions and subject to *Device logoff* is transmitted with the quality information *operator blocked* and **Validity** = *good*. The receiver recognizes this for this indication and reacts according to the settings (*Table 3-9*). A different quality processing can take place only once you have set the *Operation mode* to *Device logoff* = *false* in the transmitting device.

Communication Outage

There is communication disturbance (time allowed to live) between the transmitter and the receiver indicated by the transmitter. The indication is set in accordance with the settings (*Table 3-9*).

Invalidity

The transmitting device sends this indication with the quality information **Validity** = *invalid*. The receiver recognizes this for this indication and reacts according to the settings (*Table 3-9*).

Questionable

The transmitting device sends this indication with the quality information **Validity** = *questionable*. The receiver recognizes this for this indication and reacts according to the settings (*Table 3-9*).

Test Mismatch

The transmitting device or the function in the transmitting device that issues this indication is in test mode. As a result, the indication is transmitted with the quality information *test*. The receiving function block recognizes this for this indication and reacts, depending on its own test-mode state (specified in IEC 61850-7-4 Annex A), according to the settings (*Table 3-9*).

NOTE

Follow the sequence of tests. First, the **Functional logoff by operator blocked** is tested. Then comes **Communication outage** and so on. If a case is recognized as *active*, the test chain is canceled with the configured setting for the active case.

In the case of **Invalidity**, the tests are first performed for **Functional logoff by operator blocked** (not applicable) and then for **Communication outage** (not applicable) and canceled with the configured action for **Invalidity**.

If an indication is routed into the log, manual updating of a value is also logged based on the conditions listed above and on the reason for the manual update. Manually updating a value based on the conditions listed

above causes a change in the *Health Warning* function block, inherited up to *Device health* (specified in IEC 61850-7-4).

Keep Flag

The quality attributes and values indicated by the transmitter are accepted without change. Quality processing must be performed by the user via a logic diagram. The outputs of the logic diagram following the user-specific quality processing can be connected to the function-block inputs as before.

Data Substitute Values

Depending on the data type, different data substitute values must be used.

Data Type	Possible Data Substitute Values	
ACD, ACT	general	0 (False), 1 (True) The directional information is manually updated with *unknown* if the option ***Apply safe state value***, ***Set value to "false"***, and ***Set value to "true"*** are selected; or maintain the received value with the options ***Keep value*** or ***Keep last valid value*** selected. PhsA, phsB, phsC, and neut are manually updated with the same value just like how the general value is set.)
BAC, APC	mxVal	Floating-point range and range of values according to IEEE 754 (single precision)
BCR	actVal	-2^{63} to $2^{63} - 1$
CMV	mag, ang	Floating-point range and range of values according to IEEE 754 (single precision)
DPC, DPS	stVal	0, 1, 2, 3 (intermediate-state, off, on, bad-state)
INC	stVal	–2 147 483 648 to 2 147 483 647
INS	stVal	–2 147 483 648 to 2 147 483 647
ISC, BSC	valWTr.posVal	–64 to 64
	valWTr.transInd	0 (False), 1 (True)
SPC, SPS	stVal	0 (False), 1 (True)
MV	mag	Floating-point range and range of values according to IEEE 754 (single precision)

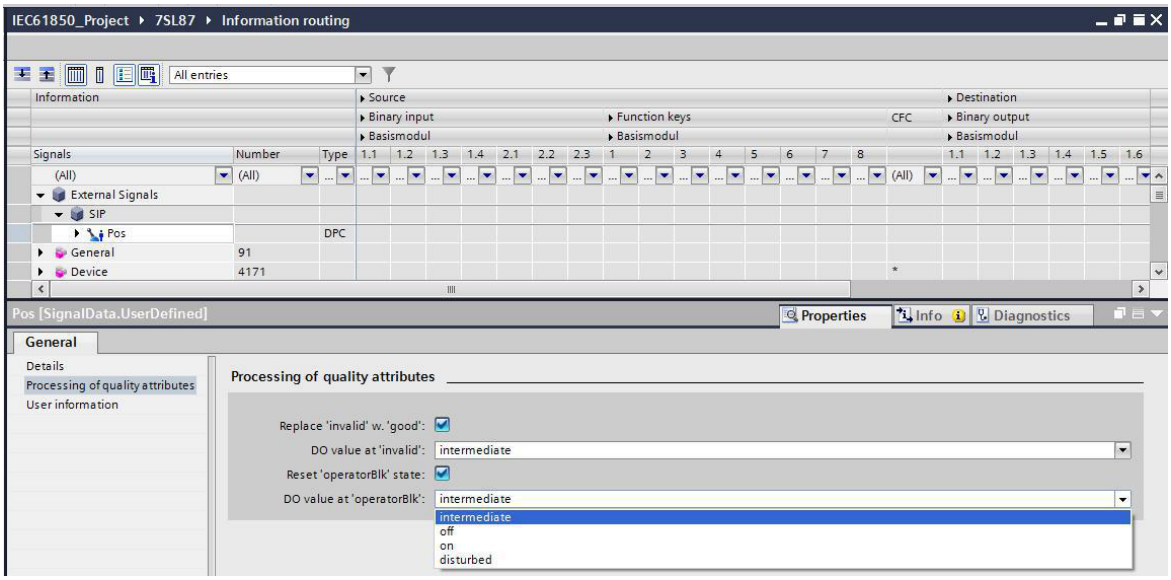
For controllable types, the following substitute values apply in addition to the settable state values or measured values:

ctlNum	=	0
stSeld	=	False
origin.orIdent	=	Substituted by quality processing
origin.orCat	=	AUTOMATIC_BAY

Previous Quality Processing/Affected by the User for Received GOOSE Values

In the **Information Routing** editor, you can influence the data value and quality of all data types. The following figure shows the possible influence using the example of a DPC data type.

- In the DIGSI 5 project tree, double-click **Information Routing**.
- Select the desired signal in the **External Signals** group.
- Open the **Properties** window and select the **Processing Quality Attributes** sheet.



[sc_GOOSE values, 1, en_US]

Figure 3-44 Influence Option When Linking a DPC Type Data Object

The setting options work for the device receiving the data.

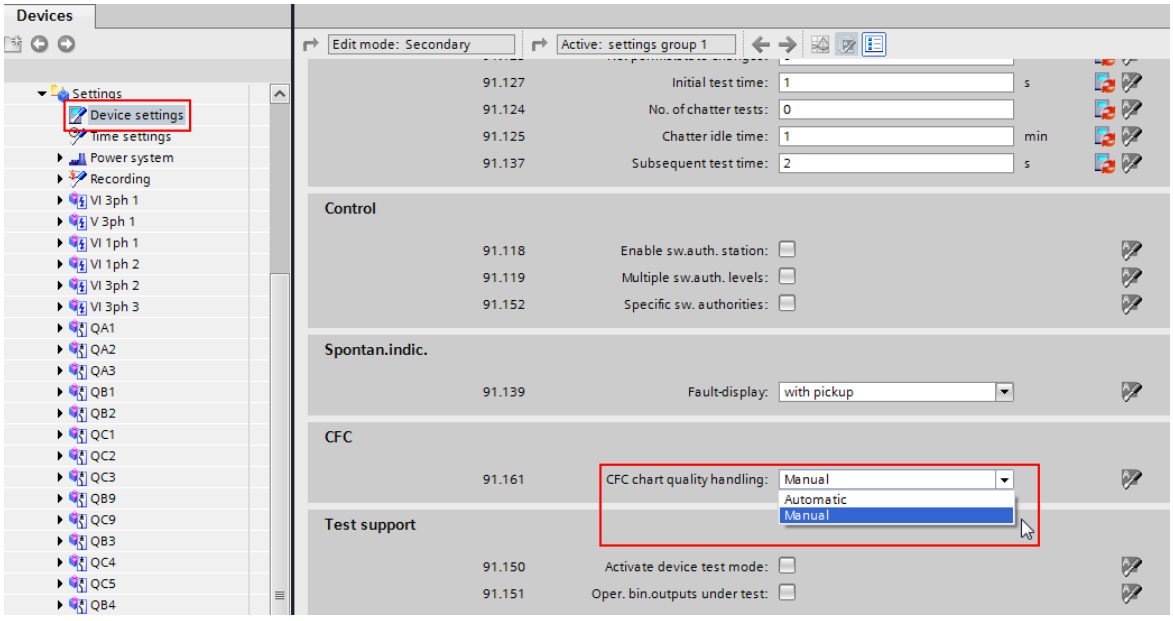
Quality Attribute: Validity	
The validity values *reserved* and *questionable* are replaced at the receiving end by the *invalid* value.	
• Check box is not set. • Check box is set and receipt of **Validity** = *good*	The validity attribute and data value are forwarded without change.
Check box is set and receipt of **Validity** = *invalid* is set (also applies to values *reserved* and *questionable*).	• The validity attribute is set to *good* and processed further using this value. • The data value is set to the defined substitute value and processed further using this substitute value.

Quality Attribute: OperatorBlocked (opBlk)	
• Check box is not set. • Check box is set and received **OperatorBlocked** = *FALSE*	The OperatorBlocked attribute and data value are forwarded without change.
Check box is set and received **OperatorBlocked** = *TRUE*	• The OperatorBlocked attribute is set to *FALSE* and processed further using this value. • The data value is set to the defined substitute value and processed further using this substitute value.

Interaction of the Quality Attribute Validity and OperatorBlocked	
OperatorBlocked check box is set and receipt of **OperatorBlocked** = *TRUE*	Regardless of whether the validity check box is set or not, and regardless of the current validity, the validity attribute is set to *good* and the substitute value of the OperatorBlocked data object is set. That is, the OperatorBlocked settings overwrite the Validity settings.
OperatorBlocked check box is not set and receipt of **OperatorBlocked** = *TRUE*	The OperatorBlocked attribute remains set and is forwarded. If the Validity check box is set and the receipt of validity = *invalid* is set, the respective data object substitute value is used. For continued signal processing and influence, it must be taken into account that in this configuration the data object substitute value for validity = *invalid* is set, but the quality attribute OperatorBlocked is not yet set.

3.4.3 Quality Processing/Affected by the User in CFC Charts

In DIGSI 5, you can control the quality processing of CFC charts. In the project tree, you can find the **CFC** building block (see the following figure) under **Device name** →, **Settings** → **Device settings** in the editor:



[sc_quali_cfc, 1, en_US]

Figure 3-45 Influencing CFC Quality Handling in DIGSI 5

With the **CFC chart quality handling** parameter, you control whether you want to influence the quality of CFC charts in a ***Manual*** or ***Automatic*** (default setting) manner.

If you select ***Manual***, the quality attribute of the CFC chart is always valid regardless of the quality of individual signals (**Validity** = ***good***)!

Only the **Test** quality attribute of the CFC chart is processed. If the device is in test mode or the input TEST of the CHART_STATE CFC building block is set, the quality attribute of the CFC chart is set to ***Test***.

If you select ***Automatic***, the quality processing of the CFC charts is influenced as follows:

In the case of CFC charts, a distinction has to be made between the general quality processing and certain CFC building blocks that are specifically designed for quality processing.

General Processing

Most of the CFC building blocks do not have an explicit quality processing. For these building blocks, the following general mechanisms shall apply.

Quality Attribute: Validity
If one *invalid* signal is received in the case of CFC input data, then **all** CFC output data will also be set to *invalid* if they originate from building blocks without explicit quality processing. In other words, the quality is not processed sequentially from building block to building block but the output data are set globally. This does not apply to CFC output data that originate from building blocks with explicit quality processing (see next section).

Quality Attribute: Test	
CFC chart is in **normal** state.	CFC input data with the **Test** = *TRUE* attribute are ignored. When the CFC chart is executed, then the data value that was used before the **Test** = *TRUE* attribute is used. The quality of this **old** value is also processed. This means that on the output side, the attribute **Test** = *FALSE*.
CFC chart is in **Test**[1)] state.	If the CFC chart is executed, then the attribute **Test** = *TRUE* is set for all data leaving the CFC chart. This does not depend on whether the data are formed via CFC building blocks with or without quality processing.

[1)]A CFC chart can be switched to the test state by switching the entire device to test mode or the input TEST of the CFC building block CHART_STATE is set.

Quality Attribute: OperatorBlocked	
CFC chart is in **normal** state.	In CFC charts for incoming data, the **OperatorBlocked** attribute is ignored.
CFC chart is in **functionally logged off**[1)] state .	In CFC charts for incoming data, the **OperatorBlocked** attribute is ignored. All CFC output data are labeled as functionally logged off.

[1)] This state only occurs if the device is functionally logged off. In this case, the quality attributes of all CFC outputs are labeled as **functionally logged off**.

Quality Processing Building Blocks (Condition Processing)

The first 3 building blocks (x_SPS) process the quality automatically according to the stated logic. The other building blocks are used to isolate the quality from a data object and add them back after separate logical processing.

<table>
<tr><th>Building Blocks</th><th>Description</th></tr>
<tr><td>OR_SPS

AND_SPS

NEG_SPS</td><td>The building blocks also process the supported quality attributes according to their logic. The following tables describe the logic using input values in connection with the quality attribute Validity. The input values are 0 or 1, the quality attribute Validity can have the value good (=g) or invalid (=i).
x = placeholder for the input value and quality attribute Validity</td></tr>
<tr><td></td><td>OR_SPS<table>
<tr><th>A (Value, Attribute)</th><th>B (Value, Attribute)</th><th>Q (Value, Attribute)</th></tr>
<tr><td>0, i</td><td>0, x</td><td>0, i</td></tr>
<tr><td>0, g</td><td>0, g</td><td>0, g</td></tr>
<tr><td>1, g</td><td>x, x</td><td>1, g</td></tr>
<tr><td>1, i</td><td>0, x</td><td>1, i</td></tr>
<tr><td>1, i</td><td>1, i</td><td>1, i</td></tr>
</table>The output thus has the logical value 1 with Validity = good as soon as at least 1 input has the logical value 1 with Validity = good. Otherwise, the inputs are treated according to the OR operation and the INVALID bit is OR-gated for the quality.</td></tr>
<tr><td></td><td>AND_SPS<table>
<tr><th>A (Value, Attribute)</th><th>B (Value, Attribute)</th><th>Q (Value, Attribute)</th></tr>
<tr><td>0, g</td><td>x, x</td><td>0, g</td></tr>
<tr><td>0, i</td><td>1, x</td><td>0, i</td></tr>
<tr><td>1, i</td><td>1, x</td><td>1, i</td></tr>
<tr><td>1, g</td><td>1, g</td><td>1, g</td></tr>
</table>The output thus has the logical value 0 with Validity = good as soon as at least 1 input has the logical value 0 with Validity = good. Otherwise, the inputs are treated according to the AND operation and the INVALID bit is OR-gated for the quality.</td></tr>
<tr><td></td><td>NEG_SPS<table>
<tr><th>A (Value, Attribute)</th><th>Q (Value, Attribute)</th><th></th></tr>
<tr><td>0, i</td><td>1, i</td><td></td></tr>
<tr><td>0, g</td><td>1, g</td><td></td></tr>
<tr><td>1, i</td><td>0, i</td><td></td></tr>
<tr><td>1, g</td><td>0, g</td><td></td></tr>
</table></td></tr>
<tr><td>SPLIT_SPS

SPLIT_DPS

SPLI_XMV</td><td>The building blocks isolate the data value and quality of a data object.
The requirement is that the quality is available from the input end. This is the case if the building block is interconnected with CFC input data, or is connected downstream with a quality processing building block (x_SPS). In other cases, the CFC editor does not allow a connection.</td></tr>
<tr><td>SPLIT_Q</td><td>The building block performs binary separation of the quality into good, bad (= invalid), test, off and OperatorBlocked.
These 5 attributes can then be processed individually in a binary operation. The building block must be connected downstream to a SPLIT_(DO) building block.</td></tr>
</table>

Building Blocks	Description
BUILD_Q	The building block enters a binary value for *good* and *bad* (= *invalid*) in each quality structure. Thus, with this building block the quality attributes *good* and *bad* (=*invalid*) can be set explicitly, for example, as the result of a monitoring logic. All other quality attributes are set to the default state, for instance, **Test** = *FALSE*. If, for example, the entire CFC chart is in the test state (*see Quality Attribute: Test Under General Processing*), this default status can again be overwritten on the CFC output side. The building block is normally connected downstream to a BUILD_(DO) building block.
BUILD_ACD **BUILD_ACT** **BUILD_BSC** **BUILD_DPS** **BUILD_ENS** **BUILD_SPS** **BUILD_XMV**	These building blocks merge data value and quality. The building-block output is generally used as a CFC output. Generally, the BUILD_Q building block is connected upstream from these building blocks.

CFC charts have a standard behavior in the processing of signals. If an input signal of the CFC chart has the quality *invalid*, all output signals of the CFC chart also get the quality *invalid*. This standard behavior is not desirable in some applications. If you use the building blocks for quality processing, the quality attributes of the input signals in the CFC chart are processed.

EXAMPLE: Switchgear Interlocking via GOOSE

The following conditions apply to the example:

- The interlocking condition for switchgear interlocking protection is stored in the device as a CFC chart.
- The removed device sends the release signal for the interlocking condition via a GOOSE telegram.

If the communication connection has been interrupted, the release signal (**GOOSEStr**) incoming via the GOOSE telegram gets the quality *invalid*. If the CFC chart obtains an invalid input signal, there are the following possibilities: The last signal valid before the communication interruption is used (quality = *good*) or a substitute data value with the quality *good* is used (True, False).

To do this, you have to create a separate CFC chart in addition to the interlocking plan of the switchgear interlocking. Use the building blocks for quality processing in a separate CFC chart. With the SPLIT_SPS building block, split the input signal (data type = SPS) into data value and quality information. You can then continue to process these signals separately in the CFC chart. Use the quality information as an input signal for a BUILD_SPS building block and assign the quality *good* to the signal. You obtain an SPS signal as a result, with the quality *good*. You can use this to process release messages correctly. You can process the release messages with the quality *good* in the CFC chart of the actual interlocking. Therefore, the release signal for a switch illustrated in the interlocking logic is available as a valid result with the quality *good*. The following figure shows an example of the CFC chart with the building blocks for quality processing:

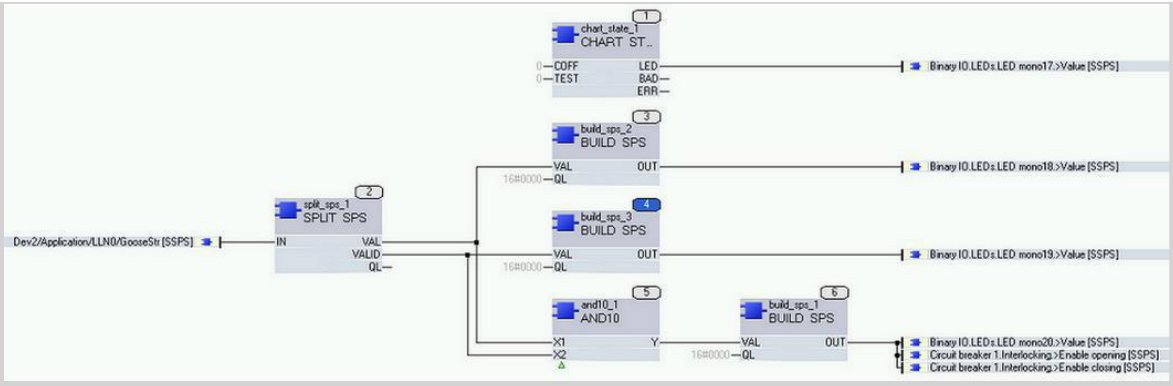


Figure 3-46 CFC Chart with Building Blocks for Quality Processing (Switchgear Interlocking via GOOSE)

If you do not want to convert the invalid release signal to a valid signal, as described, during the communication interruption, you can also assign a defined data value to the release signal. Proceed as follows: With the SPLIT_SPS building block, split the input signal (data type = SPS) into data value and quality information. Link the VALID output of the SPLIT_SPS building block with the data value of the input signal (AND gate). This way, you can set the value to a non-risk state with the valid input signals. In the example, the output of the CFC chart is set to the value *FALSE* when the input signal is invalid.

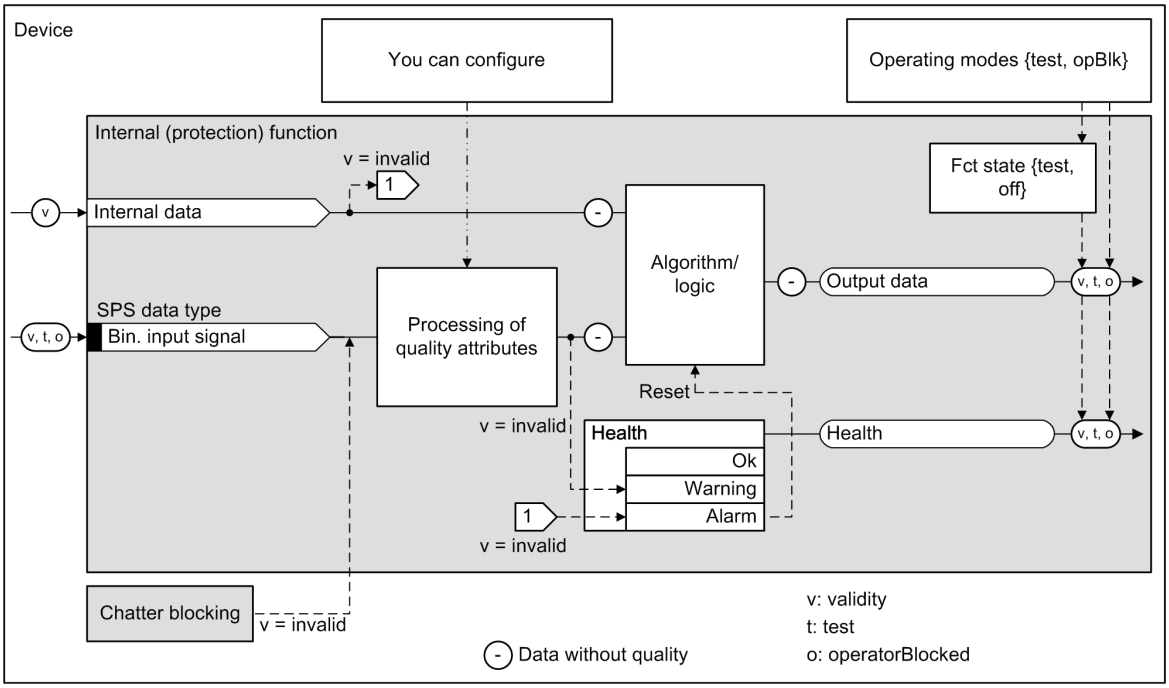
3.4.4 Quality Processing/Affected by the User in Internal Device Functions

Figure 3-47 provides an overview for processing the quality of data objects within a device-internal function.

A function can receive internal data or input data that is routable by the user (binary input signal or double commands). The respective quality attributes supported are evaluated by the function on the input side. The attributes are not passed through the specific algorithm/the specific logic of the function. The output data are supplied with a quality that is specified by the function state and device-operating mode.

NOTE

Take into account that pickup of chatter blocking (see chapter *3.9.1 Signal Filtering and Chatter Blocking for Input Signals*) sets the corresponding **Validity** attribute to *invalid*.



[lo_quali3, 2, en_US]

Figure 3-47 Overview for Processing Quality within an Internal Function

Internal Input Data

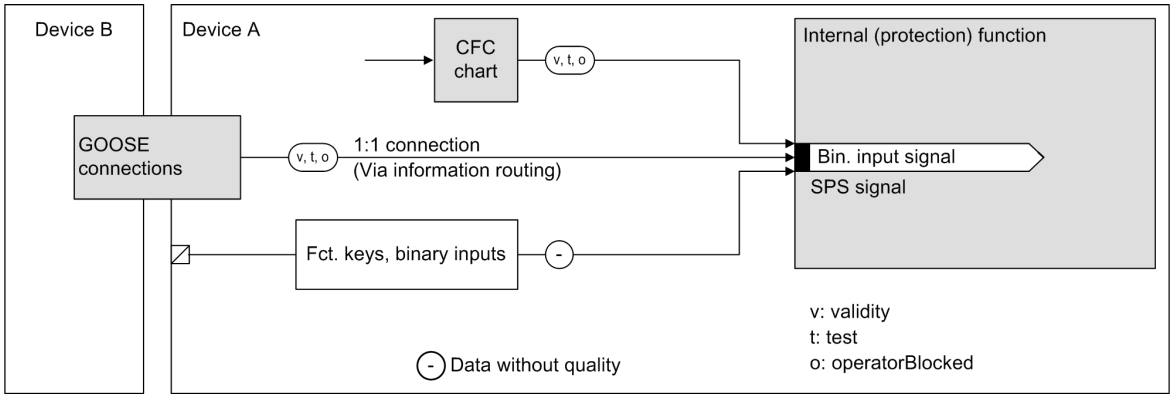
The quality processing is automatic for internal input data.

Supported Quality Attributes	Description
Validity	• At the receiving end, internal values can only be *invalid* or *good*. • If *invalid*, the function health is set to **Alarm** and the function is reset. Causes for invalid internal data are, for example: • The frequency operating range of the device was left. • The device is not calibrated. • The A/D converter monitoring identified an error.

Routable Binary Input Signals (SPS Data Type)

Figure 3-48 shows the possible sources for connecting a binary input signal. Depending on the source, different quality attributes can be set:

- CFC chart: See description in chapter *3.4.3 Quality Processing/Affected by the User in CFC Charts*
- GOOSE connection: See description in chapter *3.4.2 Quality Processing/Affected by the User for Received GOOSE Values*
- Device hardware: No quality attributes are set and supported.

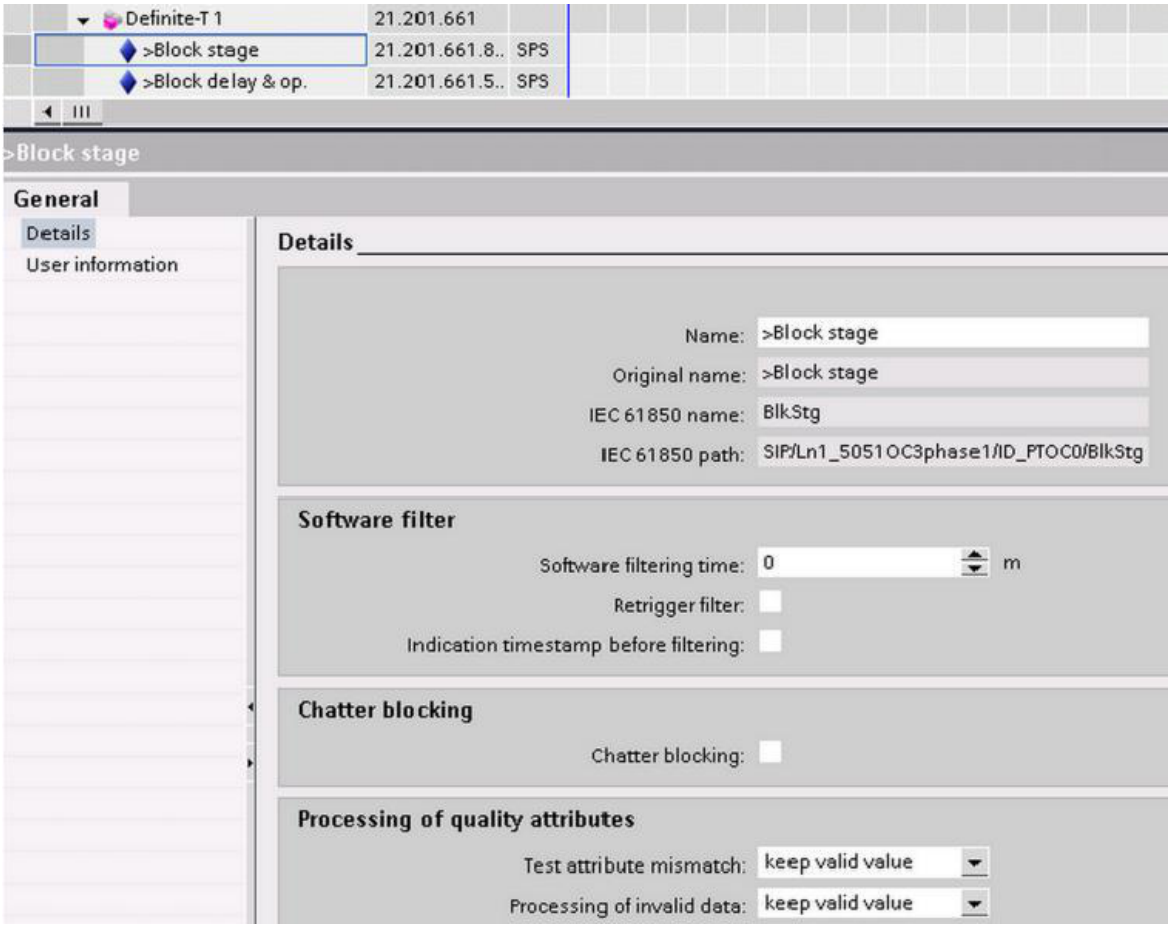


[lo_quali2, 2, en_US]

Figure 3-48 Sources for Connecting a Binary Input Signal

For this signal type (SPS), you can influence the processing of the quality, see overview in *Figure 3-47*.
The following figure shows the possible influence on a binary input signal of a protection stage.

- In the DIGSI 5 project tree, double-click **Information routing**.
- In the operating range, select the desired binary input signal.
- In the **Properties** window, select the **Details** entry. There, you will find the item **Processing quality attributes**.



[sc_influence, 1, en_US]

Figure 3-49 Influence Options for a Binary Input Signal (SPS Input Signal)

Quality Attribute: Validity	
The **Validity** attribute can have the values *good* or *invalid (reserved* and *questionable* were already replaced at the input end of the device by the value *invalid*).	
The input signal source is *invalid*.	The current data value of the source signal is ignored. You can select between the following options: • Further process last valid data value of the source signal (this is the default setting with only a few exceptions) • Set the binary value to be processed further to **0**. • Set the binary value to be processed further to **1**. This configuration option is necessary to satisfy different applications. The function health switches to Warning.
The input signal source is *good*.	The source signal data value is processed further.

Quality Attribute: Test	
• The input signal source and processed function are in test state. • The input signal source is not in test state and the function to be processed is in test state.	The source signal data value is processed further.
The input signal source is in a test state and the function to be processed is in normal state.	The data value of the source signal is ignored. You can select between the following options: • Further processing of the last valid source signal data value, before the source switches to the test state (that is the default setting) • The binary value to be processed further is set to **0**. • The binary value to be processed further is set to **1**. This configuration option is necessary to satisfy different applications.

Quality Attribute OperatorBlocked
The quality cannot be influenced at this position and does not lead to a response within the logic

Output Data

The quality is not processed through the actual algorithm/logic of the function. The following table displays the conditions required to set the quality of output signals of a function.

Cause	D0 Value	Quality Attribute	
		After **internal** (to the SIPROTEC 5 system, for example, in the direction of a CFC chart)	To the IEC 61850 interface, in buffer
Functional state = **Test** (thus, result of device operating mode = **Test** or function mode = **Test**)	Unchanged	**Test** = *TRUE*	**Test** = *TRUE*
Functional state = **Off** (thus, result of device operating mode = **Off**)	Function-specific, corresponding to the definition for switched off	**Validity** = *good*	**Validity** = *invalid*

Cause	D0 Value	Quality Attribute	
Function health = **Alarm** (for example, result of invalid receive data)	Function-specific, corresponding to the definition for reset	**Validity** = *good*	**Validity** = *invalid*
Device operating mode = **functionally logged off**	Unchanged	**Validity** = *good* **OperatorBlocked** = *TRUE*	**Validity** = *good* **detailQual** = *oldData* **OperatorBlocked** = *TRUE*

3.5 Fault Recording

3.5.1 Overview of Functions

All SIPROTEC 5 devices have a fault memory in which fault recordings are kept securely. Fault recording documents operations within the power system and the way in which protection devices respond to them. You can read out fault recordings from the device and analyze them afterwards using evaluation tools such as SIGRA.

A fault record contains the following information:

- Sample values of the analog input channels
- Measured values calculated internally
- Any binary signals (for example, pickup signals and trip signals of protection functions)

You can individually configure the signals to be recorded. Furthermore, you can define the starting condition, the record duration, and the saving criterion of a recording. Fault records saved in the device are also available after a loss of auxiliary voltage.

3.5.2 Structure of the Function

The **Fault recorder** function is a central device function. Both the recording criterion and the measured-value and binary channels to be recorded are functionally preconfigured through the application templates. You are able to individually adapt the configuration in DIGSI 5. The fault recording and the fault log are subject to the same control. This ensures that real time, relative time, and numbering of the fault data are synchronized.

This means that all fault recordings function on the same real-time and relative-time basis.

The data read out via the DIGSI-PC are saved in COMTRADE format. Fault recording data can be transferred to the substation automation technology by request in accordance with the standards via existing communication connections (such as IEC 61850, IEC 60870-5-103). The central device analyzes the data using appropriate programs.

3.5.3 Function Description

The **Fault recorder** function records the sampled values, specific to each device, of all analog inputs, the internally calculated measured values, and the binary signals. The configuration, which is predefined for each device via an application template, can be adapted individually.



NOTE

For detailed information about selecting and deleting fault records, refer to the Operating Manual (C53000-G5040-C003).

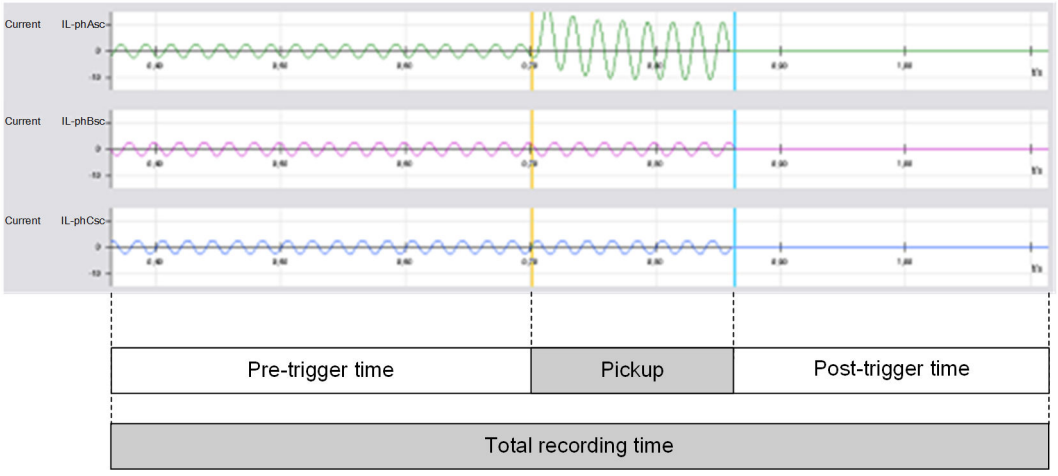
The fault memory of the device is automatically updated with every recording. When the fault memory is filled completely, the oldest recordings are overwritten automatically. Thus, the most recent recordings are always stored safely. The maximum number of recordings is 128.

Sampling Frequency

The analog measuring channels are sampled at a different sampling rate for fault recording. The **`Sampling frequency`** parameter is used to set the desired sampling frequency. Possible setting values are 1 kHz, 2 kHz, 4 kHz, and 8 kHz . This setting value applies only to fault recording and does not affect protection functions or calculated measured values.

Record Duration

The overall duration of a single fault recording comprises the total duration of the configurable recording criterion, the **Pre-trigger time** and the **Post-trigger time**. You can set the parameters for these components individually.



[dw_sigrar, 2, en_US]

Figure 3-50 Example of a Fault Recording

With the **Fault recording** parameter, you specify the start criterion of the recording.

You can set the following values:

- ***with pickup***:
  The fault recording records the complete fault until dropout. The resulting pickup signals of all function groups are taken into account.
- ***user-defined***:
  With this setting value, you can individually specify the recording criterion for the fault recording in DIGSI 5. Function-specific recording criteria can be realized in this way.

If a recording criterion reoccurs during the pickup time and post-trigger time, the recording which is active is extended to include a new post-trigger time.

For a sampling frequency of 8 kHz and 24 analog channels to be recorded, the duration of one individual fault recording can be up to 20 s.

The maximum record duration can be limited by the **Maximum record time** parameter.

In addition to starting the fault recording via the pickup, the following alternatives are possible:

- Externally via binary input signal *>External start* (for example, from an external protection device without fault recording by an object transferred via a GOOSE message)
- By way of a configurable input signal *>Manual start*, you can start fault records with a configurable length (parameter **Manual record time**).
- From DIGSI 5, you can start test fault records with a fixed length of 1 s.
- With a command from a central device via an existing communication connection (IEC 61850, IEC 60870-5-103)

NOTE

If a pickup signal is present continuously, the fault record is closed after the **Maximum record time** expires and the fault recording is not restarted!

Saving the Recording

Not every fault recording that is started actually needs to be saved. With the **Storage** parameter, you specify whether you want to save the fault recording that has started. You can also save only fault data for which the pickup of a protection function also caused a tripping . With this setting, faults beyond the self-protection range will not lead to replacing fault recordings that have already been saved.

Configuration of Signals to Be Recorded

All analog inputs of the device that have been configured (currents and voltages) are recorded as sampled channels.

Function-specific binary signals (for example, pickup and trip signals) and measured value channels can be configured individually for recording in the DIGSI information-routing matrix. For this purpose, a separate **Recorder** column is available.

You can rename the signals in the DIGSI Information-routing matrix. You can change the order of the binary signals and measured-value channels to be recorded in DIGSI under **Signal order**. You can find more detailed information on this in the DIGSI 5 Online Help, version V07.50 and higher (Order number: C53000-D5000-C001-D).

The operational measured values and the measured values of the fundamental components and symmetrical components (see the Device Manual, chapters *9.3 Operational Measured Values* and *9.4 Fundamental and Symmetrical Components*) are calculated every 9 cycles (at 50 Hz, this is every 180 ms). However, this can mean that the data are not synchronized with the sampled values of the analog channels. The recording of these measured values can be used to analyze the slowly changing processes.

Numbering and Time Stamping

All fault recordings saved are automatically numbered in ascending order and assigned a real-time stamp for the start time. The fault recording logs the fault with a relative time. The reference-time point is the start of the recording. Every fault recording has a corresponding fault log with the same number. This ensures that the fault recording can be uniquely assigned to the event log.



NOTE

When the **Fault recorder** function detects a negative time stamp of the measurand or the binary signal, an entry is added in the **Device-diagnosis log** in DIGSI. Meanwhile, the fault recording continues. The entry for an incorrect measurand or binary signal shows the prefix **Bad quality**.

Fault Memory

The device manages its available fault memory dynamically, so that the maximum recording capacity is always available. When exceeding the limits of the fault memory, the oldest recordings are automatically overwritten. This means that the most recent recordings are always available. The sampling rate, type, and number of measured value trends to be recorded are the crucial variables when it comes to restricting the length and number of recordings possible. Parallel to the sampled tracks, up to 50 tracks with function-specific measured values and up to 200 binary tracks can be recorded. The following table provides an overview of the maximum storage capacities, in seconds, for different connection variations of the protection devices.

Table 3-10 Maximum Length of All Stored Recordings

Connection Examples	Sampling 1 kHz	Sampling 2 kHz	Sampling 4 kHz	Sampling 8 kHz
Feeder: 4I, 6 measured values, 20 binary tracks	1365 s	819 s	455 s	241 s
Feeder: 4I, 4V, 20 binary tracks	1125 s	566 s	284 s	142 s

Connection Examples	Sampling 1 kHz	Sampling 2 kHz	Sampling 4 kHz	Sampling 8 kHz
Feeder: 4I, 4V, 6 measured values, 20 binary tracks	890 s	500 s	266 s	137 s
Feeder 1.5 CB: 8I, 8V, 6 measured values, 20 binary tracks	525 s	281 s	145 s	74 s

Input and Output Signals

The **Fault recorder** function provides several input signals that allow the precise starting, deleting of recordings. The output signals provide information about the function status.

In the following table, you can find input signals of the **Fault recorder** function:

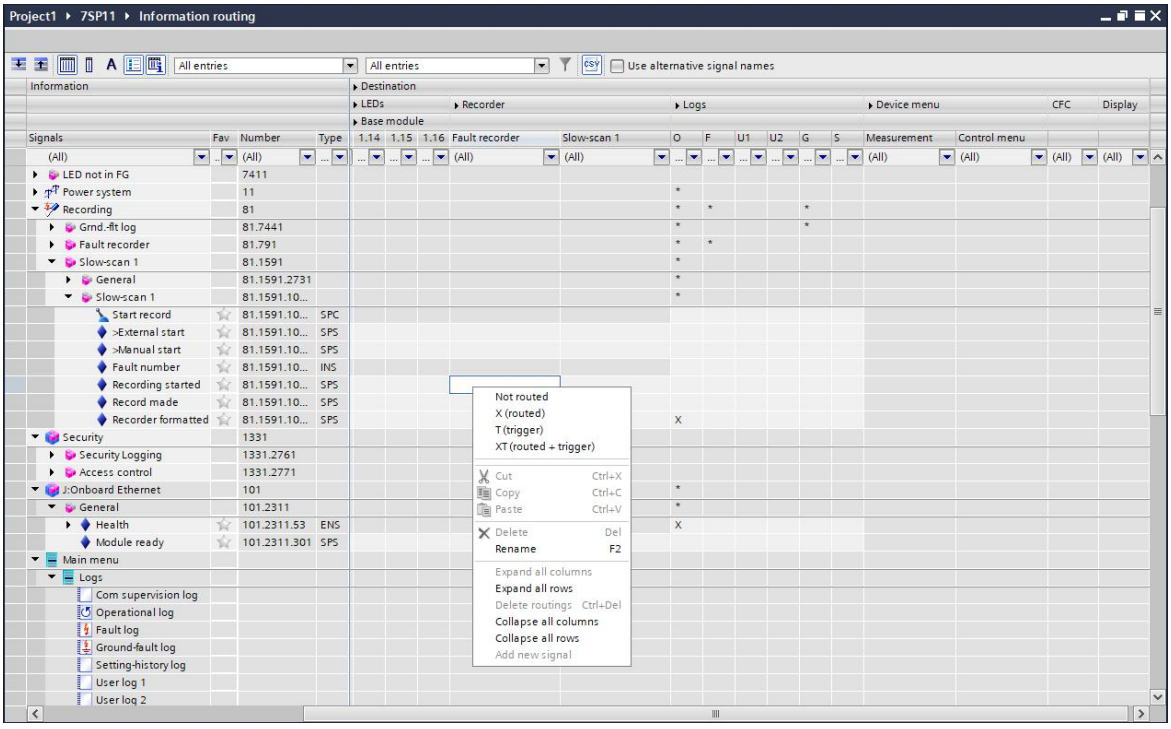
Name	Type	Description
Control: Start recording	SPC	Start recording via the function key
Control: Reset memory	SPC	Delete all recording via the function key. The error numbers are reset.
Control: Delete memory	SPC	Delete all recording via the function key. The error numbers remain as is.
Control: >External start	SPS	Start recording with an external binary signal, for example, by the trip command of an external protection device. The set pre-trigger and post-trigger time are taken into account.
Control: >Manual start	SPS	Start a recording of fixed duration (parameter **`Manual record time`**) by way of an external binary signal, for example, manually via the function key or by an external binary signal.

In the following table, you can find output signals of the **Fault recorder** function:

Name	Type	Description
Control: Error number	INS	The indication of the current error number allows a unique allocation of entries in the message buffers for the recorded fault records.
Control: Recording started	SPS	Fault recording running
Control: Recording done	SPS	Fault recording done
Control: Tmax reduced	SPS	Fault recording ends before the set **`Maximum record time`** expires, because the fault log is full.
Control: Fault log is full	INS	The fault log is full.

Configuring Stored Indications Using DIGSI 5

- In the **Information Routing** of each device set up in DIGSI 5, you can route binary signals to LEDs and output contacts. To do this, open the project tree.
  Project -> Device -> **Information routing**
- Right-click the routing field of your binary indication in the desired LED or binary output column in the routing range of the targets.



[sc_FR_information routing, 1, en_US]

Figure 3-51 Routing of the Signals in the Information Routing

3.5.4 Application and Setting Notes

Parameter: Fault recording

- Recommended setting value **(_:2761:130) Fault recording** = ***with pickup***

With the **Fault recording** parameter, you define the time interval at which faults are recorded. The total record duration is defined as the duration of the fault plus the total of the parameters **Pre-trigger time**, **Post-trigger time** and is limited by the maximum record duration.

Parameter Value	Description
with pickup	The fault recording time is determined by the total number of all protection pickups. The resulting pickup signals of all function groups are considered. Note: When the post-trigger time has expired, the indications of an automatic reclosing function are not recorded. Evolving faults after expiry of the post-trigger time can result in the opening of a new fault with its own recording.
user-defined	The fault recording time is defined user-specific. Note: Specify all signals for individual definition of the fault recording time in the DIGSI 5 information-routing matrix. In the information routing matrix in the **Fault record** column, the fault recording has for this purpose a separate column **Trigger**. The record duration is calculated from the logical OR operation of all initiated, configured signals.

Parameter: Storage

- Recommended setting value **(_:2761:131) Storage** = ***always***

With the **Storage** parameter, you define the storage criterion for a fault recording that has already started.

Parameter Value	Description
always	Each fault recording that has been started is saved.
with trip	If at least one protection function issues an operate indication during the record time, any fault recording that has been started is saved.

Parameter: Maximum record time

- Default setting **(_:2761:111) Maximum record time** = ***5.00 s***

With the **Maximum record time** parameter, you configure the maximum record duration for an individual fault recording. When the time configured expires, an ongoing fault recording is canceled. This parameter merely limits the duration of the fault recording. It does not affect the logging of faults in the fault log.

Parameter: Pre-trigger time

- Recommended setting value **(_:2761:112) Pre-trigger time** = ***0.50 s***

With the **Pre-trigger time** parameter, you configure the pre-trigger time for an individual fault recording. The set pre-trigger time is prepended to the actual recording criterion for the fault recording.

Parameter: Post-trigger time

- Recommended setting value **(_:2761:113) Post-trigger time**= ***0.50 s***

With the **Post-trigger time** parameter, you configure the post-trigger time for an individual fault recording. The post-trigger time that has been configured is added to the actual recording criterion for the fault recording after the dropout.

The following table shows how the setting range changes for the **Post-trigger time** parameter depending on the **Sampling frequency**.

Sampling Frequency	Setting Range for the Post-trigger time Parameter
8 kHz	0.05 s to 4 s
4 kHz	0.05 s to 8 s
2 kHz	0.05 s to 16 s
1 kHz	0.05 s to 24 s

Parameter: Manual record time

- Recommended setting value **(_:2761:116) Manual record time** = ***0.50 s***

With the **Manual record time** parameter, you set the length of a recording if the fault recording is activated dynamically (edge-triggered) via a separately configured input signal *>Manual start*.

In this case, pre-trigger and post-trigger times do not take effect.

Parameter: Sampling frequency

- Recommended setting value **(_:2761:140) Sampling frequency** = ***8 kHz***

With the **Sampling frequency** parameter, you define the sampling frequency of fault records that you want to download via DIGSI 5. Possible setting values are 8 kHz, 4 kHz, 2 kHz, and 1 kHz.

Parameter: Sampl. freq. IEC 61850 rec.

- Recommended setting value **(_:2761:141) Sampl. freq. IEC 61850 rec.** = ***8 kHz***

With the parameter **Sampl. freq. IEC 61850 rec.**, you define the sampling frequency of the fault record that you want to download using the IEC 61850 communication protocol. Possible setting values are 8 kHz, 4 kHz, 2 kHz, and 1 kHz.

You cannot set the parameter **Sampl. freq. IEC 61850 rec.** to be greater than the set value of the parameter **Sampling frequency**. The setting options of the parameter **Sampl. freq. IEC 61850 rec.** which are greater than the set value of the parameter **Sampling frequency** are invisible.

If the size of the COMTRADE file exceeds the maximum permissible storage capacity of the device, the original recording is truncated. The truncated data are discarded.

NOTE

If you have created a fault record with a certain sampling frequency and then set the sampling frequency to a lower value, you can no longer download this fault record using the IEC 61850 communication protocol.

You must reset the sampling frequency to the original value. Then you can download the fault record again using the IEC 61850 communication protocol.

Parameter: Cal.zero.seq.cur.channel

- Default setting **(_:2761:129) Cal.zero.seq.cur.channel** = ***no***

With the **Cal.zero.seq.cur.channel** parameter, you determine whether the calculated zero-sequence current ***3I0*** or ***-3I0*** is recorded in a separate channel or not. The separate channel is visible in the DIGSI 5 Information routing under the **I 3-phase** measuring point.

The zero-sequence currents can be calculated only with the following current-transformer connection types:

- ***3-phase + IN-separate***
- ***3-phase + IN***
- ***3-phase***

Parameter Value	Description
no	The zero-sequence current calculated from the sampled values of the currents is not recorded.
-3I0	The calculated zero-sequence current ***-3I0*** is recorded for each **I 3-phase** measuring point. ***-3I0*** is calculated from the sampled current values using the following equation: -3I0 = - (I_A + I_B + I_C).
3I0	The calculated zero-sequence current ***3I0*** is recorded for each **I 3-phase** measuring point. ***3I0*** is calculated from the sampled current values using the following equation: 3I0 = (I_A + I_B + I_C).

Parameter: Cal.zero seq.volt.channel

- Default setting **(_:2761:132) Cal.zero seq.volt.channel** = ***no***

With the **Cal.zero seq.volt.channel** parameter, you determine whether the calculated zero-sequence voltage ***V0*** or ***3V0*** is recorded in a separate channel or not. The separate channel is visible in the DIGSI 5 Information routing under the **V 3-ph** measuring point.

The zero-sequence voltages can be calculated only with the following current-transformer connection types:

- ***3 ph-to-gnd volt. + VN***
- ***3 ph-to-gnd voltages***

Parameter Value	Description
no	The zero-sequence voltage calculated from the sampled voltage values is not recorded.
V0	The calculated zero-sequence voltage ***V0*** is recorded for each **V 3-ph** measuring point. ***V0*** is calculated from the sampled voltage values using the following equation: $V0 = (V_A + V_B + V_C)/3$.
3V0	The calculated zero-sequence voltage ***3V0*** is recorded for each **V 3-ph** measuring point. ***3V0*** is calculated from the sampled voltage values using the following equation: $3V0 = (V_A + V_B + V_C)$.

3.5.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Control				
_:2761:130	Control:Fault recording		• with pickup • with pickup & AR cyc. • user-defined	with pickup
_:2761:131	Control:Storage		• always • with trip	always
_:2761:111	Control:Maximum record time		0.20 s to 20.00 s	5.00 s
_:2761:112	Control:Pre-trigger time		0.05 s to 4.00 s	0.50 s
_:2761:113	Control:Post-trigger time		0.05 s to 0.50 s	0.50 s
_:2761:116	Control:Manual record time		0.20 s to 20.00 s	0.50 s
_:2761:140	Control:Sampling frequency		• 8 kHz • 4 kHz • 2 kHz • 1 kHz	2 kHz
_:2761:141	Control:Sampl. freq. IEC 61850 rec.		• 8 kHz • 4 kHz • 2 kHz • 1 kHz	1 kHz
_:2761:129	Control:Cal.zero.seq.cur. channel		• no • -3I0 • 3I0	no
_:2761:132	Control:Cal.zero seq.volt.channel		• no • V0 • 3V0	no

3.5.6 Information List

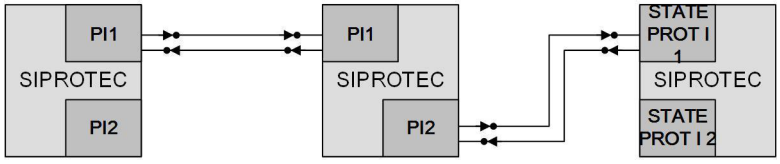
No.	Information	Data Class (Type)	Type
_:2761:300	Control:Start record	SPC	C
_:2761:305	Control:Reset memory	SPC	C
_:2761:306	Control:Clear memory	SPC	C
_:2761:502	Control:>External start	SPS	I
_:2761:503	Control:>Manual start	SPS	I
_:2761:310	Control:Fault number	INS	O
_:2761:311	Control:Recording started	SPS	O
_:2761:314	Control:Record made	SPS	O
_:2761:327	Control:Tmax reduced	SPS	O
_:2761:324	Control:Fault log is full	INS	O

3.6 Protection Communication

3.6.1 Overview

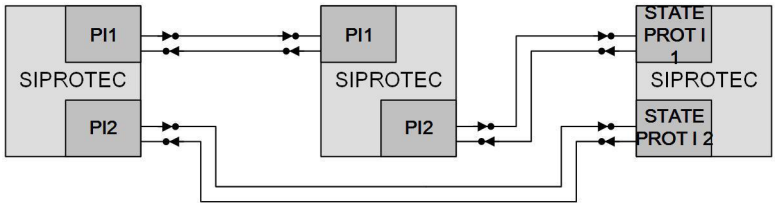
The **Protection communication** includes all functionalities necessary for data exchange via the protection interface (PI).

Devices that communicate with each other via protection interfaces form a device combination. A device combination consists of 2 to 6 devices. The devices communicate via point-to-point connections (protection connections). In this case, a device has only one connection to another device via a protection interface (PI). With a 2nd protection interface, you can establish a connection to another device or a redundant connection to the same device. With their protection connections, the devices form a protection topology in the form of a redundant ring (ring topology) or as a chain structure (chain topology).



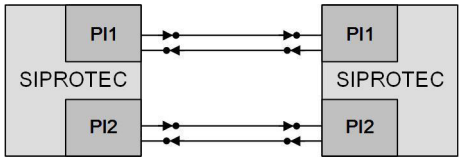
[dw_PDC_chain_3devices, 1, en_US]

Figure 3-52 Device Combination of 3 Devices in a Chain Topology



[dw_PDC_ring_3devices, 1, en_US]

Figure 3-53 Device Combination of 3 Devices in a Ring Topology



[dw_PDC_ring_2devices, 1, en_US]

Figure 3-54 Device Combination of 2 Devices in a Ring Topology

Within a device combination, the point-to-point connections can have different bandwidths. Depending on the bandwidth, a certain amount of binary information and measured values can be transmitted bidirectionally between the devices. The connection with the lowest bandwidth defines the amount of binary information and measured values.

The following information is important for protection communication and is transmitted additionally. You cannot change this information:

- Topology data and values are exchanged for monitoring and testing the connection and displayed on the device or with DIGSI 5.
- Protection data and measured values, such as line differential protection data or binary data of the teleprotection schemes for distance protection and ground-fault protection are transmitted.
- The time synchronization of the devices is possible directly via the connection, whereby a device of the protection topology assumes the role of the timing master.

The point-to-point connection between the devices is continuously monitored for data faults and failure and the signal-transit time of the data is measured.

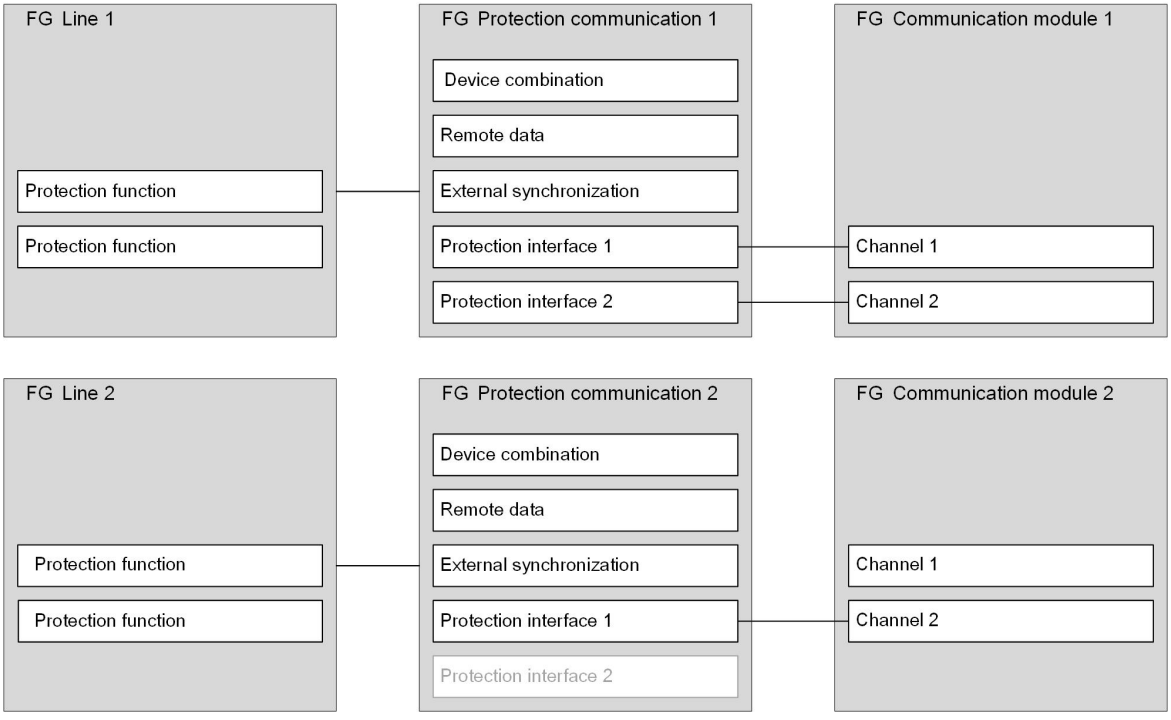
The protection communication is typically used for line differential protection and with the teleprotection schemes for distance protection and ground-fault protection. In SIPROTEC 5, you can configure the protection communication in all devices and use it for further protection applications. At the same time, any binary information and measured values can be transferred between the devices.

NOTE

The protection communication is compatible with the successor versions from firmware version V04.00 and higher.

3.6.2 Protection Communication in the Overall System

The following figure illustrates the interaction of protection communication, protection function groups, and communication modules. The **Protection communication** is integrated as follows in the overall system:



[dw_protcom_compl_system, 2, en_US]

Figure 3-55 Protection Communication in the Overall System

If protection functions want to use the protection interfaces, their superordinate protection function group, for example, the FG **Line 1**, must be connected to a **Protection communication** function group. With this connection, each protection function in the FG **Line 1** can use protection communication.

In addition, a connection must be configured between the logical protection interface in the FG **Protection communication** and a channel on the physical communication module. The physical communication module must support the protection-interface protocol.

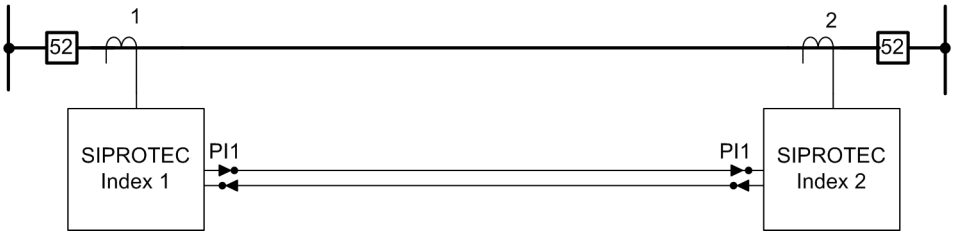
The following chapters describe the configuration of the connections.

3.6.3 Function Description

Device Combination with 2 Devices: Simple or Redundant Transmission

In a device combination with 2 devices, one protection communication with a protection interface is required per device to establish a protection connection (see next figure).

The most frequent application is the point-to-point exchange of data between 2 devices (the protection communication is of type 2), as performed by protection transmission devices. You can create a topology with up to 6 devices.



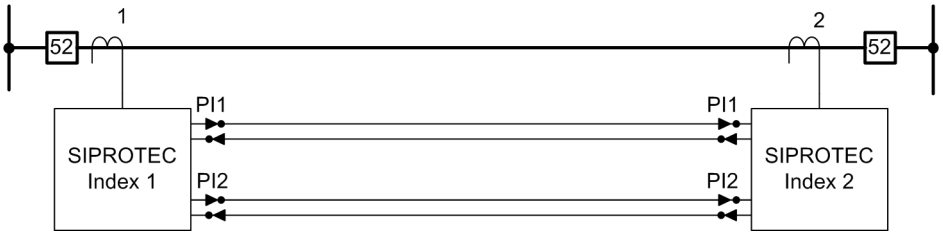
[dw_interface, 1, en_US]

Figure 3-56 Data Exchange for 2 Devices, Each with Protection Connection

NOTE

The index describes the consecutive numbering of the devices in a device combination (see parameter **`(_:5131:101) Local device is device`**).

A maximum of 2 protection interfaces per FG **Protection communication** are possible in one device, see following figure. If the **Protection communication** function groups are connected to each other in the devices via 2 protection connections of the same type, this results in 100 % redundancy regarding the transmission route. The devices then search for the communication connection with the highest bandwidth (for example, optical fiber). If this protection connection fails, the system switches over automatically to the 2nd protection connection until the 1st protection connection is available again. As the protection connection with lower bandwidth defines the maximum amount of transferable information, the same information is exchanged via both protection connections. Both protection communications in the device are then of type 1.



[dw_intera, 1, en_US]

Figure 3-57 Data Exchange for 2 Devices, Each Having 2 Protection Connections, Redundant Transmission Route

Remote Data

With the **Remote data** function, customer-specific indications and measured values can be communicated via the protection interface with settable update cycles (priorities).

There are 3 different priorities for the transmission of remote data:

- **Priority 1**: Use **Priority 1** for the transmission of fast protection signals that are transferred and updated at a maximum of every 20 ms in a telegram.
- **Priority 2**: Use **Priority 2** for the transmission of fast single-point or double-point indications that are transferred and updated at a maximum of every 40 ms.
- **Priority 3**: Use **Priority 3** for all indications, measured, and metered values that are transferred and updated a maximum of every 100 ms.

Communication Media

The communication takes place via direct fiber-optic connections, via communication networks or via 2-wire copper conductors. Siemens recommends a direct fiber-optic connection, as this offers a high transmission rate and is immune to failures in the transmission route while offering the shortest transmission time. This

also enables the transmission of a large amount of remote data in line differential protection applications and the remote control of remote devices with DIGSI 5.

The distance to be bridged and the transmission paths (communication media) available determine the settings of the protection interface. External communication converters are used for the connection to communication networks via G703.1-, X21-, or G703.6 interfaces. The connection to 2-wire copper cores also takes place via a communication converter. The C37.94 interface, for example, with 2 MBit/s, offers a direct fiber-optic connection to a multiplexer with the corresponding interface.

Table 3-11 to *Table 3-12* show examples of communication connections.

In the case of a direct connection, the transmission distance depends on the fiber type of the optical fiber. This distance can also be extended via external repeaters.

The modules in the device can be replaced from outside, so that adaptation to a transmission route is possible. In the case of the 820-nm double module USART-AE-2FO, 2 protection-interface channels can be operated on one module.

The modules can be located at slots E and F in the base device, and at slots N and P in the plug-in module assembly with integrated power supply.

When using communication converters, the connection from the device to the communication converter by a module is established via optical fibers.

Table 3-11 Plug-In Modules for Applications with Protection Communication

Plug-In Modules	Module Type: USART-AF-1LDFO	Module Type: USART-AW-2LDFO	Module Type: USART-AG-1LDFO	Module Type: USART-AU-2LDFO	Module Type: USART-AK-1LDFO	Module Type: USART-AV-2LDFO	Module Type: USART-AH-1LDFO[5]	Module Type: USART-AJ-1LDFO[6]	Module Type: USART-AX-2LDFO[7]	Module Type: USART-AY-2LDFO[8]	Module Type: ETH-BD-2FO[9]
Physical Connection											
1 x optical serial, 1300 nm, duplex LC plug, 24 km via 9/125 µm singlemode optical fiber or 4 km via 62.5/125 µm multimode optical fiber	●										
2 x optical serial, 1300 nm, duplex LC plug, 24 km via 9/125 µm singlemode optical fiber or 4 km via 62.5/125 µm multimode optical fiber		●									
1 x optical serial, 1300 nm, duplex LC plug, 60 km via 9/125 µm singlemode optical fiber			●								
2 x optical serial, 1300 nm, duplex LC plug, 60 km via 9/125 µm singlemode optical fiber				●							
1 x optical serial, 1550 nm, duplex LC plug, 100 km via 9/125 µm singlemode optical fiber					●						
2 x optical serial, 1550 nm, duplex LC plug, 100 km via 9/125 µm singlemode optical fiber						●					
1 x optical serial, bidirectional using 1 optical fiber, 1300/1550 nm (Tx/Rx), simplex LC plug, 40 km using 9/125 µm singlemode optical fiber							●				

5 USART-AH-1LDFO only pairs with USART-AJ-1LDFO or USART-AY-2LDFO

6 USART-AJ-1LDFO only pairs with USART-AH-1LDFO or USART-AX-2LDFO

7 USART-AX-2LDFO only pairs with USART-AJ-1LDFO or USART-AY-2LDFO

8 USART-AY-2LDFO only pairs with USART-AH-1LDFO or USART-AX-2LDFO

9 Suitable for DIGSI 5, IEC 61850, process bus, busbar protection etc.

Plug-In Modules	Module Type: USART-AF-1LDFO	Module Type: USART-AW-2LDFO	Module Type: USART-AG-1LDFO	Module Type: USART-AU-2LDFO	Module Type: USART-AK-1LDFO	Module Type: USART-AV-2LDFO	Module Type: USART-AH-1LDFO[5]	Module Type: USART-AJ-1LDFO[6]	Module Type: USART-AX-2LDFO[7]	Module Type: USART-AY-2LDFO[8]	Module Type: ETH-BD-2FO[9]
Physical Connection											
1 x optical serial, bidirectional using 1 optical fiber, 1550/1300 nm (Tx/Rx), simplex LC plug, 40 km using 9/125 µm singlemode optical fiber								●			
2 x optical serial, bidirectional using 1 optical fiber, 1300/1550 nm (Tx/Rx), 2 x simplex LC plug, 40 km using 9/125 µm singlemode optical fiber									●		
2 x optical serial, bidirectional using 1 optical fiber, 1550/1300 nm (Tx/Rx), 2 x simplex LC plug, 40 km using 9/125 µm singlemode optical fiber										●	
2 x optical Ethernet 100 Mbit/s, 1300 nm, duplex LC plug, 2 km via 50/125 µm or 62.5/125 µm multimode optical fiber											●

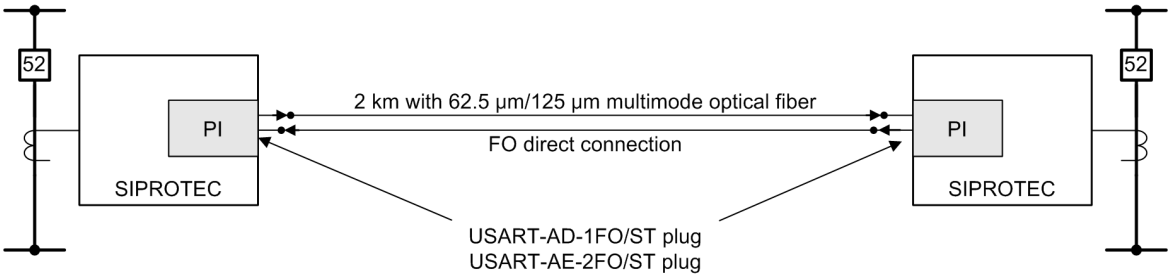
Table 3-12 Plug-In Modules USART-AD-1FO and USART-AE-2FO

Plug-In Module	USART-AD-1FO	USART-AE-2FO
Physical Connection		
1 x optical serial, 820 nm, ST connector, 2 km via 62.5/125 µm multimode optical fiber	●	
2 x optical serial, 820 nm, ST connector, 2 km via 62.5/125 µm multimode optical fiber		●
Application		
Protection interface (Sync. HDLC, IEEE C37.94)	●	●

NOTE

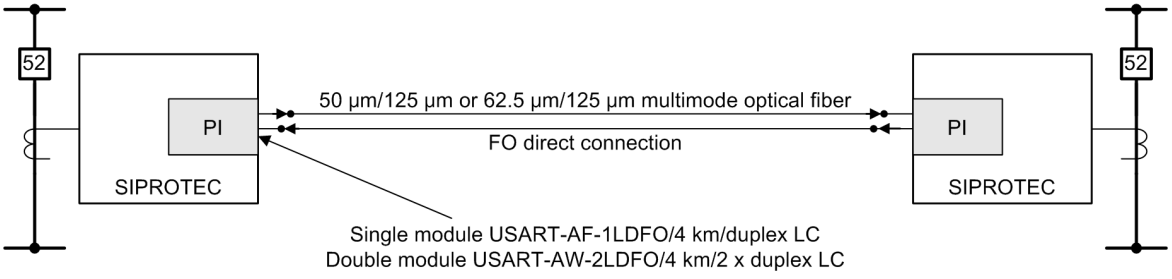
The **USART** plug-in module types can be used in slots **E** and **F** in the base module as well as in slots **N** and **P** in the CB202 expansion module. They are not suitable for use in port **M** in the **CB202** expansion module.

5 USART-AH-1LDFO only pairs with USART-AJ-1LDFO or USART-AY-2LDFO
6 USART-AJ-1LDFO only pairs with USART-AH-1LDFO or USART-AX-2LDFO
7 USART-AX-2LDFO only pairs with USART-AJ-1LDFO or USART-AY-2LDFO
8 USART-AY-2LDFO only pairs with USART-AH-1LDFO or USART-AX-2LDFO
9 Suitable for DIGSI 5, IEC 61850, process bus, busbar protection etc.



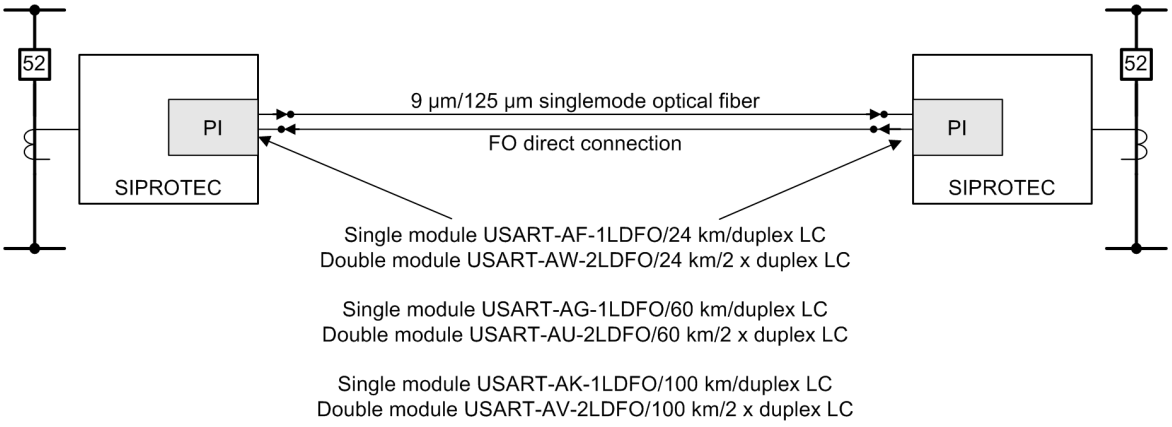
[dw_multim, 1, en_US]

Figure 3-58 Connection over Short Distances, up to 2 km via Multimode Optical Fiber



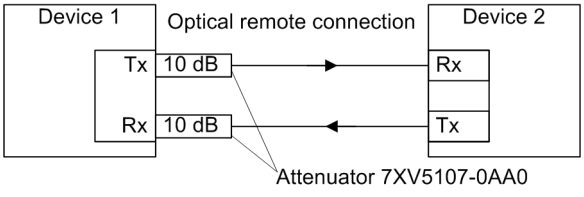
[dw_multim-02, 1, en_US]

Figure 3-59 Connection over Maximum 4 km via Multimode Optical Fiber



[dw_single2, 1, en_US]

Figure 3-60 Connection via Different Distances via Singlemode Optical Fiber

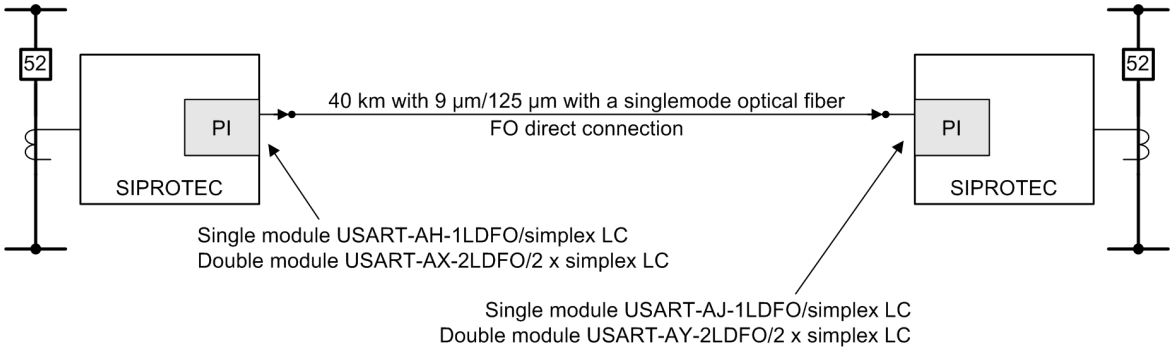


[dw_attenuator, 2, en_US]

Figure 3-61 Optical Remote Connection with Attenuators

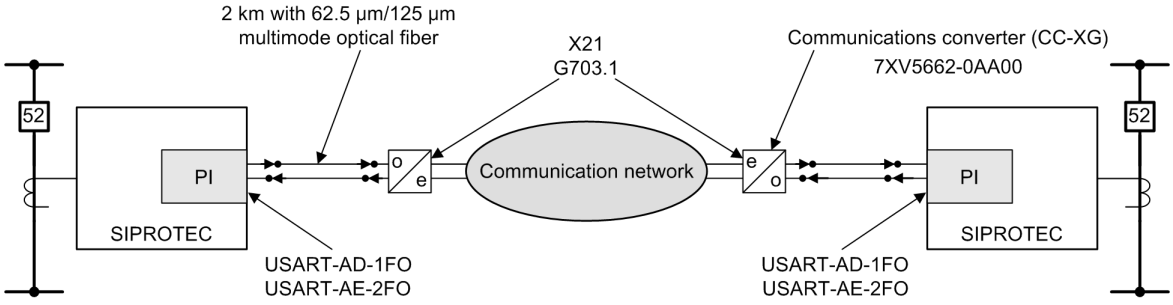
NOTE

Connect two 7XV5107-0AA00 attenuators if you use the communication modules USART-AV-2LDFO or USART-AK-1LDFO for transmission routes of less than 30 km. To continue using the duplex LC plug, attach both attenuators to one end of the protection connection (see *Figure 3-61*).



[dw_single, 1, en_US]

Figure 3-62 Connection via Singlemode Optical Fiber

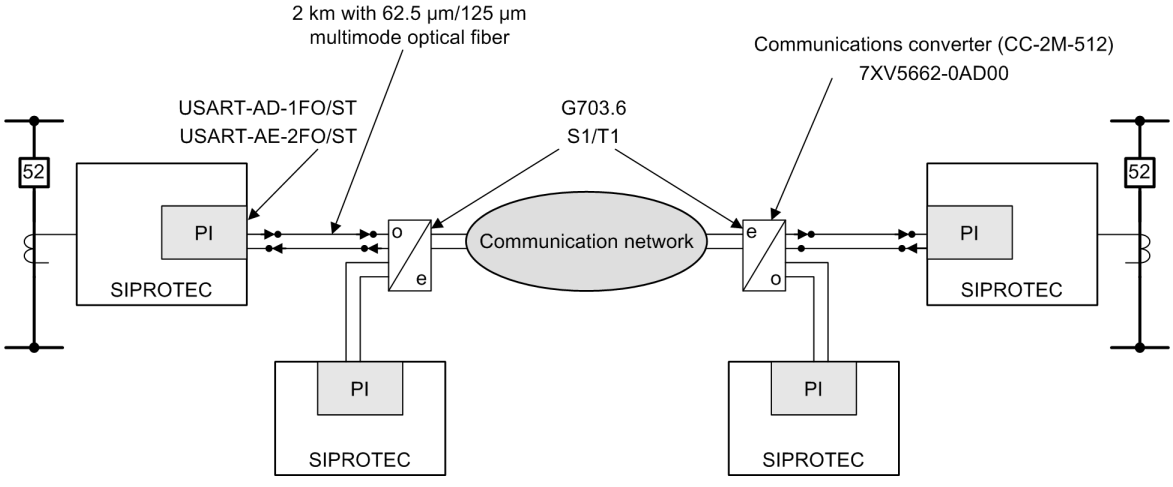


[dw_multim-05, 1, en_US]

Figure 3-63 Connection via Communication Network with a G703.1 Interface

The connection to the multiplexer is established via a communication converter with a G703.1 interface (64 kBit/s) or X21 interface (64 kBit/s to 512 kBit/s). You can set the bit rate for the KU-XG-512 (for X21), KU-XG-256 (for X21), KU-XG-128 (for X21), and KU-XG-64 (for X21 or G703.1) with the parameter **`Connection via`**.

You can find more detailed information in *Table 3-13*.

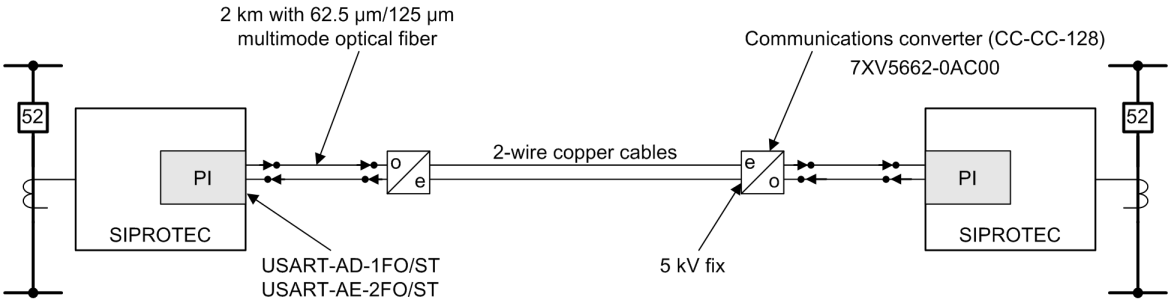


[dw_multim-06, 1, en_US]

Figure 3-64 Connection via Communication Network with a G703.6 Interface

The connection to the multiplexer is established with 512 kBit/s via a communication converter with a G703.6 interface (E1 with 2 MBit/s or T1 with 1.44 MBit/s). The communication converter offers a 2nd interface for connecting an additional protection interface.

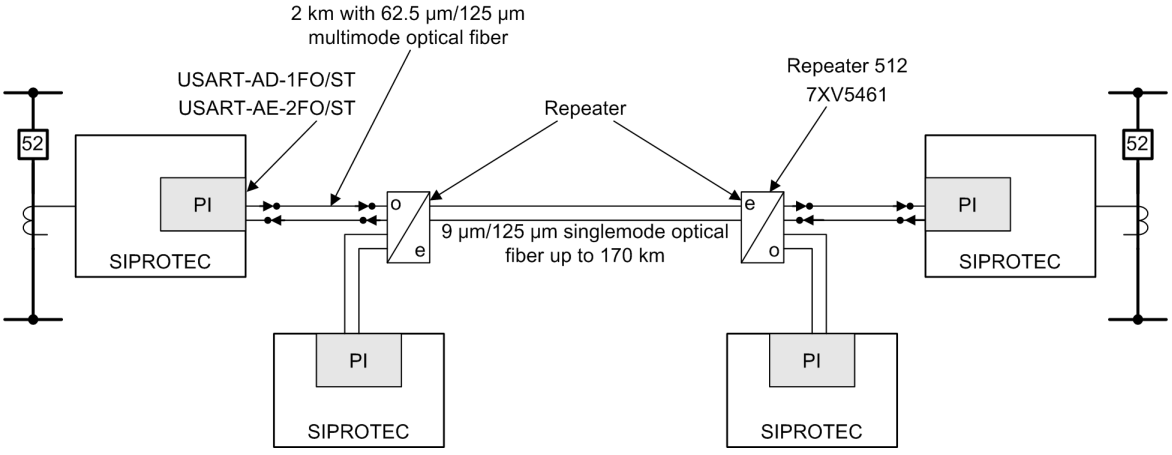
Adjust the setting for the bit rate with KU-2M-512 at 512 kBbit/s in accordance with *Table 3-13* with the parameter **`(_:105) Connection via`**.



[dw_multi_7, 1, en_US]

Figure 3-65 Connection via 2-Wire Copper Cables

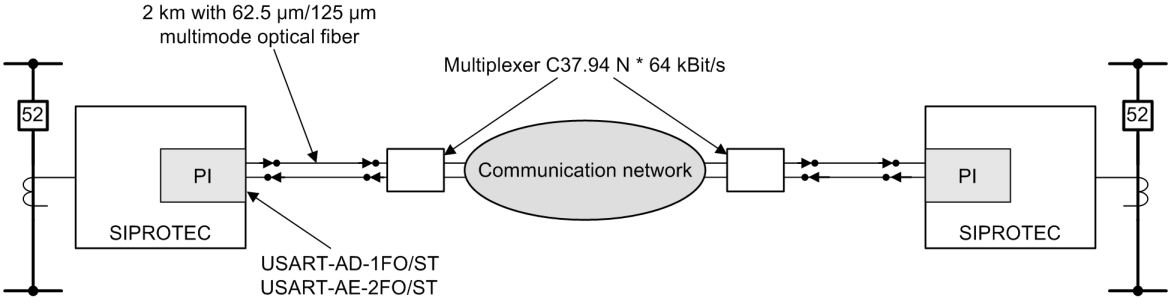
The connection to a communication converter with an integrated isolation voltage of 5 kV is established with 128 kBit/s (KU-KU-128 setting in accordance with *Table 3-13*). An isolation of 20 kV of the 2-wire connection is possible via an external 7XR9516 isolating transformer.



[dw_repeat, 1, en_US]

Figure 3-66 Direct Fiber-Optic Connection via an External Repeater

The repeater offers an interface for connecting an additional protection interface. The connection to a repeater is established with 512 kBit/s (repeater 512 kBit/s setting in accordance with *Table 3-13*).



[dw_mutip8, 1, en_US]

Figure 3-67 Direct Optical Connection to a Multiplexer with a C37.94 N * 64 kBit/s Interface (Time Slot N = 1; 2 or 8)

NOTE

The redundancy of different communication connections (for the ring topology) requires rigorous separation of all devices involved in the communication. Therefore, avoid different transmission routes via the same multiplexer board, as no more substitute paths are possible if the board fails.

Supervision of the Communication

Communication is continuously monitored by the devices and displayed with indications and measured values.

If a number of defective data telegrams, or no data telegrams at all, are received, this is regarded as a **failure** in the communication as soon as a failure time of 100 ms (default setting can be changed) is exceeded. For each protection interface, a list of the measured values is shown in a window in DIGSI 5 (defective telegrams per minute/hour; transmitted and received telegrams per minute/hour, percentage fault rate per minute/hour). A corresponding failure indication is always available. If no alternative transmission route exists (as in the ring topology), the protection function operating with the protection interface is not operating and remote data is not updated on the receiver side.

If the communication is interrupted for longer than an adjustable time **Data-connection failure**, this is regarded as a communication failure. A corresponding failure indication is always available.

Time Synchronization via the Protection Interface, Timing Master

All devices in a device combination can synchronize their time with each other. Synchronization is carried out with millisecond accuracy. The synchronization works independently of the protection function and is used exclusively for simultaneous time keeping in the devices of a device combination.

The device you set in the parameter **(_:5131:102) Address of device 1** is the device with index 1. This device functions takes on the role of the timing master in a device combination. If the timing master is logged off and switched off, the device with the next highest device index takes on the function of the timing master. The timing master synchronizes the clocks of the other devices via the protection interfaces.

The time of the timing master itself can be synchronized via the following time sources:

- IRIG B
- DCF77
- IEEE 1588
- SNTP

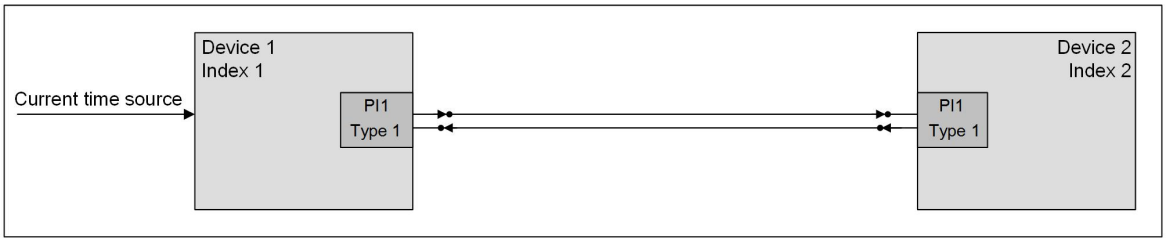
For this, these time sources must be set as the 1st time source and optionally as the 2nd time source in the timing master. If available, the system switches over to the 2nd time source upon failure of the 1st time source in the timing master.

The following chapters describe how a device is set as a timing master:

- For classic protection communication, see *Parameter: Address of Device x, Page 159*.
- For advanced protection communication, see *Parameter: Device index, Page 197*.

Set the protection interface as the 1st time source in the other devices of the device combination. You can find the setting value in DIGSI 5 via the **Project tree** → **Parameters** → **Time settings** → **Timer** → **Time source 1** → ***PI***.

In this way, all events in the devices of the device combination are recorded with the same time and are time-synchronized even across different switchgears. This simplifies fault analysis and the fault records are recorded with the same time in all devices.



[dw_ti_syst, 2, en_US]

Figure 3-68 Time Synchronization in a Protection Topology

Figure 3-68 shows how device 1 with index 1 is synchronized with device 2 via the protection interface. Device 1 is the timing master, whose time is synchronized with a selectable, external time source.

Time Synchronization of the Line Differential Protection Measured Values with Millisecond Accuracy

The measured values of the devices connected via the protection interfaces are synchronized via telegram measurement with microsecond accuracy (1*10E-06 s). The protection interface displays this state with the indication *PI synchronized* RAISING.

If communications problems occur, it is possible that the measured values may not be properly synchronized. In this case, the protection interface generates the indication *PI synchronized* CLEARED. The line differential protection is blocked. This state can be corrected only manually.



NOTE

You can reset the synchronization of the protection interface directly in the device. Proceed as follows: **Device functions > x Device protection comm. > Protection interface y > Reset synchron**.

For special line differential protection applications or synchrophasor measuring devices, you can also time-synchronize the measured values with microsecond accuracy as follows:

- Via a high-precision electrical synchronization pulse (**PPS electrical**, 1-second pulse) from a satellite receiver at time-synchronization port G
- Via a high-precision optical synchronization pulse (**PPS optical**, 1-second pulse) from a satellite receiver at a USART communication module
- Via the **IEEE 1588** time-synchronization protocol

This allows you to measure and display the signal-transit time of the transmission route in transmit and receive direction separately. This lets you achieve the maximum responsivity with the line differential protection in communication networks even with differences in the signal-transit time in the transmit and receive direction (unbalanced runtimes). For the transmission of protection data in **type 2** protection communication, different signal-transit times are irrelevant.

Constellation Measured Values

Constellation measured values are measured values predefined by Siemens with the following properties:

- They are synchronized in the devices in a device combination.
- They are substituted using the protection interface.
- They are available on every device.

You can view the constellation measured values with DIGSI 5.

In the device, current and voltage measured values are displayed in absolute value and phase as a percentage. 100 % conform to the rated current or the rated voltage of the line (see next figure). These measured values are recorded every 2 seconds by the devices participating in the device combination and then sent to the other respective devices. At the same time, the current and voltage values of the different devices are time-synchronous with one another.

When displaying the constellation measured values the local device is prioritized. The device connected directly with DIGSI 5 is the local device.

For the protection communication, the display of the constellation measured values differs between **Type 1** and **Type 2**.

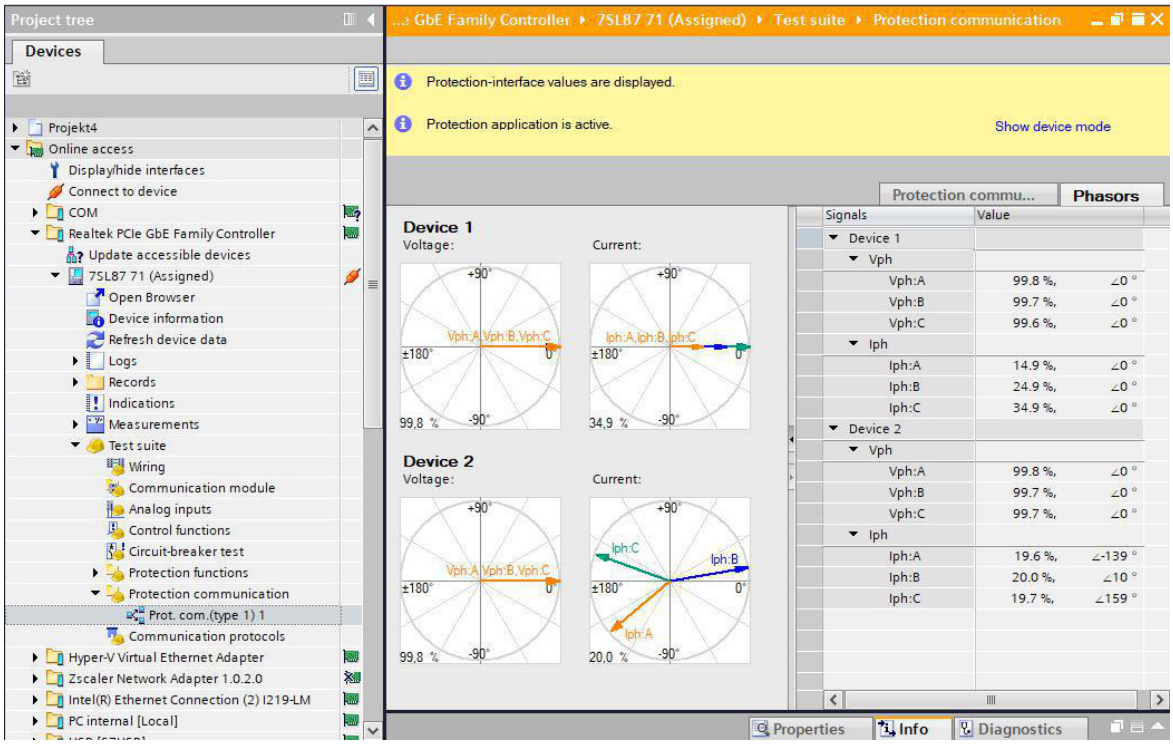
- Protection communication **Type 1**:

  The phasors of the current and voltage measured values of the local device have an angle of 0°. The angles of the measured values of the other devices relate to the local values, meaning that the angle difference to the remote ends is displayed.

- Protection communication **Type 2**:

  The voltage phasor V_A of the local device has an angle of 0°. The angles of the other local measured values and the measured values of the remote devices relate to V_A (0°).

You can find these measured values in the device under the following DIGSI mask:

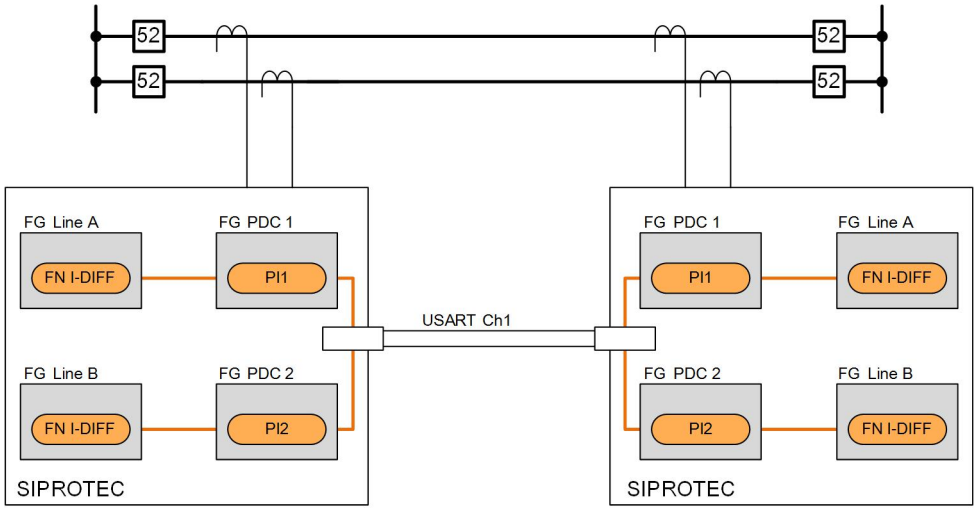


[sc_const mv, 2, en_US]

Figure 3-69 Example of Constellation Measured Values with Phases

Multiplex Operation

With extended protection communication, you have the option of having a physical USART channel used by 2 logical protection interfaces. In this way, a transmission route can be double used, for example to implement **Parallel line protection** with **Line differential protection** without additional hardware. To do this, configure the channel according to chapter *3.6.6.4 Configuration of the Advanced Protection Communication in DIGSI 5*.



[dw_channel-mux, 1, en_US]

Figure 3-70 Multiplex Operation

NOTE

Note that in case of multiple use of a physical channel, the available bandwidth is divided equally between the logical protection interfaces. Therefore, this operating mode is not suitable for baud rates under 128 kBit/s.

NOTE

In case of multiple use of a physical USART connection – for example, for protection of a double line – you must provide further redundancy concepts.

3.6.4 Available Variants for the Protection Communication

The following variants are available for protection communication:

- **Classic protection communication**
  The scope of parameterization is small for the classic protection communication. The following constraints exist:
  - IP-based communication protocols are not supported.
  - Increased parameterization effort when changing the number of devices in the device combination subsequently, for example, protection of a multi-terminal line.
- **Advanced protection communication**
  The advanced protection communication provides greater flexibility and is used with IP-based communication protocols. For this purpose, the devices must be equipped with an Ethernet BD module. The following advantages also exist for devices equipped with USART communication modules:
  - Easy subsequent expansion of the number of devices in a device combination
  - Multiple function groups **Protection communication** can be instantiated
  - Multiplex operation of a physical protection connection
  - Hierarchically structured representation in DIGSI 5 project tree

For further information on the 2 variants, refer to *3.6.5 Classic Protection Communication* and *3.6.6 Advanced Protection Communication* .

NOTE

Do not confuse the 2 variants of the protection communication with type 1 and type 2 of the protection communication!

NOTE

If you are unsure about the suitable variant for your use case during selection, use the advanced protection communication.

NOTE

If you want to change an existing classic protection communication to an advanced protection communication or vice versa, a window appears in DIGSI where you are asked whether you want to keep the mapping or not - that is, the communication settings or communication-information routing that has previously been set. In this case, click **No**

3.6.5 Classic Protection Communication

3.6.5.1 Overview

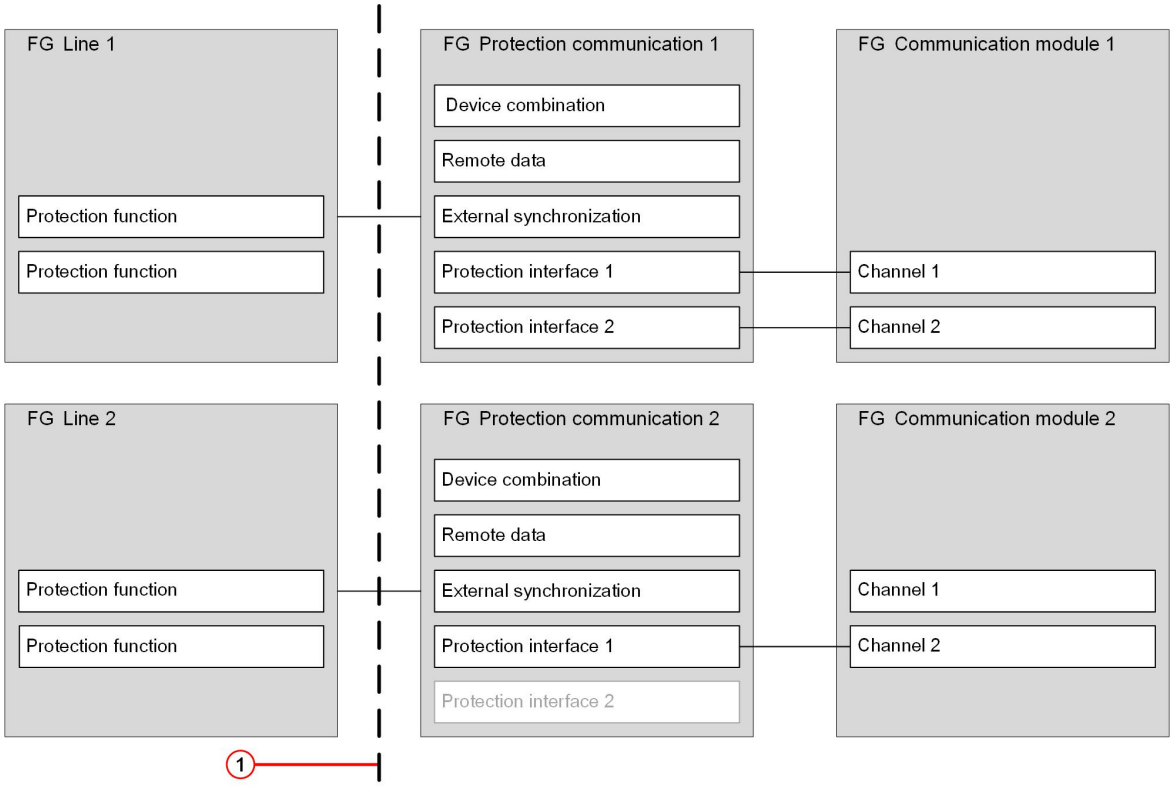
The classic protection communication enables the data exchange between the devices via synchronous serial point-to-point connections from 64 kBit/s to 2 mBit/s. These connections can be directly via optical fiber or via other communication media, for example, via dedicated lines or via communication networks. IP-based communication is not supported.

The function groups of the classic protection communication always support a fixed number of devices in the device combination:

- 2-device protection communication
- 3-device protection communication
- 4-device protection communication
- 5-device protection communication
- 6-device protection communication

3.6.5.2 Classic Protection Communication in the Overall System

The classic **protection communication** is integrated as follows in the overall system:



[dw_simple_protcom_compl_system, 2, en_US]

Figure 3-71 Classic Protection Communication in the Overall System

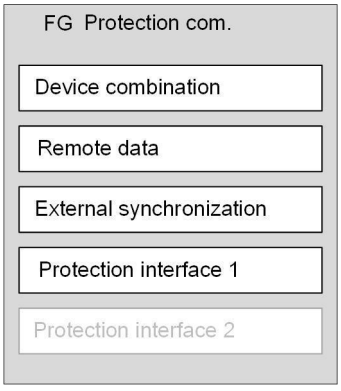
(1) The device automatically routes the connection between the protection FG and the **Protection communication** FG in DIGSI 5.

3.6.5.3 Structure of the Function Group

If you select the communication protocol **Protection interface** and the **number of devices** on a channel in the communication module, the classic function group **Protection communication** is automatically created in the DIGSI 5 information routing.

The classic function group **Protection communication** contains the following functionalities and function blocks (FB):

- **Device combination**
- **Protection interface**
- FBs for **Remote data**
- FB **External synchronization** for the synchronization of the transferred data through an external synchronous pulse (1-second-pulse, PPS[10])



[dw_structure_FG_protcom_simple, 1, en_US]

Figure 3-72 Structure of the Classic FG Protection Communication

The function **Device combination** manages the devices that exchange data via protection communication. In the device-combination settings, you set the general settings for the device combination and the device addresses.

The function **Device combination** issues the following indications:

- General indications like the
  - Number of devices
  - Type and status of the device topology
- Indications of the devices in the device combination like:
  - The availability of the device
  - The state of the device, that is whether the device is logged on or off in the device combination

Measured values are transmitted via protection communication and are acquired and exchanged at the same time in the devices. The synchronization of the measured-value acquisition can be done either internally via the telegram measurement or via an external synchronous pulse (1-second pulse, PPS) using the function block **External synchronization**. The external synchronization is switched on in the function block of the protection interface. You can find the indications of the external synchronization in the function block **External synchronization**.

The function block **Remote data** is used to transfer selected and user-specific signals and measured values from the SIPROTEC 5 system. You select the signals and measured values to be transmitted in the communication mapping of DIGSI. The remote data does not issue status indications.

The function block **Protection interface** is automatically connected to a physical channel of a communication module and can therefore send signals and measured values to the neighboring device or receive them from the neighboring device. You can find the status indications of the FB **Protection interface** in the DIGSI 5 information routing in the function group **Protection communication**.

10 PPS - **P**ulse **P**er **S**econd

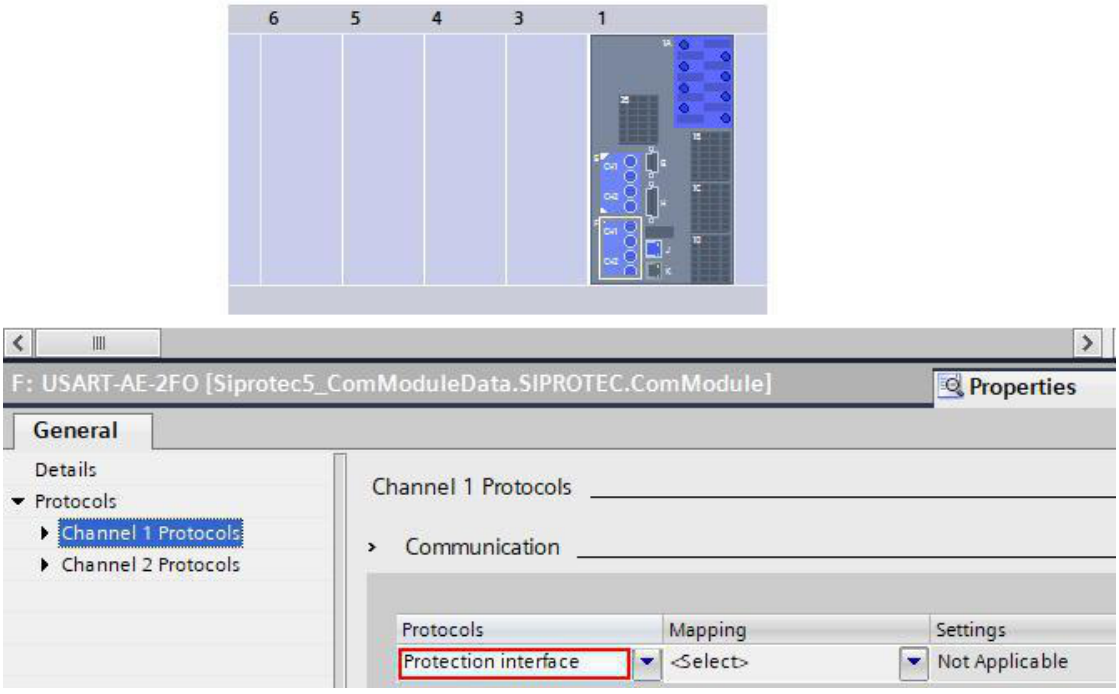
NOTE

In contrast to the protection interface in extended protection communication, the protection interface in classic protection communication is automatically connected to a physical channel of the communication module (refer to *Figure 3-71*).

3.6.5.4 Configuration of the Protection Interface in DIGSI 5

If the device is provided with modules, proceed as follows:

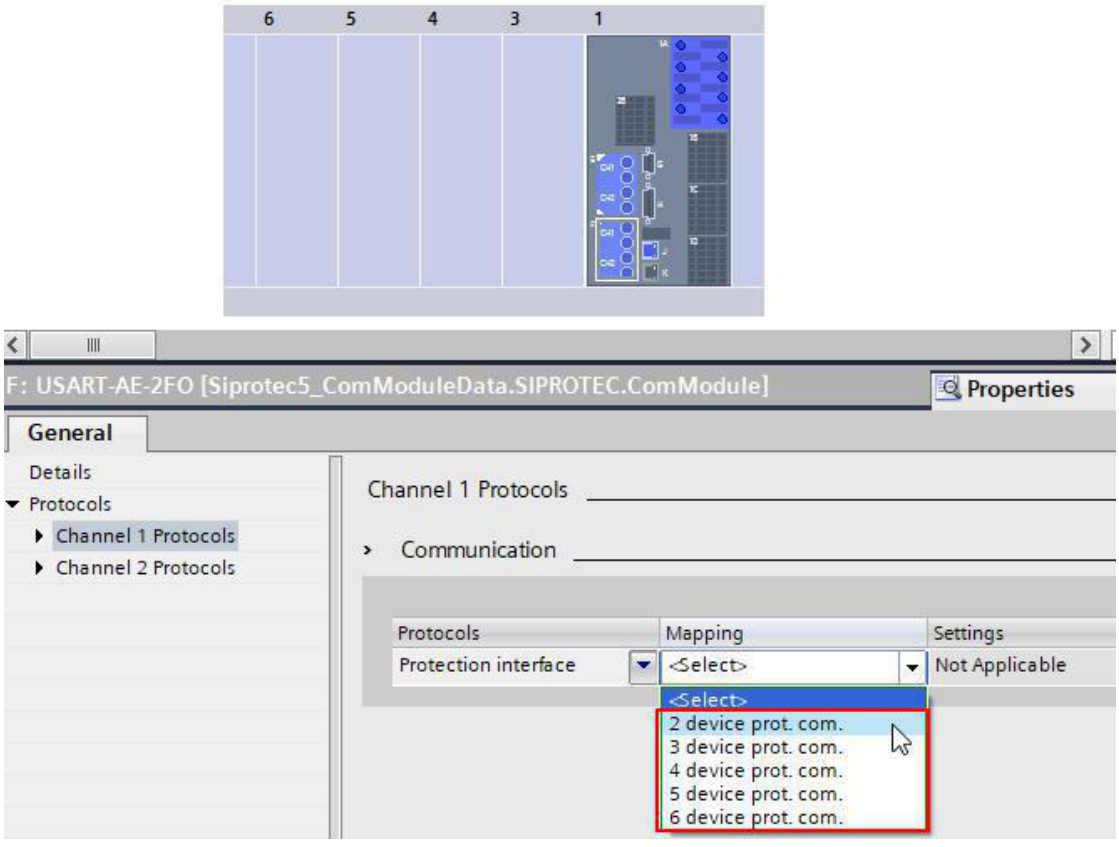
- Select the desired communication module in the rear view of the device.
- In the **Properties of the communication module** > **Protocols** > **Channel x Protocols**, select the ***Protection interface*** protocol.



[sc_PDC_classic_protocol, 1, en_US]

Figure 3-73 Selection of the Communication Protocol

- Then select the number of devices under **Mapping** (see next figure).
  Depending on the device, the selection of device combinations can be restricted to 2 or 3 devices.
  The number of devices is an order option with regard to the line differential protection.



[sc_PDC_classic_mapping, 1, en_US]

Figure 3-74 Selecting the Device Combination

NOTE

The function groups shown in *Figure 3-74* are not available in the DIGSI library.

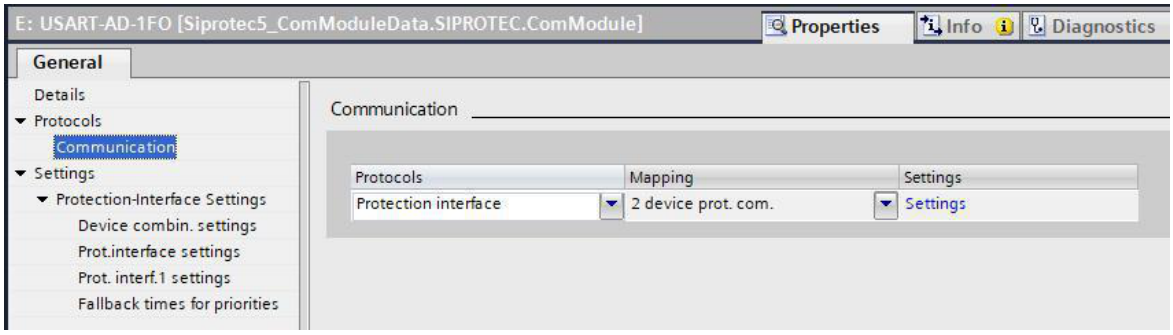
If you use the **Line differential protection** function in combination with the classic protection communication, the device only supports 2 line ends. Under **Mapping**, select the option **2 devices prot. comm.**. If you select an option that is not permitted, DIGSI reports an inconsistency.

If the module slot is not yet provided with modules, proceed as follows:

- Select the desired communication module in the rear view of the device.
- Select the module from the catalog and drag it to a channel. Thus is the channel configured with a module. DIGSI 5 indicates whether the module can be used for protection communication under **Device Information**.
- Use the **Protocols** text box to select the ***Protection interface***, see *Figure 3-73*.
- Then use the **Mapping** text box to select the number of devices, for example **2 devices protection com.**, see *Figure 3-74*.

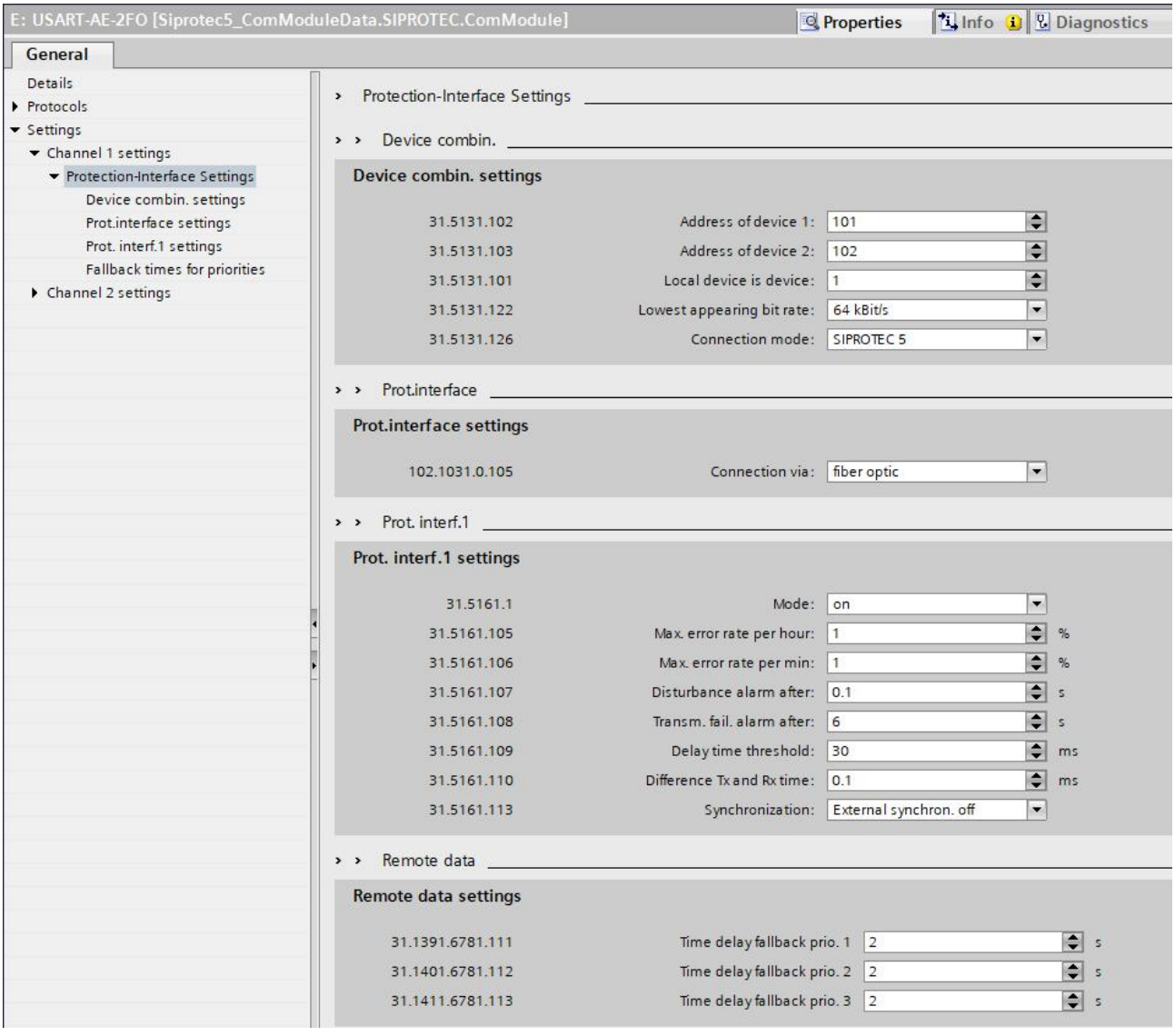
3.6.5.5 Setting Notes for the Device Combination

Select the communication module in the **Project tree** > **Hardware and protocols** in the **Device view**. In the properties of the communication module, you can find the setting sheets for the parameterization of the device-combination settings and the settings for protection communication.



[sc_config1, 1, en_US]

Figure 3-75 Selection of the Protocol: Communication via the Protection Interface



[sc_config, 4, en_US]

Figure 3-76 Protection-Interface Initialization and Configuration

Changes in the device-combination settings are always visible on the other channel as well. All further parameters can be set separately for individual channels.

Parameter: Address of Device x

- Default setting **(_:5131:102) Address of device 1** = ***101***
- Default setting **(_:5131:103) Address of device 2** = ***102***

With the parameters **Address of device 1** to **Address of device 2**, you give an address to each device. Set a unique and unambiguous address for each device.

NOTE

The device **1** is the timing master device in a device combination.

If all other devices in the device combination are to obtain their time from the timing master device, note the following:

- Under **Address of device 1** set the address for the timing master device.
- Parameterize the other devices such that they get their time from the timing master device via the protection connections.

  For more information, refer to *3.7.3 Function Description*. Select as the adjustable synchronization option ***Protection interface***.

  In the timing master device you must **not** set the protection interface as the synchronization source!

Parameter: Local device is device

- Default setting **(_:5131:101) Local device is device** = ***1***

With the parameter **Local device is device**, you set the index (number) of your device in the device combination. A maximum of 6 devices can be present in one device combination.

APPLICATION EXAMPLE

You have a device combination with 2 devices.

For example, in DIGSI 5, select the parameter setting **Address of device 1** with the parameter value ***101*** for device 1 and the parameter setting **Address of device 2** with the parameter value ***102*** for device 2.

Then, use the **Local device is device** parameter to set the index of the local device. The local device is the device that you parametrize.

The addresses must be set identically for all devices in the device combination. Functional protection communication requires that you also assign the same index in all devices of the device combination for a device with a unique address.

Parameter: Lowest appearing bit rate

- Default setting **(_:5131:122) Lowest appearing bit rate** = ***64 kBit/s***

With the parameter **Lowest appearing bit rate**, you set the lowest bit rate occurring in the device group. Set the lowest value in each device with a three-end constellation with 2 fiber-optic connections (2 MBit/s) and one 64 kBit/s connection with the lowest value (64 kBit/s). This value determines the maximum number of selected and self-created signals and measured values which are to be transmitted within the device combination (refer to *3.6.5.9 Remote Data*).

Apart from the default value, you can also set the following bit rates:

- ***128 kBit/s***
- ***512 kBit/s***
- ***2048 kBit/s***

NOTE

If you use optical fibers for a connection between the devices, set the value to ***2048 kBit/s***.

Connection mode

- Default setting **Connection mode** = ***SIPROTEC 5***

With the parameter **Connection mode**, you select the device type with which the SIPROTEC 5 device is to work in the device combination. As soon as a SIPROTEC 4 device works in the device combination, you must set the parameter **Connection mode** accordingly.

Parameter Value	Description
SIPROTEC 5	The SIPROTEC 5 device only works with SIPROTEC 5 devices in the device combination.
SIPROTEC 4 7SD610	The SIPROTEC 5 device works with at least one SIPROTEC 4 Differential protection device 7SD610 with firmware version V4.72 and higher in the device combination.
SIPROTEC 4 7SD5	The SIPROTEC 5 device works with at least one SIPROTEC 4 Differential protection device 7SD5x with firmware version V4.72 and higher in the device combination.
SIPROTEC 4 7SA5/6	The SIPROTEC 5 device works with at least one SIPROTEC 4 Distance protection device 7SA522 and 7SA6x with firmware version V4.72 and higher in the device combination.

3.6.5.6 Setting Notes on Selecting the Communication Medium

- Default setting **(_:105) Connection via** = ***fiber optic***

The **Connection via** parameter is used to set the bit rate required for the protection interface. Different discrete values can be entered depending on the means of communication (see following table).

Also refer to *Communication Media, Page 144*

Table 3-13 Means of Communication

Means of Communication	See	Setting Value	Bit Rate
Fiber-optic direct connection	*Figure 3-58* to *Figure 3-62*	***fiber optic***	2 MBit/s
CC-XG-512 communication converter	*Figure 3-63*	***CCXG 512 kBit/s***	512 kBit/s
CC-XG-128 communication converter	*Figure 3-63*	***CCXG 128 kBit/s***	128 kBit/s
CC-XG-64 communication converter	*Figure 3-63*	***CCXG 64 kBit/s***	64 kBit/s
Repeater 512 communication converter	*Figure 3-66*	***repeater 512 kBit/s***	512 kBit/s
CC-CC-128 Communication converter	*Figure 3-65*	***CCPW 128 kBit/s***	128 kBit/s
CC-2M-512 Communication converter	*Figure 3-64*	***CC2M 512 kBit/s***	512 kBit/s
Multiplexer with C37.94 interface	*Figure 3-67*	***C37.94 1 * 64 kBit/s*** ***C37.94 2 * 64 kBit/s*** ***C37.94 8 * 64 kBit/s***	64 kBit/s 128 kBit/s 512 kBit/s
Other (freely adjustable bit rates for a direct connection for special applications)		***64 kBit/s*** ***128 kBit/s*** ***512 kBit/s*** ***2048 kBit/s***	64 kBit/s 128 kBit/s 512 kBit/s 2,048 kBit/s

3.6.5.7 Setting Notes for the Classic Protection Interface

Parameter: Max. error rate per hour

- Default setting **(_:5161:105) Max. error rate per hour** = *1.0%*

If the number of faulty telegrams per hour exceeds the value set in the parameter **Max. error rate per hour**, you receive the error message *Error rate / hour exc.*.

Parameter: Max. error rate per min

- Default setting **(_:5161:106) Max. error rate per min** = *1.0%*

If the number of faulty telegrams per minute exceeds the value set in the parameter **Max. error rate per min**, you receive the error message *Error rate / min exc.*.

Parameter: Disturbance alarm after

- Default setting **(_:5161:107) Disturbance alarm after** = *100 ms*

With the parameter **Disturbance alarm after**, you determine the time delay after which defective or missing telegrams are signaled as faulty where the indication *Status of lay. 1 and 2* is *PI data fault*.

Parameter: Transm. fail. alarm after

- Default setting **(_:5161:108) Transm. fail. alarm after** = *6.0 s*

With the parameter **Transm. fail. alarm after**, you determine the time delay after which a communication failure is signaled where the indication *Status of lay. 1 and 2* is *PI data failure*.

Parameter: Delay time threshold

- Default setting **(_:5161:109) Delay time threshold** = *30.0 ms*

The time taken to transmit and receive a signal via a protection connection is the signal-transit time. You can monitor the signal-transit time. For the **Delay time threshold**, the default setting is selected in such a way that normal communication networks do not exceed the signal-transit time. If this signal-transit time is exceeded during operation (for example upon switchover to another transmission route), the indication **Time delay exceeded** is issued.

Increased runtimes only affect the operate time, and therefore the fault-clearing time of the protection functions using the protection interface. If you use the **Line differential protection** function, this remains in effect.

Parameter: Difference Tx and Rx time

- Default setting **(_:5161:110) Difference Tx and Rx time** = *0.1 ms*

For time synchronization of the measured values with microsecond accuracy using telegram measurement, the signal-transit times in the send and reception direction must be approximately the same. The device monitors the signal-transit times in the send and reception direction.

With the parameter **Difference Tx and Rx time**, you set a maximum permitted signal-transit time difference between the send and reception paths (runtimes unbalanced). Set the parameter **Difference Tx and Rx time** to the maximum difference expected.

Set this value to *0* for a direct fiber-optic connection. A higher value is necessary for transmission via communication networks. Reference value: *0.1 ms* (recommended setting value).

If the difference in the signal-transit times between the send and reception path exceeds the value set, the indication *Time delay jump* is issued.

If the difference from consecutive measurements of the signal-transit times between the send and reception paths exceeds the set value and remains for more than 5 s, the indication *Time delay different* is issued. The **Line differential protection** function is no longer working properly and is *ineffective*.

NOTE

The parameter **Difference Tx and Rx time** only shows when the function **Line differential protection** is instantiated and the parameter **Synchronization** is not set to ***External synch. only***.

NOTE

If you use a multiplexer with a C37.94 interface as a means of communication, Siemens recommends a setting value of ***0.25 ms*** to ***0.6 ms***.

Parameter: Synchronization

- Default setting **(_:5161:113) Synchronization** = ***External synchron. off***

With the parameter **Synchronization**, you control the time synchronization of the measured values with microsecond accuracy.

If the SIPROTEC device operates with the external synchronization, use the **Synchronization** parameter to define how the protection is activated after restoration of the communication connection (basic state or after transmission fault). See *Figure 3-78*.

Parameter Value	Description
External synchron. off	The external synchronization is disabled: No external synchronization is performed at the protection interface. Select this setting value if you do not expect any differences between the signal-transit times in the transmission and reception directions. Then the measured values are only synchronized internally with the telegram measurement.
Telegr. and ext. synch.	Synchronization via telegram measurement and external synchronization: The measured values are synchronized internally with the telegram measurement, supported by the external synchronization. You can set the external synchronization with the parameter **External synchronization**. The synchronization is possible via the IEEE 1588 protocol or via the synchronous pulse of a satellite receiver. In this case, an existing line differential protection is only released when a new connection is established and one of the following conditions is met. • The protection connection is synchronized with the help of the external synchronization. • Symmetric signal-transit times are signaled via the binary input signal *>Sync reset* or the controllable *Reset synchronization*. This means that the signal-transit times are the same in the send and receive direction.

Parameter Value	Description
Telegr. or ext. synch.	Synchronization via telegram measurement or external synchronization: The measured values are synchronized internally with the telegram measurement, supported by the external synchronization. You can set the external synchronization with the parameter **External synchronization**. The synchronization is possible via the IEEE 1588 protocol or via the synchronous pulse of a satellite receiver. An available line differential protection is enabled immediately upon renewed establishment of connection (data telegrams are received). The internal synchronization is used up to synchronization.
External synch. only	External synchronization only: The measured values are synchronized only through the external synchronization. You can set the external synchronization with the parameter **External synchronization**. The synchronization is possible via the IEEE 1588 protocol or via the synchronous pulse of a satellite receiver.

Parameter: External synchronization

- Default setting **(_:5161:117) External synchronization** = ***PPS electrical (Port G)***

The parameter **External synchronization** is visible only if the parameter **Synchronization** is not set to ***External synchron. off***.

External synchronization is possible separately for each protection interface.

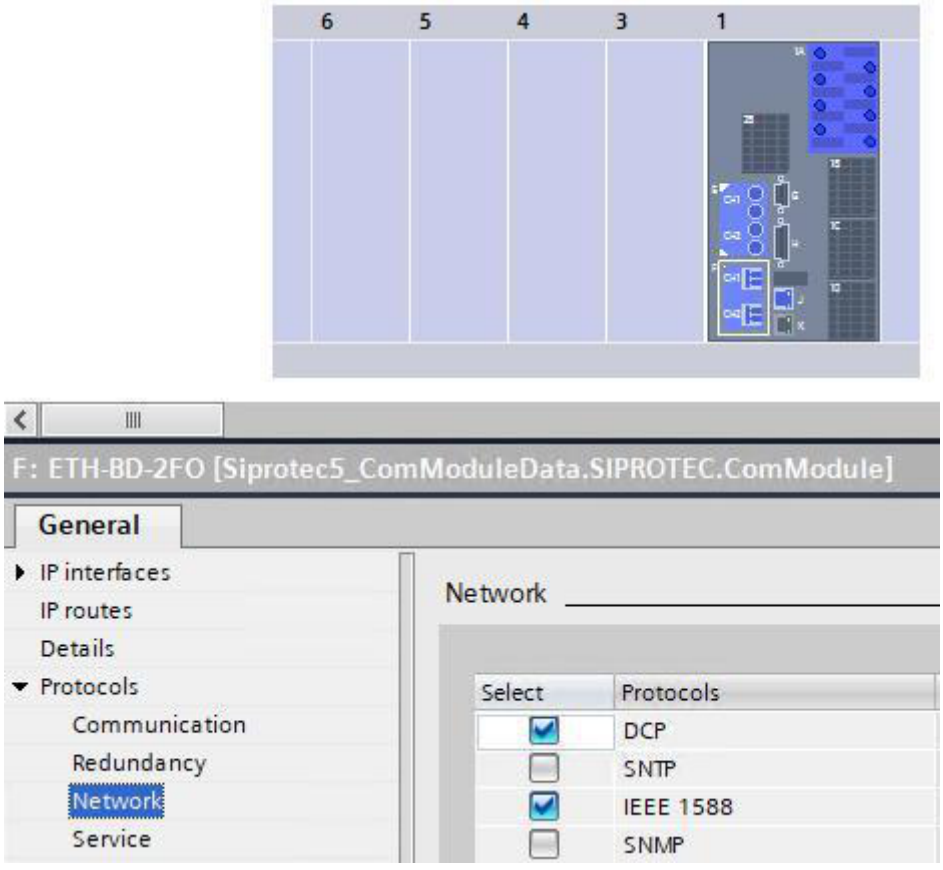
Parameter Value	Description
PPS electrical (Port G)	The electrical synchronous pulse of a satellite receiver (1-second-pulse, PPS[11]) is the synchronization source on the port **G**, the time synchronization interface.
IEEE 1588	The time synchronization protocol IEEE 1588 for an Ethernet-BD communication module is used for synchronization.



NOTE

The configuration option ***IEEE 1588*** is only visible if the device has an Ethernet-BD communication module and you have selected the communication protocol IEEE 1588, see following figure.

11 PPS - **P**ulse **P**er **S**econd



[sc_BD_1588, 1, en_US]

Figure 3-77 Ethernet-BD Communication Module: Selection of the IEEE 1588 Protocol

NOTE

External synchronization takes into account the signal-transit time in the transmission and reception directions. If external synchronization fails for a short time, for example, due to a receiving interference or an unfavorable satellite position for a brief period, internal synchronization via telegram measurement is still active.

NOTE

In contrast to the protection interface in extended protection communication, the protection interface in classic protection communication is automatically connected to a channel of a communication module (see *Figure 3-71*).

Parameter: Max. inaccuracy

- Default setting **(_:5161:119) Max. inaccuracy** = ***0.500 ms***

With the parameter **Max. inaccuracy**, you configure the maximum expected inaccuracy of the synchronization sourced used. The set value is only effective if the synchronization source used does not supply any information on the current inaccuracy in the synchronization signals. If you have not used any of the information on the inaccuracy of the synchronization source used, use the default setting.

NOTE

The inaccuracy of the synchronization source enters the stabilization of the **Line differential protection** as an error signal.

This means that a greater inaccuracy increases the calculated restraining quantity and makes the **Line differential protection** less sensitive.

If **IEEE 1588** is used as the synchronization source in the synchronization status ***SmpSynch*** = ***global***, accuracy values are supplied with the synchronization signals and the parameter **Max. inaccuracy** is not used. If the supplied accuracy values become invalid, the value set in the parameter **Max. inaccuracy** is used.

If the synchronization source **IEEE 1588** works in the synchronization status ***SmpSynch*** = ***local***, then the value set in the parameter **Max. inaccuracy** is used as permanently available inaccuracy.

If the synchronization source **PPS electrical (Port G)** or **PPS optical (USART)** is used, then the value set in the parameter **Max. inaccuracy** is used as permanent inaccuracy.

If a USART communication module with the **PPS** protocol and the **PPS generator**operating mode is also used as a synchronization source at the same time, the value set in the parameter **Max. inaccuracy** is used as permanent inaccuracy.

Parameter: Check synchron.-source

- Default setting **(_:5161:121) Check synchron.-source** = ***yes***

With the parameter **Check synchron.-source**, you can switch on or off the synchronization-sources check. During the check of the synchronization sources on the ends of a protection connection, a check is conducted as to whether both synchronization sources are working in the same synchronization status ***SmpSynch***.

If both synchronization sources are working in the synchronization status ***SmpSynch*** = ***global***, the check has been passed.

If both synchronization sources are working in the synchronization status ***SmpSynch*** = ***local***, that is decoupled from a global reference time, an additional check is conducted as to whether the synchronization source (***gmIdentity***) is the same. Synchronicity can only be guaranteed if the synchronization sources are the same.

If the synchronization sources display a different synchronization status, that is one displays the synchronization status ***SmpSynch*** = ***local*** and the other the synchronization status ***SmpSynch*** = ***global***, synchronization cannot be guaranteed.

Siemens recommends using the default setting **Check synchron.-source** = yes.

If you have problems with the synchronization-source check, you can switch off the synchronization-source check. Switch off the synchronization-source check only if the synchronization sources are synchronous at the end of their protection connection.

The parameter **Check synchron.-source** is visible only if the parameter **(_:5161:113) Synchronization** is set to ***External synch. only***.

NOTE

If you use **PPS electrical (port G)** as the synchronization source, the synchronization status (***SmpSynch***) is permanently set to ***global***.

If you use **PPS optical (USART)** as the synchronization source, you can use the setting (_:107) **Received. SmpSynch** to set the synchronization status to (***SmpSynch***) ***local*** or ***global***.

For synchronization with microsecond accuracy, for example with **Line differential protection**, adjust the parameter (_:107) **to Accepted. SmpSynch** = ***global***.

3.6.5.8 Indications and Measured Values in the Classic Protection Interface

Each individual protection interface provides different indications for commissioning and diagnostics of communication:

Indication *(_:5161:301) Status of lay. 1 and 2*

The indication *(_:5161:301) Status of lay. 1 and 2* informs you about the status of the connection. The following indications are possible:

Table 3-14 Status Indications Status of lay. 1 and 2

Indication	Description
initialized:	The protection interface is not connected and is in the Initial state.
PI connected:	The protection interface is connected to the protection interface of the partner device.
PI data fault:	The protection interface has not received any valid telegrams for the time set in parameter **(_:5161:107) Disturbance alarm after** .
PI data failure:	The protection interface has not received any valid telegrams for the time set in parameter **(_:5161:108) Transm. fail. alarm after** .
not existing:	The protection interface has not been assigned to a communication channel.

Indication *(_:5161:302) Status of lay. 3 and 4*

The indication *(_:5161:302) Status of lay. 3 and 4* informs about errors during the connection establishment. The following indications values are possible:

Status Indication	Description
no error:	No errors occurred during the connection establishment.
SW ver.incomp.:	The connection is not established because the firmware versions of the devices are incompatible. Update the firmware.
wrong dev. ID:	The connection is not established because the device address of the local device or the partner device is incorrect or set incorrectly. Check the settings for the parameters **Address of device 1** to **Address of device n** (_:5131:102 and following).
const.sett.error:	The connection is not established because the parameters are set differently. Check whether the parameter **(_:5131:122) Lowest appearing bit rate** has been set the same in all devices in the device combination.
diff.sett error:	The connection is not established because the parameters are set differently. The line differential protection settings for the connected devices are incompatible. Check whether the devices are set to operate with or without line differential protection. The rated current of the line (parameter **(_:9001:101) Rated current**) must have the same setting in all devices. With a transformer in the line, the **(_:9001:103) Rated apparent power** must be set to the same value in all devices. For further information, see *6.7 Line Differential Protection*.
net mirroring	The connection is not established. The protection interface is receiving its own data. Check the wiring.
wrong dev. idx.	The connection is not established because the device index of the local device or the partner device is incorrect. Check the setting for the parameter **(_:5131:101) Local device is device**.

Furthermore, the following output signals are available:

Output Signal	Description
(_:5161:303) Connection broken	The signal *Connection broken* indicates that during a parameterized time (parameter **(_:5161:107) Disturbance alarm after**) no telegrams or faulty telegrams were continuously received. If the indication *Connection broken* is issued, the affected protection connection is reset. This can cause the blocking of an active line differential protection or a ring topology can change to a chain topology.
(_:5161:316) Error rate / min exc.	The signal *Error rate / min exc.* indicates that the set maximum error rate per minute (parameter **(_:5161:106) Max. error rate per min**) has been exceeded. In this manner, a brief increase of the operate time and thus of the fault-clearing time is possible for the protection functions using the protection interface. If you use the **Line differential protection** function, this remains in effect.
(_:5161:317) Error rate / hour exc.	The signal *Error rate / hour exc.* indicates that the set maximum error rate per hour (parameter **(_:5161:105) Max. error rate per hour**) has been exceeded. In this manner, a brief increase of the operate time and thus of the fault-clearing time is possible for the protection functions using the protection interface. If you use the **Line differential protection** function, this remains in effect.
(_:5161:318) Time delay exceeded	The signal *Time delay exceeded* indicates that the threshold value for the set signal-transit time (parameter **(_:5161:109) Delay time threshold**) has been exceeded. Increased transmission times only affect the operate time, and therefore the fault-clearing time of the protection functions using the protection interface. If you use the **Line differential protection** function, this remains in effect.
(_:5161:319) Time delay different	The signal *Time delay different* indicates that the threshold value for the difference in signal runtimes in the transmission and reception direction (asymmetrical runtimes) has been exceeded. The setting value results from the setting value of the parameter **(_:5161:110) Difference Tx and Rx time**. The indication is visible only if the parameter **(_:5161:113) Synchronization** is not set to ***External synch. only***. If the indication *Time delay different* appears, the **Line differential protection** function is no longer working properly and is ***ineffective***.
(_:5161:320) Time delay jump	The signal *Time delay jump* indicates that the signal runtimes of the data changed abruptly. This is caused by a switchover of the communication path in the communication network. The indication is visible only if the parameter **(_:5161:113) Synchronization** is not set to ***External synch. only***.
(_:5161:321) PI synchronized	The signal *PI synchronized* indicates that the synchronization with microsecond accuracy of the measured values transferred between the local device and partner device is working correctly. The indication is visible only if the parameter **(_:5161:113) Synchronization** is not set to ***External synch. only***.

Output Signal	Description
(_:5161:340) Telegram lost	The signal *Telegram lost* indicates that an expected telegram has failed to arrive or a faulty telegram has been received. Reasons for this can be for example switching operations in the primary system or operations on the components of the communication network. If you want to assign the communication failures or faults to other events, route the signal *Telegram lost* temporarily into the operational log. **Note:** If the signal is constantly routed, the operational log can overflow. Siemens recommends routing the signal only for clarification of problems.
(_:5161:343) Partner	The indication shows the address of the partner device. A value of 0 means that no partner address is available.
(_:5161:323) PPS: time del. unsym.	This indication is only visible if you are working with a synchronous pulse. The indication shows that the difference in the signal runtimes between the sending and receiving path exceeds the value set with the parameter **(_:5161:110) Difference Tx and Rx time**. **Note:** The **Line differential protection** function remains ***effective***.
(_:5161:324) PI with PPS synchron.	This indication is only visible if you are working with a synchronous pulse. This indication is only visible if, in parallel to synchronization with the synchronization pulse, you are also working with the synchronization via telegram measurement. If both synchronization methods are working properly, the indication *PI with PPS synchron.* = RAISING is generated.

Measured Values of the Protection Interface

The protection interface provides the following measured value for the diagnosis of the protection-interface communication:

Measured Value	Description
(_:5161:308) Tx tel/h	Telegrams transmitted during the last hour
(_:5161:309) Rx tel/h	Telegrams received during the last hour
(_:5161:310) Tx tel/min	Telegrams transmitted during the last minute
(_:5161:311) Rx tel/min	Telegrams received during the last minute
(_:5161:312) Tx err/h	Transmission failure rate during the last hour
(_:5161:313) Rx err/h	Receive error rate during the last hour
(_:5161:314) Tx err/min	Transmission failure rate during the last minute
(_:5161:315) Rx err/min	Receive error rate during the last minute
(_:5161:325) Aver.Δt	Average singal runtime (average value of the runtime in transmission and reception path divided by 2, without external synchronization)
(_:5161:326) Rec. Δt	Signal runtime for reception path (with external synchronization)
(_:5161:327) Sen. Δt	Signal runtime for transmission path (with external synchronization)
(_:5161:334) Miss.tel/min	Number of telegram failures within the last minute
(_:5161:335) Miss.tel/h	Number of telegram failures within the last hour
(_:5161:336) Miss.tel/d	Number of telegram failures within the last day
(_:5161:337) Miss.tel/w	Number of telegram failures within the last week
(_:5161:338) M. loss/d	Longest lasting telegram failure within the last day
(_:5161:339) M. loss/w	Longest lasting telegram failures within the last week
(_:5161:331) Recept.	Receipt of a telegram (0 = no receipt, 1 = receipt) You can use this indication to make the telegram exchange visible in the fault record.

NOTE

You can reset the measured values of the protection interface directly in the device. Proceed as follows: **Device functions > x Device protection comm. > Protection interface y > Release measured values**.

Indications of External Synchronization

The following indications are visible only if the parameter **(_:5161:117) External synchronization** is set to ***PPS electrical (Port G)***.

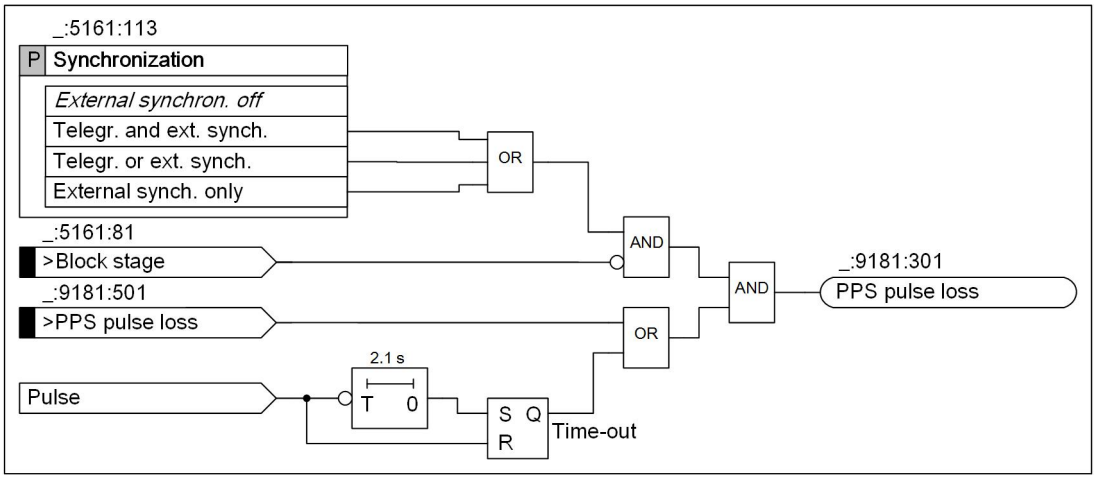
- *(_:9181:501) >PPS pulse loss*
- *(_:9181:301) PPS pulse loss*
- *(_:9181:302) PPS pulse*
- *(_:9181:303) PPS pulse OK*

The following indications are visible only if the parameter **(_:5161:117) External synchronization** is set to ***IEEE 1588***.

- *(_:304) Synchronization loss*
- *(_:305) Synchronization OK*
- *(_:306) Synchronization pulse*

Indication	Description
(_:9181:500) >Block stage	This indication shows the blocking of the external synchronization via a binary input. The external synchronization can be set to inactive through this binary input indication.
(_:9181:501) >PPS pulse loss	The binary input *(_:9181:501) >PPS pulse loss* can be used to signal an externally detected failure in the PPS synchronous pulse (for example, an error message from the satellite receiver). Setting this binary input also leads to the indication *(_:9181:301) PPS pulse loss*. The external synchronization detects immediately that there is a problem with the connected synchronization pulse. Otherwise, the problem will only be noticed after approx. 2.1 s – after the test for synchronous-pulse failure.
(_:9181:301) PPS pulse loss	This indication shows that the synchronization has failed. This can be due to the following reasons: • The input indication *(_:9181:501) >PPS pulse loss* has occurred. • The synchronous pulse has failed. • The quality of the synchronous pulse is inadequate. • There is another problem with the synchronization source. If no further PPS synchronous pulse is received within 2.1 s, the time-out monitoring responds. If no new second pulse occurs after the expiry of the monitoring time, the indication *(_:9181:301) PPS pulse loss* is issued (see *Figure 3-78*).
(_:9181:302) PPS pulse	This indication displays the synchronous pulse directly. As a rule, one pulse is generated per second. This indication works well to make the synchronous pulse visible.
(_:9181:303) PPS pulse OK	This indication shows that the synchronization is working properly.
(_:9181:304) Synchronization loss	The synchronization has failed. This can be due to a problem with the synchronization source.
(_:9181:305) Synchronization OK	The synchronization is working properly.

Indication	Description
(_:9181:306) Synchroni-zation pulse	You can use this indication to make the virtual synchronous pulse visible. As a rule, one pulse is generated per second.
(_:9181:307) Synchron. imprecise	If the set synchronization source operates in the ***global*** synchronization status (SmpSynch) and the time of the synchronization source deviates from the global time by more than 0.5 ms, the indication *Synchron. imprecise* is generated and the **Line differential protection** becomes ineffective. The indication *Synchron. imprecise* is visible only if the parameter **External synchronization** is set to ***IEEE 1588***.

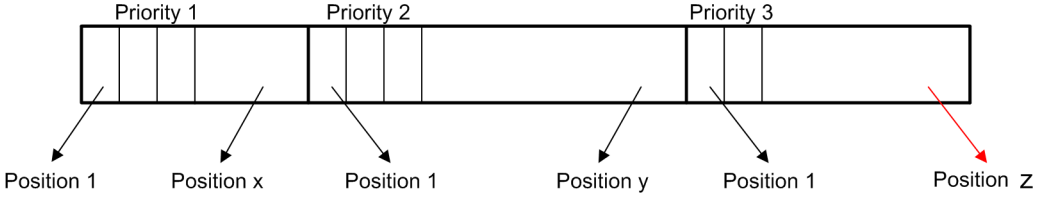


[lo_pps_syn, 2, en_US]

Figure 3-78 Logic for the Generation of the Indication *PPS pulse loss*

3.6.5.9 Remote Data

Between the devices in a device combination, a data bar is exchanged which can be written or read by the devices. It can be used for exchanging various signals between the devices. For this, each signal demands a certain number of data fields.



[dw_data, 1, en_US]

Figure 3-79 Data Bar Exchanged between Devices

The data bar is divided into 3 priorities, which have different transmission rates and data volumes.

For all signals sent, the basic principle is that only pure data contents are transmitted. The quality, for example, *Valid*, is not automatically transmitted as well. If you want to transmit the quality as well, for example, for further processing of GOOSE messages, you must transmit the quality separately, for example, using CFC. If a function is in test mode, all signals of the function are provided with a test flag. If a signal with a test flag is transmitted, all signals on the receiving side are provided with a test flag. If the connection is broken, which means there are devices that cannot be reached anymore, all received signals are flagged with the quality *invalid*. Additionally, the value is set to a predefined state after a selectable dropout time or the last value received can be retained (setting ***Hold***). This can be configured separately for each received signal, refer to *Table 3-18*.

Behavior When Devices Are Logged Off or Switched Off

If you log off a device, the behavior of the remote data is not affected. A logged-off device sends remote data as well. Logged-off devices can also receive and evaluate remote data.

If you switch off a device in the device combination, the remaining devices in the device combination do not send or receive any remote data. A failsafe state is adopted for the remote data received before that, according to the settings in the communication mapping in DIGSI. The previously received values can be either retained or replaced with a dropout value.

If you switch off a logged-off device, the remaining devices keep sending or receiving remote data. The remote data of a logged-off and switched-off device is no longer available in the communication. The remaining devices behave as if the logged-off and switched-off device has never been part of the device combination.

NOTE

For **ACT** type signals, only the phase information is transmitted.

Signals that are transferred data fields of priority 1 are sent with every telegram. They are preferably used for the transmission of rapid signals, for example, release for circuit-breaker intertripping. A strictly deterministic, rapid transmission is required there.

Signals of priority 2 are transmitted with at least every 2nd telegram. For bit rates >256 kbit, there are no differences between priority 1 and priority 2.

Priority 3 signals are transmitted at least every 100 ms. This priority is used for transmission of measured and metered values. Complex values must be routed separately as the real and the imaginary part for transmission. Measured-value thresholds that lead to an updating of a measured value are set centrally as a property of the measured value. These measured-value thresholds apply with the corresponding reporting, for example, also for the transfer via IEC 61850 to a substation automation technology.

Signals which are written to a data area x under a priority on the data bar must be routed to an indication of the same type in the device reading this information. Otherwise, they are processed incorrectly on the receiving side. The data bar is organized in terms of bits. For information on the bit requirement of each signal type, refer to *Table 3-17*.

Table 3-15 and *Table 3-16* show the number of data areas in the data bar in relation to the available baud rate.

NOTE

Adjust the parameter **(_:5131:122) Lowest appearing bit rate** in each device for the protection interfaces in a device combination. This determines the number of data areas.

If, for example, in a device combination with 3 devices with a type 2 chain topology 2 devices are connected via direct optical fibers and 2 devices with a bit rate of 64 kBit/s, the 64 kBit/s section is the limiting factor for the entire device combination.

Table 3-15 Available Bits – Minimum Constellation Baud Rate 64/128 kBit/s

	Priority 1	Priority 2	Priority 3
Type 1	8 bits	24 bits	128 bits
Type 2	32 bits	64 bits	256 bits

Table 3-16 Available Bits – Minimum Constellation Baud Rate 512/2048 kBit/s

	Priority 1	Priority 2	Priority 3
Type 1	48 bits	128 bits	384 bits
Type 2	96 bits	200 bits	1024 bits

Table 3-17 Requirement in Bits

Signal Type	Size in Bits
SP (single-point indication)	1 bit
DP (double-point indication)	2 bits
IN (metered values)	32 bits
MW (measured values)[12]	32 bits
ACT	4 bits

Table 3-18 Possible Dropout Values

Signal Type	Dropout Thresholds
SP (single-point indication)	Outgoing, Incoming, Hold
DP (double-point indication)	On, Off, Intermediate Position, Disturbed Position, Hold
IN (metered values)	0, Hold
MW (measured values)	0, Hold
ACT	Hold



NOTE

If the protection link fails, these values can be set on the receiver side.

EXAMPLE

2 devices are connected with line differential protection via a 64-kBit channel. This is a type 1 protection communication. There are 8 bits available for priority 1. Now, for example, 4 SPS and 2 DPS can be routed:
4 x 1 Bit + 2 x 2 Bits = 8 Bits



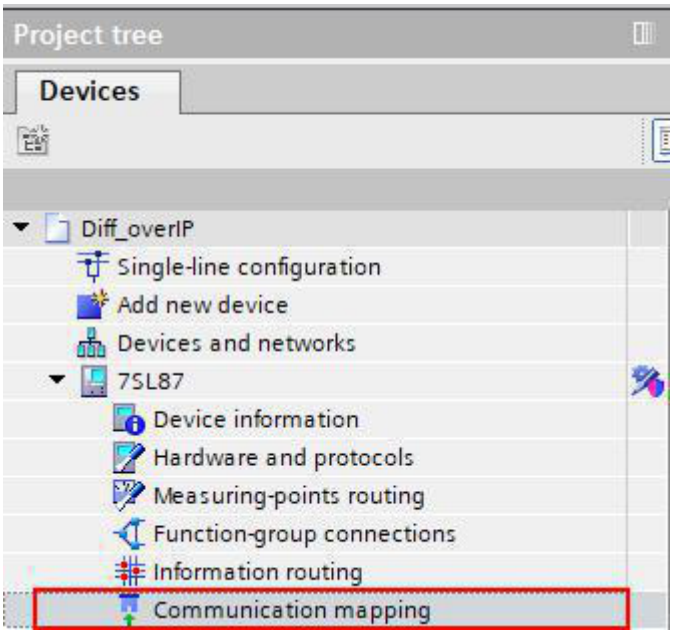
NOTE

Measured values are transmitted as primary values.

Configuration of Remote Data in DIGSI 5:

To configure remote data, navigate in DIGSI 5 through the project tree to the communication mapping.

12 The complex phasors of a measuring point are prerouted



[sc_comm_select, 1, en_US]

Figure 3-80 Communication Mapping in DIGSI 5

Figure 3-81 to *Figure 3-85* show the routing for a type 1 protection communication.

To transmit signals to other devices, these signals must be routed in the communication matrix under **Transmit**. Binary inputs 1 and 2 are single-point indications (SPS) and are routed to bit position 1 and bit position 2 of the transmission with the highest priority (priority 1). For 64 kBit/s, for example, only 8 of these data areas are available for type 1 protection communication; they are exchanged between the devices with each telegram. Signals 3 and 4 are double-point indications (DPS), for example, a switch position that is transmitted by device 1. A double-point indication occupies 2 bit positions on the data bar. In addition, a measured and metered value are communicated with priority 3.

As a measured or metered value uses 32 bits, value 2 starts at bit position 33. DIGSI 5 shows the next free bit position.

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.							
			Fault records	Receive					Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value		T	Priority level	Bit position
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)		..	(All...)	(All...)
General	91										
Device	4171										
Alarm handling	5971										
Time managem.	8821										
Time sync.	8851										
Power system	11										
Recording	51										
Binary IO	61								*		
Binary inputs	61.1051								*		
Binary input1	61.1051.3151								*		
Value	61.1051.315...	SPS							X	1	1
Binary input2	61.1051.3152								*		
Value	61.1051.315...	SPS							X	1	2

[sc_ran_sps, 1, en_US]

Figure 3-81 Routing of Single-Point Indications to Protection Communication in Device 1

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.							
			Fault records	Receive					Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position	
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)	
General	91										
Device	4171										
Alarm handling	5971										
Time managem.	8821										
Time sync.	8851										
Power system	11										
Recording	51										
Binary IO	61							*			
F:USART-AE-2FO	101										
J:Integrated Ethernet interface	102										
Circuit breaker 1	201										
Line 1	21							*			
General	21.9001										
Group indicat.	21.4501										
Process monitor	21.1131										
Operational values	21.761							*			
Behavior	21.761.1147...	ENS									
Health	21.761.1147...	ENS									
f	21.761.1021...	MV						X	3	1	

[sc_rang_mw, 1, en_US]

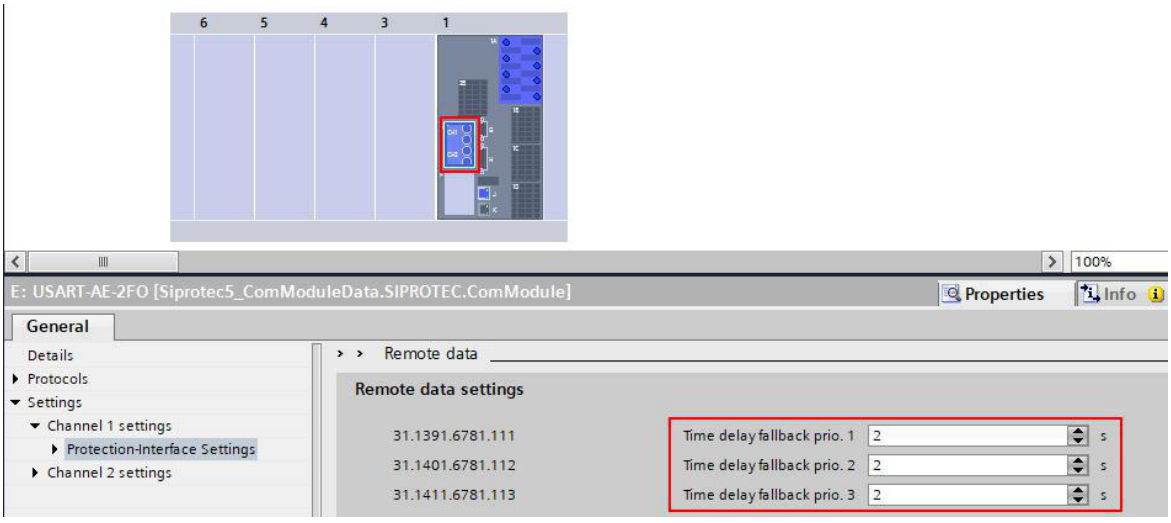
Figure 3-82 Routing of Measured Values to Protection Communication in Device 1

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.							
			Fault records	Receive					Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position	
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)	
General	91										
Device	4171										
Alarm handling	5971										
Time managem.	8821										
Time sync.	8851										
Power system	11										
Recording	51										
Binary IO	61							*			
F:USART-AE-2FO	101										
J:Integrated Ethernet interface	102										
Circuit breaker 1	201										
Line 1	21							*			
2 device prot. com.	31							*			
Device combin.	31.5131							*			
Behavior	31.5131.52	ENS									
Health	31.5131.53	ENS									
Status of topo. recog.	31.5131.301	ENS									
Topology is	31.5131.302	ENS									
Devices form	31.5131.303	ENS									
Number of detect. dev.	31.5131.304	INS						X	3	33	

[sc_rang_zw, 1, en_US]

Figure 3-83 Routing of Metered Values to Protection Communication in Device 1

Device 1 also receives signals (in the communication mapping under **Receive**, see next figure). These signals must be routed with the other devices under **Transmit**. The binary outputs 1 and 2 in device 1 receive their information via the protection communication. This is priority 1 information, which has been routed in another device to position 3 and 4 of the data bar for transmission. The secure state is predefined in the **Fallback value** column. If the protection connection fails, the single-point indication is reset to ***raising*** or **cleared** as the **fallback value** or its value is retained (***Hold***). For signals of the various priorities, you can also set a dropout time after which the reset (see following figure) to the fallback value occurs, in order to retain the original state for a short time in the event of brief interruptions. These 3 dropout times apply for all signals of one transmission priority and are set as parameters.



[sc_remotedata, 2, en_US]

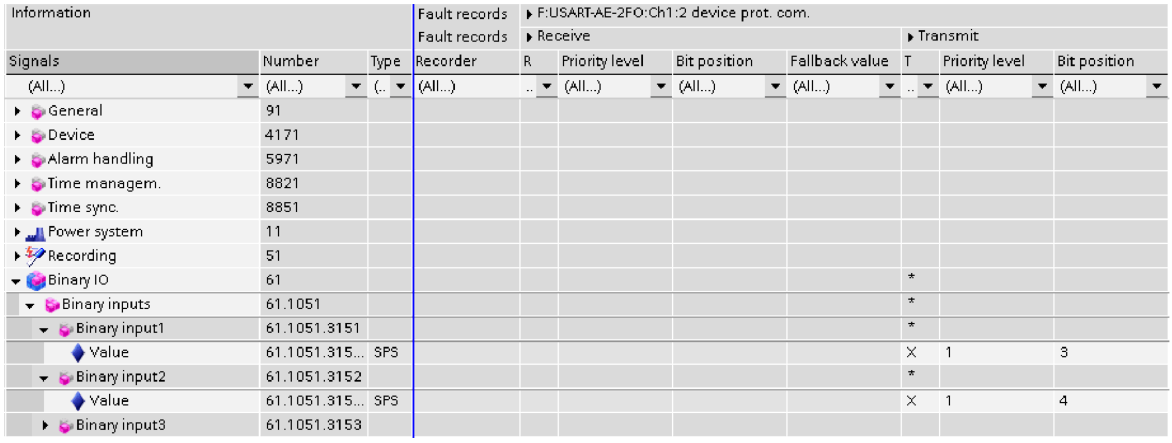
Figure 3-84 Parameterization of Dropout Time for Signals of Different Priorities

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.							
			Fault records	Receive					Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position	
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)	
General	91										
Device	4171										
Alarm handling	5971										
Time managem.	8821										
Time sync.	8851										
Power system	11										
Recording	51										
Binary IO	61			*							
Binary inputs	61.1051										
Binary outputs	61.1061			*							
Binary output1	61.1061.3181			*							
Value	61.1061.318...	SPS		X	1	3	Hold				
Binary output2	61.1061.3182			*							
Value	61.1061.318...	SPS		X	1	4	Hold				

[sc_spsemp, 1, en_US]

Figure 3-85 Routing of Single-Point Indications (Receive) to Protection Communication in Device 1

The following figure shows the routing in the 2nd device. Binary inputs 1 and 2 are routed with priority 1 to bit positions 3 and 4 there. In device 1, bit positions 1 and 2 are already occupied (see *Figure 3-81*). If you also route the signals to bit positions 1 and 2, the signals of both devices are then connected to the corresponding bit position with a logical **OR** operation. If measured and metered values are routed in the same data areas, this results in implausible values for the receivers. As a user, you are therefore responsible for the correct routing.



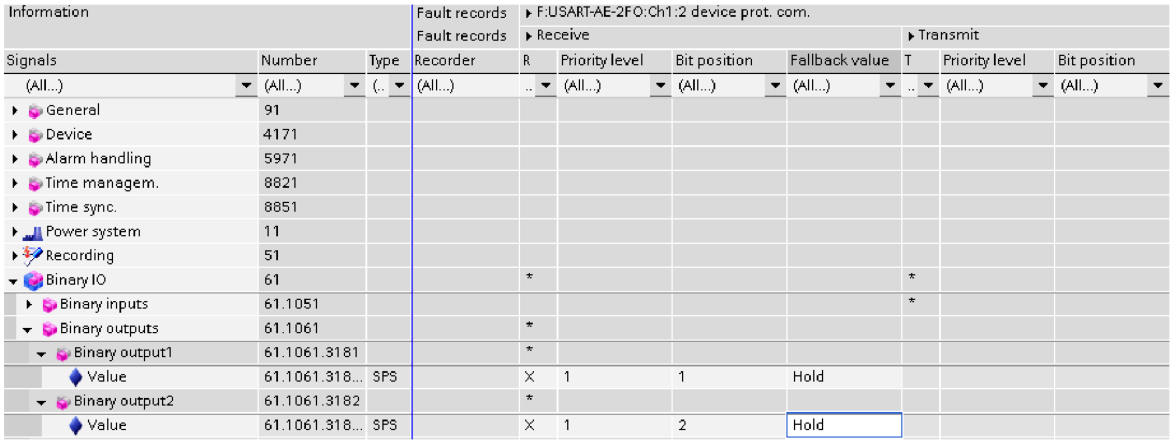
Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.							
			Fault records	Receive					Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position	
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)	
General	91										
Device	4171										
Alarm handling	5971										
Time managem.	8821										
Time sync.	8851										
Power system	11										
Recording	51										
Binary IO	61							*			
Binary inputs	61.1051							*			
Binary input1	61.1051.3151							*			
Value	61.1051.315...	SPS						X	1	3	
Binary input2	61.1051.3152							*			
Value	61.1051.315...	SPS						X	1	4	
Binary input3	61.1051.3153										

[sc_baspsr, 1, en_US]

Figure 3-86 Routing of Single-Point Indications to be Sent to Protection Communication in Device 2

The binary outputs 1 and 2 (**Receive**) in the 2nd device are connected to priority 1 signals 1 and 2 from the 1st device. This takes place via the data areas at positions 1 and 2 of the data bar, which transfer the state of the signals. Other devices can also read this information and logically link it to their internal signals. Here, too, the secure state, which is assumed when the protection connection is interrupted, is entered. This state depends on the information. With single-point indications, states 0 or 1 make sense. In the case of double-point indications, bit combinations 00, 01, 10, or 11 are possible to directly signal a disturbed position upon failure of the protection connection, for example.

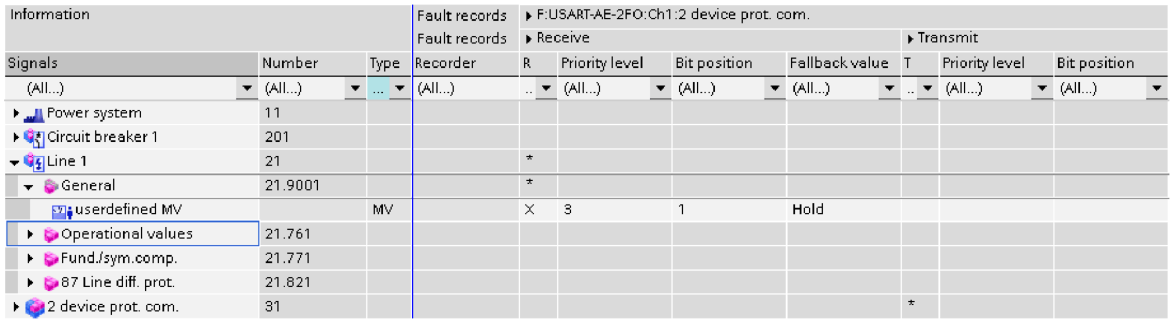
Hold is used to retain the state before the failure of the protection connection.



Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.							
			Fault records	Receive					Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position	
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)	
General	91										
Device	4171										
Alarm handling	5971										
Time managem.	8821										
Time sync.	8851										
Power system	11										
Recording	51										
Binary IO	61			*				*			
Binary inputs	61.1051							*			
Binary outputs	61.1061			*							
Binary output1	61.1061.3181			*							
Value	61.1061.318...	SPS		X	1	1	Hold				
Binary output2	61.1061.3182			*							
Value	61.1061.318...	SPS		X	1	2	Hold				

[sc_bausps, 1, en_US]

Figure 3-87 Routing of Received Single-Point Indications to Protection Communication in Device 2



Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.							
			Fault records	Receive					Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position	
(All...)	(All...)	...	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)	
Power system	11										
Circuit breaker 1	201										
Line 1	21			*							
General	21.9001			*							
userdefined MV		MV		X	3	1	Hold				
Operational values	21.761										
Fund./sym.comp.	21.771										
87 Line diff. prot.	21.821										
2 device prot. com.	31							*			

[sc_bausmw, 1, en_US]

Figure 3-88 Routing of Received Measured Values to Protection Communication in Device 2

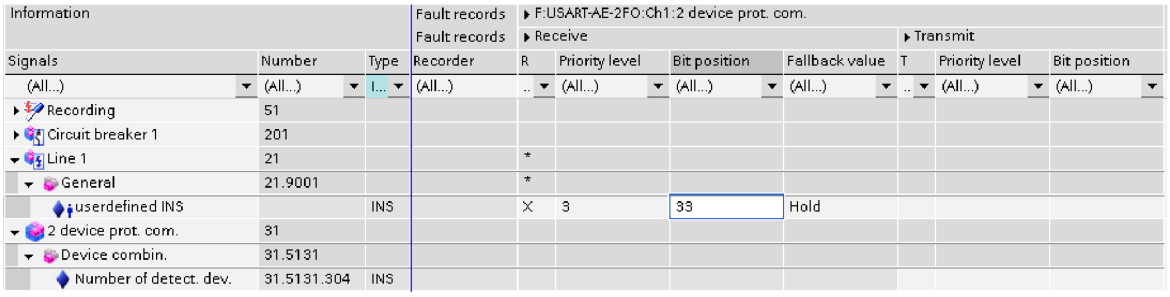


Figure 3-89 Routing of Metered Values to Protection Communication in Device 2

3.6.5.10 Constellation Measured Values for Type 1 and Type 2

NOTE

The constellation measured values are only available for the FG **Line**.

Each device in the device combination determines measured values predefined by Siemens, known as constellation measured values. You can find the constellation measured values in the DIGSI 5 information routing under the FG **n Device protection comm.** > **Constell. measured values**. The following measured values and indications are issued for each device:

Measured Value	Meaning
(_:1351:6811:302) Vph	This measured value shows the voltage of the 3 phases that is synchronized with all devices of the device combination. The absolute value and angle are issued for each phase.
(_:1351:6811:303) Iph	This measured value shows the current of the 3 phases that is synchronized with all devices of the device combination. The absolute value and angle are issued for each phase.
(_:1351:6811:300) Dev.adr.	This indication shows the device address. This allows you to assign the measured values and the circuit-breaker position in a better way.
(_:1351:6811:301) CB	This indication shows the position of the local circuit breaker and can have the following values: • *0*: The switch position of the local circuit breaker is unknown. • *1* The local circuit breaker is open. • *2* The local circuit breaker is closed.

The constellation measured values have the following properties:

- They are synchronized in the devices in a device combination.
- They are substituted using the protection interface.
- They are available on every device in the device combination.

You can view the constellation measured values with DIGSI 5.

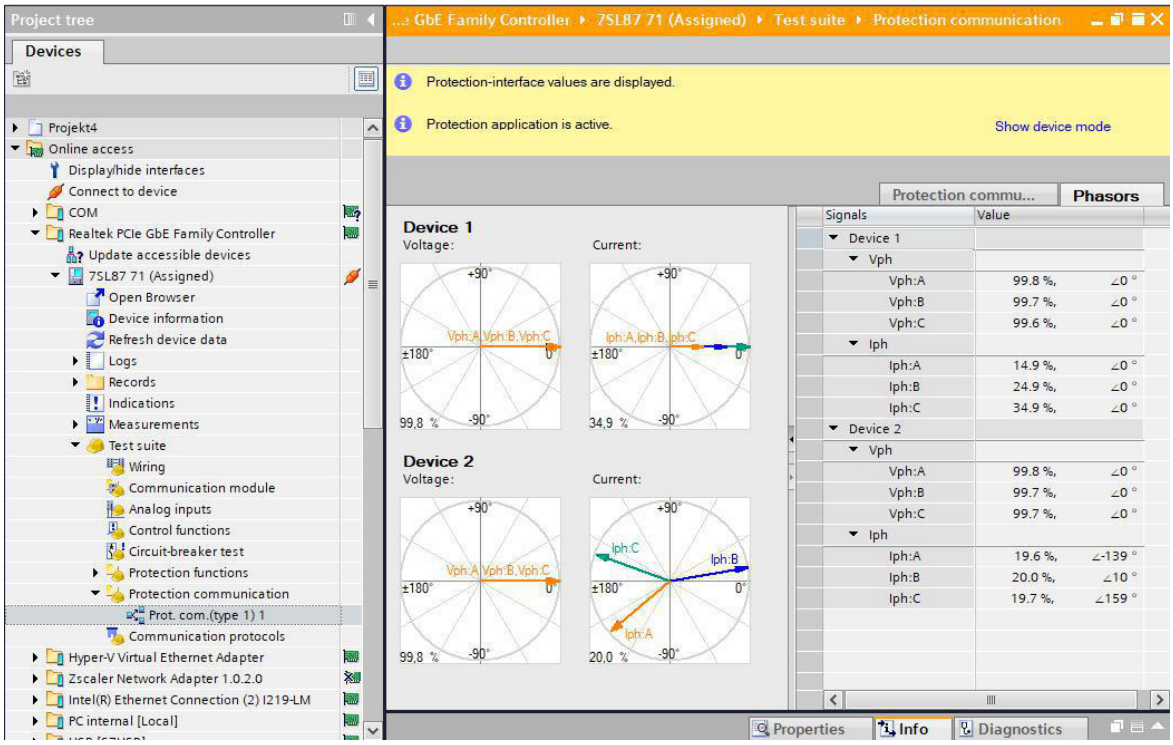
In the device, current and voltage measured values are displayed in absolute value and phase as a percentage. 100 % conform to the rated current or the rated voltage of the line (see *Figure 3-90*). These measured values are recorded every 2 seconds by the devices and then sent to the other respective devices. At the same time, the current and voltage values of the different devices are time-synchronous with one another.

When displaying the constellation measured values, the local device is prioritized. The device connected directly with DIGSI 5 is the local device.

The angle reference depends on the type of the FG **Protection communication** used:

- Protection communication **Type 1**:
  - The angle values of the voltages show the angle difference between the local and the remote voltage. The local voltage serves as the reference with an angle of 0°.
  - The angle values of the currents show the angle difference between the local and the remote current. The local current serves as the reference with an angle of 0°.
- Protection communication **Type 2**:
  The angles of the phase-to-ground voltages and the phase currents relate to the voltage V_A of the remote device.

You can find these measured values in the device under the following DIGSI mask:



[sc_const mv, 2, en_US]

Figure 3-90 Example of Constellation Measured Values with Phases

3.6.5.11 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Device combin.				
_:5131:102	Device combin.:Address of device 1		1 to 65534	101
_:5131:103	Device combin.:Address of device 2		1 to 65534	102
_:5131:104	Device combin.:Address of device 3		1 to 65534	103
_:5131:105	Device combin.:Address of device 4		1 to 65534	104
_:5131:106	Device combin.:Address of device 5		1 to 65534	105
_:5131:107	Device combin.:Address of device 6		1 to 65534	106

Addr.	Parameter	C	Setting Options	Default Setting
_:5131:101	Device combin.:Local device is device		1 to 6	1
_:5131:122	Device combin.:Lowest appearing bit rate		• 64 kBit/s • 128 kBit/s • 512 kBit/s • 2048 kBit/s	64 kBit/s
_:5131:127	Device combin.:Dev. comb. is time source		• no • yes	yes
Prot. interf.1				
_:5161:1	Prot. interf.1:Mode		• off • on	on
_:5161:105	Prot. interf.1:Max. error rate per hour		0.000 % to 100.000 %	1.000 %
_:5161:106	Prot. interf.1:Max. error rate per min		0.000 % to 100.000 %	1.000 %
_:5161:107	Prot. interf.1:Distur-bance alarm after		0.05 s to 2.00 s	0.10 s
_:5161:108	Prot. interf.1:Transm. fail. alarm after		0.0 s to 6.0 s	6.0 s
_:5161:109	Prot. interf.1:Delay time threshold		0.1 ms to 30.0 ms	30.0 ms
_:5161:110	Prot. interf.1:Difference Tx and Rx time		0.000 ms to 3.000 ms	0.100 ms
_:5161:113	Prot. interf.1:Synchroni-zation		• External synchron. off • Telegr. and ext. synch. • Telegr. or ext. synch. • External synch. only	External synchron. off
_:5161:117	Prot. interf.1:External synchronization		• PPS electrical (Port G) • IEEE 1588	PPS electrical (Port G)

3.6.5.12 Information List

No.	Information	Data Class (Type)	Type
Device combin.			
_:5131:52	Device combin.:Behavior	ENS	O
_:5131:53	Device combin.:Health	ENS	O
_:5131:301	Device combin.:Status of topo. recog.	ENS	O
_:5131:302	Device combin.:Topology is	ENS	O
_:5131:303	Device combin.:Devices form	ENS	O
_:5131:304	Device combin.:Number of detect. dev.	INS	O
_:5131:305	Device combin.:Fct. logout device 1	SPS	O
_:5131:306	Device combin.:Fct. logout device 2	SPS	O
_:5131:307	Device combin.:Fct. logout device 3	SPS	O
_:5131:309	Device combin.:Fct. logout device 4	SPS	O
_:5131:310	Device combin.:Fct. logout device 5	SPS	O
_:5131:311	Device combin.:Fct. logout device 6	SPS	O
_:5131:312	Device combin.:Device 1 available	SPS	O

No.	Information	Data Class (Type)	Type
_:5131:313	Device combin.:Device 2 available	SPS	O
_:5131:314	Device combin.:Device 3 available	SPS	O
_:5131:315	Device combin.:Device 4 available	SPS	O
_:5131:316	Device combin.:Device 5 available	SPS	O
_:5131:317	Device combin.:Device 6 available	SPS	O
Prot. interf.1			
_:5161:81	Prot. interf.1:>Block stage	SPS	I
_:5161:500	Prot. interf.1:>Sync reset	SPS	I
_:5161:341	Prot. interf.1:Reset synchronization	SPC	C
_:5161:342	Prot. interf.1:Reset measurements	SPC	C
_:5161:52	Prot. interf.1:Behavior	ENS	O
_:5161:53	Prot. interf.1:Health	ENS	O
_:5161:301	Prot. interf.1:Status of lay. 1 and 2	ENS	O
_:5161:302	Prot. interf.1:Status of lay. 3 and 4	ENS	O
_:5161:303	Prot. interf.1:Connection broken	SPS	O
_:5161:316	Prot. interf.1:Error rate / min exc.	SPS	O
_:5161:317	Prot. interf.1:Error rate / hour exc.	SPS	O
_:5161:318	Prot. interf.1:Time delay exceeded	SPS	O
_:5161:319	Prot. interf.1:Time delay different	SPS	O
_:5161:320	Prot. interf.1:Time delay jump	SPS	O
_:5161:321	Prot. interf.1:PI synchronized	SPS	O
_:5161:340	Prot. interf.1:Telegram lost	SPS	O
_:5161:308	Prot. interf.1:Tx tel/h	MV	O
_:5161:309	Prot. interf.1:Rx tel/h	MV	O
_:5161:310	Prot. interf.1:Tx tel/min	MV	O
_:5161:311	Prot. interf.1:Rx tel/min	MV	O
_:5161:312	Prot. interf.1:Tx err/h	MV	O
_:5161:313	Prot. interf.1:Rx err/h	MV	O
_:5161:314	Prot. interf.1:Tx err/min	MV	O
_:5161:315	Prot. interf.1:Rx err/min	MV	O
_:5161:334	Prot. interf.1:Miss.tel/min	MV	O
_:5161:335	Prot. interf.1:Miss.tel/h	MV	O
_:5161:336	Prot. interf.1:Miss.tel/d	MV	O
_:5161:337	Prot. interf.1:Miss.tel/w	MV	O
_:5161:338	Prot. interf.1:M. loss/d	MV	O
_:5161:339	Prot. interf.1:M. loss/w	MV	O
_:5161:331	Prot. interf.1:Recept.	MV	O
_:5161:323	Prot. interf.1:PPS: time del. unsym.	SPS	O
_:5161:324	Prot. interf.1:PI with PPS synchron.	SPS	O
_:5161:325	Prot. interf.1:Aver.Δt	MV	O
_:5161:326	Prot. interf.1:Rec. Δt	MV	O
_:5161:327	Prot. interf.1:Sen. Δt	MV	O
Ext. Synchron.			
_:9181:500	Ext. Synchron.:>Block stage	SPS	I
_:9181:501	Ext. Synchron.:>PPS pulse loss	SPS	I
_:9181:52	Ext. Synchron.:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:9181:54	Ext. Synchron.:Inactive	SPS	O
_:9181:53	Ext. Synchron.:Health	ENS	O
_:9181:301	Ext. Synchron.:PPS pulse loss	SPS	O
_:9181:303	Ext. Synchron.:PPS pulse OK	SPS	O
_:9181:302	Ext. Synchron.:PPS pulse	SPS	O
_:9181:304	Ext. Synchron.:Synchronization loss	SPS	O
_:9181:305	Ext. Synchron.:Synchronization OK	SPS	O
_:9181:306	Ext. Synchron.:Synchronization pulse	SPS	O
Meas.val.dev.1			
_:1351:6811:300	Meas.val.dev.1:Dev.adr.	INS	O
_:1351:6811:301	Meas.val.dev.1:CB	ENS	O
_:1351:6811:302	Meas.val.dev.1:Vph	WYE	O
_:1351:6811:303	Meas.val.dev.1:Iph	WYE	O
Meas.val.dev.2			
_:1351:6841:300	Meas.val.dev.2:Dev.adr.	INS	O
_:1351:6841:301	Meas.val.dev.2:CB	ENS	O
_:1351:6841:302	Meas.val.dev.2:Vph	WYE	O
_:1351:6841:303	Meas.val.dev.2:Iph	WYE	O
Meas.val.dev.3			
_:1351:6871:300	Meas.val.dev.3:Dev.adr.	INS	O
_:1351:6871:301	Meas.val.dev.3:CB	ENS	O
_:1351:6871:302	Meas.val.dev.3:Vph	WYE	O
_:1351:6871:303	Meas.val.dev.3:Iph	WYE	O
Meas.val.dev.4			
_:1351:6901:300	Meas.val.dev.4:Dev.adr.	INS	O
_:1351:6901:301	Meas.val.dev.4:CB	ENS	O
_:1351:6901:302	Meas.val.dev.4:Vph	WYE	O
_:1351:6901:303	Meas.val.dev.4:Iph	WYE	O
Meas.val.dev.5			
_:1351:6931:300	Meas val.dev.5:Dev.adr.	INS	O
_:1351:6931:301	Meas val.dev.5:CB	ENS	O
_:1351:6931:302	Meas val.dev.5:Vph	WYE	O
_:1351:6931:303	Meas val.dev.5:Iph	WYE	O
Meas.val.dev.6			
_:1351:6961:300	Meas.val.dev.6:Dev.adr.	INS	O
_:1351:6961:301	Meas.val.dev.6:CB	ENS	O
_:1351:6961:302	Meas.val.dev.6:Vph	WYE	O
_:1351:6961:303	Meas.val.dev.6:Iph	WYE	O

3.6.6 Advanced Protection Communication

3.6.6.1 Overview

The advanced protection communication contains all functionalities of classic protection communication. The view of parameters and indications is structured differently in DIGSI 5. In addition, the advanced protection communication supports the IP-based communication protocol.

In contrast to the classic protection communication, the advanced protection communication supports more than 2 devices in the device combination.

You can easily change the number of devices in the device combination. Further differences include support for external synchronization sources and an exchange of phase-selective information while sending and receiving.

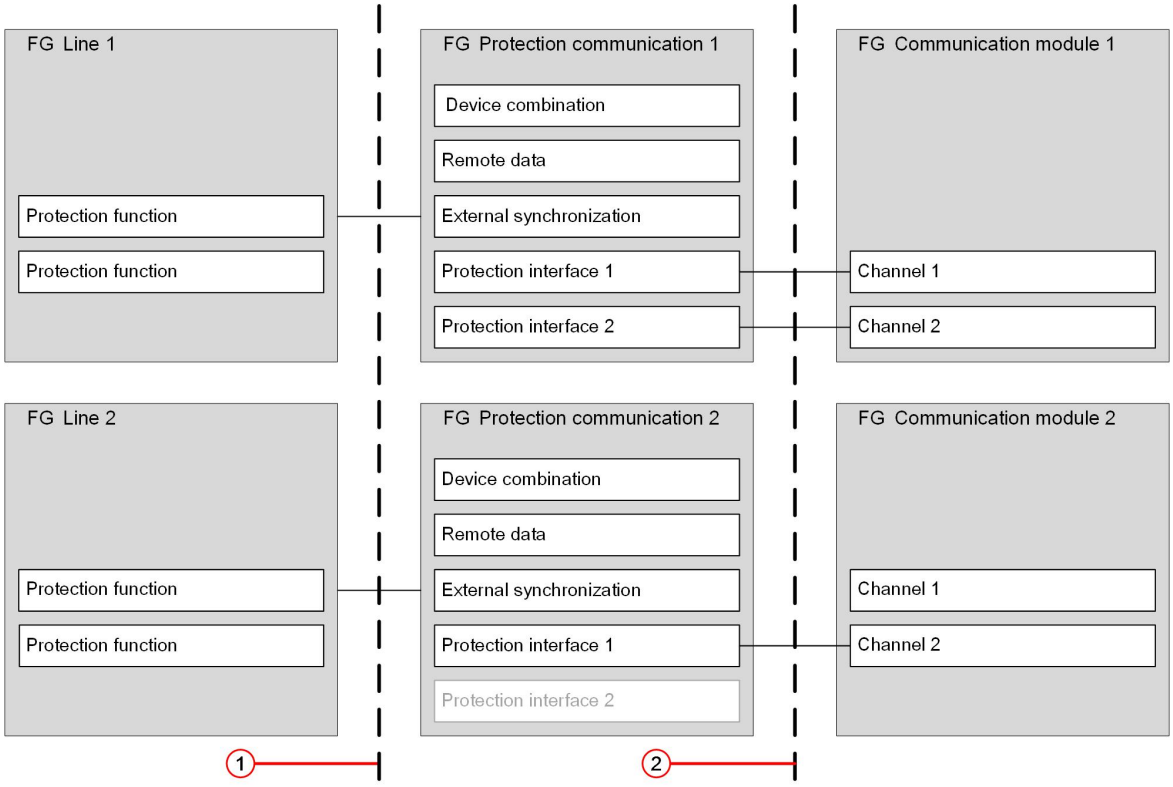
In the DIGSI 5 library, you can find the available function groups for the advanced protection communication in the **Advanced protection communication** folder. The following function-group types can be instantiated:

- FG **Protection communication type 1 (line differential protection)**
- FG **Protection communication type 2**

For configurations with line differential protection, instantiate the FG **Protection communication type 1 (line differential protection)**. In all other cases, instantiate the FG **Protection communication type 2**.

3.6.6.2 Advanced Protection Communication in the Overall System

The **Advanced protection communication** is integrated as follows in the overall system:



[dw_advanced_protcom_compl_system, 2, en_US]

Figure 3-91 Advanced Protection Communication in the Overall System

(1) The following applies for the FG **Line** and the FG **Voltage/Current 3-phase**: You must route the connection between the protection FG and the FG **Protection communication** in DIGSI 5.

(2) You must assign a channel to the protection interface, see *Parameter: PI assignment, Page 188*.

3.6.6.3 Structure of the FG Protection Communication

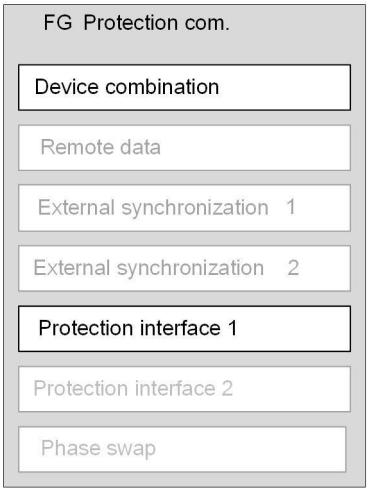
The instantiated FG **Protection communication** contains the function blocks (FB) for a protection interface and for the device combination. If you need a 2nd protection interface, add another instance.

The FG **Protection communication** contains the following functionalities and function blocks:

- FB **Device combination**
- FB for the **Protection interface**

In addition, the following FBs can be instantiated:

- A 2nd protection interface
  You can find the 2nd protection interface in the Global DIGSI 5 library under **Extended protection communication** > **Second protection interface**.
- 1 or 2 FBs for the **External synchronization** of the transmitted measured values by an external synchronization pulse (1-second pulse, PPS) or via the IEEE 1588 synchronization protocol
  You can find the FB **External synchronization** in the Global DIGSI 5 library under **Extended protection communication** > **Synchronization**.
- The FB **Remote data** is instantiated automatically, as soon as you configure remote data.
- The FB **Phase swap**



[dw_structure_FG_protcom_advanced, 2, en_US]

Figure 3-92 Structure of the FG Extended Protection Communication

Device Combination

The function **Device combination** manages the devices that exchange data via the protection communication.

The following FBs are preconfigured in the device combination:

- FB **General**
- FBs for each device in the device combination

In the **Device combination**, you configure general settings for the protection communication and the device addresses. The function **Device combination** issues the following indications:

- General indications like the
  - Amount of devices
  - Type and status of the device topology

- Indications of the devices in the device combination like:
  - The availability of the device
  - The state of the device, that is whether the device is logged on or off in the device combination
  - Measured values of the device that have been recorded and synchronized through the device combination (constellation measured values)
  - Test of the function **Line differential protection** in the device combination (only for protection communication type 1)
  - Test of the function **Line differential protection** in the local device (only for protection communication type 1)

Protection Interface

The FB **Protection interface** transmits and receives signals and measured values to/from the partner device. For this, the protection interface uses the channel of a communication module.

External Synchronization

Measured values that are acquired and exchanged in the devices at the same time, with microsecond accuracy are transmitted via the protection communication. The measured values can be synchronized as follows:

- Internally via the telegram measurement with the Ping-Pong method
- Externally via
  - An external, synchronous pulse 1-second-pulse (PPS)
  - Via the **IEEE 1588** protocol

  If you want to use an external synchronization, you must instantiate the FB **External synchronization**.

  You can use a different synchronization procedure for the 2nd protection interface than for the 1st protection interface.

Remote Data

If you want to exchange selected and user-specific data or measured values via the protection communication, you must use the **Remote data** function. If you route a specific signal or a measured value to the protection communication, the device automatically creates the **Remote data** functionality. The routed signals are then transmitted and received via the protection interface. The available bandwidth limits the amount of remote data that can be transmitted.

Phase Swap

If you want to exchange information via the protection communication with a device showing phases with a different sequence but with the same rotating field as your device, the SIPROTEC 5 device can swap the phase information when sending and receiving. It is no longer necessary to swap phases when connecting the current transformers.

This use case exists on some tie lines of different power-system operators.

For more information, refer to *3.6.6.12 Description Phase Swapping* and *3.6.6.13 Setting Notes for Phase Swapping*.

3.6.6.4 Configuration of the Advanced Protection Communication in DIGSI 5

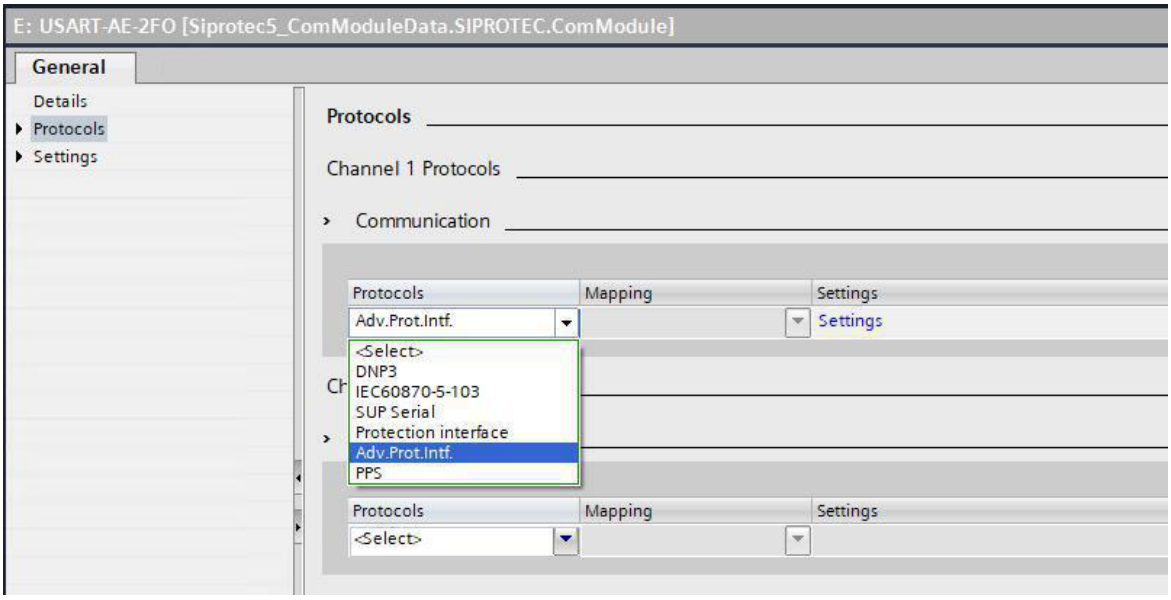
Steps during Configuration

Siemens recommends the following procedure when configuring the advanced protection communication:

- Select the desired communication module.
- Select the protocol ***Adv.Prot.Intf.***.

- The further parameterization depends on the selected communication module and is described in the following under:
  - *Advanced Protection Interface for a USART Communication Module, Page 185*
  - *Advanced Protection Interface for an Ethernet-BD Communication Module, Page 187*

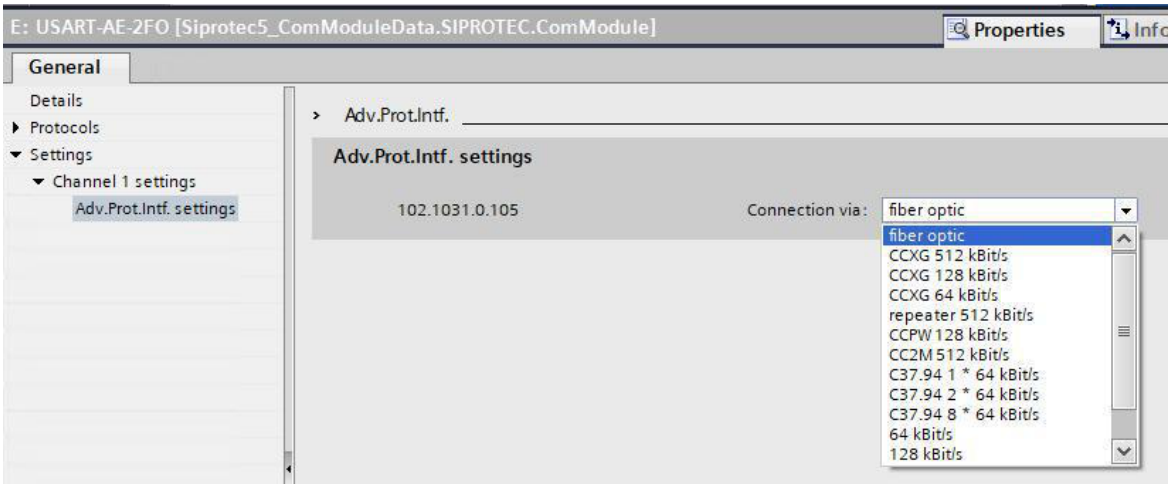
Advanced Protection Interface for a USART Communication Module



[sc_USART_01, 1, en_US]

Figure 3-93 USART Communication Module: Selection of the Protocol Advanced Protection Interface

After selecting the protocol, click **Settings** in the right column to get to the connection settings of the USART protection-interface module for channel 1.



[sc_USART_02, 1, en_US]

Figure 3-94 USART Communication Module: Settings for the Advanced Protection Interface

Parameter: Connection via

- Default setting **(_:105) Connection via** = ***fiber optic***

The **Connection via** parameter is used to set the bit rate required for the protection interface. Different discrete values can be entered depending on the means of communication (see following table).

Table 3-19 Communication Media

Communication Media	See	Setting Value	Bit Rate
Fiber-optic direct connection	*Figure 3-58* to *Figure 3-62*	***fiber optic***	2 MBit/s
CC-XG-512 communication converter	*Figure 3-63*	***CCXG 512 kBit/s***	512 kBit/s
CC-XG-128 communication converter	*Figure 3-63*	***CCXG 128 kBit/s***	128 kBit/s
CC-XG-64 communication converter	*Figure 3-63*	***CCXG 64 kBit/s***	64 kBit/s
Repeater 512 communication converter	*Figure 3-66*	***repeater 512 kBit/s***	512 kBit/s
CC-CC-128 communication converter	*Figure 3-65*	***CCPW 128 kBit/s***	128 kBit/s
CC-2M-512 communication converter	*Figure 3-64*	***CC2M 512 kBit/s***	512 kBit/s
Multiplexer with C37.94 interface	*Figure 3-67*	***C37.94 1 * 64 kBit/s*** ***C37.94 2 * 64 kBit/s*** ***C37.94 8 * 64 kBit/s***	64 kBit/s 128 kBit/s 512 kBit/s
Other (freely adjustable bit rates for a direct connection for special applications)		***64 kBit/s*** ***128 kBit/s*** ***512 kBit/s*** ***2048 kBit/s***	64 kBit/s 128 kBit/s 512 kBit/s 2048 kbit/s

Parameter: Multiplex operation

- Default setting **(_:112) Multiplex operation** = ***no***

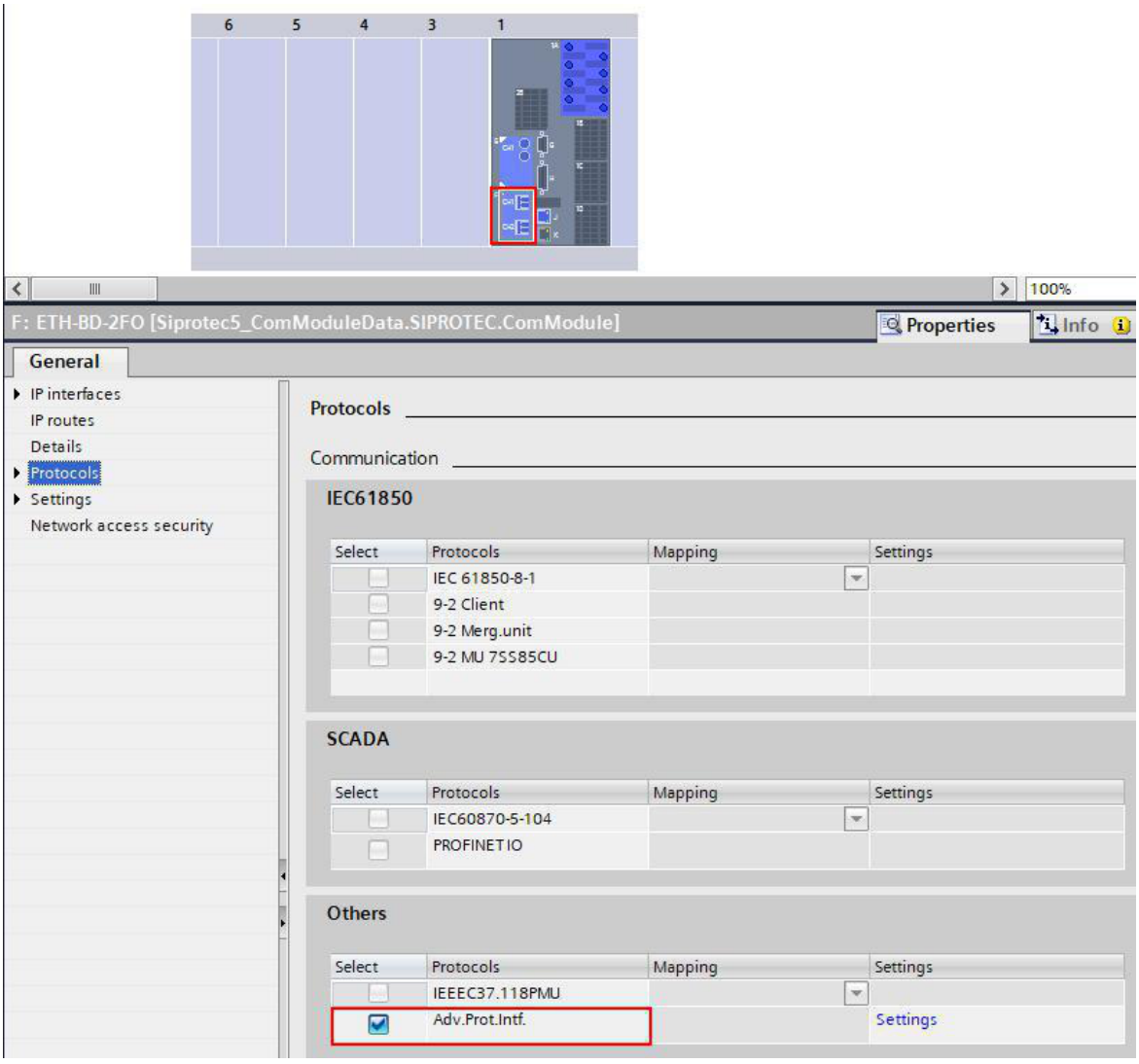
With the parameter **Multiplex operation**, you can designate the physical channel for multiplex operation. You can then route 2 protection interfaces to this channel.
Refer to *3.6.3 Function Description*.



NOTE

For safety reasons, you cannot route 2 protection interfaces from the same device combination to one channel, as this results in apparent redundancy.

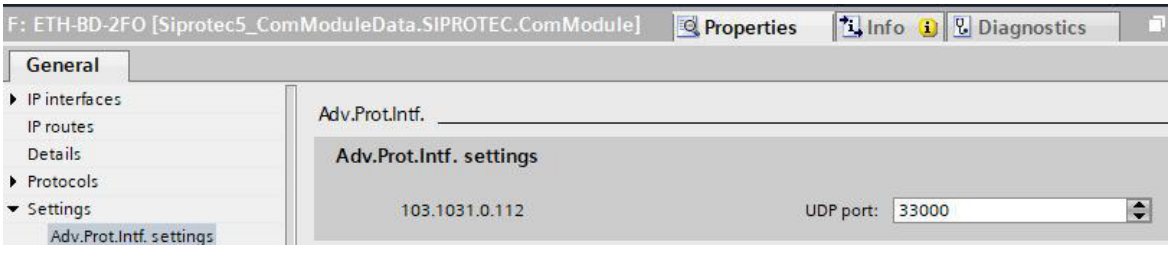
Advanced Protection Interface for an Ethernet-BD Communication Module



[sc_ETH-BD_01, 1, en_US]

Figure 3-95 Ethernet-BD Communication Module: Selection of the Protocol Advanced Protection Interface

After selecting the protocol, click **Settings** in the right column to get to the connection settings of the Ethernet-BD communication module for channel 1.



[sc_ETH-BD_02, 1, en_US]

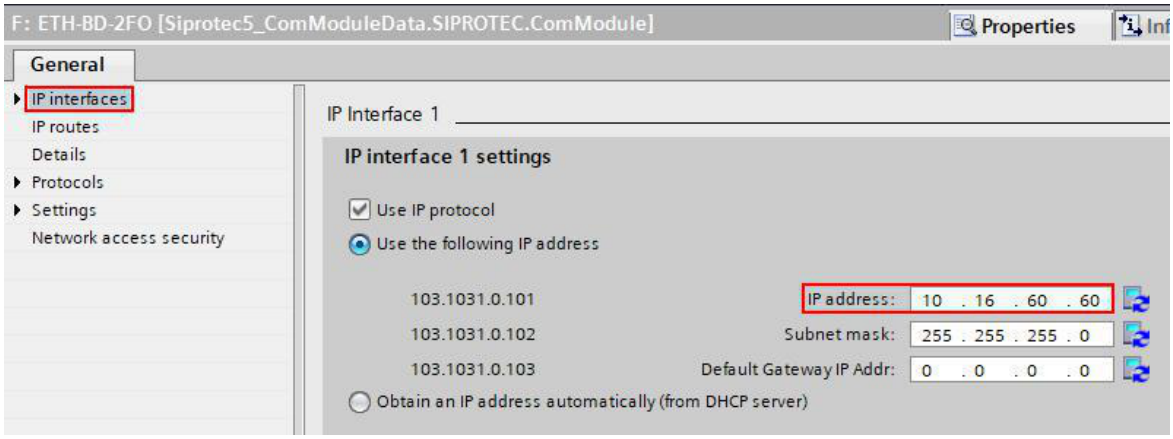
Figure 3-96 Ethernet-BD Communication Module: Settings for the Advanced Protection Interface

Parameter: UDP Port

- Default setting **`(_:112) User port`** = ***33000***

With the **UDP port** parameter, you set the value of the destination port in the UDP header of the protection-interface IP messages. You must set the same value for the parameter **UDP port** for all protection devices of a device combination that use the IP-based protection interface. Different device combinations can use the same value for the **UDP port** parameter. Normally, the default setting can always be applied. It can be necessary, for example, due to firewall policies, to configure a UDP port that differs from the default setting.

Parameterize the IP address of the Ethernet-BD communication module in the properties of the module.



[sc_IPadr, 1, en_US]

Figure 3-97 Parameterization of the IP Address for the Ethernet-BD Communication Module

The configuration and parameterization of the protection-interface communication module is now complete.

3.6.6.5 Setting Notes for the Protection Interface

The chapter provides setting notes for the logical protection interface (FB **Protection interface**).

Parameter: PI assignment

- Default setting **(_:5161:120) PI assignment** = ***Setting options depend on configuration***

In addition, you must select the channel for the protection interface in DIGSI 5 as follows: **Project tree** > **Prot. com.** > **Prot. interf.**.

In the input area under **PI assignment**, select the channel of a communication module that supports the required protection-interface protocol. As a prerequisite for this, you must have selected the protocol ***Advanced protection interface*** for the channel of the desired communication module, see *3.6.6.4 Configuration of the Advanced Protection Communication in DIGSI 5*.

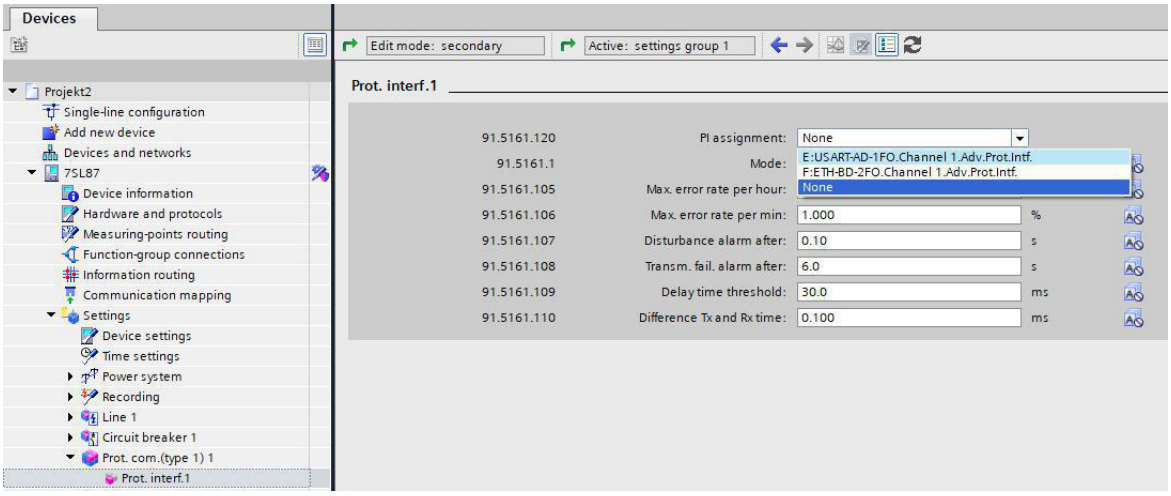


Figure 3-98 Assignment of the Protection-Interface Channel to the Protection Interface

Parameter: Max. error rate per hour

- Default setting **(_:5161:105) Max. error rate per hour** = *1.0 %*

If the number of faulty telegrams per hour exceeds the value set in the parameter **Max. error rate per hour**, you receive the error message *Error rate / hour exc.*.

Parameter: Max. error rate per min

- Default setting **(_:5161:106) Max. error rate per min** = *1.0 %*

If the number of faulty telegrams per minute exceeds the value set in the parameter **Max. error rate per min**, you receive the error message *Error rate / min exc.*.

Parameter: Disturbance alarm after

- Default setting **(_:5161:107) Disturbance alarm after** = *100 ms*

With the parameter **Disturbance alarm after**, you determine the time delay after which faulty or missing telegrams are signaled as disturbed with the indication *Status of lay. 1 and 2 = PI data fault*.

Parameter: Transm. fail. alarm after

- Default setting **(_:5161:108) Transm. fail. alarm after** = *6.0 s*

With the parameter **Transm. fail. alarm after**, you determine the time delay after which a communication failure is signaled with the indication *Status of lay. 1 and 2 = PI data failure*.

Parameter: Delay time threshold

- Default setting **(_:5161:109) Delay time threshold** = *30.0 ms*

The time taken to transmit and receive a signal via a protection connection is called the signal-transit time. You can monitor the signal-transit time. For the **Delay time threshold**, the default setting is selected in such a way that it is not exceeded by normal communication networks. If the signal-transit time is exceeded during operation (for example, upon switchover to another transmission path), the indication **Time delay exceeded** is issued.

Increased runtimes only affect the operate time, and therefore the fault-clearing time of the protection functions that use the protection interface. If you use the **Line differential protection** function, this remains in effect.

Parameter: Difference Tx and Rx time

- Default setting **(_:5161:110) Difference Tx and Rx time** = ***0.1 ms***

For a time synchronization of the measured values with microsecond accuracy by means of telegram measurement, the signal-transit times in the transmission and receive direction must be approximately the same. The device monitors the signal-transit times in the transmission and reception direction.

With the parameter **Difference Tx and Rx time**, you can set a maximum permitted signal-transit time difference between the transmission and reception paths (runtimes unbalanced). Set the parameter **Difference Tx and Rx time** to the maximum difference expected.

Set this value to ***0*** for a direct fiber-optic connection. A higher value is necessary for transmission via communication networks. ***0.1 ms*** (recommended setting value) is the reference value.

If the difference in the signal-transit times between the transmission and reception path exceeds the set value, the indication *Time delay jump* is issued.

If the difference in the signal-transit times between the transmission and reception path exceeds the set value and remains for more than 5 s, the indication *Time delay different* is issued. The **Line differential protection** function is no longer working properly and is ***ineffective***.



NOTE

The parameter **Difference Tx and Rx time** is only visible if the **Line differential protection** function is instantiated and the parameter **Synchronization** is not set to ***External synch. only***.



NOTE

If you use a multiplexer with a C37.94 interface as a communication medium, Siemens recommends a setting value of ***0.25 ms*** to ***0.6 ms***.

Parameter: Synchronization

- Default setting **(_:5161:113) Synchronization** = ***External synchron. off***

With the parameter **Synchronization**, you control the time synchronization of the measured values with microsecond accuracy.

The parameter **Synchronization** is only visible if you have instantiated the FB **External synchronization** from the Global DIGSI 5 library in the FG **Protection communication**.

If you have not instantiated the FB **External synchronization**, the measured values are time-synchronized internally with microsecond accuracy.

Parameter Value	Description
External synchron. off	The external synchronization is disabled: No external synchronization is performed on the protection interface. Select this setting value if you do not expect any differences between the signal-transit times in the transmission and reception directions. Then, the measured values are only synchronized internally with the telegram measurement.
Telegr. and ext. synch.	Synchronization via telegram measurement and external synchronization: The measured values are synchronized internally with the telegram measurement, supported by the external synchronization. The synchronization is possible via the IEEE 1588 protocol or via the synchronous pulse of a satellite receiver and configurable in the FB **External synchronization**. In this case, an existing line differential protection is only enabled when a new connection is established and one of the following conditions is met. • The protection communication link is synchronized with the help of the external synchronization. • Symmetric signal-transit times are signaled via the binary input signal *>Sync reset* or the controllable *Reset synchronization*. This means that the signal-transit times are the same in the send and receive direction.
Telegr. or ext. synch.	Telegram measurement or external synchronization: The measured values are synchronized internally with the telegram measurement, supported by the external synchronization. The synchronization is possible via the IEEE 1588 protocol or via the synchronous pulse of a satellite receiver and configurable in the FB **External synchronization**. An existing line differential protection is enabled immediately upon renewed establishment of a connection (data telegrams are received). The internal synchronization is used up to synchronization.
External synch. only	External synchronization only: The measured values are synchronized only via the external synchronization. You can set the external synchronization in the FB **External synchronization**. This enables synchronization via the IEEE 1588 protocol or via the synchronous pulse of a satellite receiver.



NOTE

If the protection interface is connected to a channel on a USART communication module (see *Parameter: PI assignment, Page 188*), the external synchronization is used to take into account the signal-transit times in the transmission and receive direction.

If the external synchronization fails for a short time, for example, due to a receiving interference or an unfavorable satellite position for a brief period, the internal synchronization via the telegram measurement is still active.



NOTE

If the protection interface is connected to a channel on an Ethernet-BD communication module (see *Parameter: PI assignment, Page 188*), the parameter **Synchronization** is permanently set to ***External synch. only***.

Parameter: FB External synchron.

- Default setting **(_:5161:117) FB External synchron.** = ***Ext. synchronization 1***

With the external synchronization, the time synchronization of the measured values with microsecond accuracy is possible through an external synchronization source.

The parameter **FB External synchron.** is only visible if you have instantiated at least 1 FB **External synchronization** from the Global DIGSI 5 library into the FG **Protection communication**. You can instantiate a maximum of 2 FBs for external synchronization.

With the parameter **FB External synchron.**, you specify whether the protection interface uses the FB **Ext. synchronization 1** or the FB **Ext. synchronization 2** for the synchronization. You parameterize the synchronization source in the corresponding FB **External synchronization**, see *3.6.6.9 Setting Notes for External Synchronization*.

NOTE

The external synchronization is possible separately for each protection interface.

Parameter: Check synchron.-source

- Default setting **(_:5161:121) Check synchron.-source** = ***yes***

With the parameter **Check synchron.-source**, you can switch the synchronization-sources check on or off. During the check of the synchronization sources on the ends of a protection connection, a check is conducted as to whether both synchronization sources are working in the same synchronization status ***SmpSynch***.

If both synchronization sources are working in the synchronization status ***SmpSynch*** = ***global***, the inspection has been passed.

If both synchronization sources are working in the synchronization status ***SmpSynch*** = ***local***, that is decoupled from a global reference time, an additional check is conducted as to whether the synchronization source (***gmIdentity***) is the same. Synchronicity can only be guaranteed if the synchronization sources are the same.

If the synchronization sources display a different synchronization status, that is one displays the synchronization status ***SmpSynch*** = ***local*** and the other the synchronization status ***SmpSynch*** = ***global***, synchronization cannot be guaranteed.

Siemens recommends using the default setting **Check synchron.-source** = ***yes***.

If you have problems with the synchronization-source check, you can switch off the synchronization-source check. Switch off the synchronization-source check only if the synchronization sources are synchronous at the end of their protection connection.

The parameter **Check synchron.-source** is visible only if the parameter **(_:5161:113) Synchronization** is set to ***External synch. only***.

NOTE

If you use **PPS electrical (port G)** as the synchronization source, the synchronization status (***SmpSynch***) is permanently set to ***global***.

If you use **PPS optical (USART)** as the synchronization source, you can use the parameter (_:107) **Received. SmpSynch** to set the synchronization status to (***SmpSynch***) ***local*** or ***global***.

For a synchronization with microsecond accuracy, for example, for the **Line differential protection**, set the parameter (_:107) **Received. SmpSynch** = ***global***.

3.6.6.6 Indications and Measured Values of the Advanced Protection Interface

Each individual protection interface provides different indications for commissioning and diagnostics of communication:

Indication ***(_:5161:301) Status of lay. 1 and 2***

The indication ***(_:5161:301) Status of lay. 1 and 2*** informs you about the status of the connection. The following indications are possible:

Table 3-20 Status Indications Status of lay. 1 and 2

Indication	Description
initialized:	The protection interface is not connected and is in the Initial state.
PI connected:	The protection interface is connected to the protection interface of the partner device.
PI data fault:	The protection interface has not received any valid telegrams for the time set in parameter **(_:5161:107) Disturbance alarm after**.
PI data failure:	The protection interface has not received any valid telegrams for the time set in parameter **(_:5161:108) Transm. fail. alarm after**.
not existing:	The protection interface has not been assigned to a communication channel.

Indication *(_:5161:302) Status of lay. 3 and 4*

The indication *(_:5161:302) Status of lay. 3 and 4* informs about errors during the connection establishment. The following indications are possible:

Status indication	Description
no error:	No errors occurred during the connection establishment.
SW ver.incomp.:	The connection is not established because the firmware versions of the devices are incompatible. Update the firmware.
wrong dev. ID:	The connection is not established because the device address of the local device or the partner device is incorrect or set incorrectly. Check the settings for the parameters **Address of device 1** to **Address of device n** (_:5131:102 and following).
const.sett.error:	The connection is not established because the parameters are set differently. Check whether the parameter **(_:5131:122) Lowest appearing bit rate** has been set the same in all devices in the device combination.
diff.sett error:	The connection is not established because the parameters are set differently. The line differential protection settings for the connected devices are incompatible. Check whether both devices are set to operate with or without line differential protection. The rated current of the line (parameter **(_:9001:101) Rated current**) must have the same setting in all devices. With a transformer in the line, the **(_:9001:103) Rated apparent power** must be set to the same value in all devices. For further information, see *6.7 Line Differential Protection*.
net mirroring	The connection is not established. The protection interface is receiving its own data. Check the wiring.
wrong dev. idx.	The connection is not established because the device index of the local device or the partner device is incorrect. Check the setting for the parameter **(_:5131:101) Local device is device**.

Furthermore, the following output signals are available:

Output Signal	Description
(_:5161:303) Connection broken	The signal *Connection broken* indicates that during a parameterized time (parameter **(_:5161:107) Disturbance alarm after**) no telegrams or faulty telegrams were continuously received. If the indication *Connection broken* is issued, the affected protection connection is reset. This can cause the blocking of an active line differential protection or a ring topology can change to a chain topology.
(_:5161:316) Error rate / min exc.	The signal *Error rate / min exc.* indicates that the set maximum error rate per minute (Parameter **(_:5161:106) Max. error rate per min**) has been exceeded. In this manner, a brief increase of the operate time and thus of the fault-clearing time is possible for the protection functions using the protection interface. If you use the **Line differential protection** function, this remains in effect.
(_:5161:317) Error rate / hour exc.	The signal *Error rate / hour exc.* indicates that the set maximum error rate per hour (Parameter **(_:5161:105) Max. error rate per hour**) has been exceeded. In this manner, a brief increase in operate time and thus the fault-clearing time is possible for the protection functions using the protection interface. If you use the **Line differential protection** function, this remains in effect.
(_:5161:318) Time delay exceeded	The signal *Time delay exceeded* indicates that the threshold value for the set signal runtime (parameter **(_:5161:109) Delay time threshold**) has been exceeded. Increased runtimes only affect the operate time, and therefore the fault-clearing time of the protection functions using the protection interface. If you use the **Line differential protection** function, this remains in effect.
(_:5161:319) Time delay different	The signal *Time delay different* indicates that the threshold value for the difference in signal runtimes in the transmission and reception direction (asymmetrical runtimes) has been exceeded. The setting value results from the setting value of the parameter **(_:5161:110) Difference Tx and Rx time**. The indication is visible only if the parameter **(_:5161:113) Synchronization** is not set to ***External synch. only***. If the indication *Time delay different* appears, the **Line differential protection** function is no longer working properly and is ***ineffective***.
(_:5161:320) Time delay jump	The signal *Time delay jump* indicates that the signal runtimes of the data changed abruptly. This is caused by a switchover of the communication path in the communication network. The indication is visible only if the parameter **(_:5161:113) Synchronization** is not set to ***External synch. only***.
(_:5161:321) PI synchronized	The signal *PI synchronized* indicates that the synchronization with microsecond accuracy of the measured values transferred between the local device and partner device is working correctly. The indication is visible only if the parameter **(_:5161:113) Synchronization** is not set to ***External synch. only***.
(_:5161:340) Telegram lost	The signal *Telegram lost* indicates that an expected telegram has failed to arrive or a faulty telegram has been received. If you want to assign the communication failures or faults to other events, route the signal *Telegram lost* temporarily into the operational log. Such events can be switching operations in the primary system or operations on the components of the communication network. **Note:** If the signal is constantly routed, the operational log can overflow. Siemens recommends routing the signal only for clarification of problems.

Output Signal	Description
(_:5161:343) Partner	The indication shows the address of the partner device. A value of 0 means that no partner address is available.
(_:5161:323) PPS: time del. unsym.	This indication is only visible if you are working with a synchronous pulse. The indication shows that the difference in the signal runtimes between the sending and receiving path exceeds the value set with the parameter **(_:5161:110) Difference Tx and Rx time**. **Note:** The **Line differential protection** function remains ***effective***.
(_:5161:324) PI with PPS synchron.	This indication is only visible if you are working with a synchronous pulse. This indication is only visible if, in parallel to synchronization with the synchronization pulse, you are also working with the synchronization via telegram measurement. If both synchronization methods are working properly, the indication *PI with PPS synchron.* = RAISING is generated.

Measured Values of the Protection Interface

The protection interface provides the following measured value for the diagnosis of the protection-interface communication:

Measured Value	Description
(_:5161:308) Tx tel/h	Telegrams transmitted during the last hour
(_:5161:309) Rx tel/h	Telegrams received during the last hour
(_:5161:310) Tx tel/min	Telegrams transmitted during the last minute
(_:5161:311) Rx tel/min	Telegrams received during the last minute
(_:5161:312) Tx err/h	Transmission failure rate during the last hour
(_:5161:313) Rx err/h	Receive error rate during the last hour
(_:5161:314) Tx err/min	Transmission failure rate during the last minute
(_:5161:315) Rx err/min	Receive error rate during the last minute
(_:5161:325) Aver.Δt	Average signal runtime (average value of the runtime in transmission and reception direction divided by 2, without external synchronization)
(_:5161:326) Rec. Δt	Signal runtime for reception path (with external synchronization)
(_:5161:327) Sen. Δt	Signal runtime for transmission path (with external synchronization)
(_:5161:334) Miss.tel/min	Number of telegram failures within the last minute
(_:5161:335) Miss.tel/h	Number of telegram failures within the last hour
(_:5161:336) Miss.tel/d	Number of telegram failures within the last day
(_:5161:337) Miss.tel/w	Number of telegram failures within the last week
(_:5161:338) M. loss/d	Longest lasting telegram failure within the last day
(_:5161:339) M. loss/w	Longest lasting telegram failures within the last week
(_:5161:331) Recept.	Receipt of a telegram (0 = no receipt, 1 = receipt) You can use this indication to make the telegram exchange visible in the fault record.

NOTE

You can reset the measured values of the protection interface directly in the device. Proceed as follows:
Device functions > Protection comm. (Type x) > Protection interface y > Reset measured values.

3.6.6.7 Setting Notes for the Device Combination

In the **Project tree** > **Settings** > **Protection comm. (type 1)** or **Protection comm. (type 2)**, select the function block **Device combination**. In the input area, you parameterize the general settings for the device combination, instantiate the number of devices in the device combination, and set the parameters for each device. A device combination consists of at least 2 devices.

Parameter: Local device is device

- Default setting **(_:2311:101) Local device is device** = ***1***

With the **Local device is device** parameter, you set the index (number) of your device in the device combination. A maximum of 6 devices can be present in a device combination.

Parameter: Lowest appearing bit rate

- Default setting **(_:2311:122) Lowest appearing bit rate** = ***64 kBit/s***

With the parameter **Lowest appearing bit rate**, you set the lowest bit rate occurring in the device combination. This value determines the maximum number of signals and measured values to be transferred in the **Remote data** function within the device combination.

EXAMPLE:

For a device combination consisting of 3 devices in a ring topology with 2 fiber-optic connections (2 MBit/s) and a 64-kBit/s connection, set the smallest value (64 kBit/s) in each device.

Apart from the default value, you can set the following bit rates:

- ***128 kBit/s***
- ***512 kBit/s***
- ***2048 kBit/s***

NOTE

If you use optical fibers for all protection connections, set the value to ***2048 kBit/s***.

Connection mode

- Default setting **(_:2311:126) Connection mode** = ***SIPROTEC 5***

With the parameter **Connection mode**, you select the device type with which the SIPROTEC 5 device works in the device combination via the protection connections.

NOTE

As soon as a SIPROTEC 4 device is present in the device combination, the SIPROTEC 5 devices must operate in a compatibility mode. For this reason, the parameter **Connection mode** must be set to the same value in all SIPROTEC 5 devices in the device combination. Select the type of SIPROTEC 4 device from the following table:

Parameter Value	Description
SIPROTEC 5	The SIPROTEC 5 device works with a SIPROTEC 5 device in the device combination.
SIPROTEC 4 7SD610	The SIPROTEC 5 device works with a SIPROTEC 4 differential protection device 7SD610 with firmware version V4.72 and higher in the device combination.
SIPROTEC 4 7SD5	The SIPROTEC 5 device works with a SIPROTEC 4 differential protection device 7SD5x with firmware version V4.72 and higher in the device combination.
SIPROTEC 4 7SA5/6	The SIPROTEC 5 device works with a SIPROTEC 4 distance protection device 7SA522 and 7SA6x with firmware version V4.70 and higher in the device combination.

Parameter: Dev. comb. is time source

- Default setting **(_:2311:129) Dev. comb. is time source** = ***yes***

The parameter **Dev. comb. is time source** is only visible if you have instantiated several function groups **Protection comm.** and you have selected the setting value ***PI*** for the parameters **Time source 1** or **Time source 2**.

The parameter **Dev. comb. is time source** determines from which FG **Protection comm.** the time is taken over.

Parameter: Protection com.

- Default setting **(_:2311:128) Protection com.** = ***Type 1 (Line diff. prot.)***

The parameter **Protection com.** is write-protected and displays only the type of the instantiated device combination.

The device combination ***Type 1 (Line diff. prot.)*** supports the function **Line differential protection**. The device combination ***Type 2 (no Line diff. pr.)*** does not support the function **Line differential protection**.



NOTE

In the Global DIGSI 5 library, the function groups **Protection communication type 1 (line diff. protection)** and **Protection com. Type 2** are available for the advanced protection communication. When instantiating the respective function group, the corresponding type of the device combination is automatically pre-instantiated.



NOTE

If you have instantiated the FG **Protection com. Type 2**, the **Device combination Type 2** is automatically pre-instantiated in this FG and the **Line differential protection** function is not supported.

If you subsequently want to use the **Line differential protection** function in the device combination of the FG **Protection com. Type 2**, proceed as follows:

- In the DIGSI 5 project tree, delete the function block **Device combination** from the **FG protection comm. (type 2)**.
- Instantiate the function block **Device combination type 1 (line diff. protection)** from the Global DIGSI 5 library into the FG **Protection com. Type 2**.
- Parameterize the **device combination** in the input area again.
- Reroute the indications of the device combination in the DIGSI 5 information routing.

All other parameterizations and routings are retained!

Parameter: Device index

- Default setting **(_:22711:101) Device index** = ***1***
- Default setting **(_:22712:101) Device index** = ***2***
- Default setting **(_:22713:101) Device index** = ***3***
- Default setting **(_:22714:101) Device index** = ***4***
- Default setting **(_:22715:101) Device index** = ***5***
- Default setting **(_:22716:101) Device index** = ***6***

The value of the parameter **Device index** is the number of the device in the device combination. Set the device index in all devices of a device combination for the same devices in the same way. The device indices must start with 1 and be incremented continuously. DIGSI 5 assigns the device indices automatically. You can change the device indices if necessary.

NOTE

The device with the **Device index** = ***1*** is the timing-master device in a device combination.

If all other devices in the device combination are to obtain their time from the timing-master device, consider the following

- Set the **Device index** to ***1*** for the timing-master device.
- Parameterize the other devices in such a way that they get their time from the timing-master device via the protection connections.

  For more information, refer to *3.7.3 Function Description*. Select ***Protection interface*** as the adjustable synchronization option.

  In the timing-master device, you must **not** set the protection interface as the synchronization source!

Parameter: Address in Device combi.

- Default setting **(_:22711:102) Address in Device combi.** = ***101***
- Default setting **(_:22712:102) Address in Device combi.** = ***102***
- Default setting **(_:22713:102) Address in Device combi.** = ***103***
- Default setting **(_:22714:102) Address in Device combi.** = ***104***
- Default setting **(_:22715:102) Address in Device combi.** = ***105***
- Default setting **(_:22716:102) Address in Device combi.** = ***106***

With the parameter **Address in Device combi.**, you assign a unique and unambiguous address for each device.

NOTE

If the preset values do not fit, Siemens recommends the following procedure:

Define a number for the device combination that is unambiguous in your area of responsibility and that must be at least 2 digits, for example, 100. The setting value of the parameter **Address in Device combi.** is then calculated as follows: **Number in the device combination** + **Device index**.

For device **2**, this leads to **Address in Device combi.** = ***102***.

Parameter: IP Address

- Default setting **(_:22711.103) IP address** = ***0.0.0.0***
- Default setting **(_:22712.103) IP address** = ***0.0.0.0***
- Default setting **(_:22713.103) IP address** = ***0.0.0.0***
- Default setting **(_:22714.103) IP address** = ***0.0.0.0***
- Default setting **(_:22715.103) IP address** = ***0.0.0.0***
- Default setting **(_:22716.103) IP address** = ***0.0.0.0***

The IP address of the local device is taken from the settings of the Ethernet-BD communication module and displayed. The local IP address cannot be edited at this point.

NOTE

If all devices of a device combination are equipped with an Ethernet-BD communication module and use the IP communication, you must enter the IP addresses for all other devices in the device combination here. The topology detection automatically sets a ring or chain topology.

NOTE

If you have a hybrid configuration, that is not all protection connections of a device combination use the IP communication, you must observe the following when setting the IP addresses:

- The topology detection does not generate the topology automatically.
- First define the order for the communication between the devices. Define chain or ring topologies for this purpose.
  The defined topology results in the partner devices for each device, with which the device communicates directly.
  Only set the IP addresses for the partner devices that are equipped with an Ethernet-BD communication module here.
- You can find examples of the parameterization of the IP addresses in hybrid configurations in the chapters *3.6.8.4 Device Combination of 3 Devices and Hybrid Communication Media* and *3.6.8.5 Device Combination of 6 Devices and Hybrid Communication Media*.

Indications and Measured Values in the Device Combination

Indication	Meaning
(_:3321:2311:301) Status of topo. recog.	The devices form a topology via the protection connections. This indication shows the status of the topology detection and can have the following values: • *Unknown*: The topology is unknown. • *Invalid*: The detected topology is not supported. • *Transient*: The topology has just been modified. • *Valid*: The topology has been detected. The indication *Devices form* shows the type of the detected topology.
(_:3321:2311:302) Topology is	The indication shows whether all configured devices in the device combination communicate with each other via the protection connections. The indication can have the following values: • *Unknown*: The topology is unknown. • *Incomplete*: At least one device in the device combination does not communicate via the protection connections. • *Complete*: All configured devices in the device combination communicate via the protection connections.

Indication	Meaning
(_:3321:2311:303) Devices form	This indication shows the type of the detected topology that the devices in the device combination form via the protection connections. The indication can have the following values: • *Unknown topol*: The topology is unknown. • *Chain topology*: The devices and their protection connections form a chain topology. • *Ring topology* The devices and their protection connections form a ring topology.
(_:3321:2311:304) Number of detect. dev.	The indication shows the number of devices that communicate via the protection connections in the device combination.

Indication and Measured Values of the Devices

The following indications and measured values are displayed for each device in the device combination and are explained using the example of a device.

Indication	Meaning
(_:22711:300) Dev.addr.	This indication shows the address of the device.
(_:22711:318) is present	This indication shows whether the device is involved in protection communication.
(_:22711:317) is logged off	This indication shows whether the local device has been logged off. If the device has been logged off, it is no longer involved in communication via the protection interfaces. If a device has been logged off, information relevant for the protection functions is no longer exchanged.
(_:22711:301) circuit breaker	This indication shows the position of the circuit breaker and can have the following values: • *0*: The switch position of the circuit breaker is unknown. • *1* The circuit breaker is open. • *2* The circuit breaker is closed.
(_:22711:328) Line diff. test [13]	This message indicates whether the function **Line differential protection** is in the state ***Test*** or ***Test/Relay blk.***.
(_:22711:329) Local Line diff. test [13]	This message indicates whether the function **Line differential protection** is in the special test mode *Test local device*.

3.6.6.8 Constellation Measured Values for Type 1 and Type 2

NOTE

The constellation measured values are only available for the FG **Line**.

Each device in the device combination determines measured values predefined by Siemens, known as constellation measured values. You can find the constellation measured values in the DIGSI 5 information routing under the FG **Protection comm. (Type x)** > **Device combination** > **Device x**. The following measured values and indications are issued for each device:

[13] This message is only available in the FG Protection communication type 1 (line diff. protection).

Measured value	Meaning
(_:3321:22711:302) Vph	This measured value shows the voltage of the 3 phases that is synchronized with all devices of the device combination. The absolute value and angle are issued for each phase.
(_:3321:22711:303) Iph	This measured value shows the current of the 3 phases that is synchronized with all devices of the device combination. The absolute value and angle are issued for each phase.
(_:3321:22711:304) f	The measured value supplies the locally calculated frequency of the measured voltage or the current.

The constellation measured values have the following properties:

- They are synchronized in the devices in a device combination.
- They are substituted using the protection interface.
- They are available on every device.

You can view the constellation measured values with DIGSI 5.

In the device, current and voltage measured values are displayed in absolute value and phase as a percentage. 100 % conform to the rated current or the rated voltage of the line (see *Figure 3-99*). These measured values are recorded every 2 seconds by the devices involved in the device combination and then sent to the other respective devices. At the same time, the current and voltage values of the different devices are time-synchronous with one another.

When displaying the constellation measured values the local device is prioritized. The device connected directly with DIGSI 5 is the local device.

The reference of the angle information depends on whether a line differential protection has been instantiated in the FG **Line**. If a line differential protection is instantiated, the protection communication is type 1, otherwise type 2.

- Protection communication **Type 1**:
  - The angle values of the voltages show the angle difference between the local and the remote voltage. The local voltage serves as the reference with an angle of 0°.
  - The angle values of the currents show the angle difference between the local and the remote current. The local current serves as the reference with an angle of 0°.
- Protection communication **Type 2**:
  The angles of the phase-to-ground voltages and the phase currents relate to the voltage V_A of the relevant device.

You can find these measured values in the device under the following DIGSI mask:

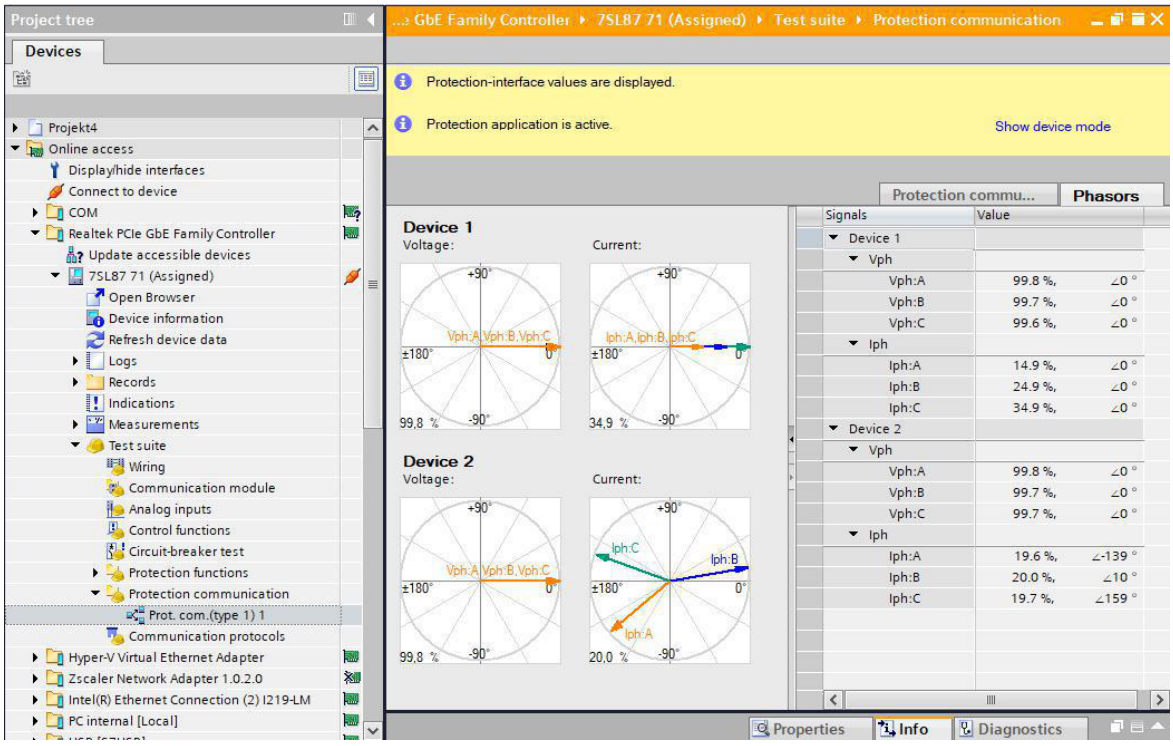


Figure 3-99 Example of Constellation Measured Values with Phases

3.6.6.9 Setting Notes for External Synchronization

With the FB **External synchronization**, you can synchronize the measured values of the devices connected via protection connections with microsecond accuracy using external synchronization sources (1*10E-06 s).

The measured values transmitted via protection communication for the line differential protection must be time-synchronized. The synchronization is possible as follows:

- Internally via telegram measurement
- Externally via the IEEE 1588 protocol
- Externally via a synchronous pulse from a satellite receiver

If you use Ethernet-BD communication modules for the protection communication of the line differential protection, the external synchronization of the measured values transmitted via the protection interface is mandatory.

If you use USART communication modules, you can synchronize the transmitted measured values either internally via telegram measurement or via external synchronization. If you do not use the external synchronization, the device automatically uses the internal synchronization.

If you want to use the external synchronization of the measured values, you must instantiate the FB **External synchronization** from the Global DIGSI 5 library into the FG **Protection comm.**. You can find the **External synchronization** in the Global DIGSI 5 library under **Advanced protection communication** > **Synchronization**.

The external synchronization is possible for line differential protection applications or synchrophasor measuring devices as follows:

- Via a high-precision electrical synchronous pulse (***PPS electrical (Port G)***, 1-second pulse) from a satellite receiver at the time-synchronization interface (Port **G**)
- Via a high-precision optical synchronous pulse (***PPS optical (USART)***, 1-second pulse) from a satellite receiver at a USART communication module
- Via the ***IEEE 1588*** time-synchronization protocol

With external synchronization, you can measure and display the signal-transit time of the transmission and receive path separately. This allows you to achieve maximum sensitivity even with unequal (unbalanced) signal-transit times in communication networks with the line differential protection. For the transmission of protection data in the **type 2** protection communication, different signal-transit times do not play a role.

If an FB **External synchronization** is instantiated, the parameter **Synchronization** is visible in the FB **Protection interf.**. With this parameter, you establish the connection between the protection interface and the type of external synchronization. See *3.6.6.5 Setting Notes for the Protection Interface*.

If you use 2 protection interfaces in the FG **Protection comm.**, you can set a different synchronization source for each protection interface if required. For this use case, you must instantiate 2 FBs **External synchronization** into the FG **Protection comm.** and set the desired synchronization source separately.

Parameter: Name of synchron. block

- Default setting **(_:101) Name of synchron. block** = ***Ext. synchronization 1***

The parameter **FB External synchron.** shows the name of the FB **External synchronization**.

If you have instantiated 2 FBs **External synchronization** into the FG **Protection comm.**, you can use this parameter to switch between the FB ***Ext. synchronization 1*** and the FB ***Ext. synchronization 2***.

Parameter: Synchronization source

- Default setting **(_:117) Synchronization source** = ***nothing***

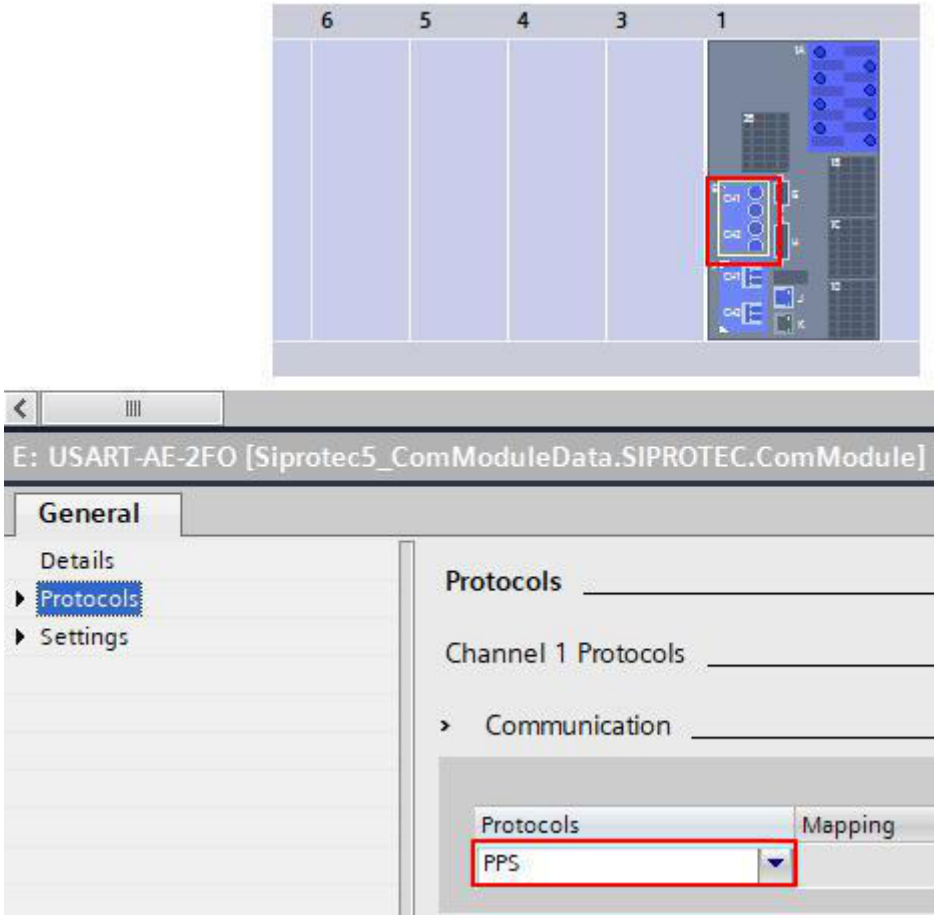
With the parameter **Synchronization source**, you select the desired synchronization source for the external synchronization of the measured values.



NOTE

The possible setting options of the parameter **Synchronization source** depend on the configuration of the protocol for the respective channel of the communication module.

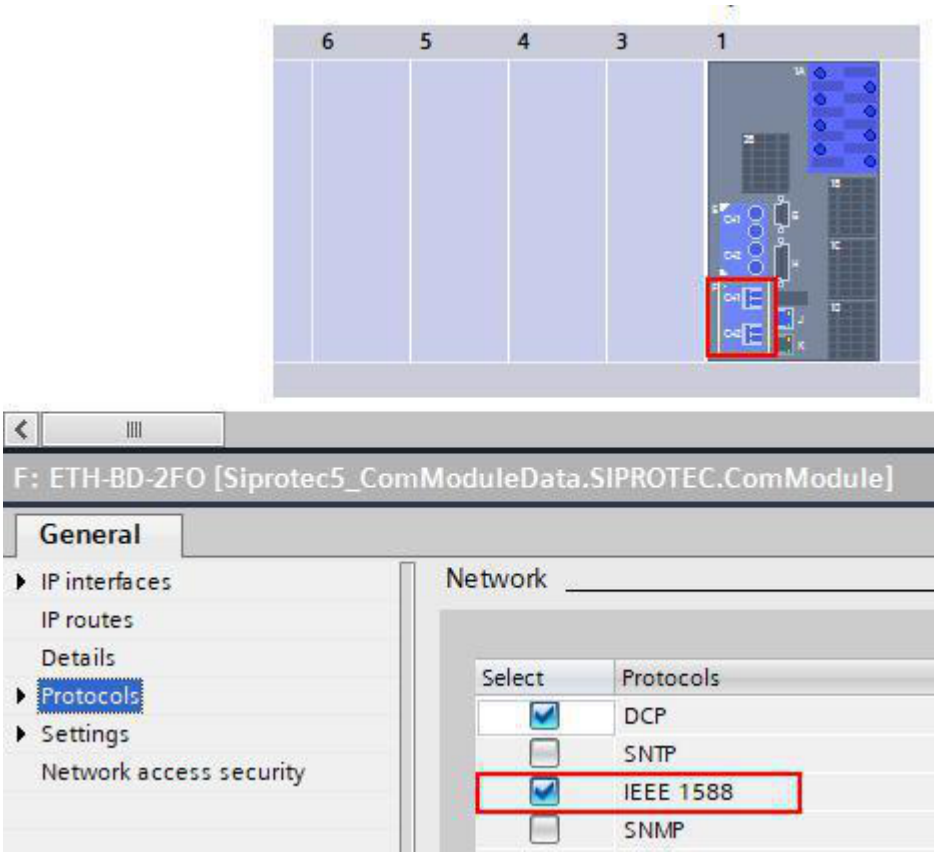
To display the selection text for the selection of an optical synchronous pulse, you must configure the protocol **PPS** on a USART communication module as follows:



[sc_PPS, 1, en_US]

Figure 3-100 Configuration of the Optical Synchronous Pulse (PPS) on a Channel of a USART Communication Module

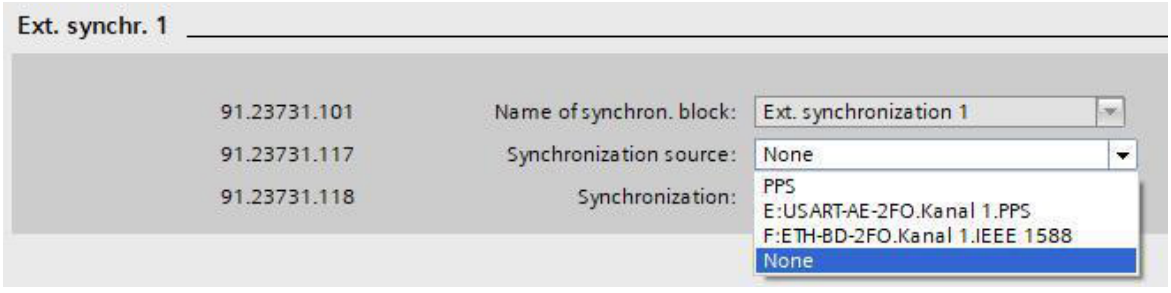
To display the selection text for the selection of the protocol IEEE 1588, you must configure the protocol **IEEE 1588** on an Ethernet-BD communication module as follows:



[sc_1588, 1, en_US]

Figure 3-101 Configuration of the Protocol IEEE 1588 on an Ethernet-BD Communication Module

The setting options for the parameter **`Synchronization source`** then look as follows, for example:



[sc_syncopt, 1, en_US]

Figure 3-102 Possible Setting Options for the Synchronization Source

Depending on the configuration, the following synchronization sources are displayed:

Parameter Value	Description
G:Timesynchron..PPS	The electrical synchronization pulse of a satellite receiver (PPS: 1 Pulse Per Second) at the time-synchronization interface Port G is the synchronization source.
[Port]:USART-AD-1FO.Channel 1.PPS	The optical synchronization pulse of a satellite receiver (PPS: 1 Pulse Per Second) on channel 1 of a USART communication module is the synchronization source.

Parameter Value	Description
[Port]:USART-AE-2FO.Channel 2.PPS	The optical synchronization pulse of a satellite receiver (PPS: 1 Pulse Per Second) on channel 2 of a USART communication module is the synchronization source.
[Port]:ETH-BD-2FO.Channel 1.IEEE 1588	The time-synchronization standard IEEE 1588 on an Ethernet-BD communication module is the synchronization source.

NOTE

You can select different synchronization sources for the same protection connection in the devices involved, for example, the synchronization via the **IEEE 1588** protocol in device **1** and via the protocol **PPS** electrical in device **2**.

Siemens recommends using the same synchronization source for the same protection connection. If it is not possible to use the same synchronization source, check the differential current in the line differential protection in the mode **Test on all devices**. If the differential current is not in the expected range, the set synchronization sources are not synchronous to each other and therefore not usable.

NOTE

For detailed information on the communication protocols, refer to the SIPROTEC 5 manual Communication Protocols.

Parameter: Synchronization using

- Default setting **(_:118) Synchronization using** = ***nothing***

This parameter **Synchronization using** cannot be adjusted. The parameter shows further information for the selected synchronization source:

Parameter Value	Description
nothing	You have not selected any external synchronization source.
PPS electrical (Port G)	The electrical synchronization pulse of a satellite receiver (PPS: 1 Pulse Per Second) at the time-synchronization interface Port **G** is the synchronization source.
PPS optical (USART)	The optical synchronization pulse of a satellite receiver (PPS: 1 Pulse Per Second) on channel 1 of a USART communication module is the synchronization source.
IEEE 1588	The time-synchronization standard IEEE 1588 on a BD communication module is the synchronization source.

Parameter: Max. inaccuracy

- Default setting **(_:119) Max. inaccuracy** = ***0,001 ms***

With the **Max. inaccuracy** parameter, you set the maximum expected inaccuracy of the synchronization sourced used. The set value is only effective if the synchronization source used does not supply any information on the current inaccuracy in the synchronization signals. If you no information on the inaccuracy of the synchronization source used, use the default setting.

NOTE

The inaccuracy of the synchronization source enters the stabilization of the **Line differential protection** as an error signal.

This means that greater inaccuracy increases the calculated stabilization quantity and makes the **Line differential protection** less sensitive.

If **IEEE 1588** is used as the synchronization source in the synchronization status ***SmpSynch*** = ***global***, accuracy values are supplied with the synchronization signals and the parameter **Max. inaccuracy** is not

used. If the supplied accuracy values become invalid, the value set in the parameter **Max. inaccuracy** is used.

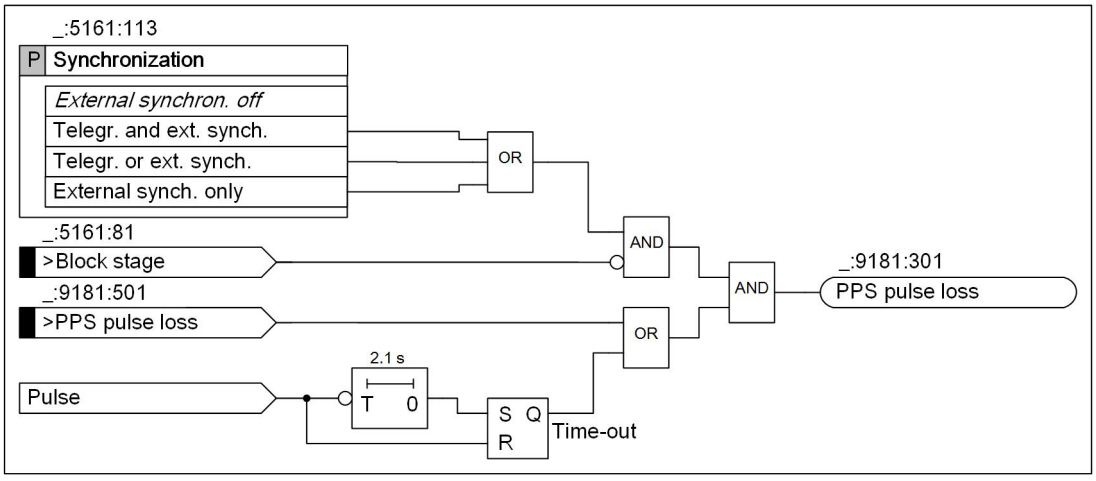
If the synchronization source **IEEE 1588** works in the synchronization status ***SmpSynch*** = ***local***, then the value set in the parameter **Max. inaccuracy** is used as permanently available inaccuracy.

If **PPS electrical (Port G)** or **PPS optical (USART)** are used as synchronization source, then the value set in the parameter **Max. inaccuracy** is used as permanently available inaccuracy.

If a USART communication module with the **PPS** protocol and the **PPS generator** operating mode is also used as a synchronization source at the same time, the value set in the parameter **Max. inaccuracy** is used as permanently available inaccuracy.

3.6.6.10 Indications and Measured Values of the External Synchronization

Indication	Description
(_:501) >PPS pulse loss	The indication *(_:501) >PPS pulse loss* is only visible with the following setting options of the parameter **(_:117) Synchronization source**: • G:Timesynchron.PPS • [Port]:USART-AD-1FO.Channel x.PPS • [Port]:USART-AE-2FO.Channel x.PPS The binary input *(_:501) >PPS pulse loss* can be used to signal an externally detected failure in the PPS synchronous pulse, for example, an error message from the satellite receiver. If the binary input *(_:501) >PPS pulse loss* is set, this leads to the indication *(_:304) Synchronization loss*. The external synchronization detects immediately that there is a problem with the connected synchronization pulse. Otherwise, the problem will only be noticed after approx. 2.1 s – after the test for synchronous-pulse failure.
(_:304) Synchronization loss	The synchronization has failed. This can be due to a problem with the synchronization source. The indication *(_:304) Synchronization loss* shows that the synchronization has failed. This can be due to the following reasons: • The input indication *(_:501) >PPS pulse loss* has occurred. • The synchronous pulse has failed. • The quality of the synchronous pulse is inadequate. • There is another problem with the synchronization source.
(_:305) Synchronization OK	The synchronization is operating correctly.
(_:306) Synchronization pulse	You can use this indication to make the synchronous pulse visible. As a rule, one pulse is generated per second.
(_:307) Synchron. imprecise	If the set synchronization source operates in the ***global*** synchronization status and the time of the synchronization source deviates from the global time by more than 0.5 ms, the indication *Synchron. imprecise* is generated and the line differential protection becomes ineffective. The indication *Synchron. imprecise* is visible if you select ***ETH-BD-2FO.Channel1.IEEE1588*** in the parameter _:103 Synchronization source. The read-only parameter **(_:118) Synchronization using** then displays ***IEEE 1588***.



[lo_pps_syn, 2, en_US]

Figure 3-103 Logic for the Generation of the Indication *>PPS pulse loss*

3.6.6.11 Setting Notes for the Remote Data

Parameter: Dropout Time Prio. x

- Default setting **(_:22741:111) Dropout time prio. 1** = ***2.00 s***
- Default setting **(_:22741:112) Dropout time prio. 2** = ***2.00 s***
- Default setting **(_:22741:113) Dropout time prio. 3** = ***2.00 s***

If you use user-specific remote data, you can set how long the last received state of your remote data is held in case of a communication failure. This allows you to bridge short-term communication failures. The time can be set separately for each priority of the remote data.

For further information, refer to *3.6.5.9 Remote Data*.

3.6.6.12 Description Phase Swapping

Phase Swap

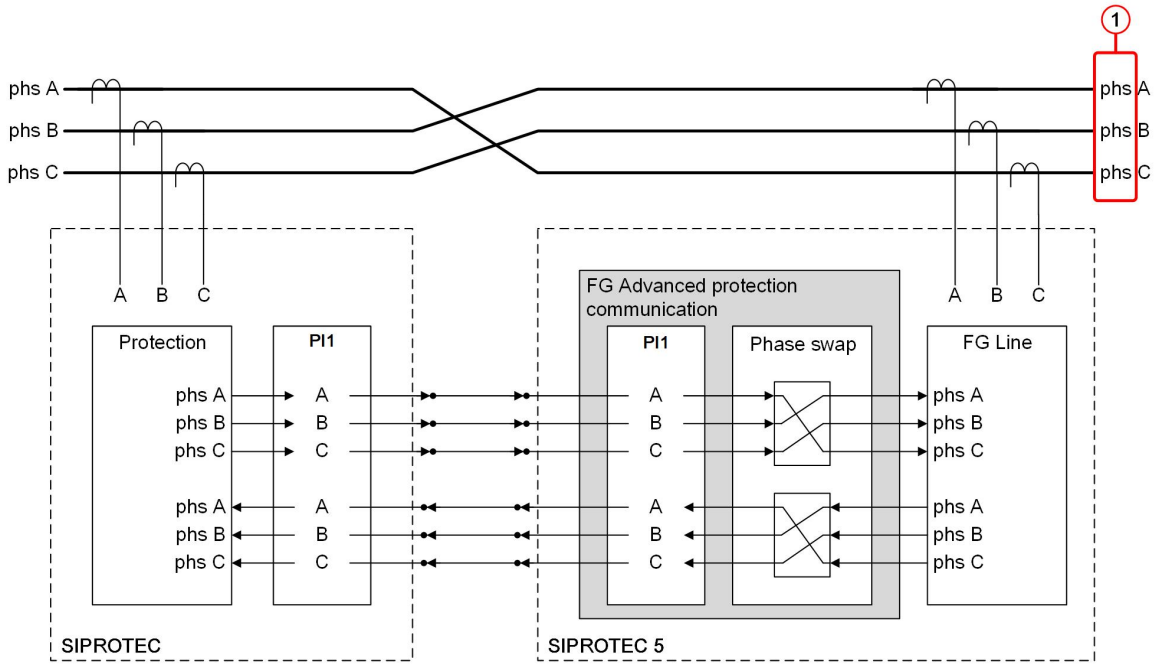
If you want to exchange information via the protection communication with a device showing phases with a different sequence but with the same rotating field as your device, the SIPROTEC 5 device can swap the phase information when sending and receiving. It is no longer necessary to swap phases when connecting the current transformers.

This use case exists on some tie lines of different power-system operators.

Figure 3-104 shows an example of the different designation of the same phases at the line ends. For example, phase **A** on the left side of the line becomes phase **C** on the right side. If a SIPROTEC 5 device is used on the right side, you can instantiate the FB **Phase swap** in the FG **Advanced protection communication**. Use the FB **Phase swap** to set how the phases are swapped when sending and receiving phase-selective information via the protection interface.

This results in the following SIPROTEC 5 device behavior:

- Connect the current and voltage transformers to the terminals **A**, **B**, and **C** of the protection device as usual.
- Connect the circuit breaker without swapping phases.
- The protection functions in both devices, such as **Line differential protection** or **Teleprotection with distance protection** cooperate without any problems.
- The phase-selective messages and measured values are displayed correctly from the point of view of the respective device.



[dw_different_phs-designation_are_compens_send-receive, 1, en_US]

Figure 3-104 Differing Phase Designations Are Compensated for while Sending and Receiving

(1) Other phase designations than at the opposite end for the same physical phase

NOTE

Phase swapping does not support the **I2-DIFF** stage of the function **Line differential protection**.

Swapping of user-specific phase-selective information sent and received using the function **Remote data** is not supported.

3.6.6.13 Setting Notes for Phase Swapping

Swap in Send Direction

- Default setting **(_:101) Swap in send direction** = ***No phase swap***

With the parameter **Swap in send direction**, you select phase swapping. The phases are swapped from the send direction view. The following options are possible:

Parameter Value	Description
No phase swap	When sending phase-selective information, there is no phase swap.
A → B, B → C, C → A	The local data such as measured values and status information of the phases are swapped and sent to the neighboring device as follows: • The local data of phase **A** as data of phase **B** • The local data of phase **B** as data of phase **C** • The local data of phase **C** as data of phase **A**
A → C, B → A, C → B	The local data such as measured values and status information of the phases are swapped and sent to the neighboring device as follows: • The local data of phase **A** as data of phase **C** • The local data of phase **B** as data of phase **A** • The local data of phase **C** as data of phase **B**

Swap in Receive Direction

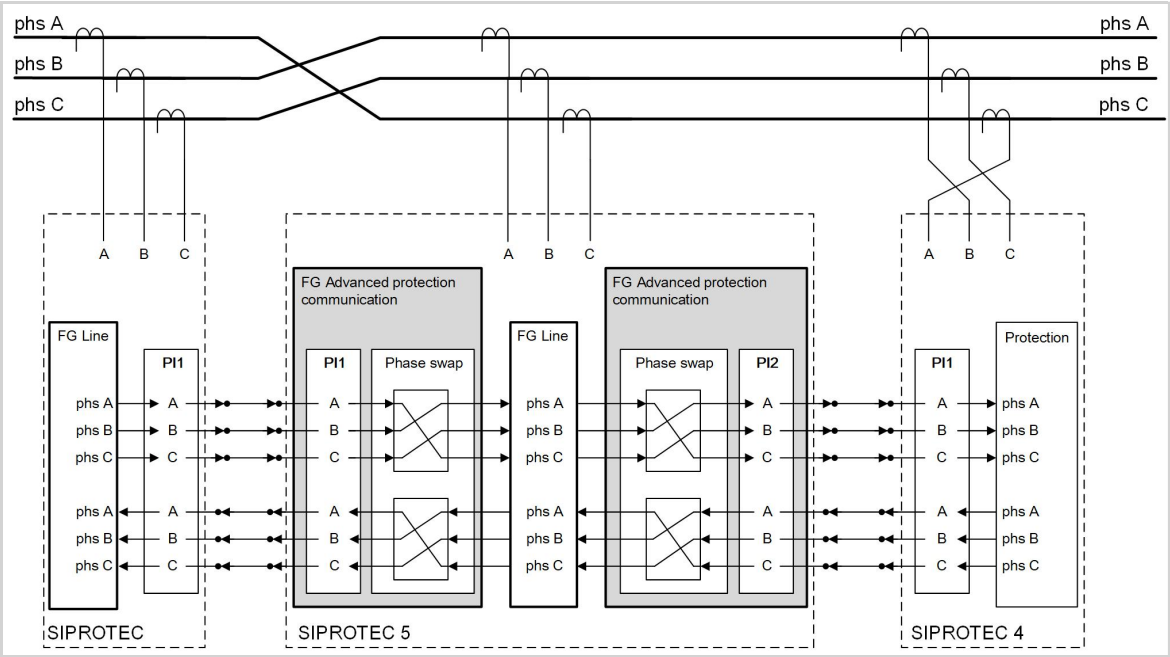
Depending on the setting value of the parameter **Swap in send direction**, the reverse swap direction results from the receive direction view. The read-only parameter **(_:102) Swap in receive direction** then indicates the resulting phase swap.

Parameter Value	Description
No phase swap	When receiving phase-selective information, there is no phase swap.
A → C, B → A, C → B	The data received from the neighboring device such as measured values and status information of the phases are used as follows: • The received data of phase **A** as local data of phase **C** • The received data of phase **B** as local data of phase **A** • The received data of phase **C** as local data of phase **B**
A → B, B → C, C → A	The data received from the neighboring device such as measured values and status information of the phases are used as follows: • The received data of phase **A** as local data of phase **B** • The received data of phase **B** as local data of phase **C** • The received data of phase **C** as local data of phase **A**

Examples of a Device Combination with 3 Devices:

For a device combination with more than 2 devices, you need to mentally divide the device combination into a section using the phase swap and a section not using the phase swap. In the section using the phase swap, you need to instantiate the FB **Phase swap** in the SIPROTEC 5 devices. When using SIPROTEC 4 devices, you need to swap phases when connecting the transformers and the circuit breaker.

The following figure shows a device combination with 3 devices. The device on the left can be a SIPROTEC 4 or SIPROTEC 5 device. There is a SIPROTEC 5 device in the middle and a SIPROTEC 4 device on the right side. The device in the middle swaps phases by using the FB **Phase swap**. The FB **Phase swap** is used for both protection interfaces, but it is instantiated only once for each FG **Advanced protection communication**. In the SIPROTEC 4 device on the right, you can implement the phase swap only by changing the wiring of the current and voltage transformers and of the circuit breaker. You must reinterpret the phase-selective indications accordingly.



[dw_Device combination with 3 devices, 1, en_US]

Figure 3-105 Device Combination with 3 Devices

3.6.6.14 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Remote data				
_:22741:111	Remote data:Dropout time prio. 1		0.00 s to 300.00 s	2.00 s
_:22741:112	Remote data:Dropout time prio. 2		0.00 s to 300.00 s	2.00 s
_:22741:113	Remote data:Dropout time prio. 3		0.00 s to 300.00 s	2.00 s
Prot. interf.1				
_:5161:1	Prot. interf.1:Mode		• off • on	on
_:5161:105	Prot. interf.1:Max. error rate per hour		0.000 % to 100.000 %	1.000 %
_:5161:106	Prot. interf.1:Max. error rate per min		0.000 % to 100.000 %	1.000 %
_:5161:107	Prot. interf.1:Distur-bance alarm after		0.05 s to 2.00 s	0.10 s
_:5161:108	Prot. interf.1:Transm. fail. alarm after		0.0 s to 6.0 s	6.0 s
_:5161:109	Prot. interf.1:Delay time threshold		0.1 ms to 30.0 ms	30.0 ms
_:5161:110	Prot. interf.1:Difference Tx and Rx time		0.000 ms to 3.000 ms	0.100 ms
_:5161:113	Prot. interf.1:Synchroni-zation		• External synchron. off • Telegr. and ext. synch. • Telegr. or ext. synch. • External synch. only	External synchron. off

Addr.	Parameter	C	Setting Options	Default Setting
_:5161:117	Prot. interf.1:FB External synchron.		• Ext. synchronization 1 • Ext. synchronization 2	Ext. synchroni-zation 1
_:5161:120	Prot. interf.1:Check synchron.-source		• no • yes	yes
_:5161:120	Prot. interf.1:PI assign-ment		Setting options depend on configuration	

3.6.6.15 Information List

No.	Information	Data Class (Type)	Type
Prot. interf.1			
_:5161:81	Prot. interf.1:>Block stage	SPS	I
_:5161:500	Prot. interf.1:>Sync reset	SPS	I
_:5161:341	Prot. interf.1:Reset synchronization	SPC	C
_:5161:342	Prot. interf.1:Reset measurements	SPC	C
_:5161:52	Prot. interf.1:Behavior	ENS	O
_:5161:53	Prot. interf.1:Health	ENS	O
_:5161:301	Prot. interf.1:Status of lay. 1 and 2	ENS	O
_:5161:302	Prot. interf.1:Status of lay. 3 and 4	ENS	O
_:5161:303	Prot. interf.1:Connection broken	SPS	O
_:5161:316	Prot. interf.1:Error rate / min exc.	SPS	O
_:5161:317	Prot. interf.1:Error rate / hour exc.	SPS	O
_:5161:318	Prot. interf.1:Time delay exceeded	SPS	O
_:5161:319	Prot. interf.1:Time delay different	SPS	O
_:5161:320	Prot. interf.1:Time delay jump	SPS	O
_:5161:321	Prot. interf.1:PI synchronized	SPS	O
_:5161:340	Prot. interf.1:Telegram lost	SPS	O
_:5161:323	Prot. interf.1:PPS: time del. unsym.	SPS	O
_:5161:324	Prot. interf.1:PI with PPS synchron.	SPS	O
_:5161:343	Prot. interf.1:Partner	INS	O
_:5161:308	Prot. interf.1:Tx tel/h	MV	O
_:5161:309	Prot. interf.1:Rx tel/h	MV	O
_:5161:310	Prot. interf.1:Tx tel/min	MV	O
_:5161:311	Prot. interf.1:Rx tel/min	MV	O
_:5161:312	Prot. interf.1:Tx err/h	MV	O
_:5161:313	Prot. interf.1:Rx err/h	MV	O
_:5161:314	Prot. interf.1:Tx err/min	MV	O
_:5161:315	Prot. interf.1:Rx err/min	MV	O
_:5161:334	Prot. interf.1:Miss.tel/min	MV	O
_:5161:335	Prot. interf.1:Miss.tel/h	MV	O
_:5161:336	Prot. interf.1:Miss.tel/d	MV	O
_:5161:337	Prot. interf.1:Miss.tel/w	MV	O
_:5161:338	Prot. interf.1:M. loss/d	MV	O
_:5161:339	Prot. interf.1:M. loss/w	MV	O
_:5161:331	Prot. interf.1:Recept.	MV	O
_:5161:325	Prot. interf.1:Aver.Δt	MV	O
_:5161:326	Prot. interf.1:Rec. Δt	MV	O

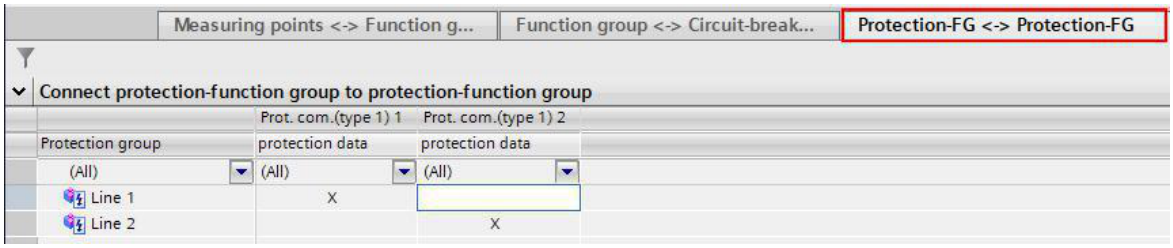
No.	Information	Data Class (Type)	Type
_:5161:327	Prot. interf.1:Sen. Δt	MV	O
Prot.interf.1B			
_:23461:81	Prot.interf.1B:>Block stage	SPS	I
_:23461:500	Prot.interf.1B:>Sync reset	SPS	I
_:23461:341	Prot.interf.1B:Reset synchronization	SPC	C
_:23461:342	Prot.interf.1B:Reset measurements	SPC	C
_:23461:52	Prot.interf.1B:Behavior	ENS	O
_:23461:53	Prot.interf.1B:Health	ENS	O
_:23461:301	Prot.interf.1B:Status of lay. 1 and 2	ENS	O
_:23461:302	Prot.interf.1B:Status of lay. 3 and 4	ENS	O
_:23461:303	Prot.interf.1B:Connection broken	SPS	O
_:23461:316	Prot.interf.1B:Error rate / min exc.	SPS	O
_:23461:317	Prot.interf.1B:Error rate / hour exc.	SPS	O
_:23461:318	Prot.interf.1B:Time delay exceeded	SPS	O
_:23461:340	Prot.interf.1B:Telegram lost	SPS	O
_:23461:323	Prot.interf.1B:PPS: time del. unsym.	SPS	O
_:23461:324	Prot.interf.1B:PI with PPS synchron.	SPS	O
_:23461:343	Prot.interf.1B:Partner	INS	O
_:23461:308	Prot.interf.1B:Tx tel/h	MV	O
_:23461:309	Prot.interf.1B:Rx tel/h	MV	O
_:23461:310	Prot.interf.1B:Tx tel/min	MV	O
_:23461:311	Prot.interf.1B:Rx tel/min	MV	O
_:23461:312	Prot.interf.1B:Tx err/h	MV	O
_:23461:313	Prot.interf.1B:Rx err/h	MV	O
_:23461:314	Prot.interf.1B:Tx err/min	MV	O
_:23461:315	Prot.interf.1B:Rx err/min	MV	O
_:23461:334	Prot.interf.1B:Miss.tel/min	MV	O
_:23461:335	Prot.interf.1B:Miss.tel/h	MV	O
_:23461:336	Prot.interf.1B:Miss.tel/d	MV	O
_:23461:337	Prot.interf.1B:Miss.tel/w	MV	O
_:23461:338	Prot.interf.1B:M. loss/d	MV	O
_:23461:339	Prot.interf.1B:M. loss/w	MV	O
_:23461:331	Prot.interf.1B:Recept.	MV	O
_:23461:325	Prot.interf.1B:Aver.Δt	MV	O
_:23461:326	Prot.interf.1B:Rec. Δt	MV	O
_:23461:327	Prot.interf.1B:Sen. Δt	MV	O

3.6.7 Assignment of the Protection Function Group to the FG Protection Communication

If protection functions want to use the protection interfaces in a protection function group, you must route the connection of the protection function group, for example, the FG **Line 1**, with a function group **Protection communication** in DIGSI 5. Then, each protection function in the FG **Line 1** can use the protection communication.

Route the connection between the FG **Line** and the FG **Protection communication** in DIGSI 5 as follows:

Project tree > **Function-group connections** > Tab **Protection FG** ↔ **Protection FG**. Right-click to route the connection in the desired line/column.



[sc_PDC_rout1, 1, en_US]

Figure 3-106 Routing of the Connection between the Protection FG and the FG Protection Communication in DIGSI 5

NOTE

If only one protection function group and one FG **Protection communication** are instantiated in the device, DIGSI 5 connects both function groups automatically.

3.6.8 Application Examples and Setting Notes for IP Communication

3.6.8.1 Overview

The advanced protection communication supports the IP communication via MPLS[14] communication networks.

- If existing systems are to be upgraded for protection-interface communication via IP, you must retrofit an Ethernet-BD communication module in the respective SIPROTEC 5 devices.
- The protection-interface communication via IP requires an Ethernet-BD communication module per device in the device combination.
- In a device, only one Ethernet-BD communication module can be used per device combination.
- However, another device combination can use the same Ethernet-BD communication module of the device.

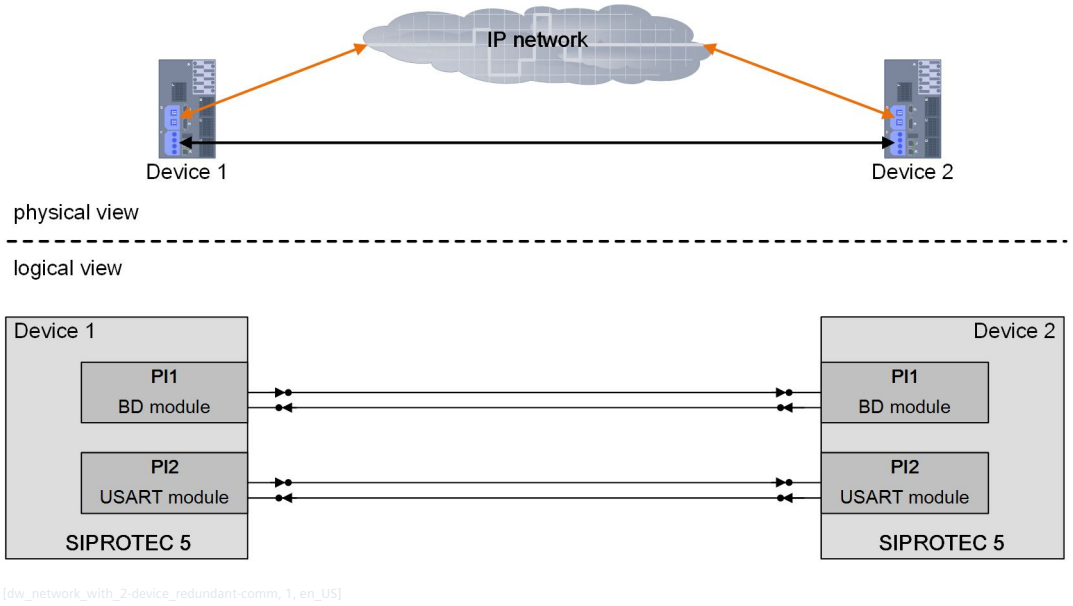
The following application examples show what you must consider when using the IP communication via MPLS communication networks.

3.6.8.2 Device Combination of 2 Devices and Redundant Communication Connection

If redundancy of the communication connection is required for a device combination consisting of 2 devices, 2 different procedures are possible:

- You can use the redundancy mechanisms of the LAN and the Ethernet-BD communication module (PRP, HSR, RSTP). In this case, the redundant communication route runs through the same Ethernet-BD communication module.
- You can set up a 2nd communication connection via a physically separate path. It is best to use a different medium for this, for example, a fiber-optic direct connection, a direct cable connection (pilot wire), or a connection based on C37.94. That is, for the 2nd communication connection, you must use another communication module in each device. The following figure shows this case from a physical and logical view:

14 MPLS = Multi-Protocol Label Switching



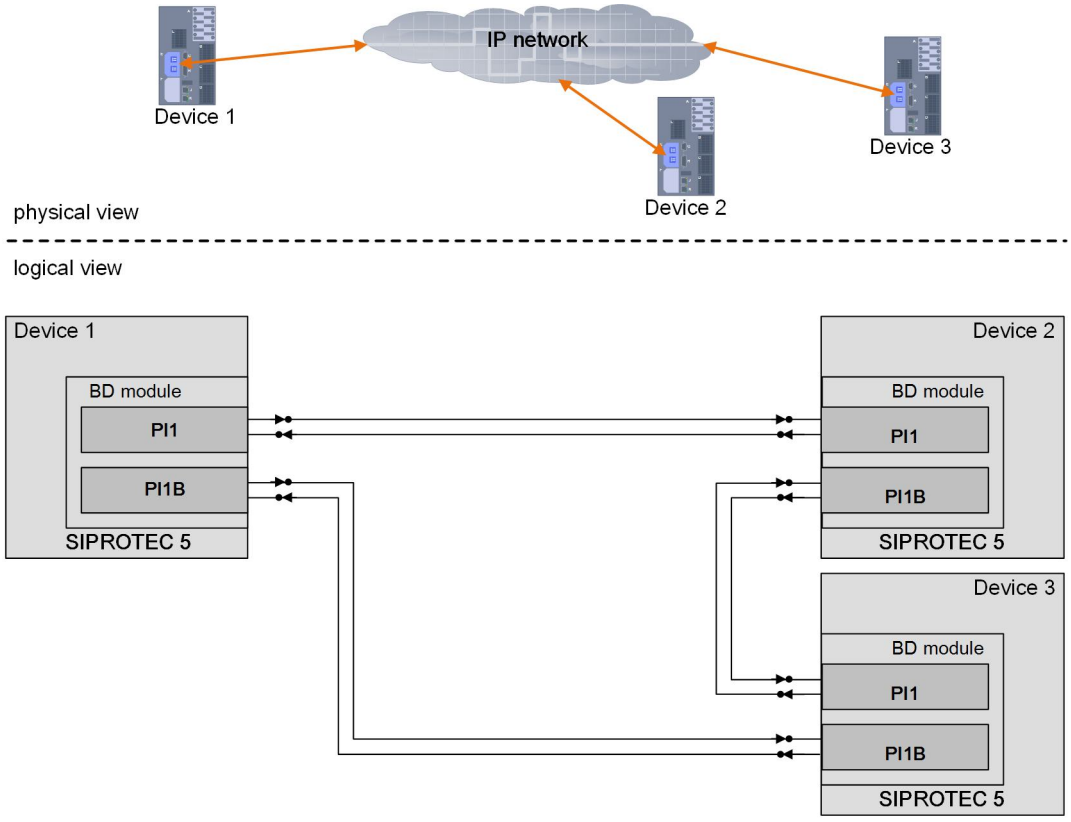
[dw_network_with_2-device_redundant-comm, 1, en_US]

Figure 3-107 Device Combination with 2 Devices and Redundant Communication Connection

3.6.8.3 Device Combination of 3 Devices and Only IP Communication

If you configure a device combination with 3 devices and all devices are using the IP communication, then, from the view of a device, the 2 other devices in the network are visible and reachable. For this, you configure in each device the protocol ***Advanced protection interface*** on the Ethernet-BD communication module and the **Protection interface 1**. The Ethernet-BD communication module is assigned to the **Protection interface 1**.

The special feature of this configuration is that the topology detection automatically generates a 3-device ring topology (logical view). That is, 3 point-to-point communication connections are established between the devices. In addition, another **Protection interface 1B** is automatically visible in each device, which provides the necessary 2nd communication channel for the ring topology, see the following figure:



[dw_network_with_3-device_redundant-comm, 1, en_US]

Figure 3-108 Device Combination with 3 Devices in the IP Communication Network

The **Protection interface 1B** takes over the settings of **Protection interface 1**, that is **Protection interface 1B** does not have its own settings view. The **Protection interface 1B** has its own indications and measured values, which you can see in the information routing.

NOTE

If you use 3 devices in the device combination with IP communication, the aim of the topology detection is to form a ring topology, as in addition to a redundant connection, shorter transmission times are also possible.

If you have instantiated a 2nd protection interface, for example to establish a communication connection via another medium, the device hides the **Protection interface 1B**.

NOTE

In the following cases, the **Protection interface 1B** becomes inactive and does not have any messages or measured values:

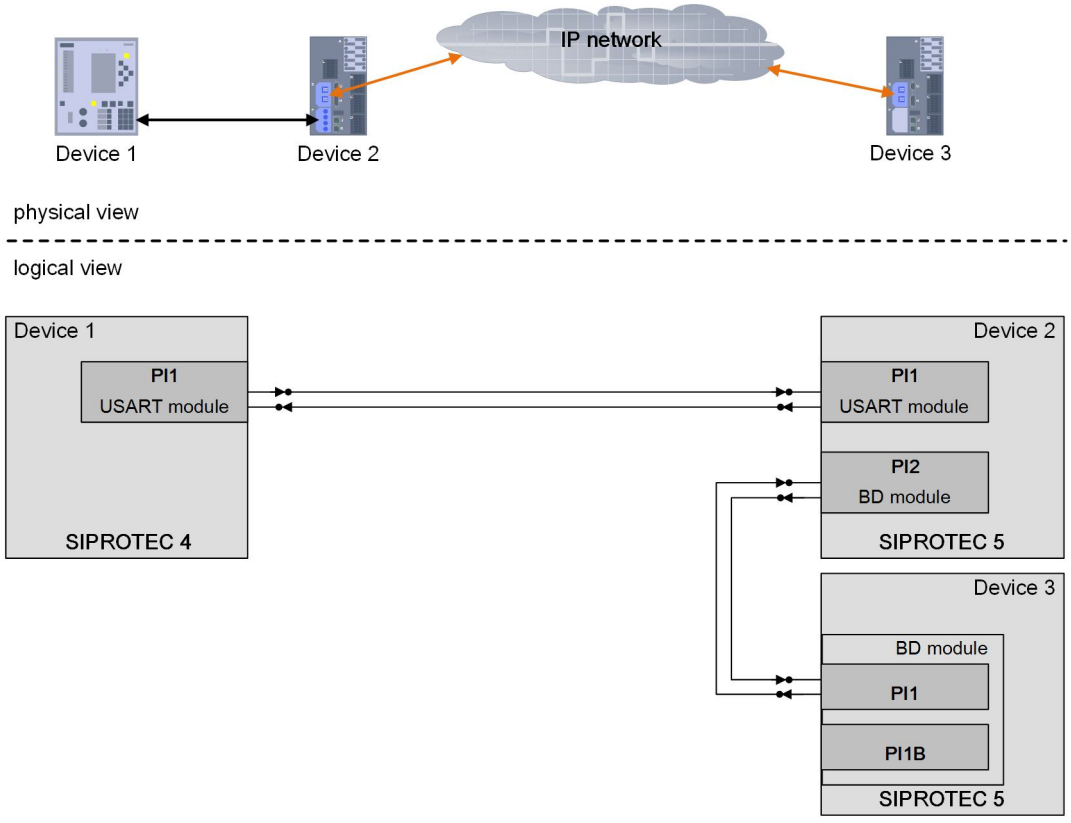
- A 2nd protection interface is instantiated.
- Only 2 devices are present in the device combination.
- No protection interface is assigned to an Ethernet-BD communication module.

3.6.8.4 Device Combination of 3 Devices and Hybrid Communication Media

If you extend a system, it can be necessary to extend a device combination consisting of 2 existing devices by 1 device, see the following figure.

The previous 2 devices are connected to each other, for example, via a fiber-optic direct connection or via other communication media. The left device, for example, a SIPROTEC 4 device, and the middle SIPROTEC 5

device are the 2 devices previously present in the system. This device combination is to be extended by adding the right SIPROTEC 5 device. The communication between the middle and the right device is to take place via an IP communication network.



[dw_network_with_3-device_mixed-comm, 1, en_US]

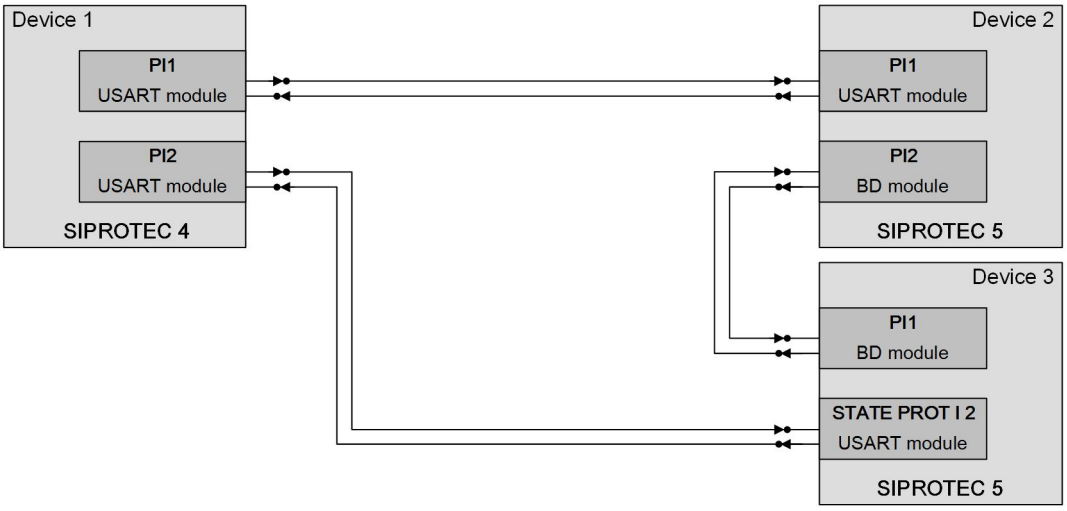
Figure 3-109 Device Combination with 3 Devices and Hybrid Communication Media

For this configuration of a 3-device chain topology, you must configure a **device combination with 3 devices** in all devices.

In the middle device, an Ethernet-BD communication module is additionally required. Configure the protocol ***Advanced protection interface*** in the properties of the Ethernet-BD communication module. Instantiate the function block **Protection interface 2** in the FG **Protection communication**. Assign the Ethernet-BD communication module to the **Protection interface 2**.

The device on the right must also have an Ethernet-BD communication module. Also configure here the protocol ***Advanced protection interface*** in the properties of the Ethernet-BD communication module and assign the Ethernet-BD communication module to the **Protection interface 1**. **Protection interface 1B** is created here as a special feature, but it is not used.

If a redundant communication connection is required for this configuration, Siemens recommends establishing a 3-device ring topology. For this purpose, you must connect the left and right devices via another communication channel. This creates the 3-device ring topology. The following figure shows this configuration:



[dw_3-device_and_mixed-comm, 1, en_US]

Figure 3-110 Device Combination with 3 Devices and Hybrid Communication Media and Redundant Communication Connection

The SIPROTEC 4 device (left device) does not support any IP communication. In this case, you must switch to another communication medium and retrofit a corresponding SIPROTEC 4 communication module. In any case, the communication medium used is also supported by the SIPROTEC 5 device on the right side, by retrofitting a corresponding equivalent communication module there. Configure this communication module with the protocol ***Advanced protection interface***, add an additional **Protection interface 2** to the FG **Protection communication**. Assign the **Protection interface 2** to the communication module.

3.6.8.5 Device Combination of 6 Devices and Hybrid Communication Media

IP Addresses in Hybrid Topologies

To ensure redundancy or downward compatibility, the devices also allow a mix of classic and IP-based communication media.

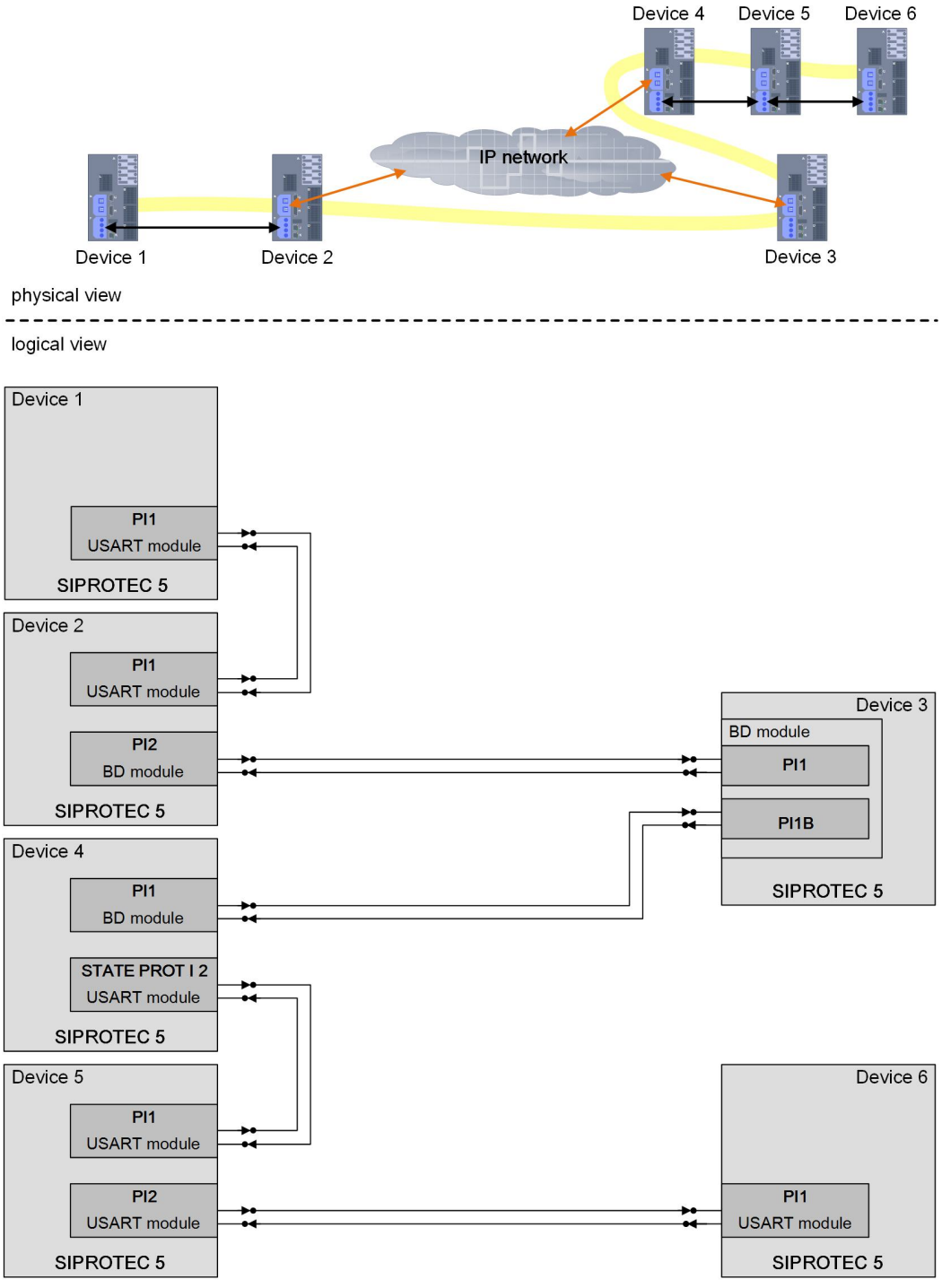
In such applications, special consideration must be given to the configuration of the IP addresses. When parametrizing the devices, you must first clarify which path the communication is to take through the network. That is, it must be clear which devices communicate with each other. To define a route, you may only configure its planned communication partners in a device. The following examples illustrate the correct IP configuration.

For device combinations with more than 3 devices and hybrid communication media, different configurations are possible. If you want to use the IP communication, consider that only one Ethernet-BD communication module per device combination is supported for the protection-interface communication.

The following figure shows a device combination with 6 devices. In the example, several devices are connected by other communication media, which form 3 device groups. The device groups are connected by an IP network. The result is a 6-device chain topology. The yellow line illustrates the communication route.

To establish this communication route, you may only parameterize the IP addresses of their direct communication partners in the devices. The following example applies:

- The devices **2** and **4** only know the IP address of device **3**.
- Device **3** only knows the IP addresses of the devices **2** and **4**.
- Leave all other IP addresses at ***0.0.0.0***.



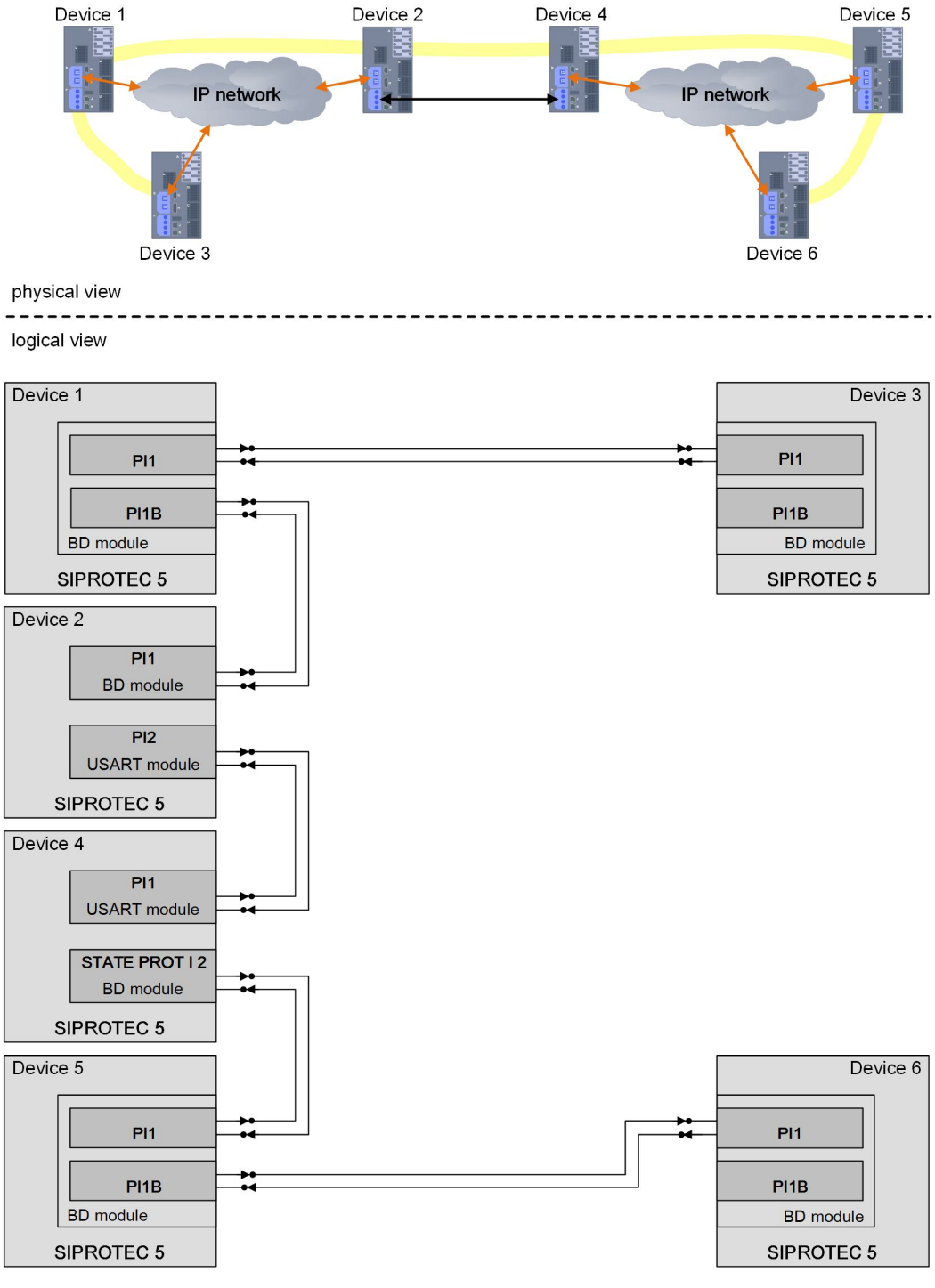
[dw_network_with_6-device_redundant-comm, 1, en_US]

Figure 3-111 Example 1 of a Device Combination with 6 Devices

Another example shows 2 device groups whose devices are connected to each other via IP networks. The 2 device groups are connected to each other by a different communication medium. The topology detection in turn forms a 6-device chain topology.

To establish this communication route, you may only parameterize the IP addresses of their direct communication partners in the devices. The following example applies:

- Device **1** only knows the IP addresses of the devices **2** and **3**.
- The devices **2** and **3** only know the IP address of device **1**.
- Device **5** only knows the IP addresses of the devices **4** and **6**.
- The devices **4** and **6** only know the IP address of device **5**.
- Leave all other IP addresses at *0.0.0.0*.



[dw_network_with_6-device, 1, en_US]

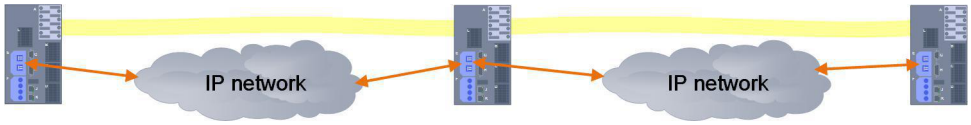
Figure 3-112 Example 2 of a Device Combination with 6 Devices

3.6.8.6 Unsupported Configurations

The following figure shows an example of a device combination with 3 devices. In the example, all devices use the IP communication. The middle device contains 2 Ethernet-BD communication modules, which are both configured with the ***Advanced protection interface*** protocol.

NOTE

You can only use 1 Ethernet-BD communication module in one device!
2 Ethernet-BD communication modules with the ***Advanced protection interface*** protocol are not supported.



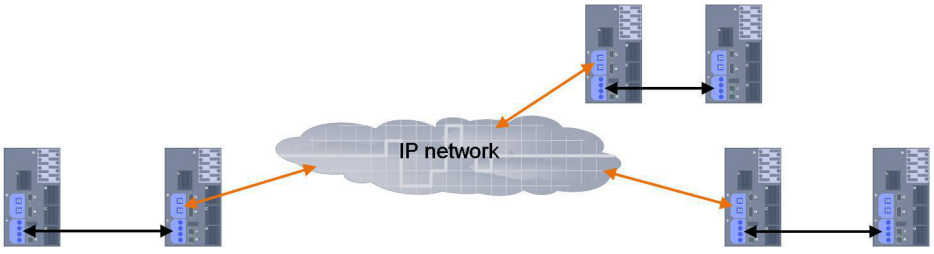
[dw_non-supported-confic_network_with_3-device, 1, en_US]

Figure 3-113 Unsupported Configuration of a Device Combination with 3 Devices

NOTE

If you use the IP communication, the aim of the topology detection is to form a chain topology if there are 4 or more devices. For certain configurations, the topology detection cannot form a working chain topology.

The following figure shows an example of a device combination with 6 devices and hybrid communication media. In this case, the topology detection cannot form a functioning 6-device chain topology.



[dw_non-supported-confic_network_with_6-device, 1, en_US]

Figure 3-114 Unsupported Configuration of a Device Combination with 6 Devices

3.7 Date and Time Synchronization

3.7.1 Overview of Functions

Timely recording of process data requires precise time synchronization of the devices. The integrated date/time synchronization allows the exact chronological assignment of events to an internally managed device time that is used to time stamp events in logs, which are then transmitted to a substation automation technology or transferred via the protection interface. A clock module internal to the device and having battery backup is synchronized cyclically with the current device time so that the right device time is available and used even in case of auxiliary-voltage failure. At the same time, this permits hardware-supported monitoring of the device time.

3.7.2 Structure of the Function

The integrated date/time synchronization is a supervisory device function. Setting parameters and indications can be found in the following menus for the DIGSI and the device:

Set date and time:

- DIGSI: Online access -> Interface -> Device -> Device Information -> **Time Information**
- Device: Main menu → Device functions → **Date & Time**

Parameter:

- DIGSI: Project -> Device -> Parameter -> **Time Settings**

Indications:

- DIGSI: Project -> Device -> Information routing ->**Time keeping** or **Time Sync.**

3.7.3 Function Description

Every SIPROTEC 5 device maintains an internal device time with date. The date and time can also be set on the device via the on-site operation panel or via DIGSI 5. Within a system, or even beyond, it is usually necessary to record the time of process data accurately and to have exact time synchronization of all devices. For SIPROTEC 5 devices, the sources of time and synchronization options can be configured.

Configurable Synchronization Options:

- **None** (default setting)
  The device functions without any external time synchronization. The internal time synchronization continues to work with the help of the back-up battery even when the auxiliary voltage is shut down temporarily. The time can be adjusted manually.
- **Telegram**
  The time is synchronized via a telegram with an appropriately configured communication interface in accordance with the IEC 60870-5-103 or DNP3 protocol.
- **Connection to a radio clock**
  The time synchronization takes place with the set time telegram from an external IRIG B or DCF77 receiver via the time synchronization interface of the device.
- **Ethernet**
  The time synchronization is done via Ethernet-based SNTP protocol (Simple Network Time Protocol), for example with IEC 61850 stations or via IEEE 1588. If you enable both services during configuration of Ethernet interfaces, these protocols are available as an option for the time synchronization.

- **Protection interface**
  The time synchronization takes place via the protection interfaces configured for your SIPROTEC 5 device. Here, the timing master takes over the time management.

Configurable Time Sources:

- 2 time sources can be taken into consideration with the SIPROTEC 5 devices. For each time source, the synchronization type may be selected based on the options provided.
- **`Time source 1`** takes precedence over **`Time source 2`**, that is, **`Time source 2`** will be effective for the synchronization of the device time only if **`Time source 1`** fails. If only one time source is available and it fails, then only the internal clock continues unsynchronized. The status of the time sources is indicated.
- For every time source, it is possible to define via the **`Time zone time source 1`** parameter (or **`Time zone time source 2`**) if this source transmits its time by UTC (universal time) or if the settings correspond to the local time zone of the device.



NOTE

Make sure that the settings for the time sources coincide with the actual hardware configuration of your SIPROTEC 5 device. In any event, incorrect settings cause the status indications of time sources to pick up.

Configurable Date Format

Regardless of a feed time-synchronization source, a uniform format is maintained internally within the device. The following options are available for the customary local representation of the date format:

- Day.Month.Year: 24.12.2009
- Month/Day/Year: 12/24/2009
- Year-Month-Day: 2009-12-24

Taking Local Time Zones into Account

The internal device time is maintained in universal time (UTC). To display time stamps in DIGSI and on the device display, you can define the local time zone of the device (parameter Offset time zone for GMT), including the applicable daylight saving times (start, end, and offset of daylight saving time) using parameters. This allows the display of the local time.



NOTE

- For time sources that transmit the status of the switch to daylight saving time, this will be taken into account automatically when creating the internal device time in the UTC format. The differential time of the daylight saving time set in the device (parameter Offset daylight saving time) is taken into consideration. However, in contrast, the settings of the start of daylight saving time and end of the daylight saving times are ignored when converting into the device internal UTC format.
- For active time sources, it is not possible to set the time via the device display or DIGSI 5. An exception is setting the calendar year for active time protocol IRIG B.

Status, Supervision, and Indications of Time Management

Your SIPROTEC 5 device generates status and monitoring indications that provide important information regarding the correct configuration of the time source and the status of the internal time management during startup and device operation.

Internal time synchronization is monitored cyclically. Important synchronization processes, the status of the time sources and errors detected are reported. A device time that has become invalid will be marked accordingly so that affected functions can go to a safe state.

Indication	Description
Device: *Clock fail*	This indication signals a high difference between the internally managed time and the time of the clock module that is not permissible. The pickup of the indication can point to a defect in the clock module or to an unacceptable high drift of the system quartz crystal. The time maintained internally is marked as invalid.
Time management: *Daylight saving time*	This indication signals whether daylight saving time has been enabled.
Time management: *Clock set manually*	This indication signals that the device time has been set manually via the on-site operation panel or via DIGSI 5.
Time synchronization: *Status time source 1* *Status time source 2*	These 2 indications signal whether the active time sources are recognized as valid and active from the device point of view. When the indications pick up, it can also be an indication that an incorrect configuration of the port or channel numbers was done at the on-site operation panel.
Time synchronization: *Time sync. error*	This indication signals after the parameterized time **Fault indication after** that synchronization using an external time source has failed.
Time synchronization: *Leap second*	This indication signals that a Leap second has occurred during time synchronization using an external GPS receiver (protocol variant IRIG B 005(004) with extension according to IEEE C37.118-2005).
Time synchronization: *High accuracy*	This indication signals that the device is synchronized with an accuracy better than 1 µs The indication is only of significance when the PMU function is used.

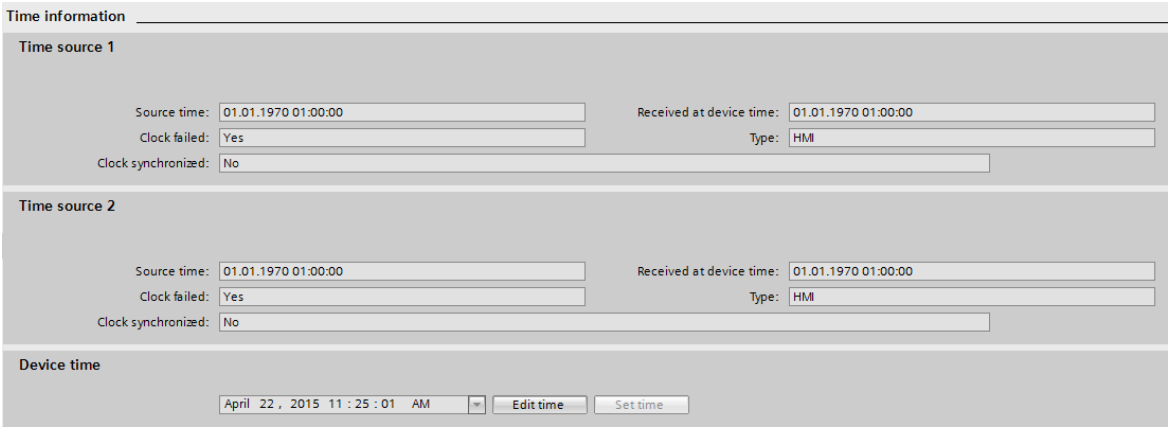


NOTE

In case of a missing or discharged battery, the device starts without active external time synchronization with the device time 2011-01-01 00:00:00 (UTC).

For the device, DIGSI 5 provides a compact overview of the status of the time synchronization of your SIPROTEC 5 device in online mode. All displays are updated continuously. You can access the overview in the project-tree window via Online access.

DIGSI: Online access -> Interface -> Device -> Device Information -> **Time Information**



[sc_time_dg, 1, en_US]

Figure 3-115 Time Information in DIGSI

For every time source, you see the following:

- Last received time (with date)
- Receipt time of the last received time telegram
- Configured type of timer
- Indication of timer outage or failure
- Whether the device time is currently synchronized from the time source

The lower section displays the device time, which is continuously updated. If the internal device time and the infeed time source were synchronous at the time of telegram receipt, both displayed times are identical.

NOTE

All times displayed (also the time source) take into consideration the local time settings (zone and daylight saving time of the device) in the form of a numerical offset for UTC (universal time).

3.7.4 Application and Setting Notes

Parameter: Date Format

- Default setting **`Date format`** = ***`YYYY-MM-DD`***

With the parameter **`Date format`**, you define the local customary format of the date display.

Parameter Value	Description
`DD.MM.YYYY`	Day.Month.Year: Typical European display Example: 24.12.2010
`MM/DD/YYYY`	Month/Day/Year: Typical US representation Example: 12/24/2010
`YYYY-MM-DD`	Year-Month-Day: Typical Chinese display Example: 2010-12-24

Parameter: Time zone time source 1, Time zone time source 2

- Default setting **`Time zone time source 1`** = ***`local`***, **`Time zone time source 2`** = ***`local`***

With the parameters **`Time zone time source 1`** and **`Time zone time source 2`**, you define the handling of time zones of the external timer.

Parameter Value	Description
local	Local time zone and daylight saving time are considered as time zone offsets to GMT.
UTC	Time format according to UTC (universal time)

Parameter: Time source 1, Time source 2

- Default setting **Time source 1** = ***none***, **Time source 2** = ***none***

With the parameters **Time source 1** and **Time source 2**, you can configure an external timer. The prerequisite is to have the corresponding hardware configuration of the communication interfaces of your SIPROTEC 5 device. This is listed as a prefix when making a selection in DIGSI 5.

Parameter Value	Description
none	The time source is not configured.
IRIG-B	Time synchronization by an external GPS receiver: SIPROTEC 5 devices support several protocol variants of the IRIG-B standard: • **IRIG-B 002(003)** The control function bits of the signal are not occupied. The missing year is formed from the current device time. In this case, it is possible to set the year via the online access in DIGSI 5. • **IRIG-B 006(007)** The bits for the calendar year are not equal to 00. The calendar year is set automatically by the time protocol. • **IRIG-B 005(004) with extension according to IEEE C37.118-2005** If, in the time signal, other control function bits are occupied in addition to the calendar year, then the device takes the additional information into consideration for leap seconds, daylight saving time, time offset (zone, daylight saving time), and time accuracy. **Time zone time source 1** or **Time zone time source 2**: The value of this setting is not evaluated by the device, since this protocol either transmits in UTC or in the case of local time, specifies the appropriate offset to UTC in each set time telegram.
DCF77	Time synchronization by an external DCF77 receiver **Time zone time source 1** or **Time zone time source 2** = ***local*** Note: There are also clocks that generate a DCF77 signal representing UTC. In this case, UTC must be set.
PI	The time synchronization takes place via the protection interfaces configured for your SIPROTEC 5 device. Here, the timing master takes over the time management. Signal-transit times of the protection interface communication are calculated automatically. **Time zone time source 1** or **Time zone time source 2** = ***UTC*** A slave that receives a time or a SIPROTEC 5 master, receives its system time kept in UTC.

Parameter Value	Description
SNTP	The time synchronization is done via the Ethernet service SNTP (SNTP server or via IEC 61850). SIPROTEC 5 devices support both Edition1 and Edition2 in accordance with IEC 61850-7-2. In Edition2, the logical attributes LeapSecondsKnown, ClockFailure, ClockNotSynchronized, and the value TimeAccuracy are maintained in each time stamp. For Edition1, these signals contain default settings. Thus, the interoperability for substation automation technology is ensured for both editions! The SNTP service must be enabled during configuration of Ethernet interfaces so that it is available as an option for the time synchronization. **Time zone time source 1** or **Time zone time source 2** = ***UTC***
IEC 60870-5-103	The time is synchronized via telegram with an appropriately configured communication interface in accordance with the IEC 60870-5-103 protocol. **Time zone time source 1** or **Time zone time source 2** = ***local*** However, there are also T103 systems that send the UTC.
DNP3	The time is synchronized via telegram with the appropriately configured communication interface in accordance with the DNP3 protocol. 2 characteristics are supported in the process: • **Time synchronization via UTC** • **Time synchronization with local time** The daylight saving time status is not transmitted. The device assumes that the DNP3 master follows the same rules for the start and end of the daylight saving time as those that were set for the device. **Time zone time source 1** or **Time zone time source 2** = ***UTC*** is the current implementation, ***local*** concerns older implementations.
IEEE 1588	Time is synchronized via an IEEE 1588 timing master. In this case, SIPROTEC 5 devices operate as slave-only clocks. IEEE 1588 v2 is supported with P2P and Ethernet Transport. The IEEE 1588 service must be enabled during configuration of Ethernet interfaces so that it is available as an option for the time synchronization. **Time zone time source 1** or **Time zone time source 2** = ***UTC***.

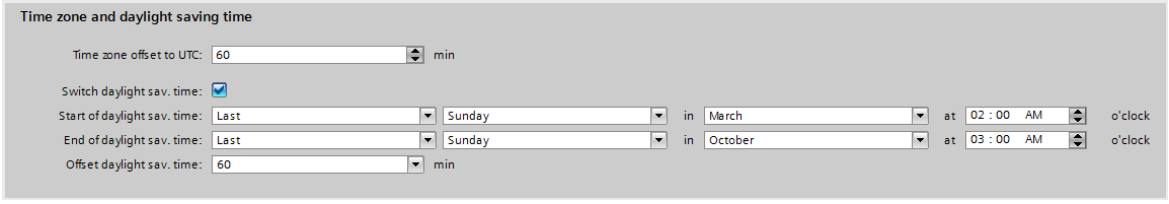
Parameter: Fault indication after

- Default setting **Fault indication after** = ***600 s***

With the parameter **Fault indication after**, you set the time delay after which the unsuccessful attempts of time synchronization with external time sources configured are indicated.

Parameter: Time Zone and Daylight Saving Time

This parameter block contains all the settings for the local time zone and daylight saving time of your SIPROTEC 5 device. In addition to the individual parameters, configure the basic settings by preselecting via the option buttons or check box.



[sc_time_zo, 1, en_US]

Figure 3-116 Settings for Time Zone and Daylight Saving Time in DIGSI

Selection Button	Description
Manual settings (local time zone and daylight saving time regulation)	This setting must be selected if you want to select the local time zone and daylight saving time zone regulations of your SIPROTEC 5 device regardless of the PC settings. Input: **Offset time zone for GMT** [min] Selection: **Switchover to daylight saving time** [yes/no] via check box  • Input: **Start of daylight saving time** [Day and time] • Input: **End of daylight saving time** [Day and time] • Input: **Offset daylight saving time** [min] • Default settings as in the picture above

3.7.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Time sync.				
_:102	Time sync.:Time source 1		• none • IRIG-B • DCF77 • PI • SNTP • IEC 60870-5-103 • PROFIBUS DP • Modbus • DNP3 • IEEE 1588 • IEC 60870-5-104	none
_:103	Time sync.:Time source 1 port		• port J • port F • port E • port P • port N • port G	
_:104	Time sync.:Time source 1 channel		• Ch1 • Ch2	

Addr.	Parameter	C	Setting Options	Default Setting
_:105	Time sync.:Time source 2		• none • IRIG-B • DCF77 • PI • SNTP • IEC 60870-5-103 • PROFIBUS DP • Modbus • DNP3 • IEEE 1588 • IEC 60870-5-104	none
_:106	Time sync.:Time source 2 port		• port J • port F • port E • port P • port N • port G	
_:107	Time sync.:Time source 2 channel		• Ch1 • Ch2	
_:108	Time sync.:Time zone time source 1		• UTC • local	local
_:109	Time sync.:Time zone time source 2		• UTC • local	local
_:101	Time sync.:Fault indication after		0 s to 3600 s	600 s

3.7.6 Information List

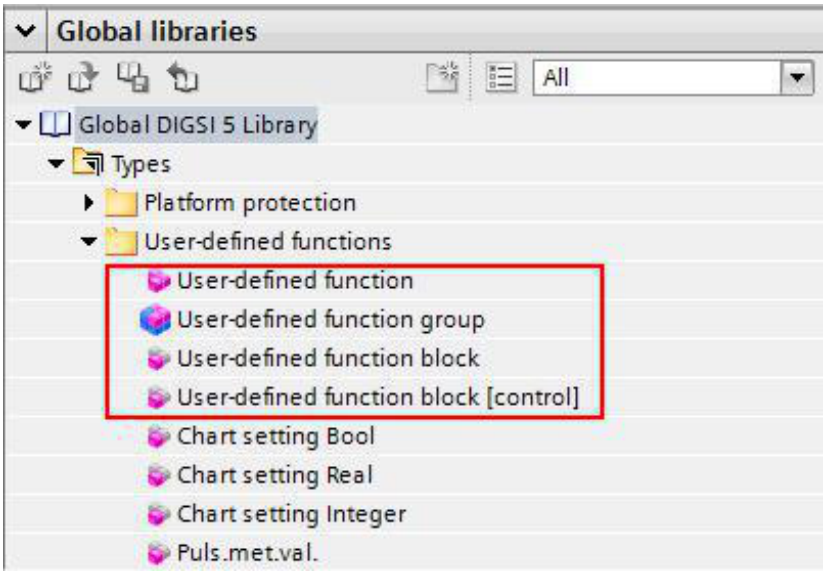
No.	Information	Data Class (Type)	Type
Time managem.			
_:300	Time managem.:Daylight saving time	SPS	O
_:301	Time managem.:Clock set manually	SPS	O

No.	Information	Data Class (Type)	Type
Time sync.			
_:303	Time sync.:Status time source 1	SPS	O
_:304	Time sync.:Status time source 2	SPS	O
_:305	Time sync.:Time sync. error	SPS	O
_:306	Time sync.:Leap second	SPS	O
_:307	Time sync.:High accuracy	SPS	O

3.8 User-Defined Objects

3.8.1 Overview

With help from user-defined function groups and user-defined functions you can group user-defined objects, for example user-defined function blocks. 2 user-defined function blocks are available (see following figure).



[sc_udef_lib, 1, en_US]

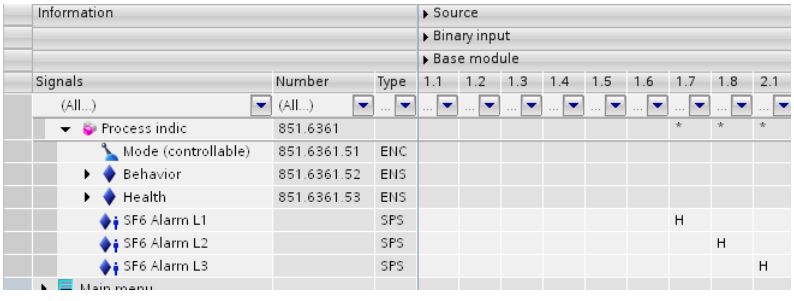
Figure 3-117 User-Defined Objects in the DIGSI 5 Library

The **user-defined function block** allows you to add (see following figure) single-point indications, pickup indications, operate indications (ADC, ACT), single and double commands, commands with a controllable whole number as well as measured values. You can assign the group a superordinate name (for example **process indications** for a group of single-point indications which are read via binary inputs). This function can be deactivated using the mode. The standby mode is also analyzed or displayed.

The user-defined function blocks can be instantiated at the highest level (alongside other function groups) as well as within function groups and functions.

In addition, there is a **user-defined function block [control]**. Alongside the aforementioned possibilities presented by **user-defined function blocks**, this block offers additional tests for user-defined control signals, for example SPC or DPC.

These are described in chapter *7.6.1 Overview of Functions*.



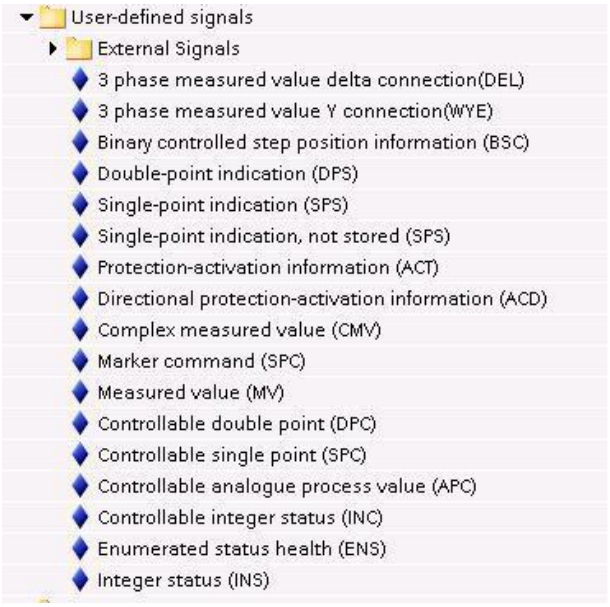
[sc_user, 1, en_US]

Figure 3-118 Information Routing with Incorporated User-Defined Function Block: Process Indications and some Single-Point Indications

3.8.2 Basic Data Types

The following data types are available for user-defined objects in the DIGSI 5 library under the heading **User-defined signals**. Additionally, a folder for external signals is available (see chapter *3.8.5 External Signals*).

User-Defined Signals



[sc_LB_userdefsig, 1, en_US]

Figure 3-119 User-Defined Signals

Single-Point Indication (Type SPS: Single-Point Status)

The status of a binary input can be registered in the form of a single-point indication or forwarded as the binary result from a CFC chart.

EXAMPLE

Acquisition using binary input, further processing in a CFC and/or signaling using an LED.

Single-Point Indication (Type SPS unsaved: Single-Point Status Unsaved)

In contrast to **SPS** single-point indications, the state of the **SPS unsaved** indication is not maintained after the device restarts.

For this purpose, go to **Properties > Details > Initialization > Restart** and set the ***Value***.

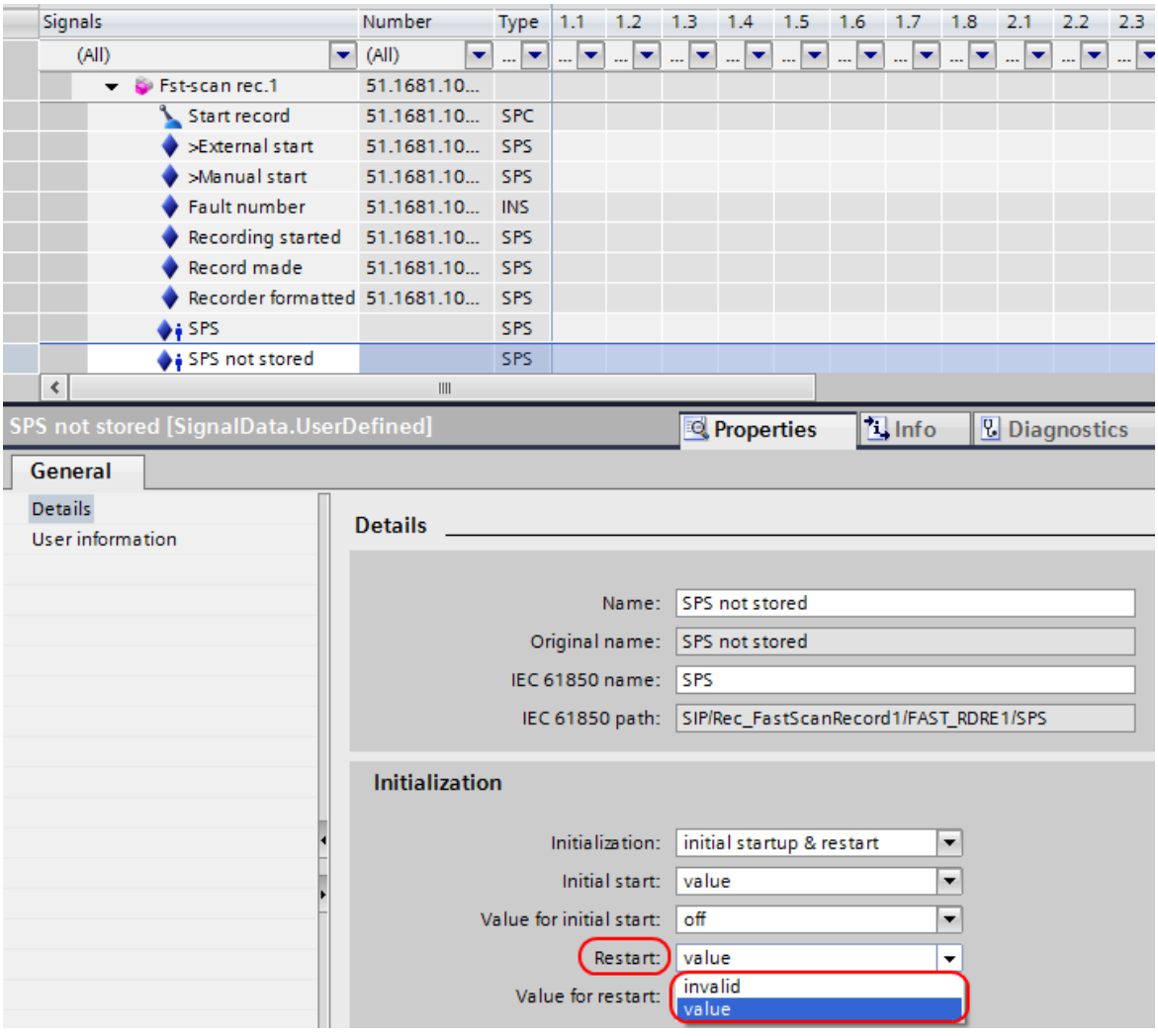


Figure 3-120 Single-Point Indication SPS Unsaved (Example: 7KE85 Fault Recorder)

Double-Point Indication (Type DPS: Double-Point Status)

When using a double-point indication, the status of 2 binary inputs can be captured simultaneously and mapped in an indication with 4 possible conditions (***ON***, ***Intermediate position***, ***OFF***, ***Disturbed position***).

EXAMPLE

Acquisition of a disconnector or circuit-breaker switch position.

Marker Command (Type SPC, Single-Point Controllable)

This data type can be used as a command without feedback for simple signaling or as an internal variable (marker).

Integer Status Value (Type INS)

The data type **INS** is used to create a whole number that represents a CFC result.

EXAMPLE

The output of the CFC block **ADD_D** can, for example, be connected with the data type **INS**. The result can be shown on the display of the device.

State of an Enumeration Value (Type ENS)

The data type **ENS** is used to create an enumerated value that represents a CFC result.

Controllable Single-Point Indication (SPC, Single-Point Controllable)

This can be used to issue a command (to one or several relays, selectable under information routing) that is monitored via a single feedback.

Command with Double-Point Feedback (DPC, Double-Point Controllable)

This can be used to issue a command (to one or several relays, selectable under information routing) that is monitored via double-point indication as feedback.

Command with a Whole Number (INC, Controllable Integer Status)

This can be used to issue a command (to one or more relays, selectable under information routing) that is monitored via a whole number as feedback.

Complex Measured Values (CMV)

This data type provides a complex measured value that can be used as a CFC result, for example.

Measured Values (MV)

This data type provides a measured value that can be used as a CFC result, for example.



NOTE

Additional data types can be found under other headings in the DIGSI 5 library as well as in the corresponding function blocks. This applies to the following data types:

- Pulse-metered values (see **User-defined functions** in the DIGSI 5 library)
- Transformer taps
- Metered values

Phase-to-Ground Measured Values (WYE)

This data type represents the phase-to-ground measured values of a 3-phase system.

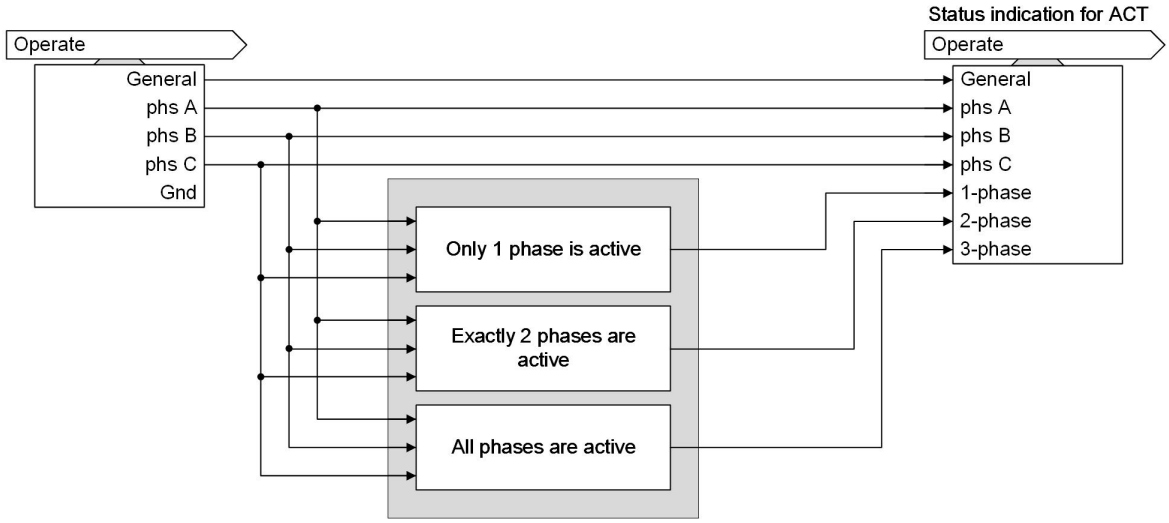
Phase-to-Phase Measured Values (DEL, Delta)

This data type represents the phase-to-phase measured values of a 3-phase system.

Protection Activation Information (ACT)

This object type is used by the protection functions for **Tripping**. It is available in the library for receiving protection information via the protection interface, which could also indicate **Tripping**.

The status indications for the **ACT** data type are built as follows:



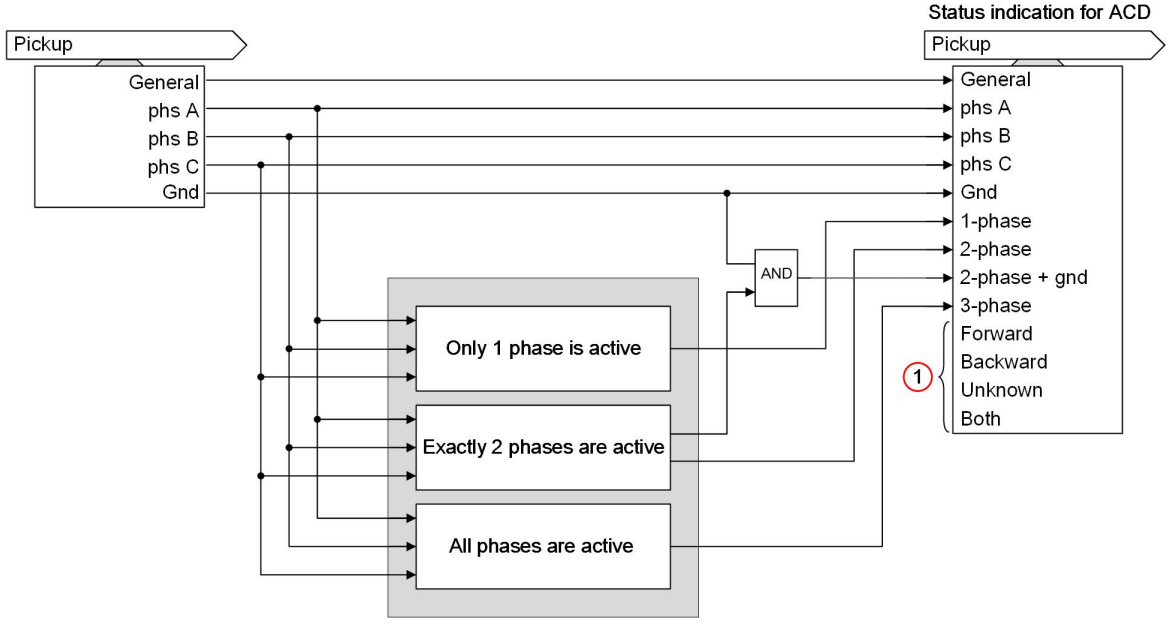
[lo_ACT-information, 1, en_US]

Figure 3-121 Building of the Status Indications ACT

Protection Activation Information with Direction (ACD)

This object type is used by the protection functions for **Pickup**. It is available in the library for receiving protection information via the protection interface, which could also indicate **Pickup**. In addition, both ACD and ACT, can be generated and processed by CFC charts.

The status indications for the **ACD** data type are built as follows:



[lo_ACD-information, 1, en_US]

Figure 3-122 Building of the Status Indications ACD

(1) Further information, see *Table 3-21*

Table 3-21 Building of the Direction Information for the Data Type **ACD**

Direction Information	Description
forward	All picked up phases have picked up in forward direction.
backward	All picked up phases have picked up in backward direction.
unknown	The direction could not be determined for the pickup.
both	At least 1 phase has picked up in forward direction and at least 1 phase has picked up in backward direction.

3.8.3 Pulse-Metered and Energy-Metered Values

Pulse-Metered Values

Pulse-metered values are available as data type **BCR** (Binary Counter Reading) in the function group **transformer** as well as the function group**Circuit breaker**. There you will find **Pulse-metered values** under **Measured values**/**User-defined values**/**Pulse-metered value**.

The functionality and the settings of the pulse-metered values can be found in chapter *9.9.1 Function Description of Pulse-Metered Values*.

Energy Metered Values

Energy metered values no longer need to be created by the user separately. They are available as active and reactive power in each **transformer** function group for reference and output direction. The calculation is based on the current and voltage transformers associated with the transformer.

Detailed information can be found in the **transformer** function group in chapter *9.8.1 Function Description of Energy Values*

3.8.4 Additional Data Types

The following data types are also used in the system but are not available for general use as user-defined signals in the library:

- **ENC** (Enumerated Setting Controllable)
  The data type **ENC** models a command with which the user can set predefined values.
- **SEQ** (Sequence)
- **BSC** (Binary Controlled Step Position)
  The data type **BSC** can, for example, be used to control a transformer tap changer. The commands **up**, **down** can be given.



NOTE

Transformer taps are included in the **Transformer tap changer** switching element. If this switching element is created in the device, the transformer tap position is available as a data object of type **BSC** (binary controlled step position information).

3.8.5 External Signals

User-defined signals of different types (see *Figure 3-123*) are available for GOOSE Later Binding. After instantiation in a logical node, an external reference is generated during IID export and provided to a IEC 61850 system tool (for example, System Configurator) for GOOSE Later Binding (according to the Later-Binding procedure specified in IEC 61850-6).

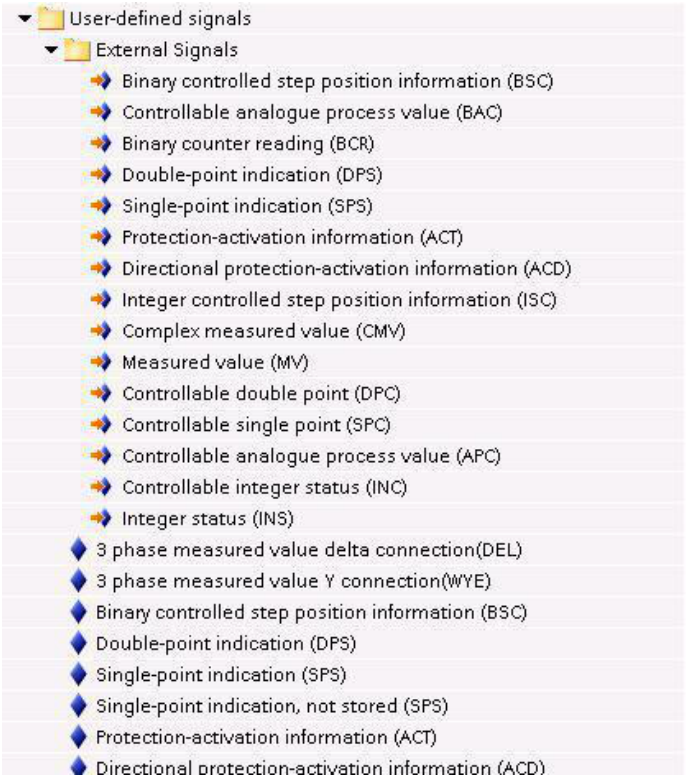


Figure 3-123 External Signals

NOTE

Consider the chapter on GOOSE Later Binding in the DIGSI Online Help. User-defined signals exist as external signals and as preconfigured inputs that have been activated via the GOOSE column.

3.9 Other Functions

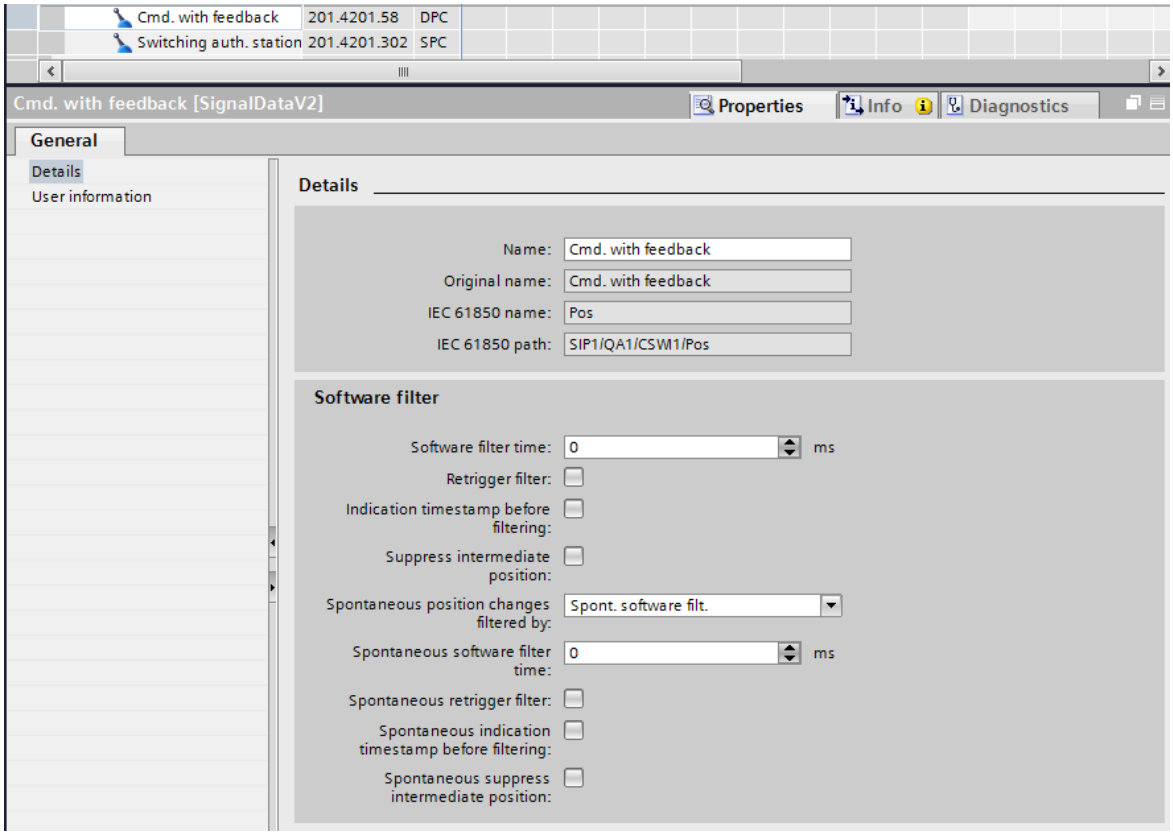
3.9.1 Signal Filtering and Chatter Blocking for Input Signals

Input signals can be filtered to suppress brief changes at the binary input. Chatter blocking can be used to prevent continuously changing indications from clogging the event list. After an adjustable number of changes, the indication is blocked for a certain period.

The settings for indication filtering can be found at the individual signals. The next figure shows the settings using the example of a controllable (circuit-breaker switch position).

NOTE

The software filtering time is available only for the circuit breaker and disconnector in the controllable **Cmd. with feedback** (**control** function block), as this is used for logging purposes. The controllable **position** (**circuit breaker** or **disconnector** function block) is used for interlocking conditions and must always show the unfiltered position of the switching object.



[sc_lposi, 1, en_US]

Figure 3-124 Settings for Circuit-Breaker Switch Position

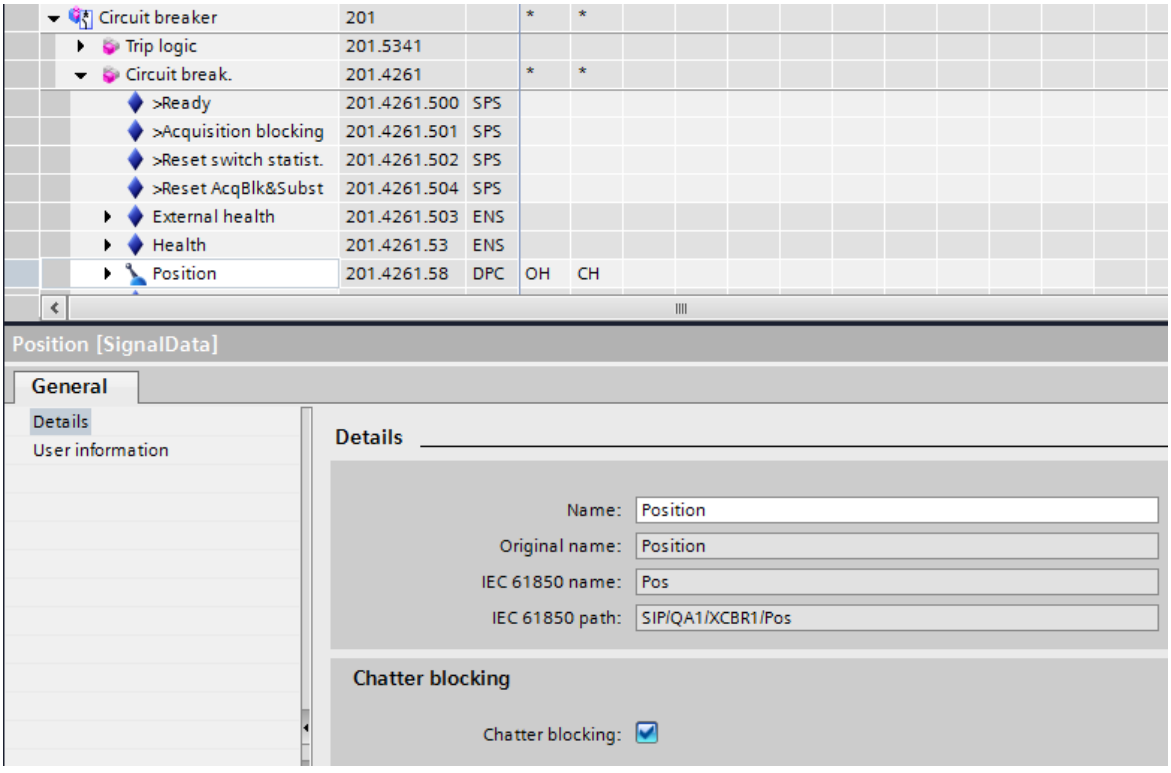
The setting range for the **Software filter time** parameter ranges from 0 ms to 100 000 ms in ms increments. The **Retrigger filter** check box can be used to select whether to restart the filtering time whenever a status change is performed within the software filtering time. When activated, the **Indication timestamp before filtering** check box backdates the time stamp by the set software filtering time. In this case, the time stamp corresponds to the actual status change of the signal. If you activate the **Suppress intermediate position** check box, the intermediate position is suppressed for the duration of this software filtering time.

If you leave the software filtering time at 0 ms, the time for the suppression of the intermediate position is also 0 ms. The activated **Suppress intermediate position** check box then remains ineffective.

If you do not activate the **Suppress intermediate position** check box, the software filtering time affects the **on**, **off**, **intermediate**, and **disturbed** positions of the circuit breaker or disconnector switch.

With the parameter **Spontaneous position changes filtered by:**, you set how such position changes are to be filtered. Spontaneous position changes are caused by external switching commands, for example. If you select the ***General software filter*** setting, the general settings for software filtering of spontaneous position changes and for position changes caused by a switching command apply. The settings for spontaneous position changes then cannot be edited. A separate filtering for spontaneous position changes is activated with the ***Spontaneous software filter*** setting and you can edit the settings for this.

Chatter blocking can be activated or deactivated as an input parameter, for example as a parameter of the position in the **Circuit breaker** or **Disconnector** function block.



[sc_flatte, 1, en_US]

Figure 3-125 Setting Chatter Blocking

The settings for the chatter blocking function are set centrally for the entire device in DIGSI. They are accessible as settings in the **General** function group (see the following figure).

The chatter-blocking settings have the following meaning (see also *Figure 3-126* and *Figure 3-127* in the examples shown in the following):

- **No. permis.state changes**

  This number specifies how often the state of a signal may toggle within the chatter-test time and the chatter-checking time. If this number is exceeded, the signal will be or remains blocked.

  Enter a number from 0 to 65535 in this field. If the entry is 0, chatter blocking is essentially inactive.

- **Initial test time**

  During this time, the number of times a signal changes its status is checked. This time is started if chatter blocking is configured for at least one signal and this signal changes its status. If the configured number of permissible status changes is exceeded during the initial test time, the signal is temporarily blocked and the indication *Chatter blocking* is set.

  Enter a number from 1 to 65535 in this field. The number entered corresponds to the time in seconds. When the set time has expired, the timer restarts automatically (cycle time).

- **No. of chatter tests**

  This number specifies the maximum number of test cycles to be run. If the number of permissible status changes of the signal stays exceeded during the initial test time of the last test cycle, the signal is finally blocked. In this case, the indication *Group warning* (**Alarm handling** group and **Device** group) is set additionally to the *Chatter blocking* indication after expiry of the set number. Restarting the devices removes this block again.

  Enter a number from 0 to 32767 in this field. The value Infinite (∞) is also permissible here.

  Enter this value as character string oo.

- **Chatter idle time**

  If the number of permissible status changes for a signal is exceeded during the initial test time or the subsequent test time, the **Chatter idle time** starts. Within this time, this signal is blocked temporarily and the *Chatter blocking* indication is set. The blocked input signal is assigned the **oscillatory** quality.

  Enter a number from 1 to 65535 in this field. The number entered corresponds to the time in minutes. An entry here is only considered if the number of chatter tests does not equal to 0.

- **Subsequent test time**

  During this second test time, the number of times a signal changes its status is checked once again. The time begins when the **Chatter idle time** expires. If the number of status changes is within the permissible limits, the signal is released. Otherwise, an additional dead time begins, unless the maximum number of chatter tests has been reached.

  Enter a number from 2 to 65535 in this field. The number entered corresponds to the time in seconds. An entry here is only considered if the number of chatter tests does not equal 0.

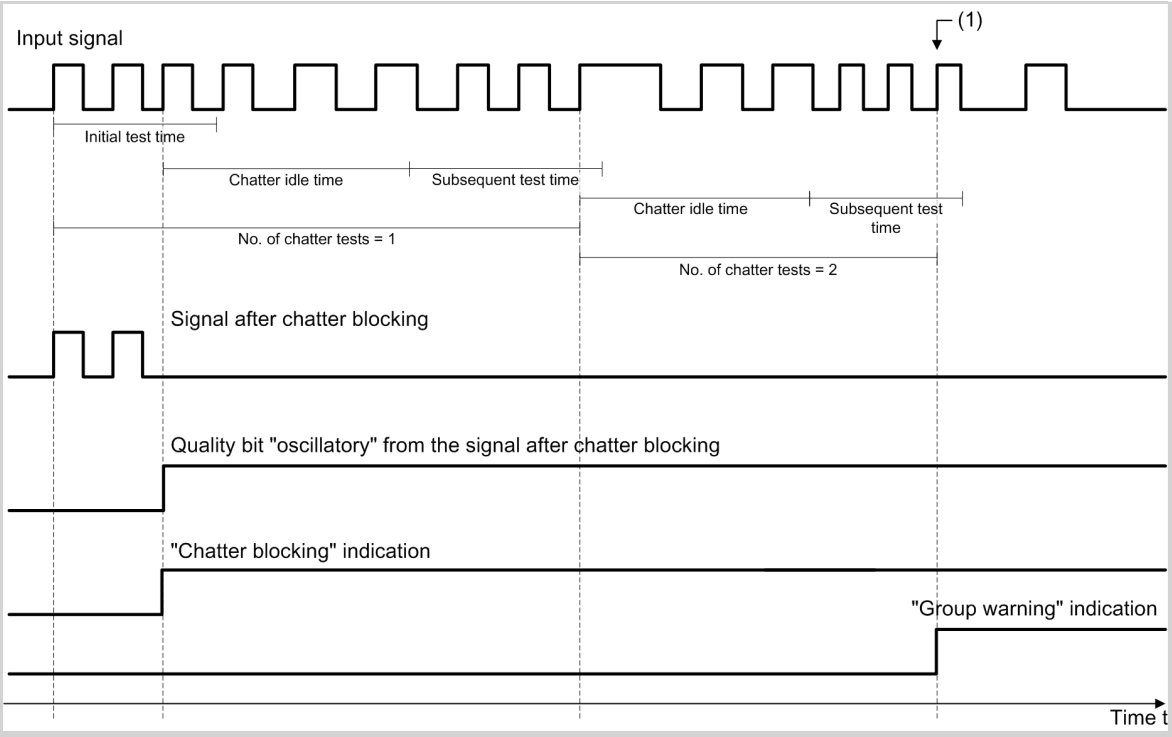
Example 1: Permanent Blocking

The chatter-blocking settings are set as follows:

- **No. permis.state changes** = 4
- **No. of chatter tests** = 2

After more than 4 state changes within the **Initial test time**, the input signal is set to the original state by the chatter blocking and the **oscillatory** quality is assigned. Additionally, a corresponding indication is added to the operational log. At the same time, the *Chatter blocking* indication is set. After expiry of the settable **Chatter idle time**, during the following **Subsequent test time**, it is checked whether the input signal is still chattering. This check is repeated, as the **No. of chatter tests** is set to 2 in this example.

If, during the 2nd **Subsequent test time**, it has been detected that the number of status changes of the input signal exceeds the set **No. permis.state changes**, the chatter blocking detects a persistent violation of the signal stability and sets the *Group warning* indication. The original state of the signal is permanently frozen. Only a device restart removes the chatter blocking again.



[dw_chatter-block-01, 1, en_US]

Figure 3-126 Signal Change during Chatter Blocking with too Important Number of Signal State Changes During 2nd Subsequent Test Time

(1) The input signal is permanently blocked starting from this point in time.

Example 2: Temporary Blocking

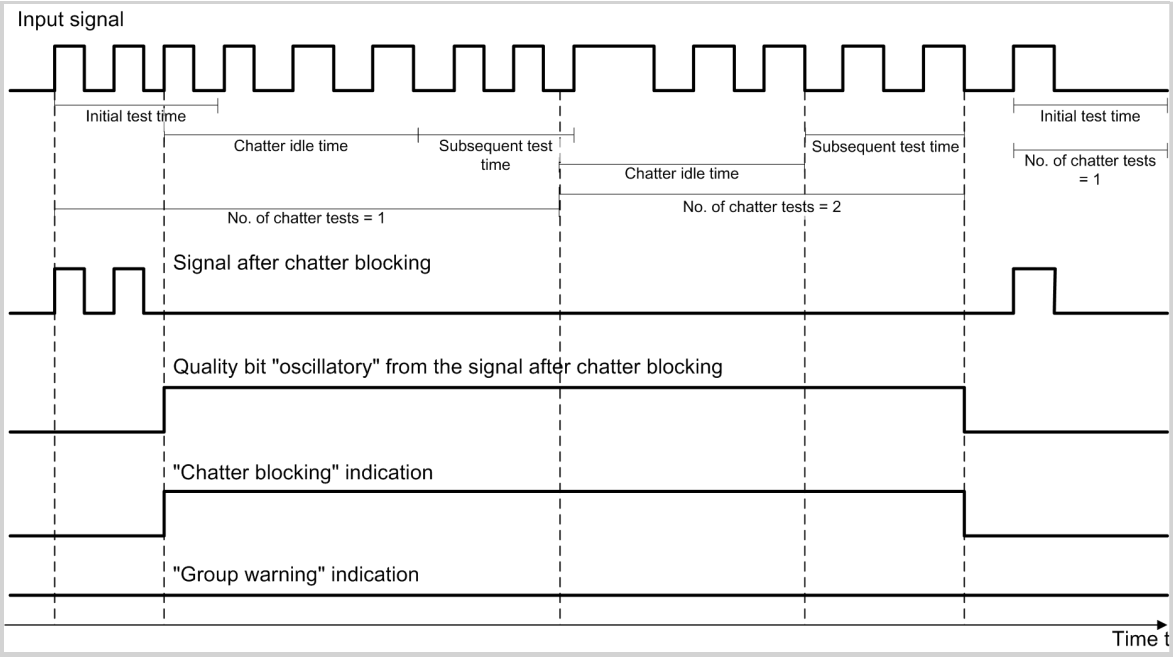
The chatter-blocking settings are set as follows:

- **No. permis.state changes** = 4
- **No. of chatter tests** = 2

After more than 4 state changes within the **Initial test time**, the input signal is set to the original state by the chatter blocking and the **oscillatory** quality is assigned. Additionally, a corresponding indication is added to the operational log. At the same time, the *Chatter blocking* indication is set. After expiry of the settable **Chatter idle time**, during the following **Subsequent test time**, it is checked whether the input signal is still chattering. This check is repeated, as the **No. of chatter tests** is set to 2 in this example.

If, during the 2nd **Subsequent test time**, it has been detected that the number of state changes of the input signal is within the set **No. permis.state changes**, the temporary blocking of state changes of the signal is removed and the actual signal state is released.

The quality bit **oscillatory** is removed and the *Chatter blocking* indication is reset. As the temporary blocking of the signal is removed, the *Group warning* indication is not set. The chatter test starts again.



[dw_chatter-block-02, 1, en_US]

Figure 3-127 Signal Change during Chatter Blocking with Permissible Number of Signal State Changes During 2nd Subsequent Test Time

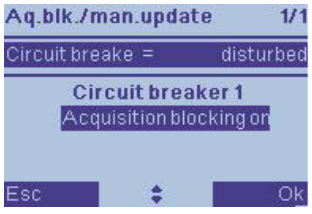
3.9.2 Acquisition Blocking and Manual Updating

During commissioning, maintenance, or testing, a brief interruption of the connection between the logical signals and binary inputs may be useful. It allows you to manually update the status of a switching device that is not providing feedback correctly. Before this can take place, you must first set acquisition blocking.

To set the acquisition blocking, proceed as follows:

- Using the navigation keys, move in the **main menu** of the device display to **Commands→Equipment→Aq.blkman. update**.
- Select the appropriate device (for example, a circuit breaker) from among the several switching devices using the navigation keys.
- Press the **Change** softkey.
- Enter the confirmation ID (not relevant for active role-based access control (RBAC) in the device).
- Confirm the process with the softkey marked **OK** in the display.

After entering the confirmation ID (only with the RBAC inactive), acquisition blocking is switched on.

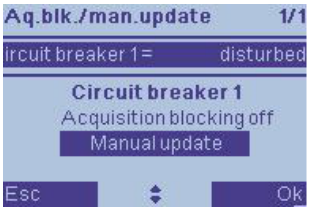


[sc_detection, 1, en_US]

Figure 3-128 Activating the Acquisition Blocking

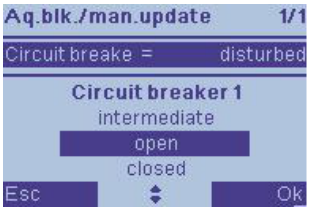
Manual updating of the switching device is possible from within the same menu.

- Select **Manual update** (*Figure 3-129*) using the navigation keys.
- Select the switching device setting to be manually updated using the navigation keys (for example, **off**, *Figure 3-130*).
- Confirm the process with the softkey marked **Ok** in the display.



[sc_status, 1, en_US]

Figure 3-129 Activating Manual Update



[sc_statu2, 1, en_US]

Figure 3-130 Selecting Position

The manually updated position of the switching device will be displayed.



[sc_statu3, 1, en_US]

Figure 3-131 Position of the Switching Device

NOTE

For security reasons, manual updating is possible only directly through the on-site operation panel of the device and not through DIGSI 5.

NOTE

Setting acquisition blocking and the subsequent manual updating are also possible via the IEC 61850 system interface.

You can set acquisition blocking also via a binary input. If you want to put in the feeder or the switching device in revision, you can set the acquisition blocking with an external toggle switch for one or more switching devices. For this purpose, every switching device in the **Switch** function block (circuit breaker or disconnector switch) has the input signal **`>Acquisition blocking`**. This signal can also be set from the CFC.

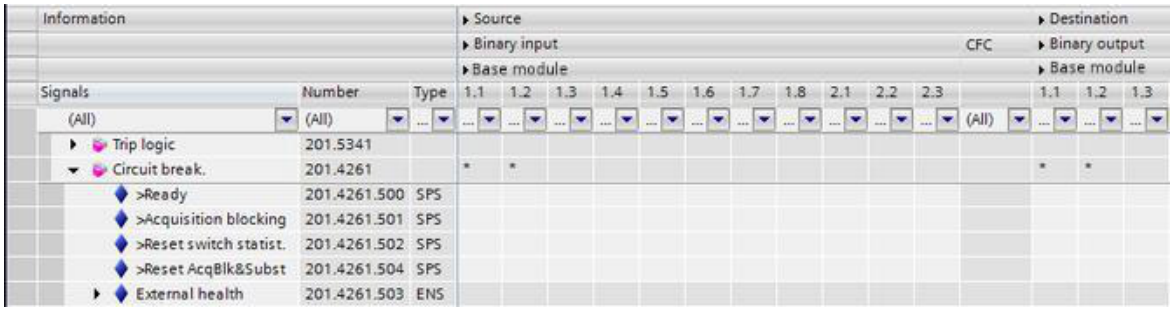


Figure 3-132 Input Signals *>Acquisition Block* and *>Release Acquisition Block & Manual Updating* on the Switching Device

NOTE

Interlockings are carried out with the status changes of the switching device. Remove acquisition blocking again manually. Otherwise, position changes of the switching device are not detected and interlockings are ineffective.

If the acquisition blocking and the manually updated position are set using the operation panel of the device or the system interface IEC 61850, these are retained until the acquisition blocking is manually deactivated. When you initially start the device, the acquisition blocking is deactivated.

Except for a restart, the acquisition blocking and the manually updated position are retained.

If the acquisition blocking is activated via the input signal **>Acquisition blocking**, it is retained as long as the binary input is active.

To set the acquisition blocking of a switching device, the following sources are possible:

- Operation panel of the device
- System interface IEC 61850
- Input signal **>Acquisition blocking**

All sources undergo OR operations, that is, the acquisition blocking remains set until all the sources are deactivated.

After deactivation of the acquisition blocking, the actual position of the switching device is adopted and displayed in the operation panel of the device.

NOTE

When the acquisition blocking is activated or the switching device updated manually while the entire device or the switching device is in application mode, these states are not saved. The acquisition blocking and the manual updating are not retained after a restart.

The acquisition blocking and the manual update for the circuit breaker, the disconnector, and the tap changer are reset by way of the **>Reset AcqBlk&Subst** binary input. Setting acquisition blocking and manual update is blocked with the input activated.

3.9.3 Persistent Commands

In addition to the switching commands, which are issued as pulse commands, and stored for the standard switching devices (circuit breaker, disconnector switch), persistent commands are also possible. In this case, a distinction must be drawn between controllables with the **Continuous output** operating mode and a stored signal output that is immune to reset.

You can change a controllable from pulse to persistent command with the **Command output** parameter.

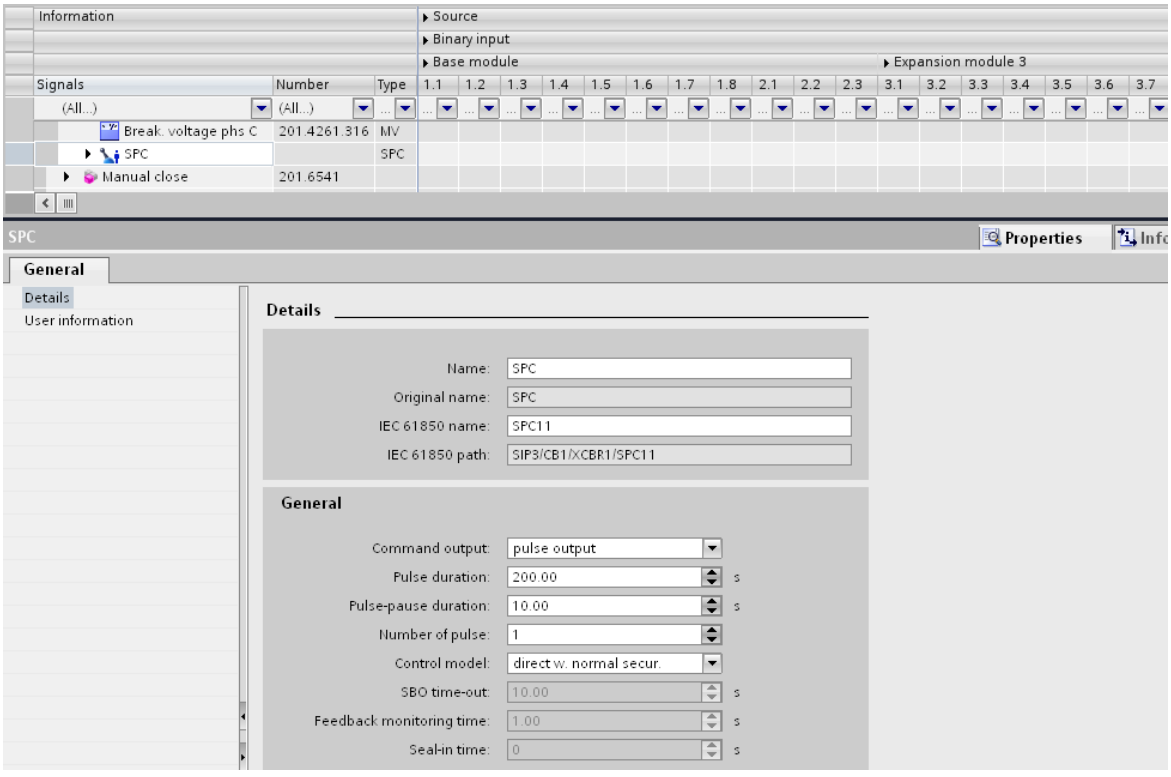


Figure 3-133 Setting the Command Type in DIGSI 5

Select ***Pulse output*** or ***Continuous output*** for the command output type. If a persistent command is selected, the Pulse parameter is irrelevant.

3.9.4 Device Logout

3.9.4.1 Overview

In the case of multibay functions, a device uses information from one or more other devices. For some applications, it may be necessary for you to remove a device with all effective functions temporarily from the plant and even to switch it off. These applications are, for example:

- Maintenance work
- System upgrades
- Testing the local protection functions, for example, the local line differential protection

The *Device logout* functionality informs the receiver devices about the imminent disconnection of the transmitter devices. To do this, the last valid received information is stored in the receiver devices and used for the multibay functions.

NOTE

If you need to remove a device temporarily from the plant, you must log off the device.

Protection functions distributed to several devices operate in a healthy manner with the remaining devices only if you have logged off the device.

You can log off the device as follows:

- Via the on-site operation panel
- Via a communication interface using the *Device logout* (*_:319*) controllable
- Via the binary inputs, general: *>Dev. funct.logout on* (*_:507*) or *>Dev. funct.logout off* (*_:508*)

You can find the controllable and the binary inputs in the DIGSI 5 project tree under **Name of the device** → **Information routing** in the working area in the **General** block.

During the log-off process, the device checks whether all conditions for a logout have been met. If the conditions for the log off have not been met, the logout is rejected.

The logout is rejected under the following conditions:

- The devices are communicating via the protection interface and switching off the device leads to an interruption in protection-interface communication.
- The **Line differential protection** function is operating in the device and the local circuit breaker is still switched on.

  In this case, you must switch off the local circuit breaker and repeat the log-off process for the device. After the logout, the local **Line differential protection** function is removed from the summation of the currents for the **Line differential protection** of the other devices. The **Line differential protection** function remains active in the other devices.



NOTE

The path used to log the device off is stored in the operational log.

Even if you switch off the device after logout, the *Device logged off* (_:315) state is stored.

If you want to establish the initial state again after logging off the device, you must log on the device again. To log on the device, you must use the same option used for logout. For example, if you have logged off the device via binary inputs, you must log it on again via the binary inputs. This applies in similar manner if you have logged off the device via DIGSI or via on-site operation.

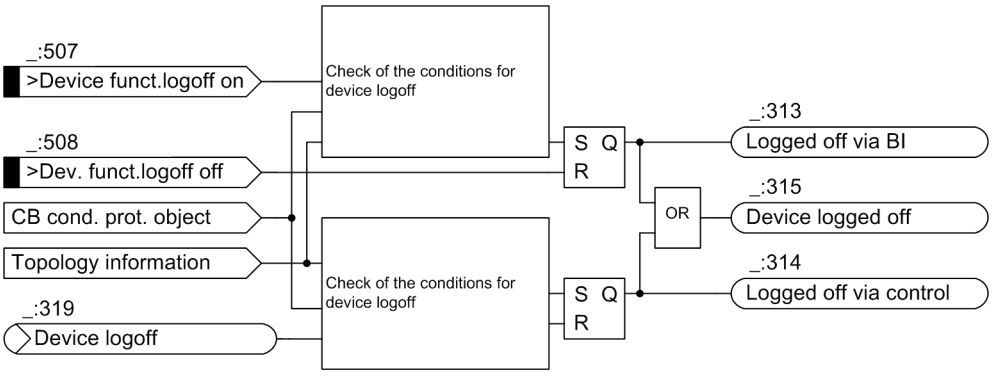
3.9.4.2 Application and Setting Notes

Logoff Options for a Device

You can log a device off as follows:

- Via the on-site operation panel
- Via communication through the controllable *Device logout* (*_:319*)
- Via the binary inputs, general: *>Dev. funct.logout on* (*_:507*) or *>Dev. funct.logout off* (*_:508*)

Conditions for Logging off the Device



[lo_functional logoff device, 1, en_US]

Figure 3-134 Logic for Logging off the Device

The conditions for a successful logout of the device result from the conditions for every activated protection function.

Logoff of a Device from a Device Combination with Communication via the IEC 61850-8-1 (GOOSE) Protocol

If devices are exchanging data using the IEC 61850-8-1 (GOOSE) protocol – for example in the case of substation interlocking – for each received data point the value of this data point can be set in the receiver device when the transmitter device logs off. This value remains effective in the receiver device until the logout is canceled by the transmitter device, even if the transmitter and/or the receiver are switched off in the meantime.

Logoff of a Device from a Device Combination Using Protection Communication

If devices in a device combination communicate via the protection interface, you can only log off a device under the following conditions:

- Logging off and switching off a device in a device combination must not result in an interruption in the protection communication.
- For series-connected topologies, the device must be located at one end of the communication chain as otherwise the protection communication is interrupted when the device is logged off and switched off.

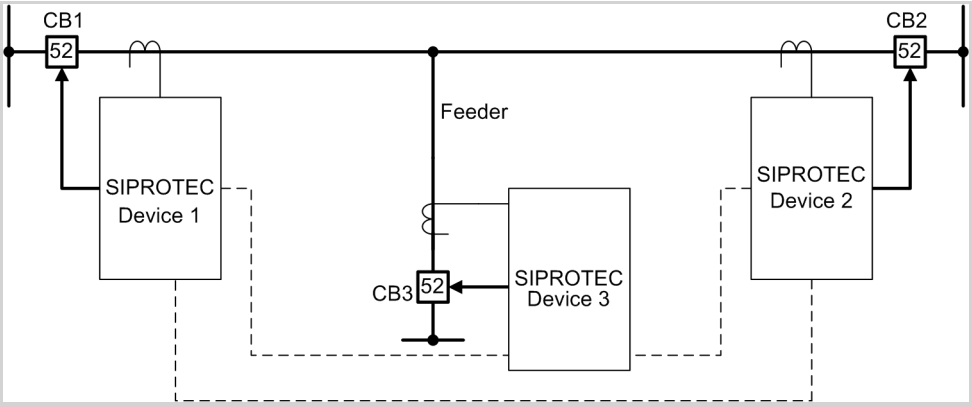
  For this reason, devices not at one of the ends in series-connected topologies cannot be logged off.

Logging Off a Device from a Protection Application with Line Differential Protection

If you are using the **Line differential protection** function, you must ensure that the functionality is still effective even after a device in a device combination is logged off and switched off. The following example describes the procedure:

EXAMPLE:

The following line formation is protected by the **Line differential protection** with 3 devices.



[dw_example logoff ldiff, 2, en_US]

Figure 3-135 Differential Protection with 3 Devices for a Line with a Feeder

In the example, the feeder is to be decommissioned for maintenance or modification work. Device 3 should therefore also be switched off. Without additional measures, the **Line differential protection** will no longer function and sends an ineffective indication.

For this use case, the **Line differential protection** function must be logged off in Device 3.

NOTE

Before logging off, you must de-energize the feeder protected by the local **Line differential protection**.

Line differential protection in device 3 can only be logged off if no current is flowing through the feeder. Device 3 checks during the log-off process whether the circuit breaker 3 is really switched off.

The **Circuit-breaker position recognition** in the function group **Circuit breaker** (CB) provides the circuit-breaker position using the internal signal *CB state protected obj.*.

If a protected object is supplied via 2 circuit breakers (CBs), for example with the 1 1/2 circuit-breaker layout, then the circuit-breaker position of the protected object must be determined with the aid of both circuit breakers. In this case, the Circuit-breaker position function block performs linking of the individual CB positions for the protected object.

If one of the following 2 conditions is met, the *CB status protected object* internal signal assumes the position *Open*:

- All connected circuit breakers signal internally the position *Open*.
- The binary input signal *>Disconnector open* is active.

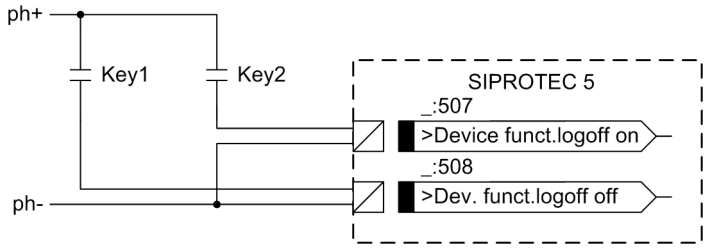
For further information refer to *5.5.4.6 Circuit-Breaker Condition for the Protected Object*.

If the **Line differential protection** is logged off in device 3, the remaining devices 1 and 2 will save this state and the total current for the Kirchoff's current law will then be calculated with the currents in devices 1 and 2 only.

If device 3 is successfully logged off, you can switch it off. The logoff of device 3 will also be saved in the remaining devices after it is switched off. If you switch device 3 on again, you must log it on again in the device combination.

Logout via Binary Inputs

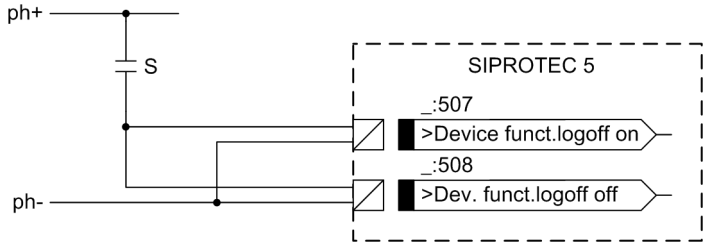
The following diagrams show potential variants on how to control binary inputs. If you want to use push-buttons, switch on this function as shown in the following figure. Log off the device using the push-button **Key2**; log on the device again with the push-button **Key1**.



[lo_extta logoff device, 1, en_US]

Figure 3-136 External Push-Button Wiring for Logging off the Device

If a switch is being used for control, route the binary input *>Dev. funct.logout on* as ***H (active with voltage)*** and the binary input *>Dev. funct.logout off* as ***L (active without voltage)***. If the switch **S** is closed, the device is logged off.



[lo_extsx logoff device, 1, en_US]

Figure 3-137 External Switch Wiring for Logging off the Device

Indications

The logged-off device reports the status (*(_:315) Device logged off*) and cause of the logout.
If you have logged off the device using binary inputs, the indication *(_:313) Logged off via BI* results.
If you have logged off the device using on-site operation, via DIGSI 5 or via the protection interface,the indication *(_:314) Logged off via control* is issued.
The indications are stored in the operational log.

3.9.4.3 Information List

No.	Information	Data Class (Type)	Type
General			
_:507	General:>Dev. funct.logout on	SPS	I
_:508	General:>Dev. funct.logout off	SPS	I
_:319	General:Device logout	SPC	C
_:313	General:Logged off via BI	SPS	O
_:314	General:Logged off via control	SPS	O
_:315	General:Device logged off	SPS	O

3.10 General Notes for Setting the Threshold Value of Protection Functions

3.10.1 Overview

You can set the threshold values of protection functions directly on the device or by using DIGSI 5.

An innovative design was implemented for the protection settings.

You can switchover the edit mode between the following setting views:

- Primary
- Secondary
- Percent

If you change settings in a setting view, DIGSI 5 calculates the settings of the 2 inactive views in the background. If you wish to save, for example, conversion to secondary values, then select the primary view. Configure all the settings and switchover to the secondary view.

Edit Mode: Primary

The parameters are set as primary values and thus refer directly to the primary system. The manual conversion on the secondary circuit omitted.

Edit Mode: Secondary

The settings refer to the secondary circuit of the transformer. This means that the settings must be converted. The secondary setting is the customary setting view. For secondary tests, the pickup values can be read directly.

Edit Mode: Percent

This setting type is beneficial for electric machines (generators, transformers, motors, and busbars). The setting values can be standardized regardless of the machine size. The reference values for the percentage settings are the rated values of the function groups, for example, rated voltage and rated current or rated apparent power. The setting values are, thus, related exclusively to the primary settings. If other reference values are used, then this is documented for the respective protection function in the application and setting notes.

If parameters are selected it may happen that they are set only in percent in all 3 setting views.

Recommendation for Setting Sequence

When setting the protection function, Siemens recommends the following procedure:

- First, set the transformation ratios of the transformers. You can find these under **Power-system data**.
- Subsequently, set the reference parameters for the percent setting. You will find these parameters in function group , for example, in function group **Transformer** in General Nodes under Rated Values and Coil Data..
- Next, set the parameter of the protection functions.

  If the transformer data have changed after completing the protection setting, remain in the setting sheet (for example, primary setting) and change the transformer data. In the background, DIGSI 5 obtains the new settings in the inactive setting views (for example, new secondary values).

The following section explains, by way of an example, how to modify the transformer ratios in DIGSI 5 using the corresponding alternatives.

3.10.2 Modifying the Transformer Ratios in DIGSI 5

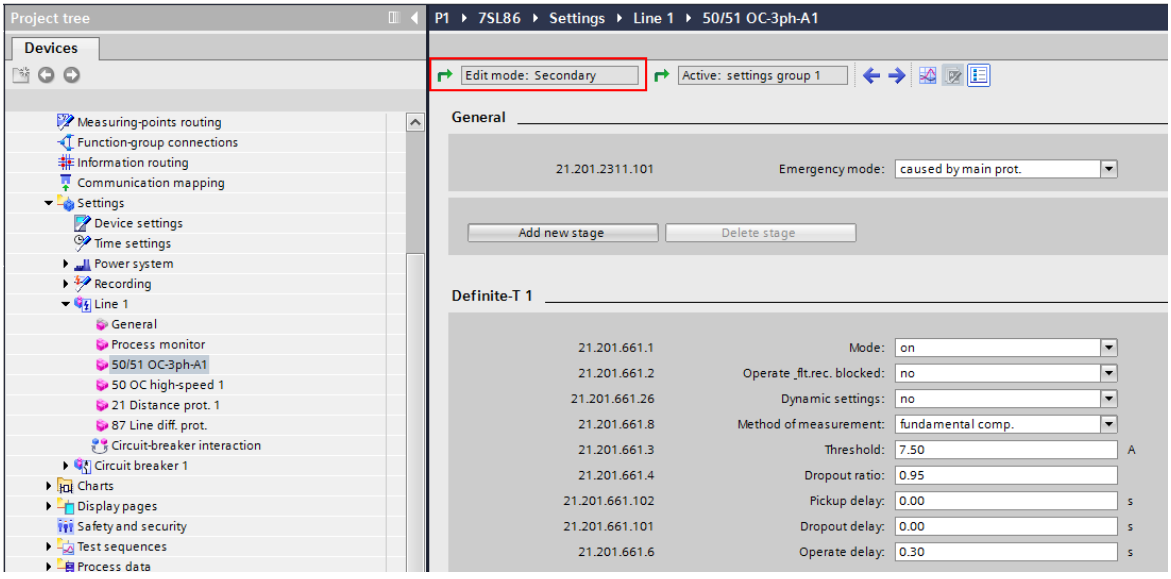
In the delivery setting, DIGSI 5 is set to the edit mode **Secondary**.

The following setting example shows how you can change the transformer ratio in DIGSI 5, and what impact this has on the settings in the setting views **Primary** and **Secondary**. The protection setting is observed in the example of the function **Overcurrent protection**.

The following output data are assumed:

Current transformer:	1000 A/1 A
Protection pickup value:	1.5 A

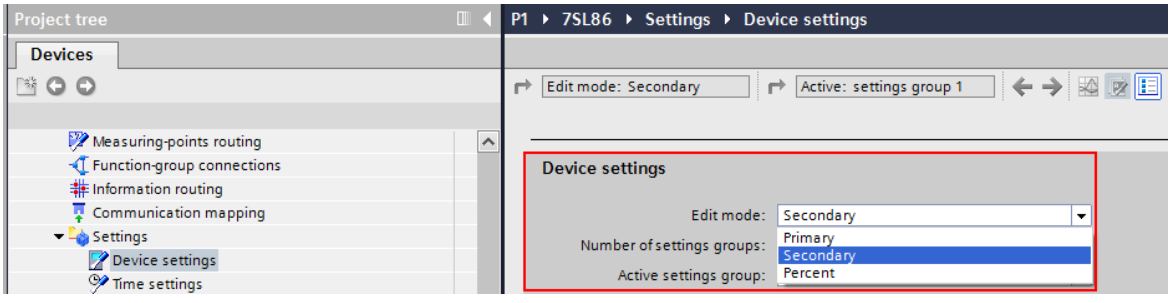
The following figure shows the protection setting of the function **Overcurrent protection** in the secondary view. The threshold value of the stage is set to 1.5 A.



[scmodsek_1, 1, en_US]

Figure 3-138 Protection Setting, Display of the Active Setting Sheet

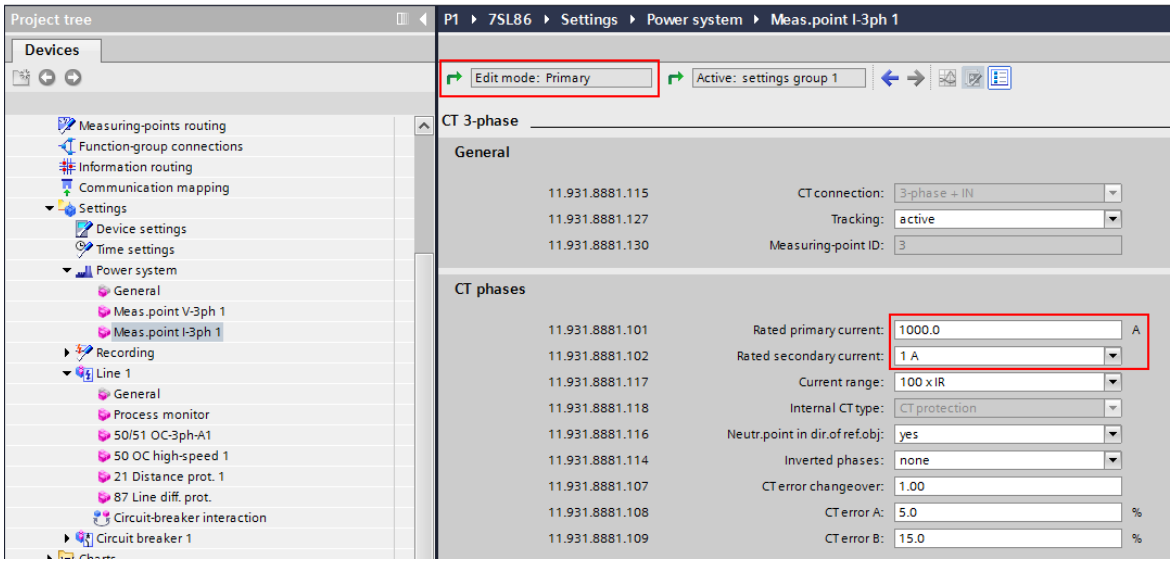
When you click the green arrow in the setting sheet at the upper left, you get to the window for switching over to the setting view (see the following figure). Select the setting view you prefer.



[scmodums_2, 1, en_US]

Figure 3-139 Switchover to the Desired Setting View

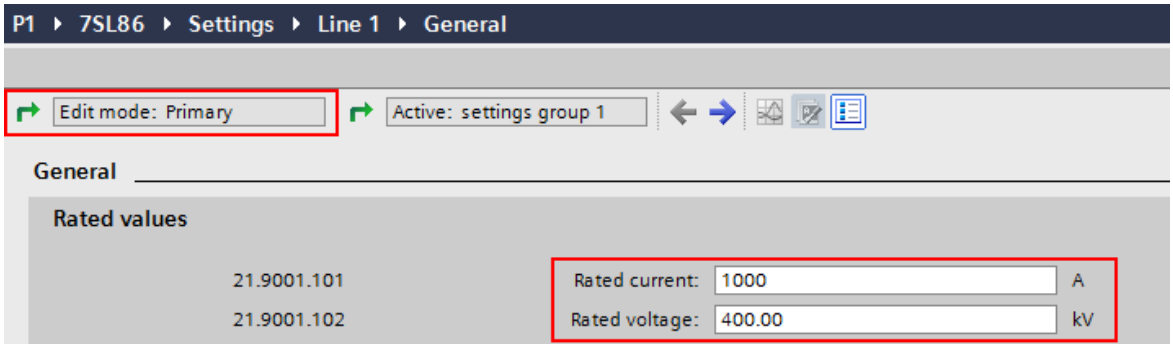
The following figures show the setting sequence in the edit mode **Primary**. Set the transformer data. In the example, the current transformer has a transformation ratio of 1000 A/1 A.



[scpwandl_3, 1, en_US]

Figure 3-140 Setting Sheet: Transformer Data

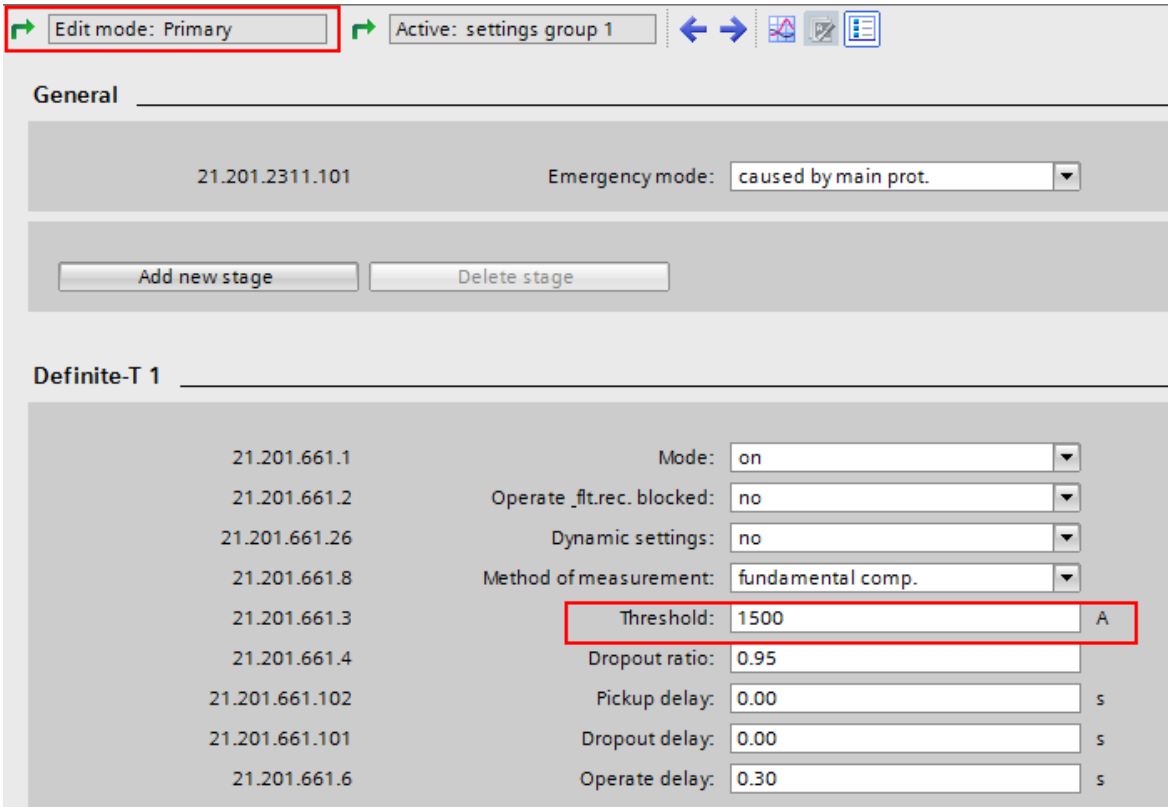
In the function group **Transformer**, you set the transformer data (see following figure). Rated current, rated voltage and rated apparent power are the reference variables for the percent setting.



[scproref_4, 1, en_US]

Figure 3-141 Reference Data for Percentage Settings

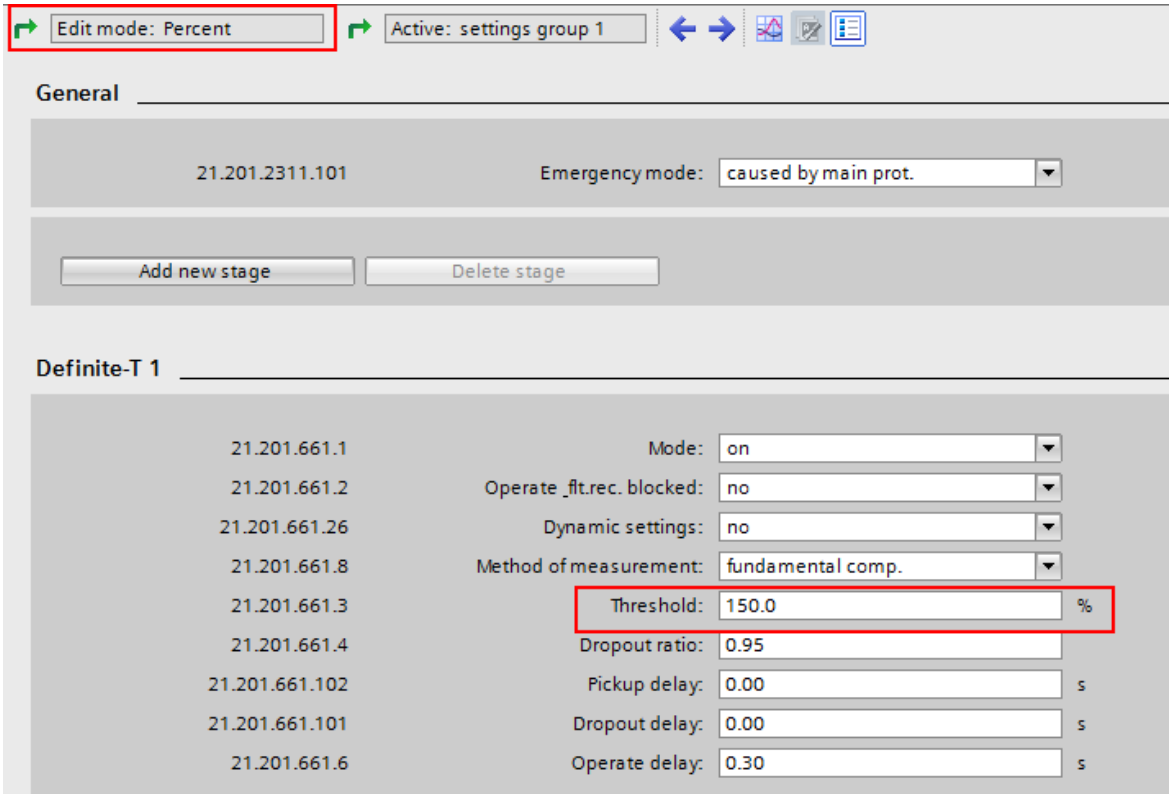
The following figure shows the threshold value of the function **Overcurrent protection** in the primary view at 1500 A.



[scumzpri_5, 1, en_US]

Figure 3-142 Example of the Threshold Value of the Definite-Time Overcurrent Protection Stage (Edit Mode: Primary)

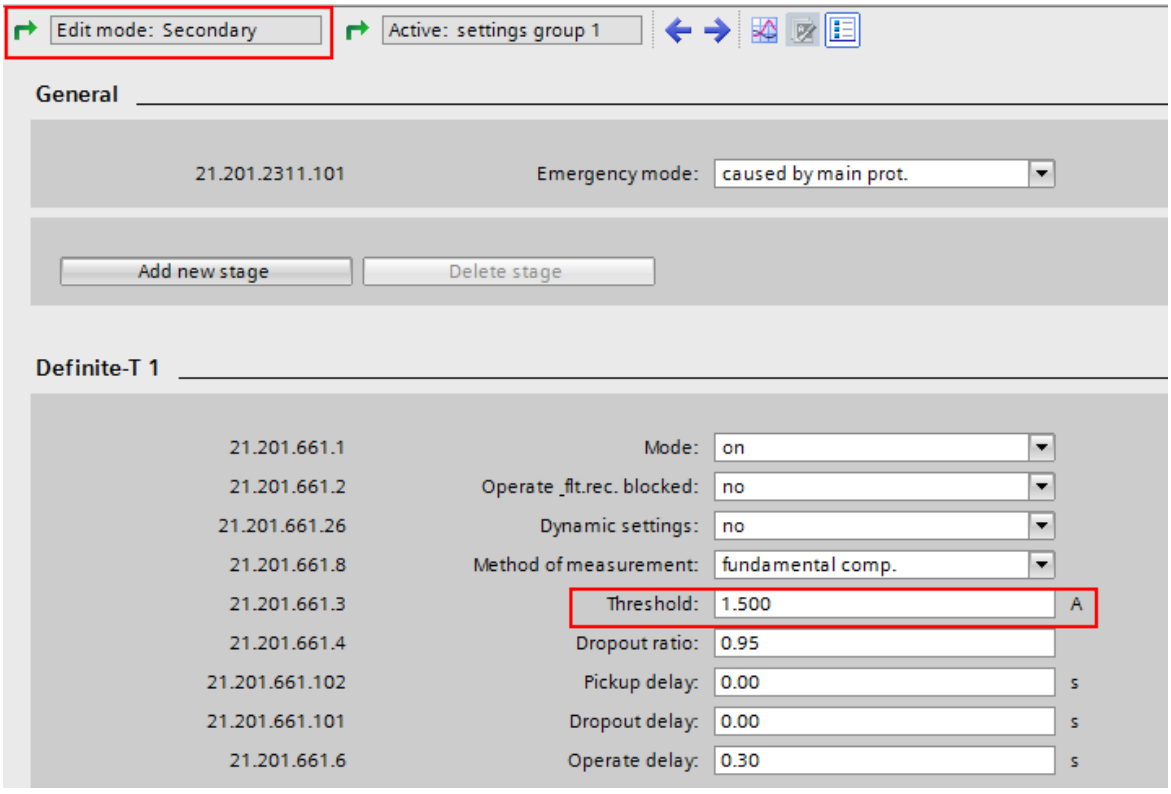
When switching over to the percent view, the result should be the following value:
1500 A/1000 A · 100 % = 150 %



[scumzpro_6, 1, en_US]

Figure 3-143 Example of the Threshold Value of the Definite-Time Overcurrent Protection Stage (Edit Mode: Percent)

When switching over to the secondary view, the result should be the following value:
1500 A/(1000 A/1 A) = 1.5 A



[scumzsek_7, 1, en_US]

Figure 3-144 Example of the Threshold Value of the Definite-Time Overcurrent Protection Stage (Edit Mode: Secondary)

If you only want to work in the secondary view, DIGSI 5 supports you if the transformer ratio changes during the project phase.

In the example, the current-transformer ratio changes from 1000 A/**1 A** to 1000 A/**5 A**. Change the secondary rated current of the current transformer in the setting sheet of the transformer data from 1 A to 5 A (Edit mode: Secondary). If you change the transformer data, a window will appear (see the following figure) that will ask you for the action desired.

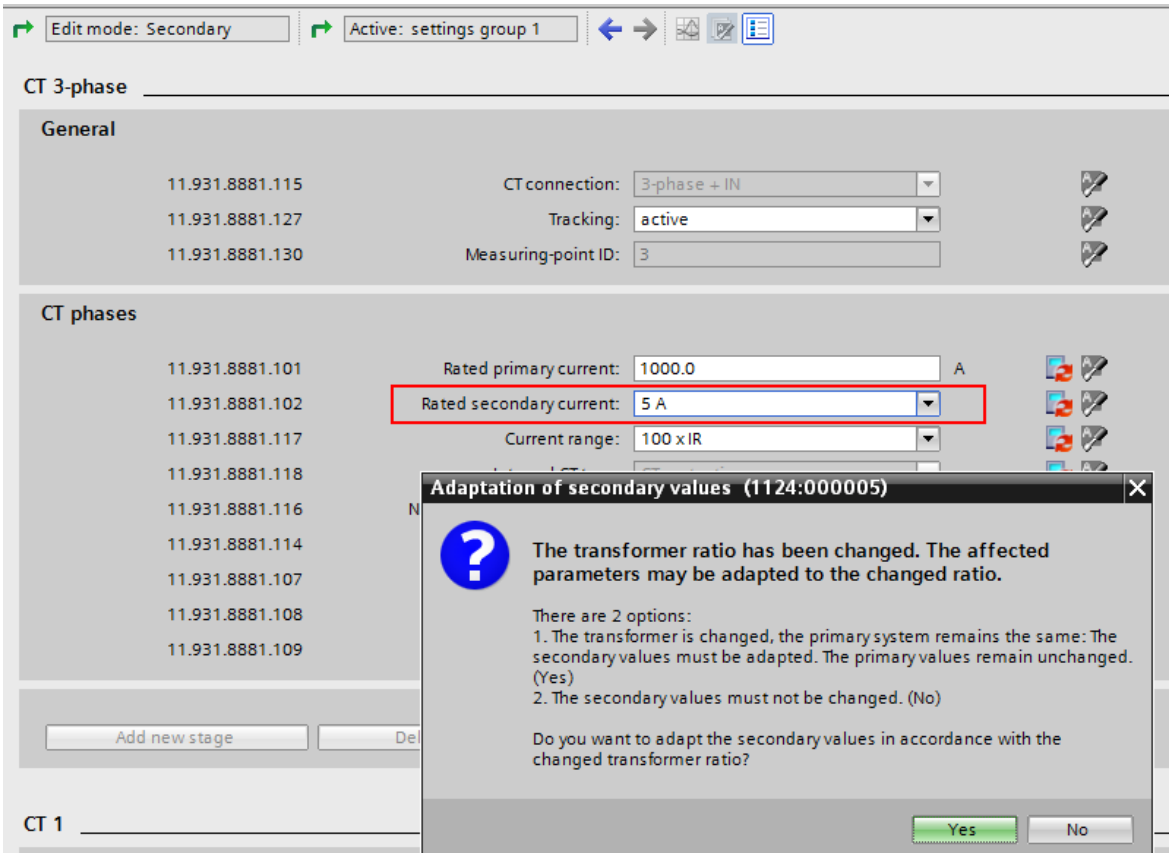
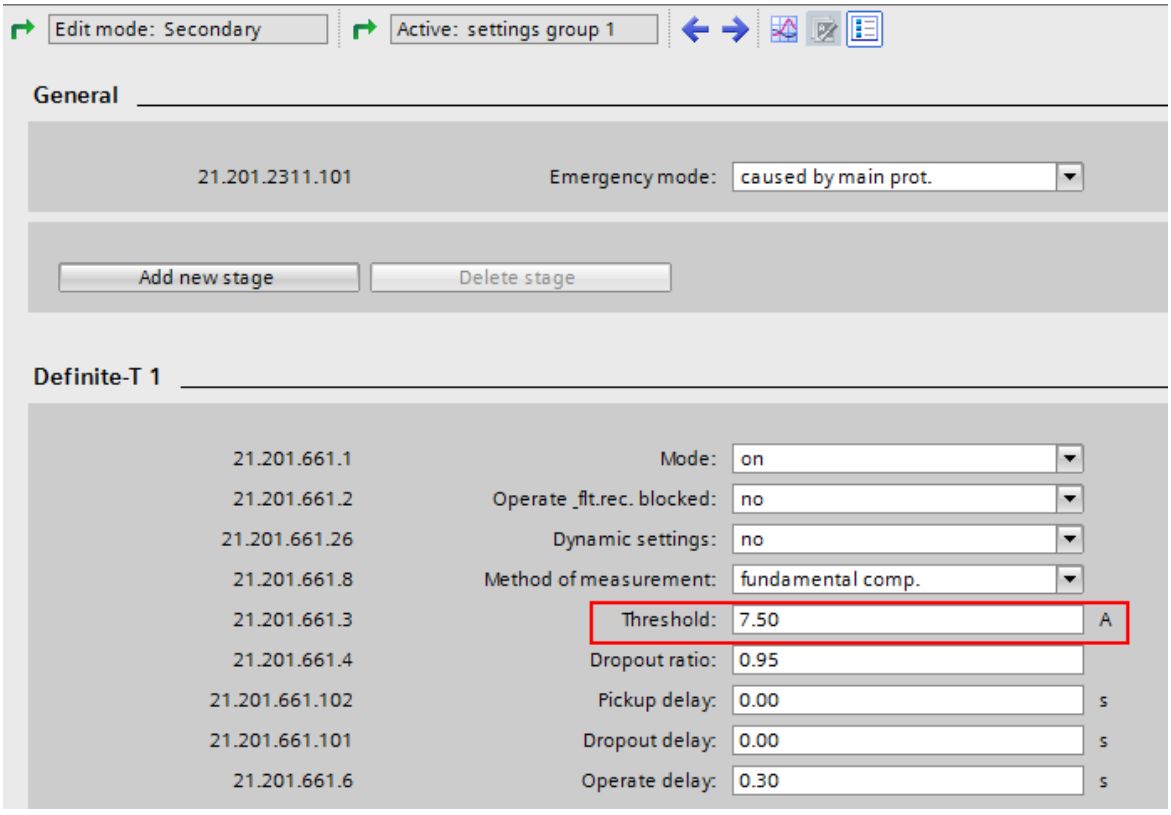


Figure 3-145 Query after Changing the Transformer Data (Setting View: Secondary)

If you answer the question with **Yes**, then DIGSI 5 will recalculate the pickup values (threshold values) in the active secondary view. For the new secondary transformer current 5 A, the new secondary threshold value obtained is 7.5 A (1.5 A * 5 = 7.5 A). The primary and percent values remain unchanged.

The following figure shows the newly calculated threshold value in the secondary view.



[scsekneu_9, 1, en_US]

Figure 3-146 Automatically Recalculated Secondary Values After Changes in the Transformer Data

If you have already set the settings in the secondary view by including the new transformation ratio of the transformer in the calculation, then answer the question with **No**. In this case, the protection settings in the secondary view remain unchanged. DIGSI 5 recalculates the settings (threshold values) of the primary view. In the example, the primary threshold value is then 300 A (1.5 A · 1000 A/5 A = 300 A).

In the example, the current-transformer ratio changes from 1000 A/1 A to 1000 A/5 A. The following table summarizes the pickup values that DIGSI 5 will recalculate in the setting view. The new values (in bold) depend on the reply to your question (refer to *Figure 3-145*).

	Reply to the Question	
	Yes	**No**
Threshold value secondary (active setting view)	**7.5** A	1.5 A
Threshold value primary (covered setting view)	1500 A	**300** A

Changing the Transformer Ratio in the Single-Line Editor

If you want to change the primary or secondary rated currents of the current transformer in the Single-Line Editor, select the current transformer. You can view and change the currents in the tab **Properties** of the object bar.

If you change the rated currents, the corresponding field has a red border to indicate currents that differ between the Single-Line Editor and the power-system data. During **synchronization** in the Single-Line Editor, these rated currents are adopted into the power-system data.

3.10.3 Changing the Transformation Ratios of the Transformer on the Device

In the delivery setting, the device is preset to secondary values. Only secondary values can be set directly on the device.

If you change transformer data directly on the device, it is not followed by a query, like in DIGSI 5 (see *Figure 3-145*). Instead, the device assumes that all settings remain unchanged in the secondary view.



NOTE

If the device works with IEC 61850 protocol, then change the transformer data only via DIGSI 5 and not directly on the device. If you change the transformer data directly on the device, the IEC 61850 configuration of the measurement and metered values can be faulty.

3.11 Device Settings

3.11.1 Settings-Group Switching

3.11.1.1 Overview of Functions

For different applications you can save the respective function settings in so-called **Settings groups**, and if necessary enable them quickly.

You can save up to 8 different settings groups in the device. In the process, only one settings group is active at any given time. During operation, you can switch between settings groups. The source of the switchover can be selected via a parameter.

You can switchover the settings groups via the following alternatives:

- Via the on-site operation panel directly on the device
- Via an online DIGSI connection to the device
- Via binary inputs
- Via a communication connection to the substation automation technology.
  The communication protocols IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP, or Modbus TCP can be used for switching the settings groups.

A settings group includes all switchable settings of the device. Except for a few exceptions (for example, general device settings such as rated frequency), all device settings can be switched.

For detailed information about the settings groups, refer to the *Operating Manual* and to the *DIGSI 5 Online Help*.

3.11.1.2 Structure of the Function

The function of the **Settings group switching** is a supervisory device function. Accordingly, the settings and indications of the settings group switching can be found in DIGSI 5 and at the on-site operation panel of the device, below the general device settings respectively.

If you want to switchover a settings group, navigate to DIGSI 5 or proceed on the on-site operation panel of the device, as follows:

- Via the project tree in DIGSI 5:
  Project -> Device -> Settings -> Device settings
- Via the on-site operation panel of the device:
  Main menu → Settings → General → Group switchover

The indications for the settings group switching can be found in the DIGSI 5 project tree under:
Project → Device → Information routing → General

3.11.1.3 Function Description

Activation

If you want to use the **Settings group switching** function, you must first set at least 2 settings groups in DIGSI 5 (parameter **Number of settings groups** > 1). You can set up a maximum of 8 settings groups. The settings groups set in DIGSI 5 are subsequently loaded into the device.

Mechanism of the Switchover

When switching over from one settings group to another, the device operation is not interrupted. With the parameter **Active settings group** you are either specifying a certain settings group or you allow switching ***via control*** (IEC 60870-5-103, IEC 61850) or ***via binary input***.

Switching via Control

When using the ***Control*** function for switching, the settings groups can be switched via a communication connection from the substation automation technology or via a CFC chart.

The communication protocols IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP, or Modbus TCP can be used for switching the settings groups via a communication connection.

In order to use a CFC chart for switching, you must create a new CFC chart in DIGSI 5. Create the CFC chart in the DIGSI 5 project tree under **Name of the device** →**Charts** →**Add new chart**. Link the signals that control settings group switching in the CFC chart.

Switching via Binary Input

There are 3 appropriate input signals available for switching via binary inputs. These input signals allow selection of the settings group via a binary code. If one of the 3 signals changes, the signal image present will, after 100 ms (stabilization time), result in switching over to the appropriate settings group. If only 2 settings groups must be switched over, only 1 binary input is required. The following table shows the possible binary codes (BCD) and applicable settings groups (PG).

Table 3-22 Binary Codes of the Input Signals and Applicable Settings Groups

BCD Code via Binary Inputs	PG 1	PG 2	PG 3	PG 4	PG 5	PG 6	PG 7	PG 8
>PG selection bit 3	0	0	0	0	1	1	1	1
>PG selection bit 2	0	0	1	1	0	0	1	1
>PG selection bit 1	0	1	0	1	0	1	0	1

Copying and Comparing Settings Groups

In DIGSI 5, you can copy or compare settings groups with each other.

If you want to copy settings groups, select a source and target parameter group in DIGSI 5 in the device settings, and then start the copy process. The device settings can be found in the DIGSI 5 project tree under Project → Device → Settings → Device settings.

If you want to compare settings groups, it is possible to do so in all setting sheets for settings. You will then select in addition to the active settings group, a 2nd settings group for comparison. Active setting values and the comparable values are displayed next to each other. For settings that cannot be switched over, no comparable values are displayed.

Indication of Settings Group Switchings

Every settings group shows an applicable binary indication as well as its activation and deactivation. The process of settings group switching is also logged in the log for settings changes.

3.11.1.4 Application and Setting Notes

Parameter: Number settings groups

- Default setting **(_:113) Number settings groups** = ***1***

With the parameter **Number settings groups**, you can set the number of available settings groups; you can switch between these.

Parameter: Activat. of settings group

- Default setting **(_:114) Activat. of settings group** = ***settings group 1***

With the parameter **Activat. of settings group**, you specify the settings groups that you want to activate, or the mechanisms via which the switchover is allowed. You can switchover only between the settings groups specified with the parameter **Number settings groups**.

Parameter Value	Description
via control	The switchover between the settings groups can only be initiated via a communication connection from a substation automation technology or via a CFC chart. The communication protocols IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP, or Modbus TCP can be used for switching the settings groups via a communication connection.
via binary input	The switchover between the settings groups functions exclusively via the binary input signals routed to the settings group switching.
settings group 1 ... ***settings group 8***	They define the active settings groups. You can define the active settings groups in DIGSI 5, or directly on the device via the on-site operation.

3.11.1.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Change group				
_:113	General:Number settings groups		1 to 8	1
_:114	General:Activat. of settings group		• via control • via binary input • settings group 1 • settings group 2 • settings group 3 • settings group 4 • settings group 5 • settings group 6 • settings group 7 • settings group 8	settings group 1

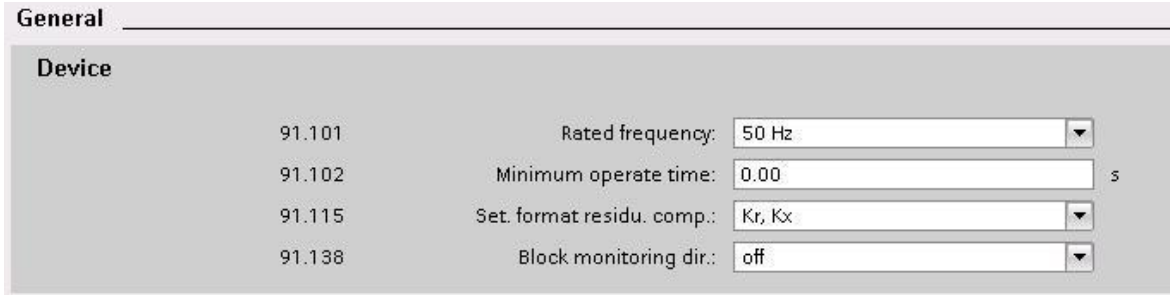
3.11.1.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:500	General:>SG choice bit 1	SPS	I
_:501	General:>SG choice bit 2	SPS	I
_:502	General:>SG choice bit 3	SPS	I
_:300	General:Act. settings group 1	SPC	C
_:301	General:Act. settings group 2	SPC	C
_:302	General:Act. settings group 3	SPC	C
_:303	General:Act. settings group 4	SPC	C
_:304	General:Act. settings group 5	SPC	C
_:305	General:Act. settings group 6	SPC	C
_:306	General:Act. settings group 7	SPC	C
_:307	General:Act. settings group 8	SPC	C

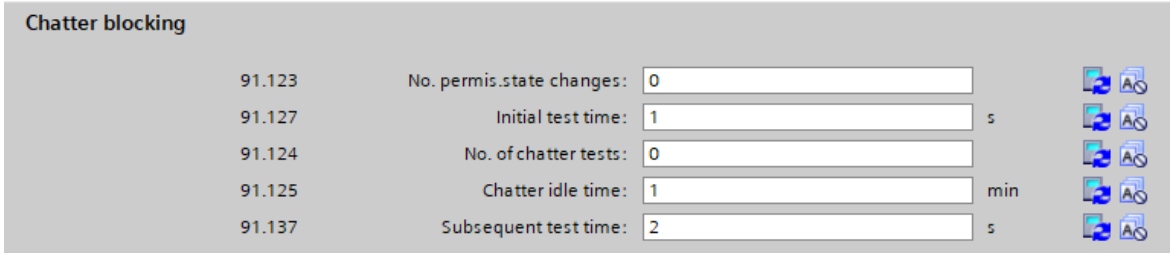
3.11.2 General Device Settings

3.11.2.1 Overview

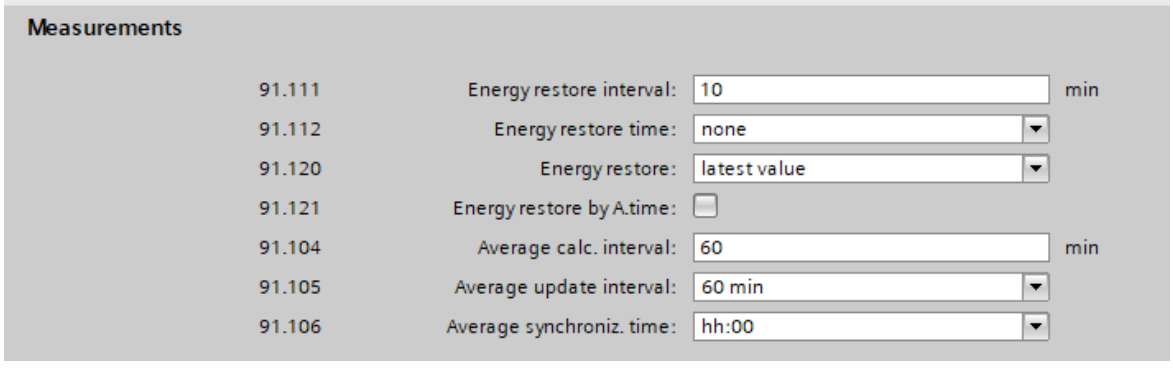
In **Device settings** in DIGSI 5, you find the following general settings.



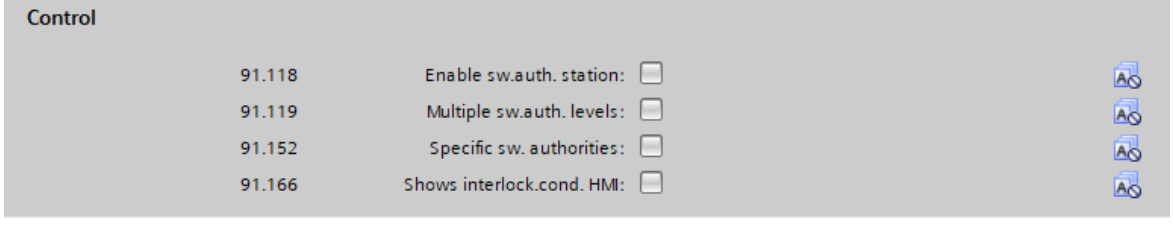
[sc_deSeDe2, 1, en_US]



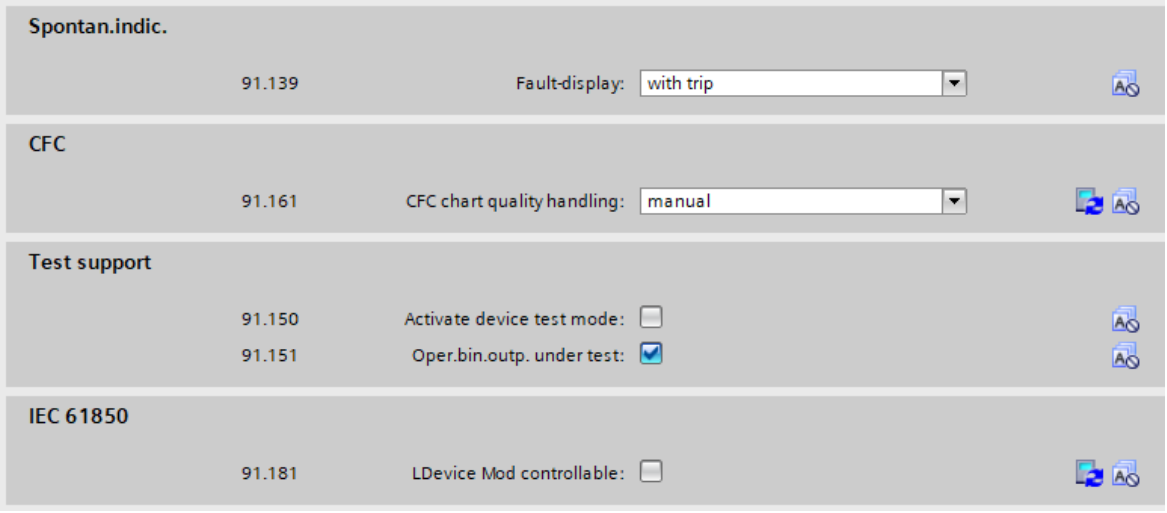
[sc_deSeAl, 4, en_US]



[sc_measurement, 1, en_US]



[sc_control, 1, en_US]



[sc_deSeBB, 2, en_US]

Figure 3-147 General Device Settings

The following list shows you the chapters containing the desired information.
You can find more about:

- **Chatter blocking** in *3.9.1 Signal Filtering and Chatter Blocking for Input Signals*.
- **Control** in *7.4 Control Functionality*.
- **Measured values** in *9.1 Overview of Functions*
- **Spontaneous indications** in *3.1.7 Spontaneous Indication Display in DIGSI 5*.
- **Continuous Function Chart Quality Treatment** in *3.4.3 Quality Processing/Affected by the User in CFC Charts*.

Under **Device**, you set the parameters for the device that are valid across functions.

With **Test support**, indications issued via communication interfaces are labeled with an additional test bit, if this is supported by the protocol. With this test bit you can determine whether an indication is generated in a test and all or individual functions of the device are in the test mode. In this manner the reactions that are necessary in normal operation due to an indication can be suppressed in other devices that receive these indications. You can also permit, for example, a trip command to close an energized binary output for test purposes. Siemens recommends deactivating the **Test support** again after the test phase.

From version **DIGSI V09.70** on, you can control the state of the logical nodes (LLN0) in a logical device (LD) under **IEC 61850** with the parameter **`LDevice Mod controllable`**. If you want to test and change the behavior of logical nodes individually, place a checkmark on the parameter **`LDevice Mod controllable`**.

3.11.2.2 Application and Setting Notes

The major portion of the settings is described in the chapters cited above. Then, the parameters on the section **Device**, **Spontaneous indication** and **Test support** are described.

Parameter: Rated frequency

- Default setting **`(_:101) Rated frequency`** = ***`50 Hz`***

With the parameter **`Rated frequency`**, you set the rated frequency of the electrical power system.

Parameter: Minimum operate time

- Default setting **`(_:102) Minimum operate time`** = ***`0.00 s`***

With the parameter **`Minimum operate time`**, you set the minimum duration for the trip command of the functions. The trip command is maintained for the set duration.

Parameter: Set. format residu. comp.

- Default setting **_:115** = ***Kr, Kx***

With the parameter **Set. format residu. comp.**, you specify the setting format for the residual compensation factors that apply across functions. You can set the residual compensation using the scalar factors ***Kr, Kx*** or as a complex factor using ***K0***.

The setting format controls the visibility of the residual compensation factors in the **Distance protection**.

Parameter: Block monitoring dir.

- Default setting **(_:138) Block monitoring dir.** = ***off***

With the parameter **Block monitoring dir.**, you set whether indications are output via the system interface(s) of the SIPROTEC 5 device or not.

If transmission blocking is switched on, no indications are output via the system interface(s) of a SIPROTEC 5 device, except via the IEC 61850 interface(s).

To avoid receiving IEC 61850 data, the corresponding IEC 61850 Client must stop the reporting or freeze the data. You can find more information in the Communication Protocols Manual (C53000-L1840-C055-3).

Parameter: Fault-display

- Default setting **(_:139) Fault-display** = ***with pickup***

With the parameter **Fault-display**, you set whether spontaneous fault indications which are signed as ***NT (conditioned latching)*** in the matrix, get stored with every pickup or only for one tripping.

Keep the DIGSI 5 routing options in chapters *3.1.7 Spontaneous Indication Display in DIGSI 5* and *3.1.9 Stored Indications in the SIPROTEC 5 Device* in mind.

Parameter: Activate device test mode

- Default setting **(_:150) Activate device test mode** = inactive

With the parameter **Activate device test mode**, you can activate the test mode for the complete device. This means that all indications generated in the device are given a test bit.

For further information, refer to *11.2 Enabling/Disabling the Application/Test Mode for the Entire Device*.

Apart from activating the test mode via this parameter, you can also activate the test mode using the IEC 61850-8-1 protocol. For more information, refer to the manual *SIPROTEC 5 Communication protocol*.

When the test mode is activated for the complete device, but the parameter **Oper.bin.outp. under test** is not, the routed relay outputs of the device are not activated by the generated the indications.



NOTE

The device remains in test mode during every restart until you intentionally set the device back into process mode or you have carried out an initial start.

You can set the process mode by switching the parameter **Activate device test mode** to inactive again (removing the check mark) or by deactivating the test mode again via the protocol IEC 61850-8-1.

NOTE

Besides the cross device test mode, you also have the option to place an individual function or stage into test mode depending on the supported operating modes of a function or stage. To do this, see the description of the relevant function or stage.

When you place an individual function or stage into the test mode, all indications issued by this function or stage are given a test bit.

When you activate the test mode for an individual function or stage, but not the parameter **Oper.bin.outp. under test**, the routed relay outputs of the function or stage are not activated by the generated indications.

An individual function or stage remains in the test mode during every restart until you have intentionally deactivated the test mode for this function or stage again or carried out an initial start.

Parameter: Oper.bin.outp. under test

- Default setting **(_:151) Oper.bin.outp. under test** = inactive

If you activate the parameter **Oper.bin.outp. under test**, the indications generated in the device and marked with a test bit can be issued to a routed relay output of the device, that is, you enable the relay outputs of the device to be opened and closed.

If only one individual function or stage of the device is in test mode, that is, the cross device tested mode has not been activated, only the indications of this function or stage are marked with a test bit and the routed relay outputs of the device are activated.

With the parameter **(_:151) Oper.bin.outp. under test**, you define whether the functions in ***Test*** state can activate relay outputs. If the parameter **(_:151) Oper.bin.outp. under test** and the test mode are activated for the entire device, all functions – including the relay outputs – are in ***Test*** state. If the parameter **(_:151) Oper.bin.outp. under test** is not active and the test mode is activated for the entire device, all functions – except the relay outputs – are in ***Test*** state. The relay outputs adopt the **Test/Relay blk.** state.

Output Signal: Functions in Test mode

Normally, the output signal *Functions in Test mode* is prerouted to the last LED of the device base module. If one or more protection or control functions are in test mode, the output signal *Functions in Test mode* is generated and the corresponding LED of the device lights up red.

Parameter: LDevice Mod controllable

- Default setting **(_:181) LDevice Mod controllable** = inactive

With the parameter **LDevice Mod controllable**, you control the state of the logical nodes (LLN0) in a logical device (LD). If you want to test and change the behavior of logical nodes individually, place a checkmark on the parameter **LDevice Mod controllable**.

Once the checkmark is placed, the **LLN0:Mode** can be controlled in a logical device.

3.11.2.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Device				
_:101	General:Rated frequency		• 50 Hz • 60 Hz	50 Hz
_:102	General:Minimum operate time		0.00 s to 60.00 s	0.00 s
_:115	General:Set. format residu. comp.		• Kr, Kx • K0	Kr, Kx
_:138	General:Block monitoring dir.		• off • on	off

Addr.	Parameter	C	Setting Options	Default Setting
_:164	General:Station name		Freely editable text	
Chatter blocking				
_:123	General:No. permis.state changes		0 to 65 535	0
_:127	General:Initial test time		1 s to 65 535 s	1 s
_:124	General:No. of chatter tests		0 to 32 767; ∞	0
_:125	General:Chatter idle time		1 min to 65 535 min	1 min
_:137	General:Subsequent test time		2 s to 65 535 s	2 s
Change group				
_:113	General:Number settings groups		1 to 8	1
_:114	General:Activat. of settings group		• via control • via binary input • settings group 1 • settings group 2 • settings group 3 • settings group 4 • settings group 5 • settings group 6 • settings group 7 • settings group 8	settings group 1
_:162	General:Blk setting change		• 0 • 1	false
_:163	General:Reserv.time for com.prot.		0 s to 65 535 s	120 s
Measurements				
_:111	General:Energy restore interval		0 min to 60 min	10 min
_:112	General:Energy restore time		• none • hh:00 • hh:15 • hh:30 • hh:45	none
_:120	General:Energy restore		• latest value • delta value	latest value
_:121	General:Energy restore by A.time		• 0 • 1	false
_:104	General:Average calc. interval		1 min to 60 min	60 min

Addr.	Parameter	C	Setting Options	Default Setting
_:105	General:Average update interval		• 1 min • 2 min • 3 min • 4 min • 5 min • 6 min • 10 min • 15 min • 20 min • 30 min • 60 min	60 min
_:106	General:Average synchroniz. time		• hh:00 • hh:15 • hh:30 • hh:45	hh:00
_:107	General:Min/Max cyclic reset		• no • yes	yes
_:108	General:Min/Max reset each		1 day(s) to 365 day(s)	1 day(s)
_:109	General:Min/Max reset minute		0 min to 1439 min	0 min
_:110	General:Min/Max days until start		1 day(s) to 365 day(s)	1 day(s)
Control				
_:118	General:Enable sw.auth. station		• 0 • 1	false
_:119	General:Multiple sw.auth. levels		• 0 • 1	false
_:152	General:Specific sw. authorities		• 0 • 1	false
_:153	General:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:154	General:Num. of specific sw.auth.		2 to 5	2
_:156	General:Ident. sw.auth. 1		Freely editable text	
_:157	General:Ident. sw.auth. 2		Freely editable text	
_:158	General:Ident. sw.auth. 3		Freely editable text	
_:159	General:Ident. sw.auth. 4		Freely editable text	
_:160	General:Ident. sw.auth. 5		Freely editable text	

Addr.	Parameter	C	Setting Options	Default Setting
_:155	General:Multiple specific sw.auth.		• 0 • 1	false
_:166	General:Show int.lck.cond. on HMI		• 0 • 1	false
Spontan.indic.				
_:139	General:Fault-display		• with pickup • with trip	with pickup
CFC				
_:161	General:CFC chart quality handling		• automatic • manual	manual
Test support				
_:150	General:Activate device test mode		• 0 • 1	false
_:151	General:Oper.bin.outp. under test		• 0 • 1	false
IEC 61850				
_:181	General:LDevice Mod controllable		• 0 • 1	false

3.11.2.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:500	General:>SG choice bit 1	SPS	I
_:501	General:>SG choice bit 2	SPS	I
_:502	General:>SG choice bit 3	SPS	I
_:503	General:>Sw. authority local	SPS	I
_:504	General:>Sw. authority remote	SPS	I
_:505	General:>Sw. mode interlocked	SPS	I
_:506	General:>Sw. mode non-interl.	SPS	I
_:510	General:>Test mode on	SPS	I
_:511	General:>Test mode off	SPS	I
_:507	General:>Dev. funct.logout on	SPS	I
_:508	General:>Dev. funct.logout off	SPS	I
_:512	General:>LED reset	SPS	I
_:513	General:>Light on	SPS	I
_:514	General:>Block relays	SPS	I
_:300	General:Act. settings group 1	SPC	C
_:301	General:Act. settings group 2	SPC	C
_:302	General:Act. settings group 3	SPC	C
_:303	General:Act. settings group 4	SPC	C
_:304	General:Act. settings group 5	SPC	C
_:305	General:Act. settings group 6	SPC	C
_:306	General:Act. settings group 7	SPC	C
_:307	General:Act. settings group 8	SPC	C
_:318	General:Active settings group	INS	O

No.	Information	Data Class (Type)	Type
_:308	General:Switching auth. station	SPC	C
_:324	General:Enable sw. auth. 1	SPC	C
_:325	General:Enable sw. auth. 2	SPC	C
_:326	General:Enable sw. auth. 3	SPC	C
_:327	General:Enable sw. auth. 4	SPC	C
_:328	General:Enable sw. auth. 5	SPC	C
_:311	General:Switching authority	ENS	O
_:312	General:Switching mode	ENS	O
_:309	General:Sw.authority key/set	ENS	O
_:310	General:Sw.mode key/set	ENS	O
_:330	General:Acq.blocking active	SPS	O
_:331	General:Manual update active	SPS	O
_:52	General:Behavior	ENS	O
_:53	General:Health	ENS	O
_:51	General:Test mode	ENC	C
_:56	General:Application mode	ENC	C
_:321	General:Protection on	SPC	C
_:54	General:Protection inactive	SPS	O
_:319	General:Device logout	SPC	C
_:313	General:Logged off via BI	SPS	O
_:314	General:Logged off via control	SPS	O
_:315	General:Device logged off	SPS	O
_:323	General:LED reset	SPC	C
_:320	General:LED have been reset	SPS	O
_:509	General:>Block monitoring dir.	SPS	I
_:317	General:Block monitoring dir.	SPS	O
_:329	General:Functions in Test mode	SPS	O

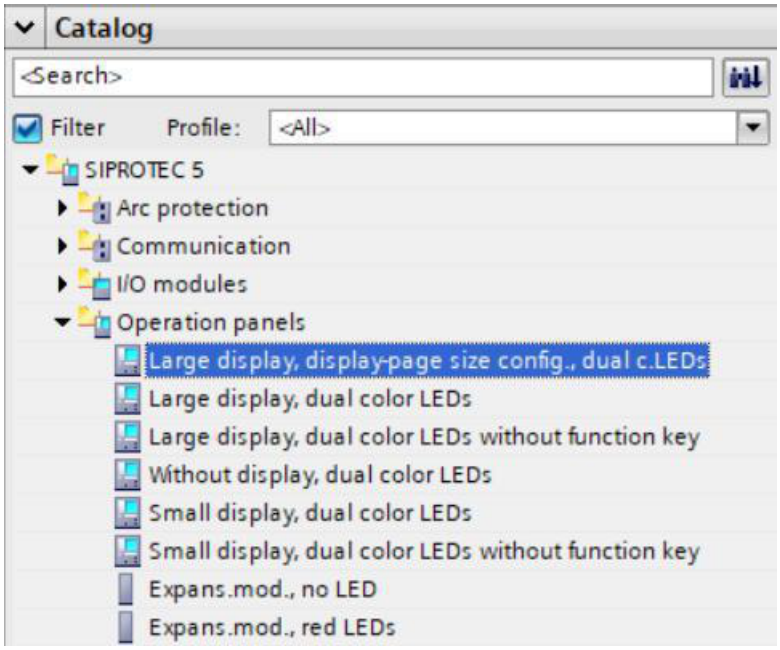
3.11.3 Display-Page Setting

3.11.3.1 Overview

Specific SIPROTEC 5 devices can be ordered with the operation-panel option **Large display, display-page size config., dual c.LEDs**. In this case, the size of the configurable display pages is settable by the user, and is function-points dependent:

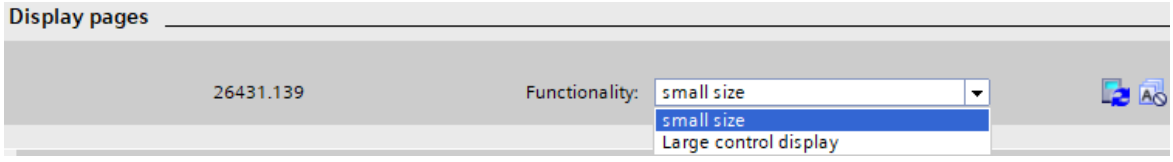
- Small display pages can be configured without extra function points.
- Large display pages for large control displays require extra function points.

For devices with the operation panel **Large display, display-page size config., dual c.LEDs**, you can find the block **Display pages** in **Device settings** in DIGSI 5.



[sc_Display_page_Operation Panels, 1, en_US]

Figure 3-148 Operation Panel **Large display, display-page size config., dual c.LEDs** in DIGSI 5



[sc_Functionality_block1, 2, en_US]

Figure 3-149 Block **Display pages** in DIGSI 5

3.11.3.2 Application and Setting Notes

Parameter: Functionality

- Default setting **(_:139) Functionality** = ***small size***

With the parameter **Functionality**, you set the size of the display pages that are shown in DIGSI 5 and in the HMI.

Parameter Value	Description
small size	The size of the display page is 240 x 128 pixels. With this size, usually up to 8 operational values or very small control displays with, for example, up to 3 switches can be configured.
Large control display	The size of the display page is 240 x 320 pixels. With this size, large control displays or a large number of operational values, or a combination of both can be configured.

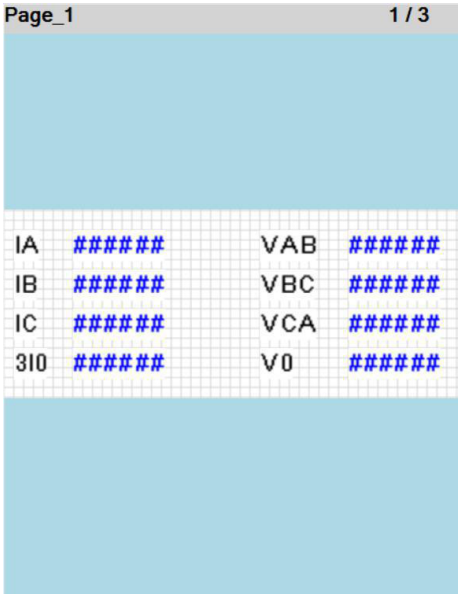


Figure 3-150 Example of Display Page in DIGSI 5 (Small Size)

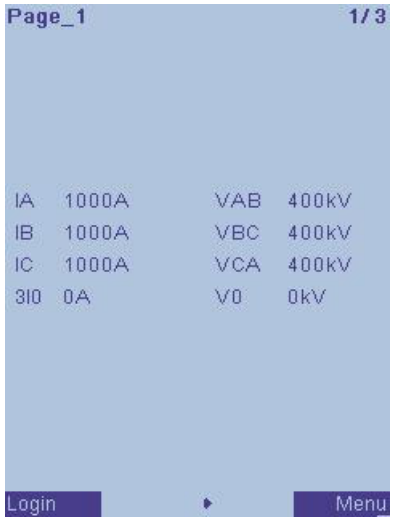


Figure 3-151 Example of Display Page in the HMI (Small Size)

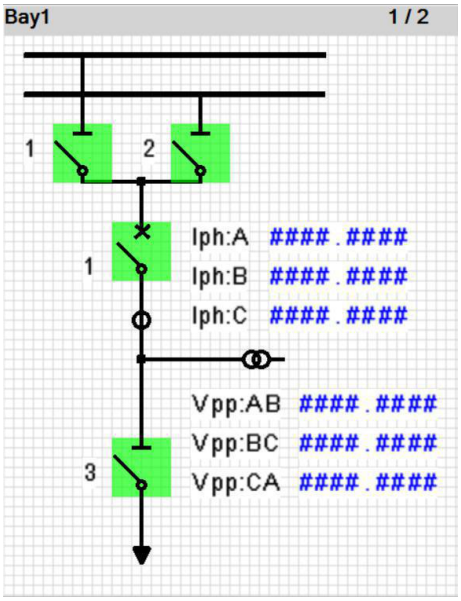


Figure 3-152 Example of Display Page in DIGSI 5 (Large Control Display)

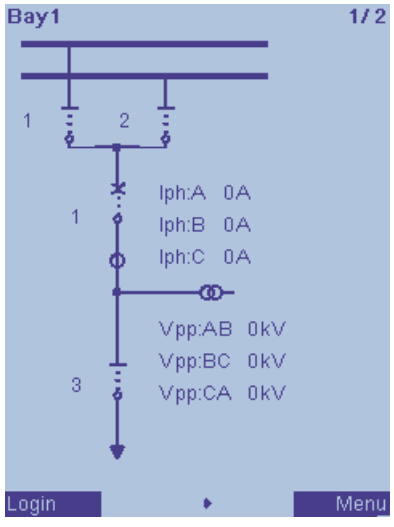


Figure 3-153 Example of Display Page in the HMI (Large Control Display)

3.11.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Display pages				
_:139	Display pages:Functionality		• small size • Large control display	small size

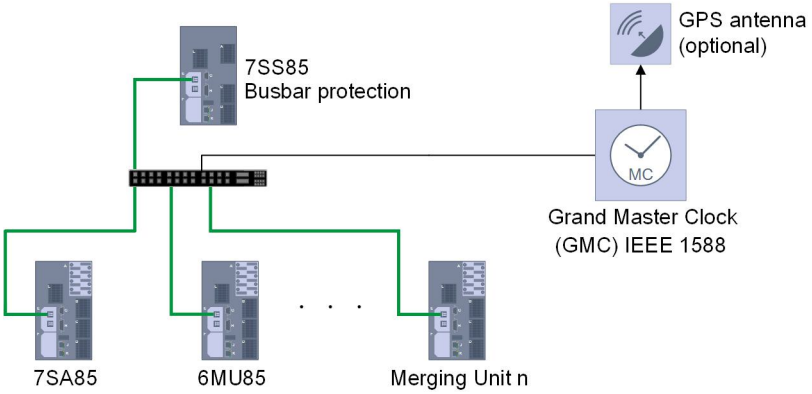
3.12 Using a SIPROTEC 5 Device as a Client or Merging Unit

Overview with the Distributed Busbar Protection as an Example (IEC 61850 Compliant):

- Process bus: for cross-device transmission of the measured values for current and voltage
- GOOSE: For cross-device transmission of the position information of disconnectors and circuit breakers, their trip commands and additional signals
- Distributed busbar protection
- Further information

Process Bus:

The process bus is available for the modular SIPROTEC 5 devices. The current and voltage measured values can be transmitted across devices using the process bus. Prerequisite: a ETH-BD-2FO communication module with the appropriate communication protocols. In the following figure, you can see the 7SS85 as an example of the client, and the 6MU85 and other modular SIPROTEC 5 devices as merging units.



[dw_bb8_proj-71-star, 2, en_US]

Figure 3-154 Star Structure for Distributed Busbar Protection with Merging Units Connected via Optical Fibers

Prerequisites for the Merging Units for the Distributed Busbar Protection (IEC 61850 Compliant)

You can use all modular SIPROTEC 5 devices (except the railway protection devices 7ST8x and 6MD89) and other IEC 61850 compliant devices as merging units. The following prerequisites apply:

- All clients and merging units must have the firmware version V8.0x or higher.
- All clients and merging units must be connected to the ETH-BD-2FO communication module and must use the process-bus protocols. These include:
  - Consistent use of **IEC 61850 Edition 2.x**. Siemens recommends IEC 61850 Edition 2.1.
  - Process-bus protocol **9-2 Merging Unit** for Merging Units and **9-2 Client** for clients
  - Joint time synchronization. Siemens recommends the **IEEE 1588 protocol**.
- The current and voltage transformers suitable for the target application in the client must be present in the merging units.

GOOSE:

As an alternative to using the local binary inputs and binary outputs of a SIPROTEC 5 device, you can use the inputs and outputs of other SIPROTEC 5 devices and transmit them via IEC 61850 including GOOSE.

Examples of binary routings for transmission using GOOSE.

- Circuit-breaker and disconnector position information from the transmitters to the receivers
- Circuit-breaker trip commands from the transmitter to the receivers

Distributed Busbar Protection

The distributed busbar protection is a distributed protection system with the 7SS85 as the central unit (CU) and other SIPROTEC 5 devices, the merging units (MU) as bay units.

The distributed busbar protection provides the following advantages over the centralized busbar protection or the distributed busbar protection (IEC 61850 compliant):

- Transmission of current measured values (SMV) as per IEC 61850-9-2 (process bus) from the merging units
- Automatic interconnection of current measured values, disconnector-switch and circuit-breaker switch positions
- Local functional enhancements of the merging units
- Maximum number of bays and busbar zones

Functional Enhancements in the Devices

Starting with V8.40, the merging units have the following functional enhancements that are especially intended for use with the distributed busbar protection and evaluated there:

- End-fault protection (1-pole/3-pole, 3-pole)
- External tripping
- Inherent circuit-breaker failure protection
- Extension in circuit-breaker failure protection
- Measuring point out of service



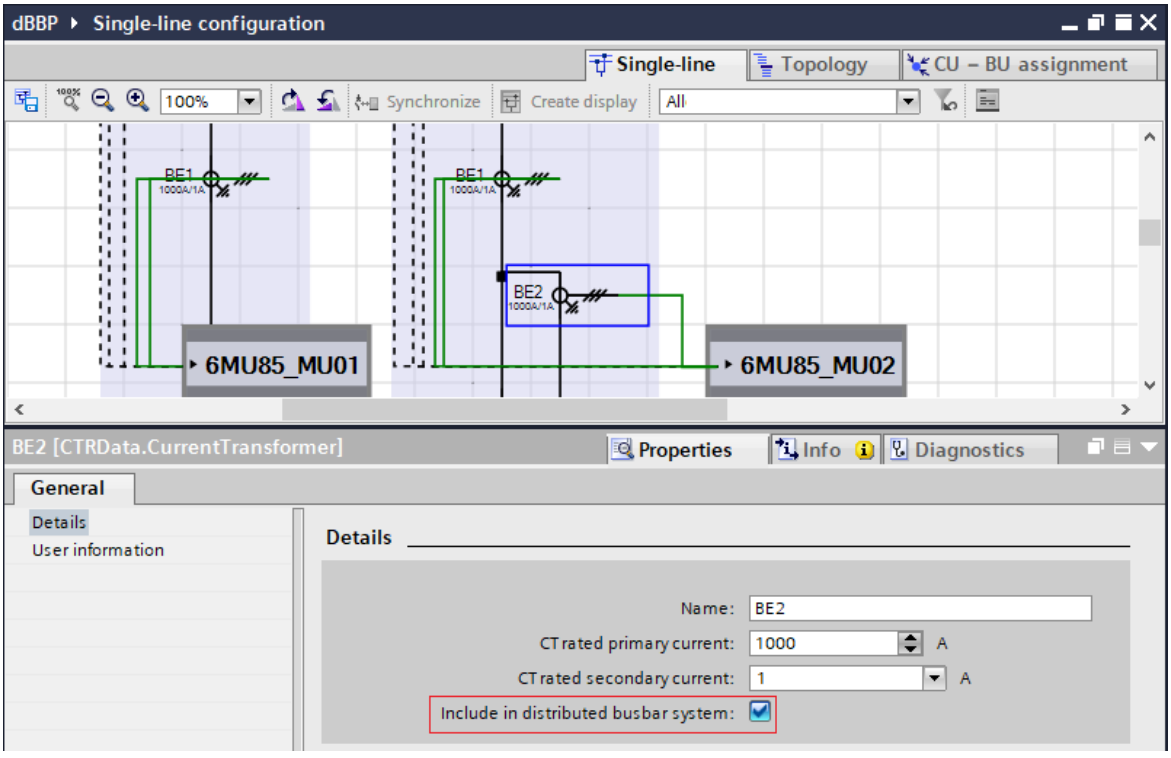
NOTE

You can find these functional enhancements in the Global DIGSI 5 Library in the respective device, under **FG Circuit breaker** > **dBBP Function extensions**. You can find the function **Measuring point out of service** under **Measuring inputs** > **Current 3-phase** > **dBBP Function extensions** in the respective device.

Functional Enhancement in DIGSI 5

If a **distributed busbar protection** is present in the project, the following functional enhancements especially intended for use with the distributed busbar protection are provided in the Single-Line Editor:

- New **CU – BU assignment** tab with the **Update central unit** function.
- Additional **Include in distributed busbar system** check box for current transformers, circuit breakers, and disconnectors in the **Properties** tab.



[sc_bbp8_SLE_incl, 1, en_US]

Figure 3-155 Extension in the **Properties** Tab if the Distributed Busbar Protection is Available

Further Information

NOTE

Analog measured values, binary inputs, and binary outputs are routed across devices in the **IEC 61850 System Configurator**.

For a detailed description of how to use it as a Merging Unit/bay unit for the distributed busbar protection or distributed busbar protection (IEC 61850 compliant), refer to the **Project Engineering** chapter in the **Busbar Protection 7SS85** device manual.

For further information on the process bus, GOOSE, IEC 61850 System Configurator, descriptions of stream types, GOOSE Later Binding, VLAN priority, network redundancies, for example, PRP protocol or the sample and time synchronization using IEEE 1588, refer to the **Process Bus**, **Communication Protocols**, **IEC 61850 System Configurator** and the **DIGSI 5 Help** manuals.

4 Applications

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4.1 Overview

The Global DIGSI 5 library provides application templates for the applications of the devices. The application template

- Supports the fast realization of complete protection solutions for applications
- Contains the basic configuration for the use case
- Contains functions and default settings for the use case

EXAMPLE, Page 58 in chapter *2 Basic Structure of the Function* provides an example for the structure of an application template.

When using an application template, note the following:

- Adapt the application template to your specific use (check/adapt default settings, delete/add functions). You can find more detailed information in the *2.1 Embedding of Functions in the Device*.
- Check the routing of binary outputs with respect to fast and normal relays.
- Check the CFC charts for the group-warning indications and group-fault indications.

Application of the devices 7UT82, 7UT85, 7UT86, and 7UT87

The transformer differential protection **7UT8x** is a selective short-circuit protection for transformers of all voltage series, for longitudinal and shunt reactors, as well as for short lines. The devices contain all functions that you need for protection from transformers and are therefore universally applicable. The main protection function of the devices is the differential protection.

The following describes the application templates and maximum functional scope for the devices 7UT82, 7UT85, 7UT86, and 7UT87.



NOTE

The availability of certain settings and setting options depends on the device type and the functions available on the device!

Number of Measuring Points

The following table shows you the maximum number of device-dependent current and voltage measuring points, which are available to you.

Table 4-1 Number of the Possible Measuring Points per Device

Device	Number of Measuring Points			
	I-3ph	I-1ph	V-3ph	V-1ph
7UT82	2	2	–	–
7UT85	5	5	5	5
7UT86	7	7	7	7
7UT87	20	20	20	20

4.2 Application Templates and Functional Scope of the Device 7UT82

Application templates are available in **DIGSI 5** for the applications of the device 7UT82. The application templates contain the basic configurations, required functions, and default settings.

The following application templates are available for the device 7UT82 in the **DIGSI 5** function library:

- Two-winding transformer basic (87T)
- Two-winding transformer (87T, 50BF, 87N)
- Motor (87M)

So that the application templates function in the device, the following minimum hardware configuration requirements must be met:

Application Templates		Hardware Configuration
Template 1	Two-winding transformer basic (87T)	7 BI, 6 BO, 8 I (base module)
Template 2	Two-winding transformer (87T, 50BF, 87N)	7 BI, 6 BO, 8 I (base module)
Template 3	Motor (87M)	7 BI, 6 BO, 8 I (base module)

The following table shows the functional scope and the required function points of the application templates for device 7UT82:

Table 4-2 Functional Scope of the Application Template for the Device 7UT82

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3
37	Undercurrent	I<	X			
38	Temperature supervision	θ>	X			
46	Negative-sequence system overcurrent protection	I_2>, I_2/I_1>	X			
	Unbalanced-load protection (thermal)	$I^2_2(t)$	X			
49	Thermal overload protection	θ, I^2t	X	X	X	X
49H	Hotspot calculation	h, I^2t	X			
50/51 TD	Overcurrent protection, phases	I>, I_P>	X	X	X	X
50N/51N TD	Overcurrent protection, ground	I_N>, I_{NP}>	X		X	
	Overcurrent protection, 1-phase	I_N>	X			
50Ns/51Ns	Sensitive ground-current detection for systems with resonant-grounded or isolated neutral	I_{Ns}>, I_{NsP}>	X			
	Intermittent ground-fault protection	IIE>	X			
50HS	Instantaneous high-current tripping	I>>>	X			
	Instantaneous tripping at switch onto fault	SOTF	X			
50BF	Circuit-breaker failure protection	CBFP	X		X	

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3
50RS	Circuit-breaker restrike protection	CBRS	X			
	Circuit-breaker monitoring	∑Ix, I^2t, 2P	X			
74TC	Trip-circuit supervision	TCS	X	X	X	X
86	Lockout		X	X	X	X
87G	Generator differential protection	ΔI	X			
87M	Motor differential protection	ΔI	X			X
87T	Transformer differential protection	ΔI	X	X	X	
	Differential protection for phase-angle regulating transformer (single core)	ΔI	X			
87T Node	Differential protection (Node protection for auto transformer)	ΔI nodes	X			
87N T	Restricted ground-fault protection	ΔI_N	X		X	
AFD	Arc protection	AFD	X			
	Measured values, standard		X	X	X	X
	Measured values, extended: Min, Max, Avg (function points per type)		X			
	Switching statistic counters		X	X	X	X
	CFC standard		X	X	X	X
	CFC arithmetic		X			
	CFC switching sequences		X			
	Inrush-current detection		X	X	X	X
	External trip initiation		X			
	Control for 4 switching devices		X	X	X	X
	Fault recording of analog and binary signals		X	X	X	X
	Monitoring and supervision		X	X	X	X
	Protection interface, serial		X			
	Circuit breaker		X	X	X	X
	Disconnector/grounding switch		X			
Total function points:				0	30	0

Application Template: Two-winding transformer basic (87T)

The **`Two-winding transformer basic (87T)`** application template is preconfigured for the following applications:

- Transformer differential protection (default setting for Yd)
- Overload protection, backup protection for the downstream electrical power system

Application Template: Two-winding transformer (87T, 50BF, 87N)

The **`Two-winding transformer (87T, 50BF, 87N)`** application template is preconfigured for the following applications:

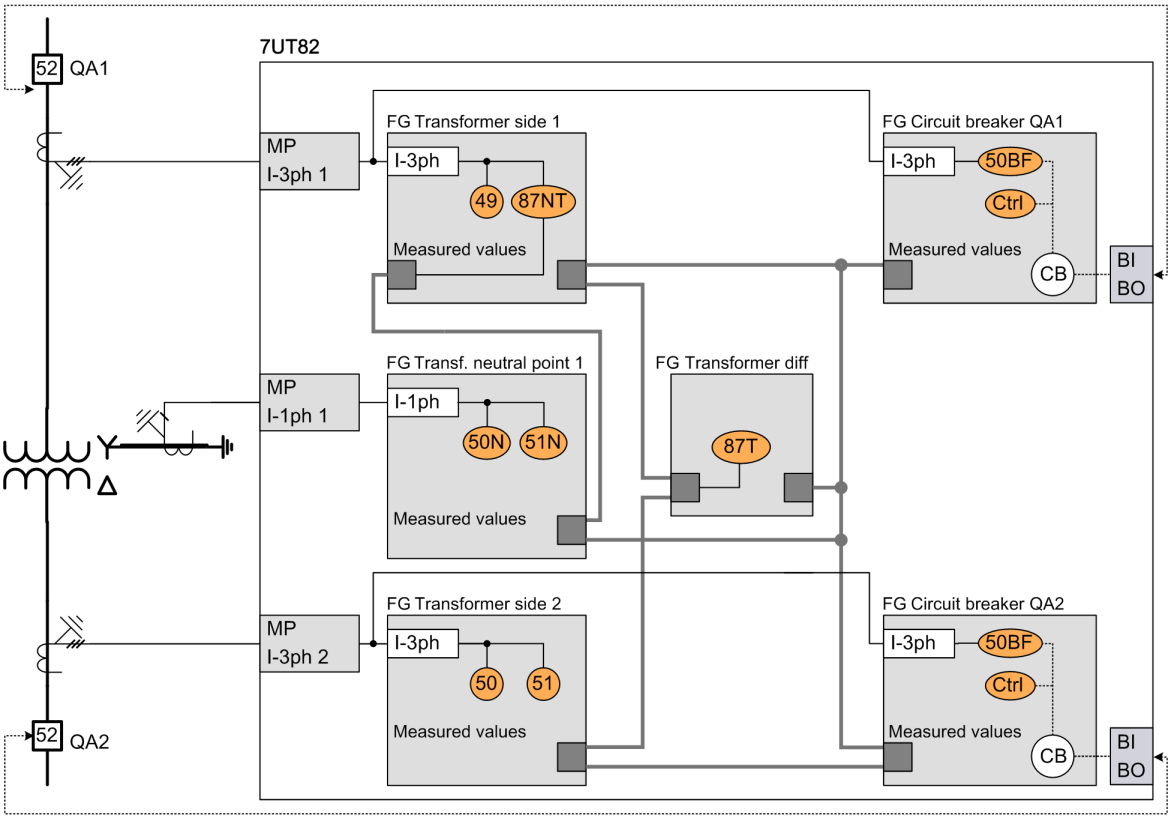
- Transformer differential protection (default setting for Yd)
- Restricted ground-fault protection on the star side
- Overload protection, backup protection for the downstream electrical power system
- Circuit-breaker failure protection

Application Template: Motor (87M)

The **`Motor (87M)`** application template is preconfigured for the following applications:

- Differential motor protection
- Overload protection, backup protection for the downstream electrical power system
- Circuit-breaker failure protection

The following *Figure 4-1* shows the structure of the application template **Transformer protection with restricted ground-fault protection**, the measuring points used, the function groups used, their internal circuiting, and the predefined functions.



[dwap2wik82-180314-01, 1, en_US]

Figure 4-1 Protection of a Two-Winding Transformer

4.3 Application Templates and Functional Scope of the Device 7UT85

Application templates are available in **DIGSI 5** for the applications of the device 7UT85. The application templates contain the basic configurations, required functions, and default settings.

The following application templates are available for the device 7UT85 in the **DIGSI 5** function library:

- Two-winding transformer basic (87T)
- Two-winding transformer (87T, 50BF, 87N)
- Two-winding transformer 1.5CB (87T, 50BF, 87N)
- Two-winding transformer (87T, 50BF, 90V)
- Motor (87M, 50BF, 59, 27, 81, 46, 49)

So that the application templates function in the device, the following minimum hardware configuration requirements must be met:

Application Templates		Hardware Configuration
Template 1	Two-winding transformer basic (87T)	7 BI, 7 BO, 8 I (base module)
Template 2	Two-winding transformer (87T, 50BF, 87N)	7 BI, 7 BO, 8 I (base module)
Template 3	Two-winding transformer 1.5CB (87T, 50BF, 87N)	Base module + expansion module with current inputs (for example, IO201)
Template 4	Two-winding transformer (87T, 50BF, 90V)	7 BI, 7 BO, 8 I (base module)
Template 5	Motor (87M, 50BF, 59, 27, 81, 46, 49)	7 BI, 7 BO, 8 I (base module)

The following table shows the functional scope and the required function points of the application templates for device 7UT85:

Table 4-3 Functional Scope of the Application Template for the Device 7UT85

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3	Template 4	Template 5
21/21N	Distance protection	Z<, V<, I>, ∠ (V/I)	X					
21T	Impedance protection for transformers	Z<	X					
24	Overexcitation protection	V/f	X					
25	Synchrocheck, synchronization function	Sync	X					
27	Undervoltage protection, 3-phase	V<	X					
	Undervoltage protection, positive-sequence system	V1<	X					
	Undervoltage protection, universal	Vx<	X					
27R, 59R	Rate-of-voltage-change protection	dV/dt	X					
32/37	Power protection active/reactive power	P<>, Q<>	X					
32R	Reverse-power protection	-P<	X					
37	Undercurrent	I<	X					
	Power-plant disconnection protection	-dP	X					
38	Temperature supervision	θ>	X					
46	Negative-sequence system overcurrent protection	I_2>, I_2/I_1>	X					X
	Unbalanced-load protection (thermal)	$I^2_2(t)$	X					

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3	Template 4	Template 5
47	Overvoltage protection, negative-sequence system	V2>	X					
	Overvoltage protection, negative-sequence/positive-sequence system	V2/V1>	X					
49	Thermal overload protection	θ, I^2t	X	X	X	X	X	X
	Thermal overload protection, user-defined characteristic		X					
49H	Hotspot calculation	h, I^2t	X					
50BF	Circuit-breaker failure protection	CBFP	X		X	X	X	X
50RS	Circuit-breaker restrike protection	CBRM	X					
	Circuit-breaker monitoring	∑Ix, I^2t, 2P	X					
50/51 TD	Overcurrent protection, phases	I>, I_P>	X	X	X	X	X	X
50N/51N TD	Overcurrent protection, ground	I_N>, I_{NP}>	X		X			
	Overcurrent protection, 1-phase	I_N>	X			X		
50Ns/51Ns	Sensitive ground-current detection for systems with resonant or isolated neutral	I_{Ns}>, I_{NsP}>	X					
	Intermittent ground-fault protection	IIE>	X					
50HS	Instantaneous high-current tripping	I>>>	X					
51V	Overcurrent protection, voltage dependent	t = f(I,V)	X					
59	Overvoltage protection, 3-phase	V>	X					
	Overvoltage protection, positive-sequence system	V1>	X					
	Overvoltage protection, universal	Vx>	X					
59N	Overvoltage protection, zero-sequence system	V0>	X					
60	Voltage-comparison supervision	ΔV>	X					
67	Directional overcurrent protection, phases	I>, I_P, ∠(V/I)	X					
67N	Directional overcurrent protection, ground	I_N>, I_{NP}, ∠(V/I)	X					X
67Ns	Sensitive ground-fault detection for systems with resonant or isolated neutral incl.: • V0> • cos/sinφ • Transient ground fault • φ(V,I) • Admittance • IN pulse	I_{Ns}>, ∠(V/I), W0p, tr>	X					
	Directional intermittent ground-fault protection	IIEdir>	X					
68	Power-swing blocking	ΔZ/Δt	X					
74CC	Closing-circuit supervision, 1 BI, 2 BI	CCS	X					
74TC	Trip-circuit supervision	TCS	X	X	X	X	X	

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3	Template 4	Template 5
79	Automatic reclosing, 3-pole	AR	X					
81O	Overfrequency protection	f>	X					
81U	Underfrequency protection	f<	X					
81R	Frequency change protection	df/dt	X					
81U	Underfrequency load shedding	f<(UFLS)	X					
	Vector-jump protection	Δφ>	X					
85/21	Teleprotection for distance protection		X					
85/27	Weak or no infeed: echo and tripping		X					
85/67N	Teleprotection for directional ground-fault protection		X					
86	Lockout		X	X	X	X	X	
87G	Generator differential protection	ΔI	X					
87L	Differential protection for lines with 2 ends	ΔI	X					
87M	Motor differential protection	ΔI	X					X
87 STUB	Stub-fault differential protection (for breaker-and-a-half layout)		X					
	Option for line differential protection: charging-current compensation	ΔI	X					
87T	Transformer differential protection	ΔI	X	X	X	X	X	
	Differential protection for phase-angle regulating transformer (single core)	ΔI	X					
	Differential protection for special transformers	ΔI	X					
87T Node	Differential protection (Node protection for auto transformer)	ΔI nodes	X					
87N T	Restricted ground-fault protection	ΔI_N	X		X	X		
90V	Voltage controller for two-winding transformer		X				X	
	Voltage controller for three-winding transformer		X					
	Voltage controller for grid coupling transformer		X					
FL	Fault locator, single-side Fault locator plus	FL-one FL+	X					
PMU	Synchrophasor measurement	PMU	X					
SOTF	Instantaneous tripping at switch onto fault	SOTF	X					
AFD	Arc protection	AFD	X					
	Measured values, standard		X	X	X	X	X	
	Measured values, extended: Min, Max, Avg (function points per type)		X					

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3	Template 4	Template 5
	Power Quality – Basic: • Voltage Variation • Voltage Unbalance • THD and Harmonics • Total Demand Distortion		X					
	Switching statistic counters		X	X	X		X	
	CFC standard		X	X	X	X	X	
	CFC arithmetic		X					
	CFC switching sequences		X					
	Inrush-current detection		X	X	X	X	X	
	External trip initiation		X			X		
	Control for 4 switching devices		X	X	X	X	X	
	Fault recording of analog and binary signals		X	X	X	X	X	
	Monitoring and supervision		X	X	X	X	X	
	Protection interface, serial		X					
	Circuit breaker		X	X	X	X	X	
	Point-on-wave switching[15]		X					
	Disconnector/grounding switch		X					
	Transformer side 7UT85		X					
	Access control		X	X	X	X	X	X
	Security logging		X	X	X	X	X	X
Total function points:				0	30	30	175	50

Application Template: Two-winding transformer basic (87T)

The **`Two-winding transformer basic (87T)`** application template is preconfigured for the following applications:

- Transformer differential protection (default setting for Yd)
- Overload protection, backup protection for the downstream electrical power system

Application Template: Two-winding transformer (87T, 50BF, 87N)

The **`Two-winding transformer (87T, 50BF, 87N)`** application template is preconfigured for the following applications:

- Transformer differential protection (default setting for Yd)
- Restricted ground-fault protection on the star side
- Overload protection, backup protection for the downstream electrical power system
- Circuit-breaker failure protection

15 This function is described in the Point-on-Wave Switching Manual

Application Template: Two-winding transformer 1.5CB (87T, 50BF, 87N)

The **Two-winding transformer 1.5CB (87T, 50BF, 87N)** application template is preconfigured for the following applications:

- Transformer differential protection (default setting for Yd)
- Restricted ground-fault protection on the star side
- Overload protection, backup protection for the downstream electrical power system
- Circuit-breaker failure protection

Application Template: Two-winding transformer (87T, 50BF, 90V)

The **Two-winding transformer (87T, 50BF, 90V)** application template is preconfigured for the following applications:

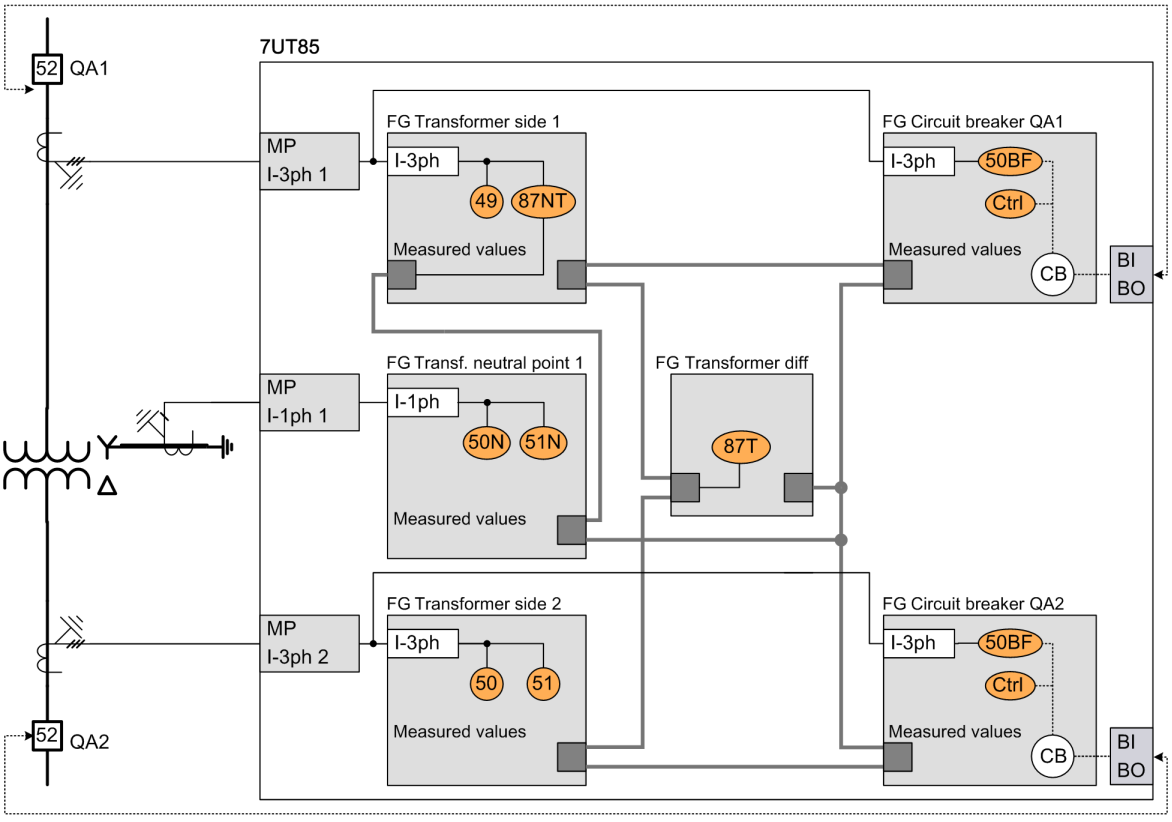
- Transformer differential protection (default setting for Yd)
- Overload protection, backup protection for the downstream electrical power system
- Circuit-breaker failure protection
- Voltage controller

Application Template: Motor (87M, 50BF, 59, 27, 81, 46, 49)

The **Motor (87M, 50BF, 59, 27, 81, 46, 49)** application template is preconfigured for the following applications:

- Differential motor protection
- Overload protection, backup protection for the downstream electrical power system
- Frequency and voltage protection on the upper-voltage side
- Circuit-breaker failure protection

The following *Figure 4-2* shows the structure of the application template **Transformer protection with restricted ground-fault protection**, the measuring points used, the function groups used, their internal circuiting, and the predefined functions.



[dwap2wiklr-151013, 3, en_US]

Figure 4-2 Protection of a Two-Winding Transformer

4.4 Application Templates and Functional Scope of the Device 7UT86

Application templates are available in **DIGSI 5** for the applications of the device 7UT86. The application templates contain the basic configurations, required functions, and default settings.

The following application templates are available for the device 7UT86 in the **DIGSI 5** function library:

- Three-winding transformer basic (87T)
- Three-winding transformer 1.5CB (87T, 50BF, 87N)
- Three-winding transformer (87T, 50BF, 87N, 21)
- Auto transformer (87T, 87N, 50BF)
- Auto transformer 1.5CB (2 x 87T, 50BF, 59, 81)

The application templates for a two-winding application can also be used in a 7UT86.

You can find more information in *4.3 Application Templates and Functional Scope of the Device 7UT85*.

So that the application templates function in the device, the following minimum hardware configuration requirements must be met:

Application Templates		Hardware Configuration
Template 1	Three-winding transformer basic (87T)	11 BI, 19 BO, 12 I, 4 V
Template 2	Three-winding transformer 1.5CB (87T, 50BF, 87N)	11 BI, 19 BO, 12 I, 4 V
Template 3	Three-winding transformer (87T, 50BF, 87N, 21)	11 BI, 19 BO, 12 I, 4 V
Template 4	Auto transformer (87T, 87N, 50BF)	11 BI, 19 BO, 12 I, 4 V
Template 5	Auto transformer 1.5CB (2 x 87T, 50BF, 59, 81)	23 BI, 34 BO, 12 I, 4 V

The following table shows the functional scope and the required function points of the application templates for device 7UT86:

Table 4-4 Functional Scope of the Application Template for the Device 7UT86

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3	Template 4	Template 5
21/21N	Distance protection	Z<, V<, I>, ∠ (V/I)	X			X		
21T	Impedance protection for transformers	Z<	X					
24	Overexcitation protection	V/f	X					
25	Synchrocheck, synchronization function	Sync	X					
27	Undervoltage protection, 3-phase	V<	X					
	Undervoltage protection, positive-sequence system	V1<	X					
	Undervoltage protection, universal	Vx<	X					
27/Q	Undervoltage-controlled reactive power protection	V</Q>	X					
27R, 59R	Rate-of-voltage-change protection	dV/dt	X					
37	Power-plant disconnection protection	-dP	X					
32/37	Power protection active/reactive power	P<>, Q<>	X					
32R	Reverse-power protection	-P<	X					
37	Undercurrent	I<	X					
38	Temperature supervision	θ>	X					

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3	Template 4	Template 5
46	Negative-sequence system overcurrent protection	$I_2>$, $I_2/I_1>$	X					
	Unbalanced-load protection (thermal)	$I^2_2(t)$	X					
47	Overvoltage protection, negative-sequence system	V2>	X					
	Overvoltage protection, negative-sequence/positive-sequence system	V2/V1>	X					
49	Thermal overload protection	θ, I^2t	X		X	X	X	X
	Thermal overload protection, user-defined characteristic		X					
49H	Hotspot calculation	h, I^2t	X					
50BF	Circuit-breaker failure protection	CBFP	X		X	X	X	X
50RS	Circuit breaker restrike protection	CBRM	X					
	Circuit-breaker monitoring	∑Ix, I^2t, 2P	X					
50/51	Positive-sequence system overcurrent protection	I>	X					
50/51 TD	Overcurrent protection, phases	I>, $I_P>$	X		X	X	X	X
50N/51N TD	Overcurrent protection, ground	$I_N>$, $I_{NP}>$	X					
	Overcurrent protection, 1-phase	$I_N>$	X		X	X	X	
50Ns/51Ns	Sensitive ground-current detection for systems with resonant or isolated neutral	$I_{Ns}>$, $I_{NsP}>$	X					
	Intermittent ground-fault protection	IIE>	X					
50HS	Instantaneous high-current tripping	I>>>	X					
50N/51N TD	Overcurrent protection, 1-phase	$I_N>$	X					
51V	Overcurrent protection, voltage dependent	t = f(I,V)	X					
59	Overvoltage protection, 3-phase	V>	X					
	Overvoltage protection, positive-sequence system	V1>	X					
	Overvoltage protection, universal	Vx>	X					
59N	Overvoltage protection, zero-sequence system	V0>	X					
60	Voltage-comparison supervision		X					
67	Directional overcurrent protection, phases	I>, I_P, ∠(V/I)	X					
67N	Directional overcurrent protection, ground	$I_N>$, I_{NP}, ∠(V/I)	X					
	Directional overcurrent ground-fault protection in grounded systems		X					

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3	Template 4	Template 5
67Ns	Sensitive ground-fault detection for systems with resonant-grounded or isolated neutral, incl. • V0> • cos/sinφ • Transient ground fault • φ(V,I) • Admittance • IN pulse	I_{Ns}>, ∠(V/I), W0p, tr>	X					
	Directional intermittent ground-fault protection	IIEdir>	X					
68	Power-swing blocking	ΔZ/Δt	X					
74TC	Trip-circuit supervision	TCS	X	X	X	X	X	X
74CC	Closing-circuit supervision, 1 BI, 2 BI	CCS	X					
79	Automatic reclosing, 3-pole	AREC	X					
81O	Overfrequency protection	f>	X					
81U	Underfrequency protection	f<	X					
81R	Frequency change protection	df/dt	X					
81U	Underfrequency load shedding	f<(UFLS)	X					
85/21	Teleprotection for distance protection		X					
85/27	Weak or no infeed: echo and tripping		X					
85/67N	Teleprotection for directional ground-fault protection		X					
86	Lockout		X	X	X	X	X	X
87G	Generator differential protection	ΔI	X					
87L	Differential protection for lines with 2 ends	ΔI	X					
87M	Motor differential protection	ΔI	X					
87 STUB	Stub-fault differential protection (for breaker-and-a-half layout)		X					
87T	Transformer differential protection	ΔI	X	X	X	X	X	X
	Differential protection for phase-angle regulating transformer (single core)	ΔI	X					
	Differential protection for special transformers	ΔI	X					
87T Node	Transformer differential protection (intersection protection for auto transformers)	ΔI (nodes)	X					X
87N T	Restricted ground-fault protection	$ΔI_N$	X		X	X	X	
90V	Voltage controller for two-winding transformer		X					
	Voltage controller for three-winding transformer		X					
	Voltage controller for grid coupling transformer		X					

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3	Template 4	Template 5
FL	Fault locator, single-side Fault locator plus	FL-one FL+	X					
PMU	Synchrophasor measurement	PMU	X					
SOTF	Instantaneous tripping at switch onto fault	SOTF	X					
AFD	Arc protection	AFD	X					
	Vector-jump protection	Δφ>	X					
	Measured values, standard		X	X	X	X	X	X
	Measured values, extended: Min, Max, Avg (function points per type)		X					
	Power Quality – Basic: • Voltage Variation • Voltage Unbalance • THD and Harmonics • Total Demand Distortion		X					
	Switching statistic counters		X					
	CFC standard		X	X	X	X	X	X
	CFC arithmetic		X					
	CFC switching sequences		X					
	Inrush-current detection		X		X	X	X	X
	External trip initiation		X					
	Control for 4 switching devices		X	X	X	X	X	X
	Fault recording of analog and binary signals		X	X	X	X	X	X
	Monitoring and supervision		X	X	X	X	X	X
	Protection interface, serial		X					
	Circuit breaker		X	X	X	X	X	X
	Point-on-wave switching[16]		X					
	Disconnector/grounding switch		X					
	Transformer side 7UT86		X					
	Access control		X	X	X	X	X	X
	Security logging		X	X	X	X	X	X
Total function points:				0	50	150	30	30

Application Template: Three-winding transformer basic (87T)

The **`Three-winding transformer basic (87T)`** application template is preconfigured for the following applications:

- Transformer differential protection (default setting for Ydxdy)

16 This function is described in the Point-on-Wave Switching Manual

Application Template: Three-winding transformer 1.5CB (87T, 50BF, 87N)

The **Three-winding transformer 1.5CB (87T, 50BF, 87N)** application template is preconfigured for the following applications:

- Transformer differential protection (default setting for YNdxdx)
- Restricted ground-fault protection on the star side
- Ground current protection on the neutral side as backup protection for the electrical power system
- Overload protection
- Frequency and voltage protection on the neutral side
- Circuit-breaker failure protection

Application Template: Three-winding transformer (87T, 50BF, 87N, 21)

The **Three-winding transformer (87T, 50BF, 87N, 21)** application template is preconfigured for the following applications:

- Transformer differential protection (default setting for YNdxdx)
- Restricted ground-fault protection on the star side
- Ground current protection on the neutral side as backup protection for the electrical power system
- Overload protection
- Frequency and voltage protection on the neutral side
- Circuit-breaker failure protection
- Distance protection

Application Template: Auto transformer (87T, 87N, 50BF)

The **Auto transformer (87T, 87N, 50BF)** application template is preconfigured for the following applications:

- Transformer differential protection for the entire transformer (auto winding and stabilizing winding)
- Restricted ground-fault protection (neutral point and maximum side current)
- Overload protection, backup protection for the downstream electrical power system
- Circuit-breaker failure protection

Application Template: Auto transformer 1.5CB (2 x 87T, 50BF, 59, 81)

The **Auto transformer 1.5CB (2 x 87T, 50BF, 59, 81)** application template is preconfigured for the following applications:

- Transformer differential protection for the entire transformer (auto winding and stabilizing winding)
- Node-point protection for the auto winding for recording ground faults (3-phase recording of the neutral-point current)
- Overload protection, backup protection for the downstream electrical power system
- Frequency and voltage protection on the upper-voltage side
- Circuit-breaker failure protection

To display the different, and at the same time new, options, 5 application templates are described in detail.

Application Template: Three-Winding Transformer in a Breaker-and-a-half Layout

The 1st application is the template for protection of a three-winding transformer in a breaker-and-a-half layout. You can recognize the 3 required function groups for the transformer side, the integration of the restricted ground-fault protection as well as the internal circuiting, and selected functions. In addition, a voltage transformer is available on the upper-voltage side. Here, for example, voltage and frequency limits can be monitored. The required protection settings are made depending on the system.

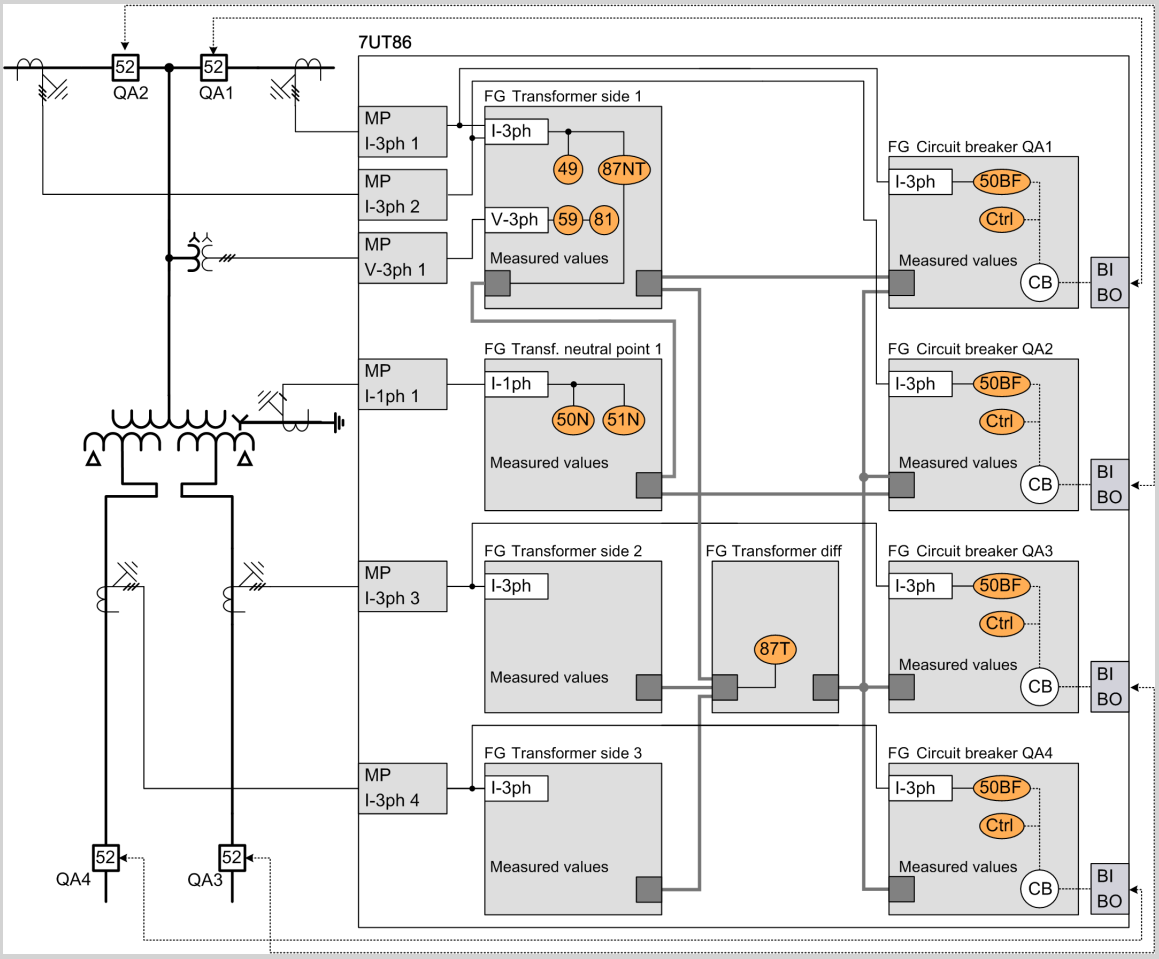


Figure 4-3 Protection of a Three-Winding Transformer

Application Template: Protection of an Auto-Transformer Bank in a Breaker-and-a-Half Layout

The 2nd application is the template for protection of an auto-transformer bank, which is connected to a breaker-and-a-half layout. The special feature of this application is that per phase the neutral-point side current is directly recorded. A separate node-point differential protection via the auto winding reliably records ground faults and winding shorts. There are 2 differential protection functions (87T and 87TNode) assigned across the entire transformer (auto and stabilizing winding). Both functions run in the **Auto transformer** function group.

Through this type of execution you have a redundant, differential protection supplemented in sensitivity. A separate restricted ground-fault protection is not required. In addition, a voltage transformer is available on the upper-voltage side. Here, for example, voltage and frequency limits can be monitored. The required protection settings are made depending on the system.

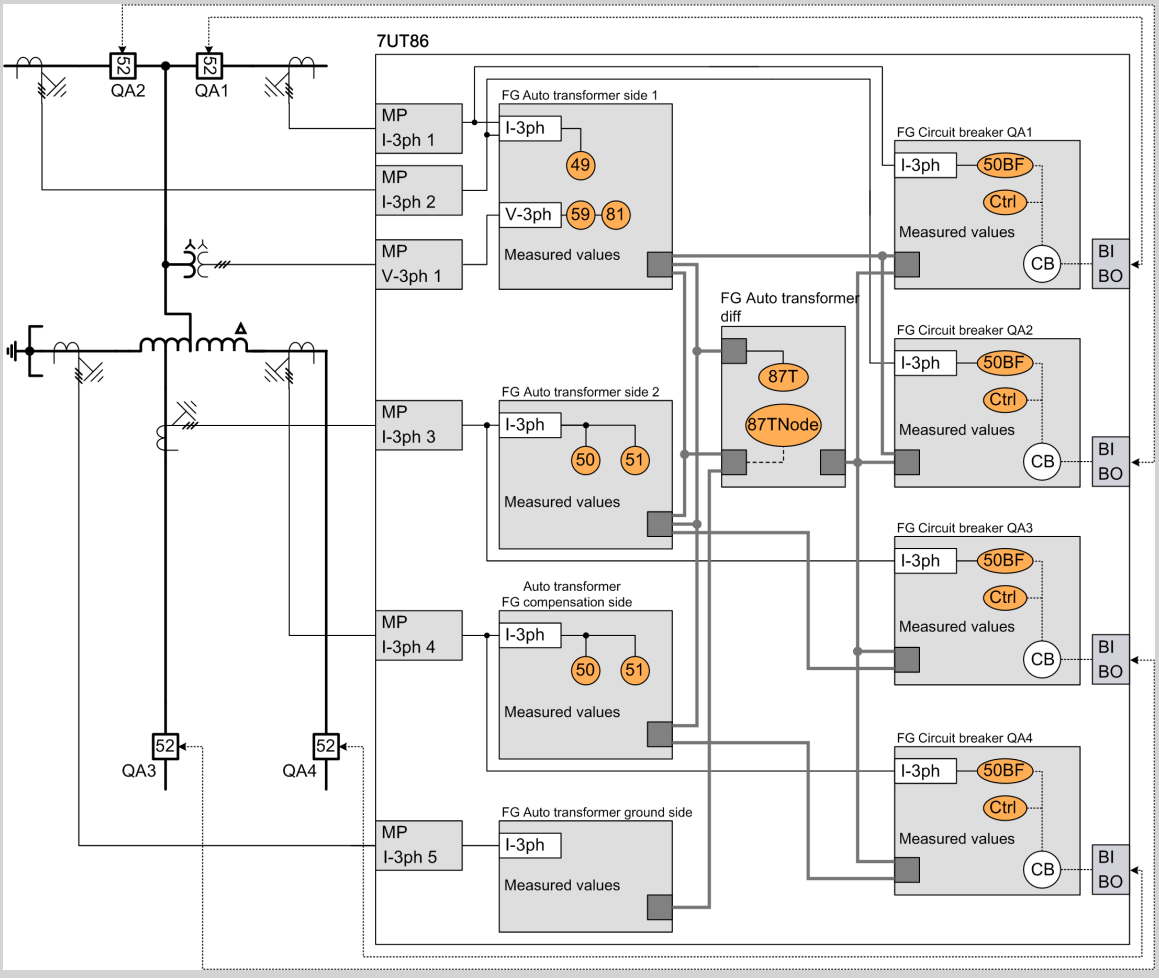


Figure 4-4 Protection of an Auto-Transformer Bank

Application Template: Motor Protection

The 3rd application is the template for motor protection. You can see the 2 function groups that are required for the motor sides as well as the circuiting, and selected functions. In addition, a voltage transformer is available on the upper-voltage side. Here, for example, voltage and frequency limits can be monitored. The required protection settings are made depending on the system.

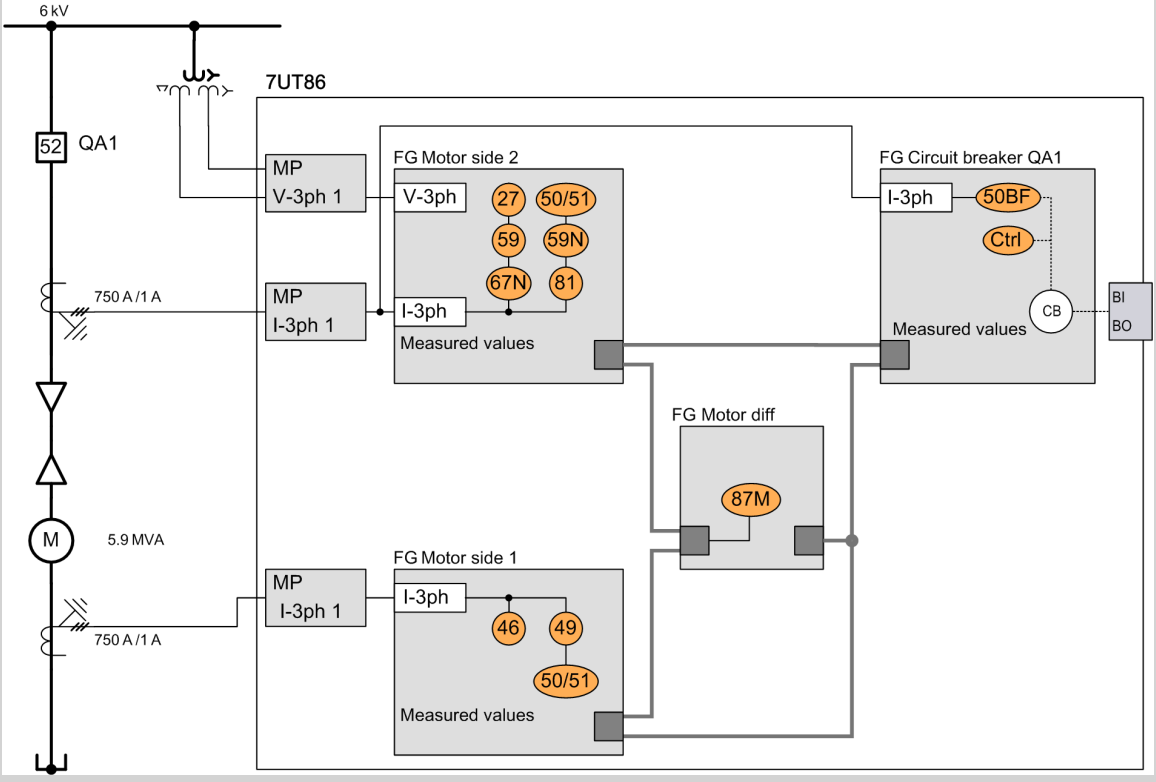


Figure 4-5 Motor Protection

Application Template: Control/Feedback Control of Power Transformers

The 4th application is the template for control/feedback control of power transformers (two-winding transformers, three-winding transformers or grid coupling transformers) and auto transformers using a motor-operated tap changer with transformer voltage regulator functionality (ANSI 90 V).

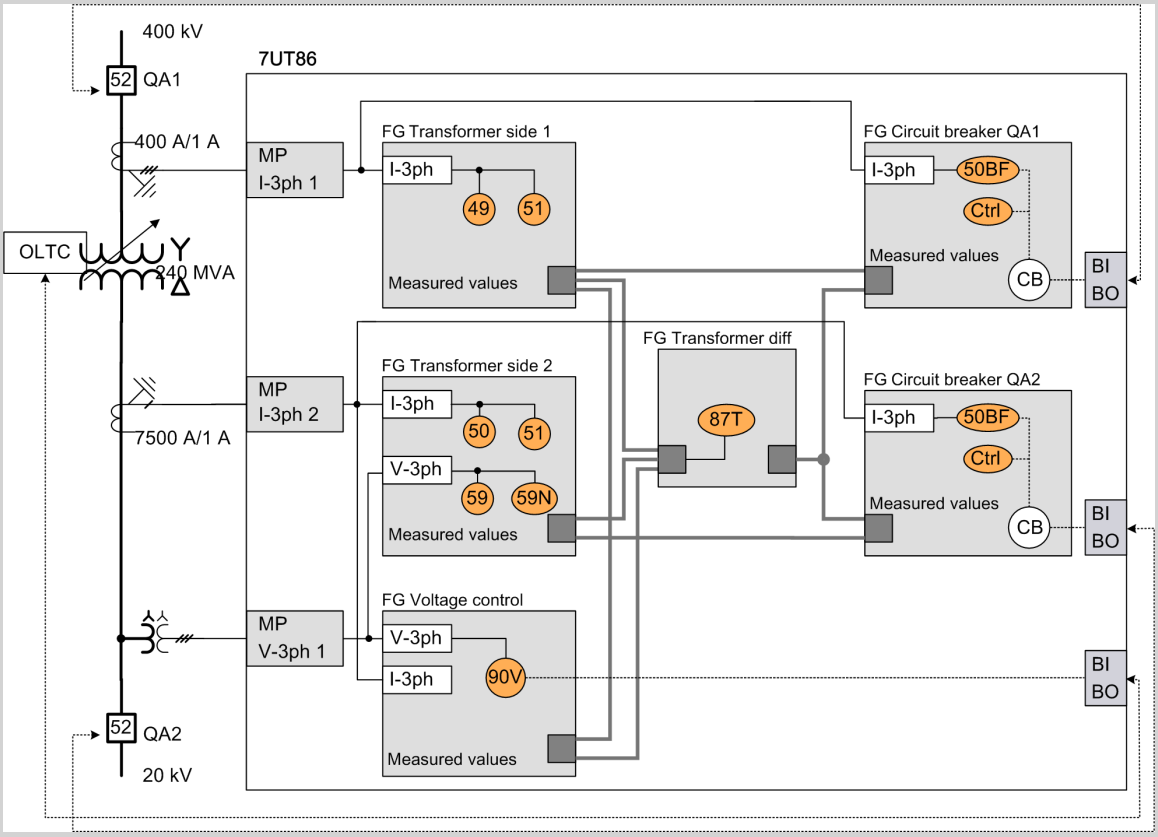


Figure 4-6 Transformer Protection with Voltage Control Functionality

Application Template: Protection of a Three-Winding Transformer with Distance Protection

The 5th application is the template for protection of a three-winding transformer. The neutral-point current of the upper-voltage side is measured and taken into account for the differential protection. In addition, restricted ground-fault protection is instantiated for the upper-voltage side. A special feature of this application is the additional protection for the feeder on the 3rd side. The distance protection used trips the circuit breaker for this feeder if there is a fault in the line. If the distance protection is only tripped at the tripping stage **Z4 non-directional** due to the power system or error conditions, circuit breaker 1 of the transformer feed is tripped.

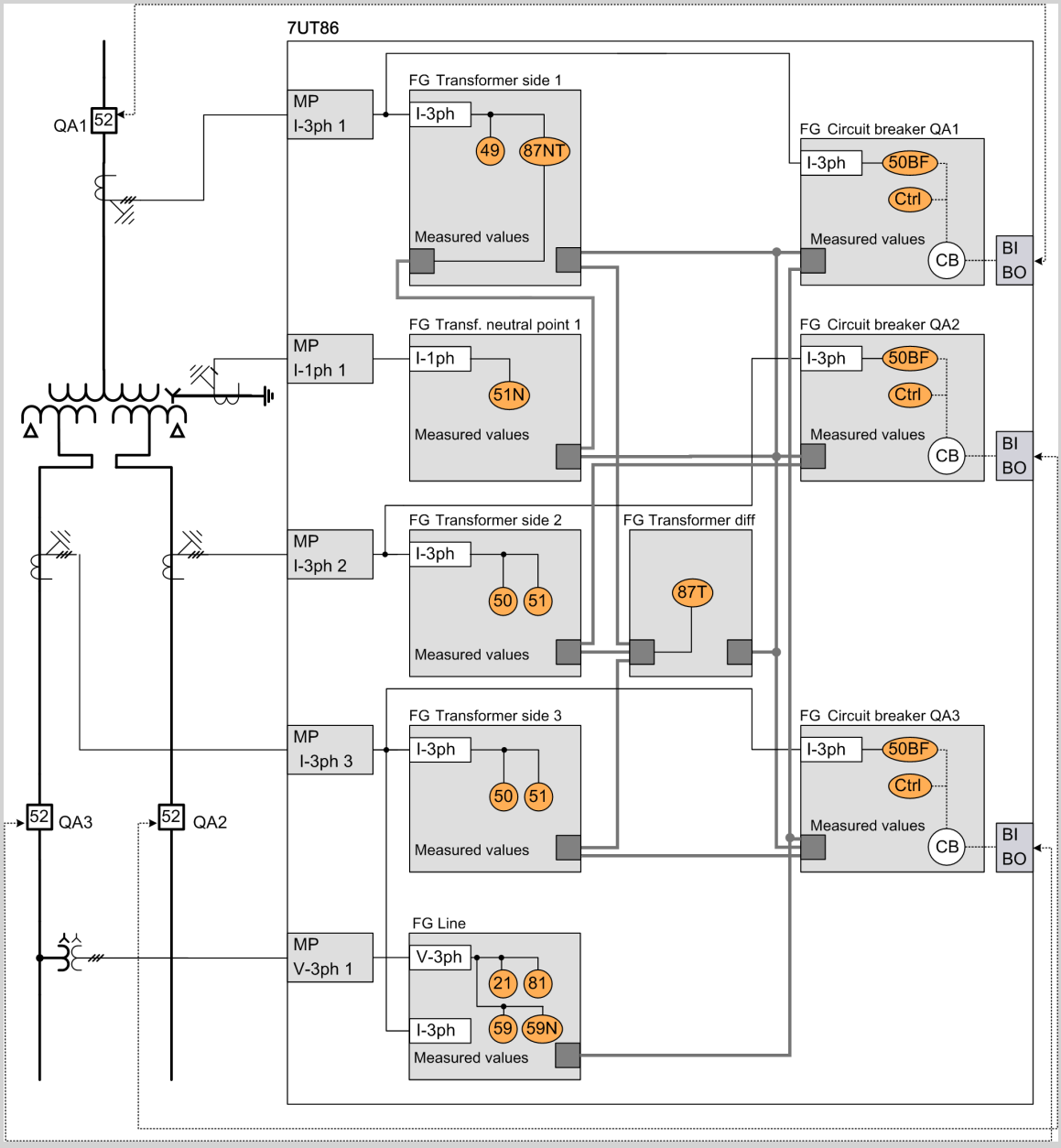


Figure 4-7 Three-Winding Transformer with Distance Protection

4.5 Application Templates and Functional Scope of the Device 7UT87

Application templates are available in **DIGSI 5** for the applications of the device 7UT87. The application templates contain the basic configurations, required functions, and default settings.

All application templates, which were described for the devices 7UT82, 7TUT85, and 7UT86, can be implemented in 7UT87.

Besides the functional scope of the 7UT86, the **Differential protection for phase-angle regulating transformers (Two-Core PST)** function is available.

The 7UT87 is intended for special applications (up to 5 sides and 7 measuring points), therefore, create your own application template depending on the application. Save this template with the device. To make your work easier, you can use an available template and modify it. Application suggestions can be taken from the device catalog **Transformer Differential Protection 7UT82, 7UT85, 7UT86, 7UT87**.

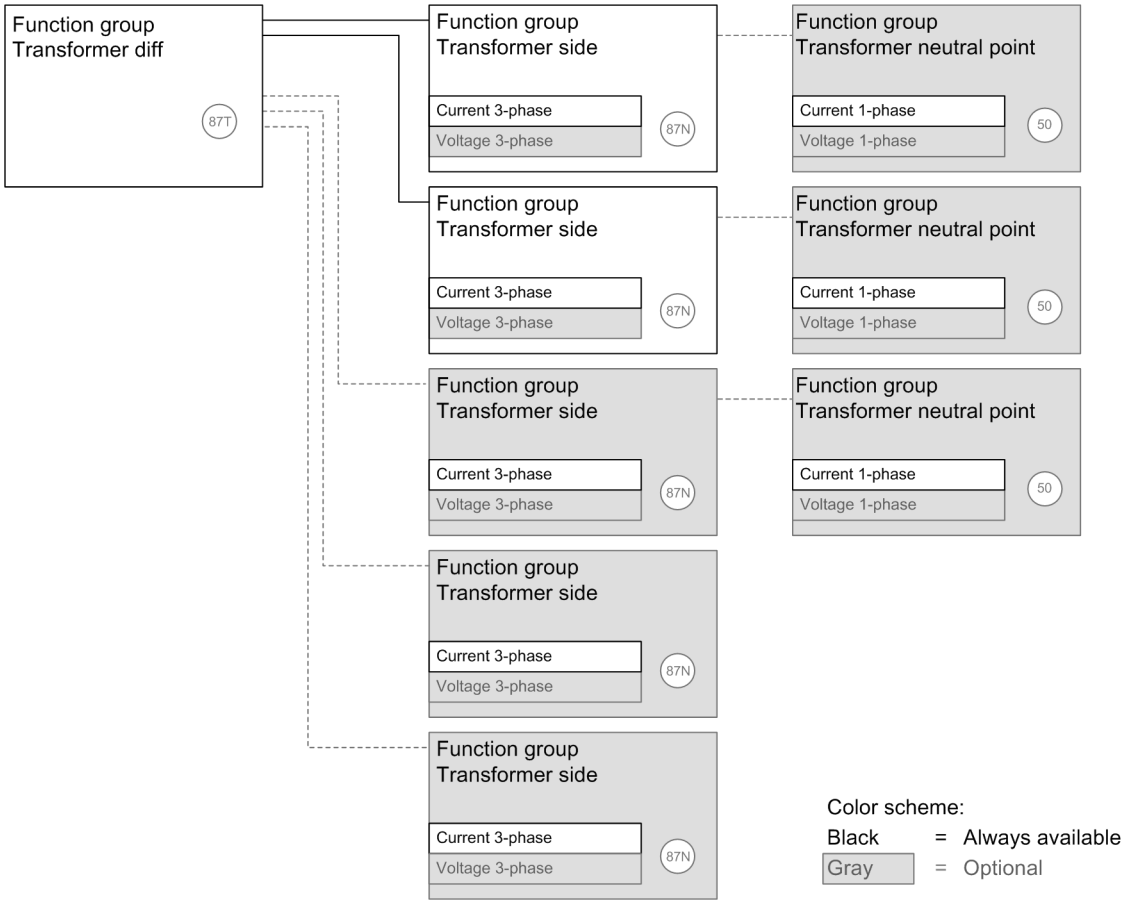
5 Function-Group Types and Bay Proxy

5.1	Overview Function Group Transformer Differential Protection	300
5.2	Function-Group Type Auto Transformer Differential Protection	322
5.3	Overview Function Group Motor Differential Protection	361
5.4	Overview Function Groups Generator Differential Protection	375
5.5	Function-Group Type Line	376
5.6	Function-Group Type Voltage 3-Phase	400
5.7	Function-Group Type Voltage/current 1-Phase	403
5.8	Function-Group Type Voltage/current 3-Phase	408
5.9	Function-Group Type Circuit Breaker	414
5.10	Function-Group Type Circuit Breaker [without Current]	433
5.11	Function-Group Type Analog Units	449
5.12	Function-Group Recording	520
5.13	Bay Proxy	522
5.14	Process Monitor	532

5.1 Overview Function Group Transformer Differential Protection

5.1.1 Function-Group Types

In the following graphic, you can see the structural association of the function-group types.



[dwfguebt-291112-01.tif, 1, en_US]

Figure 5-1 Transformer Diff Function-Group Types

The following function-group types are summarized in the Global DIGSI 5 library:

- **Transf. diff.**
- **Transformer side**
- **Transf. neutral point** (transformer neutral point)

The individual function group types are stored in the **Transformer diff function group** folder and can be selected. In the protection function folders, you find all protection functions which are operational in each function group. A **Transf. diff.** function group always contains 2 **Transformer side** function groups. The **Transf. neutral point** function group can be connected if needed with the **Transformer side** function group.

The following table shows the number of function-group types that can be instantiated depending on the device (7UT82, 7UT85, 7UT86, 7UT87).

NOTE

By purchasing 70 or 120 function points, the 7UT85 and 7UT86 can be expanded to a three-winding transformer or a multi-winding transformer. Provide the respective number of measuring inputs that are required for the expansion.

Table 5-1 Function-Group Types in the Device

Device	Function-Group Type		
	Transf. Diff.	Transformer Side	Transf. Neutral-Point Function Group
7UT82	Max. 1	Max. 2	Max. 2
7UT85	Max. 1	Max. 3 (2 open)	Max. 2
7UT86	Max. 1	Max. 4 (3 open)	Max. 3
7UT87	Max. 3	Max. 7	Max. 5

In order for the transformer protection to operate properly, switching of the function group is necessary. *Table 5-2* provides an overview of those switching options that are permitted. The Circuit-breaker function group is not listed. The figures shown in the application templates (see *Figure 4-2* to *Figure 4-7*) offer a good overview of the interconnection options.

A **Transformer side** function group must always be connected with the **Transformer Diff.** function group. Depending on the application, an interconnection of the **Transf. neutral point** function group with the **Transformer side** function group is required. This is the case, for example, if a restricted ground-fault protection is used or if the neutral point current in the differential protection should be considered (zero-sequence current correction). The reverse can also be the case, that the **Transf. neutral point** needs signals from the **Transf. diff.** function group. A typical case is the inrush-current detection, which can be used for blocking a 1-phase overcurrent protection (with a short time delay set).

Table 5-2 Assignment of Protection Function Groups to Protection Function Groups

Winding	Transf. Diff. 1	Transformer Side 1	Transformer Side 2
	Side (2 ... 5)	Neutral-Point Function Group (0 ... 1)	Neutral-Point Function Group (0 ... 1)
Transformer side 1	X	-	-
Transformer side 2	X	-	-
Transformer side 3 [17]	X	-	-
Transformer side 4 [18]	X	-	-
Transformer side 5 [19]	X	-	-
Transf. neutral point 1	-	X	
Transf. neutral point 2	-		X

The individual function-group types are described in the following.

5.1.2 Function-Group Type Transformer Differential Protection

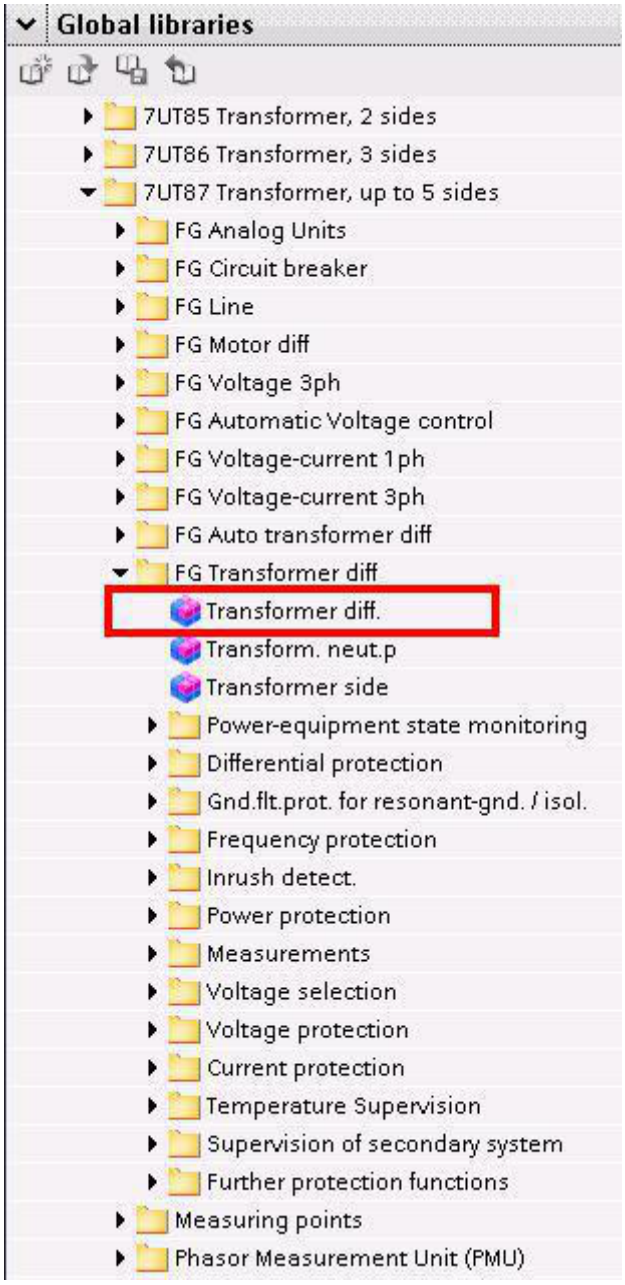
5.1.2.1 Overview

The **Transf. diff.** function group contains the differential protection function and protection function relevant measured values.

You can find more information in chapter *9 Measured Values, Energy Values, and Supervision of the Primary System*.

You will find the corresponding function groups and also the folders with the usable protection functions in the Global DIGSI library under each device type. You can only load the Differential protection function in the **Transf. diff.** function group.

17 depending on device and application
18 depending on device and application
19 depending on device and application



[scpowtrf-230114-01-DE, 1, en_US]

Figure 5-2 Transformer Diff. Function Group - Functional Scope for Device Type 7UT87

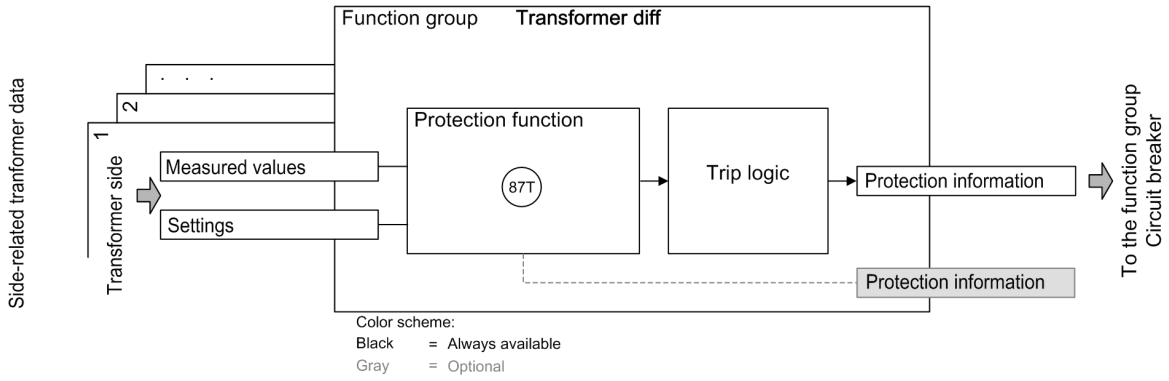
For more information about the embedding of the functions in the device, please refer to chapter *2 Basic Structure of the Function*. For information about the overall functional scope of the application templates for the various device types, please refer to chapter *4 Applications*.

5.1.2.2 Structure of the Function Group

The **Transf. diff.** function group according to *Figure 5-3* has interfaces with the **Transformer side** and **Circuit breaker** function groups. The **Transf. diff.** function group contains the function blocks:

- Protection function (execution of the differential protection function)
- Trip logic (generation of forwarding of the operate indication)

In order for the protection functionality to be guaranteed, the differential protection function must always be present in the **Transf. Diff.** function group. If you do not use an application template, load this from the Global DIGSI 5 library.



[dwpwrtrf-201112-01.tif, 1, en_US]

Figure 5-3 Structure of the Transformer Differential Function Group

The **Transf. diff.** function group has interfaces to the following function groups:

- **Transformer side** function group
- **Circuit-breaker** function group

Interface with the Transformer Side Function Group

The **Transf. diff.** function group receives the required measured values via the interface to the **Transformer side** function group. In addition, the required parameters are transferred.

When an application template is used, the **Transf. diff.** function group is connected with the required measuring points.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the **Transf. diff.** function group and the **Circuit-breaker** function group via the interface of the **Circuit-breaker** function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the Protection function groups

The **Transf. diff.** function group is connected with one or more circuit-breaker function groups. This connection determines the following data:

- Which circuit breakers are activated by the protection functions of the **Transf. diff.** function group
- Start of the **Circuit-breaker failure protection** function, if available in the circuit-breaker function group, through the protection functions of the connected protection function group **Transf. diff.**

In addition to the general assignment of the **Transf. diff.** function group to the Circuit-breaker function groups, you can configure the interface in detail for specific functionalities. Configure the details in DIGSI 5 using the **Circuit-breaker interaction** editor in the **Transf. diff.** function group.

In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the **Circuit-breaker failure protection** function?

If an application template is used, the function groups are connected to each other because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter *2.1 Embedding of Functions in the Device*.

Interface with Protection Communication (Optional)

All required data is exchanged between the protection function group and the protection communication via the interface with **Protection communication** . These data are for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter *3.6 Protection Communication*.

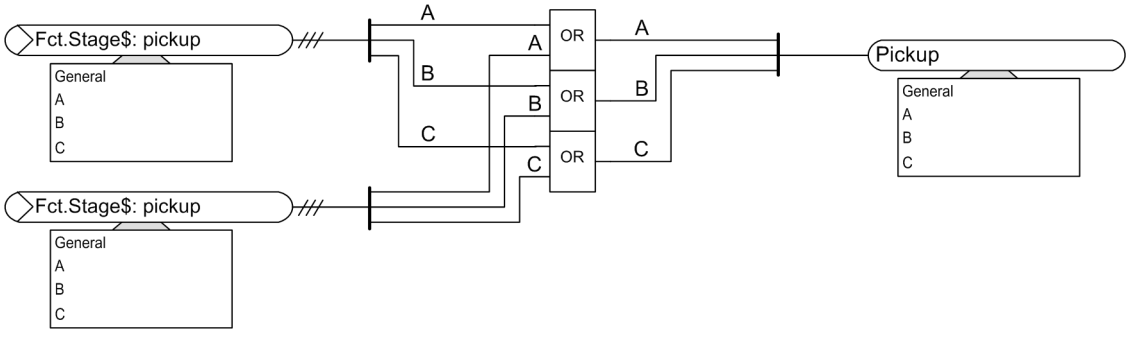
Transformer Data (Side-Related)

The transformer data characterize the data of the transformer to be protected. The **Transf. diff.** function group takes these data from the coupled **Transformer side** function group.

Output Logic

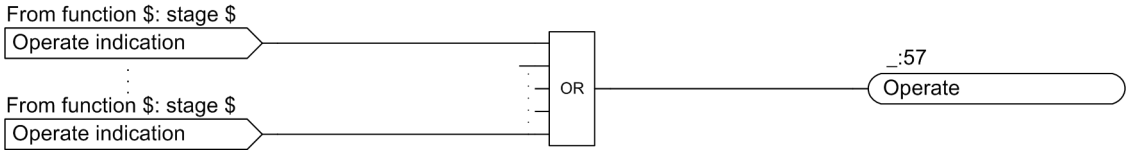
The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately, in a pickup logic and an output logic respectively. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the **Protection information** interface to the **Circuit-breaker** function group and are processed further there.

The pickup and trip signals of the protection functions in the**Transf. diff.** function group are combined phase-selectively and output as a group indication.



[lo_anrlin, 3, en_US]

Figure 5-4 Generation of Pickup Indication of the Transf. Diff. Function Group



[lo_auslin, 3, en_US]

Figure 5-5 Generation of Operate Indication of the Transf. Diff. Function Group

5.1.2.3 Information List

No.	Information	Data class (type)	Type
Generic			
_:91:52	General: State	ENS	O
_:91:53	General: State	ENS	O
Group indication			
_:4501:55	Group indication: pickup	ACD	O
_:4501:57	Group indication: operate indication	ACT	O

No.	Information	Data class (type)	Type
Reset LED FG			
_:7381:500	Reset LED FG: >LED reset	SPS	I
_:7381:320	Reset LED FG: LED reset	SPS	O

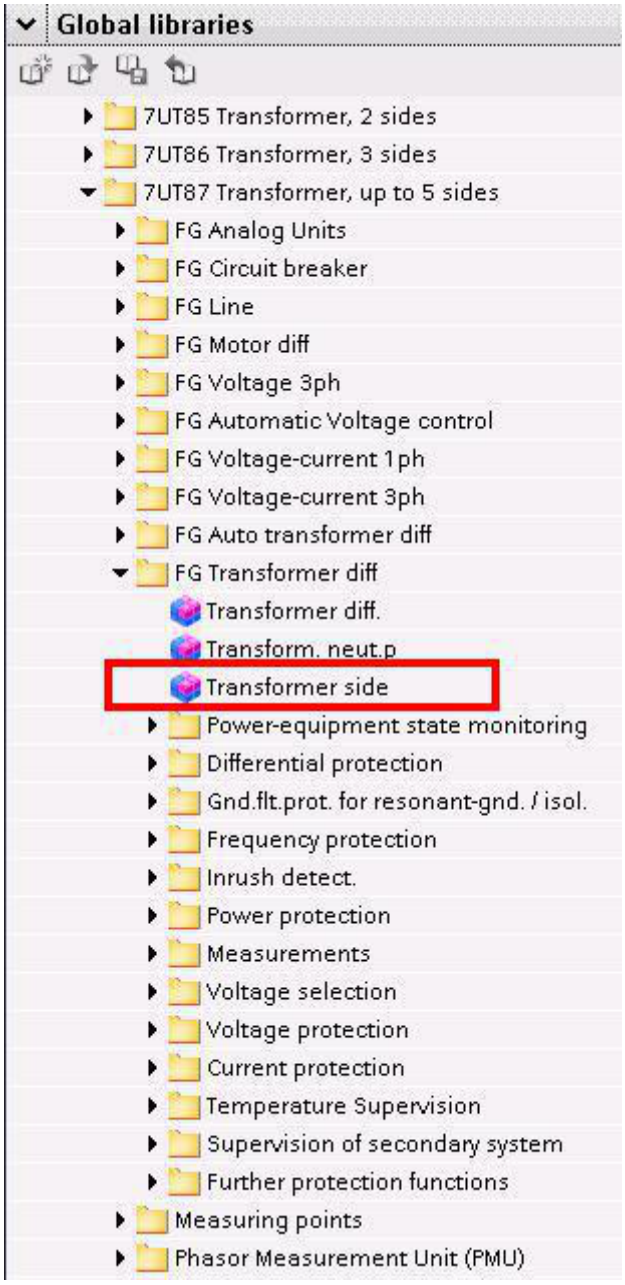
5.1.3 Function-Group Type Transformer Side

5.1.3.1 Overview

In the **Transformer side** function group, all of the functions that are necessary for protecting and monitoring a transformer side can be used. The **Transformer side** function group also contains the measuring functions. You can find more information in chapter *9 Measured Values, Energy Values, and Supervision of the Primary System*.

The **Transformer side** function group must always have an interfacing to the **Transformer** function group.

You will find the **Transformer side** function group and the folder with the respective protection functions under each device type in the Global DIGSI 5 library. Depending on the connected measuring points, you can load the respective protection and supervision functions in the **Transformer side** function group. The application templates show you the possible applications. The functions are described in chapter *6 Protection and Automation Functions*.



[scpowsit-230114-01-DE, 1, en_US]

Figure 5-6 Transformer Side Function Group - Functional Scope for Device Type 7UT87

For more information about the embedding of the functions in the device, refer to *2 Basic Structure of the Function*. For information about the overall functional scope of the application templates for the various device types, refer to *4 Applications*.

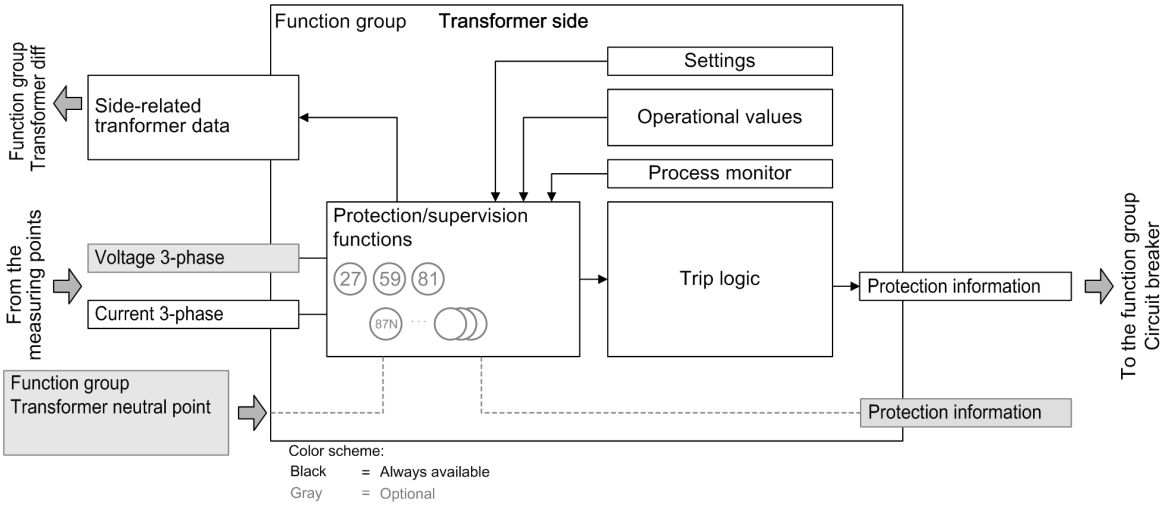
5.1.3.2 Structure of the Function Group

The **Transformer side** function group always contains the following function blocks:

- Side-dependent transformer data
- Operational measured values
- Process monitor
- Output logic of the function group

These blocks are required for the **Transformer side** function group and therefore cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the **Transformer side** function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.



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Figure 5-7 Structure of the Transformer Side Function Group

The **Transformer side** function group has interfaces with the following function groups: Measuring points

- **Measuring points**
- **Circuit-breaker** function group
- **Transformer diff.** function group
- **Transformer neutral point** function group

Interfaces with Measuring Points

The **Transformer side** function group receives the required measured values via its interfaces with the measuring points.

If you are using an application template, the **Transformer side** function group is connected to the necessary measuring points.

If you add functions to the **Transformer side** function group, they will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the **Function-group connections** Editor.

You can find more detailed information in chapter *2 Basic Structure of the Function*.

The **Transformer side** function group has the following interfaces with the measuring points:

- **`3-phase voltage`** (optional):

  The measurands from the 3-phase voltage system are supplied via this interface. Different transformer connection types are possible. All values that can be calculated from the measurands are also provided via this interface.

- **3-phase current**:

  The measurands from the 3-phase power system are supplied via this interface. Depending on the transformer connection type, these are for example: I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The **Transformer side** function group must always be linked to the **I-3ph measuring point**.

  You can connect the **3-phase current** interface to a maximum of **four** 3-phase current measuring points, for example, for 1 1/2 circuit-breaker layouts, two 3-phase current measuring points are required. If 2 current measuring points have been connected to the **3-phase current** interface, the total current is also determined from measured values from both measuring points in the **Transformer side** function group. All functions in the **Transformer side** function group have access to these total current values.



NOTE

The other interfaces can only be connected to one measuring point each!

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the **Transformer side** function group and the **Circuit-breaker** function group via the interface of the **Circuit-breaker** function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the Protection function groups

The **Transformer side** function group is connected to one or more circuit-breaker function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the **Transformer side** protection function group
- Start of the **Circuit-breaker failure protection** function, if available in the circuit-breaker function group, through the protection functions of the connected **Transformer side** protection function group

Besides the general allocation of the **Transformer side** protection function group to the circuit-breaker function groups, you can also configure the interface for certain functionalities in detail. Configure the details in DIGSI 5 using the **Circuit-breaker interaction** editor in the **Transformer side** function group.

In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the **Circuit-breaker failure protection** function?

If an application template is used, the function groups are connected to each other because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter *2.1 Embedding of Functions in the Device*.

Interface with Protection Communication (optional)

All required data is exchanged between the protection function group and the protection communication via the interface with **Protection communication**, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter *3.6 Protection Communication*.

Side-Dependent Transformer Data

The side dependent transformer data characterize the transformer side to be protected. The side dependent transformer data applies for all of the functions in the **Transformer side** function group.

Process Monitor

The process monitor is always present in the **Transformer side** function group and cannot be removed. The process monitor provides the following information in the **Transformer side** function group:

- Current-flow criterion:
  Detection of an open/activated transformer side based on the flow of leakage current
- Closure detection:
  Detection of closure of the transformer side
- Cold-load pickup detection (optional):

This information is in the **Transformer side** function group and is available to all the functions in the function group.
The description of the process monitor begins in chapter *5.14 Process Monitor*.

Operational Measured Values

The operational measured values are always present in the **Transformer side** function group and cannot be deleted. If a 3-phase voltage measuring point is connected, the following table shows the total scope. Only the first 3 lines apply for exclusive current connection.

Table 5-3 Possible Operational Measured Values of the Transformer Side Function Group

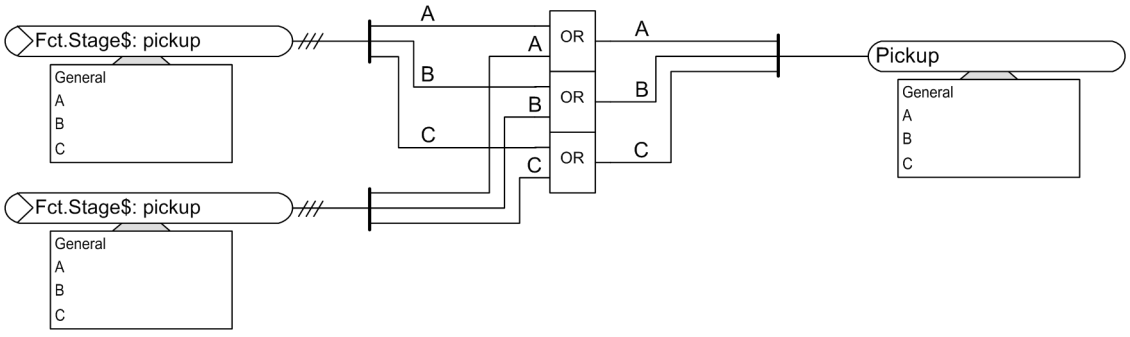
Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary system
I_N	Measured zero-sequence current	A	A	Rated operating current of the primary system
V_A, V_B,V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary system
V_0	Calculated zero-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
V_N	Measured neutral-point displacement voltage	kV	V	Rated operating voltage of the primary system/√3
f	Frequency	Hz	Hz	Rated frequency
P	Active power (total power)	MW	–	Active power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q	Reactive power (total power)	Mvar	–	Reactive power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S	Apparent power (total power)	MVA	–	Apparent power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active factor	(abs)	(abs)	100% corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	–	Active power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$

Measured Values		Primary	Secondary	% Referenced to
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	–	Reactive power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$
S_A, S_B, S_C	Phase-related apparent power	MVA	–	Apparent power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$

Output Logic

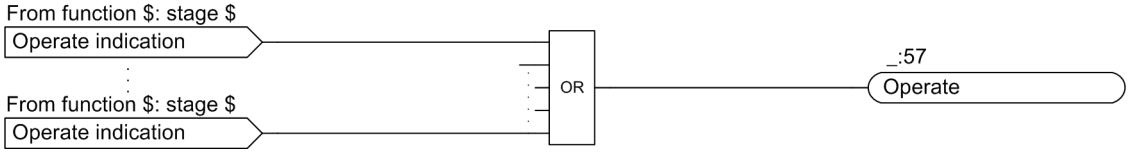
The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the **Protection information** interface to the **Circuit-breaker** function group and are processed further there.

The pickup and trip signals of the protection and supervision functions in the **Transformer side** function group are combined in a phase-selective manner and output as a group indication.



[lo_anrlin, 3, en_US]

Figure 5-8 Generation of Pickup Indication of the Transformer Side Function Group



[lo_auslin, 3, en_US]

Figure 5-9 Generation of an Operate Indication of the Transformer Side Function Group

5.1.3.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

Depending on the protection function used and the circuit breakers to be activated, the connection to the corresponding **Circuit breaker** must be provided.

You can find more information in chapter *2 Basic Structure of the Function*.

Parameter: Rated apparent power

- Default setting **(_:91:103) Rated apparent power** = ***692.82 MVA***

With the **Rated apparent power** parameter, you can set the primary rated apparent power of the transformer to be protected.

NOTE

The windings for transformers with more than 2 windings can have different rated apparent powers. Here the power alone is decisive for the winding, which is assigned to the side.

The **Rated apparent power** parameter is relevant for the main protection function of the device. The **Rated apparent power** set here is the reference value for the percentage-measured values and setting values made in percentages.

NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated voltage

- Default setting **(_:91:102) Rated voltage** = ***400.00 kV***

With the **Rated voltage** parameter, you can set the primary rated voltage of the transformer to be protected. The **Rated voltage** parameter is relevant for the main protection function of the device. The **Rated voltage** set here is the reference value for the percentage-measured values and setting values made in percentages.

NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated current

- Default setting **(_:91:101) Rated current** = ***1000 A***

The **Rated current** parameter indicates to you the primary rated current of the transformer side. The **Rated current** parameter is relevant for the main protection function of the device. The setting value is formed from the **Rated voltage** and **Rated apparent power** parameters.

Parameter: Neutral point

- Default setting **(_:91:149) Neutral point** = ***grounded***

With the **Neutral point** parameter, you specify whether the neutral point is ***grounded*** or ***isolated***. If the neutral point is grounded via a ground current limiting (low-ohmic) or via a arc-suppression coil (high-ohmic), then also set ***grounded***. If there is a neutral point former or a surge arrester within the protection range between the neutral point and ground, the neutral point also is valid as ***grounded***.

Parameter: Winding configuration

- Default setting **(_:91:104) Winding configuration** = ***Y (Wye)***

With the **Winding configuration** parameter, you set ***Y (Wye)*** for a star connection of the transformer. Other setting options are ***D (Delta)*** for a delta connection and ***Z (Zig-Zag)*** for a zigzag connection. The **Winding configuration** parameter is relevant for the main protection function of the device.

Parameter: Vector group numeral

- Default setting **(_:91:163) Vector group numeral** = ***0***

With the **Vector group numeral** parameter, you set the vector group for the transformer to be protected. Each **Vector group numeral** from 0 to 11 can be set provided it is possible, for example, for Yy, Dd, and Dz only even numerals are possible, for Yd, Yz, and Dy only odd numerals are possible. The **Vector group numeral** parameter is relevant for the main protection function of the device.

NOTE

The device also automatically calculates the current adaptation formulas required for the winding rated currents from the rated data of the transformer to be protected and its windings. The currents are converted so that the sensitivity of the protection is based on the rated apparent power of the transformer.

Parameter: Side number

- Default setting **(_:91:130) Side number** = ***not assigned***

The **Side number** parameter shows you which transformer side is currently valid for the following parameters. The side number (***Side 1*** to ***Side 5***) is automatically assigned when connecting to a transformer side.

Parameter: MI3ph1 usesMeasP with ID

- Default setting **(_:91:210) MI3ph1 usesMeasP with ID** = ***0***

The parameters **MI3ph1 usesMeasP with ID** to **MI3ph4 usesMeasP with ID** show you which 3-phase measuring points (**MI3ph 1** to **MI3ph 4**) are connected to the transformer side. Every measuring point is assigned a unique ID.

Parameter: M I-1ph uses MeasP with ID

- Default setting **(_:91:214) M I-1ph uses MeasP with ID** = ***0***

The **M I-1ph uses MeasP with ID** parameter shows you which 1-phase measuring point is connected to the transformer side. Every measuring point is assigned a unique ID.

Parameter: CT mismatch M I-3ph 1

- Default setting **(_:91:215) CT mismatch M I-3ph 1** = ***0.000***

The **CT mismatch M I-3ph 1** parameter shows you the magnitude scaling of the phase currents of the 1st assigned measuring point. The numerical value is made up from the ratio of the primary rated current of the current transformer to the transformer rated current of the side.

Parameter: CT mismatch M I-3ph 1 IN

- Default setting **(_:91:216) CT mismatch M I-3ph 1 IN** = ***0.000***

The **CT mismatch M I-3ph 1 IN** parameter shows you the magnitude scaling of the ground current of the 1st assigned measuring point.

Parameter: CT mismatch M I-3ph 2

- Default setting **(_:91:217) CT mismatch M I-3ph 2** = ***0.000***

The **CT mismatch M I-3ph 2** parameter shows you the magnitude scaling of the phase currents of the 2nd assigned measuring point.

Parameter: CT mismatch M I-3ph 2 IN

- Default setting **(_:91:218) CT mismatch M I-3ph 2 IN** = ***0.000***

The **CT mismatch M I-3ph 2 IN** parameter shows you the magnitude scaling of the ground current of the 2nd assigned measuring point.

Parameter: CT mismatch M I-3ph 3

- Default setting **(_:91:219) CT mismatch M I-3ph 3** = ***0.000***

The **CT mismatch M I-3ph 3** parameter shows you the magnitude scaling of the phase currents of the 3rd assigned measuring point.

Parameter: CT mismatch M I-3ph 3 IN

- Default setting **(_:91:220) CT mismatch M I-3ph 3 IN** = ***0.000***

The **CT mismatch M I-3ph 3 IN** parameter shows you the magnitude scaling of the ground current of the 3rd assigned measuring point.

Parameter: CT mismatch M I-3ph 4

- Default setting **(_:91:221) CT mismatch M I-3ph 4** = ***0.000***

The **CT mismatch M I-3ph 4** parameter shows you the magnitude scaling of the phase currents of the 4th assigned measuring point.

Parameter: CT mismatch M I-3ph 4 IN

- Default setting **(_:91:222) CT mismatch M I-3ph 4 IN** = ***0.000***

The **CT mismatch M I-3ph 4 IN** parameter shows you the magnitude scaling of the ground current of the 4th assigned measuring point.

Parameter: CT mismatch M I-1ph

- Default setting **(_:91:223) CT mismatch M I-1ph** = ***0.000***

The **CT mismatch M I-1ph** parameter shows you the magnitude scaling of the transformer neutral-point current.

5.1.3.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameters	C	Range of Values	Default Setting
Rated values				
_:91:101	General:Rated current		1 A to 100 000 A	1 000 A
Side data				
_:91:130	General:Side number		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	not assigned
_:91:210	General:MI3ph1 uses-MeasP with ID		0 to 100	0
_:91:211	General:MI3ph2 uses-MeasP with ID		0 to 100	0
_:91:212	General:MI3ph3 uses-MeasP with ID		0 to 100	0
_:91:213	General:MI3ph4 uses-MeasP with ID		0 to 100	0
_:91:214	General:M I-1ph uses MeasP with ID		0 to 100	0
_:91:215	General:CT mismatch M I-3ph 1		0.000 to 100.000	0.000
_:91:216	General:CT mismatch M I-3ph 1 IN		0.000 to 100.000	0.000

Addr.	Parameters	C	Range of Values	Default Setting
Rated values				
_:91:217	General:CT mismatch M I-3ph 2		0.000 to 100.000	0.000
_:91:218	General:CT mismatch M I-3ph 2 IN		0.000 to 100.000	0.000
_:91:219	General:CT mismatch M I-3ph 3		0.000 to 100.000	0.000
_:91:220	General:CT mismatch M I-3ph 3 IN		0.000 to 100.000	0.000
_:91:221	General:CT mismatch M I-3ph 4		0.000 to 100.000	0.000
_:91:222	General:CT mismatch M I-3ph 4 IN		0.000 to 100.000	0.000
_:91:223	General:CT mismatch M I-1ph		0.000 to 100.000	0.000

NOTE

You can find more detailed information on the Process monitor in chapter *5.14 Process Monitor*.

5.1.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:91:103	General:Rated apparent power		0.20 MVA to 5000.00 MVA	692.82 MVA
_:91:102	General:Rated voltage		0.40 kV to 800.00 kV	400.00 V
Side data				
_:91:149	General:Neutral point		• grounded • isolated	grounded
_:91:104	General:Winding configuration		• Y (Wye) • D (Delta) • Z (Zig-Zag)	Y (Wye)
_:91:163	General:Vector group numeral		• 0 • 1 • 2 • 3 • 4 • 5 • 6 • 7 • 8 • 9 • 10 • 11 • user-defined	0

Addr.	Parameter	C	Setting Options	Default Setting
Measurements				
_:91:158	General:P, Q sign		• not reversed • reversed	not reversed

5.1.3.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:91:52	General:Behavior	ENS	O
_:91:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
_:7381:52	Reset LED Group:Behavior	ENS	O
_:7381:53	Reset LED Group:Health	ENS	O
Closure detec.			
_:1131:4681:500	Closure detec.:>Disconnector open	SPS	I
_:1131:4681:300	Closure detec.:Closure	SPS	O
_:1131:4681:52	Closure detec.:Behavior	ENS	O
_:1131:4681:53	Closure detec.:Health	ENS	O

5.1.4 Function-Group Type Transformer Neutral Point

5.1.4.1 Overview

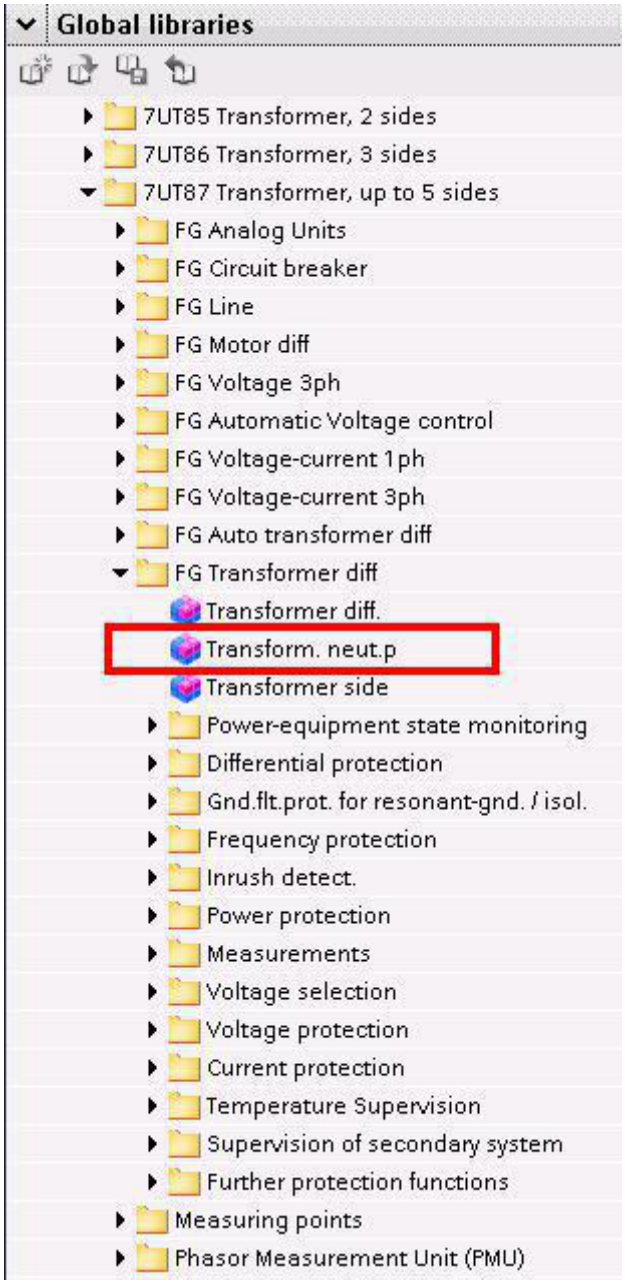
In the**Transf. neutral point** function group, all the necessary functions for protection and for supervision of a transformer are used, which are related to a neutral-point current. The **Transf. neutral point** function group also includes the measurement functions. You can find more information in chapter *9 Measured Values, Energy Values, and Supervision of the Primary System*.



NOTE

The transformer and restricted ground-fault protection do not work with sensitive ground-current transformers. Responsive transformers go to saturation too fast and generate incorrect differential currents.

In the Global DIGSI 5 library, you will find the **Transf. neutral point** function group under each device type and the folder with the respective protection functions. Depending on the connected measuring points, you can load the respective protection and supervision functions in the **Transf. neutral point** function group. Here you can only load 1-phase current functions or optional 1-phase voltage functions.The functions are described in chapter *6 Protection and Automation Functions*.



[scpowspt-230114-01-DE, 1, en_US]

Figure 5-10 Transformer Neutral Point Function Group – Functional Scope for Device Type 7UT87

For more information about the embedding of the functions in the device, refer to *2 Basic Structure of the Function*. For information about the overall functional scope of the application templates for the various device types, refer to *4 Applications*.

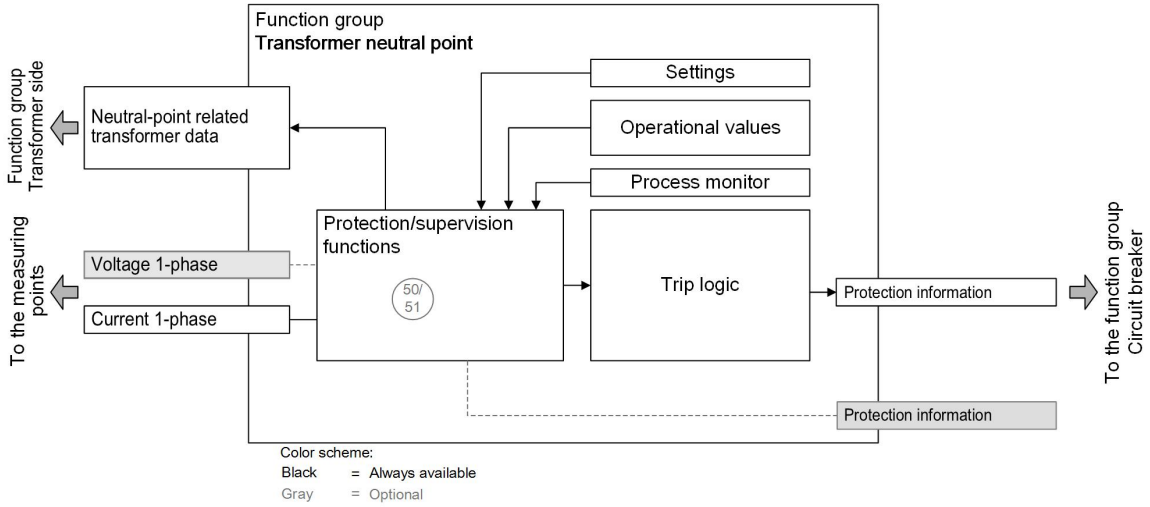
5.1.4.2 Structure of the Function Group

The function group **Transf. neutral point** always includes the following function blocks:

- Neutral point oriented transformer data
- Operational measured values
- Output logic of the function group

These blocks are required in the function group **Transf. neutral point** and therefore cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the function group **Transf. neutral point**. The functions are available in the function library in DIGSI 5. Functions that are not needed can be deleted from the function group.



[dwpwrstp-161012-01.tif, 2, en_US]

Figure 5-11 Structure of the Function Group Transf. Neutral Point

The function group **Transf. neutral point** has interfaces to the following function groups:

- **Measuring points**
- **Circuit breaker**
- **Transformer side**

Interfaces with Measuring Points

The function group **Transf. neutral point** receives the required measured values via its interfaces with the measuring points.

When an application template is used, the function group **Transf. neutral point** is connected with the required measuring points.

If you insert functions in the function group **Transf. neutral point**, they automatically receive the measured values of the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the **Function-Group connections** Editor.

You can find more detailed information in *2 Basic Structure of the Function*.

The function group **Transf. neutral point** has the following interfaces with the measuring points.

- **`1-phase voltage`** (optional):

  The measurands from the 1-phase voltage system are supplied via this interface. All values that can be calculated from the measurands are also provided via this interface.

  If you want to test or change the connection between the voltages and the **V-1ph measuring point** double-click **Measuring-point routing** (name of the device) in the DIGSI 5 project tree → **7UT87**.

  For more information, refer to the description of the *power-system data* starting from *6.1 Power-System Data*.

  You must connect the **`1-phase voltage`** interface with the **Measuring point V-1ph** only if functions in the function group **Transf. neutral point** work with this measurand.

- **`1-phase current`**:
  The measurands from the 1-phase current system are supplied via this interface. Depending on type of transformer connection, this is, for example I_x. All values that can be calculated from the measurands are also provided via this interface. The function group **Transf. neutral point** must always be linked with the **Measuring point I-1ph**.



NOTE

You can connect the **`1-phase current`** interface with a maximum of **one** 1-phase current measuring point.
All functions in the function group **Transformer side** have access to these values.



NOTE

If you instantiate functions in the function group **Transf. neutral point**, the function **Overcurrent protection 1ph**, the information for the inrush-current detection is taken from the assigned function group **Transformer side**.

Interface to the Function Group Circuit Breaker

Via the interface of the function group **Circuit breaker**, all necessary data is transferred between the function group **Transf. neutral point** and the function group **Circuit breaker**. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the function group circuit breaker
- Information on the circuit-breaker condition in the direction of the protection function groups

The function group **Transf. neutral point** is connected with one or more function groups Circuit breaker. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the function group **Transf. neutral point**
- Start of the function **Circuit-breaker failure protection**, if available in the function group Circuit breaker, through the protection functions of the connected protection function group **Transf. neutral point**

In addition to the general assignment of the function group **Transf. neutral point** to the function groups Circuit breaker, you can configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 using the **Circuit-breaker interaction** Editor in the function group **Transf. neutral point**.
In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the function **Circuit-breaker failure protection**?

If an application template is used, the function groups are connected to each other because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor. If the connection is missing, DIGSI 5 reports an inconsistency.
You can find more detailed information in *2.1 Embedding of Functions in the Device*.

Interface with Protection Communication (Optional)

All required data is exchanged between the protection function group and the protection communication via the interface with **Protection communication**, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in *3.6 Protection Communication*.

Neutral-Point Related Transformer Data

The transformer data characterize the transformer neutral point to be protected. The transformer data applies for all of the functions in the function group **Transf. neutral point**.

Operational Measured Values

The operational measured values are always available in the function group **Transf. neutral point** and cannot be deleted.

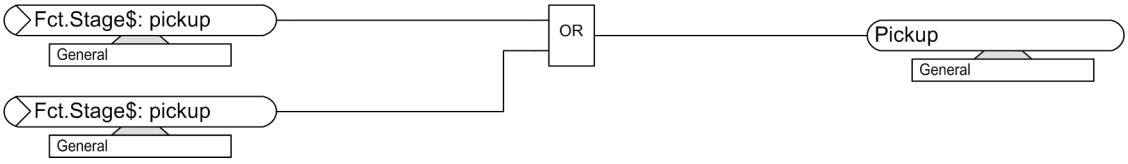
Table 5-4 Operational Measured Values of the Function Group Transformer Neutral Point

Measured Values		Primary	Secondary	% Referenced to
I	Neutral-point current	A	A	Rated operating current of the primary system
V	Voltage	kV	V	Rated operating voltage of the primary system

Output Logic

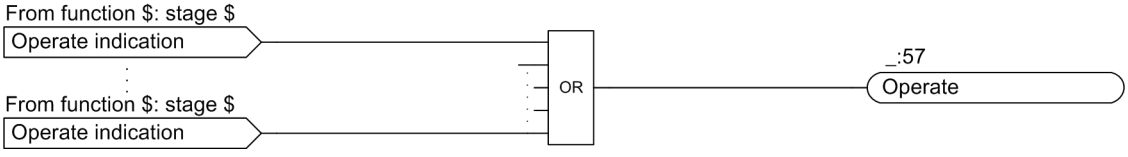
The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the **Protection information** interface to the function group **Circuit breaker** and are processed further there.

The pickup and trip signals of the protection and supervision functions in the function group **Transf. neutral point** are combined phase-selectively and output as group indication.



[loanrstp-201112-01.tif, 1, en_US]

Figure 5-12 Generation of Pickup Indication of the Function Group Transf. Neutral Point



[lo_auslin, 3, en_US]

Figure 5-13 Generation of Operate Indication of the Function Group Transf. Neutral Point

5.1.4.3 Application and Setting Notes

Parameter: Rated current (Write-Protected)

- Default setting **(_9421:104) Rated current** = ***1000 A***

The **Rated current** parameter indicates the primary rated current of the transformer to be protected. The **Rated current** can correspond to the following variables:

- Rated current of the connected transformer side
- Rated current of the reference side of the connected auto transformer

The **Rated current** cannot be changed.

Parameter: Rated voltage (Write-Protected)

- Default setting **(_:9421:105) Rated voltage** = ***400.00 kV***

The **Rated voltage** parameter indicates the primary rated voltage of the transformer to be protected. The **Rated voltage** can correspond to the following variables:

- Rated voltage of the connected transformer side
- Rated voltage of the reference side of the connected auto transformer

The **Rated voltage** cannot be changed.

Parameter: Rated apparent power

- Default setting **(_:9421:103) Rated apparent power** = ***692.82 MVA***

The **Rated apparent power** parameter indicates the calculated value from **Rated voltage** and **Rated current**. If current and voltage are available, this value is only displayed for you and cannot be changed.

Parameter: M I-1ph uses MeasP with ID

- Default setting **(_:9421:214) M I-1ph uses MeasP with ID** = ***0***

The **M I-1ph uses MeasP with ID** parameter indicates which 1-phase measuring point is connected to the transformer neutral point. Every measuring point is assigned a unique ID.

Parameter: CT mismatch M I-1ph

- Default setting **(_:9421:223) CT mismatch M I-1ph** = ***0.000***

The **CT mismatch M I-1ph** parameter indicates the magnitude scaling of the transformer neutral-point current.

5.1.4.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_:9421:103	General:Rated apparent power		0.20 MVA to 5 000.00 MVA	692.82 MVA
_:9421:104	General:Rated current		1 A to 100 000 A	1 000 A
_:9421:105	General:Rated voltage		0.20 kV to 1 200.00 kV	400 kV
Power-system data				
_:9421:214	General:M I-1ph uses MeasP with ID		0 to 100	0
_:9421:223	General:CT mismatch M I-1ph		0.00 to 100.00	0.000

5.1.4.5 Information List

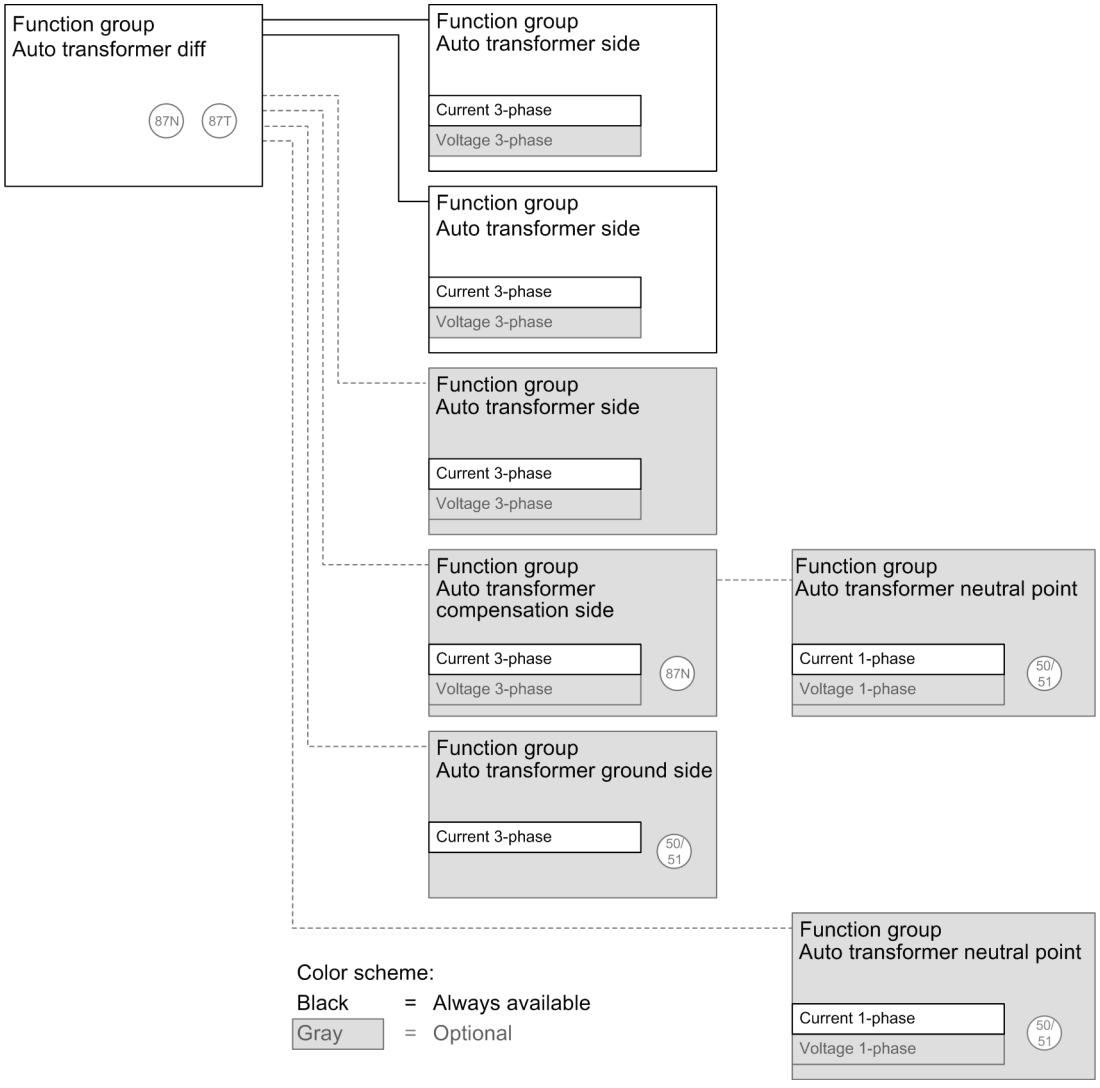
No.	Information	Data Class (Type)	Type
General			
_:9421:52	General:Behavior	ENS	O
_:9421:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O

No.	Information	Data Class (Type)	Type
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
_:7381:52	Reset LED Group:Behavior	ENS	O
_:7381:53	Reset LED Group:Health	ENS	O

5.2 Function-Group Type Auto Transformer Differential Protection

5.2.1 Function-Group Types

The following figure shows the structural association of the function-group types.



[dwfguebs-291112-01.tif, 1, en_US]

Figure 5-14 Function-Group Types Auto Transformer Diff.

The following function-group types are summarized in the Global DIGSI 5 library:

- **Auto transf. diff.** (Auto transformer)
- **Auto transf. auto side** (Auto transformer auto side)
- **Auto transf. comp. side** (Auto transformer compensation side)
- **Auto transf. grd. side** (Auto transformer ground side)
- **Auto transf. neutral point** (Auto transformer neutral point)

The individual function-group types are stored in the **Auto Transformer function group** folder and can be selected. In the protection function folders, you find all protection functions which are operational in each function group. A **Transf. diff.** function group always contains 2 **Auto transf. auto side** function groups. The

Auto transf. neutral point function group can be connected if needed with the **Auto transf. comp. side** or directly with the **Auto transf. diff.** function group.

The following table shows the number of function-group types that can be instantiated depending on the device (7UT82, 7UT85, 7UT86, 7UT87).

NOTE

By purchasing 70 or 120 function points, the 7UT85 and 7UT86 can be expanded to a three-winding transformer or a multi-winding transformer. Consider to provide the respective number of measuring points that are required for the expansion.

Table 5-5 Function-Group Types in the Device

Device	Function-Group Type				
	Auto Transf. Diff.	Auto Transf. Auto Side	Auto Transf. Comp. Side	Auto Transf. Ground Side	Auto Transf. Neutral-Point Function Group
7UT82	Max. 1	Max. 2	-	-	Max. 1
7UT85	Max. 1	Max. 2	Max. 1 (not open)	Max. 1	Max. 1
7UT86	Max. 1	Max. 3 (2 open)	Max. 1	Max. 1	Max. 2
7UT87	Max. 2	Max. 5[20]	Max. 1	Max. 1	Max. 2

In order for the transformer protection to operate properly, switching of the function groups is necessary. *Table 5-6* provides an overview of those switching options that are permitted. The Circuit-breaker function group is not listed. The images shown in the application templates (see *Figure 4-2* to *Figure 4-7*) give you a good overview of the connection options.

An **Auto transf. auto side** function group must always be connected to the **Auto transf. diff.** function group. Depending on the application, a connection of the **Auto transf. neutral point** function group with the **Auto transf. comp. side** function group is required. This is the case, for example, if a restricted ground-fault protection is used or if the neutral-point current in the differential protection should be considered (zero-sequence current correction). Conversely, the **Auto transf. neutral point** function group can also require signals from the **Auto transf. diff.** function group. A typical case is the inrush-current detection, which can be used for blocking a 1-phase overcurrent protection (with a short time delay set).

Table 5-6 Assignment of Protection Function Groups to Protection Function Groups

Winding	Auto Transf. Diff. 1				Auto Transf. Comp. Side
	Auto Side (2 ... 3)	Comp. Side (0 ... 1)	Ground Side (0 ... 1)	Neutral Point Function Group (0 ... 1)	Neutral Point Function Group (0 ... 1)
Auto transf. auto side 1	X	–	–	–	–
Auto transf. auto side 2	X	–	–	–	–
Auto transformer comp. side	–	X	–	–	–
Auto transformer grd. side	–	–	X	–	–
Auto transf. neutral point 1	–	–	–	X	
Auto transf. neutral point 2	–	–	–		X

The individual function-group types are described in the following.

20 A maximum of 3 auto sides can be assigned to an auto transformer. The remaining auto sides are available for the 2nd auto transformer.

5.2.2 Function-Group Type Auto Transformer Differential Protection

5.2.2.1 Overview

The **Auto transf. Diff.** function group contains the differential protection function and protection function relevant measured values. You can find more information in chapter *9 Measured Values, Energy Values, and Supervision of the Primary System*.

You will find the corresponding function groups and also the folders with the usable protection functions in the Global DIGSI library under each device type. You can only load the Differential protection function in the **Auto transf. diff.** function group.



[scauttrf-230114-01-DE, 1, en_US]

Figure 5-15 Auto Transformer Diff. Function Group - Functional Scope for Device Type 7UT87

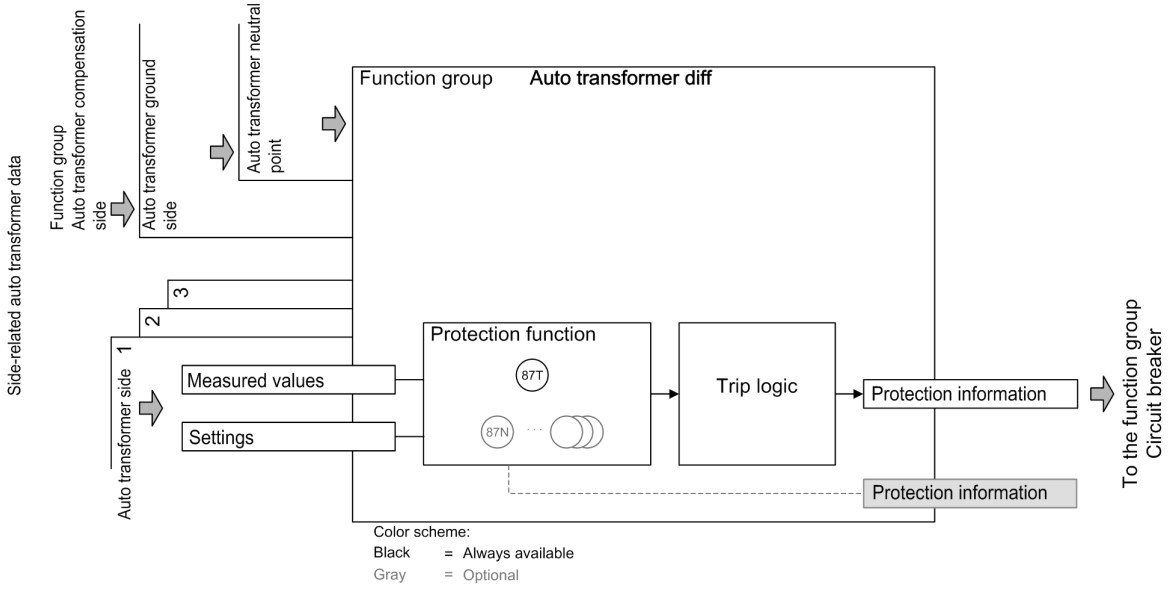
For more information about the embedding of the functions in the device, refer to chapter *2 Basic Structure of the Function*. For information about the overall functional scope of the application templates for the various device types, please refer to chapter *4 Applications*.

5.2.2.2 Structure of the Function Group

The **Auto transf. diff.** function group according to *Figure 5-16* has interfaces with the **Auto transf. auto side** and **Circuit-breaker** function groups. The **Auto transf. diff.** function group contains the function blocks:

- Protection function (execution of the differential protection function)
- Trip logic (generation of forwarding of the operate indication)

In order for the protection functionality to be guaranteed, the differential protection function must always be present in the **Auto transf. diff.** function group. If you do not use an application template, load this from the Global DIGSI 5 library.



[dwauttrf-201112-01.tif, 1, en_US]

Figure 5-16 Structure of the Auto Transf. Diff. Function Group

The **Auto transf. diff.** function group has interfaces to the following function groups:

- The **Auto transf. auto side** function group
- The **Auto transf. comp. side** function group
- The **Auto transf. ground side** function group
- The **Auto transf. neutral point** function group
- **Circuit-breaker** function group

Interface to the Auto Transformer Auto Side Function Group

The **Auto transf. diff.** function group receives the required measured values via the interface to the **Auto transf. auto side** function group. In addition, the required settings are transferred.

By using an application template the **Auto transf. diff.** function group is connected with the required measuring points.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and Circuit-breaker function groups via the interface with the **Circuit-breaker** function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the Protection function groups

The **Auto transf. diff.** function group is connected with one or more circuit-breaker function groups. This connection generally determines:

- Which circuit breakers are activated by the protection functions of the **Auto transf. diff.** function group
- Start of the **Circuit-breaker failure protection** function, if available in the Circuit-breaker function group via the protection functions of the connected **Auto transf. diff.** function group.

In addition to the general assignment of the **Auto transf. diff.** function group to the Circuit-breaker function groups, you can configure the interface in detail for specific functionalities. Configure the details in DIGSI 5 using the **Circuit-breaker interaction** Editor in the **Auto transf. diff.** function group.

In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the **Circuit-breaker failure protection** function?

If an application template is used, the function groups are connected to each other because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter *2.1 Embedding of Functions in the Device*.

Interface with Protection Communication (Optional)

All required data is exchanged between the Protection function group and the protection communication via the interface with **Protection communication**, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter *3.6 Protection Communication*.

Auto Transformer Data (Side-Related)

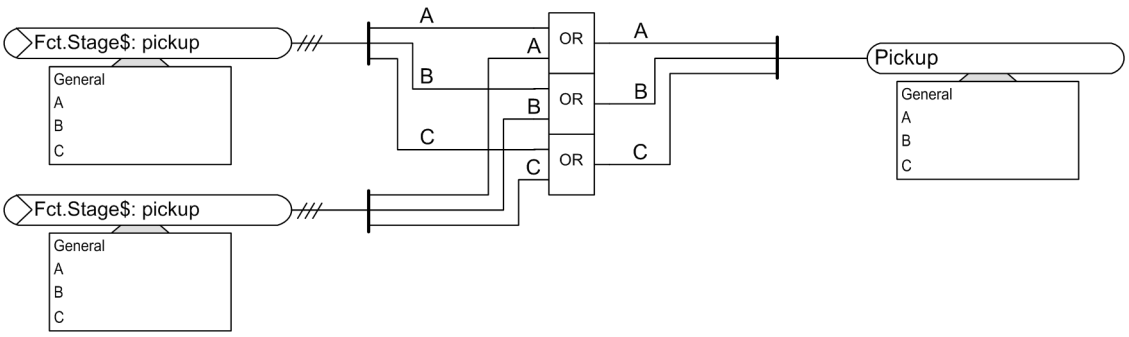
The auto transformer data characterize the auto transformer to be protected. The **Auto transf. diff.** function group takes these data from the coupled function groups.

- **Auto transf. auto side** function group
- **Auto transf. comp. side** function group
- **Auto transf. ground side** function group
- **Auto transf. neutral point** function group

Output Logic

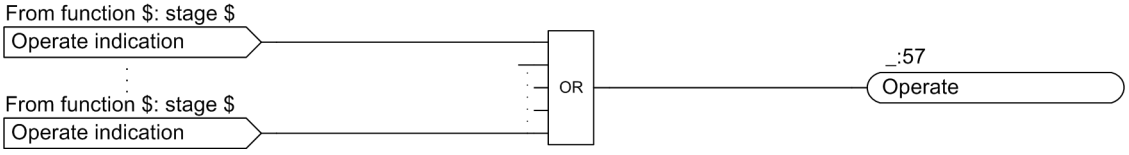
The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the **Protection information** interface to the **Circuit-breaker** function group and are processed further there.

The pickup and trip signals of the protection and supervision functions in the **Auto transf. diff.** function group are combined phase-selectively and output as a group indication.



[lo_anrlin, 3, en_US]

Figure 5-17 Generation of Pickup Indication of the Auto Transformer Diff. Function Group



[lo_auslin, 3, en_US]

Figure 5-18 Generation of Operate Indication of the Auto Transformer Diff. Function Group

5.2.2.3 Application and Setting Notes

Parameter: Neutral point

- Default setting **(_:91:149) Neutral point** = ***grounded***

With the **Neutral point** parameter, you specify whether the neutral point of the auto transformer is ***grounded*** or ***isolated***.

NOTE

The **Neutral point** parameter is only visible or changeable if you have connected the **Auto transformer Diff.** function group with the **Auto transf. neutral point**.function group.

5.2.2.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:91:149	General:Neutral point		• grounded • isolated	grounded

5.2.2.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:91:52	General:Behavior	ENS	O
_:91:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O

No.	Information	Data Class (Type)	Type
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
_:7381:52	Reset LED Group:Behavior	ENS	O
_:7381:53	Reset LED Group:Health	ENS	O

5.2.3 Function-Group Type Auto Transformer Auto Side

5.2.3.1 Overview

In the **Auto transf. auto side** function group all functions required for protection and supervision of an auto transformer auto side can be used. The **Auto transf. auto side** function group also includes the measurement functions. You can find more information in chapter *9 Measured Values, Energy Values, and Supervision of the Primary System*.

The **Auto transf. auto side** function group must always have a link to the **Auto transformer** function group.

In the Global DIGSI 5 library, you will find the **Auto transf. auto side** function group under each device type and the folder with the respective protection functions. Depending on the connected measuring points, you can load the respective protection and supervision functions in the **Auto transf. auto side**. The functions are described in chapter *6 Protection and Automation Functions*.



[scautspr-230114-01-DE, 1, en_US]

Figure 5-19 Auto Transformer Auto Side Function Group – Functional Scope for Device Type 7UT87

For more information about the embedding of the functions in the device, refer to *2 Basic Structure of the Function*. For information about the overall functional scope of the application templates for the various device types, refer to *4 Applications*.

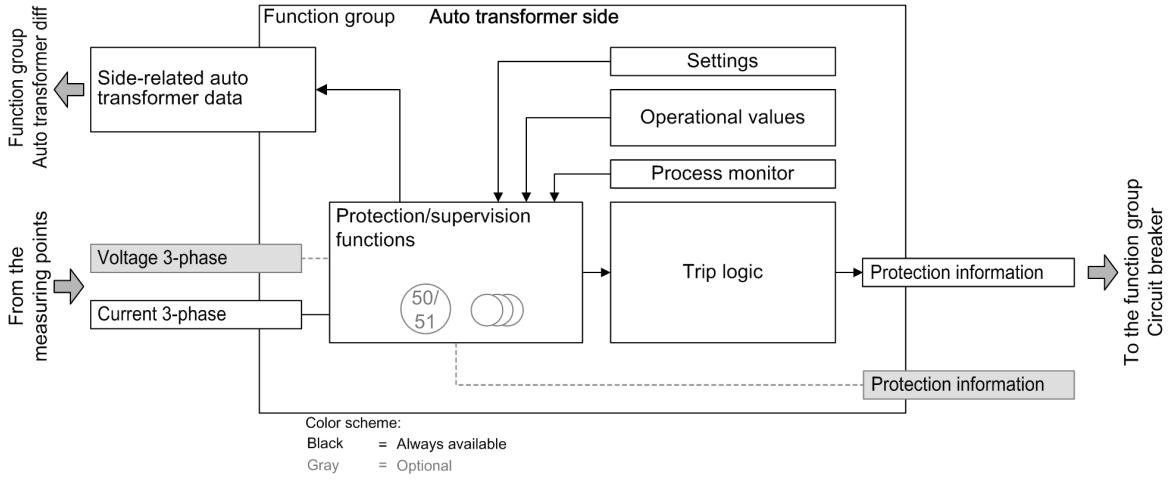
5.2.3.2 Structure of the Function Group

The **Auto transf. auto side** function group always includes the following function blocks:

- Side-dependent auto transformer data
- Operational measured values
- Process monitor
- Output logic of the function group

These blocks are required in the **Auto transf. auto side** function group and therefore cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the **Auto transf. auto side** function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.



[dwautsid-201112-01.tif, 1, en_US]

Figure 5-20 Structure of the Auto Transf. Auto Side Function Group

The **Auto transf. auto side** function group has interfaces to the following function groups:

- **Measuring points**
- **Circuit-breaker** function group
- **Auto transformer** function group

Interfaces with Measuring Points

The **Auto transf. auto side** function group receives the required measured values via its interfaces with the measuring points.

By using an application template the **Auto transf. auto side** function group is connected with the required measuring points.

If you insert functions in the **Auto transf. auto side** function group, they automatically receive the measured values of the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the **Function-group connections** Editor.

You can find more detailed information in chapter *2 Basic Structure of the Function*.

The **Auto transf. auto side** function group has the following interfaces with the measuring points.

- **`3-phase voltage`** (optional):

  The measurands from the 3-phase voltage system are supplied via this interface. Different transformer connection types are possible. All values that can be calculated from the measurands are also provided via this interface.

- **3-phase current**:

  The measurands from the 3-phase power system are supplied via this interface. Depending on the transformer connection type, these are for example: I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The **Auto transf. auto side** function group must always be connected with the **Measuring point I-3ph**.

  You can connect the **3-phase current** interface to a maximum of **four** 3-phase current measuring points, for example, for 1 1/2 circuit-breaker layouts, two 3-phase current measuring points are required. If 2 current measuring points are connected with the **3-phase current** interface, in the **Auto transf. auto side** function group the total current is additionally formed from the measured values of both measuring points. All functions of the **Auto transf. auto side** function group have access to these values.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and circuit-breaker function groups via the interface with the **Circuit-breaker** function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the protection function groups

The **Auto transf. auto side** function group is connected with one or more Circuit-breaker function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the **Auto transf. auto side** function group
- Start of the **Circuit-breaker failure protection** function, if available in the Circuit-breaker function group, through the protection functions of the connected **Auto transf. auto side** function group

In addition to the general assignment of the **Auto transf. auto side** protection function group to the circuit-breaker function groups, you can configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 using the **Circuit-breaker interaction** editor in the **Auto transf. auto side** function groups.

In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the **Circuit-breaker failure protection** function?

If an application template is used, the function groups are connected to each other because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter *2.1 Embedding of Functions in the Device*.

Interface with Protection Communication (Optional)

All required data is exchanged between the protection function group and the protection communication via the interface with **Protection communication**, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter *3.6 Protection Communication*.

Side-Dependent Auto Transformer Data

The auto transformer data characterize the auto transformer auto side to be protected. The side-related auto transformer data applies for all of the functions in the **Auto transf. auto side** function group.

Process Monitor

The process monitor is always available in the **Auto transf. auto side** function group and cannot be removed. The process monitor makes the following information available in the **Auto transf. auto side** function group:

- Current-flow criterion:
  Detection of an open/activated auto transformer auto side based on the flow of leakage current
- Closure detection:
  Recognition of the switching on of the auto transformer auto side
- Cold-load pickup detection (optional):

This information is available in the **Auto transf. auto side** function group for all the functions included in it.

The description of the process monitor begins in chapter *5.14 Process Monitor*.

Operational Measured Values

The operational measured values are always available in the **Auto transf. auto side** function group and cannot be deleted. If a 3-phase voltage measuring point is connected, the following table shows the total scope. Only the first 3 lines apply for exclusive current connection.

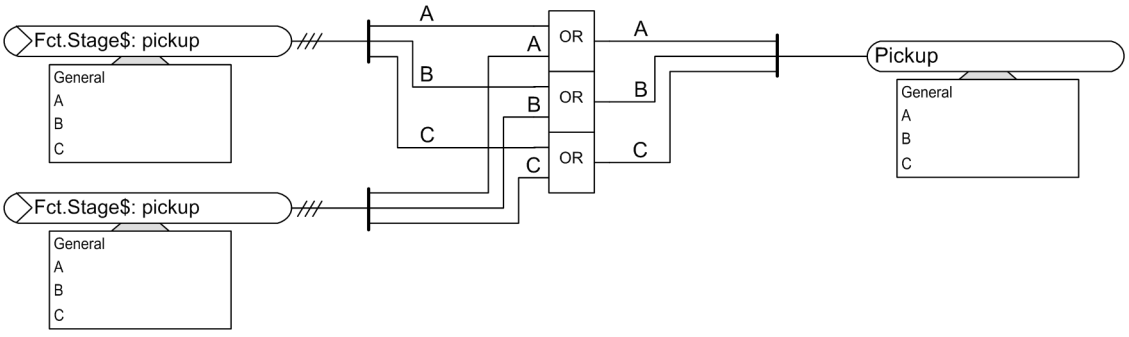
Table 5-7 Possible Operational Measured Values of the Auto Transformer Auto Side Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary system
I_N	Measured zero-sequence current	A	A	Rated operating current of the primary system
V_A, V_B,V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary system
V_0	Calculated zero-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
V_N	Measured neutral-point displacement voltage	kV	V	Rated operating voltage of the primary system/√3
f	Frequency	Hz	Hz	Rated frequency
P	Active power (total power)	MW	–	Active power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q	Reactive power (total power)	Mvar	–	Reactive power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S	Apparent power (total power)	MVA	–	Apparent power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active factor	(abs)	(abs)	100% corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	–	Active power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	–	Reactive power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$
S_A, S_B, S_C	Phase-related apparent power	MVA	–	Apparent power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$

Output Logic

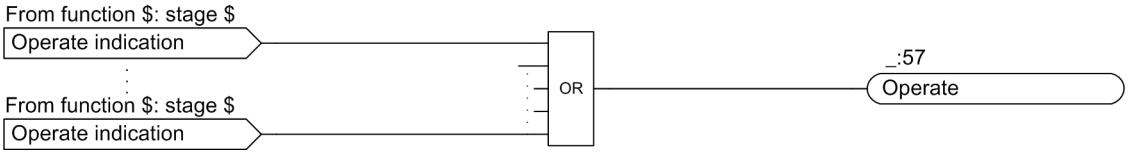
The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the **Protection-information** interface to the **Circuit-breaker** function group and are processed further there.

The pickup and trip signals of the protection and supervision functions in the **Auto transf. auto side** function group are combined phase-selectively and output as group indication.



[lo_anrlin, 3, en_US]

Figure 5-21 Generation of Pickup Indication of the Auto Transformer Auto Side Function Group



[lo_auslin, 3, en_US]

Figure 5-22 Generation of Operate Indication of the Auto Transformer Auto Side Function Group

5.2.3.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

Depending on the protection function used and the circuit breakers to be activated, the connection to the corresponding **Circuit breaker** must be provided.

You can find more information in chapter *2 Basic Structure of the Function*.

Parameter: Rated apparent power

- Default setting **(_:91:103) Rated apparent power** = ***692.82 MVA***

With the **Rated apparent power** parameter, you can set the primary rated apparent power for the auto transformer to be protected. The **Rated apparent power** parameter is relevant for the main protection function of the device. The **Rated apparent power** set here is the reference value for the percentage-measured values and setting values made in percentages.

NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated voltage

- Default setting **(_:91:102) Rated voltage** = ***400.00 kV***

With the **Rated voltage** parameter, you can set the primary rated voltage of the auto transformer to be protected. The **Rated voltage** parameter is relevant for the main protection function of the device. The **Rated voltage** set here is the reference value for the percentage-measured values and setting values made in percentages.

NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated current

- Default setting **(_:91:101) Rated current** = ***1000 A***

The **Rated current** parameter indicates to you the primary rated current of the auto transformer auto side. The **Rated current** parameter is relevant for the main protection function of the device. The setting value is formed from the **Rated voltage** and **Rated apparent power** parameters.

NOTE

The device also automatically calculates the current adaptation formulas required for the winding rated currents from the rated data of the auto transformer to be protected and its windings. The currents are converted so that the sensitivity of the protection is based on the rated apparent power of the auto transformer.

Parameter: Side number

- Default setting **(_:91:130) Side number** = ***not assigned***

The **Side number** parameter shows you which auto transformer auto side is currently valid for the following parameters. The side number (***Side 1*** to ***Side 5***) is automatically assigned with the connection to an auto transformer auto side.

Parameter: MI3ph1 usesMeasP with ID

- Default setting **(_:91:210) MI3ph1 usesMeasP with ID** = ***0***

The parameters **MI3ph1 usesMeasP with ID** to **MI3ph4 usesMeasP with ID** show you which 3-phase measuring points (**MI3ph 1** to **MI3ph 4**) are connected to the auto transformer auto side. Every measuring point is assigned a unique ID.

Parameter: CT mismatch M I-3ph 1

- Default setting **(_:91:215) CT mismatch M I-3ph 1** = ***0.000***

The **CT mismatch M I-3ph 1** parameter shows you the magnitude scaling of the phase currents of the 1st assigned measuring point. The numerical value is made up from the ratio of the primary rated current of the current transformer to the auto transformer rated current of the side.

Parameter: CT mismatch M I-3ph 1 IN

- Default setting **(_:91:216) CT mismatch M I-3ph 1 IN** = ***0.000***

The **CT mismatch M I-3ph 1 IN** parameter shows you the magnitude scaling of the ground current of the 1st assigned measuring point.

Parameter: CT mismatch M I-3ph 2

- Default setting **(_:91:217) CT mismatch M I-3ph 2** = ***0.000***

The **CT mismatch M I-3ph 2** parameter shows you the magnitude scaling of the phase currents of the 2nd assigned measuring point.

Parameter: CT mismatch M I-3ph 2 IN

- Default setting **(_:91:218) CT mismatch M I-3ph 2 IN** = ***0.000***

The **CT mismatch M I-3ph 2 IN** parameter shows you the magnitude scaling of the ground current of the 2nd assigned measuring point.

Parameter: CT mismatch M I-3ph 3

- Default setting **(_:91:219) CT mismatch M I-3ph 3** = ***0.000***

The **CT mismatch M I-3ph 3** parameter shows you the magnitude scaling of the phase currents of the 3rd assigned measuring point.

Parameter: CT mismatch M I-3ph 3 IN

- Default setting **(_:91:220) CT mismatch M I-3ph 3 IN** = ***0.000***

The **CT mismatch M I-3ph 3 IN** parameter shows you the magnitude scaling of the ground current of the 3rd assigned measuring point.

Parameter: CT mismatch M I-3ph 4

- Default setting **(_:91:221) CT mismatch M I-3ph 4** = ***0.000***

The **CT mismatch M I-3ph 4** parameter shows you the magnitude scaling of the phase currents of the 4th assigned measuring point.

Parameter: CT mismatch M I-3ph 4 IN

- Default setting **(_:91:222) CT mismatch M I-3ph 4 IN** = ***0.000***

The **CT mismatch M I-3ph 4 IN** parameter shows you the magnitude scaling of the ground current of the 4th assigned measuring point.

5.2.3.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameters	C	Range of Values	Default Setting
Rated values				
_:91:101	General:Rated current		1 A to 100 000 A	1 000 A
Side data				
_:91:130	General:Side number		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	not assigned
_:91:210	General:MI3ph1 uses-MeasP with ID		0 to 100	0
_:91:211	General:MI3ph2 uses-MeasP with ID		0 to 100	0
_:91:212	General:MI3ph3 uses-MeasP with ID		0 to 100	0
_:91:213	General:MI3ph4 uses-MeasP with ID		0 to 100	0
_:91:215	General:CT mismatch M I-3ph 1		0.000 to 100.000	0.000

Addr.	Parameters	C	Range of Values	Default Setting
_:91:216	General:CT mismatch M I-3ph 1 IN		0.000 to 100.000	0.000
_:91:217	General:CT mismatch M I-3ph 2		0.000 to 100.000	0.000
_:91:218	General:CT mismatch M I-3ph 2 IN		0.000 to 100.000	0.000
_:91:219	General:CT mismatch M I-3ph 3		0.000 to 100.000	0.000
_:91:220	General:CT mismatch M I-3ph 3 IN		0.000 to 100.000	0.000
_:91:221	General:CT mismatch M I-3ph 4		0.000 to 100.000	0.000
_:91:222	General:CT mismatch M I-3ph 4 IN		0.000 to 100.000	0.000

NOTE

You can find more detailed information on the Process monitor in chapter *5.14 Process Monitor*.

5.2.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:91:103	General:Rated apparent power		0.20 MVA to 5000.00 MVA	692.82 MVA
_:91:102	General:Rated voltage		0.40 kVto 800.00 kV	400.00 kV
Measurements				
_:91:158	General:P, Q sign		• not reversed • reversed	not reversed

5.2.3.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:91:52	General:Behavior	ENS	O
_:91:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
_:7381:52	Reset LED Group:Behavior	ENS	O
_:7381:53	Reset LED Group:Health	ENS	O
Closure detec.			
_:1131:4681:500	Closure detec.:>Disconnector open	SPS	I
_:1131:4681:300	Closure detec.:Closure	SPS	O

No.	Information	Data Class (Type)	Type
_:1131:4681:52	Closure detec.:Behavior	ENS	O
_:1131:4681:53	Closure detec.:Health	ENS	O

5.2.4 Function-Group Type Auto Transformer Compensation Side

5.2.4.1 Overview

In the **Auto transf. comp. side** all the functions required for protection and supervision of an auto transformer compensation side can be used. The **Auto transf. comp. side** also includes the measurement functions. You can find more information in chapter *9 Measured Values, Energy Values, and Supervision of the Primary System*.

The **Auto transf. comp. side** must always have a link to the **Auto transformer** function group.

In the Global DIGSI 5 library, you will find the **Auto transf. comp. side** function group under each device type and the folders with the respective protection functions. Depending on the connected measuring points, you can load the respective protection and supervision functions in the **Auto transf. comp. side** function group. The functions are described in chapter *6 Protection and Automation Functions*.



[scautcmp-230114-01-DE, 1, en_US]

Figure 5-23 Auto Transformer Comp. Side Function Group - Functional Scope for Device Type 7UT87

For more information about the embedding of the functions in the device, refer to *2 Basic Structure of the Function*. For information about the overall functional scope of the application templates for the various device types, refer to chapter *4 Applications*.

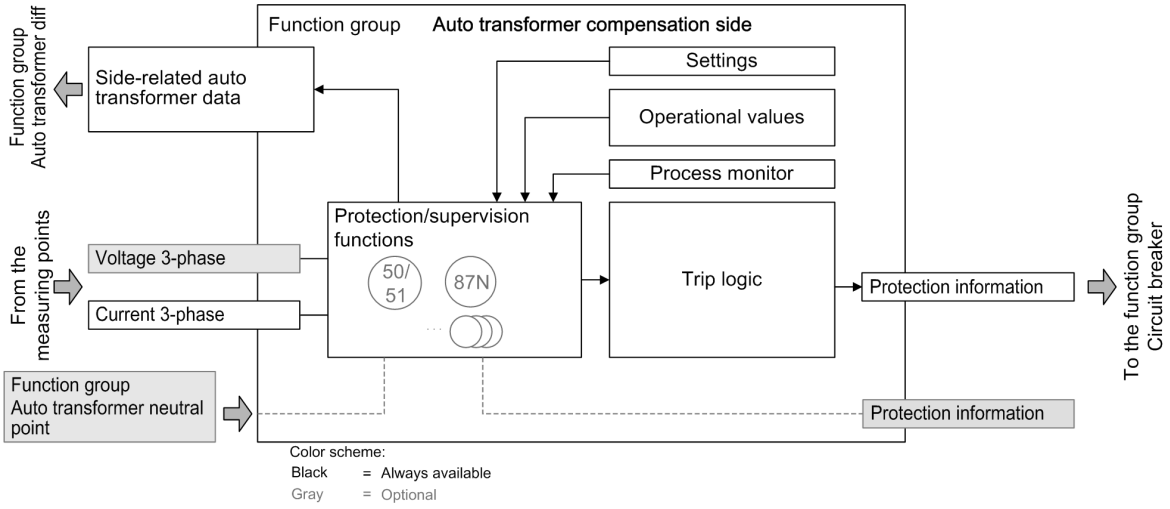
5.2.4.2 Structure of the Function Group

The **Auto transf. comp. side** function group always contains the following function blocks:

- Side-dependent auto transformer data
- Operational measured values
- Process monitor
- Output logic of the function group

These blocks are required for the **Auto transf. comp. side** function group and therefore cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the **Auto transf. comp. side** function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.



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Figure 5-24 Structure of the Auto Transf. Comp. Side Function Group

The **Auto transf. comp. side** function group has interfaces to the following function groups:

- **Measuring points**
- **Circuit-breaker** function group
- **Auto transf. diff.** function group
- **Auto transf. neutral point** function group

Interfaces with Measuring Points

The **Auto transf. comp. side** function group receives the required measured values via its interfaces with the measuring points.

By using an application template the **Auto transf. comp. side** function group is connected with the required measuring points.

If you insert functions in the **Auto transf. comp. side** function group, they automatically receive the measured values of the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the **Function-group connections** Editor.

You can find more detailed information in chapter *2 Basic Structure of the Function*.

The **Auto transf. comp. side** function group has the following interfaces with the measuring points:

- **`3-phase voltage`** (optional):

  The measurands from the 3-phase voltage system are supplied via this interface. Different transformer connection types are possible. All values that can be calculated from the measurands are also provided via this interface.

- **3-phase current**:

  The measurands from the 3-phase power system are supplied via this interface. Depending on the transformer connection type, these are for example: I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The **Auto transf. comp. side** function group must always be linked to the **I-3ph measuring point**.

  You can connect the **3-phase current** interface to a maximum of **four** 3-phase current measuring points, for example, for 1 1/2 circuit-breaker layouts, two 3-phase current measuring points are required. If 2 current measuring points are connected with the **3-phase current** interface, in the **Auto transf. comp. side** function group the total current is additionally formed from the measured values of both measuring points. All functions of the **Auto transf. comp. side** function group have access to these values.



NOTE

The other interfaces can only be connected to one measuring point each!

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and circuit-breaker function groups via the interface with the **Circuit-breaker** function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the protection function groups

The **Auto transf. comp. side** function group is connected with one or more Circuit-breaker function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the **Auto transf. comp. side** function group.
- Start of the **Circuit-breaker failure protection** function (if available in the Circuit-breaker function group) through the protection functions of the connected **Auto transf. comp. side** function group

In addition to the general assignment of the **Auto transf. comp. side** function group to the Circuit-breaker function groups, you can configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 using the **Circuit-breaker interaction** editor in the **Auto transf. comp. side** function group.

In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the **Circuit-breaker failure protection** function?

If an application template is used, the function groups are connected to each other because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter *2.1 Embedding of Functions in the Device*.

Interface with Protection Communication (Optional)

All required data is exchanged between the protection function group and the protection communication via the interface with **Protection communication**, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter *3.6 Protection Communication*.

Side-Dependent Auto Transformer Data

The auto transformer data characterize the auto transformer compensation side to be protected. The auto transformer data applies for all of the functions in the **Auto transf. comp. side** function group.

Process Monitor

The process monitor is always available in the **Auto transf. comp. side** function group and cannot be removed. The process monitor makes the following information available in the **Auto transf. comp. side** function group:

- Current-flow criterion:
  Recognition of an open/closed auto transf. comp. side based on the flowing leakage current
- Closure detection:
  Recognition of the switching on of the auto transf. comp. side
- Cold-load pickup detection (optional):

This information is available in the **Auto transf. comp. side** function group for all the functions included in it.

The description of the process monitor begins in chapter *5.14 Process Monitor*.

Operational Measured Values

The operational measured values are always available in the **Auto transf. comp. side** function group and cannot be deleted. If a 3-phase voltage measuring point is connected, the following table shows the total scope. Only the first 3 lines apply for exclusive current connection.

Table 5-8 Possible Operational Measured Values of the Auto Transformer Comp. Side Function Group

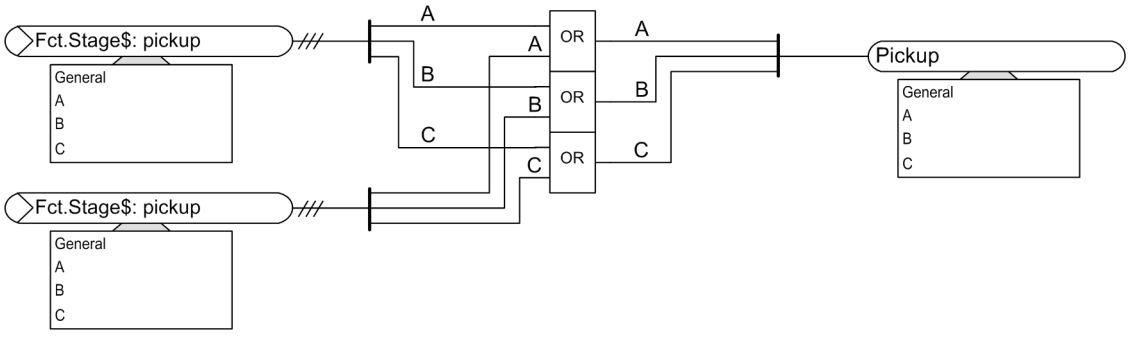
Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary system
I_N	Measured zero-sequence current	A	A	Rated operating current of the primary system
V_A, V_B,V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary system
V_0	Calculated zero-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
V_N	Measured neutral-point displacement voltage	kV	V	Rated operating voltage of the primary system/√3
f	Frequency	Hz	Hz	Rated frequency
P	Active power (total power)	MW	–	Active power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q	Reactive power (total power)	Mvar	–	Reactive power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S	Apparent power (total power)	MVA	–	Apparent power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active factor	(abs)	(abs)	100 % corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	–	Active power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$

Measured Values		Primary	Secondary	% Referenced to
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	–	Reactive power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$
S_A, S_B, S_C	Phase-related apparent power	MVA	–	Apparent power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$

Output Logic

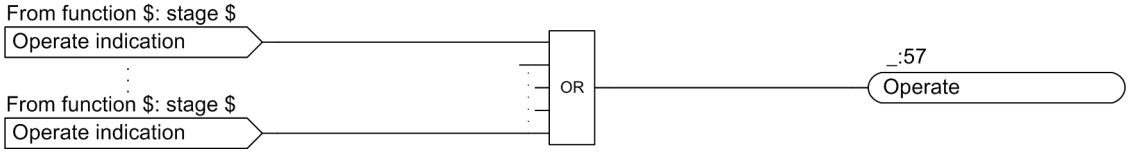
The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the **Protection information** interface to the **Circuit-breaker** function group and are processed further there.

The pickup and trip signals of the protection and supervision functions in the **Auto transf. comp. side** function group are combined phase-selectively and output as group indication.



[lo_anrlin, 3, en_US]

Figure 5-25 Generation of Pickup Indication of the Auto Transformer Comp. Side Function Group



[lo_auslin, 3, en_US]

Figure 5-26 Generation of Operate Indication of the Auto Transformer Comp. Side Function Group

5.2.4.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

Depending on the protection function used and the circuit breakers to be activated, the connection to the corresponding **Circuit breaker** must be provided.

You can find more information in chapter *2 Basic Structure of the Function*.

Parameter: Rated apparent power

- Default setting **(_:91:103) Rated apparent power** = ***692.82 MVA***

With the **Rated apparent power** parameter, you can set the primary rated apparent power for the auto transformer to be protected. The **Rated apparent power** parameter is relevant for the main protection function of the device. The **Rated apparent power** set here is the reference value for the percentage-measured values and setting values made in percentages.

NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated voltage

- Default setting **(_:91:102) Rated voltage** = ***400.00 kV***

With the **Rated voltage** parameter, you can set the primary rated voltage of the auto transformer to be protected. The **Rated voltage** parameter is relevant for the main protection functions of the device. The **Rated voltage** set here is the reference value for the percentage-measured values and setting values made in percentages.

NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated current

- Default setting **(_:91:101) Rated current** = ***1000 A***

The **Rated current** parameter indicates to you the primary rated current of the auto transformer. The **Rated current** parameter is relevant for the main protection function of the device. The setting value is formed from the **Rated voltage** and **Rated apparent power** parameters.

Parameter: Neutral point

- Default setting **(_:91:149) Neutral point** = ***isolated***

With the **Neutral point** parameter, you specify whether the neutral point is ***grounded*** or ***isolated***.

Parameter: Winding configuration

- Default setting **(_:91:104) Winding configuration** = ***D (Delta)***

With the **Winding configuration** parameter, you set ***D (Delta)*** for a delta connection of the auto transformer. Other setting options are ***Y (Wye)*** for a star connection and ***Z (Zig-Zag)*** for a zigzag connection. The **Winding configuration** parameter is relevant for the main protection function.

Parameter: Vector group numeral

- Default setting **(_:91:163) Vector group numeral** = ***1***

With the **Vector group numeral** parameter you set the vector group for the auto transformer to be protected. Every **Vector group numeral** from 0 to 11 can be set provided it is possible, for example, for Yy, Dd, and Dz only even numerals are possible, for Yd, Yz, and Dy only odd numerals. The **Vector group numeral** parameter is relevant for the main protection function.

NOTE

The device automatically calculates the current adaptation formulas required for the winding rated currents from the rated data of the auto transformer to be protected and its windings. The currents are converted so that the sensitivity of the protection is based on the rated apparent power of the auto transformer.

Parameter: Side number

- Default setting **(_:91:130) Side number** = ***not assigned***

The **Side number** parameter shows you which auto transformer side is currently valid for the following parameters. The side number (***Side 1*** to ***Side 5***) is automatically assigned with the connection to an auto transformer side.

Parameter: MI3ph1 usesMeasP with ID

- Default setting **(_:91:210) MI3ph1 usesMeasP with ID** = ***0***

The parameters **MI3ph1 usesMeasP with ID** to **MI3ph4 usesMeasP with ID** show you which 3-phase measuring points (**MI3ph 1** to **MI3ph 4**) are connected to the auto transformer compensation side. Every measuring point is assigned a unique ID.

Parameter: M I-1ph uses MeasP with ID

- Default setting **(_:91:214) M I-1ph uses MeasP with ID** = ***0***

The **M I-1ph uses MeasP with ID** parameter shows you which 1-phase measuring point is connected to the auto transformer compensation side. Every measuring point is assigned a unique ID.

Parameter: CT mismatch M I-3ph 1

- Default setting **(_:91:215) CT mismatch M I-3ph 1** = ***0.000***

The **CT mismatch M I-3ph 1** parameter shows you the magnitude scaling of the phase currents of the 1st assigned measuring point. The numerical value is made up from the ratio of the primary rated current of the current transformer to the auto transformer rated current of the compensation side.

Parameter: CT mismatch M I-3ph 1 IN

- Default setting **(_:91:216) CT mismatch M I-3ph 1 IN** = ***0.000***

The **CT mismatch M I-3ph 1 IN** parameter shows you the magnitude scaling of the ground current of the 1st assigned measuring point.

Parameter: CT mismatch M I-3ph 2

- Default setting **(_:91:217) CT mismatch M I-3ph 2** = ***0.000***

The **CT mismatch M I-3ph 2** parameter shows you the magnitude scaling of the phase currents of the 2nd assigned measuring point.

Parameter: CT mismatch M I-3ph 2 IN

- Default setting **(_:91:218) CT mismatch M I-3ph 2 IN** = ***0.000***

The **CT mismatch M I-3ph 2 IN** parameter shows you the magnitude scaling of the ground current of the 2nd assigned measuring point.

Parameter: CT mismatch M I-3ph 3

- Default setting **(_:91:219) CT mismatch M I-3ph 3** = ***0.000***

The **CT mismatch M I-3ph 3** parameter shows you the magnitude scaling of the phase currents of the 3rd assigned measuring point.

Parameter: CT mismatch M I-3ph 3 IN

- Default setting **(_:91:220) CT mismatch M I-3ph 3 IN** = ***0.000***

The **CT mismatch M I-3ph 3 IN** parameter shows you the magnitude scaling of the ground current of the 3rd assigned measuring point.

Parameter: CT mismatch M I-3ph 4

- Default setting **(_:91:221) CT mismatch M I-3ph 4** = ***0.000***

The **CT mismatch M I-3ph 4** parameter shows you the magnitude scaling of the phase currents of the 4th assigned measuring point.

Parameter: CT mismatch M I-3ph 4 IN

- Default setting **(_:91:222) CT mismatch M I-3ph 4 IN** = *0.000*

The **CT mismatch M I-3ph 4 IN** parameter shows you the magnitude scaling of the ground current of the 4th assigned measuring point.

Parameter: CT mismatch M I-1ph

- Default setting **(_:91:223) CT mismatch M I-1ph** = *0.000*

The **CT mismatch M I-1ph** parameter shows you the magnitude scaling of the auto transformer neutral-point current.

5.2.4.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameters	C	Range of Values	Default Setting
Rated values				
_:91:101	General:Rated current		1 A to 100 000 A	1 000 A
Side data				
_:91:130	General:Side number		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	not assigned
_:91:210	General:MI3ph1 uses-MeasP with ID		0 to 100	0
_:91:211	General:MI3ph2 uses-MeasP with ID		0 to 100	0
_:91:212	General:MI3ph3 uses-MeasP with ID		0 to 100	0
_:91:213	General:MI3ph4 uses-MeasP with ID		0 to 100	0
_:91:214	General:M I-1ph uses MeasP with ID		0 to 100	0
_:91:215	General:CT mismatch M I-3ph 1		0.000 to 100.000	0.000
_:91:216	General:CT mismatch M I-3ph 1 IN		0.000 to 100.000	0.000
_:91:217	General:CT mismatch M I-3ph 2		0.000 to 100.000	0.000
_:91:218	General:CT mismatch M I-3ph 2 IN		0.000 to 100.000	0.000
_:91:219	General:CT mismatch M I-3ph 3		0.000 to 100.000	0.000
_:91:220	General:CT mismatch M I-3ph 3 IN		0.000 to 100.000	0.000
_:91:221	General:CT mismatch M I-3ph 4		0.000 to 100.000	0.000

Addr.	Parameters	C	Range of Values	Default Setting
_:91:222	General:CT mismatch M I-3ph 3 IN		0.000 to 100.000	0.000
_:91:223	General:CT mismatch M I-1ph		0.000 to 100.000	0.000



NOTE

You can find more detailed information on the Process monitor in chapter *5.14 Process Monitor*.

5.2.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:91:103	General:Rated apparent power		0.20 MVA to 5000.00 MVA	692.82 MVA
_:91:102	General:Rated voltage		0.40 kV to 800.00 kV	400.00 kV
Side data				
_:91:149	General:Neutral point		• grounded • isolated	isolated
_:91:104	General:Winding configuration		• Y (Wye) • D (Delta) • Z (Zig-Zag)	D (Delta)
_:91:163	General:Vector group numeral		• 0 • 1 • 2 • 3 • 4 • 5 • 6 • 7 • 8 • 9 • 10 • 11 • user-defined	1
Measurements				
_:91:158	General:P, Q sign		• not reversed • reversed	not reversed

5.2.4.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:91:52	General:Behavior	ENS	O
_:91:53	General:Health	ENS	O

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
_:7381:52	Reset LED Group:Behavior	ENS	O
_:7381:53	Reset LED Group:Health	ENS	O
Closure detec.			
_:1131:4681:500	Closure detec.:>Disconnector open	SPS	I
_:1131:4681:300	Closure detec.:Closure	SPS	O
_:1131:4681:52	Closure detec.:Behavior	ENS	O
_:1131:4681:53	Closure detec.:Health	ENS	O

5.2.5 Function-Group Type Auto Transformer Ground Side

5.2.5.1 Overview

In the **Auto transf. ground side** function group all the functions required for protection and supervision of an auto transformer ground side can be used. The **Auto transf. ground side** function group also includes the measurement functions. You can find more information in chapter *9 Measured Values, Energy Values, and Supervision of the Primary System*.

The **Auto transf. ground side** function group must always have a link to the **Auto transf.** function group.

In the Global DIGSI 5 library, you will find the **Auto transf. ground side** function group under each device type and the folders with the respective protection functions. Depending on the connected measuring points, you can load the respective protection and supervision functions in the **Auto transf. ground side** function group.The functions are described in chapter *6 Protection and Automation Functions*.



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Figure 5-27 Auto Transformer Comp. Ground Side Function Group - Functional Scope for Device Type 7UT87

For more information about the embedding of the functions in the device, refer to *2 Basic Structure of the Function*. For information about the overall functional scope of the application templates for the various device types, refer to *4 Applications*.

5.2.5.2 Structure of the Function Group

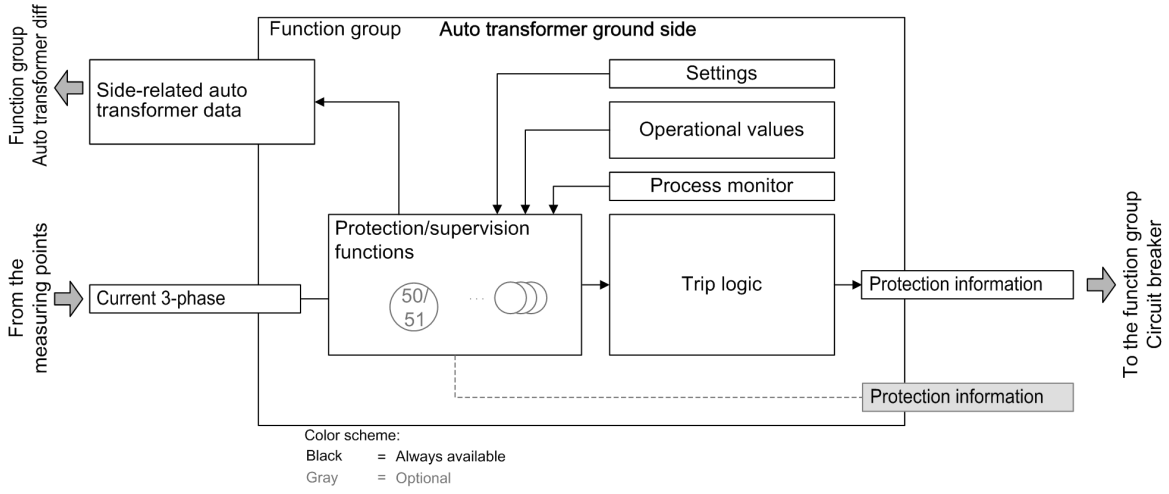
The **Auto transf. ground side** function group always includes the following function blocks:

- Protection and supervision functions
- Auto transformer data
- Operational measured values

- Process monitor
- Output logic of the function group

These blocks are required in the **Auto transf. ground side** function group and therefore cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the **Auto transf. ground side** function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.



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Figure 5-28 Structure of the Auto Transformer Ground Side Function Group

The **Auto transf. ground side** function group has interfaces to the following function groups:

- **Measuring points**
- **Circuit-breaker** function group
- **Auto transf. diff.**function group

Interfaces with Measuring Points

The **Auto transf. ground side** function group receives the required measured values via its interfaces with the measuring points.

By using an application template the **Auto transf. ground side** function group is connected with the required measuring points.

If you insert functions in the **Auto transf. ground side** function group, they automatically receive the measured values of the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the **Function-group connections** Editor.

You can find more detailed information in chapter *2 Basic Structure of the Function*.

The **Auto transf. ground side** function group has the following interface with the measuring points:

- **`3-phase current`**:

  The measurands from the 3-phase power system are supplied via this interface. Depending on the connection type of the transformers, these are for example I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The **Auto transf. ground side** function group must always be linked to the **I-3ph measuring point**.

  All functions of the **Auto transf. ground side** function group have access to these values.



NOTE

You can connect the **3-phase current** interface with a maximum of **one** 3-phase current measuring point.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and Circuit-breaker function groups via the interface with the **Circuit-breaker** function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the protection function groups

The **Auto transf. ground side** function group is connected with one or more Circuit-breaker function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the **Auto transf. ground side** function group
- Start of the **Circuit-breaker failure protection** function, if available in the Circuit-breaker function group, through the protection functions of the connected **Auto transf. ground side** function group

In addition to the general assignment of the **Auto transf. ground side** function group to the circuit-breaker function groups, you can configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 using the **Circuit-breaker interaction** Editor in the **Auto transf. ground side** function group.
In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the **Circuit-breaker failure protection** function?

If an application template is used, the function groups are connected to each other because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor. If the connection is missing, DIGSI 5 reports an inconsistency.
You can find more detailed information in chapter *2.1 Embedding of Functions in the Device*.

Interface with Protection Communication (Optional)

All required data is exchanged between the protection function group and the protection communication via the interface with **Protection communication**, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter *3.6 Protection Communication*.

Side-Dependent Auto Transformer Data

The auto transformer data characterize the auto transformer ground side to be protected. The auto transformer data applies for all of the functions in the **Auto transf. ground side** function group.

Process Monitor

The process monitor is always available in the **Auto transf. ground side** function group and cannot be removed. The process monitor makes the following information available in the **Auto transf. ground side** function group:

- Current-flow criterion:
  Recognition of an open/closed auto transf. ground side based on the flowing leakage current

- Closure detection:
  Recognition of the switching on of the auto transf. ground side
- Cold-load pickup detection (optional):

This information is available in the **Auto transf. ground side** function group for all the functions included in it.
The description of the process monitor begins in chapter *5.14 Process Monitor*.

Operational Measured Values

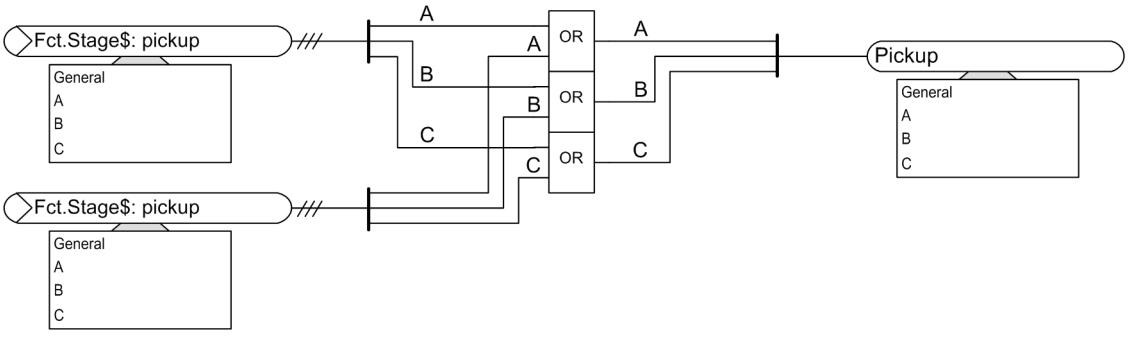
The operational measured values are always available in the **Auto transf. ground side** function group and cannot be deleted.

Table 5-9 Possible Operational Measured Values of the Auto Transformer Ground Side Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Currents	A	A	Rated operating current of the primary system
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary system
I_N	Measured zero-sequence current	A	A	Rated operating current of the primary system
f	Frequency	Hz	Hz	Rated frequency

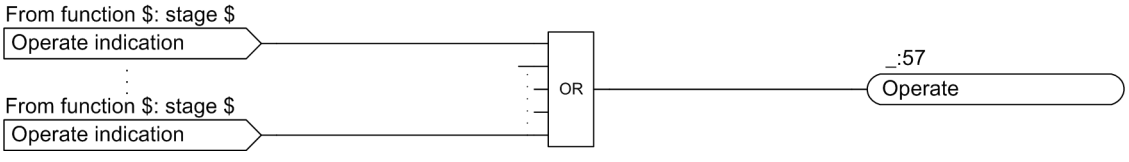
Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the **Protection information** interface to the **Circuit-breaker** function group and are processed further there.
The pickup and trip signals of the protection and supervision functions in the **Auto transf. ground side** function group are combined phase-selectively and output as group indication.



[lo_anrlin, 3, en_US]

Figure 5-29 Generation of Pickup Indication of the Auto Transformer Ground Side Function Group



[lo_auslin, 3, en_US]

Figure 5-30 Generation of Operate Indication of the Auto Transformer Ground Side Function Group

5.2.5.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

Depending on the protection function used and the circuit breakers to be activated, the connection to the corresponding **Circuit breaker** must be provided.

You can find more information in chapter *2 Basic Structure of the Function*.

Parameter: Rated apparent power

- Default setting **(_:91:103) Rated apparent power** = ***692.82 MVA***

With the **Rated apparent power** parameter, you can set the primary rated apparent power for the auto transformer to be protected. The **Rated apparent power** parameter is relevant for the main protection function of the device. The **Rated apparent power** set here is the reference value for the percentage-measured values and setting values made in percentages.

NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated voltage

- Default setting **(_:91:102) Rated voltage** = ***400.00 kV***

With the **Rated voltage** parameter, you can set the primary rated voltage of the auto transformer to be protected. The **Rated voltage** parameter is relevant for the main protection function of the device. The **Rated voltage** set here is the reference value for the percentage-measured values and setting values made in percentages.

NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated current

- Default setting **(_:91:101) Rated current** = ***1000 A***

The **Rated current** parameter indicates to you the primary rated current of the auto transformer side. The **Rated current** parameter is relevant for the main protection function of the device. The setting value is formed from the **Rated voltage** and **Rated apparent power** parameters.

NOTE

The device automatically calculates the current adaptation formulas required for the winding rated currents from the rated data of the auto transformer to be protected and its windings. The currents are converted so that the sensitivity of the protection is based on the rated apparent power of the auto transformer.

Parameter: Side number

- Default setting **(_:91:130) Side number** = ***not assigned***

The **Side number** parameter shows you which auto transformer side is currently valid for the following parameters. The side number (***Side 1*** to ***Side 5***) is automatically assigned with the connection to an auto transformer side.

Parameter: MI3ph1 usesMeasP with ID

- Default setting **(_:91:210) MI3ph1 usesMeasP with ID** = ***0***

The **MI3ph1 usesMeasP with ID** parameter shows you which 3-phase measuring point (**MI3ph 1**) is connected to the auto transformer side. The measuring point is assigned a unique ID.

Parameter: M I-1ph uses MeasP with ID

- Default setting **(_:91:214) M I-1ph uses MeasP with ID** = ***0***

The **M I-1ph uses MeasP with ID** parameter shows you which 1-phase measuring point is connected to the auto transformer side. Every measuring point is assigned a unique ID.

Parameter: CT mismatch M I-3ph 1

- Default setting **(_:91:215) CT mismatch M I-3ph 1** = ***0.000***

The **CT mismatch M I-3ph 1** parameter shows you the magnitude scaling of the phase currents of the 1st assigned measuring point. The numerical value is made up from the ratio of the primary rated current of the current transformer to the auto transformer rated current of the ground side.

Parameter: CT mismatch M I-3ph 1 IN

- Default setting **(_:91:216) CT mismatch M I-3ph 1 IN** = ***0.000***

The **CT mismatch M I-3ph 1 IN** parameter shows you the magnitude scaling of the ground current of the 1st assigned measuring point.

5.2.5.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameters	C	Range of Values	Default Setting
Rated values				
_:91:101	General:Rated current		1 A to 100 000 A	1 000 A
Side data				
_:91:130	General:Side number		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	not assigned
_:91:210	General:MI3ph1 uses-MeasP with ID		0 to 100	0
_:91:215	General:CT mismatch M I-3ph 1		0.000 to 100.000	0.000
_:91:216	General:CT mismatch M I-3ph 1 IN		0.000 to 100.000	0.000



NOTE

You can find more detailed information on the Process monitor in chapter *5.14 Process Monitor*.

5.2.5.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:91:52	General:Behavior	ENS	O
_:91:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
_:7381:52	Reset LED Group:Behavior	ENS	O
_:7381:53	Reset LED Group:Health	ENS	O
Closure detec.			
_:1131:4681:500	Closure detec.:>Disconnector open	SPS	I
_:1131:4681:300	Closure detec.:Closure	SPS	O
_:1131:4681:52	Closure detec.:Behavior	ENS	O
_:1131:4681:53	Closure detec.:Health	ENS	O

5.2.6 Function-Group Type Auto Transformer Neutral Point

5.2.6.1 Overview

In the **Auto transf. neutral point** function group all the necessary functions for protection and for supervision of an auto transformer are used, which are related to a neutral-point current. The **Auto transf. neutral point** also includes the measurement functions. You can find more information in chapter *9 Measured Values, Energy Values, and Supervision of the Primary System*.



NOTE

The transformer and restricted ground-fault protection do not work with responsive ground-current transformers. Responsive transformers go to saturation too fast and generate incorrect differential currents.

In the Global DIGSI 5 library, you will find the **Auto transf. neutral point** function group under each device type and the folders with the respective protection functions. Depending on the connected measuring points, you can load the respective protection and supervision functions in the **Auto transf. neutral point** function group. Here you can only load 1-phase current functions or optional 1-phase voltage functions. The functions are described in chapter *6 Protection and Automation Functions*.



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Figure 5-31 Auto Transformer Comp. Neutral Point Function Group - Functional Scope for Device Type 7UT87

For more information about the embedding of the functions in the device, refer to *2 Basic Structure of the Function*. For information about the overall functional scope of the application templates for the various device types, refer to *4 Applications*.

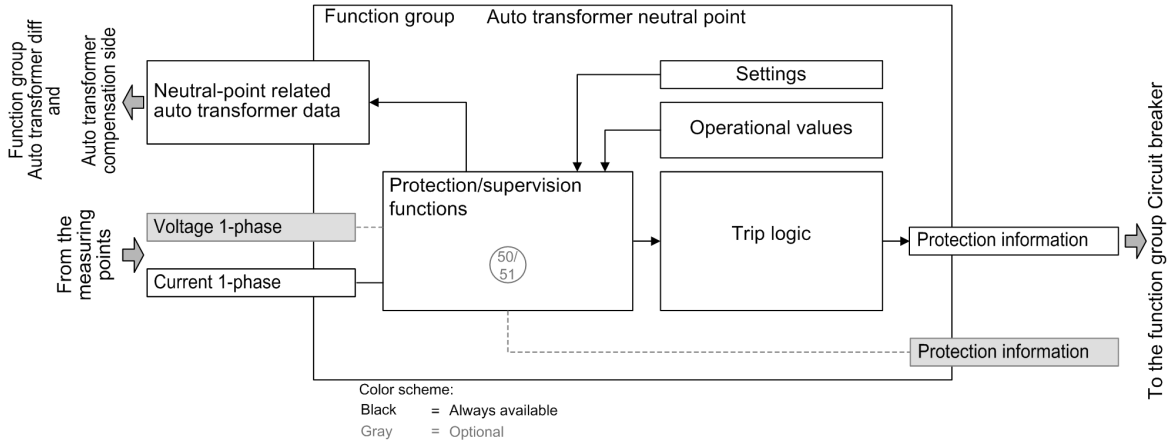
5.2.6.2 Structure of the Function Group

The **Auto transf. neutral point** function group always includes the following function blocks:

- Neutral-point related auto transformer data
- Operational measured values
- Output logic of the function group

These blocks are required in the **Auto transf. neutral point** function group and therefore cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the **Auto transf. neutral point** function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.



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Figure 5-32 Structure of the Auto Transf. Neutral Point Function Group

The **Auto transf. neutral point** function group has interfaces to the following function groups:

- **Measuring points**
- **Circuit-breaker** function group
- **Auto transf. diff.** function group
- **Auto transformer comp. side** function group

Interfaces with Measuring Points

The **Auto transf. neutral point** receives the required measured values via its interfaces with the measuring points.

By using an application template the **Auto transf. neutral point** function group is connected with the required measuring points.

If you insert functions in the **Auto transf. neutral point** function group, they automatically receive the measured values of the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the **Function-group connections** Editor.

You can find more detailed information in chapter *2 Basic Structure of the Function*.

The **Auto transf. neutral point** function group has the following interfaces with the measuring points:

- **`1-phase voltage`** (optional):

  The measurands from the 1-phase voltage system are supplied via this interface. All values that can be calculated from the measurands are also provided via this interface.

  You have to connect the **`1-phase voltage`** interface with the **Measuring point V-1ph** only if the functions in the **Auto transf. neutral point** function group work with this measurand.

- **`1-phase current`**:

  The measurands from the 1-phase power system are supplied via this interface. Depending on the connection type for the transformers, this is for example I_x. All values that can be calculated from the measurands are also provided via this interface. The **Auto transf. neutral point** must always be linked with the **Measuring point I-1ph** .

NOTE

You can connect the **`1-phase current`** interface with a maximum of **one** 1-phase current measuring point.

All functions of the **Auto transf. auto side** function group have access to these values.

NOTE

If you instantiate in the **Auto transf. neutral point** function group, the **Overcurrent protection 1ph** function, the information for the inrush-current detection is taken from the assigned **Auto transf. auto side** function group.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and Circuit-breaker function groups via the interface with the **Circuit-breaker** function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the protection function groups

The **Auto transf. neutral point** function group is connected with one or more Circuit-breaker function groups. This connection generally determines:

- Which circuit breakers are activated by the protection functions of the **Auto transf. neutral point** function group
- Start of the **Circuit-breaker failure protection** function, if available in the Circuit-breaker function group, through the protection functions of the connected **Auto transf. neutral point** function group

In addition to the general assignment of the **Auto transf. neutral point** function group to the Circuit-breaker function groups, you can configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 using the **Circuit-breaker interaction** Editor in the **Auto transf. neutral point** function group.

In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the **Circuit-breaker failure protection** function?

If an application template is used, the function groups are connected to each other because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter *2.1 Embedding of Functions in the Device*.

Interface with Protection Communication (Optional)

All required data is exchanged between the protection function group and the protection communication via the interface with **Protection communication**, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter *3.6 Protection Communication*.

Neutral-Point Related Auto Transformer Data

The auto transformer data characterize the auto transformer neutral point to be protected. The auto transformer data applies for all of the functions in the **Auto transf. neutral point** function group.

Operational Measured Values

The operational measured values are always available in the **Auto transf. neutral point** function group and cannot be deleted.

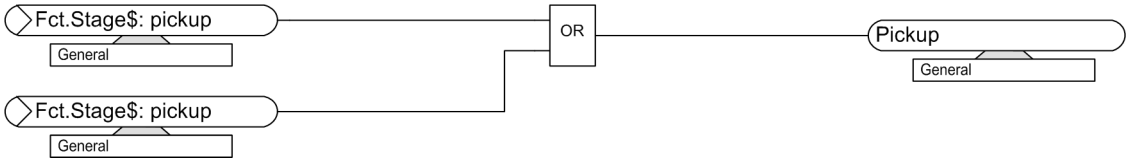
Table 5-10 Operational Measured Values of the Auto Transf. Neutral Point Function Group

Measured Values		Primary	Secondary	% Referenced to
I	Neutral-point current	A	A	Rated operating current of the primary system
V	Voltage	kV	V	Rated operating voltage of the primary system

Output Logic

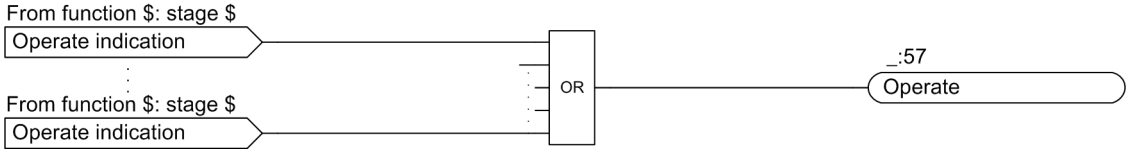
The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately, in a pickup logic and an output logic respectively. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the **Protection-information** interface to the **Circuit-breaker** function group and are processed further there.

The pickup and trip signals of the protection and supervision functions in the **Auto transf. neutral point** are combined phase-selectively and output as group indication.



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Figure 5-33 Generation of Pickup Indication of the Auto Transf. Neutral Point Function Group



[lo_auslin, 3, en_US]

Figure 5-34 Generation of Operate Indication of the Auto Transf. Neutral Point Function Group

5.2.6.3 Application and Setting Notes

Parameter: Rated current

- Default setting **(_:9421:101) Rated current** = ***1000 A***

With the **Rated current** parameter, you can set the primary rated current for the auto transformer to be protected. The **Rated current** parameter is relevant for the main protection function of the device. The **Rated current** specified here is the reference value for the percentage-measured values and setting values made in percentages.

NOTE

The **(_:9421:101) Rated current** parameter is not visible with a circuiting of the **Auto transformer compensation side** or **Auto transformer diff.** function groups with a **Auto transformer auto side** function group. Instead the write-protected parameter **(_:9421:104) Rated current** is displayed.

The **(_:9421:102) Rated voltage** parameter behaves the same with this circuiting. In its place the **(_:9421:105) Rated voltage** parameter is displayed.

Parameter: Rated current (write-protected)

- Default setting **(_9421:104) Rated current** = ***1000 A***

The **Rated current** parameter indicates to you the primary rated current of the auto transformer to be protected. The **Rated current** can correspond to the following variables:

- Rated current of the connected transformer side
- Rated current of the reference side of the connected auto transformer

The **Rated current** cannot be changed.

Parameter: Rated voltage

- Default setting **(_:9421:102) Rated voltage** = ***400.00 kV***

With the **Rated voltage** parameter, you can set the primary rated voltage of the auto transformer to be protected. The **Rated voltage** parameter is relevant for the main protection function of the device. The **Rated voltage** set here is the reference value for the percentage-measured values and setting values made in percentages.

Parameter: Rated voltage (write-protected)

- Default setting **(_:9421:105) Rated voltage** = ***400.00 kV***

The **Rated voltage** parameter indicates to you the primary rated voltage of the auto transformer to be protected. The **Rated voltage** can correspond to the following variables:

- Rated voltage of the connected transformer side
- Rated voltage of the reference side of the connected auto transformer

The **Rated voltage** cannot be changed.

Parameter: Rated apparent power

- Default setting **(_:9421:103) Rated apparent power** = ***692.82 MVA***

The **Rated apparent power** parameter indicates to you the calculated value from **Rated voltage** and **Rated current**. If current and voltage are available, this value is only displayed for you and cannot be changed.

Parameter: M I-1ph uses MeasP with ID

- Default setting **(_:9421:214) M I-1ph uses MeasP with ID** = ***0***

The **M I-1ph uses MeasP with ID** parameter shows you which 1-phase measuring point is connected to the transformer neutral point. Every measuring point is assigned a unique ID.

Parameter: CT mismatch M I-1ph

- Default setting **(_:9421:223) CT mismatch M I-1ph** = ***0.000***

The **CT mismatch M I-1ph** parameter shows you the magnitude scaling of the auto transformer neutral-point current.

5.2.6.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_:9421:101	General:Rated current		1 A to 100 000 A	1 000 A
_:9421:102	General:Rated voltage		0.20 kV to 1 200.00 kV	400 kV

Addr.	Parameter	C	Range of Values	Default Setting
_:9421:103	General:Rated apparent power		0.20 MVA to 5 000.00 MVA	692.82 MVA
_:9421:104	General:Rated current		1 A to 100 000 A	1 000 A
_:9421:105	General:Rated voltage		0.20 kV to 1 200.00 kV	400 kV
Power-system data				
_:9421:214	General:M I-1ph uses MeasP with ID		0 to 100	0
_:9421:223	General:CT mismatch M I-1ph		0.00 to 100.00	0.000

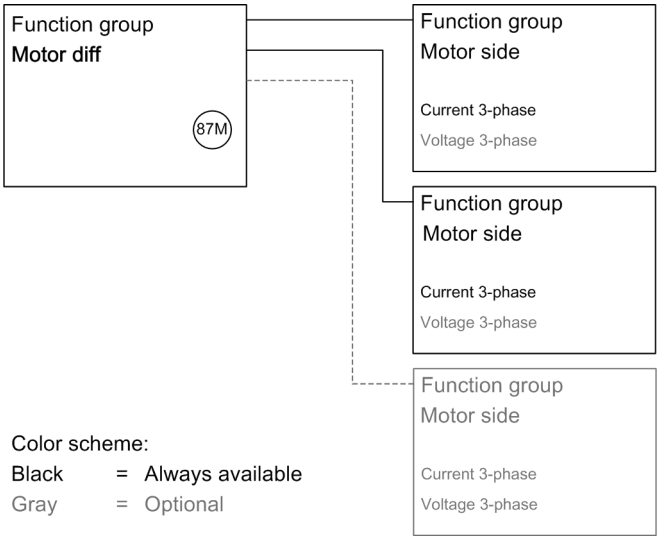
5.2.6.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:9421:52	General:Behavior	ENS	O
_:9421:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
_:7381:52	Reset LED Group:Behavior	ENS	O
_:7381:53	Reset LED Group:Health	ENS	O

5.3 Overview Function Group Motor Differential Protection

5.3.1 Function-Group Types

In the following figure, you can see the structural association of the function-group types **Motor differential**



[dwfguest-040713-01.vsd, 1, en_US]

Figure 5-35 Function-Group Types Motor differential

The following function-group types are summarized in the Global DIGSI 5 library:

- **Motor differential**
- **Motor side**

The individual function-group types are stored under the folder **FG Motor diff** and can be selected. In the protection function folders, you find all protection functions which are operational in each function group. One function group **Motor differential** always has 2 function groups **Motor side** ; at a maximum, you can assign a total of 3 function groups **Motor side** to the function group **Motor differential** .

The following table shows the number of function-group types that can be instantiated depending on the device (7UT82, 7UT85, 7UT86, 7UT87).

Table 5-11 Function-Group Types in the Device

Device	Function-Group Type	
	Motor differential	Motor side
7UT82	Max. 1	Max. 2
7UT85	Max. 2	Max. 4
7UT86	Max. 2	Max. 5
7UT87	Max. 3	Max. 7

Interconnection of the function groups is necessary so that the Motor differential protection functions properly. The Circuit-breaker function group is not listed. The figure shown in the application template (refer to *Figure 4-5*) offers a good overview of the interconnection options.

Table 5-12 Assignment of Protection Function Groups to Protection Function Groups

	Motor differential 1
	Side (2 ... 3)
Motor side 1	X
Motor side 2	X

The individual function-group types are described in the following.

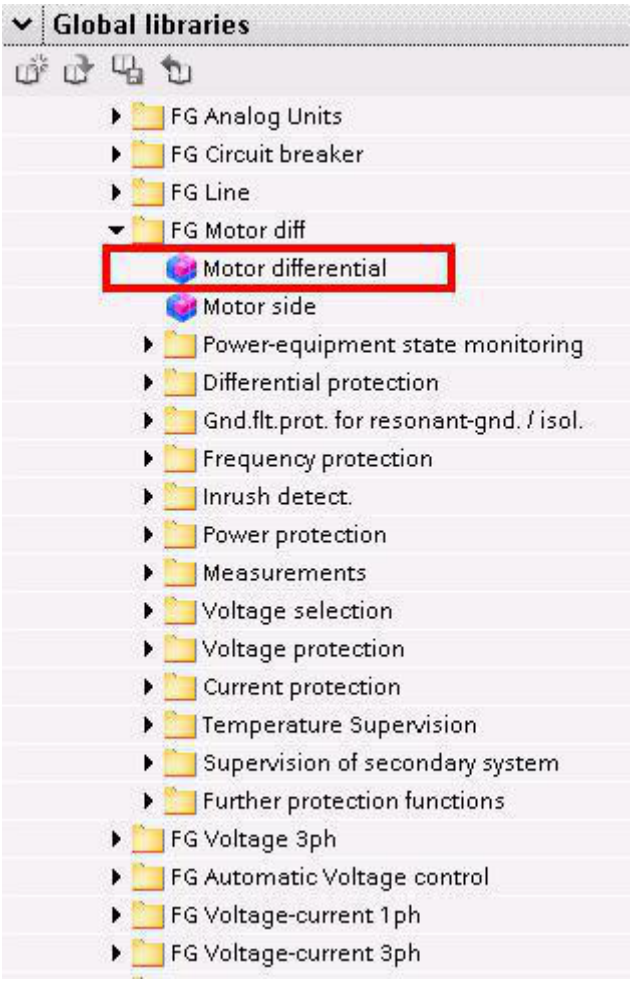
5.3.2 Function-Group Type Motor Diff

5.3.2.1 Overview

The **Motor diff.** function group contains the differential protection function and protection-function-relevant measured values.

You can find more information in chapter *9 Measured Values, Energy Values, and Supervision of the Primary System*.

You will find the corresponding function groups and also the folders with the usable protection functions in the Global DIGSI library under each device type. You can load only the differential protection function in the **Motor diff.** function group.



[scfgmodi-240114-01-DE, 1, en_US]

Figure 5-36 Motor Differential Protection Function Group - Functional Scope

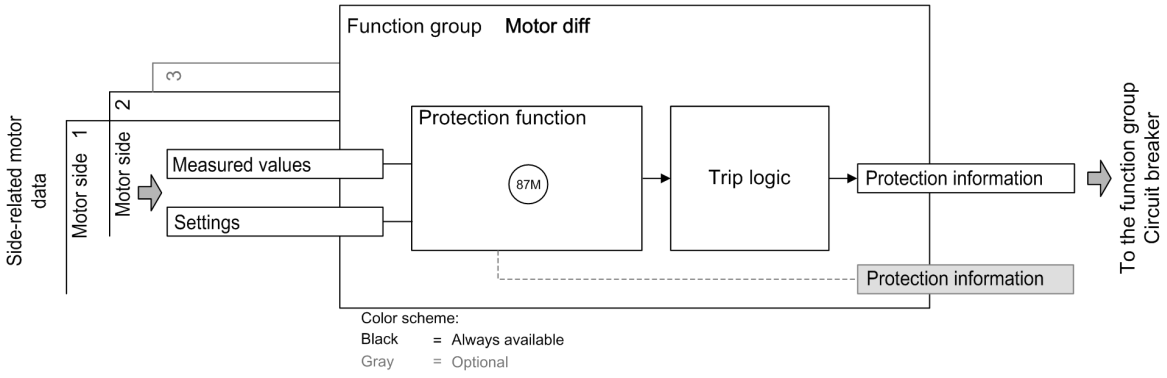
For more information about the embedding of the functions in the device, refer to chapter *2 Basic Structure of the Function*. For information about the overall functional scope of the application templates for the various device types, refer to chapter *4 Applications*.

5.3.2.2 Structure of the Function Group

The **Motor diff.** function group according to *5.3.2.1 Overview* has interfaces with the **Motor side** and **Circuit-breaker** function groups. The **Motor diff.** function group contains the function blocks:

- Protection function (execution of the differential protection function)
- Trip logic (generation of forwarding of the operate indication)

In the **Motor diff.** function group, the differential protection function must always be available so that the protection functionality can be ensured. If you do not use an application template, load this from the Global DIGSI 5 library.



[dwfgmodz-211013-01.tif, 1, en_US]

Figure 5-37 Structure of the Motor Differential Protection Function Group

The **Motor diff.** function group has interfaces to the following components:

- **Motor side** function group
- **Circuit-breaker** function group

Interfaces to the Circuit-Breaker Function Group

All required data is exchanged between the **Motor diff.** function group and the **Circuit-breaker** function group via the interface of the **Circuit-breaker** function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the **Circuit-breaker** function group
- Information on the circuit-breaker condition in the direction of the protection function groups

You can connect the **Motor diff.** function group to one or more **Circuit-breaker** function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the **Motor diff.** function group
- Start of the **Circuit-breaker failure protection** function, if available in the **Circuit-breaker** function group, through the protection functions of the connected **Motor diff.** function group

Besides the general assignment of the **Motor diff.** function group to the **Circuit-breaker** function groups, you can also configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 via the **Circuit-breaker interaction** Editor in the **Motor diff.** function group.
In the detail configuration of the interface, you define:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the **Circuit-breaker failure protection** function

If you are using an application template, the function groups are already connected to each other, because this connection is essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor. If the connection is missing, DIGSI 5 reports an inconsistency.
You can find more detailed information in chapter *2.1 Embedding of Functions in the Device*.

Resetting the LED Group

Using the **Reset the LED group** function, you can reset the stored LEDs of the functions in one specific function group while the activated, stored LEDs of other functions in other function groups remain activated.

Interface with Protection Communication (Optional)

All required data is exchanged between the protection function group and the protection communication via the interface with **Protection communication**. These data are for example:

- Binary signals
- Measured values
- Complex data

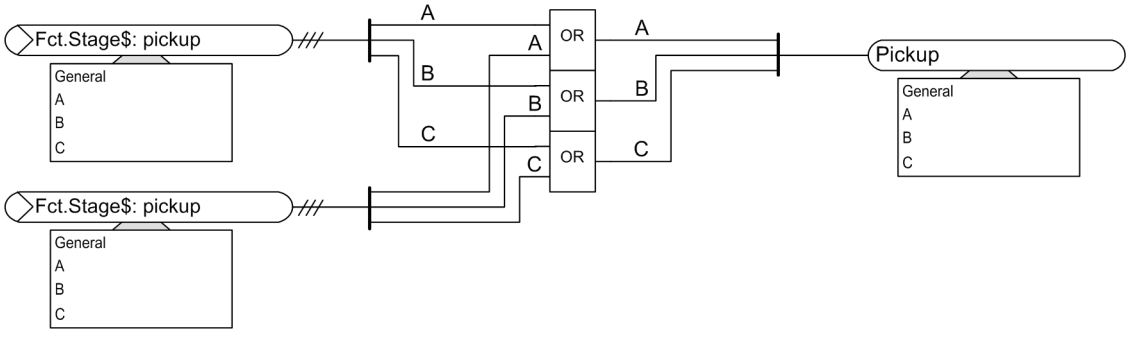
You can find more detailed information in chapter *3.6 Protection Communication*.

Motor Data (General)

The motor data characterizes the data of the motor to be protected. The data relevant for the differential protection is shown. The **Motor diff.** function group takes these data from the coupled function group **Motor side** function groups.

Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the **Protection-information** interface to the **Circuit-breaker** function group and are processed further there.
The pickup and operate indications of the protection and supervision functions in the **Motor diff.** function group are combined into one group indication using the following numbers and outputs.



[lo_anrlin, 3, en_US]

Figure 5-38 Generation of Pickup Indication of the Motor Differential Protection Function Group

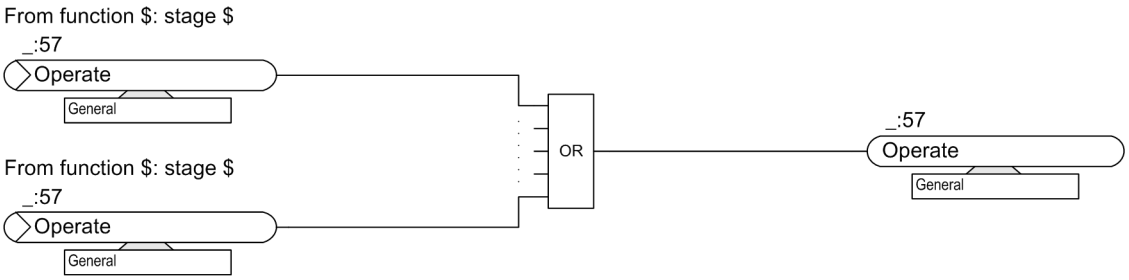


Figure 5-39 Generation of Operate Indication of the Motor Differential Protection Function Group

5.3.2.3 Information List

No.	Information	Data Class (Type)	Type
General			
_:91:52	General:Behavior	ENS	O
_:91:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
_:7381:52	Reset LED Group:Behavior	ENS	O
_:7381:53	Reset LED Group:Health	ENS	O

5.3.3 Function-Group Type Motor Side

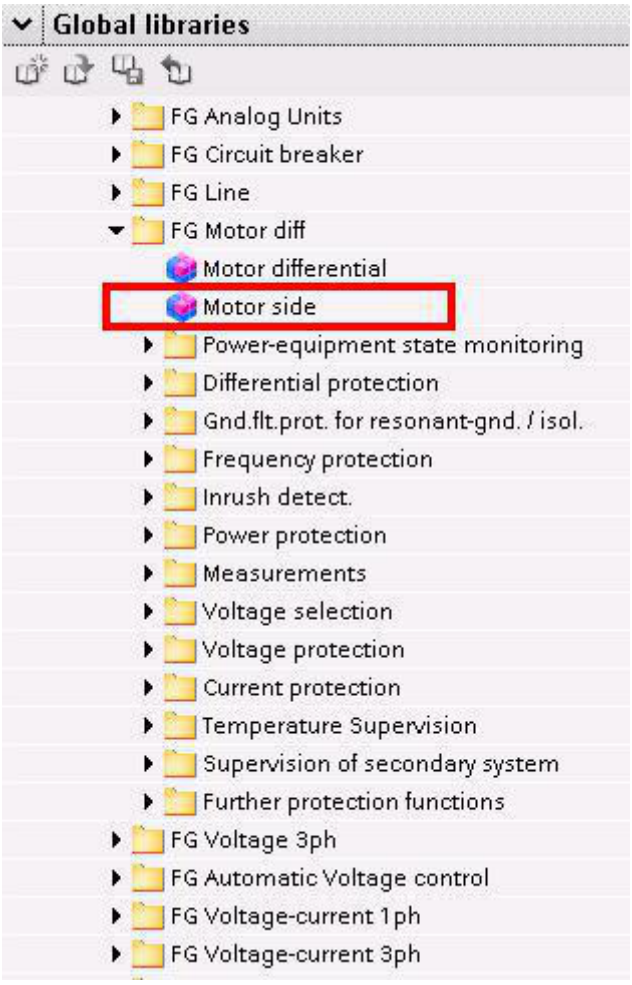
5.3.3.1 Overview

In the **Motor side** function group, all of the functions that are necessary for protecting and supervising a motor side can be used. The **Motor side** function group also contains the measuring functions.

You can find more information in chapter *9 Measured Values, Energy Values, and Supervision of the Primary System*.

The **Motor side** function group must always have interfacing to the **Motor diff.** function group.

You will find the corresponding function groups and also the folders with the usable protection functions in the Global DIGSI 5 library under each device type. Depending on the connected measuring points, you can load the respective protection and supervision functions in the **Motor side** function group. The functions are described in chapter *6 Protection and Automation Functions*.



[scfgmosd-240114-01-DE, 1, en_US]

Figure 5-40 Motor Side Function Group - Functional Scope

For more information about the embedding of the functions in the device, refer to *2 Basic Structure of the Function*. For information about the overall functional scope of the application templates for the various device types, refer to *4 Applications*.

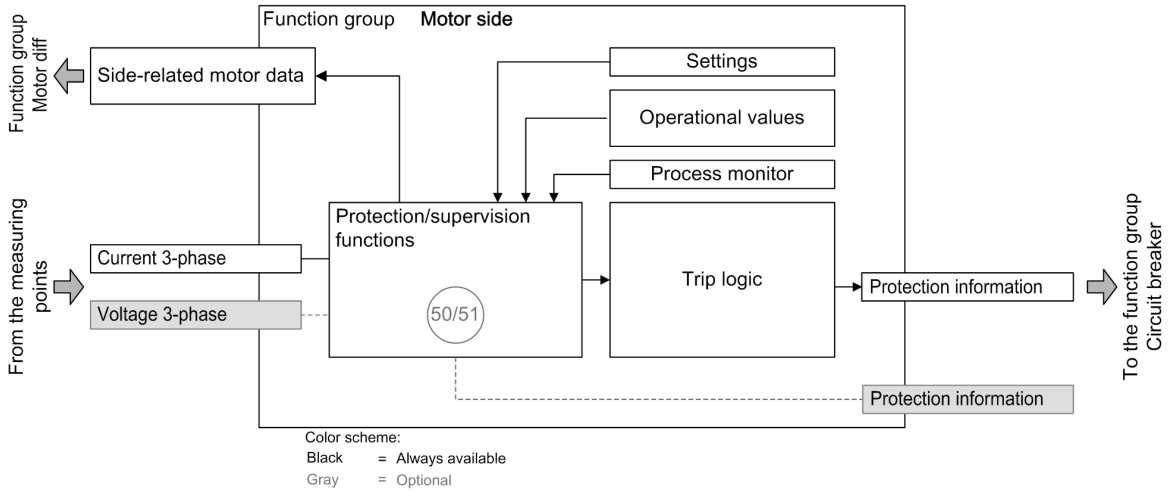
5.3.3.2 Structure of the Function Group

The **Motor side** function group always contains the following function blocks:

- Side-dependent motor data
- Operational measured values
- Process monitor
- Trip logic of the function group

These blocks are required for the **Motor side** function group and therefore cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the **Motor side** function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.



[dwfgmosi-030713-01.tif, 1, en_US]

Figure 5-41 Structure of the Motor Side Function Group

The **Motor side** function group has interfaces to the following components:

- **Measuring points**
- **Motor diff.** function group
- **Circuit-breaker** function group

Interfaces with Measuring Points

The **Motor side** function group receives the required measured values via its interfaces with the measuring points. If you are using an application template, the **Motor side** function group is already connected to the necessary measuring points.

If you add functions to the **Motor side** function group, they will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the **Function-group connections** Editor.

You can find more detailed information in chapter *2 Basic Structure of the Function*.

The **Motor side** function group has the following interfaces with the measuring points:

- **`3-phase current`**

  The measurands from the 3-phase power system are supplied via this interface. Depending on the transformer connection type, these are for example: I_A, I_B, I_C, I_N, or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The **Motor side** function group must always be connected to the **I-3ph measuring point**.

  You can connect the **`3-phase current`** interface to a maximum of **four** 3-phase current measuring points, for example, for 1 1/2 circuit-breaker layouts, two 3-phase current measuring points are required. If 2 current measuring points have been connected to the **3-phase current** interface, the total current is also determined from measured values from both measuring points in the **Motor side** function group. All functions in the **Motor side** function group have access to these values.

- **`3-phase voltage`** (optional):

  The measurands from the 3-phase voltage system are supplied via this interface. Different transformer connection types are possible. All values that can be calculated from the measurands are also provided via this interface.

  Connection of the **3-phase voltage** interface is optional. This connection is necessary only if protection or supervision functions that require voltage measurements are used.

Interfaces to the Circuit-Breaker Function Group

All required data is exchanged between the **Motor side** function group and the **Circuit-breaker** function group via the interface of the **Circuit-breaker** function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the protection function groups

You can connect the **Motor side** function group to one or more **Circuit-breaker** function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the **Motor side** function group
- Start of the **Circuit-breaker failure protection** function, if available in the **Circuit-breaker** function group, through the protection functions of the connected **Motor side** function group

Besides the general assignment of the **Motor side** function group to the **Circuit-breaker** function group, you can also configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 via the **Circuit-breaker interaction** Editor in the **Motor side** function group.
In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the **Circuit-breaker failure protection** function

If you are using an application template, the function groups are already connected to each other, because this connection is essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor. If the connection is missing, DIGSI 5 reports an inconsistency.
You can find more detailed information in chapter *2.1 Embedding of Functions in the Device*.

Interface with Protection Communication (Optional)

All required data is exchanged between the Protection function group and the protection communication via the interface with **Protection communication**, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter *3.6 Protection Communication*.

Resetting the LED Group

Using the **Reset the LED group** function, you can reset the stored LEDs of the functions in one specific function group while the activated, stored LEDs of other functions in other function groups remain activated.

Process Monitor

The process monitor is always present in the **Motor side** function group and cannot be removed. The process monitor provides the following information in the **Motor side** function group:

- Current-flow criterion:
  Detection of an open/activated motor side based on the flow of leakage current
- Closure detection:
  Detection of closure of the motor side
- Cold-load pickup detection (optional):

This information is in the **Motor side** function group and is available to all the functions in the function group.
The description of the process monitor begins in chapter *5.14 Process Monitor*.

Operational Measured Values

The operational measured values are always present in the **Motor side** function group and cannot be deleted. If a 3-phase voltage measuring point is connected, the following table shows the total scope. Only the first 3 lines apply for exclusive current connection.

Table 5-13 Possible Operational Measured Values of the Motor Side Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary system
I_N	Measured zero-sequence current	A	A	Rated operating current of the primary system
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary system
V_0	Calculated zero-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
V_N	Measured neutral-point displacement voltage	kV	V	Rated operating voltage of the primary system/√3
f	Frequency	Hz	Hz	Rated frequency
P	Active power (total power)	MW	–	Active power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q	Reactive power (total power)	Mvar	–	Reactive power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S	Apparent power (total power)	MVA	–	Apparent power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active factor	(abs)	(abs)	100% corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	–	Active power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	–	Reactive power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$
S_A, S_B, S_C	Phase-related apparent power	MVA	–	Apparent power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$

If a **V-3ph measuring point** was connected to the **Motor side** function group, voltage and phase measurements are available.

The energy measurements are not predefined. If necessary, you must load them from the Global DIGSI 5 library.

Depending on the protection and supervision functions used, additional function measurements can be available. The function values are listed in the **Information list** for the relevant protection or supervision function (refer to *6 Protection and Automation Functions* and *8 Supervision Functions*).

NOTE

With the **`P, Q sign`** parameter in the function block **General**, the sign of the following measured values of the respective function group can be inverted (see chapter *9.2 Structure of the Function* Structure of the Function, section Inversion of Output-Related Measured and Statistical Values):

- Active power (total): P total
- Active power (phase-related): P_A, P_B, P_C
- Reactive power (total): Q total
- Reactive power (phase-related): Q_A, Q_B, and Q_C

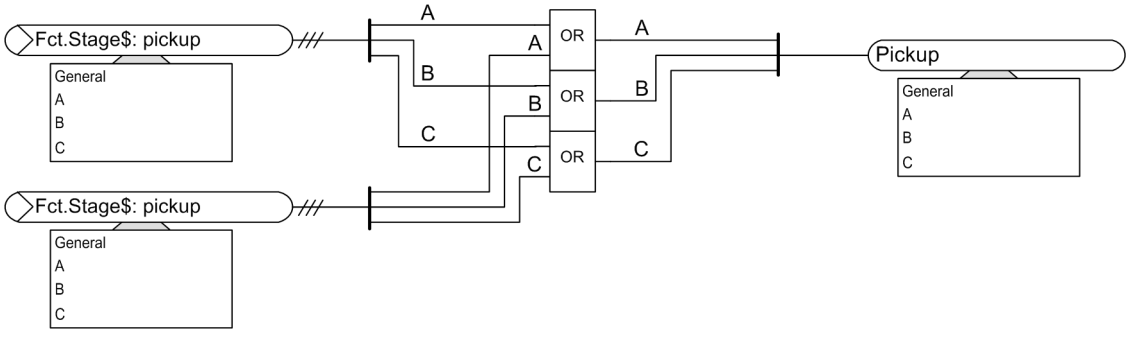
Motor Data (Side-Related)

The motor data characterizes the data of the motor to be protected. The side-dependent motor data applies for all of the functions in the **Motor side** function group.

Output Logic

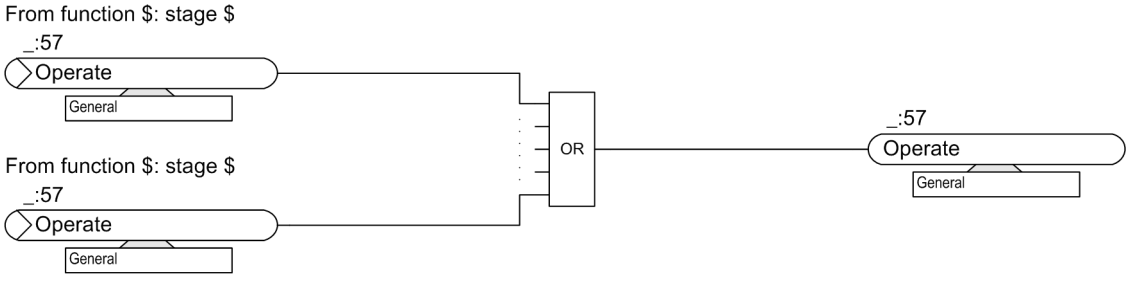
The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the **Protection-information** interface to the **Circuit-breaker** function group and are processed further there.

The pickup and operate indications of the protection and supervision functions in the **Motor side** function group are combined into one group indication using the following numbers and outputs.



[lo_anrlin, 3, en_US]

Figure 5-42 Generation of Pickup Indication of the Motor Side Function Group



[lo_geopi1-231013-01, 2, en_US]

Figure 5-43 Generation of Operate Indication of the Motor Side Function Group

5.3.3.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

The **Motor side** function group is usually connected to 1 **Circuit-breaker** function group. The **Circuit-breaker** function group is assigned to the circuit breaker of the motor.

Parameter: `Rated apparent power`

- Default setting **`(_:1781:14671:103) Rated apparent power`** = ***`692.82 MVA`***

With the **`Rated apparent power`** parameter, you can set the primary rated apparent power for the motor to be protected. The **`Rated apparent power`** parameter is relevant for the main protection function of the device. The **`Rated apparent power`** set here is the reference value for the percentage-measured values and setting values made in percentages.



NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: `Motor rated voltage`

- Default setting **`(_:1781:14671:102) Motor rated voltage`** = ***`400.00 kV`***

With the **`Motor rated voltage`** parameter, you can set the primary rated apparent power for the motor to be protected. The **`Motor rated voltage`** parameter is relevant for the main protection function of the device. The **`Motor rated voltage`** set here is the reference value for the percentage-measured values and setting values made in percentages.



NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: `Motor rated current`

- Default setting **`(_:1781:14671:101) Motor rated current`** = ***`1000 A`***

The **`Motor rated current`** parameter shows you the primary rated current of the motor side. The**`Motor rated current`** parameter is relevant for the main protection function of the device. The setting value is formed from the **`Motor rated voltage`** and **`Rated apparent power`** parameters.



NOTE

The device also automatically calculates the current adaptation formulas required for the winding rated currents from the rated data of the motor to be protected and its windings. The currents are converted so that the sensitivity of the protection is based on the rated apparent power of the motor.

Parameter: `Side number`

- Default setting **`(_:1781:14611:130) Side number`** = ***`not assigned`***

The **`Side number`** parameter shows you which motor side is currently valid for the following settings. The side number (***`Side 1`*** to ***`Side 3`***) is automatically assigned with the connection to a motor side.

Parameter: `MI3ph1 usesMeasP with ID`

- Default setting **`(_:1781:14611:210) MI3ph1 usesMeasP with ID`** = ***`0`***

The parameters **MI3ph1 usesMeasP with ID** to **MI3ph4 usesMeasP with ID** show you which 3-phase measuring points (**MI3ph 1** to **MI3ph 4**) are connected to the motor side. Every measuring point is assigned a unique ID.

Parameter: CT mismatch M I-3ph 1

- Default setting **(_:1781:14611:215) CT mismatch M I-3ph 1** = ***0.000***

The **CT mismatch M I-3ph 1** parameter shows you the magnitude adaptation of the phase currents of the 1st assigned measuring point. The numerical value is made up from the ratio of the primary rated current of the current transformer to the motor rated current of the side.

Parameter: CT mismatch M I-3ph 1 IN

- Default setting **(_:1781:14611:216) CT mismatch M I-3ph 1 IN** = ***0.000***

The **CT mismatch M I-3ph 1 IN** parameter shows you the magnitude adaptation of the ground current of the 1st assigned measuring point.

Parameter: CT mismatch M I-3ph 2

- Default setting **(_:1781:14611:217) CT mismatch M I-3ph 2** = ***0.000***

The **CT mismatch M I-3ph 2** parameter shows you the magnitude adaptation of the phase currents of the 2nd assigned measuring point.

Parameter: CT mismatch M I-3ph 2 IN

- Default setting **(_:1781:14611:218) CT mismatch M I-3ph 2 IN** = ***0.000***

The **CT mismatch M I-3ph 2 IN** parameter shows you the magnitude adaptation of the ground current of the 2nd assigned measuring point.

Parameter: CT mismatch M I-3ph 3

- Default setting **(_:1781:14611:219) CT mismatch M I-3ph 3** = ***0.000***

The **CT mismatch M I-3ph 3** parameter shows you the magnitude adaptation of the phase currents of the 3rd assigned measuring point.

Parameter: CT mismatch M I-3ph 3 IN

- Default setting **(_:1781:14611:220) CT mismatch M I-3ph 3 IN** = ***0.000***

The **CT mismatch M I-3ph 3 IN** parameter shows you the magnitude adaptation of the ground current of the 3rd assigned measuring point.

Parameter: CT mismatch M I-3ph 4

- Default setting **(_:1781:14611:221) CT mismatch M I-3ph 4** = ***0.000***

The **CT mismatch M I-3ph 4** parameter shows you the magnitude adaptation of the phase currents of the 4th assigned measuring point.

Parameter: CT mismatch M I-3ph 4 IN

- Default setting **(_:1781:14611:222) CT mismatch M I-3ph 4 IN** = ***0.000***

The **CT mismatch M I-3ph 4 IN** parameter shows you the magnitude adaptation of the ground current of the 4th assigned measuring point.

5.3.3.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_:1781:14671:101	Motor rated current		1 A to 100 000 A	1000 A
Side data				
_:1781:14611:130	Side number		• not assigned • Side 1 • Side 2 • Side 3	not assigned
_:1781:14611:210	MI3ph1 usesMeasP with ID		0 to 100	0
_:1781:14611:211	MI3ph2 usesMeasP with ID		0 to 100	0
_:1781:14611:212	MI3ph3 usesMeasP with ID		0 to 100	0
_:1781:14611:213	MI3ph4 usesMeasP with ID		0 to 100	0
_:1781:14611:215	CT mismatch M I-3ph 1		0.010 to 100.000	0.000
_:1781:14611:216	CT mismatch M I-3ph 1 IN		0.010 to 100.000	0.000
_:1781:14611:217	CT mismatch M I-3ph 2		0.010 to 100.000	0.000
_:1781:14611:218	CT mismatch M I-3ph 2 IN		0.010 to 100.000	0.000
_:1781:14611:219	CT mismatch M I-3ph 3		0.010 to 100.000	0.000
_:1781:14611:220	CT mismatch M I-3ph 3 IN		0.010 to 100.000	0.000
_:1781:14611:221	CT mismatch M I-3ph 4		0.010 to 100.000	0.000
_:1781:14611:222	CT mismatch M I-3ph 4 IN		0.010 to 100.000	0.000

NOTE

You can find more detailed information on the Process monitor in chapter *5.14 Process Monitor*.

5.3.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:1781:14671:103	General:Rated apparent power		0.20 MVA to 5000.00 MVA	692.82 MVA
_:1781:14671:102	General:Motor rated voltage		0.40 kVto 800.00 kV	400.00 kV
Measurements				
_:1781:14611:158	Further settings:P, Q sign		• not reversed • reversed	not reversed

5.3.3.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
_:7381:52	Reset LED Group:Behavior	ENS	O
_:7381:53	Reset LED Group:Health	ENS	O
Closure detec.			
_:1131:4681:500	Closure detec.:>Disconnector open	SPS	I
_:1131:4681:300	Closure detec.:Closure	SPS	O
_:1131:4681:52	Closure detec.:Behavior	ENS	O
_:1131:4681:53	Closure detec.:Health	ENS	O

5.4 Overview Function Groups Generator Differential Protection

5.4.1 Overview



NOTE

This chapter gives you a short overview of the function group Generator differential protection. You can find descriptions of the 3 listed function-group types and the Generator differential protection function in the generator protection manual (C53000-G5040-C027).

- **Generator Diff** function-group type
- **Generator Side** function-group type
- **Generator Stator** function-group type

The **Generator Diff** function-group type contains the Differential protection function and protection-function-relevant measured values.

Generator-specific protection and supervision functions can operate in the **Generator Side** and **Generator Stator** function-group types. The scope depends on the type of protection concept selected. The **Generator Side** and **Generator Stator** function-group types also contain measuring functions.

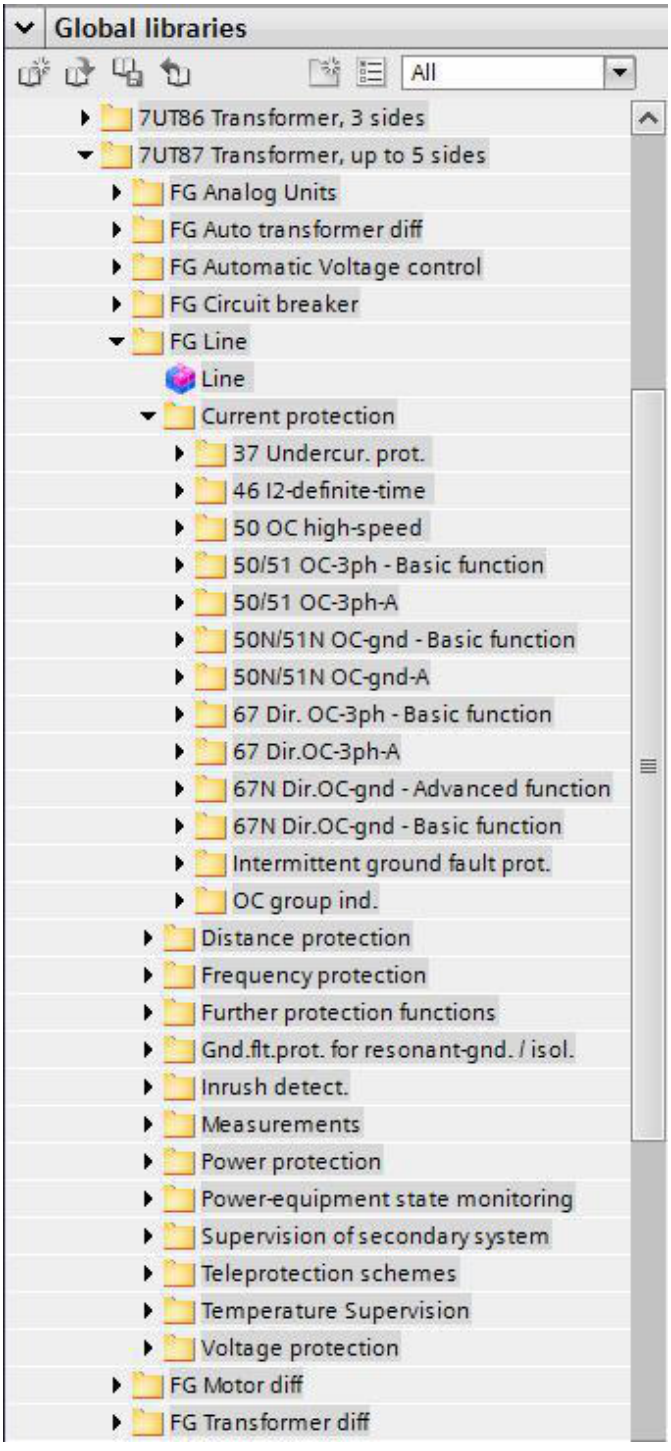
You can find the corresponding function groups and the folders with the usable protection functions in the Global DIGSI 5 library under each device type. For example, you can load the Differential protection function in the **Generator Diff** function-group type.

5.5 Function-Group Type Line

5.5.1 Overview

In the **Line** function group, all of the functions that are necessary for protecting and monitoring a line can be used. The **Line** function group also contains the measuring functions (for more information, see *9 Measured Values, Energy Values, and Supervision of the Primary System*).

You can find the **Line** function group under each device type in the function library in DIGSI 5. The **Line** function group contains all of the protection and supervision functions that you can use for this device type.These functions are described in *6 Protection and Automation Functions*. The following figure shows the functional scope of the **Line** function group using the example of a device.



[scprutli-221013-01, 1, en_US]

Figure 5-44 Function Group Line – Functional Scope for Device Type 7UT87

For more information about the embedding of the functions in the device, refer to *2 Basic Structure of the Function*. For information about the overall functional scope of the application templates for the various device types, refer to *4 Applications*.

5.5.2 Structure of the Function Group

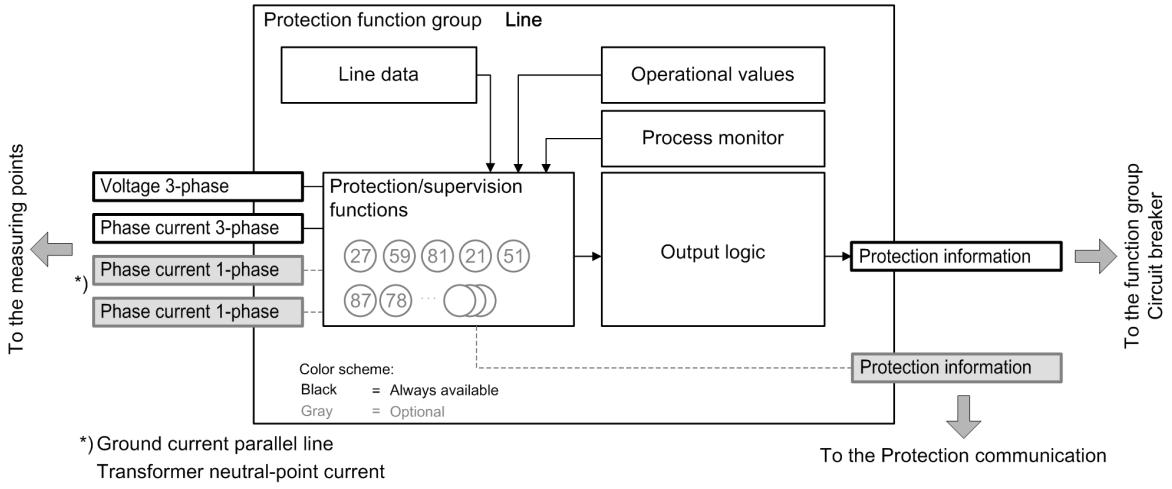
The **Line** function group always contains the following blocks:

- Line data
- Operational measurement
- Process monitor
- Output logic of the function group

These blocks are essential for the function group **Line**, so they cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the function group **Line**. The functions are available in the function library in DIGSI 5. Functions that are not needed can be deleted from the function group.

The following figure shows the structure of the **Line** function group:



[dwfgline-160812-01.tif, 1, en_US]

Figure 5-45 Structure of the Function Group Line

The **Line** function group has interfaces with

- **Measuring points**
- **Circuit-breaker** function group
- **Protection communication**

Interfaces with Measuring Points

The function group **Line** receives the required measured values via its interfaces with the measuring points.

If you are using an application template, the function group **Line** is already connected to the necessary measuring points.

If you add functions to the function group **Line**, they will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the **Function-group connections** Editor.

For further information, refer to *2 Basic Structure of the Function*.

The function group **Line** has the following interfaces with the measuring points:

- **3-Phase Voltage**:
  The measurands from the 3-phase voltage system are supplied via this interface. Various transformer connection types are possible. All values that can be calculated from the measurands are also provided via this interface. The function group Line must always be connected to the **V-3ph measuring point**.
  If you want to use the **Distance protection** in the function group **Line**, you must connect the 3 phase-to-ground voltages to the **V-3ph measuring point**. If you want to test or change the connection between the voltages and the **V-3ph measuring point**, double-click **Measuring-point routing** in the DIGSI 5 project tree → **7SL86** (name of device) (connection type = 3 phase-to-ground voltage).
  For further information, refer to the description of the *Power-system data* starting from *6.1.1 Overview*.
- **3-phase phase current**:
  The measurands from the 3-phase power system are supplied via this interface. Depending on the connection type of the transformers, these are, for example, I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The Line function group must always be connected to the **I-3ph measuring point**.
  You can connect the **3-phase phase current** interface to a **maximum of two** 3-phase current measuring points (for example, for 1 1/2 circuit-breaker layouts). If 2 current measuring points have been connected to the **3-phase phase current** interface, the total current is also determined from measured values from both measuring points in the function group **Line**. All functions in the **Line** function group have access to these values.
- **Ground current parallel line**:
  If the device measures the ground current in the parallel line, this 1-phase measurand of the **Line** function group is provided via this interface.
  You only have to connect the **Ground current parallel line** interface to the **I-1ph measuring point** if functions in the **Line** function group are working with this measurand.
- **Transformer neutral-point current**:
  If the device measures the ground current in the transformer neutral point, this 1-phase measurand of the **Line** function group is provided via this interface.
  You only have to connect the **Transformer neutral-point current** interface to the **I-1ph measuring point** if functions in the **Line** function group are working with this measurand.



NOTE

You can connect the interface **3-phase phase current** to **at most two** 3-phase current measuring points (for example, for 1 1/2 circuit-breaker layouts).
The other interfaces can only be connected to one measuring point each!

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and **Circuit-breaker** function groups via the interface with the Circuit-breaker function group. This data includes, for example, the pickup and operate indications of the protection functions sent in the direction of the circuit-breaker function group and, for example, the circuit-breaker position information in the direction of the protection function groups.

The **Line** function group is connected to one or more circuit-breaker function groups. This connection generally determines:

- Which circuit breaker(s) is/are activated by the protection functions of the protection function group **Line**
- Start of the function **Circuit-breaker failure protection** (if available in the function group Circuit-breaker) through the protection functions of the connected protection function group **Line**
- Start of the function **Automatic reclosing** (AREC if available in the function group Circuit-breaker) through the protection functions of the connected protection function group **Line**

Besides the general allocation of the protection function group **Line** to the circuit-breaker function groups, you can also configure the interface for certain functionalities in detail. Configure the details in DIGSI 5 using the **Circuit-breaker interaction** Editor in the function group **Line**.

In the detail configuration of the interface, you define:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the automatic reclosing function
- Which protection functions start the circuit-breaker failure protection function

If you are using an application template, the function groups are already connected to each other, because this connection is essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor. For more detailed information, refer to *2.1 Embedding of Functions in the Device*. If the connection is missing, DIGSI 5 reports an inconsistency.

Interface with Protection Communication

All required data is exchanged between the protection function group and the protection communication via the interface with **Protection communication**. These are, for example, binary signals, measured values and complex data. Functions such as differential protection or teleprotection scheme exchange information with other protection devices via the protection interface.

If an application template is used, the protection function group and protection communication are already connected to each other because this connection is absolutely essential to ensure proper operation.

For further information, refer to *3.6 Protection Communication*.

If this connection is missing, DIGSI 5 reports an inconsistency.

Line Data

The line data characterizes the line that is to be protected. The line data applies for all of the functions in the function group **Line**.

Process Monitor

The process monitor is always present in the function group **Line** and cannot be removed. The process monitor provides the following information in the function group **Line**:

- Current-flow criterion:
  Detection of an open/closed line based on the flow of minimum current
- Voltage criterion (optional):
  Detection of an open/closed line based on the minimum voltage present
- Closure detection:
  Detection of closure of the line
- Cold-load pickup detection (optional):
  Detection of a transient state of the network after a long period of disconnection (such as a blackout) followed by automatic reclosing

This information is in the function group **Line** and all is available to all the functions in the function group. The description of the process monitor begins in *5.5.4 Process Monitor (FG Line)*.

Operational Measured Values

The operational measured values are always present in the **Line** function group and cannot be deleted.

The following table shows the operational measured values of the **Line** function group:

Table 5-14 Operational Measured Values of the Function Group Line

Measured Values		Primary	Secon-dary	% Reference to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary system
I_N	Neutral-point phase current	A	A	Rated operating current of the primary system
I_{NS}	Sensitive ground current	A	mA	Rated operating current of the primary system
V_A, V_B,V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltage	kV	V	Rated operating voltage of the primary system
V_0	Zero-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
V_{NE}	Neutral-point displacement voltage	kV	V	Rated operating voltage of the primary system/√3
f	Frequency	Hz	Hz	Rated Frequency
P	Active power (total power)	MW	–	Active power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q	Reactive power (total power)	Mvar	–	Reactive power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S	Apparent power (total power)	MVA	–	Apparent power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active factor	(abs)	(abs)	100% corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	–	Apparent power of the phase $V_{rated\ Lx} \cdot I_{rated\ Lx}$
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	–	Apparent power of the phase $V_{rated\ Lx} \cdot I_{rated\ Lx}$
S_A, S_B, S_C	Phase-related apparent power	MVA	–	Apparent power of the phase $V_{rated\ Lx} \cdot I_{rated\ Lx}$

Inversion of Power-Related Measured and Statistical Values (FB General)

The following directional values calculated in operational measured values are defined positively in the direction of the protected object.

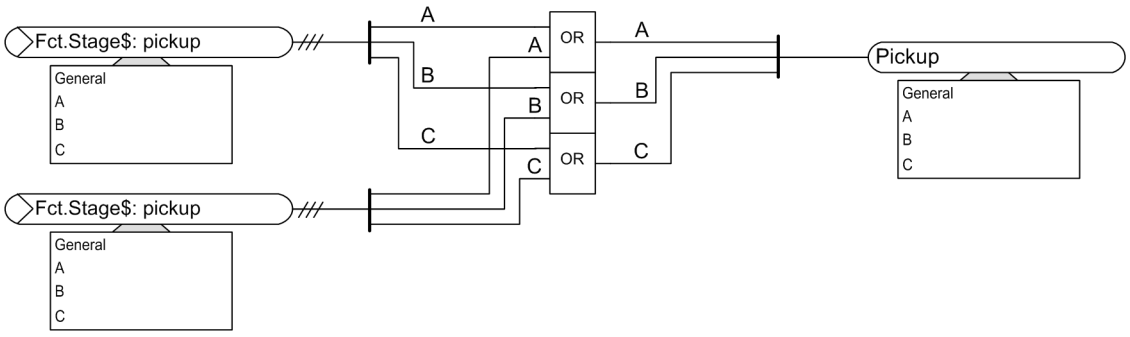
- Power
- Power factor
- Energy
- Minimum, maximum values
- Mean values

With the **`P, Q sign`** parameter, you can invert the sign of these operational measured values such that a power flow from the line to the busbar is displayed positively.
For further information, refer to *9.1 Overview of Functions*.

Output Logic

The output logic treats the pick up and operate indications of the protection and supervision functions in the function group separately, in either a pickup logic or an output logic. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the **Protection information** interface to the function group **Circuit breaker** and are processed further there.

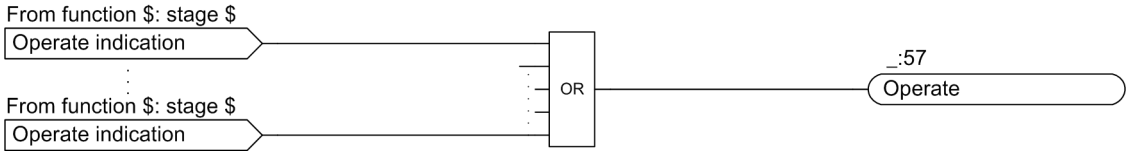
The pickup indications of the protection and supervision functions in the function group **Line**are combined phase-segregated and output as a group indication.



[lo_anrlin, 3, en_US]

Figure 5-46 Generation of Pickup Indication of the Function Group Line

The operate indications from the protection functions of the function group **Line** always result in 3-pole tripping of the device.



[lo_auslin, 3, en_US]

Figure 5-47 Generation of an Operate Indication of the Function Group Line

5.5.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

The **Line** protection function group is linked to 2 circuit breakers (2 Circuit-breaker function groups) for the breaker-and-a-half layout.

You can find more information in chapter *2 Basic Structure of the Function*.

Line Data

The following application and setting instructions apply for the line data. The line data are configured in the **Line** function group and apply for all functions in the function group.

NOTE

Specify the line data for your specific application!

Parameter: Rated current

- Default setting **(_:9001:101) Rated current** = ***1000 A***

With the **Rated current** parameter, you can set the primary rated current for the line to be protected. The **Rated current** parameter is relevant for the **Differential-protection** function. The **Rated current** specified here is the reference value for the percentage-measured values and setting values made in percentages.

NOTE

If the optional function block **Transformer** has been instantiated in the**Line Differential Protection** function, the parameter **Rated apparent power** can be set. The parameter **Rated current** is then calculated internally and is displayed as a write-protected parameter.

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated voltage

- Default setting **(_:9001:102) Rated voltage** = ***400 kV***

With the **Rated voltage** parameter, you can set the primary rated voltage for the line to be protected. The **Rated voltage** parameter is relevant for the **Differential-protection**, **Distance-protection**, and **Voltage-protection** functions. The **Rated voltage** set here is the reference value for the percentage-measured values and setting values made in percentages.

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated apparent power

- Default setting _:9001:103 **Rated apparent power** = ***692.8 MVA***

NOTE

The parameter **Rated apparent power** is only configurable if the optional function block **Transformer** has been instantiated in the **Line Differential Protection** function.

If the function block **Transformer** has not been instantiated, the **Rated apparent power** is calculated internally from parameters **Rated current** and **Rated voltage** and is displayed as a write-protected parameter.

With the **Rated apparent power** parameter, you can set the primary rated apparent power of the protected transformer. The **Rated apparent power** parameter is relevant for the main protection function of the device. The **Rated apparent power** set here is the reference value for the percentage-measured values and setting values made in percentages.

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Neutral point

- Default setting **(_:9001:149) Neutral point** = ***grounded***

With the **Neutral point** parameter, you specify whether the system-neutral point is ***grounded***, ***isolated*** or ***suppress. coil grounded*** (grounded via arc-suppression coil).

Parameter: C1 per length unit

- Default setting **(_:9001:112) C1 per length unit** = ***0.010 µF/km***

With the **C1 per length unit** parameter, you specify the capacitance per unit length in the positive-sequence system for the line to be protected. You set the **C1 per length unit** parameter as a relative value in µF/km or µF/miles. The capacitance per unit length in the positive-sequence system is identical to the operating capacitance c_b'. The **C1 per length unit** parameter is relevant for the **Differential protection**, **Overvoltage protection with positive-sequence system and compounding** and **Fault locator** functions.

Parameter: C0 per length unit

- Default setting **(_:9001:148) C0 per length unit** = ***0.010 µF/km***

With the **C0 per length unit** parameter, you specify the capacitance per unit length in the zero-sequence system for the line to be protected. You set the **C0 per length unit** parameter as a relative value in µF/km or µF/miles. The capacitance per unit length in the zero-sequence system is identical to the ground capacitance c_{gnd}'. The **C0 per length unit** parameter is relevant for the **Differential protection** and **Fault locator** functions.

EXAMPLE

110-kV single-phase liquid-filled cable 3 · 185 mm² Cu with the data:

$c_b = c_{gnd} = 0.27$ µF/km

The setting value for the parameters **C1 per length unit** and **C0 per length unit** is 0.27 µF/km.

Parameter: X per length unit

- Default setting **(_:9001:113) X per length unit** = ***0.0525 Ω/km***

With the **X per length unit** parameter, you set the reactance per unit length for the line to be protected. You set the **X per length unit** parameter as a relative value in Ω/km or Ω/miles. The **X per length unit** parameter is relevant for the **Distance protection, Differential protection**, **Overvoltage protection with positive-sequence system and compounding**, and **Fault locator** functions.

Parameter: Line length

- Default setting **(_:9001:114) Line length** = ***60 km***

With the **Line length** parameter, you can set the length of the line to be protected as a unit of length in km or miles. The **Line length** parameter is relevant for the **Distance protection, Differential protection**, **Overvoltage protection with positive-sequence system and compounding**, **Fault locator** and **Fault locator plus** functions.

Parameter: Line angle

- Default setting **(_:9001:108) Line angle** = ***85°***

The **Line angle** parameter is relevant for the **Distance protection**, **Differential protection**, **Overvoltage protection with positive-sequence system and compounding**, **Fault locator** and **Fault locator plus** functions. Calculate the setting value for the parameter **Line angle** from the line constants for the line to be protected as follows:

$$\tan\varphi = \frac{X_L}{R_L} \qquad \text{or} \qquad \varphi = \arctan\left(\frac{X_L}{R_L}\right)$$

{fo_lwinkl, 1, en_US}

where:

R_L	Resistance of the line to be protected
X_L	Reactance of the line to be protected

EXAMPLE

110-kV overhead line 150 mm² with the data

$R'_1 = 0.19$ Ω/km

$X'_1 = 0.42$ Ω/km

You calculate the setting value for the line angle as follows:

$$\tan \varphi = \frac{X_L}{R_L} = \frac{X'_1}{R'_1} = \frac{0.42\ \Omega/\mathrm{km}}{0.19\ \Omega/\mathrm{km}} = 2.21$$

[fo_tan_phi, 1, en_US]

$$\arctan(2.21) = 65.7°$$

[fo_arctan_phi, 1, en_US]

Parameter: Kr and Kx

- Default setting **(_:9001:104) Kr** = ***1.0***
- Default setting **(_:9001:105) Kx** = ***1.0***

NOTE

The visibility of the **Kr** and **Kx** parameters depends on the selected setting format of the residual compensation factors. The parameters **Kr** and **Kx** only become visible after you have set the parameter **Set. format residu. comp.** = ***Kr, Kx*** for the device.

The **Kr** and **Kx** parameters are used to set the residual compensation factors as scalar values. The **Kr** and **Kx** parameters are relevant for the **Distance protection** and **Fault locator** functions.

NOTE

You can overwrite the residual compensation factors specified here in the distance-protection zones with specific parameters for each zone.

Calculate the setting values for the parameters **Kr** and **Kx** from the line data as follows:

Resistance ratio	Reactance ratio
$Kr = \frac{R_{gnd}}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1 \right)$	$Kx = \frac{X_{gnd}}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1 \right)$

where:

R_0	Zero-sequence system resistance of the line
X_0	Zero-sequence system reactance of the line
R_1	Positive-sequence system resistance of the line
X_1	Positive-sequence system reactance of the line

This data can either be used for the entire line or as length-related values, since the quotients are length-independent. You can calculate the data both from the primary values and from the secondary values.

EXAMPLE

110-kV overhead line 150 mm² with the data:

R_1/s	0.19 Ω/km positive-sequence system resistance
X_1/s	0.42 Ω/km positive-sequence system reactance
R_0/s	0.53 Ω/km zero-sequence system resistance
X_0/s	1.19 Ω/km zero-sequence system reactance
s	Line length

You receive the following setting values for the parameters **Kr** and **Kx**:

$$k_r = \frac{R_{Gnd}}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1\right) = \frac{1}{3} \cdot \left(\frac{0.53\ \Omega/km}{0.19\ \Omega/km} - 1\right) = 0.60$$

[fo_kr, 1, en_US]

$$k_x = \frac{X_{Gnd}}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1\right) = \frac{1}{3} \cdot \left(\frac{1.19\ \Omega/km}{0.42\ \Omega/km} - 1\right) = 0.61$$

[fo_kx, 1, en_US]

Parameter: K0 and Angle (K0)

- Default setting **(_:9001:118) K0** = ***1.000***
- Default setting **(_:9001:150) Angle (K0)** = ***0.00°***

NOTE

The visibility of the **K0** and **Angle (K0)** parameters depends on the selected setting format of the residual compensation factors. The parameters **K0** and **Angle (K0)** only become visible after you have set the parameter **Set. format residu. comp.** = ***K0*** for the device.

The **K0** and **Angle (K0)** parameters are used to set the complex grounding-resistance factor. The **K0** and **Angle (K0)** parameters are relevant for the **Distance protection**, **Fault locator** and **Fault locator plus** functions.

NOTE

You can overwrite the residual compensation factors specified here in the distance-protection zones with local parameters for each zone.

Make sure that the line angle is set correctly because the device needs the line angle for calculation of the compensation components from the K0 factor. The complex grounding-resistance factor is defined by the value and the angle. You can calculate the complex grounding-resistance factor from the line data as follows:

$$K_0 = \left|\frac{\underline{Z}_{Gnd}}{\underline{Z}_L}\right| = \left|\frac{1}{3} \cdot \left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1\right)\right|$$

[fo_K01, 1, en_US]

where:

$\underline{Z}_0$	(complex) zero-sequence impedance
$\underline{Z}_1$	(complex) positive-sequence impedance

This data can either be used for the entire line or as length-related values, since the quotients are length-independent. The data can be calculated both from the primary values and from the secondary values.

For overhead lines, you can use the values for the calculation because the angles of the zero-sequence system and the positive-sequence system differ only slightly. For cables, however, significant angular differences can occur, as the following example illustrates.

EXAMPLE

110-kV single-phase liquid filled cable 3 · 185 mm² Cu with the data:

Z_1/s	$0.408 \cdot e^{j73^\circ}$ Ω/km positive-sequence impedance
Z_0/s	$0.632 \cdot e^{j18.4^\circ}$ Ω/km zero-sequence impedance
s	Line length

The values for calculation of the grounding-resistance factor K0 are:

$$\frac{\underline{Z}_0}{\underline{Z}_1} = \frac{0.632}{0.408} \cdot e^{j(18.4° - 73°)} = 1.55 \cdot e^{-j\,54.6°} = 1.55 \cdot (0.579 - j\,0.815) = 0.898 - j\,1.263$$

[fo_1_k0, 1, en_US]

$$k_0 = \left|\frac{1}{3} \cdot \left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1\right)\right| = \left|\frac{1}{3} \cdot (0.898 - j\,1.263 - 1)\right| = \left|\frac{1}{3} \cdot (-0.102 - j\,1.263)\right|$$

[fo_2_k0, 1, en_US]

The setting value of the parameter **K0** is calculated from:

$$k_0 = \left|\frac{1}{3} \cdot \sqrt{(-0.102^2) + (-1.263^2)}\right| = 0.42$$

[fo_3_k0, 1, en_US]

When determining the angle, take note of the quadrant of the result. The following table lists the quadrants and the angle range obtained from the operational signs of the real and imaginary parts of K0.

Real Part	Imaginary Part	tan Phi (K0)	Quadrant/Range		Calculation Method
+	+	+	I	0° to 90°	arc tan (|Im| / |Re|)
+	-	-	IV	-90° to 0°	–arc tan (|Im| / |Re|)
-	-	+	III	-90° to -180°	arc tan (|Im| / |Re|) –180°
-	+	-	II	+90° to +180°	–arc tan (|Im| / |Re|) +180°

In this example, the following setting value for the **Angle (K0)** parameter is obtained:

$$\varphi(K_0) = \arctan\left(\frac{1.263}{0.102}\right) - 180° = -94.6°$$

[fo_phi_K0, 1, en_US]

Parameter: KmR and KmX

- Default setting **(_:9001:106) KmR** = ***0.00***
- Default setting **(_:9001:107) KmX** = ***0.00***

The **KmR** and **KmX** parameters are used to set the coupling impedance for parallel-line compensation. The **KmR** parameter (= R0m/3RL) is used to set the coupling resistance. The **KmX** parameter (= X0m/3XL) is used to set the coupling reactance. The **KmR** and **KmX** parameters are only relevant for the **Distance-protection** function.

Parameter: Km0 and Angle (Km0)

- Default setting **(_:9001:124) Km0** = ***0.00***
- Default setting **(_:9001:125) Angle (Km0)** = ***0.00°***

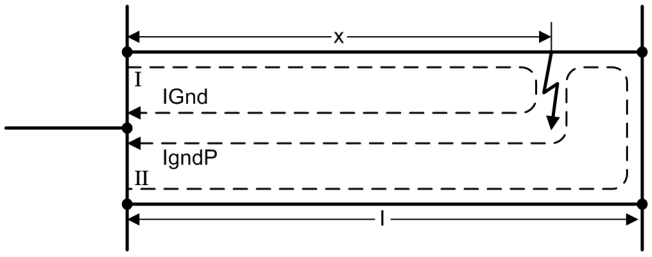
Use the parameters **Km0** (= Z0m/3ZL) and **Angle (Km0)** to set the coupling impedance for parallel-line compensation as a complex value in quantity and angle. The **Km0** parameter allows you to set the value for the coupling-impedance factor. The **Angle (Km0)** parameter allows you to set the angle of the coupling-impedance factor. The **Km0** and **Angle (Km0)** parameters are only relevant for the **Distance-protection** function.

Parameter: Gnd.curr.ratio(MutComp)

- Recommended setting value **(_:9001:109) Gnd.curr.ratio(MutComp)** = ***85 %***

The **Gnd.curr.ratio(MutComp)** parameter is only relevant for the **Distance protection** and single-ended **Fault locator** functions. With the **Gnd.curr.ratio(MutComp)** parameter, you define the ground-current balance for parallel-line compensation. This parameter is important for parallel-line compensation in the event of ground faults outside of the line to be protected.

For the ground-current balance of the distance protection, the setting value returns the current ratio I_{Gnd}/I_{gndP} for the protection device at installation site II (see *Figure 5-48*).



[dwparkomrw-161013, 1, en_US]

Figure 5-48 Range of Parallel-Line Compensation at II

Parallel-line compensation is only carried out if the ground current of the line to be protected (I_{Gnd}) is greater than the ground current of the parallel line (I_{gndP}) evaluated with the parameter **Gnd.curr.ratio(MutComp)**.

Siemens recommends retaining the default setting **Gnd.curr.ratio(MutComp)** = ***85 %*** . In highly unbalanced system conditions and if the coupling factor is very small (XM/XL less than 0.4), a smaller value may be advisable.

Parameter: CT saturation detection

- Default setting **(_:9001:119) CT saturation detection** = ***no***

With the parameter **CT saturation detection**, you specify whether the device is to work with saturation detection or not. The saturation detection detects measuring errors due to saturation of the current transformers and switches over the method of measurement for distance measurement. The **CT saturation detection** parameter is only relevant for the **Distance-protection** function.

Parameter: CT saturation threshold

- Default setting **(_:9001:120) CT saturation threshold** = ***10 A***

The **CT saturation threshold** parameter allows you to set the current threshold for the saturation detection. If the set value is exceeded, saturation detection becomes active. If the saturation detection detects a current-transformer saturation, the device switches over the method of measurement for distance measurement. Calculate the setting value for the parameter **CT saturation threshold** according to the following formula:

$$I_{sat} > = \frac{n'}{5} \cdot I_{rated}$$

[fo1isaet-041210-01.tif, 1, en_US]

where:

$$n' = n \cdot \frac{S_N + S_i}{S' + S_i}$$ Effective overcurrent factor

S_N	Rated burden of the current transformers [VA]
S_i	Inherent burden of the current transformers [VA]
S'	Actually connected burden (protection device + secondary lines)

NOTE

The parameter **CT saturation threshold** only becomes visible when you have set the parameter **CT saturation detection** = ***yes***.

Parameter: Series compensation

- Default setting **(_:9001:111) Series compensation** = ***no***

Use the parameter **Series compensation** to specify whether the line to be protected is to work with or without series compensation. The **Series compensation** parameter is relevant for the **Distance-protection** and **Directional ground-fault protection** functions. To ensure that the direction determination functions correctly in applications for or in the vicinity of series-compensated lines, set the parameter **Series compensation** = ***yes***.

Parameter: Series capacit. reactance

- Default setting **(_:9001:110) Series capacit. reactance** = ***0 Ω***

The **Series capacit. reactance** parameter is used to define the positive-sequence system reactance of the series capacitor. The reactance of the series capacitor is calculated as follows from the capacitance of the capacitor (c_s):

$$X = \frac{1}{2\pi f \cdot c_s}$$

[foforcse-060509-01.tif, 1, en_US]

The **Series capacit. reactance** parameter is only relevant for the **Directional ground-fault protection** function.

Parameter: P, Q sign

- Default setting **(_:9001:158) P, Q sign** = ***not reversed***

The power and energy values are designed by the manufacturer such that power in the direction of the protected object is considered positive. You can also positively define the power dissipation through the protected object (for example, as seen by the consumer). With the **P, Q sign** parameter, you can invert the sign for these components. This inversion does not influence any protection function.

5.5.4 Process Monitor (FG Line)

5.5.4.1 Overview of Functions

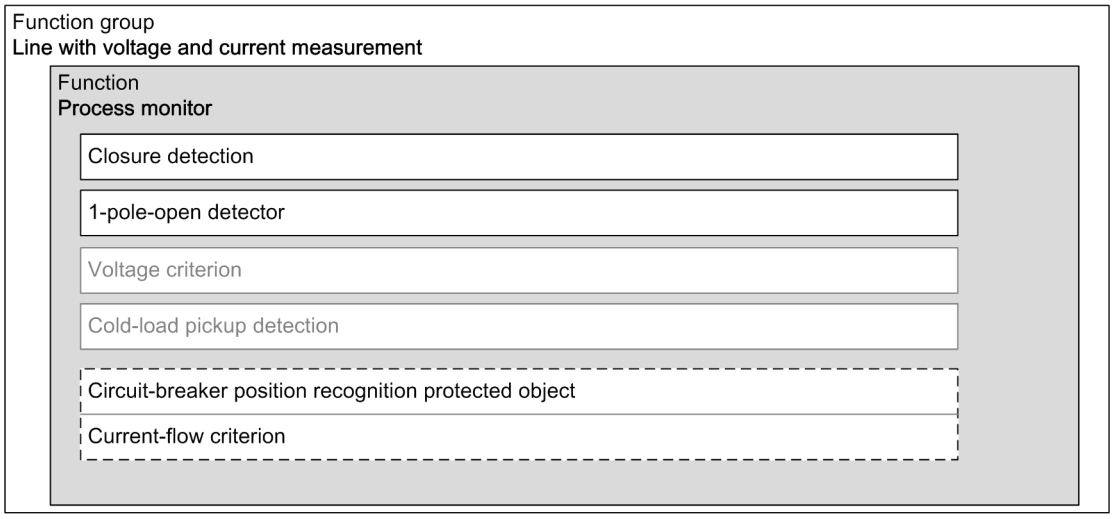
All function groups that have functions with dependencies on the state of the protected object contain a process monitor. The process monitor detects the current state of the protected object.

5.5.4.2 Structure of the Function

The **Process monitor** function is used in the **Line** protection function group with voltage and current measurement.

The **Process monitor** function is preconfigured by the manufacturer with the following function blocks:

- Closure detection
- 1-pole-open detector
- Cold-load pickup detection (optional)
- Voltage criterion (optional)
- Circuit-breaker condition
- Current-flow criterion

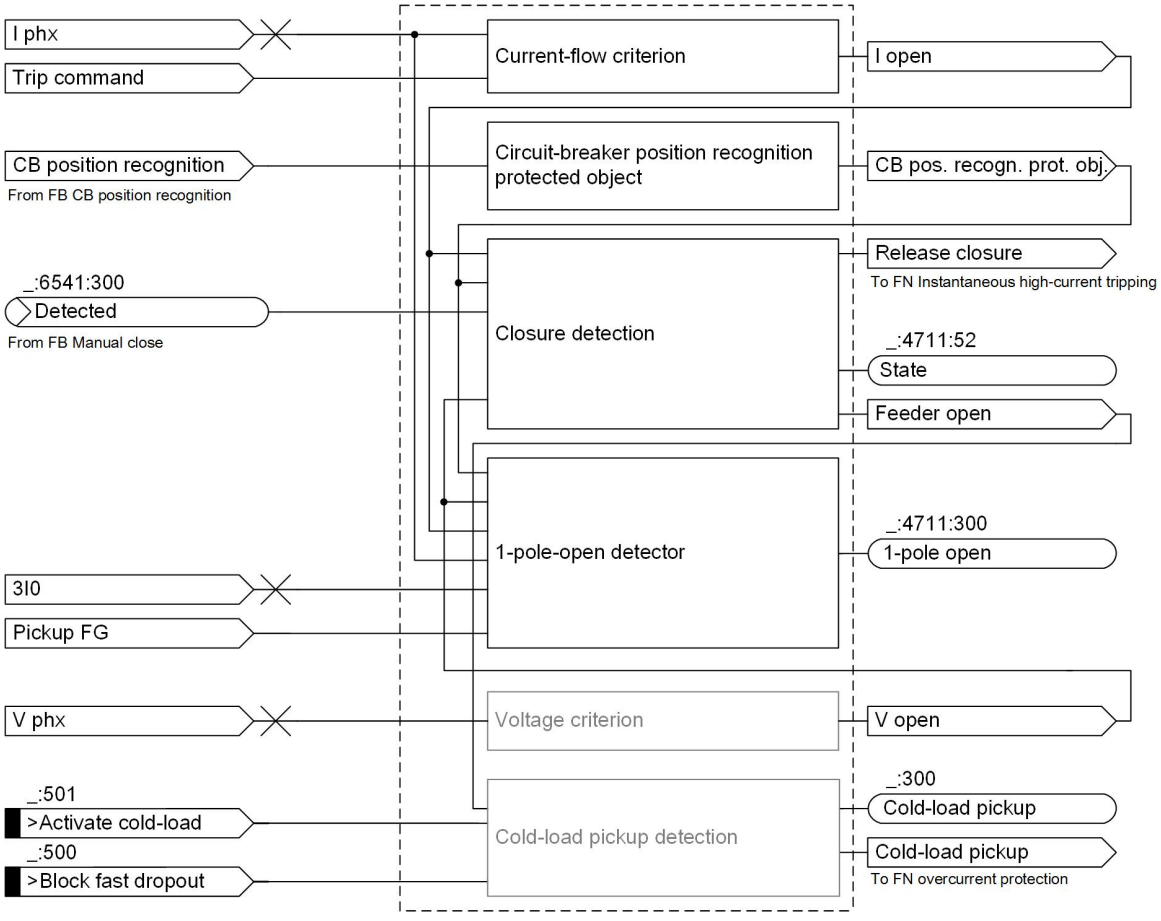


[dwpro1p1-050612-01.tif, 3, en_US]

Figure 5-49 Structure/Embedding of the Function

You can switch the voltage criterion and the cold-load pickup detection as necessary. The circuit-breaker position recognition and the current-flow criterion run permanently in the background and are not displayed in DIGSI.

The following figure shows the relationships of the individual function blocks.

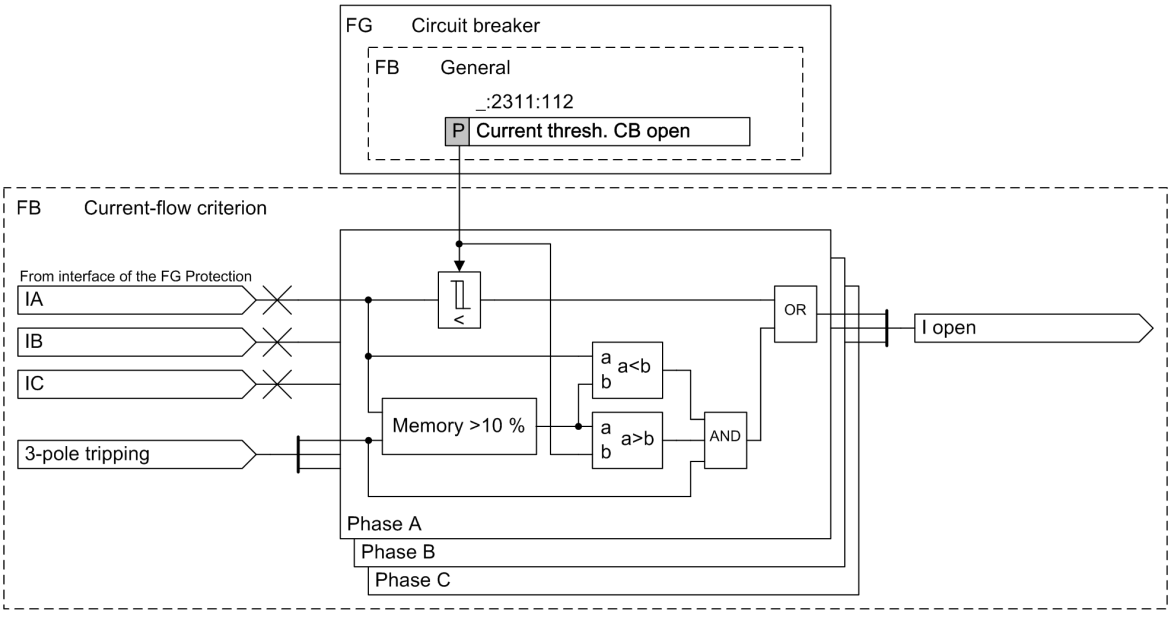


[lopro1p1-171012-01.tif, 3, en_US]

Figure 5-50 Logic Diagram of the Overall Function Process Monitor

5.5.4.3 Current-Flow Criterion

Logic



[lo_proikr, 2, en_US]

Figure 5-51 Logic Diagram of the Current-Flow Criterion Function Block

The phase currents are provided via the interface to the protection function group.

The **I open** signal of one phase is generated if one of the following conditions is met:

- A phase current falls below the set threshold of the **Current thresh. CB open** parameter. The hysteresis stabilizes the signal.
- The corresponding phase current, for example, **I A**, falls below 10 % of the phase current when the trip command arrives. If the current does not drop until after a delay due to current transformer influences, an open pole can therefore be detected quickly even after a high-current fault on the line.

With the **Current thresh. CB open** parameter, you define the minimum current as the criterion for a deactivated line. The parameter lies in the **Circuit-breaker** function group. It acts both in the **Circuit-breaker** function group, for example circuit-breaker position recognition, and also for the process monitor in the protection function group.

If a protection function group with integrated process monitor is connected to several **Circuit breaker** FGs, the **Current thresh. CB open** parameter is present in each FG **Circuit breaker**. The smallest setting value of the parameter **Current thresh. CB open** is used.

5.5.4.4 Application and Setting Notes (Current-Flow Criterion)

Parameter: Current thresh. CB open

- Recommended setting value **(_:2311:112) Current thresh. CB open** = ***0.100 A***

The **Current thresh. CB open** parameter is used to define the threshold for the leakage current as the criterion for a deactivated line.

Set the **Current thresh. CB open** parameter so that the current measured when the feeder is deactivated falls below the value of the **Current thresh. CB open** parameter with certainty. The hysteresis is additionally active if the threshold is exceeded.

If parasitic currents, for example, due to induction, are ruled out when the feeder is deactivated, set the **Current thresh. CB open** parameter sensitively.

Siemens recommends a setting value of ***0.100 A***.

5.5.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Breaker settings				
_:2311:112	General:Current thresh. CB open	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2311:136	General:Op. mode BFP		• unbalancing • I> query	unbalancing

5.5.4.6 Circuit-Breaker Condition for the Protected Object

Logic

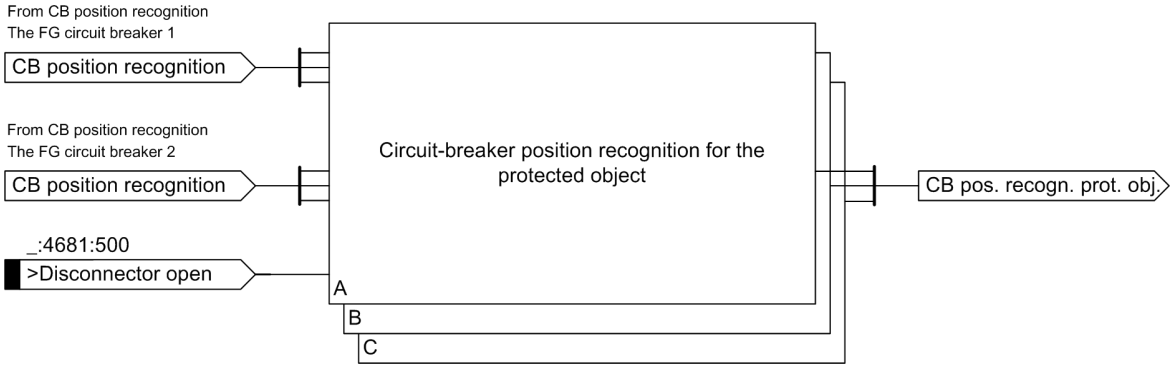


Figure 5-52 Logic Diagram of the Circuit-Breaker Condition for the Protected-Object Function Block

The circuit-breaker position recognition in the **Circuit-breaker** (CB) function group provides the circuit-breaker condition by way of the internal signal ***CB pos. recogn. prot. obj.***.

If a protected object is supplied via 2 circuit breakers (CBs), for example with the 1 1/2 circuit-breaker layout, then the circuit-breaker switch position of the protected object must be determined with the aid of both circuit breakers. In this case, the **Circuit-breaker position recognition for the protected object** function block connects the individual CB states. The connection provides the internal ***CB pos. recogn. prot. obj.*** signal to the other function blocks of the process monitor and to other functions, for example, **Trip in the event of weak infeed** and **Echo function for teleprotection method**, within the same function group.

If one of the following 2 conditions is met, the ***CB pos. recogn. prot. obj.*** signal is in the ***Open*** state:

- All connected circuit breakers signal the ***Open*** state internally.
- The **>Disconnector open** input is active.

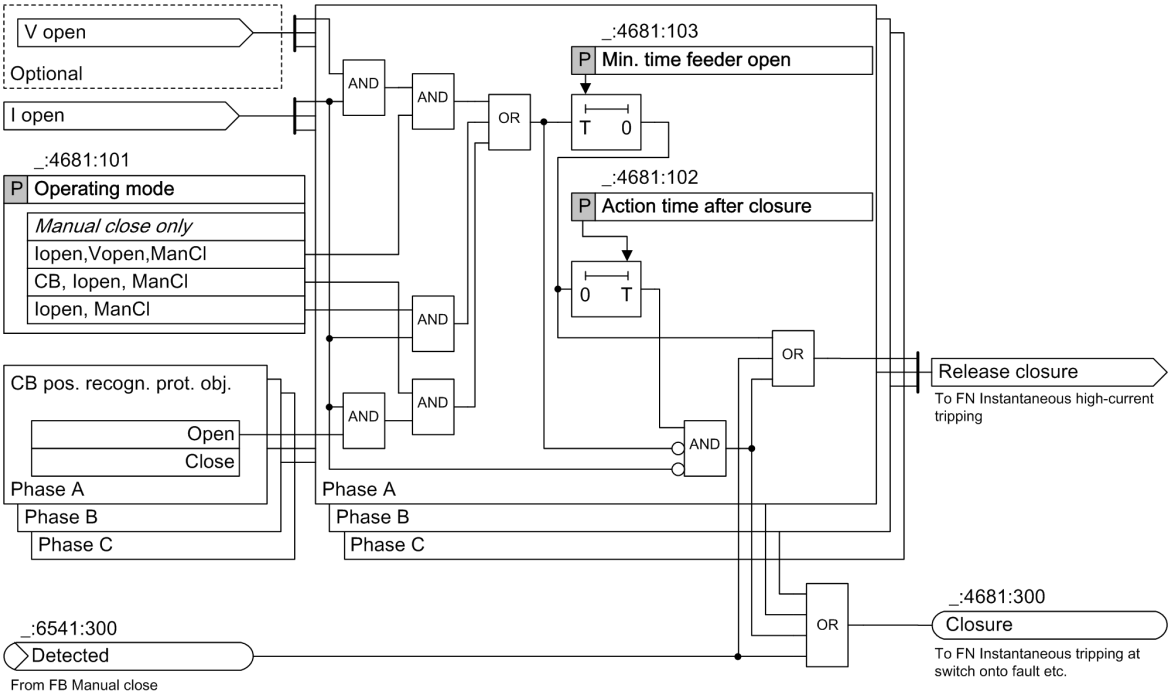
If the following 2 conditions are met, the ***CB pos. recogn. prot. obj.*** signal is in the ***Closed*** state:

- At least one of the connected circuit breakers signals the ***Closed*** state internally.
- The **>Disconnector open** input is not active.

5.5.4.7 Closure Detection

Logic

The closure detection enables the immediate tripping of selected protection functions or protection stages when switching to short circuit or the reduction of the responsivity. The closure detection determines whether the protected object is switched on.



[loproein-121012-01.tif, 2, en_US]

Figure 5-53 Logic Diagram of the Closure-Detection Function Block

For an applied binary input signal **Detected** (from function block Manual close), the indication **Closure** is always active. The indication **Closure** can also be activated via the measurand. In addition, the protected object must be switched off for at least the time **Min. time feeder open**.

This time is started as follows depending on the **Operating mode** parameter:

- For parameter **Operating mode** = ***Iopen,Vopen,ManCl***:
  If the current-flow criterion and the voltage criterion are detected open-circuited.
- For parameter **Operating mode** = ***CB, Iopen, ManCl***:
  If the circuit-breaker auxiliary contact(s) and the current-flow criterion are detected as open-circuited.
- For parameter **Operating mode** = ***Iopen, ManCl***:
  If the current-flow criterion is detected as open-circuited.

If the protected object is detected as switched off, the phase-segregated internal output signal **Release (Closure)** is formed. The **Instantaneous high-current tripping** function can trip immediately, for example with the **Release (Closure)** signal in the event of connection to a short circuit.

If all the following conditions are active, the **Closure** indication is activated via the measurands.

- The protected object is switched off for at least the time **Min. time feeder open**.
- The time **Action time after closure** is running.
- The current-flow criterion no longer detects the state open-circuited.

The time **Action time after closure** is started depending on the **Operating mode** parameter:

- For parameter **Operating mode** = ***Iopen,Vopen,ManCl***:
  If the current-flow criterion or the voltage criterion is no longer detected open-circuited.
- For parameter **Operating mode** = ***CB, Iopen, ManCl***:
  If the circuit-breaker auxiliary contact(s) or the current-flow criterion are no longer detected as open-circuited.
- For parameter **Operating mode** = ***Iopen, ManCl***:
  If the current-flow criterion is no longer detected as open-circuited.

5.5.4.8 Application and Setting Notes (Closure Detection)

Parameter: Operating mode

- Default setting **(_:4681:101) Operating mode**=***Manual close only***

With the **Operating mode** parameter, you set the criteria with which the **Closure-detection** function block operates.

Parameter Value	Description
Manual close only	The detection of feeder closure is exclusively decided using the binary input signal **Detected** (from Manual close function block). Siemens recommends this setting, if both of the following conditions are met: • The binary input signal **Manual On** is available on the side of the system. • A closure detection must not happen due to an additional current and voltage measurement, for example, after an automatic reclosing.
Iopen,Vopen,ManCl	The closure detection is done additionally with the current and voltage measurement. If the voltage transformers are installed at the busbar side or if there is no voltage connected, you must not use this setting.
CB, Iopen, ManCl	The closure detection is done additionally with the current measurement and with the evaluation of connected circuit breaker position contacts.
Iopen, ManCl	The closure detection is done additionally with the current measurement. For this setting, make sure that the **Current thresh. CB open** parameter is set lower than the lowest possible load current. If this is not ensured, open-circuit is detected continuously and each current value that exceeds the **Current thresh. CB open** parameter is interpreted as closure.

Parameter: Min. time feeder open

- Recommended setting value **(_:4681:103) Min. time feeder open** = ***0.25 s***

To avoid incorrect closure detection, the protected object must be switched off for the minimum time of **Min. time feeder open** before the **Closure** indication can become active. You define the duration of the release delay with the **Min. time feeder open** parameter.

Siemens recommends a setting value of ***0.25 s***.

Parameter: Action time after closure

- Recommended setting value **(_:4681:102) Action time after closure** = ***0.05 s***

The **Closure** indication signals detected closure. With the **Action time after closure** parameter, you set the **Closure** indication to a defined length.

Siemens recommends a setting value of ***0.05 s***.

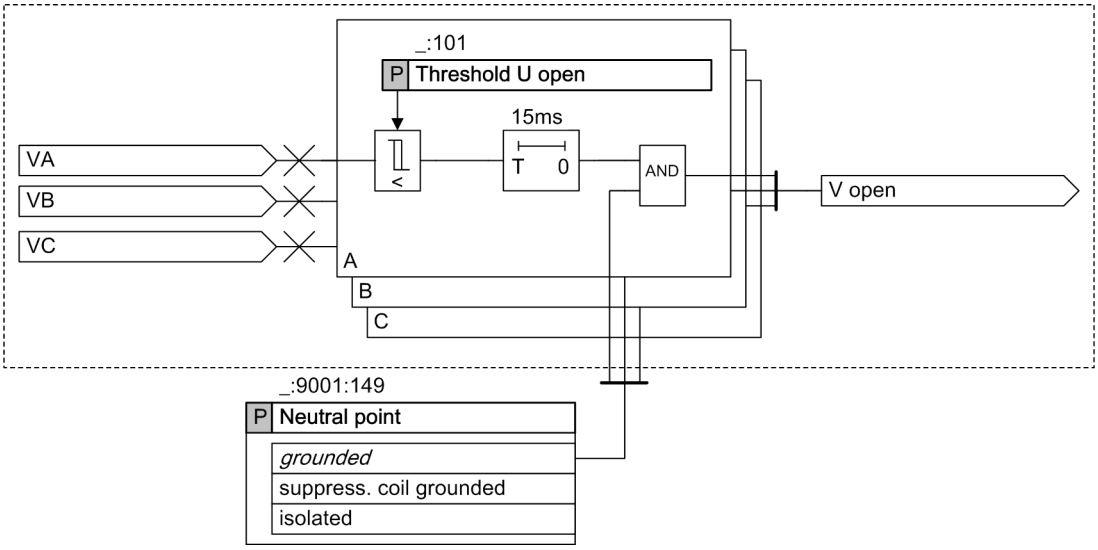
5.5.4.9 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Closure detec.				
_:4681:101	Closure detec.:Operating mode		• Manual close only • Iopen,Vopen,ManCl • CB, Iopen, ManCl • Iopen, ManCl	Manual close only

Addr.	Parameter	C	Setting Options	Default Setting
_:4681:102	Closure detec.:Action time after closure		0.01 s to 60.00 s	0.05 s
_:4681:103	Closure detec.:Min. time feeder open		0.05 s to 60.00 s	0.25 s

5.5.4.10 Voltage Criterion (Optional)

Logic



[loproure-020211-01.tif, 1, en_US]

Figure 5-54 Logic Diagram of the Voltage-Criterion Function Block

If you want to test closure detection or an open-pole detector via a voltage, you need a voltage transformer installed on the line side and electrical power systems with a grounded neutral point. In this case, add the **Voltage criterion** function block to the process monitor.

If the voltage transformers are installed on the busbar side or if there is no voltage connected, you must not use the voltage criterion to detect a deactivated phase.

With the **(_:101) Threshold U open** parameter, you define the residual voltage as the criterion for a deactivated line. If the phase-to-ground voltage falls below the value of the **Threshold U open** parameter, the **V open** signal is generated. The function stabilizes the signal with a hysteresis and a delay of the rising edge of the signal. The falling edge of the signal is forwarded without delay.

5.5.4.11 Application and Setting Notes (Voltage Criterion)

Parameter: Threshold U open

NOTE

The **Threshold U open** parameter is available only when the optional **Voltage criterion** function block is used. Use this parameter only with a voltage transformer installed on the line side and in electrical power systems with a grounded neutral point.

- Recommended setting value **(_:101) Threshold U open** = ***30.000 V***

With the **Threshold U open** parameter, you define the threshold for the leakage voltage as the criterion for a deactivated feeder.

Set the **Threshold U open** parameter so that the voltage measured when the feeder is deactivated falls below the value of the **Threshold U open** parameter with certainty. The hysteresis is additionally active

if the threshold is exceeded. The value of the **Threshold U open** parameter must lie below the minimum expected phase-to-ground voltage. The voltage transformers must be connected on the line side.

Due to possible parasitic voltages (for example, due to capacitive coupling in), do not set the value of the **Threshold U open** too sensitively.

Siemens recommends a setting value of ***30.000 V***.

5.5.4.12 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Volt.criterion				
_:101	Volt.criterion:Threshold U open		0.300 V to 170.000 V	30.000 V

5.5.4.13 Cold-Load Pickup Detection (Optional)

Logic

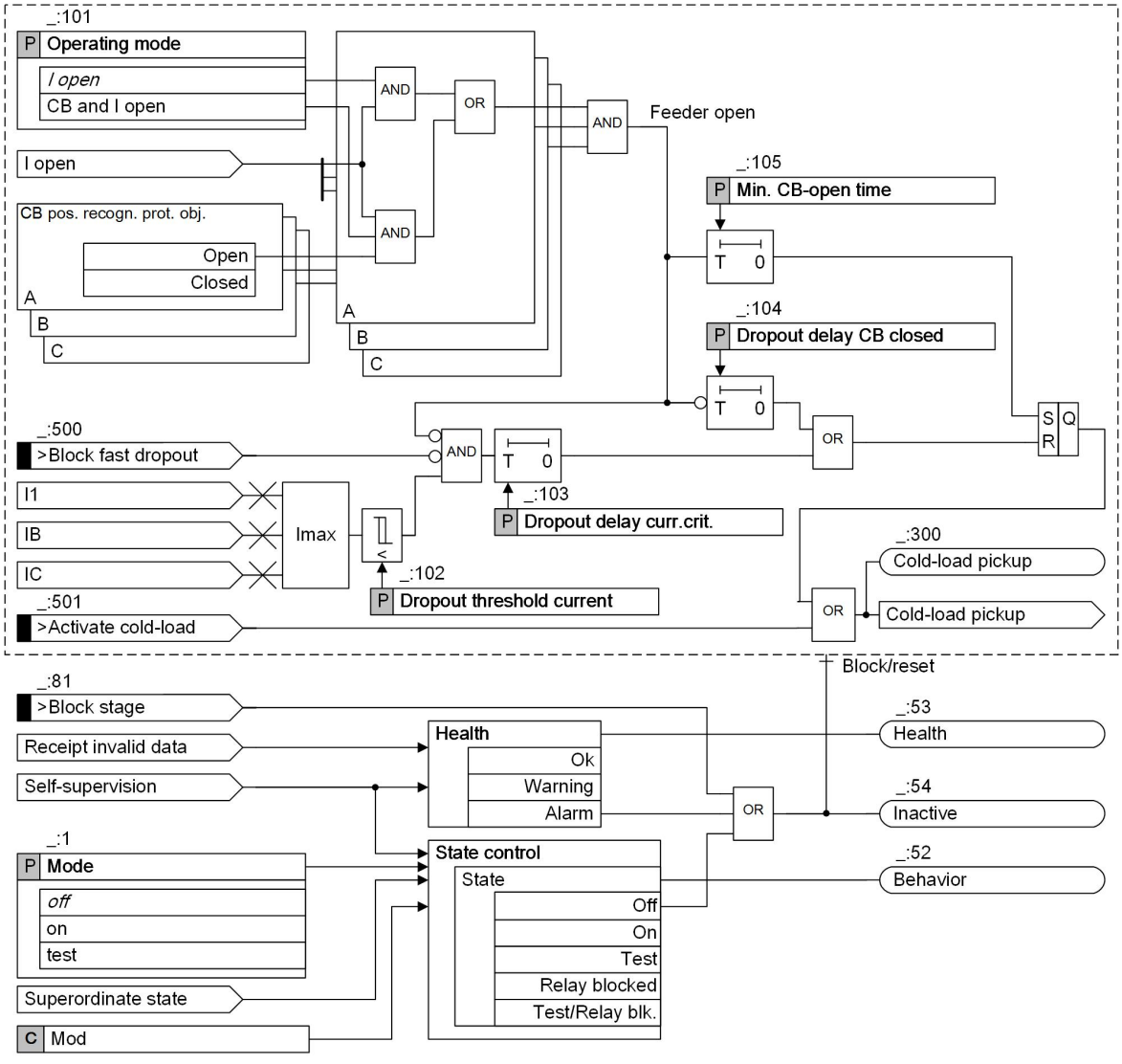


Figure 5-55 Logic Diagram of the Cold-Load Pickup Detection Function Block

The **Cold-load pickup detection** function block detects that a specific time has been exceeded after deactivation of the line or protected object. If you want to connect the protected object again, you must note that an increased load-current requirement exists for a limited time after connection. This results from the nature of the load.

The **Cold-load pickup detection** function block ensures that different parameters are used for an adjustable time after connection. For example, for the time of the **Min. CB-open time** parameter, you can increase the threshold value of a protection function or you can select a special characteristic curve.

If the **Cold-load pickup detection** function block detects an open feeder and the set time of the **Min. CB-open time** parameter has expired, the indication **>Activate cold-load** is generated.

With the **>Activate cold-load** indication, you can activate a parameter set of the **Cold-load pickup** function. Via the binary input signal **>Activate cold-load**, you can also activate the **>Activate cold-load** indication directly.

If the **Cold-load pickup detection** function block detects closure and the corresponding load current, it starts the time set in the **Dropout delay CB closed** parameter. The **>Activate cold-load** indication and the activated parameter set are deactivated after this time has elapsed.

If, for the time set in the **Dropout delay curr.crit.** parameter, the maximum phase current falls below the threshold value **Dropout threshold current**, the parameter set for the **Cold-load pickup detection** function block is also deactivated. As a result, if the load current is very low, the action time **Dropout delay curr.crit.** of the **>Activate cold-load** indication can be shortened.

5.5.4.14 Application and Setting Notes (Cold-Load Pickup Detection)

NOTE

The settings and indications described in this chapter are only available when using the optional **Cold-load pickup detection** function block.

Parameter: Operating mode

- Default setting **(_:101) Operating mode** = ***I open***

With the **Operating mode** parameter, you set the criteria with which the Closure-detection function block operates.

Parameter Value	Description
I open	When the Current-flow criterion function block detects a clearing open condition, the decision is made for pickup. For this setting, make sure that the **Current thresh. CB open** parameter is set lower than the possible load current. If this is not the case, open is detected continuously and each fault current that exceeds the **Current thresh. CB open** parameter is interpreted as closure.
CB and I open	Closure is detected if one of the following conditions is met: • Analysis of the circuit-breaker auxiliary contact detects a clearing open condition in at least one phase. • The current-flow criterion detects a clearing open condition.

Parameter: Dropout threshold current

- Default setting **(_:102) Dropout threshold current** = ***1.00 A***

With the **Dropout threshold current** parameter, you set the threshold at which the output signal **Cold-load pickup** is deactivated when the current in at least one phase falls below this threshold.

Parameter: Dropout delay current criterion

- Default setting **(_:103) Dropout delay curr.crit.** = ***600 s***

With the **Dropout delay curr.crit.** parameter, you set the time for which the actual value must be below the **Dropout threshold current** threshold so that the output signal **Cold-load pickup** can be deactivated prematurely.

Parameter: Dropout delay CB closed

- Default setting **(_:104) Dropout delay CB closed** = ***3600 s***

With the **Dropout delay CB closed** parameter, you set the action time for the dynamic parameter set switching in the event of cold-load pickup detection.

Parameter: Min. CB open time

- Default setting **(_:105) Min. CB-open time** = ***3600 s***

With the **Min. CB-open time** parameter, you set the time after which the dynamic parameter set is activated in the event of **cold-load pickup** when the line is opened.

5.5.4.15 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Cold-load PU				
_:1	Cold-load PU:Mode		• off • on • test	off
_:101	Cold-load PU:Operating mode		• I open • CB and I open	I open
_:102	Cold-load PU:Dropout threshold current	1 A @ 100 Irated	0.030 A to 10.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 50.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 10.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 50.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:103	Cold-load PU:Dropout delay curr.crit.		1sto600 s	600s
_:104	Cold-load PU:Dropout delay CB closed		1 s to 21600 s	3600 s
_:105	Cold-load PU:Min. CB-open time		0 s to 21600 s	3600 s

5.5.4.16 Information List

No.	Information	Data Class (Type)	Type
Cold-load PU			
_:81	Cold-load PU:>Block stage	SPS	I
_:500	Cold-load PU:>Block fast dropout	SPS	I
_:501	Cold-load PU:>Activate cold-load	SPS	I
_:54	Cold-load PU:Inactive	SPS	O
_:52	Cold-load PU:Behavior	ENS	O
_:53	Cold-load PU:Health	ENS	O
_:300	Cold-load PU:Cold-load pickup	SPS	O

5.5.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Closure detec.				
_:4681:101	Closure detec.:Operating mode		• Manual close only • I open and V open • CB and I open • I open	Manual close only
_:4681:102	Closure detec.:Action time after closure		0.01 s to 60.00 s	0.05 s
_:4681:103	Closure detec.:Min. time feeder open		0.05 s to 60.00 s	0.25 s

5.5.6 Information List

No.	Information	Data Class (Type)	Type
Closure detec.			
_:4681:500	Closure detec.:>Disconnector open	PLC	I
_:4681:300	Closure detec.:Closure	PLC	O

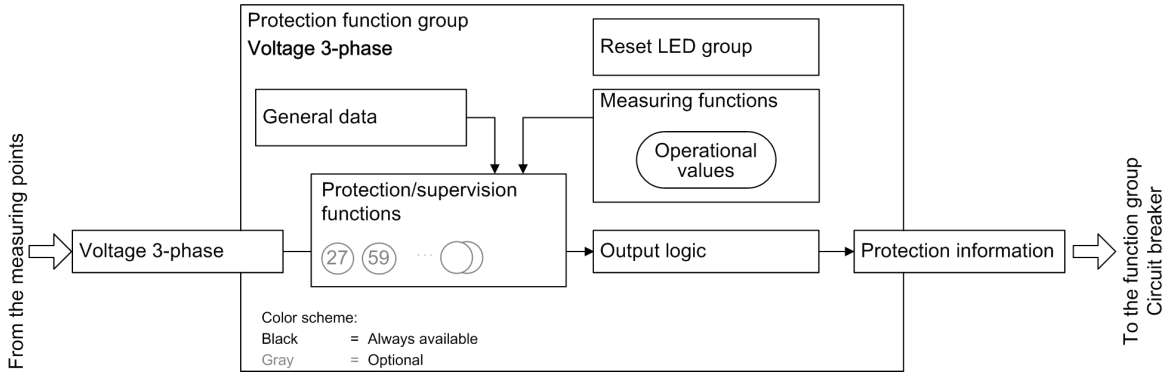
5.6 Function-Group Type Voltage 3-Phase

5.6.1 Overview

In the **Voltage 3-phase** function group, all functions can be used for protecting and for monitoring a protected object or equipment which allows a 3-phase voltage measurement. The function group also contains the operational measurement for the protected object or equipment (on this topic, see chapter *9 Measured Values, Energy Values, and Supervision of the Primary System*). Applicable functions are, for example, Voltage protection or Frequency protection.

5.6.2 Structure of the Function Group

The function group **Voltage 3-phase** has interfaces to the measuring points and the function group **Circuit breaker**.

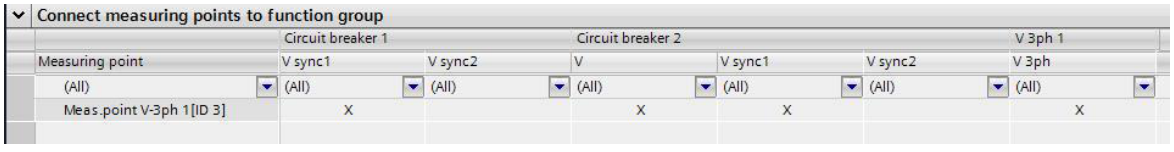


[dw_3phase_voltage, 1, en_US]

Figure 5-56 Structure of the Function Group Voltage 3-Phase

Interface with Measuring Points

You connect the function group **Voltage 3-phase** to the voltage measuring points via the interface to the measuring points. This assignment can only be made in DIGSI via **Project tree** → **Function group connections**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.



[sc_3_voltage1, 1, en_US]

Figure 5-57 Connecting Measuring Points to the Voltage 3-Phase Function Group

If you add functions to the function group **Voltage 3-phase**, these are connected to the measuring point automatically.

You can connect multiple measuring points with this interface. For more information, refer to chapter *6.71 Voltage Measuring-Point Selection*.

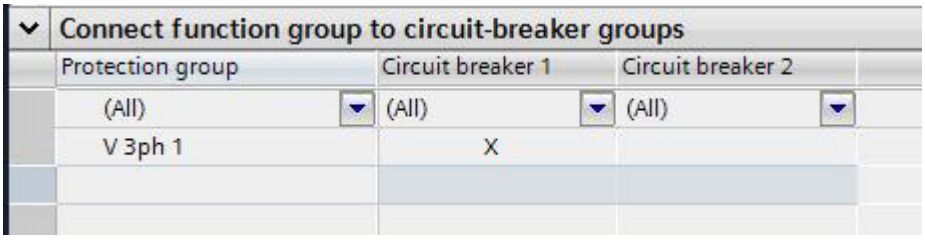
The measurands from the 3-phase voltage system are supplied via the interface **V 3-ph**. Depending on the connection type of the transformers, for example, V_A, V_B, V_C, V_{gnd}. All values that can be calculated from the measurands are also provided via this interface.

Interface to the Function Group Circuit Breaker

All required data is exchanged between the function group **Voltage 3-phase** and the function group **Circuit breaker** via the interface of the function group **Circuit breaker**.

In this example, the pickup and operate indications of the protection functions are exchanged in the direction of the function group Circuit breaker.

You must connect the function group **Voltage 3-phase** with the function group **Circuit breaker**. This assignment can be made in DIGSI only via **Project tree** → **Connect function group**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.



[sc_3_voltage2, 1, en_US]

Figure 5-58 Connecting the Function Group Voltage 3-Phase with the Function Group Circuit Breaker

Operational Measured Values

The operational measured values are always present in the function group **Voltage 3-phase** and cannot be deleted.

The following table shows the operational measured values of the function group **Voltage 3-phase**:

Table 5-15 Operational Measured Values of the Voltage 3-Phase Function Group

Measured Values		Primary	Secondary	% with respect to
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Operating rated voltage of primary values/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltage	kV	V	Rated operating voltage of the primary values
V_0	Zero-sequence voltage	kV	V	Operating rated voltage of primary values/√3
V_{NG}	Neutral-point displacement voltage	kV	V	Operating rated voltage of primary values/√3
f	Frequency	Hz	Hz	Rated frequency

5.6.3 Application and Setting Notes

NOTE

Before creating the protection functions in the function group, you should connect them to the appropriate **Circuit-breaker** function group.

Parameter: Rated voltage

- Default setting **(_:9421:102) Rated voltage** = ***400.00 kV***

With the **Rated voltage** parameter, you set the primary rated voltage. The parameter **Rated voltage** set here is the reference value for the percentage-measured values and setting values made in percentages.

5.6.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9421:102	General:Rated voltage		0.10 kV to 1200.00 kV	400.00 kV

5.6.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:9421:52	General:Behavior	ENS	O
_:9421:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
_:7381:52	Reset LED Group:Behavior	ENS	O
_:7381:53	Reset LED Group:Health	ENS	O

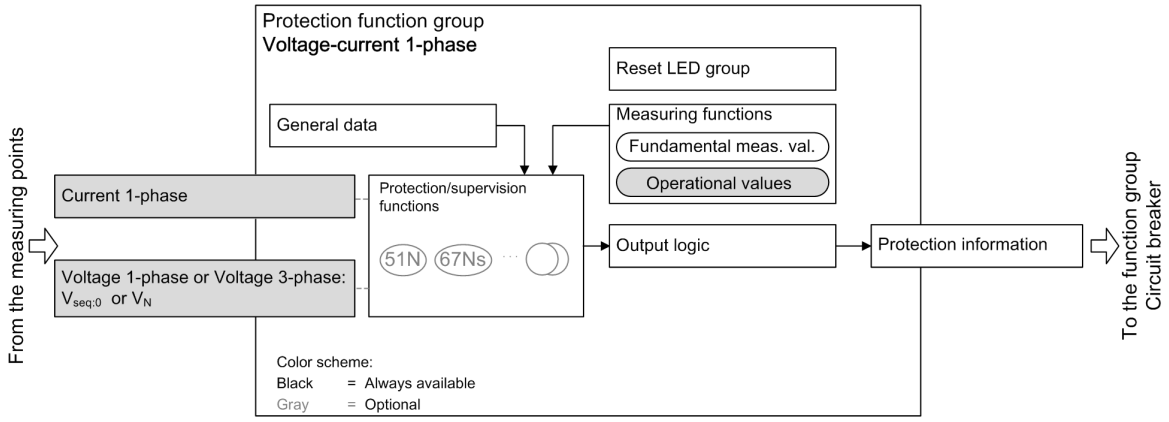
5.7 Function-Group Type Voltage/current 1-Phase

5.7.1 Overview

In the **Voltage-current 1-phase** function group, all functions can be used for protecting and for monitoring a protection object or equipment that allow a 1-phase current and voltage measurement or a zero-sequence voltage measurement via the 3-phase voltage measuring point. The function group also contains the operational measurement for the protected object or equipment (see chapter *9 Measured Values, Energy Values, and Supervision of the Primary System*).

5.7.2 Structure of the Function Group

The function group **Voltage-current 1-phase** has interfaces to the measuring points and the function group **Circuit breaker**.



[dw_1spstr, 1, en_US]

Figure 5-59 Structure of the Function Group Voltage-Current 1-Phase

Interface with Measuring Points

You connect the function group **Voltage-current 1-phase** to the current and voltage measuring points via the interfaces to the measuring points. At least one measuring point has to be connected. The other is optional. This assignment can only be made in DIGSI via **Project tree** → **Function group connections**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.

The function group has the following interfaces to the measuring points:

- **1-phase current**

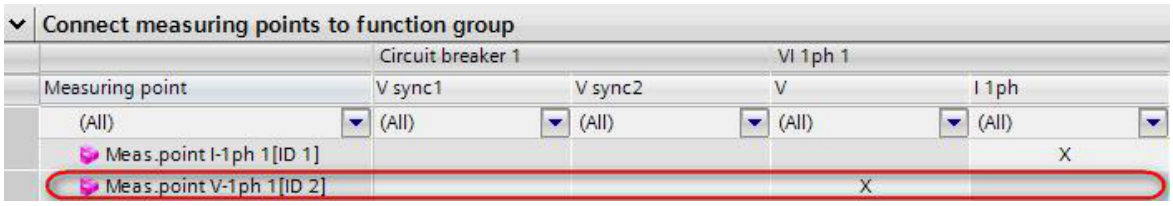
  The 1-phase current measured values are provided via this interface.

  You can only connect a 1-phase current measuring point to the interface **1-phase current**.

- **Voltage 1-phase** or **Voltage 3-phase**

  You can connect the voltage interface of the function group **Voltage-current 1-phase** with a 1-phase or a 3-phase measuring point. The calculated zero-sequence voltage or the measured residual voltage is available for connection with a 3-phase measuring point. The phase-to-ground voltages are not available in the function group **Voltage-current 1-phase**. You can use both connection types at the same time.

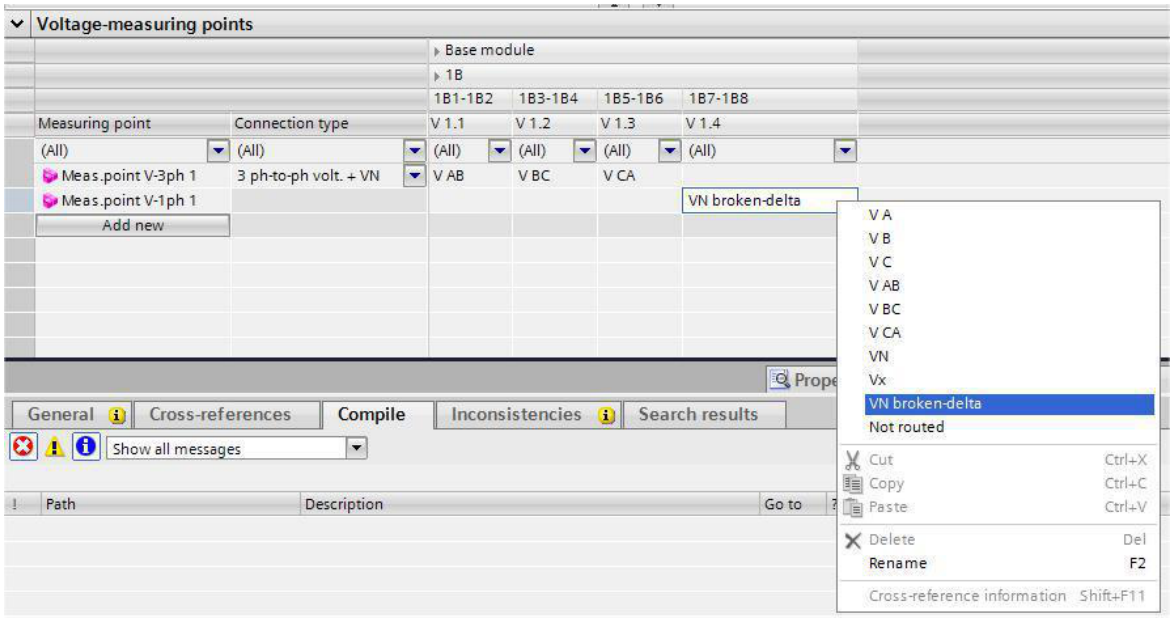
  You configure the 1-phase voltage measuring points via the voltage interface (see the following figure).



[scVI1ph_V1ph, 1, en_US]

Figure 5-60 Connecting Measuring Points to the Function Group Voltage-Current 1-Phase

If you select the voltage type ***VN broken-delta*** for the 1-phase voltage measuring point in the measuring point routing (see the following figure), the device measures the residual voltage V_N at the broken-delta winding. The residual voltage is converted into the voltage equivalent of the zero-sequence voltage. This converted voltage is used as the voltage input for all functions in the function group **Voltage-current 1-phase**.

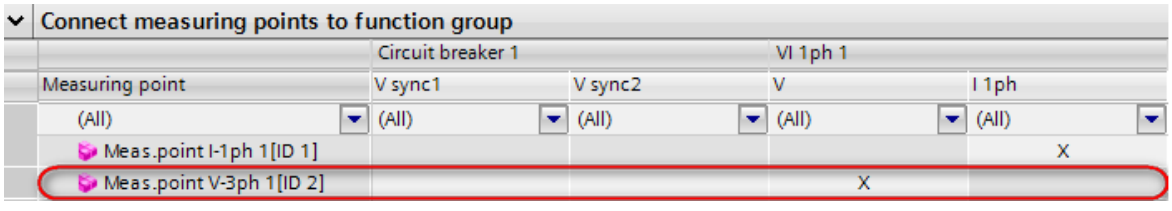


[scvnopen, 1, en_US]

Figure 5-61 Selection of the ***VN broken-delta*** Voltage Type for the 1-Phase Voltage Measuring Point

The zero-sequence voltage calculated from the 3-phase voltage system or the measured residual voltage is available via the voltage interface (see the following figure).

The zero-sequence voltage calculated from the 3-phase voltage system is available via the voltage interface (see the following figure).



[scVI1ph_V3ph, 1, en_US]

Figure 5-62 Connecting Measuring Points 3-Phase Voltage and 1-Phase Current to the Function Group 1-Phase Voltage-Current

You can connect the voltage interface of the function group **Voltage-current 1-phase** with precisely one 3-phase voltage measuring point. 3 types of 3-phase voltage measuring-point connection are supported.

With the different connection types, the type of voltage input for the functions in the function group **Voltage-current 1-phase** also changes.

The following table shows the properties of the voltage input for the function group **Voltage-current 1-phase** depending on the connection types.

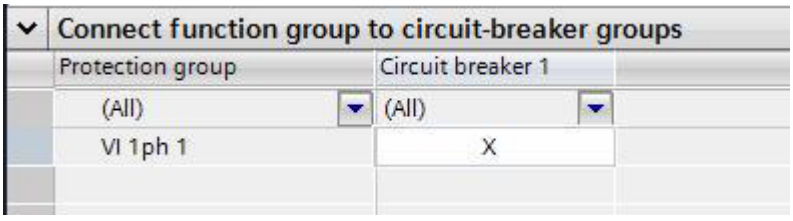
Connection Type of the 3-Phase Voltage Measuring Point	Voltage Input
3 ph-to-gnd voltages	The zero-sequence voltage is calculated from the phase-to-ground voltages and used as a voltage input for all functions.
3 ph-to-gnd volt. + VN	The residual voltage VN is converted into the voltage equivalent of the zero-sequence voltage. This converted voltage is used as a voltage input for functions.
3 ph-to-ph volt. + VN	

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the function group **Voltage-current 1-phase** and the function group **Circuit breaker** via the interface of the function group **Circuit breaker**.

In this example, the pickup and operate indications of the protection functions are exchanged in the direction of the Circuit-breaker function group.

You must connect the function group **Voltage-current 1-phase** with the function group **Circuit breaker**. This assignment can only be made in DIGSI via **Project tree** → **Function group connections**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix. If the interface is not connected, the functions operate as supervision functions in the function group **Voltage-current 1-phase**.



[sc_1stspc, 1, en_US]

Figure 5-63 Connecting Function Group Voltage-Current 1-Phase with Function Group Circuit Breaker

Fundamental Components

The fundamental components are always present in the function group **Voltage-current 1-phase** and cannot be deleted.

The following table shows the fundamental components of the function group **Voltage-current 1-phase**:

Table 5-16 Fundamental Components of the Function Group Voltage-Current 1-Phase

Measured Values		Primary	Secondary	% Referring to
I	1-phase current	A	A	Parameter **Rated operating current**
V[21]	1-phase voltage	kV	V	Parameter **Rated operating voltage**
V_0[22]	Zero-sequence voltage	kV	V	Parameter **Rated operating voltage**/√3
V_N[23]	Residual voltage	kV	V	Parameter **Rated operating voltage**/√3

21 The 1-phase voltage V is only visible if it is connected to a 1-phase voltage measuring point.

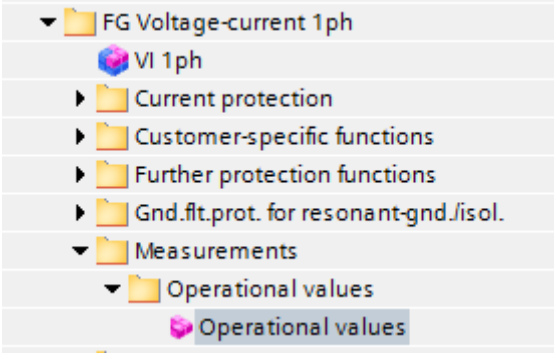
22 The zero-sequence voltage V0 is only visible if it is connected to a 3-phase voltage measuring point with the connection type 3-phase phase-to-ground voltage.

23 The residual voltage VN is only visible if it is connected to a 3-phase voltage measuring point with the connection type 3-phase phase-to-ground voltage + VN or 3-phase phase-to-phase voltage + VN.

You can find the parameters **Rated operating current** and **Rated operating voltage** in the function block **General** of the function group **Voltage-current 1-phase**.

Operational Measured Values

The operational measured values are not preconfigured in the function group **Voltage-current 1-phase**. You can instantiate them in the function group or delete them from the function group. You can find the operational measured values in the DIGSI library, in the folder **FG Voltage-current 1-phase** under **Measurements** → **Operational values**.



[scui1pom, 1, en_US]

Figure 5-64 Operational Measured Values

Table 5-17 Operational Measured Values of the Function Group Voltage-Current 1-Phase

Measured Values		Primary	Secondary	% Referring to
I	1-phase current	A	A	Parameter **Rated operating current**
V[24]	1-phase voltage	kV	V	Parameter **Rated operating voltage**
V_N[25]	Residual Voltage	kV	V	Parameter **Rated operating voltage**/√3
V_0[26]	Zero-sequence voltage	kV	V	Parameter **Rated operating voltage**/√3
f	Frequency	Hz	Hz	Parameter **Rated frequency**
P	Active power	MW	W	Parameter **Rated apparent power**
Q	Reactive power	Mvar	var	Parameter **Rated apparent power**

You can find the parameters **Rated operating current**, **Rated operating voltage**, and **Rated apparent power** in the function block **General** of the function group **Voltage-current 1-phase**. You can find the parameter **Rated frequency** in the function block **General** of the **Device settings**.

NOTE

The frequency can be calculated from the voltage or current measured value.

The active and reactive power are only displayed if the voltage and the 1-phase current are connected to the function group. If the connected voltage is a phase-to-ground voltage (VA, VB , VC) or any voltage Vx, the specific power values are displayed. Otherwise the power is displayed as not available.

24 V is only visible if it is connected to a 1-phase voltage measuring point.

25 VN is only visible if it is connected to a 3-phase voltage measuring point of the type 3 ph-to-gnd volt. + VN or 3 ph-to-ph volt. + VN.

26 V0 is only visible if it is connected to a 3-phase voltage measuring point of the type 3 ph-to-gnd voltages.

5.7.3 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9421:103	General:Rated apparent power		-1.00 MVA to -1.00 MVA	0.00 MVA
Power-system data				
_:9421:214	General:M I-1ph uses MeasP with ID		0 to 100	0
_:9421:223	General:CT mismatch M I-1ph		0.00 to 100.00	0.00

5.7.4 Parameter

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9421:101	General:Rated current		1 A to 100 000 A	1000 A
_:9421:102	General:Rated voltage		0.10 kV to 1200.00 kV	400.00 kV
Power-system data				
_:9421:214	General:M I-1ph uses MeasP with ID		0 to 100	0
_:9421:127	General:Number of Meas.point. 1ph		0 to 11	0

5.7.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:9421:52	General:Behavior	ENS	O
_:9421:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Reset LED Group			
_:13381:500	Reset LED Group:>LED reset	SPS	I
_:13381:320	Reset LED Group:LED have been reset	SPS	O
_:13381:52	Reset LED Group:Behavior	ENS	O
_:13381:53	Reset LED Group:Health	ENS	O

5.8 Function-Group Type Voltage/current 3-Phase

5.8.1 Overview

In the **Voltage-current 3-phase** function group, you can use all the functions for protection and supervision of a protected object or equipment that allows 3-phase current and voltage measurement. The function group also contains the operational measurement for the protected object or equipment (on this topic, see chapter *9 Measured Values, Energy Values, and Supervision of the Primary System*).

You will find the **Voltage-current 3-phase** function group under each device type in the Global DIGSI 5 library. You will find all protection and supervision functions that you can use for this function-group type in the function group **Voltage-current 3-phase**. These functions are described in chapter *6 Protection and Automation Functions*.

For more information about the embedding of the functions in the device, refer to chapter *2 Basic Structure of the Function*. For information regarding the functional scope of the application templates for the various device types, refer to chapter *4 Applications*.

5.8.2 Structure of the Function Group

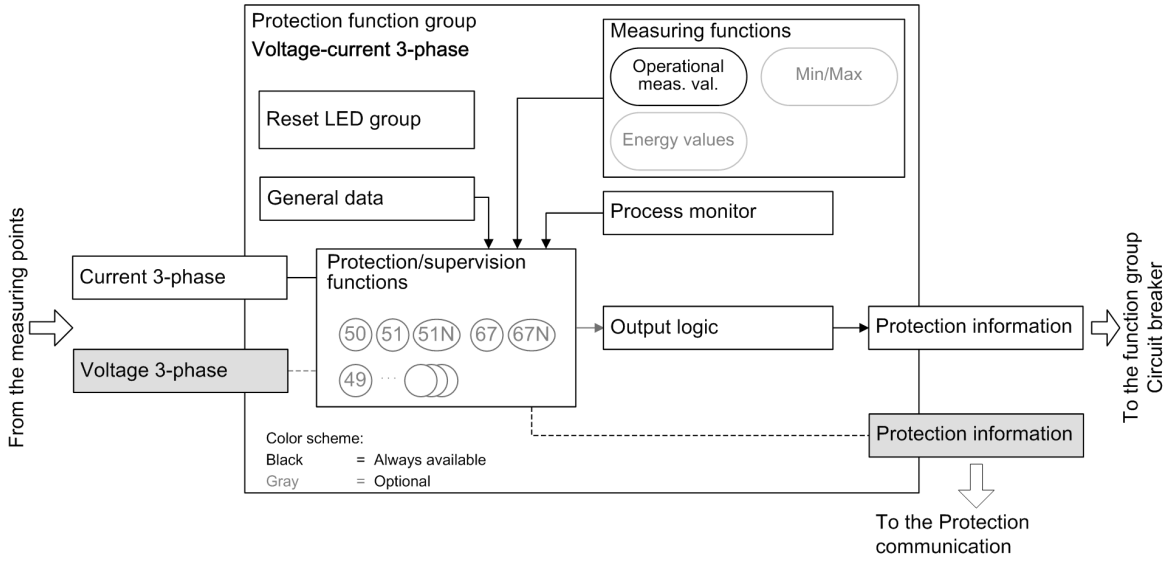
The function group always contains the following blocks:

- Protected object/equipment data (FB General)
- Operational measured values
- Process monitor
- Output logic of the function group
- Reset the LED group

These blocks are essential for the function group under all circumstances, so they cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the function group. The functions are available in the function library in DIGSI 5. Functions that are not needed can be deleted from the function group.

The following figure shows the structure of the function group **Voltage-current 3-phase**:



[dw_fg_ui3p, 4, en_US]

Figure 5-65 Structure of the Voltage-Current 3-Phase Function Group

The function group has interfaces with:

- **Measuring points**
- Function group **Circuit breaker**

Interface with Measuring Points

The function group receives the required measured values via its interfaces with the measuring points. If you are using an application template, the function group is already connected to the necessary measuring points. If you add functions to the function group, they will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the **Function-group connections** Editor. For more detailed information, refer to *2 Basic Structure of the Function*.

The function group has the following interfaces with the measuring points:

- **3-phase voltage**

  The measurands from the 3-phase voltage system are supplied via this interface. There are various types of transformer connections possible. All values that can be calculated from the measurands are also provided via this interface. The function group must always be linked to the **V-3ph** measuring point.

  You can connect multiple measuring points with this interface. For more information, refer to *6.71 Voltage Measuring-Point Selection*.

  If you want to test or change the connection between the voltages and the V-3ph measuring point, double-click in the DIGSI 5 project tree **(Name of the device)** > **Measuring point routing** (Connection type = 3 phase-to-ground voltage). For more information, refer to the description of the power-system data starting with *6.1 Power-System Data*.

- **3-phase current**

  The measurands from the 3-phase current system are supplied via this interface. Depending on the connection type of the transformers, these are, for example, I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The function group must always be connected to the **I-3ph** measuring point.

  You can connect the **3-phase current** interface to a maximum of **four** 3-phase current measuring points, (for example, for 1 1/2 circuit-breaker layouts). If 2 current measuring points have been connected with the **3-phase current** interface, the total current is also determined from measured values from both measuring points in the function group. All functions in the function group have access to these values.

Interface to the Circuit-Breaker Function Group

All required data are exchanged between the function groups **Voltage-current 3-phase** and **Circuit breaker** via the interface of the **Circuit-breaker** function group.

This data includes, for example, the pickup and operate indications of the protection functions sent in the direction of the Circuit-breaker function group and, for example, the circuit-breaker position information in the direction of the protection function groups.

The **Voltage-current 3-phase** function group is connected to one or more Circuit-breaker function groups. This connection generally determines:

- Which circuit breaker(s) is/are activated by the protection functions of the protection function group
- Starting the Circuit-breaker failure protection function (if available in the Circuit-breaker function group) through the protection functions of the connected protection function group
- Starting the Automatic reclosing function (AREC, if available in the Circuit-breaker function group) through the protection functions of the connected Protection function group

Besides the general allocation of the protection function group to the Circuit-breaker function groups, you can also configure the interface for certain functionalities in detail. Configure the details in DIGSI 5 using the **Circuit-breaker interaction** Editor in the protection function group.

In the detail configuration of the interface, you define:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the Automatic reclosing function
- Which protection functions start the Circuit-breaker failure protection function

If you are using an application template, the function groups are already connected to each other, because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor.

For more information, refer to *2.1 Embedding of Functions in the Device*.

If the connection is missing, DIGSI 5 reports an inconsistency.

Protected Object/Equipment Data (FB General)

The rated voltage and rated current as well as the neutral-point treatment of the protected object or the equipment are defined here. These data apply to all functions in the **Voltage-current 3-phase** function group.

Resetting the LED Group

Using the **Reset the LED group** function, you can reset the stored LEDs of the functions in one specific function group while the activated, stored LEDs of other functions in other function groups remain activated.

For more detailed information, refer to *3.1.11 Resetting Stored Indications of the Function Group* .

Process Monitor

The process monitor is always present in the **Voltage-current 3-phase** function group and cannot be removed.

The process monitor provides the following information in the **Voltage-current 3-phase** function group:

- Current-flow criterion:
  Detection of an open/activated protected object/equipment based on the flow of leakage current
- Closure detection:
  Detection of the switching on of the protected object/equipment
- Cold-load pickup detection (optional, only for protection devices):

This information applies to all functions available in the **Voltage-current 3-phase** function group.

The description of the process monitor begins with *5.14 Process Monitor*.

Operational Measured Values

The operational measured values are always present in the **Voltage-current 3-phase** function group and cannot be deleted.

The following table shows the operational measured values of the **Voltage-current 3-phase** function group:

Table 5-18 Operational Measured Values of the Voltage-Current 3-Phase Function Group

Measured Values		Primary	Secon-dary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary values
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary values
I_N	Neutral-point phase current	A	A	Rated operating current of the primary values
I_{NS}	Sensitive ground current	A	mA	Rated operating current of the primary values
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary values/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary values

Measured Values		Primary	Secon-dary	% Referenced to
V_0	Zero-sequence voltage	kV	V	Rated operating voltage of the primary values/√3
V_{NG}	Neutral-point displacement voltage	kV	V	Rated operating voltage of the primary values/√3
f	Frequency	Hz	Hz	Rated frequency
P_{total}	Active power (total power)	MW	W	Active power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q_{total}	Reactive power (total power)	Mvar	var	Reactive power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S_{total}	Apparent power (total power)	MVA	VA	Apparent power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active factor	(abs)	(abs)	100 % corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	W	Active power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	var	Reactive power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$
S_A, S_B, S_C	Phase-related apparent power	MVA	VA	Apparent power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$

For a more detailed explanation of the operational measured values, refer to *9.3 Operational Measured Values*.

Inversion of Power-Related Measured and Statistical Values (FB General)

The following directional values calculated in operational measured values are defined positively in the direction of the protected object.

- Power
- Active factor
- Energy
- Minimum, maximum values
- Average values

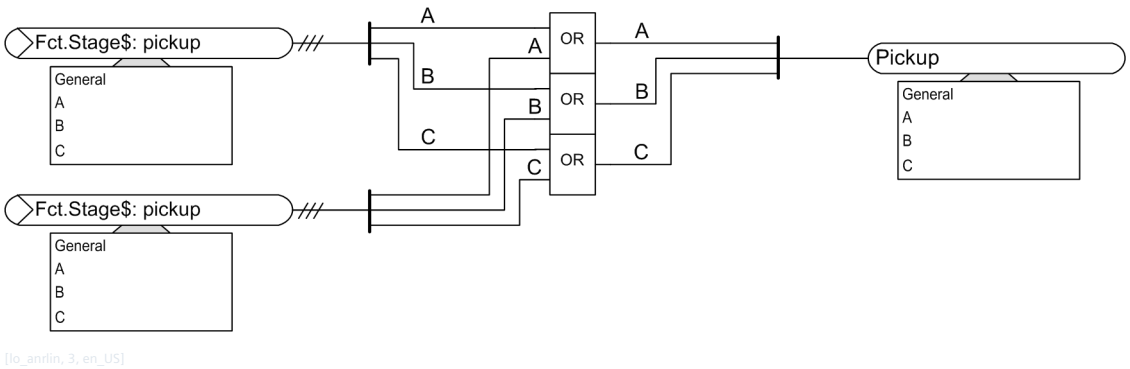
With the parameter **`P, Q sign`**, you can invert the sign of these operational measured values such that a power flow from the line to the busbar is displayed positively.

For more information on this, refer to *9.1 Overview of Functions*.

Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions that are available in the function group separately, in a pickup logic and a trip logic, respectively. The pickup and trip logic generate the overreaching indications (group indications) of the function group. These group indications are transferred via the **Protection information** interface to the **Circuit-breaker** function group and are processed further there.

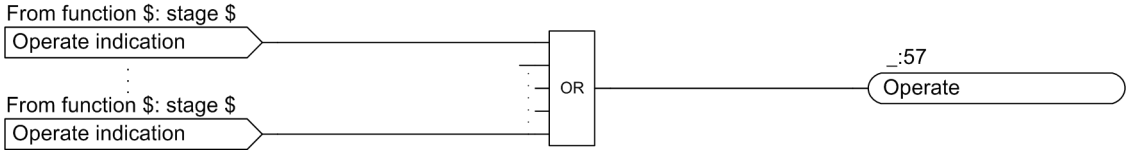
The pickup signals of the protection and supervision functions in the **Voltage-current 3-phase** function group are combined in a phase-selective manner and output as a group indication.



[lo_anrlin, 3, en_US]

Figure 5-66 Creation of the Pickup Indication of the Voltage-Current 3-Phase Function Group

The trip signals from the protection and supervision functions of the **Voltage-current 3-phase** function group always result in 3-pole tripping of the device.



[lo_auslin, 3, en_US]

Figure 5-67 Creation of the Operate Indication of the Voltage-Current 3-Phase Function Group

5.8.3 Write-Protected Settings

Parameter: Rated apparent power

- Default setting (_:103) **Rated apparent power** = ***692.82 MVA***

With the parameter **Rated apparent power**, you can set the primary rated apparent power for the auto transformer to be protected. The parameter **Rated apparent power** is relevant for the main protection function of the device. The **Rated apparent power** set here is the reference value for the percentage-measured values and setting values made in percentages.

NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameters	C	Range of Values	Default Setting
Network data				
_:103	General:rated apparent power		0.20 MVA to 5 000.00 MVA	692.82 MVA

NOTE

For more detailed information on the process monitor, refer to *5.14 Process Monitor*.

5.8.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9451:101	General:Rated current		1 A to 100 000 A	1000 A
_:9451:102	General:Rated voltage		0.10 kV to 1200.00 kV	400.00 kV
Power-system data				
_:9451:149	General:Power-sys. neutral point		• grounded • suppress. coil grounded • isolated	grounded
Measurements				
_:9451:158	General:P, Q sign		• not reversed • reversed	not reversed

5.8.5 Information List

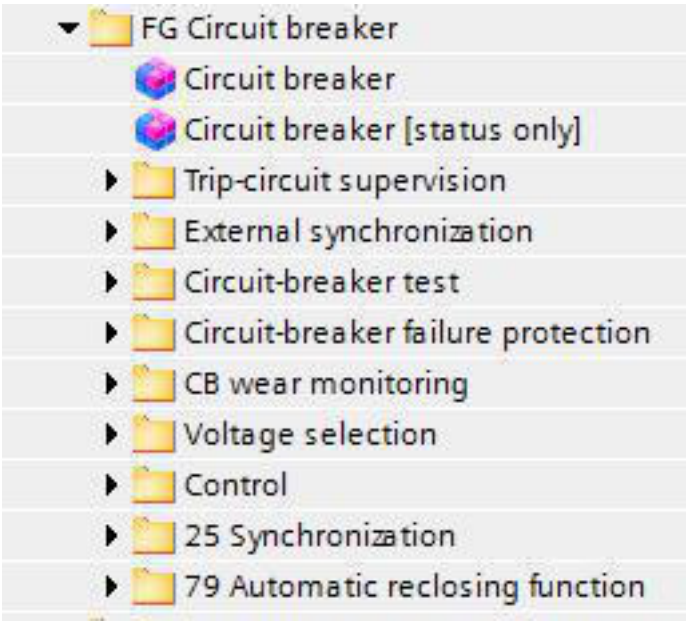
No.	Information	Data Class (Type)	Type
General			
_:9451:52	General:Behavior	ENS	O
_:9451:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
_:7381:52	Reset LED Group:Behavior	ENS	O
_:7381:53	Reset LED Group:Health	ENS	O
Closure detec.			
_:1131:4681:500	Closure detec.:>Disconnector open	SPS	I
_:1131:4681:300	Closure detec.:Closure	SPS	O
_:1131:4681:52	Closure detec.:Behavior	ENS	O
_:1131:4681:53	Closure detec.:Health	ENS	O

5.9 Function-Group Type Circuit Breaker

5.9.1 Overview

The **Circuit-breaker** function group combines all the user functions that relate to a circuit breaker.

You will find the **Circuit-breaker** function group under each device type in the function library in DIGSI 5. The **Circuit-breaker** function group contains all of the protection, control, and supervision functions that you can use for this device type. The following figure shows, for example, the functional scope of the **Circuit-breaker** function group.



[sc_cb2typ, 1, en_US]

Figure 5-68 Circuit-Breaker Function Group – Example of the Functional Scope

The Circuit-breaker function group includes 2 different types of circuit breakers:

- Circuit breaker
- Circuit breaker [status only]

The type circuit breaker can accept additional basic function blocks for protection functions along with the actual circuit-breaker control.

The type circuit breaker [status only] is used only for acquiring the circuit-breaker switch position. This type can be used to model switches that can only be read but not controlled by the SIPROTEC 5 device.

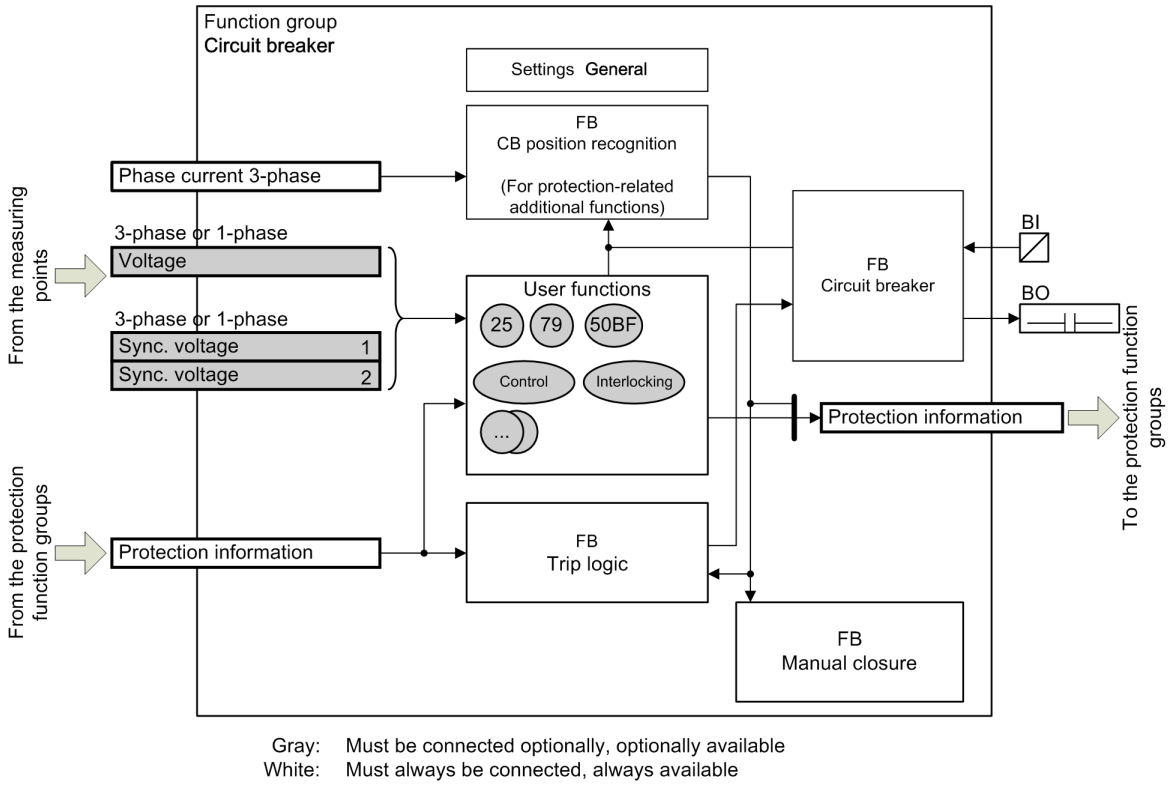
The available functions are described in *6 Protection and Automation Functions* and *7 Control Functions*.

5.9.2 Structure of the Function Group

Besides the user functions, the **Circuit-breaker** function group contains certain functionalities that are essential for general purposes and therefore cannot be loaded or deleted:

- Trip logic
- Mapping the physical circuit breaker
- Circuit-breaker position recognition for protection functions
- Detection of manual closure
- General settings

The following figure shows the structure of the **Circuit-breaker** function group. The individual function blocks in the image are described in the following chapters.



[dw_fg_stru, 1, en_US]

Figure 5-69 Structure of the Circuit-Breaker Function Group

The **Circuit-breaker** function group has interfaces with:

- Measuring points
- Protection function groups (for example the protection function group **Transformer** or **Auto transformer** as well as side-related function groups)

Interfaces with Measuring Points

The function group contains the measured values needed from the measuring points associated with this function group.

If an application template is used, the function group is connected to the measuring point of the 3-phase current because this connection is essential. It can be necessary to connect additional measuring points to the function group, depending on the nature of the user functions used. The configuration is done via the **Function-group connections** editor in DIGSI 5. You can find more detailed information on this in *2.1 Embedding of Functions in the Device*.

If a user function, for example, synchronization, is used in the function group but the required measuring point has not linked to it, DIGSI 5 reports an inconsistency. This inconsistency provides an indication of the missing measuring-point connection.

The function group **Circuit breaker** has interfaces with the following measuring points:

- **3-phase line current**
  The measurands from the 3-phase current system are supplied via this interface. The function group must always be connected to this measuring point.

- **Voltage**

  The measurands from the 3-phase voltage system are supplied via this interface. Depending on the connection type of the transformers, in the 3-phase voltage system these are, for example, V_A, V_B, V_C of the line or the feeder. The connection of the function group to this measuring point is optional.

- **Sync. Voltage1, Sync. Voltage2**

  A 1-phase synchronization voltage (for example, voltage of the busbar with a 1-phase connection) or a 3-phase synchronization voltage (for example, voltage of the busbar with a 3-phase connection) is supplied via this interface.

  The connection to the corresponding measuring point is necessary only if synchronization is used.

Interface with Protection-Function Groups

All required data are exchanged between the protection function group and the function groups **Circuit breaker** via the interfaces of the function group **Circuit breaker**. This data includes, for example, the pickup and operate indications of the protection functions sent in the direction of the function group circuit-breaker and, for example, the circuit-breaker position information in the direction of the protection function groups.

If an application template is used, the function groups are connected to each other because this connection is essential to ensure proper operation. You can modify the connection using the **Function-group connections** Editor in DIGSI 5.

You can find more detailed information in *2.1 Embedding of Functions in the Device*.

If the linkage is missing, DIGSI 5 reports an inconsistency.

Besides the general assignments of the protection function group or groups to the Circuit-breaker function groups, you can also configure the interface for certain functionalities in detail:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the **Automatic reclosing** function?
- Which protection functions activate the **Circuit-breaker failure protection** function?

You can find more detailed information in *2.1 Embedding of Functions in the Device*.

5.9.3 Application and Setting Notes

Interface with Measuring Points

The interface with the 3-phase current system must have been configured. Otherwise, DIGSI 5 supplies an inconsistency message.

If the function **Synchronization** is used, the measuring points that represent voltages V1 and V2 of the power-supply units to be synchronized must be connected.

For further information refer to *7.5 Synchronization Function*.

The function **Automatic reclosing** provides the auxiliary functions **Dead-line check** and **Reduced dead time**. For these auxiliary functions, the 3-phase voltage system has to be measured. If you want to use these auxiliary functions, the measuring point of the 3-phase voltage system must be connected to the function-group interface **Voltage**. This connection is also necessary if the function type **Automatic reclosing function with adaptive dead time** is used.

Interface with Protection-Function Groups

The protection-function group **Transformer** is connected to 2 circuit breakers (2 function groups **Circuit breaker**) for 1 1/2 circuit-breaker layouts.

Parameter: I Reference for % Values

- Default setting **(_:2311:101) Rated normal current** = ***1000.00 A***

With the parameter **Rated normal current**, you set the primary current, which serves as a reference for all current-related % values within the function group Circuit breaker. This applies both for operational measured values and for setting values in %.

Enter the primary rated current of the protected object (for example, the transformer) here.

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: V Reference for % Values

- Default setting **(_:2311:102) Rated voltage** = ***400.00 kV***

With the parameter **Rated voltage**, you set the primary voltage, which serves as a reference for all voltage-related % values within the function group Circuit breaker. This applies both for operational measured values and for setting values in %.

Enter the primary rated voltage of the protected object (for example, the line) here.

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Current Threshold Circuit Breaker Open

- Default setting **(_:2311:112) Current thresh. CB open** = ***0.10 A***

With the parameter **Current thresh. CB open**, you specify the current threshold below which the circuit-breaker pole or the circuit breaker is recognized as open.

Set the parameter **Current thresh. CB open** so that the current measured when the circuit-breaker pole is open will certainly fall below the parameterized value. If parasitic currents (for example, due to induction) are excluded with the line deactivated, you can make a secondary setting of the value with a high degree of sensitivity, to ***0.05 A*** for example.

If no special requirements exist, Siemens recommends retaining the setting value of ***0.10 A*** for secondary purposes.

5.9.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Ref. for %-values				
_:2311:101	General:Rated normal current		0.20 A to 100000.00 A	1000.00 A
_:2311:102	General:Rated voltage		0.10 kV to 1200.00 kV	400.00 kV
Breaker settings				
_:2311:112	General:Current thresh. CB open	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2311:136	General:Op. mode BFP		• unbalancing • I> query	unbalancing

5.9.5 Information List

No.	Information	Data Class (Type)	Type
Circuit break.			
_:4261:500	Circuit break.:>Ready	SPS	I

No.	Information	Data Class (Type)	Type
_:4261:501	Circuit break.:>Acquisition blocking	SPS	I
_:4261:502	Circuit break.:>Reset switch statist.	SPS	I
_:4261:504	Circuit break.:>Reset AcqBlk&Subst	SPS	I
_:4261:505	Circuit break.:>Trip release BBP	SPS	I
_:4261:506	Circuit break.:>Manual start HSBT	SPS	I
_:4261:503	Circuit break.:External health	ENS	I
_:4261:52	Circuit break.:Behavior	ENS	O
_:4261:53	Circuit break.:Health	ENS	O
_:4261:58	Circuit break.:Position	DPC	C
_:4261:300	Circuit break.:Trip/open cmd.	SPS	O
_:4261:301	Circuit break.:Close command	SPS	O
_:4261:302	Circuit break.:Command active	SPS	O
_:4261:303	Circuit break.:Definitive trip	SPS	O
_:4261:326	Circuit break.:BBP trip relays blocked	SPS	O
_:4261:327	Circuit break.:no release of trip cmd	SPS	O
_:4261:304	Circuit break.:Alarm suppression	SPS	O
_:4261:306	Circuit break.:Op.ct.	INS	O
_:4261:307	Circuit break.:ΣI Brk.	BCR	O
_:4261:308	Circuit break.:ΣIA Brk.	BCR	O
_:4261:309	Circuit break.:ΣIB Brk.	BCR	O
_:4261:310	Circuit break.:ΣIC Brk.	BCR	O
_:4261:311	Circuit break.:Break.-current phs A	MV	O
_:4261:312	Circuit break.:Break.-current phs B	MV	O
_:4261:313	Circuit break.:Break.-current phs C	MV	O
_:4261:317	Circuit break.:Break. current 3I0/IN	MV	O
_:4261:314	Circuit break.:Break. voltage phs A	MV	O
_:4261:315	Circuit break.:Break. voltage phs B	MV	O
_:4261:316	Circuit break.:Break. voltage phs C	MV	O
_:4261:322	Circuit break.:CB open hours	INS	O
_:4261:323	Circuit break.:Operating hours	INS	O

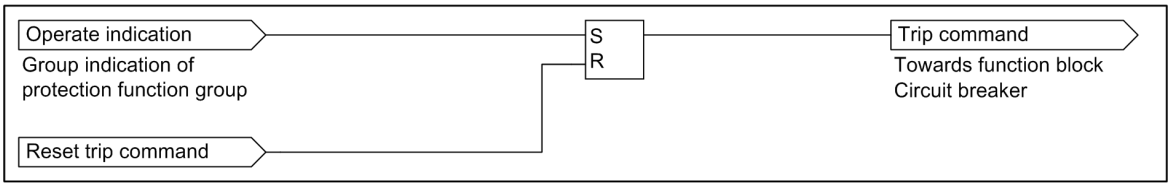
5.9.6 Trip Logic

5.9.6.1 Function Description

The **Trip logic** function block receives the group operate indication from the Protection function group or Protection function groups and forms the protection trip command that is transmitted to the **Circuit-breaker** function block.

The **Circuit-breaker** function block activates the device contact and thus causes the circuit breaker to open (see *5.9.7 Circuit Breaker*). The command output time is also effective here.

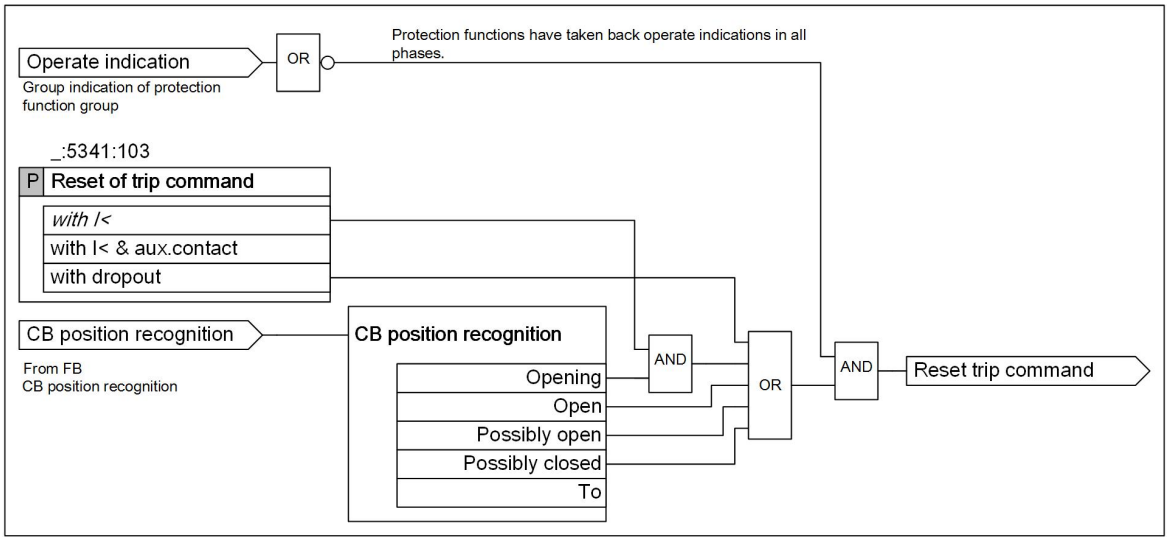
The trip logic also decides when the protection trip command is reset (see *Figure 5-71*).



[lo_ausbef, 1, en_US]

Figure 5-70 Trip Command

Trip-Command Reset



[lo_befe3p, 1, en_US]

Figure 5-71 Trip-Command Reset

Once a trip command is issued, it is stored (see *Figure 5-70*).

You determine the criteria for resetting a trip command that has been issued with the parameter **`Reset of trip command`**. The following setting options are possible:

- **`with dropout`**
  If the function that initiated tripping resets its operate indication the trip command is reset. This occurs typically with dropout. Command reset of the trip command takes place regardless of verification of the circuit-breaker condition.
- **`with I<`**
- **`with I< & aux.contact`**
  For these criteria, the state of the circuit breaker is also taken into account as a further criterion in addition to the dropout of the tripping function (operate indication is reset by command). You can select whether the state is determined by means of the current (**`with I<`**) or by means of the current in conjunction with the circuit-breaker auxiliary contacts (**`with I< & aux.contact`**). The behavior of these setting options only differs in one situation of the circuit-breaker state. If the circuit breaker is in the **opening** state, the trip command is reset in the case of the option **`with I<`**, whereas it is not reset yet in the case of the option with **`with I< & aux.contact`**. The **opening** state is detected if the auxiliary contacts still detect the circuit breaker as being closed and opening is detected via the decreasing current flow.
  As long as the circuit breaker is detected unambiguously as closed (**fully closed**), the trip command will not be reset with these setting options.
  The information about the condition of the circuit breaker and the determination of the various conditions is supplied by the **Circuit-breaker position recognition** function block. You can find further information in chapter *5.9.8 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions*.

5.9.6.2 Application and Setting Notes

Parameter: Reset of trip command

- Recommended setting value **(_:5341:103) Reset of trip command** = ***with I<***

Parameter Value	Description
with I<	The trip command is reset under the following conditions: • Dropout of the tripping function • The current falls short of the value set in the parameter **(_:2311:112) Current thresh. CB open**
with I< & aux.contact	The trip command is reset under the following conditions: • The current falls short of the value set in the parameter **(_:2311:112) Current thresh. CB open** • The circuit-breaker auxiliary contact reports that the circuit breaker is open. This setting assumes that the setting of the auxiliary contact has been routed via a binary input (for more information, see *5.9.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information*).
with dropout	If the load current in the system cannot be interrupted during the protection device test and the test current is fed in parallel with the load current this setting is useful. The setting can be selected for special applications in which the trip command does not result in complete interruption of the current in every case. In this case, the trip command is reset if the pickup of the tripping protection function drops out.

5.9.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Trip logic				
_:103	Trip logic:Reset of trip command		• with I< • with I< & aux.contact • with dropout	with I<

5.9.6.4 Information List

No.	Information	Data Class (Type)	Type
Trip logic			
_:300	Trip logic:Trip indication	ACT	O
_:52	Trip logic:Behavior	ENS	O
_:53	Trip logic:Health	ENS	O

5.9.7 Circuit Breaker

5.9.7.1 Overview

The function block **Circuit breaker** represents the physical switch in the SIPROTEC 5 device.

The basic tasks of this function block are:

- Operation of the circuit breaker (CB)
- Acquisition of the circuit-breaker auxiliary contacts
- Acquisition of other circuit-breaker information

The function block **Circuit breaker** provides the following information:

- Number of switching cycles
- Breaking current, breaking voltage, and breaking frequency
- Summation breaking current

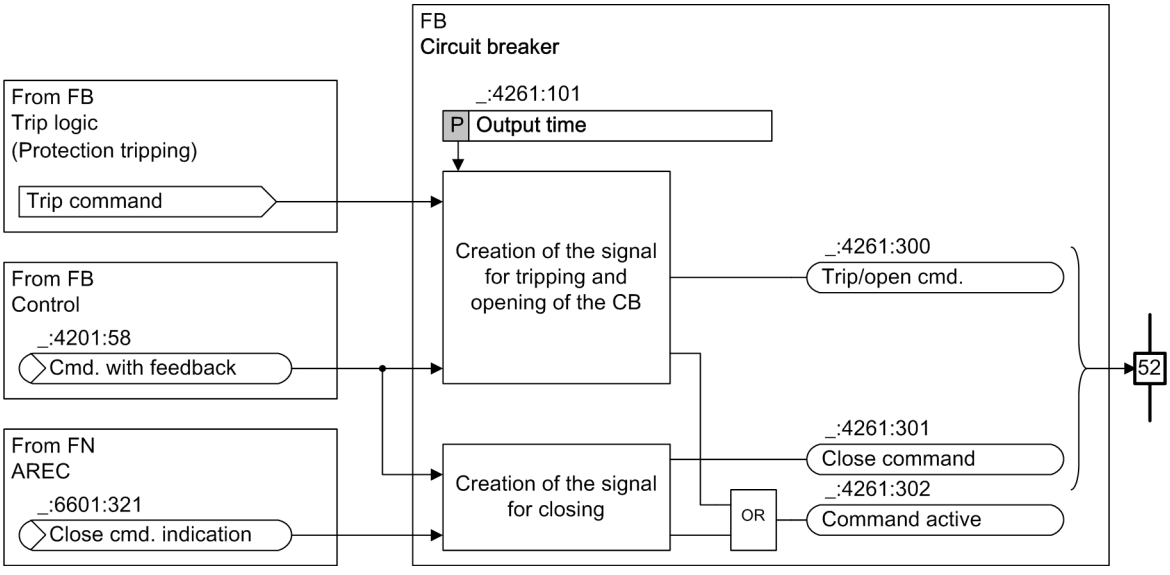
5.9.7.2 Tripping, Opening and Closing the Circuit Breaker

The circuit breaker is operated in the following situations:

- Tripping of the circuit breaker as a result of a protection trip command
- Opening of the circuit breaker as a result of control operations
- Closing of the circuit breaker as a result of an automatic reclosing or of control operations

Tripping is always the result of a protection function. The operate indications of the individual protection functions are summarized in the **Trip logic** function block. The trip command that causes the tripping in the function block **Circuit breaker** is generated there.

For the operational handling of the circuit breaker, the function block **Circuit breaker** provides the output signals that must be routed to the corresponding binary outputs of the device (see *Table 5-19*).



[lo_ausssc, 1, en_US]

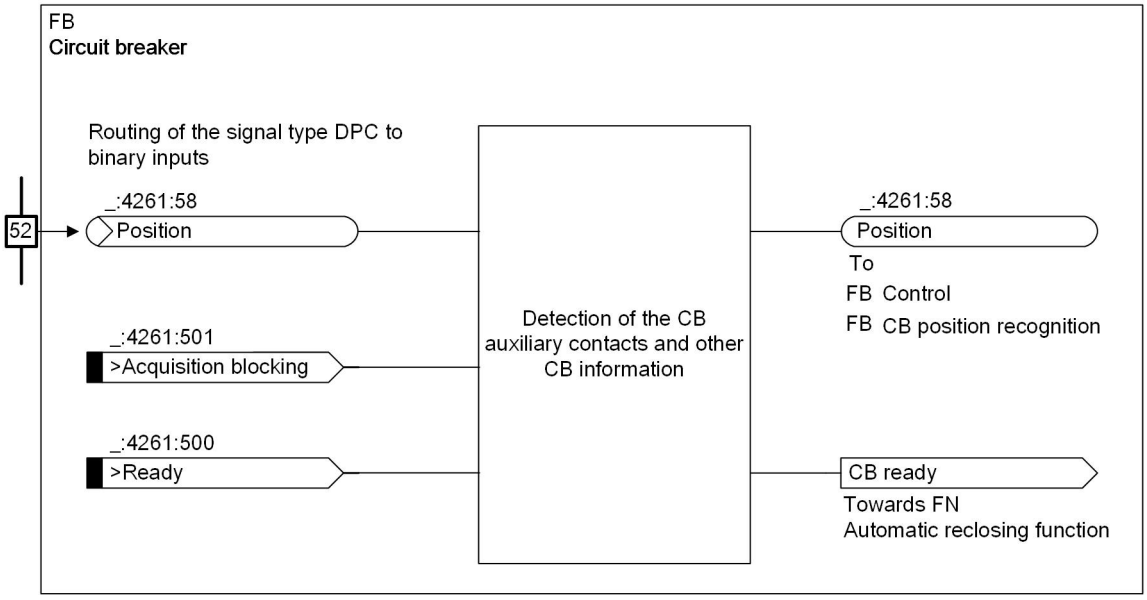
Figure 5-72 Tripping, Opening, and Closing the Circuit Breaker

Table 5-19 Description of the Output Signals

Signal	Description	Routing Options
Trip/open cmd.	This signal executes all tripping and opening operations. The **Output time** parameter affects the signal. The signal is pending for the duration of the output time, with the following exceptions: • **Only when switched off by the control:** The signal is reset before expiration of the period if the auxiliary contacts report that the circuit breaker is open before expiration of the period. • **Only in the event of protection tripping:** – The signal remains active as long as the trip command is still active after expiration of the period (see also *5.9.6.1 Function Description*). If the trip signal is no longer active and the auxiliary contacts report that the circuit breaker is open before expiration of the period, the signal is canceled before expiration of the period. – With the routing option **Only saved in the event of tripping**, the signal remains pending until it is acknowledged manually. This only applies for protection tripping.	• Unlatched • Only saved in the event of protection tripping (not when opened)
Close command	This signal executes all closing operations. The **Output time** parameter affects the signal. The signal is pending for the duration of the output time, with the following exception: The signal is canceled before expiration of the period if the auxiliary contacts report that the circuit breaker is closed before expiration of the period.	Normal routing
Command active	This signal is active if one of the following binary outputs is active: • **Trip/open cmd.** • **Close command** The binary outputs are active as long as a switching command is being executed by the control.	Normal routing

5.9.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information

To determine the circuit-breaker position, the function block **Circuit breaker** provides position signals. These signals are of the **Double-point indication** (DPC) type. A double-point indication can be routed to 2 binary inputs so that the open and closed circuit-breaker switch positions can be reliably acquired.



[lo_erfass, 2, en_US]

Figure 5-73 Acquisition of the Circuit-Breaker Information

Signal	Type	Description
Position	DPC	Acquisition of the circuit-breaker switch position The switch position CB 3-pole **open** and/or the position CB 3-pole **closed** can be detected by routing to 1 or 2 binary inputs.

The signals must be routed to the binary input that is with the CB auxiliary contacts. The **open** and **closed** signals do not necessarily have to be routed in parallel. The advantage of parallel routing is that it can be used to determine an intermediate or disturbed position. If you route only one signal (**open** or **closed**), you cannot determine an intermediate position or a disturbed position.

In the monitoring direction, the position signals generate the following information when the **open** and **closed** positions are detected (see following table). This information is further processed by the **Circuit-breaker position recognition** and **Control** function blocks.

Information	Type	Description
Open	SPS	The circuit-breaker switch position is **opened**.
Closed	SPS	The circuit-breaker switch position is **closed**.
Intermediate position	SPS	The circuit-breaker switch position is in the **intermediate position**. The signal **open** and the signal **closed** have not been set.
Disturbed position	SPS	The circuit-breaker switch position is in the **disturbed position**. The signal **open** and the signal **closed** have been set simultaneously.
Not selected	SPS	The circuit breaker is **not selected** for a control operation.

The following table shows the additional input signals:

Signal	Type	Description
>Acquisition blocking	SPS	This is used to activate acquisition blocking of the circuit-breaker auxiliary contacts (see *Other Functions 3.9.3 Persistent Commands* for a description of acquisition blocking).
>Reset AcqBlk&Subst	SPS	This is used to reset acquisition blocking and manual update of the circuit breaker. If the signal is active, acquisition blocking and manual update are reset.
>Ready	SPS	The active signal indicates that the circuit breaker is ready for an **Open-Closed-Open** cycle. The signal remains active as long as the circuit breaker is unable to trip. The signal is used in the **Automatic reclosing** and **Circuit-breaker test** functions.

The following table shows one additional output signal:

Signal	Type	Description
External health	ENS	This can be used to indicate the health of the physical circuit breaker. For this, all failure information of the circuit breaker must be detected via a binary input. This failure information can set the appropriate state of the **External health** signal with a CFC chart (using the **BUILD_ENS** block). The signal has no effect on the health of the function block.

5.9.7.4 Circuit-Breaker Tripping Alarm Suppression

Circuit-Breaker Tripping Alarm Suppression

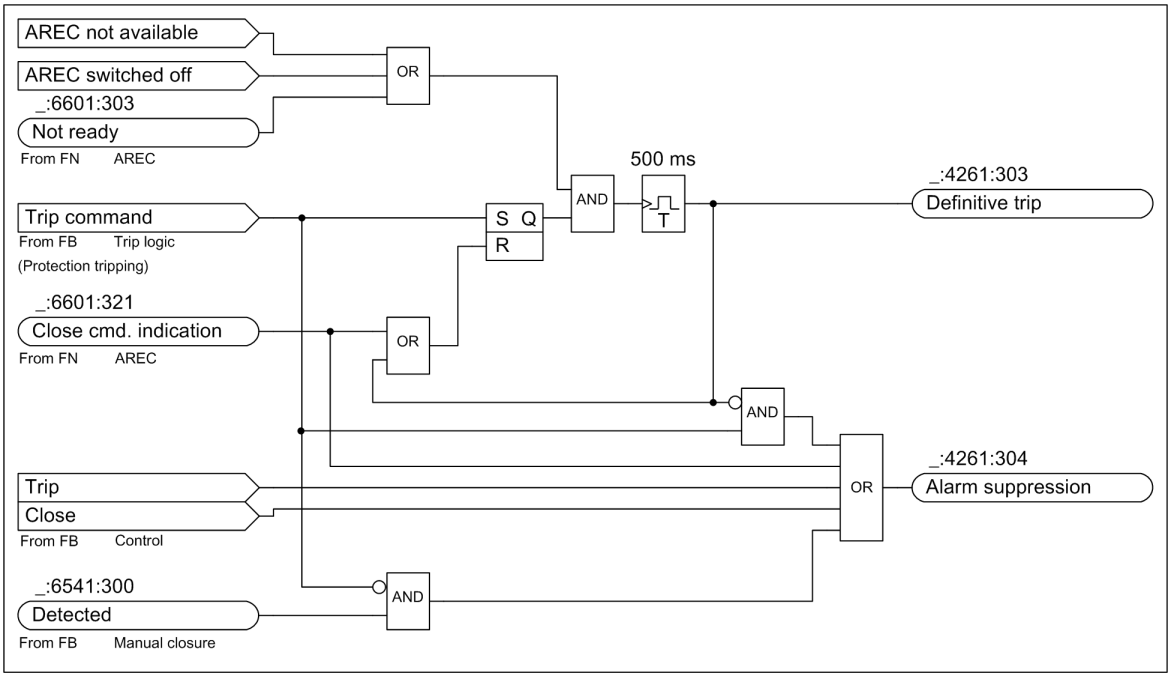
In certain systems, the user may wish to actuate an alarm (for example, a horn) when tripping (circuit-breaker tripping) occurs. This alarm should not be issued if it is to be reclosed automatically after tripping, or if it is to be closed or opened via the control. The alarm is only to be issued in the event of definitive tripping.

Depending on how the alarm is generated (for example, triggered by a fleeting contact of the circuit breaker), the *Alarm suppression* signal can be used to suppress the alarm.

If one of the following conditions is met, the *Alarm suppression* signal is generated:

- The definitive protection tripping is not present.
- The integrated automatic reclosing function executes a closure.
- The integrated control executes a closure or opening action.
- The function **Manual close** detects an external closing.

For further information about its use, refer to *5.9.9.2 Application and Setting Notes*.

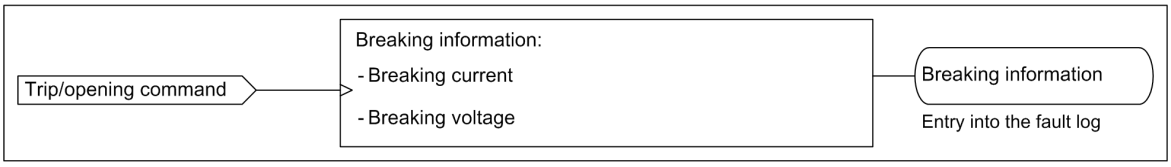


[lo_unterd, 2, en_US]

Figure 5-74 Definitive Tripping and Circuit-Breaker Tripping Alarm Suppression

5.9.7.5 Tripping and Opening Information

When a trip or opening command is issued, the breaking information shown in the next figure is saved in the fault log.



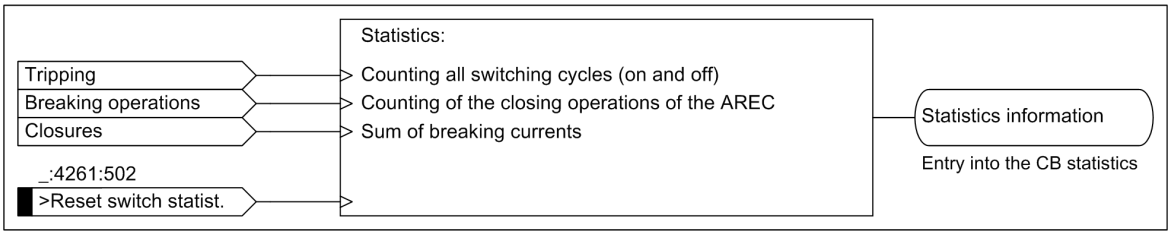
[lo_ausloe, 2, en_US]

Figure 5-75 Breaking Information

The following statistics information is saved for the circuit breaker:

- Number of switching cycles:
  All tripping, opening, and closing operations are counted.
- Number of closing operations by the automatic reclosing function
- Total of breaking currents

The statistics information can be individually set and reset via the device control. It is also possible to reset all values via the binary input signal **`>Reset switch statist.`**.



[lo_statistics information circuit-breaker, 2, en_US]

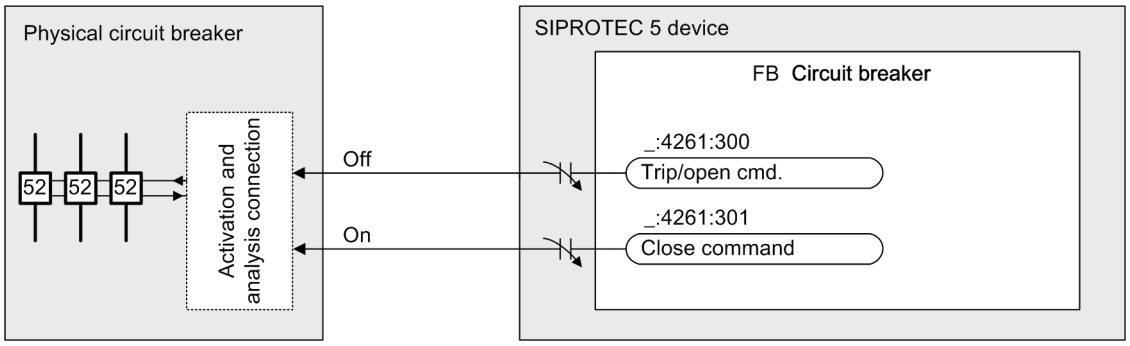
Figure 5-76 Statistics Information About the Circuit Breaker

5.9.7.6 Application and Setting Notes

Routings for Activation of the Circuit Breaker

Figure 5-77 shows the necessary routings for the device:

- 3-pole tripping via the protection
- 3-pole opening via the control



[lo_ansteu, 2, en_US]

Figure 5-77 Activation of the Circuit Breaker

By routing the **`Trip/open cmd.`** signals to 1 or 2 binary outputs, you can carry out 1-pole, 1.5-pole, and 2-pole activations of the circuit breaker. You can find a detailed description of this in chapter *7.2.2.3 Connection Variants of the Circuit Breaker*.



NOTE

Do not confuse these 1-pole, 1.5-pole, and 2-pole activations of the circuit breaker with 1-pole or 3-pole tripping of the circuit breaker.

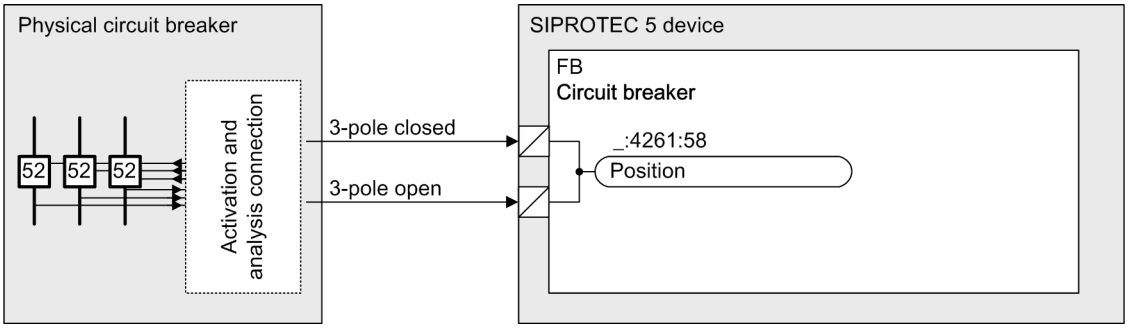
Routing to Evaluate the Circuit-Breaker Switch Position

For certain functions of the device, it is useful to detect the circuit-breaker switch position via its auxiliary contacts. The following shows a number of examples:

- **Circuit-breaker position recognition** function block
- **Circuit-breaker failure protection** function
- **Control** function block

The operating principle of the auxiliary contacts is described in the individual functions.

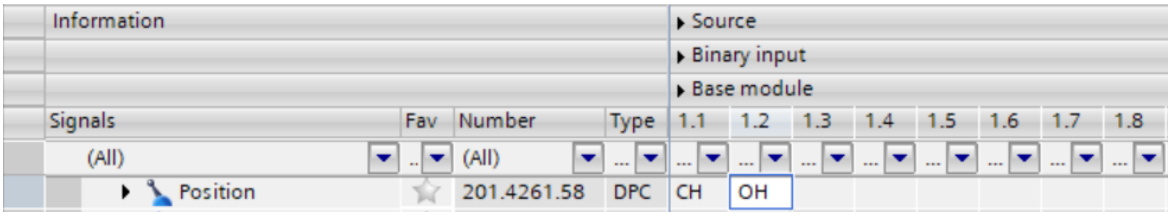
Siemens recommends capturing the information *`Circuit breaker is open in 3 poles`* and *`Circuit breaker is closed in 3 poles`* via auxiliary contacts. This is the optimal configuration for the control functionality. For purely protection applications, it is also sufficient to acquire just one of the 2 circuit-breaker switch positions. When used as a protection and control device, Siemens recommends the following evaluation of the circuit-breaker switch position:



[lo_evaluation2, 1, en_US]

Figure 5-78 Recommended Evaluation of the Circuit-Breaker Switch Position

The following diagram shows the recommended routing, in which **OH** stands for **active with voltage**.



[sc_polg3p, 1, en_US]

Figure 5-79 Routing for Acquisition of the Circuit-Breaker Switch Position via 2 Auxiliary Contacts

The device can also function without the analysis from the circuit-breaker auxiliary contacts, that is, routing of the auxiliary contacts is not absolutely necessary. However, this is a requirement for control functions.

Parameter: Output Time

- Default setting **(_:101) Output time** = ***0.10 s***

The **Output time** parameter acts on the signals for tripping, opening, and closing of the circuit breaker.

CAUTION

Do not set a time that is too short.

If you set a time that is too short, there is a danger that the device contacts will interrupt the control circuit. If this happens, the device contacts will burn out.

✧ Set a time that is long enough to ensure that the circuit breaker reliably reaches its final position (**open** or **closed**) after a control operation.

Parameter: Indicat. of breaking values

- Default setting **(_:105) Indicat. of breaking values** = ***always***

With the parameter **Indicat. of breaking values**, you specify whether the measured values are to be reported if the circuit breaker is opened via the control function.

Parameter Value	Description
always	With this setting, the measured values are reported if the circuit breaker is opened either via the control function or via the trip command of a protection function.
with trip	With this setting, the measured values are only reported if the circuit breaker is opened via the trip command of a protection function.

Measured Values

When a protection function opens the circuit breaker, the following measured values can be stored in the fault log:

- *Break.-current phs A*
- *Break.-current phs B*
- *Break.-current phs C*
- *Break. current 3I0/IN*
- *Break. voltage phs A*
- *Break. voltage phs B*
- *Break. voltage phs C*

The measured value *Break. current 3I0/IN* is the neutral-point current. Dependent on the connection type of the **measuring point I-3ph** that is connected with the function group **Circuit breaker**, the neutral-point current differs as follows:

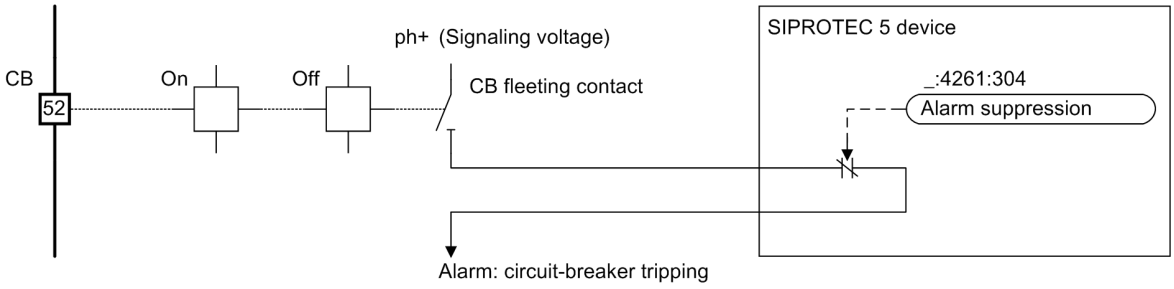
Connection Type of the Measuring Point I-3ph	Neutral-Point Current
3-phase	Calculated zero-sequence current $3I_0$
3-phase + IN 3-phase + IN-separate 3ph,2prim.CT + IN-sep 2ph, 2p. CT + IN-sep	Measured neutral-point current I_N If the secondary ground current exceeds the linear section of the sensitive measuring input (1.6 Irated) with sensitive current transformers, the neutral-point current of the measured I_N is switched to the calculated $3I_0$.

Output Signal: Indication Suppression

Whereas in the case of feeders without an automatic reclosing function every trip command is final due to a protection function, the use of an automatic reclosing function should only cause the motion detector of the circuit breaker (fleeting contact on the circuit breaker) to trigger an alarm if tripping of the circuit breaker is definitive (see next figure for more details). Likewise, a tripping alarm should not be triggered for switching operations by the control.

For this, the alarm activation circuit should be looped via a suitably routed output contact of the device (output signal **Alarm suppression**). In the idle state and when the device is switched off, this contact is always closed. For this, an output contact with a break contact must be routed. The contact opens whenever the output signal **Alarm suppression** becomes active, so that tripping or a switching operation does not cause an alarm.

You can find more detailed information in the logic in *5.9.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information*.



[lo_schalt_2, en_US]

Figure 5-80 Circuit-Breaker Tripping Alarm Suppression

5.9.7.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Circuit break.				
_:101	Circuit break.:Output time		0.02 s to 1800.00 s	0.10 s
_:105	Circuit break.:Indicat. of breaking values		• with trip • always	always

5.9.7.8 Information List

No.	Information	Data Class (Type)	Type
Circuit break.			
_:500	Circuit break.:>Ready	SPS	I
_:501	Circuit break.:>Acquisition blocking	SPS	I
_:502	Circuit break.:>Reset switch statist.	SPS	I
_:504	Circuit break.:>Reset AcqBlk&Subst	SPS	I
_:503	Circuit break.:External health	ENS	I
_:52	Circuit break.:Behavior	ENS	O
_:53	Circuit break.:Health	ENS	O
_:58	Circuit break.:Position	DPC	C
_:300	Circuit break.:Trip/open cmd.	SPS	O
_:301	Circuit break.:Close command	SPS	O
_:302	Circuit break.:Command active	SPS	O
_:303	Circuit break.:Definitive trip	SPS	O
_:304	Circuit break.:Alarm suppression	SPS	O
_:306	Circuit break.:Op.ct.	INS	O
_:307	Circuit break.:ΣI Brk.	BCR	O
_:308	Circuit break.:ΣIA Brk.	BCR	O
_:309	Circuit break.:ΣIB Brk.	BCR	O
_:310	Circuit break.:ΣIC Brk.	BCR	O
_:311	Circuit break.:Break.-current phs A	MV	O
_:312	Circuit break.:Break.-current phs B	MV	O
_:313	Circuit break.:Break.-current phs C	MV	O
_:317	Circuit break.:Break. current 3I0/IN	MV	O
_:314	Circuit break.:Break. voltage phs A	MV	O
_:315	Circuit break.:Break. voltage phs B	MV	O
_:316	Circuit break.:Break. voltage phs C	MV	O
_:322	Circuit break.:CB open hours	INS	O
_:323	Circuit break.:Operating hours	INS	O

5.9.8 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions

5.9.8.1 Overview

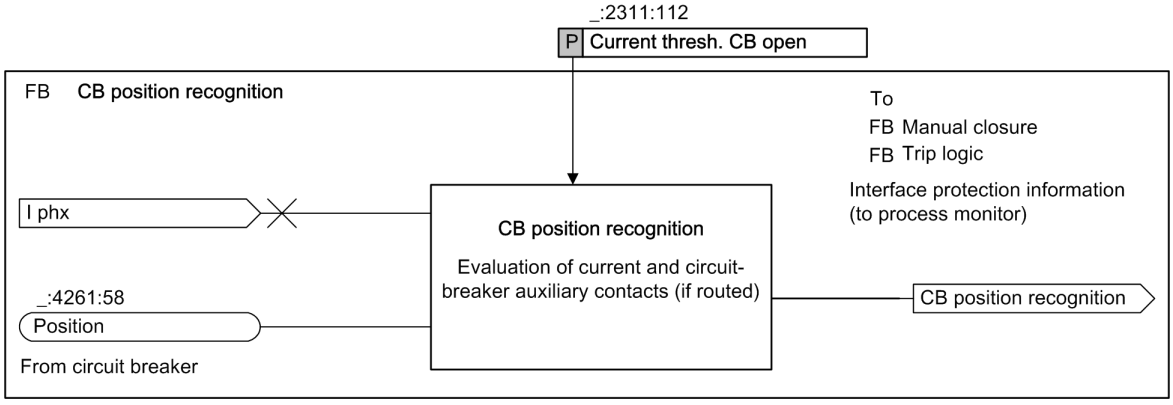
This function block calculates the position of the circuit breaker from the evaluation of the auxiliary contacts and the current flow.

This information is needed in the following protection-related additional functions:

- Trip logic (see *5.9.6.1 Function Description*)
- Detection of manual closing (see *5.9.9.1 Function Description*)
- Process monitor (see Process monitor (Line Function group) *5.5.4 Process Monitor (FG Line)* or Process monitor (Standard V/I) *5.14 Process Monitor*)

The specified chapters describe the way the protection-related additional functions are processing the information of this function block.

The control does not use this information. The control evaluates the circuit-breaker auxiliary contacts.



[lo_zust3p, 1, en_US]

Figure 5-81 Overview of the Circuit-Breaker Condition Position Function

Based on the link between the information from the auxiliary contacts and the current flow, shown in *Figure 5-81*, the circuit breaker can assume the following positions. The following table shows the possible circuit-breaker conditions:

Circuit-Breaker Condition	Description
Open	The circuit-breaker pole is detected unambiguously as ***open*** according to both criteria.
Closed	The circuit-breaker pole is detected unambiguously as ***closed*** according to both criteria.
Possibly open, possibly closed	These conditions can occur if the information is incomplete due to the routing of the auxiliary contacts and the condition can no longer be determined reliably. These ***uncertain conditions*** are evaluated differently by certain functions.
Opening	This is a dynamically occurring condition that results when, while a trip command is active and the auxiliary contact is still closed, the current is detected to have fallen below the threshold value. The reason for that is that the current-flow criterion takes effect faster than the auxiliary contact can open.

5.9.9 Detection Manual Closure (for AREC and Process Monitor)

5.9.9.1 Function Description

Detection of Manual Closure (for Process Monitor)

The **Manual closure** function block detects any closure carried out by hand. This information is used in the **Process monitor** functions (within protection function groups).

The following figure shows the logic for manual closure detection.

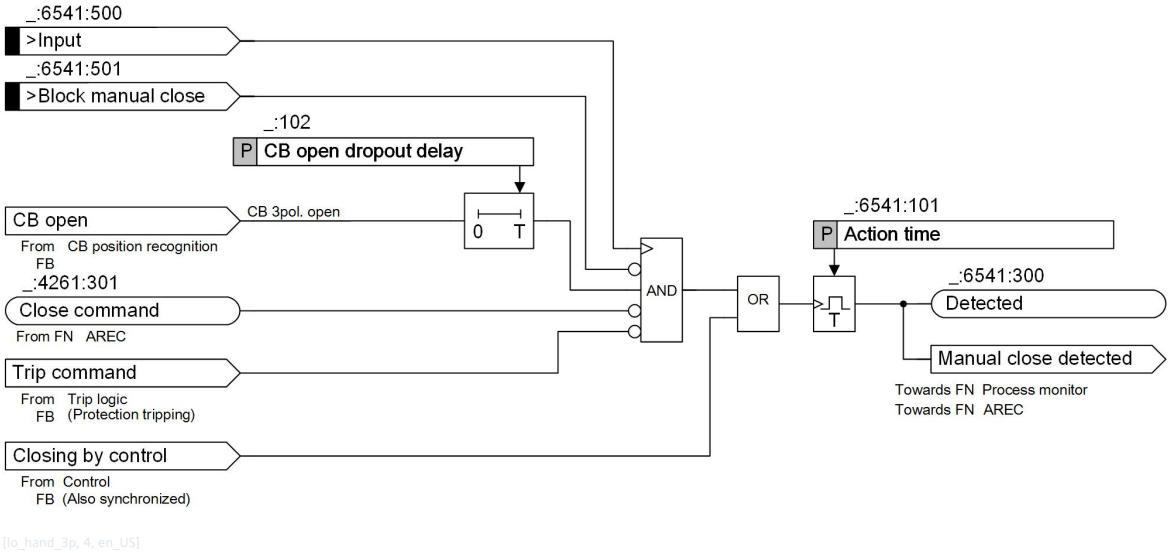


Figure 5-82 Logic for Manual Closure Detection

External Manual Closure

An external manual closure is communicated to the device via the input signal **>Input**. The input signal can also be connected directly to the control circuit of the circuit-breaker closing coil. Detection via the input signal **>Input** is also blocked if the circuit breaker is closed or if a protection trip is active.

Internal Manual Closure

Manual closure is detected in all cases if a close command is transmitted by the internal control function of the device. This is possible because the control carries out plausibility checks itself and is also subject to interlocking.

5.9.9.2 Application and Setting Notes

Input Signals: >Input, >Blocking of Manual Closure

In practice, the input signal **>Input** is connected directly to the control circuit of the circuit-breaker closing coil (see following figure).

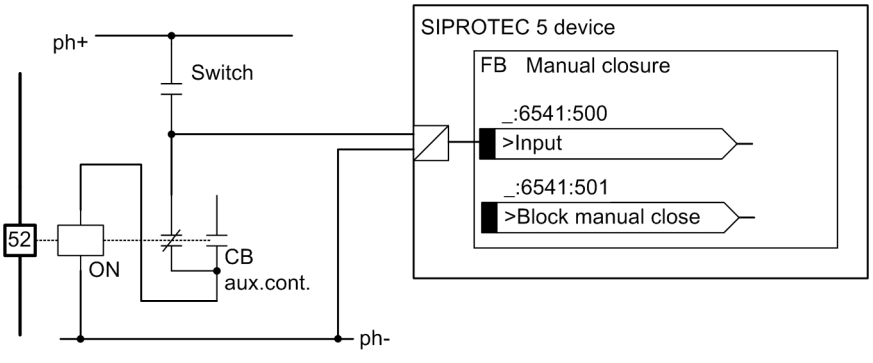


Figure 5-83 Connection of the Input Signal to the Control Circuit of the Circuit-Breaker Closing Coil

Every closure of the circuit breaker is recorded in the process.

If external close commands are possible (actuation of the circuit breaker by other devices), which are not intended to promptly detect a manual closure, this can be ensured in 2 ways:

- The input signal is connected in such a way that it is not activated in the event of external close commands.
- The external close command is connected to the blocking input **>Block manual close** for manual closure detection.

Parameter: Action time

- Recommended setting value **(_:101) Action time** = ***0.30 s***

In order to ensure independence from manual activation of the input signal, the detection function is extended for a defined length of time using the parameter **Action time**.

Siemens recommends an action time of ***0.30 s***.

Parameter: CB open dropout delay

- Default setting **(_:102) CB open dropout delay** = ***0.00 s***

With the **CB open dropout delay** parameter, you can maintain the effectiveness of internal indication *CB open* for the set time. If the input signal **>Input** becomes active after external delayed manual closure, the indication *(_:300) Detected* is output as long as the dropout delay is effective.

5.9.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Manual close				
_:101	Manual close:Action time		0.01 s to 60.00 s	0.30 s
_:102	Manual close:CB open dropout delay		0.00 s to 60.00 s	0.00 s

5.9.9.4 Information List

No.	Information	Data Class (Type)	Type
Manual close			
_:6541:501	Manual close:>Block manual close	SPS	I
_:6541:500	Manual close:>Input	SPS	I
_:6541:300	Manual close:Detected	SPS	O
_:6541:52	Manual close:Behavior	ENS	O
_:6541:53	Manual close:Health	ENS	O

5.10 Function-Group Type Circuit Breaker [without Current]

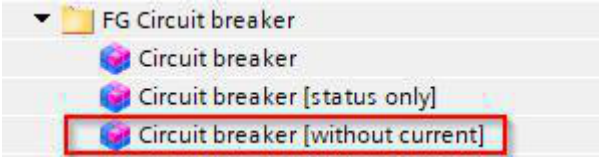
5.10.1 Overview

The function group **Circuit breaker [without current]** is a circuit-breaker function group that does not measure the primary current of the circuit breaker. For the applications that do not need to monitor the current information of circuit breakers, the function group **Circuit breaker [without current]** is a good option.

The function group **Circuit breaker [without current]** is also suitable for sending tripping signals to external equipment, for example, excitation system, turbine controller, and transformer fire-fighting system.

The advantage of the function group **Circuit breaker [without current]** is the usage with the matrix **Circuit-breaker interaction**. You can easily create a tripping concept for the unit protection.

You can find the function group **Circuit breaker [without current]** under the device types in the Global DIGSI 5 Library.



[sc_fg cb without I_7ut_7um, 1, en_US]

Figure 5-84 Function Group Circuit Breaker [without Current]

The following functions are available in the function group **Circuit breaker [without current]**:

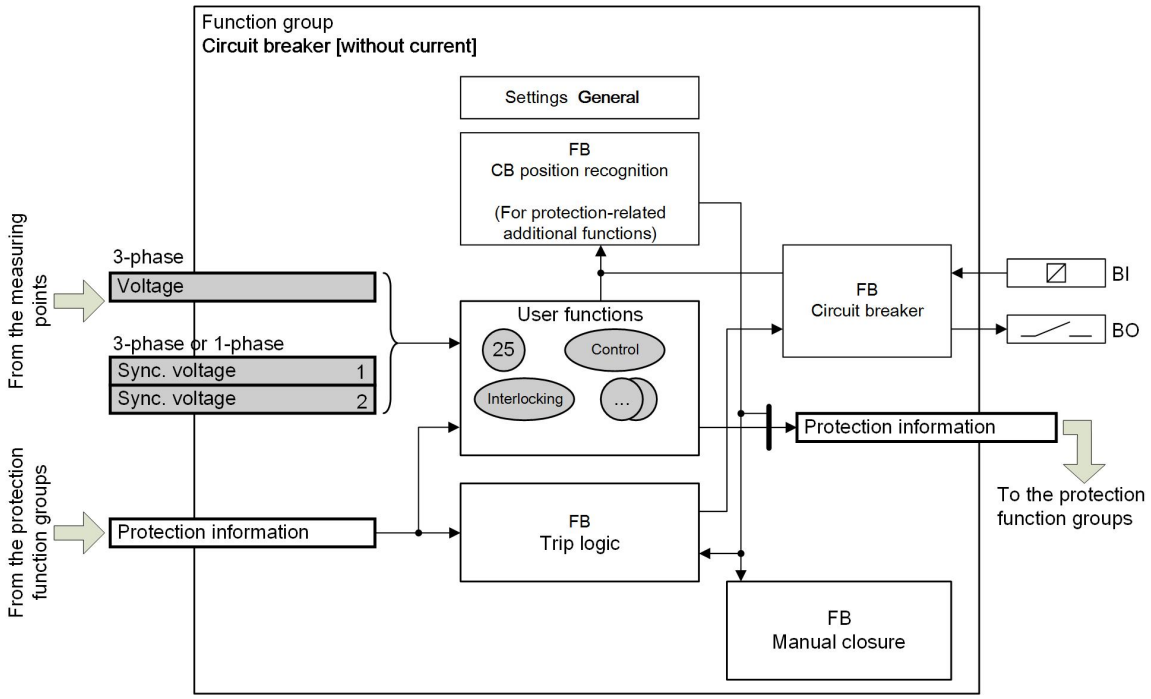
- Circuit-breaker control
- Circuit-breaker interlocking
- Circuit-breaker test
- Synchronization
- External synchronization
- Trip-circuit supervision
- Closing-circuit supervision
- Voltage measuring-point selection

5.10.2 Structure of the Function Group

Besides the user functions, the function group **Circuit breaker [without current]** contains certain functionalities that are essential for general purposes. These functionalities cannot be loaded or deleted:

- Trip logic
- Mapping the physical circuit breaker
- Circuit-breaker position recognition for protection functions
- Detection of manual closure
- General settings

The following figure shows the structure of the function group **Circuit breaker [without current]**. The individual function blocks in the figure are described in the following chapters.



[dw_fg_stru, 1, en_US]

Figure 5-85 Structure of the Function-Group Type Circuit breaker [without current]

Gray: Optionally connected

The function group **Circuit breaker [without current]** has interfaces with the following items:

- Measuring points
- Function groups

Interfaces with Measuring Points

The function group receives the required measured values from the measuring points which are connected to this function group.

If a user function, for example, the function **Synchronization**, is used in the function group, but the required measuring point is not linked to the function group, DIGSI 5 reports an inconsistency. This inconsistency provides an indication of the missing measuring-point connection.

The function group **Circuit breaker [without current]** has interfaces with the following measuring points:

- **3-phase voltage**

  The measurands of the 3-phase voltage system are supplied via this interface. The voltages are different due to the different connection types of the voltage transformers, for example, V_A, V_B, and V_C in one 3-phase voltage system, but V_{AB}, V_{BC}, and V_{CA} in another 3-phase voltage system.

  The connection to the corresponding measuring point is necessary only if a function that needs the measurand of the 3-phase voltage system is used.

- **Sync. voltage1, Sync. voltage2**

  A 1-phase synchronization voltage (for example, voltage of the busbar with a 1-phase connection) or a 3-phase synchronization voltage (for example, voltage of the busbar with a 3-phase connection) is supplied via this interface.

  The connection to the corresponding measuring point is necessary only if the function **Synchronization** is used.

Interface with Function Groups

All required data is exchanged between the function group **Circuit breaker [without current]** and the other function groups via the interfaces of the function group **Circuit breaker [without current]**. This data includes, for example, the circuit-breaker position information in the direction of the other function groups.

If an application template is used, the function groups are connected to each other because this connection is essential to ensure proper operation. You can modify the connection using the Editor **Function-group connections** in DIGSI 5. If the connection is missing, DIGSI 5 reports an inconsistency.

Besides the general assignments of other function groups to the circuit-breaker function groups, you can assign the protection functions to the desired circuit-breaker function groups for the tripping operation in the Editor **Circuit-breaker interaction** under the corresponding protection function group.

For more information, refer to *2.1 Embedding of Functions in the Device*.

5.10.3 Application and Setting Notes

Interface with Measuring Points

If the function **Synchronization** is used, the measuring points that represent voltages V1 and V2 of the parts of the electrical power systems to be synchronized must be connected.

You can find more detailed information in *7.5 Synchronization Function*.

Parameter: `Rated voltage`

- Default setting `(_:2311:102) Rated voltage` = ***400.00 kV***

With the parameter **`Rated voltage`**, you set the primary rated voltage of the protected object. The primary rated voltage serves as a reference for all voltage-related % values within the function group **Circuit breaker [without current]**. This setting applies both for the operational measured values and for the setting values in %.

If the device works with the IEC 61850 protocol, you can only change the setting value of the parameter via DIGSI 5. If you change the setting value directly on the device, the IEC 61850 configuration of the metered values can be faulty.

5.10.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Ref. for %-values				
_:2311:102	General:Rated voltage		0.10 kV to 1200.00 kV	400.00 kV

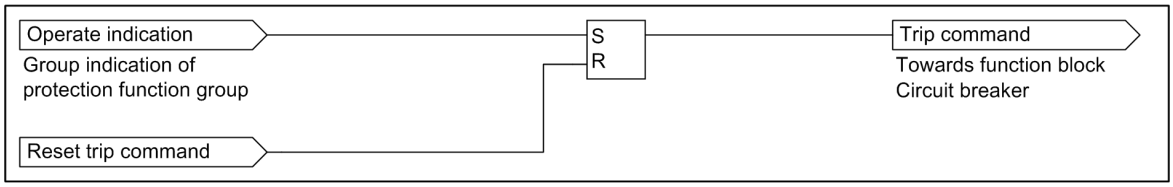
5.10.5 Trip Logic

5.10.5.1 Function Description

The **Trip logic** function block receives the operate group indication from the protection function groups and forms the protection trip command that is transmitted to the **Circuit-breaker** function block.

The **Circuit-breaker** function block activates the device contact and thus causes the circuit breaker to open (see *5.9.7 Circuit Breaker*). The command output time is also effective here.

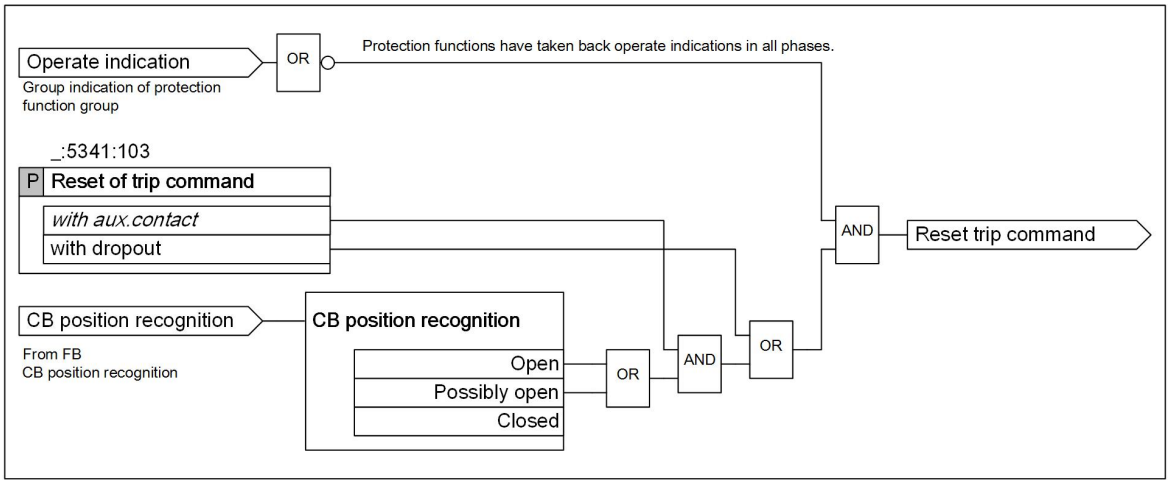
The trip logic also decides when the protection trip command is reset (see *Figure 5-87*).



[lo_ausbef, 1, en_US]

Figure 5-86 Trip Command

Trip-Command Reset



[lo_befe3p_4CB_without_I, 1, en_US]

Figure 5-87 Trip-Command Reset

Once a trip command is issued, it is stored (see *Figure 5-86*).

You determine the criteria for resetting a trip command that has been issued with the parameter **Reset of trip command**. The following setting options are possible:

- ***with dropout***

  If the function that initiated tripping resets its operate indication the trip command is reset. This occurs typically with dropout. Command reset of the trip command takes place regardless of verification of the circuit-breaker condition.

- ***with aux.contact***

  For this criteria, the state of the circuit breaker is also taken into account as a further criterion in addition to the dropout of the tripping function (operate indication is reset). The state is determined by the circuit-breaker auxiliary contacts (***with aux.contact***).

  As long as the circuit breaker is detected unambiguously as closed (**fully closed**), the trip command will not be reset with this setting option.

  The information about the condition of the circuit breaker and the determination of the various conditions is supplied by the **Circuit-breaker position recognition** function block. You can find further information in chapter *5.9.8 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions*.

5.10.5.2 Application and Setting Notes

Parameter: Reset of trip command

- Default setting **(_:5341:103) Reset of trip command** = ***with aux.contact***

Parameter Value	Description
with aux.contact	The trip command is reset if the state of the circuit-breaker auxiliary contact indicates that the circuit breaker is open. This setting assumes that the setting of the auxiliary contact has been routed via a binary input. For more information, refer to *5.10.6.3 Detection of Circuit-Breaker Auxiliary Contacts and Further Information*.
with dropout	The trip command is reset if the pickup of the tripping protection function drops out.

5.10.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Trip logic				
_:103	Trip logic:Reset of trip command		• with aux.contact • with dropout	with aux.contact

5.10.5.4 Information List

No.	Information	Data Class (Type)	Type
Trip logic			
_:300	Trip logic:Trip indication	ACT	O
_:52	Trip logic:Behavior	ENS	O
_:53	Trip logic:Health	ENS	O

5.10.6 Circuit Breaker

5.10.6.1 Overview

The function block **Circuit breaker** represents the physical switch in the SIPROTEC 5 device.
The basic tasks of this function block are:

- Operation of the circuit breaker
- Acquisition of the circuit-breaker auxiliary contacts
- Acquistion of other circuit-breaker information

The function block **Circuit breaker** provides the following information:

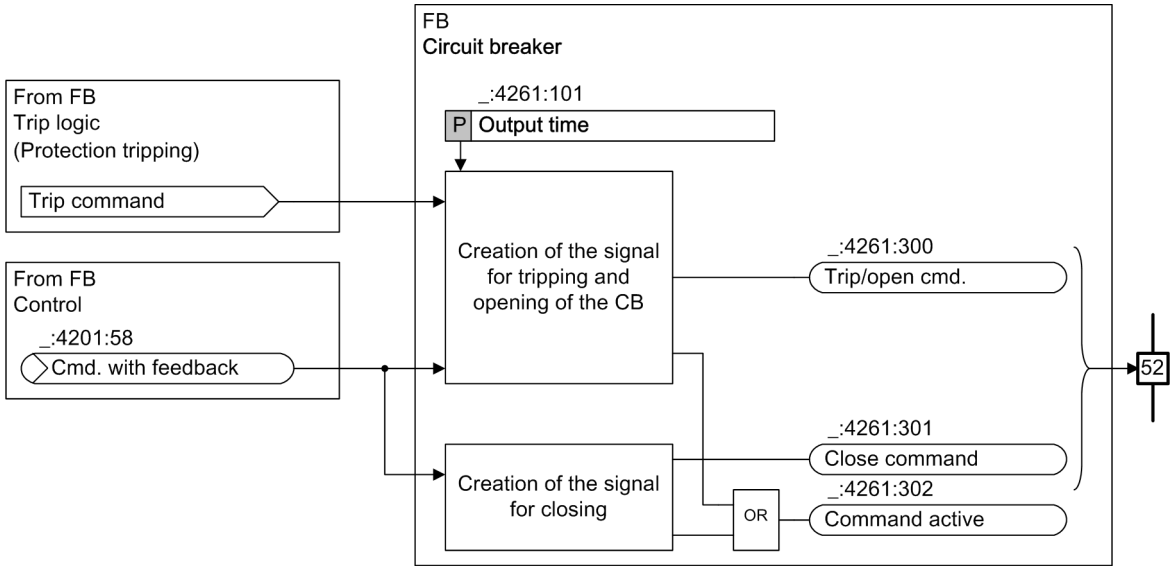
- Number of switching cycles
- Breaking voltage and breaking frequency

5.10.6.2 Tripping, Opening, and Closing the Circuit Breaker

The circuit breaker is operated in the following situations:

- Tripping of the circuit breaker as a result of a protection trip command
- Opening of the circuit breaker as a result of control operations
- Closing of the circuit breaker as a result of control operations

Tripping is always the result of a protection function. The operate indications of the individual protection functions are summarized in the **Trip logic** function block. The trip command that causes the tripping in the function block **Circuit breaker** is generated there.
To operate the circuit breaker, the **Circuit-breaker** function block provides the output signals that must be routed to the corresponding binary outputs of the device (see *Table 5-19*).



[lo_CB_tripping-opening-closing, 1, en_US]

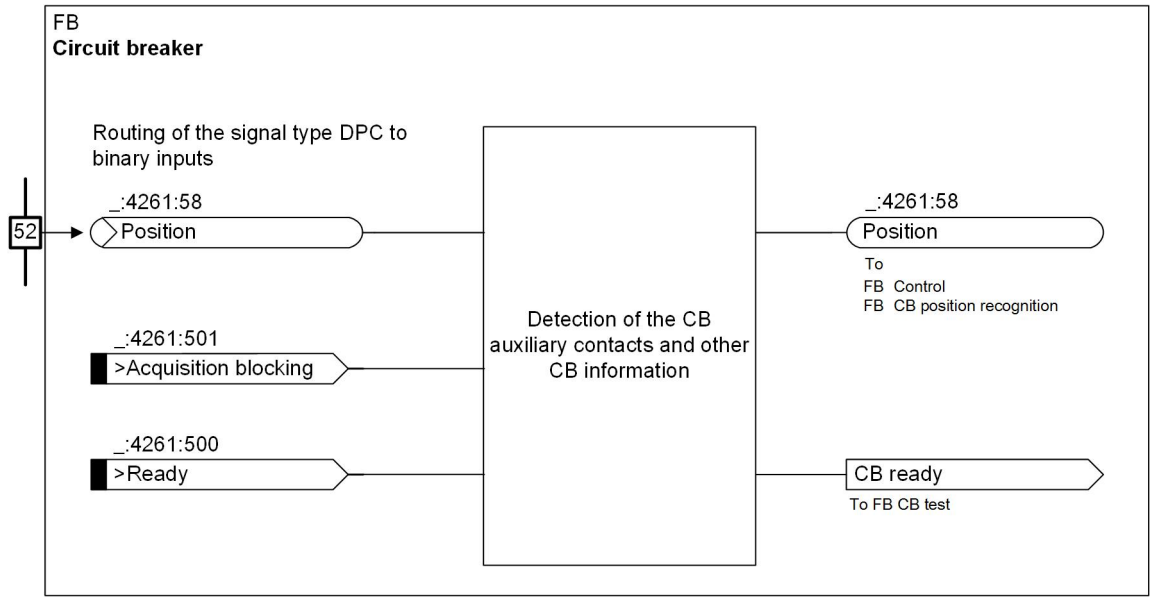
Figure 5-88 Tripping, Opening, and Closing the Circuit Breaker

Table 5-20 Description of the Output Signals

Signal	Description	Routing Options
Trip/open cmd.	This signal executes all tripping and opening operations. The **Output time** parameter affects the signal. The signal is pending for the duration of the output time, with the following exceptions: • **Only when switched off by the control:** The signal is reset before expiration of the period if the auxiliary contacts report that the circuit breaker is open before expiration of the period. • **Only in the event of protection tripping:** – The signal remains active as long as the trip command is still active after expiration of the period (see also *5.9.6.1 Function Description*). If the trip signal is no longer active and the auxiliary contacts report that the circuit breaker is open before expiration of the period, the signal is canceled before expiration of the period. – With the routing option **Only saved in the event of tripping**, the signal remains pending until it is acknowledged manually. This only applies for protection tripping.	• Unlatched • Only saved in the event of protection tripping (not when opened)
Close command	This signal executes all closing operations. The **Output time** parameter affects the signal. The signal is pending for the duration of the output time, with the following exception: The signal is canceled before expiration of the period if the auxiliary contacts report that the circuit breaker is closed before expiration of the period.	Normal routing
Command active	This signal is active if one of the following binary outputs is active: • **Trip/open cmd.** • **Close command** The binary outputs are active as long as a switching command is being executed by the control.	Normal routing

5.10.6.3 Detection of Circuit-Breaker Auxiliary Contacts and Further Information

To determine the circuit-breaker position, the function block **Circuit breaker** provides position signals. These signals are of the **Double-point indication** (DPC) type. A double-point indication can be routed to 2 binary inputs so that the open and closed circuit-breaker switch positions can be reliably acquired.



[lo_erfass_4CB_withoout_1, 1, en_US]

Figure 5-89 Acquisition of the Circuit-Breaker Information

Signal	Type	Description
Position	DPC	Acquisition of the circuit-breaker switch position The switch position CB 3-pole **open** and/or the position CB 3-pole **closed** can be detected by routing to 1 or 2 binary inputs.

The signals must be routed to the binary input that is with the CB auxiliary contacts. The **open** and **closed** signals do not necessarily have to be routed in parallel. The advantage of parallel routing is that it can be used to determine an intermediate or disturbed position. If you route only one signal (**open** or **closed**), you cannot determine an intermediate position or a disturbed position.

In the monitoring direction, the position signals generate the following information when the **open** and **closed** positions are detected (see following table). This information is further processed by the **Circuit-breaker position recognition** and **Control** function blocks.

Information	Type	Description
Open	SPS	The circuit-breaker switch position is **opened**.
Closed	SPS	The circuit-breaker switch position is **closed**.
Intermediate position	SPS	The circuit-breaker switch position is in the **intermediate position**. The signal **open** and the signal **closed** have not been set.
Disturbed position	SPS	The circuit-breaker switch position is in the **disturbed position**. The signal **open** and the signal **closed** have been set simultaneously.
Not selected	SPS	The circuit breaker is **not selected** for a control operation.

The following table shows the additional input signals:

Signal	Type	Description
>Acquisition blocking	SPS	This is used to activate acquisition blocking of the circuit-breaker auxiliary contacts (see *Other Functions 3.9.3 Persistent Commands* for a description of acquisition blocking).
>Reset AcqBlk&Subst	SPS	This is used to reset acquisition blocking and manual update of the circuit breaker. If the signal is active, acquisition blocking and manual update are reset.
>Ready	SPS	The active signal indicates that the circuit breaker is ready for an **Open-Closed-Open** cycle. The signal remains active as long as the circuit breaker is unable to trip. The signal is used in the **Circuit-breaker test** function.

The following table shows one additional output signal:

Signal	Type	Description
External health	ENS	This can be used to indicate the health of the physical circuit breaker. For this, all failure information of the circuit breaker must be detected via a binary input. This failure information can set the appropriate state of the **External health** signal with a CFC chart (using the **BUILD_ENS** block). The signal has no effect on the health of the function block.

5.10.6.4 Circuit-Breaker Tripping Alarm Suppression

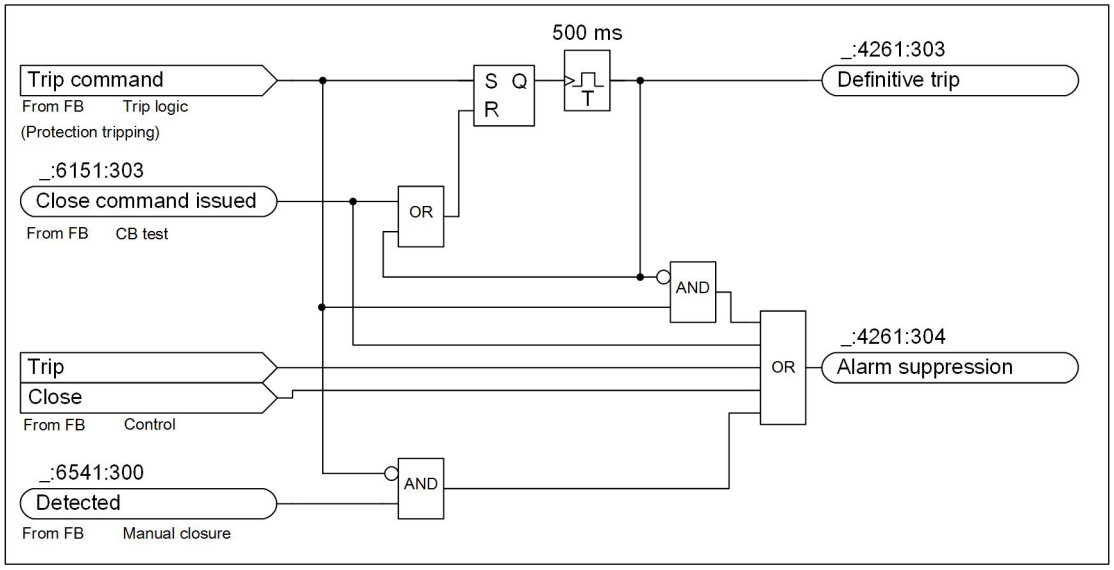
Circuit-Breaker Tripping Alarm Suppression

In certain systems, you possibly want to actuate an alarm (for example, a horn) when tripping (circuit-breaker tripping) occurs. This alarm should not to be issued if the control is used to switch on or off. The alarm is only to be issued in the event of final tripping.

Depending on how the alarm is generated (for example, triggered by a fleeting contact of the circuit breaker), the *Alarm suppression* signal can be used to suppress the alarm.

If one of the following conditions is met, the *Alarm suppression* signal is generated:

- The definitive protection tripping is not present.
- A close command is issued via the **Circuit-breaker test** function.
- The integrated control executes a closure or opening action.
- External closing is detected via the **Manual close** function.

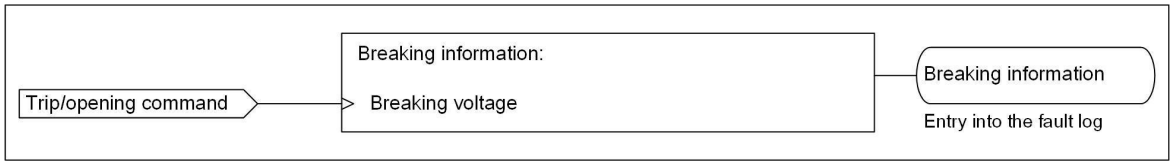


[lo_unterd_4CB_without_I, 2, en_US]

Figure 5-90 Definitive Tripping and Circuit-Breaker Tripping Alarm Suppression

5.10.6.5 Tripping and Opening Information

When a trip or opening command is issued, the breaking information shown in the next figure is saved in the fault log.

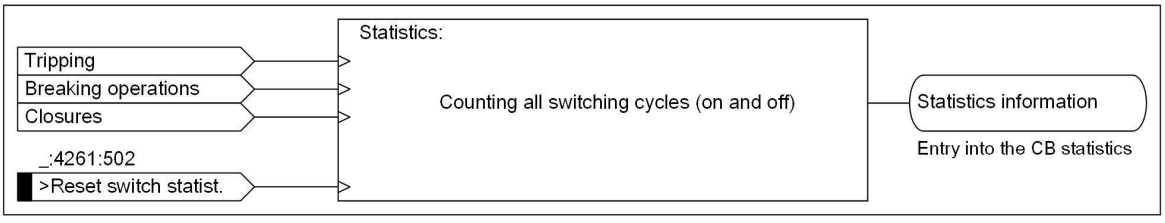


[lo_ausloe_4CB_without_I, 1, en_US]

Figure 5-91 Breaking Information

The number of switching cycles is saved for the circuit breaker as the statistics information. All tripping, opening, and closing operations are counted.

The statistics information can be individually set and reset via the device control. It is also possible to reset all values via the binary input signal **>Reset switch statist.**.



[lo_statistics information CB_4CB_without_I, 1, en_US]

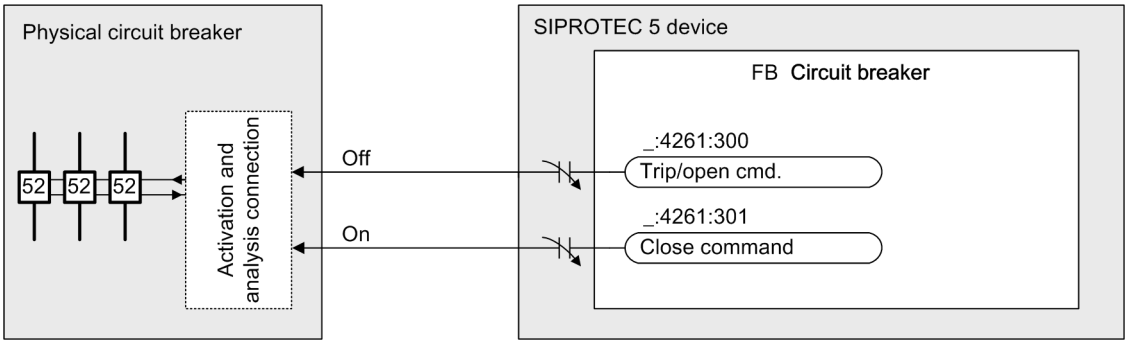
Figure 5-92 Statistics Information about the Circuit Breaker

5.10.6.6 Application and Setting Notes

Routings for Activation of the Circuit Breaker

Figure 5-93 shows the necessary routings for the device:

- 3-pole tripping via the protection
- 3-pole opening via the control



[lo_ansteu, 2, en_US]

Figure 5-93 Activation of the Circuit Breaker

By routing the **`Trip/open cmd.`** signals to 1 or 2 binary outputs, you can carry out 1-pole, 1.5-pole, and 2-pole activations of the circuit breaker. You can find a detailed description of this in chapter *7.2.2.3 Connection Variants of the Circuit Breaker*.

NOTE

Do not confuse these 1-pole, 1.5-pole, and 2-pole activations of the circuit breaker with 1-pole or 3-pole tripping of the circuit breaker.

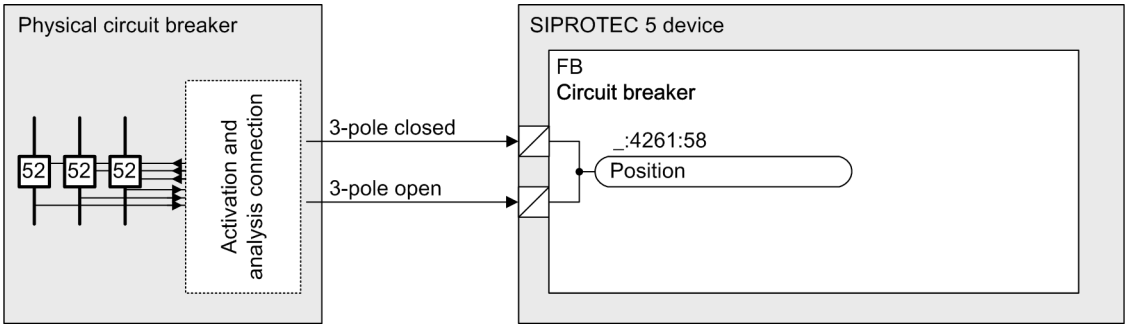
Routing for Analysis of the Circuit-Breaker Switch Position

For certain functions of the device, it is useful to detect the circuit-breaker switch position via its auxiliary contacts. The following shows a number of examples:

- Function block **Circuit-breaker position recognition**
- Function block **Control**

The operating principle of the auxiliary contacts is described in the individual functions.

Siemens recommends detecting the *`Circuit breaker is open in 3 poles`* and *`Circuit breaker is closed in 3 poles`* information via auxiliary contacts. This is the optimal configuration for the control functionality. For purely protection applications, it is also sufficient to detect just one of the 2 circuit-breaker switch positions. When used as a protection and control device, Siemens recommends the following analysis of the circuit-breaker switch position:



[lo_evaluation2, 1, en_US]

Figure 5-94 Recommended Analysis of the Circuit-Breaker Switch Position

The following figure shows the recommended routing, in which **OH** stands for **active with voltage**.

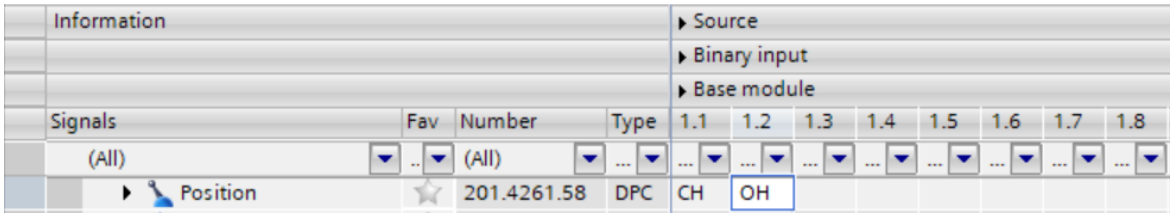


Figure 5-95 Routing for Acquisition of the Circuit-Breaker Switch Position via 2 Auxiliary Contacts

The device can also function without the analysis from the circuit-breaker auxiliary contacts, that is, routing of the auxiliary contacts is not absolutely necessary. However, this is a requirement for the control functions.

Parameter: Output Time

- Default setting **(_:101) Output time** = ***0.10 s***

The **Output time** parameter acts on the signals for tripping, opening, and closing of the circuit breaker.

CAUTION

Do not set a time that is too short.

If you set a time that is too short, there is a danger that the device contacts will interrupt the control circuit. If this happens, the device contacts will burn out.

✧ Set a time that is long enough to ensure that the circuit breaker reliably reaches its final position (**open** or **closed**) after a control operation.

Parameter: Indicat. of breaking values

- Default setting **(_:105) Indicat. of breaking values** = ***always***

With the parameter **Indicat. of breaking values**, you specify whether the measured values are to be reported if the circuit breaker is opened via the control function.

Parameter Value	Description
always	With this setting, the measured values are reported if the circuit breaker is opened either via the control function or via the trip command of a protection function.
with trip	With this setting, the measured values are only reported if the circuit breaker is opened via the trip command of a protection function.

Measured Values

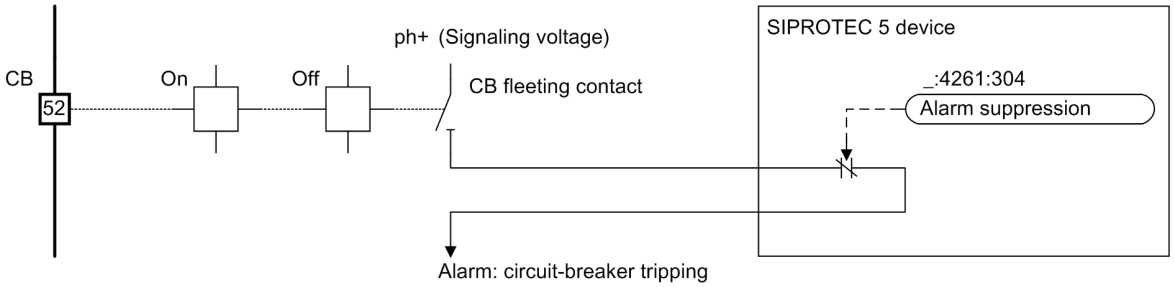
When a protection function opens the circuit breaker, the following measured values can be stored in the fault log:

- *Break. voltage phs A*
- *Break. voltage phs B*
- *Break. voltage phs C*

Output Signal: Indication Suppression

For this, the alarm activation circuit should be looped via a suitably routed output contact of the device (output signal **Alarm suppression**). In the idle state and when the device is switched off, this contact is always closed. For this, an output contact with a break contact must be routed. The contact opens whenever the output signal **Alarm suppression** becomes active, so that tripping or a switching operation does not cause an alarm.

You can find more detailed information in the logic in *5.9.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information*.



[lo_schalt, 2, en_US]

Figure 5-96 Circuit-Breaker Tripping Alarm Suppression

5.10.6.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Circuit break.				
_:101	Circuit break.:Output time		0.02 s to 1800.00 s	0.10 s
_:105	Circuit break.:Indicat. of breaking values		• with trip • always	always

5.10.6.8 Information List

No.	Information	Data Class (Type)	Type
Circuit break.			
_:500	Circuit break.:>Ready	SPS	I
_:501	Circuit break.:>Acquisition blocking	SPS	I
_:502	Circuit break.:>Reset switch statist.	SPS	I
_:504	Circuit break.:>Reset AcqBlk&Subst	SPS	I
_:503	Circuit break.:External health	ENS	I
_:53	Circuit break.:Health	ENS	O
_:58	Circuit break.:Position	DPC	C
_:300	Circuit break.:Trip/open cmd.	SPS	O
_:301	Circuit break.:Close command	SPS	O
_:302	Circuit break.:Command active	SPS	O
_:303	Circuit break.:Definitive trip	SPS	O
_:304	Circuit break.:Alarm suppression	SPS	O
_:306	Circuit break.:Op.ct.	INS	O
_:314	Circuit break.:Break. voltage phs A	MV	O
_:315	Circuit break.:Break. voltage phs B	MV	O
_:316	Circuit break.:Break. voltage phs C	MV	O
_:322	Circuit break.:CB open hours	INS	O

5.10.7 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions

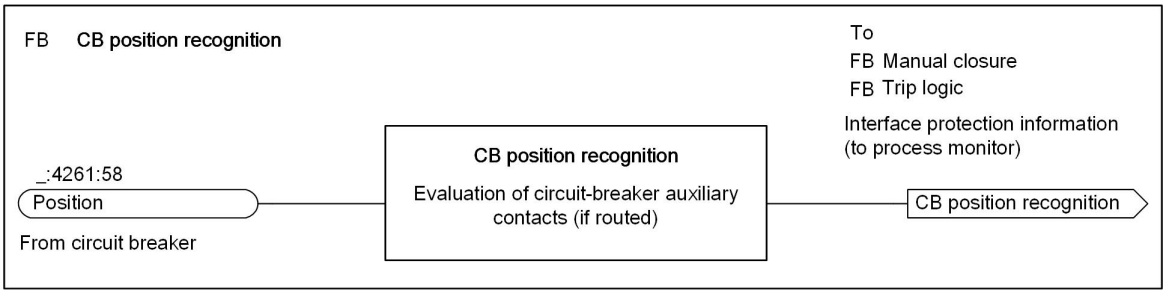
5.10.7.1 Overview

This function block calculates the position of the circuit breaker from the evaluation of the auxiliary contacts.

This information is needed in the following protection-related additional functions:

- Trip logic (see *5.10.5.1 Function Description*)
- Detection of manual closing (see *5.10.8.1 Function Description*)
- Process monitor (Standard V/I) (see *5.14 Process Monitor*)

The specified chapters describe the way the protection-related additional functions are processing the information of this function block.
The control does not use this information. The control evaluates the circuit-breaker auxiliary contacts.



[lo_zust3p_4CB_without_I, 1, en_US]

Figure 5-97 Overview of the Circuit-Breaker Position Recognition

Based on the link between the information from the auxiliary contacts, shown in *Figure 5-81*, the circuit breaker can assume the following positions. The following table shows the possible circuit-breaker positions:

Circuit-Breaker Position	Description
Open	The circuit-breaker pole is detected unambiguously as ***open*** according to both criteria.
Closed	The circuit-breaker pole is detected unambiguously as ***closed*** according to both criteria.
Possibly open	This condition occurs if the information is incomplete due to the routing of the auxiliary contacts and the condition can no longer be determined reliably. This uncertain condition is evaluated differently by certain functions.

5.10.8 Detection Manual Closure (for Processor Monitor)

5.10.8.1 Function Description

Detection of Manual Closure (for Process Monitor)

The **Manual closure** function block detects any closure carried out by hand. This information is used in the **Process monitor** functions (within protection function groups).
The following figure shows the logic for manual closure detection.

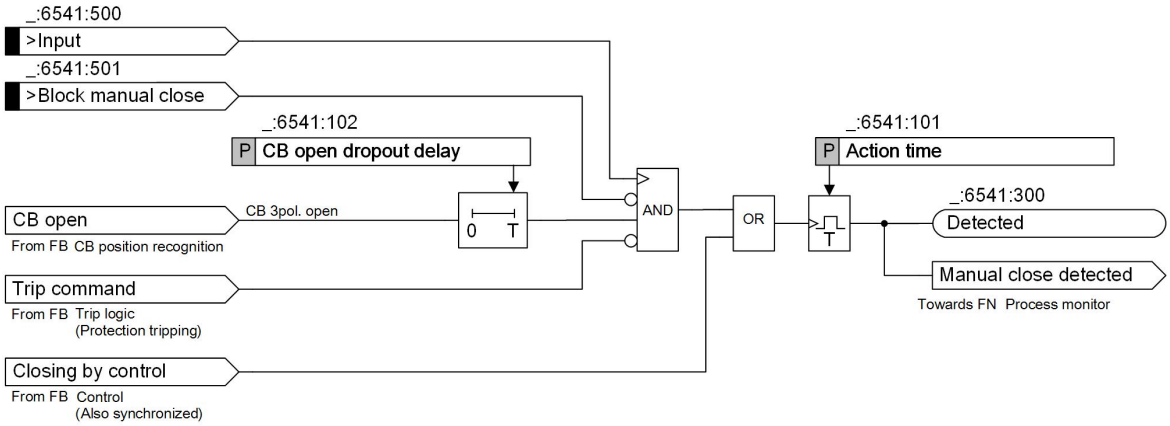


Figure 5-98 Logic for Manual Closure Detection

External Manual Closure

An external manual closure is communicated to the device via the input signal **>Input**. The input signal can also be connected directly to the control circuit of the circuit-breaker closing coil. Detection via the input signal **>Input** is also blocked if the circuit breaker is closed or if a protection trip is active.

Internal Manual Closure

Manual closure is detected in all cases if a close command is transmitted by the internal control function of the device. This is possible because the control carries out plausibility checks itself and is also subject to interlocking.

5.10.8.2 Application and Setting Notes

Input Signals: >Input, >Blocking of Manual Closure

In practice, the input signal **>Input** is connected directly to the control circuit of the circuit-breaker closing coil (see following figure).

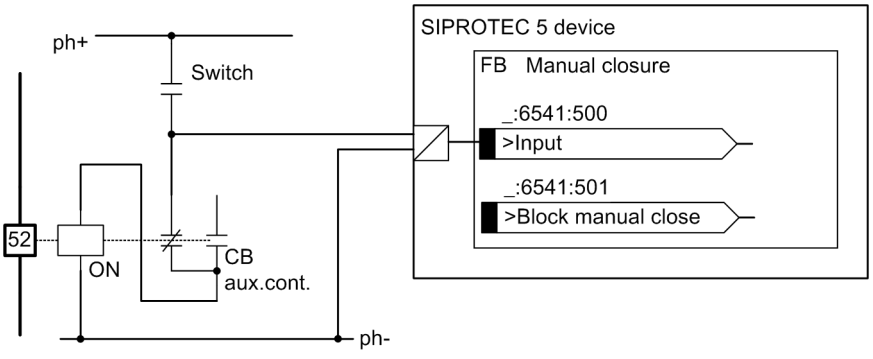


Figure 5-99 Connection of the Input Signal to the Control Circuit of the Circuit-Breaker Closing Coil

Every closure of the circuit breaker is recorded in the process.

If external close commands are possible (actuation of the circuit breaker by other devices), which are not intended to promptly detect a manual closure, this can be ensured in 2 ways:

- The input signal is connected in such a way that it is not activated in the event of external close commands.
- The external close command is connected to the blocking input **>Block manual close** for manual closure detection.

Parameter: Action time

- Recommended setting value **(_:101) Action time** = ***0.30 s***

In order to ensure independence from manual activation of the input signal, the detection function is extended for a defined length of time using the parameter **Action time**.

Siemens recommends an action time of ***0.30 s***.

Parameter: CB open dropout delay

- Default setting **(_:102) CB open dropout delay** = ***0.00 s***

With the **CB open dropout delay** parameter, you can maintain the effectiveness of internal indication *CB open* for the set time. If the input signal **>Input** becomes active after external delayed manual closure, the indication *(_:300) Detected* is output as long as the dropout delay is effective.

5.10.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Manual close				
_:101	Manual close:Action time		0.01 s to 60.00 s	0.30 s
_:102	Manual close:CB open dropout delay		0.00 s to 60.00 s	0.00 s

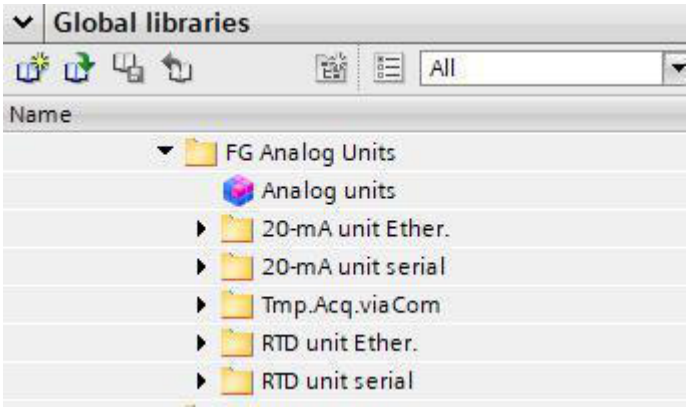
5.10.8.4 Information List

No.	Information	Data Class (Type)	Type
Manual close			
_:6541:501	Manual close:>Block manual close	SPS	I
_:6541:500	Manual close:>Input	SPS	I
_:6541:300	Manual close:Detected	SPS	O
_:6541:52	Manual close:Behavior	ENS	O
_:6541:53	Manual close:Health	ENS	O

5.11 Function-Group Type Analog Units

5.11.1 Overview

The function group **Analog units** is used to map analog units and communicate with them. Analog units are external devices, such as RTD units, or analog plug-in modules or measuring-transducer modules.
You can find the function group **Analog units** for many device types in the Global DIGSI 5 library.

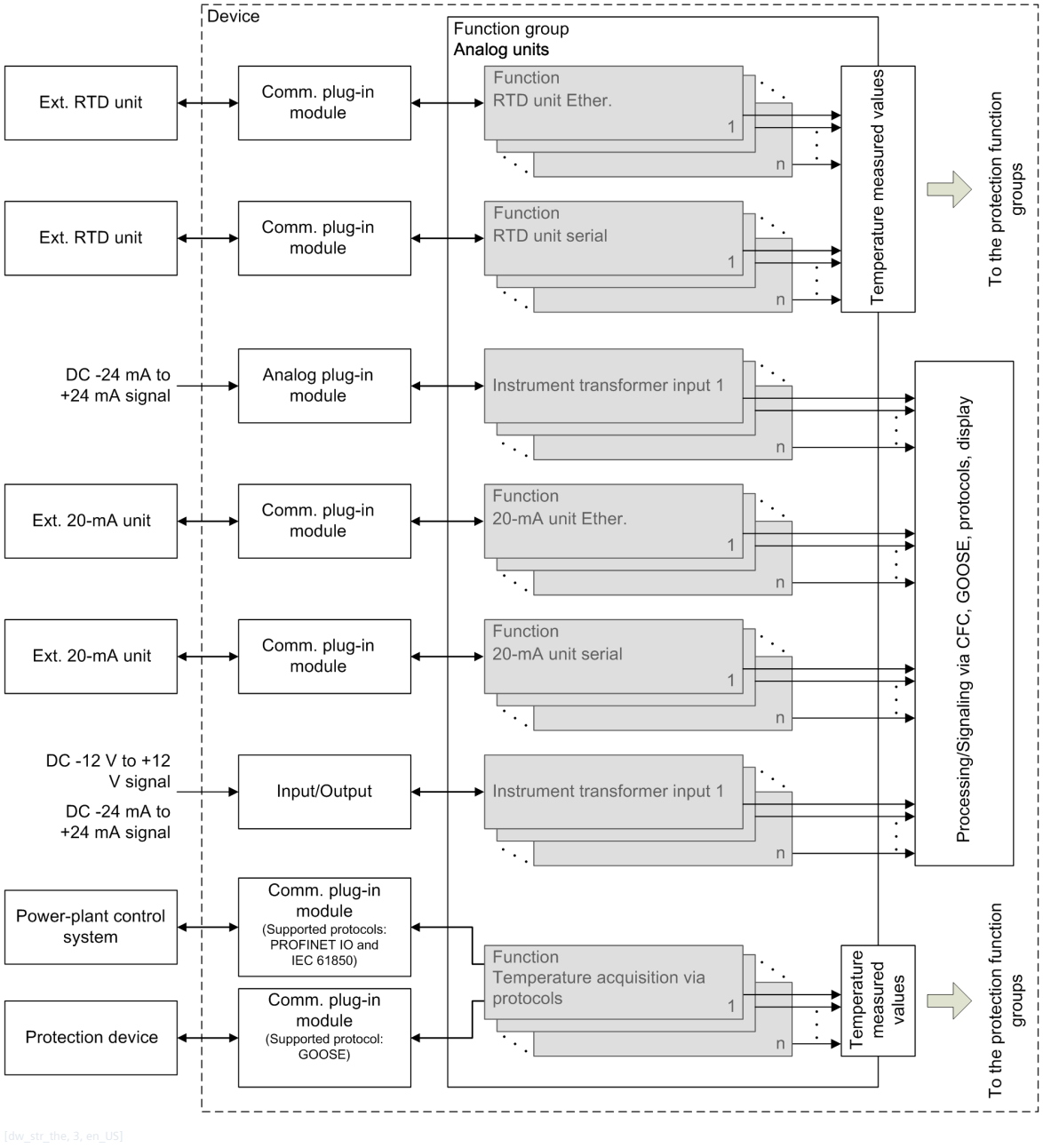


[sc_20_maee, 3, en_US]

Figure 5-100 Analog Unit Function Group in DIGSI

5.11.2 Structure of the Function Group

If the device has a measuring transducer, it is automatically mapped in the function group **Analog units**. If one or more RTD units are connected to the device, you have to load one or more **RTD unit Ether.** or **RTD unit serial** functions from the Global DIGSI 5 library in order to map the RTD units.
If the device is connected to a power-plant control system or another protection device, you must load one or more **Temperature acquisition via protocols** functions from the Global DIGSI 5 library to form the protocols.
The following figure shows the structure of the function group.



[dw_str_the, 3, en_US]

Figure 5-101 Structure of the Function Group Analog Unit

Gray: Optionally wired, optionally available
White: Always wired, always available

The function group **Analog units** has interfaces to protection function groups. The function group **Analog units** provides, for example, measured temperature values that come from an external RTD unit , a measuring transducer or via protocols. These measured temperature values are available for all protection function groups in which a temperature monitoring function works.

The function **RTD unit Ether.** is not preconfigured by the manufacturer. A maximum of 20 function instances can operate simultaneously.

The structure of the function **RTD unit serial** is identical to the structure of the function **RTD unit Ether.**.

The function **20-mA unit Ether.** is not preconfigured by the manufacturer. A maximum of 4 function instances can operate simultaneously. The structure of the function **20 mA serial unit** is identical to the structure of the function **20-mA unit Ether.**.

The function **Temperature acquisition via protocols** has 2 stage types: The **Temperature acquisition via PROFINET IO or IEC 61850** and the **Temperature acquisition via GOOSE**. One instance of the **Temperature acquisition via PROFINET IO or IEC 61850** is preconfigured by the manufacturer. A maximum of 12 instances can operate simultaneously for both stage types.

5.11.3 20-mA Unit Ethernet

5.11.3.1 Overview

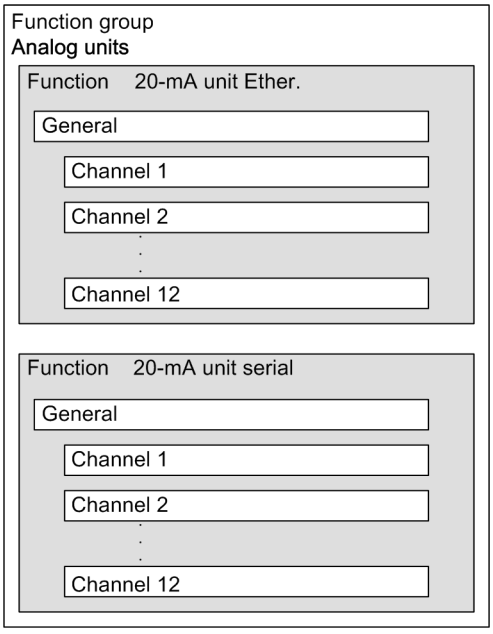
The function **20-mA unit Ether.**:

- Communicates in series with a 20-mA unit via the Slave Unit Protocol (SUP) and records the values measured by the 20-mA unit
- Transforms the measured 20-mA values into slowly changing process tags such as temperature or gas pressure
- Makes the recorded process tags available to CFC, GOOSE, protocols and the device display
- Monitors communication with the 20-mA unit

5.11.3.2 Structure of the Function

The function **20-mA unit Ether.** can only work in the function group **Analog units**. A maximum of 4 function instances can work simultaneously. Each instance contains 12 preconfigured channel function blocks.

The function **20-mA unit Ether.** contains input and output channels which can be configured independently of one another.

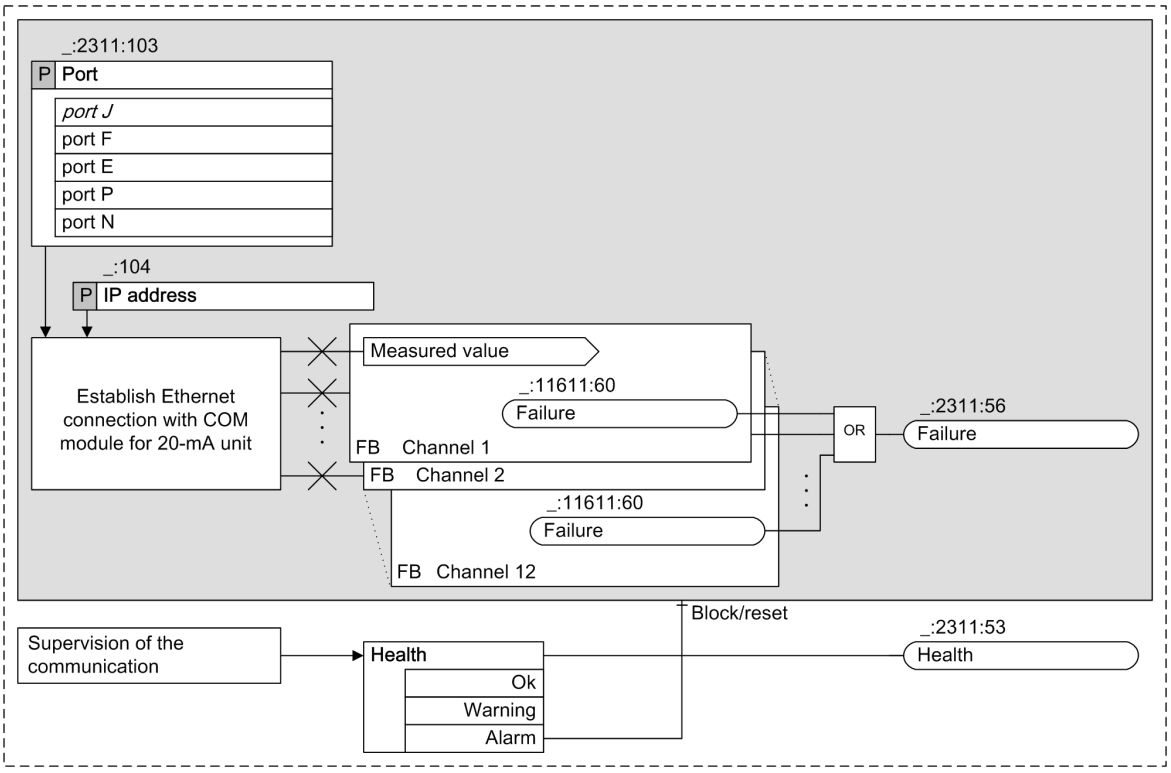


[dw_str_fn2, 2, en_US]

Figure 5-102 Structure/Embedding of the Function

5.11.3.3 Communication with 20-mA Unit Ethernet

Logic



[lo_20mtcp_1, en_US]

Figure 5-103 Logic of the Function 20-mA Unit Ethernet

Communication with 20-mA Unit

The function is used to communicate with a 20-mA unit connected via an Ethernet connection. When a connection of the function to an external 20-mA unit via an Ethernet interface has successfully been established, the 20-mA unit sends the measured values of all connected channels to the function **20-mA unit. Ether.**. For the connection to be established successfully, specific communication settings must be specified.

You can find more detailed information in *5.11.3.4 Application and Setting Notes*.

The 20-mA measuring unit **7XV5674** is supported.

Error Responses

The following table lists the conditions under which the status *Health* transitions to the Alarm or Warning state.

Table 5-21 Error Responses

Error Description	Status Health
The function **20-mA unit Ether.** cannot establish a connection witha communication module.	Alarm
The function **20-mA unit Ether.** sends TCP settings to the communication module, which evidently would like to connect to the 20-mA unit via a serial protocol. This communication module does not establish a connection to the 20-mA unit.	Alarm

Error Description	Status Health
The connection between the communication module and the 20-mA unit causes a time-out indication.	Warning
A communication module has not received any more data from the 20-mA unit for 9 sec.	Warning

The signal *Failure* is issued as soon as one of the channel function blocks reports a failure.

5.11.3.4 Application and Setting Notes

Parameter: Port

- Default setting **(_:2311:103) Port** = ***port J***

With the parameter **Port**, you define the port connecting the 20-mA unit to the SIPROTEC 5 device.

Parameter: IP address

- Default setting **(_:2311:104) IP address** = ***10.16.60.1***

With the parameter **IP address**, you set the IP address of the 20-mA unit connected to the communication module via the TCP protocol. You must assign each 20-mA unit an unambiguous IP address. The IP address to be set depends on your network configuration. You can set any valid IPv4 address that does not cause conflicts with other IP addresses in the network. First set an IP address for the **7XV5674 20-mA unit**. Then specify the parameter **IP address** for the communication module to the same address.

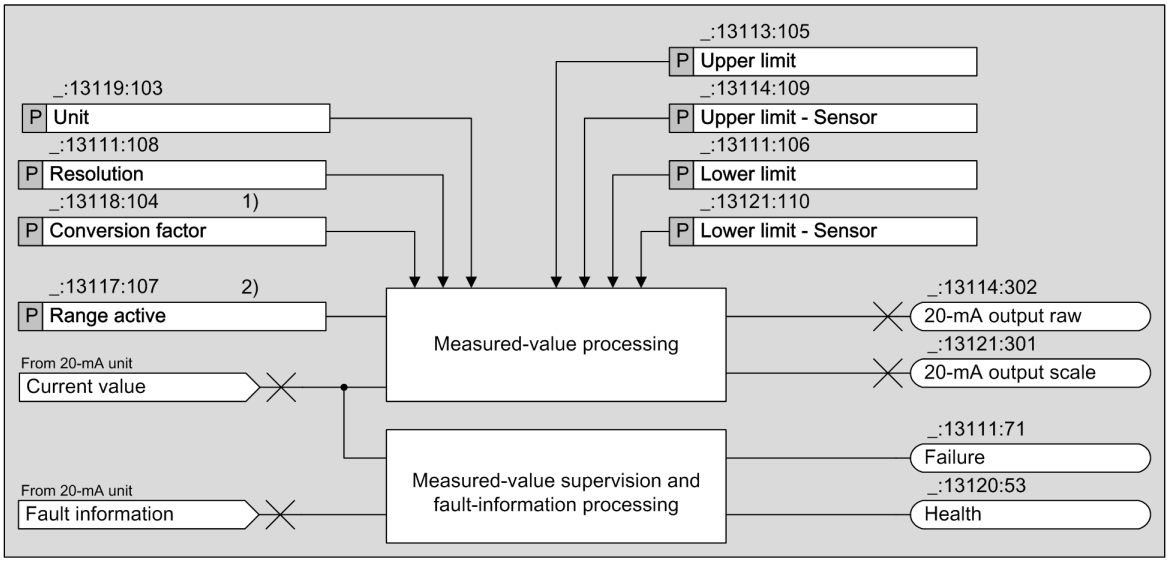
Settings on the 20-mA Unit

Set the **7XV5674 20-mA unit** with a Web browser on the laptop computer via the latter's Ethernet interface. Set ***Modbus TCP*** as a bus protocol/operating mode.

You can find detailed notes on the settings in the 7XV5674 manual that accompanies the 20-mA unit. The documents are also available in the SIPROTEC download area (*www.support.industry.siemens.com*).

5.11.3.5 20-mA Channel

Logic



[lo_20mcha, 1, en_US]

Figure 5-104 Logic Diagram of the Function 20-mA Channel

(1) If the setting **Range active** is set to ***test***, the setting **Transformation ratio** is not displayed.

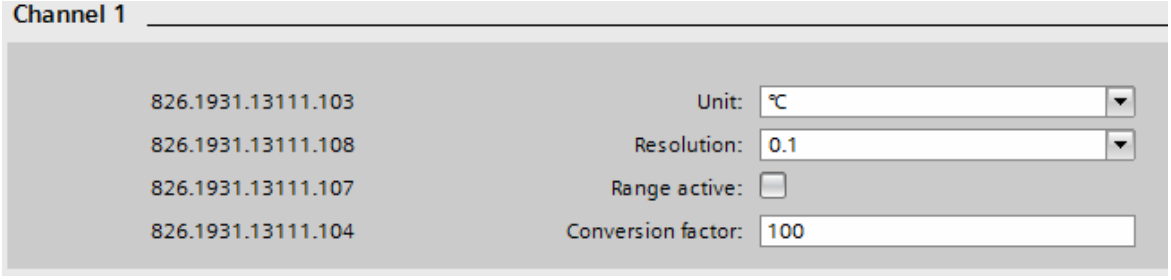
(2) If the setting **Range active** is set to ***false***, the settings **Upper limit**, **Transformation ratio upper limit**, **Lower limit** and **Transformation ratio** are not displayed.

Measured-Value Calculation

The function **20-mA channel** processes a single 20-mA current signal supplied by the 20-mA unit of the corresponding channel. The 20-mA current measured value is converted into the correct physical quantities such as temperature or pressure. In each 20-mA functional unit (Ether. and serial) there are always 12 of the 20-mA channel function blocks, even if fewer channels are connected with the 20-mA unit. The calculated values are available for further processing via CFC, GOOSE, protocols, and the display image.

Measured-Value Processing

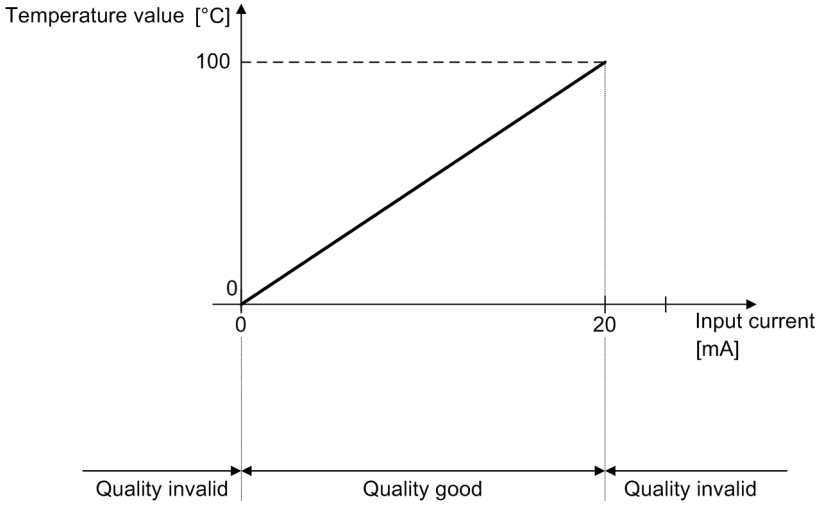
The 20-mA unit typically transmits a value which represents a physical quantity, such as a temperature or a pressure. Therefore, the device must contain a characteristic curve that maps the physical quantity to the 20-mA value. If you do not activate the **Range active** setting (no x in the check box), the function operates over the range 0 mA to 20 mA. If a value smaller than 0 mA or greater than 20 mA is active at the input of the 20-mA unit, the measured value is identified as invalid. The setting of the range for the scaled value goes from a usable range of 0 mA to 20 mA. The following figure shows an example.



[sckanumw-190214-01, 1, en_US]

Figure 5-105 Settings for Example 1

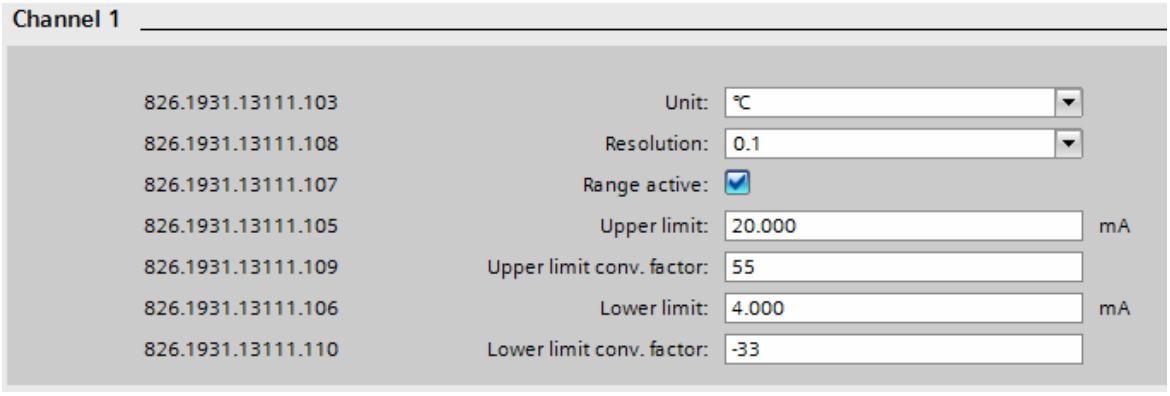
In this example, the measured value 0 mA means a temperature of 0 °C and the measured value 20 mA means a temperature of 100 °C. So enter as **Unit** = ***°C*** and **Conversion factor** = ***100***. The resolution (decimal place) of the temperature value can be chosen; for a decimal place, select **Resolution** = ***0.1***.



[dw_knges3, 1, en_US]

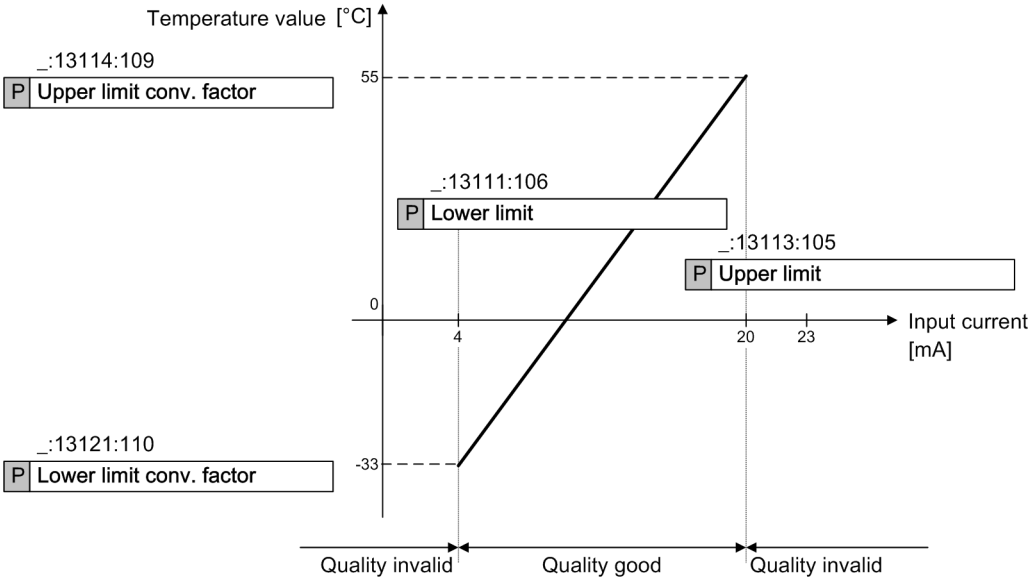
Figure 5-106 Characteristic Curve of a 20-mA Input (Example 1)

If you activate the **Range active** setting, then 4 additional parameters **Upper limit**, **Lower limit**, **Upper limit - Sensor**, and **Lower limit - Sensor** appear. The parameters **Upper limit** and **Lower limit** indicate the range of the input current in mA. The setting **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The setting **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting. The setting of the range for the scaled value corresponds to the useable range between **Lower limit** and **Upper limit** (see following figure).



[sckanumf-190214-01, 1, en_US]

Figure 5-107 Settings for Example 2



[dw_knges2, 1, en_US]

Figure 5-108 Characteristic Curve of a 20-mA Unit (Example 2)

In this example, the **Range active** setting is selected. The setting **Upper limit** is at 20 mA, the setting **Lower limit** is at 4 mA. The setting **Upper limit - Sensor** is at 55 and the setting **Lower limit - Sensor** is at -33. If the input current is smaller than 4 mA or greater than 20 mA, the quality of the scaled measured value in this example is invalid.

Each 20-mA channel makes available the scaled measured value in the information routing (these are the temperature values in the examples) and the original current measured value in mA for further processing.

The 20-mA values can be displayed in the display page and processed with CFC charts.

Error Responses

If the current input value is determined to be incorrect, the quality attribute of the output value is set to *invalid* That status for *Health* and the defect status assume the states displayed in the table.

Table 5-22 Error Responses

Error Description	Status *Health*	Error Status
The input value lies outside the given limits	OK	Yes
Channel not connected	OK	No

5.11.3.6 Application and Setting Notes

Parameter: Unit

- Default setting **(_:13111:103) Unit** = ***°C***

With the **Unit** parameter, you set the physical unit of measurement the measured values. The possible setting values are listed in the settings table.

Parameter: Conversion factor

- Default setting **(_:13111:104) Conversion factor** = ***100***

With the **Conversion factor** parameter, you set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting **(_:13111:108) Resolution** = ***0.1***

With the **Resolution** parameter, you set the resolution of the scaled values.

Parameter: Range active

- Default setting **(_:13111:107) Range active** = ***false***

If you do not activate the parameter **Range active** (no x in the check box), the function operates over the range 0 mA to 20 mA. The setting of the range for the scaled value goes from a usable range of 0 mA to 20 mA.

If you activate the parameter **Range active**, the 4 additional parameters **Upper limit**, **Upper limit - Sensor**, **Lower limit**, and **Lower limit - Sensor** appear.

Parameter: Upper limitLower limitUpper limit - Sensor and Lower limit - Sensor

- Default setting **(_:13111:105) Upper limit** = ***20.000 mA***
- Default setting **(_:13111:109) Upper limit - Sensor** = ***100***
- Default setting **(_:13111:106) Lower limit** = ***4.000 mA***
- Default setting **(_:13111:110) Lower limit - Sensor** = ***100***

If you activate the parameter **Range active** , the 4 additional parameters **Upper limit**, **Lower limit**, **Upper limit - Sensor**, and **Lower limit - Sensor** appear. The parameter **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The parameter **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting.

The following settings and information table shows only 1 of the 12 channels, as the setting possibilities of the 12 channels do not differ.

5.11.3.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port E • port F • port J • port N • port P	port J

Addr.	Parameter	C	Setting Options	Default Setting
Channel 1				
_:13111:103	Channel 1:Unit		• % • ° • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • in • J • J/Wh • K • l/s • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W	m

Addr.	Parameter	C	Setting Options	Default Setting
			• W/s • Wh	
_:13111:108	Channel 1:Resolution		• 1 • 0.1 • 0.01 • 0.001	0.1
_:13111:107	Channel 1:Range active		• 0 • 1	false
_:13111:104	Channel 1:Conversion factor		1 to 1000000	100
_:13111:105	Channel 1:Upper limit		0.00 mA to 20.00 mA	20.00 mA
_:13111:109	Channel 1:Upper limit - Sensor		-1000000 to 1000000	100
_:13111:106	Channel 1:Lower limit		0.00 mA to 20.00 mA	4.00 mA
_:13111:110	Channel 1:Lower limit - Sensor		-1000000 to 1000000	100

5.11.3.8 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Channel 1			
_:13111:50	Channel 1:Behavior	ENS	O
_:13111:53	Channel 1:Health	ENS	O
_:13111:71	Channel 1:Failure	SPS	O
_:13111:301	Channel 1:20-mA output scale	MV	O
_:13111:302	Channel 1:20-mA output raw	MV	O

5.11.4 20-mA Unit Serial

5.11.4.1 Overview

The function **20-mA unit Serial**:

- Provides serial communications with a 20-mA unit via the Modbus protocol and records the values measured by the 20-mA unit
- Transforms the measured 20-mA values into slowly changing process variables such as temperature or gas pressure
- Makes the recorded process tags available to CFC, GOOSE, protocols and the device display
- Monitors communication with the 20-mA unit

The function **20-mA unit Serial** is structured in the same way as the function **20-mA Unit Ether.**. The mode of operation is also identical. The only difference is that the measured values are transferred to the communication module via a serial connection instead of an Ethernet connection.

You can find more information in Chapter *5.11.3.2 Structure of the Function*.

5.11.4.2 Application and Setting Notes

Parameter: Port

- Default setting **(_:2311:103) Port** = ***Port J***

With the parameter **Port**, you specify the slot for the communication module that will be used for the connection with an external 20-mA unit.

Parameter: Channel number

- Default setting **(_:2311:105) Channel number** = ***1***

A serial communication module optionally uses 2 channels. With the parameter **Channel number**, you specify the channel number (1 or 2) used to connect the 20-mA unit to the device. The communication module inputs are labeled with the channel numbers.

Parameter: Slave address

- Default setting **(_:2311:106) Slave address** = ***1***

With the parameter **Slave address**, you define the device address of the 20-mA unit. If only one 20-mA unit is connected to the serial bus, the default value *1* can be used. Set the same device address as used with the 20-mA unit. The device address is important for distinguishing several 20-mA units that are connected to a serial bus. Set an unambiguous device address on every 20-mA unit, for example, 1, 2 and 3 when connecting 3 of the 20-mA units. On every 20-mA unit, set for the parameter **Slave address** in the 3 functions **20-mA Unit Serial**.

Parameter: Unit

- Default setting **(_:13111:103) Unit** = ***°C***

With the parameter **Unit**, you set the physical unit of measurement the measured values. The possible setting values are listed in the settings table.

Parameter: Conversion factor

- Default setting **(_:13111:104) Conversion factor** = ***100***

With the parameter **Conversion factor**, you set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting **(_:13111:108) Resolution** = ***0.1***

With the parameter **Resolution**, you set the resolution of the scaled values.

Parameter: Range active

- Default setting **(_:13111:107) Range active** = ***false***

If you do not activate the parameter **Range active** (no x in the check box), the function operates over the range 0 mA to 20 mA. The setting of the range for the scaled value goes from a usable range of 0 mA to 20 mA.
If you activate the parameter **Range active**, the 4 additional parameters **Upper limit**, **Upper limit - Sensor**, **Lower limit**, and **Lower limit - Sensor** appear.

Parameter: Upper limit, Lower limit, Upper limit - Sensor, and Lower limit - Sensor

- Default setting **(_:13111:105) Upper limit** = ***20 mA***
- Default setting **(_:13111:109) Upper limit - Sensor** = ***100***
- Default setting **(_:13111:106) Lower limit** = ***4 mA***
- Default setting **(_:13111:110) Lower limit - Sensor** = ***100***

If you activate the parameter **Range active**, the 4 additional parameters **Upper limit**, **Lower limit**, **Upper limit - Sensor**, and **Lower limit - Sensor** appear. The parameter **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The parameter **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting.

The following settings and information table shows only 1 of the 12 channels, as the setting possibilities of the 12 channels do not differ.

5.11.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port F • port E • port J • port N • port P	port J
_:2311:105	General:Channel number		1 to 2	1
_:2311:106	General:Slave address		1 to 247	1

Addr.	Parameter	C	Setting Options	Default Setting
Channel 1				
_:13111:103	Channel 1:Unit		• % • ° • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • in • J • J/Wh • K • l/s • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W	m

Addr.	Parameter	C	Setting Options	Default Setting
			• W/s • Wh	
_:13111:108	Channel 1:Resolution		• 1 • 0.1 • 0.01 • 0.001	0.1
_:13111:107	Channel 1:Range active		• 0 • 1	false
_:13111:104	Channel 1:Conversion factor		1 to 1000000	100
_:13111:105	Channel 1:Upper limit		0.00 mA to 20.00 mA	20.00 mA
_:13111:109	Channel 1:Upper limit - Sensor		-1000000 to 1000000	100
_:13111:106	Channel 1:Lower limit		0.00 mA to 20.00 mA	4.00 mA
_:13111:110	Channel 1:Lower limit - Sensor		-1000000 to 1000000	100

5.11.4.4 Information List

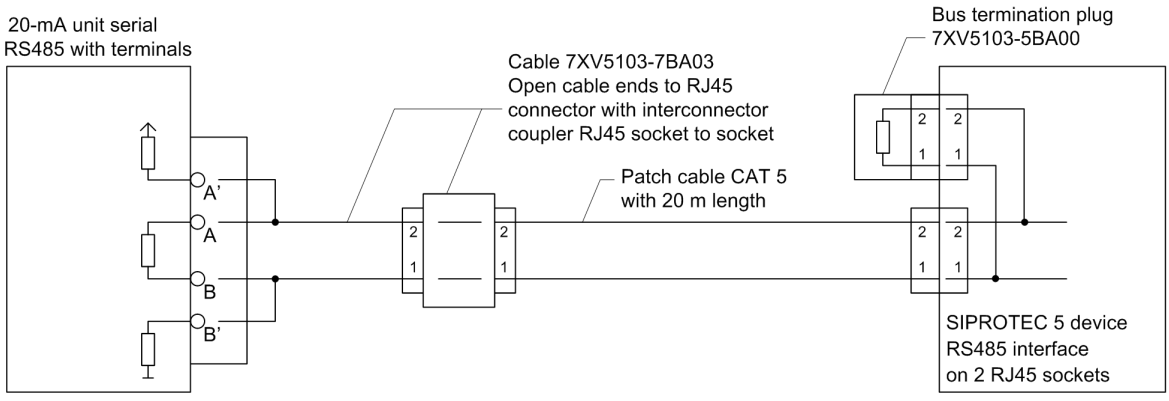
No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Channel 1			
_:13111:50	Channel 1:Behavior	ENS	O
_:13111:53	Channel 1:Health	ENS	O
_:13111:71	Channel 1:Failure	SPS	O
_:13111:301	Channel 1:20-mA output scale	MV	O
_:13111:302	Channel 1:20-mA output raw	MV	O

5.11.5 Communication with 20-mA Unit

5.11.5.1 Integration of a Serial 20-mA Unit

Connection of the Communication Lines

Figure 5-109 shows how to connect the 20-mA unit to the SIPROTEC 5 device. Note that Pin 1 of the RJ45 plug is connected to RTD-B and Pin 2 is connected to RTD-A.

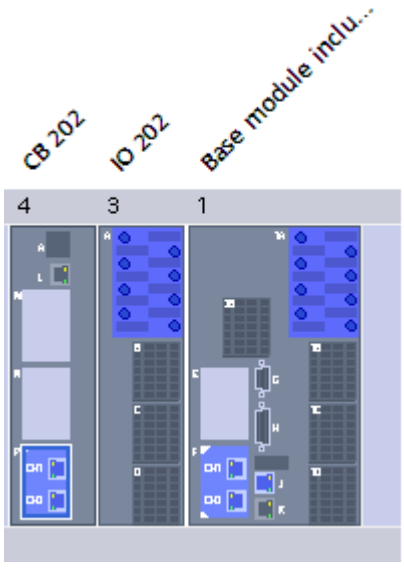


[dwve20au-150213-01.tif, 1, en_US]

Figure 5-109 Connection of the 20-mA Unit to the SIPROTEC 5 Device

Adding a USART Module

Add a USART-AB-1EL or a USART-AC-2EL USART module in DIGSI to the device. The USART module must be inserted at one of the plug-in positions for communication modules in the base module or in the CB202 expansion module (refer to the following figure).

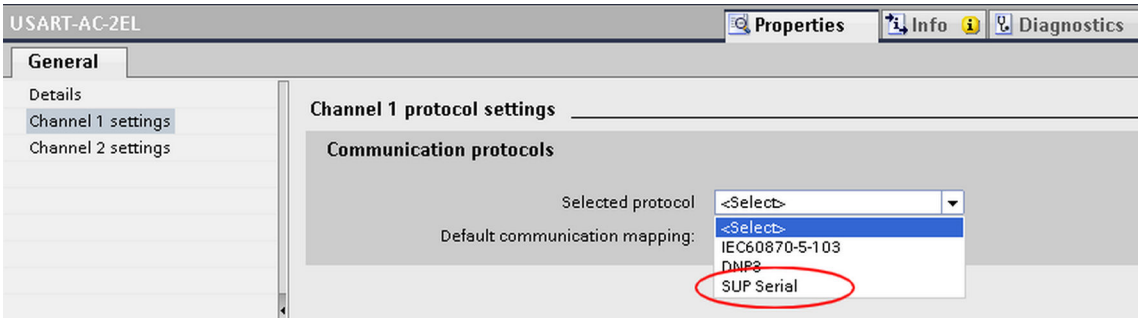


[sc20ser3-220114-01-DE, 1, en_US]

Figure 5-110 Insertion Position for a USART Module

Selecting the SUP Protocol

Select the Slave Unit Protocol (SUP). This protocol is responsible for the communication between the SIPROTEC 5 device and the 20-mA unit.



[scauser4-301012-01.tif, 1, en_US]

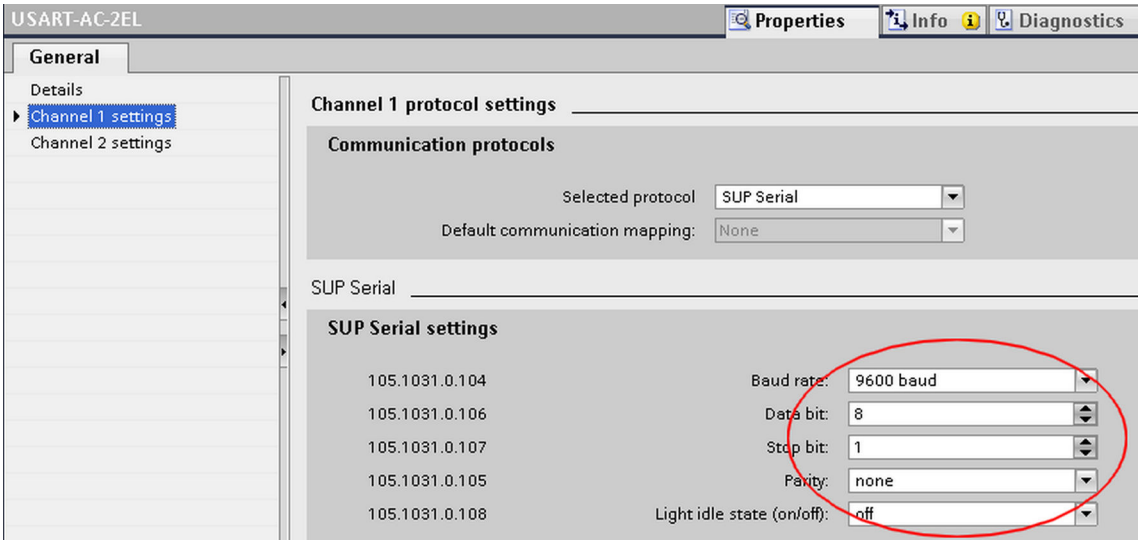
Figure 5-111 Selecting the SUP Protocol

Communication Settings

Make the communications settings for the relevant serial channels. For this, use the default settings specified by the 20-mA unit. Normally, you must adapt only the parameterization of the SIPROTEC 5 device to the settings of the 20-mA unit. Make sure that the setting values in both devices are the same. The setting of the parameter **`Non-flickering light (on/off)`:** is not relevant for the RS485 interface.

NOTE

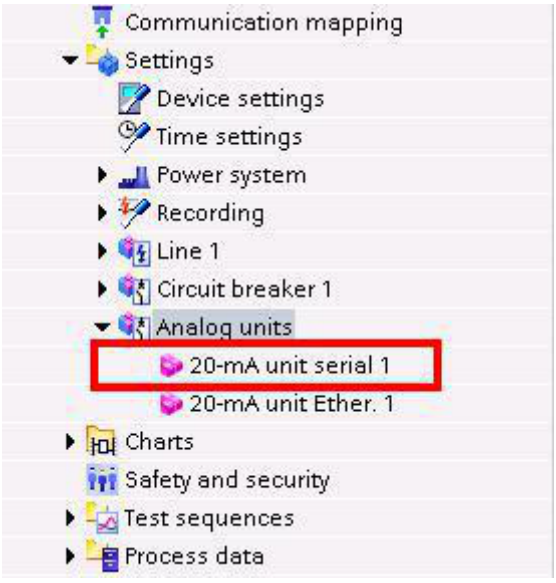
The driver for the USART module for the SUP protocol is not preinstalled as standard for the initial use of this interface (following the firmware update).



[scauser5-301012-01.tif, 1, en_US]

Figure 5-112 Making the Communication Settings

With the selection of the SUP protocol for the 20-mA unit DIGSI automatically adds the function group **Analog units** to your device configuration. You can now instantiate the function **20-mA unit serial 1** (see the following figure).



[sc20ser6-220114-01-DE, 1, en_US]

Figure 5-113 Insertion of the Function 20-mA Unit Serial 1

Now, set the channel number over which the SUP protocol runs. In addition, set the slave address of the 20-mA unit. This address must be set with the same value in the 20-mA unit (refer to the following figure).
For the first use of the 20-mA unit, the following device configuration must be set on the 20-mA unit:

- Bus protocol: mod
- Device address: 1
- Baud rate: 9600
- Parity: no



[scauser7-220114-01-DE, 1, en_US]

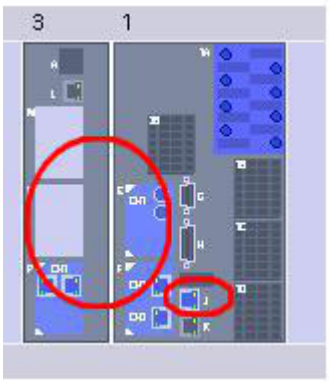
Figure 5-114 Setting the Port, Channel Number, and Device Address

Finally, load the configuration in the device.

5.11.5.2 Integration of a 20-mA Unit Ethernet

Device Configuration

In DIGSI, insert an Ethernet module into the provided slot, thus adding the module to the device configuration. *Figure 5-115* displays the available slots in the base module or on the expansion module CB202. Alternatively, you can also use the integrated Ethernet interface Port J.

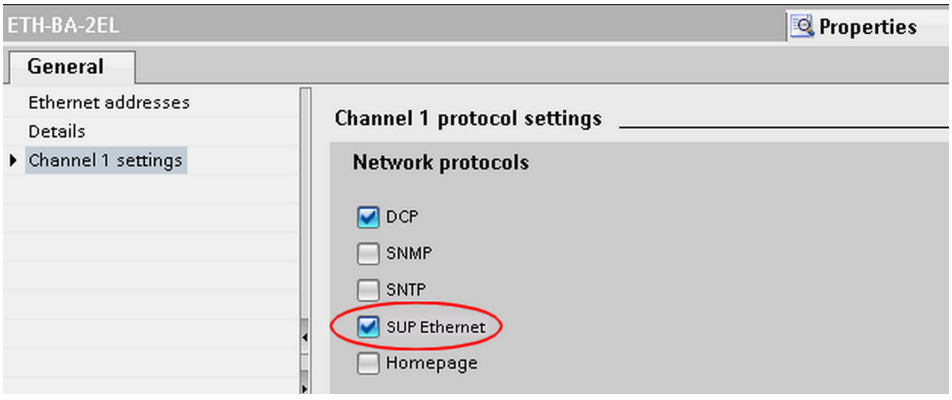


[sc_autcp1, 1, en_US]

Figure 5-115 Inserting an Ethernet Module

Communication Settings

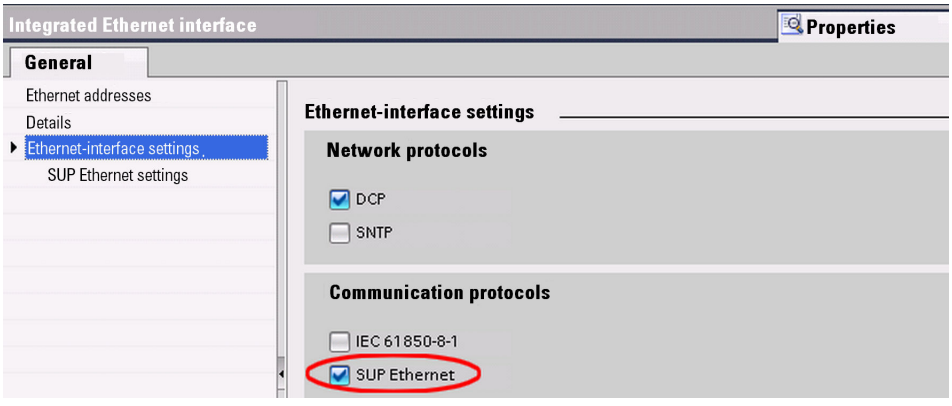
Activate the SUP Ethernet protocol for the Ethernet module.



[sc_autcp2, 1, en_US]

Figure 5-116 Activation of the Protocol

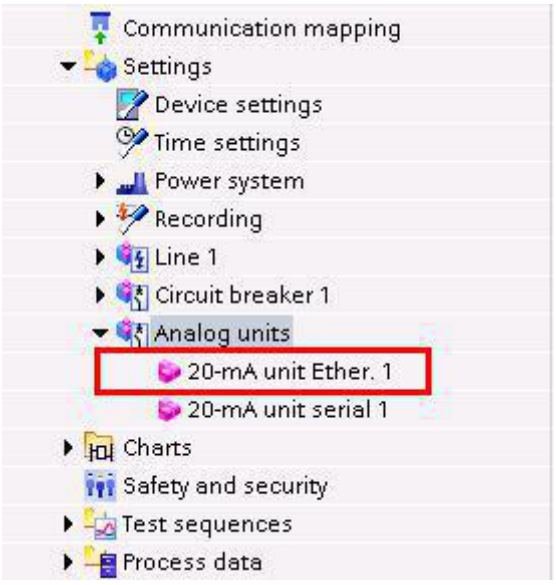
This protocol is also available for Port J of the integrated Ethernet interface of the base module (refer to following figure).



[sc_autcp3, 1, en_US]

Figure 5-117 Selection of the Protocol

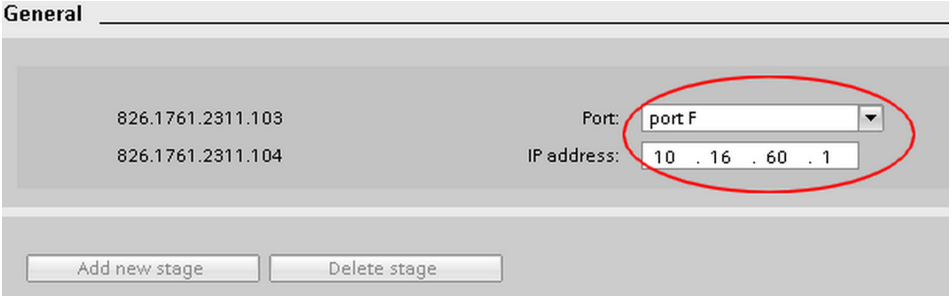
With the selection of the SUP protocol for the 20-mA unit, DIGSI automatically adds the **Analog units** function group and the **20-mA unit Ether. 1** function to your device configuration (refer to the following figure).



[sc_20tcp4, 1, en_US]

Figure 5-118 Insertion of the Function 20-mA Unit Ether. 1

Now, set the port over which the SUP protocol runs. In addition, set the IP address of the 20-mA unit (refer to the following figure). This address must be set with the same value in the 20-mA unit.



[sc_autcp5, 1, en_US]

Figure 5-119 Setting the Port and IP Address

Finally, load the configuration in the device.

5.11.6 V/I-Measuring-Transducer Unit with Fast Inputs

5.11.6.1 Overview

The fast analog measuring-transducer inputs process voltage values (DC -10 V to +10 V) as well as current values (DC -20 mA to 20 mA).

The function **MT fast input**:

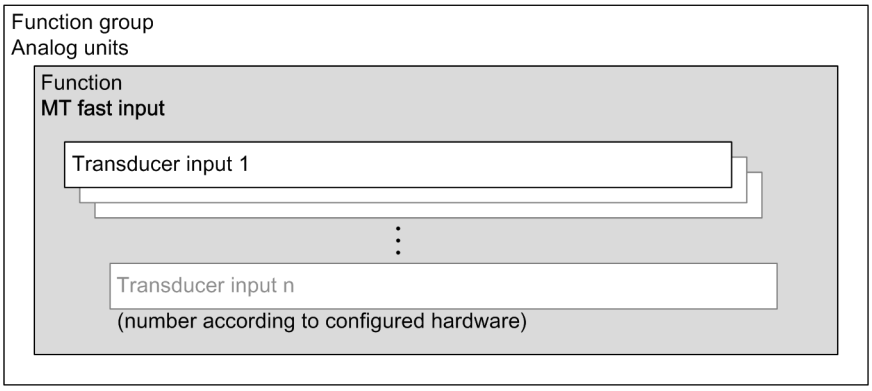
- Provides sampled values for recording in the fault record (the maximum sampling frequency is 8 kHz for all other SIPROTEC 5 devices). The recorded sampling frequency results from the setting of the fault-recorder function.
- Calculated measured values from the sampled values. These measured values have been deduced from the arithmetic mean values. The measuring range for the mean-value calculation is adjustable in the interval from 10 ms to 100 ms.

- Converts the measured current or voltage values into process values, for example, temperature, gas pressure, etc.
- Provides the recorded process variables for further processing by the fault recorder, the CFC, and in GOOSE-applications for transmission via communication protocols, and for visualization

The fast measuring-transducer inputs are located on the IO212 module with 8 inputs (optionally current or voltage inputs), and the IO210 module with 4 inputs (optionally current or voltage inputs).

5.11.6.2 Structure of the Function

The function **MT fast input** works in the function group **Analog units** and contains the number of available measuring-transducer inputs, depending on the hardware configuration. You can configure these channels independently from one another either as current or voltage inputs.



[dw_mu-structure, 1, en_US]

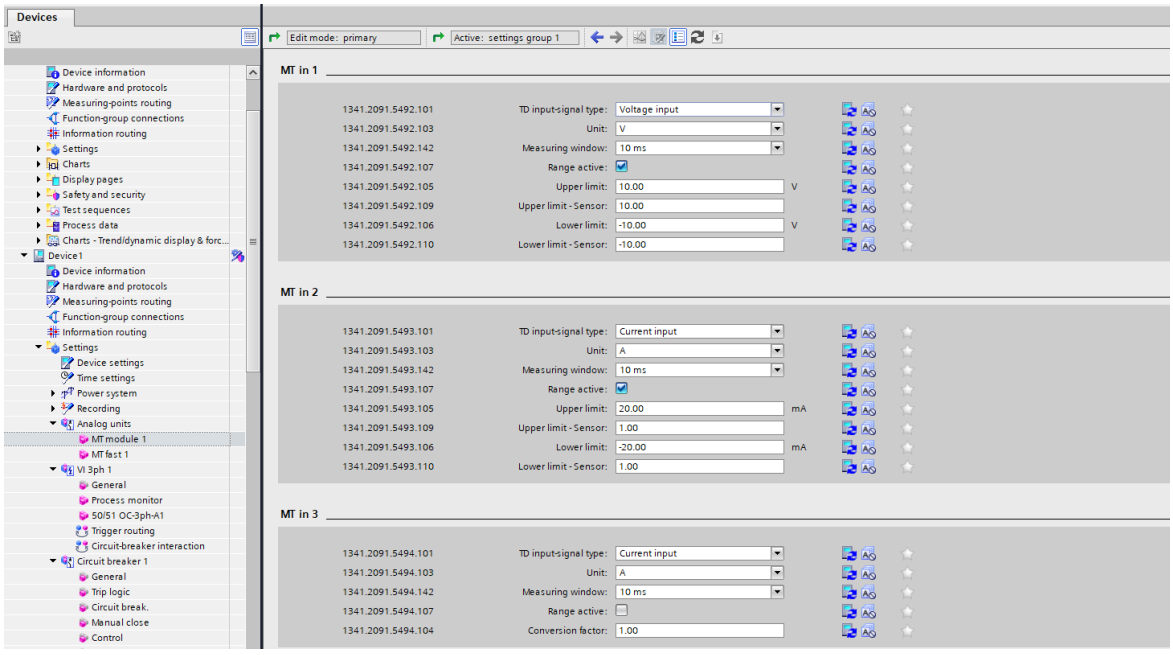
Figure 5-120 Structure/Embedding of the Function

5.11.6.3 Function Description

Once you have instantiated the **MT fast input** function, it will be visible in the project tree in the function group **Analog units**. You can find the function group **Analog units** in DIGSI in the **Settings** folder.

If you open the subdirectory **MT fast input**, you reach the setting sheet for the respective input (for more details, see *5.11.6.4 Application and Setting Notes*).

The hardware is designed in such a way that either a current or a voltage can be processed at each input. Use the corresponding terminals (see Hardware manual). Configure the input in accordance with the selected connection (Parameter **`TD input-signal type`**). With the parameter **`Measuring window`**, you set the measuring range with which the arithmetic mean value is determined. With the parameter **`Measuring window`**, you also determine measurement speed for the input. For example, a setting of 100 ms means that the measured value is updated every 100 ms.



[scmuio212, 2, en_US]

Figure 5-121 Parameters of the Measuring-Transducer Channels.

The fast measuring-transducer channels can be configured either as current or as voltage inputs. Apart from this, their function corresponds to the basic function of the 20-mA channels (see chapter *5.11.3.5 20-mA Channel*).

5.11.6.4 Application and Setting Notes

Parameter: `TD input-signal type`

- Default setting **`(_:101) TD input-signal type`** = ***`Current input`***

With the parameter **`TD input-signal type`**, you determine whether the measuring-transducer input channel works as a ***`Current input`*** or as a ***`Voltage input`***.

Make sure that the selected channel has also been wired correctly (see *Hardware manual, Input and Output Module IO212)*.

Parameter: `Unit`

- Default setting **`(_:103) Unit`** = ***`A`***

With the parameter **`Unit`**, you set the physical unit of measurement of the measured values. The possible setting values are listed in the settings table.

Parameter: `Measuring window`

- Default setting **`(_:142) Measuring window`** = ***`10 ms`***

With the parameter **`Measuring window`**, you set the measuring window that is used to determine the arithmetic mean value from the sampled values. In case of slowly varying signals, Siemens recommends setting the top value to 100 ms. With this value, a new, current measured value is provided every 100 ms for further processing.

Parameter: `Range active`

- Default setting **`(_:107) Range active`** = ***`false`***

If you do not activate the **Range active** parameter, the function assumes a range of -20 mA to +20 mA or -10 V to +10 V. The setting of the range for the scaled value then assumes a usable range of -20 mA to +20 mA or -10 V to +10 V.

If you activate the parameter **Range active**, the 4 additional parameters **Upper limit**,**Upper limit - Sensor**, **Lower limit**, and **Lower limit - Sensor** appear.

Note that this setting is activated by either placing, or not placing the relevant check mark in DIGSI (see *Figure 5-121*).

Parameter: Conversion factor

- Default setting **(_:104) Conversion factor** = ***1.00***

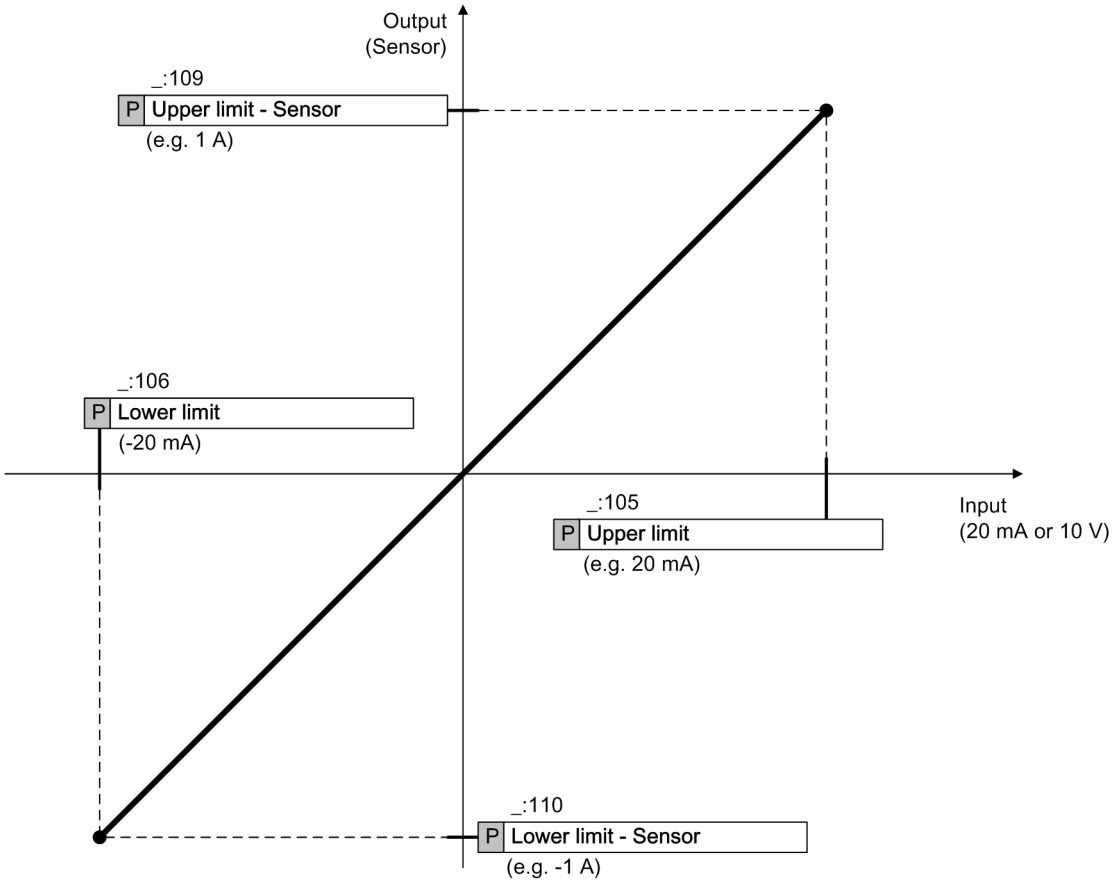
With the parameter **Conversion factor**, you set the conversion factor for the measuring transducer.

Parameter: Upper limit, Upper limit - Sensor, Lower limit, and Lower limit - Sensor

With the following parameters, you set the scaling of the measuring variables. By that, you can scale in an application-specific way:

- Default setting **Upper limit** = ***20.00 mA***
- Default setting **Upper limit - Sensor** = ***1.00***
- Default setting **Lower limit** = ***-20.00 mA***
- Default setting **Lower limit - Sensor** = ***1.00***

With these setting parameters, you set the operating range of the measuring transducer as well as the conversion of the values transmitted to the sensor values. Harmonize the operating range of the measuring transducer with the transmitter of the sensor. Using the free scalability of the system, you can meet different requirements. The following figure shows the setting parameters in general terms.



[dw_measured-value-scaling, 1, en_US]

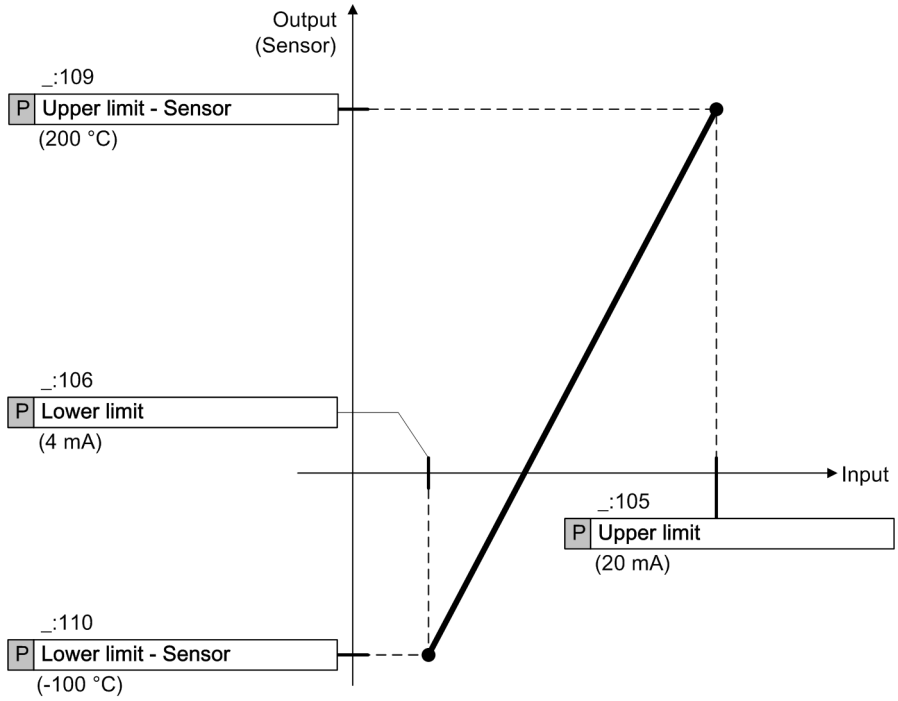
Figure 5-122 Scaling Principle

If you keep the preset limiting values, the following conditions are possible:

- If the input current is < 2.000 mA
  The function issues the indication *Broken wire* and the quality of the output value is invalid. The functions that use the output value as the measured value can be deactivated.
- If the input current is > 2.500 mA
  The indication *Broken wire* drops out.

Setting Example 1:

A measuring transducer transmitting a current signal of 4 mA to 20 mA is used as a transmitter. Currents well below -25.6 mA or above +25.6 mA indicate a transmitter failure. A sensor detecting a temperature is attached to the transmitter. The upper value corresponds to 200 °C and the lower value to -100 °C. This results in the following characteristic. In accordance with the set characteristic curve, the function calculates the sensor value from the measured current. The coefficients of the linear equation (gradient and foot point) are calculated from the set threshold and the sensor values are determined. A supplied current of 9.333 mA corresponds to a temperature of 0 °C.



[dw_measuring-transducer-characteristic, 1, en_US]

Figure 5-123 Characteristic Curve of Setting Example 1

NOTE

The hardware of the measuring transducer has been designed in such a way that measured values are transmitted and analyzed using the setting range (**`Upper limit`** or**`Lower limit`**). Therefore, special applications are possible, if necessary. The limits are at approx. +20 mA and -20 mA or +10 V and -10 V.

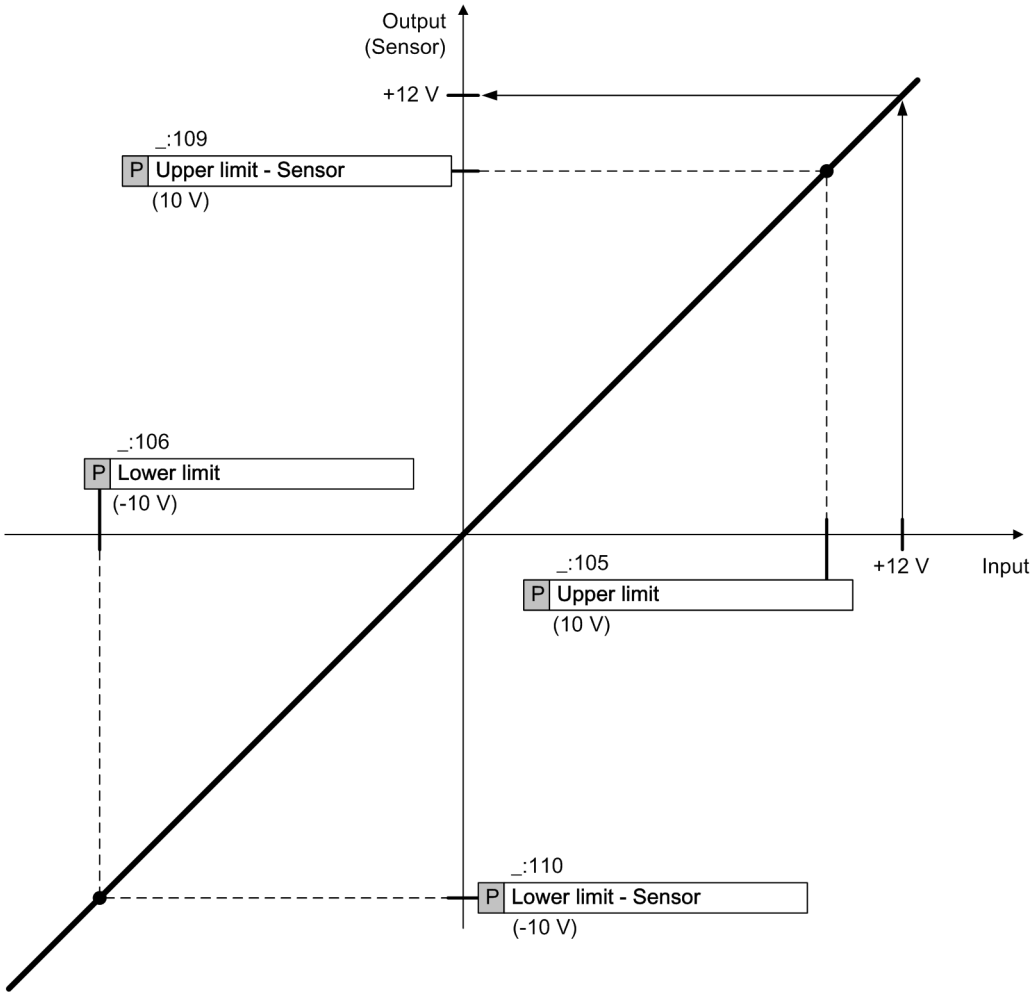
Setting Example 2:

For special applications, the transmitter sends a maximum of ±12 V. This voltage shall be issued accordingly as sensor voltage.

Set the parameters as follows:

- **`Upper limit`** = ***`10.00 V`***
- **`Upper limit - Sensor`** = ***`10.00 V`***
- **`Lower limit`** = ***`-10.00 V`***
- **`Lower limit - Sensor`** = ***`-10.00 V`***

With this setting, a signal of 12 V is issued as a 12-V measured value (see following figure).



[dw_measuring-transducer-setting, 1, en_US]

Figure 5-124 Parameter Settings and Representation of an Input Signal Greater than 10 V

5.11.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MT fast #				
_:101	MT in #:TD input-signal type		• Voltage input • Current input	Current input

Addr.	Parameter	C	Setting Options	Default Setting
_:103	MT in #:Unit		• % • ° • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • in • J • J/Wh • K • l/s • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • W/s • Wh	A

Addr.	Parameter	C	Setting Options	Default Setting
_:142	MT in #:Measuring window		• 10 ms • 20 ms • 40 ms • 60 ms • 80 ms • 100 ms	10 ms
_:107	MT in #:Range active		• 0 • 1	false
_:104	MT in #:Conversion factor		-1000000.00 to 1000000.00	1.00
_:105	MT in #:Upper limit		-20.00 m Ato 20.00 mA	5.00 mA
_:109	MT in #:Upper limit - Sensor		-1000000.00 to 1000000.00	1.00
_:106	MT in #:Lower limit		-20.00 m Ato 20.00 mA	4.00 mA
_:110	MT in #:Lower limit - Sensor		-1000000.00 to 1000000.00	1.00

5.11.6.6 Information List

No.	Information	Data Class (Type)	Type
MT in #			
_:307	MT in #:Broken wire	SPS	O
_:302	MT in #:TD scale MV	MV	O
_:306	MT in #:TD scale SAV	SAV	O
_:300	MT in #:Behavior	ENS	O
_:303	MT in #:Health	ENS	O

5.11.7 RTD Unit Ethernet

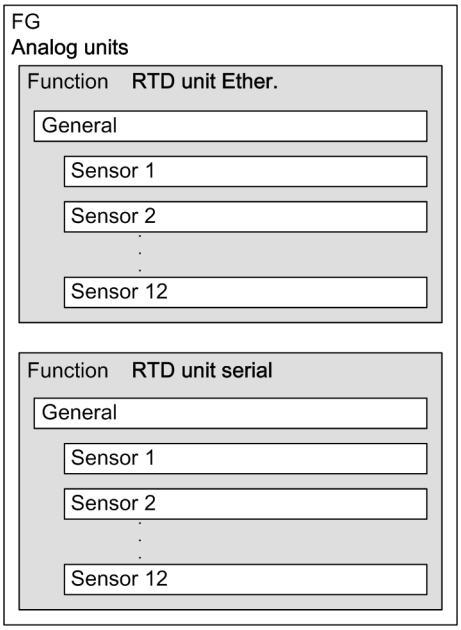
5.11.7.1 Overview

The **RTD unit Ether.** function:

- Communicates with an external RTD unit via the Slave Unit Protocol (SUP) and records the measured temperatures from the RTD unit
- Provides the captured temperatures to the temperature monitoring function
- Monitors communication with the RTD unit

5.11.7.2 Structure of the Function

The **RTD unit Ether.** function can only work in the **Analog units** function group. A maximum of 20 function instances can work simultaneously. Each instance contains 12 preconfigured sensor function blocks.

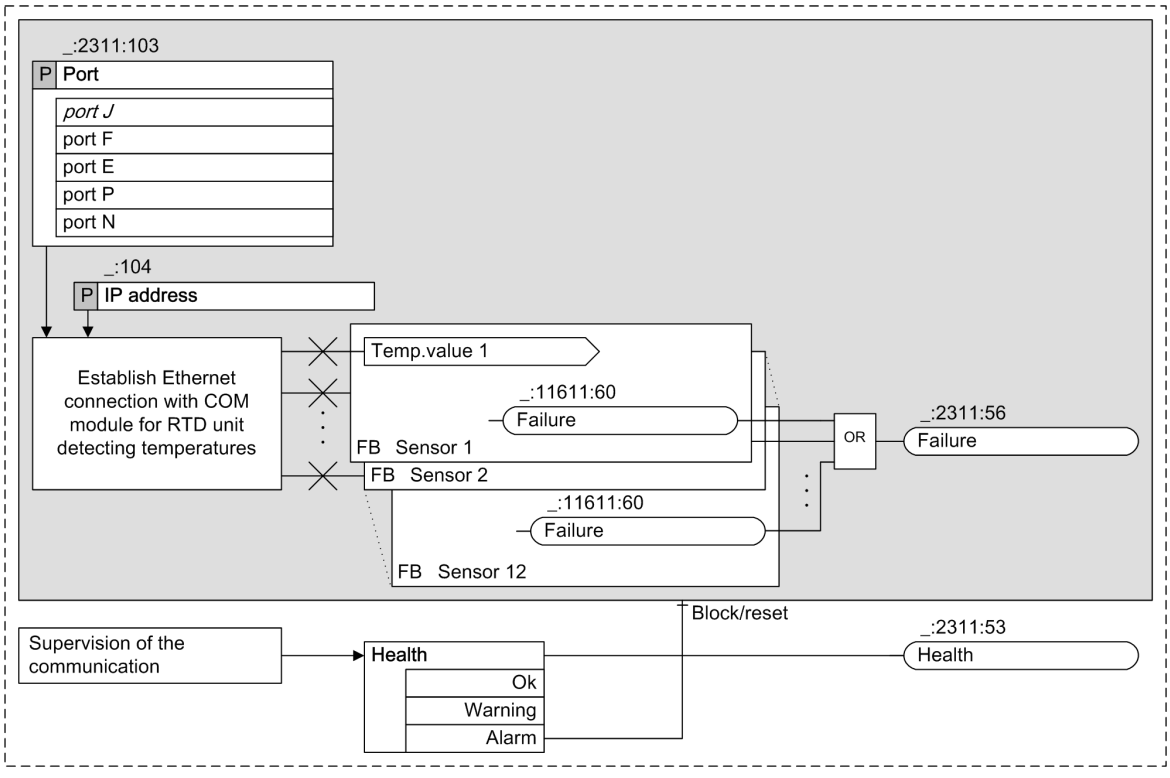


[dw_str_fnc, 2, en_US]

Figure 5-125 Structure/Embedding of the Function

5.11.7.3 Communication with an RTD Unit

Logic



[lo_rtdtcp, 1, en_US]

Figure 5-126 Logic of the RTD Unit Ether. Function

Communication with an RTD Unit

The function is used to communicate with an RTD unit connected via an Ethernet connection. If the connection of the function is successfully established to the external RTD unit via the Ethernet interface, the RTD unit transmits the temperatures of all connected sensors to the **RTD unit Ether.** function. For the connection to be established successfully, specific communication settings must be set, see chapter *5.11.7.4 Application and Setting Notes*.

The RTD unit **Ziehl TR1200 IP** supports only an Ethernet connection of 10 MBit/s. A direct connection to a 100-Mbit communication module is therefore not possible. For this reason, you must connect the RTD unit to the communication module via a 10/100 MBit/s autosensing switch which automatically recognizes the transmission rates and adapts them accordingly. Further information can be found in the Application and setting notes, see chapter *5.11.7.4 Application and Setting Notes*.

Error Responses

The following table lists the conditions under which the *Health* status transitions to the Alarm or Warning state.

Table 5-23 Error Responses

Error Description	Status Health
The **RTD unit Ether.** function cannot establish a connection with a communication module.	Alarm
The connection between the communication module and the RTD unit causes a time-out.	Warning
A communication module has not received any more data from the RTD unit for 9 sec.	Warning

The *Failure* signal is issued as soon as one of the sensor function blocks reports a failure.

5.11.7.4 Application and Setting Notes

Parameter: Port

- Default setting **(_:2311:103) Port** = ***port J***

Use the **Port** parameter to define over which port the external RTD unit is connected to the SIPROTEC 5 device.

If you want to connect the external RTD unit to the integrated Ethernet interface, set the parameter **Port** = ***Port J***. If you want to connect the external RTD unit to an Ethernet plug-in module, set the parameter **Port** = ***Port F***, ***Port E***, ***Port P***, or ***Port N***.

You can connect directly the RTD unit to the device via the internal 10-Mbit Ethernet port J. If you operate the RTD unit on another port via a 100-Mbit communication module, you need an interconnected 10/100-Mbit autosensing switch, which adapts transmission rates accordingly.

Parameter: IP address

- Default setting **(_:2311:104) IP address** = ***10.16.60.1***

With the parameter **IP address**, you set the IP address of the RTD unit connected to the communication module via the SUP protocol. Every RTD unit has to be assigned a unique IP address. The IP address to be set depends on your network configuration. You can set any valid IPv4 address that does not cause conflicts with other IP addresses in the network. Set an appropriate IP address first at the **Ziehl TR1200 IP** RTD unit. Then specify the parameter **IP address** for the communication module to the same address.

Settings on the RTD Unit

The **Ziehl TR1200 IP** RTD unit is set with the front keys or in a Web browser on a laptop computer via its Ethernet interface. Set the connection type of the sensors (3-wire connection or resistance value for 2-wire connection), the idle state of the fault-indication relay, as well as the IP interface setting.

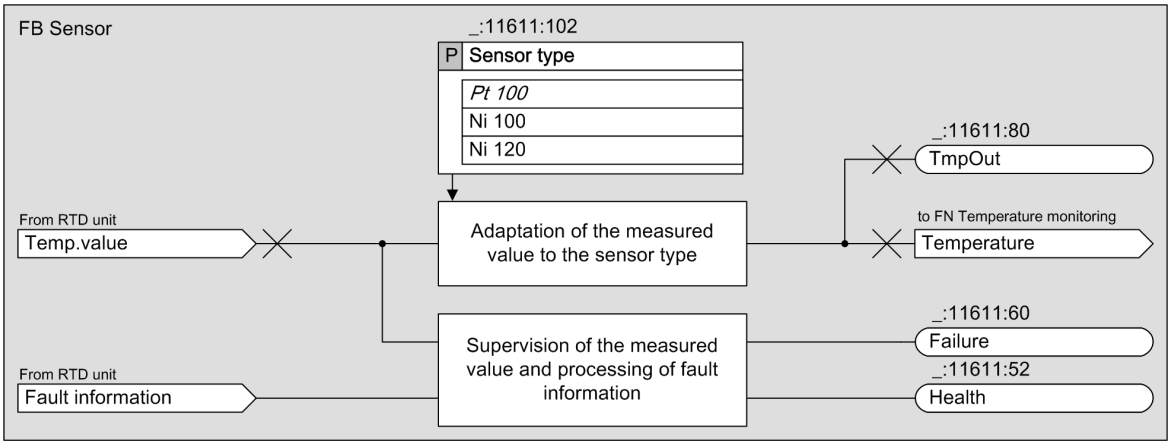
The code lock has to be switched off for parameterization. This is only possible using the front keys of the RTD unit. The code lock is **off** (switched off) in as-delivered condition and has pin **504**.

For detailed information on the settings, refer to the TR1200 IP manual that comes with the RTD unit. The documents are also available in the SIPROTEC download area (http://www.siprotec.de) under **Accessories -> 7XV5662-xAD**.

For an Ethernet connection to a SIPROTEC 5 device communicating with the RTD unit TR1200 IP via the **SUP protocol** (Slave Unit Protocol), the **`Modbus TCP`** setting must be activated in the RTD unit. You can activate the Modbus TCP protocol using the function keys under the **tcP.** → **Mod / on** menu item or with the Web browser in the **TCP/UDP Config** tab. The **RTD** (RTD protocol) and **UDP Port** settings have no effect here. The Modbus TCP port is permanently set to 502 and cannot be changed.

5.11.7.5 Temperature Sensor

Logic



[lo_tmpval, 1, en_US]

Figure 5-127 Logic Diagram of the Temperature Sensor Function Block

Measured Temperature Value

The **Temperature sensor** function block processes one single measured temperature value delivered from the RTD unit for the assigned sensor. 12 temperature sensor function blocks are always available in each RTD unit function (both via Ethernet and serial), even if fewer sensors are connected to the RTD unit.

Various temperature sensor types are supported: Pt100, Ni100, and Ni120 sensors. The function block is notified regarding the selection of connected type via the **`Sensor type`** parameter.

The function block delivers a measured temperature value in °C or °F as an output variable. The measured temperature value is available as an operational measured value and can be monitored by the **Temperature supervision** function.

Error Responses

If the measured input value is determined to be incorrect, the quality attribute of the output measured temperature value is set to *`invalid`*. The statuses for Health and Error take the statuses in accordance with the following table:

Table 5-24 Error response

Error Description	Health Status	Error Status
Sensor or line short circuited	Alarm	Yes
Sensor or line interrupted	Alarm	Yes

Error Description	Health Status	Error Status
Measured temperature value outside the valid measuring range specified in the technical data. The valid measuring range depends on the sensor type.	Alarm	Yes
Sensor not connected	OK	No

5.11.7.6 Application and Setting Notes

Parameter: Sensor type

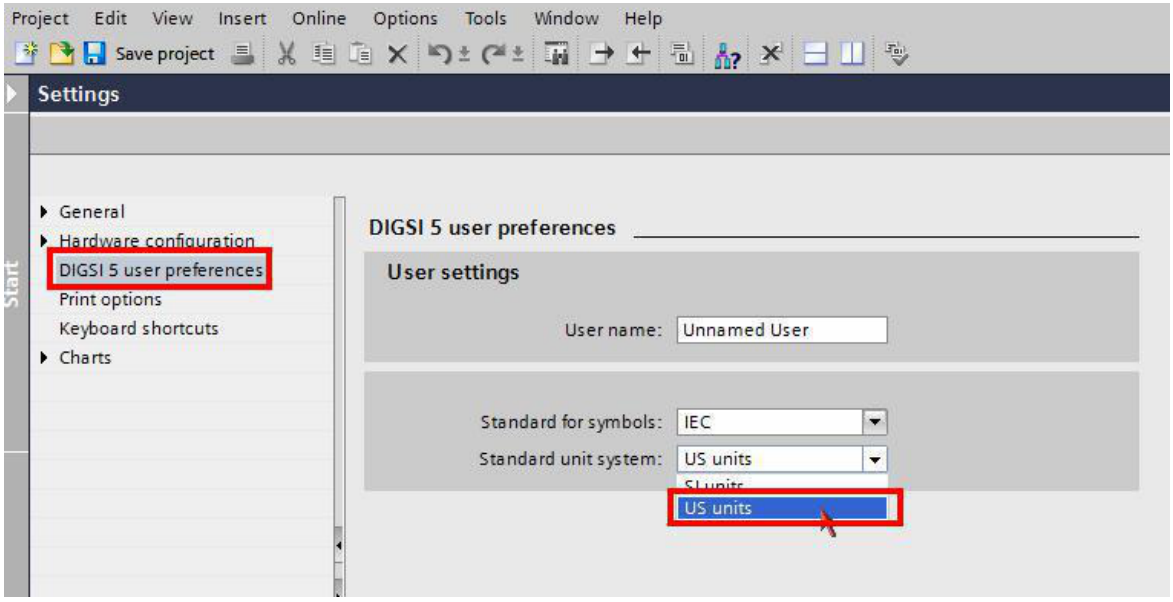
- Default setting **(_:11611:102) Sensor type** = ***Pt 100***

The **Sensor type** parameter is used to set the sensor element used. You can select between ***Pt 100***, ***Ni 100*** and ***Ni 120***.

Parameter: Temperature unit

To change the display and evaluation of measured temperature values from °C to °F, adapt the DIGSI user default settings accordingly.
Proceed as follows:

- In DIGSI select the menu item **Extras** --> **Settings**.
- In the **Settings** view select the menu item **DIGSI 5 User preferences**.
- Under **Standard unit system** change the setting value of the unit system used from ***SI units*** to ***US units***.



[scfahrht-190214-01, 1, en_US]

Figure 5-128 Change of the Display Between °C and °F

The following settings and information table shows only 1 of the 12 sensors, as the setting possibilities of the 12 sensors do not differ.

5.11.7.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port E • port F • port J • port N • port P	port J
Sensor 1				
_:11611:102	Sensor 1:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100

5.11.7.8 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Sensor 1			
_:11611:51	Sensor 1:Behavior	ENS	O
_:11611:52	Sensor 1:Health	ENS	O
_:11611:60	Sensor 1:Failure	SPS	O
_:11611:80	Sensor 1:TmpOut	MV	O

5.11.8 RTD Unit, Serial

5.11.8.1 Overview

The **RTD unit serial** function:

- Communicates with an external RTD unit serial via the Slave Unit Protocol (SUP) and records the measured temperatures from the RTD unit
- Provides the captured temperatures to the temperature supervision function
- Monitors communication with the RTD unit

The **RTD unit Serial** function is set up structurally in the same manner as the **RTD unit Ether.** function. The mode of operation is also identical (see *5.11.7.3 Communication with an RTD Unit*).

5.11.8.2 Application and Setting Notes

Parameter: Port

- Default setting **(_:2311:103) Port** = ***F***

With the parameter **Port**, you set the slot for the communication module that will be used for the connection with an external RTD unit.

If you want to connect the external RTD unit to an Ethernet plug-in module, set the parameter **Port** = ***Port F***, ***Port E***, ***Port P***, or ***plug-in module position***.

Parameter: Channel number

- Default setting **(_:2311:105) Channel number** = *1*

A serial communication module optionally uses 2 channels. With the parameter **Channel number**, you set the channel number (1 or 2) through which the RTD unit is connected to the device. The communication module inputs are labeled with the channel numbers.

Parameter: Slave address

- Default setting **(_:2311:106) Slave address** = *1*

With the parameter **Slave address**, you define the device address of the RTD unit. If only one RTD unit is connected to the serial bus, the default value *1* can be used. The same device address has to be set on the RTD unit. The device address is important for distinguishing among several RTD units connected to a serial bus. Set a unique device address (for example 1, 2, and 3 when connecting 3 RTD units) for each RTD unit and the same device address for the parameter **Slave address** in the 3 **RTD unit serial** functions.

The following settings and information table shows only 1 of the 12 sensors, as the setting possibilities of the 12 sensors do not differ.

5.11.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port F • port E • port J • port N • port P	port J
_:2311:105	General:Channel number		1 to 2	1
_:2311:106	General:Slave address		1 to 247	1
Sensor 1				
_:11611:102	Sensor 1:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100

5.11.8.4 Information List

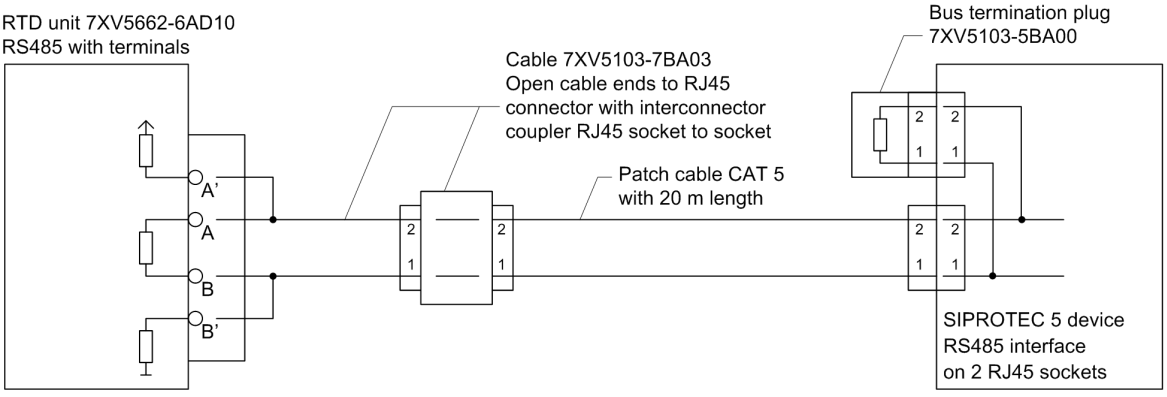
No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Sensor 1			
_:11611:51	Sensor 1:Behavior	ENS	O
_:11611:52	Sensor 1:Health	ENS	O
_:11611:60	Sensor 1:Failure	SPS	O
_:11611:80	Sensor 1:TmpOut	MV	O

5.11.9 Communication with RTD Unit

5.11.9.1 Integration of a Serial RTD Unit (Ziehl TR1200)

Connection of the Communication Lines

Figure 5-129 shows how you connect the RTD unit to the SIPROTEC 5 device. Note that Pin 1 of the RJ45 plug is connected to RTD-B and Pin 2 is connected to RTD-A.



[dwverbau-201112-01.tif, 1, en_US]

Figure 5-129 Connection of the RTD Unit to the SIPROTEC 5 Device

Adding a USART Module

Add a USART-AB-1EL or a USART-AC-2EL USART module in DIGSI to the device. The USART module must be inserted at one of the plug-in positions for communication modules in the base module or in the CB202 expansion module (refer to the following figure).

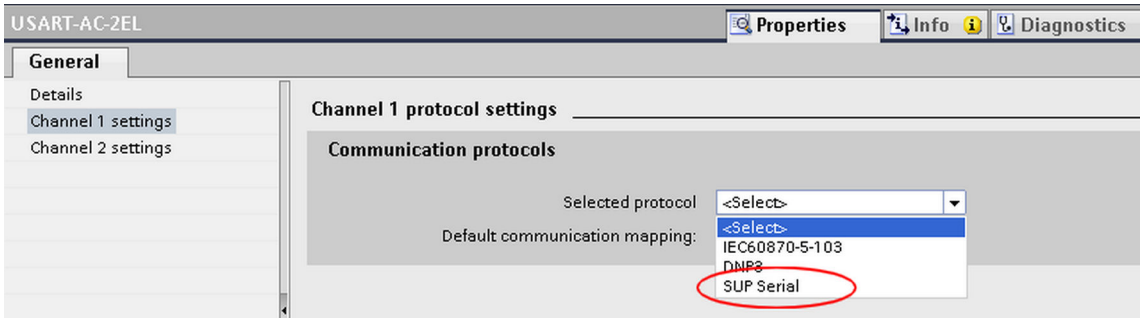


[scauser3-190214-01, 1, en_US]

Figure 5-130 Insertion Position for a USART Module

Selecting the SUP Protocol

Select the Slave Unit Protocol (SUP). This protocol is responsible for the communication between the SIPROTEC 5 device and the RTD Unit.



[scauser4-301012-01.tif, 1, en_US]

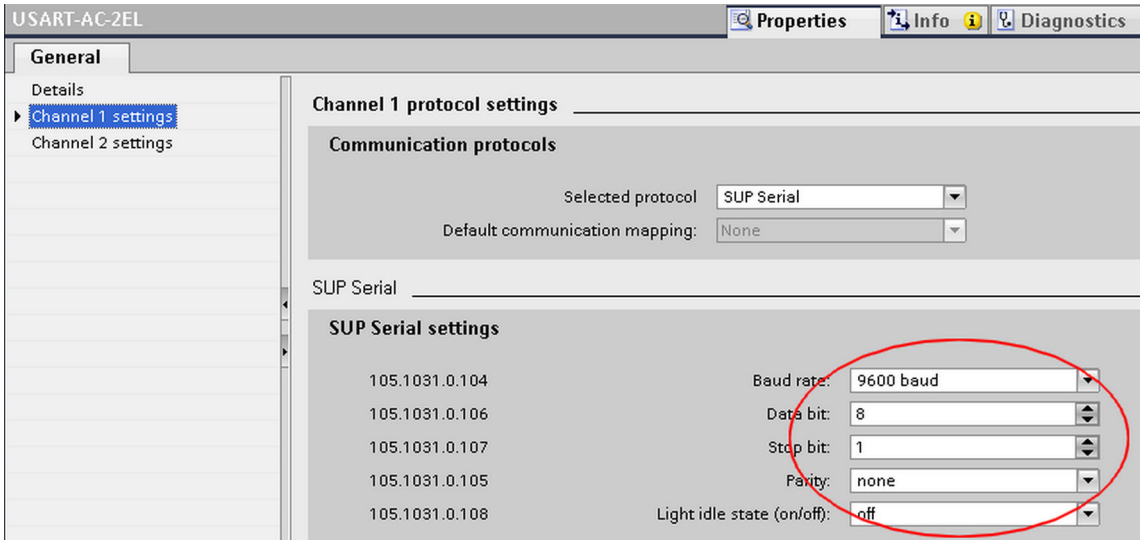
Figure 5-131 Selecting the SUP Protocol

Communication Settings

Make the communications settings for the relevant serial channels. For this, use the default settings specified by the RTD box. Normally, you must adapt only the parameterization of the SIPROTEC 5 device to the settings of the RTD box. Make sure that the setting values in both devices are the same. The setting of the parameter **`Non-flickering light (on/off)`**: is not relevant for the RS485 interface.

NOTE

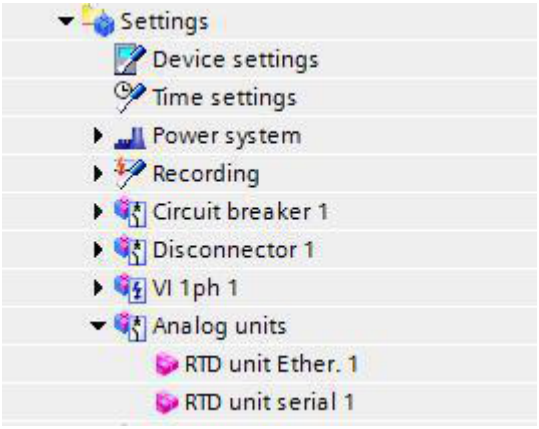
The driver for the USART module for the SUP protocol is not preinstalled as standard for the initial use of this interface (following the firmware update).



[scauser5-301012-01.tif, 1, en_US]

Figure 5-132 Making the Communication Settings

With the selection of the SUP protocol for the RTD box DIGSI automatically adds the function group **Analog units** to your device configuration. You can now instantiate the function **RTD unit serial 1** (refer to the following figure).



[sc_auser6, 1, en_US]

Figure 5-133 Analog-Unit Instance

Now, set the channel number over which the SUP protocol runs. In addition, set the slave address of the RTD unit. This address must be set with the same value in the RTD box (refer to the following figure).
The following device configuration must be set on the TR1200 RTD unit when the RTD unit is used for the first time:

- Bus protocol: mod
- Device address: 1
- Baud rate: 9600
- Parity: no



[scauser7-220114-01-DE, 1, en_US]

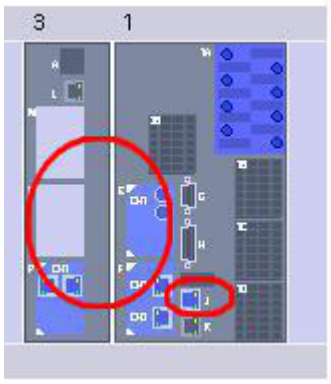
Figure 5-134 Setting the Port, Channel Number, and Slave Address

Finally, load the configuration in the device.

5.11.9.2 Integration of an RTD Unit Ether. (TR1200 IP)

Device Configuration

In the DIGSI, insert an Ethernet module into the provided slot, thus adding the module to the device configuration. *Figure 5-135* displays the available slots in the base module or on the expansion module CB202. Alternatively, you can also use the integrated Ethernet interface port J.

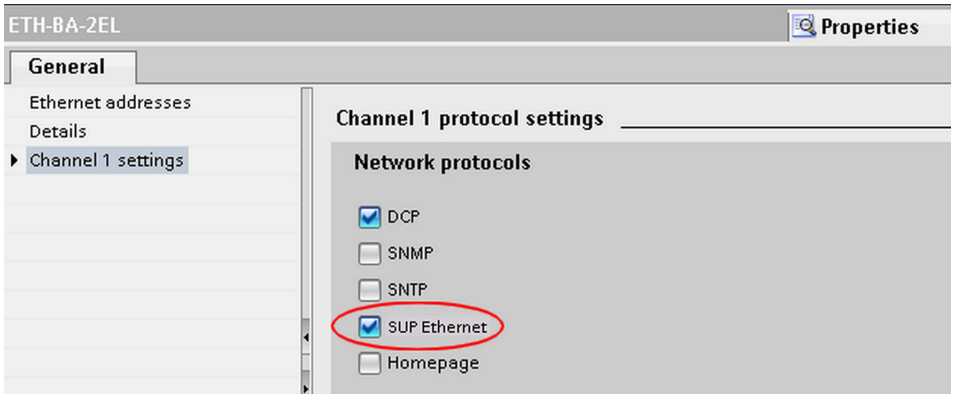


[sc_autcp1, 1, en_US]

Figure 5-135 Inserting an Ethernet Module

Communication Settings

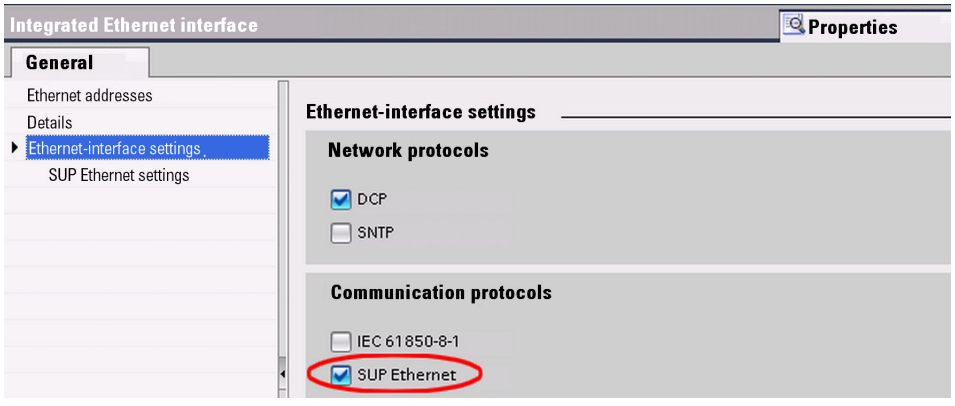
Activate the SUP Ethernet protocol for the Ethernet module.



[sc_autcp2, 1, en_US]

Figure 5-136 SUP Ethernet Protocol Activation

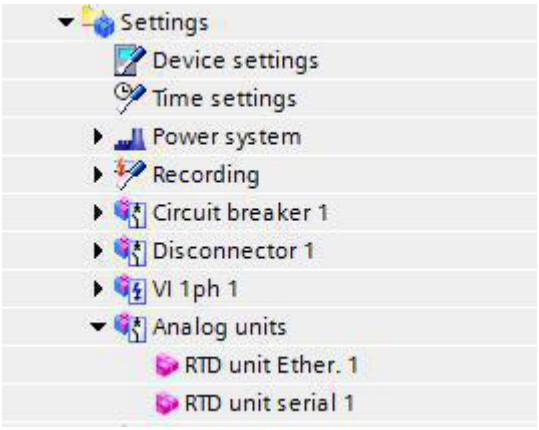
This protocol is also available for Port J of the integrated Ethernet interface of the base module (refer to following figure).



[sc_autcp3, 1, en_US]

Figure 5-137 SUP Ethernet Protocol Activation (Base Module)

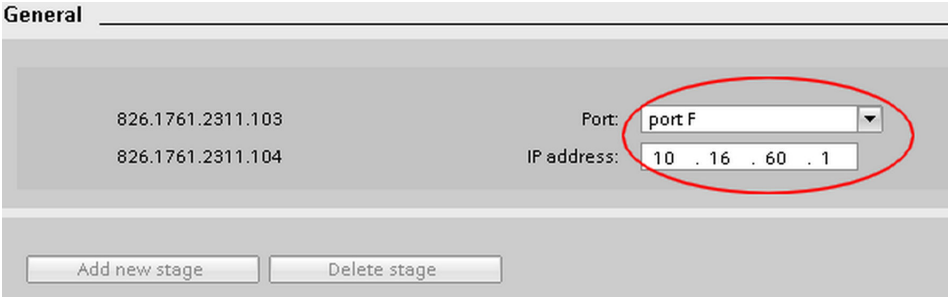
With the selection of the SUP protocol for the RTD unit, DIGSI automatically adds the **Analog units** function group and the **RTD unit Ether.** function to your device configuration (refer to the following figure).



[sc_auser6, 1, en_US]

Figure 5-138 Analog Unit Instance

Now, set the port over which the SUP protocol runs. In addition, set the IP address of the RTD unit (refer to the following figure). This address must be set with the same value in the RTD unit.



[sc_autcp5, 1, en_US]

Figure 5-139 Setting the Port and IP Address

Finally, load the configuration in the device.

5.11.9.3 Temperature Simulation without Sensors

Connect a resistor on the sensor terminals of the RTD unit. Using this resistor, simulate a constant temperature. The resistance value should be around 50 Ω to 200 Ω.

If you want to simulate a changeable temperature, connect an adjustable resistor of maximum 470 Ω instead of a fixed resistor.

5.11.10 Temperature Acquisition via Protocols

5.11.10.1 Overview

The function **Temperature acquisition via protocols**:

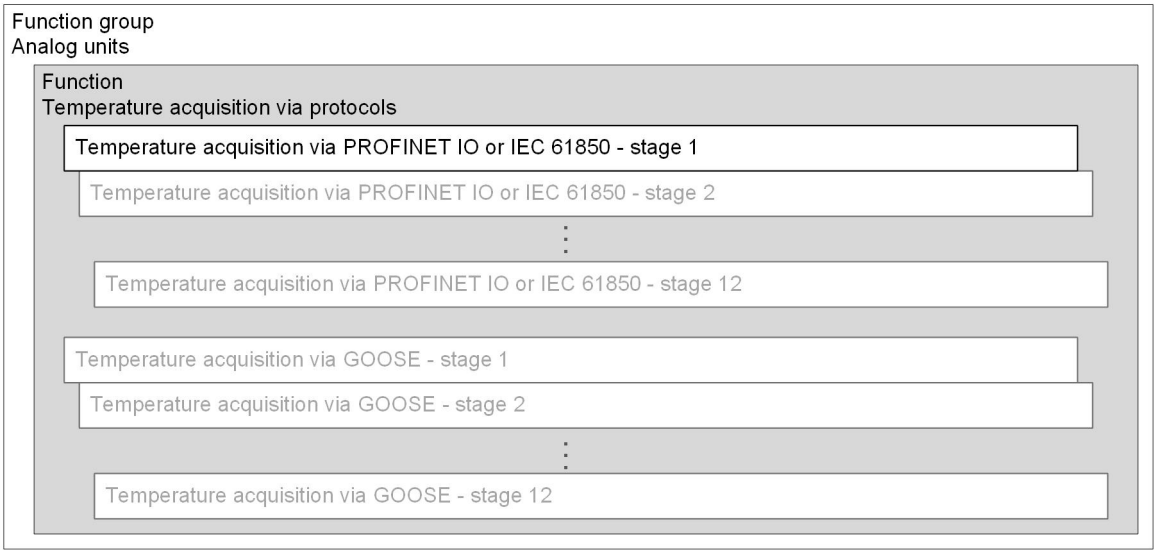
- Obtains the temperature from a power-plant control system or from another protection device
- Processes the temperature, for example, supervises the temperature in the CFC
- Transfers the temperature to other protection devices

5.11.10.2 Structure of the Function

The function **Temperature acquisition via protocols** can work only in the function group **Analog units**. In this function, the following stages can operate simultaneously:

- 12 stages **Temperature acquisition via PROFINET IO or IEC 61850**
  The stage can obtain the temperature from a power-plant control system via the PROFINET IO protocol or the IEC 61850 protocol.
- 12 stages **Temperature acquisition via GOOSE**
  The stage can obtain the temperature from another SIPROTEC 5 protection device via the GOOSE protocol.

The function **Temperature acquisition via protocols** comes factory-set with 1 stage **Temperature acquisition via PROFINET IO or IEC 61850**.

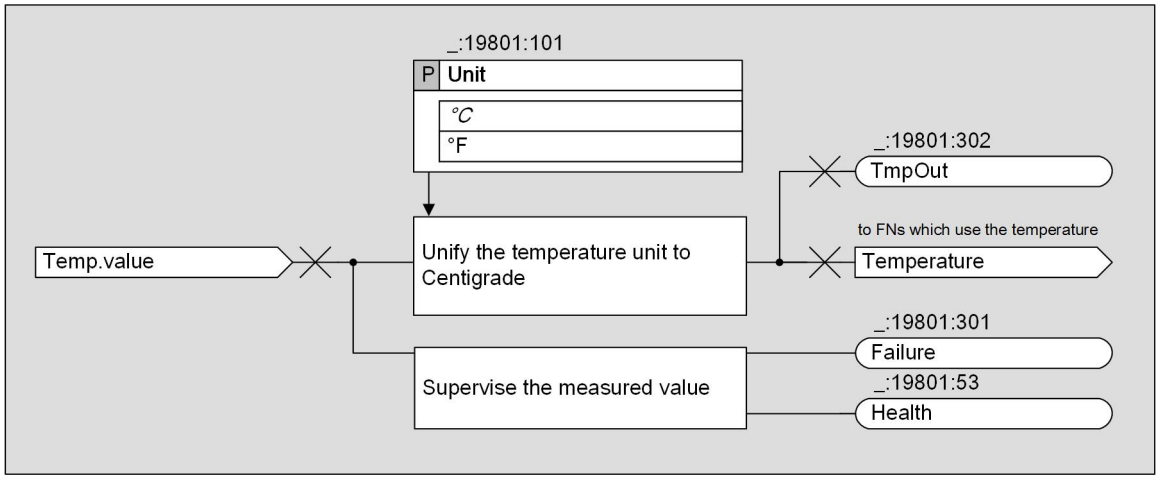


[dw_structure_TmpviaProt, 1, en_US]

Figure 5-140 Structure/Embedding of the Function

5.11.10.3 Stage Temperature Acquisition via PROFINET IO or IEC 61850

Logic



[lo_tmpval, 1, en_US]

Figure 5-141 Logic Diagram of the Stage

The stage **Temperature acquisition via PROFINET IO or IEC 61850** supports 2 protocols:

- PROFINET IO protocol
  If you set the PROFINET IO protocol for the temperature acquisition, you can only get the analog value.
- IEC 61850 protocol
  If you set the IEC 61850 protocol for the temperature acquisition, you get the analog value, the quality, and the time stamp.

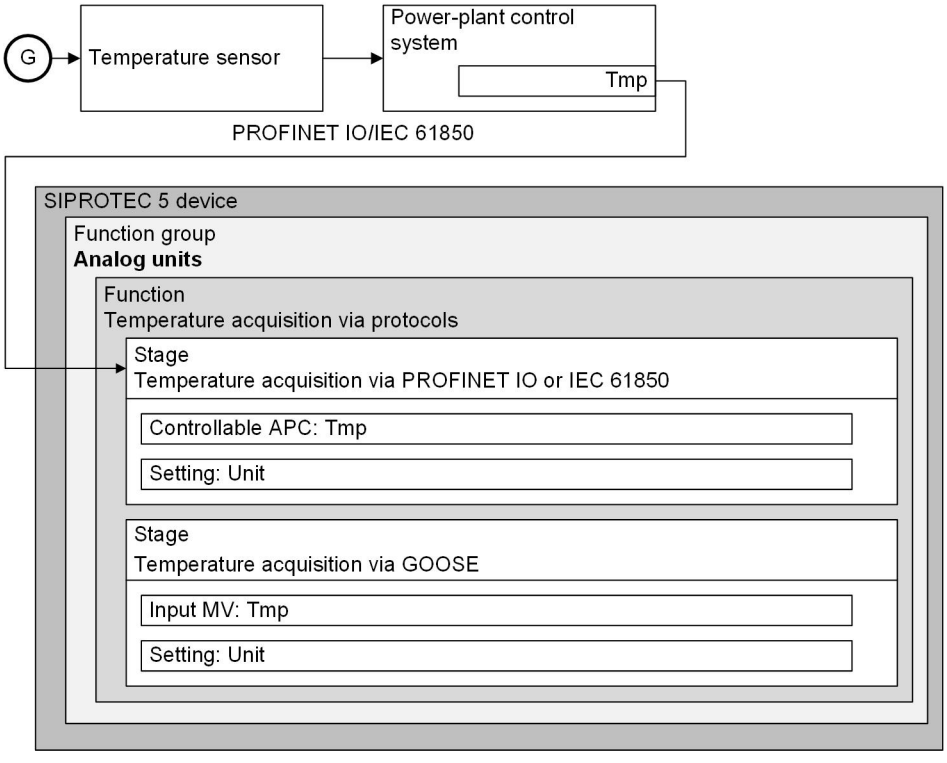
Invalid Temperature Indication

If the received temperature is invalid, the failure indication *Temperature failure* is issued.

Stage Application

You can use the stage **Temperature acquisition via PROFINET IO or IEC 61850** for the following purposes:

- Acquire the cold-gas temperature from the power-plant control system
- Process the received cold-gas temperature value
- Send the processed cold-gas temperature value to other functions for further processing



[dw_app-example_IEC, 1, en_US]

Figure 5-142 Application Example

The following table explains the data.

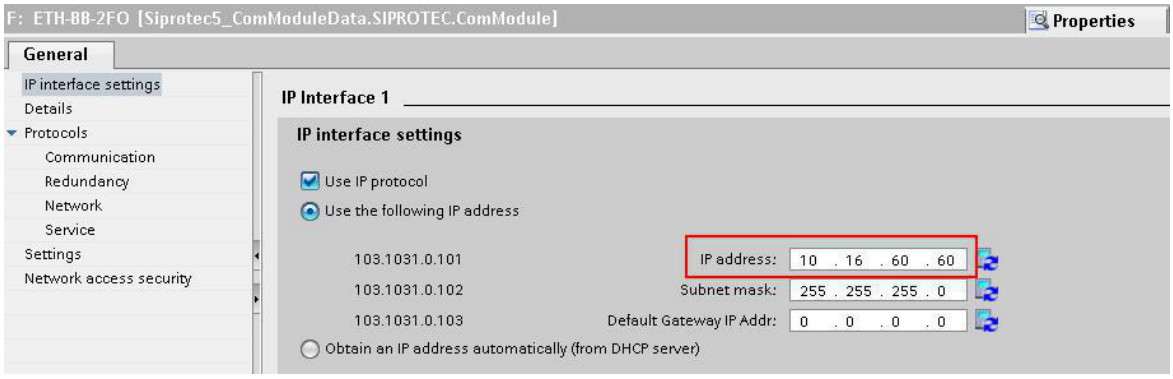
Data Name	Description
Tmp	With this variable, you can set the PROFINET IO protocol or the IEC 61850 protocol for the temperature acquisition. In the stage **Temperature acquisition via PROFINET IO or IEC 61850**, the data type is APC.
Unit	With this parameter, you can select the unit **°F** or **°C** for the temperature which is acquired from the power-plant control system.

5.11.10.4 PROFINET IO Configuration for the Temperature Acquisition

With the stage **Temperature acquisition via PROFINET IO or IEC 61850**, to acquire the cold-gas temperature via the PROFINET IO protocol, the following configurations are necessary.

IP-Address Configuration and Protocol Selection

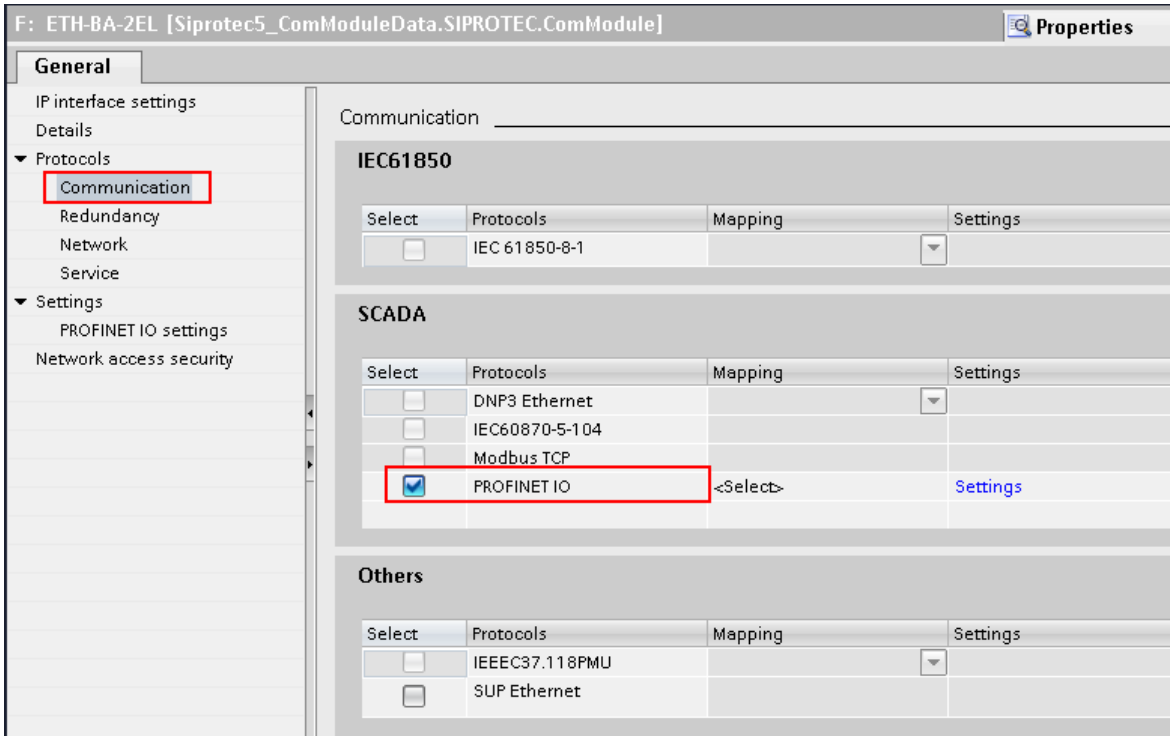
- ✧ In the project tree, navigate to your device and double-click **Hardware and protocols**.
- ✧ In the **Device view** tab, select an Ethernet communication module for which you want to configure the PROFINET IO protocol.
- ✧ In the **Properties** tab of the communication module, select **General** > **IP interface settings**.
- ✧ Set the **IP address** for the communication module.



[sc_PROFINET IP, 2, en_US]

Figure 5-143 IP-Address Configuration

- ✧ Select **General** > **Protocols** > **Communication**.
- ✧ Under **SCADA**, select the item ***PROFINET IO***.



[sc_PROFINET_IO, 2, en_US]

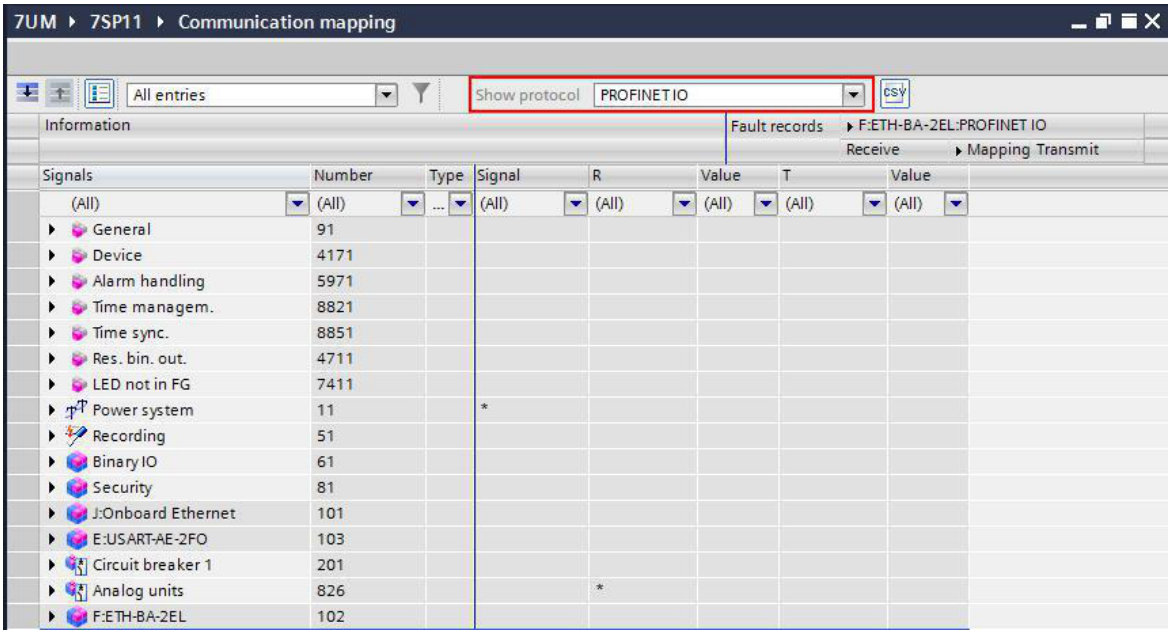
Figure 5-144 Protocol Selection

Function Instantiation

- ✧ In the project tree, navigate to your device and select **Settings** > **Analog units**.
  If there is no function group **Analog units**, instantiate one.
- ✧ Instantiate the function **Tmp.Acq.viaCom** in the function group **Analog units**.

Signal Mapping and Configuration

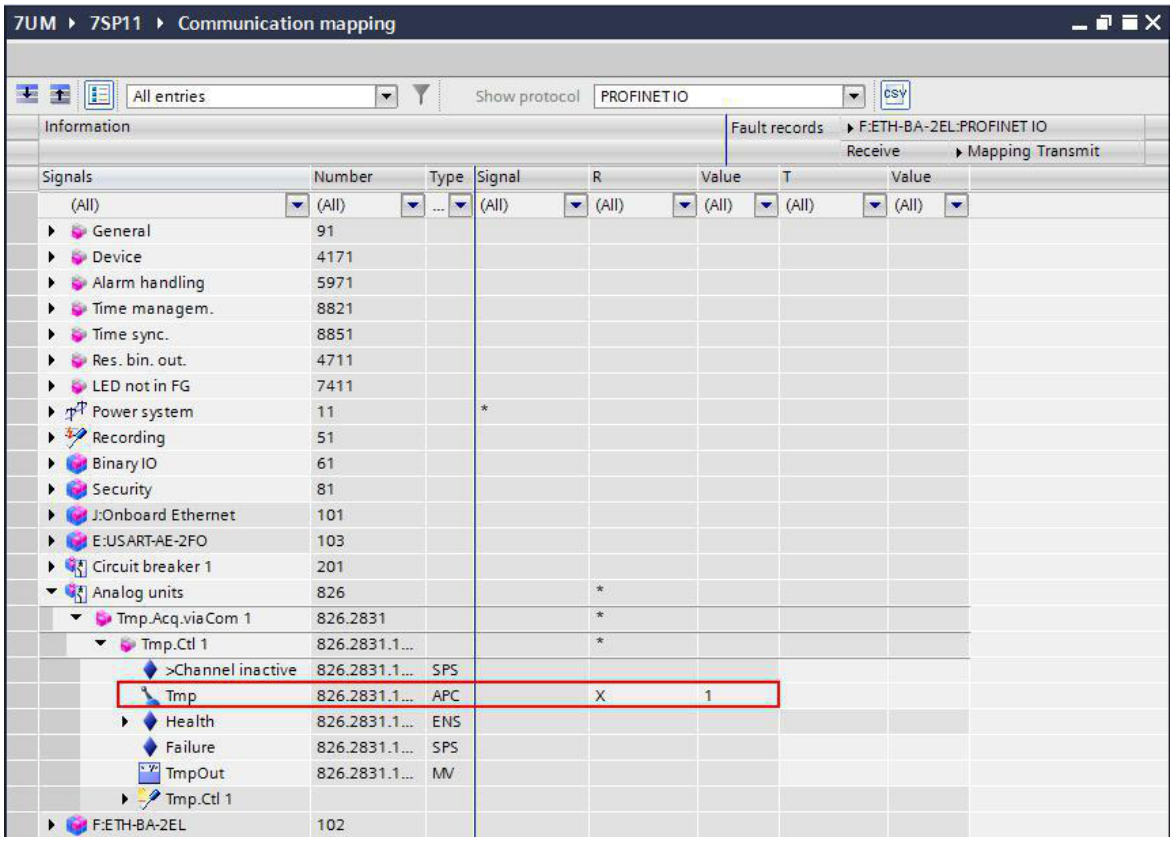
- ✧ In the project tree, navigate to your device and double-click **Communication mapping**.
- ✧ In the **Communication mapping** matrix, set **Show protocol** to ***PROFINET IO***.



[sc_PROFI_Filter, 2, en_US]

Figure 5-145 Protocol Filter

- ✧ In the column **Signals**, select **Analog units** > **Tmp.Acq.viaCom 1** > **Tmp.Ctl 1**.
- ✧ Route the data *Tmp* in column **R** and set the value to ***1***.



[sc_PROFI_Setting, 1, en_US]

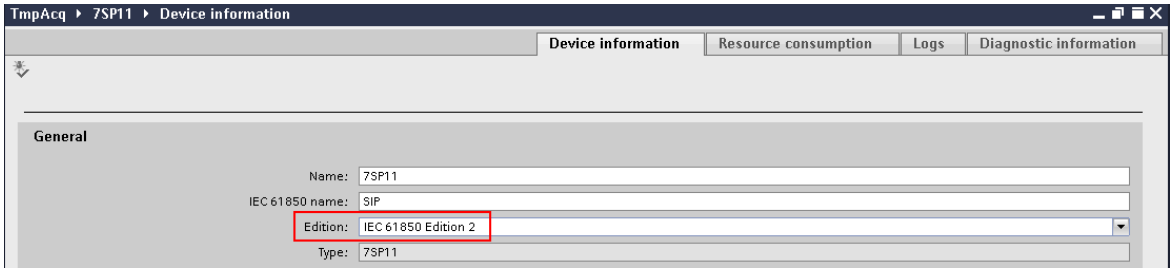
Figure 5-146 Signal Configuration

5.11.10.5 IEC 61850 Configuration for the Temperature Acquisition

With the stage **Temperature acquisition via PROFINET IO or IEC 61850**, to acquire the cold-gas temperature via the IEC 61850 protocol, the following configurations are necessary.

IEC 61850 Edition Selection

- ✧ In the project tree, navigate to your device and double-click **Device information**.
- ✧ In the **Device information** tab, set the parameter **`Edition`** to ***`IEC 61850 Edition 2`*** or a higher edition.



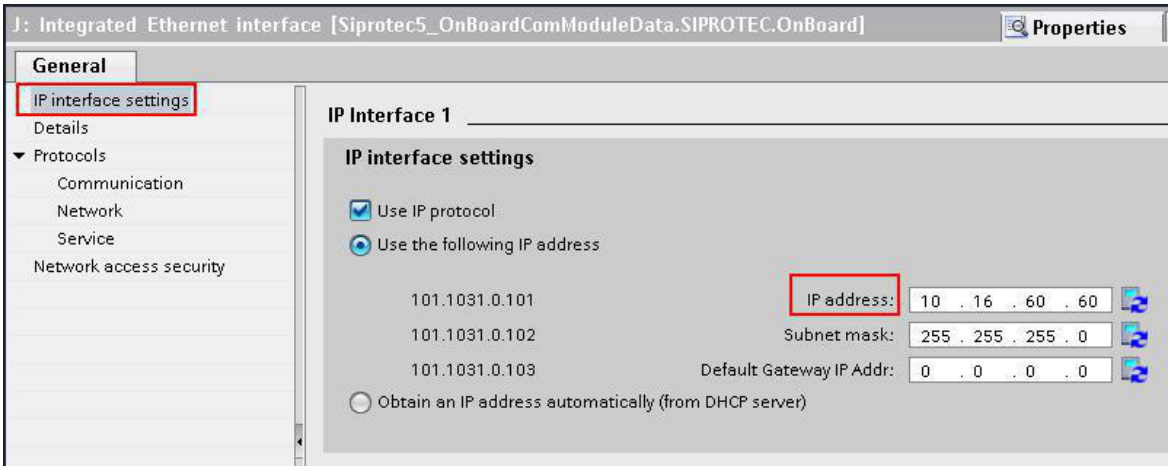
[sc_iec_edition, 1, en_US]

Figure 5-147 IEC 61850 Edition

IP-Address Configuration and Protocol Selection

- ✧ In the project tree, navigate to your device and double-click **Hardware and protocols**.
- ✧ In the **Device view** tab, select the communication module for which you want to configure the IEC 61850 protocol.

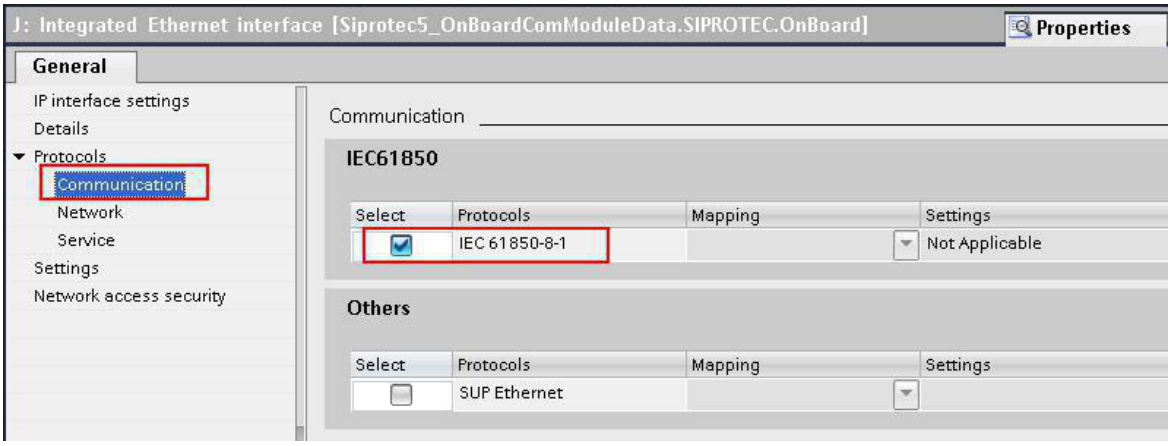
- ✧ In the **Properties** tab of the communication module, select **General** > **IP interface settings**.
- ✧ Set the **IP address** for the communication module.



[sc_iec_61850_ip, 2, en_US]

Figure 5-148 IP-Address Configuration

- ✧ Select **General** > **Protocols** > **Communication**.
- ✧ Under **IEC61850**, select the item ***IEC 61850-8-1***.

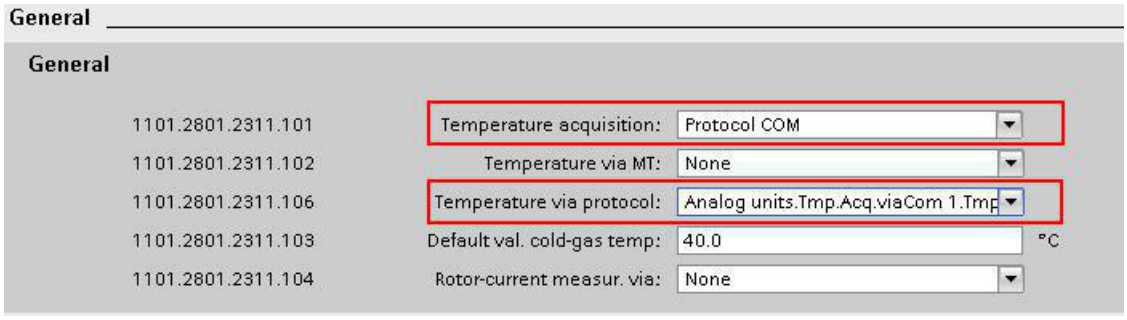


[sc_iec_61850_sel, 2, en_US]

Figure 5-149 Protocol Selection

Function Instantiation

- ✧ In the project tree, navigate to your device and select **Settings** > **Analog units**.
  If there is no function group **Analog units**, instantiate one.
- ✧ Instantiate the function **Tmp.Acq.viaCom** in the function group **Analog units**.
- ✧ Instantiate the function that requires the cold-gas temperature in the corresponding function group.
  The function **49R RotorTOLP** is taken as an example in the following steps.
- ✧ Under **General** of the function **49R RotorTOLP**, set the parameter **`Temperature acquisition`** to ***`Protocol COM`***.
- ✧ Set the parameter **`Temperature via protocol`** to ***`Analog units.Tmp.Acq.viaCom 1.Tmp.Ctl 1`***.



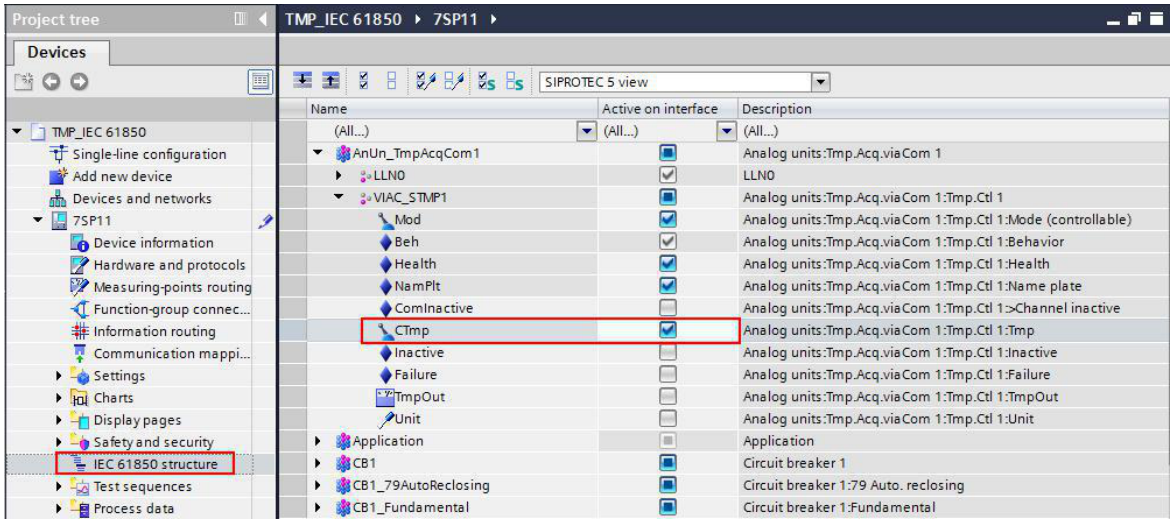
[sc_iec_61850_3, 2, en_US]

Figure 5-150 Parameter Configuration

Configuration in the IEC 61850 structure

✧ In the project tree, navigate to your device and double-click **IEC 61850 structure**.

✧ In the column **Name**, select **AnUn_TmpAcqCom 1** > **VIAC_STMP1** > **CTmp**.

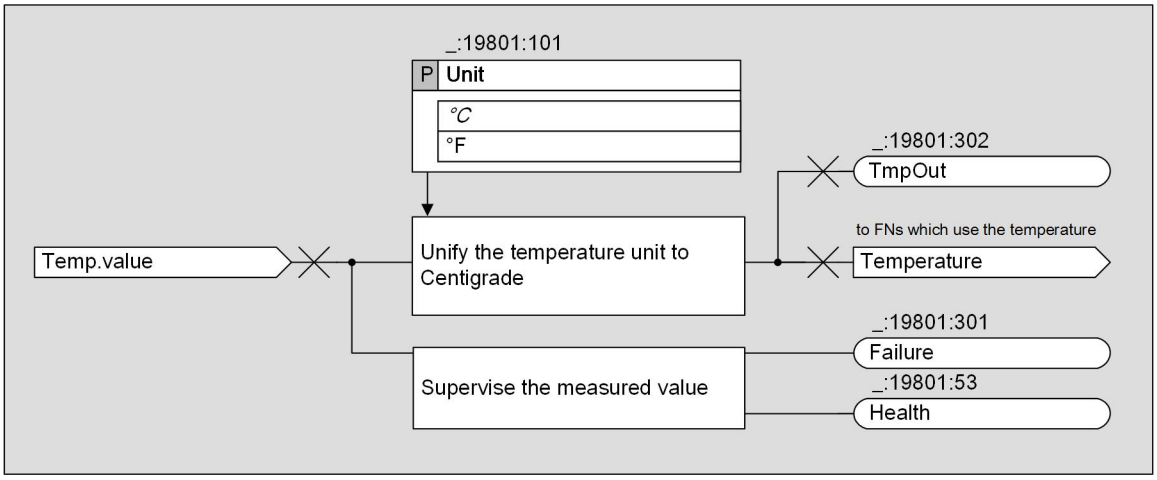


[sc_iec_61850_cgt, 1, en_US]

Figure 5-151 Data Selection

5.11.10.6 Stage Temperature Acquisition via GOOSE

Logic



[lo_tmpval, 1, en_US]

Figure 5-152 Logic Diagram of the Stage

Invalid Temperature Indication

If the received temperature is invalid, the failure indication *Temperature failure* is issued.

Stage Application

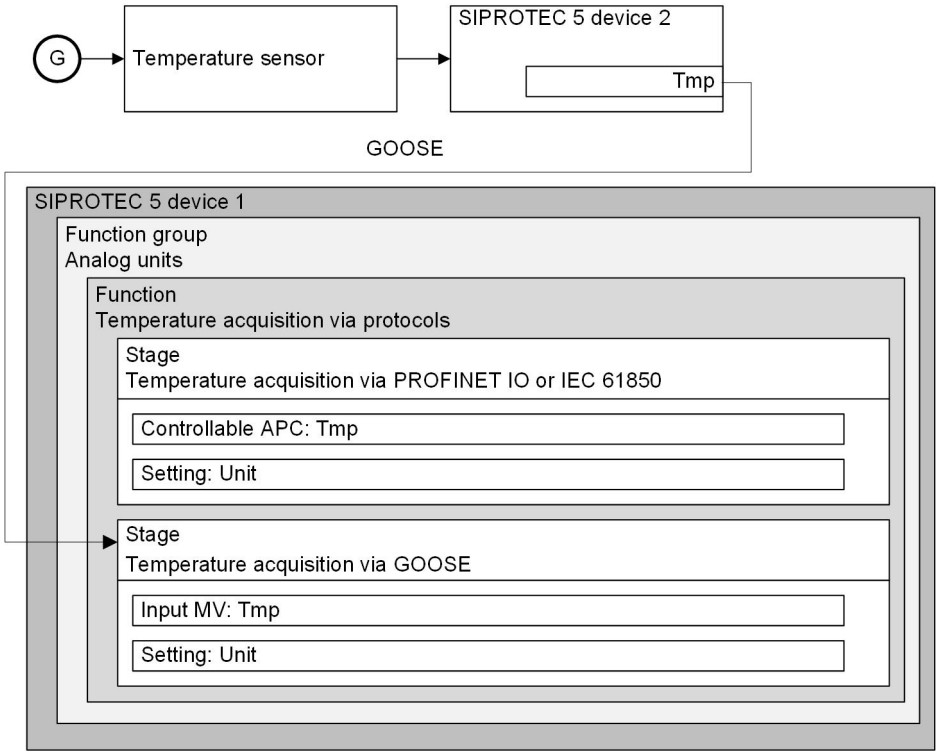
The following terms are used for the stage **Temperature acquisition via GOOSE**:

- Source device
  SIPROTEC 5 protection device that provides data
- Target device
  SIPROTEC 5 protection device that requests data from the source device

In the target device, you can use the stage **Temperature acquisition via GOOSE** for the following purposes:

- Acquire the cold-gas temperature from the source device
- Process the received cold-gas temperature value
- Send the processed cold-gas temperature value to other functions for further processing

In the following figure, the source device is SIPROTEC 5 device 2 and the target device is SIPROTEC 5 device 1.



[dw_app-example_GOOSE, 2, en_US]

Figure 5-153 Application Example

The following table explains the data.

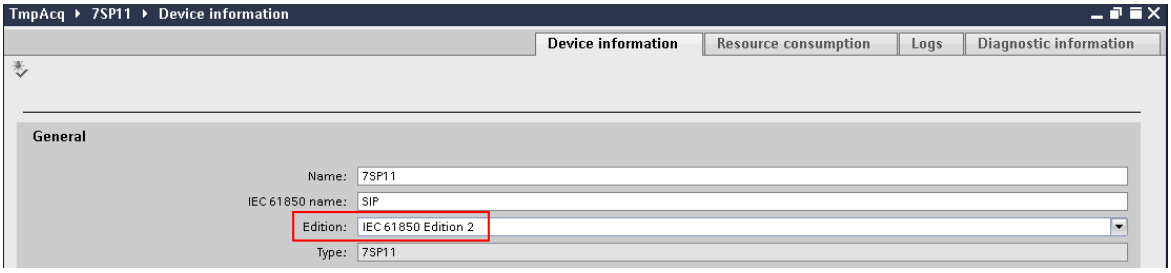
Data Name	Description
Tmp	With this variable, you can set the GOOSE protocol for the temperature acquisition. In the stage **Temperature acquisition via GOOSE**, the input measured value with a COM template is designed to acquire the data from another SIPROTEC 5 protection device.
Unit	With this parameter, you can select the unit ***°F*** or ***°C*** for the temperature which is acquired from another SIPROTEC 5 protection device.

5.11.10.7 GOOSE Configuration for the Temperature Acquisition

To acquire the cold-gas temperature with the stage **Temperature acquisition via GOOSE**, the following configurations are necessary.

IEC 61850 Edition Selection – Source Device

- ✧ In the project tree, select the source device and double-click **Device information**.
- ✧ In the **Device information** tab, set the parameter **Edition** to ***IEC 61850 Edition 2*** or a higher edition.

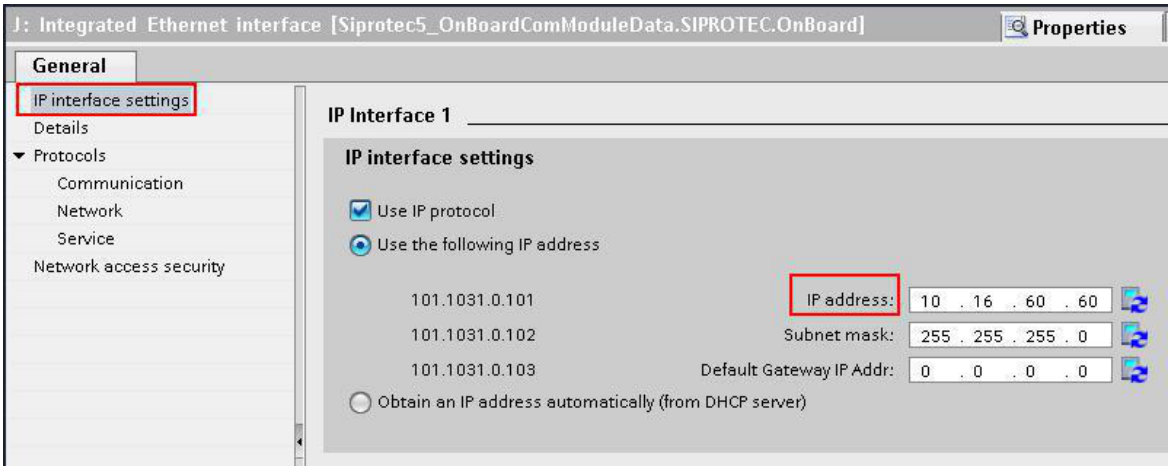


[sc_iec_edition, 1, en_US]

Figure 5-154 IEC 61850 Edition

IP-Address Configuration and Protocol Selection – Source Device

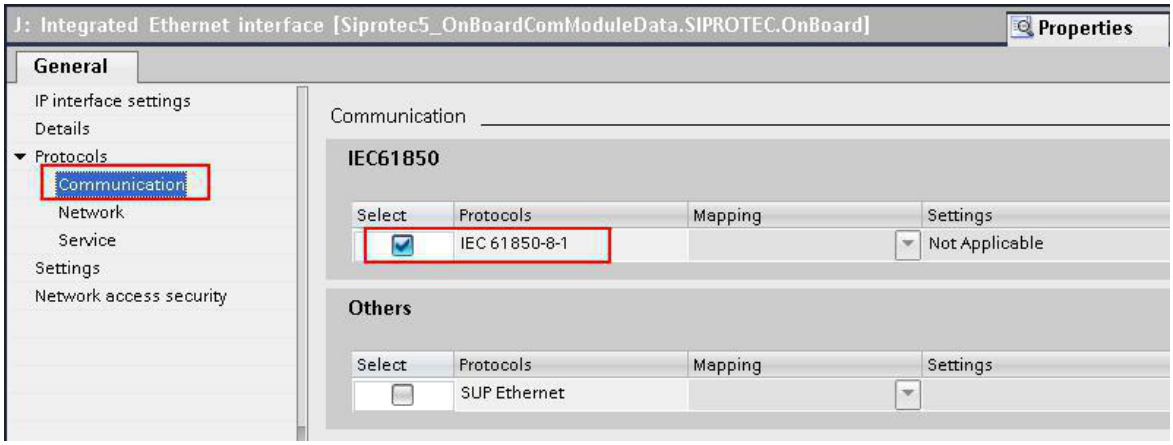
- ✧ In the project tree, select the source device and double-click **Hardware and protocols**.
- ✧ In the **Device view** tab, select the communication module for which you want to configure the IEC 61850 protocol.
- ✧ In the **Properties** tab of the communication module, select **General** > **IP interface settings**.
- ✧ Set the **IP address** for the communication module.



[sc_iec_61850_ip, 2, en_US]

Figure 5-155 IP-Address Configuration

- ✧ Select **General** > **Protocols** > **Communication**.
- ✧ Under **IEC61850**, select the item ***IEC 61850-8-1***.

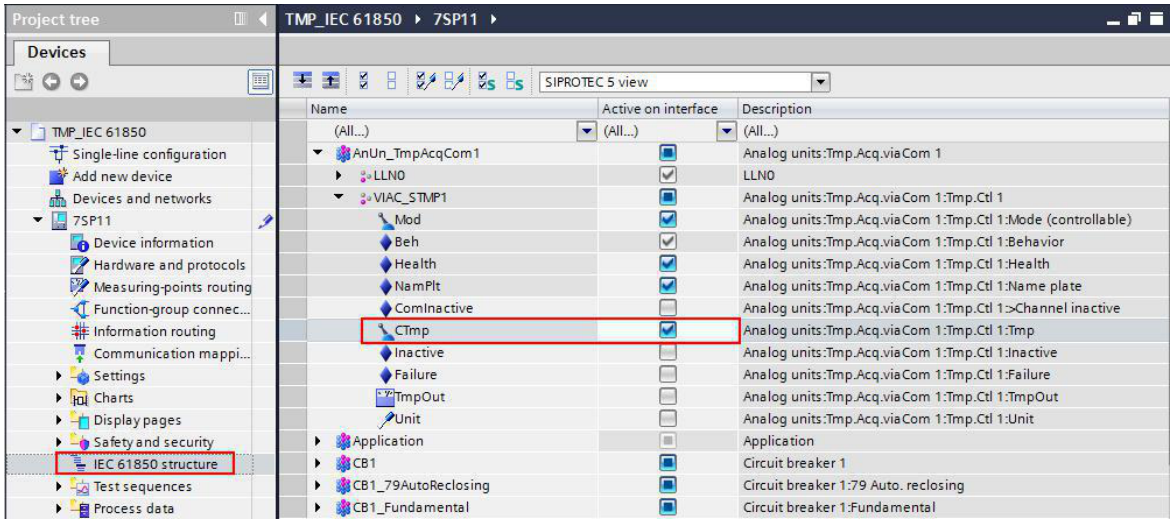


[sc_iec_61850_sel, 2, en_US]

Figure 5-156 Protocol Selection

Configuration in IEC 61850 structure – Source Device

- ✧ In the project tree, select the source device and double-click **IEC 61850 structure**.
- ✧ In the column **Name**, select **AnUn_TmpAcqCom 1** > **VIAC_STMP1** > **CTmp**.



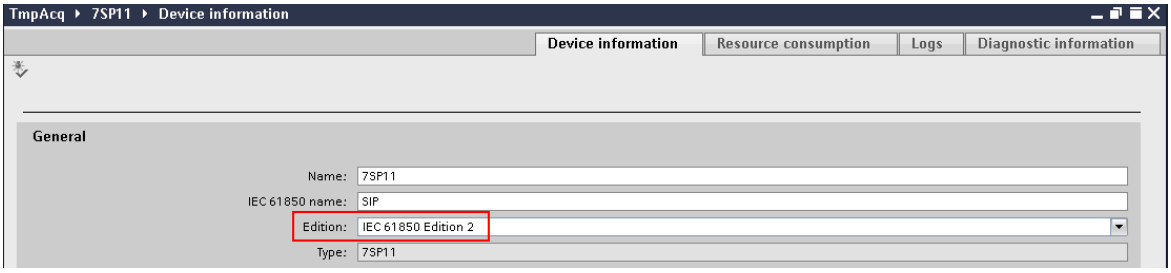
[sc_iec_61850_cgt, 1, en_US]

Figure 5-157 Data Selection

Now, the device can be used to send the cold-gas temperature to other devices.

IEC 61850 Edition Selection – Target Device

- ✧ In the project tree, select the target device and double-click **Device information**.
- ✧ In the **Device information** tab, set the parameter **`Edition`** to ***`IEC 61850 Edition 2`*** or a higher edition.

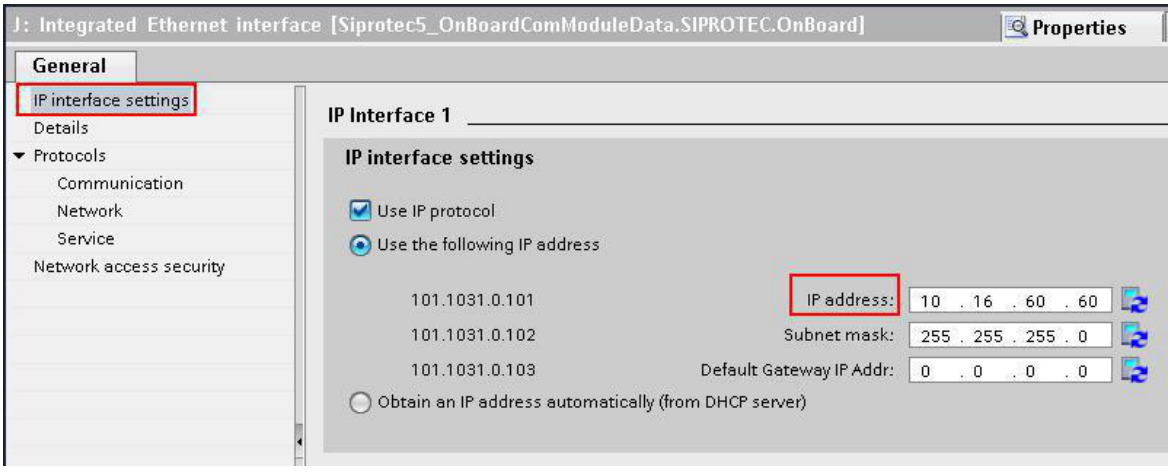


[sc_iec_edition, 1, en_US]

Figure 5-158 IEC 61850 Edition

IP-Address Configuration and Protocol Selection – Target Device

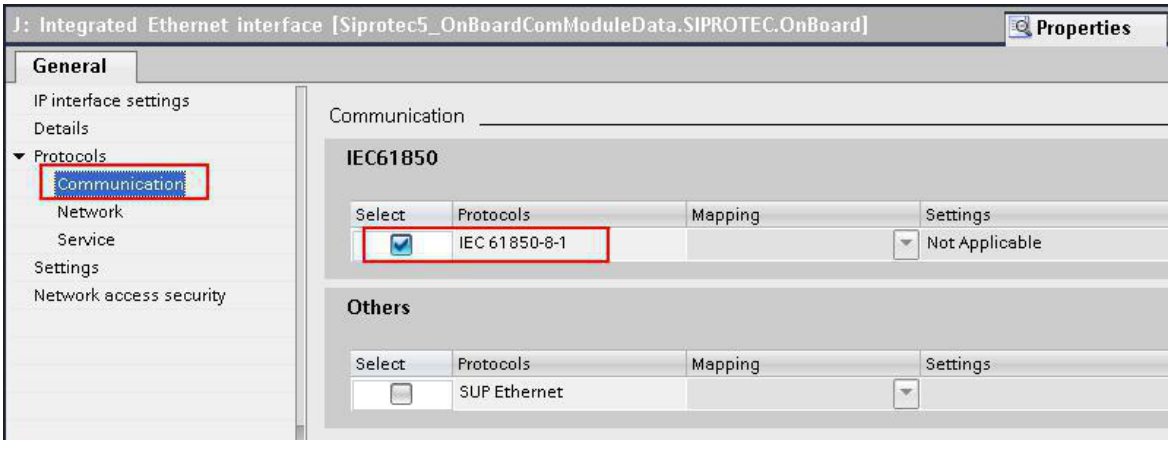
- ✧ In the project tree, select the target device and double-click **Hardware and protocols**.
- ✧ In the **Device view** tab, select the communication module for which you want to configure GOOSE.
- ✧ In the **Properties** tab of the communication module, select **General** > **IP interface settings**.
- ✧ Set the **IP address** for the communication module.



[sc_iec_61850_ip, 2, en_US]

Figure 5-159 IP-Address Configuration

- ✧ Select **Protocols** > **Communication** > **IEC 61850-8-1**.



[sc_iec_61850_sel, 2, en_US]

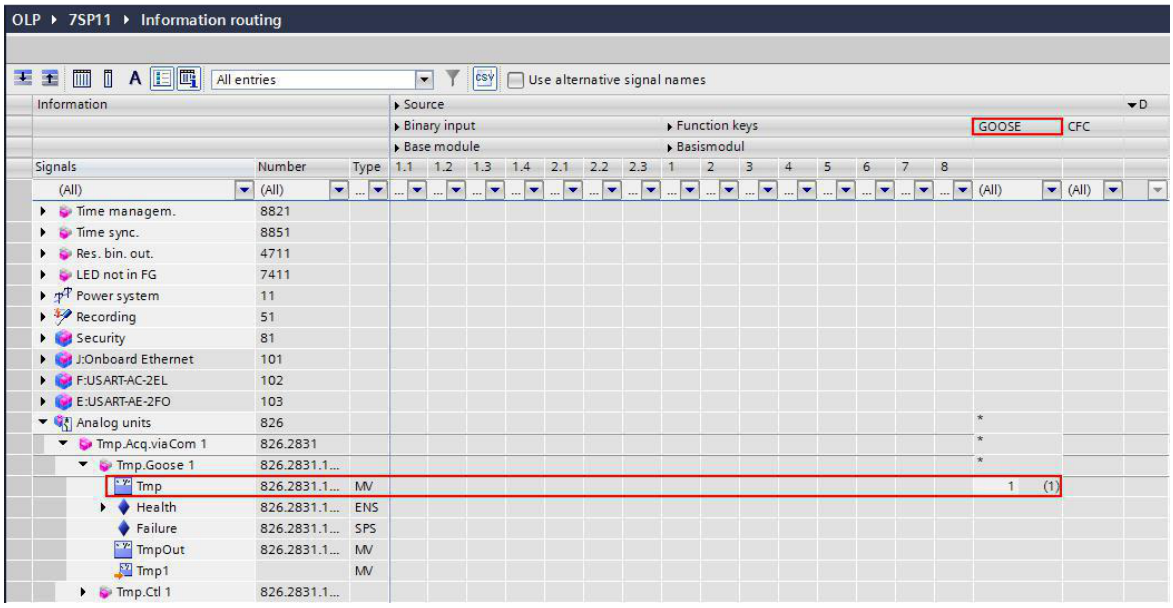
Figure 5-160 Protocol Selection

Function Instantiation – Target Device

- ✧ In the project tree, select the target device and select **Settings** > **Analog units**.
  If there is no function group **Analog units**, instantiate one.
- ✧ Instantiate the function **Tmp.Acq.viaCom** in the function group **Analog units**.
- ✧ Instantiate the stage **Tmp.GOOSE** in the function **Tmp.Acq.viaCom**.

Configuration in Information Routing – Target Device

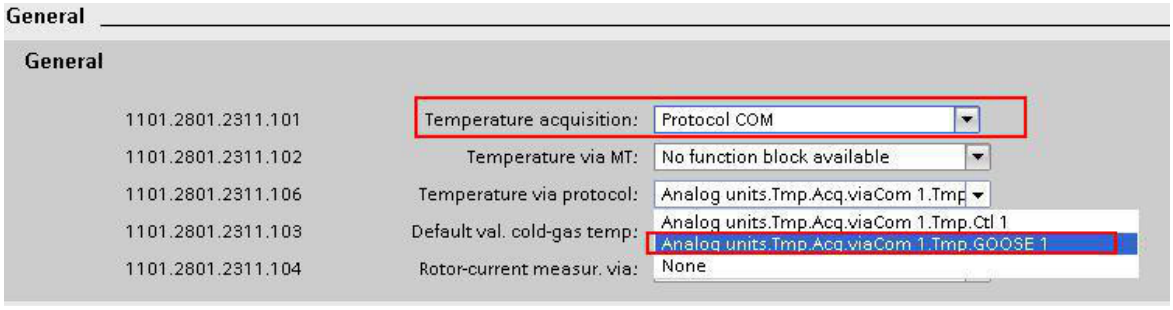
- ✧ In the project tree, select the target device and double-click **Information routing**.
- ✧ In the column **Signals**, select **Analog units** > **Tmp.Acq.viaCom 1** > **Tmp.Goose 1**.
- ✧ Set the value to ***1*** in the column **GOOSE** for the data **Tmp**.



[sc_station_10, 1, en_US]

Configuration of the Protection Function – Target Device

- ✧ Instantiate the function that requires the cold-gas temperature in the corresponding function group.
  The function **49R RotorTOLP** is taken as an example in the following steps.
- ✧ Under **General** of the function **49R RotorTOLP**, set the parameters **`Temperature acquisition`** to ***`Protocol COM`***.
- ✧ Set the parameter **`Temperature via protocol`** to ***`Analog units.Tmp.Acq.viaCom 1.Tmp.GOOSE 1`*** .



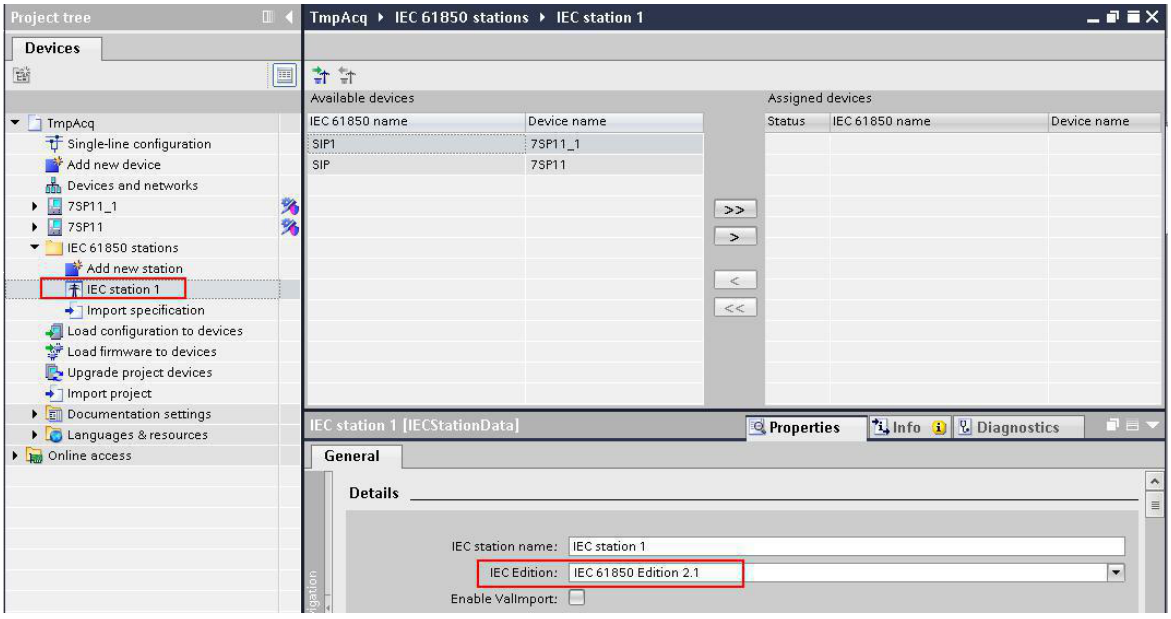
[sc_GOOSE_CGT, 2, en_US]

Figure 5-161 Parameter Configuration

Connection of the Source Device and the Target Device

✧ In the project tree, select **IEC 61850 stations** > **IEC station 1**.
If there is no station, double-click **Add new station** and create one.

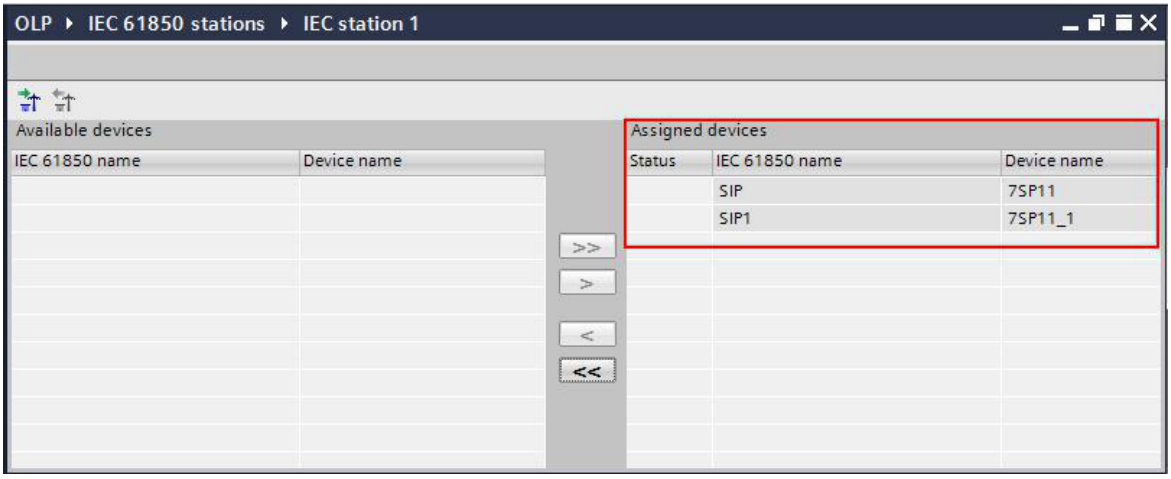
✧ Double-click **IEC station 1** and set the parameter **`IEC Edition`** to ***`IEC 61850 Edition 2`*** or a higher edition in the **Properties** tab.



[sc_iec_station, 2, en_US]

Figure 5-162 IEC 61850 Edition

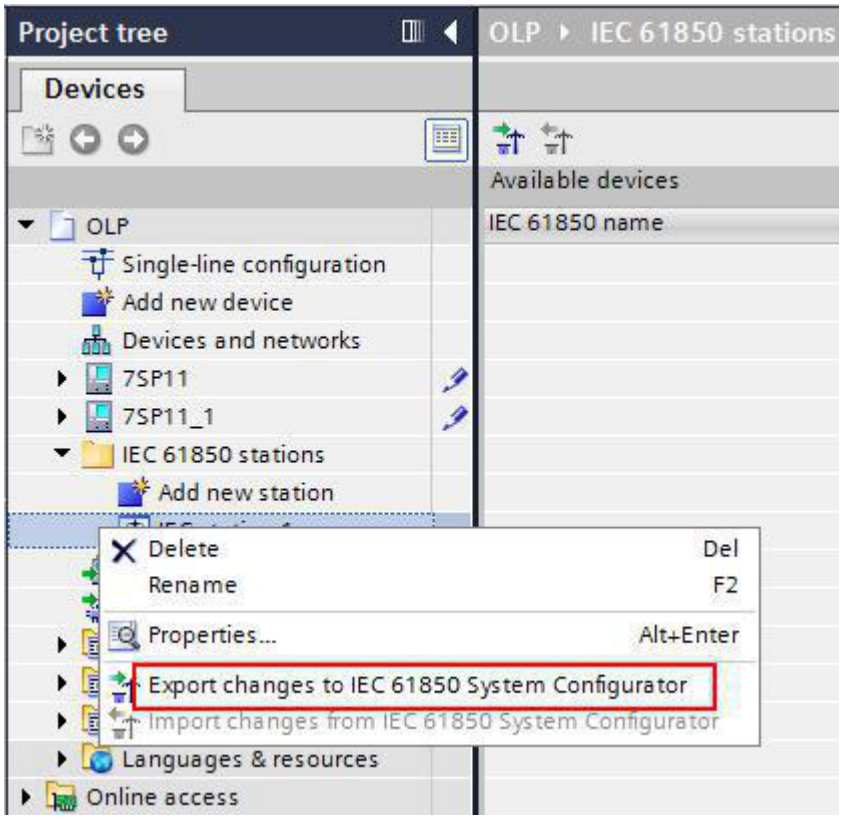
✧ Assign the available devices to the IEC station.



[sc_device_assign, 1, en_US]

Figure 5-163 Device Assignment

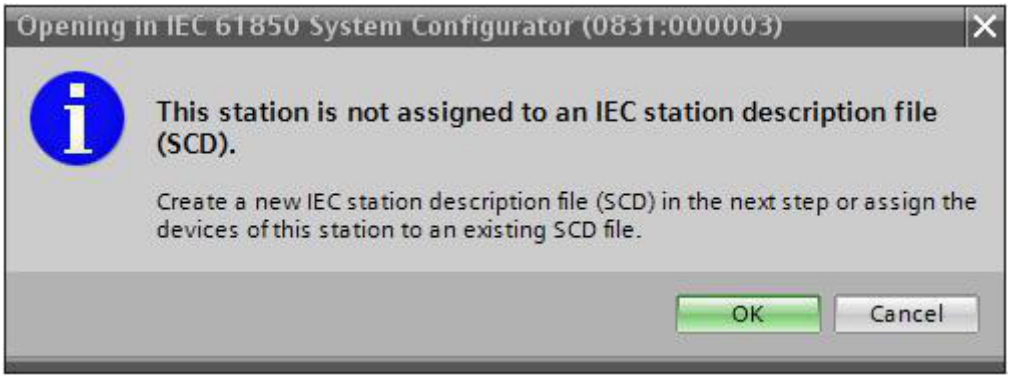
✧ Right-click the station and select **Export changes to IEC 61850 System Configurator** in the context menu.



[sc_export_IEC, 1, en_US]

Figure 5-164 Export Changes to IEC 61850 System Configurator

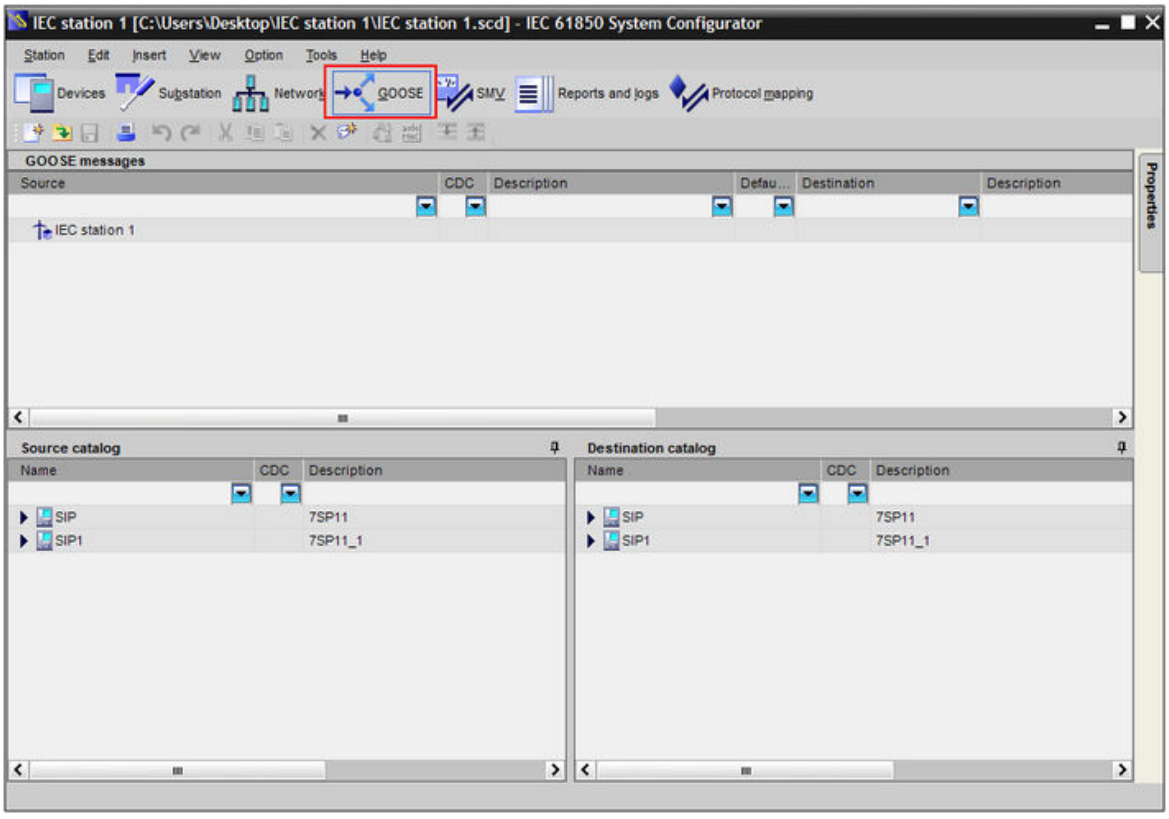
✧ If the following dialog appears, click **OK** and save the SCD file to a folder.



[sc_iec_confim, 1, en_US]

Figure 5-165 SCD File Creation

✧ In the opened **IEC 61850 System Configurator** window, select **GOOSE** in the toolbar.

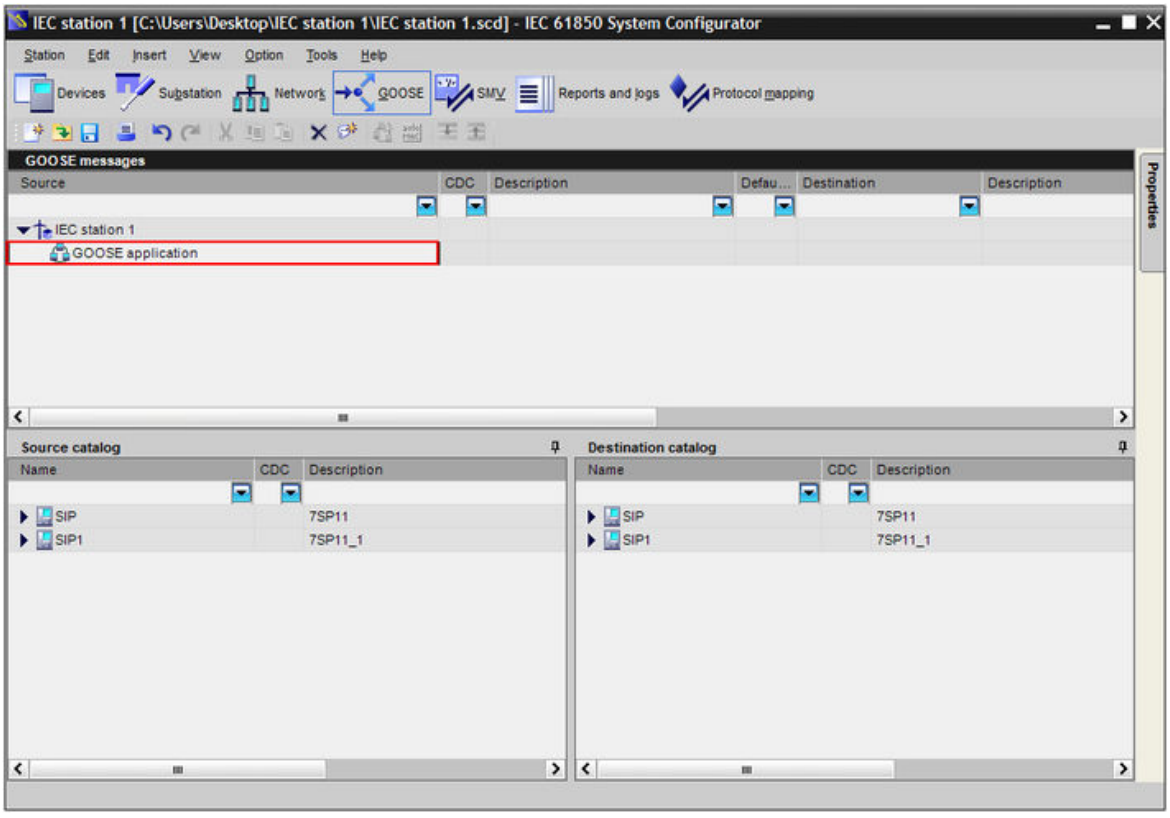


[sc_station_01, 2, en_US]

Figure 5-166 GOOSE-Function Selection

✧ In the **GOOSE messages** view, right-click the IEC station and select **GOOSE application** in the context menu.

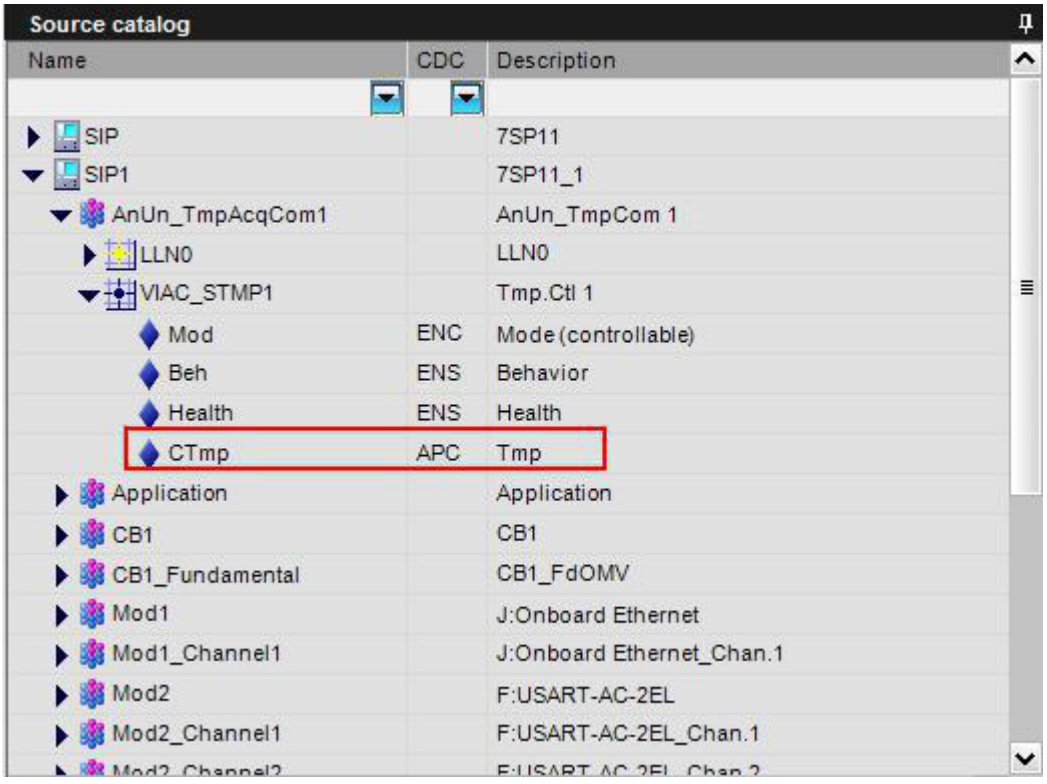
The **GOOSE application** is listed under the IEC station.



[sc_station_02, 2, en_US]

Figure 5-167 GOOSE Application Creation

✧ In the **Source catalog** area, navigate to the source device and select **AnUn_TmpAcqCom 1** > **VIAC_STMP1** > **CTmp**.



[sc_station_03, 1, en_US]

Figure 5-168 Source-Data Selection

✧ Drag the data **CTmp** and drop it to **GOOSE application** in the **GOOSE messages** view.

You can see the assigned source data.



[sc_station_04, 1, en_US]

Figure 5-169 Source-Data Assignment

✧ Unfold the assigned source data.

✧ In the **Destination catalog** area, navigate to the target device and select **AnUn_TmpAcqCom1** > **RxTmp1**.

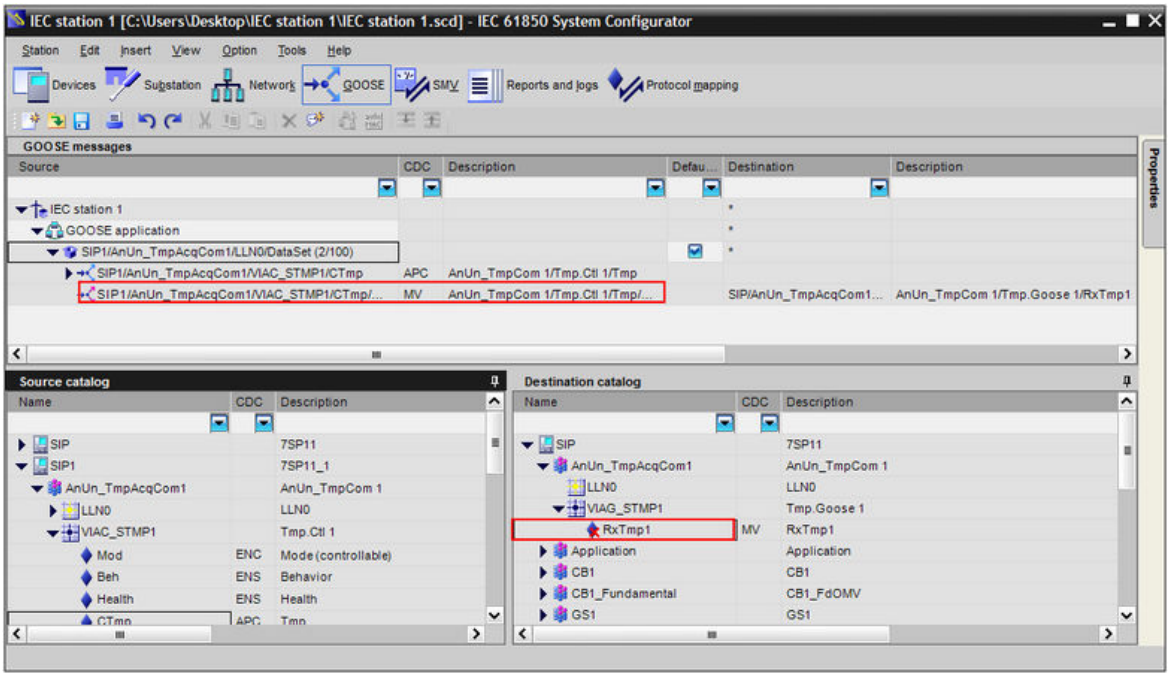


[sc_station_06, 1, en_US]

Figure 5-170 Target-Data Selection

✧ Drag the data **RxTmp1** and drop it to the assigned source data.

Now, the target data is connected with the source data.

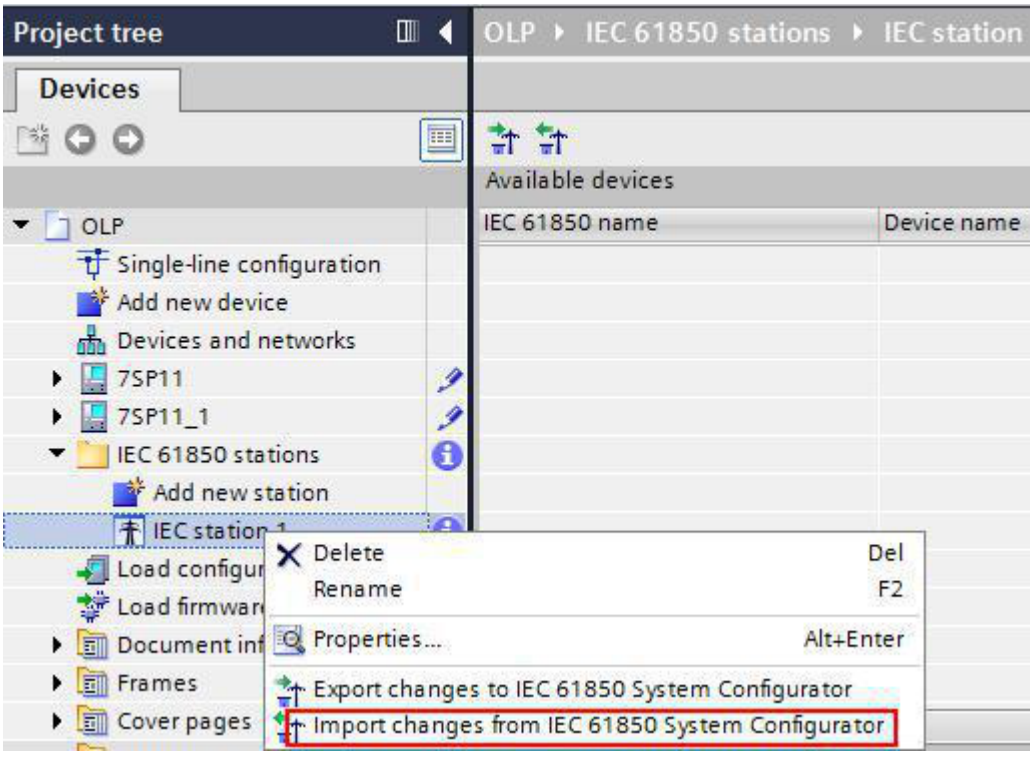


[sc_station_11, 2, en_US]

Figure 5-171 Destination-Data Assignment

✧ Save the configurations.

✧ In DIGSI 5 in the project tree, right-click the IEC station and select **Import changes from IEC 61850 System Configurator** in the context menu.



[sc_station_08, 1, en_US]

Figure 5-172 Import Changes from IEC 61850 System Configurator

If the following dialog appears, the source device and the target device are successfully connected.



[sc_End, 1, en_US]

Figure 5-173 Successful Device Connection

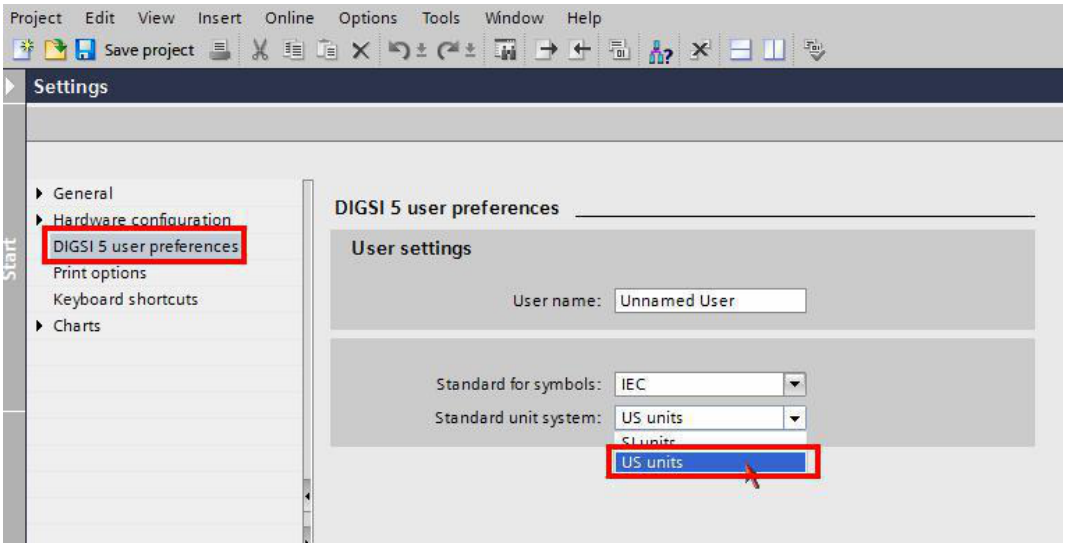
✧ Click **OK** to finish the connection.

5.11.10.8 Application and Setting Notes

Change of the Temperature Unit

Commonly, the temperature unit °C is used in the display and evaluation of measured temperature values.

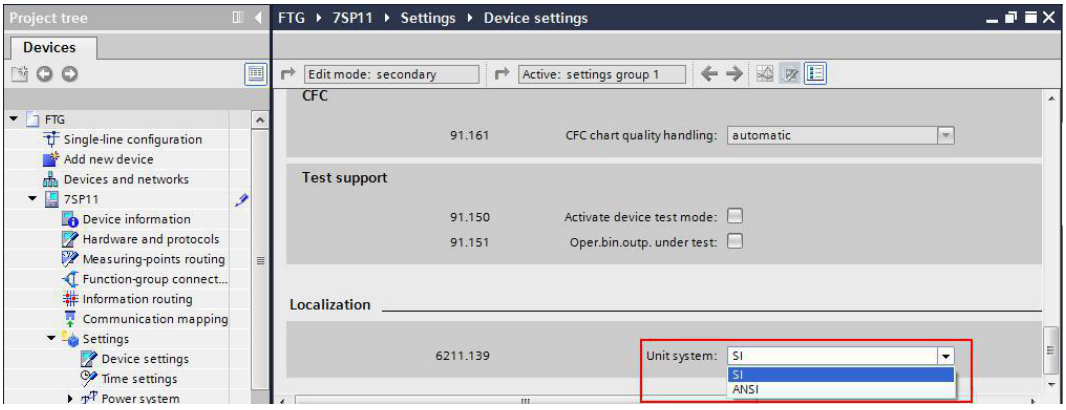
- To change the temperature unit from °C to °F for all devices in the current DIGSI project, proceed as follows:
  - In DIGSI, select the menu item **Options** > **Settings**.
  - In the **Settings** view, select the menu item **DIGSI 5 user preferences**.
  - Set the parameter **`Standard unit system`** to ***`US units`***.



[scfahrht-190214-01, 1, en_US]

Figure 5-174 Change of the Temperature Unit between °C and °F for all Devices

- To change the temperature unit from °C to °F for 1 device, proceed as follows:
  - In the project tree, navigate to your device and select **Settings** > **Device settings**.
  - In the **Device settings** view, navigate to the menu item **Localization**.
  - Set the parameter **`Unit system`** to ***`ANSI`***.



[sc_SITmp, 1, en_US]

Figure 5-175 Change of the Temperature Unit between °C and °F for 1 Device

NOTE

If the parameter **Unit system** is set to ***ANSI***, only the unit of the measuring values and parameters changes to °F.

The unit of the following data is still °C:

- Other temperature data in the device
- The temperature thresholds in DCF

Parameter: Unit

- Default setting **(_:19801:101) Unit** = ***°C***

You use the setting **Unit** to specify which physical unit of the source data the measured values represent. The possible setting values are listed in the settings table.

5.11.10.9 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Tmp.Ctl 1				
_:19801:101	Tmp.Ctl 1:Unit		• °C • °F	°C

5.11.10.10 Information List

No.	Information	Data Class (Type)	Type
Tmp.Ctl 1			
_:19801:501	Tmp.Ctl 1:>COM channel inactive	SPS	I
_:19801:300	Tmp.Ctl 1:Tmp	APC	C
_:19801:52	Tmp.Ctl 1:Behavior	ENS	O
_:19801:53	Tmp.Ctl 1:Health	ENS	O
_:19801:301	Tmp.Ctl 1:Failure	SPS	O
_:19801:302	Tmp.Ctl 1:TmpOut	MV	O

5.11.11 LPIT Module IO240

5.11.11.1 Overview

The input module IO240 for the low-power instrument transformer in the gas insulated switchgear (GIS-LPIT) and for the resistive-capacitive voltage transformer (RCVT) from Siemens Energy (**LPIT module IO240**):

- Measures temperature values, voltage values, and current values
- Provides an interface for SIPROTEC 5 modular devices to connect to Siemens Energy GIS-LPIT (GIS-LPVT and GIS-LPCT) and RCVT
- Converts current values into primary values
- Converts voltage values into primary values according to the sensor type (GIS-LPVT or RCVT)
- Provides primary values for protection functions, the voltage measurement, and the current measurement

The input module IO240 is available in a hardware variant of the 6MU85 device as part of the 1/3 base module or as an expansion module for installation in modular SIPROTEC 5 devices.

NOTE

Due to the higher power demand of the IO240 boards, a maximum of 2 IO240 modules are allowed per device row and totally a maximum of 4 IO240 modules are allowed in a SIPROTEC 5 device. This limitation also applies to the case that 1 of the IO240 modules is used in the 1/3 basic housing.

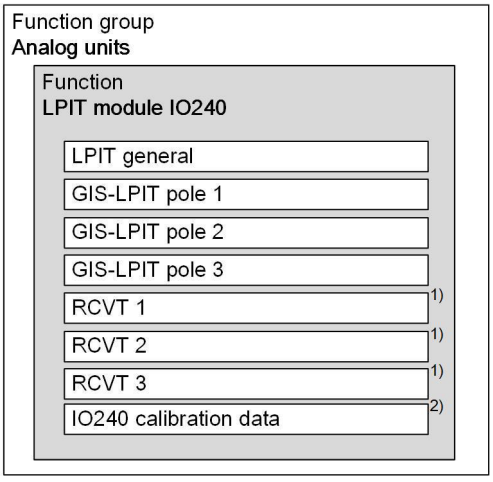
For more information on the use and configuration of the IO240 module combined with the connected LPIT, refer to the *Application Note APN-090 IO240 and LPITs*.

5.11.11.2 Structure of the Function

The function **LPIT module IO240** works in the function group **Analog units**.

The function **LPIT module IO240** contains the following function blocks:

- 3 for **GIS-LPIT pole**
- 3 for **RCVT**
- 1 for **IO240 calibration data**

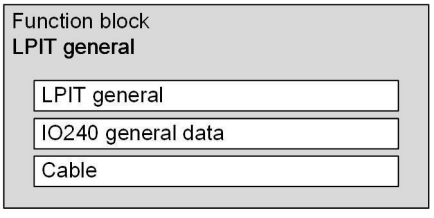


[dw_strIO240, 4, en_US]

Figure 5-176 Structure of the Function LPIT module IO240

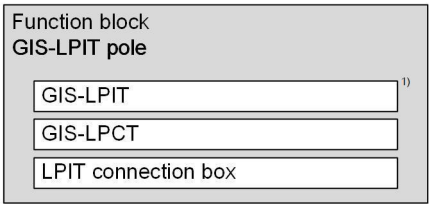
(1) It is available when the parameter **`Use RCVT as volt. sensor`** under **LPIT General** is checked.

(2) It is available when the parameter **`Use cal. data IO240 board`** under **IO240 general data** is checked.



[dw_strIO240_LPIT General, 4, en_US]

Figure 5-177 Structure of the Function Block LPIT general



[dw_strIO240_LPIT Sensor, 5, en_US]

Figure 5-178 Structure of the Function Block GIS-LPIT pole

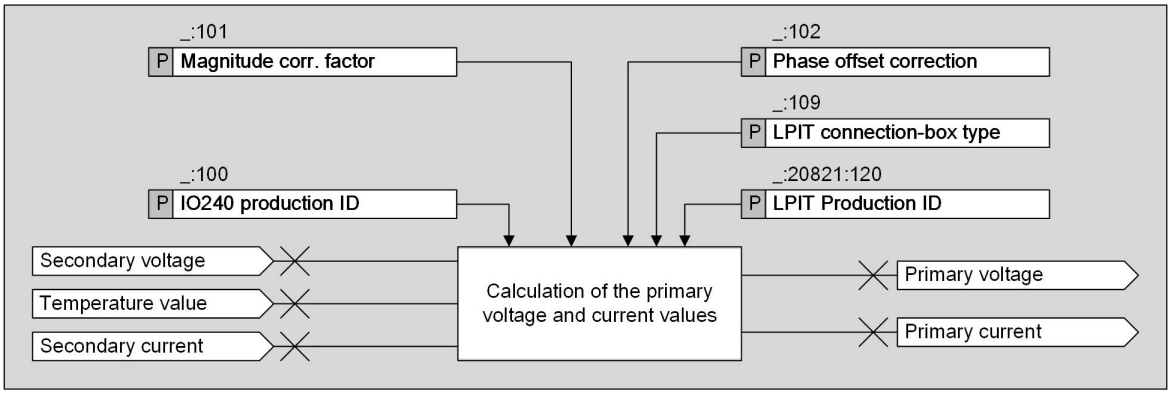
(1) It is available when the parameter **GIS-LPIT type** under **LPIT General** is set to ***LPIT 1-phase***.

5.11.11.3 Function Description

Once you have instantiated the **LPIT module IO240**, it is visible in the project tree in the function group **Analog units**. You can find the function group **Analog units** in the folder **Settings** of the device in the DIGSI 5 project tree.

If you open the subdirectory **LPIT-IO240**, you reach the setting sheet for the function blocks **LPIT General**, **GIS-LPIT pole**, **RCVT**, and **IO240 cal.data**. For more information, refer to *5.11.11.4 Application and Setting Notes* and *5.11.11.5 Settings*.

Logic of the LPIT Module IO240



[lo_IO240_logic_diagram, 4, en_US]

Figure 5-179 Logic of the LPIT Module IO240

NOTE

The parameter **IO240 production ID** is only used for calculation when the parameter **Use cal. data IO240 board** in the function block **IO240 general data** is checked.

The parameters **Magnitude corr. factor** and **Phase offset correction** are only used for calculation when the parameter **Use RCVT as volt. sensor** in the function block **LPIT General** is checked.

Calculation of the Primary Values

When RCVT is not used, the **LPIT module IO240** obtains the temperature values and secondary values from the GIS-LPIT sensor. When RCVT is used, the **LPIT module IO240** obtains the temperature values and secondary-current values from the GIS-LPIT sensor, and the secondary-voltage values from the RCVT sensor. The secondary values are converted into the corresponding primary values based on the settings in the function blocks **LPIT general**, **GIS-LPIT pole**, **RCVT**, and **IO240 calibration data**. The primary values are then internally provided to the device for the measurement functions or protection functions, and can be optionally published as sampled measured values.

Temperature Value of the GIS-LPIT Sensor

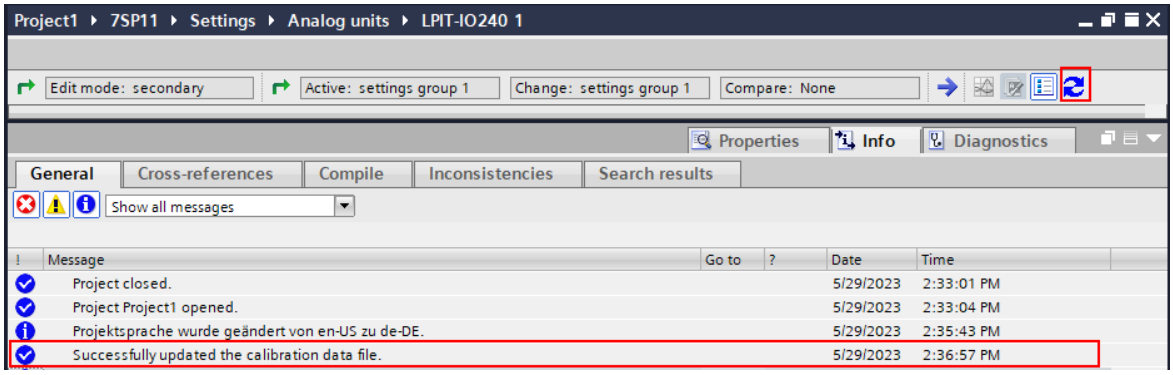
The **LPIT module IO240** measures the temperature value of the GIS-LPIT sensor via the PT100 sensors of the GIS-LPIT. The temperature is used to compensate the temperature influence of the measured secondary values. This allows an accurate calculation of the primary values. The measured resistance of the PT100 sensor and the resulting temperature are available as information in the device for further use, such as customized logic charts (CFC) and recording. The resistance and temperature values are shown on the HMI.

If RCVT is used as the voltage input, the temperature value of the GIS-LPIT sensor has no influence on the voltage measurement.

5.11.11.4 Application and Setting Notes

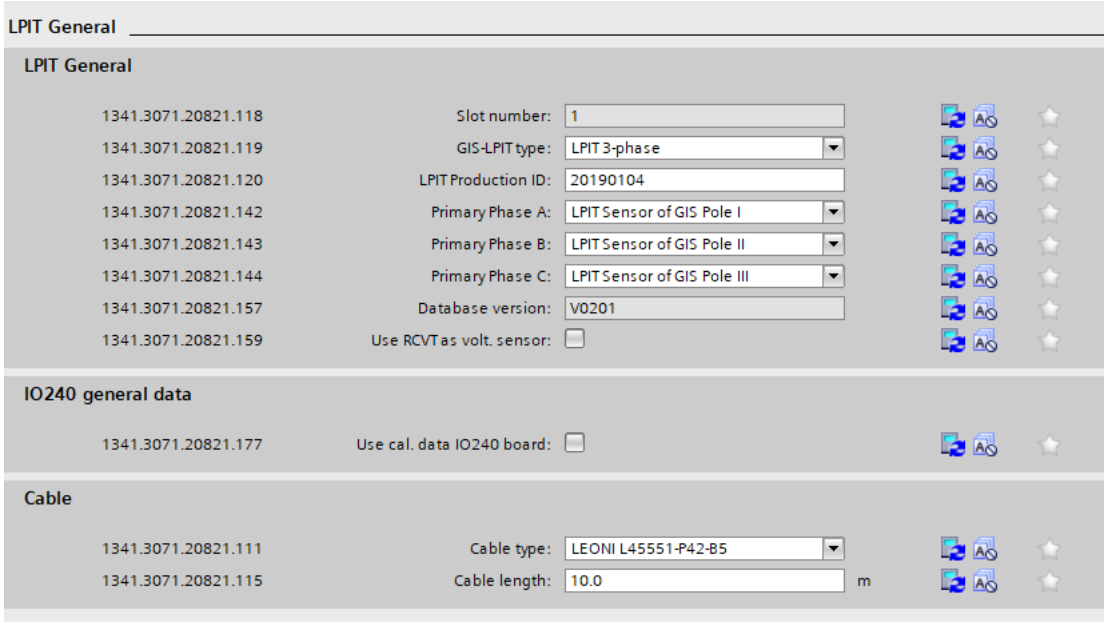
Calibration Data

The calibration data of the GIS-LPIT sensor, the GIS-LPIT connection box, and the IO240 board are stored in a cloud storage. Therefore, the calibration data for DIGSI are available independently from the DIGSI 5 version and can be updated for newly produced GIS-LPIT and IO240 board. To update the local copy of the calibration data file, you can click the refresh button  . The feedback of a successful or unsuccessful update of the calibration data file is given in the **Info** tab.



[sc_refresh button and message, 2, en_US]

Settings of the LPIT General



[sc_LPIT_General, 3, en_US]

Figure 5-180 Settings of the LPIT General

Parameter: `Slot number`

The parameter specifies the mounting location of the IO240 board in the SIPROTEC 5 device and is used to identify the board mounting location when multiple IO240 boards are used in a device.

Parameter: `GIS-LPIT type`

- Default setting **`(_:20821:119) GIS-LPIT type`** = ***`LPIT 3-phase`***

With the parameter **`GIS-LPIT type`**, you set the GIS type used.

Parameter Value	Connection to the LPIT Module IO240	GIS-LPIT Sensor Type
`LPIT 3-phase`	Rogowski coil Capacitive voltage sensor	3-phase encapsulated (8DN8-5, 8DN8-6, 8VN1)
`3-phase without LPVT`	Rogowski coil	
`LPIT 1-phase`	Rogowski coil Capacitive voltage sensor	1-phase encapsulated
`1-phase without LPVT`	Rogowski coil	

Parameter: `LPIT Production ID`

To load the calibration data of your GIS-LPIT sensor from the calibration data file, enter the corresponding GIS-LPIT production ID. You can find the GIS-LPIT Production ID at the GIS-LPIT sensor name plate.



NOTE

Each **LPIT Production ID** is unique.

Parameter: `Primary Phase A`, `Primary Phase B`, `Primary Phase C`

- Default setting **`(_:142) Primary Phase A`** = ***`LPIT Sensor of GIS Pole I`***
- Default setting **`(_:143) Primary Phase B`** = ***`LPIT Sensor of GIS Pole II`***
- Default setting **`(_:144) Primary Phase C`** = ***`LPIT Sensor of GIS Pole III`***

With these parameters, you define the mapping relationship between the primary phase and the LPIT sensor of GIS pole, according to the physical connection. The **LPIT module IO240** takes the settings of the corresponding LPIT sensor of GIS pole for each phase.

Parameter: `Use RCVT as volt. sensor`

- Default setting: the parameter **`(_:20281:159) Use RCVT as volt. sensor`** is unchecked.

With the parameter **`Use RCVT as volt. sensor`**, you decide whether to use the GIS-LPVT or RCVT as the voltage sensor type for the primary-voltage measurement. When this parameter is checked, the 3 function blocks for **RCVTs** are available and all the settings related to GIS-LPVT are invisible.

Parameter: `Crosstalk RCVT 1 to 2`, `Crosstalk RCVT 2 to 1`, `Crosstalk RCVT 2 to 3`, `Crosstalk RCVT 3 to 2`, `Crosstalk RCVT 3 to 1`, `Crosstalk RCVT 1 to 3`

- Default setting **`(_:160) Crosstalk RCVT 1 to 2`** = ***`0.000 %`***
- Default setting **`(_:161) Crosstalk RCVT 2 to 1`** = ***`0.000 %`***
- Default setting **`(_:162) Crosstalk RCVT 2 to 3`** = ***`0.000 %`***
- Default setting **`(_:163) Crosstalk RCVT 3 to 2`** = ***`0.000 %`***
- Default setting **`(_:164) Crosstalk RCVT 3 to 1`** = ***`0.000 %`***
- Default setting **`(_:165) Crosstalk RCVT 1 to 3`** = ***`0.000 %`***

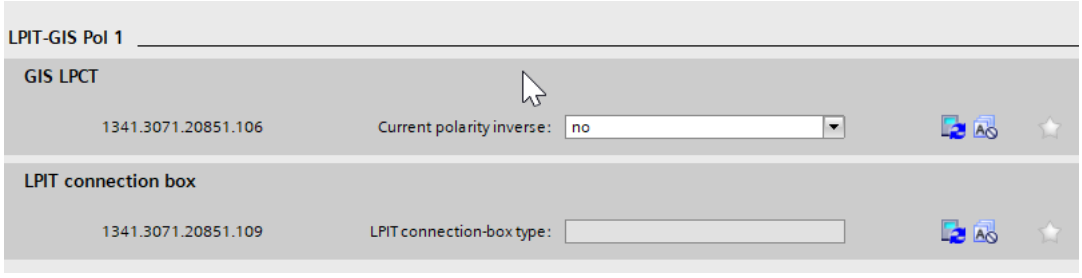
With these parameters, you configure the mutual influence of crosstalk from the RCVT in one phase to the one in another phase.

Parameter: `Use cal. data IO240 board`

- Default setting: the parameter **`(_:20821:177) Use cal. data IO240 board`** is unchecked.

With the parameter **`Use cal. data IO240 board`**, you decide whether to use the calibration data of the IO240 board for the primary-value calculation to achieve measuring accuracy class 0.1. When this parameter is checked, the function block **IO240 cal.data** is available.

Settings of the LPIT-GIS Pole



[sc_LPIT-GIS_pole, 2, en_US]

Figure 5-181 Settings of the LPIT-GIS Pole, Example

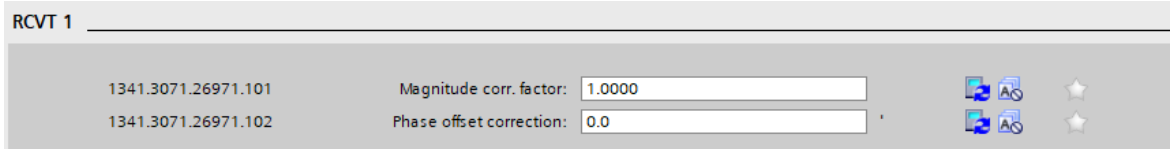
Parameter: `Current polarity inverse`

With this parameter, you confirm whether the polarity of the physically-connected current is inversed. If the current polarity is inversely connected, set this parameter to ***`yes`***.

Parameter: `LPIT connection-box type`

After the GIS-LPIT production ID is entered, the type of the LPIT connection box is visible in DIGSI. It is not configurable.

Settings of the RCVT Sensors



[sc_settings_RCVT, 1, en_US]

Figure 5-182 Settings of the RCVT

Parameter: `Magnitude corr. factor`, `Phase offset correction`

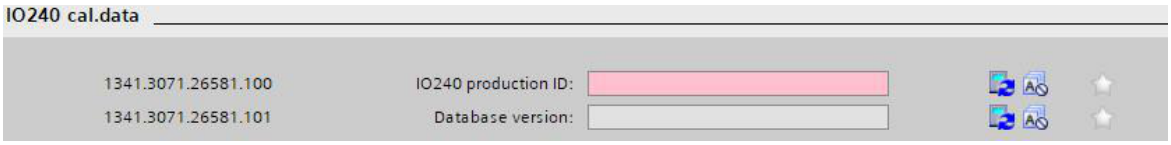
- Default setting **`(_:101) Magnitude corr. factor`** = ***`1.0000`***
  With the parameter **`Magnitude corr. factor`**, you adjust the magnitude for the voltage input.
- Default setting **`(_:102) Phase offset correction`** = ***`0.0 '`***
  With the parameter **`Phase offset correction`**, you adjust the phase angle for the voltage input.

These parameters allow you to correct the tolerances of the primary-voltage transformer phase-selectively. Magnitude correction and phase-offset correction are probably required for high-precision measurements.

Settings of the IO240 Calibration Data

To achieve the measuring accuracy class 0.1, the calibration data of the IO240 board used are required. The board-specific calibration data can be ordered separately from the supplier of the LPIT sensor.

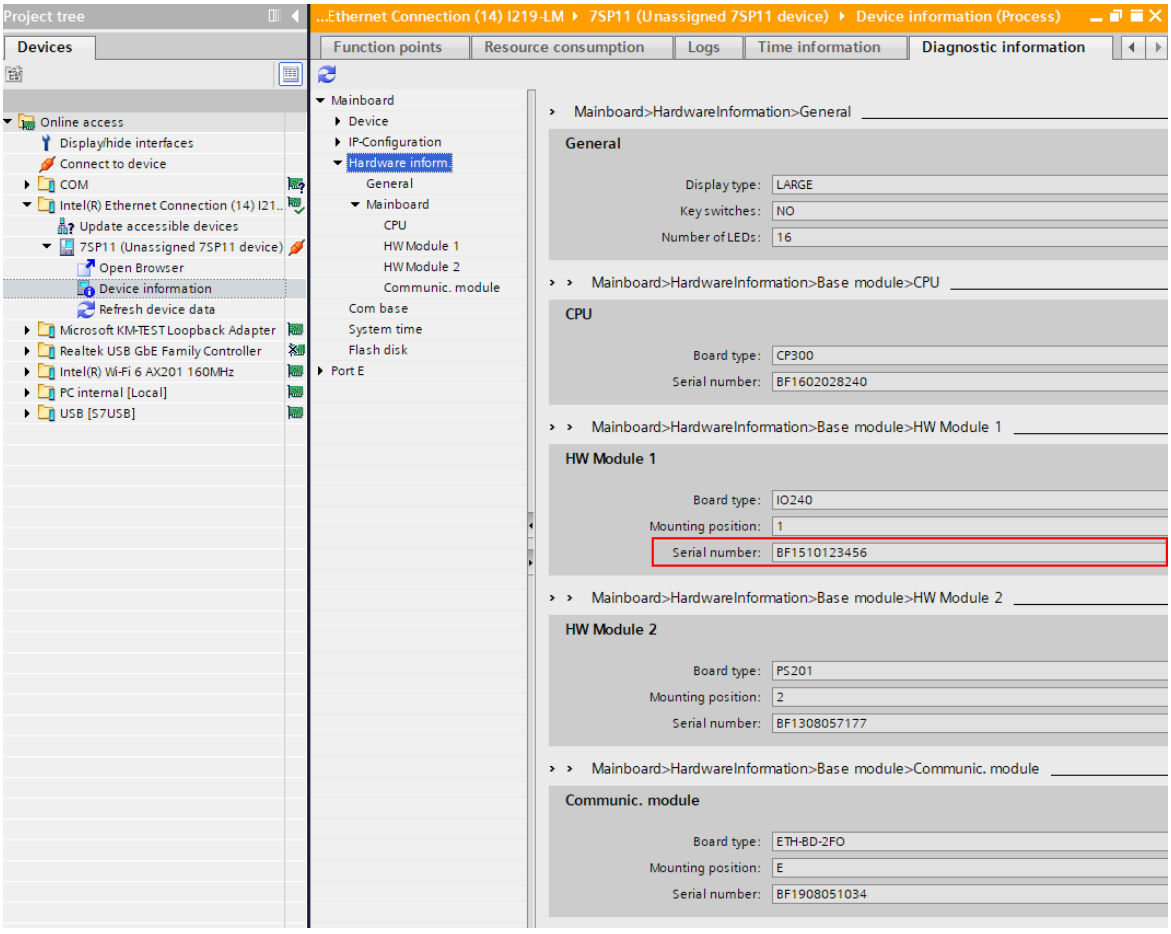
In the function block **IO240 cal.data**, there are 2 parameters **`IO240 production ID`** and **`Database version`**.



[sc_IO240 cal. data, 1, en_US]

Figure 5-183 Settings of the IO240 Calibration Data

For the parameter **`IO240 production ID`**, you must enter the value manually. You can find the production ID of the IO240 board in DIGSI 5 via **Online access** > **Device information** > **Hardware inform.** > HW module with the board type: IO240. You can also get the production ID of the specific IO240 board from the LPIT supplier.



[sc_IO240_production_ID, 1, en_US]

Figure 5-184 IO240 Production ID

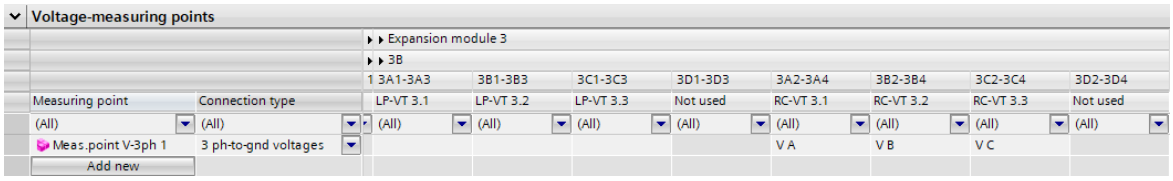
After the production ID is entered, the corresponding version of database is visible in DIGSI. The version is not configurable.

Measuring-Points Routing

The **LPIT module IO240** only supports the ***`3 ph-to-gnd voltages`*** connection type of voltage and the ***`3-phase`*** connection type of current in the **Measuring-points routing**.

2 groups of 3-phase voltage measuring channels with different voltage-transformer types derived from the connected voltage sensor are available in the **Measuring-points routing**. For each **LPIT module IO240**, you can only route 1 group of the 3-phase voltage measuring channels according to the connected voltage sensor,

either GIS-LPVT or RCVT. The measuring-points routing must be consistent with the configuration of the parameter **`Use RCVT as volt. sensor`**. Otherwise, DIGSI 5 reports an inconsistency.



[sc_IO240 voltage connection type, 3, en_US]

Figure 5-185 IO240 Voltage Connection Type

NOTE

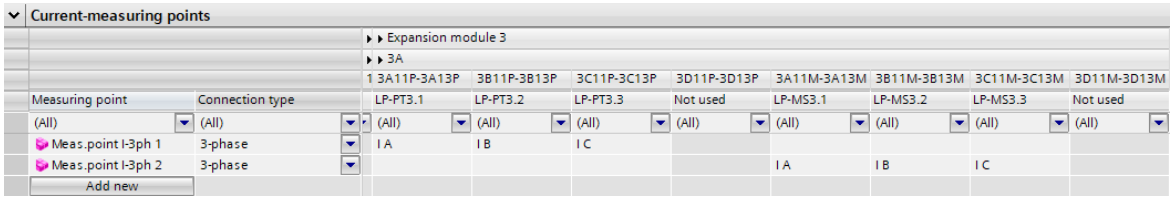
The voltages in the following channels are for the GIS-LPVT sensor:

- LP-VT3.1
- LP-VT3.2
- LP-VT3.3

The voltages in the following channels are for the RCVT sensor:

- RC-VT3.1
- RC-VT3.2
- RC-VT3.3

2 groups of 3-phase current measuring channels with different measuring ranges derived from the connected Rogowski coil are available in the **Measuring-points routing**. The protection channel supplies a dynamic range of 100 times the rated primary current of the assigned current measuring point. The measuring channel supplies a dynamic range of 1.6 times the rated primary current of the assigned measuring point, with higher accuracy than the protection channel. The rated primary current must be set accordingly in the settings for the current measuring points. The settings for the current measuring points can be found in the device settings under **Settings** and **Power System**.



[sc_IO240 current connection type, 3, en_US]

Figure 5-186 IO240 Current Connection Type

NOTE

The currents in the following channels are for the protection function:

- LP-PT3.1
- LP-PT3.2
- LP-PT3.3

The currents in the following channels are for the measurement function:

- LP-MS3.1
- LP-MS3.2
- LP-MS3.3

Measuring Point Voltage 3-Phase (V-3ph)

For the voltage measuring points of the **LPIT module IO240**, the value of the parameter **`Rated secondary voltage`** is the basis for the configuration of the parameters in secondary values. When connected to the GIS-LPVT sensor, the rated secondary voltage is preset permanently to a virtual voltage of 100 V and is invisible in DIGSI. When connected to the RCVT sensor, the rated secondary voltage is preset permanently to a real voltage of 100 V, which is visible and read-only in DIGSI.

For more information on the measuring point voltage 3-phase (V-3ph), refer to *6.1.4 Application and Setting Notes for Measuring-Point Voltage 3-Phase (V-3ph)*.

Measuring Point Current 3-Phase (I-3ph)

For the current measuring point of the **LPIT module IO240** for both the protection and measuring channels, the rated secondary current is preset permanently to a virtual current of 1 A. This value is the basis for the parameterization of the settings in secondary values. The parameter **`Rated secondary current`** is invisible in DIGSI.

For more information on the measuring point current 3-phase (I-3ph), refer to *6.1.5 Application and Setting Notes for Measuring-Point Current 3-Phase (I-3ph)*.

Avoiding Unauthorized Access to IO240 Terminals

For revenue metering, to protect the measurement chain against unauthorized access, you have the following options:

- Use a shield cover; if necessary a sealing can be applied.
- Extend the shield cover with an optional microswitch (product code P1X596).

Application of the Optional Microswitch

After connection of the 2 leads from the microswitch to the terminals D9 and D10, the IO240 module can detect an opening of the shield cover and report it via SCADA communication. When the connected microswitch is actuated, the information *`(_:76) Shield cover`* changes the status. The information can be further processed via the information routing and reported to the control system, for example.

For more information on the installation, refer to the *SIPROTEC 5 Hardware manual*.

5.11.11.5 Settings

Addr.	Parameter	Setting Options	Default Setting
`LPIT General`			
_:118	LPIT General:Slot number	1 to 12 Not settable	Physical slot number of the IO240 board connection
_:119	LPIT General:GIS-LPIT type	• LPIT 1-phase • LPIT 3-phase • 1-phase without LPVT • 3-phase without LPVT	LPIT 3-phase
_:120	LPIT General:LPIT Production ID[27]	Production ID of the GIS sensor	–
_:142	LPIT General:Primary Phase A	• LPIT Sensor of GIS Pole I • LPIT Sensor of GIS Pole II • LPIT Sensor of GIS Pole III	LPIT Sensor of GIS Pole I

27 This parameter is visible under **GIS-LPIT** of each sensor when you set **GIS-LPIT type** to **LPIT 1-phase**.

Addr.	Parameter	Setting Options	Default Setting
_:143	LPIT General:Primary Phase B	• LPIT Sensor of GIS Pole I • LPIT Sensor of GIS Pole II • LPIT Sensor of GIS Pole III	LPIT Sensor of GIS Pole II
_:144	LPIT General:Primary Phase C	• LPIT Sensor of GIS Pole I • LPIT Sensor of GIS Pole II • LPIT Sensor of GIS Pole III	LPIT Sensor of GIS Pole III
_:20821:157	LPIT General:Database version	The database version from which the LPIT calibration data are derived It is not configurable, but obtained from the used calibration data after the LPIT production ID is entered.	–
_:20281:159	LPIT General:Use RCVT as volt. sensor	• no • yes	no
IO240 general data			
_:20821:177	LPIT General:Use cal. data IO240 board	• no • yes	no
Voltage channels for RCVT			
_:160	LPIT General:Crosstalk RCVT 1 to 2	-5.000 % to 5.000 %	0.000 %
_:161	LPIT General:Crosstalk RCVT 2 to 1	-5.000 % to 5.000 %	0.000 %
_:162	LPIT General:Crosstalk RCVT 2 to 3	-5.000 % to 5.000 %	0.000 %
_:163	LPIT General:Crosstalk RCVT 3 to 2	-5.000 % to 5.000 %	0.000 %
_:164	LPIT General:Crosstalk RCVT 3 to 1	-5.000 % to 5.000 %	0.000 %
_:163	LPIT General:Crosstalk RCVT 1 to 3	-5.000 % to 5.000 %	0.000 %
Cable			
_:111	LPIT General:Cable type	LEONI L45551-P42-B5	LEONI L45551-P42-B5
_:115	LPIT General:Cable length	0.1 m to 100.0 m	10.0 m

The following setting table shows only 1 of the 3 LPIT-GIS poles, as the setting possibilities of the 3 poles are the same.

Addr.	Parameter	Setting Options	Default Setting
GIS-LPIT[28]			
_:102	LPIT-GIS Pol #:LPIT Production ID	Production ID of the GIS sensor	–
GIS LPCT			
_:106	LPIT-GIS Pol #:Current polarity inverse	• no • yes	no
LPIT connection box			
_:109	LPIT-GIS Pol #:LPIT connection-box type	Type of the LPIT connection box	–

[28] This parameter section is visible only when you have set **GIS-LPIT type** under **LPIT General** to **LPIT 1-phase**.

The following setting table shows only 1 of the 3 RCVTs, as the setting possibilities of the 3 RCVTs are the same.

Only when the parameter **Use RCVT as volt. sensor** is checked, the following function block is available.

Addr.	Parameter	Setting Options	Default Setting
RCVT #			
_:101	RCVT #:Magnitude corr. factor	0.9000 to 1.1000	1.0000
_:102	RCVT #:Phase offset correction	-300.0 ' to 15.0 '	0.0 '

Only when the parameter **Use cal. data IO240 board** is checked, the following function block is available.

Addr.	Parameter	Setting Options	Default Setting
IO240 cal.data			
_:100	IO240 cal.data:IO240 production ID	Production ID of the IO240 board	–
_:101	IO240 cal.data:Database version	The database version from which the IO240 board calibration data are derived It is not configurable, but obtained from the used calibration data after the IO240 production ID is entered.	–

5.11.11.6 Information List

No.	Information	Data Class (Type)	Type
LPIT General			
_:20821:76	LPIT General:Shield cover	SPS	O
_:20821:77	LPIT General:GIS LPIT cali. data error	SPS	O
_:20281:315	LPIT General:RCVT unsupported	SPS	O
_:20281:316	LPIT General:RCVT cali. data error	SPS	O

The following table shows only 1 of the 3 sensors, as the setting possibilities of the 3 sensors do not differ.

No.	Information	Data Class (Type)	Type
LPIT-GIS Pol #			
_:80	LPIT-GIS Pol #:TmpOut	MV	O
_:79	LPIT-GIS Pol #:R	MV	O

5.12 Function-Group Recording

5.12.1 Overview

The device has a flash memory in which records can be saved. The recording documents operations within the power system and how devices respond to them. You can read out records from the device and analyze them. Depending on the recorder, the records are available in different file formats (see the following table).

Table 5-25 File Format Used by Individual Recorders

Interface	File Format	FR[29]	SSR[30]	CR[31]	TR[32]
DIGSI 5	SIPROTEC 5	–	X	X	X
DIGSI 5	COMTRADE	X	–	–	–
IEC 61850	SIPROTEC 5	–	X	–	–
IEC 61850	COMTRADE	X	X	–	–
IEC 61850	PQDIF	–	–	X	X
Browser-based user interface	SIPROTEC 5	–	X	–	–
Browser-based user interface	COMTRADE	X	X	–	–
Browser-based user interface	PQDIF	–	–	X	X
T103	COMTRADE	X	–	–	–
T104	COMTRADE	X	–	–	–
DNP	COMTRADE	X	–	–	–

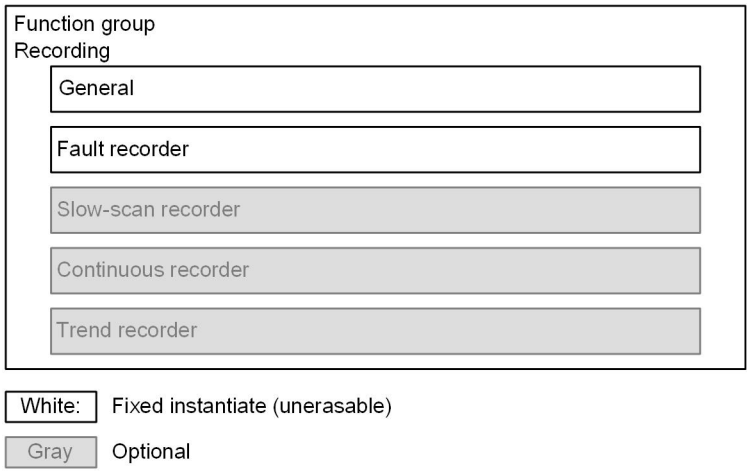
5.12.2 Structure of the Function Group

The **Recording** function group consists of the following functionalities:

- **General** function block
- **Fault recorder** function
- **Slow-scan recorder** function
- **Continuous recorder** function
- **Trend recorder** function

The following figure shows the structure of the **Recording** function group. The function blocks are described in the following chapters.

29 FR: Protection fault recorder
30 SSR: Slow-scan recorder
31 CR: Continuous recorder
32 TR: Trend recorder



[dw_fg_recorder, 4, en_US]

Figure 5-187 Structure of the Recording Function Group

NOTE

If you want to use one of the following functions, the device must be equipped with the CP300, CP150, or CP050 CPU printed circuit board assembly:

- Slow-scan recorder
- Continuous recorder
- Trend recorder

The function group **Protection Recording** is a central device function. The recording criterion, measured-value channels, and binary channels to be recorded are functionally preconfigured through the application templates. You can individually adapt the configuration in DIGSI 5 after enabling Recorder Routing functions.

For more information on the **Fault recorder** function, refer to **Fault Recording**, starting at *3.5.1 Overview of Functions* .

For more information on the function group **Recording**, refer to the *SIPROTEC 5 Protection Recording manual* (C53000-H5040-C089).

5.13 Bay Proxy

5.13.1 Overview

In a substation, the **Bay** represents a feeder, a line, a transformer, or a coupler. The **Bay** comprises function groups such as **Voltage/current 3-phase**, **Circuit breaker**, and **Disconnector**. For the complete list of supported function groups, refer to *5.13.2 Structure of the Bay*.

SIPROTEC 5 can protect multiple feeders in one device. To have a clear structure and additional configuration and testing benefits, you can group the functions groups inside **Bays**.

NOTE

This functionality is available for SIPROTEC 5 modular devices.

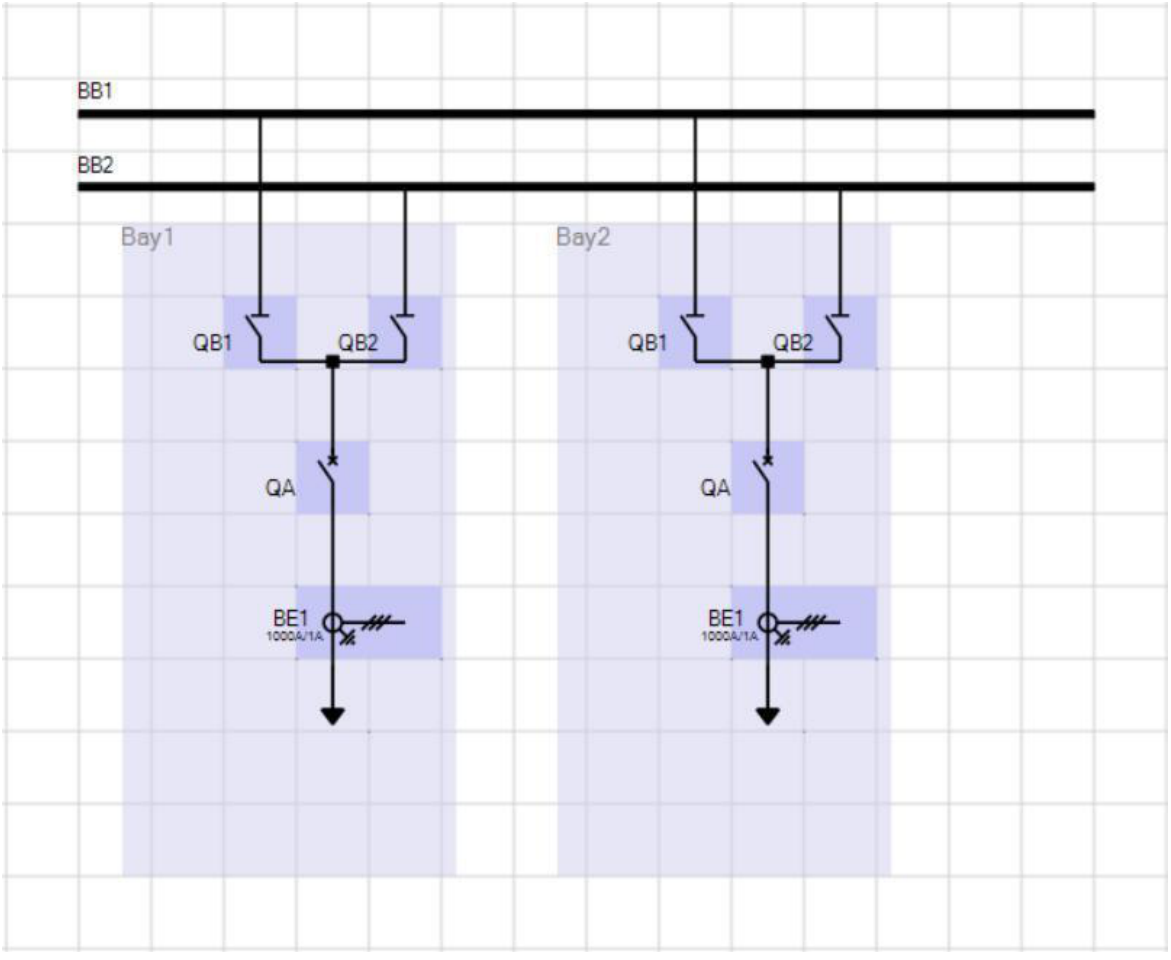


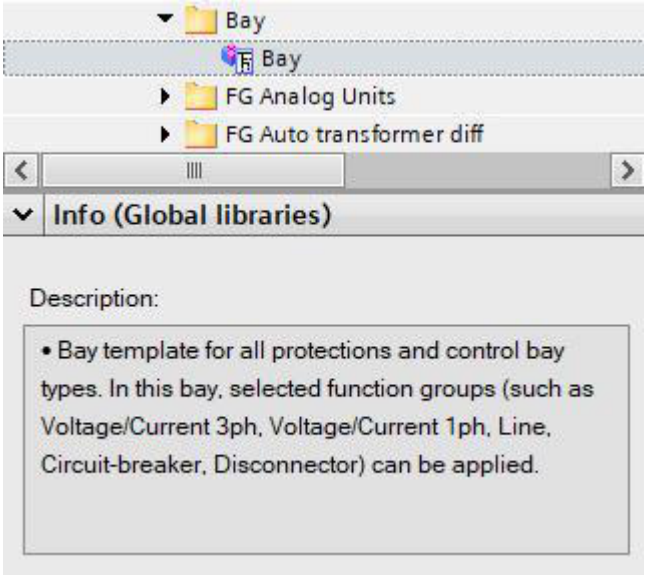
Figure 5-188 Example of Bays

NOTE

The single-line diagram is not mandatory for the **Bay**.

5.13.2 Structure of the Bay

You can find the **Bay** under the device in the Global DIGSI 5 Library.

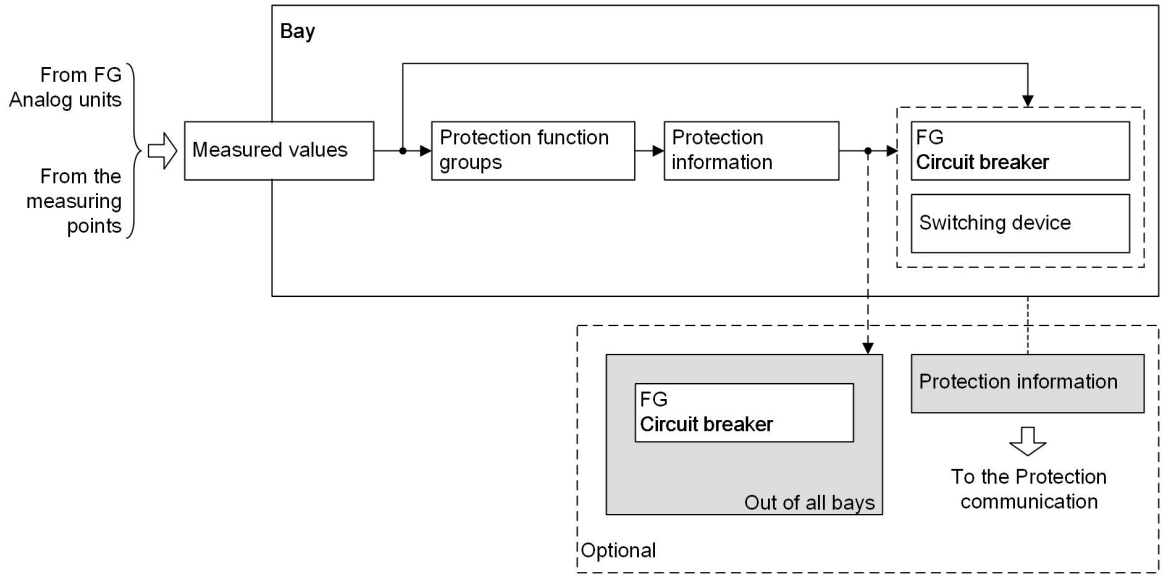


[sc_AOMBay, 3, en_US]

You can instantiate the following function groups under the **Bay**:

- FG **Circuit breaker**
  - **Circuit breaker**
  - **Circuit breaker [status only]**
- FG **Voltage/current 1-phase**
- FG **Voltage/current 3-phase**
- FG **Voltage 3-phase**
- FG **Line**
- FG **Transformer diff**
  - **Transformer diff**
  - **Transformer side**
  - **Transformer neutral point**
- FG **Auto transformer diff**
  - **Auto transformer diff**
  - **Auto transformer side**
  - **Auto transformer compensation side**
  - **Auto transformer ground side**
  - **Auto transformer neutral point**
- FG **Voltage controller**
  - **Voltage control grid coupling transformer**
  - **Voltage control three-winding transformer**
  - **Voltage control two-winding transformer**

- Switching device
  - **Disconnector**
  - **Disconnector [status only]**
  - **Tap changer**
- User-defined function group



[dw_structure AOM Bay Universal, 1, en_US]

Figure 5-189 Structure of the Bay

The **Bay** has interfaces to:

- Measuring points
- Function group **Analog units**
- Function group **Circuit breaker**
- Protection communication

Interfaces with Measuring Points and Function Group Analog Units

The function groups in the **Bay** receive the required measured values via the interfaces with the measuring points and via the interfaces with the function group **Analog units**.

For details, refer to the descriptions of the specific function-group types.

Interface with the Function Group Circuit Breaker

All required data is exchanged between the function groups in the **Bay** and the function group **Circuit breaker** out of **Bays** via the interface of this function group **Circuit breaker**.

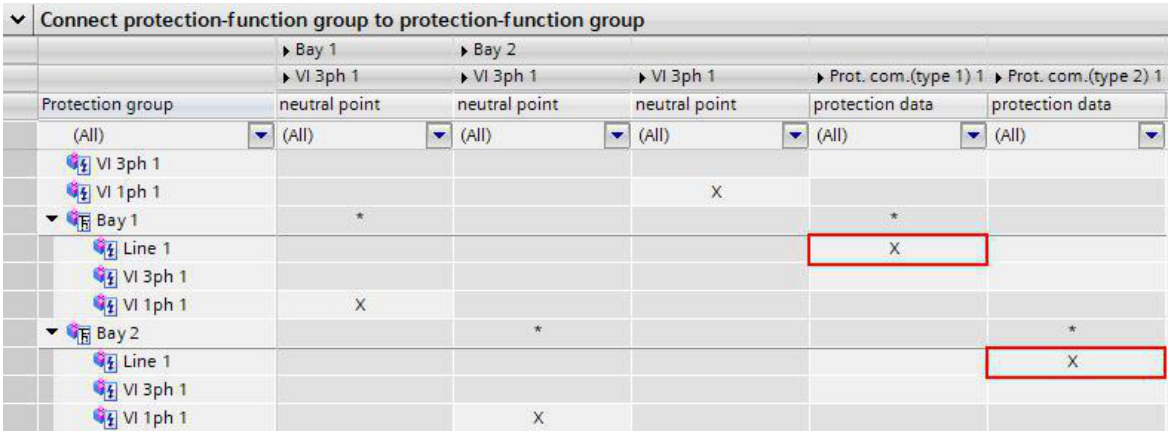
For details, refer to the descriptions of the specific function-group types.

Interface with Protection Communication

All required data is exchanged between the protection function group and the protection communication via the interface with the **Protection communication**. These data are for example:

- Binary signals
- Measured values
- Complex data

The protection communication is typically used for line differential protection and with the teleprotection schemes for distance protection and ground-fault protection. If you want to use the function **Line differential protection** in a **Bay**, you must configure the protection interface for the function group **Line**.



[sc_Protection_interface_Line_AOMBay, 2, en_US]

Figure 5-190 Example of Configuring the Protection Interfaces

For more details, see *3.6 Protection Communication*.

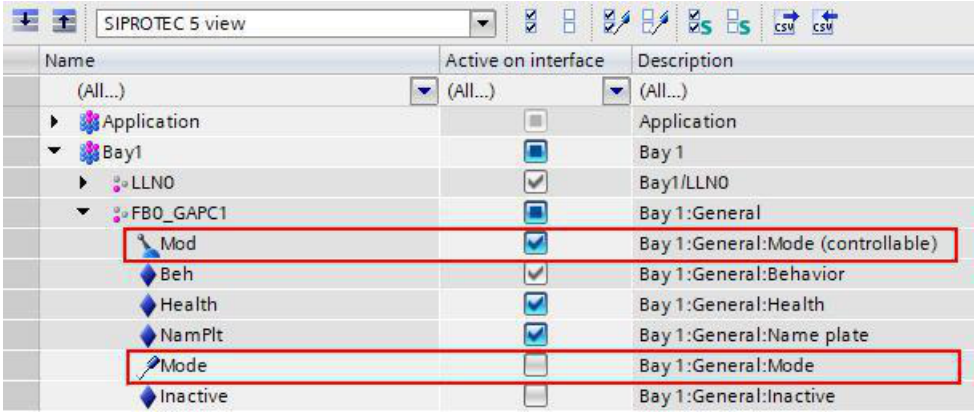
5.13.3 Application and Setting Notes (Mode Behavior of Bay)

Parameter: Mode

- Default setting **(_:1) Mode** = ***on***

A **Bay**, including all functions under the **Bay**, can be switched to different operating modes. With the parameter **Mode**, you define whether you want a **Bay** to run (***on***) or not (***off***). In addition, you can temporarily block a **Bay** or switch it into test mode for commissioning (parameter **Mode** = ***test***).

Additionally, the state of the **Bay** can be influenced using the controllable **Mod** in the IEC 61850 representation. The **Mode (controllable)** in the DIGSI 5 Information routing supports the states ***On***, ***Off***, ***Test***, ***Relay blocked***, and ***Test/Relay blk.***



[sc_Mode(controllable), 2, en_US]

Figure 5-191 Controllable **Mod** and parameter **Mode** in the IEC 61850 structure

The **overall device state** can have the values ***On***, ***Relay blocked***, ***Test***, and ***Test/Relay blk.***.

The states of the **Bay** resulting from the parameter **Mode**, the controllable **Mod**, and the **overall device state** are shown in the following table. The resulting state of the **Bay** results from the combination of all sources (parameter **Mode**, controllable **Mod**, and **overall device state**). As a simplification, the table only shows the combination of 2 sources.

Table 5-26 Resulting State of the Bay

Inputs		State of the Bay
Device	Bay	
On	On	On
	Relay blocked	Relay blocked
	Test	Test[33]
	Test/Relay blk.	Test/Relay blk.
	Off	Off
Relay blocked	On	Relay blocked
	Relay blocked	Relay blocked
	Test	Test/Relay blk.
	Test/Relay blk.	Test/Relay blk.
	Off	Off
Test	On	Test[33]
	Relay blocked	Test/Relay blk.
	Test	Test[33]
	Test/Relay blk.	Test/Relay blk.
	Off	Off
Test/Relay blk.	On	Test/Relay blk.
	Relay blocked	Test/Relay blk.
	Test	Test/Relay blk.
	Test/Relay blk.	Test/Relay blk.
	Off	Off

For more information about function state control, refer to *2.3 Function Control*.

5.13.4 Application and Setting Notes (Bay-Related Switching Authority)

Parameter: Bay-related sw.auth.

- Default setting **(_:151) Bay-related sw.auth.** = ***false***

When activating the parameter **Bay-related sw.auth.**, an individual switching authority as well as an individual switching mode for this bay are configured. They are valid for all switching devices in the bay provided no own **Swi.dev. related sw.auth.**, is activated. Additional signals are displayed in the information routing (see also *7.4.1 Command Checks and Switchgear Interlocking Protection*).

Parameter: Specific sw. authorities

- Default setting **(_:152) Specific sw. authorities** = ***false***

You can enable additional options for the switching authority check. For more information about these options, see *Specific Switching Authority, Page 1869*.

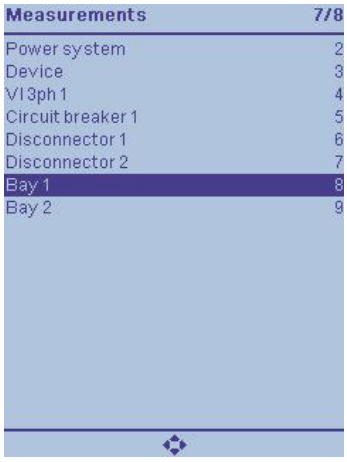
[33] With the parameter **(_:151) Oper.bin.outp. under test**, you can set whether the relay outputs are to be activated by functions in the **Test** state. If this parameter is deactivated (default setting), the **Test** state of a function is changed to **Test/Relay blk.**.

5.13.5 Application and Setting Notes (Displays and Connections for Bay)

Displays for the Bay on the On-Site Operation Panel

If **Bays** are instantiated, the displays contain the **Bay** menu items on the on-site operation panel, as shown in the following example screenshots.

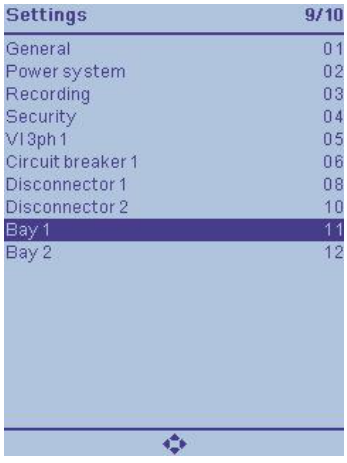
- Measurements



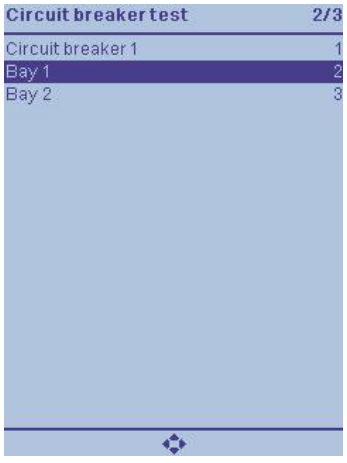
- Control



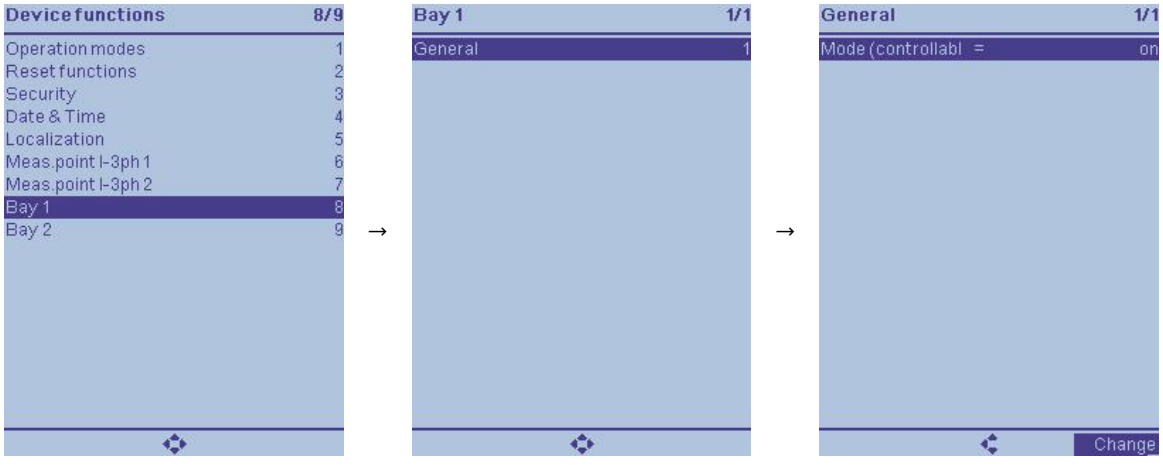
- Settings



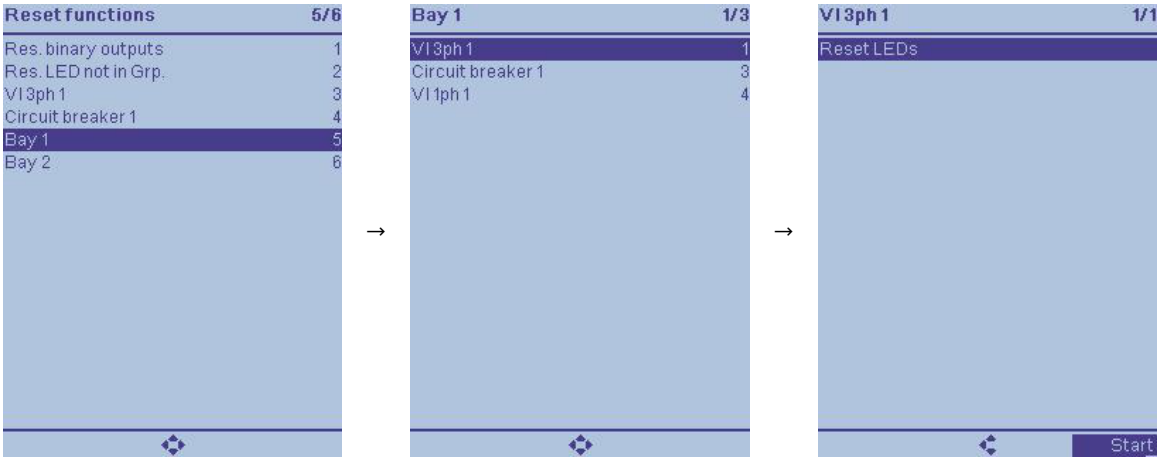
- Circuit breaker test



- Device functions



- Reset functions



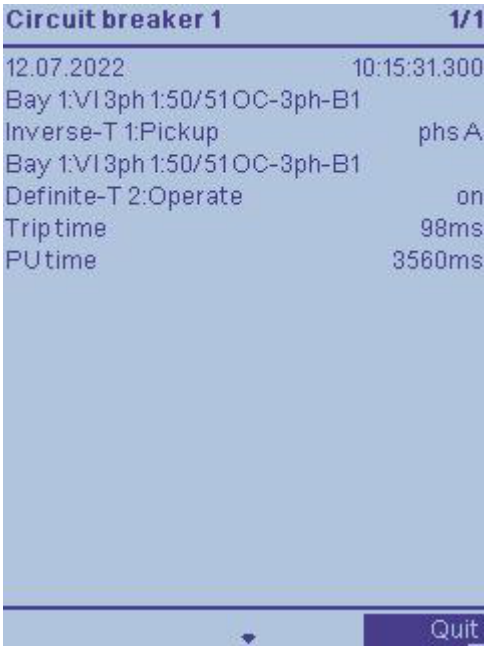
Fault Display for the Bay

For the **Bay**, the configuration of the fault display with DIGSI 5 and the acknowledgment of the fault display on the on-site operation panel are as follows:

Display	Function group	Displayed information
☑	Circuit breaker 1	
	Display line 1	Pickup indication
	Display line 2	Operate indication
	Display line 3	Trip time
	Display line 4	PU time
	Display line 5	No alarm
	Display line 6	No alarm
	Bay 1	
☑	Circuit breaker 1	
	Display line 1	Pickup indication
	Display line 2	Operate indication
	Display line 3	Trip time
	Display line 4	PU time
	Display line 5	No alarm
	Display line 6	No alarm

[sc_fault_display_configure_AOMBay, 2, en_US]

Figure 5-192 Configuration of the Fault Display for the Bay with DIGSI 5



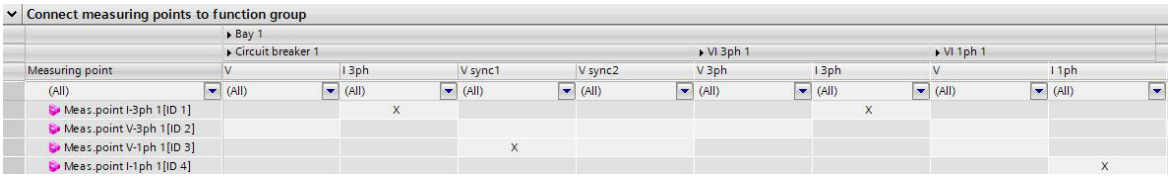
[sc_fault_display_ack_AOMBay, 2, en_US]

Figure 5-193 Fault Display for the Bay on the On-Site Operation Panel

For more information about fault display, refer to *3.1.8 Spontaneous Fault Display on the On-Site Operation Panel* .

Connecting Measuring Points to Function Groups in a Bay

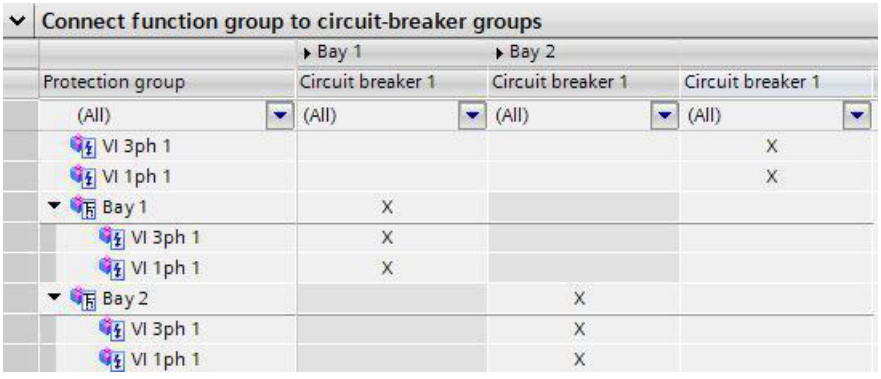
Under **Function-group connections** > **Connect measuring points to function group**, you can connect measuring points to the function groups in a **Bay**, as shown in the following figure.



[Connecting measuring points to function groups in a bay, 2, en_US]

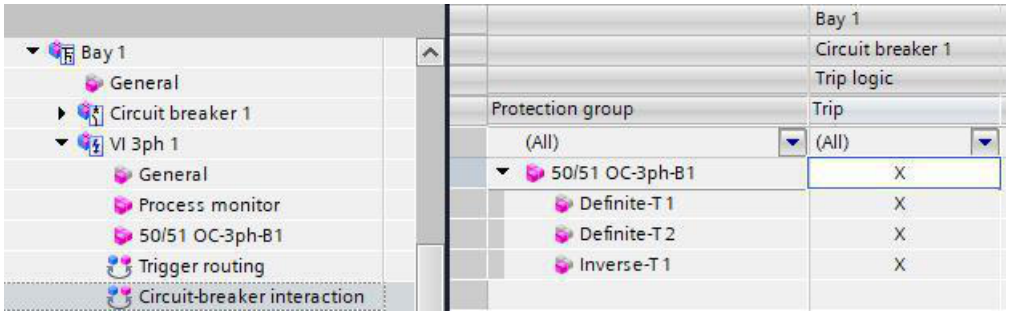
Connecting Function Groups in a Bay to Circuit Breakers

Under **Function-group connections** > **Connect function group to circuit-breaker groups**, you can connect protection function groups in a **Bay** to function groups **Circuit breaker** in the **Bay** or out of **Bays**, as shown in the following figure.



[Connecting function groups in a bay to circuit breakers, 2, en_US]

Besides the general allocation of the protection function groups to the function groups **Circuit breaker**, you can also configure the interface for certain functionalities in detail. Configure the details in DIGSI 5 using the **Circuit-breaker interaction** Editor in the protection function groups, as shown in the following figure.

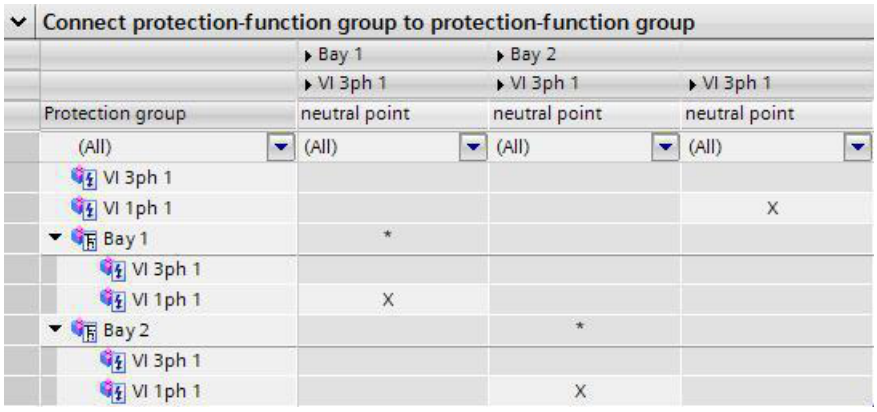


[Circuit-breaker interaction, 2, en_US]

In the preceding figure, the routable function groups **Circuit breaker** are those connected under **Function-group connections** > **Connect function group to circuit-breaker groups**.

Connecting Function Groups in the Same Bay

Under **Function-group connections** > **Connect protection-function group to protection-function group**, you can connect function groups to other function groups in the same **Bay**, as shown in the following figure. You cannot connect a function group in a **Bay** to a function group out of the **Bay**.



[Connecting function groups in the same bay, 2, en_US]

5.13.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	General:Mode		• off • on • test	on
Switching authority				
_:151	General:Bay-related sw.auth.		• 0 • 1	false
_:152	General:Specific sw. authorities		• 0 • 1	false

Addr.	Parameter	C	Setting Options	Default Setting
_:153	General:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:154	General:Num. of specific sw.auth.		2 to 5	2
_:155	General:Ident. sw.auth. 1		Freely editable text	
_:156	General:Ident. sw.auth. 2		Freely editable text	
_:157	General:Ident. sw.auth. 3		Freely editable text	
_:158	General:Ident. sw.auth. 4		Freely editable text	
_:159	General:Ident. sw.auth. 5		Freely editable text	
_:170	General:Multiple specific sw.auth.		• 0 • 1	false

5.13.7 Information List

No.	Information	Data Class (Type)	Type
General			
_:51	General:Mode (controllable)	ENC	C
_:54	General:Inactive	SPS	O
_:52	General:Behavior	ENS	O
_:53	General:Health	ENS	O

5.14 Process Monitor

5.14.1 Overview of Functions

All function groups that have functions with dependencies on the state of the protected object contain a process monitor. The process monitor detects the current state of the protected object.

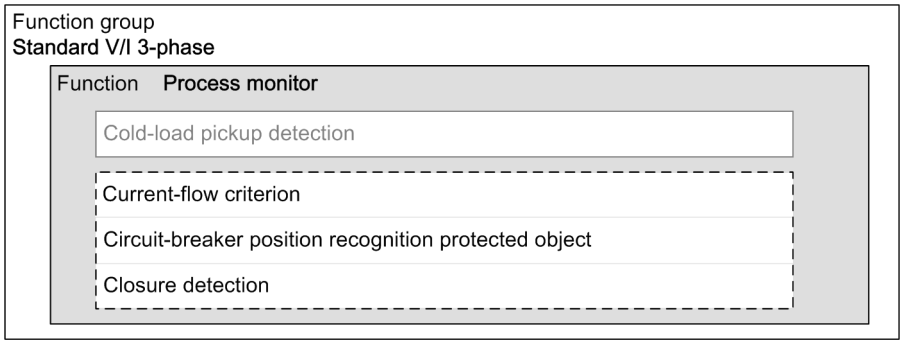
5.14.2 Structure of the Function

The **Process monitor** function is used in the following protection function groups with current measurement:

- **Transformer side**
- **Auto transf. auto side**
- **Auto Transf. comp. side**
- **Auto transf. ground side**
- **Motor Side**
- **Standard V/I**

The **Process monitor** function is provided by the manufacturer with the following function blocks:

- Cold-load pickup detection (optional)
- Current-flow criterion
- Circuit-breaker condition
- Closure detection



[dw_pro3pt, 2, en_US]

Figure 5-194 Structure/Embedding of the Function

You can activate the cold-load pickup detection as needed. All other stages of the process monitor run permanently in the background and are not displayed in DIGSI.

The following figure shows the relationships of the individual function blocks.

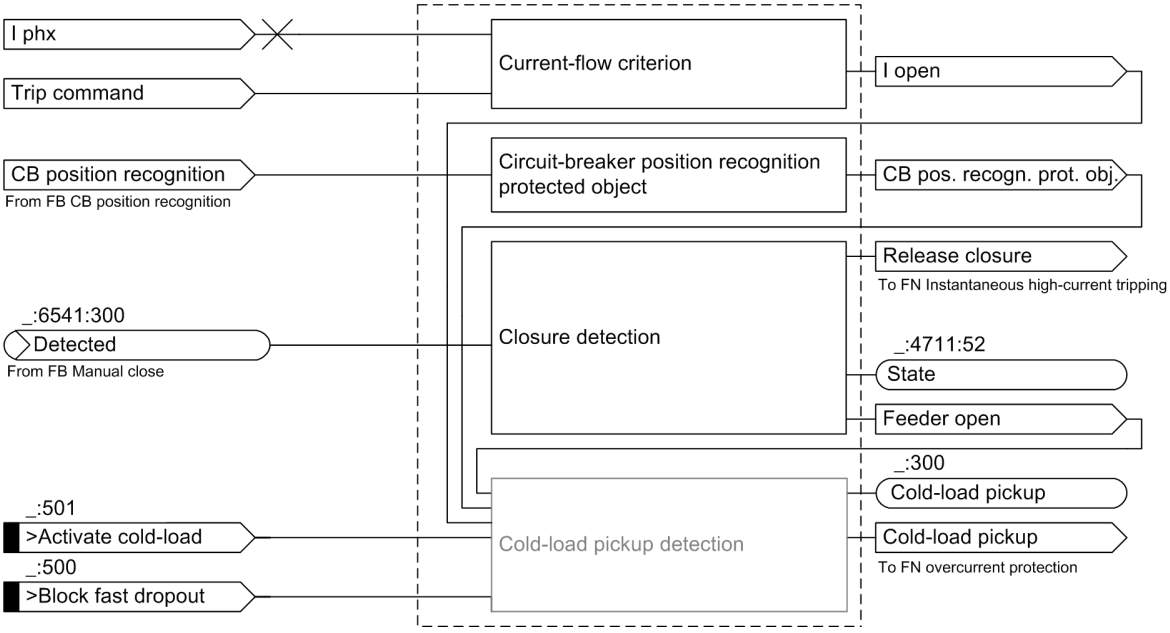


Figure 5-195 Logic Diagram of the Overall Function Process Monitor

5.14.3 Current-Flow Criterion

Logic

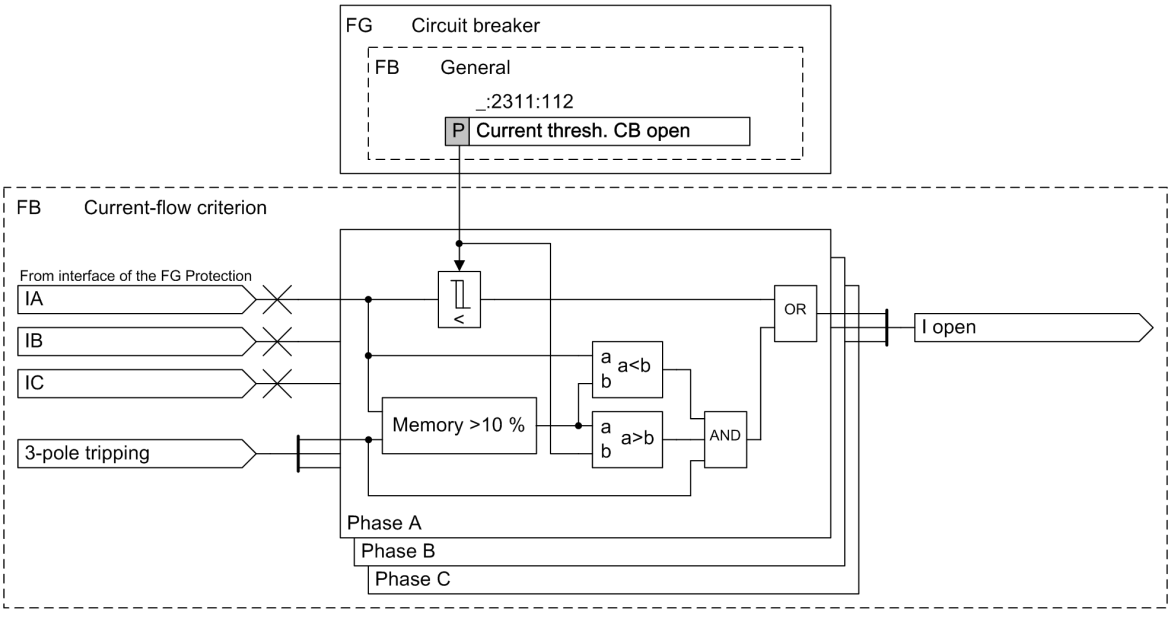


Figure 5-196 Logic Diagram of the Current-Flow Criterion Function Block

The phase currents are provided via the interface to the protection function group.

The **I open** signal of one phase is generated if one of the following conditions is met:

- A phase current falls below the set threshold of the **Current thresh. CB open** parameter. The hysteresis stabilizes the signal.
- The corresponding phase current, for example, **I A**, falls below 10 % of the phase current when the trip command arrives. If the current does not drop until after a delay due to current transformer influences, an open pole can therefore be detected quickly even after a high-current fault on the line.

With the **Current thresh. CB open** parameter, you define the minimum current as the criterion for a deactivated line. The parameter lies in the **Circuit-breaker** function group. It acts both in the **Circuit-breaker** function group, for example circuit-breaker position recognition, and also for the process monitor in the protection function group.

If a protection function group with integrated process monitor is connected to several **Circuit breaker** FGs, the **Current thresh. CB open** parameter is present in each FG **Circuit breaker**. The smallest setting value of the parameter **Current thresh. CB open** is used.

5.14.4 Application and Setting Notes (Current-Flow Criterion)

Parameter: Current thresh. CB open

- Recommended setting value **(_:2311:112) Current thresh. CB open** = ***0.100 A***

The **Current thresh. CB open** parameter is used to define the threshold for the leakage current as the criterion for a deactivated line.

Set the **Current thresh. CB open** parameter so that the current measured when the feeder is deactivated falls below the value of the **Current thresh. CB open** parameter with certainty. The hysteresis is additionally active if the threshold is exceeded.

If parasitic currents, for example, due to induction, are ruled out when the feeder is deactivated, set the **Current thresh. CB open** parameter sensitively.

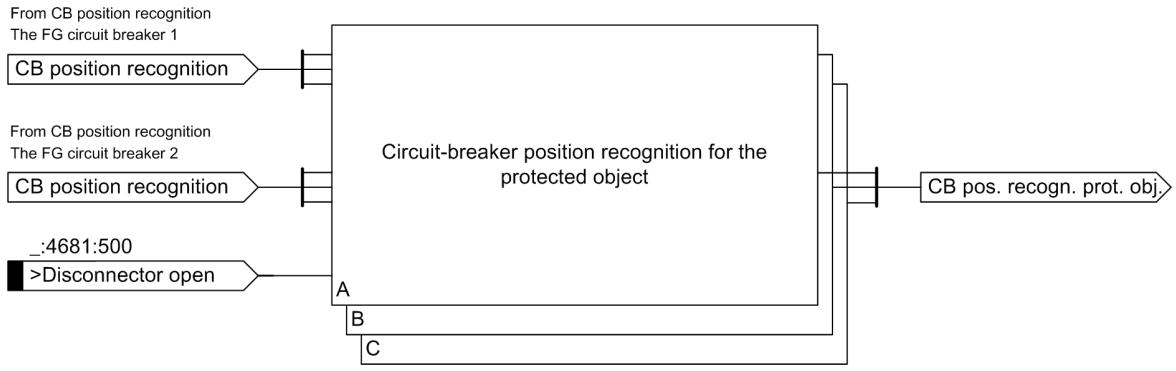
Siemens recommends a setting value of ***0.100 A***.

5.14.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Breaker settings				
_:2311:112	General:Current thresh. CB open	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2311:136	General:Op. mode BFP		• unbalancing • I> query	unbalancing

5.14.6 Circuit-Breaker Condition for the Protected Object

Logic



[lo_prolsz, 2, en_US]

Figure 5-197 Logic Diagram of the Circuit-Breaker Condition for the Protected-Object Function Block

The circuit-breaker position recognition in the **Circuit-breaker** (CB) function group provides the circuit-breaker condition by way of the internal signal *CB pos. recogn. prot. obj.*.

If a protected object is supplied via 2 circuit breakers (CBs), for example with the 1 1/2 circuit-breaker layout, then the circuit-breaker switch position of the protected object must be determined with the aid of both circuit breakers. In this case, the **Circuit-breaker position recognition for the protected object** function block connects the individual CB states. The connection provides the internal *CB pos. recogn. prot. obj.* signal to the other function blocks of the process monitor and to other functions, for example, **Trip in the event of weak infeed** and **Echo function for teleprotection method**, within the same function group.

If one of the following 2 conditions is met, the *CB pos. recogn. prot. obj.* signal is in the ***Open*** state:

- All connected circuit breakers signal the ***Open*** state internally.
- The **>Disconnector open** input is active.

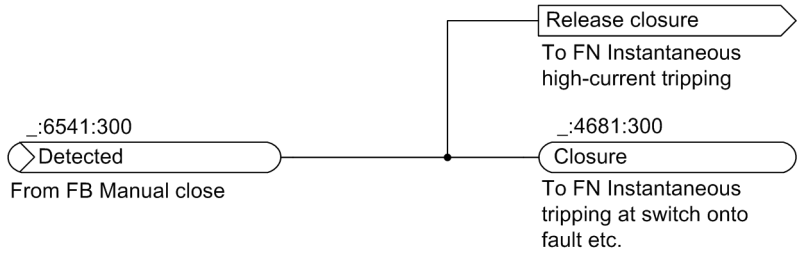
If the following 2 conditions are met, the *CB pos. recogn. prot. obj.* signal is in the ***Closed*** state:

- At least one of the connected circuit breakers signals the ***Closed*** state internally.
- The **>Disconnector open** input is not active.

5.14.7 Closure Detection

The closure detection enables the immediate tripping of selected protection functions or protection stages when switching to a short circuit or the reduction of the responsivity. The closure detection determines whether the protected object is switched on.

Logic



[lo_ein_6md, 1, en_US]

Figure 5-198 Logic Diagram of Closure Detection

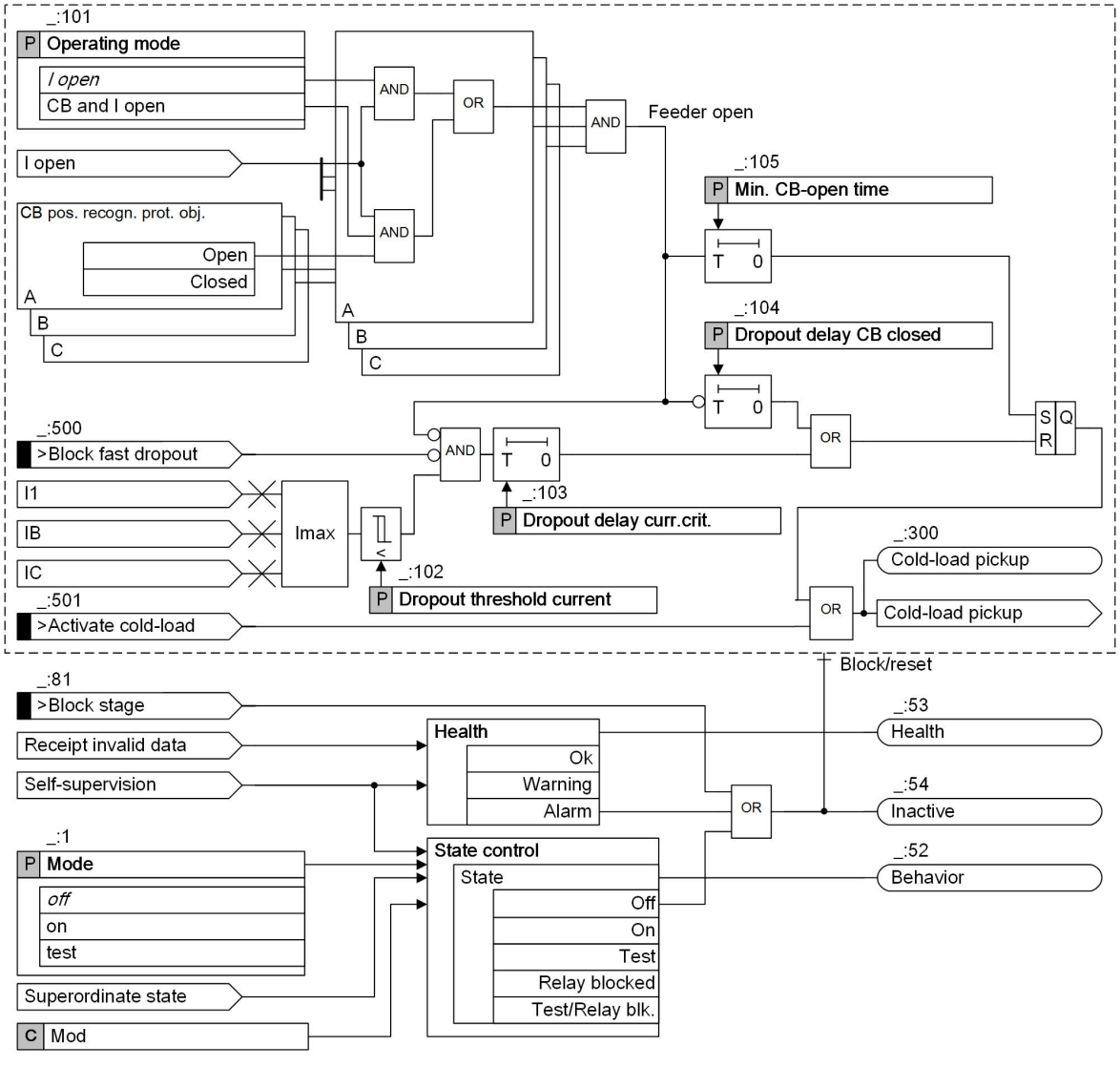
For an applied binary input signal **(_:6541:300) Detected** (from function block Manual close), the indication **(_:4681:300) Closure** is active.

5.14.8 Information List

No.	Information	Data Class (Type)	Type
Closure detec.			
_:4681:500	Closure detec.:>Disconnector open	SPS	I
_:4681:300	Closure detec.:Closure	SPS	O

5.14.9 Cold-Load Pickup Detection (Optional)

Logic



[lo_pro_cls, 2, en_US]

Figure 5-199 Logic Diagram of the Cold-Load Pickup Detection Function Block

The **Cold-load pickup detection** function block detects that a specific time has been exceeded after deactivation of the line or protected object. If you want to connect the protected object again, you must note that an increased load-current requirement exists for a limited time after connection. This results from the nature of the load.

The **Cold-load pickup detection** function block ensures that different parameters are used for an adjustable time after connection. For example, for the time of the **Min. CB-open time** parameter, you can increase the threshold value of a protection function or you can select a special characteristic curve.

If the **Cold-load pickup detection** function block detects an open feeder and the set time of the **Min. CB-open time** parameter has expired, the indication **>Activate cold-load** is generated.

With the **>Activate cold-load** indication, you can activate a parameter set of the **Cold-load pickup** function. Via the binary input signal **>Activate cold-load**, you can also activate the **>Activate cold-load** indication directly.

If the **Cold-load pickup detection** function block detects closure and the corresponding load current, it starts the time set in the **Dropout delay CB closed** parameter. The **>Activate cold-load** indication and the activated parameter set are deactivated after this time has elapsed.

If, for the time set in the **Dropout delay curr.crit.** parameter, the maximum phase current falls below the threshold value **Dropout threshold current**, the parameter set for the **Cold-load pickup detection** function block is also deactivated. As a result, if the load current is very low, the action time **Dropout delay curr.crit.** of the **>Activate cold-load** indication can be shortened.

5.14.10 Application and Setting Notes (Cold-Load Pickup Detection)



NOTE

The settings and indications described in this chapter are only available when using the optional **Cold-load pickup detection** function block.

Parameter: Operating mode

- Default setting **(_:101) Operating mode** = ***I open***

With the **Operating mode** parameter, you set the criteria with which the Closure-detection function block operates.

Parameter Value	Description
I open	When the Current-flow criterion function block detects a clearing open condition, the decision is made for pickup. For this setting, make sure that the **Current thresh. CB open** parameter is set lower than the possible load current. If this is not the case, open is detected continuously and each fault current that exceeds the **Current thresh. CB open** parameter is interpreted as closure.
CB and I open	Closure is detected if one of the following conditions is met: • Analysis of the circuit-breaker auxiliary contact detects a clearing open condition in at least one phase. • The current-flow criterion detects a clearing open condition.

Parameter: Dropout threshold current

- Default setting **(_:102) Dropout threshold current** = ***1.00 A***

With the **Dropout threshold current** parameter, you set the threshold at which the output signal **Cold-load pickup** is deactivated when the current in at least one phase falls below this threshold.

Parameter: Dropout delay current criterion

- Default setting **(_:103) Dropout delay curr.crit.** = ***600 s***

With the **Dropout delay curr.crit.** parameter, you set the time for which the actual value must be below the **Dropout threshold current** threshold so that the output signal **Cold-load pickup** can be deactivated prematurely.

Parameter: Dropout delay CB closed

- Default setting **(_:104) Dropout delay CB closed** = ***3600 s***

With the **Dropout delay CB closed** parameter, you set the action time for the dynamic parameter set switching in the event of cold-load pickup detection.

Parameter: Min. CB open time

- Default setting **(_:105) Min. CB-open time** = ***3600 s***

With the **Min. CB-open time** parameter, you set the time after which the dynamic parameter set is activated in the event of **cold-load pickup** when the line is opened.

5.14.11 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Cold-load PU				
_:1	Cold-load PU:Mode		• off • on • test	off
_:101	Cold-load PU:Operating mode		• I open • CB and I open	I open
_:102	Cold-load PU:Dropout threshold current	1 A @ 100 Irated	0.030 A to 10.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 50.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 10.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 50.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:103	Cold-load PU:Dropout delay curr.crit.		1sto600 s	600s
_:104	Cold-load PU:Dropout delay CB closed		1 s to 21600 s	3600 s
_:105	Cold-load PU:Min. CB-open time		0 s to 21600 s	3600 s

5.14.12 Information List

No.	Information	Data Class (Type)	Type
Cold-load PU			
_:81	Cold-load PU:>Block stage	SPS	I
_:500	Cold-load PU:>Block fast dropout	SPS	I
_:501	Cold-load PU:>Activate cold-load	SPS	I
_:54	Cold-load PU:Inactive	SPS	O
_:52	Cold-load PU:Behavior	ENS	O
_:53	Cold-load PU:Health	ENS	O
_:300	Cold-load PU:Cold-load pickup	SPS	O

6 Protection and Automation Functions

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6.43	Undervoltage Protection with 3-Phase Voltage	1509
6.44	Undervoltage Protection with Positive-Sequence Voltage	1526
6.45	Undervoltage Protection with Any Voltage	1532
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6.48	Voltage-Comparison Supervision	1555
6.49	Fault Locator	1561
6.50	Fault Locator Plus	1577
6.51	Overfrequency Protection	1591
6.52	Underfrequency Protection	1597
6.53	Underfrequency Load Shedding	1603
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6.73	Voltage-Jump Detection	1808
6.74	Vector-Jump Protection	1812

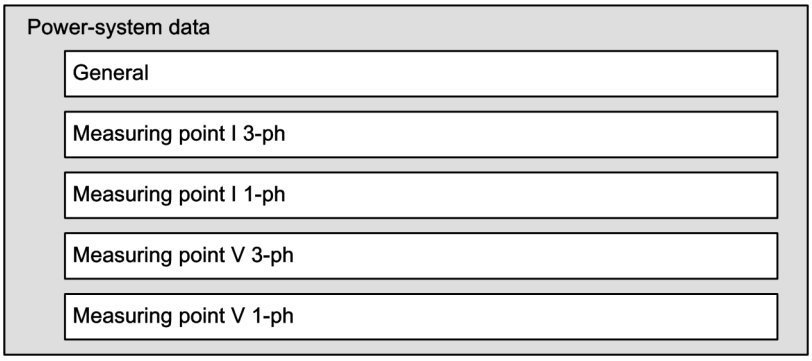
6.1 Power-System Data

6.1.1 Overview

The **Power-system data** are provided with each SIPROTEC 5 device and cannot be deleted. You will find them in DIGSI under **Settings** → **Power system**.

6.1.2 Structure of the Power-System Data

The **Power-system data** contain the block **General** and the **Measuring points** of the device. The following figure shows the structure of the **Power-system data**:



[dw_system data, 2, en_US]

Figure 6-1 Structure of the Power-System Data

In order to adjust its functions to the application, the device requires some data about the power system. The necessary settings can be found in the Power-system data under **General** as well as in the **Measuring points**.

NOTE

You can find information on the supervision-function parameters in *8.3 Supervision of the Secondary System*.

Type and scope of the required measuring points depend on the application. Possible measuring points are:

- Voltage 3-phase (measuring point V 3-ph)
- Current 3-phase (measuring point I 3-ph)
- Voltage 1-phase (measuring point V 1-ph)
- Current 1-phase (measuring point I 1-ph)

The measuring points have interfaces to the function groups, which require voltage and/or current measured values of the power system.

6.1.3 Application and Setting Instructions - General Settings

Parameter: Phase sequence

- Recommended setting value **(_:2311:101) Phase sequence** = ***ABC***

The parameter **Phase sequence** is used to set the phase sequence (***ABC***) or (***ACB***). The setting value applies to the entire SIPROTEC 5 device.

Use the **General** function to set the settings in the power-system data.

You can find detailed information about phase-rotation reversal in chapter *6.55 Phase-Sequence Switchover*.

6.1.4 Application and Setting Notes for Measuring-Point Voltage 3-Phase (V-3ph)

The following example describes the settings of the voltage measuring point **Measuring point V-3ph** (Voltage 3-phase). The **V-1ph measuring point** has only a subset of the parameters described here. The description of the parameter is also valid for the **V-1ph measuring point**.

Parameter: Rated primary voltage

- Default setting **(_:8911:101) Rated primary voltage** = ***400 kV***

With the parameter **Rated primary voltage**, you set the primary rated voltage of the voltage transformer.

Parameter: Rated secondary voltage

- Default setting **(_:8911:102) Rated secondary voltage** = ***100 V***

With the parameter **Rated secondary voltage**, you set the secondary rated voltage of the voltage transformer.

Parameter: Matching ratio Vph / VN

- Default setting **(_:8911:103) Matching ratio Vph / VN** = ***1.73***

With the parameter **Matching ratio Vph / VN**, you set the deviation between the calculated zero-sequence voltage and the residual voltage measured directly via a measuring input. The different ratio of the voltage transformers is the cause for the deviation (see *Figure 6-2*).

The **Matching ratio Vph / VN** is equal to the ratio $3V_{0\,sec}/V_{N\,sec}$

with

$V_{0\,sec}$	Calculated zero-sequence voltage
$V_{N\,sec}$	Measured residual voltage

The zero-sequence voltage is calculated as phase-to-ground voltages. The residual voltage is measured on the broken-delta winding of the voltage transformer. For 1-phase voltage transformers the residual voltage is measured in the generator or the transformer neutral point.

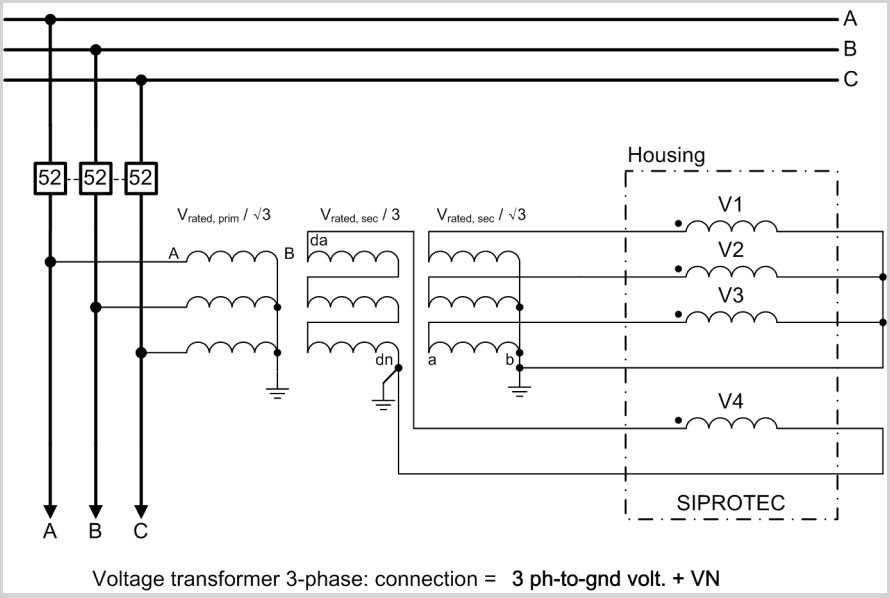


NOTE

The measured residual voltage $V_{N\,sec}$ is converted to a zero-sequence voltage in the device as follows:

$$V_{0\,sec} = V_{N\,sec} \cdot \frac{\text{Matching ratio Vph/VN}}{3}$$

EXAMPLE 1:



[dw_bsp1uwdl_anpassfaktor, 2, en_US]

Figure 6-2 3-Phase Voltage Transformer: Connection = 3 Phase-to-Ground Voltage + VN

When the type of connection for the voltage transformer is ***3 ph-to-gnd volt. + VN*** (parameter: **VT connection**) and the voltage input V4 is connected to the broken-delta winding of the voltage transformer (da/dn), the **Matching ratio Vph / VN** is as follows:

When changing the neutral point according to *Figure 6-2*, this results in the following values:

- The calculated secondary zero-sequence voltage $V_{0\,sec}$ is equal to the secondary phase-to-ground voltage. Expressed as secondary transformer rated voltage, then $V_{rated,sec}/\sqrt{3}$.
- The measured residual voltage on the broken-delta winding is the sum of the voltage drops on the 3 sides. Expressed with the side ratio, the result is $V_{N,\,sec} = 3\ V_{rated,sec}/3$.

Calculate the **Matching ratio Vph / VN** parameter as follows:

$$\text{Matching ratio } \frac{\text{Vph}}{\text{VN}} = \frac{3 \cdot V_{0\,sec}}{V_{N\,sec}} = \frac{3 \cdot \frac{V_{rated\ sec}}{\sqrt{3}}}{3 \cdot \frac{V_{rated\ sec}}{3}} = \frac{3}{\sqrt{3}} = \sqrt{3} = 1.73$$

[fo_example_1, 2, en_US]

Set **Matching ratio Vph / VN** = ***1.73***.

In **example 1** $V_{rated\,sec}$, the phase-to-ground voltage and the secondary voltage on the broken-delta winding were identical. If these voltages are different, use the actual numerical values in the calculation.

EXAMPLE 2:

Phase-to-ground voltage	$V_{rated\,sec} = 100$ V
Broken-delta winding (for example, grounding transformer in generator protection)	$V_{rated\,sec} = 500$ V The voltage input of the device is designed for a continuous operation, using 230 V max. Therefore, the voltage on the broken-delta winding (500 V) is reduced to a 5:2 ratio, using an ohmic divider. In order to calculate the matching factor, the secondary voltage of 200 V will be applied.

Calculate the **Matching ratio Vph / VN** parameter as follows:

$$\text{Matching ratio } \frac{\text{Vph}}{\text{VN}} = \frac{3 \cdot V_{0\,\text{sec}}}{V_{\text{N sec}}} = \frac{3 \cdot \frac{V_{\text{rated sec}}}{\sqrt{3}}}{3 \cdot \frac{V_{\text{rated sec}}}{3}} = \frac{3 \cdot \frac{100\ \text{V}}{\sqrt{3}}}{3 \cdot \frac{200\ \text{V}}{3}} = \frac{3}{2 \cdot \sqrt{3}} = \frac{\sqrt{3}}{2} = 0.866$$

[fo_example_2, 1, en_US]

Set **Matching ratio Vph / VN** = ***0.866***.

Interpretation of the result:

The zero-sequence voltage calculated from the phase-to-ground voltage is 57.73 V (= 100V/√3). The measured residual voltage is 200 V. The calculated matching factor is 0.866. The measured residual voltage is converted to a zero-sequence voltage inside the device:

$$V_{0\,\text{sec}} = V_{\text{N sec}} \cdot \frac{\text{Matching ratio Vph/VN}}{3} = 200\ \text{V} \cdot \frac{0.866}{3} = 57.73\ \text{V}$$

[fo_conversion2, 2, en_US]

NOTE

During the ground-fault test, the set matching factor can be checked by comparing the operational measured values. The operational measured values contain the calculated zero-sequence voltage $V_{0\,\text{sec}}$ and the measured residual voltage $V_{\text{N sec}}$. Proceed with the compilation as follows:

$$\text{Matching ratio.} \frac{\text{Vph}}{\text{VN}} = \frac{3 \cdot V_{0\,\text{sec}}}{V_{\text{N sec}}}$$

The **Matching ratio Vph / VN** parameter is significant for the following functions of the device:

- Overvoltage protection with zero-sequence/residual voltage
- Measured-value supervision
- Scaling of the faulty and measured values

Parameter: VT connection

- Default setting **(_:8911:104) VT connection** = ***3 ph-to-gnd volt. + VN***

The parameter **VT connection** shows the connection type of the voltage transformer for the 3-phase voltage measuring point. The parameter can be found in the DIGSI 5 project tree under **Name of the device** → **Parameter** → **Power-system data** → **Measuring point V 3-phase**. You cannot change the connection type of the voltage transformer in the power-system data.

You can change the connection type of the voltage transformer only under measuring point routing in DIGSI 5. Under **Name of the device** → **Measuring point routing** → **Voltage measuring points**, select the desired connection type under **Connection type**. The following types of connections are possible:

- ***3 ph-to-gnd volt. + VN***
- ***3 ph-to-gnd voltages***
- ***3 ph-to-ph volt. + VN***
- ***3 ph-to-ph voltages***
- ***2 ph-to-ph volt. + VN***
- ***2 ph-to-ph voltages***

Depending on the connection type selected, you must route the measured values to the terminals of the voltage measuring point in DIGSI 5. You can find connection examples for voltage transformers in *A.10 Connection Examples of Voltage Transformers for Modular Devices*. The connection examples provide assistance when selecting the type of connection.

Parameter: Inverted phases

- Default setting **(_:8911:106) Inverted phases** = ***none***

The **Inverted phases** parameter is intended for special applications, for example, pumped-storage hydropower plants (see *6.55 Phase-Sequence Switchover*). This default setting can be retained for power-system protection applications.

Parameter: Tracking

- Default setting **(_:8911:111) Tracking** = ***active***

The **Tracking** parameter is used to determine whether the measuring channels of this measuring point shall be used to determine the sampling frequency.

The sampling frequency of the device is adjusted to the power frequency. The device selects a measuring channel, through which the sampling frequency is determined. Preferably, this should be a voltage metering channel. This validity of the signal is monitored (minimum level, frequency range). If these values are invalid, the device switches to another channel (etc.). Once switched to a current channel, the system automatically switches back to this channel if a voltage channel is valid again.

Parameter Value	Description
active	If the parameter **Tracking** = ***active*** has been set, the measuring point will be included when determining the sampling frequency. If possible, only the 3-phase measuring points shall be considered. Siemens recommends using the default setting. **Note:** Note that, during sampling-frequency tracking, the entire device is set to the determined sampling frequency. That is to say, all of the measuring point channels work with the determined main sampling frequency. Please keep this in mind when working with the device.
inactive	If the channels of the measuring point are not to be considered for determining the sampling frequency, select the setting value ***inactive***.

Parameter: Magnitude correction

- Default setting **(_:3811:103) Magnitude correction** = ***1.000***

With the **Magnitude correction** parameter, you adjust the amplitude (magnitude correction) for the voltage input. This allows you to correct the tolerances of the primary current transformer phase-selectively. The magnitude correction can be required for highly precise measurements. Use a comparison measurement to determine the setting value (for example, a high-precision measuring-voltage transformer). If a primary correction is not necessary, retain the default setting.



NOTE

The **Magnitude correction** parameter has nothing to do with the internal adjustment of the input circuit.

6.1.5 Application and Setting Notes for Measuring-Point Current 3-Phase (I-3ph)

The following example describes the settings for the current measuring points **Measuring point I-3ph** (Current 3-phase). The **I-1ph measuring point** has only a subset of the parameters described here. The description of the parameter is also valid for the **I-1ph measuring point**.

Parameter: CT connection

- Default setting **(_:8881:115) CT connection** = ***3-phase + IN-separate***

The parameter **CT connection** shows the connection type of the current transformer for the 3-phase current measuring point. The parameter can be found in the DIGSI 5 project tree under **Name of the device**

→ **Parameter** → **Power-system data** → **Measuring point I 3-phase**. You cannot change the connection type of the current transformer in the power-system data.

You can change the connection type of the current transformer only under measuring point routing in DIGSI 5. Under **Name of the device** → **Measuring point routing** → **Current measuring points**, select the desired connection type under Connection type. The following types of connections are possible:

- ***3-phase + IN-separate***
- ***3-phase + IN***
- ***3-phase***
- ***3-phase, 2 primary CT***
- ***3ph,2prim.CT + IN-sep***

Depending on the connection type selected, you must route the measured values to the terminals of the current measuring point in DIGSI 5. You can find connection examples for current transformers in chapter *A.9 Connection Examples for Current Transformers*. The connection examples provide assistance when selecting the type of connection.

Parameter: `Tracking`

- Default setting **`(_:8881:127) Tracking`** = ***`active`***

With the parameter **`Tracking`**, you specify whether you would like to work with the manual updating function of the sampling frequency.

Parameter Value	Description
`active`	If the parameter **`Tracking`** = ***`active`*** has been set, the measuring point will be included when determining the sampling frequency. If possible, only the 3-phase measuring points shall be considered. Siemens recommends using the default setting. **Note:** During the manual updating of the sampling frequency, the entire device adjusts itself to different sampling frequencies corresponding to the frequency tracking groups. That is to say, the channels of the measuring points work with the determined sampling frequency of the frequency tracking groups. Keep this in mind when working with the device.
`inactive`	If the channels of the measuring point are not to be considered for determining the sampling frequency, please select the setting value ***`inactive`***.

Parameter: Rated primary current

- Default setting **`(_:8881:101) Rated primary current`** = ***`1000 A`***

With the **`Rated primary current`** parameter, you set the active rated primary current of the current transformer.

Parameter: Rated secondary current

- Default setting **`(_:8881:102) Rated secondary current`** = ***`1 A`***

With the **`Rated secondary current`** parameter, you set the active rated secondary current of the current transformer.

Parameter: Current range

- Default setting **`(_:8881:117) Current range`** = ***`100 x IR`***

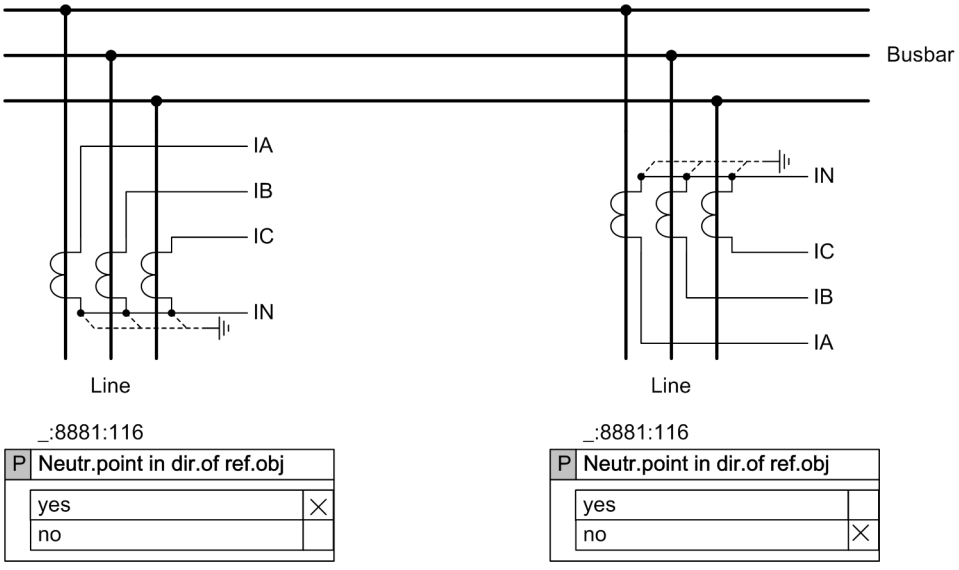
The **`Current range`** parameter allows you to set the dynamic range for the current input. Retain the default setting for power-system protection applications. The setting value for the sensitive current input and the measuring current input is 1.6 x I_{rated}.

Parameter: Neutr.point in dir.of ref.obj

- Default setting **(_:8881:116) Neutr.point in dir.of ref.obj** = ***yes***

The **Neutr.point in dir.of ref.obj** parameter is used to set the direction of the neutral point of the current transformer (see the following figure). Often, the neutral point of the current transformer is determined by the direction of the protected object (for example, in the direction of the line, cable, transformer). For this reason, the default setting of the parameter was defined as ***yes***.

When switching the parameter, the direction of the phase currents and of the ground current IN or IN-separate is changed device-internally.



[dw_polstromwdl, 1, en_US]

Figure 6-3 Polarity of Current Transformers

Parameter: Inverted phases

- Default setting **(_:8881:114) Inverted phases** = ***none***

The **Inverted phases** parameter is intended for special applications, for example, pumped-storage hydropower plants (see chapter *6.55 Phase-Sequence Switchover*). This default setting can be retained for power-system protection applications.

Parameter: CT error changeover

- Default setting **(_:8881:107) CT error changeover** = ***1.00***

The **CT error changeover** parameter is only relevant for the Line differential protection function. The **CT error changeover** parameter defines the transition range of the transformer fault from low to higher currents.

Parameter: CT error A

- Default setting **(_:8881:108) CT error A** = ***5.0***

The **CT error A** parameter considers the transformer fault at rated current plus a safety margin.

Parameter: CT error B

- Default setting **(_:8881:109) CT error B** = ***15.0***

The **CT error B** parameter considers the transformer fault at rated overcurrent factor plus a safety margin. It is the number preceding the letter P of the transformer data.

Parameter: Magnitude correction

- Default setting **(_:3841:103) Magnitude correction** = *1.000*

When using the **Magnitude correction** parameter, you adjust the amplitude (amplitude correction) for the current input. This allows you to correct the tolerances of the primary current transformer phase-selectively. The magnitude correction may be required for highly precise measurements. Use a comparison measurement to determine the setting value (for example, a high-precision measuring-voltage transformer). If a primary correction is not necessary, retain the default setting.



NOTE

The **Magnitude correction** parameter has nothing to do with the internal adjustment of the input circuit.

Note Regarding Routable Information

Indications for the current rotating field and the information pertaining to the manual updating can be found in **Information routing** under **Power-system data** → **General** in DIGSI 5. The indication *Freq.out of oper.range* means that the frequency operating range has been exceeded. Either the frequency is out of range (10 Hz to 90 Hz) or the input signals are too small for a manual update. Should this condition occur, the system switches the update frequency to a sampling rate that corresponds to the rated frequency.

Furthermore, there are 2 additional measured frequency values available. The measured value *f sys* displays the current system frequency, and the measured value *f track* displays the sampling frequency currently set. Siemens recommends routing both measured values as fault-recording channel.

6.1.6 Disconnection of Measuring Points

6.1.6.1 Overview

Maintenance work or specific operating and switching states of the power system can require disconnection of measuring point. Therefore, it is sometimes necessary to take individual measuring points out of processing, for example, to prevent an unwanted tripping of the Differential protection. With the **Disconnection of measuring points** functionality, you can disconnect the connection of the **Measuring point I-3ph** to a protection function group.

If the measuring point has been disconnected, you can carry out any work without influencing the work of the protection functions that are assigned to the measuring point. Once the measuring point has been disconnected, the Differential protection, for example, does not take the measured values of this measuring point into account anymore for calculating the differential current.

An exception applies for the following protection functions of the FG **Line**:

- Distance Protection with Classic Method
- Distance Protection with Reactance Method (RMD)
- Power-Swing Blocking
- Ground-Fault Protection for High-Resistance Ground Faults in Grounded Systems (67N)
- Measuring-voltage failure detection



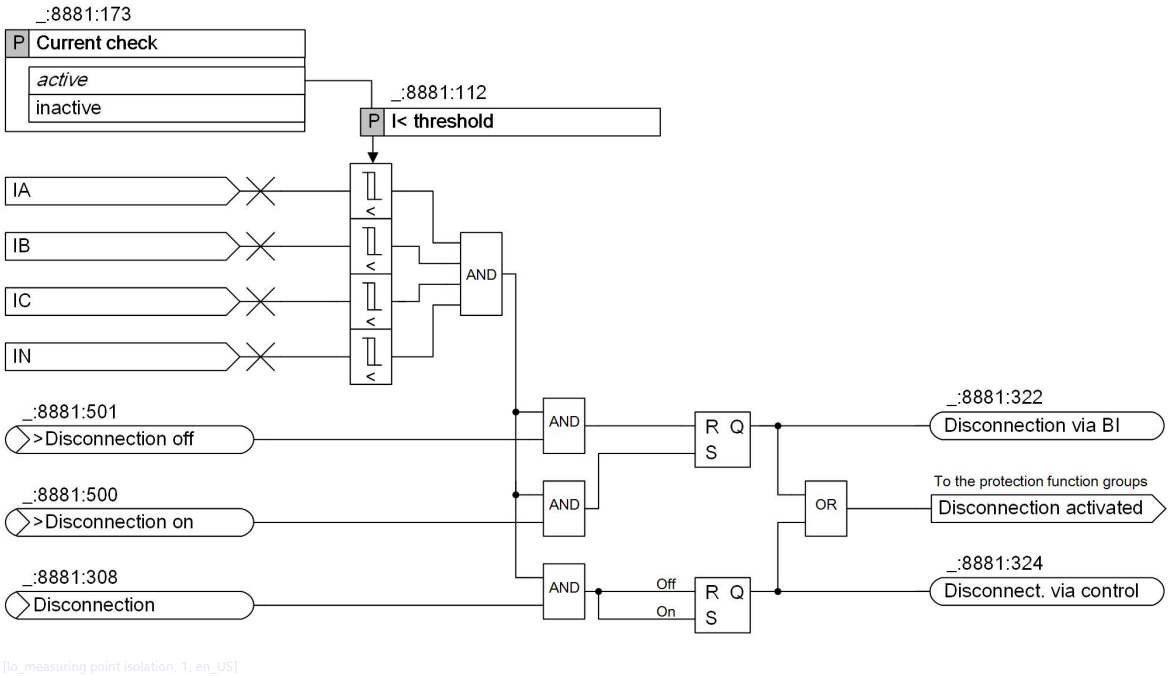
NOTE

If one of the current measuring points is disconnected, the mentioned protection functions of the FG **Line** switch to the *Alarm* state and are not active.

There is another exception for the disconnection of measuring points for the FG **Circuit breaker**: If the FG **Circuit breaker** is connected to a disconnected measuring point, the functional measured values are indicated as usual and used by the functions in the FG **Circuit breaker**. That is, the disconnection does not set the functional measured values to 0. If a circuit-breaker failure detection is instantiated in the FG **Circuit breaker**, Siemens recommends blocking the function for current tests.

6.1.6.2 Description

Logic



[lo_measuring point isolation, 1, en_US]

Figure 6-4 Logic of the Disconnection of Measuring Point

You can find the signals for the **Disconnection of measuring points** in the Information routing matrix in DIGSI under **Settings** → **Power system** → **Meas.point I-3ph**.

The following signals are available for activating the **Measuring point I-3ph**:

- The binary inputs *(_:8881:500) >Disconnection on* and *(_:8881:501) >Disconnection off*
- The controllable *(_:8881:308) Disconnection*

You can control whether the **Measuring point I-3ph** may only be disconnected if the measured currents fall below the set threshold value. The measuring point can also be disconnected without checking the threshold value. If you want to disconnect the measuring point without threshold-value check, consider that no currents are flowing anymore in the primary plant.

Disconnection messages are also available after a restart of the device. The device stores the disconnection efficacy in NVRAM[34] The last information on disconnection remains available, even if the auxiliary voltage fails. When the auxiliary voltage returns, the device compares the stored state with that of the binary inputs.

6.1.6.3 Application and Setting Notes

Parameter: Current check

- Default setting **(_:8881:173) Current check** = ***active***

With the **Current check** parameter, you can set whether you want to compare the RMS values of the phase currents IA, IB, IC and of the measured zero-sequence current IN with a threshold value.

34 NVRAM = Non-Volatile Random Access Memory; RAM, which does not lose the stored data, even when there is no power.

Parameter Value	Description
active	The RMS values of the phase currents IA, IB, IC and of the measured zero-sequence current IN are compared to the setting value of the parameter **I< threshold**. The **Measuring point I-3ph** can only be activated if the current measured values fall below the threshold value.
inactive	The RMS values of the phase currents IA, IB, IC and of the measured zero-sequence current IN are not compared to the setting value of the parameter **I< threshold**.

Parameter: I< threshold

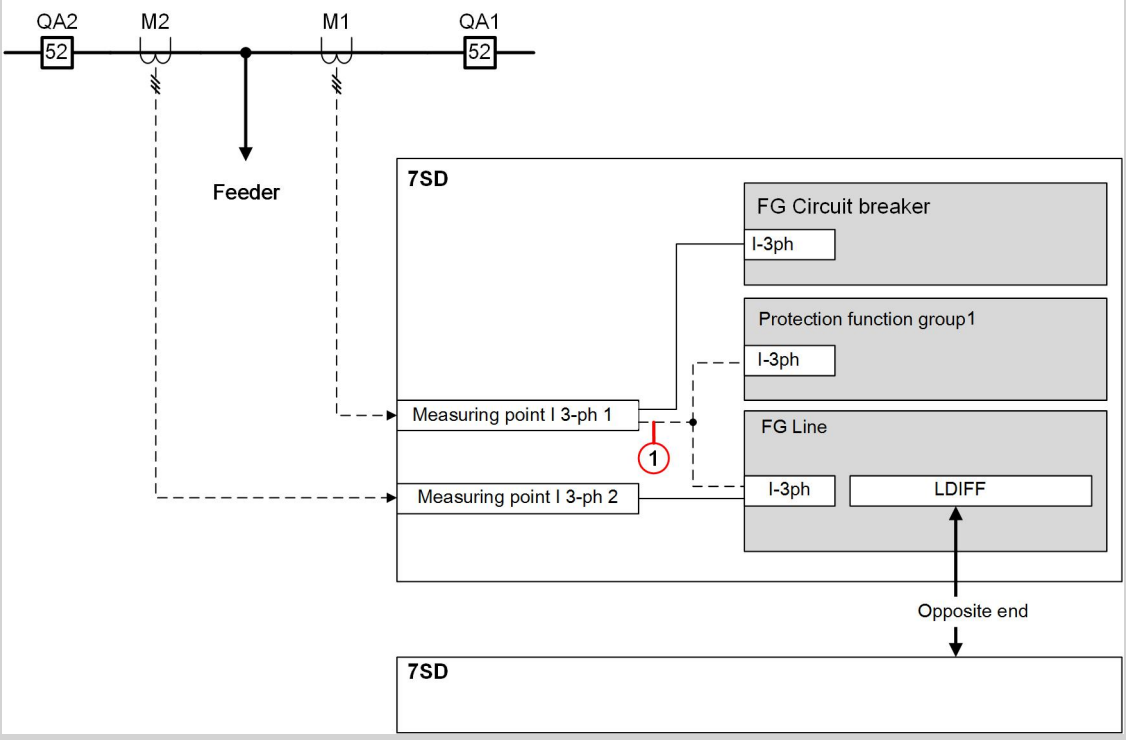
- Default setting **(_:8881:112) I< threshold** = ***0.100 A***

With the **I< threshold** parameter, you set the threshold for disconnection of a measuring point. If the current measured values fall below the threshold value, the **Measuring point I-3ph** can be activated.

Set the **I< threshold** parameter so that the measured current will certainly fall below the parameterized value, for example, if the circuit-breaker pole is open. If parasitic currents, for example, due to induction, are not possible with the line/feeder deactivated, you can make a secondary setting of the value with a high degree of sensitivity, to 0.050 A for example. If no special requirements exist, Siemens recommends retaining the setting value of 0.100 A for secondary purposes.

EXAMPLE

Temporary Disconnection of a Connection of a Current Measuring Point to a Protection Function Group, Using the Example of a Line Differential Protection



[dw_similar-application_7SD_with_2-MU, 1, en_US]

Figure 6-5 Possible Disconnection of Measuring Point for the Line Differential Protection

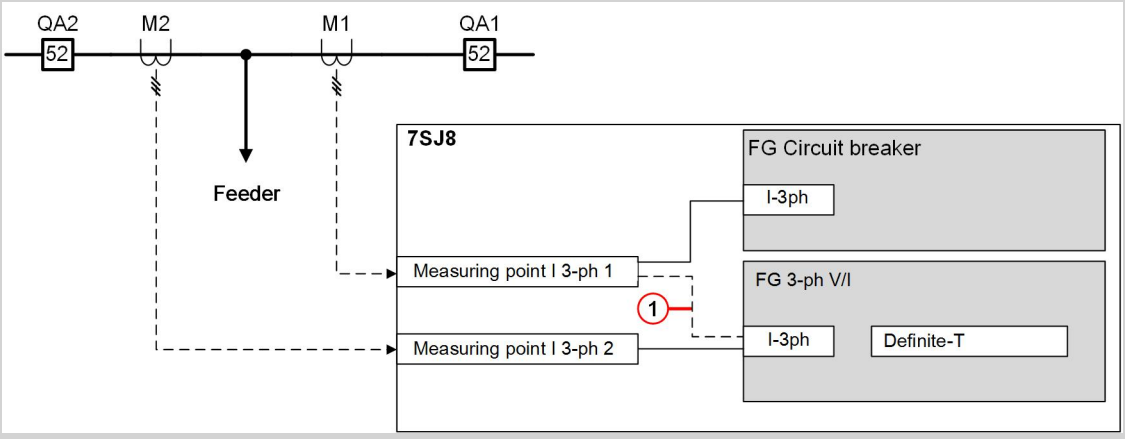
(1) Temporary disconnection of the connection to the **Measuring point I-3ph 1** for the FG **Line** and to the Protection Function Group 1

NOTE

If you disconnect the **Measuring point I-3ph 1**, you must make sure that no currents flows into the feeder via **M1**. Otherwise, this leads to an unwanted tripping of the **Line differential protection** function.

EXAMPLE

Temporary Disconnection of a Connection of a Current Measuring Point to the Protection Function Group 3-ph Voltage/Current



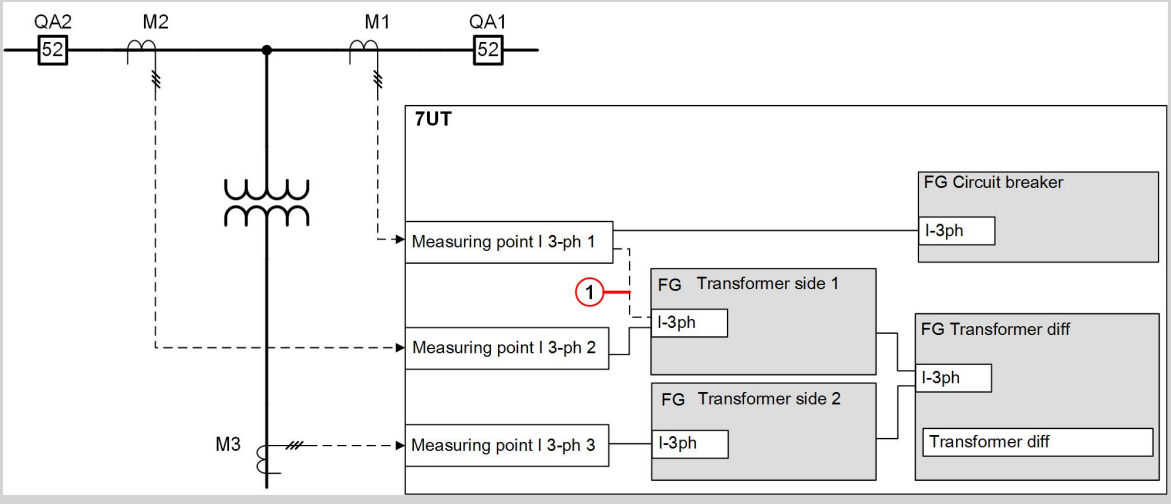
[dw_similar-application_7SJ8_with_2-MU_1_en_US]

Figure 6-6 Possible Disconnection of Measuring Point for the Feeder Protection

(1) Temporary disconnection of the connection of the **Measuring point I-3ph 1** to the FG **3-ph voltage/current**

EXAMPLE

Temporary Disconnection of the Connection of a Current Measuring Point to a Protection Function Group, Using the Example of a Transformer Differential Protection



[dw_similar-application_7UT_with_2-MU_1_en_US]

Figure 6-7 Possible Disconnection of Measuring Point for the Transformer Differential Protection

(1) Temporary disconnection of the **Measuring point I-3ph 1** for the FG **Transformer side 1**

NOTE

If you disconnect the **Measuring point I-3ph 1**, you must make sure that no current flows into the transformer via **M1**. Otherwise, this leads to an unwanted tripping of the **Transformer differential protection** function.

6.1.6.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MP disconnection				
_:8881:173	CT 3-phase:Current check		• inactive • active	active
_:8881:112	CT 3-phase:I< threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A

6.1.6.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:8881:500	CT 3-phase:>Disconnection on	SPS	I
_:8881:501	CT 3-phase:>Disconnection off	SPS	I
_:8881:308	CT 3-phase:Disconnection	SPC	C
_:8881:322	CT 3-phase:Disconnection via BI	SPS	O
_:8881:324	CT 3-phase:Disconnect. via control	SPS	O
_:8881:319	CT 3-phase:Phases AB inverted	SPS	O
_:8881:320	CT 3-phase:Phases BC inverted	SPS	O
_:8881:321	CT 3-phase:Phases AC inverted	SPS	O

6.1.7 Application and Setting Notes for Line Differential Protection Settings

NOTE

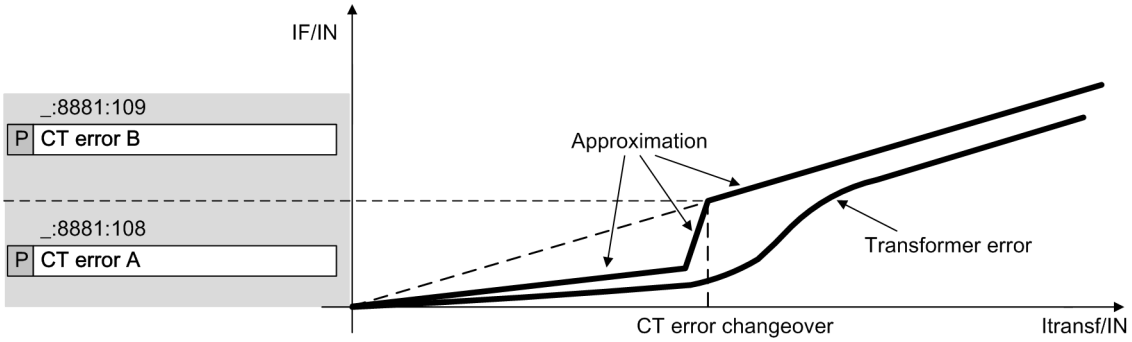
The following parameters are only important for the **Line differential protection** function. You can find these parameters in the DIGSI 5 project tree under **Device name** (for example, **7SL86**) → **Settings** → **Power-system data** under **Measuring point I-3ph**.

Current-Transformer Characteristic Curve

The basic principle of the Differential protection function assumes that all currents flowing into a healthy protected object add up to 0. If the sets of current transformers indicate different transformation errors at the line ends in the overcurrent range, the secondarily measured sum of the current may reach a significant magnitude during external short circuits and the high flow of current resulting from this fact. This may simulate an internal short circuit.

The adaptive stabilization method of the line differential protection considers the erroneous behavior during current-transformer transmission errors. For this reason, the measuring error protection must be known with regard to the value of the current transformed by the current transformer. To do this, set the characteristic data of the current transformer and the secondary circuits. In many cases, the default setting can be main-

tained. It considers the data of the most unfavorable protection current transformer. By using the following settings, the Line differential protection function approximates the characteristic curve of the transformer error and calculates the stabilization value.



[dwctfail-310111-01.tif, 2, en_US]

Figure 6-8 Transmission Behavior of the Current Transformer

Parameter: CT error changeover

- Default setting **(_:8881:107) CT error changeover** = ***1.00***

The **CT error changeover** parameter defines the transition range of the transformer error from low to higher currents.

$$\text{CT error changeover} = \frac{n'}{n} = \frac{P_N + P_i}{P' + P_i}$$

[fofueber-090311-01.tif, 1, en_US]

with

n'	Operational overcurrent factor (effective overcurrent factor)
n	Rated overcurrent factor of the current transformer (index following the letter "P")
P_N	Rated burden of the current transformer at rated current in [VA]
P_i	Inherent burden of the current transformers at rated current in [VA]
P'	Actually connected burden (devices and secondary lines) at rated current in [VA]

The rated overcurrent factor **n** and the rated power $\mathbf{P_N}$ of the current transformer can be found on the name plate of the current transformer. These values refer to the specified conditions (rated current, rated burden).

EXAMPLE:

Current transformer per VDE 0414/Part 1 or IEC 60044

Current transformer 10P10; 30 VA → n = 10; P_N = 30 VA

Current transformer 10P20; 20 VA → n = 20; P_N = 20 VA

The operational overcurrent factor **n'** is the result of the rated data and the actual secondary burden **P'**.

Under normal circumstances, the inherent burden of the current transformer is documented in the test report. If this value is unknown, the inherent burden Pi can be approximated and determined from the DC resistance Ri of the secondary winding:

$$P_i = R_i \cdot I^2_{rated}$$

[foeigbue-090311-01.tif, 1, en_US]

You can find the Siemens setting recommendation in *Table 6-1*.

Parameter: CT error A

- Default setting **(_:8881:108) CT error A** = ***5.0***

The **CT error A** parameter considers the transformer error at rated current plus a safety margin. According to VDE 0414/Part 1 or IEC 60044, at a primary rated current F1, the **CT error A** is equal to the measured current deviation.

Example:

Current transformer 5P:	3 %
Current transformer 10P:	5 %

You can find the Siemens setting recommendations in *Table 6-1*.

Parameter: CT error B

- Default setting **(_:8881:109) CT error B** = ***15.0***

The **CT error B** parameter considers the transformer error during rated overcurrent factor in addition to the safety margin. It is the number preceding the letter **P** of the transformer data.
You can find the Siemens setting recommendation in *Table 6-1*.

Setting Recommendations for General Protection Current Transformers

The following table lists general protection current transformers with characteristic data, including associated setting recommendations:

Table 6-1 Setting Recommendations for Current-Transformer Data

Transformer Class	STANDARD	Ratio Error at Rated Current	Angle Error at Rated Current	Fault at Rated Overcurrent Factor	Fault Transition[35]	CT error A[35]	CT error B[35]
5P	IEC 60044-1	1.0 %	± 60 min	≤ 5 %	1.50	3.0 %	10.0 %
10P		3.0 %	_	≤ 10 %	1.50	5.0 %	15.0 %
TPX		0.5 %	± 30 min	ϵ ≤ 10 %	1.50	1.0 %	15.0 %
TPY		1.0 %	± 30 min	ϵ ≤ 10 %	1.50	3.0 %	15.0 %
TPZ		1.0 %	180 min ± 18 min	ϵ ≤ 10 % (only I ≈)	1.50	6.0 %	20.0 %
PX	IEC 60044-1 OV: Class X				1.50	3.0 %	10.0 %
C100 to C800	ANSI				1.50	5.0 %	15.0 %
5TPE	IEC 61869-10	1.0 %	± 60 min	≤ 5 %	1.50	5.0 %	15.0 %
Low-power current transformer	IEC 61869-6	< 1 %	< ± 30 min	< 1 %	1.50	3.0 %	3.0 %
Optical current transformer	IEC 61869-6	< 1 %	< ± 30 min	< 1 %	1.50	3.0 %	3.0 %

35 Setting recommendation for the parameter

EXAMPLE:

Current transformer	5P10; 20 VA
Ratio $\ddot{U}_I$	600 A/5 A
Inherent burden	2 VA
Secondary lines	4 mm^2 copper (Cu)
Specific resistance of Cu	0.0175 Ω mm^2/m
Length	20 m
I_{rated}	5 A
Burden at 5 A	0.1 VA

The resistance of the secondary lines is calculated as follows:

$$R_l = 2 \cdot 0.0175 \frac{\Omega \cdot mm^2}{m} \cdot \frac{20\ m}{4\ mm^2} = 0.175\ \Omega$$

[fo_rl, 1, en_US]

The worst-case scenario has been assumed for the calculation, whereby during a 1-pole error the current flows back and forth across the secondary lines (factor 2). This follows that the power at a rated current of I_{rated} = 5 A can be calculated as:

$$P_i = 0.0175\ \Omega \cdot (5\ A) \cdot 2 = 4.375\ VA$$

[fo_pi, 1, en_US]

The entire connected burden comprises the burden of the supply lines and the burden of the device, and is calculated as follows:

$$P' = 4.375\ VA + 2 \cdot 0.1\ VA = 4.575\ VA$$

[fo_pges, 1, en_US]

The ratio of the overcurrent factors is calculated as follows:

$$\text{CT error changeover} = \frac{n'}{n} = \frac{P_N + P_i}{P' + P_i} = \frac{20\ VA + 2\ VA}{4.575\ VA + 2\ VA} = 3.35$$

[fo_fehlerueb, 1, en_US]

According to *Table 6-1*, Siemens recommends the following setting values:

CT error changeover	= 1.50
CT error A	= 3.0 %
CT error B	= 10.0 %

Transformer with Voltage Control

If the power transformer with voltage control is within the protection range, please observe the following: A differential current occurs already during stationary operation. This differential current depends on the current and the position of the tap changer. This is a current-proportional error. For this reason, it should be dealt with as an additional current-transformer error.

Calculate the max. deviation along the limit of the control range (referring to the mean current of the control range). Add the max. deviation to the calculated transformer errors A and B. Implement this correction only for the end that is facing the controlled side of the transformer.

EXAMPLE:

For a transformer YNd5, 35 MV, 110 kV/25 kV, Y-side controlled ± 10 %

This results in the following values:

Rated current at rated voltage	= 184 A
Rated current at V_{rated} + 10% I_{min}	= 167 A
Rated current at V_{rated} - 10% I_{max}	= 202 A

For the controlled side of the transformer, the following mean current is determined:

$$I_{mean} = \frac{I_{min} + I_{max}}{2} = \frac{167\,A + 202\,A}{2} = 184.5\,A$$

[foimittl-090311-01.tif, 1, en_US]

The max. deviation of this mean current is:

$$\delta_{max} = \frac{I_{max} + I_{mean}}{I_{mean}} = \frac{202\,A - 184.5\,A}{184.5\,A} = 0.095 = 9.5\,\%$$

[fodelmax-090311-01.tif, 1, en_US]

Add this max. deviation to the transformer errors **`CT error A`** and **`CT error B`** determined as described above. Ensure that this deviation due to voltage control relates to the mean current at rated apparent power and not to the rated current at the rated voltage.

6.1.8 Settings

General

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Phase sequence		• ABC • ACB	ABC

Measuring Point I-3ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:8881:115	CT 3-phase:CT connection		• not assigned • 3-phase + IN • 3-phase • 3-phase + IN-separate • 3-phase, 2 primary CT • 2ph, 2p. CT + IN-sep	3-phase + IN
_:8881:127	CT 3-phase:Tracking		• inactive • active	active
_:8881:130	CT 3-phase:Measuring-point ID		0 to 100	0
CT phases				
_:8881:101	CT 3-phase:Rated primary current		1.0 A to 100 000.0 A	1000.0 A

Addr.	Parameter	C	Setting Options	Default Setting
_:8881:102	CT 3-phase:Rated secondary current		• 1 A • 5 A	1 A
_:8881:117	CT 3-phase:Current range		• 1.6 x IR • 8 x IR • 20 x IR • 100 x IR • 50 x IR	100 x IR
_:8881:118	CT 3-phase:Internal CT type		• CT protection • CT measurement • CT protection • CT measurement • CT Process bus	CT protection
_:8881:116	CT 3-phase:Neutr.point in dir.of ref.obj		• no • yes	yes
_:8881:114	CT 3-phase:Inverted phases		• none • AC • BC • AB	none
_:8881:107	CT 3-phase:CT error changeover		1.00 to 10.00	1.00
_:8881:108	CT 3-phase:CT error A		0.5 % to 50.0 %	5.0 %
_:8881:109	CT 3-phase:CT error B		0.5 % to 50.0 %	15.0 %
CT IN				
_:8881:104	CT 3-phase:Rated primary current		1.0 A to 100 000.0 A	1000.0 A
_:8881:105	CT 3-phase:Rated secondary current		• 1 A • 5 A	1 A
_:8881:119	CT 3-phase:Current range		• 1.6 x IR • 8 x IR • 20 x IR • 100 x IR • 50 x IR	100 x IR
_:8881:120	CT 3-phase:Internal CT type		• CT protection • CT measurement • CT protection • CT measurement • CT Process bus	CT protection
CT 1				
_:3841:103	CT 1:Magnitude correction		0.010 to 10.000	1.000

Addr.	Parameter	C	Setting Options	Default Setting
_:3841:117	CT 1:Phase		• I A • I B • I C • IN • INsens • Ix	
CT 2				
_:3842:103	CT 2:Magnitude correction		0.010 to 10.000	1.000
_:3842:117	CT 2:Phase		• I A • I B • I C • IN • INsens • Ix	
CT 3				
_:3843:103	CT 3:Magnitude correction		0.010 to 10.000	1.000
_:3843:117	CT 3:Phase		• I A • I B • I C • IN • INsens • Ix	
CT 4				
_:3844:103	CT 4:Magnitude correction		0.010 to 10.000	1.000
_:3844:117	CT 4:Phase		• I A • I B • I C • IN • INsens • Ix	
Supv. balan. I				
_:2491:1	Supv. balan. I:Mode		• off • on • test	off
_:2491:101	Supv. balan. I:Release threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	2.500 A
_:2491:102	Supv. balan. I:Threshold min/max		0.10 to 0.95	0.50

Addr.	Parameter	C	Setting Options	Default Setting
_:2491:6	Supv. balan. I:Delay failure indication		0.00 s to 100.00 s	5.00 s
Supv. ph.seq.I				
_:2551:1	Supv. ph.seq.I:Mode		• off • on • test	off
_:2551:6	Supv. ph.seq.I:Delay failure indication		0.00 s to 100.00 s	5.00 s
Supv. sum I				
_:2431:1	Supv. sum I:Mode		• off • on • test	off
_:2431:102	Supv. sum I:Threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2431:101	Supv. sum I:Slope factor		0.00 to 0.95	0.10
_:2431:6	Supv. sum I:Delay failure indication		0.00 s to 100.00 s	5.00 s
Supv.ADC sum I				
_:2401:1	Supv.ADC sum I:Mode		• off • on • test	off
Saturat. det.				
_:17731:1	Saturat. det.:Mode		• off • on	on
_:17731:101	Saturat. det.:CT saturation threshold	1 A @ 100 Irated	1.200 A to 100.000 A	8.000 A
		5 A @ 100 Irated	6.00 A to 500.00 A	40.00 A
		1 A @ 50 Irated	1.200 A to 50.000 A	8.000 A
		5 A @ 50 Irated	6.00 A to 250.00 A	40.00 A
		1 A @ 1.6 Irated	0.040 A to 1.600 A	8.000 A
		5 A @ 1.6 Irated	0.200 A to 8.000 A	40.000 A

Measuring Point I-1ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Rated primary current		1.0 A to 100 000.0 A	1000.0 A
_:2311:102	General:Rated secondary current		• 1 A • 5 A	1 A

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:103	General:Current range		• 1.6 x IR • 8 x IR • 20 x IR • 100 x IR • 50 x IR	100 x IR
_:2311:104	General:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
_:2311:116	General:Term. 1,3,5,7 in dir. of obj.		• no • yes	yes
_:2311:105	General:Tracking		• inactive • active	inactive
_:2311:130	General:Measuring-point ID		0 to 100	0
CT 1				
_:3841:103	CT 1:Magnitude correction		0.010 to 10.000	1.000
_:3841:117	CT 1:Phase		• I A • I B • I C • IN • INsens • Ix	

Measuring Point V-3ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:8911:101	VT 3-phase:Rated primary voltage		0.100 kV to 1200.000 kV	400.000 kV
_:8911:102	VT 3-phase:Rated secondary voltage		80 V to 230 V	100 V
_:8911:103	VT 3-phase:Matching ratio Vph / VN		0.10 to 9.99	1.73
_:8911:104	VT 3-phase:VT connection		• not assigned • 3 ph-to-gnd volt. + VN • 3 ph-to-gnd voltages • 3 ph-to-ph volt. + VN • 3 ph-to-ph voltages	3 ph-to-gnd volt. + VN
_:8911:106	VT 3-phase:Inverted phases		• none • AC • BC • AB	none
_:8911:111	VT 3-phase:Tracking		• inactive • active	active

Addr.	Parameter	C	Setting Options	Default Setting
_:8911:130	VT 3-phase:Measuring-point ID		0 to 100	0
VT 1				
_:3811:103	VT 1:Magnitude correction		0.010 to 10.000	1.000
_:3811:108	VT 1:Phase		• V A • V B • V C • V AB • V BC • V CA • VN • Vx • VCB	
VT 2				
_:3812:103	VT 2:Magnitude correction		0.010 to 10.000	1.000
_:3812:108	VT 2:Phase		• V A • V B • V C • V AB • V BC • V CA • VN • Vx • VCB	
VT 3				
_:3813:103	VT 3:Magnitude correction		0.010 to 10.000	1.000
_:3813:108	VT 3:Phase		• V A • V B • V C • V AB • V BC • V CA • VN • Vx • VCB	
VT 4				
_:3814:103	VT 4:Magnitude correction		0.010 to 10.000	1.000

Addr.	Parameter	C	Setting Options	Default Setting
_:3814:108	VT 4:Phase		• V A • V B • V C • V AB • V BC • V CA • VN • Vx • VCB	
Supv. balan. V				
_:2521:1	Supv. balan. V:Mode		• off • on • test	off
_:2521:101	Supv. balan. V:Release threshold		0.300 V to 170.000 V	50.000 V
_:2521:102	Supv. balan. V:Threshold min/max		0.58 to 0.95	0.75
_:2521:6	Supv. balan. V:Delay failure indication		0.00 s to 100.00 s	5.00 s
Supv. ph.seq.V				
_:2581:1	Supv. ph.seq.V:Mode		• off • on • test	off
_:2581:6	Supv. ph.seq.V:Delay failure indication		0.00 s to 100.00 s	5.00 s
Supv. sum V				
_:2461:1	Supv. sum V:Mode		• off • on • test	off
_:2461:3	Supv. sum V:Threshold		0.300 V to 170.000 V	25.000 V
_:2461:6	Supv. sum V:Delay failure indication		0.00 s to 100.00 s	5.00 s
VT miniatureCB				
_:2641:101	VT minia-tureCB:Response time		0.00 s to 0.03 s	0.00 s

Measuring Point V-1ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Rated primary voltage		0.100 kV to 1200.000 kV	400.000 kV
_:2311:102	General:Rated secondary voltage		80 V to 340 V	100 V
_:2311:108	General:Matching ratio Vph / VN		0.10 to 9.99	1.73
_:2311:103	General:Tracking		• inactive • active	inactive

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:130	General:Measuring-point ID		0 to 100	0
VT 1				
_:3811:103	VT 1:Magnitude correction		0.010 to 10.000	1.000
_:3811:108	VT 1:Phase		• V A • V B • V C • V AB • V BC • V CA • VN • Vx • VCB • VN broken-delta	
_:3811:107	VT 1:Sequence number device		1 to 2147483647	2147483647
VT miniatureCB				
_:2641:101	VT miniatureCB:Response time		0.00 s to 0.03 s	0.00 s

6.1.9 Information List

General

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Phs-rotation reversal	SPS	I
_:2311:501	General:>Invert Phases	SPS	I
General			
_:2311:319	General:Phase sequence ABC	SPS	O
_:2311:320	General:Phase sequence ACB	SPS	O
_:2311:321	General:Freq.out of oper.range	SPS	O
_:2311:322	General:f sys	MV	O
_:2311:323	General:f track	MV	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O

Measuring Point I-3ph

No.	Information	Data Class (Type)	Type
General			
_:8881:500	CT 3-phase:>Disconnection on	SPS	I
_:8881:501	CT 3-phase:>Disconnection off	SPS	I
_:8881:502	CT 3-phase:>Invert polarity	SPS	I
_:8881:308	CT 3-phase:Disconnection	SPC	C

No.	Information	Data Class (Type)	Type
_:8881:322	CT 3-phase:Disconnection via BI	SPS	O
_:8881:324	CT 3-phase:Disconnect. via control	SPS	O
_:8881:319	CT 3-phase:Phases AB inverted	SPS	O
_:8881:320	CT 3-phase:Phases BC inverted	SPS	O
_:8881:321	CT 3-phase:Phases AC inverted	SPS	O
_:8881:73	CT 3-phase:Polarity inverted	SPS	O
CT 1			
_:3841:300	CT 1:Sampled val. current	SAV	O
_:3841:52	CT 1:Behavior	ENS	O
_:3841:53	CT 1:Health	ENS	O
CT 2			
_:3842:300	CT 2:Sampled val. current	SAV	O
_:3842:52	CT 2:Behavior	ENS	O
_:3842:53	CT 2:Health	ENS	O
CT 3			
_:3843:300	CT 3:Sampled val. current	SAV	O
_:3843:52	CT 3:Behavior	ENS	O
_:3843:53	CT 3:Health	ENS	O
CT 4			
_:3844:300	CT 4:Sampled val. current	SAV	O
_:3844:52	CT 4:Behavior	ENS	O
_:3844:53	CT 4:Health	ENS	O
Calc.IN			
_:20191:300	Calc.IN:Sampled val. current	SAV	O
Supv. balan. I			
_:2491:82	Supv. balan. I:>Block function	SPS	I
_:2491:51	Supv. balan. I:Mode (controllable)	ENC	C
_:2491:54	Supv. balan. I:Inactive	SPS	O
_:2491:52	Supv. balan. I:Behavior	ENS	O
_:2491:53	Supv. balan. I:Health	ENS	O
_:2491:71	Supv. balan. I:Failure	SPS	O
Supv. ph.seq.I			
_:2551:82	Supv. ph.seq.I:>Block function	SPS	I
_:2551:51	Supv. ph.seq.I:Mode (controllable)	ENC	C
_:2551:54	Supv. ph.seq.I:Inactive	SPS	O
_:2551:52	Supv. ph.seq.I:Behavior	ENS	O
_:2551:53	Supv. ph.seq.I:Health	ENS	O
_:2551:71	Supv. ph.seq.I:Failure	SPS	O
Supv. sum I			
_:2431:82	Supv. sum I:>Block function	SPS	I
_:2431:51	Supv. sum I:Mode (controllable)	ENC	C
_:2431:54	Supv. sum I:Inactive	SPS	O
_:2431:52	Supv. sum I:Behavior	ENS	O
_:2431:53	Supv. sum I:Health	ENS	O
_:2431:71	Supv. sum I:Failure	SPS	O

No.	Information	Data Class (Type)	Type
Supv.ADC sum I			
_:2401:82	Supv.ADC sum I:>Block function	SPS	I
_:2401:51	Supv.ADC sum I:Mode (controllable)	ENC	C
_:2401:54	Supv.ADC sum I:Inactive	SPS	O
_:2401:52	Supv.ADC sum I:Behavior	ENS	O
_:2401:53	Supv.ADC sum I:Health	ENS	O
_:2401:71	Supv.ADC sum I:Failure	SPS	O

Measuring Point I-1ph

No.	Information	Data Class (Type)	Type
CT 1			
_:3841:300	CT 1:Sampled val. current	SAV	O
_:3841:52	CT 1:Behavior	ENS	O
_:3841:53	CT 1:Health	ENS	O

Measuring Point V-3ph

No.	Information	Data Class (Type)	Type
General			
_:8911:315	VT 3-phase:Phases AB inverted	SPS	O
_:8911:316	VT 3-phase:Phases BC inverted	SPS	O
_:8911:317	VT 3-phase:Phases AC inverted	SPS	O
VT 1			
_:3811:300	VT 1:Sampled val. voltage	SAV	O
_:3811:52	VT 1:Behavior	ENS	O
_:3811:53	VT 1:Health	ENS	O
VT 2			
_:3812:300	VT 2:Sampled val. voltage	SAV	O
_:3812:52	VT 2:Behavior	ENS	O
_:3812:53	VT 2:Health	ENS	O
VT 3			
_:3813:300	VT 3:Sampled val. voltage	SAV	O
_:3813:52	VT 3:Behavior	ENS	O
_:3813:53	VT 3:Health	ENS	O
VT 4			
_:3814:300	VT 4:Sampled val. voltage	SAV	O
_:3814:52	VT 4:Behavior	ENS	O
_:3814:53	VT 4:Health	ENS	O
Supv. balan. V			
_:2521:82	Supv. balan. V:>Block function	SPS	I
_:2521:51	Supv. balan. V:Mode (controllable)	ENC	C
_:2521:54	Supv. balan. V:Inactive	SPS	O
_:2521:52	Supv. balan. V:Behavior	ENS	O
_:2521:53	Supv. balan. V:Health	ENS	O
_:2521:71	Supv. balan. V:Failure	SPS	O

No.	Information	Data Class (Type)	Type
Supv. ph.seq.V			
_:2581:82	Supv. ph.seq.V:>Block function	SPS	I
_:2581:51	Supv. ph.seq.V:Mode (controllable)	ENC	C
_:2581:54	Supv. ph.seq.V:Inactive	SPS	O
_:2581:52	Supv. ph.seq.V:Behavior	ENS	O
_:2581:53	Supv. ph.seq.V:Health	ENS	O
_:2581:71	Supv. ph.seq.V:Failure	SPS	O
Supv. sum V			
_:2461:82	Supv. sum V:>Block function	SPS	I
_:2461:51	Supv. sum V:Mode (controllable)	ENC	C
_:2461:54	Supv. sum V:Inactive	SPS	O
_:2461:52	Supv. sum V:Behavior	ENS	O
_:2461:53	Supv. sum V:Health	ENS	O
_:2461:71	Supv. sum V:Failure	SPS	O
Definite-T 1			
_:2641:500	VT miniatureCB:>Open	SPS	I
_:2641:52	VT miniatureCB:Behavior	ENS	O
_:2641:53	VT miniatureCB:Health	ENS	O
Calc.VN			
_:20221:300	Calc.VN:Sampled val. voltage	SAV	O

Measuring Point V-1ph

No.	Information	Data Class (Type)	Type
VT 1			
_:3811:300	VT 1:Sampled val. voltage	SAV	O
_:3811:52	VT 1:Behavior	ENS	O
_:3811:53	VT 1:Health	ENS	O
Definite-T 1			
_:2641:500	VT miniatureCB:>Open	SPS	I
_:2641:52	VT miniatureCB:Behavior	ENS	O
_:2641:53	VT miniatureCB:Health	ENS	O

6.2 Transformer Differential Protection

6.2.1 Overview of Functions

The function **Transformer differential protection** (ANSI 87T):

- Detects ground faults and multiphase short-circuits in transformers, reactors, short lines, as wells as generators and motors
- Is appropriate for block protection for generator-transformer blocks, transformer-reactor combinations or transformer-neutral reactors
- Has available the necessary stabilization methods in the event of connection and overexcitation processes
- Is stable in the event of external short-circuits with current transformer saturation through intelligent saturation recognition methods
- Triggers safely in the case of internal high-current faults through an additional high-current stage

Depending on the basic type of the device selected, can protect different system configurations. In the simplest implementation (7UT82), this is a two-winding transformer. The 7UT85 protects a two-winding transformer or an auto transformer. The 7UT86 processes 3 sides or 3 measuring points. In a function group, 2 differential protection functions can run in parallel for auto-transformer applications and 2-core phase-angle regulating transformers. In the maximum implementation (7UT87), up to 5 sides or a maximum of 7 measuring points can be processed. Furthermore, the 7UT87 can process 3 function groups **Transformer differential protection**.

6.2.2 Structure of the Function

The function **Transformer differential protection** is used in the protection function group **Transformer** or **Auto Transformer**. The function depends upon application in the corresponding application template preconfigured by the manufacturer or can be copied during the engineering into the corresponding function group.

The function **Transformer differential protection** consists of the stages **I-DIFF** and **I-DIFF fast**. In addition, the stage **I-DIFF unrestr** is available. You can select this stage from the function catalog and copy it into the function **Transformer differential protection**. The stages can be blocked, in addition you can switch the stages on and off.

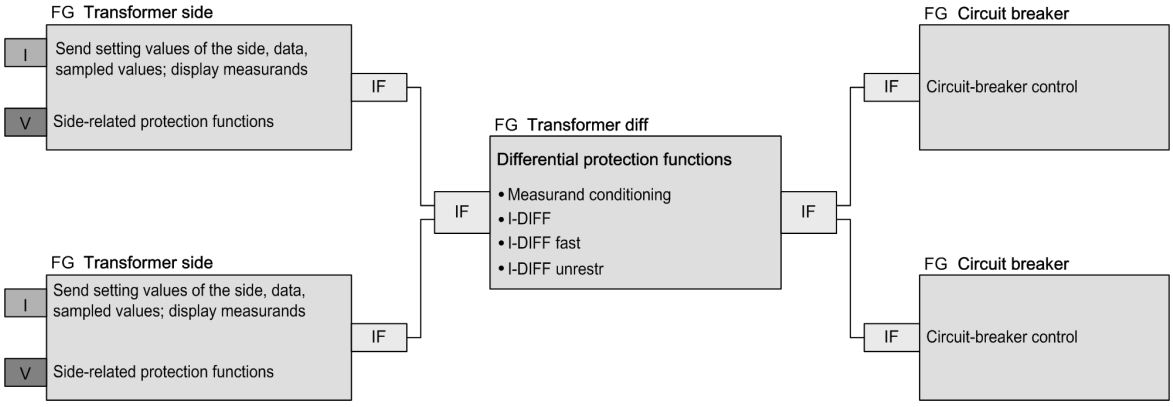
The following actions are performed in the function group **Transformer side**:

- Accept side-related protection settings
- Perform side-related calculations
- Send all data (setting values, included currents) to the function group **Transformer**
- Accept necessary settings for adapting differential protection to the current tap changer setting

The number of instances of the function **Transformer differential protection** is limited as follows in the device types and in the function groups:

Device	Max. Number of Instances of the Function Transformer Differential Protection per		
	Device	FG Transformer diff	FG Auto transformer diff
7UT82	1	1	1
7UT85	1	1	1
7UT86	2	2	2
7UT87	3	2	2

Side-related protection functions can run in the function group **Transformer side**, for example, restricted ground-fault protection, overload protection, overcurrent protection.



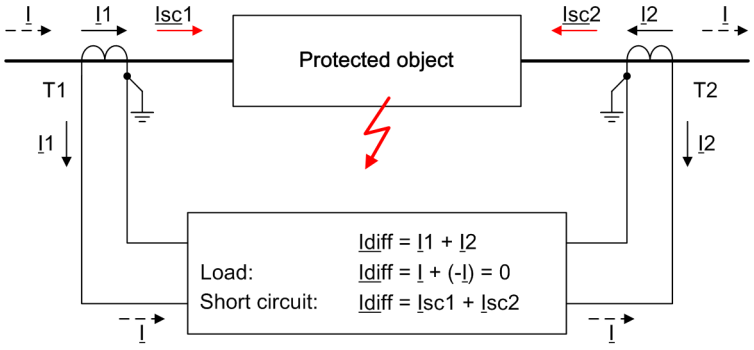
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Figure 6-9 Structure/Embedding of the Function

6.2.3 Functional Description

6.2.3.1 Basic Principle of Differential Protection

Differential protection is based on a current comparison (set of nodal representation according to Kirchhoff, however, accounting for the current ratio of the transformer). When comparing the current, use is made of the fact that a protected object uses the same current I in a non-faulty operating state on both sides (dotted in *Figure 6-10*). This current flows into the range being observed on one side and leaves it again on the other side. A current differential is a sure indication of a fault within the protected object. The calculation of the difference is determined through the current direction definition. The current direction is defined as positive to the protected object. The current difference results from the vector addition of the currents.



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Figure 6-10 Basic Principle of Differential Protection Using the Example of 2 Sides

For safe operation, additional functions are required. The implementation of these additional functions is described in Chapter *6.2.3.6 Differential Protection Function (I-DIFF)*.

Current Stabilization

If very large currents flow through the protection range in the case of external faults, with different transmission behavior of the transformers **W1** and **W2** (*Figure 6-10*) a corresponding differential current I_{diff} occurs.

When this is larger than the corresponding pickup threshold, the device can issue a trip command, even though no fault is present in the protection range. Such a malfunction of the protection is avoided by the restraint current ($I_{rest.}$) and is implemented in the form of a characteristic curve $I_{diff} = f(I_{rest.})$.

The largest current of 2 or more measuring points of the protected object is used for stabilization.

The definition for 2 measuring points is:

A trip or differential current is

$I_{diff} = (\underline{I}_1 + \underline{I}_2)$

as well as a restraint current of

$I_{rest.} = Max (|\underline{I}_1| ; |\underline{I}_2|)$

For more than 2 measuring points this definition is expanded. This restraint method allows a reliable trip decision for more than 2 measuring points and different feeding behavior for internal short circuits.

$I_{rest.} = Max (|\underline{I}_1| ; |\underline{I}_2| ; ... |\underline{I}_n|)$

To clarify the effect 3 important operating states are observed with ideal and adapted measurands.

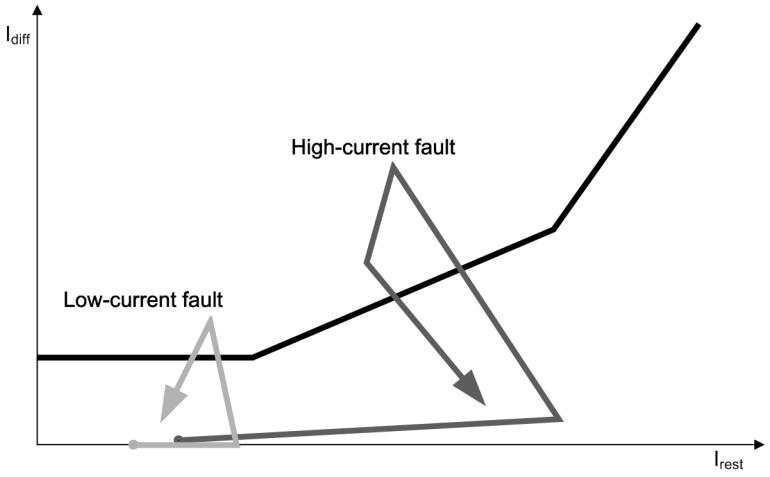
- Through fault current in healthy operation or external short circuit:
  $\underline{I}_1$ flows into the protection range, $\underline{I}_2$ flows out of the protection range, that is, negative compared with the prefix definition, thus $\underline{I}_2 = -\underline{I}_1$;
  in addition $|\underline{I}_2| = |\underline{I}_1|$
  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 - \underline{I}_1| = 0$
  $I_{rest} = Max (|\underline{I}_1| ; |\underline{I}_2|) = |\underline{I}_1| = |\underline{I}_2|$
  No tripping quantity ($I_{diff} = 0$); the stabilization ($I_{rest.}$) corresponds to the flowing current.
- Internal short circuit, feed from both sides with equal amount of currents, for example:
  Then $\underline{I}_2 = \underline{I}_1$; In addition $|\underline{I}_2| = |\underline{I}_1|$;
  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 + \underline{I}_1| = 2 \cdot |\underline{I}_1|$
  $I_{rest} = Max (|\underline{I}_1| ; |\underline{I}_2|) = |\underline{I}_1| = |\underline{I}_2|$
  The tripping quantity (I_{diff}) is twice as large as the short-circuit current and the restraining quantity ($I_{rest.}$).
- Internal short circuit, feed only from one side:
  Then $\underline{I}_2 = 0$
  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 + 0| = |\underline{I}_1|$
  $I_{rest} = Max (|\underline{I}_1| ; |\underline{I}_2|) = |\underline{I}_1|$
  The tripping quantity (I_{diff}) and the restraining quantity ($I_{rest.}$) are the same size and correspond to the short-circuit current.

Additional Stabilization with External Short Circuits

In case of an external short circuit, high short-circuit currents flowing through can lead to current transformer saturation. This saturation can be more or less strongly pronounced at the measuring points, and in this way simulate a differential current. The differential current can lie in the tripping range of the characteristic curve for a certain time and lead to unwanted tripping without any particular measures. In accordance with *Figure 6-11* there are 2 typical scenarios:

- High-current, external short circuit
  First, the current on both sides is transferred and leads to a large restraint current. After this, a transformer becomes saturated, resulting in a differential current I_{diff} that can exceed the operate curve. Simultaneously, the restraint current $I_{rest.}$ drops out. Once the transformer is no longer saturated, the differential current decreases and falls below the characteristic curve.
- Low-current, external short circuit
  Current transformers can also become saturated through the large direct-current time constant (switching of transformers, motors), but small currents flowing. This manifests itself as a phase angle rotation of the current. Exceeding the characteristic curve in a non-stabilized area is possible.

Intelligent saturation detection methods capture this state and lead to a temporally limited blocking of the Differential protection function.

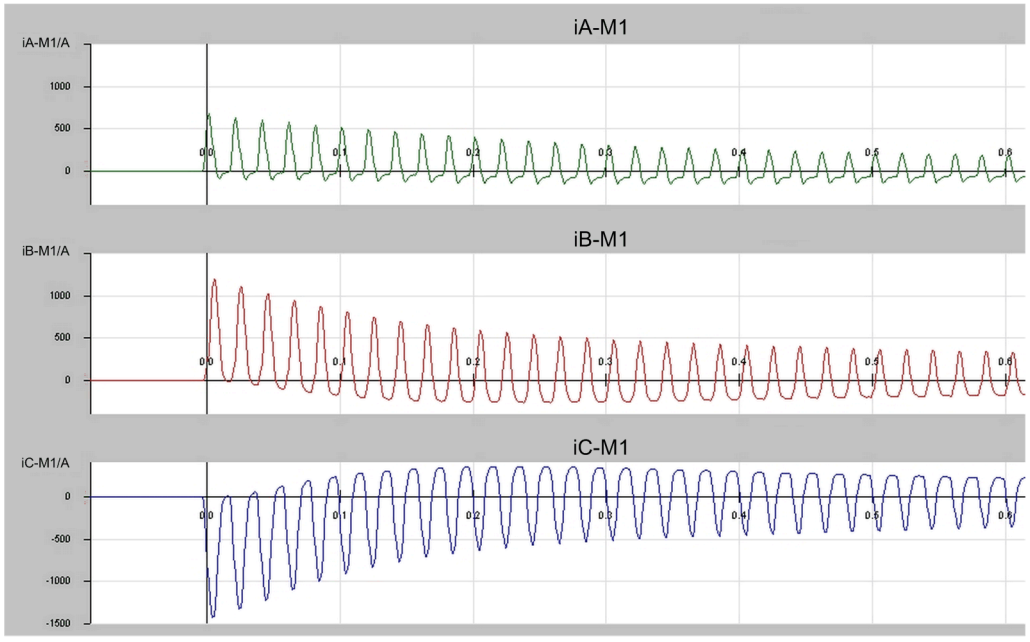


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Figure 6-11 Principle Current Course in External Short Circuit and Temporary Current Transformer Saturation on One Side

Inrush Current and Overexcitation Stabilization

When a transformer is switched on, an inrush current with a DC component flows, since the flow cannot change itself erratically. The inrush current develops in all phases and appears immediately as differential current. The direct-current time constant can amount to several seconds with large transformers. The following figure shows a typical situation.



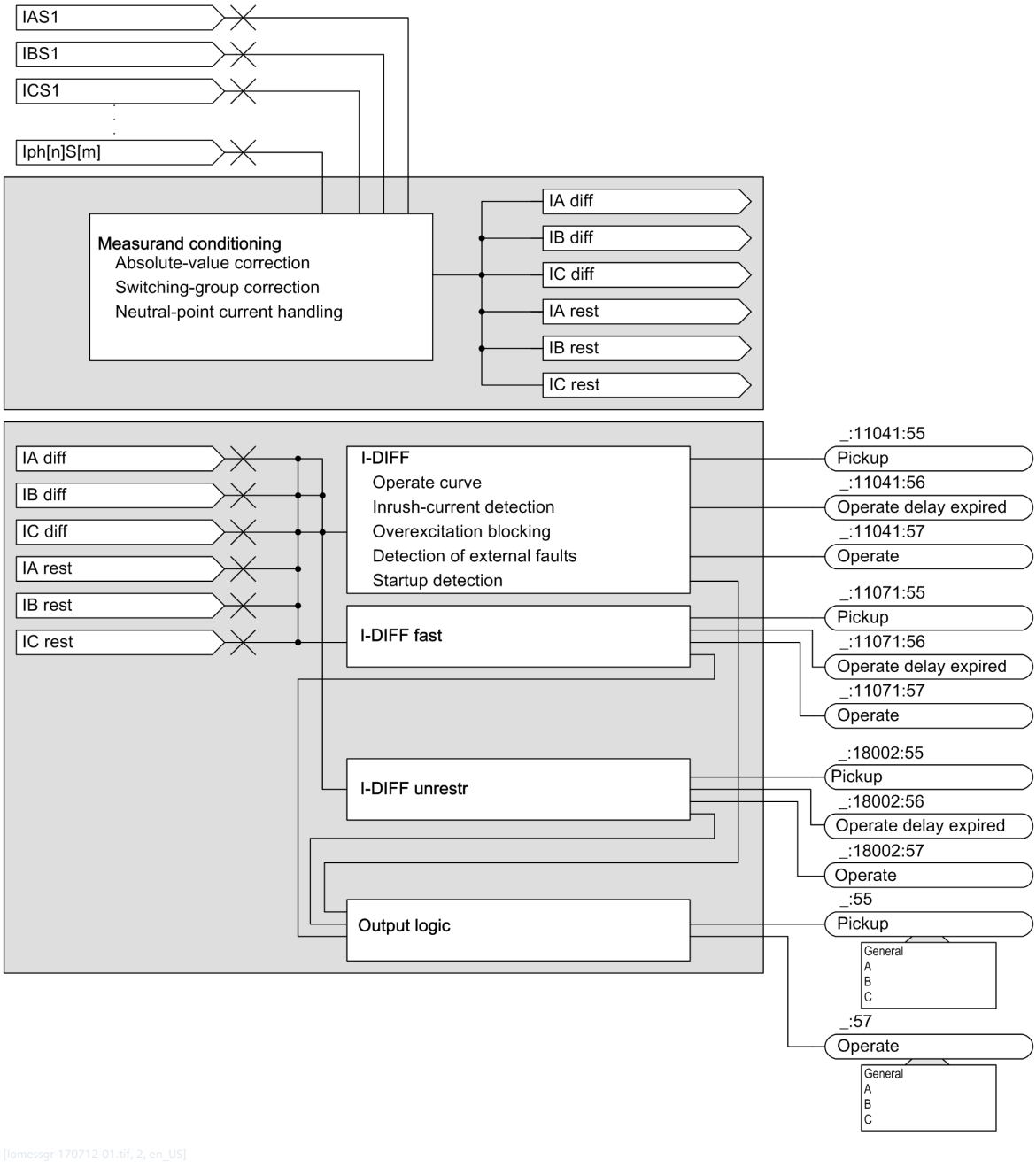
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Figure 6-12 Typical Inrush Current Curve

If a transformer is operated with too high of a voltage, it can be modulated up into the non-linear part of the magnetization characteristic curve. An increased magnetizing current results, which manifests itself as an increased differential current and can lead to an overfunction.

For this reason, additional functions are required which block the differential protection with closure and overexcitation processes.

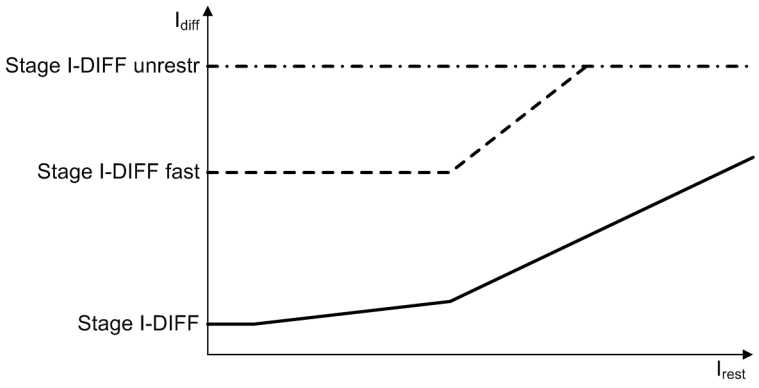
6.2.3.2 Logic of the Function



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Figure 6-13 Logic Diagram of the Transformer Differential Protection Function

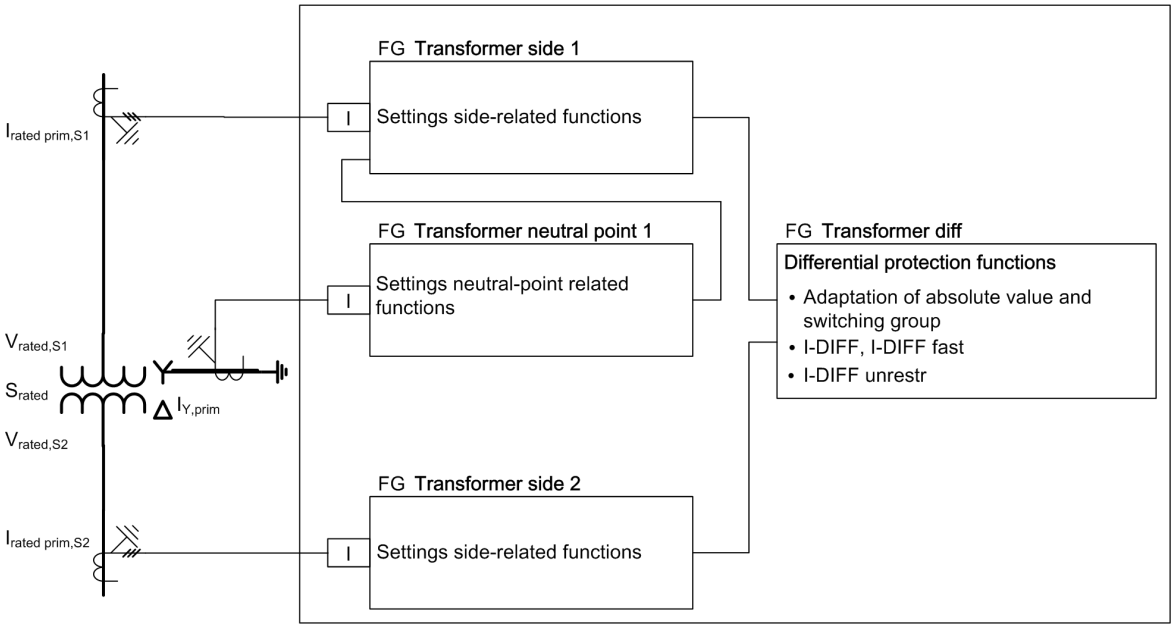
The interaction of the I-DIFF, I-DIFF fast and I-DIFF unrestrained tripping stages is shown in the operate curve below.



[dw_charac_function_trans-dif, 1, en_US]

Figure 6-14 Operate Curve of the Transformer Differential Protection Function

In the following, the essential components of differential protection are described in detail. The two-winding implementation, the basic structure of which shows *Figure 6-15*, serves as an example. The connection is between the phase current transformers and the neutral-point current transformer. Additionally, both relevant function groups for differential protection are represented.



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Figure 6-15 Connection and Basic Structure for the Example of a Two-Winding Transformer Yd5

6.2.3.3 Measurand Processing

Absolute-Value Correction

Since the current transformers cannot be adapted exactly to the rated currents of the protected object with regard to their primary rated data, a standardization to the nominal sizes of the protected object takes place. The conversion occurs every sampling time (thus, for instantaneous values). The differential protection function processes 20 sampled values per period. In addition, the sampled values tracked are used. A high degree of accuracy can be attained over the entire tracking range (from 10 Hz to 90 Hz).

The IDIFF-fast tripping and the IDIFF-unrestrained tripping stages work on non-frequency tracked values and thus, implement fast operate times at low frequencies.

The absolute value is adapted via the following formula:

$$i^{*}_{phsx} = k\, i_{phsx}$$

$$\text{with } k = \frac{I_{\text{rated prim, Sx}}}{I_{\text{rated obj, Sx}}} = \frac{I_{\text{rated prim, Sx}}}{\frac{S_{\text{rated, ref}}}{V_{\text{rated, Sx}}\sqrt{3}}}$$

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i_{phsx}*	Adapted instantaneous value per phase (x = 1, 2, 3)
i_{phsx}	Instantaneous value per phase (x = 1, 2, 3)
k	Correction value per measuring point
$I_{\text{rated prim,Sx}}$	Primary transformer rated current per measuring point
$S_{\text{rated,ref}}$	Reference power (maximum rated apparent power of the protected object)
$V_{\text{rated,Sx}}$	Rated voltage of the respective side (measuring point) of the protected object

NOTE

The largest power is used as reference winding with a multi-winding transformer. If several windings have the same absolute value of power, then, the highest current winding is selected as the reference winding. The absolute value of the neutral-point transformer is also adapted according to the previous formula. In this case, the absolute value should be adapted to the side with the greatest power.

Tap-Changer Adaptation

If a tap changer is present and is allocated to a transformer side, the side currents are also adapted to the current tap-changer position. In order to activate this functionality, the settings must be made in the **Transformer side** function group. You can find a more detailed description of the parameters **`Tap changer`**, **`Basic position`** and **`Volt. diff. adjacent taps`** are in the Application and Setting Instructions, subtitle Parameters: Tap changer.

Make the stage setting that corresponds to the rated voltage and the setting for the stage voltage. With these settings, an adjustment factor is calculated for each existing tap-changer position.

$$k_{(i)} = k_{\text{Base position}} \cdot \left(1 + \frac{\left(\text{Pos}_{(1)} - \text{BasPos}\right) \cdot \Delta V}{V_{\text{rated}}}\right)$$

[foBasPo1-231013-01, 1, en_US]

with

$\text{Pos}_{(i)}$	Existing tap-changer position
BasPos	Basic position of the tap changer
ΔV	Voltage difference of a stage
V_{rated}	Rated voltage
$k_{\text{Base position}}$	Corresponds to the correction value for each measuring point

When the sliding contact of the motor drive is activated by the tap changer, the previous stage remains active until the running contact signals the end of the motor run.

If capture of the current tap-changer position malfunctions, a higher operate curve takes effect. In this case, 2 measures become effective:

1. Calculation of an average adjustment factor

$$k_{\text{ref}} = k_{\text{Base position}} \cdot \frac{V_{\text{ref}}}{V_{\text{rated}}}$$

[foBasPo2-231013-01, 1, en_US]

$$V_{ref} = \frac{2}{\frac{1}{V_{min}} + \frac{1}{V_{max}}}$$

[foBasPo3-231013-01, 1, en_US]

2. Non-sensitive setting of the operate curve with factor k_{tcr}

$$k_{tcr} = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$$

[foBasPo4-231013-01, 1, en_US]

Vector-Group Correction

The vector groups of the transformer sides arise from the different side-wise coupling of the transformer windings to the transformer core as well as its configuration (Y, D, Z). The measured currents can therefore not be used directly for summation. The vector-group correction replicates the magnetic coupling of the transformer coils and makes the measured currents comparable. The correction occurs such that each side is converted to vector group 0. Since you are in the 3-phase system, the conversion occurs via matrices which are stored for the respective vector-group type. The general description is given in the following formula. In the same calculation step, the absolute value is corrected:

$$\begin{bmatrix} i_A^* \\ i_B^* \\ i_C^* \end{bmatrix} = k * M_{SG} * \begin{bmatrix} i_A \\ i_B \\ i_C \end{bmatrix}$$

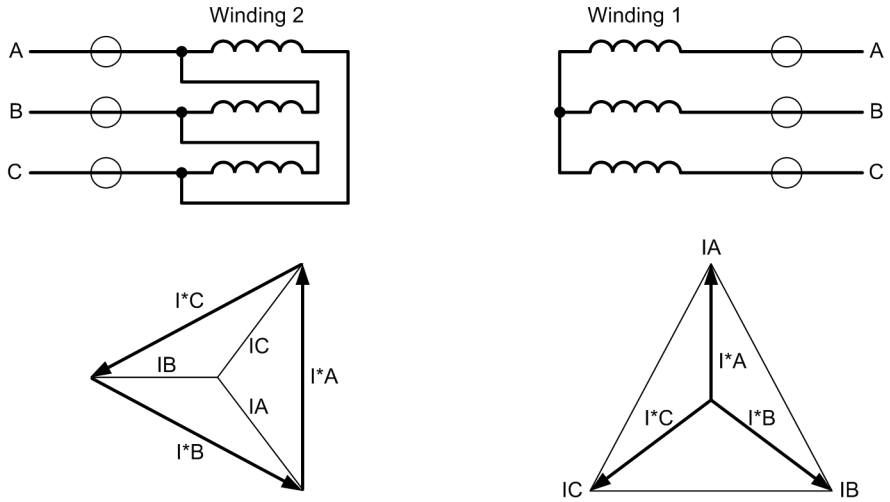
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with

i_{phx}*	Adapted instantaneous value per phase (x = 1, 2, 3)
i_{phx}	Instantaneous value per phase (x = 1, 2, 3)
k	Correction of absolute value per measuring point
M_{SG}	Correction matrix

The following example (*Figure 6-16*) shows the conversion. The neutral point is insulated against *Figure 6-15*, such that no zero-sequence current (short-circuit current) can arise in case of an external fault and can therefore not cause a faulty measurement.

In the example, the currents are processed directly. On the delta side, the conversion takes place into a vector group 0. If the measured zero-sequence current is also taken into account while using this matrix with the present neutral reactor, a higher sensitivity with regard to the usual elimination matrix can be attained (see *Figure 6-19*).



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$$\begin{pmatrix} I_A^* \\ I_B^* \\ I_C^* \end{pmatrix} = \frac{1}{3} \cdot \begin{pmatrix} 1-\sqrt{3} & 1 & 1+\sqrt{3} \\ 1+\sqrt{3} & 1-\sqrt{3} & 1 \\ 1 & 1+\sqrt{3} & 1-\sqrt{3} \end{pmatrix} \cdot \begin{pmatrix} IA \\ IB \\ IC \end{pmatrix} \qquad \begin{pmatrix} I_A^* \\ I_B^* \\ I_C^* \end{pmatrix} = 1 \cdot \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} IA \\ IB \\ IC \end{pmatrix}$$

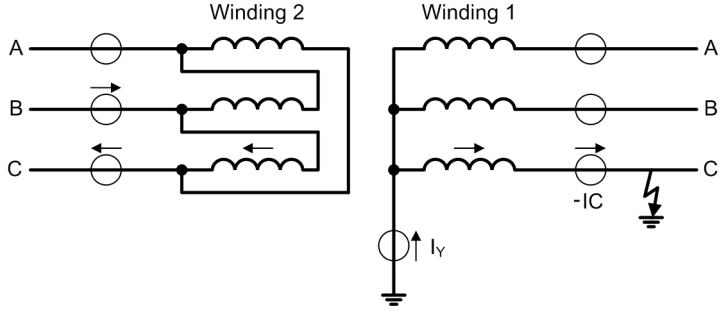
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Figure 6-16 Vector-Group Adaptation with the Example of Yd5 without Accounting for the Absolute-Value Adaptation

6.2.3.4 Neutral-Point Current Treatment

Considering the Neutral-Point Current

If the neutral point of a transformer winding is grounded, a current can also flow into the protection range in the case of a ground fault via this neutral point. For a complete summation, this current must be included. In *Figure 6-17* an outflowing zero-sequence current, for example, a fault occurs on the right side in the phase currents ($-I_C = -3I_0$). This corresponds to the current flowing into the neutral point ($I_Y = 3I_0$), such that the currents enter into the sum.



[dwsgayd5-170712-01.tif, 1, en_US]

Figure 6-17 Vector-Group Adaptation with the Example of Yd5

The complete matrix equation for the grounded side (Y side) with inclusion of all currents flowing in is, in this case:

$$\begin{pmatrix} I_A^* \\ I_B^* \\ I_C^* \end{pmatrix} = 1 \cdot \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} I_A \\ I_B \\ I_C \end{pmatrix} + \frac{1}{3} \cdot \begin{pmatrix} I_Y \\ I_Y \\ I_Y \end{pmatrix}$$

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$\underline{I}_{St}$ corresponds to $-3\underline{I}_0$ with current flowing. With a ground fault **within** the transformer area, the zero-sequence current goes in as a result ($\underline{I}_0 = 1/3\ \underline{I}_Y$). With a ground fault **outside**, however, the zero-sequence current falls out, since the zero-sequence current measured on the terminals $3\underline{I}_0 = (\underline{I}_A + \underline{I}_B + \underline{I}_C)$ (negative here) removes the neutral-point current $\underline{I}_Y$. Given this, nearly complete sensitivity is guaranteed for internal ground faults, while the zero-sequence current is automatically eliminated in case of an external ground fault.
If the following conditions are satisfied, the neutral-point current is accounted for:

- In the function group **Transformer side**, the parameter **`Neutral point`** = ***`grounded`*** is set.
- The function group **Transformer neutral point** is connected with the measuring point and the function group **Transformer side** (see *Figure 6-15*).
- In the function group **Transformer**, the parameter **`Meas. gnd. current side 1`** = ***`yes`*** is set.

You can attain increased sensitivity for ground faults in the protection range by using restricted ground-fault protection (see chapter *6.4 Restricted Ground-Fault Protection*).



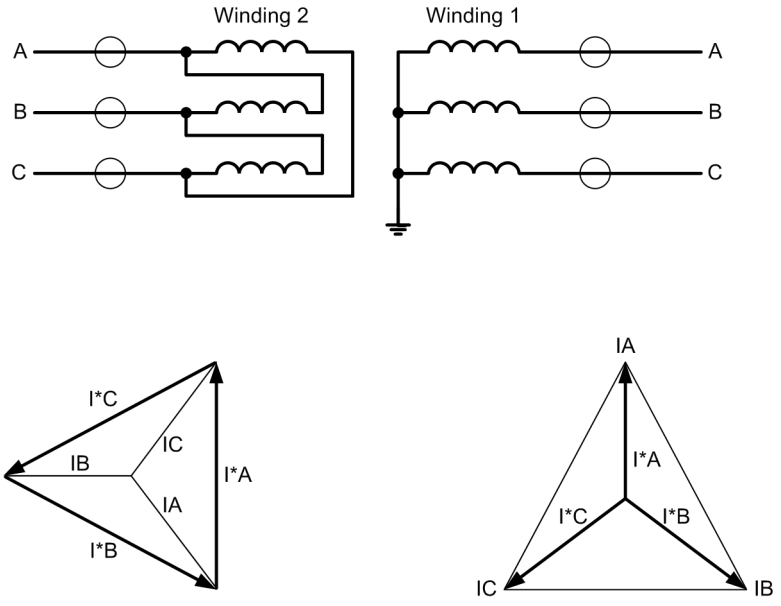
NOTE

In order to enable the proper function of the differential protection, the neutral-point transformer must be designed correspondingly strong (almost saturation-free). Interior 1-pole short circuits can lead to too high neutral-point currents. The harmonic resulting from a saturation can lead to a blocking of the tripping by the inrush-current detection. In addition a saturation when tripping can result in no unambiguous fault situation, that is unaffected phases also signal a tripping.

Neutral-Point Current is not Measured

Often the neutral-point current is not accessible, however, or is not coupled into the differential protection. Then, in accordance with *Figure 6-16*, a complete summation across all currents flowing into the protected object is not possible, since $\underline{I}_Y$ does not go in. So that the zero-sequence current in the phase currents ($-\underline{I}_C = -3\underline{I}_0$) does not lead to a faulty differential current, it must be eliminated.

The *Figure 6-18* shows an example of the vector group YNd5 with grounded neutral point on the Y side.
On the left side (delta side) of *Figure 6-18*, the zero-sequence current drops out automatically through formation of the differential current. Even in the transformer itself, no zero-sequence current is possible outside of the delta winding. If the neutral-point current cannot be measured, the zero-sequence current on the right side must be eliminated. This results from the matrix equation, for example, for:
$\underline{I}^*_A$: $1/3\ (2\ \underline{I}_A - 1\ \underline{I}_B - 1\ \underline{I}_C) = 1/3\ (3\ \underline{I}_A - \underline{I}_A - \underline{I}_B - \underline{I}_C) = 1/3\ (3\ \underline{I}_A - 3\ \underline{I}_0) = (\underline{I}_A - \underline{I}_0)$
By eliminating the zero-sequence current, fault currents are rendered harmless without special external measures. The fault currents also flow as a consequence of grounding in the protection range (transformer neutral point or neutral reactor) with ground faults in the power system via the current transformer. In *Figure 6-18* a zero-sequence current arises on the right side during an external fault, for example, but not on the left side. A comparison of the currents without zero-sequence current elimination and without inclusion of the neutral-point current, leads to a false result (differential current despite fault being external).



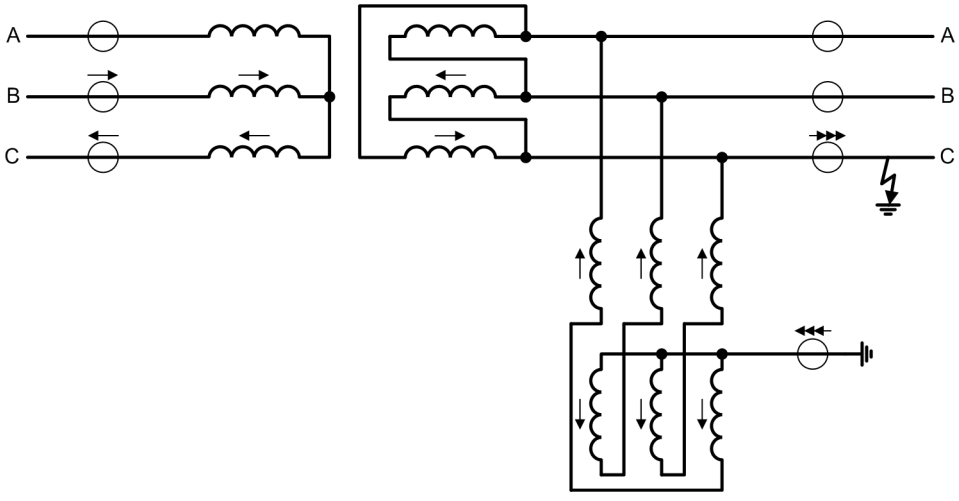
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$$\begin{pmatrix} I_A^* \\ I_B^* \\ I_C^* \end{pmatrix} = \frac{1}{\sqrt{3}} \cdot \begin{pmatrix} -1 & 0 & 1 \\ 1 & -1 & 0 \\ 0 & 1 & -1 \end{pmatrix} \cdot \begin{pmatrix} I_A \\ I_B \\ I_C \end{pmatrix} \qquad \begin{pmatrix} I_A^* \\ I_B^* \\ I_C^* \end{pmatrix} = \frac{1}{3} \cdot \begin{pmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{pmatrix} \cdot \begin{pmatrix} I_A \\ I_B \\ I_C \end{pmatrix}$$

[foyd5002-170712-01.tif, 2, en_US]

Figure 6-18 Vector-Group Adaptation for the Example of YNd5

Figure 6-19 shows an example of a ground fault on a delta side outside of the protection range with a neutral reactor (zigzag reactors) within the protection range. Here, too, a zero-sequence current arises on the right side, but not on the left side. If the neutral reactor is outside of the protection range (current transformer between power transformer and neutral reactor), then the zero-sequence current is harmless, since it does not flow through a measuring point (current transformer).



[dwtstern-120120-01.tif, 1, en_US]

Figure 6-19 Example of Ground Fault Outside of the Grounding Transformer within the Protection Range with Current Distribution

Zero-sequence current elimination has the disadvantage that the differential protection is less sensitive with ground faults in the protection range of the grounded side around the zero-sequence current. Since the

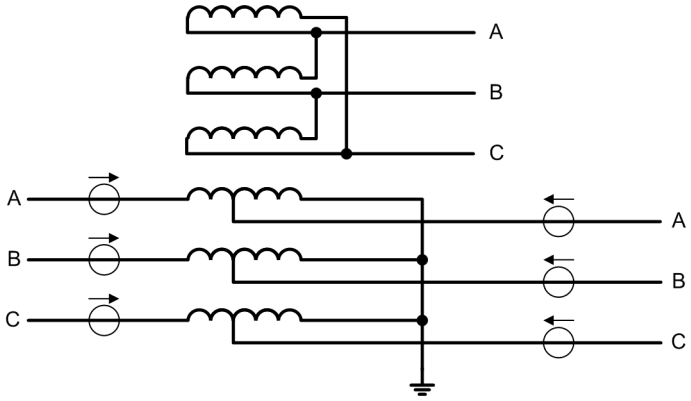
zero-sequence current makes up 1/3 of the short-circuit current, a sensitivity of 2/3 is achieved. If there is no neutral-point grounding present in the protection range or the neutral-point current can be captured (*Figure 6-17*), the zero-sequence current elimination is unnecessary (see *Figure 6-16*). In order to not recognize an electric breakdown as an internal fault with a connected **surge arrester on the neutral point** you must make do without this advantage.

If, in the function group **Transformer side**, the parameter **`Neutral point`** = ***`grounded`*** is set and no neutral-point current is coupled into the function group (see *Figure 6-15*), then the zero-sequence current elimination always takes place. If a neutral-point current is coupled into the function group **Transformer side** (for example, for the restricted ground-fault protection) and in the function group **Transformer**, the parameter **`Meas. gnd. current side 1`** = ***`no`*** is present, then a zero-sequence current elimination is also performed. If **`Neutral point`** = ***`isolated`*** is set, the phase currents are processed directly, without the zero-sequence currents being taken into account. If nothing is connected to the neutral point, make this setting.

6.2.3.5 Special Aspects of an Auto Transformer

In order to make the resulting currents for the differential protection comparable, all currents refer to the auto winding (= side of the protected object) with the largest rated apparent power. This is designated **rated power of the protected object**. If the highest rated apparent power occurs multiple times, the side with the higher rated current is selected as the reference side.

With auto transformers, there is only the vector group for the auto-transformer winding Y(N)y0 (*Figure 6-20*). Neutral-point grounding affects all auto-transformer windings connected to the parts of the electrical power system (upper-voltage and undervoltage). With a ground fault, coupling between the 2 parts of the electrical power system occurs via the common neutral-point grounding.



[dwstern1-040912-01.tif, 1, en_US]

Figure 6-20 Auto Transformer with Grounded Neutral Point

Here, too, the neutral-point current $I_{rest.}$ is necessary for a complete treatment of all currents flowing into the protected area. If the neutral point is not accessible, the residual current from the two phase currents must be eliminated. This means that the matrix with the residual current elimination is used on both sides. As with separated windings, differential protection with ground faults in the protection range is then reduced in sensitivity to 2/3 of the fault current. The residual current amounts to 1/3 of the short-circuit current.

If the neutral-point current is accessible and connected to the device, all currents flowing into the protection range are available. The residual current in the phases then enters into the sum with outward-lying ground faults through the neutral-point current. With an inward-lying ground fault, the full sensitivity of differential protection is thereby guaranteed.

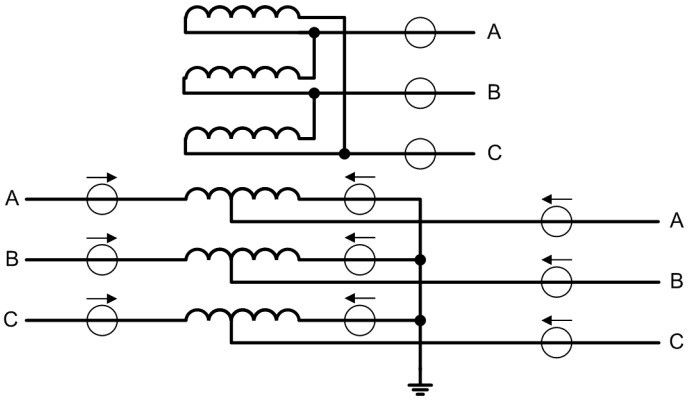
In order to attain an even higher sensitivity with ground faults in the protection range with the help of the neutral-point current, you can use the restricted ground-fault protection.

If, in the case of an auto transformer, three 1-phase auto transformers are interconnected, it is possible to attain a good ground fault sensitivity. With this arrangement, the 1-phase ground fault is the most likely fault. Short-circuits between the phases are excluded due to spatial separation. Here you can create current differential protection through each winding which captures the sum of all currents flowing to the node (the winding).

The requirements for this are that you configure an auto transformer with a 3-phase current connection for the grounding side and set the parameter **(_:2311:186) Protection Mode** = ***Current node*** .

NOTE

The differential protection function records no stabilizing winding with ***Current node*** . A stabilizing winding must be additionally protected.



[dwtspstr-040912-01.tif, 1, en_US]

Figure 6-21 Auto Transformer Bank with Current Transformer in the Neutral-Point Feed

6.2.3.6 Differential Protection Function (I-DIFF)

A differential current per phase based on the instantaneous value variables is calculated from the processed currents (see section *6.2.3.3 Measurand Processing*). The direction of current flow is defined as to the **protected object as positive**. The fundamental component contribution to the differential current (I_{diff}) is calculated via a Fourier filter (filter length = 1 period (20 sampled values)).

If the neutral-point current is connected, it is accounted for in the differential current as well as in the restraint current. This state of affairs is not represented for the reason of simplification in the following formulas. The currents of that measuring point whose RMS value is the largest are used as restraint current. Neutral or zero-sequence currents are also accounted for. If, for example, the current collapses at a measuring point as a consequence of current-transformer saturation, the measuring point that has the largest current is automatically switched to at the point in time of the calculation.

NOTE

Differential protection does not work with sensitive ground-current transformers. Since sensitive transformers can go into saturation too quickly, false differential currents arise.

$$i_{diff,phsx} = \sum_{m=1}^{N} i^{*}_{phsx,Mm} \rightarrow I_{diff,phsx} = FIR(i_{diff,phsx})$$

$$I_{phsx,Mm} = \sqrt{\frac{1}{n}\sum_{k=1}^{n} i^{*2}_{phsx,Mm}(k)}$$

$$I_{rest,phsx} = \underset{m=1}{\overset{N}{MAX}}\, I_{phsx,Mm}$$

[fogrds16-170712-01.tif, 1, en_US]

with

x	Variable (1, 2, 3) for the phase currents (A, B, C)
m	Variable (1, 2, ..., N) for the measuring points
N	Number of measuring points
n	Number of samples per period (n = 20)

FIR	Fourier filter
MAX	Maximum value determination

Pickup Characteristic

The *Figure 6-22* shows the pickup characteristic of the 7UT8x. The characteristic curve branch **a** represents the sensitivity threshold of the differential protection (parameter **Threshold**) and considers constant fault currents like magnetizing currents.

The characteristic branch **b** (parameter **Intersection 1 Irest** and **Slope 1**) considers current-proportional faults under normal operating conditions.

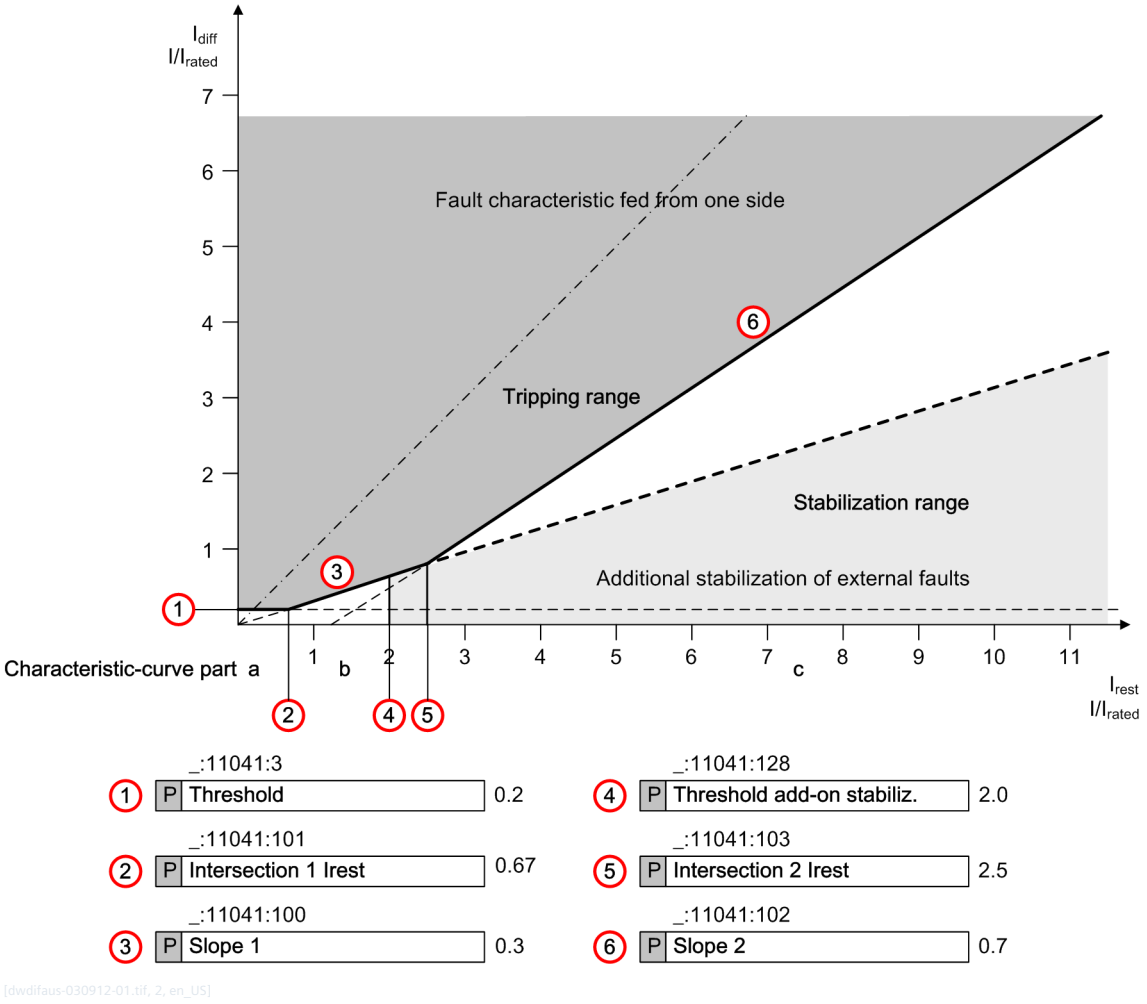
These faults can occur for the following reasons:

- Transformation errors in the current transformer and the input transformer of the device
- Adaptation deviations and tap changers in transformers with voltage control (but only if the tap-changer position is not taken into account in the differential protection)

The characteristic curve branch **c** (parameter **Intersection 2 Irest** and **Slope 2**) secures the differential protection from overfunction in case of high-current external faults and transformer saturation. In this area, transformer saturation can arise due to high short-circuit currents, and because of this a higher differential current results.

To avoid overfunction with external faults with current-transformer saturation (also see *Figure 6-11*), a logic is implemented that uses the characteristic curve **additional stabilization of external faults**. If the operating point is located in the additional stabilization area and exceeds the operate curve from there, then the logic becomes active, and blocks the differential protection.

The additional stabilization range is derived from the parameters **Threshold add-on stabiliz.** and **Slope 1**.



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Figure 6-22 Pickup Characteristic of the Differential Protection

If the differential current multiplied by the dropout ratio of 0.7 does not reach the pickup characteristic, the pickup drops out.

Inrush-Current Detection

The inrush-current detection evaluates the calculated instantaneous values of the differential current. The inrush current develops with Sympathetic Inrush – connection of a parallel transformer or Recovery Inrush – inrush current subsequent to returning voltage after a fault in the system in the differential current considerably higher than in the side currents. An assignment to the corresponding blocking phases is possible only in the differential current due to the vector-group correction.

The inrush-current detection is activated when the pickup characteristic is exceeded. It is deactivated when it is blocked by an external fault.

For inrush-current detection, 2 methods working in parallel are used:

- **Component of the 2nd harmonic relative to the fundamental component in the differential current ($I_{2nd\ harm}/I_{1st\ harm}$)**

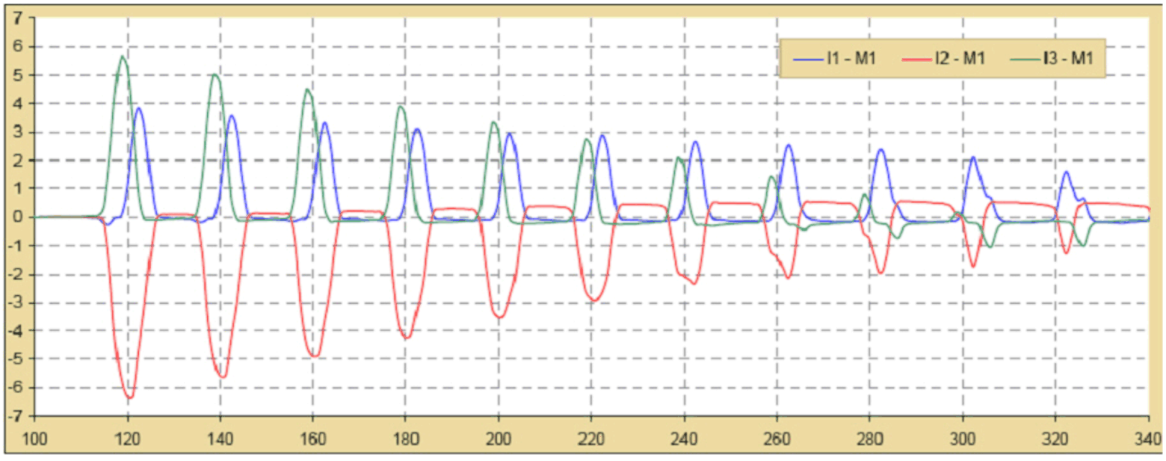
  As also shown in *Figure 6-12*, the 2nd harmonic is clearly pronounced in the inrush current. If the component of the 2nd harmonic exceeds the set threshold value (parameter: **`2nd harmonic content`**), a phase-segregated blocking occurs. The harmonics develop differently in the different phases. If exceeding of the 2nd harmonic is detected in a phase, it can be necessary to block all phases simultaneously. This blocking must be limited with regard to time and is controlled by the parameter **`Crossblock. time 2nd har.`**. The correct positioning of the filter windows is controlled by the internal pickup.

- **Curve form analysis (current wave shape analysis – CWA)**

  The occurrence of flat areas in the current course is typical for a connection process (see *Figure 6-23*). If these flat areas occur in all 3 phases at the same point in time, this is a typical characteristic of the connection process. The method works as a supplement to the 2nd harmonic and covers cases that are not controlled through the 2nd harmonic. Based on the method of measurement, the blocking always affects all phases simultaneously. The method has internal, firmly-set thresholds available.

  If the CWA method does not find any flat areas precisely one period after fault inception, an **Internal fault** is detected, the 2nd harmonic and the CWA inrush-current method are blocked and the **`CWA int. fault detected`** indication is output. In this way, blocking or delayed tripping of the differential protection by the 2nd harmonic is prevented during the connection process with internal faults or current-transformer saturation.

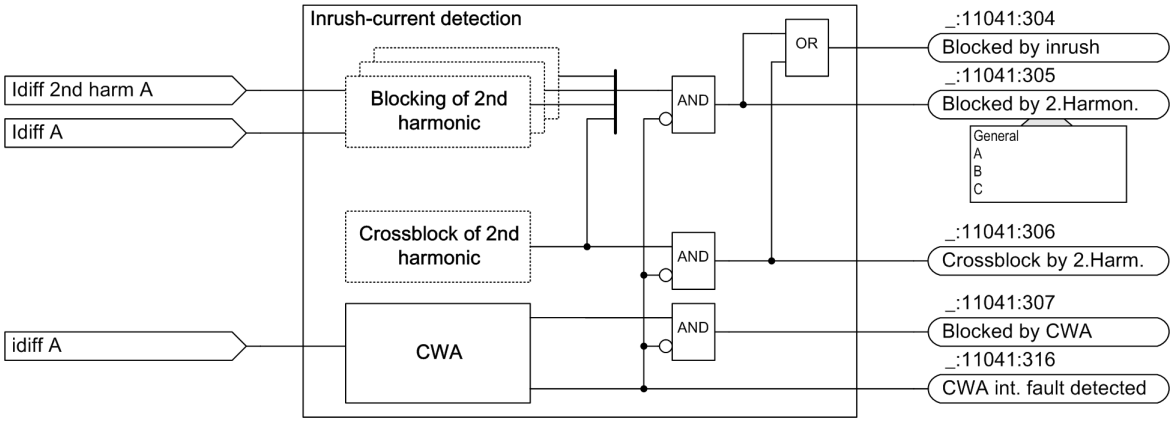
If you want only one method to be active, the other method can be changed to inactive. The parameters **`Blocking with 2. harmonic`** = ***no*** or **`Blocking with CWA`** = ***no*** serve this end.



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Figure 6-23 Inrush Current with Pronounced Flat Areas

Figure 6-24 shows the logical input and output signals.



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Figure 6-24 Logic Inrush-Current Detection

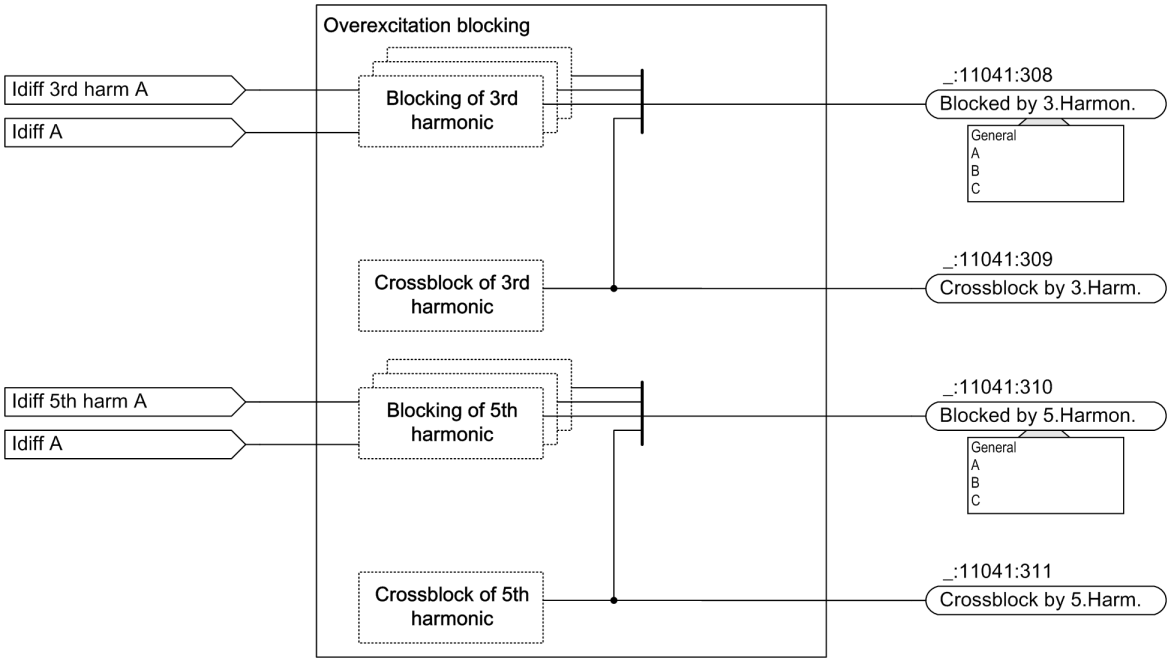
Blocking of Overexcitation

Stationary overexcitation is characterized by odd-numbered harmonics. Here the 3rd or 5th harmonic is suited to stabilization. Since with transformers, the 3rd harmonic is eliminated, for example, in the case of a delta winding, the 5th harmonic is used. The overexcitation blocking is activated when the pickup characteristic is exceeded. It is deactivated when it is blocked by an external fault.

Odd-numbered harmonics, which are not present with an internal short circuit, also play a role in converter transformers.

The shares of the 3rd and 5th harmonics in relation to the fundamental component are determined from the instantaneous values of the differential current via Fourier filters. If the threshold value (**3rd harmonics content** or **5th harmonics content**) is exceeded, a phase-selective blocking occurs. It is also possible here to block all 3 phases simultaneously via the crossblock function (parameter: **Crossblock. time 3rd har.** or **Crossblock. time 5th har.**). Contrary to the 2nd harmonic, the overexcitation stabilization becomes inactive if the differential current (fundamental component value) exceeds a limiting value (parameter: **Limit Idiff 3., 5. harmonics**).

The *Figure 6-25* shows the logical input and output signals.



[lofehler-170712-01.tif, 1, en_US]

Figure 6-25 Behavior under Different Fault Conditions

Detection of External Short Circuits

To reliably detect external short circuits with current-transformer saturation, the measurand curve is evaluated in the Diff.-Rest level with a detector. The detector has 2 essential tasks:

- **Blocking in the case of an unambiguous high-current external short circuit**

  The differential current and the restraint current are monitored on a phase basis in the Diff/Restr level immediately after fault inception. To ensure the stability of the saturation detection for low saturation-free times of the primary current transformer, estimated values based on the difference quotients of the instantaneous values are used.

  If the estimated restraint current exceeds the **Threshold add-on stabiliz.** parameter and the expected value of the differential current of all phases are in the additional stabilization range (parameter **Slope 1**) (*Figure 6-22*) simultaneously, the detector is active and the indication *Blocked by ext. fault phsx* appears. The tripping of the Differential protection function is blocked.

  If an external short circuit arises and is cleared by the protection responsible for it, the additional stabilization drops out. If the dropout ratio (0.7) of the RMS value of the restraint current does not reach the parameter **Threshold add-on stabiliz.** (*Figure 6-22*), the additional stabilization drops out. The indication *Blocked by ext. fault phsx* is reset.

  If the differential current exceeds **Slope 1** as a result of transformer saturation, that is, there is a pickup phsx, the blocking is limited in time (parameter: **Time of add-on stabiliz.**).

  Starting with the indication *Blocked by ext. fault phsx* the other phases can be blocked with it via the parameter **Crossblk. time add-on st.**. If differential currents spread to the other phases through the vector-group correction or zero-sequence current elimination subsequent to transformer saturation, this blocking is necessary.

- **Removal of the blocking with a change in fault location from external to internal**

  An internal short circuit can arise as a consequence of an external short circuit. This fault-location change must be recognized and the blocking must be removed. The critical case is a short circuit with current-transformer saturation. The saturation detection examines here the instantaneous values of the differential current. With transformer saturation the instantaneous values do not reach an internal threshold in the saturation-free time. If this threshold is permanently exceeded and a pickup is present in the corresponding phase, an internal error is assumed. The other phases are also examined during the parameterization with crossblock.

  The blocking of the tripping (including crossblock) is removed and the indication *Blocked by ext. fault phsx* is reset.

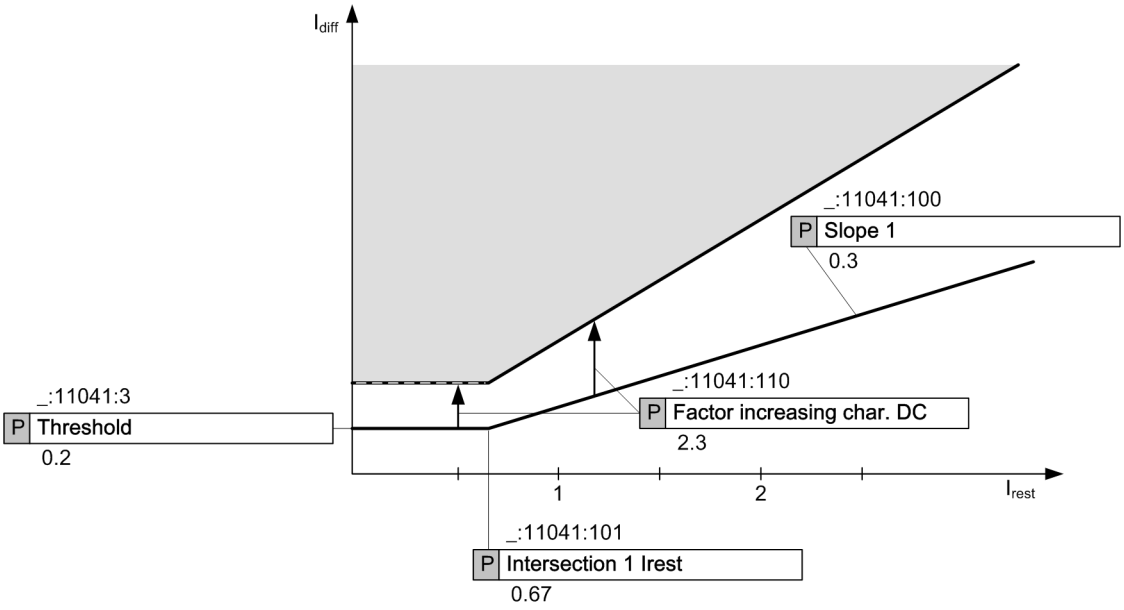
DC-Component Detection

In accordance with *Figure 6-11* low-current external faults with large DC components can also lead to exceeding of the operate curve. The additional stabilization area is not attained, however.
To avoid an overfunction, the following steps are taken:

- The restraint current $I_{rest.;phsx}$ is monitored for a jump.
- If the jump occurs, the DC component is calculated, with a temporal delay (1 period), from the instantaneous value of the restraint current (current at the measuring point with the largest current) $i_{rest.,phsx} = i_{phsx,Mm}$. The result is $I_{rest.DC,phsx}$. This current is compared to the restraint current $I_{rest.,phsx}$ and is checked for exceeding of the internal threshold.
- The differential current $I_{Diff,phsx}$ must lie below the dropout characteristic curve (characteristic curve · 0.7) in all 3 phases.
- If the first 3 points lead to positive results, then the operate curve is raised by the parameter **Factor increasing char.** with a default setting of ***2.3***. Here, only the threshold value and the slope 1 are raised (see *Figure 6-26*). The indication *Increase of char. (DC)* is issued. If the product of parameters **Factor increasing char.** and **Slope 1** exceeds **0.85**, the maximum increase of the raised **Slope 1** is limited to 0.85.
- As additional criterion, the pickup indication *Pickup* (internal fault is present) or the indication of the additional stabilization *Blocked by ext. fault phsx* (high-current external fault) is interrogated. If one of the 2 conditions is present, the characteristic curve increase is stopped. A retroactive pickup no longer resets the characteristic curve increase. A pickup with DC-component detection occurs only if the raised operate curve is exceeded.

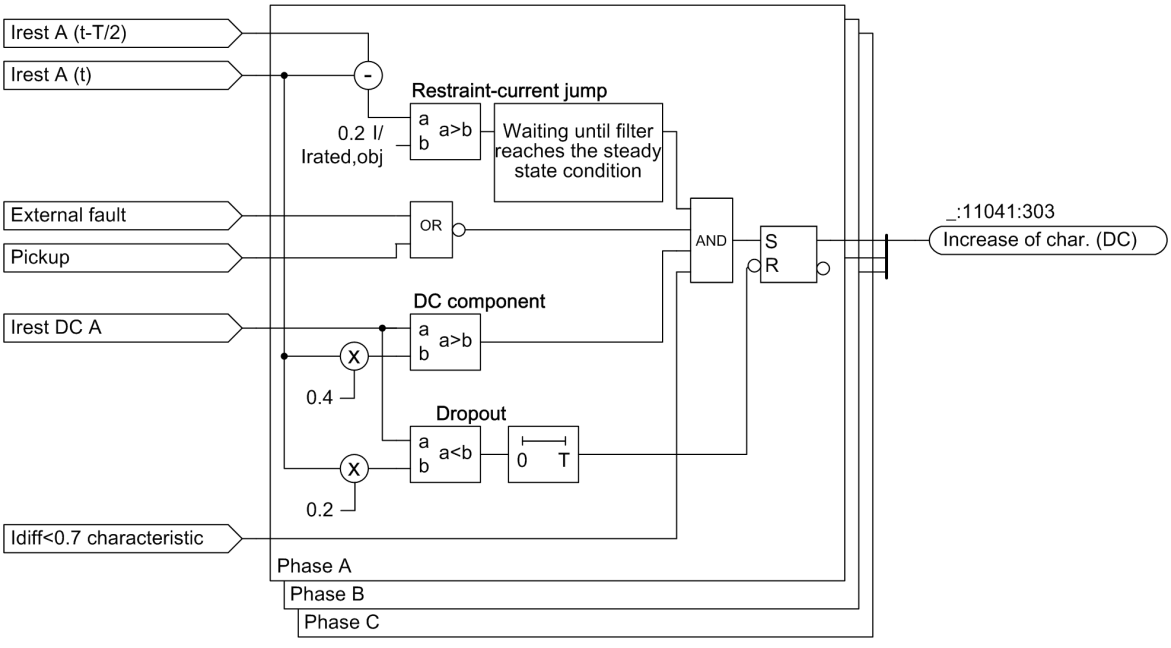
If the DC component $I_{rest.DC,phsx}$ falls below the internal dropout threshold, the dropout delay is determined as follows:

It is assumed that the de- and re-magnetization of the transformer last equally long. The magnetization is at the highest at the point in time in which the internal dropout threshold is attained. The time is measured from the start of the DC-component detection until the internal dropout threshold is reached. Added to this time are 5 periods and from this, the dropout delay is derived. Following this, the characteristic curve increase is reset to the original value. *Figure 6-27* shows the overall logic.



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Figure 6-26 Increasing the Characteristic Curve after DC Detection



[lodcerkn-170712-01.tif, 3, en_US]

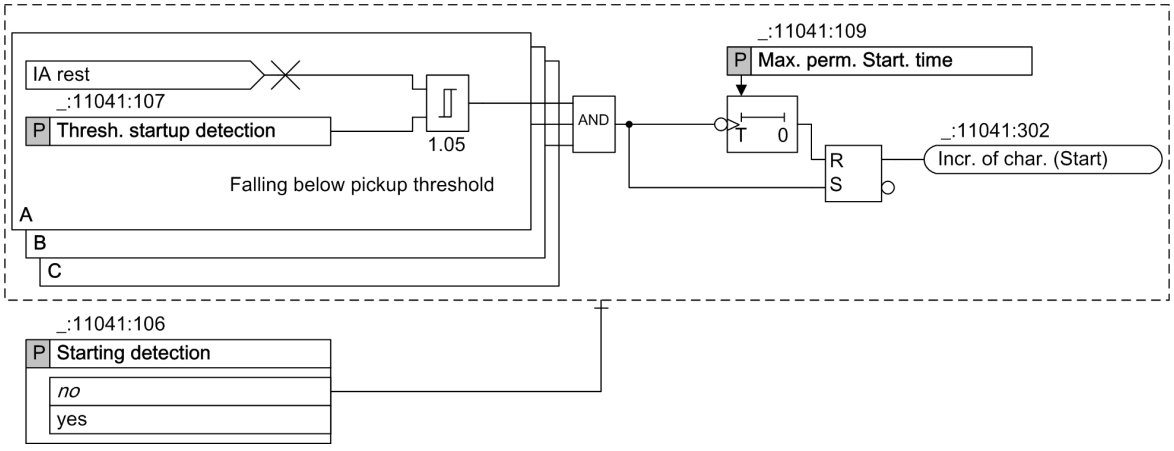
Figure 6-27 Logic DC Detection

Startup Detection

The startup detection is particularly useful in the case of motors. In contrast to transformers, the inrush current with motors is a flowing current. Differential currents can arise, however, by the current transformers having different residual magnetization and being supplied with current act different operating points of their hysteresis. These differential currents are low in fact, but with sensitive setting of the differential protection can lead to overfunction.

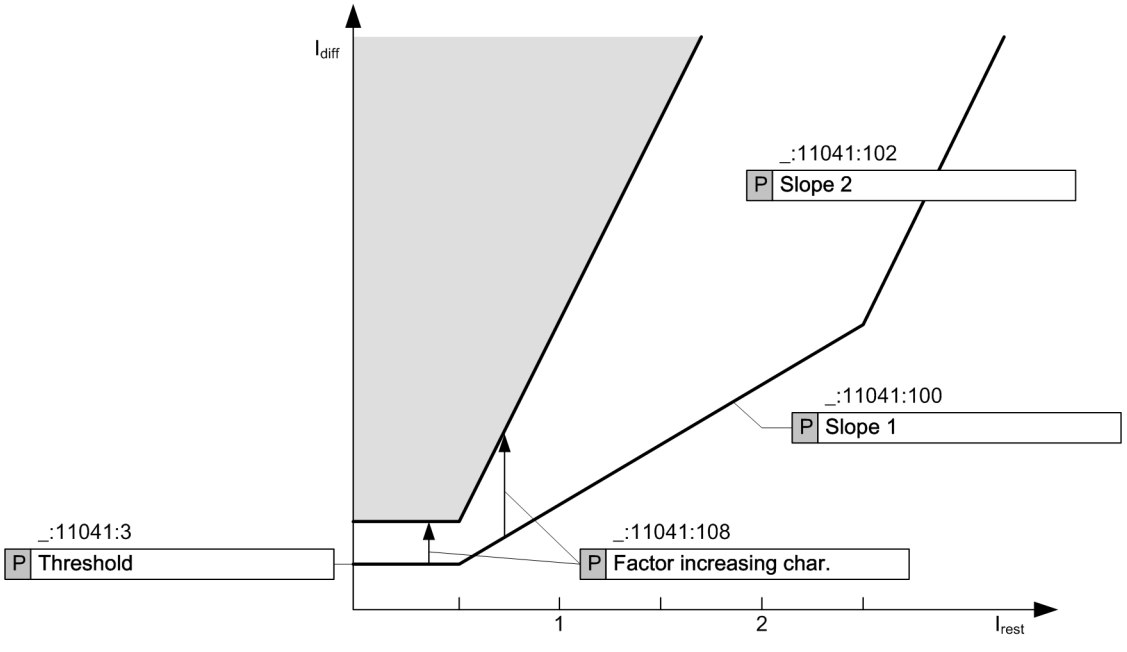
As additional security against overfunction when switching in a previously protected object that carries no current, you can use the pickup-value increase at startup. If the restraint current falls below a settable value in all phases **`Thresh. startup detection`** the pickup-value increase is activated. The pickup value **`Threshold`** and **`Slope 1`** are raised by the set value in accordance with paramete **`Factor increasing char.`**. As a rule here, **`Slope 1`** cannot exceed a value of 0.85.

If the parameter **`Thresh. startup detection`** is exceeded, dropout occurs and a timing element (parameter: **`Max. perm. Start. time`**) is activated. Once this time has elapsed, the characteristic curve that was increased in all phases is reset to its source value. *Figure 6-28* shows the logic diagram of the startup detection and *Figure 6-29* the increased characteristic curve.



[loanlauf-170712-01.tif, 3, en_US]

Figure 6-28 Logic Startup Detection



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Figure 6-29 Characteristic Curve Increase at Startup

Trip Logic of the Differential Protection Function I-DIFF

Figure 6-30 shows the trip logic. If the characteristic curve is exceeded (see *Figure 6-22*) a pickup occurs. Redirection of the information for tripping can be blocked by the additional functions.

Blocking is possible through use of the following influencing variables:

- Detection of a connection process (2nd harmonic and CWA method)
- Identification of further harmonics (3rd and 5th harmonics (overexcitation detection))
- Detection of external short circuits that can simulate an internal short circuit through transformer saturation

Additionally, the **Crossblock** mechanisms operate with blocking functions, depending on the settings.

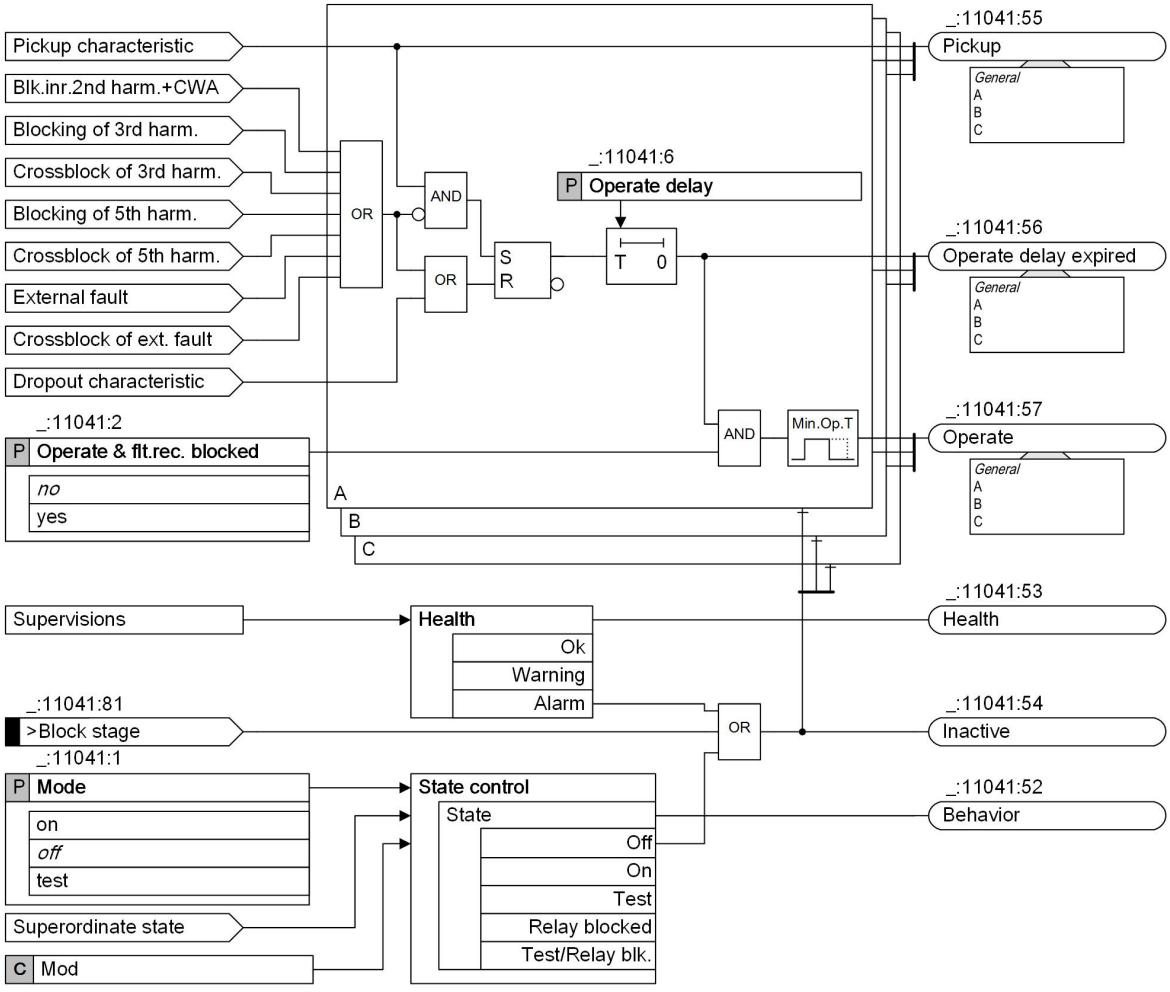


Figure 6-30 Trip Logic of I-DIFF

Reaction to Broken Wire in the Secondary System

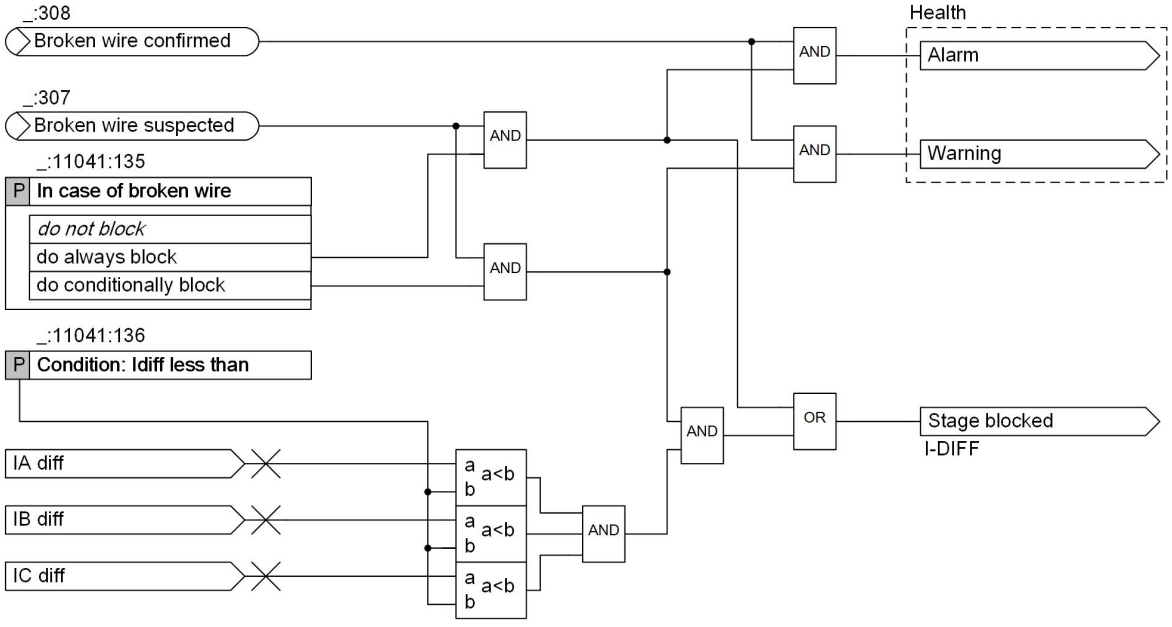
During steady-state operation, the function **Broken-wire detection** in the current measuring point detects interruptions in the secondary circuit of the current transformers, refer to *8.3.5 Broken-Wire Detection*.

Inherent to the working principle of protection functions that evaluate a current difference, interruptions in the secondary circuit cause unwanted tripping. With the **Broken-wire detection** and a corresponding parameterization in the stage **I-DIFF**, you can immediately block the stage **I-DIFF** in the function **Transformer differential protection** if a wire break is suspected.

If the **Broken-wire detection** is switched on in at least one current measuring point on a transformer side and the parameter **(_:5581:101) Mode of blocking** is set to ***blocking***, the parameters **(_:11041:135)**

In case of broken wire and **(_:11041:136) Condition: Idiff less than** are visible in the stage **I-DIFF**. These 2 parameters control the reaction of the stage **I-DIFF** to a wire break.

With the parameter **In case of broken wire**, you specify whether the stage **I-DIFF** is supposed to ***do not block***, ***do always block***, or ***do conditionally block*** in case of a wire break in the secondary system. If the parameter **In case of broken wire** is set to ***do conditionally block***, the blocking of the stage **I-DIFF** depends on the level of the differential current. The stage **I-DIFF** is only blocked if the differential current is less than the value set in the parameter **Condition: Idiff less than**.

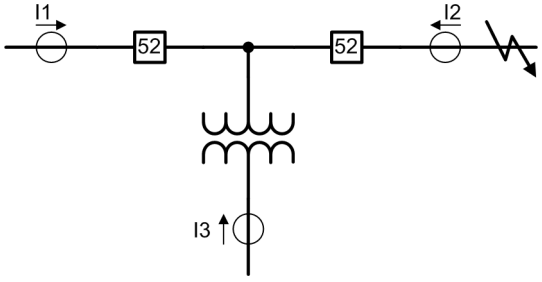


[lo_broken_wire_tdiff, 1, en_US]

Figure 6-31 Logic of the Wire-Break Blocking in the Stage **I-DIFF**

6.2.3.7 Differential Protection Function I-DIFF Fast

As a supplement to the differential protection function I-DIFF, the function I-DIFF fast is available. The main task consists in switching off high-current internal short circuits in the shortest amount of time. The method controls current-transformer saturation and is stable with external transverse faults (see *Figure 6-32*).



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Figure 6-32 External Fault in a 1 1/2 Circuit-Breaker Layout

Metrologically, 2 methods are combined:

- Instantaneous-value method
- Filter-based method

Instantaneous-Value Method

Through the instantaneous-values method, an immediate evaluation of the sampled values of the differential $i_{Diff}(t)$ and restraint current $i_{rest}(t)$ occurs. The absolute-value and vector-group adapted currents (i*) are also

the basis. The currents are defined positively to the node. The restraint current is the maximum current of all measuring points. The instantaneous values are formed via an estimation method from 2 sampled values.

$$i_{diff,phsx}(t) = \left| \sum_{m=1}^{N} i^{*}_{phsx,Mm}(t) \right|$$

$$i_{rest,phsx}(t) = \frac{N}{2} \cdot \underset{m=1}{\overset{N}{MAX}} \left| i^{*}_{phsx,Mm}(t) \right|$$

[fomome27-170712-01.tif, 1, en_US]

where

x	Variable (1, 2, 3) for the phase currents (A, B, C)
m	Variable (1, 2, ..., N) for the measuring points
N	Number of measuring points

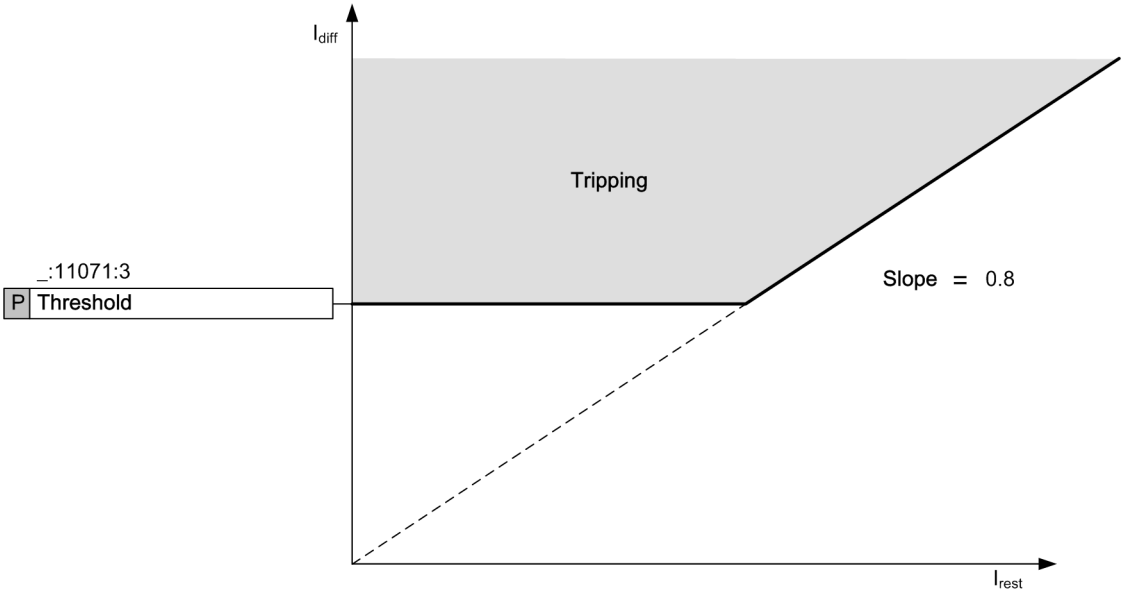
The evaluation of the restraint current is used for stabilization in the event of high-current external short circuits with transformer saturation (see *Figure 6-32*).

Figure 6-33 shows the operate curve. The parameter **Threshold** is set to the maximum fault current to be expected when switching on the transformer (see *Parameter: **Threshold** (Setting the Characteristic-Curve Parameters), Page 604*). The slope of the characteristic curve is fixed at 0.8.

In the algorithm, the following conditions are processed:

- Condition 1: The increase of the restraint current $di_{rest.}(t)/dt$ is determined continuously and compared with an internal threshold value.
- Condition 2: After that, a comparison determines whether the differential-current instantaneous value is larger than the restraint current (characteristic curve **Slope** in *Figure 6-33*): $i_{diff}(t) > 0.8 \cdot i_{rest.}(t)$.
- Condition 3: After that, a comparison determines whether the differential-current instantaneous value exceeds the parameter **Threshold**.

When all conditions are met, tripping occurs immediately. If the 1st condition is recognized and not the 2nd condition, then the instantaneous-value function is blocked for 300 ms.

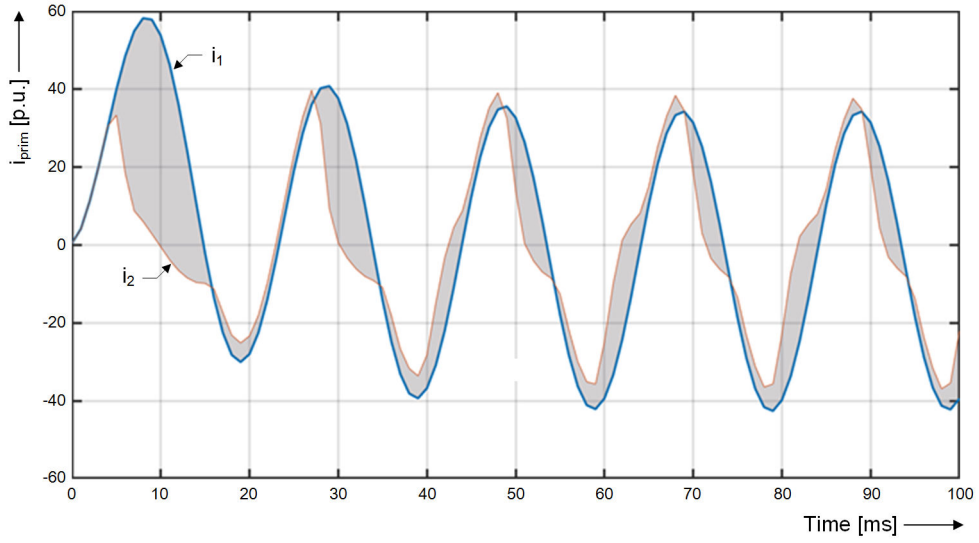


[dwidfast-300114-01.tif, 1, en_US]

Figure 6-33 Characteristic Curve of I-DIFF Fast

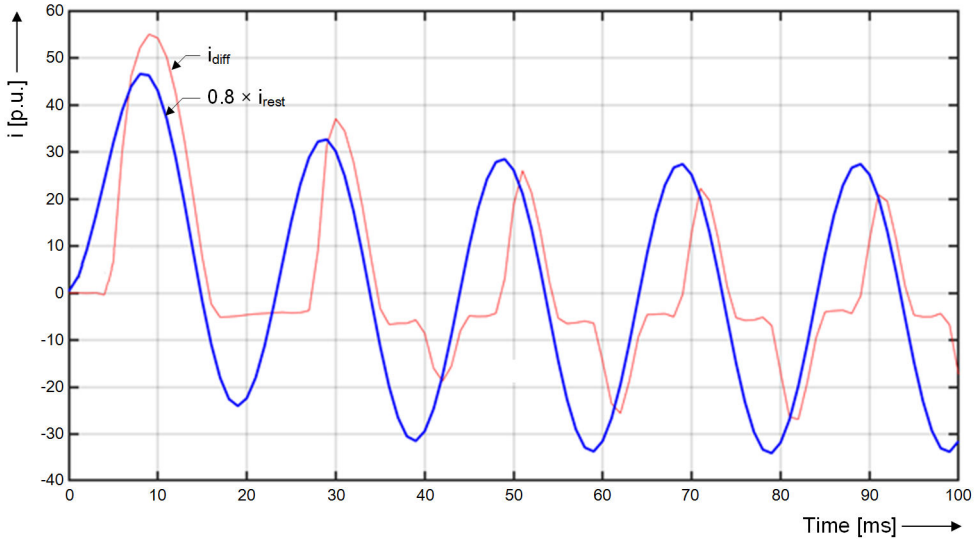
Behavior in the event of a high-current external fault with transformer saturation

The following example in *Figure 6-34* shows a high-current fault with transformer saturation. The short-circuit current with DC component flows through a protected object, for example, a busbar with a 1 1/2 circuit-breaker layout. The current flows through 2 current transformers, where the i1 current is properly transmitted through one of them, and transformer saturation occurs for the other one after a few milliseconds. The range between the flows of the i1 and i2 currents is the differential current that has been measured by the protection device. The differential current and restraint current flow $i_{rest}(t)$ multiplied by factor 0.8 is shown in *Figure 6-35*. Condition 1 is met when the restraint current rises quickly when the $di_{rest}(t)/dt$ fault occurs. At this point, condition 2 is thoroughly checked to determine whether the differential-current instantaneous value is greater than 0.8 of the restraint-current instantaneous value. The evaluation is carried out within a max. of 1/8 of a system period once the fault occurs. As the differential current, and thereby condition 2, has not been met in the event of heavy transformer saturation, the instantaneous-value method for the I-DIFF fast stage is blocked for 300 ms.



[dwinnfel-201112-01.tif, 2, en_US]

Figure 6-34 Curve Plot for Primary Currents in the Event of an External Short Circuit with Transformer Saturation



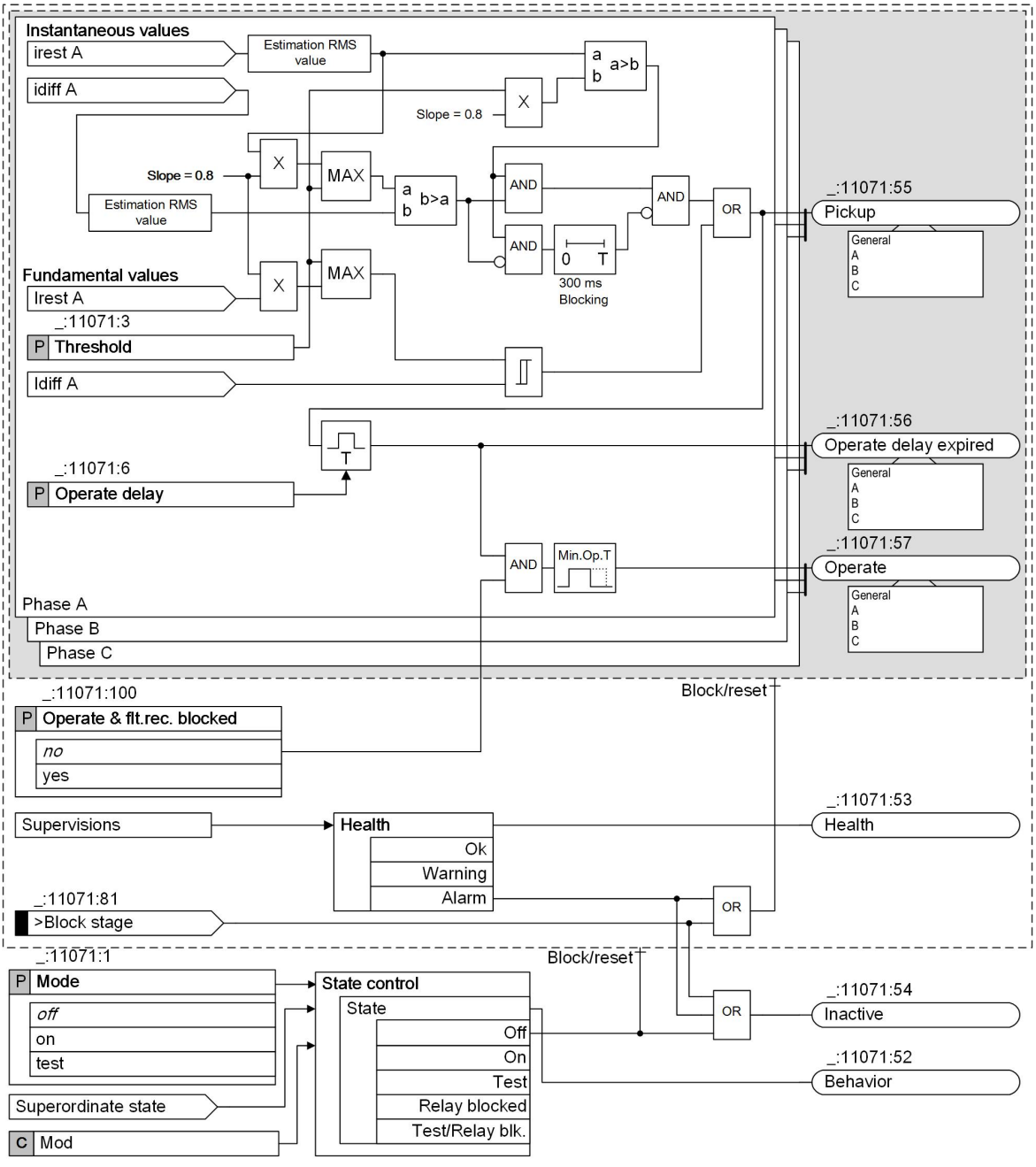
[dwextfel-170712-01.tif, 2, en_US]

Figure 6-35 Curve Plot for the Differential Current and Restraint Current i_{rest} · 0.8 in the Event of an External Short Circuit with Transformer Saturation

Fundamental-Component Method

Parallel to the instantaneous-value method, the fundamental component works with a temporal delay. Here, the same measured values are processed as with the I-DIFF method. The fundamental component of the differential current I_{diff} and the stabilization value (maximum current of a measuring point) $I_{rest.}$ are ordered in the operate curve *Figure 6-33* and the trip decision is made.

Figure 6-36 shows the overall logic.



[lo_id_fast, 4, en_US]

Figure 6-36 Logic of the Differential Protection Function I-DIFF Fast

6.2.3.8 I-DIFF Unrestrained Differential Protection Function

When protected objects with a high longitudinal impedance (transformer, generator, reactor) are protected without busbar sections, the I-DIFF unrestrained differential protection stage can be used as an alternative to the I-DIFF Fast protection stage. This stage does not control transformer saturation. Therefore, the setting value of this stage must be adjusted to the maximum short-circuit current that flows through this protected object.

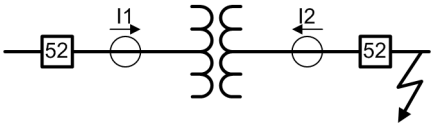
High-current faults in the protection range can always be switched off immediately without consideration of the restraint currents if, due to the current magnitude, it is determined that an external fault is not involved. In the case of protected objects with a large intrinsic longitudinal impedance (transformer, generator, reactor), a current can be found that is never exceeded by a flowing short-circuit current.

For a transformer, that is, for example, the (primary) value:

$$\frac{1}{u_{sc\ transf}} \cdot I_{Ntransf}$$

[fo_diff_current_error, 1, en_US]

The I-DIFF unrestrained stage also acts if, for example, due to current-transformer saturation because of a DC component in the short-circuit current, a 2nd harmonic occurs. The inrush-current detection could interpret this as the closed-circuit current.



[dwextfehzw-100117-01, 1, en_US]

Figure 6-37 External Fault in a Two-Winding Transformer

The I-DIFF unrestrained protection stage operates both with the fundamental component of the differential protection and with instantaneous values.

Metrologically, 2 methods are combined:

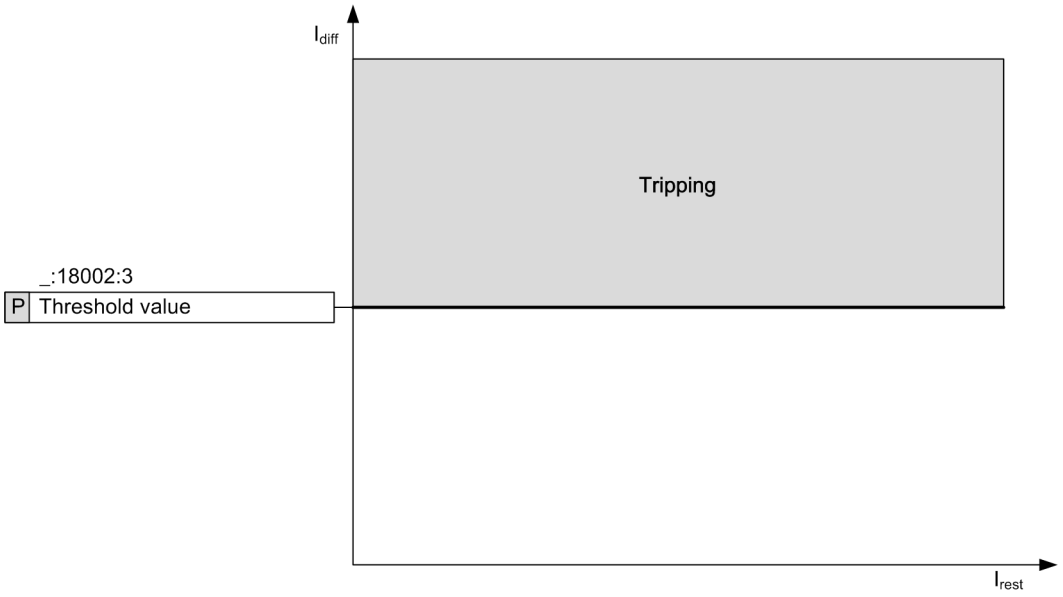
- Instantaneous-value method
- Filter-based method

Instantaneous-Value Method

With the instantaneous-values method, an immediate evaluation of the sampled values of the differential current $i_{Diff}(t)$ occurs. The instantaneous-value stage only works above $2 \cdot \sqrt{2}$ of the setting value due to a potential full shift in the short-circuit current once the fault occurs. The absolute-value and vector-group adapted currents (i*) are also the basis. If the fundamental component is greatly damped by current transformer saturation, the instantaneous-value method ensures quick tripping.

Fundamental-Component Method

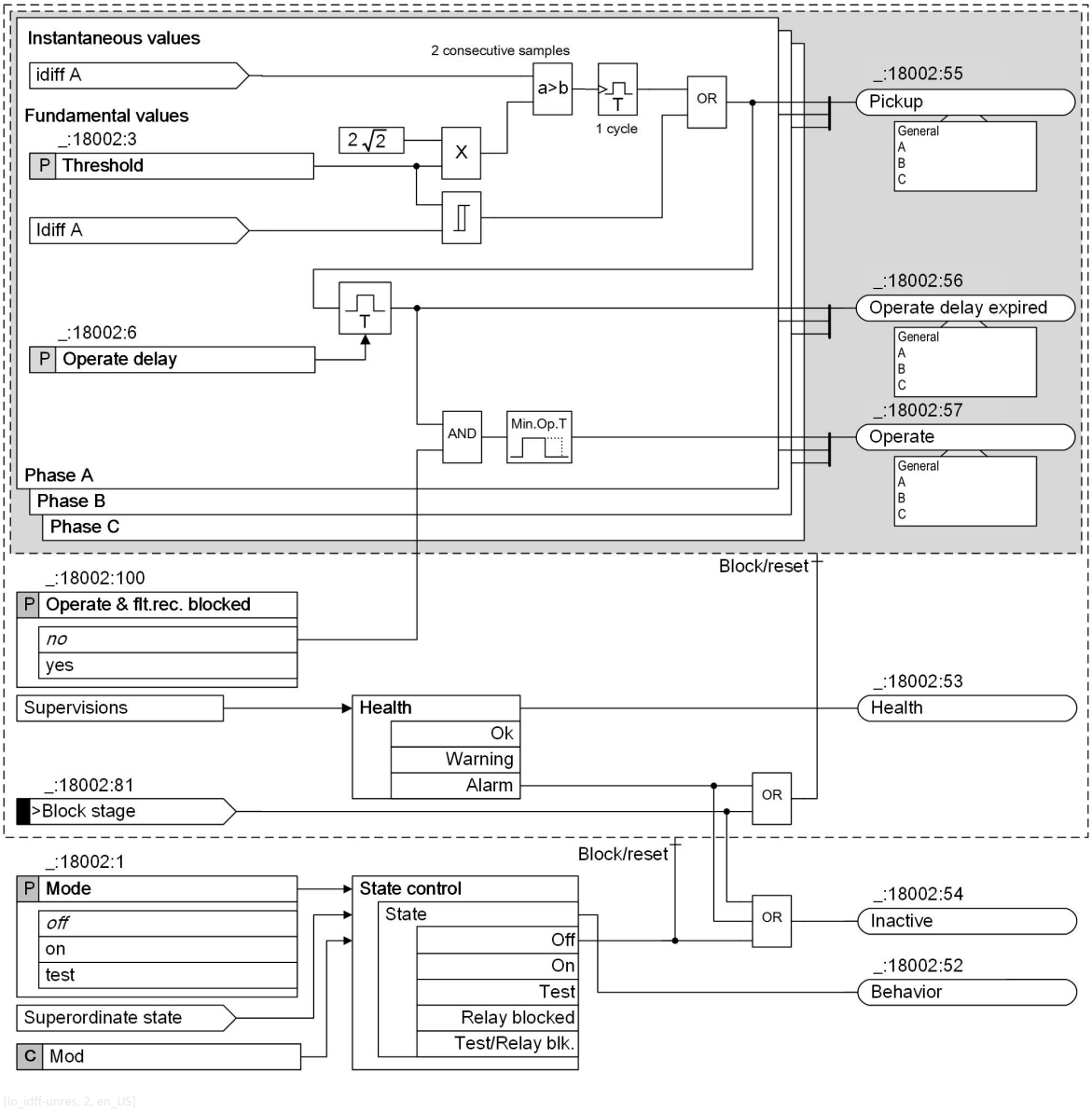
Parallel to the instantaneous-value method, the fundamental component works with a temporal delay. Here, the same measured values are processed as with the I-DIFF method. The fundamental component of the differential current I_{diff} is ordered in the operate curve *Figure 6-38* and the trip decision is made.



[dw_idffunres, 1, en_US]

Figure 6-38 I-DIFF Unrestrained Characteristic Curve

Figure 6-39 shows the overall logic.

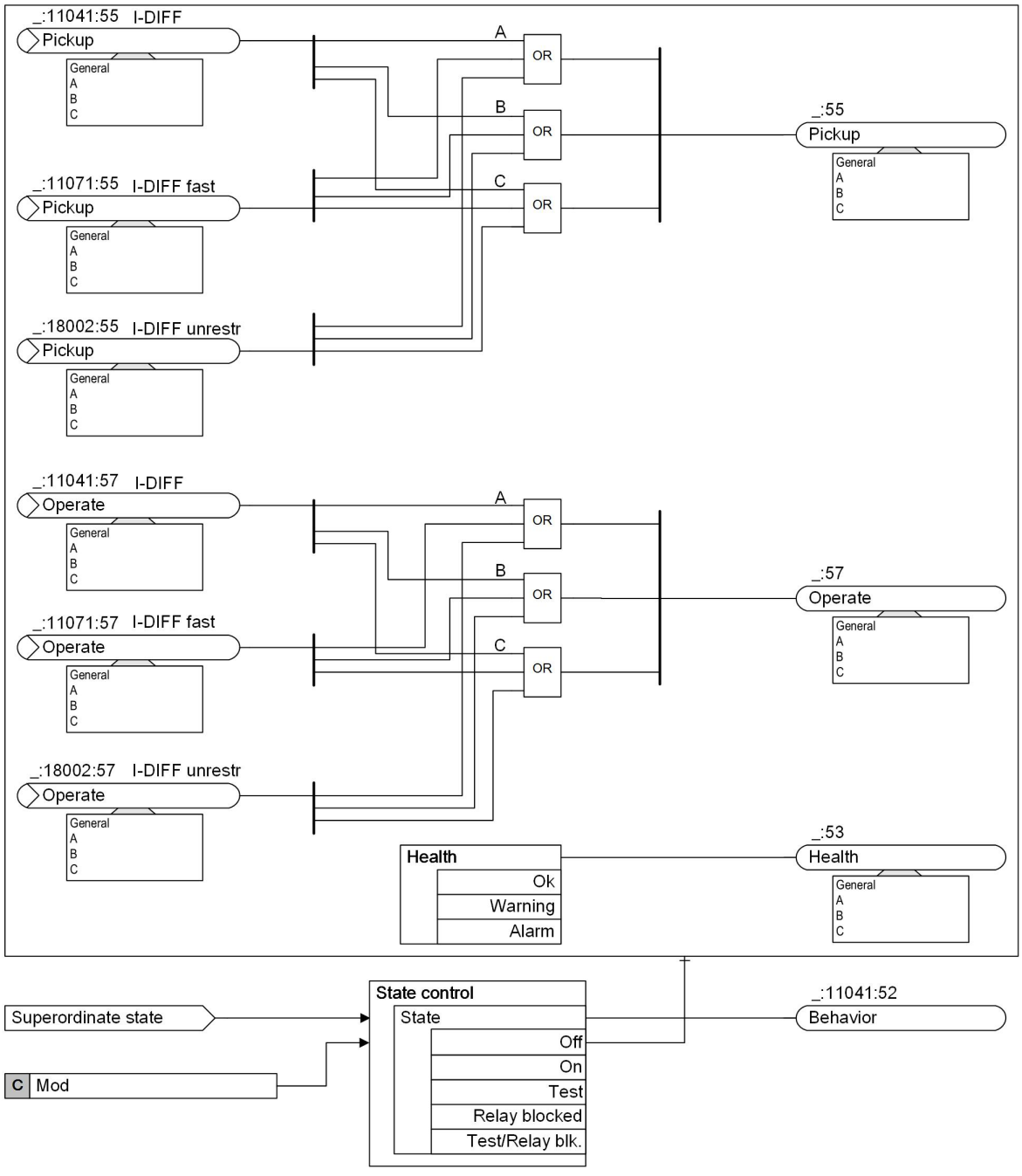


[lo_idff-unres, 2, en_US]

Figure 6-39 Logic of the I-DIFF Unrestrained Differential Protection Function

6.2.3.9 Trip Logic of the Differential Protection

In accordance with *Figure 6-13*, a common trip signal is formed from subfunctions I-DIFF, I-DIFF fast and I-DIFF unrestrained. *Figure 6-40* shows the appropriate logic.



[lo_gesamt, 3, en_US]

Figure 6-40 Overall Trip Logic

Functional Measured Values

Measured Value	Description
_:2311:300 A, B, C	Differential current
_:2311:301 A, B, C	Restraint current

6.2.3.10 Disconnection of the Measuring Point from the Transformer Differential Protection Function

For special applications, for example, in a pumped-storage hydropower plant, an individual measuring point must be disconnected from but then reconnected to the **Transformer differential protection** function under different specific operating conditions.

The disconnection and reconnection can be automatically and reliably achieved by the **Current transformer disconnection** function. The following example describes a mixed application of the functions **Transformer differential protection** and **Current transformer disconnection**.

Transformer Differential Protection in a Pumped-Storage Hydropower Plant

In a pumped-storage hydropower plant, the synchronous machine can operate in the pump operation mode (for example, the generator in the following figure) and in the pump startup mode (for example, the motor in *Figure 6-42*).

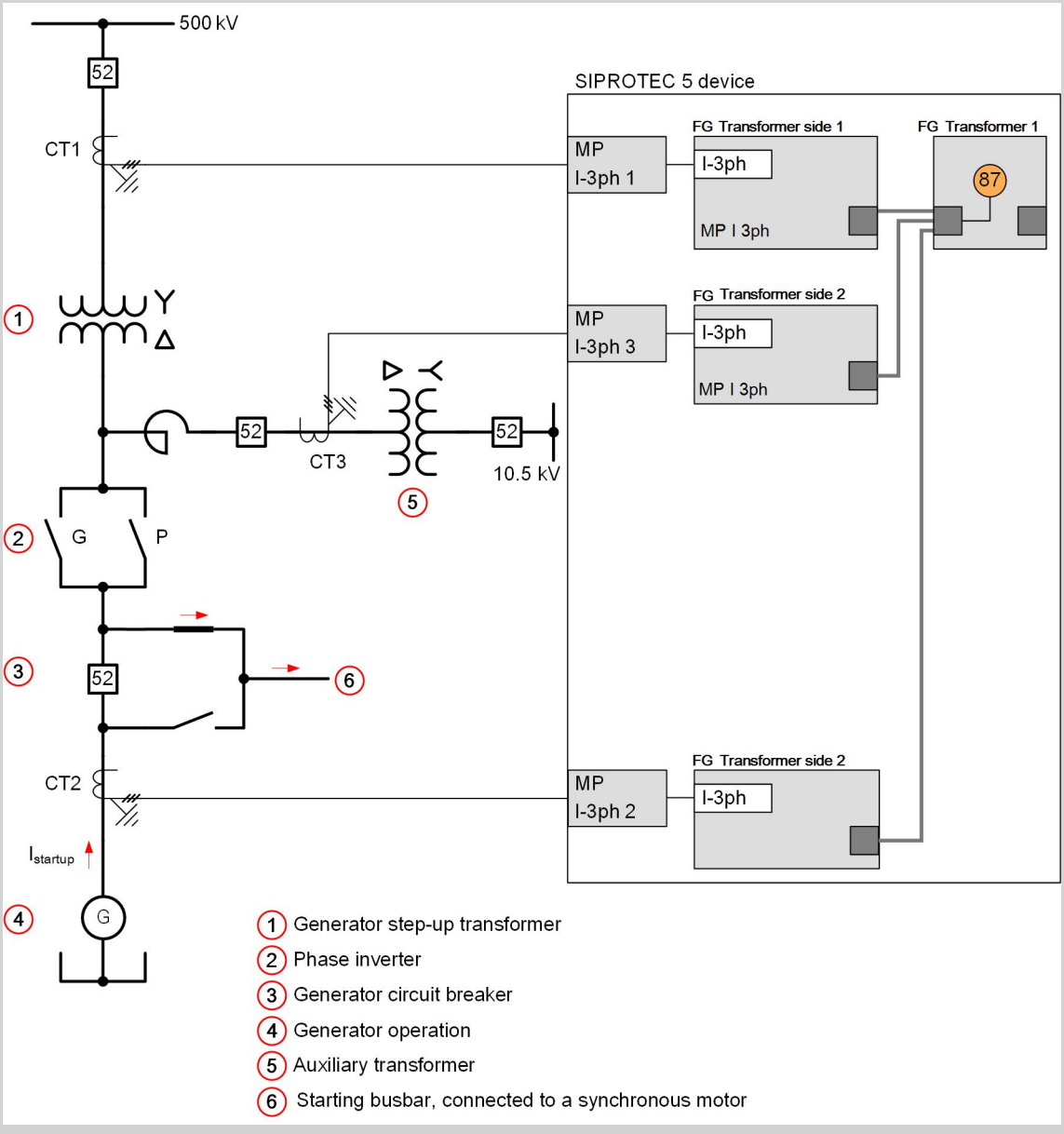
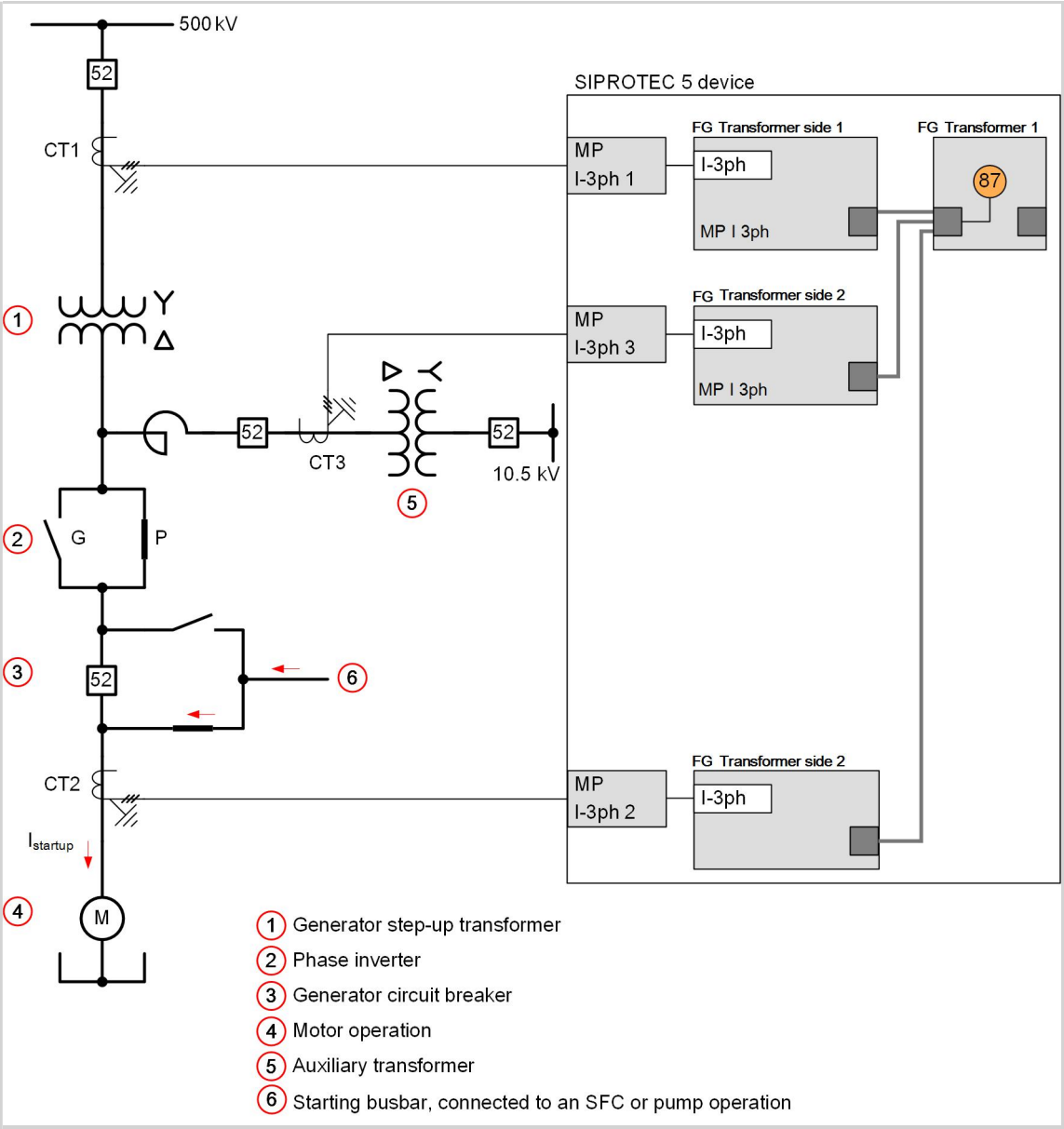


Figure 6-41 Pump Operation Mode

If the generator acts as pump operation, it feeds the starting current $I_{startup}$ into the starting busbar with a frequency change from 0 Hz to the rated value.



[lo_Pp_Startup, 1, en_US]

Figure 6-42 Pump Startup Mode

In the pump startup mode, the motor is excited and connected to the starting busbar during the startup. It is started up via an external-current infeed from a static-frequency converter (SFC) or pump operation. The motor runs from a speed of 0 to the rated value, and then, it is connected to the power grid by a paralleling device. During the speedup of the motor, the frequency of the injected starting current $I_{startup}$ changes from 0 Hz to the rated value.

The synchronous machine is connected to the power grid via a generator step-up transformer (GSUT). The GSUT is protected by the **Transformer differential protection** function (ANSI 87T) and detects short circuits and ground faults. In the pump operation mode or the pump startup mode, the synchronous machine is disconnected from the GSUT via a phase inverter or a generator circuit breaker (GCB). On the one hand, according to the Kirchhoff's law, to avoid overfunction, the measured current $I_{startup}$ from CT2 must be disconnected from the **Transformer differential protection** function. On the other hand, in the pump startup mode, after the motor is connected to the power grid, the measured current $I_{startup}$ from CT2 must be reconnected to the **Transformer differential protection** function. The disconnection and reconnection are realized by the **Current transformer disconnection** function.

The following figure shows an example of a logic diagram for this application.

NOTE

Disconnection or reconnection of the current transformer has a direct impact on the **Transformer differential protection** function. To avoid overfunction caused by the disturbance of binary input signals *>Disconnection on* and *>Disconnection off*, Siemens recommends not activating *>Disconnection on* and *>Disconnection off* with external single-point binary inputs. Siemens recommends using a CFC logic with double-point binary inputs.

In case of overfunction caused by power loss of device and binary input signals at the same time, do not obtain the binary input signal *>Disconnection off* from the **NOT** logic of the binary input signal *>Disconnection on*.

6.2.3.11 Fault Logging and Fault Recording

A fault is opened with every protection pickup. This means that a fault log and a fault recording are started. Saving of the fault record depends on the setting (see *3.5.3 Function Description*). Since pickup and tripping are the same in differential protection, the recording setting can be used with the pickup function. To enable fault recording even with an external short circuit, along with the exceedance of the characteristic curve, a fault record is opened in case of blocking by an external short circuit or from characteristic curve increase through DC-component recognition. This has the advantage that you can evaluate the transformer transfer method of the current transformers very well in case of a fault.

6.2.4 Application and Setting Notes

Selected applications for differential protection are described in the following. Setting instructions for the necessary setting parameters are given for these applications.

Protection of a Two-Winding Transformer

As an example a transformer in the vector group YNd5 is selected, whose neutral side is solidly grounded. If different settings are produced by different variants (vector group, grounding), reference to them is made for the corresponding setting parameters. *Figure 6-43* shows the basic structure with the typical system parameters. The function is operational in the devices 7UT82, 7UT85, 7UT86, and 7UT87.

NOTE

Also, observe the connection of the current transformer *A.8 Requirements for Current Transformers* in the Appendix.

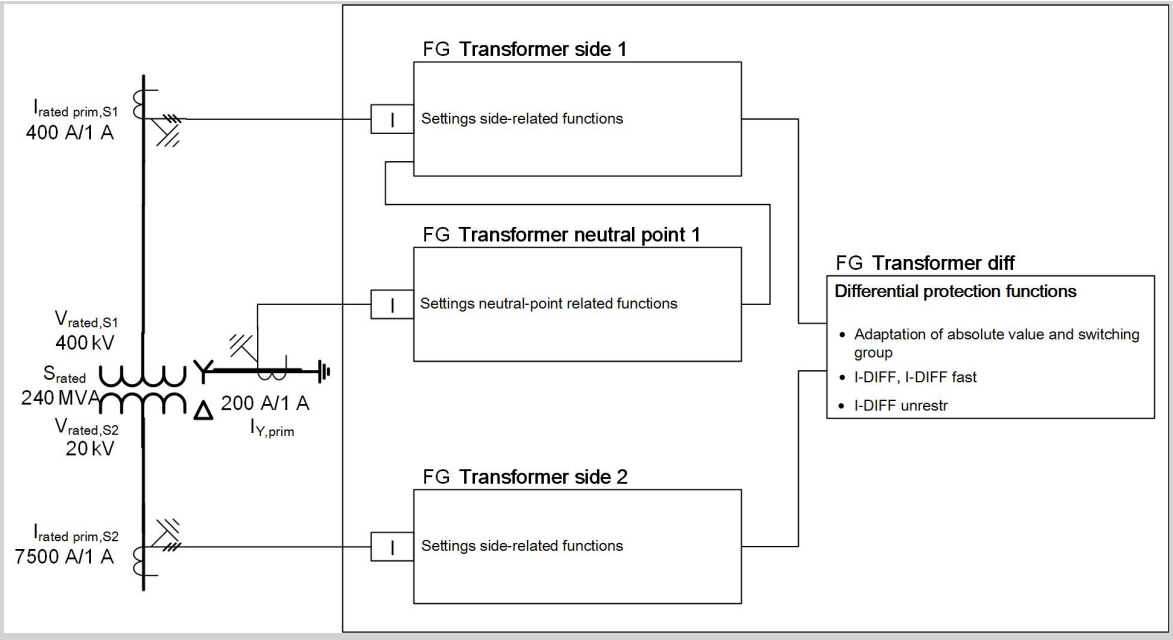


Figure 6-43 Connection of a Two-Winding Transformer

In the example, a 7UT85 is selected.

2 measuring inputs are interconnected on the 3-phase measuring points of side 1 and side 2. The measuring points must be interconnected with the corresponding function groups.

Figure 6-44 shows the corresponding screenshot from DIGSI 5.

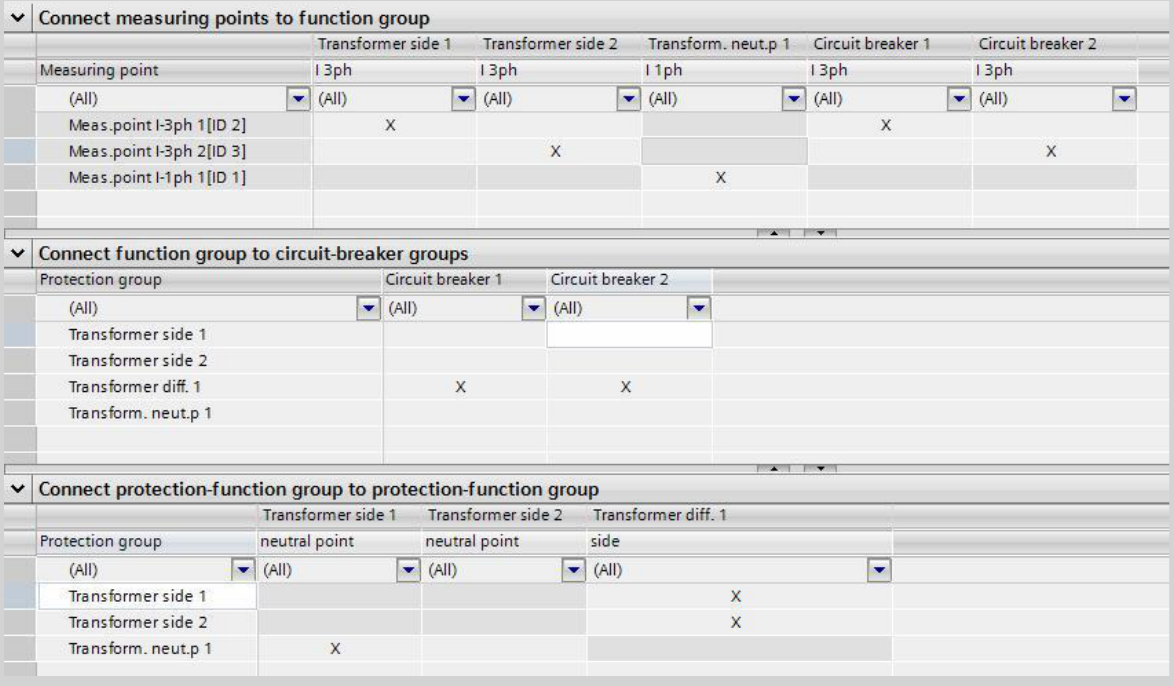


Figure 6-44 Internal Circuiting in DIGSI 5

Transformer Side Function Group

Go to the function group **Transformer side** and make the following settings:

NOTE

Ensure that the correct transformer data is set at the measuring points.

NOTE

Keep in mind that the matching factors in each case are calculated from the primary transformer current and a reference rated current. For a standard transformer and an auto transformer, the reference rated current of each side is the rated current of the reference side transformed on the individual side. The matching factors are calculated and displayed as write-protected parameters. Only the matching factors used appear in the menu.

The matching factor for one transformer side is calculated by the equation below:

$$\text{CT ratio}_{(m)} = \frac{I_{\text{rated transf. (m)}}}{I_{\text{rated (m)}}}$$

The reference current $I_{\text{rated (m)}}$ is the rated current of the transformer side and is calculated using:

$$I_{\text{rated (m)}} = \frac{S_{\text{rated (m)}}}{\sqrt{3} \cdot V_{\text{rated (m)}}}$$

with

CT ratio	Matching factor
$I_{\text{rated transf.}}$	Primary rated current of the current transformer
I_{rated}	Rated current of the transformer side
S_{rated}	Rated apparent power
V_{rated}	Rated voltage of the transformer side
m	Measuring point

Parameter: `Rated apparent power`

- Default setting **`(_:91:103) Rated apparent power`** = ***`240 MVA`***

With this parameter, you set the rated apparent power of the appropriate side. The setting value for both sides is the same with a two-winding transformer.

Parameter: `Rated voltage`

- Default setting **`(_:91:102) Rated voltage`** = ***`400 kV`***

With this parameter, you set the rated voltage of the appropriate side. For side 1, it is 400 kV. Set 20 kV for side 2 in the example.

If a transformer with tap changers is used, do not use the actual rated voltage, but set a medium-sized voltage as **`Rated voltage`**. Use the following relationship to calculate the voltage:

$$V_{\text{ref}} = 2\frac{V_{\text{max}} \cdot V_{\text{min}}}{V_{\text{max}} + V_{\text{min}}}$$

[fonensei-170712-01.tif, 1, en_US]

V_{ref}	Voltage to be set
V_{max}	Voltage at upper tap position
V_{min}	Voltage at lower tap position

The calculated rated current of the side is displayed as additional information. In the example, this is a value of 346 A (240 MVA/(√3 · 400 kV) = 346.4 A).

Parameter: `Neutral point`

- Default setting **`(_:91:149) Neutral point`** = ***`grounded`***

This parameter is important for zero-sequence current treatment. In the example, the transformer is solidly grounded on side 1. For this reason, set ***`grounded`***. For side 2 (delta side) set ***`isolated`***. If a neutral reactor is located within the protection range of the transformer differential protection on the delta side, set ***`grounded`***. If a star winding is not grounded, then set ***`isolated`***.



NOTE

If a star winding is implemented to be insulated with regard to the neutral-point treatment and a surge arrester is connected, then to avoid overfunction of the differential protection, the setting ***`grounded`*** is recommended. If the surge arrester picks up, then it grounds the neutral point.

Parameter: `Winding configuration`

- Default setting **`(_:91:104) Winding configuration`** = ***`Y (Wye)`***

You set the circuiting of the windings with this parameter. Side 1 is interconnected in the star. For this reason, set ***`Y (Wye)`***. For side 2, which is interconnected in the delta, you must set a ***`D (Delta)`***. If the windings are interconnected in zigzag, set a ***`Z (Zig-Zag)`***.

Parameter: `Vector group numeral`

- Default setting **`(_:91:163) Vector group numeral`** = ***`0`***

This parameter is used to account for phase-angle rotation, which is expressed by a number.

Phase-angle rotation	0°	-30°	-60°	-90°	-120°	-150°	-180°	-210°	-240°	-270°	-300°	-330°
Vector group numeral	0	1	2	3	4	5	6	7	8	9	10	11

In the example, a transformer YNd5 is used. For this transformer, side 1 gets the Vector group numeral 0 and side 2 the Vector group numeral 5.

In the function group, the following information is displayed additionally in the setting sheet:

- Side number
- Identification of the measuring points used
- Matching factor for the 3-phase measuring point (with reference to the side)
- Matching factor for the measuring point at the neutral point (with reference to the side)

You can set each Vector group numeral from 0 to 11 to the extent possible. Thus, for example, only even numbers are possible for the vector group Yy, Dd, and Dz and only odd numbers are possible for Yd, Yz, and Dy.

Parameter: `Tap changer`

- Default setting **`(_:91:44) Tap changer`** = ***`No function block has been selected`***

When using this parameter, the transformer side is assigned to a tap changer. If a tap changer is assigned, other parameters also become visible. You can use a separate tap changer or the tap changer in the voltage controller.



[sctssdi2-260913-01, 2, en_US]

Figure 6-45 Settings in DIGSI 5

Parameter: `Basic position`

- Default setting **`(_:91:138) Basic position`** = ***8***

With the parameter **`Basic position`** you specify the stage at which the voltage matches the rated voltage of the transformer side.

Parameter: `Volt. diff. adjacent taps`

- Default setting **`(_:91:139) Volt. diff. adjacent taps`** = ***0.000***

With the parameter **`Volt. diff. adjacent taps`**, you set the voltage difference of a stage under idle conditions.

Function Group Transformer DIFF

Make the following settings in the function group **Transformer Diff** for the function I-DIFF:

NOTE

Keep in mind that the matching factors in each case are calculated from the primary transformer current and the object rated current. For a standard transformer, the object rated current of the side is the rated current of the reference side transformed on the individual side. The matching factors are calculated and displayed as write-protected parameters. Only the matching factors used appear in the menu.

The matching factor for one transformer side is calculated by the equation below:

$$\text{CT ratio}_{(m)} = \frac{I_{\text{rated transf. (m)}}}{I_{\text{rated obj.}}}$$

The reference current $I_{\text{rated obj.}}$ is the rated current of the transformer side and is calculated using:

$$I_{\text{rated obj.}} = \frac{S_{\text{rated obj.}}}{\sqrt{3} \cdot V_{\text{rated obj.}}}$$

with

CT ratio	Matching factor
$I_{\text{rated transf.}}$	Primary rated current of the current transformer
$I_{\text{rated obj.}}$	Rated current of the transformer side
$S_{\text{rated obj.}}$	Rated apparent power
$V_{\text{rated obj.}}$	Rated voltage of the transformer side
m	Measuring point

Tap Changer

In the **General** setting sheet in DIGSI 5, you specify whether the adaptation of the differential protection to the current tap-changer position is to be used. Make the setting and allocation in the transformer side.

Parameter: `Use tap-changer position`

- Default setting **`(_:2311:187) Use tap-changer position`** = ***yes***

With setting ***yes***, you adapt the differential protection function to the current tap-changer position.

NOTE

- In the properties dialog Position of the tap changer, enable the parameter **`Moving contact (highest binary input)`**. Set the parameter **`Supervision behavior`** of the tap changer to ***`warning`*** or ***`alarm block`***.

Zero-Sequence Current Treatment

You set how the ground current is handled on the **General** setting sheet in DIGSI 5. On **Transformer Side 1**, the neutral point of the transformer is set as grounded. In this way, the protection function knows that the zero-sequence current is to be accounted for. With the following parameter, you can set the treatment of the zero-sequence current.

NOTE

In the Appendix, also note the requirements for current transformers of the differential protection *A.8 Requirements for Current Transformers* .

Parameter: `Meas. gnd. current side 1`

- Default setting **`(_:2311:100) Meas. gnd. current side 1`** = ***`no`***

With the setting ***yes*** a zero-sequence current correction is performed. The setting ***no*** causes the elimination of the zero-sequence current. With the zero-sequence current correction, a higher sensitivity is attained in the case of 1-pole ground faults. If the neutral point current transformer should be taken into consideration in the differential protection, set ***yes***.

NOTE

For this application, design the neutral point current transformer appropriately strong (almost saturation-free over approx. 30 ms).

More information on this in *6.2.3.1 Basic Principle of Differential Protection*, section **Neutral point current handling**.

Parameter: `Threshold` (Setting the Characteristic-Curve Parameters)

- Default setting **`(_:11041:3) Threshold`** = ***`0.2 I/Irated,obj`***

With this parameter, you set the pickup threshold for the differential current. This is the total current flowing into the protection range during a short circuit, regardless of how it is distributed on the sides of the protected object. The **`Threshold`** is referenced to the rated current of the protected object. With transformers, a sensitive setting can by selected since a relatively small magnetizing current arises as a constant fault current. The default setting of ***`0.2 I/Irated,obj`*** is a practical value between sensitivity and possible disturbing influence.

If the transformer sets are of similar construction in the case of reactors, generators and motors (identical in transmission behavior), a more sensitive setting is possible.

In the event of a very pronounced deviation of the current-transformer rated currents from the rated current of the protected object or with several measuring points, expect greater measuring tolerances. If loads with large time constants (external transformers, motors) are connected, transmission problems (for example, through remanence) can arise with currents in the rated current range with a closed iron core transformer (p-cores). In this case, Siemens recommends an increased setting value of 0.3 I/Irated,obj.

If the position of the tap changer cannot or should not be taken into account in the differential protection, set the pickup value slightly higher than the default setting. Use the following relationship for estimation.

Threshold value$_{New}$ = threshold value + (k_{StS} · Intersection 1 Irest) I/Irated,obj

$$k_{StS} = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} = \frac{(100\,\% + St_{max}) - (100\,\% + St_{min})}{(100\,\% + St_{max}) + (100\,\% + St_{min})}$$

[fokorwr2-180912-01.tif, 1, en_US]

k_{StS} Correction value to account for the tap changer

Example: Tap changer $St_{max} = +12\,\%$, $St_{min} = -12\,\%$.

$$k_{StS} = \frac{(100\,\% + 12\,\%) - (100\,\% - 12\,\%)}{(100\,\% + 12\,\%) + (100\,\% - 12\,\%)} = 0.12$$

[fokorwr3-180912-01.tif, 2, en_US]

Threshold value$_{New}$ = 0.20 I/Irated,obj + (0.12 · 0.67) I/Irated,obj ≈ ***0.28 I/Irated,obj***

Parameter: `Slope 1`

- Default setting **`(_:11041:100) Slope 1`** = ***0.3***

NOTE

The stabilization method has been changed from that in SIPROTEC 4 (7UT6x, 7UM62). For this reason, select a higher slope (also see *6.2.3.1 Basic Principle of Differential Protection*).

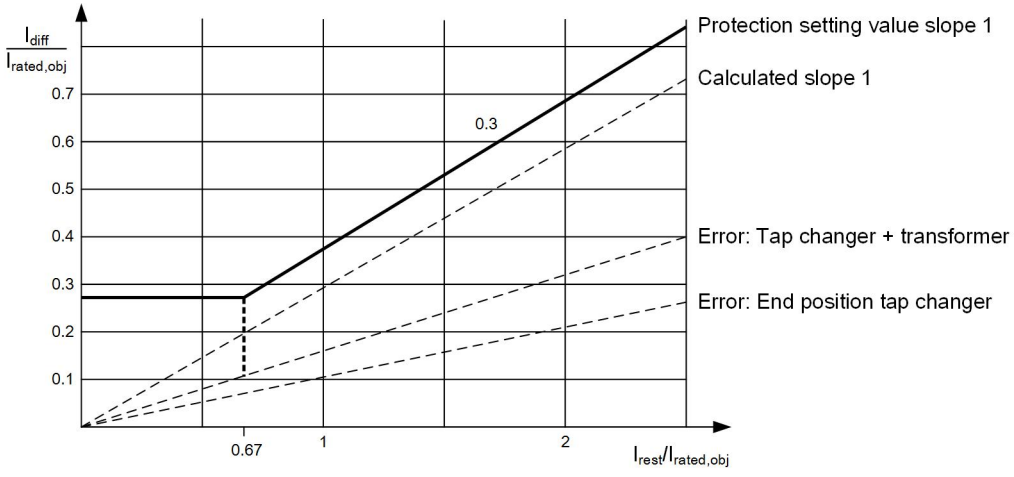
If the position of the tap changer cannot or should not be taken into account in the differential protection, check the increase.

The Slope 1 should be approximately 2 times higher than the current-proportional fault currents, which are caused by transformer transmission faults and non-adaption of a tap changer. In general, you can use a factor of 1.2 for the transformer fault currents.

`Slope 1New` = 2 · 1.2 · k_{StS}

for example **`Slope 1New`** = 2.4 · 0.12 = 0.288

However, you should set a slope of at least ***0.3***. *Figure 6-46* illustrates the situation.



[dwstgsfs-261012-01.tif, 3, en_US]

Figure 6-46 Setting Slope 1 with Tap Changer

Parameter: `Intersection 1 Irest`

- Default setting **`(_:11041:101) Intersection 1 Irest`** = ***0.67 I/Irated,obj***

The maximum current of the measuring point is used as restraint current. If you have to expect dynamic transmission faults of the current transformer even with small currents, Siemens recommends keeping the default setting of 0.67.

The setting of the parameter **Intersection 1 Irest** determines the end of the horizontal section with the threshold value I Diff>. Therefore also take into account the formula in the setting notes for the threshold value I Diff>.

Parameter: Intersection 2 Irest

- Default setting **(_:11041:103) Intersection 2 Irest** = ***2.5 I/Irated,obj***



NOTE

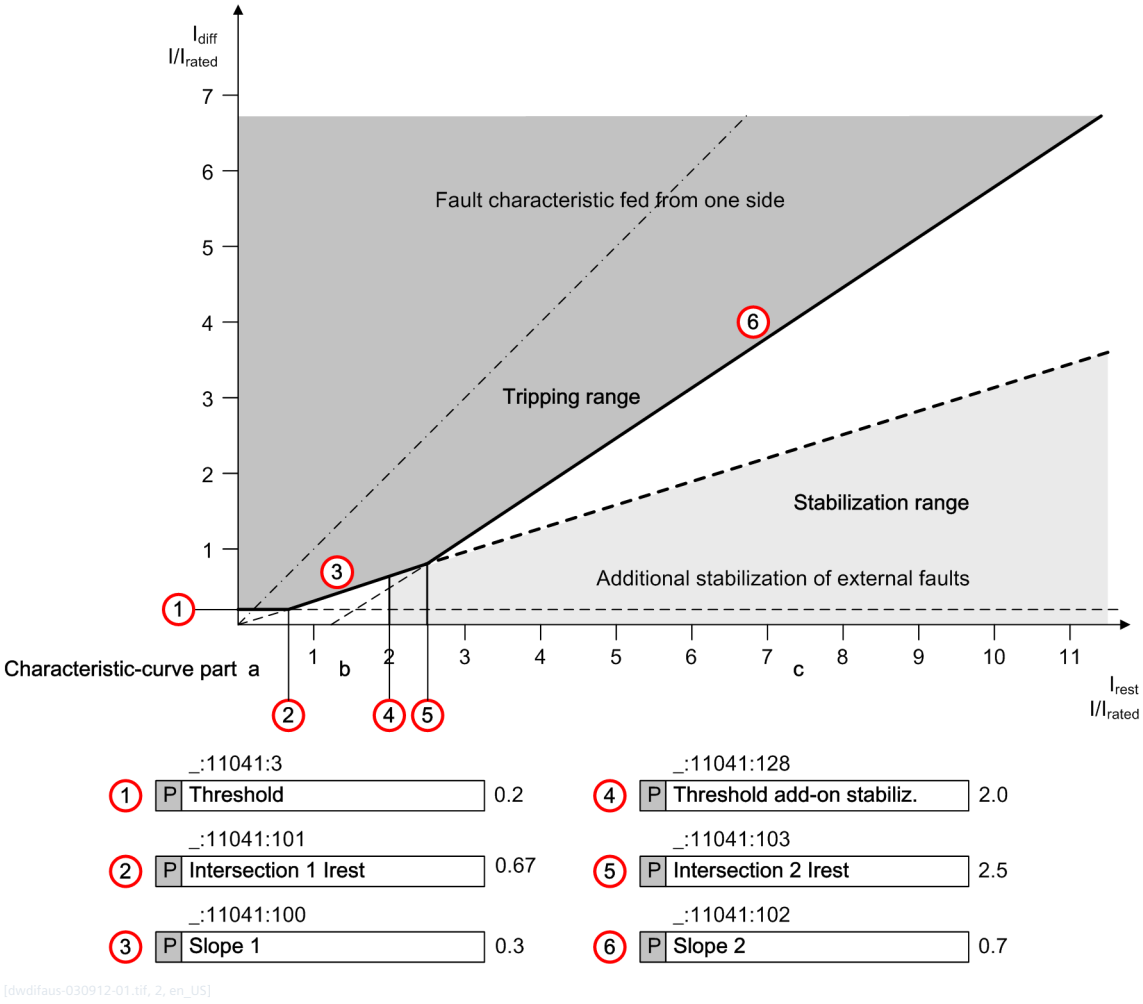
If excessive current flows are cause to expect transmission problems for the current transformer, set the **Slope 2** to a higher value.

When using the parameter **Intersection 2 Irest**, you determine at which restraint current the **Slope 2** will start. The default setting ***2.5 I/Irated,obj*** is a practical value.

Parameter: Slope 2

- Default setting **(_:11041:102) Slope 2** = ***0.7***

With the parameter **Slope 2**, an overfunction of the differential protection is avoided with high-current external faults as a consequence of current-transformer transmission faults (for example, due to saturation). A value greater than or equal to double the value of **Slope 1** is practical. As the default setting, ***0.7*** was selected.



[dwdifaus-030912-01.tif, 2, en_US]

Figure 6-47 Characteristic Curve with the Default Settings

Parameter: `Starting detection`

- Default setting **`(_:11041:106) Starting detection`** = ***no***

If motors are operated by a transformer to be protected, Siemens recommends the activation of the startup detection. The startup detection prevents an overfunction caused by the startup currents of the motors. Siemens recommends this also for the protection of power-compensating reactors. In this case, set the default setting **`Starting detection`** = ***yes***.

Parameter: `Thresh. startup detection`

- Default setting **`(_:11041:107) Thresh. startup detection`** = ***0.1 I/Irated,obj***

If the restraint current falls below this threshold value, the subsequently set characteristic curve increase becomes effective with activated function. For this application, Siemens recommends a default setting of ***0.1 I/Irated,obj***.

Parameter: `Factor increasing char.`

- Default setting **`(_:11041:108) Factor increasing char.`** = ***2.0***

Change the default setting value in the case of application. A setting to the value 2.0 has proven itself to be sufficient for many applications. For this reason, the recommended setting value is **`Factor increasing char.`** = ***2.0***.

Parameter: `Max. perm. Start. time`

- Default setting **`(_:11041:109) Max. perm. Start. time`** = ***`5.0 s`***

The setting value must lie above the maximum permissible start time of the connected motors. Find the start time in the motor data sheets (for example, **Locked Rotor** time). To ensure tripping through the motor protection (starting-time supervision) and avoid overfunctions, select a somewhat longer time (factor 1.2).

Parameter: `Factor increasing char. DC` (DC-Component Detection)

- Default setting **`(_:11041:110) Factor increasing char. DC`** = ***`2.3`***

DC-component detection is always active. As a result of the DC components, transmission problems can arise (for example, phase-angle rotations) in current transformers with small currents flowing. For this reason, the **`Threshold`** and the **`Slope 1`** are raised by the set factor. The default setting of 2.3 has proven itself with numerous applications.

Parameter: `Blocking with 2. harmonic` (Inrush-Current Detection)

- Default setting **`(_:11041:115) Blocking with 2. harmonic`** = ***`yes`***

Always activate inrush-current detection with transformer applications.

Parameter: `2nd harmonic content`

- Default setting **`(_:11041:116) 2nd harmonic content`** = ***`15 %`***

For many practical applications, the default setting value of ***`15 %`*** has proven useful. In exceptional cases, the setting value can be decreased with a small proportion of 2nd harmonic. Avoid a setting under 10 %, however. With an internal fault and current-transformer saturation, a proportion of 2nd harmonic also arises. Too sensitive of a setting leads to a blocking of the protection function.

Parameter: `Crossblock. time 2nd har.`

- Default setting **`(_:11041:117) Crossblock. time 2nd har.`** = ***`0 s`***

Since the inrush currents develop differently in the 3 phases, the pickup value, for example, is not attained in a phase, but the differential current exceeds the characteristic curve. Corrective action creates a mutual blocking. If a time unequal to 0 s is set, the crossblock function works. If an overfunction arises, the setting cannot be made until commissioning takes place. Do not set the duration for an excessive amount of time. Practical values showed a setting between 3 and 5 periods.

Parameter: `Blocking with CWA`

- Default setting **`(_:11041:118) Blocking with CWA`** = ***`yes`***

In accordance with the application sheet, an additional, supplementary method is used for the inrush-current detection. Siemens recommends using the default setting. If you wish to perform the inrush-current detection only when monitoring the 2nd harmonic, you can switch off the CWA method (**`Blocking with CWA`** = ***`no`***).



NOTE

When using a shunt reactor, Siemens recommends deactivating the CWA process, since the process results in a false pickup in the event of an external fault. The background is that the CWA-internal fault detection deactivates the blocking of the 2nd harmonic in the differential protection.

Parameter: `Blocking with 3rd harm.` (Overexcitation Blocking)

- Default setting **`(_:11041:121) Blocking with 3rd harm.`** = ***`no`***

Blocking with the 3rd harmonic is intended for special applications, for example, when supplying power to blast furnaces. Even with standard transformers, the 3rd harmonic can arise in a case of overexcitation, but this is eliminated through the delta winding. For this reason, using the 5th harmonic is preferred.

Parameter: 3rd harmonics content

- Default setting **(_:11041:122) 3rd harmonics content** = ***30 %***

For many practical applications, the default setting value of ***30 %*** has proven useful. Also see explanations for setting the 5th harmonic.

Parameter: Crossblock. time 3rd har.

- Default setting **(_:11041:123) Crossblock. time 3rd har.** = ***0 s***

See explanation of inrush-current detection.

Parameter: Blocking with 5th harm.

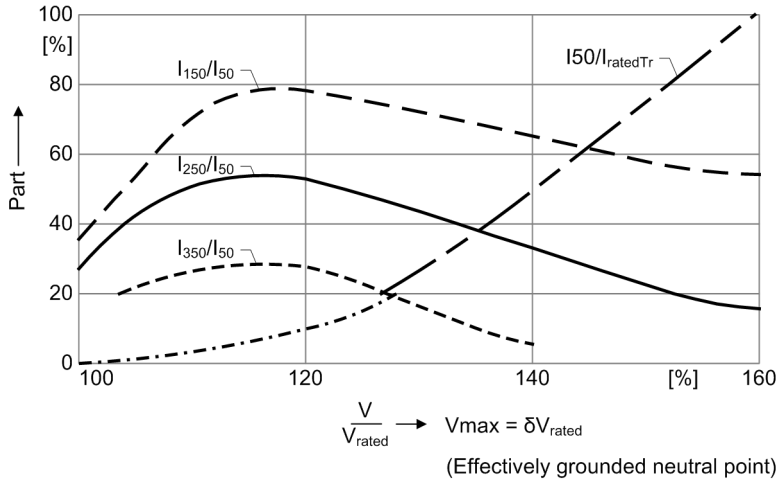
- Default setting **(_:11041:124) Blocking with 5th harm.** = ***no***

If you expect higher overvoltages that can bring about a failure of the differential protection, change the default setting (also see explanations below) and activate the functionality (**Blocking with 5th harm.** = ***yes***).

Parameter: 5th harmonics content

- Default setting **(_:11041:125) 5th harmonics content** = ***30 %***

For many practical applications, the default setting value of 30 % has proven useful. It can be derived from the *Figure 6-48* in the graphic shown. The voltage is represented on the x-axis, and the percentage of the individual measurable variables on the y-axis. On the curve $I_{50}/I_{ratedTr}$ you can see that the pickup value of the differential protection can be exceeded in case of overvoltage. If you assume 140 % [V/V_{rated}] as the maximum overvoltage, you can read from the curve I_{250}/I_{50}, that the proportion of the 5th harmonic still amounts to approx. 35 %. A setting value of ***30 %*** is therefore sufficient.



[dwanhaub-170712-01.tif, 1, en_US]

Figure 6-48 Part of the Harmonic in Case of Overexcitation

Parameter: Crossblock. time 5th har.

- Default setting **(_:11041:126) Crossblock. time 5th har.** = ***0 s***

You can leave the default setting as is. If problems arise during system operation, you can take corrective measures by setting an appropriate time. You can derive the necessary time from the fault record by evaluating the proportion of the harmonic.

Parameter: Limit Idiff 3., 5. harmonics

- Default setting **(_:11041:127) Limit Idiff 3., 5. harmonics** = ***1.5 I/Irated,obj***

If large differential currents arise, you can assume an internal fault. To avoid a subfunction of the differential protection, overexcitation blocking is inhibited from the threshold value on. Distorted fault currents produce predominantly odd-numbered harmonics in case of an internal fault. In accordance with *Figure 6-48*, a possible differential current is caused that lies below the rated current due to overexcitation. On the other hand, distorted fault currents arise only with currents far above the rated current. Therefore, ***1.5 I/Irated,obj*** is a practical setting value.

Detection of External Faults

In *Figure 6-47*, the range **Add-on stabilization with external fault** is represented. The range is described by the parameters **Threshold add-on stabiliz.** and **Slope 1**. With an external short circuit, the differential currents can increase beyond this range and reach into the tripping area. With the following parameters, time-limited blocking can be performed.

Parameter: Threshold add-on stabiliz.

- Default setting **(_:11041:128) Threshold add-on stabiliz.** = ***2.0***

The parameter **Threshold add-on stabiliz.** allows you to set the pickup value for the additional stabilization. Due to the selected method of measurement, a setting value of 2 is practical. The additional stabilization range is limited by the parameters **Threshold add-on stabiliz.** and **Slope 1**.

Parameter: Time of add-on stabiliz.

- Default setting **(_:11041:129) Time of add-on stabiliz.** = ***0.3 s***

As orientation for the setting value, you can use the operate time of the external feeder protection. Additionally, take into account the break time of the circuit breaker. Thus, the following calculation rule results:

$t_{Z\text{-rest}} \geq t_{Trip.,ext\ protection} + t_{Trip,circuit\ breaker}$

The default value is a practical value. You must adapt the value appropriately to use. The value 0 deactivates the detection of external faults.

Parameter: Crossblk. time add-on st.

- Default setting **(_:11041:130) Crossblk. time add-on st.** = ***0.3 s***

As a consequence of the vector-group correction and zero-sequence current elimination, the differential currents can spread to the other phases in case of transformer saturation. For this reason, Siemens recommends the activation of the crossblock function with a corresponding setting of the time. The set time must be identical to the time that is set for the duration of the additional stabilization.

Broken wire action in the Stage I-DIFF

If the **Broken-wire detection** is switched on in at least one current measuring point on a transformer side and the parameter **(_:5581:101) Mode of blocking** is set to ***blocking***, the parameters **(_:11041:135) In case of broken wire** and **(_:11041:136) Condition: Idiff less than** are visible in the stage **I-DIFF**. These 2 parameters control the reaction of the stage **I-DIFF** to a wire break.

Parameter: In case of broken wire

- Default setting **(_:11041:135) In case of broken wire** = ***do not block***

With the parameter **In case of broken wire**, you specify whether the stage **I-DIFF** is supposed to ***do not block***, ***do always block***, or ***do conditionally block*** in case of a wire break in the secondary system.

Parameter: Condition: Idiff less than

- Default setting **(_:11041:136) Condition: Idiff less than** = ***1.20 I/IrObj***

If the parameter **In case of broken wire** is set to ***do conditionally block***, the blocking of the stage **I-DIFF** depends on the level of the differential current. The stage **I-DIFF** is only blocked if the differential

current is less than the value set in the parameter **Condition: Idiff less than**. If the differential current exceeds the set value, the blocking of the stage **I-DIFF** is canceled.

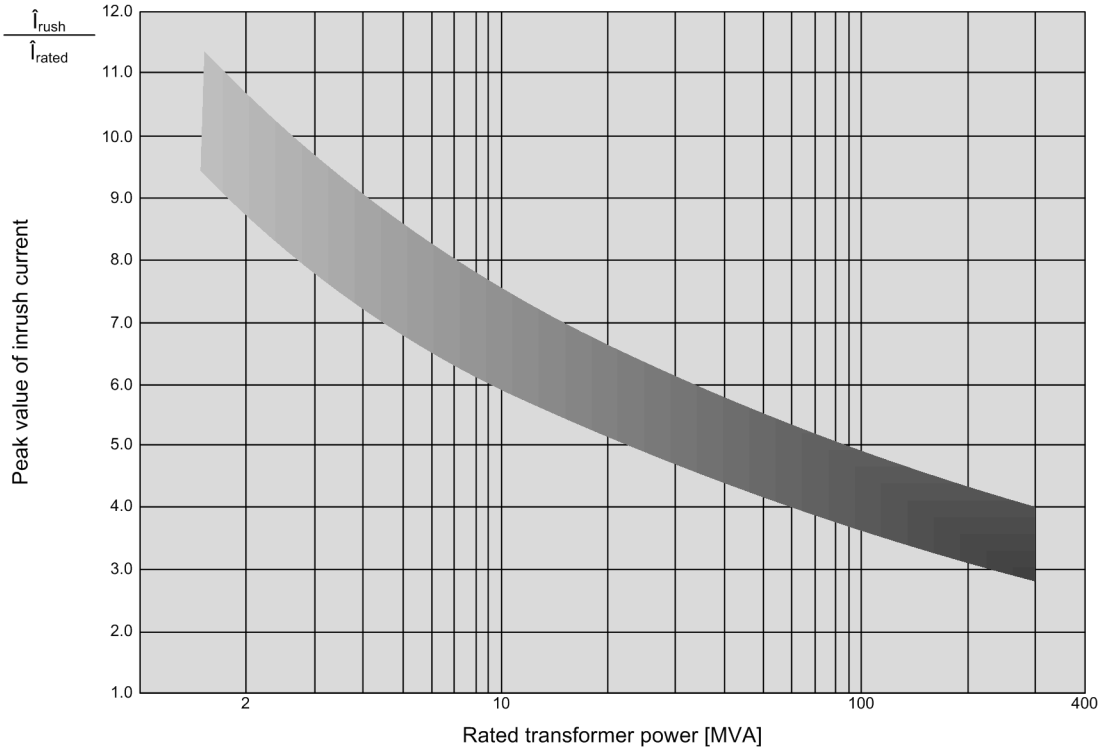
Protection Stage I-DIFF Fast

The task of this protection stage is the fast detection of high-current internal faults (see also *6.2.3.1 Basic Principle of Differential Protection*). For this reason, the protection stage must always be activated.

Parameter: Threshold

- Default setting **(_:11071:3) Threshold** = ***7.5 I/Irated,obj***

The **Threshold** must exceed the expected inrush current. The inrush current depends on the construction, the core material, and the impedances of the transformer. There are typical power-dependent values. Use the graphic below for estimating purposes (*Figure 6-49*).
In the case of transformers with a low power rating (<10 MVA) the inrush current can lie above the default setting value of ***7.5 I/Irated,obj***.



[Dw-Nennleistung-Transf-060214, 1, en_US]

Figure 6-49 Transformer Inrush Currents, Typical Data

Example:
At a power of 100 MVA, a value of approx. 4.5 I/Irated,obj. is derived from *Figure 6-49*. For this application, reduce the default setting from 7.5 I/Irated,obj to the determined value.

Protection Stage I-DIFF Unrestrained

The task of this protection stage is the fast detection of high-current internal faults (also refer to *6.2.3.8 I-DIFF Unrestrained Differential Protection Function*).

Parameter: Threshold

- Default setting **(_:18002:3) Threshold** = ***10.0 I/Irated,obj***

To set the parameter **Threshold** correctly, you must take into account the short-circuit impedance of the system and the protected object as well as the maximum inrush current.

Protection of a Three-Winding Transformer with Several Measuring Points

In this complex example, the main focus is on the configuration. A three-winding transformer YNd1d1, which is connected on the upper-voltage side to a breaker-and-a-half layout, is protected. A generator feeds in power on the delta side, while a generator also supplies its own power. On the upper-voltage side, the transformer is solidly grounded. As can be seen in *Figure 6-50*, five 3-phase measuring points and one 1-phase measuring point is required. A 1-phase overcurrent protection is located in the 1-phase measuring point as ground current backup protection. So that the restricted ground-fault protection found there can process the neutral-point current, circuiting with the **Transformer side 1** is required. The individual measuring points are described by ID1 to ID6. Furthermore, 3 function groups **Transformer side**, 1 function group **Transformer neutral point**, and the function group **Transformer** are required.

The functionality is available in the devices 7UT86 and 7UT87.

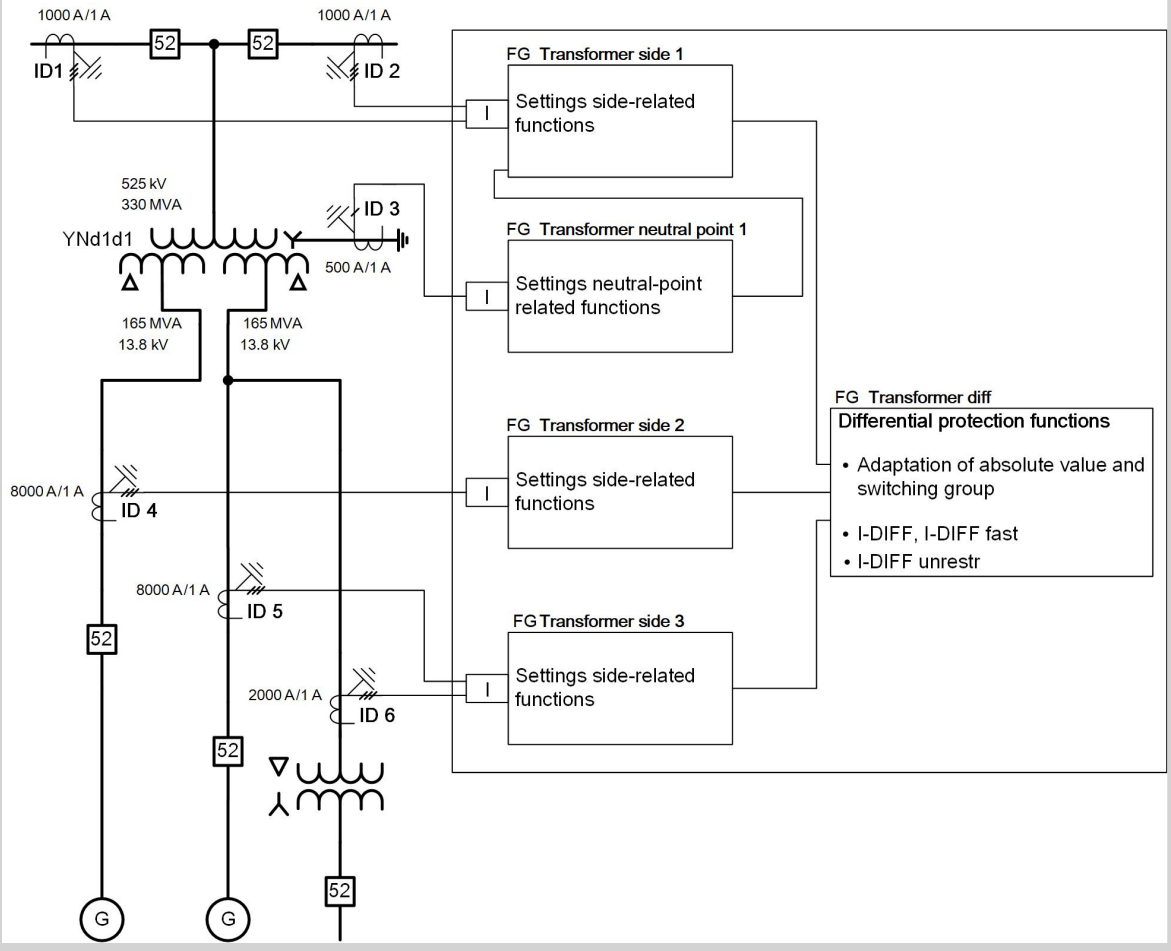
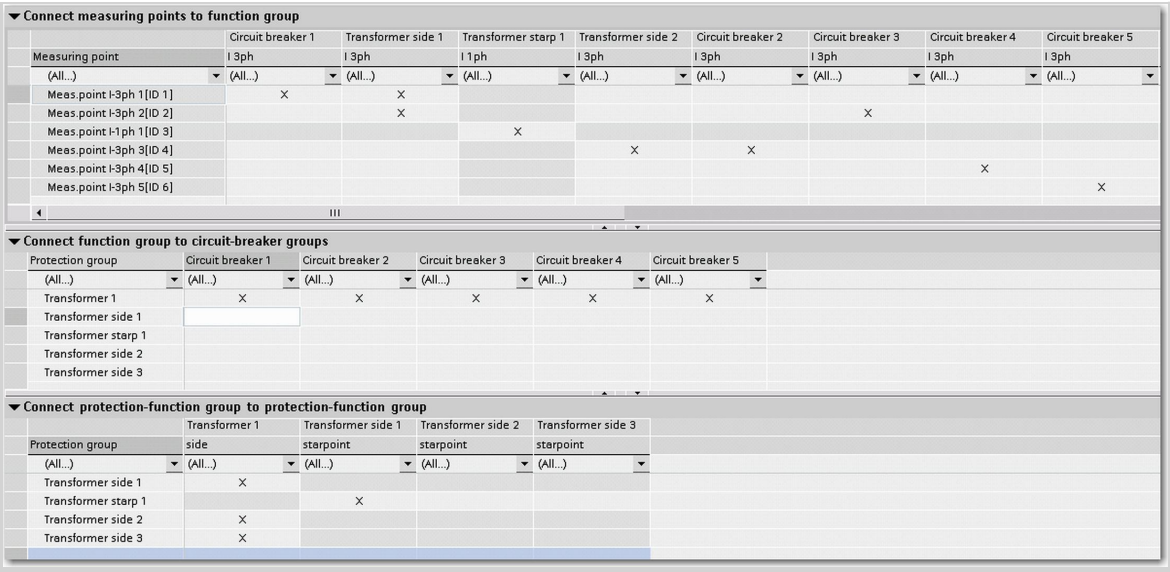


Figure 6-50 Connection of a Three-Winding Transformer with Several Measuring Points

Figure 6-50 shows you the measuring point assignment to the function groups and the circuiting of the function groups among one another from DIGSI 5. Since a total of 5 circuit breakers are operated, 5 function groups **Circuit Breaker** are present.



[ScTrDfFG-230216, 1, en_US]

Figure 6-51 Circuiting of the Measuring Points and Function Groups (Principle)

Make the settings in the function group **Transformer side**, using the procedure described for the two-winding transformer. Ensure that the transformer data with the measuring points have been set. The following screenshot shows the settings for the function group **Transformer side 1** (upper-voltage side).

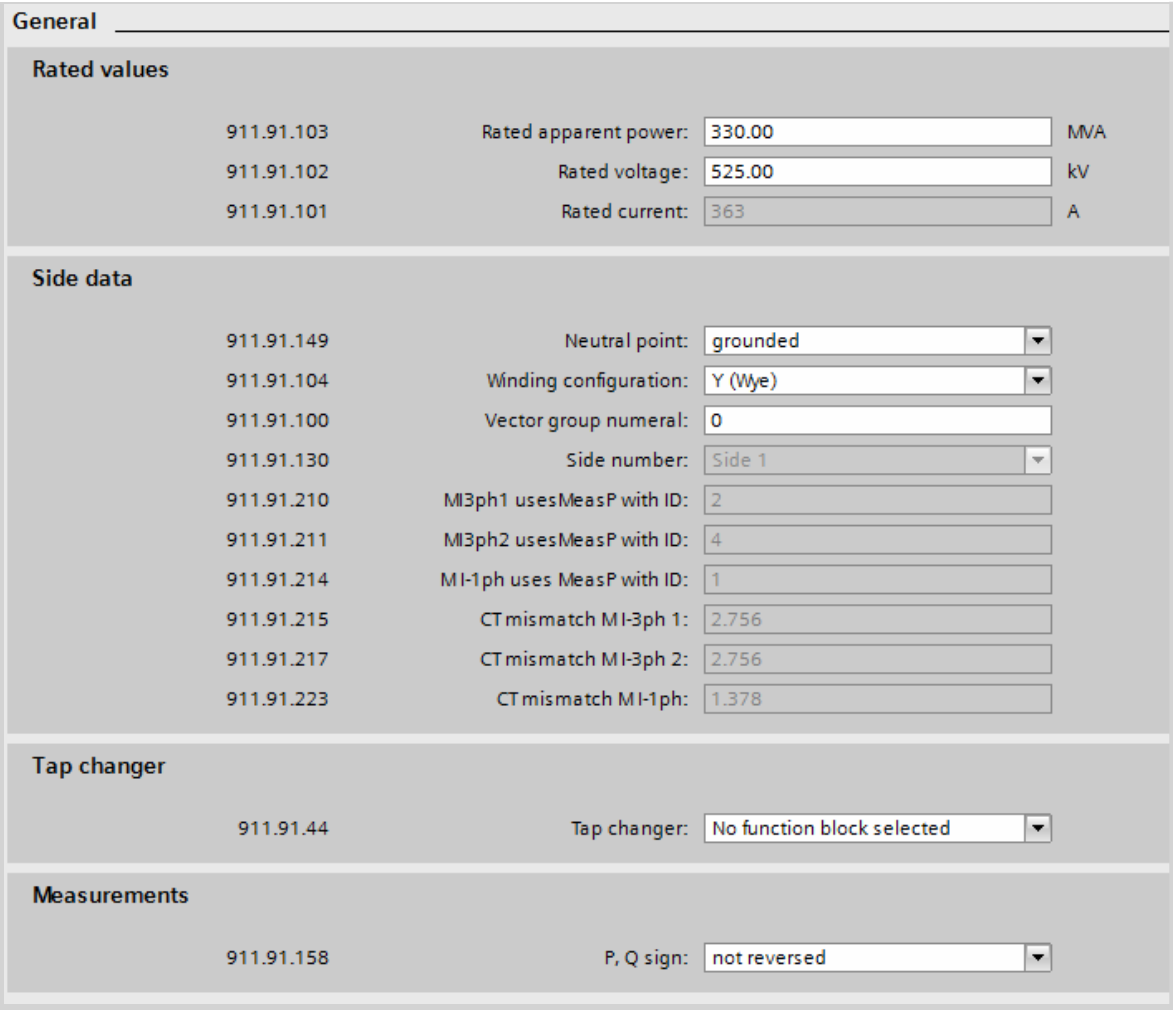


Figure 6-52 Setting the Function Group Transformer Side 1

Besides the standard data of the transformer side, additional information is stored. These are colored gray.
The following values are displayed:

- Side number of the transformer side
- IDs of the assigned measuring points
- Side-related matching factors for the current correction

NOTE

Ensure that the current correction factors refer to the side.

The rated current of the side amounts to 363 A and phase current transformers of 1000 A/1 A are present. The matching factor results in 1000 A/363 A = 2.76. For the neutral point transformer 500 A/363 A = 1.38 is the result.
Analog to the two-winding transformer, the identical setting parameters for the function group **Transformer** may be used. *Figure 6-53* to *Figure 6-55* show the appropriate setting sheet for the stage I-DIFF.

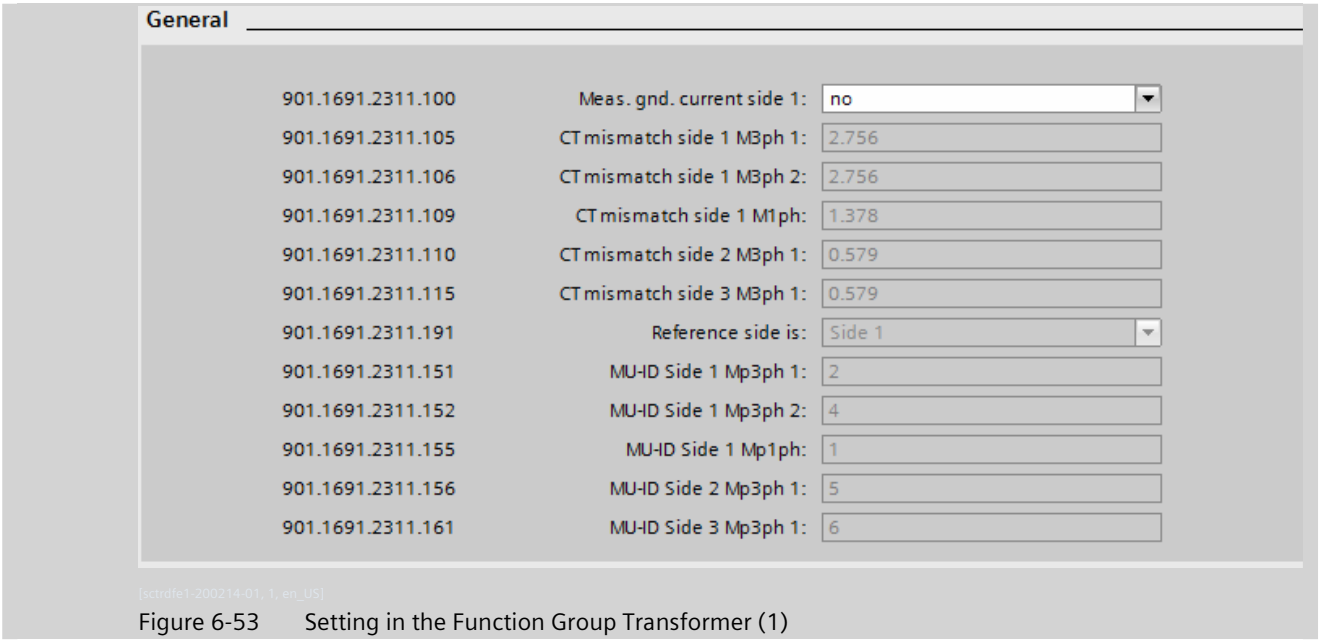


Figure 6-53 Setting in the Function Group Transformer (1)

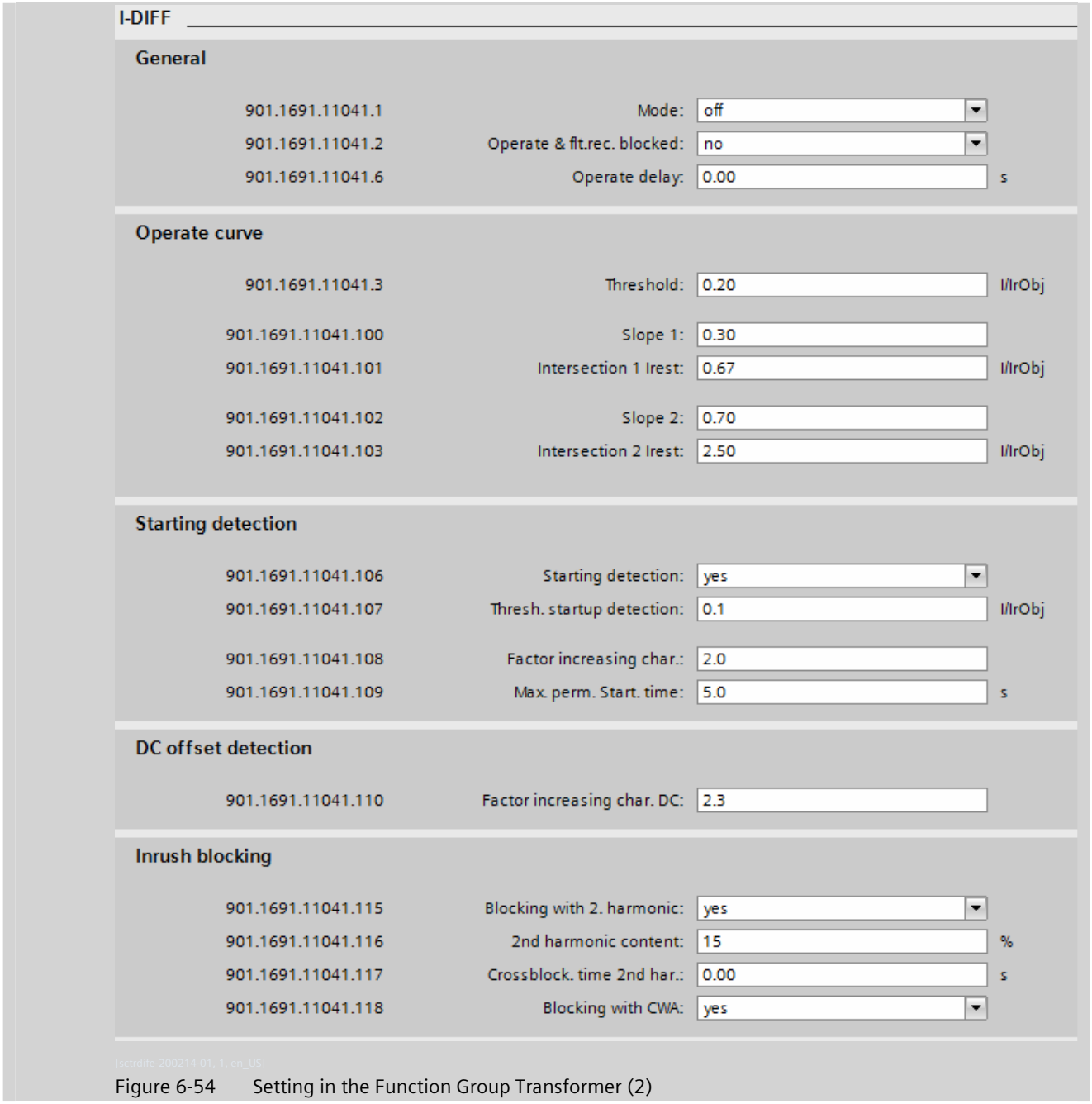


Figure 6-54 Setting in the Function Group Transformer (2)

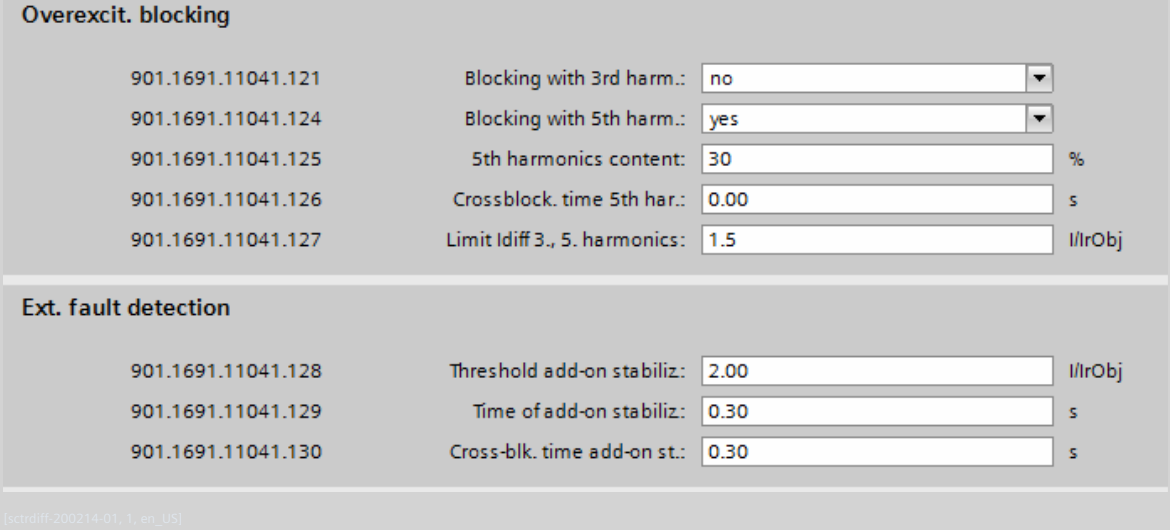


Figure 6-55 Setting in the Function Group Transformer (3)

You set how the ground current is handled on the **General** setting sheet. On transformer side (*Figure 6-52*), the neutral point of the transformer is set as grounded. In this way, the protection function knows that the zero-sequence current is to be accounted for. With the following parameter, you can set the treatment of the zero-sequence current.

Parameter: `Meas. gnd. current side 1`

- Default setting `(_:2311:100) Meas. gnd. current side 1` = ***no***

With the setting ***yes*** a zero-sequence current correction is performed. The setting ***no*** causes the elimination of the zero-sequence current. With the zero-sequence current correction, a higher sensitivity is attained in the case of 1-pole ground faults. If the neutral-point current transformer and the differential protection are connected, you must set ***yes***. Ensure beforehand that you have set the transformer data with the measuring points.

For further explanations for zero-sequence current handling, refer to *6.2.3.1 Basic Principle of Differential Protection*.

Additionally, the correction factors that the differential protection uses for current adaptation are shown under **General**. The currents are based on the transformed rated current of the reference side.

NOTE

The reference side is the side with the highest rated apparent power. If this should be several sides, the largest side rated current is selected from these.

Since side 1 is the side with the greatest power, the matching factors are identical to those in the function group **Transformer Side**. For side 2, the following adaptation results:

I_{Ref} = (330 MVA/(13.8 kV · √3)) = 13 806 A; 8000 A/13 806 A = 0.58. Since 2 measuring points with different primary rated currents are connected on side 3, 2 different matching factors result. For the 2 000 A transformer, that is 2 000 A/13 806 A = 0.14.

Protection of an Auto Transformer with Stabilizing Winding

In addition to the configuration, this example focuses on protection-relevant implementation. A transformer bank is protected with a stabilizing winding that is connected on the upper-voltage side to a breaker-and-a-half layout. *Figure 6-56* shows the system connection and the internal circuiting of the function groups. Altogether, four 3-phase voltage measuring points are processed. The auto transformer also has a 3-phase current transformer (ID4) at the neutral point. Differential protection which treats the auto transformer as a pure node can be realized additionally. You thereby attain a higher sensitivity in faults near the neutral point;

on the basis of how the transformer bank is set up, these are 1-pole ground faults. Settings instructions are given below.

NOTE

This supplemented protection function does not record the stabilizing windings!

In contrary to this, the conventional differential protection function also takes into consideration the stabilizing winding. The measuring points ID1, ID2, ID3, and ID5 are processed. The protection function is identical to the function of the standard transformer. You can read settings instructions below. The function is operational in the devices 7UT86 and 7UT87.

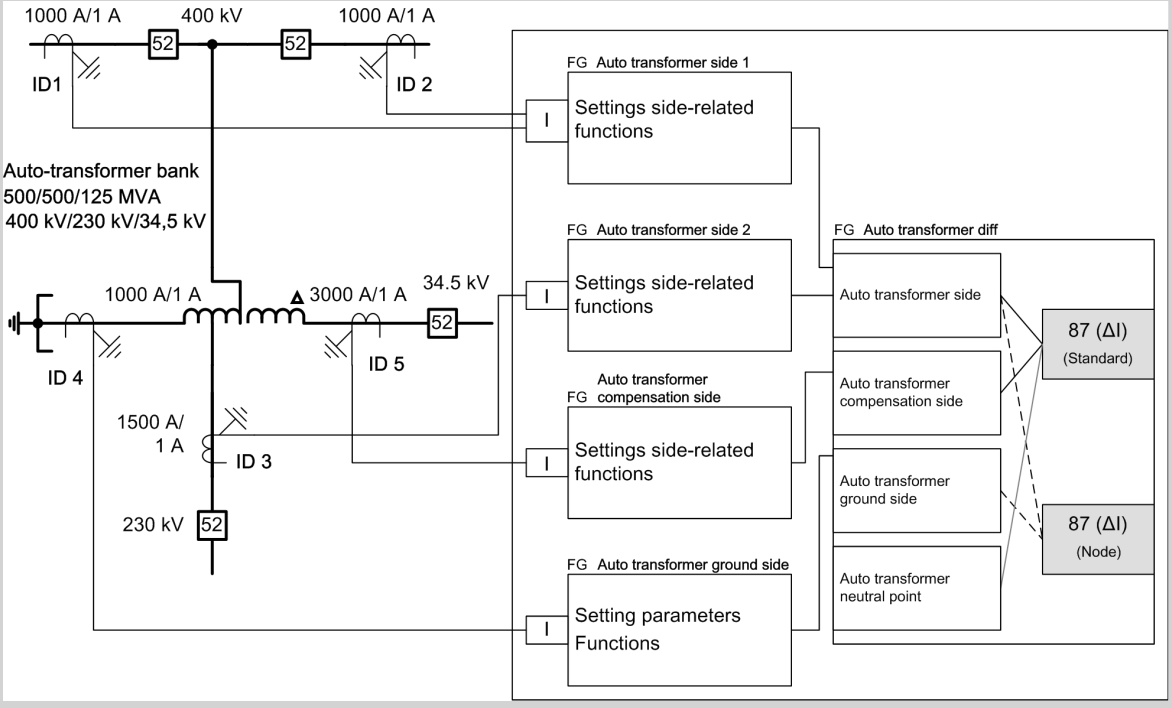


Figure 6-56 Connection of an Auto-Transformer Bank with Stabilizing Winding and Several Measuring Points

From *Figure 6-56* it can be seen that 4 function groups are required side-specifically. The connection of the measuring points to this and the side-specific settings occur. The differential protection functions are processed in the function group **Auto transformer diff**. The 2 differential protection functions run in parallel in the application. *Figure 6-56* also shows the circuiting of the function groups to the different interfaces of the function group **Auto transformer diff**. The auto-transformer/neutral point interface is used for applications where a 1-phase current transformer is present at the neutral point. In this application, connect the current transformer with a function group **Auto transformer neutral point**.

6.2.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:186	General:Protection Mode		• Transformer • Current node	Transformer
_:2311:100	General:Meas. gnd. current side 1		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:101	General:Meas. gnd. current side 2		• no • yes	no
_:2311:102	General:Meas. gnd. current side 3		• no • yes	no
_:2311:103	General:Meas. gnd. current side 4		• no • yes	no
_:2311:104	General:Meas. gnd. current side 5		• no • yes	no
_:2311:181	General:Meas. gnd. curr. autosides		• no • with CT 1ph • with CT 3ph	no
_:2311:182	General:Meas. gnd. curr. comp.side		• no • yes	no
_:2311:105	General:CT mismatch side 1 M3ph 1		0.000 to 100.000	0.000
_:2311:106	General:CT mismatch side 1 M3ph 2		0.000 to 100.000	0.000
_:2311:107	General:CT mismatch side 1 M3ph 3		0.000 to 100.000	0.000
_:2311:108	General:CT mismatch side 1 M3ph 4		0.000 to 100.000	0.000
_:2311:109	General:CT mismatch side 1 M1ph		0.000 to 100.000	0.000
_:2311:110	General:CT mismatch side 2 M3ph 1		0.000 to 100.000	0.000
_:2311:111	General:CT mismatch side 2 M3ph 2		0.000 to 100.000	0.000
_:2311:112	General:CT mismatch side 2 M3ph 3		0.000 to 100.000	0.000
_:2311:113	General:CT mismatch side 2 M3ph 4		0.000 to 100.000	0.000
_:2311:114	General:CT mismatch side 2 M1ph		0.000 to 100.000	0.000
_:2311:115	General:CT mismatch side 3 M3ph 1		0.000 to 100.000	0.000
_:2311:116	General:CT mismatch side 3 M3ph 2		0.000 to 100.000	0.000
_:2311:117	General:CT mismatch side 3 M3ph 3		0.000 to 100.000	0.000
_:2311:118	General:CT mismatch side 3 M3ph 4		0.000 to 100.000	0.000
_:2311:119	General:CT mismatch side 3 M1ph		0.000 to 100.000	0.000
_:2311:120	General:CT mismatch side 4 M3ph 1		0.000 to 100.000	0.000
_:2311:121	General:CT mismatch side 4 M3ph 2		0.000 to 100.000	0.000
_:2311:122	General:CT mismatch side 4 M3ph 3		0.000 to 100.000	0.000

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:123	General:CT mismatch side 4 M3ph 4		0.000 to 100.000	0.000
_:2311:124	General:CT mismatch side 4 M1ph		0.000 to 100.000	0.000
_:2311:125	General:CT mismatch side 5 M3ph 1		0.000 to 100.000	0.000
_:2311:126	General:CT mismatch side 5 M3ph 2		0.000 to 100.000	0.000
_:2311:127	General:CT mismatch side 5 M3ph 3		0.000 to 100.000	0.000
_:2311:128	General:CT mismatch side 5 M3ph 4		0.000 to 100.000	0.000
_:2311:129	General:CT mismatch side 5 M1ph		0.000 to 100.000	0.000
_:2311:183	General:CT mismatch M1ph		0.000 to 100.000	0.000
_:2311:130	General:CT mismatch S1 M3ph 1 N		0.000 to 100.000	0.000
_:2311:131	General:CT mismatch S1 M3ph 2 N		0.000 to 100.000	0.000
_:2311:132	General:CT mismatch S1 M3ph 3 N		0.000 to 100.000	0.000
_:2311:133	General:CT mismatch S1 M3ph 4 N		0.000 to 100.000	0.000
_:2311:134	General:CT mismatch side 1 M1ph N		0.000 to 100.000	0.000
_:2311:176	General:CT mismatch S2 M3ph 1 N		0.000 to 100.000	0.000
_:2311:135	General:CT mismatch S2 M3ph 2 N		0.000 to 100.000	0.000
_:2311:136	General:CT mismatch S2 M3ph 3 N		0.000 to 100.000	0.000
_:2311:137	General:CT mismatch S2 M3ph 4 N		0.000 to 100.000	0.000
_:2311:177	General:CT mismatch side 2 M1ph N		0.000 to 100.000	0.000
_:2311:138	General:CT mismatch S3 M3ph 1 N		0.000 to 100.000	0.000
_:2311:139	General:CT mismatch S3 M3ph 2 N		0.000 to 100.000	0.000
_:2311:140	General:CT mismatch S3 M3ph 3 N		0.000 to 100.000	0.000
_:2311:141	General:CT mismatch S3 M3ph 4 N		0.000 to 100.000	0.000
_:2311:178	General:CT mismatch side 3 M1ph N		0.000 to 100.000	0.000
_:2311:142	General:CT mismatch S4 M3ph 1 N		0.000 to 100.000	0.000
_:2311:143	General:CT mismatch S4 M3ph 2 N		0.000 to 100.000	0.000
_:2311:144	General:CT mismatch S4 M3ph 3 N		0.000 to 100.000	0.000

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:145	General:CT mismatch S4 M3ph 4 N		0.000 to 100.000	0.000
_:2311:179	General:CT mismatch side 4 M1ph N		0.000 to 100.000	0.000
_:2311:146	General:CT mismatch S5 M3ph 1 N		0.000 to 100.000	0.000
_:2311:147	General:CT mismatch S5 M3ph 2 N		0.000 to 100.000	0.000
_:2311:148	General:CT mismatch S5 M3ph 3 N		0.000 to 100.000	0.000
_:2311:149	General:CT mismatch S5 M3ph 4 N		0.000 to 100.000	0.000
_:2311:180	General:CT mismatch side 5 M1ph N		0.000 to 100.000	0.000
_:2311:184	General:CT mismatch M1ph N		0.000 to 100.000	0.000
_:2311:191	General:Reference side is		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	not assigned
_:2311:151	General:MU-ID Side 1 Mp3ph 1		0 to 100	0
_:2311:152	General:MU-ID Side 1 Mp3ph 2		0 to 100	0
_:2311:153	General:MU-ID Side 1 Mp3ph 3		0 to 100	0
_:2311:154	General:MU-ID Side 1 Mp3ph 4		0 to 100	0
_:2311:155	General:MU-ID Side 1 Mp1ph		0 to 100	0
_:2311:156	General:MU-ID Side 2 Mp3ph 1		0 to 100	0
_:2311:157	General:MU-ID Side 2 Mp3ph 2		0 to 100	0
_:2311:158	General:MU-ID Side 2 Mp3ph 3		0 to 100	0
_:2311:159	General:MU-ID Side 2 Mp3ph 4		0 to 100	0
_:2311:160	General:MU-ID Side 2 Mp1ph		0 to 100	0
_:2311:161	General:MU-ID Side 3 Mp3ph 1		0 to 100	0
_:2311:162	General:MU-ID Side 3 Mp3ph 2		0 to 100	0
_:2311:163	General:MU-ID Side 3 Mp3ph 3		0 to 100	0
_:2311:164	General:MU-ID Side 3 Mp3ph 4		0 to 100	0

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:165	General:MU-ID Side 3 Mp1ph		0 to 100	0
_:2311:166	General:MU-ID Side 4 Mp3ph 1		0 to 100	0
_:2311:167	General:MU-ID Side 4 Mp3ph 2		0 to 100	0
_:2311:168	General:MU-ID Side 4 Mp3ph 3		0 to 100	0
_:2311:169	General:MU-ID Side 4 Mp3ph 4		0 to 100	0
_:2311:170	General:MU-ID Side 4 Mp1ph		0 to 100	0
_:2311:171	General:MU-ID Side 5 Mp3ph 1		0 to 100	0
_:2311:172	General:MU-ID Side 5 Mp3ph 2		0 to 100	0
_:2311:173	General:MU-ID Side 5 Mp3ph 3		0 to 100	0
_:2311:174	General:MU-ID Side 5 Mp3ph 4		0 to 100	0
_:2311:175	General:MU-ID Side 5 Mp1ph		0 to 100	0
_:2311:185	General:MU-ID Mp1ph		0 to 100	0
_:2311:187	General:Use tap-changer position		• no • yes	yes
Two-core PST				
_:2311:188	General:Diff function mode		• 87T primary prot • 87T secondary prot	87T primary prot
_:2311:189	General:Series unit ratio		0.001 to 100.000	1.000
General				
_:11041:1	I-DIFF:Mode		• off • on • test	off
_:11041:2	I-DIFF:Operate & flt.rec. blocked		• no • yes	no
_:11041:6	I-DIFF:Operate delay		0.00 s to 60.00 s	0.00 s
Operate curve				
_:11041:3	I-DIFF:Threshold		0.05 I/IrObj to 2.00 I/IrObj	0.20 I/IrObj
_:11041:100	I-DIFF:Slope 1		0.00 to 0.80	0.30
_:11041:101	I-DIFF:Intersection 1 Irest		0.00 I/IrObj to 5.00 I/IrObj	0.67 I/IrObj
_:11041:102	I-DIFF:Slope 2		0.25 to 0.95	0.70
_:11041:103	I-DIFF:Intersection 2 Irest		1.00 I/IrObj to 20.00 I/IrObj	2.50 I/IrObj
Starting detection				
_:11041:106	I-DIFF:Starting detection		• no • yes	no
_:11041:107	I-DIFF:Thresh. startup detection		0.1 I/IrObj to 2.0 I/IrObj	0.1 I/IrObj
_:11041:108	I-DIFF:Factor increasing char.		1.0 to 5.0	2.0

Addr.	Parameter	C	Setting Options	Default Setting
_:11041:109	I-DIFF:Max. perm. Start. time		0.1 s to 180.0 s	5.0 s
DC offset detection				
_:11041:110	I-DIFF:Factor increasing char. DC		1.0 to 5.0	2.3
Inrush blocking				
_:11041:115	I-DIFF:Blocking with 2. harmonic		• no • yes	yes
_:11041:116	I-DIFF:2nd harmonic content		10 % to 45 %	15 %
_:11041:117	I-DIFF:Crossblock. time 2nd har.		0.00 s to 200.00 s; ∞	0.00 s
_:11041:118	I-DIFF:Blocking with CWA		• no • yes	yes
Overexcit. blocking				
_:11041:121	I-DIFF:Blocking with 3rd harm.		• no • yes	no
_:11041:122	I-DIFF:3rd harmonics content		10 % to 80 %	30 %
_:11041:123	I-DIFF:Crossblock. time 3rd har.		0.00 s to 200.00 s; ∞	0.00 s
_:11041:124	I-DIFF:Blocking with 5th harm.		• no • yes	no
_:11041:125	I-DIFF:5th harmonics content		10 % to 80 %	30 %
_:11041:126	I-DIFF:Crossblock. time 5th har.		0.00 s to 200.00 s; ∞	0.00 s
_:11041:127	I-DIFF:Limit Idiff 3., 5. harmonics		0.5 I/IrObj to 20.0 I/IrObj	1.5 I/IrObj
Ext. fault detection				
_:11041:128	I-DIFF:Threshold add-on stabiliz.		1.00 I/IrObj to 20.00 I/IrObj	2.00 I/IrObj
_:11041:129	I-DIFF:Time of add-on stabiliz.		0.00 s to 5.00 s; ∞	0.30 s
_:11041:130	I-DIFF:Crossblk. time add-on st.		0.00 s to 2.00 s; ∞	0.30 s
Broken wire action				
_:11041:135	I-DIFF:In case of broken wire		• do not block • do always block • do conditionally block	do not block
_:11041:136	I-DIFF:Condition: Idiff less than		0.05 I/IrObj to 5.00 I/IrObj	1.20 I/IrObj
I-DIFF fast				
_:11071:1	I-DIFF fast:Mode		• off • on • test	off
_:11071:3	I-DIFF fast:Threshold		0.5 I/IrObj to 35.0 I/IrObj	7.5 I/IrObj
_:11071:6	I-DIFF fast:Operate delay		0.00 s to 60.00 s	0.00 s

Addr.	Parameter	C	Setting Options	Default Setting
_:11071:100	I-DIFF fast:Operate & flt.rec. blocked		• no • yes	no
I-DIFF unrestr				
_:18002:1	I-DIFF unrestr:Mode		• off • on • test	off
_:18002:3	I-DIFF unrestr:Threshold		0.5 I/IrObj to 35.0 I/IrObj	10.0 I/IrObj
_:18002:6	I-DIFF unrestr:Operate delay		0.00 s to 60.00 s	0.00 s
_:18002:100	I-DIFF unrestr:Operate & flt.rec. blocked		• no • yes	no

6.2.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:I diff.	WYE	O
_:2311:301	General:I restr.	WYE	O
_:2311:311	General:I diff. operate phA	MV	O
_:2311:312	General:I diff. operate phB	MV	O
_:2311:313	General:I diff. operate phC	MV	O
_:2311:314	General:I restr. operate phA	MV	O
_:2311:315	General:I restr. operate phB	MV	O
_:2311:316	General:I restr. operate phC	MV	O
_:2311:317	General:Adapt. adjustm. inact.	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
I-DIFF			
_:11041:81	I-DIFF:>Block stage	SPS	I
_:11041:51	I-DIFF:Mode (controllable)	ENC	C
_:11041:54	I-DIFF:Inactive	SPS	O
_:11041:52	I-DIFF:Behavior	ENS	O
_:11041:53	I-DIFF:Health	ENS	O
_:11041:55	I-DIFF:Pickup	ACD	O
_:11041:56	I-DIFF:Operate delay expired	ACT	O
_:11041:57	I-DIFF:Operate	ACT	O
_:11041:301	I-DIFF:Slope 1	MV	O
_:11041:302	I-DIFF:Incr. of char. (Start)	SPS	O
_:11041:303	I-DIFF:Increase of char. (DC)	SPS	O
_:11041:304	I-DIFF:Blocked by inrush	SPS	O
_:11041:305	I-DIFF:Blocked by 2.Harmon.	ACT	O
_:11041:306	I-DIFF:Crossblock by 2.Harm.	SPS	O
_:11041:307	I-DIFF:Blocked by CWA	SPS	O
_:11041:308	I-DIFF:Blocked by 3.Harmon.	ACT	O
_:11041:309	I-DIFF:Crossblock by 3.Harm.	SPS	O

No.	Information	Data Class (Type)	Type
_:11041:310	I-DIFF:Blocked by 5.Harmon.	ACT	O
_:11041:311	I-DIFF:Crossblock by 5.Harm.	SPS	O
_:11041:312	I-DIFF:Blocked by ext. fault	ACT	O
_:11041:313	I-DIFF:Crossbl. by ext. fault	SPS	O
_:11041:316	I-DIFF:CWA int. fault detected	SPS	O
I-DIFF fast			
_:11071:81	I-DIFF fast:>Block stage	SPS	I
_:11071:51	I-DIFF fast:Mode (controllable)	ENC	C
_:11071:54	I-DIFF fast:Inactive	SPS	O
_:11071:52	I-DIFF fast:Behavior	ENS	O
_:11071:53	I-DIFF fast:Health	ENS	O
_:11071:55	I-DIFF fast:Pickup	ACD	O
_:11071:57	I-DIFF fast:Operate	ACT	O
_:11071:56	I-DIFF fast:Operate delay expired	ACT	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O

6.3 Differential Protection for Phase-Angle Regulating Transformer

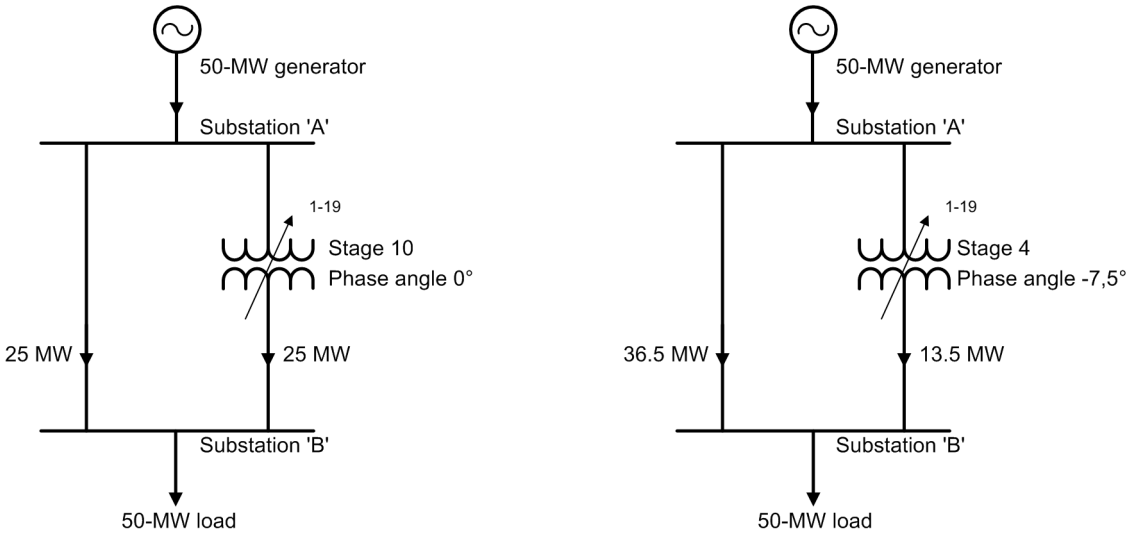
6.3.1 Overview of Functions

The function **Differential protection for phase-angle regulating transformers** (PST) supplements the existing function **Transformer differential protection** (ANSI 87T). You can find the structure of the function in chapter *6.2.2 Structure of the Function*.

Phase-angle regulating transformers are used to control the reactive-power flow and active-power flow in high-voltage power systems. The objective is to achieve voltage stability, a uniform load dispatching in parallel transmission lines, and to prevent unbalanced current in the meshes of the transmission systems.

The main function of the phase-angle regulating transformer is to alter the effective phase displacement between the input and output voltage of a transmission line. This function controls the amount of current that can be transmitted by a single line.

In order to apply an introduced voltage boost to influence the active-power flow, phase-angle regulating transformers are integrated into the electrical power system in series. This situation arises, for example, if an increase in the transmission capacity is required due to the installation of an additional line. By using selective control of the angle between the current and the voltage in a line, both lines can be used up to their projected load limit.



[dw_PST_DIFF_01, 1, en_US]

Figure 6-57 Power Distribution between 2 Lines when Using Different Phase-Angle Values

The control of the power flow or the energy-flow direction at the tie-point of 2 electrical power systems is another typical application.

To parameterize the Transformer differential protection for the phase-angle regulating transformer application, add a corresponding function block from the DIGSI 5 library to the function group **Transf.Diff** .



[sc_PST_DIFF_08, 1, en_US]

Figure 6-58 Instances of the Phase-Angle Regulating Transformer

There are 3 function blocks available for the adaptation to the various types of phase-angle regulating transformers:

Sing.-core PST — Phase-angle regulating transformers of the single-core transformer type

These transformers contain all necessary windings on a 3-phase transformer core. When the angle is adjusted, the absolute value of the voltage does not change linearly. To compensate for the change in the absolute value of the voltage, an additional voltage controller (transformer with in-phase regulation) is usually required.

Spec. transf. — Special transformers

Special transformers are transformers with a fixed interconnection of the windings. This will result in a vector-group number that is not an integer value (for example, SG 0.25 = 7.5°). They can be used, for instance, as inverter transformers. When the rectified currents from several windings are joined with shifted phase displacements, the result is reduced ripple of the direct current.

Two-core PST — Phase-angle regulating transformers of the two-core transformer type

These transformers connect the phase-shifted voltage via an adjustable shunt transformer. Therefore, the tap changer does not carry the load current and is suitable for higher power levels. The absolute value of the voltage ratio does not change with the angle.

The number of function blocks of the **phase-angle regulating transformer** is limited as follows in the device types:

Device	Sing.-core PST	Spec. transf.	Two-core PST
7UT82	1	1	0
7UT85	1	1	0
7UT86	1	1	1
7UT87	3	3	3

The transformer differential protection automatically considers the resulting change in the absolute value and change in angle. Therefore, the changes do not need to be taken into consideration in the pickup-characteristic settings for the differential protection.

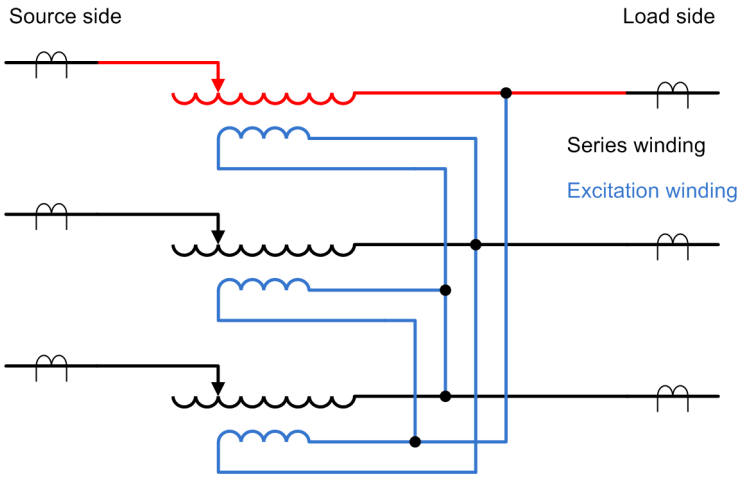
The switch makes it possible to change between negative and positive no-load phase displacement even under full load. In this case, blocking of the stage I-DIFF of the differential protection is adjustable.

6.3.2 Phase-Angle Regulating Transformers of the Single-Core PST Type

The phase-angle regulating transformer of the type single-core PST consists of a 3-phase series winding and a 3-phase excitation winding. The excitation winding uses a delta connection and induces the voltage ΔV in the series winding. The excitation winding is installed on the same transformer core.

You can use one or several tap changers to change the phase displacement and the output voltage of the transformer.

The differential protection of this transformer requires information regarding the position of the tap changer, information about the no-load voltage, and the angle of the respective stage. The following figure shows the corresponding connection of an asymmetrical single-core transformer scheme, Single-core PST.



[dw_PST_DIFF_02, 1, en_US]

Figure 6-59 Asymmetrical Single-Core Transformer Scheme, Single-Core PST

Configure the differential protection for the phase-angle regulating transformers by adding the **Sing.-core PST** function block to the **Transformer diff.** function.



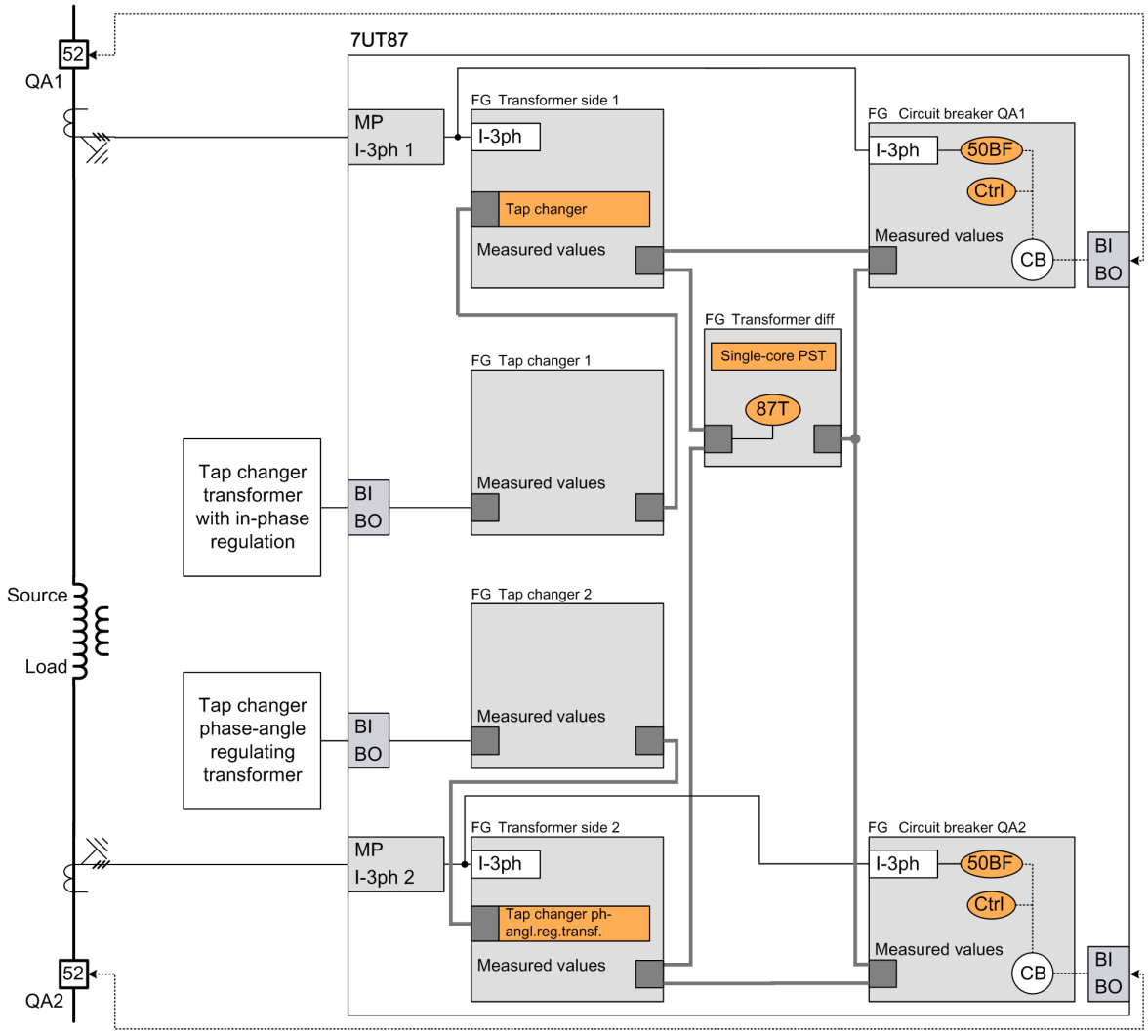
[sc_PST_DIFF_07, 1, en_US]

Figure 6-60 Instance of the Single-Core PST Function Block

After instantiation of the **Sing.-core PST** function block, additional required parameters are displayed in the **Transformer side** function group and in the **Transformer diff.** function group.

The tap changers for the phase-angle regulation and the in-phase regulation are assigned in the transformer side. The phase-angle regulating transformer tap changer detects the voltage and the angle for each tap-changer position.

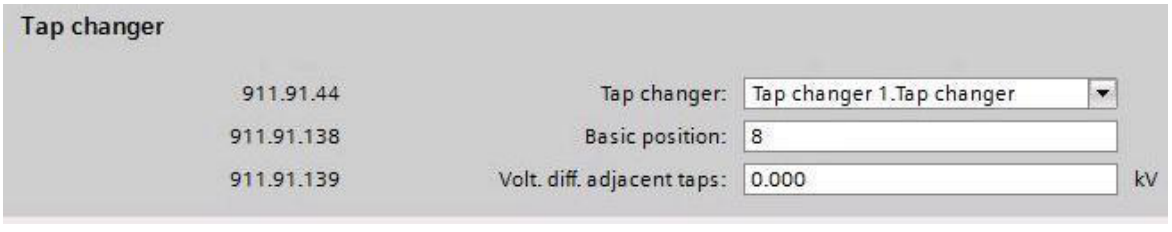
If using asymmetrical phase-angle regulating transformers, changing the phase angle also affects the voltage. Therefore, a second tap changer may be required in order to compensate for the changed absolute value of the voltage. This additional tap changer collects the information required to correct the voltage of the transformer with in-phase regulation.



[dw_PST_DIFF_03, 2, en_US]

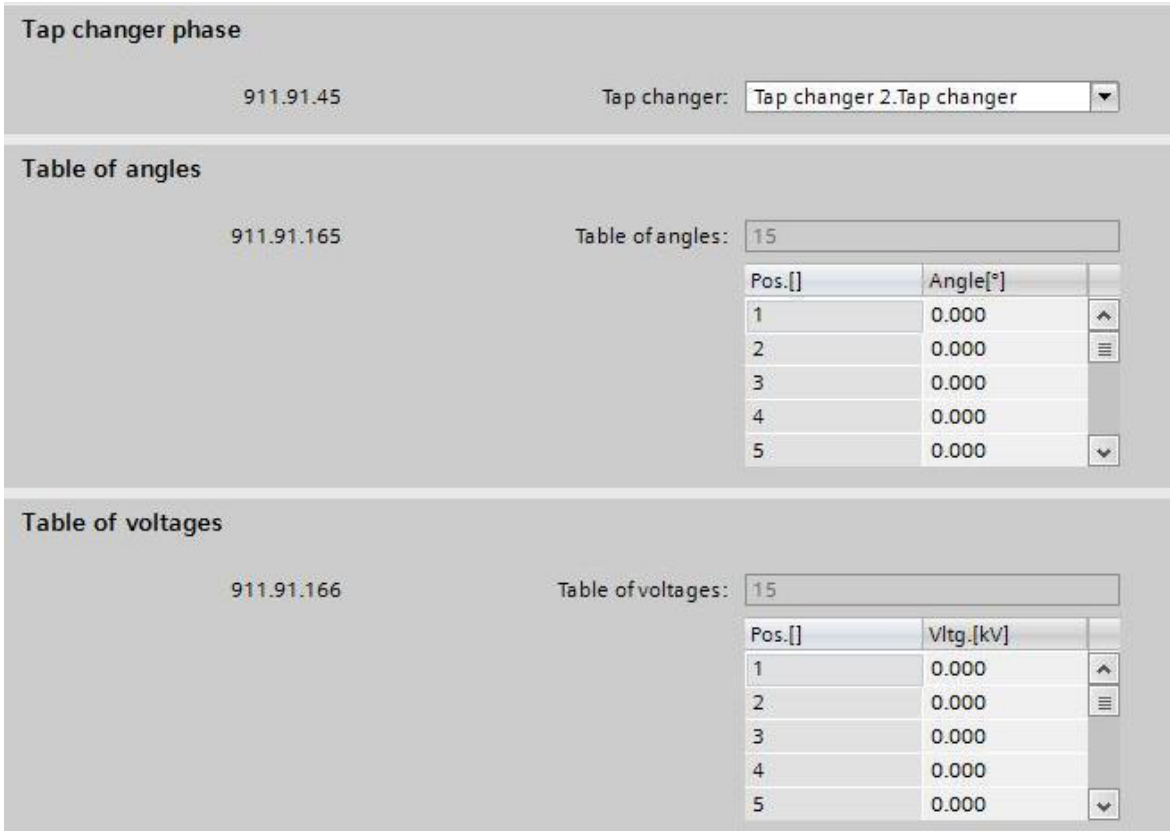
Figure 6-61 Logic of the Single-Core PST Function Block

The *Figure 6-62* and the *Figure 6-63* show the settings for adaptation to the tap changers of the transformer sides 1 and 2. Additional settings of the tap changer are described in chapter *7.8 Tap Changers*.



[sc_PST_Diff_20_b, 1, en_US]

Figure 6-62 Setting of the Tap Changer Transformer Side 1



[sc_PST_Diff_20_a, 1, en_US]

Figure 6-63 Setting of the Tap Changer for Transformer Side 2

You can use the set table values to adjust the differential protection to the control of the transformer. This prevents additional differential currents that are caused by different tap-changer positions.

Set the software filtering time for the binary inputs of the tap changer. This software filtering time avoids the fact that the transient states in the binary image of the tap-changer position lead to an incorrect adaptation of the differential protection during the transition from one stage to the next. When you set the software filtering time, you must take into consideration the runtime of the tap changer. If the motor-driven contact of the tap changer is also detected, you can select a small value for the software filtering time.

In case of a failure or a loss of tap-changer information, for example, in case of an inadmissible combination of values of the tap-changer position, the I-DIFF stage of the differential protection is blocked. The I-DIFF fast stage remains active.

If the phase-angle regulating transformer is equipped with a tap changer for the in-phase regulation in addition to the phase-angle regulation or quadrature regulation, you can consider both tap changers in the differential protection.

AR Switch

The Advanced-Retard switch (AR switch) toggles the direction of the no-load phase displacement without interruption of the load current.

With the parameter **`Use AR switch`** in the **`Sing.-core PST`** function block, you determine how the differential protection responds when changing the AR switch.

In order to prevent an overfunction of the transformer differential protection, blocking of the transformer differential protection is adjustable. The blocking must be selected for the time that is required by the AR switch to reach a new position. Blocking applies only to the I-DIFF stage. The I-DIFF fast stage is not blocked.

6.3.3 Application and Setting Notes for the Single-Core PST

The following text describes the settings required for the application of the differential protection for the phase-angle regulating transformer of the single-core transformer type. You can find the general setting information for the transformer differential protection in *6.2.4 Application and Setting Notes*.

Transformer Side Function Group

After the instantiation of the **Single-core PST** function block, additional parameters for the setting of the tap changers are displayed.

NOTE

Ensure that the correct transformer data are set at the measuring points.

NOTE

Consider that only one tap changer can be parameterized on one transformer side.

Parameters for the Tap Changer Transformer with In-Phase Regulation

In the **Transformer side** function group, to set the **tap changer**, enter the following settings for the **transformer with in-phase regulation** tap changer.

Parameter: `Tap changer`

- Default setting **`(_:91:44) Tap changer`** = ***none***

With the **`Tap changer`** parameter, you assign a tap changer to the transformer side. This tap changer is used to detect the in-phase regulation. If a tap changer is assigned, other parameters also become visible. You can use a separate tap changer or the tap changer in the voltage controller.

Parameter: `Basic position`

- Default setting **`(_:91:138) Basic position`** = ***8***

With the **`Basic position`** parameter, you determine the position of the tap changer for the in-phase regulation at which the transformer operates at the rated voltage.

Parameter: `Volt. diff. adjacent taps`

- Default setting **`(_:91:139) Volt. diff. adjacent taps`** = ***0.000 kV***

With the **`Volt. diff. adjacent taps`** parameter, you set the voltage difference of a stage under no-load conditions.

Parameters for the Phase-Angle Regulating Transformer Tap Changer

In the **Transformer side** function group, to set the **tap changer**, enter the following settings for the **phase-angle regulating transformer** tap changer.

Parameter: `Tap changer`

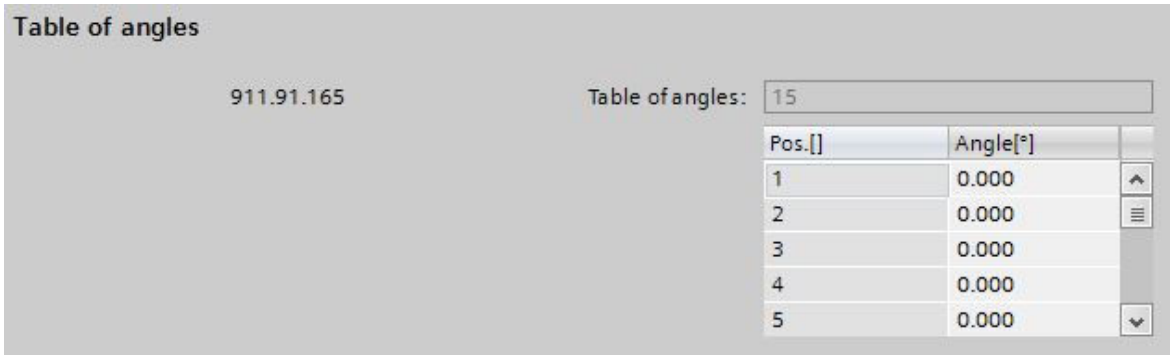
- Default setting **`(_:91:45) Tap changer`** = ***none***

With the **`Tap changer`** parameter, you assign a tap changer to the transformer side. This tap changer is used to detect the phase-angle regulation.

NOTE

You must parameterize this tap changer when using the application phase-angle regulating transformer of the single-core PST type.

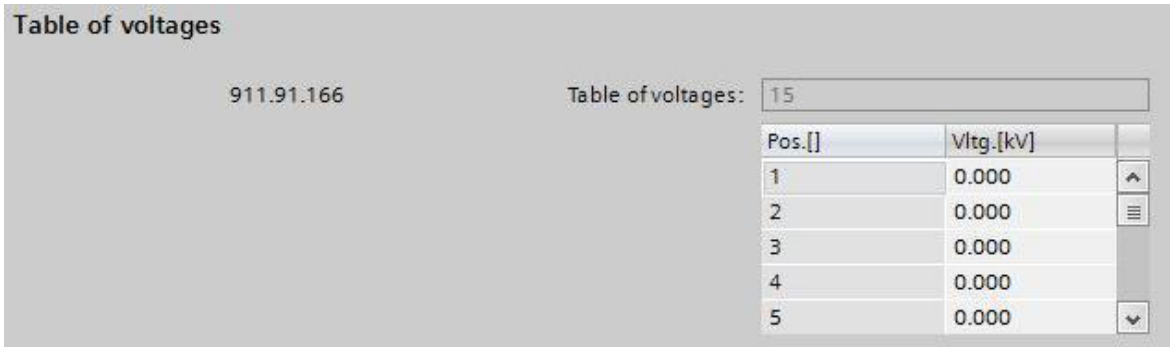
Parameter: `Table of Angles`



[sc_PST_DIFF_01, 1, en_US]

Figure 6-64 Table Display of the Angles in DIGSI

Parameter: `Table of Voltages`



[sc_PST_DIFF_02, 1, en_US]

Figure 6-65 Table Display of the Voltages in DIGSI

Function Group Transformer Diff.

In the **Transformer. diff.** function group and in the **`Sing.-core PST`** function block, make the following settings.

Parameter: `Use AR switch`

- Default setting **`(_:101) Use AR switch`** = ***`no`***

With the **`Use AR switch`** parameter, you define whether the differential protection considers the switchover of the AR switch. When using the setting ***`Block function`***, the parameter **`(_:102) Blocking time ARS`** is visible.

Parameter: `Blocking time ARS`

- Default setting **`(_:102) Blocking time ARS`** = ***`12.00 s`***

With the **`Blocking time ARS`** parameter, you determine how long the I-DIFF stage of the differential protection will be blocked during the switchover of the AR switch. This blocking function is necessary in order to avoid an overfunction of the differential protection. In order for the AR switch to reach its new position safely, you must select a sufficient blocking time.

NOTE

If you have assigned a transformer neutral point to a grounded side with a user-defined vector-group number, Siemens recommends not to use the measured 1-phase current of the neutral point in the differential-protection calculation.

Example:

Transformer example: Single-Core PST 90°

Information provided by the manufacturer:

Type:	Three-legged core with stabilizing winding. The stabilizing winding cannot be accessed from the outside.
Power	200 MVA
Rated voltages:	110 kV/110 kV ±10° (± 13 stages)
Frequency:	50 Hz
Phase angle:	No-load state: ±10° (position 1 = -10°, position 14 = 0°, position 27 = +10°) Full load: position 1 = -13°, position 14 = 2.4°, position 27 = +7°)

Stage	No-Load Phase Angle [°]	No-Load Output Voltage [kV]
1	-10.00°	111.70 kV
2	-9.24°	111.45 kV
3	-8.49°	111.22 kV
4	-7.72°	111.01 kV
5	-6.96°	110.82 kV
6	-6.19°	110.65 kV
7	-5.42°	110.49 kV
8	-4.65°	110.36 kV
9	-3.88°	110.25 kV
10	-3.11°	110.16 kV
11	-2.33°	110.09 kV
12	-1.55°	110.04 kV
13	-0.78°	110.01 kV
14	**0.00°**	**110.00 kV**
15	0.78°	110.01 kV
16	1.55°	110.04 kV
17	2.33°	110.09 kV
18	3.11°	110.16 kV
19	3.88°	110.25 kV
20	4.65°	110.36 kV
21	5.42°	110.49 kV
22	6.19°	110.65 kV
23	6.96°	110.82 kV
24	7.72°	111.01 kV
25	8.49°	111.22 kV
26	9.24°	111.45 kV
27	10.00°	111.70 kV

Parameterization of the function block:

- Set the parameters for a 2-sided transformer (for example with the application template: two-winding transformer, basic).
- Set the parameters for the tap changer.
- Set the parameters for the **Sing.-core PST** function block in the current **Transformer diff.** function group.

Tap-changer settings:

- Set the required motor monitoring time of the motor runtime.
  The setting for the highest tap-changer position is not required for the quadrature regulation tap changer. In this case, the tap changer is not considered.
- You set the additional settings for the tap changer in the Information routing found in the Properties dialog for the tap-changer position. To adjust the settings, follow the information of the manufacturer.
  These settings include:
  - Offset of the tap display: 0
  - Number of tap positions: 27
  - Tap coding type: Binary
  - Motor run signal: Activate the detection of the motor run signal if this signal is available.
  - Software filtering time: Set the software filtering time on the basis of the runtime needed by the tap changer to change the position from one stage to the adjacent stage.
- Route the position of the tap changer to the corresponding binary inputs.

Settings for the transformer sides:

- Set the rated data of transformer side 1 according to the documentation of the manufacturer:
  - Rated apparent power: 200 MVA
  - Rated voltage: 110 kV
  - Vector-group number: 0
- Set the rated data of transformer side 2 according to the documentation of the manufacturer:
  - Rated apparent power: 200 MVA
  - Rated voltage: 110 kV
- Set the parameters of the **Tap changer** as a **Tap changer phase**. Subsequently, the tables for the position, angles, and voltages settings become visible.
- Set the angles and the voltages of the individual stages of the tap changer according to the table in the documentation of the manufacturer.

Settings for the transformer differential protection:

- Set the **Sing.-core PST** function block:
  - **Use AR switch**: ***no***

    For phase-angle regulating transformers of the single-core type, this setting can be selected frequently, since switching can occur without interruption at 0°.

6.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Tap changer				
_:91:138	General:Basic position		-128 to 127	8

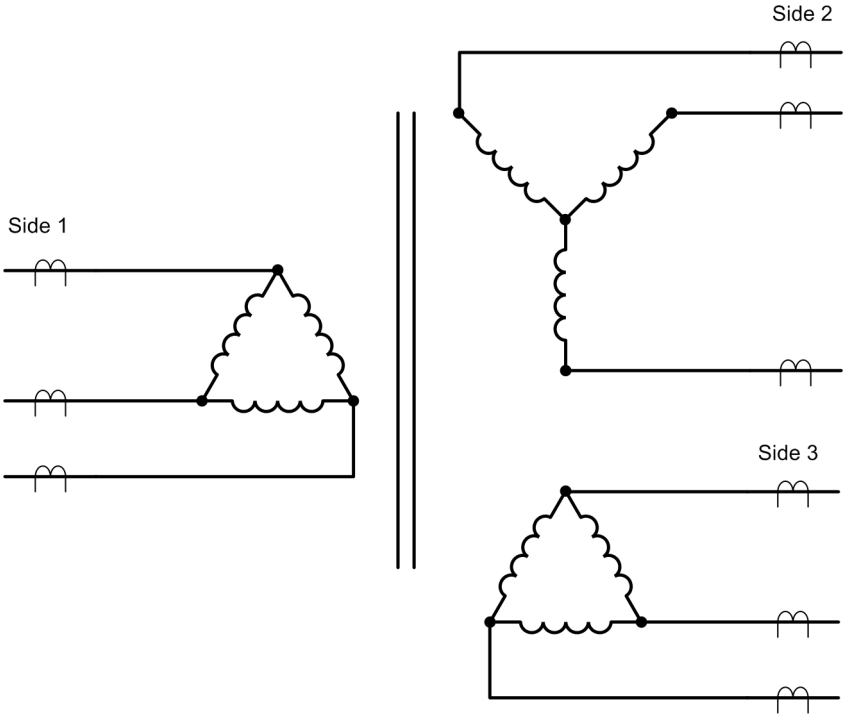
Addr.	Parameter	C	Setting Options	Default Setting
_:91:139	General:Volt. diff. adjacent taps		0.000 kV to 800.000 kV	0.000 kV
_:91:44	General:Tap changer		Setting options depend on configuration	
_:91:45	General:Tap changer		Setting options depend on configuration	
Sing.-core PST				
_:101	Sing.-core PST:Use AR switch		• no • Block function	no
_:102	Sing.-core PST:Blocking time ARS		0.00 s to 60.00 s	12.00 s

6.3.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:90	Sing.-core PST:>AR switch	DPS	I

6.3.6 Phase-Angle Regulating Transformers of the Type Special Transformer

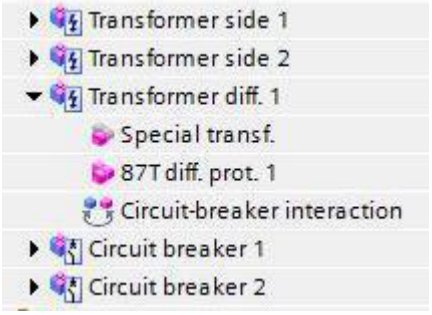
The term special transformer refers to industrial-type transformers. Their windings are interconnected in such a way that a phase displacement that is different to 30°, for example ±7.5°, is possible. Special transformers can be used, for example, to supply power to electrical drives, frequency converters, and rectifiers. When joining the rectified currents from several windings with shifted phase displacements, the result is reduced ripple of the direct current.



[dw_PST_DIFF_04, 1, en_US]

Figure 6-66 Basic Scheme of a Special Transformer

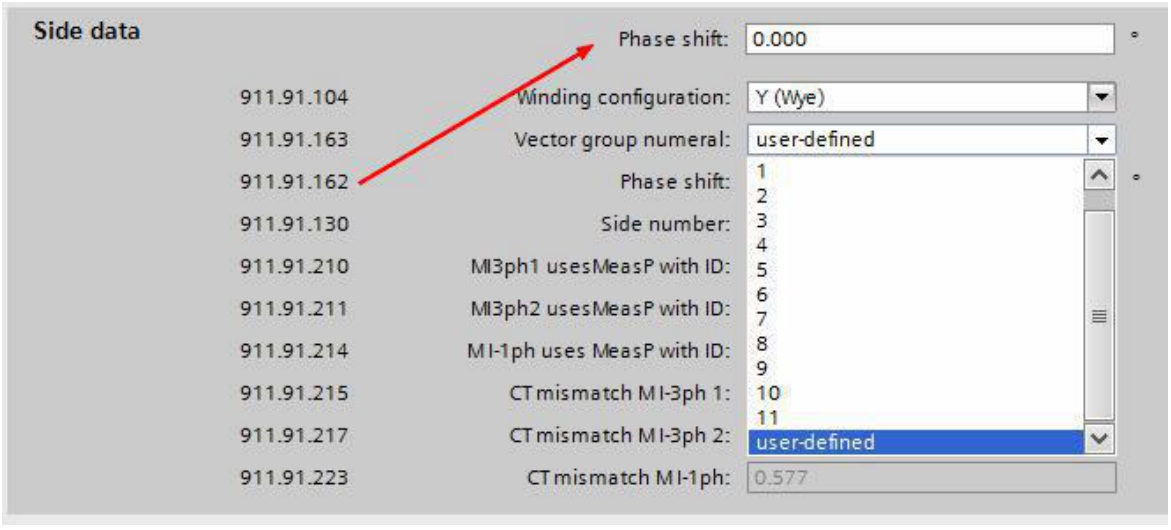
Configure the differential protection for special transformers by adding the **Transformer diff.** function to the **Special transformer** function block.



[sc_PST_DIFF_03, 1, en_US]

Figure 6-67 Instance of the Special Transformer Function Block

After instantiation of the **Special transformer** function block in the **Transformer diff.** function group, the setting range of the parameter **(_:91:163) Vector group numeral** will be extended by the ***user-defined*** setting in the assigned **Transformer side** function group. If you select this setting option, the additional parameter **(_:91:162) Phase shift** is visible. You can set this parameter in a range of values from -180.000° to +180.000°. The **Special transformer** function block has no settings of its own.



[sctrstst-180215-01, 1, en_US]

Figure 6-68 Settings for the Transformer Side

You can combine the special transformer and a transformer with in-phase regulation for adaptive adjustment of the transformer differential protection.

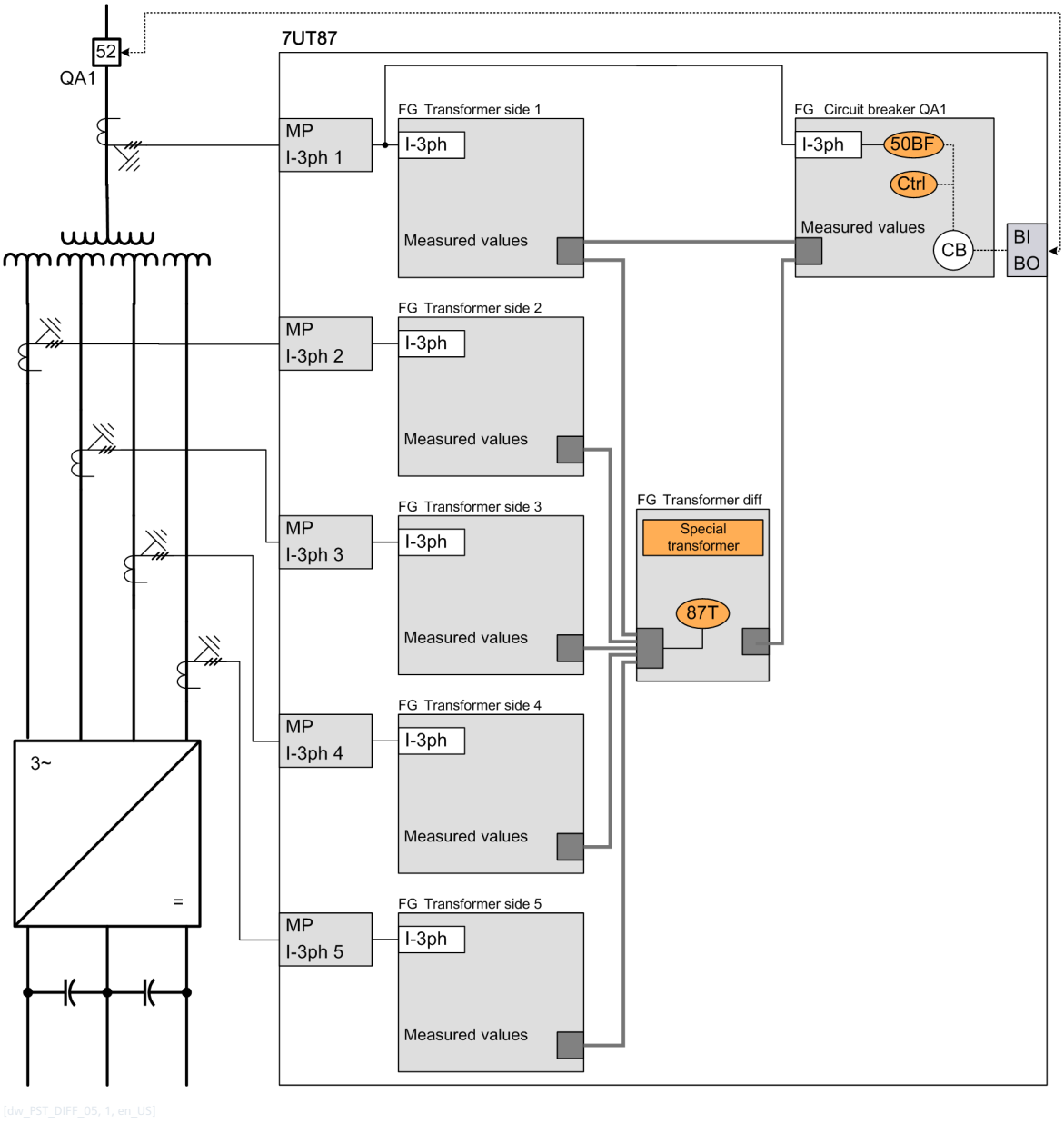


Figure 6-69 Logic of the Special Transformer Function Block

6.3.7 Application and Setting Notes for the Special Transformer

The following text describes the settings required for the application of the differential protection for the phase-angle regulating transformer of the special transformer type. You can find the general setting information for the transformer differential protection in chapter *6.2.4 Application and Setting Notes*.

Parameter: (_:91:163) Vector group numeral

- Default setting **Vector group numeral** = *0*

With the **Vector group numeral** parameter, you set the vector-group number of the transformer side. To use special transformers, select the ***user-defined*** setting. If you select this setting, the parameter **(_:91:162) Phase shift** is displayed.

Parameter: (_:91:162) Phase shift

- Default setting **Phase shift** = *0*

With the **Phase shift** parameter, you set the phase displacement of the transformer side

NOTE

If you have assigned a transformer neutral point to a grounded side with a user-defined vector-group number, Siemens recommends not to use the measured 1-phase current of the neutral point in the differential protection calculation.

6.3.8 Settings

Addr.	Parameter	C	Setting Options	Default Setting
_:91:104	General:Winding configuration		• Y (Wye) • D (Delta) • Z (Zig-Zag)	Y (Wye)
_:91:163	General:Vector group numeral		• 0 • 1 • 2 • 3 • 4 • 5 • 6 • 7 • 8 • 9 • 10 • 11 • user-defined	0
_:91:162	General:Phase shift		-180.000 ° to 180.000 °	0.000 °

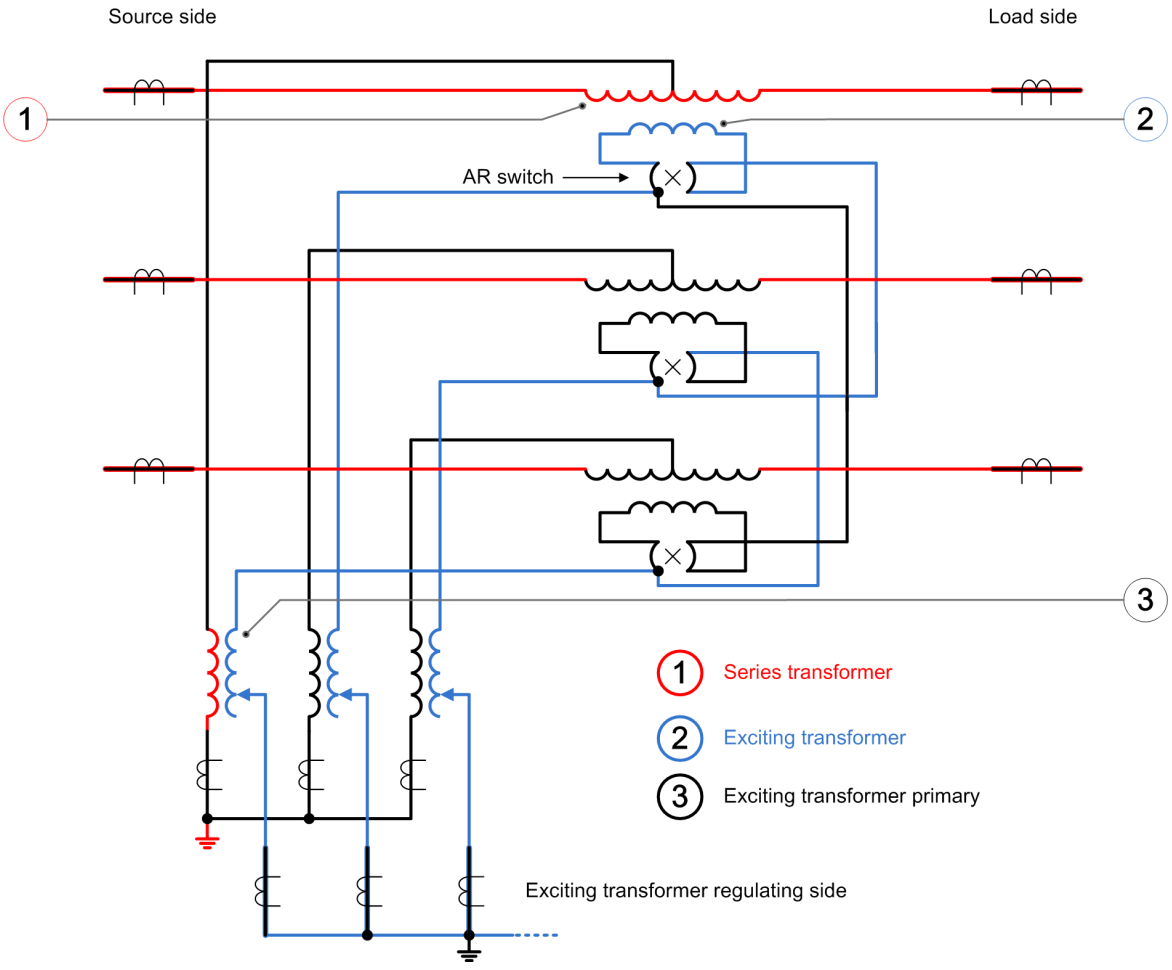
6.3.9 Phase-Angle Regulating Transformers of the Two-Core PST Type

The phase-angle regulating transformer of the two-core transformer type (Two-Core PST) consists of a 3-phase series transformer and a 3-phase exciting transformer. The voltage generated by the exciting transformer can be set as a series voltage ΔV and can be coupled to the delta winding of the series transformer. Series and exciting transformers can be integrated in a single tank or in separate tanks.

A protection system with 2 differential protection functions has established itself for the differential protection of this transformer (see IEC 62032, IEEE Std C57.135 and IEEE C37.245):

- Primary differential protection (ANSI 87P)
- Secondary differential protection (ANSI 87S)

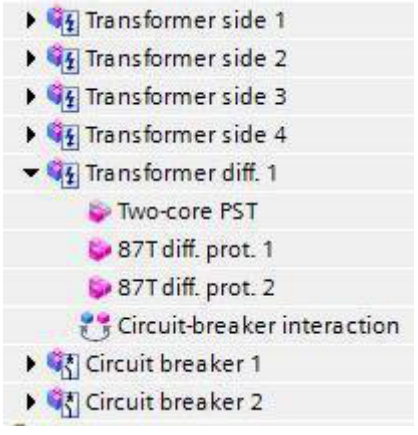
For this protection system, the connections of 4 current measuring points are required. Connect those points with 4 transformer sides.



[dw_PST_DIFF_06, 2, en_US]

Figure 6-70 Symmetrical Two-Core Transformer Scheme, Two-Core PST

Configure the differential protection for the phase-angle regulating transformer by adding the function group **Two-Core PST** function block to the **Transf. diff.** function group.

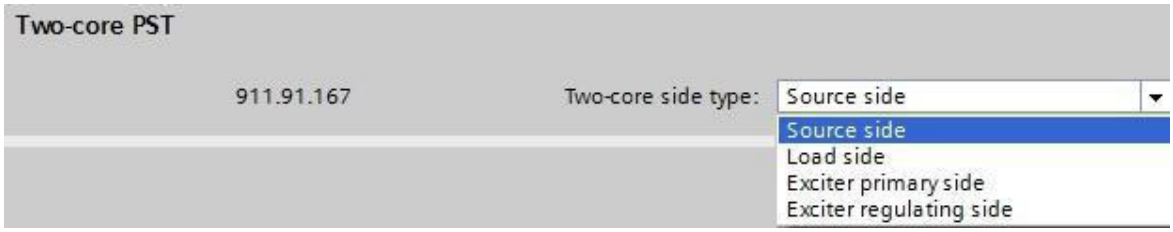


[sc_PST_DIFF_12, 1, en_US]

Figure 6-71 Instance of the Two-Core PST Function Block

After instantiation of the function block **Two-core PST**, additional parameters are displayed on the transformer sides. With the parameter **`(_:91:167) Two-core side type`**, you specify the type of the side.

All 4 sides of the phase-angle regulating transformer must be of different types. This is tested when setting the transformer sides.

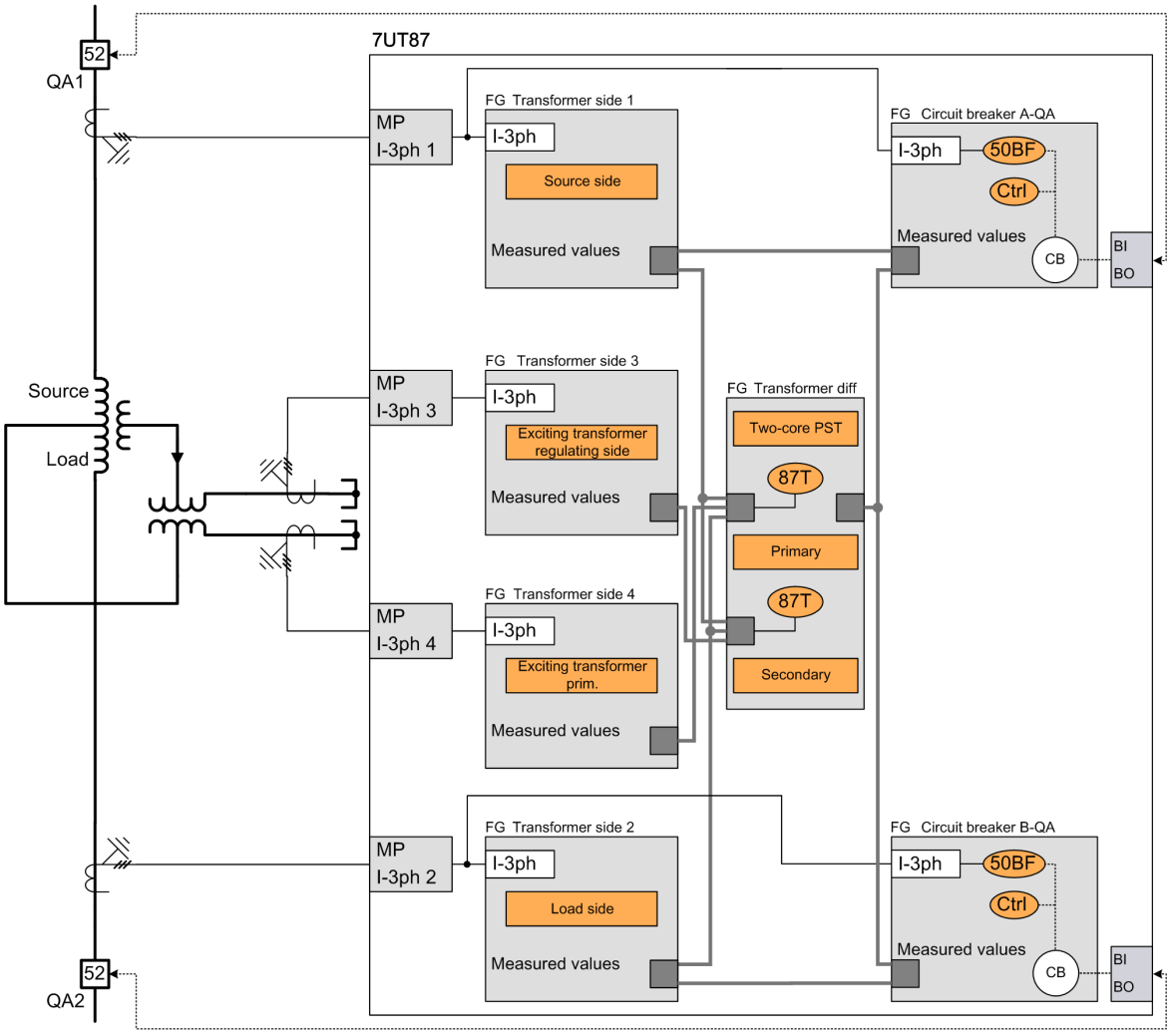


[sc_PST_DIFF_11, 1, en_US]

Figure 6-72 Setting the Transformer Sides

NOTE

Parameterization of the tap changer is not required for the application Two-core PST phase-angle regulating transformer application. Therefore, you must set the parameter **`Tap changer`** to ***No***.



[dw_PST_DIFF_07, 3, en_US]

Figure 6-73 Logic of the Function Block Two-Core PST

Advanced-Retard Switch

The Advanced-Retard switch (AR switch) toggles the direction of the no-load phase displacement without interruption of the load current.

With the parameter **Use AR switch** in the function block **Two-core PST**, you specify how the differential protection responds when changing the Advanced-Retard switch.

In order to prevent an overfunction of the transformer differential protection, blocking of the transformer differential protection is adjustable. The blocking must be selected for the time that is required by the AR switch to reach a new position. Blocking applies only to the stage **I-DIFF**. The stage **I-DIFF fast** is not blocked.

In addition to blocking the differential protection functions, a further switchover of the vector group number (0 and 6) can be required. This is necessary when positioning the switch in the triangle of the delta winding, since the direction of the electric current in the measuring points of the excitation winding (regulating side) is inverted.

6.3.10 Application and Setting Notes for the Two-Core PST

The following text describes the settings required for the application of the differential protection for the phase-angle regulating transformer of the two-core transformer type. You can find the general setting information for the transformer differential protection in chapter *6.2.4 Application and Setting Notes*.

You cannot combine the Two-Core PST with a transformer with in-phase regulation for adaptive adjustment of the transformer differential protection.

Transformer Side Function Group

After the instantiation of **Two-core PST** function block, additional parameters for the setting of the tap changers are displayed.

Go to the **Transformer side** function group and make the following settings.



NOTE

Ensure that the correct transformer data are set at the measuring points.

Parameter: Two-core side type

- Default setting **(_:91:167) Two-core side type** = ***Source side***

With the **Two-core side type** parameter, you set the following side types: ***Source side***, ***Load side***, ***Exciter primary side*** and ***Exciter regulating side*** .

To use the phase-angle regulating transformer of the two-core transformer type with both protection functions ***87T primary prot*** and ***87T secondary prot***, all 4 sides are required.

The tap-changer position information is not required for the protection scheme.



NOTE

The setting of the neutral-point grounding is not available, since it must not be changed in this protection scheme (see IEC 62032 / IEEE Std C57.135). The appropriate values are used in the device in accordance with the type of side.

The settings of both parameters **rated apparent power** and **rated voltage** on the exciting-unit side do not affect the differential protection. In order for them to function correctly, they must be derived in the device from the information received from the other sides. However, these settings may be required for additional but only side-relevant protection functions.

Parameter: (_:91:163) Vector group numeral

- Default setting **Vector group numeral** = ***0***

The **Vector group numeral** parameter is only visible and required for the regulating side of the exciting transformer. This setting is applicable for the forward direction of the switch when setting the parameter **Use AR switch** = ***Block fct. & switch VG***. If another setting is select, the parameter applies to both switch positions.

Function Group Transformer Diff.

A phase-angle regulating transformer of the Two-Core PST type can only be protected completely by using 2 differential protection functions. To do this, instantiate the **Transformer diff.** function twice in the **Transformer diff.** function group.

Make the following settings in the **Transformer diff.** function of the **Transformer diff.** function group:

Parameter: Diff function mode

- Default setting **(_:2311:188) Diff function mode** = ***87T primary prot***

With the parameter **Diff function mode**, you assign an operating mode to the differential protection.

Parameter Value	Description
87T primary prot	In the primary protection operating mode, this protection function uses primarily the source side, load side, and the exciting-transformer primary side. The regulating side of the exciting transformer is ignored.
87T secondary prot	In the secondary protection operating mode, this protection function preferably uses the source side, the load side, and the regulating side of the exciting transformer. The primary side of the exciting transformer is ignored.

Parameter: Series unit ratio

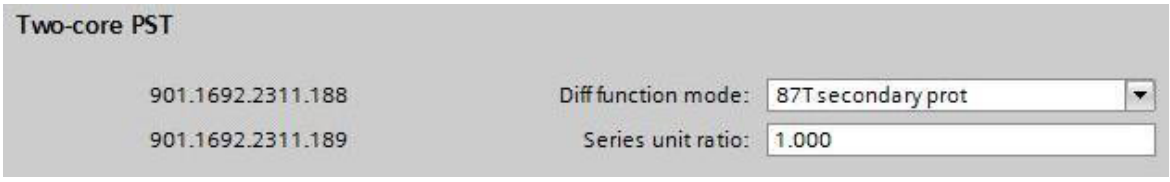
- Default setting **(_:2311:189) Series unit ratio** = ***1.000***

With the parameter **Series unit ratio**, you set the winding number ratio of the series transformer:

$$K = \frac{n_{Source} + n_{Load}}{n_{Delta}}$$

[fo_PST_DIFF_01, 1, en_US]

You can also generate this ratio with the information about the no-load voltage of the windings.



[sc_PST_DIFF_13, 1, en_US]

Figure 6-74 Setting the Winding Ratio in DIGSI

Two-Core PST Function Block

Make the following settings in the **Two-core PST** function block in the **Transformer diff.** function group:

Parameter: Use AR switch

- Default setting **(_:101) Use AR switch** = ***no***

With the parameter **Use AR switch**, you define whether the differential protection considers the switchover of the AR switch.

Parameter Value	Description
no	No consideration of the AR switch
Block function	During AR switchover, the I-DIFF differential protection stage is blocked.
Block fct. & switch VG	During AR switchover, the I-DIFF differential protection stage is blocked and the vector group of the regulating side of the exciting transformer is switched internally.



[sc_PST_DIFF_10, 1, en_US]

Figure 6-75 Setting the AR Switch in DIGSI

When installing the switch in the triangle of the delta winding, the direction of the current in the measuring points of the excitation winding (regulating side) is inverted. Therefore, you must also switch the vector-group number (0 or 6).

When the switch changes the activation of the excitation winding (regulating side), the current through the measuring point on this side does not change in most cases. This depends on the installation location of the transformer. In this case, you can set the parameter **Use AR switch** to ***no***. If you still face short-term differential current during the switchover phase, you can use the ***Block function*** setting to avoid an unwanted tripping of the **87T secondary** function.

If you set the parameter to ***Block function*** or ***Block fct. & switch VG***, the parameter **(_:102) Blocking time ARS** becomes visible and you can use it to set the blocking time of the I-DIFF stage of the transformer differential protection ***87T secondary prot***. During the blocking time, the stage switches to the ***not active*** condition. If the switch has not reached a valid position after the time has elapsed, the I-DIFF stage switches to the **Alarm** condition. In this condition, you must route the input signals of the switch.

Since the protection must block immediately, no software filtering time is available for the switch. The blocking time is not triggered.

The transformer differential protection ***87T primary prot*** remains unaffected by this parameter.

In order to ensure the proper detection of the AR switch condition by the binary inputs *>Switch*, a connection as double-point indication is provided. This will detect and report intermediate positions and disturbed positions.

If only one binary input is available, you can proceed with the conversion in the CFC by using the **Build_DSP** converter building block. The DSP position **closed** indicates a forward direction. The DSP position **open** indicates a reverse direction.

Parameter: (_:102) Blocking time ARS

- Default setting **Blocking time ARS** = ***12.00 s***

With the **Blocking time ARS** parameter, you determine how long the I-DIFF stage of the differential protection will be blocked during the switchover of the AR switch. This time is necessary in order to prevent an overfunction of the differential protection. In order for the AR switch to reach its new position safely, you must select a sufficient blocking time. Typically, this time is 12 s.

Example:

Transformer example: Two-core PST	
Information provided by the manufacturer:	
Rated voltage/rated power:	410 kV/1200 MVA
Frequency:	50 Hz
Number of tap positions:	±32 positions

Rated voltage of the winding parts source side/load side of the series transformer:	2x 41.1 kV
Rated voltage of the secondary winding of the series transformer:	105.8 kV
Output of the exciting transformer:	410 MVA
Rated voltage of the primary excitation winding:	410 kV
Rated voltage of the control winding:	105.8 kV

The AR switch toggles the forward and reverse direction of the delta winding (secondary windings of the series transformer). Therefore, you must switch the vector group of the regulating side of the exciting transformer between the vector-group number 0 and 6.

Parameterization of the function block:

- Set the parameters for a 4-sided transformer, for example, with the application template for a three-winding transformer as basis and extend it.
- Set the parameters for the **Two-core PST** function block in the available **Transformer diff.** function group.
- Set the parameters for a 2nd Differential protection function in the **Transformer Diff.** function group.
  Capturing the information for the tap changer is not required for the protection scheme.

Settings for the transformer sides:

- Transformer side 1:
  - **Two-core side type**: ***Source side***
  - Rated apparent power: 1200 MVA
  - Rated voltage: 410 kV
- Transformer side 2:
  - **Two-core side type**: ***Load side***
  - Rated apparent power: 1200 MVA
  - Rated voltage: 410 kV
- Transformer side 3:
  - **Two-core side type**: ***Exciter primary side***
  - Rated apparent power: 410 MVA (affects only the reference-side selection in the differential protection)
  - Rated voltage: 410 kV (affects only the reference-side selection in the differential protection)
- Transformer side 4:
  - **Two-core side type**: ***Exciter regulating side***
  - Rated apparent power: 410 MVA (does not affect the differential protection)
  - Rated voltage: 105.8 kV (does not affect the differential protection)
  - Vector-group number: 0 (information about the vector-group number for the forward direction)

Settings for the transformer differential protection:

- **Two-Core PST** function block:
  - Parameter **(_:101) Use AR switch** = ***Block fct. & switch VG***
  - Parameter **(_:102) Blocking time ARS** = ***12 s***

  If the AR switch toggles its position, the I-DIFF stage of the differential protection will be blocked for the set time. If the AR switch has not reached a valid position after the time has elapsed, the function switches to the **Alarm** condition.

- **Transformer diff. 1**:
  - **Operating mode Diff**:***87T primary differential protection***
- **Transformer diff. 2**:
  - **Operating mode Diff**: ***87T secondary differential protection***
  - Series-transformer ratio: 0.777 (2 x 41.1 kV/105.8 kV)
- Information routing:
  - Route the binary-input signal **>Toggle switch**.
    Since the protection must block immediately, no software filtering time is available for the switch. The blocking time is not triggered.

6.3.11 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Side data				
_:91:104	General:Winding configuration		• Y (Wye) • D (Delta) • Z (Zig-Zag)	Y (Wye)
_:91:163	General:Vector group numeral		• 0 • 1 • 2 • 3 • 4 • 5 • 6 • 7 • 8 • 9 • 10 • 11 • user-defined	0
_:91:162	General:Phase shift		-180.000 ° to 180.000 °	0.000 °
Two-core PST				
_:91:167	General:Two-core side type		• Source side • Load side • Exciter primary side • Exciter regulating side	Source side
_:101	Two-core PST:Use AR switch		• no • Block function • Block fct. & switch VG	no
_:102	Two-core PST:Blocking time ARS		0.00 s to 60.00 s	12.00 s
_:2311:188	General:Diff function mode		• 87T primary prot • 87T secondary prot	87T primary prot
_:2311:189	General:Series unit ratio		0.001 to 100.000	1.000

6.4 Restricted Ground-Fault Protection

6.4.1 Overview of Functions

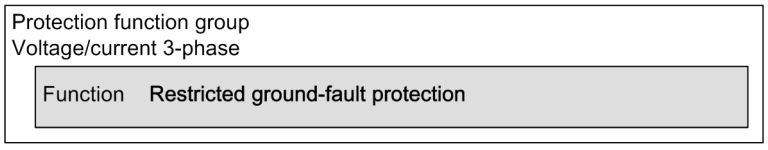
The **Restricted ground-fault protection** function (ANSI 87N, REF):

- Detects ground faults in transformers, shunt reactors, neutral reactors, or rotating machinery in which the neutral point is grounded.
- Has high sensitivity to ground faults near the neutral point.
- Is supplemental main protection to longitudinal differential protection.
- Protects grounding transformers in the protection range. It is required that a current transformer be used in the case of neutral point feed, that is, between neutral point and grounding conductor. The neutral point transformer and the phase current transformer define the protection range.
- Automatically adapts itself to the highest-amperage side with auto transformers, and thereby prevents overfunction in the event of external ground faults.

6.4.2 Structure of the Function

The function **Restricted ground-fault protection** is used in the protection function group **Transformer side** or **Auto transformer** . Furthermore, you can use the function in the stabilizing winding of the auto transformer as well as in the function **Standard UI**. The function depends upon application in the corresponding application template preconfigured by the manufacturer or can be copied during the engineering into the corresponding function group.

The function **Restricted ground-fault protection** is stepless.

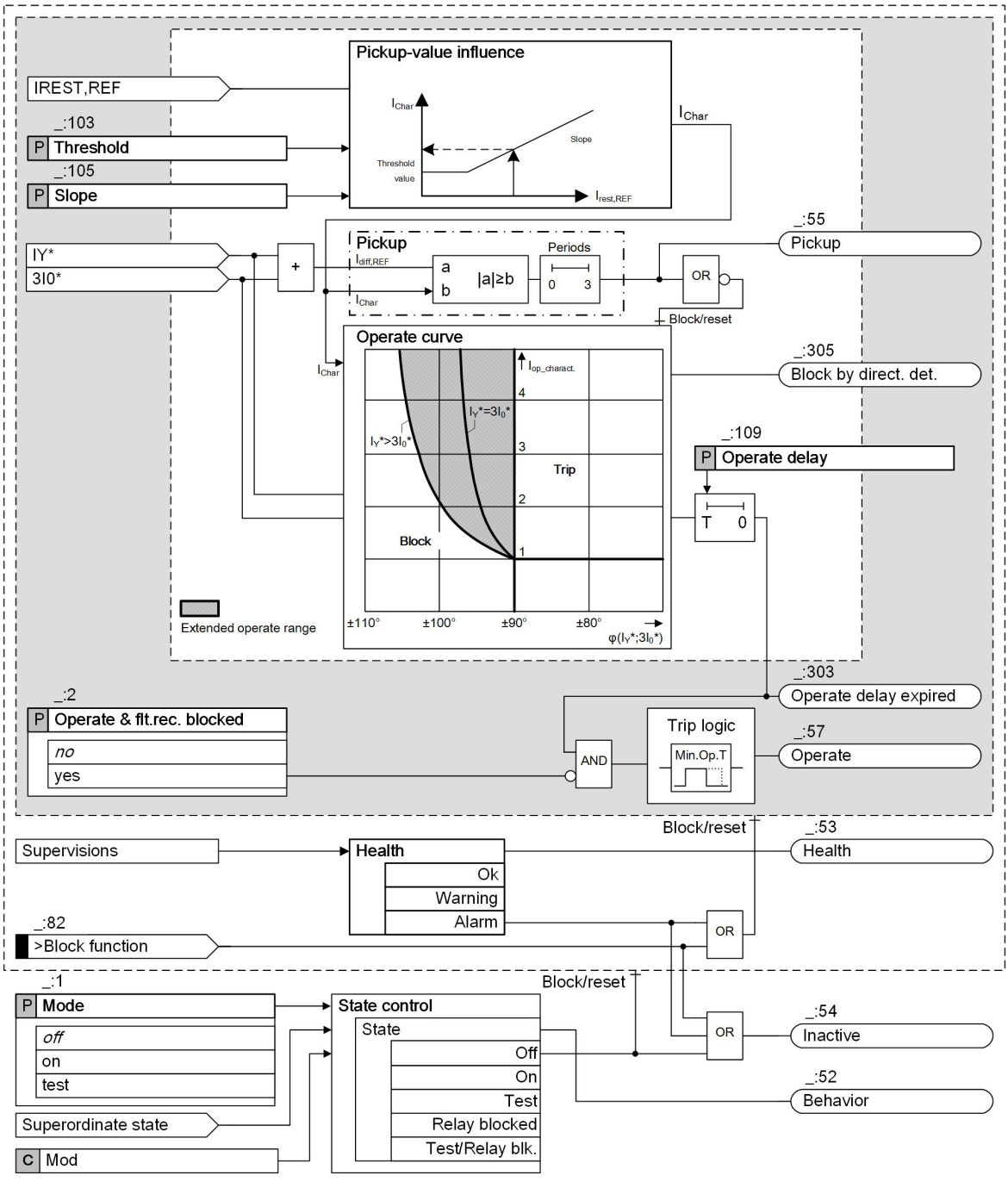


[dw_stru_pt, 2, en_US]

Figure 6-76 Structure/Embedding of the Function

6.4.3 Function Description

Logic of the Function

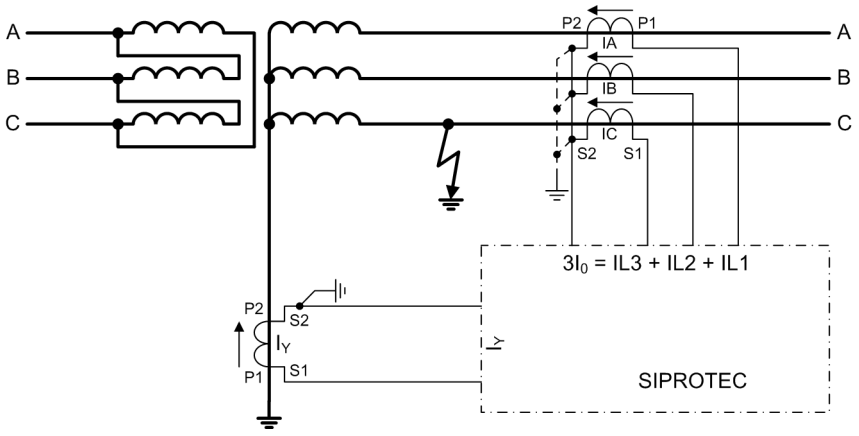


[lo_reffkt, 4, en_US]

Figure 6-77 Logic Diagram of the Restricted Ground-Fault Protection Function

The protection function processes the neutral-point current $\underline{I}_Y$* and the zero-sequence current 3 $\underline{I}_0$ calculated from the phase currents (see following figure). The amount-adapted (compensated) currents are described by the * symbol. They are normalized to the rated object current of the respective side. The protection range extends exclusively over the transformer winding, including current transformer.

In case of an internal ground fault, the zero-sequence currents flow to the fault location. With an external ground fault, the fault current inverts itself in the phase current transformers. In this way, the direction of current flow serves as the decisive criterion for an internal fault.



[dw_grdpri, 2, en_US]

Figure 6-78 Basic Principle of the Function

NOTE

Consider the polarity of the current transformers. It must be set in accordance with the connection type. Connect the neutral point to the 3-pole measuring points on the device side using the even-numbered terminals.

The protection function operates in 3 steps according to the logic diagram *Figure 6-77*:

- Effect of pickup value:
  Increasing the set pickup threshold using the restraint current. This prevents overfunction in the event of high-current external ground faults.
- Pickup:
  If the calculated current $I_{Diff,REF}$ exceeds the adapted pickup threshold, pickup starts.
- Operate curve based on phase-angle difference:
  The angle difference between the neutral-point current (I_y*) and the calculated zero-sequence current ($3I_0$*) in the operate curve is taken into consideration to differentiate between internal and external faults.

Effect of Pickup Value

The restraint current ($I_{Rest,REF}$) is calculated from the measured currents. The reference arrows are defined as positive when pointing to the protected object (see *Figure 6-78*). Consider that the neutral-point current (I_Y) detected using the 1-phase measuring point is displayed as positive in the fault record and in the DIGSI 5 Test Suite if the current flows from the protected object to ground.

NOTE

The following calculation applies to the configurations with one current measuring point for the side. In a special case of 2 current measuring points per side, the calculation of the restraint current must be performed in greater detail.

$\underline{I}_Y^* = k_{yx} \cdot 3\underline{I}_y$

$3\underline{I}_0^* = k_{sx} \cdot (\underline{I}_A + \underline{I}_B + \underline{I}_C)$

with

$k_{yx} = I_{N,transformerY}/I_{N,side}$ with the secondary current measured in the neutral point (Y)

$k_{sx} = I_{N,transformerS}/I_{N,side}$ with the secondary current measured on the transformer side (S)

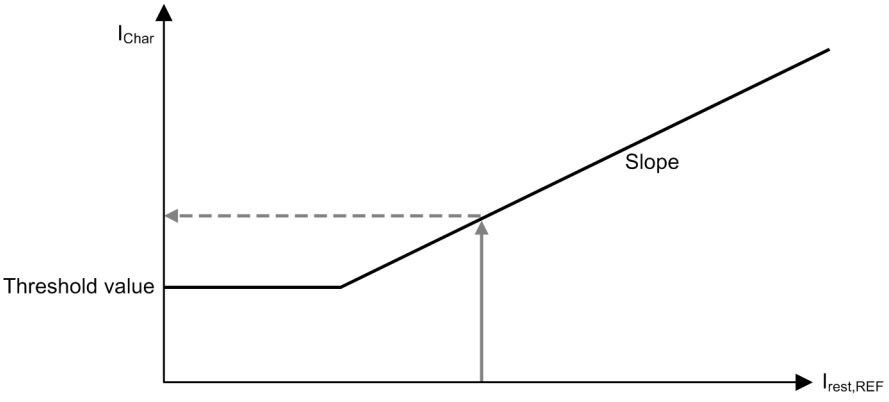
$I_{Diff,REF} = |\underline{I}_Y^* + 3\underline{I}_0^*|$

$I_{Rest,REF} = |\underline{I}_Y^*| + |\underline{I}_A^*| + |\underline{I}_B^*| + |\underline{I}_C^*|$ with all currents normalized to the rated object current

where:

$\underline{I}_Y$	Measured zero-sequence current at neutral point
k_{yx}	Factor for magnitude adaptation (neutral point)
k_{sx}	Factor for magnitude adaptation (side)
$I_{N,transformer}$	Primary transformer rated current
$I_{N,side}$	Primary rated current of the transformer side (rated object current)
$I_{Diff,REF}$	Differential current
$I_{Rest,REF}$	Restraint current

Using the calculated restraint current, a current I_{Char} which represents the pickup value for the tripping is determined from the characteristic curve (*Figure 6-79*). In this way, the protection function is stabilized in the event of external, multiphase ground faults, for example, a 2-pole ground fault. This means that the protection function becomes less sensitive.
If the **`Slope = 0`** is set here (as an exception), the set **`Threshold`** of the operate curve is passed regardless of the restraint current.



[dw_stab_ke, 2, en_US]

Figure 6-79 Stabilized Characteristic Curve

The ratio between the neutral-point current and the value for the current I_{Char} determined from *Figure 6-79* is observed in the operate curve.

$$I_{op_charact.} = \frac{|I_Y^*|}{I_{Char}}$$

[fo_trip current, 1, en_US]

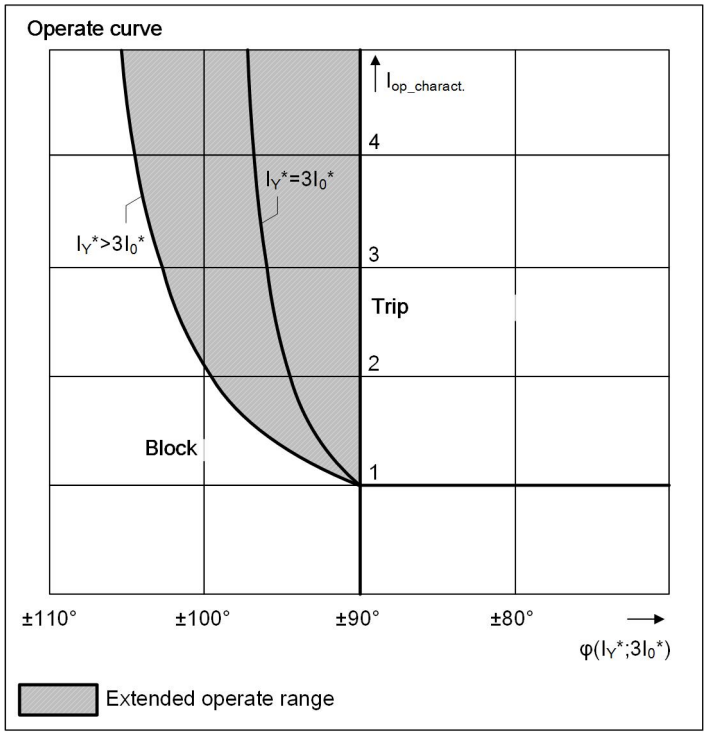
Pickup

If the $I_{Diff,REF}$ calculated differential current exceeds the calculated current I_{Char} (see *Figure 6-77*), pickup occurs and the internal processing is enabled. The pickup is indicated.

Operate Curve Based on Phase-Angle Difference

The operate curve represented in the following figure consists of 2 parts. In the right part of the characteristic curve (angle magnitude ≤ 90°), you will find the case of an **internal ground fault**. Under ideal conditions, the angle between the evaluated currents ($\angle(\underline{I}_Y^*, 3\underline{I}_0^*)$) equals 0 in the event of an internal fault. In the right section of the characteristic curve (internal fault), the trip threshold for the current $I_{op_charact.}$ is >1.

If the measured current on the transformer side yields only a very small $3I_0$* amount, there is no sense in determining the angle difference. If, in the event of an internal fault, a small $3I_0$* current simulates an angle error due to a measuring error, the **extended operate range** allows reliable tripping with an angle difference of >90°.



[dw_ausken, 3, en_US]

Figure 6-80 Operate Curve Depending on the Phase Angle

NOTE

The characteristic curve shown in *Figure 6-80* shows the limit of the tripping range with the angle criterion. The **extended operate range** is shown symbolically for 2 conditions:

- Condition 1: $|\underline{I}_Y^*| = |3\underline{I}_0^*|$
- Condition 2: $|\underline{I}_Y^*| = 3 \cdot |3\underline{I}_0^*|$

The characteristic curve $|\underline{I}_Y^*| = |3\underline{I}_0^*|$ is the angle limit of the extended operate range for this condition.

In the event of an external fault with $|\underline{I}_Y^*| = |3\underline{I}_0^*|$, the phase angle is between $\underline{I}_Y^*$ and $3\underline{I}_0^* \approx 180°$.

If a measuring error now changes the angle and this angle error is <80°, unwanted tripping does not occur. In *Figure 6-80*, that is the section to the left of 100°.

If, for example, the ratio is $|\underline{I}_Y^*| >> |3\underline{I}_0^*|$, tripping is theoretically not possible for an angle difference of 180°. This is the case if no fault current is flowing on the transformer side and the current $3I_0$* results from a measuring error. With the **extended operate range**, internal faults are cleared in a secured way.

In case of an **external ground fault**, the zero-sequence current calculated from the phase currents reverses by 180°. The phase angle between the zero-sequence currents thus ($\angle(\underline{I}_Y^*, 3\underline{I}_0^*)$) equals ± 180°. They are located in the left part of the operate curve and detect a clearly increased tripping limit.

As specified in *Figure 6-80*, the characteristic-curve limit with regard to the angle specification on the x-axis depends on the ratio $|\underline{I}_Y^*|$ to $|3\underline{I}_0^*|$. If the amounts differ, the characteristic curve shifts.

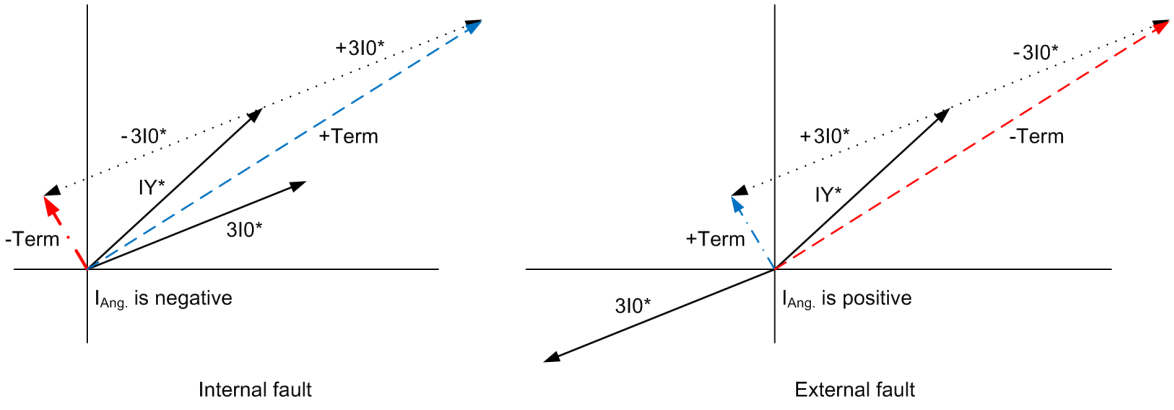
The current $I_{Angle,REF}$ for the **Angle decision** is determined from the following subtraction and summation:

$I_{Angle,REF} = |\underline{I}_Y^* - 3\underline{I}_0^*| - |\underline{I}_Y^* + 3\underline{I}_0^*|$

The resulting current $I_{Angle,REF}$ results from the respective fault conditions, which are illustrated in the following figure. With an internal fault (angle difference ≈ 0°) a value results for $I_{Angle,REF}$ that has a negative sign. The sign remains negative, even when angle errors occur. The amount of $I_{Angle,REF}$ decreases.

With an external short circuit (≈180°), the value of $I_{Angle,REF}$ becomes positive. The current $I_{Angle,REF}$ remains positive, even if an angle error occurs. The amount also decreases.

The following figure shows this for $I_{Angle,REF}$ = (-Term) - (+Term).



[dw_angle-decision_for_external-faults, 1, en_US]

Figure 6-81 Angle Decision in Internal and External Faults

For tripping to occur, the neutral-point current $\underline{I}_Y$* must reach the value $I_{REF,Trip}$.

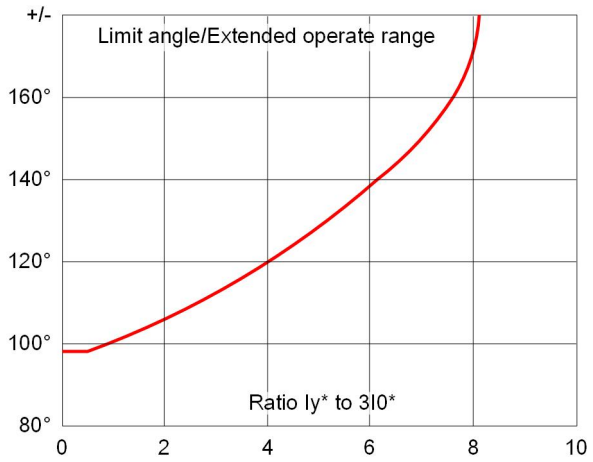
The following table shows the relationship between angle magnitude φ($\underline{I}_Y$*, 3$\underline{I}_0$*), angle dimension $I_{Angle,REF}$, and trip variable $I_{REF,Trip}$

Angle Magnitude φ($\underline{I}_Y$*, 3$\underline{I}_0$*)	Angle Dimension $I_{Angle,REF}$	Trip Variable $I_{REF,Trip}$	Comments
0° < φ ≤ 90°	$I_{Angle,REF}$ = 0	$I_{REF,Trip} = \lvert\underline{I}_Y^*\rvert$	Internal fault
90° < φ < 180°	$I_{Angle,REF}$ > 0	$I_{REF,Trip}$ = max (0, $\lvert\underline{I}_Y^*\rvert$ - $k_{REF}I_{Angle,REF}$)	Normal operation or external fault

where:

k_{REF} Factor (permanently set to 4.05657)
With this value, the limit angle at $\lvert\underline{I}_Y^*\rvert = \lvert 3\underline{I}_0^*\rvert$ is precisely 100°. No tripping is possible from this angle on.

The following figure shows an example of the effect on the **extended operate** by the different ratio $\underline{I}_Y$* to $3\underline{I}_0$* ($I_{rest,REF}$ is not considered in the representation).



[dw_angle_trip_relationship, 1, en_US]

Figure 6-82 Ratio $\underline{I}_Y$* to $3\underline{I}_0$*

Tripping is possible for each angle from a ratio of $\underline{I}_Y$* to $3\underline{I}_0$* > 8.2.

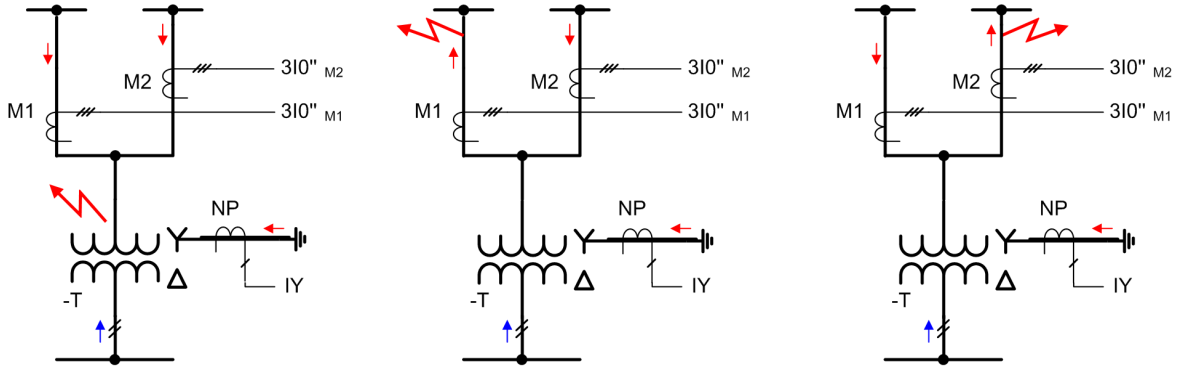
Processing of Several Measuring Points on One Side

If several measuring points are present on one side of a star winding, as with a 1 1/2 circuit-breaker layout, the angle decision occurs separately for each measuring point. The maximum current $I_{Angle,REF}$ is used to establish the tripping decision.

NOTE

With an external fault, the current $I_{Angle,REF}$ is always > 0.

The following figure shows the behavior under different fault conditions.
Also observe that the restraint current ($I_{Rest.,REF}$) always results from the sum of all currents (phase currents of the measuring points and the neutral-point current). For pickup, the differential current $I_{Diff,REF}$ is necessary. This differential current results from the geometric sum of all adapted zero-sequence currents. The zero-sequence currents of the measuring points on the outgoing side and of the neutral-point current are meant here.



$I_{Ang, REFM1} \leq 0, \Delta\varphi_{_M1} = 0°$
$I_{Ang, REFM2} \leq 0, \Delta\varphi_{_M2} = 0°$
$I_{REF, Trip} = I_{Char}$

$I_{Ang, REFM1} \geq 0, \Delta\varphi_{_M1} = 180°$
$I_{Ang, REFM2} \leq 0, \Delta\varphi_{_M2} = 0°$
$I_{REF, Trip} = I_{Char} + k * I_{Ang, REFM1}$

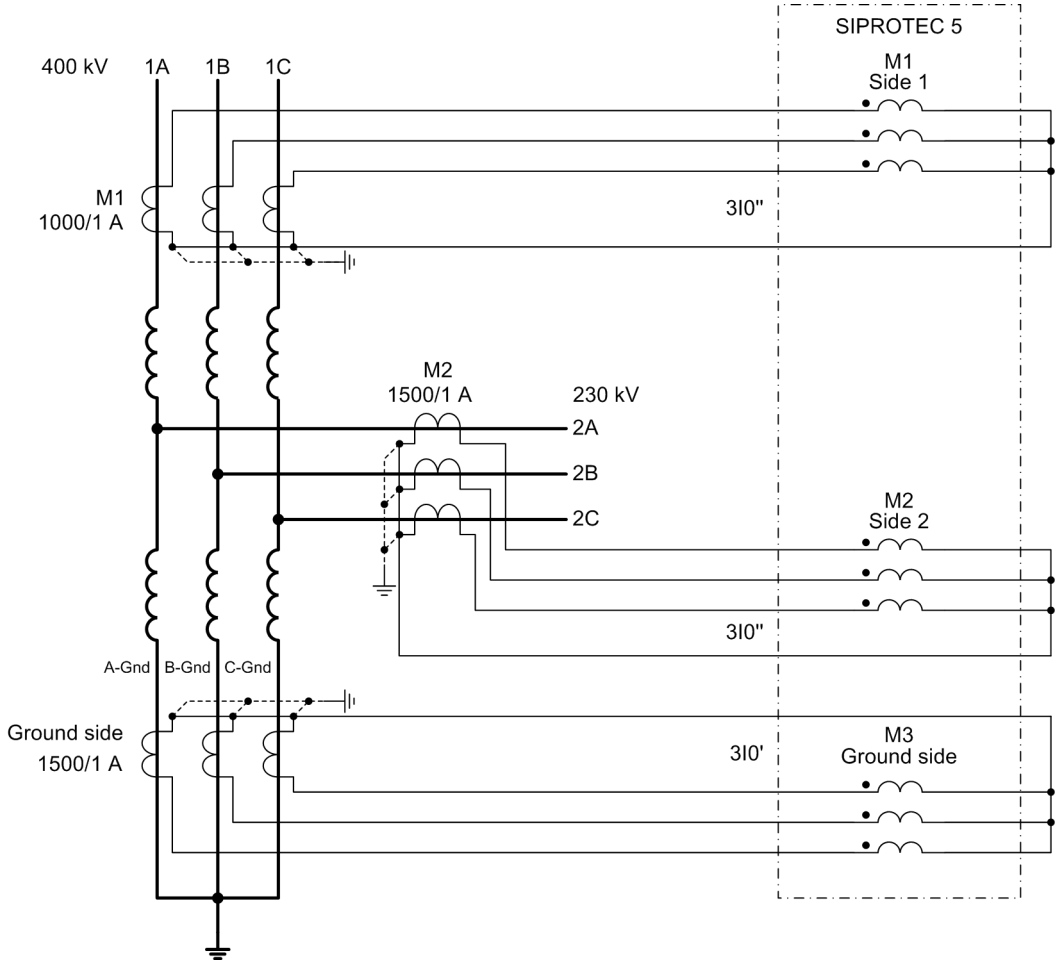
$I_{Ang, REFM1} \leq 0, \Delta\varphi_{_M1} = 0°$
$I_{Ang, REFM2} \geq 0, \Delta\varphi_{_M2} = 180°$
$I_{REF, Trip} = I_{Char} + k * I_{Ang, REFM2}$

[dw_fehler, 2, en_US]

Figure 6-83 Behavior under Different Fault Conditions

Processing a Ground Side for Auto Transformer

Instead of a 1-phase neutral point, with an auto transformer, a 3-phase ground side can also be used.



[dw_autraf, 1, en_US]

Figure 6-84 Connecting a Ground Side on the Auto Transformer

NOTE

The largest rated object current from both sides of the auto transformer is used as a reference current ($I_{N,side}$) for an auto transformer. It is the rated object current on the 230-kV side in *Figure 6-84*.

In this case, the neutral-point current is calculated as the sum of the phase currents of the ground side as follows:

$\underline{I}_Y^* = k_{my} \cdot (\underline{I}_{Gnd,A} + \underline{I}_{Gnd,B} + \underline{I}_{Gnd,C})$

with

$k_{my} = I_{NY,transformer}/I_{N,\ M2\ side}$

The following applies for the restraint current:

$I_{Rest,REF} = |\underline{I}_{Gnd,A}^*| + |\underline{I}_{Gnd,B}^*| + |\underline{I}_{Gnd,C}^*| + |\underline{I}_{M1A}^*| + |\underline{I}_{M1B}^*| + |\underline{I}_{M1C}^*| + |\underline{I}_{M2A}^*| + |\underline{I}_{M2B}^*| + |\underline{I}_{M2C}^*|$

NOTE

If both the 1-phase neutral point and the 3-phase ground side are connected, the restricted ground-fault protection uses only the 1-phase neutral point. The 3-phase ground side is not considered.

Functional Measured Values

Measured Value	Description
(_:306) I REF,operate	Operate quantity of the restricted ground-fault protection from the angle criterion and can be displayed in the fault record
(_:307) I Angle,REF	Stabilizing value (angle) of the restricted ground-fault protection from the angle criterion and can be displayed in the fault record
(_:311) I REF,Trip operate	Operate quantity of the restricted ground-fault protection when OFF; will be issued in the log
(_:312) I angle,REF operate	Stabilizing value of the restricted ground-fault protection when OFF; will be issued in the log
(_:301) I diff.	Differential current; can be displayed in the fault record
(_:302) I restr.	Restraint current; can be displayed in the fault record

You can find the measured values for the **Restricted ground-fault protection** under the following device menu items:

- Main menu → Measurements → function → Function values → 87N REF

6.4.4 Application and Setting Notes

NOTE

You can determine the setting limits for the threshold values as follows (the adaption is done automatically and a setting is only possible within the permissible range):

Lower limit:

Threshold value ≥ max {*0.05 I/Irated,S*; *0.05 I/Irated,S* * $I_{prim\ transf.\ max}$ / $I_{rated,\ protected\ object}$}

Upper limit:

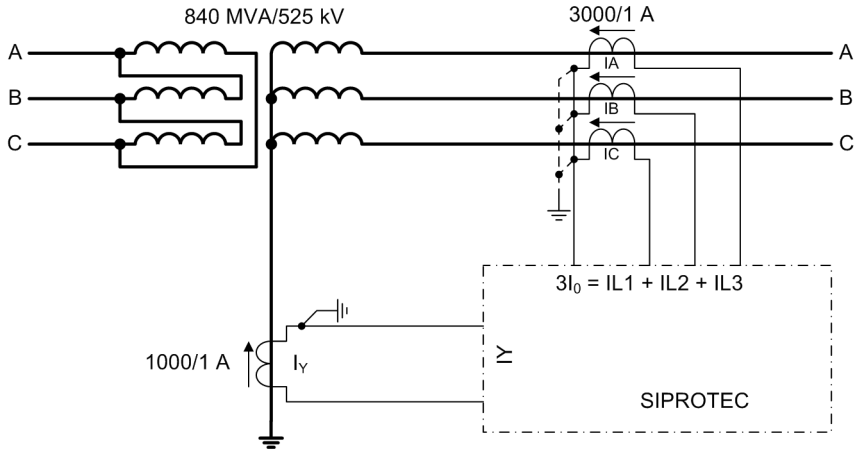
Threshold value ≤ min {*2.00 I/Irated,S*; *100.00 I/Irated,S* * $I_{prim\ transf.\ max}$ / $I_{rated,\ protected\ object}$}

The value ***0.05 I/Irated,S*** is the minimum possible setting value and ***2.00 I/Irated,S*** the maximum possible. $I_{prim,transf.\ max}$ is the largest transformer current and $I_{rated,protected\ object}$ the protected object rated current (reference current) ***100.00 I/Irated,S*** is the upper measurement limit.

The adaptation of the setting limits is done automatically. In addition, a setting is prevented outside of these limits.

In the following, typical applications are described for the restricted ground-fault protection.

Protection of a Solidly Grounded Star Winding (Y Side)



[dw_anster, 3, en_US]

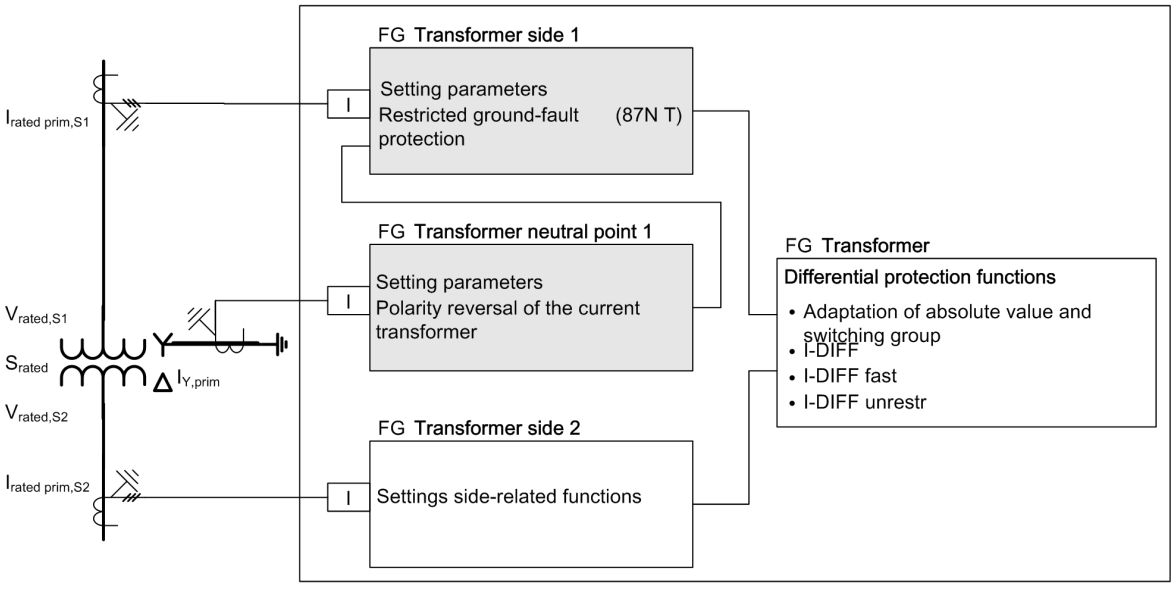
Figure 6-85 Application Star Side

This application is a standard application. Here the phase currents of one side and the neutral-point current are processed. The function is located in the **Transformer Side** function group.

The following figure shows the structural division of the function. The restricted ground-fault protection gets its measurands from the current transformers, which are connected to the **Transformer side** function group. The neutral-point current is guided via the **Transformer neutral point** function group to the **Transformer side** function group. The current I_y measured at the neutral point is inverted by 180° in the fault record (COMTRADE). This is due to the fact that, for a Holmgreen connection, the summation current flows via the terminal with an even connection number, and for a 1-phase connection, it flows via the terminal with an uneven connection number. To be compatible with SIPROTEC 4 (including reference arrow definition of the restricted ground-fault protection), in addition to the magnitude scaling of the neutral-point current, a rotation of the polarity (phase rotation by 180°) is also carried out in the function group **Transformer neutral point**.

NOTE

The fault record indicates the analog traces according to the connection. For this reason, the neutral-point current is shown rotated by 180° in comparison to SIPROTEC 4. This is due to the fact that, for a Holmgreen connection, the summation current flows via the terminal with an even connection number, and for a 1-phase connection, it flows via the terminal with an uneven connection number.



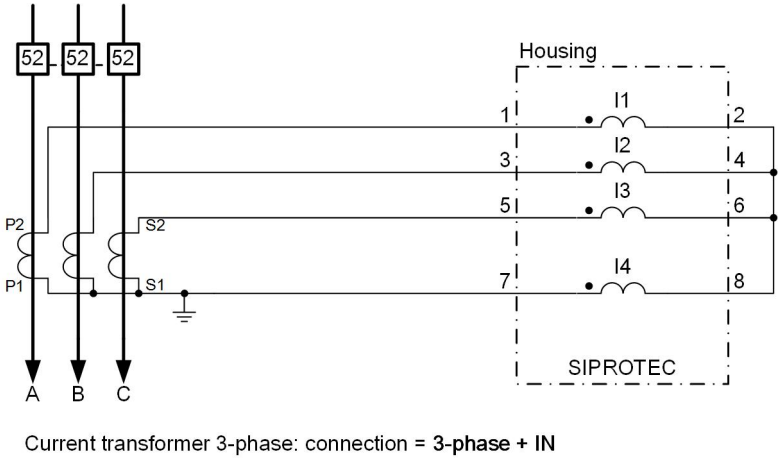
[dw_2wtyde, 3, en_US]

Figure 6-86 Function Group Structure of the Restricted Ground-Fault Protection

Explanations on the Connection and Current-Direction Definition

Uniform reference arrows and transformer burdens are defined for the SIPROTEC 5 device series. These agreements also apply to the transformer protection devices. The special handling of the neutral-point current described previously is a result of this.

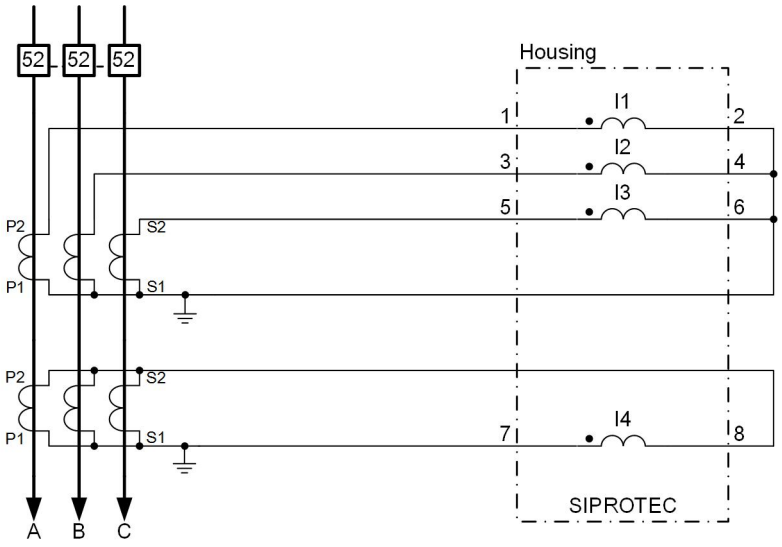
Due to the current definition, the current in the direction of the protected object is always positive. For the 3-phase current-transformer connection, the representation in *Figure 6-87* and *Figure 6-88* applies. For a Holmgreen connection, the summation current is always generated with the neutral point at the terminals with even numbers. If a separate I_N is detected (*Figure 6-88*), for example, with a core balance current transformer, the current I4 must have the same directional mode as in *Figure 6-87* with Holmgreen. The protected object is located to the right or left of the transformer set. The polarity in case of a 3-phase transformer connection is set with the neutral point (in the direction of the protected object or not). The following basic connections result from this.



[ti_phase_2, 4, en_US]

Figure 6-87 Current-Transformer Connection (1) According to Definition

or



Current transformer 3-phase: connection = **3-phase + IN-separate**

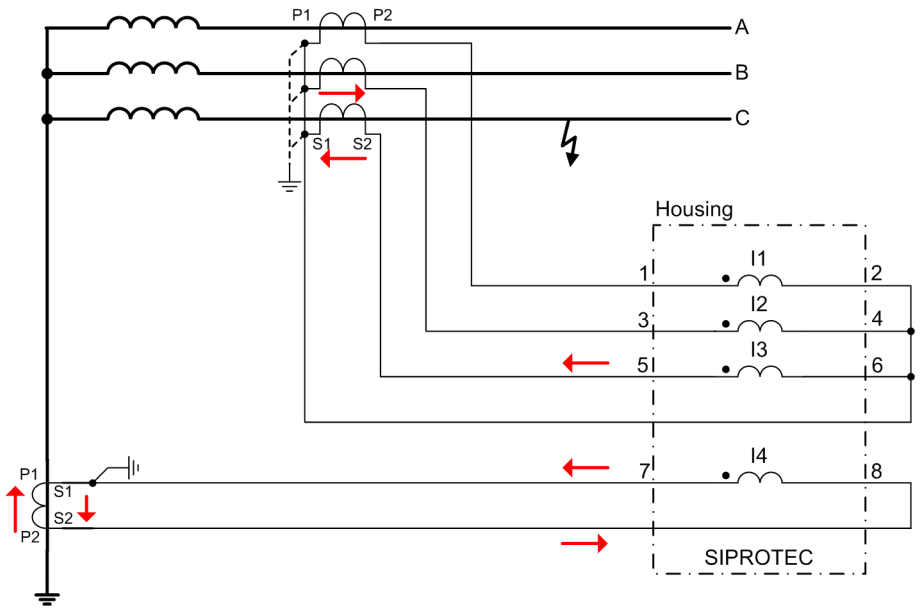
[tileite4-260313-01.tif, 4, en_US]

Figure 6-88 Current-Transformer Connection (2) According to Definition

The following connection is defined for the transformer according to *Figure 6-89*. The current flow for an external ground fault is entered at the same time. It is recognized that the secondary currents each flow from the device. From this, a differential current ($I_{Diff,REF} = |\underline{I}_Y + \underline{I}_A + \underline{I}_B + \underline{I}_C| = |-\underline{I}_4 - \underline{I}_3|$) results, according to the reference arrow definition for the restricted ground-fault protection (positive to the protected object) with an external ground fault. To prevent that, the neutral-point current is rotated in the **Transformer neutral-point** function group. It follows that: $I_{Diff, REF} = |\underline{I}_4 - \underline{I}_3| = 0$.

NOTE

Consider the current-transformer requirements in *A.8 Requirements for Current Transformers* .



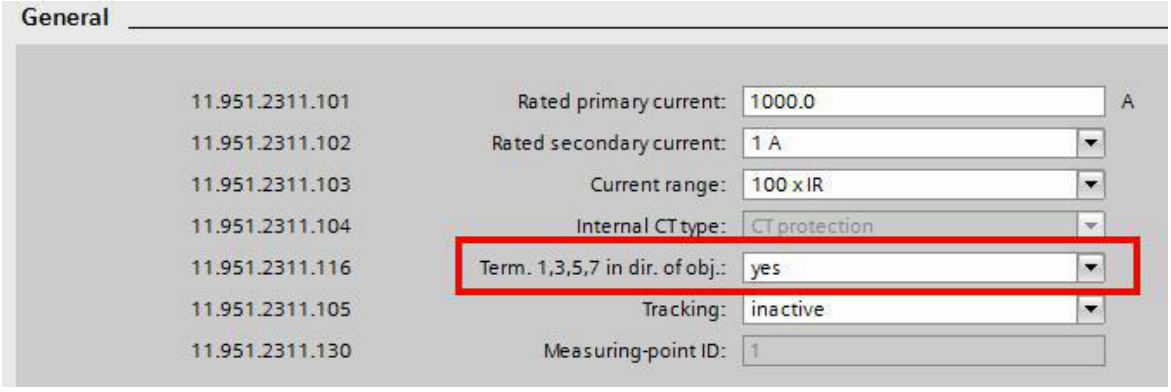
Current transformer 3-phase: connection = **3-phase**

Current transformer 1-phase: connection = **IN**

[dw_stwnas, 2, en_US]

Figure 6-89 Current-Transformer Connection on the Transformer

The setting of the 1-phase measuring point based on the definition is carried out as follows:



[scedsall-200214-01, 1, en_US]

Figure 6-90 DIGSI 5 Setting

The point in *Figure 6-89* describes the polarity of the current transformer. At the same time, the current terminal is designed so that this side is fed out on an odd number terminal point. Since in the SIPROTEC 5 system each current transformer can be assigned a 1-phase measuring point, the odd number terminal points are named in the setting parameters. According to *Figure 6-89*, the setting must be ***yes***.

- Default setting **(_:115) terminal 1,3,5,7 in dir.obj.** = ***yes***

The polarity of the 3-phase transformer connection is always configured on the side of the terminals with even numbers for orientation of the neutral point.

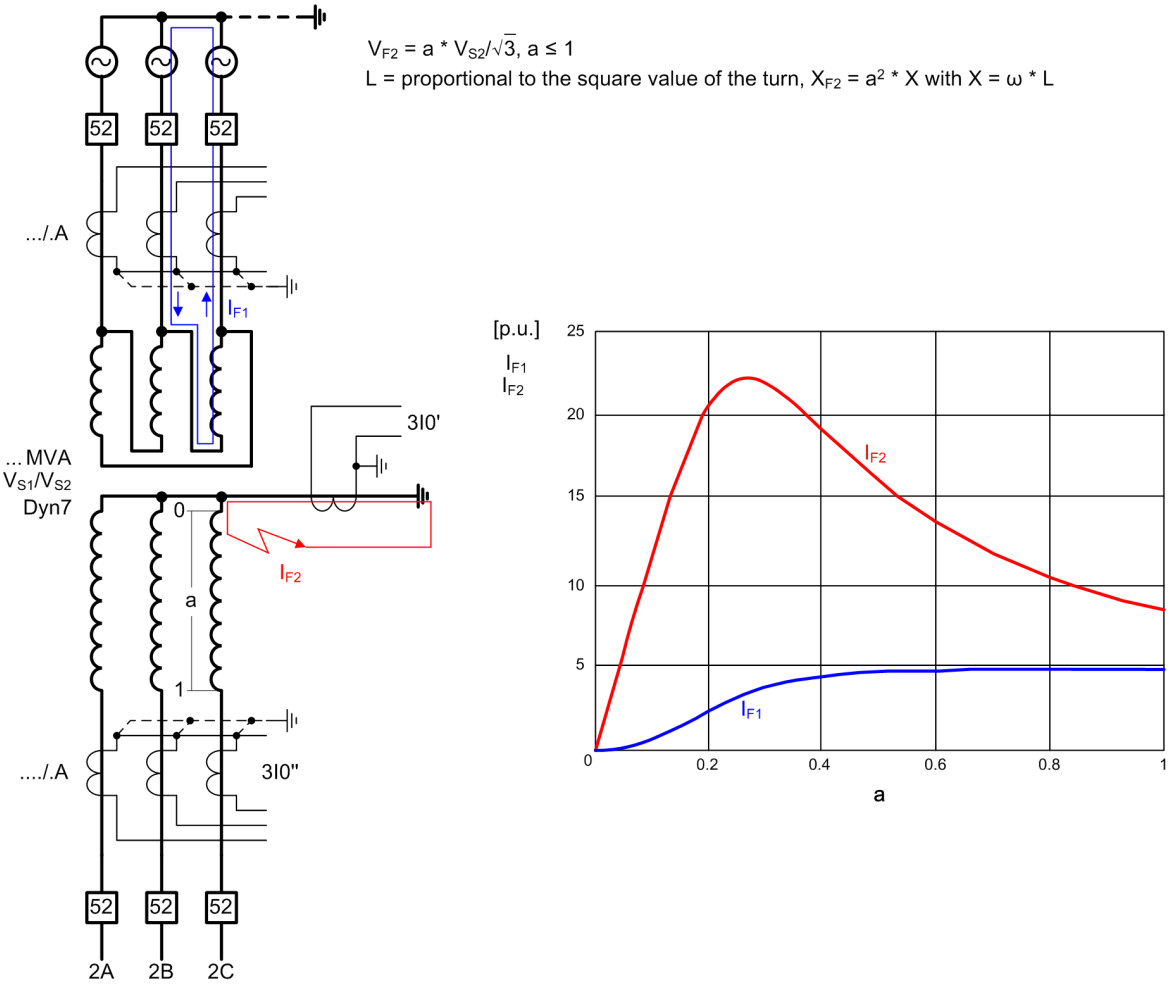
Threshold Value

The following view can be used to derive the threshold value. The transformer is supplied, for example, via the delta winding and a 1-pole ground fault occurs on the star side.

NOTE

For estimation of the short-circuit current, note that the inductance changes quadratically with the winding and linearly with the voltage.

The right part in the following figure represents the fault current as a function of the fault location. The fault current curve I_{F1} shows that the longitudinal differential protection with faults near the neutral point has sensitivity problems due to the sinking current. On the other hand, the neutral-point current I_{F2} is sufficiently large. There is therefore no need to set the **Threshold** (current through the neutral point transformer) to sensitive.



[dw_f1pole, 2, en_US]

Figure 6-91 Principal Fault Current Curves with a 1-Pole Ground Fault

- Recommended setting value **(_:103) Threshold** = ***0.2 I/Irated,S***

The previously mentioned setting limits must be maintained during the setting process (refer to the following example):

$$\text{Threshold value} \geq 0.05\ \text{I/Irated, S} \cdot \frac{I_{CT\ max,prim}}{I_{rated,side}}$$

[fo_schwe1, 1, en_US]

The following lower limiting value results from the data from *Figure 6-85*:

$$\text{Threshold value} \geq 0.05\ \text{I/Irated,S} \cdot \frac{3000\,\text{A}}{924\,\text{A}} = 0.162\ \text{I/Irated,S}$$

$$\text{with } I_{\text{object,side}} = \frac{S_{\text{rated}}}{\sqrt{3}\,V_{\text{rated}}} = \frac{840\,\text{MVA}}{\sqrt{3}\,525\,\text{kV}} = 924\,\text{A}$$

[fo_schwe2, 1, en_US]

The recommended setting value of ***0.2 I/Irated,S*** lies above it.

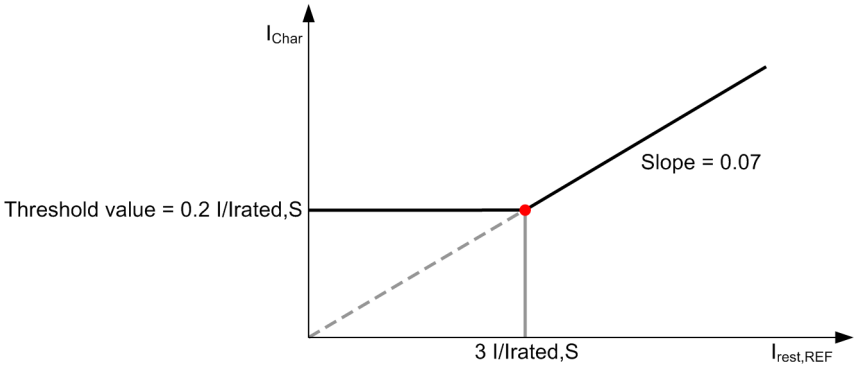
- Recommended setting value **(_:105) Slope** = ***0.07***

You can stabilize the protection function with external multiphase short-circuits to ground with the parameter **Slope**. To determine the setting value, no pickup value increase can occur up to the rated current. After this, the gradient must be active. To derive the gradient, it is assumed that continuation of the straight line must go through the coordinate origin (see *Figure 6-92*). Determine the intersection from the threshold value and the restraint current at rated current. Calculate the gradient as follows:

$$I_{\text{rest,REF}} = \left|I_0^*\right| + \left|I_A\right| + \left|I_B\right| + \left|I_C\right| = 0 + 3\ \text{I/Irated, S} = 3\ \text{I/Irated, S}$$

$$\text{Slope} = \frac{\text{Threshold value}}{I_{\text{rest,REF}}} = \frac{0.2\ \text{I/Irated, S}}{3\ \text{I/Irated, S}} = 0.07$$

[fo_stbref, 2, en_US]



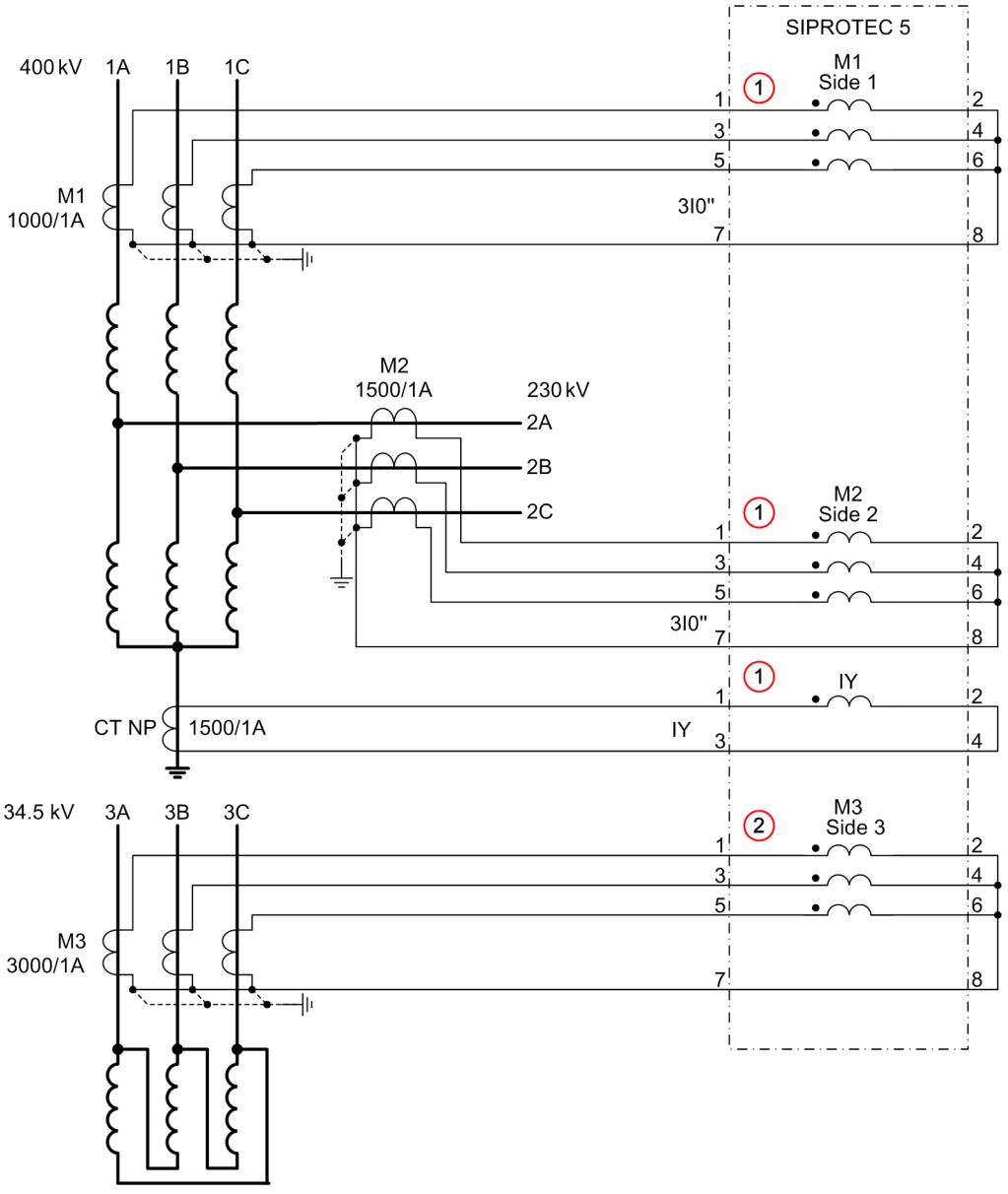
[dw_steiga, 3, en_US]

Figure 6-92 Derivation of the Setting Value for the Gradient

If you have several measuring points on an outgoing side (see *Figure 6-83*), Siemens recommends using the value **3 I/Irated,S** in the intersection calculation for the restraint current. In the load case, the maximum transformer rated current flows on one side.

If, however, several measuring points are on the supply side (for example, breaker-and-a-half layout), Siemens recommends including all phase currents in the intersection calculation, in order to avoid too strong a stabilization. With 2 measuring points, a value of **6 I/Irated,S** results as intersection with the threshold value. The slope becomes flatter (**0.2 I/Irated,S/6 I/Irated,S = 0.03**).

Protection of an Auto Transformer



[dw_sp_tran, 2, en_US]

Figure 6-93 Activation and Application Example of an Auto Transformer (500 MVA: 400 kV, 230 kV; 125 MVA: 34.5 kV)

(1) Base module

(2) Expansion module

For an auto transformer, the highest side rated current is used for normalization. In the example (*Figure 6-93*), the measuring point is M2 (230-kV side). For this side, a rated current of 500 MVA/(√(3) · 230 kV) = 1255 A results. The primary transformer rated current is 1500 A. With this, you can calculate the minimum permissible pickup value.

$$\text{Threshold value} \geq 0.05\ \text{I/Irated,S} \cdot \frac{I_{\text{CT max,prim}}}{I_{\text{object,side}}} = 0.05\ \text{I/Irated,S} \cdot \frac{1500\text{A}}{1255\text{A}} = 0.06\ \text{I/rated,S}$$

[fo_scwe01, 1, en_US]

Siemens recommends a setting value of **0.2 I/Irated,S**.

- Recommended setting value **(_:103) Threshold** = ***0.2 I/Irated,S***

To determine the **Slope**, the restraint current of both sides (400 kV and 230 kV) must be used. The rated current is used as starting value for the gradient. Since side 2 (230 kV) is the reference side for the normalization, the value of the 400-kV side must be adapted to this rated current. The adaptation factor results from the inverse ratio (230 kV/400 kV). The following restraint current goes into the calculation:

$$I_{rest,REF} = 3\ I/Irated,S2 + 3\frac{230\,kV}{400\,kV}\ I/Irated,S2 = 3\ I/Irated,S2 + 1.725\ I/Irated,S2 = 4.73\ I/Irated,S$$

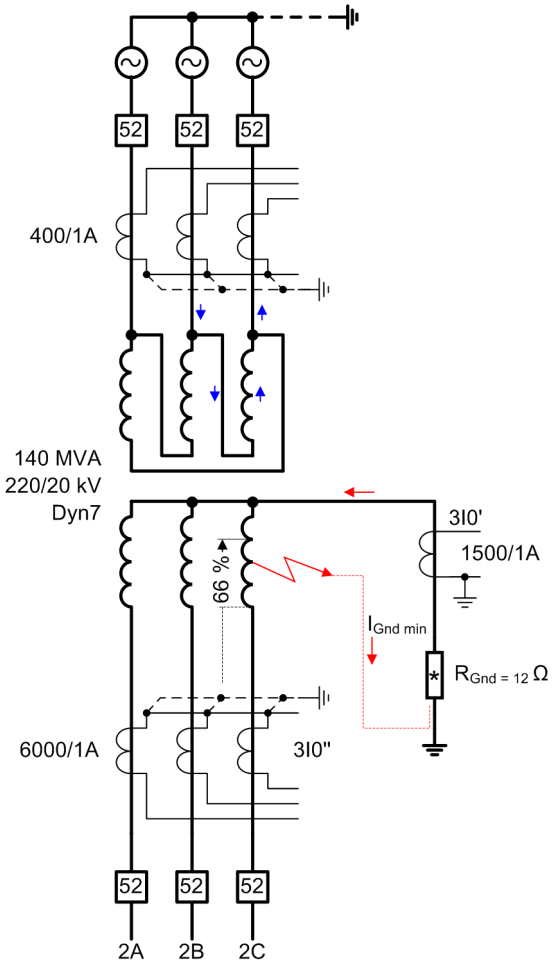
$$Slope = \frac{Threshold\ value}{I_{rest,REF}} = \frac{0.2\ I/Irated,S}{4.73\ I/Irated,S} \approx 0.042$$

[fo_stbrst, 2, en_US]

Siemens recommends using the setting value 0.07.

- Recommended setting value **(_:105) Slope** = ***0.07***

Protection of a Resistance-Grounded Star Winding (Y Side)



[dw_ref_spa, 1, en_US]

Figure 6-94 Application with Resistance-Grounded Neutral Point

The pickup values can be derived from the example data in *Figure 6-94*. As side rated value, the following results:

140 MVA/(√3 · 20 kV) = 4042 A

The following threshold value results as lower limit:

$$\text{Threshold value} \geq 0.05\ \text{I/Irated,S} \cdot \frac{6000\,\text{A}}{4042\,\text{A}} = 0.07422\ \text{I/Irated,S}$$

$$\text{with } I_{\text{object,side}} = \frac{S_{\text{rated}}}{\sqrt{3} \cdot V_{\text{rated}}} = \frac{840\text{MVA}}{\sqrt{3} \cdot 525\text{kV}} = 924\text{A}$$

[fo_schwe3, 1, en_US]

So that the function is responsive, select a setting value of 0.08 I/Irated,S.

- Recommended setting value **(_:103) Threshold** = ***0.08 I/Irated,S***

As slope, the following results:

$$\text{Slope} = \frac{\text{Threshold value}}{I_{\text{rest,REF}}} = \frac{0.08\ \text{I/Irated,S}}{3\ \text{I/Irated,S}} \approx 0.03$$

[fo_steig1, 2, en_US]

- Recommended setting value **(_:105) Slope** = ***0.03***

Because of the grounding resistance R_E reduced protection range results. This can be estimated as follows: The grounding resistance is much larger than the winding reactance, thus the following maximum ground current results:

$I_{\text{gnd max}} = 20\ \text{kV}/(\sqrt{3} \cdot 12\ \Omega) = 962\ \text{A}$

You can determine the minimum tripping current from the setting value:

$I_{\text{gnd min}}$ = side rated current * threshold value = 4042 A · 0.08 = 323 A

Thus, the following protection range results:

$$\text{Protection range} = 1 - \frac{I_{\text{gnd min}}}{I_{\text{gnd max}}} = 1 - \frac{323\,\text{A}}{962\,\text{A}} = 0.664$$

[fo_schwe4, 1, en_US]

The attainable protection range amounts to approx. 66.4 %. In order to capture ground faults near the neutral point, it is also recommended to connect a sensitive ground current protection to the neutral point transformer. You must coordinate its operate time with the line protection.

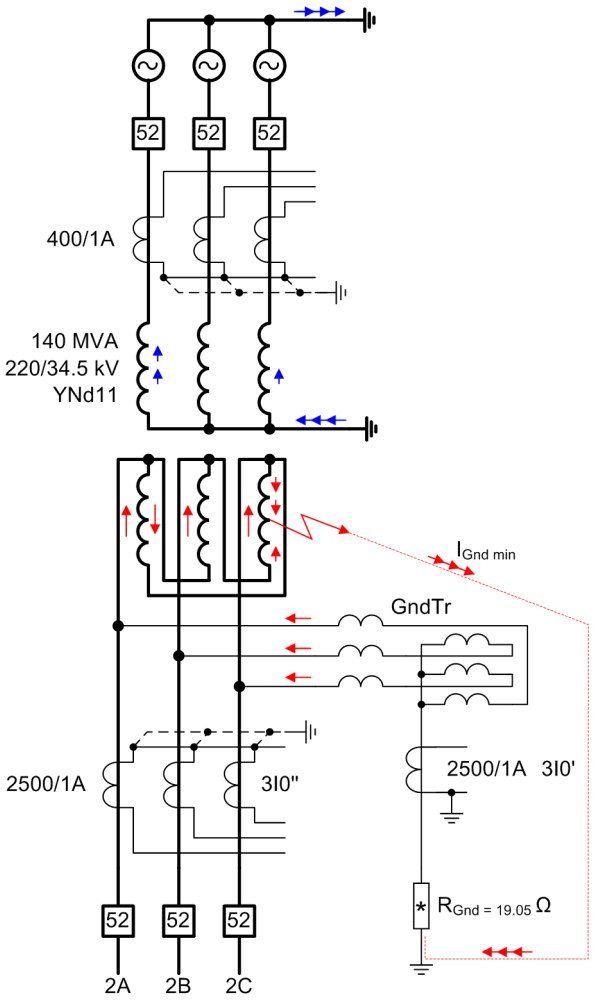
NOTE

Ensure that the protection range further limits itself with larger neutral-point resistances, or the restricted ground-fault protection can no longer be used.

Protection with Neutral Reactors on the Delta Side

To produce ground currents on the delta side of a transformer, neutral reactors (zigzag reactors) are used. A resistance for ground current limitation can also be present. In this case, the resistance is much greater than the reactor and delta reactance of the transformer. The following figure shows a typical implementation. The restricted ground-fault protection works between output-sided phase current transformers and the current transformer in the neutral point of the neutral reactor.

In the example, the fault current curve with the ground fault in a delta winding is also represented. The fault location at which the lowest fault current flows can also be seen. This current influences the protection setting set close.



[dw_strpkt, 1, en_US]

Figure 6-95 Application with Neutral Reactor

As side rated value, the following results:

140 MVA/($\sqrt{3}$ · 34.5 kV) = 2343 A

You can thus define the lower limit for the threshold value:

$$\text{Threshold value} \geq 0.05\ \text{I/Irated,S} \cdot \frac{2500\ \text{A}}{2343\ \text{A}} = 0.06\ \text{I/Irated,S}$$

[fo_schwe5, 1, en_US]

If the fault is in the middle of the winding, as shown in *Figure 6-95*, the minimum ground current will arise. The driving voltage is:

$V_{gnd\ min} = V_{rated,S2}/(2\sqrt{3}) = 34.5\ kV/(2\sqrt{3}) = 9.96\ kV$

The following minimum ground current results:

$I_{gnd\ min} = V_{gnd\ min}/R_{gnd} = 9.96\ kV/19.05\ \Omega = 523\ A$

With reference to the side rated current, the relationship is:

$I_{gnd\ min}/I_{rated,S} = 523\ A/2343\ A = 0.223$

With a safety margin of 2, 0.223/2 = 0.1115 is the result. Select this value as threshold value (rounded: 0.12 I/Irated,S).

- Recommended setting value **(_:103) Threshold** = ***0.12 I/Irated,S***

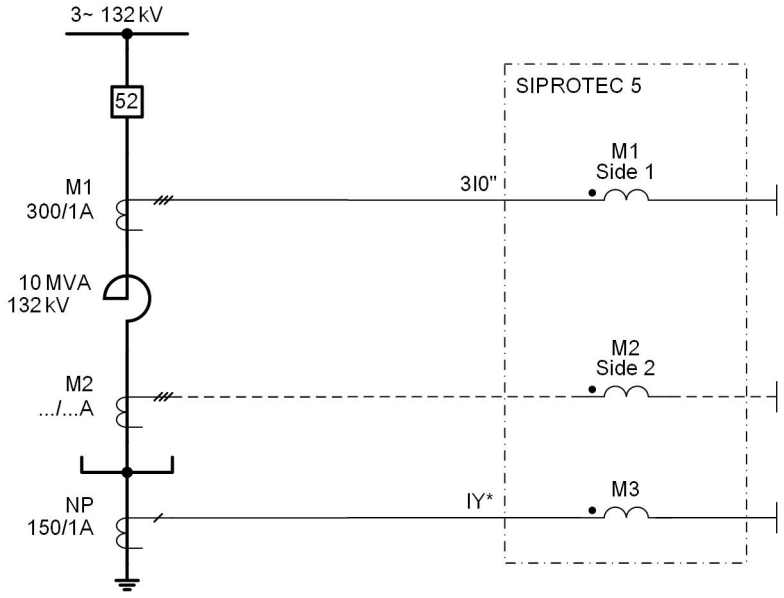
As slope, the following results:

$$\text{Slope} = \frac{\text{Threshold value}}{I_{rest,REF}} = \frac{0.12\ I/I_{rated,S}}{3\ I/I_{rated,S}} \approx 0.04$$

[fo_steig2, 2, en_US]

- Recommended setting value **(_:105) Slope** = ***0.04***

Protection of a Shunt Reactor



[dw_anquer, 2, en_US]

Figure 6-96 Application with Neutral Reactor

As side rated value, the following results:
10 MVA/(√3 · 132 kV) = 43.7 A
You can thus define the lower limit for the threshold value:

$$\text{Threshold value} \geq 0.05\ I/I_{rated,S} \cdot \frac{300\ A}{43.7\ A} = 0.343\ I/I_{rated,S}$$

[fo_schwe6, 1, en_US]

Select 0.35 I/Irated,S as threshold value.

- Recommended setting value **(_:103) Threshold** = ***0.35 I/Irated,S***

There are no fault currents which could potentially lead to a current-transformer saturation flowing through the protection range of the shunt reactor. The characteristic curve therefore does not require an increased value for stabilization (parameter **(_:11041:100) Slope 1**). You can set the operate curve very flat since there are no transient faults due to magnetization, transformer tap changers, or transformer faults. Siemens recommends a minimum slope of 0.05.

- Recommended setting value **(_:105) Slope** = ***0.05***

6.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
87N REF #				
_:1	87N REF #:Mode		• off • on • test	off
_:2	87N REF #:Operate & flt.rec. blocked		• no • yes	no
_:103	87N REF #:Threshold		0.05 I/IrObj to 2.00 I/IrObj	0.20 I/IrObj
_:105	87N REF #:Slope		0.00 to 0.95	0.07
_:109	87N REF #:Operate delay		0.00 s to 60.00 s; ∞	0.00 s
_:191	87N REF #:Reference side is		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	not assigned
_:151	87N REF #:MU-ID Side 1 Mp3ph 1		0 to 100	0
_:152	87N REF #:MU-ID Side 1 Mp3ph 2		0 to 100	0
_:153	87N REF #:MU-ID Side 1 Mp3ph 3		0 to 100	0
_:154	87N REF #:MU-ID Side 1 Mp3ph 4		0 to 100	0
_:156	87N REF #:MU-ID Side 2 Mp3ph 1		0 to 100	0
_:157	87N REF #:MU-ID Side 2 Mp3ph 2		0 to 100	0
_:158	87N REF #:MU-ID Side 2 Mp3ph 3		0 to 100	0
_:159	87N REF #:MU-ID Side 2 Mp3ph 4		0 to 100	0
_:161	87N REF #:MU-ID Side 3 Mp3ph 1		0 to 100	0
_:162	87N REF #:MU-ID Side 3 Mp3ph 2		0 to 100	0
_:163	87N REF #:MU-ID Side 3 Mp3ph 3		0 to 100	0
_:164	87N REF #:MU-ID Side 3 Mp3ph 4		0 to 100	0
_:166	87N REF #:MU-ID Side 4 Mp3ph 1		0 to 100	0
_:167	87N REF #:MU-ID Side 4 Mp3ph 2		0 to 100	0
_:168	87N REF #:MU-ID Side 4 Mp3ph 3		0 to 100	0
_:169	87N REF #:MU-ID Side 4 Mp3ph 4		0 to 100	0

Addr.	Parameter	C	Setting Options	Default Setting
_:171	87N REF #:MU-ID Side 5 Mp3ph 1		0 to 100	0
_:172	87N REF #:MU-ID Side 5 Mp3ph 2		0 to 100	0
_:173	87N REF #:MU-ID Side 5 Mp3ph 3		0 to 100	0
_:174	87N REF #:MU-ID Side 5 Mp3ph 4		0 to 100	0
_:185	87N REF #:MU-ID Mp1ph		0 to 100	0

6.4.6 Information List

No.	Information	Data Class (Type)	Type
87N REF #			
_:82	87N REF #:>Block function	SPS	I
_:54	87N REF #:Inactive	SPS	O
_:52	87N REF #:Behavior	ENS	O
_:53	87N REF #:Health	ENS	O
_:55	87N REF #:Pickup	ACD	O
_:57	87N REF #:Operate	ACT	O
_:303	87N REF #:Operate delay expired	ACT	O
_:305	87N REF #:Block by direct. det.	SPS	O
_:306	87N REF #:I REF,operate	MV	O
_:307	87N REF #:I Angle,REF	MV	O
_:311	87N REF #:I REF,Trip operate	MV	O
_:312	87N REF #:I angle,REF operate	MV	O
_:301	87N REF #:I diff.	MV	O
_:302	87N REF #:I restr.	MV	O

6.5 Motor Differential Protection

6.5.1 Overview of Functions

The **Motor Differential Protection** function (ANSI 87M):

- Detects ground faults and multiphase short circuits in motors
- Detects ground faults during the operation of motors using mains with a grounded neutral point
- Is stable during startup processes with current-transformer saturation through intelligent saturation recognition methods
- Triggers safely in the case of internal high-current faults through an additional high-current stage

6.5.2 Structure of the Function

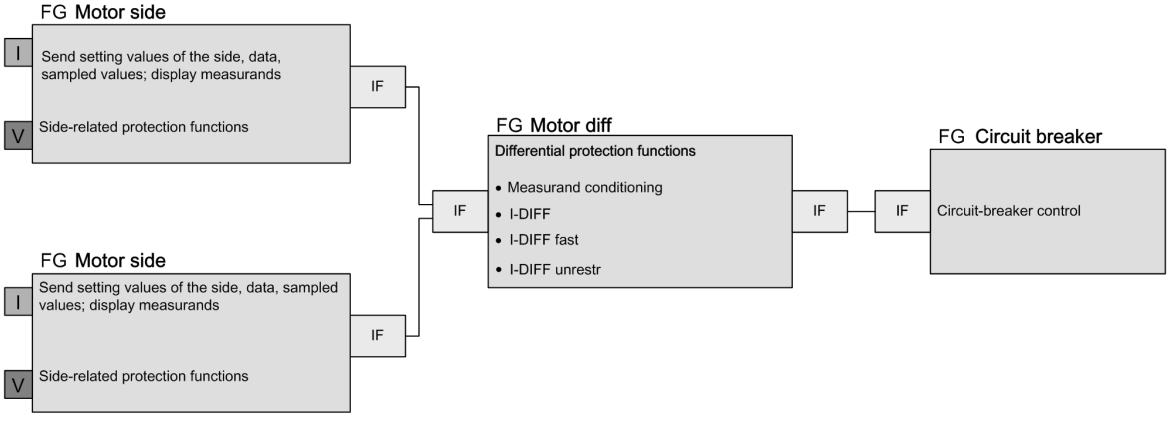
The **Motor differential protection** function is used in the **Motor diff** protection function group. The function depends upon application in the corresponding application template preconfigured by the manufacturer or can be copied during the engineering into the corresponding function group.

The **Motor differential protection** function consists of the 2 tripping stages I-DIFF and I-DIFF fast. In addition, the I-DIFF unrestrained tripping stage is available. You can select this tripping stage from the function catalog and copy it into the **Motor differential protection** function. The tripping stages can be blocked, in addition you can switch the tripping stages on and off.

In the function group **Motor Side**:

- The side-related protection settings are performed
- The side-related calculations are performed
- All data (setting values, detected currents) are relayed to the **Motor** function group

Motor side-related protection functions can run in the **Motor Side** function group, for example overload protection, overcurrent protection, etc.



[dweimbfk-190712-01.tif, 2, en_US]

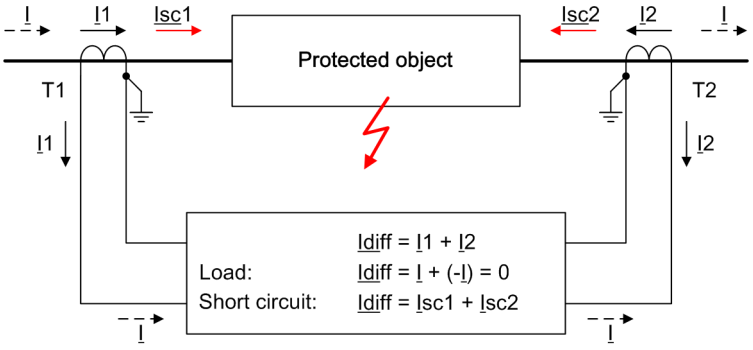
Figure 6-97 Structure/Embedding of the Function

6.5.3 Function Description

Basic Principle of Differential Protection

Differential protection is based on a comparison of currents (Kirchhoff current law). When comparing the current, use is made of the fact that a protected object uses the same current I in a non-faulty operating state on both sides (dotted in *Figure 6-98*). This current flows into the range being observed on one side and leaves

it again on the other side. A current differential is a sure indication of a fault within the protected object. The calculation of the difference is determined through the current-direction definition. The current direction is defined as positive to the protected object. The current difference results from the vector addition of the currents.



[dwprin2s-170712-01.tif, 1, en_US]

Figure 6-98 Basic Principle of Differential Protection Using the Example of 2 Sides

For safe operation, additional functions are required. The implementation of these additional functions is described in chapter *I-DIFF Differential Protection Function, Page 672*.

Current Stabilization

If very large currents flow through the protection range in the case of external faults, with different transmission behavior of the transformers **T1** and **T2** (*Figure 6-98*), a corresponding differential current I_{diff} occurs. When this is larger than the corresponding pickup threshold, the device can issue a trip command, even though no fault is present in the protection range. Such a malfunction of the protection is avoided by the restraint current (I_{rest}) and is implemented in the form of a characteristic curve $I_{diff} = f(I_{rest})$.

The largest current of 2 or more measuring points of the protected object is used for stabilization.

The definition for 2 measuring points is:

A trip or differential current is

$I_{diff} = (\underline{I}_1 + \underline{I}_2)$

as well as a restraint current of

$I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2|)$

For more than 2 measuring points, this definition is expanded. This restraint method allows a reliable trip decision for more than 2 measuring points and different feeding behavior for internal short circuits.

$I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2| ; \ldots |\underline{I}_n|)$

To clarify the effect, 3 important operating states are observed with ideal and adapted measurands.

- Through fault current in healthy operation or externally caused error:
  $\underline{I}_1$ flows into the protection range, $\underline{I}_2$ flows out of the protection range, that is, negative compared with the prefix definition, thus $\underline{I}_2 = -\underline{I}_1$;
  in addition $|\underline{I}_2| = |\underline{I}_1|$
  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 - \underline{I}_1| = 0$
  $I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2|) = |\underline{I}_1| = |\underline{I}_2|$
  No tripping quantity ($I_{diff} = 0$); the stabilization (I_{rest}) corresponds to the flowing current.
- Internal short circuit, feed from both sides with equal amount of currents, for example:
  Then $\underline{I}_2 = \underline{I}_1$; In addition $|\underline{I}_2| = |\underline{I}_1|$;
  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 + \underline{I}_1| = 2 \cdot |\underline{I}_1|$
  $I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2|) = |\underline{I}_1| = |\underline{I}_2|$
  The tripping quantity (I_{diff}) is twice as large as the short-circuit current and the restraining quantity (I_{rest}).

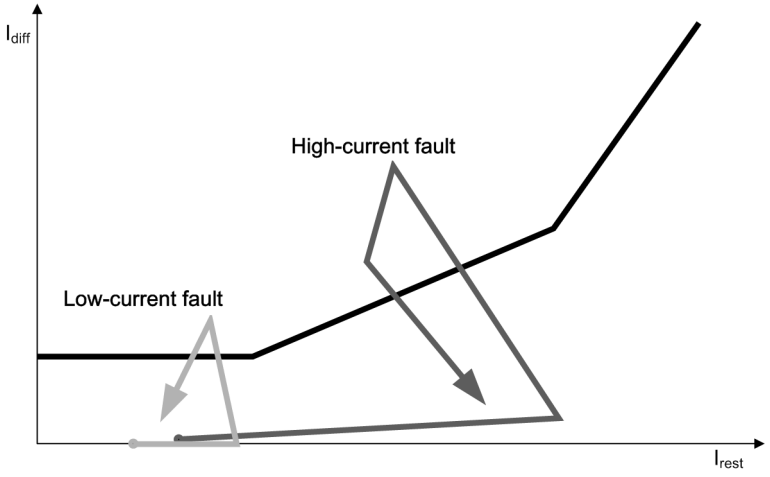
- Internal short circuit, feed only from one side:
  Then $\underline{I}_2 = 0$
  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 + 0| = |\underline{I}_1|$
  $I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2|) = |\underline{I}_1|$
  The tripping quantity (I_{diff}) and the restraining quantity (I_{rest}) are of the same size and correspond to the short-circuit current.

Additional Stabilization with External Short Circuits

In case of an external short circuit, high short-circuit currents flowing through can lead to current-transformer saturation. This saturation can be more or less strongly pronounced at the measuring points, and in this way simulate a differential current. The differential current can lie in the tripping range of the characteristic curve for a certain time and lead to unwanted tripping without any particular measures. In accordance with *Figure 6-99*, there are 2 typical scenarios:

- High-current, external short circuit
  First, the current on both sides is transferred and leads to a large restraint current. After this, a transformer becomes saturated, resulting in a differential current I_{diff} that can exceed the operate curve. Simultaneously, the restraint current I_{rest} drops. Once the transformer is no longer saturated, the differential current decreases and falls below the characteristic curve.
- Low-current, external short circuit
  Current transformers can also become saturated through the large direct-current time constant (switching of transformers, motors), but small currents flowing through. This manifests itself as a phase-angle rotation of the current. Exceeding the characteristic curve in a non-stabilized area is possible.

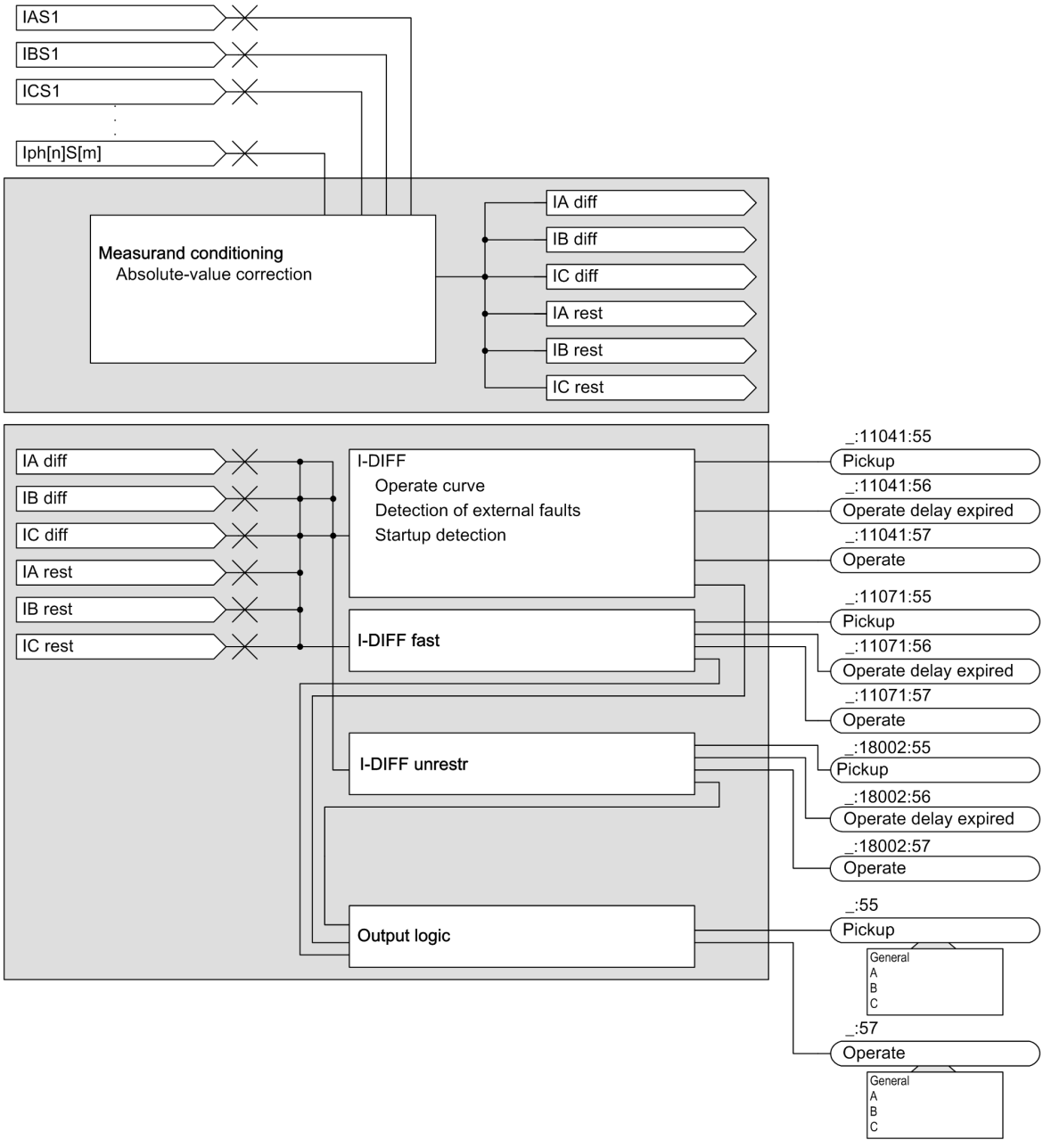
Intelligent saturation-detection methods capture this state and lead to a temporally limited blocking of the Differential protection function.



[dwislauf-170712-01.tif, 1, en_US]

Figure 6-99 Principle Current Course in External Short Circuit and Temporary Current-Transformer Saturation on One Side

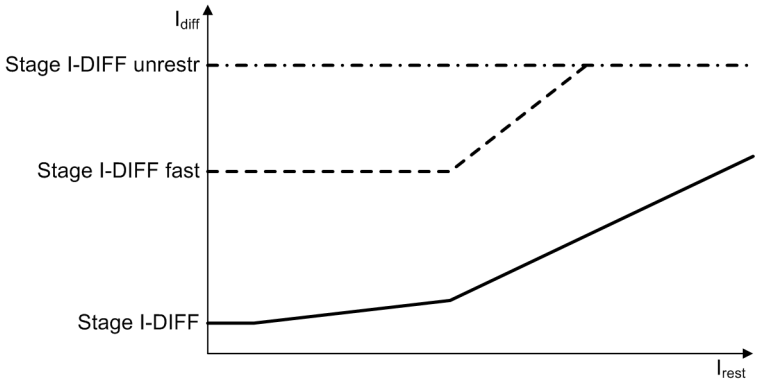
Logic of the Function



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Figure 6-100 Logic Diagram of the Differential Protection Function

The interaction of the I-DIFF, I-DIFF fast, and I-DIFF unrestrained tripping stages is shown in the following operate curve.



[dw_charac_function_trans-dif, 1, en_US]

Figure 6-101 Operate Curve of the Differential Protection Function

In the following, the essential components of differential protection are described in detail.

Measurand Processing

Amount Correction

Since the current transformers cannot be adapted exactly to the rated currents of the protected object with regard to their primary rated data, a standardization to the nominal sizes of the protected object takes place. The conversion occurs every sampling time (thus, for instantaneous values). The differential protection function processes 20 sampled values per period. In addition, the sampled values tracked are used. A high degree of accuracy can be attained over the entire tracking range (from 10 Hz to 90 Hz).

The IDIFF-fast tripping and the IDIFF-unrestrained tripping stages work on non-frequency tracked values and thus, implement fast operate times at low frequencies.

The amount is adapted via the following formula:

$$i^{*}_{phsx} = k\, i_{phsx}$$

$$\text{with } k = \frac{I_{rated\,prim,\,Sx}}{I_{rated\,obj,\,Sx}} = \frac{I_{rated\,prim,\,Sx}}{\frac{S_{rated,\,ref}}{V_{rated,\,Sx}\sqrt{3}}}$$

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i_{phsx}*	Adapted instantaneous value per phase (x = A, B, C)
i_{phsx}	Instantaneous value per phase (x = A, B, C)
k	Correction value per measuring point
$I_{rated\ prim,Sx}$	Primary transformer rated current per measuring point
$I_{rated\ obj,Sx}$	Primary rated current of the protected object
$S_{rated,ref}$	Reference power (maximum rated apparent power of the protected object)
$V_{rated,Sx}$	Rated voltage of the respective side (measuring point) of the protected object

I-DIFF Differential Protection Function

A differential current per phase based on the instantaneous value variables is calculated from the processed currents (see section Measurand Processing). The direction of current flow is defined as to the **protected object as positive**. The fundamental component contribution to the differential current (I_{diff}) is calculated via a Fourier filter (filter length = 1 period (20 sampled values)).

The currents of that measuring point whose RMS value is the largest are used as restraint current. If, for example, the current collapses at a measuring point as a consequence of current-transformer saturation,

the measuring point that has the largest current is automatically switched to at the point in time of the calculation.

$$i_{diff,phsx} = \sum_{m=1}^{N} i^{*}_{phsx,Mm} \rightarrow I_{diff,phsx} = FIR(i_{diff,phsx})$$

$$I_{phsx,Mm} = \sqrt{\frac{1}{n}\sum_{k=1}^{n} i^{*2}_{phsx,Mm}(k)}$$

$$I_{rest,phsx} = \underset{m=1}{\overset{N}{MAX}}\, I_{phsx,Mm}$$

[fogrds16-170712-01.tif, 1, en_US]

With

x	Variable (1, 2, 3) for the phase currents (A, B, C)
m	Variable (1, 2, ..., N) for the measuring points
N	Number of measuring points
n	Number of samples per period (n = 20)
FIR	Fourier filter
MAX	Maximum value determination

Pickup Characteristic

Figure 6-102 shows the pickup characteristic of the differential protection. The characteristic curve branch **a** represents the sensitivity threshold of the differential protection (parameter **`Threshold`**) and considers constant fault currents like magnetizing currents.

The characteristic branch **b** (parameter **`Intersection 1 Irest`** and **`Slope 1`**) considers current-proportional faults under normal operating conditions.

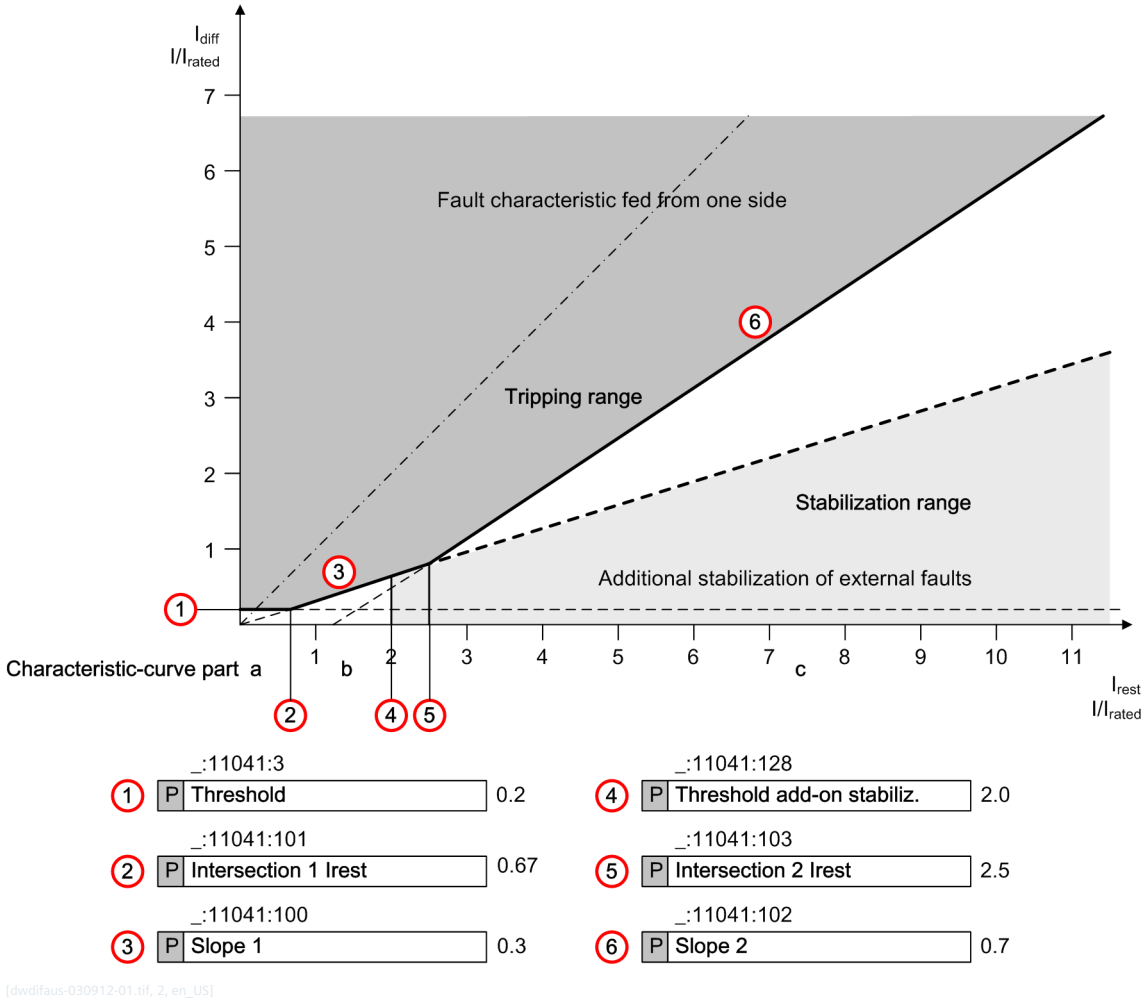
These faults can occur for the following reasons:

- Transformation errors in the current transformer and the input transformer of the device
- Adaptation deviations

The characteristic curve branch **c** (parameter **`Intersection 2 Irest`** and **`Slope 2`**) protects the differential protection against overfunction in case of high-current external faults and transformer saturation. In this range, transformer saturation can arise due to high short-circuit currents, and because of this, a higher differential current results.

In order to avoid overfunction in the event of external faults with current-transformer saturation, a logic is implemented that uses the characteristic curve **Additional stabilization of external faults**. If the operating point is located in the additional stabilization range and exceeds the operate curve from there, then the logic becomes active and blocks the differential protection.

The additional stabilization range is derived from the **`Threshold add-on stabiliz.`** and **`Slope 1`** parameters.



[dwdifaus-030912-01.tif, 2, en_US]

Figure 6-102 Pickup Characteristic of the Differential Protection

If the differential current multiplied by the dropout ratio of 0.7 does not reach the pickup characteristic, the pickup drops out.

Detection of External Faults

To detect external faults with transformer saturation in a reliable way, the measurand curve is evaluated in the Diff.-Rest level by means of a detector. An external fault can occur if the motor feeds back to an external short circuit or if the motor starts up.

The detector has 2 essential tasks:

- **Blocking in the case of a definite high-current external fault**

  The differential current and the restraint current are monitored on a phase basis in the Diff/Restr level immediately after fault inception. To ensure the stability of the saturation detection for low saturation-free times of the primary current transformer, estimated values based on the difference quotients of the instantaneous values are used.

  If the estimated restraint current exceeds the **Threshold add-on stabiliz.** parameter and the expected value of the differential current of all phases is in the additional stabilization range (parameter **Slope 1**) (*Figure 6-102*) at the same time, the detector is active and the indication *Blocked by ext. fault phsx* appears. The tripping of the Differential protection function is blocked.

  If an external fault arises and is cleared by the protection responsible for it, the additional stabilization drops out. If the dropout ratio (0.7) of the RMS value of the restraint current does not reach the **Threshold add-on stabiliz.** parameter (*Figure 6-102*), the additional stabilization drops out. The indication *Blocked by ext. fault phsx* is reset.

  If the differential current exceeds **Slope 1** as a result of transformer saturation, that is, there is a pickup phsx, the blocking is limited in time (parameter: **Time of add-on stabiliz.**).

  Starting with the indication *Blocked by ext. fault phsx*, the other phases can be blocked with it via the **Crossblk. time add-on st.** parameter. If differential currents due to transformer saturation spread to the other phases through the vector-group correction or residual current elimination, this blocking is necessary.

- **Removal of the blocking with a change in fault location from external to internal**

  An internal fault can arise as a consequence of an external fault. This fault change must be recognized and the blocking must be removed. The critical case is a short-circuit with current-transformer saturation. The saturation detection examines here the instantaneous values of the differential current. With transformer saturation, the instantaneous values fall below an internal threshold in the saturation-free time. If this threshold is permanently exceeded and a pickup is present in the corresponding phase, an internal error is assumed. The other phases are also examined during the parameterization with crossblock.

  The blocking of the tripping is removed and the indication *Blocked by ext. fault phsx* is reset.

DC-Component Detection

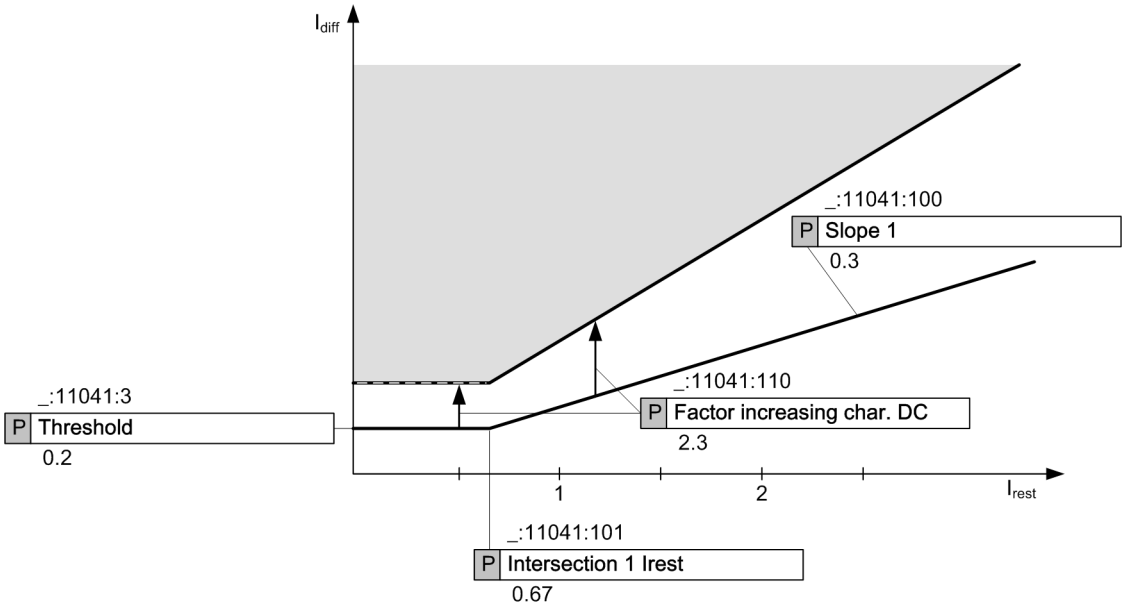
Low-current external faults with large DC components can also lead to exceeding of the operate curve. The additional stabilization range is not attained, however.

To avoid an overfunction, the following steps are taken:

- The restraint current $I_{rest.;phsx}$ is monitored for a jump.
- If the jump occurs, the DC component is calculated, with a temporal delay (1 period), from the instantaneous value of the restraint current (current at the measuring point with the largest current) $i_{rest.,phsx} = i_{phsx,Mm}$. The result is $I_{rest.DC,phsx}$. This current is compared to the restraint current $I_{rest.,\ phsx}$ and is checked for exceeding of the internal threshold.
- The differential current $I_{diff,phsx}$ must lie below the dropout characteristic curve (characteristic curve · 0.7) in all 3 phases.
- If the first 3 points lead to positive results, then the operate curve is raised by the parameter **Factor increasing char.** with a default setting of ***2.3***. Here, only the threshold value and the slope 1 are raised (see *Figure 6-103*). The indication *Increase of char. (DC)* is output. If the product of parameter **Factor increasing char.** and **Slope 1** exceeds **0.85**, the maximum increase of the raised **Slope 1** is limited to 0.85.
- As additional criterion, the pickup indication *Pickup* (internal fault is present) or the indication of the additional stabilization *Blocked by ext. fault phsx* (high-current external fault) is interrogated. If one of the 2 conditions is present, the characteristic-curve increase is stopped. A retroactive pickup no longer resets the characteristic-curve increase. A pickup with DC-component detection occurs only if the raised operate curve is exceeded.

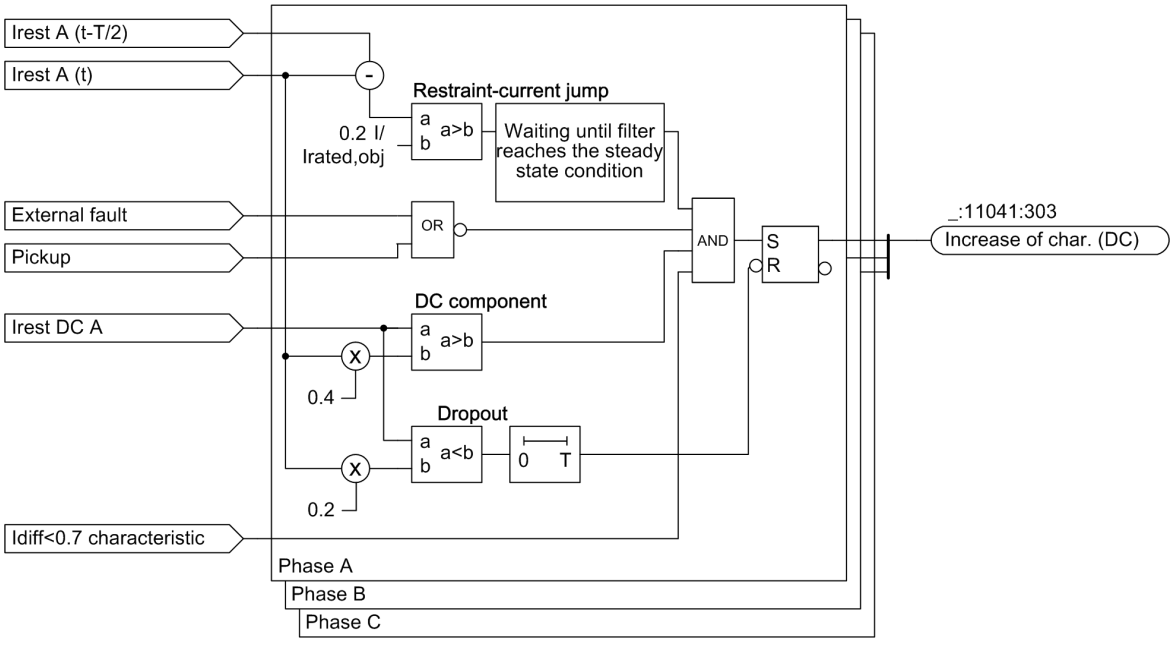
If the DC component $I_{rest.DC,phsx}$ falls below the internal dropout threshold, the dropout delay is determined as follows:

It is assumed that the de- and re-magnetization of the transformer last equally long. The magnetization is at the highest at the point in time in which the internal dropout threshold is attained. The time is measured from the start of the DC-component detection until the internal dropout threshold is reached. Added to this time are 5 periods and from this, the dropout delay is derived. Following this, the characteristic-curve increase is reset to the original value. *Figure 6-104* shows the overall logic.



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Figure 6-103 Increasing the Characteristic Curve after DC Detection



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Figure 6-104 Logic DC Detection

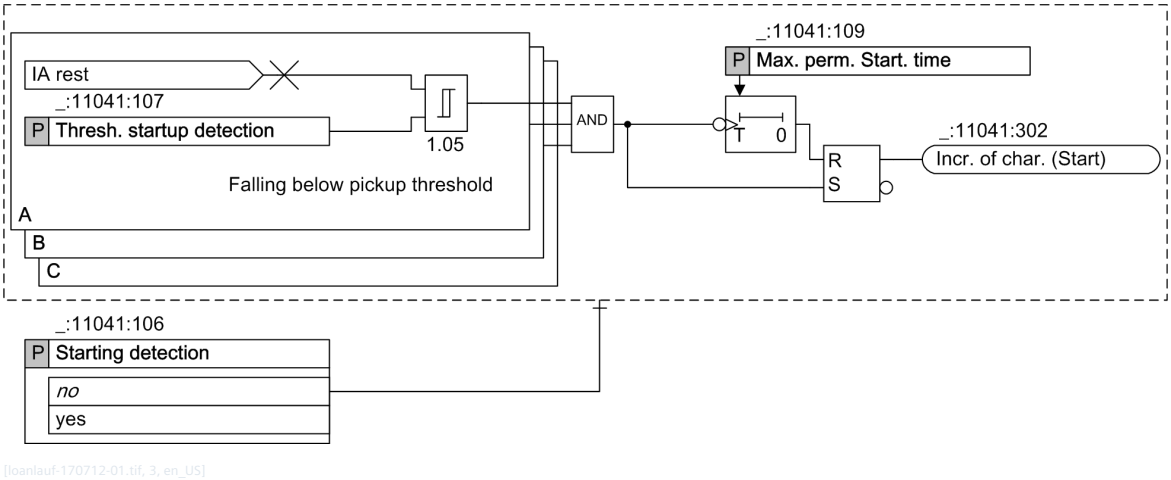
Startup Detection

The startup detection is particularly useful in the case of motors. In contrast to transformers, the inrush current with motors is a flowing current. Differential currents can arise, however, by the current transformers having different residual magnetization and being supplied with current at different operating points of their hysteresis. These differential currents are low in fact, but they can lead to overfunction with sensitive setting of the differential protection.

With generators, the motor startup can also lead to higher currents. With the startup detection, you can make the protection somewhat less sensitive for a specific period of time and avoid overfunction. As a result you achieve a comparable effect to that of DC-component detection.

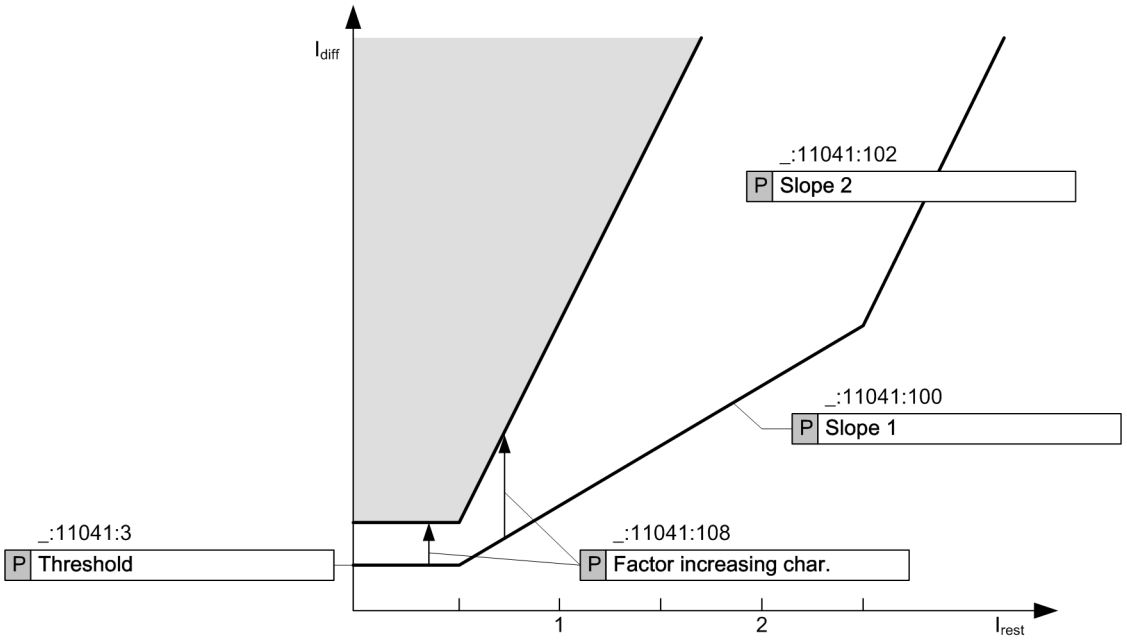
As additional security against overfunction when switching in a previously protected object that carries no current, you can use the pickup-value increase at startup. If the restraint current falls below a settable value **Thresh. startup detection** in all phases, the pickup-value increase is activated. The pickup value **Threshold** and **Slope 1** are raised by the set value in accordance with parameter **Factor increasing char.**. As a rule here, **Slope 1** cannot exceed a value of 0.85.

If the parameter **Thresh. startup detection** is exceeded, dropout occurs and a timing element (parameter: **Max. perm. Start. time**) is activated. Once this time has elapsed, the characteristic curve that was increased in all phases is reset to its original value. *Figure 6-105* shows the logic diagram of the startup detection and *Figure 6-106* the increased characteristic curve.



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Figure 6-105 Logic Startup Detection



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Figure 6-106 Characteristic-Curve Increase at Startup

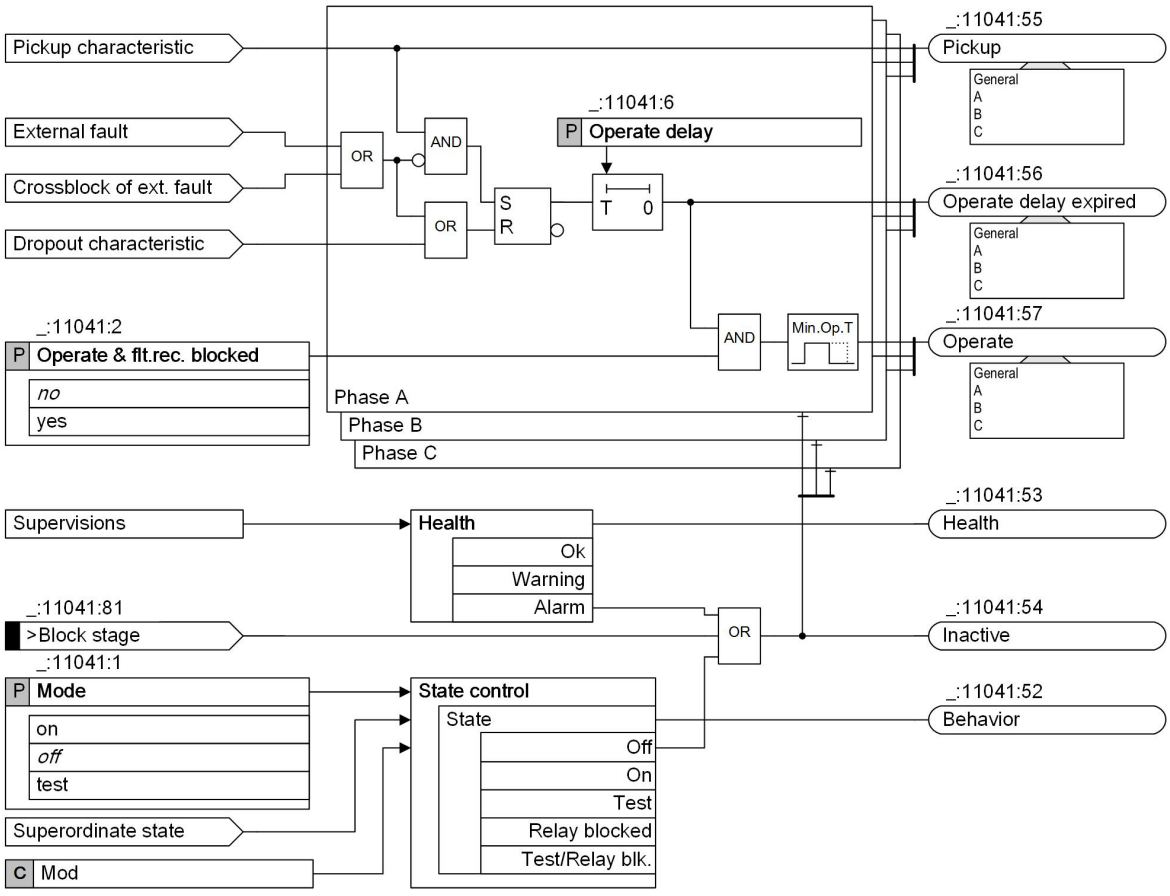
Trip Logic of the Differential Protection Function I-DIFF

Figure 6-107 shows the trip logic. If the characteristic curve is exceeded (see *Figure 6-102*) a pickup occurs. Redirection of the information for tripping can be blocked by the additional functions.

Blocking is possible through use of the following influencing variables:

- Recognition of external faults that can simulate an internal fault through transformer saturation

In addition, in case of blocking due to an *external error*, a **crossblock** mechanism comes into effect.



[lo_aus_mid, 2, en_US]

Figure 6-107 Trip Logic of I-DIFF

I-DIFF Fast Differential Protection Function

As a supplement to the I-DIFF differential protection function, the function I-DIFF fast is available. The main task consists in switching off high-current internal faults in the shortest amount of time. The method controls current-transformer saturation and is stable in the event of external transverse faults (integration in breaker-and-a-half arrangements).

Metrologically, 2 methods are combined:

- Instantaneous-value method
- Filter-based method

Instantaneous-Value Method

Through the instantaneous-values method, an immediate evaluation of the sampled values of the differential $i_{Diff}(t)$ and restraint current $i_{rest}(t)$ occurs. The absolute-value and vector-group adapted currents (i*) are also the basis. The currents are defined positively to the node. The restraint current is the maximum current of all measuring points.

$$i_{diff,phsx}(t) = \left| \sum_{m=1}^{N} i^{*}_{phsx,Mm}(t) \right|$$

$$i_{rest,phsx}(t) = \max_{m=1}^{N} \left| i^{*}_{phsx,Mm}(t) \right|$$

[fomome27-170712-01.tif, 1, en_US]

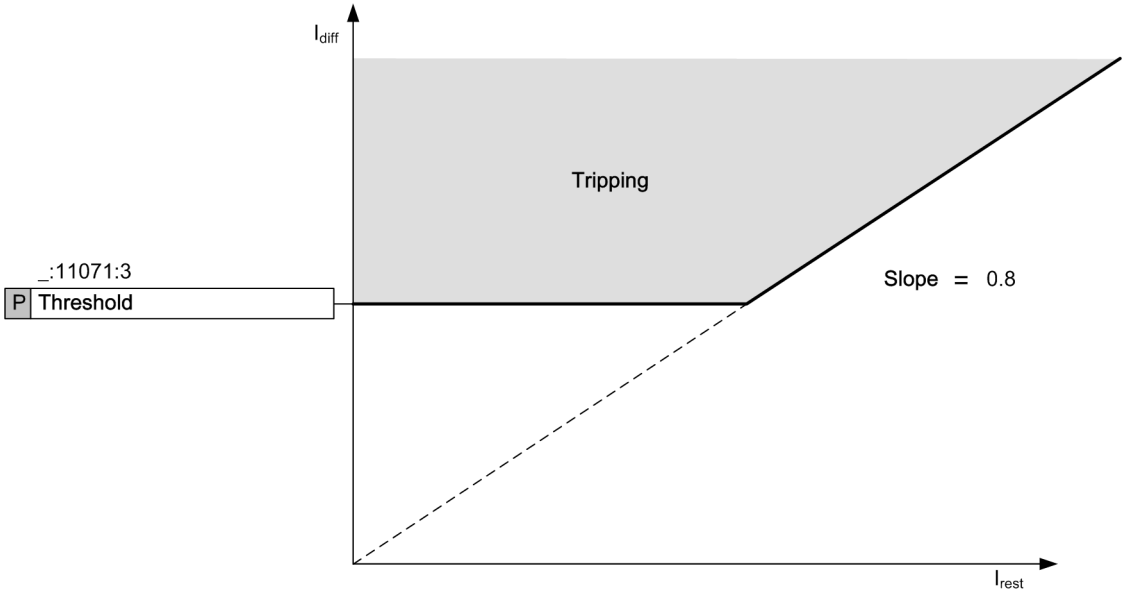
where

x	Variable (1, 2, 3) for the phase currents (A, B, C)
m	Variable (1, 2, ..., N) for the measuring points
N	Number of measuring points

The evaluation of the restraint current is used to recognize saturated, high-current external faults.
Figure 6-108 shows the operate curve. The parameter **Threshold** is set here such that it lies over the maximum fault current flowing. The slope of the characteristic curve is fixed at 0.8.
In the algorithm, the following conditions are processed:

- Condition 1: The increase of the restraint current $di_{rest}(t)/dt$ is determined continuously and compared with an internal threshold value.
- Condition 2: After that, a comparison determines whether the differential current is larger than the restraint current (characteristic curve **Slope** in *Figure 6-108*): $i_{diff}(t) > 0.8 \cdot i_{rest}(t)$.
- Condition 3: After that, a comparison determines whether the differential current exceeds the parameter **Threshold**.

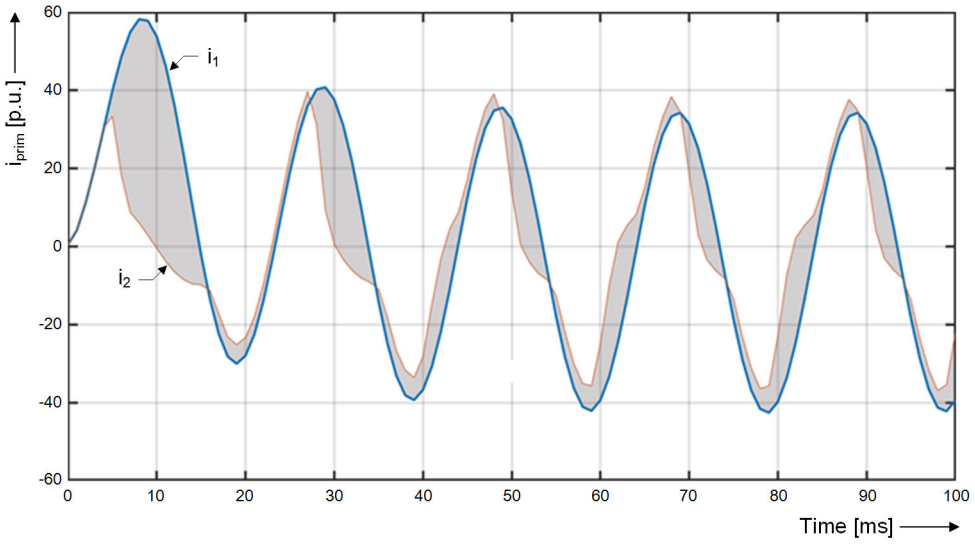
When all conditions are met, tripping occurs immediately. If the 1st condition is recognized and not the 2nd condition, then the function is blocked for 300 ms.



[dwidfast-300114-01.tif, 1, en_US]

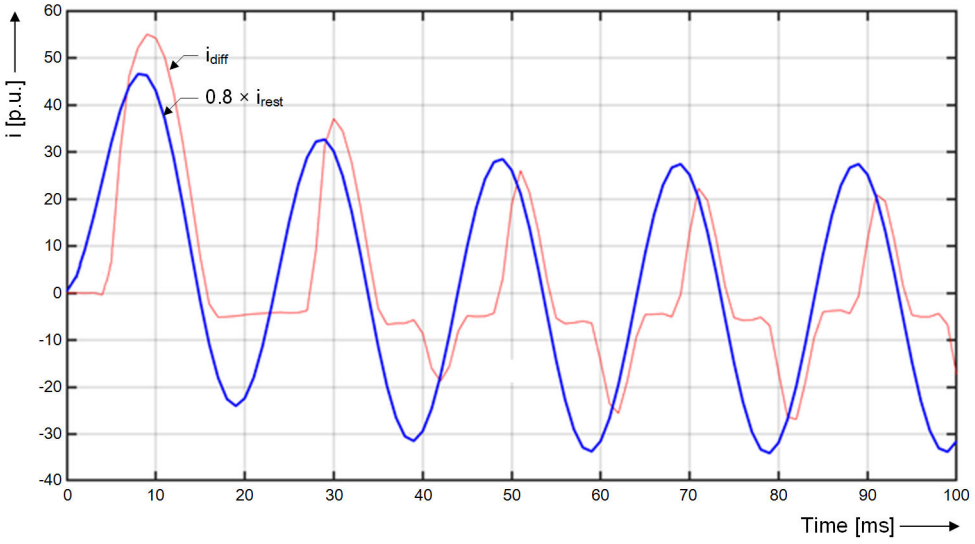
Figure 6-108 I-DIFF Fast Characteristic Curve

The 2 following figures show the behavior during an internal and an external fault. It is typical for the internal fault (*Figure 6-109*) that the differential current rises more quickly than the restraint current. After a few sampled values, the trip signal is issued. In case of an external fault, a differential current arises only after transformer saturation occurs. You can always assume, however, that the current is transferred a few milliseconds after occurrence of the fault. In accordance with *Figure 6-111*, the restraint current is larger than the differential current after occurrence of the fault, but condition 2 is not met and the function is therefore blocked.



[dwinnfel-201112-01.tif, 2, en_US]

Figure 6-109 Curve Plot for Internal Fault with Transformer Saturation (k= 0.65)



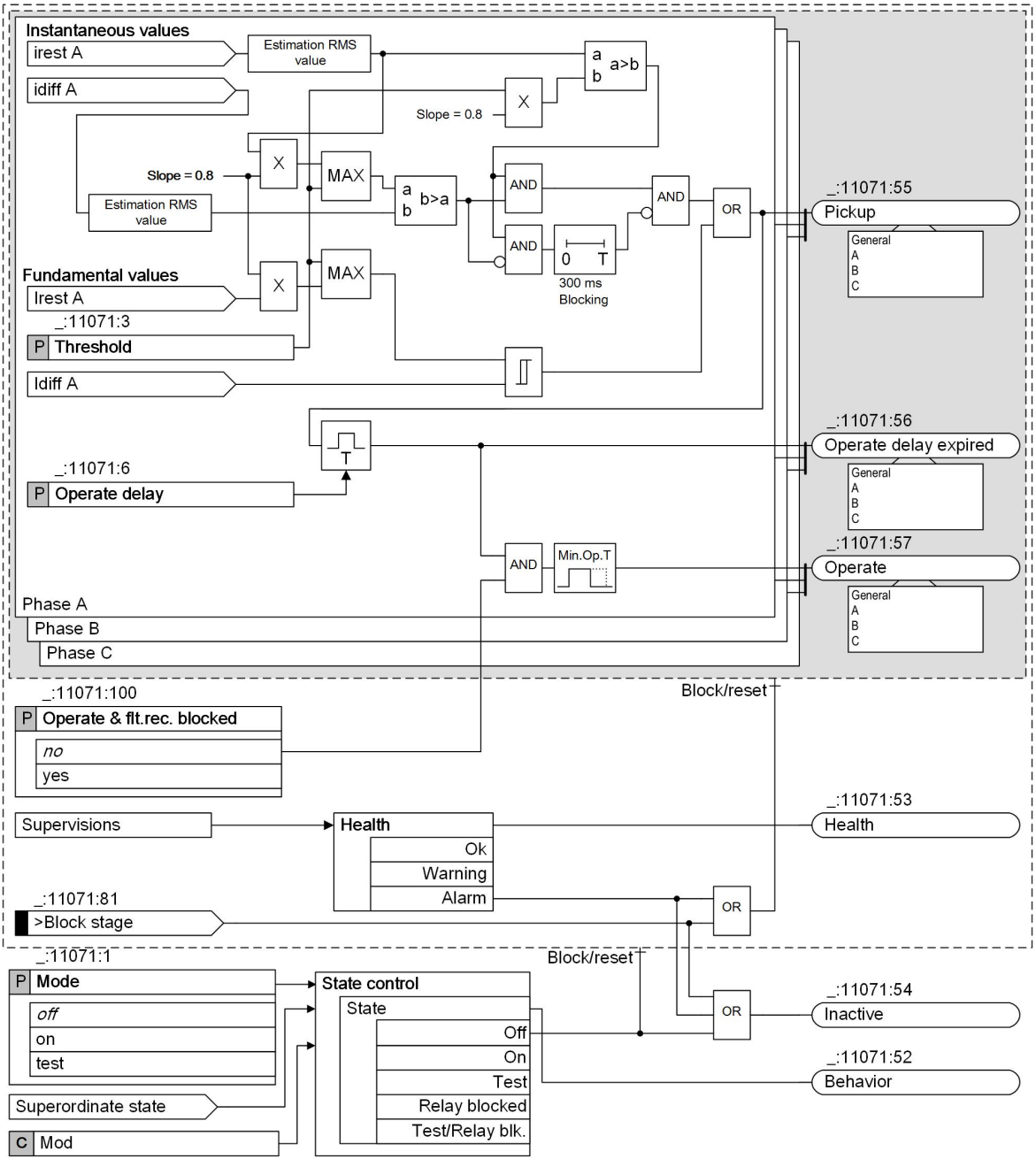
[dwextfel-170712-01.tif, 2, en_US]

Figure 6-110 Curve Plot for External Fault with Transformer Saturation (k= 0.65)

Fundamental-Component Method

Parallel to the instantaneous-value method, the fundamental component works with a temporal delay. Here, the same measured values are processed as with the I-DIFF method. The fundamental component of the differential current I_{diff} and the stabilization value (maximum current of a measuring point) $I_{rest.}$ are ordered in the operate curve according to *Figure 6-108* and the trip decision is made.

Figure 6-111 shows the overall logic.



[lo_id_fast, 4, en_US]

Figure 6-111 Logic of the I-DIFF Fast Differential Protection Function

I-DIFF Unrestrained Differential Protection Function

In addition to the I-DIFF and I-DIFF fast differential protection function, the function I-DIFF unrestrained is available. The main task of this function consists in switching off high-current internal short circuits in the shortest amount of time. The method controls current-transformer saturation.

High-current faults in the protection range can always be switched off immediately without consideration of the restraint currents if, due to the current magnitude, it is determined that an external fault is not involved. In the case of protected objects with a large intrinsic longitudinal impedance (transformer, generator, reactor), a current can be found that is never exceeded by a flowing short-circuit current.

For a transformer, for example, the (primary) value is:

$$\frac{1}{v_{sc\ transf.}} \cdot I_{N\ transf.}$$

[fo_Idiff-error, 1, en_US]

The I-DIFF unrestrained stage also acts if, for example, due to current-transformer saturation because of a DC component in the short-circuit current, a 2nd harmonic occurs. The inrush-current detection could interpret this as the closed-circuit current.

The I-DIFF unrestrained protection stage operates both with the fundamental component of the differential protection and with the instantaneous value.

Metrologically, 2 methods are combined:

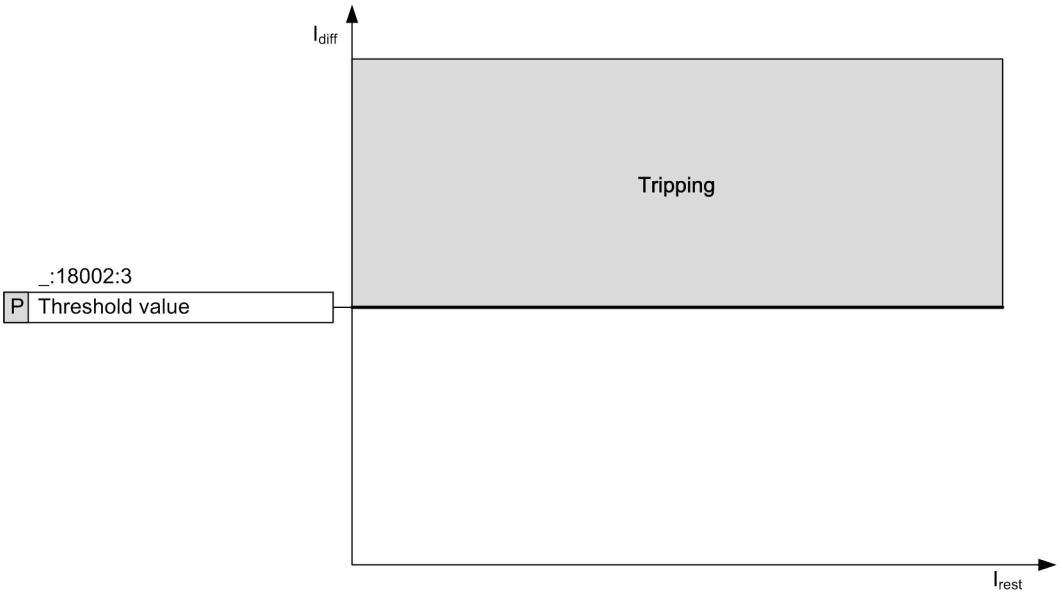
- Instantaneous-value method
- Filter-based method

Instantaneous-Value Method

With the instantaneous-values method, an immediate evaluation of the sampled values of the differential current $i_{Diff}(t)$ occurs. The absolute-value and vector-group adapted currents (i*) are also the basis.

Fundamental-Component Method

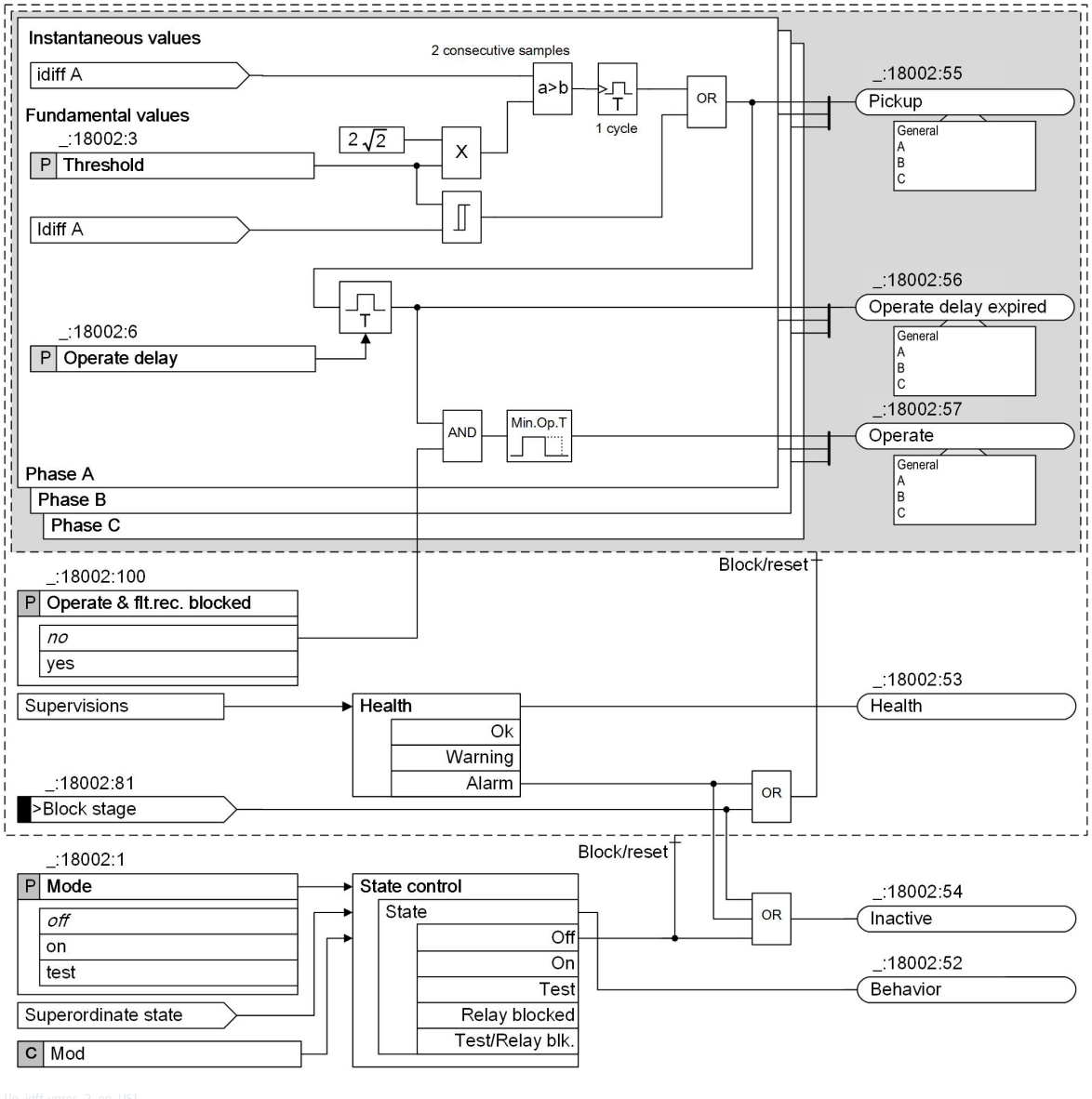
Parallel to the instantaneous-value method, the fundamental component works with a temporal delay. Here, the same measured values are processed as with the I-DIFF method. The fundamental component of the differential current I_{diff} is ordered in the operate curve *Figure 6-112* and the trip decision is made.



[dw_idffunres, 1, en_US]

Figure 6-112 I-DIFF Unrestrained Characteristic Curve

Figure 6-113 shows the overall logic.

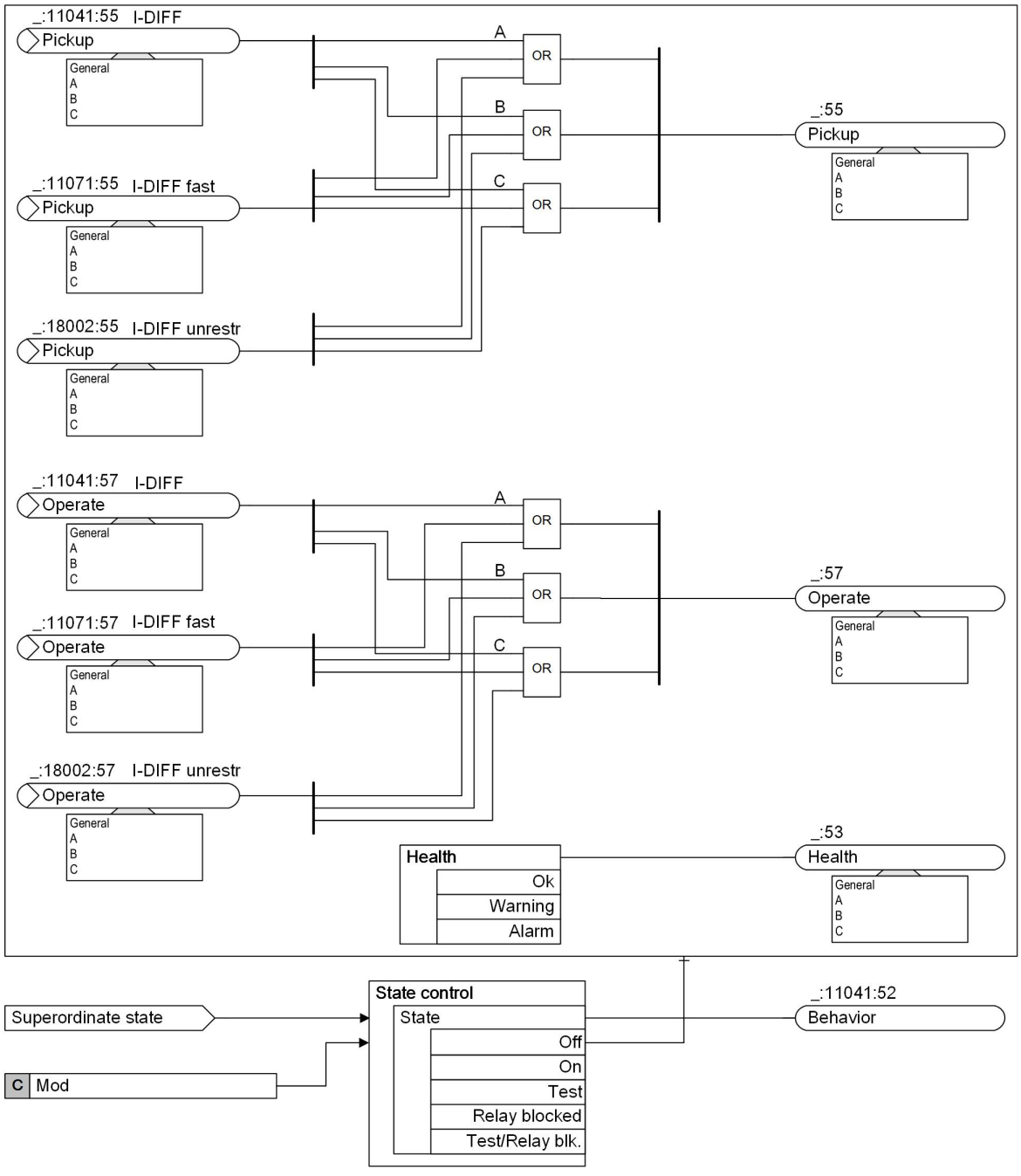


[lo_idff-unres, 2, en_US]

Figure 6-113 Logic of the I-DIFF Unrestrained Differential Protection Function

Trip Logic of the Differential Protection

A common trip signal is formed from the subfunctions I-DIFF, I-DIFF fast, and I-DIFF unrestrained. *Figure 6-114* shows the corresponding logic.



[lo_gesamt, 3, en_US]

Figure 6-114 Overall Trip Logic

Fault Logging and Fault Recording

A fault is opened with every protection pickup. This means that a fault log and a fault recording are started. Saving of the fault record depends on the setting (see *3.5.3 Function Description*). Since pickup and tripping are the same in differential protection, the recording setting can be used with the pickup function. To enable fault recording even with external errors, along with the exceedance of the characteristic curve, a fault record is opened in case of a blocking by an external error or in case of a characteristic-curve increase through a DC-component detection. This has the advantage that you can evaluate the transformer transfer method of the current transformers very well in case of a fault.

6.5.4 Application and Setting Notes

Setting information for the required setting parameters is provided for a typical motor protection application. *Figure 6-115* shows a typical motor protection application. For motors with a power of more than 1 MW to 2 MW, Siemens recommends the use of differential protection. This prevents damage in the event of tripping in case of a short circuit. The application assumes that a current-transformer set is available at the motor neutral point. The **Motor differential protection** is operational in the devices 7UT82, 7UT85, 7UT86, and 7UT87.

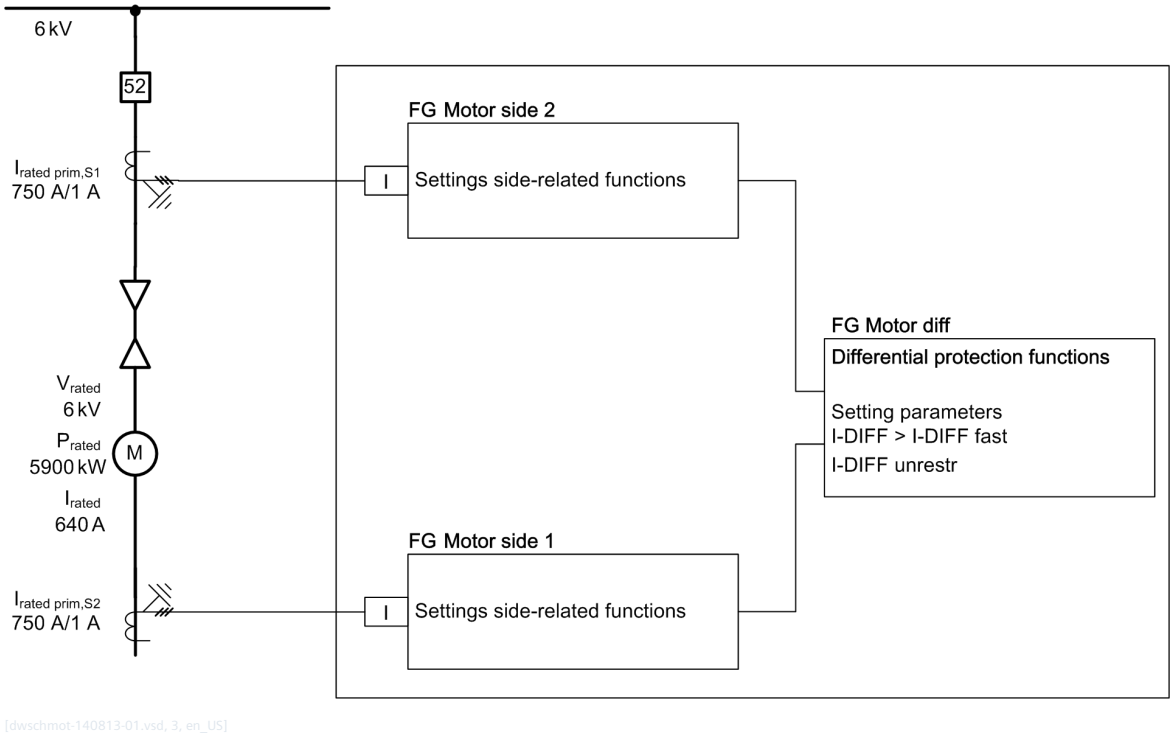
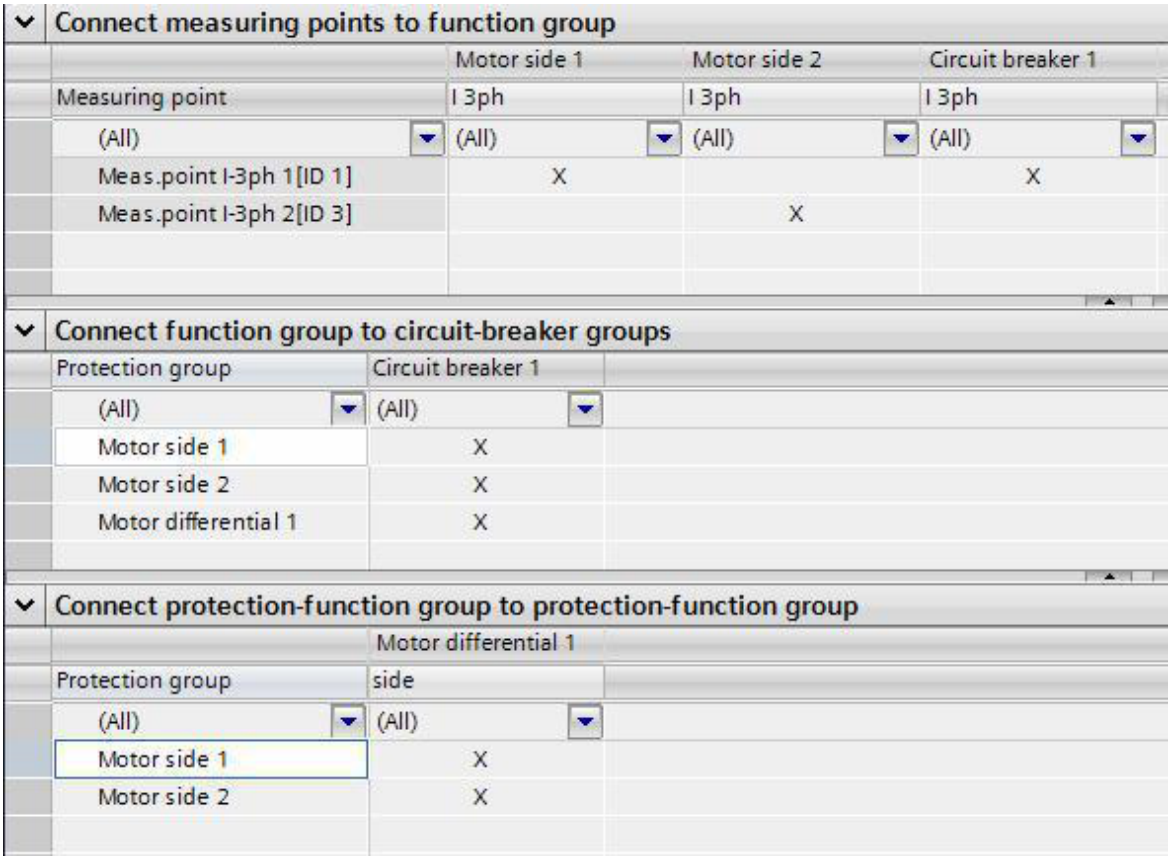


Figure 6-115 Connection Example

In the example, a 7UT85 is selected. Here, 2 measuring inputs are interconnected on the 3-phase measuring points of side 1 and side 2. The measuring points must be interconnected with the corresponding function groups.

Figure 6-116 shows the corresponding screenshot from DIGSI 5.



[scmesveb-200214-01, 1, en_US]

Figure 6-116 Internal Interconnection in DIGSI 5

Motor Side Function Group

In the **Motor side** function group, make the following settings:



NOTE

Ensure that the correct transformer data are set at the measuring points.

Parameter: `Rated apparent power`

- Default setting **`(_:14671:103) Rated apparent power`** = ***`6.65 MVA`***
  With this parameter, you set the rated apparent power of the motor. For a motor with 2 sides, the setting value is the same for both sides.

Parameter: `Motor rated voltage`

- Default setting **`(_:14671:102) Motor rated voltage`** = ***`6 kV`***
  With this parameter, you set the motor rated voltage of the motor. This is 6 kV in this example.

Motor Diff. Function Group

Make the following settings in the **Motor Diff.** function group for the I-Diff function:

Parameter: `Threshold` (Setting the Characteristic-Curve Parameters)

- Default setting **`(_:11041:3) Threshold`** = ***`0.20 I/Irated,obj`***

With this parameter, you set the pickup threshold for the differential current. This is the total current flowing into the protection range during a short circuit, regardless of how it is distributed on the sides of the protected object. The pickup value is relative to the rated current of the protected object. The default setting of ***0.20 I/Irated,obj*** is a practical value between sensitivity and possible disturbing influence.

Parameter: `Intersection 1 Irest`

- Default setting **`(_:11041:101) Intersection 1 Irest`** = ***0.67 I/Irated,obj***

The maximum current of the measuring point is used as restraint current. If you have to expect dynamic transmission faults of the current transformer even with small currents, half of the rated current is an appropriate setting value.

Parameter: `Slope 1`

- Default setting **`(_:11041:100) Slope 1`** = ***0.30***

With the **`Slope 1`**, you avoid an overfunction of the differential protection with low-current external faults as a consequence of current-transformer transmission faults (stationary and dynamic faults). The default setting of ***0.30*** is sufficient for many applications.

NOTE

The stabilization method has been changed from that in SIPROTEC 4 (7UT6x, 7UM62). For this reason, select a higher slope (also see *6.5.3 Function Description*).

Parameter: `Intersection 2 Irest`

- Default setting **`(_:11041:103) Intersection 2 Irest`** = ***2.50 I/Irated,obj***

NOTE

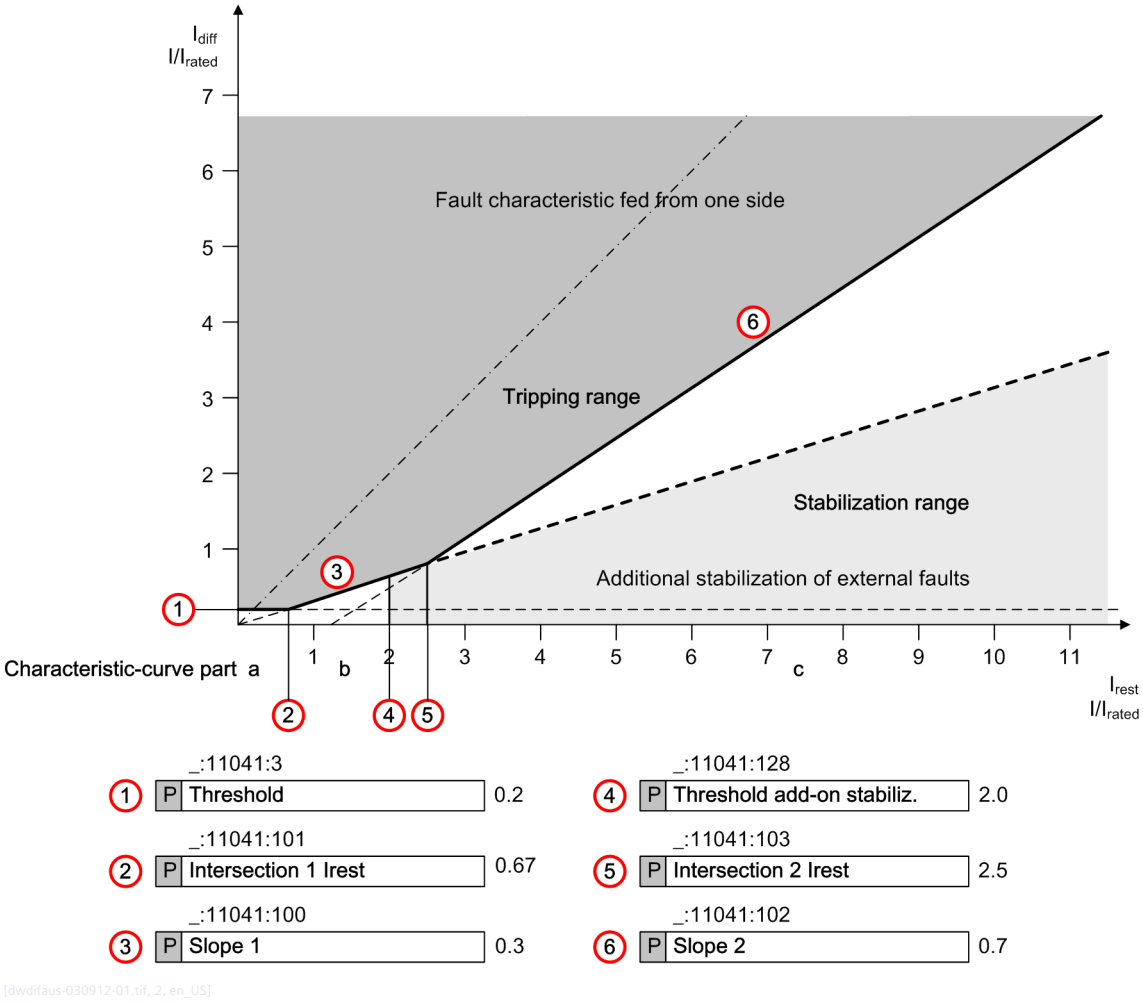
If you expect transmission problems with current transformers with larger currents flowing through, then the **`Slope 2`** must be selected to be larger.

The parameter **`Intersection 2 Irest`** determines from which restraint current the **`Slope 2`** begins. The default setting ***2.50 I/Irated,obj*** is a practical value.

Parameter: `Slope 2`

- Default setting **`(_:11041:102) Slope 2`** = ***0.70***

With the parameter **`Slope 2`**, an overfunction of the differential protection is avoided with high-current external faults as a consequence of current-transformer transmission faults (for example, due to saturation). A value greater than or equal to double the value of **`Slope 1`** is practical. As the default setting, ***0.70*** was selected.



[dwdifaus-030912-01.tif, 2, en_US]

Figure 6-117 Characteristic Curve with the Default Settings

Parameter: `Starting detection`

- Default setting **`(_:11041:106) Starting detection`** = ***`yes`***

To avoid overfunction due to the motor starting current, Siemens recommends activating startup detection for motor-protection applications. This is also recommended for protecting common-mode reactors. In this case, set the default setting **`Starting detection`** = ***`yes`***.

Parameter: `Thresh. startup detection`

- Default setting **`(_:11041:107) Thresh. startup detection`** = ***`0.1 I/Irated,obj`***

If the restraint current falls below this threshold value, the subsequently set characteristic-curve increase becomes effective with activated function. The default setting value of ***`0.1 I/Irated,obj`*** is recommended for the application.

Parameter: `Factor increasing char.`

- Default setting **`(_:11041:108) Factor increasing char.`** = ***`1.0`***

Change the default setting value in the case of application. An increase to the value 2.0 has proven itself to be sufficient for many applications.

Parameter: `Max. perm. Start. time`

- Default setting **`(_:11041:109) Max. perm. Start. time`** = ***`5.0 s`***

The setting value must lie above the maximum permissible starting time of the connected motor. Refer to the motor data sheets for the starting time (for example, **Locked Rotor** time). To guarantee tripping through the motor protection (starting time monitoring) and avoid overfunctions, select a somewhat longer time (factor 1.2 or higher). For the motor in the example, a rated torque for 6.5 s was assumed for 90 % rated voltage. The setting value should be larger than 1.2 * 6.5 s = 7.8 s. Siemens recommends a setting value of 10 s.

Parameter: `Factor increasing char. DC` (DC-Component Detection)

- Default setting **`(_:11041:110) Factor increasing char. DC`** = ***`2.3`***

DC-component detection is always active. As a result of the DC components, transmission problems can arise (for example, phase-angle rotations) in current transformers with small currents flowing. For this reason, the **`Threshold`** and the **`Slope 1`** are raised by the set factor. The default setting of 2.3 has proven itself with numerous applications.

Detection of External Faults

In *Figure 6-117*, the range **Add-on stabilization with external fault** is represented. The range is described by the parameters **`Add-on stabilization threshold value`** and **`Slope 1`**. With an external short circuit, the differential currents can increase beyond this range and reach into the tripping area. With the following parameters, time-limited blocking can be performed.

Parameter: `Threshold add-on stabiliz.`

- Default setting **`(_:11041:128) Threshold add-on stabiliz.`** = ***`2.00 I/Irated,obj`***

The **`Threshold add-on stabiliz.`** parameter allows you to set the pickup value for the additional stabilization. Due to the selected method of measurement, a setting value of ***`2.00 I/Irated,obj`*** is practical. The additional stabilization range is limited by the parameters **`Threshold add-on stabiliz.`** and **`Slope 1`**.

Parameter: `Time of add-on stabiliz.`

- Default setting **`(_:11041:129) Time of add-on stabiliz.`** = ***`0.30 s`***

As orientation for the setting value, you can use the operate time of the external feeder protection. Additionally, take into account the break time of the circuit breaker. Thus, the following calculation method results:

$t_{Z\text{-rest}} \geq t_{Trip,ext\ protection} + t_{Trip,circuit\ breaker}$

The default value is a practical value. You must adapt the value appropriately to use. The value 0 s deactivates the recognition of external faults.

Parameter: `Crossblk. time add-on st.`

- Default setting **`(_:11041:130) Crossblk. time add-on st.`** = ***`0.30 s`***

The additional stabilization acts separately on each phase. However, it can be extended to block all phases. Siemens recommends the activation of the crossblock function with a corresponding setting of the time. The set time must be identical to the time that is set for the duration of the additional stabilization.

Protection Stage I-DIFF Fast

The task of this protection stage is the fast detection of high-current internal faults (see also *I-DIFF Fast Differential Protection Function, Page 679*). For this reason, the protection stage must always be activated.

Parameter: `Threshold`

- Default setting **`(_:11071:3) Threshold`** = ***`7.5 I/Irated,obj`***

Siemens recommends setting the threshold value greater or equal to the starting current. For example, if the starting current of the motor is 5.6 $I/I_{rated,motor}$, set the threshold value to 6.0 $I/I_{rated,obj}$.

Protection Stage I-DIFF Unrestrained

The task of this protection stage is the fast detection of high-current internal faults (see also *I-DIFF Unrestrained Differential Protection Function, Page 682*).

Parameter: `Threshold`

- Default setting **`(_:18002:3) Threshold`** = ***`10.0 I/Irated,obj`***

Use the description of the protection stage **I-DIFF fast** (*Protection Stage I-DIFF Fast, Page 690*) for setting the threshold value.

6.5.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:186	General:Protection Mode		• Transformer • Current node	Transformer
_:2311:100	General:Meas. gnd. current side 1		• no • yes	no
_:2311:101	General:Meas. gnd. current side 2		• no • yes	no
_:2311:102	General:Meas. gnd. current side 3		• no • yes	no
_:2311:181	General:Meas. gnd. curr. autosides		• no • with CT 1ph • with CT 3ph	no
_:2311:182	General:Meas. gnd. curr. comp.side		• no • yes	no
_:2311:191	General:Reference side is		• not assigned • Side 1 • Side 2 • Side 3	not assigned
_:2311:151	General:MU-ID Side 1 Mp3ph 1		0 to 100	0
_:2311:152	General:MU-ID Side 1 Mp3ph 2		0 to 100	0
_:2311:153	General:MU-ID Side 1 Mp3ph 3		0 to 100	0
_:2311:154	General:MU-ID Side 1 Mp3ph 4		0 to 100	0
_:2311:155	General:MU-ID Side 1 Mp1ph		0 to 100	0
_:2311:156	General:MU-ID Side 2 Mp3ph 1		0 to 100	0
_:2311:157	General:MU-ID Side 2 Mp3ph 2		0 to 100	0
_:2311:158	General:MU-ID Side 2 Mp3ph 3		0 to 100	0
_:2311:159	General:MU-ID Side 2 Mp3ph 4		0 to 100	0

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:160	General:MU-ID Side 2 Mp1ph		0 to 100	0
_:2311:161	General:MU-ID Side 3 Mp3ph 1		0 to 100	0
_:2311:162	General:MU-ID Side 3 Mp3ph 2		0 to 100	0
_:2311:163	General:MU-ID Side 3 Mp3ph 3		0 to 100	0
_:2311:164	General:MU-ID Side 3 Mp3ph 4		0 to 100	0
_:2311:165	General:MU-ID Side 3 Mp1ph		0 to 100	0
_:2311:185	General:MU-ID Mp1ph		0 to 100	0
General				
_:11041:1	I-DIFF:Mode		• off • on • test	off
_:11041:2	I-DIFF:Operate & flt.rec. blocked		• no • yes	no
_:11041:6	I-DIFF:Operate delay		0.00 s to 60.00 s	0.00 s
Operate curve				
_:11041:3	I-DIFF:Threshold		0.05 I/IrObj to 2.00 I/IrObj	0.20 I/IrObj
_:11041:100	I-DIFF:Slope 1		0.00 to 0.80	0.30
_:11041:101	I-DIFF:Intersection 1 Irest		0.00 I/IrObj to 5.00 I/IrObj	0.67 I/IrObj
_:11041:102	I-DIFF:Slope 2		0.25 to 0.95	0.70
_:11041:103	I-DIFF:Intersection 2 Irest		1.00 I/IrObj to 20.00 I/IrObj	2.50 I/IrObj
Starting detection				
_:11041:106	I-DIFF:Starting detection		• no • yes	yes
_:11041:107	I-DIFF:Thresh. startup detection		0.1 I/IrObj to 2.0 I/IrObj	0.1 I/IrObj
_:11041:108	I-DIFF:Factor increasing char.		1.0 to 5.0	1.0
_:11041:109	I-DIFF:Max. perm. Start. time		0.1 s to 180.0 s	5.0 s
DC offset detection				
_:11041:110	I-DIFF:Factor increasing char. DC		1.0 to 5.0	2.3
Ext. fault detection				
_:11041:128	I-DIFF:Threshold add-on stabiliz.		1.00 I/IrObj to 20.00 I/IrObj	2.00 I/IrObj
_:11041:129	I-DIFF:Time of add-on stabiliz.		0.00 s to 5.00 s;∞	0.30 s
_:11041:130	I-DIFF:Crossblk. time add-on st.		0.00 s to 2.00 s;∞	0.30 s
I-DIFF fast				
_:11071:1	I-DIFF fast:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:11071:3	I-DIFF fast:Threshold		0.5 I/IrObj to 35.0 I/IrObj	7.5 I/IrObj
_:11071:6	I-DIFF fast:Operate delay		0.00 s to 60.00 s	0.00 s
_:11071:100	I-DIFF fast:Operate & flt.rec. blocked		• no • yes	no
I-DIFF unrestr				
_:18002:1	I-DIFF unrestr:Mode		• off • on • test	off
_:18002:3	I-DIFF unrestr:Threshold		0.5 I/IrObj to 35.0 I/IrObj	10.0 I/IrObj
_:18002:6	I-DIFF unrestr:Operate delay		0.00 s to 60.00 s	0.00 s
_:18002:100	I-DIFF unrestr:Operate & flt.rec. blocked		• no • yes	no

6.5.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:I diff.	WYE	O
_:2311:301	General:I restr.	WYE	O
_:2311:311	General:I diff. operate phA	MV	O
_:2311:312	General:I diff. operate phB	MV	O
_:2311:313	General:I diff. operate phC	MV	O
_:2311:314	General:I restr. operate phA	MV	O
_:2311:315	General:I restr. operate phB	MV	O
_:2311:316	General:I restr. operate phC	MV	O
I-DIFF			
_:11041:81	I-DIFF:>Block stage	SPS	I
_:11041:54	I-DIFF:Inactive	SPS	O
_:11041:52	I-DIFF:Behavior	ENS	O
_:11041:53	I-DIFF:Health	ENS	O
_:11041:55	I-DIFF:Pickup	ACD	O
_:11041:56	I-DIFF:Operate delay expired	ACT	O
_:11041:57	I-DIFF:Operate	ACT	O
_:11041:301	I-DIFF:Slope 1	MV	O
_:11041:302	I-DIFF:Incr. of char. (Start)	SPS	O
_:11041:303	I-DIFF:Increase of char. (DC)	SPS	O
_:11041:312	I-DIFF:Blocked by ext. fault	ACT	O
_:11041:313	I-DIFF:Crossbl. by ext. fault	SPS	O
I-DIFF fast			
_:11071:81	I-DIFF fast:>Block stage	SPS	I
_:11071:54	I-DIFF fast:Inactive	SPS	O
_:11071:52	I-DIFF fast:Behavior	ENS	O
_:11071:53	I-DIFF fast:Health	ENS	O
_:11071:55	I-DIFF fast:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:11071:57	I-DIFF fast:Operate	ACT	O
_:11071:56	I-DIFF fast:Operate delay expired	ACT	O
I-DIFF unrestr			
_:18002:81	I-DIFF unrestr:>Block stage	SPS	I
_:18002:54	I-DIFF unrestr:Inactive	SPS	O
_:18002:52	I-DIFF unrestr:Behavior	ENS	O
_:18002:53	I-DIFF unrestr:Health	ENS	O
_:18002:55	I-DIFF unrestr:Pickup	ACD	O
_:18002:57	I-DIFF unrestr:Operate	ACT	O
_:18002:56	I-DIFF unrestr:Operate delay expired	ACT	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O

6.6 Generator Differential Protection

6.6.1 Overview of Functions

The **Generator differential protection** function (ANSI 87G):

- Detects short circuits in generators
- Detects ground faults in generators with a grounded neutral point (typical for low voltage)
- Is stable in the event of external short-circuits with current-transformer saturation through intelligent saturation-detection methods
- Triggers safely in the case of internal high-current faults through an additional high-current stage

6.6.2 Structure of the Function

The **Generator differential protection** function is used in the **Generator Diff** protection function group. The function depends upon application in the corresponding application template preconfigured by the manufacturer or can be copied during the engineering into the corresponding function group.

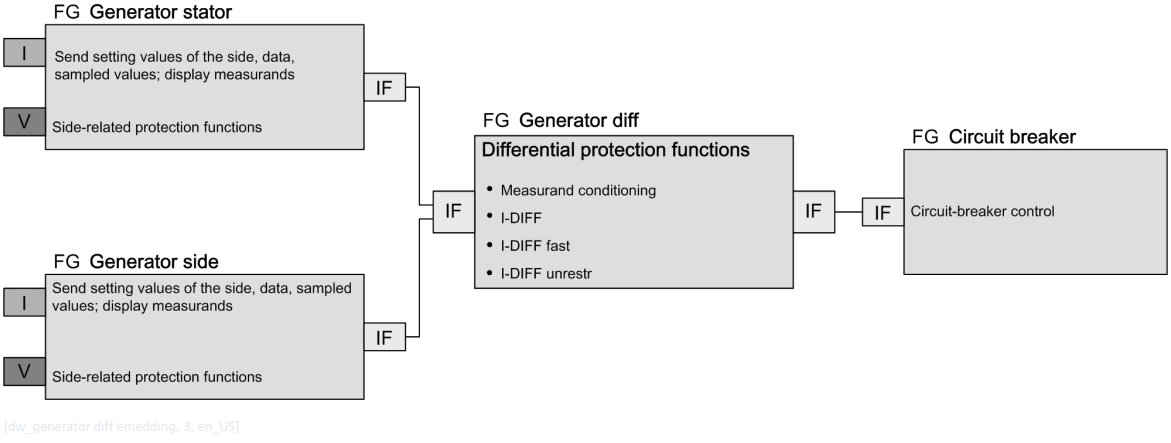
The **Generator differential protection** function consists of the 2 tripping stages I-DIFF and I-DIFF fast. In addition, the I-DIFF unrestrained tripping stage is available. You can select this tripping stage from the function catalog and copy it into the **Generator differential protection** function. The tripping stages can be blocked, in addition you can switch the tripping stages on and off.

In the function groups **Generator side** and **Generator stator**:

- The side-related protection settings are performed
- The side-related calculations are performed
- All data (setting values, detected currents) are relayed to the **Generator diff** function group

The side-related protection functions can run in the **Generator side** function group, for example overload protection, overcurrent protection, etc.

The majority of the typical generator protection functions are located in the **Generator stator** function group. These work with the neutral-point side current transformers.



[dw_generator diff emedding, 3, en_US]

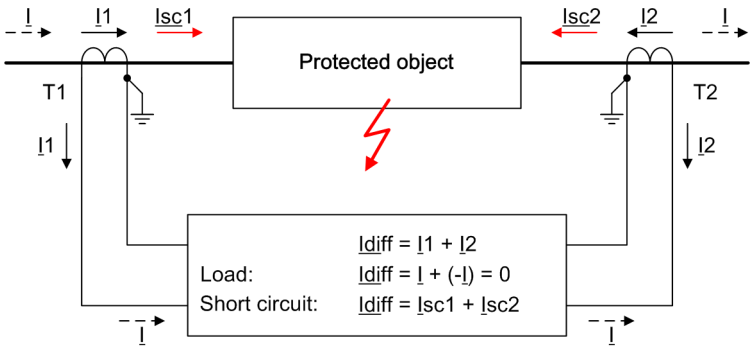
Figure 6-118 Embedding of the Function

6.6.3 Function Description

Basic Principle of Differential Protection

Differential protection is based on a comparison of currents (Kirchhoff current law). When comparing the current, use is made of the fact that a protected object uses the same current I in a non-faulty operating state

on both sides (dotted in *Figure 6-98*). This current flows into the range being observed on one side and leaves it again on the other side. A current differential is a sure indication of a fault within the protected object. The calculation of the difference is determined through the current-direction definition. The current direction is defined as positive to the protected object. The current difference results from the vector addition of the currents.



[dwprin2s-170712-01.tif, 1, en_US]

Figure 6-119 Basic Principle of Differential Protection Using the Example of 2 Sides

For safe operation, additional functions are required. The implementation of these additional functions is described in chapter *I-DIFF Differential Protection Function, Page 672*.

Current Stabilization

If very large currents flow through the protection range in the case of external faults, with different transmission behavior of the transformers **T1** and **T2** (*Figure 6-98*), a corresponding differential current I_{diff} occurs. When this is larger than the corresponding pickup threshold, the device can issue a trip command, even though no fault is present in the protection range. Such a malfunction of the protection is avoided by the restraint current (I_{rest}) and is implemented in the form of a characteristic curve $I_{diff} = f(I_{rest})$.

The largest current of 2 or more measuring points of the protected object is used for stabilization.

The definition for 2 measuring points is:

A trip or differential current is

$I_{diff} = (\underline{I}_1 + \underline{I}_2)$

as well as a restraint current of

$I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2|)$

For more than 2 measuring points, this definition is expanded. This restraint method allows a reliable trip decision for more than 2 measuring points and different feeding behavior for internal short circuits.

$I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2| ; \ldots |\underline{I}_n|)$

To clarify the effect, 3 important operating states are observed with ideal and adapted measurands.

- Through fault current in healthy operation or externally caused error:

  $\underline{I}_1$ flows into the protection range, $\underline{I}_2$ flows out of the protection range, that is, negative compared with the prefix definition, thus $\underline{I}_2 = -\underline{I}_1$;

  in addition $|\underline{I}_2| = |\underline{I}_1|$

  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 - \underline{I}_1| = 0$

  $I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2|) = |\underline{I}_1| = |\underline{I}_2|$

  No tripping quantity ($I_{diff} = 0$); the stabilization (I_{rest}) corresponds to the flowing current.

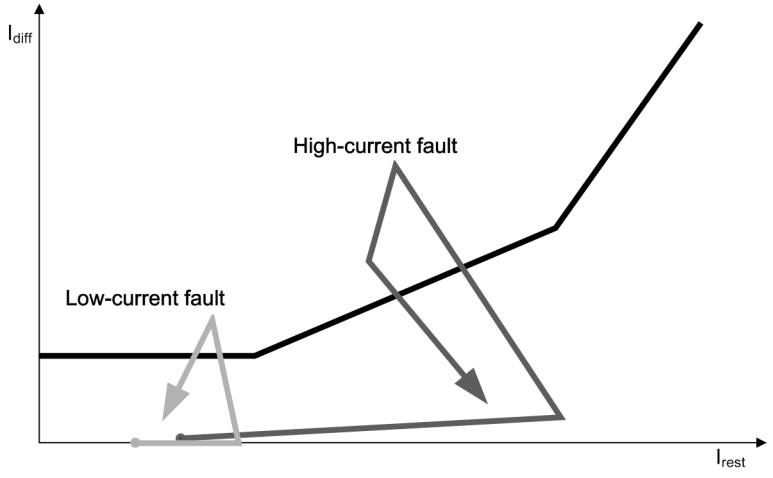
- Internal short circuit, feed from both sides with equal amount of currents, for example:
  Then $\underline{I}_2 = \underline{I}_1$; In addition $|\underline{I}_2| = |\underline{I}_1|$;
  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 + \underline{I}_1| = 2 \cdot |\underline{I}_1|$
  $I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2|) = |\underline{I}_1| = |\underline{I}_2|$
  The tripping quantity (I_{diff}) is twice as large as the short-circuit current and the restraining quantity (I_{rest}).
- Internal short circuit, feed only from one side:
  Then $\underline{I}_2 = 0$
  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 + 0| = |\underline{I}_1|$
  $I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2|) = |\underline{I}_1|$
  The tripping quantity (I_{diff}) and the restraining quantity (I_{rest}) are of the same size and correspond to the short-circuit current.

Additional Stabilization with External Short Circuits

In case of an external short circuit, high short-circuit currents flowing through can lead to current-transformer saturation. This saturation can be more or less strongly pronounced at the measuring points, and in this way simulate a differential current. The differential current can lie in the tripping range of the characteristic curve for a certain time and lead to unwanted tripping without any particular measures. In accordance with *Figure 6-99*, there are 2 typical scenarios:

- High-current, external short circuit
  First, the current on both sides is transferred and leads to a large restraint current. After this, a transformer becomes saturated, resulting in a differential current I_{diff} that can exceed the operate curve. Simultaneously, the restraint current I_{rest} drops. Once the transformer is no longer saturated, the differential current decreases and falls below the characteristic curve.
- Low-current, external short circuit
  Current transformers can also become saturated through the large direct-current time constant (switching of transformers, motors), but small currents flowing through. This manifests itself as a phase-angle rotation of the current. Exceeding the characteristic curve in a non-stabilized area is possible.

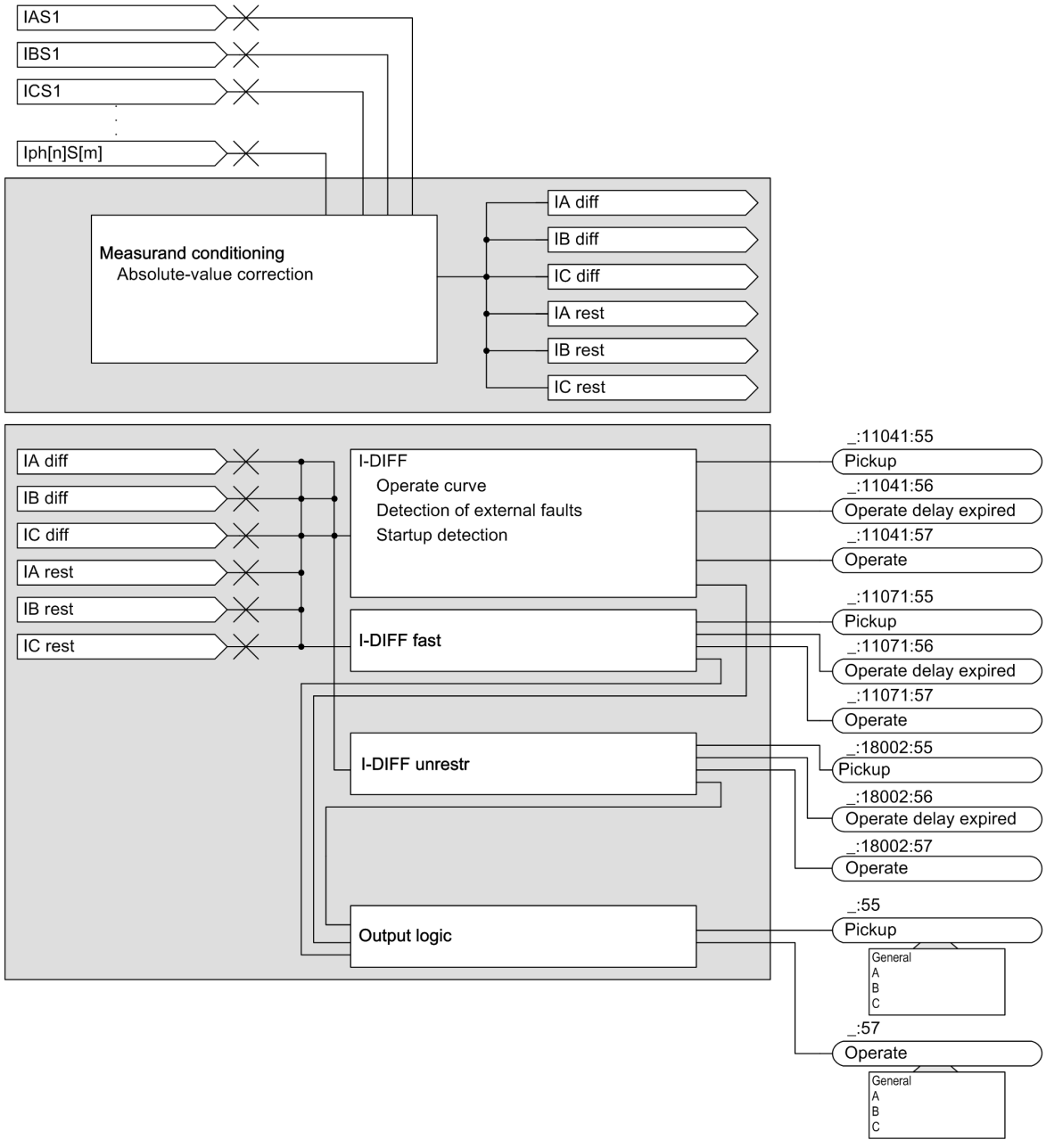
Intelligent saturation-detection methods capture this state and lead to a temporally limited blocking of the Differential protection function.



[dwislauf-170712-01.tif, 1, en_US]

Figure 6-120 Principle Current Course in External Short Circuit and Temporary Current-Transformer Saturation on One Side

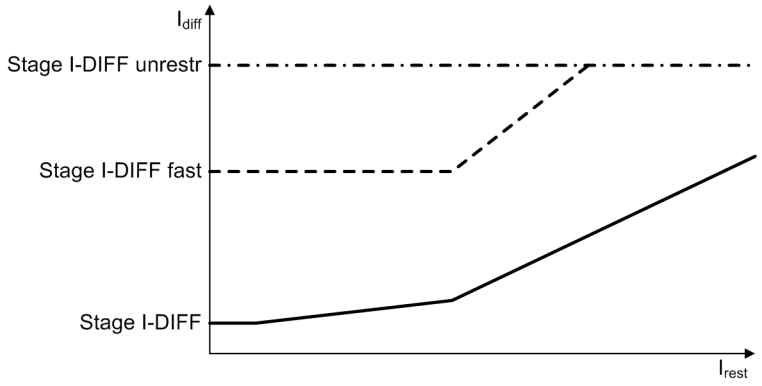
Logic of the Function



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Figure 6-121 Logic Diagram of the Differential Protection Function

The interaction of the I-DIFF, I-DIFF fast, and I-DIFF unrestrained tripping stages is shown in the following operate curve.



[dw_charac_function_trans-dif, 1, en_US]

Figure 6-122 Operate Curve of the Differential Protection Function

In the following, the essential components of differential protection are described in detail.

Measurand Processing

Amount Correction

Since the current transformers cannot be adapted exactly to the rated currents of the protected object with regard to their primary rated data, a standardization to the nominal sizes of the protected object takes place. The conversion occurs every sampling time (thus, for instantaneous values). The differential protection function processes 20 sampled values per period. In addition, the sampled values tracked are used. A high degree of accuracy can be attained over the entire tracking range (from 10 Hz to 90 Hz).

The IDIFF-fast tripping and the IDIFF-unrestrained tripping stages work on non-frequency tracked values and thus, implement fast operate times at low frequencies.

The amount is adapted via the following formula:

$$i^{*}_{phsx} = k\, i_{phsx}$$

$$\text{with } k = \frac{I_{rated\,prim,\,Sx}}{I_{rated\,obj,\,Sx}} = \frac{I_{rated\,prim,\,Sx}}{\frac{S_{rated,\,ref}}{V_{rated,\,Sx}\sqrt{3}}}$$

[fobetr07-170712-01.tif, 1, en_US]

i_{phsx}*	Adapted instantaneous value per phase (x = A, B, C)
i_{phsx}	Instantaneous value per phase (x = A, B, C)
k	Correction value per measuring point
$I_{rated\ prim,Sx}$	Primary transformer rated current per measuring point
$I_{rated\ obj,Sx}$	Primary rated current of the protected object
$S_{rated,ref}$	Reference power (maximum rated apparent power of the protected object)
$V_{rated,Sx}$	Rated voltage of the respective side (measuring point) of the protected object

I-DIFF Differential Protection Function

A differential current per phase based on the instantaneous value variables is calculated from the processed currents (see section Measurand Processing). The direction of current flow is defined as to the **protected object as positive**. The fundamental component contribution to the differential current (I_{diff}) is calculated via a Fourier filter (filter length = 1 period (20 sampled values)).

The currents of that measuring point whose RMS value is the largest are used as restraint current. If, for example, the current collapses at a measuring point as a consequence of current-transformer saturation,

the measuring point that has the largest current is automatically switched to at the point in time of the calculation.

$$i_{diff,phsx} = \sum_{m=1}^{N} i^{*}_{phsx,Mm} \rightarrow I_{diff,phsx} = FIR(i_{diff,phsx})$$

$$I_{phsx,Mm} = \sqrt{\frac{1}{n}\sum_{k=1}^{n} i^{*2}_{phsx,Mm}(k)}$$

$$I_{rest,phsx} = \underset{m=1}{\overset{N}{MAX}}\, I_{phsx,Mm}$$

[fogrds16-170712-01.tif, 1, en_US]

With

x	Variable (1, 2, 3) for the phase currents (A, B, C)
m	Variable (1, 2, ..., N) for the measuring points
N	Number of measuring points
n	Number of samples per period (n = 20)
FIR	Fourier filter
MAX	Maximum value determination

Pickup Characteristic

Figure 6-102 shows the pickup characteristic of the differential protection. The characteristic curve branch **a** represents the sensitivity threshold of the differential protection (parameter **Threshold**) and considers constant fault currents like magnetizing currents.

The characteristic branch **b** (parameter **Intersection 1 Irest** and **Slope 1**) considers current-proportional faults under normal operating conditions.

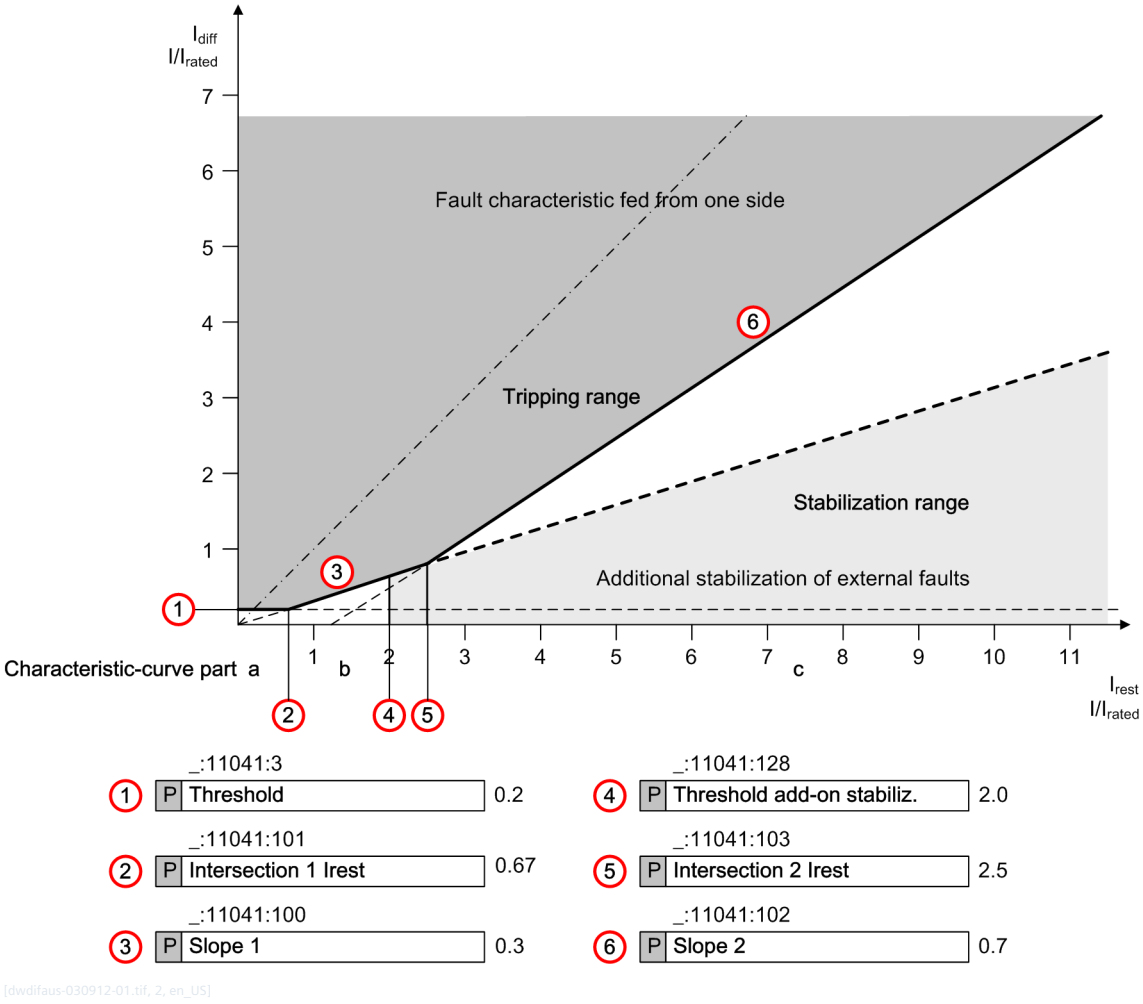
These faults can occur for the following reasons:

- Transformation errors in the current transformer and the input transformer of the device
- Adaptation deviations

The characteristic curve branch **c** (parameter **Intersection 2 Irest** and **Slope 2**) protects the differential protection against overfunction in case of high-current external faults and transformer saturation. In this range, transformer saturation can arise due to high short-circuit currents, and because of this, a higher differential current results.

In order to avoid overfunction in the event of external faults with current-transformer saturation, a logic is implemented that uses the characteristic curve **Additional stabilization of external faults**. If the operating point is located in the additional stabilization range and exceeds the operate curve from there, then the logic becomes active and blocks the differential protection.

The additional stabilization range is derived from the **Threshold add-on stabiliz.** and **Slope 1** parameters.



[dwdifaus-030912-01.tif, 2, en_US]

Figure 6-123 Pickup Characteristic of the Differential Protection

If the differential current multiplied by the dropout ratio of 0.7 does not reach the pickup characteristic, the pickup drops out.

Detection of External Faults

To detect external faults with transformer saturation in a reliable way, the measurand curve is evaluated in the Diff.-Rest level by means of a detector. An external fault can occur if the motor feeds back to an external short circuit or if the motor starts up.

The detector has 2 essential tasks:

- **Blocking in the case of a definite high-current external fault**

  The differential current and the restraint current are monitored on a phase basis in the Diff/Restr level immediately after fault inception. To ensure the stability of the saturation detection for low saturation-free times of the primary current transformer, estimated values based on the difference quotients of the instantaneous values are used.

  If the estimated restraint current exceeds the **Threshold add-on stabiliz.** parameter and the expected value of the differential current of all phases is in the additional stabilization range (parameter **Slope 1**) (*Figure 6-102*) at the same time, the detector is active and the indication *Blocked by ext. fault phsx* appears. The tripping of the Differential protection function is blocked.

  If an external fault arises and is cleared by the protection responsible for it, the additional stabilization drops out. If the dropout ratio (0.7) of the RMS value of the restraint current does not reach the **Threshold add-on stabiliz.** parameter (*Figure 6-102*), the additional stabilization drops out. The indication *Blocked by ext. fault phsx* is reset.

  If the differential current exceeds **Slope 1** as a result of transformer saturation, that is, there is a pickup phsx, the blocking is limited in time (parameter: **Time of add-on stabiliz.**).

  Starting with the indication *Blocked by ext. fault phsx*, the other phases can be blocked with it via the **Crossblk. time add-on st.** parameter. If differential currents due to transformer saturation spread to the other phases through the vector-group correction or residual current elimination, this blocking is necessary.

- **Removal of the blocking with a change in fault location from external to internal**

  An internal fault can arise as a consequence of an external fault. This fault change must be recognized and the blocking must be removed. The critical case is a short-circuit with current-transformer saturation. The saturation detection examines here the instantaneous values of the differential current. With transformer saturation, the instantaneous values fall below an internal threshold in the saturation-free time. If this threshold is permanently exceeded and a pickup is present in the corresponding phase, an internal error is assumed. The other phases are also examined during the parameterization with crossblock.

  The blocking of the tripping is removed and the indication *Blocked by ext. fault phsx* is reset.

DC-Component Detection

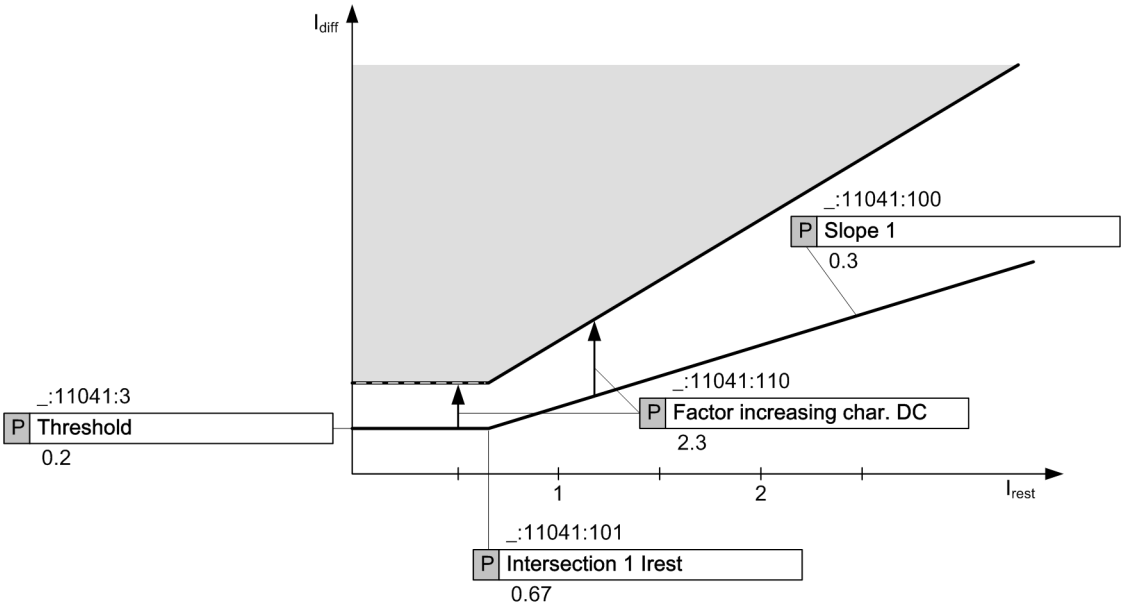
Low-current external faults with large DC components can also lead to exceeding of the operate curve. The additional stabilization range is not attained, however.

To avoid an overfunction, the following steps are taken:

- The restraint current $I_{rest.;phsx}$ is monitored for a jump.
- If the jump occurs, the DC component is calculated, with a temporal delay (1 period), from the instantaneous value of the restraint current (current at the measuring point with the largest current) $i_{rest.,phsx} = i_{phsx,Mm}$. The result is $I_{rest.DC,phsx}$. This current is compared to the restraint current $I_{rest.,\ phsx}$ and is checked for exceeding of the internal threshold.
- The differential current $I_{diff,phsx}$ must lie below the dropout characteristic curve (characteristic curve · 0.7) in all 3 phases.
- If the first 3 points lead to positive results, then the operate curve is raised by the parameter **Factor increasing char.** with a default setting of ***2.3***. Here, only the threshold value and the slope 1 are raised (see *Figure 6-103*). The indication *Increase of char. (DC)* is output. If the product of parameter **Factor increasing char.** and **Slope 1** exceeds **0.85**, the maximum increase of the raised **Slope 1** is limited to 0.85.
- As additional criterion, the pickup indication *Pickup* (internal fault is present) or the indication of the additional stabilization *Blocked by ext. fault phsx* (high-current external fault) is interrogated. If one of the 2 conditions is present, the characteristic-curve increase is stopped. A retroactive pickup no longer resets the characteristic-curve increase. A pickup with DC-component detection occurs only if the raised operate curve is exceeded.

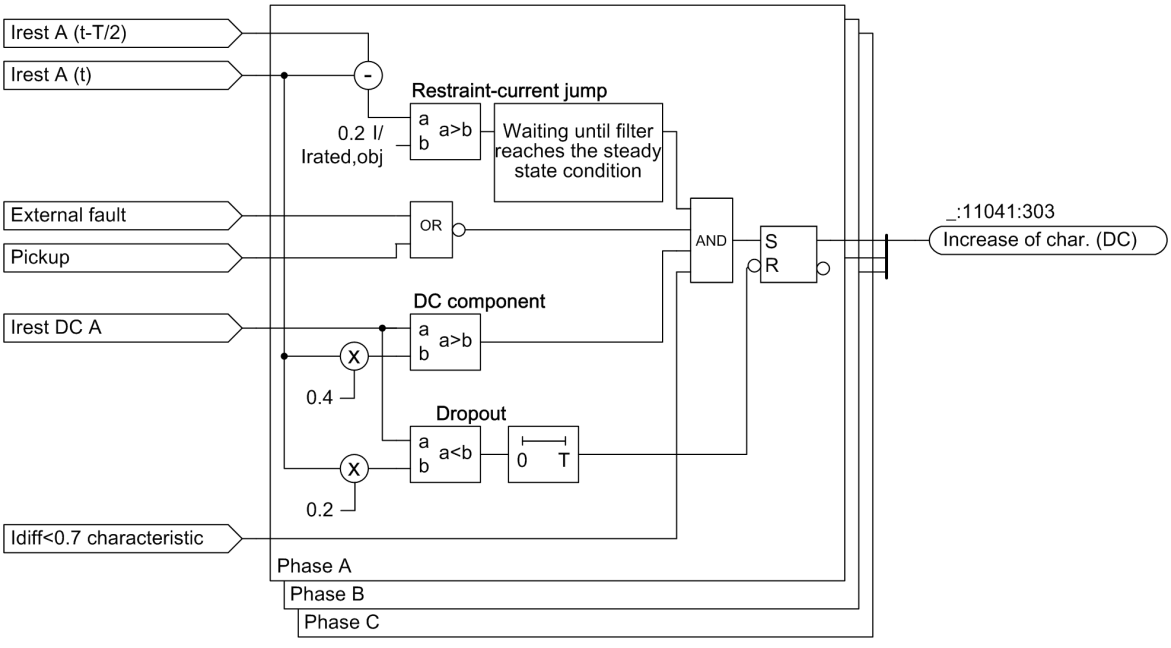
If the DC component $I_{rest.DC,phsx}$ falls below the internal dropout threshold, the dropout delay is determined as follows:

It is assumed that the de- and re-magnetization of the transformer last equally long. The magnetization is at the highest at the point in time in which the internal dropout threshold is attained. The time is measured from the start of the DC-component detection until the internal dropout threshold is reached. Added to this time are 5 periods and from this, the dropout delay is derived. Following this, the characteristic-curve increase is reset to the original value. *Figure 6-104* shows the overall logic.



[dwdcerkn-201112-01.tif, 2, en_US]

Figure 6-124 Increasing the Characteristic Curve after DC Detection



[lodcerkn-170712-01.tif, 3, en_US]

Figure 6-125 Logic DC Detection

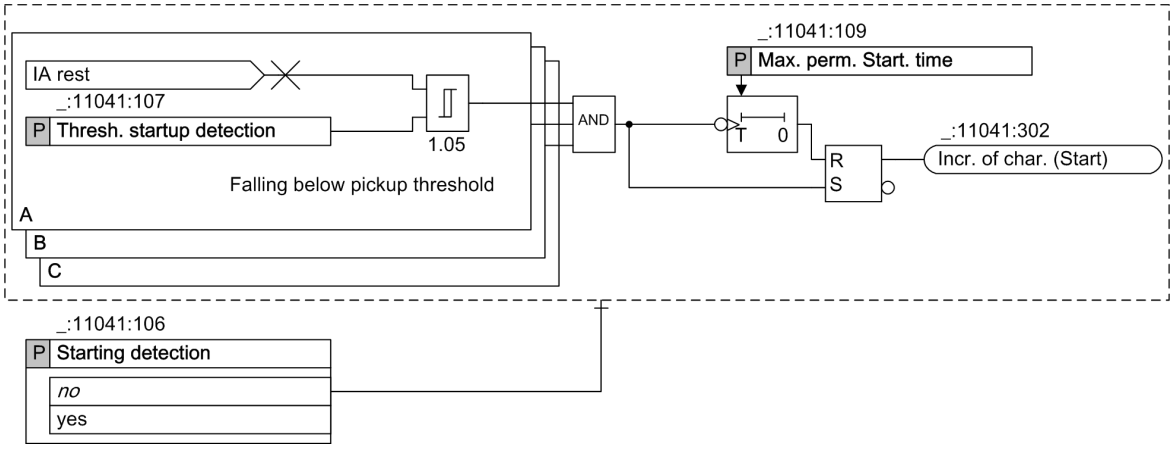
Startup Detection

The startup detection is particularly useful in the case of motors. In contrast to transformers, the inrush current with motors is a flowing current. Differential currents can arise, however, by the current transformers having different residual magnetization and being supplied with current at different operating points of their hysteresis. These differential currents are low in fact, but they can lead to overfunction with sensitive setting of the differential protection.

With generators, the motor startup can also lead to higher currents. With the startup detection, you can make the protection somewhat less sensitive for a specific period of time and avoid overfunction. As a result you achieve a comparable effect to that of DC-component detection.

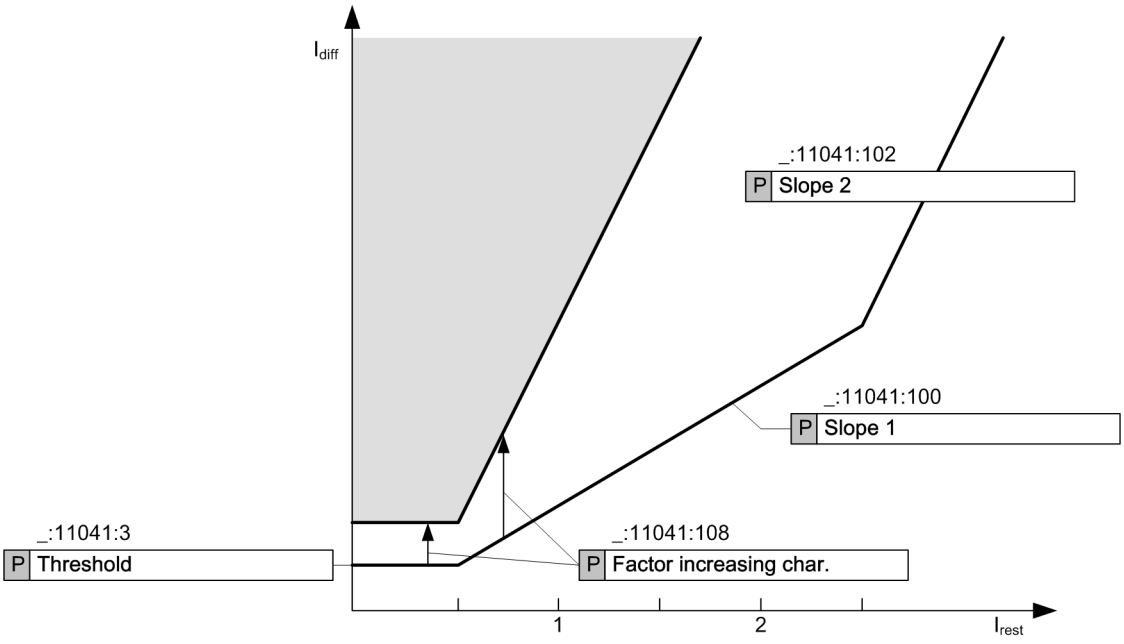
As additional security against overfunction when switching in a previously protected object that carries no current, you can use the pickup-value increase at startup. If the restraint current falls below a settable value **`Thresh. startup detection`** in all phases, the pickup-value increase is activated. The pickup value **`Threshold`** and **`Slope 1`** are raised by the set value in accordance with parameter **`Factor increasing char.`**. As a rule here, **`Slope 1`** cannot exceed a value of 0.85.

If the parameter **`Thresh. startup detection`** is exceeded, dropout occurs and a timing element (parameter: **`Max. perm. Start. time`**) is activated. Once this time has elapsed, the characteristic curve that was increased in all phases is reset to its original value. *Figure 6-105* shows the logic diagram of the startup detection and *Figure 6-106* the increased characteristic curve.



[loanlauf-170712-01.tif, 3, en_US]

Figure 6-126 Logic Startup Detection



[dwanlken-201112-01.tif, 1, en_US]

Figure 6-127 Characteristic-Curve Increase at Startup

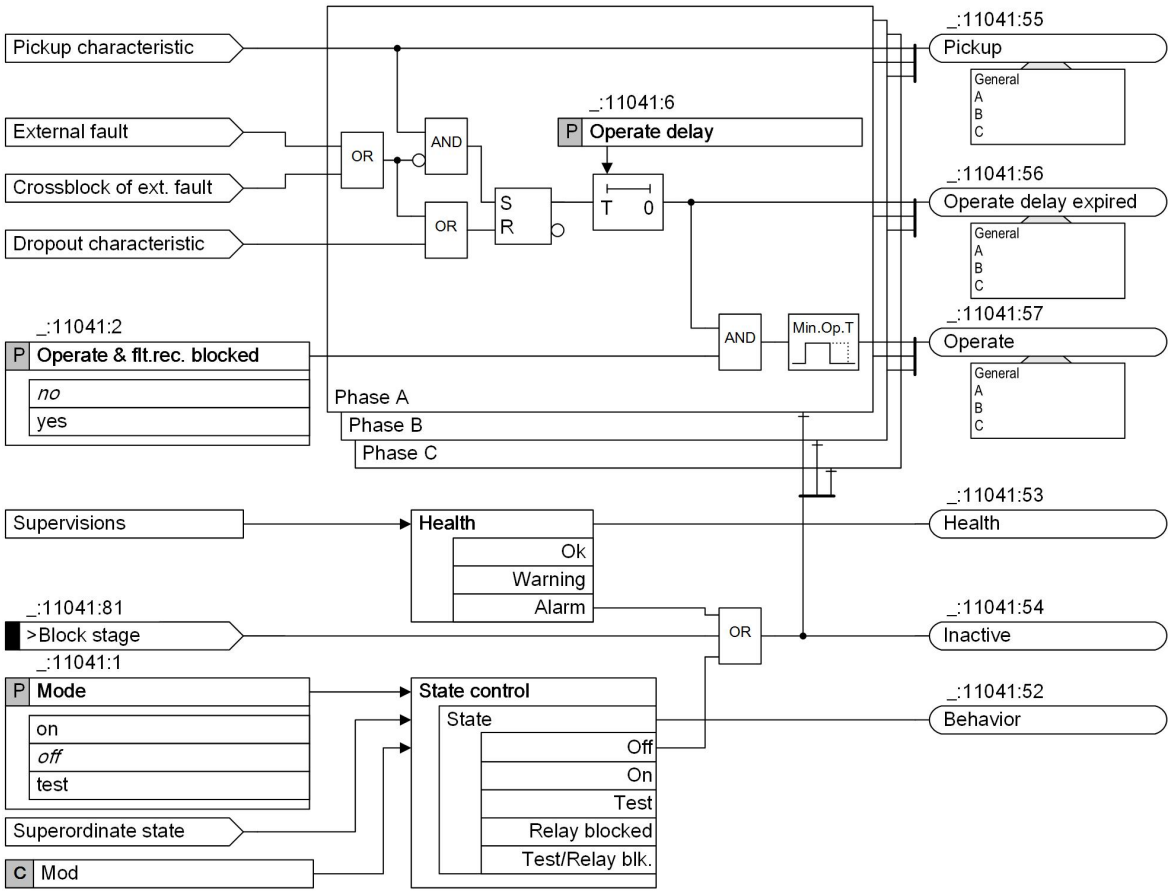
Trip Logic of the Differential Protection Function I-DIFF

Figure 6-107 shows the trip logic. If the characteristic curve is exceeded (see *Figure 6-102*) a pickup occurs. Redirection of the information for tripping can be blocked by the additional functions.

Blocking is possible through use of the following influencing variables:

- Recognition of external faults that can simulate an internal fault through transformer saturation

In addition, in case of blocking due to an *external error*, a **crossblock** mechanism comes into effect.



[lo_aus_mid, 2, en_US]

Figure 6-128 Trip Logic of I-DIFF

I-DIFF Fast Differential Protection Function

As a supplement to the I-DIFF differential protection function, the function I-DIFF fast is available. The main task consists in switching off high-current internal faults in the shortest amount of time. The method controls current-transformer saturation and is stable in the event of external transverse faults (integration in breaker-and-a-half arrangements).

Metrologically, 2 methods are combined:

- Instantaneous-value method
- Filter-based method

Instantaneous-Value Method

Through the instantaneous-values method, an immediate evaluation of the sampled values of the differential $i_{Diff}(t)$ and restraint current $i_{rest}(t)$ occurs. The absolute-value and vector-group adapted currents (i*) are also the basis. The currents are defined positively to the node. The restraint current is the maximum current of all measuring points.

$$i_{diff,phsx}(t) = \left| \sum_{m=1}^{N} i^{*}_{phsx,Mm}(t) \right|$$

$$i_{rest,phsx}(t) = \max_{m=1}^{N} \left| i^{*}_{phsx,Mm}(t) \right|$$

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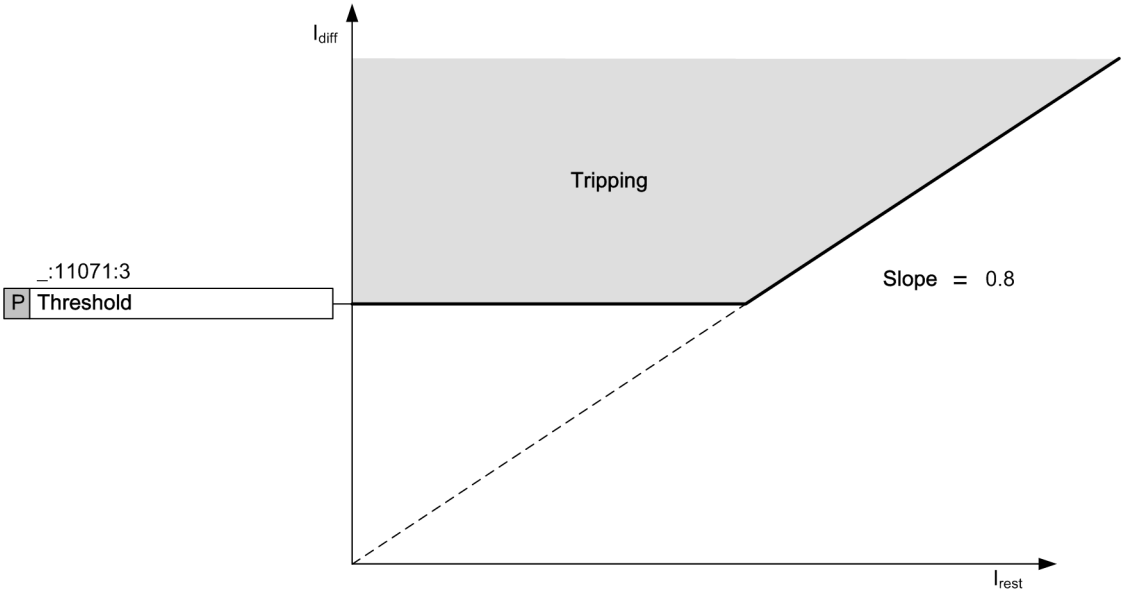
where

x	Variable (1, 2, 3) for the phase currents (A, B, C)
m	Variable (1, 2, ..., N) for the measuring points
N	Number of measuring points

The evaluation of the restraint current is used to recognize saturated, high-current external faults.
Figure 6-108 shows the operate curve. The parameter **Threshold** is set here such that it lies over the maximum fault current flowing. The slope of the characteristic curve is fixed at 0.8.
In the algorithm, the following conditions are processed:

- Condition 1: The increase of the restraint current $di_{rest}(t)/dt$ is determined continuously and compared with an internal threshold value.
- Condition 2: After that, a comparison determines whether the differential current is larger than the restraint current (characteristic curve **Slope** in *Figure 6-108*): $i_{diff}(t) > 0.8 \cdot i_{rest}(t)$.
- Condition 3: After that, a comparison determines whether the differential current exceeds the parameter **Threshold**.

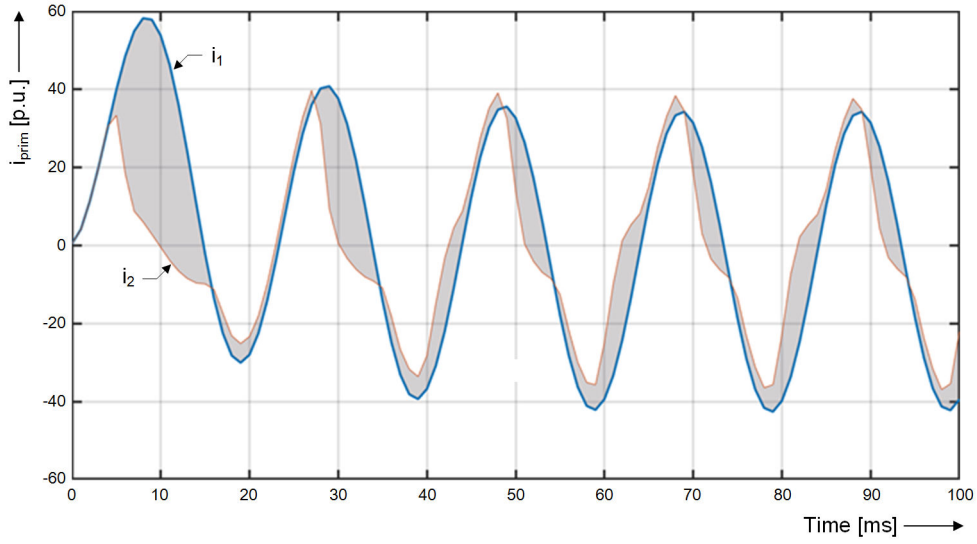
When all conditions are met, tripping occurs immediately. If the 1st condition is recognized and not the 2nd condition, then the function is blocked for 300 ms.



[dwidfast-300114-01.tif, 1, en_US]

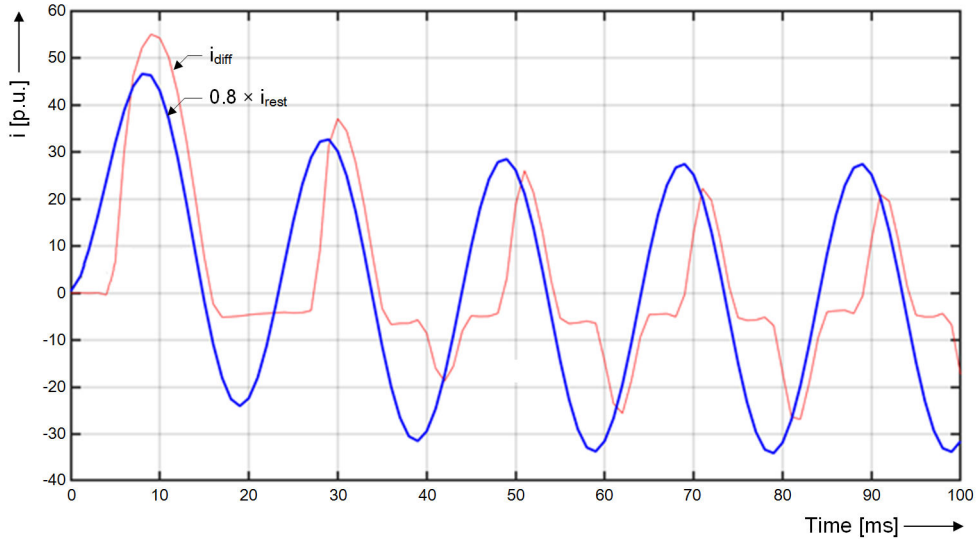
Figure 6-129 I-DIFF Fast Characteristic Curve

The 2 following figures show the behavior during an internal and an external fault. It is typical for the internal fault (*Figure 6-109*) that the differential current rises more quickly than the restraint current. After a few sampled values, the trip signal is issued. In case of an external fault, a differential current arises only after transformer saturation occurs. You can always assume, however, that the current is transferred a few milliseconds after occurrence of the fault. In accordance with *Figure 6-111*, the restraint current is larger than the differential current after occurrence of the fault, but condition 2 is not met and the function is therefore blocked.



[dwinnfel-201112-01.tif, 2, en_US]

Figure 6-130 Curve Plot for Internal Fault with Transformer Saturation (k= 0.65)



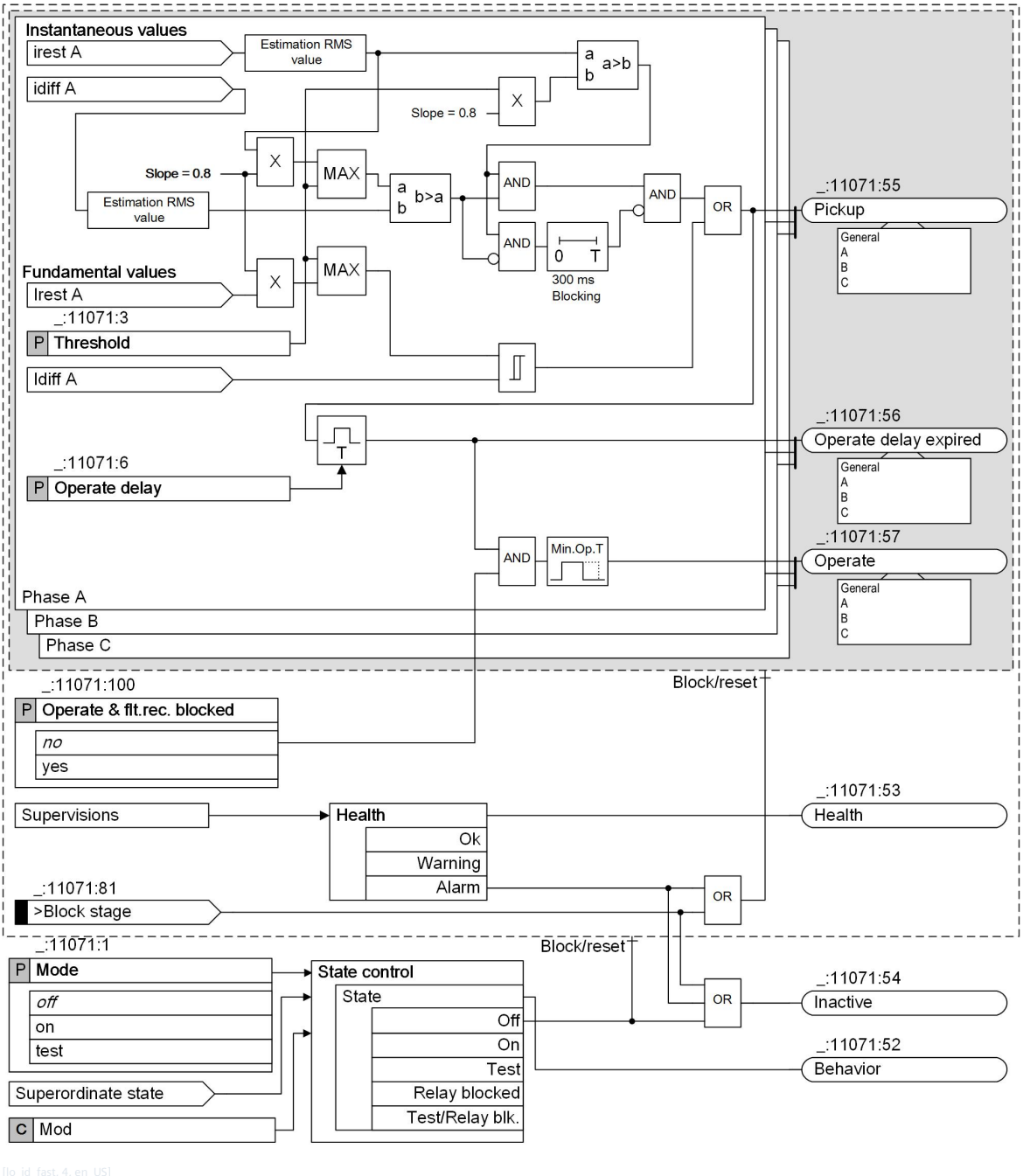
[dwextfel-170712-01.tif, 2, en_US]

Figure 6-131 Curve Plot for External Fault with Transformer Saturation (k= 0.65)

Fundamental-Component Method

Parallel to the instantaneous-value method, the fundamental component works with a temporal delay. Here, the same measured values are processed as with the I-DIFF method. The fundamental component of the differential current I_{diff} and the stabilization value (maximum current of a measuring point) $I_{rest.}$ are ordered in the operate curve according to *Figure 6-108* and the trip decision is made.

Figure 6-111 shows the overall logic.



[lo_id_fast, 4, en_US]

Figure 6-132 Logic of the I-DIFF Fast Differential Protection Function

I-DIFF Unrestrained Differential Protection Function

In addition to the I-DIFF and I-DIFF fast differential protection function, the function I-DIFF unrestrained is available. The main task of this function consists in switching off high-current internal short circuits in the shortest amount of time. The method controls current-transformer saturation.

High-current faults in the protection range can always be switched off immediately without consideration of the restraint currents if, due to the current magnitude, it is determined that an external fault is not involved. In the case of protected objects with a large intrinsic longitudinal impedance (transformer, generator, reactor), a current can be found that is never exceeded by a flowing short-circuit current.

For a transformer, for example, the (primary) value is:

$$\frac{1}{v_{sc\ transf.}} \cdot I_{N\ transf.}$$

[fo_Idiff-error, 1, en_US]

The I-DIFF unrestrained stage also acts if, for example, due to current-transformer saturation because of a DC component in the short-circuit current, a 2nd harmonic occurs. The inrush-current detection could interpret this as the closed-circuit current.

The I-DIFF unrestrained protection stage operates both with the fundamental component of the differential protection and with the instantaneous value.

Metrologically, 2 methods are combined:

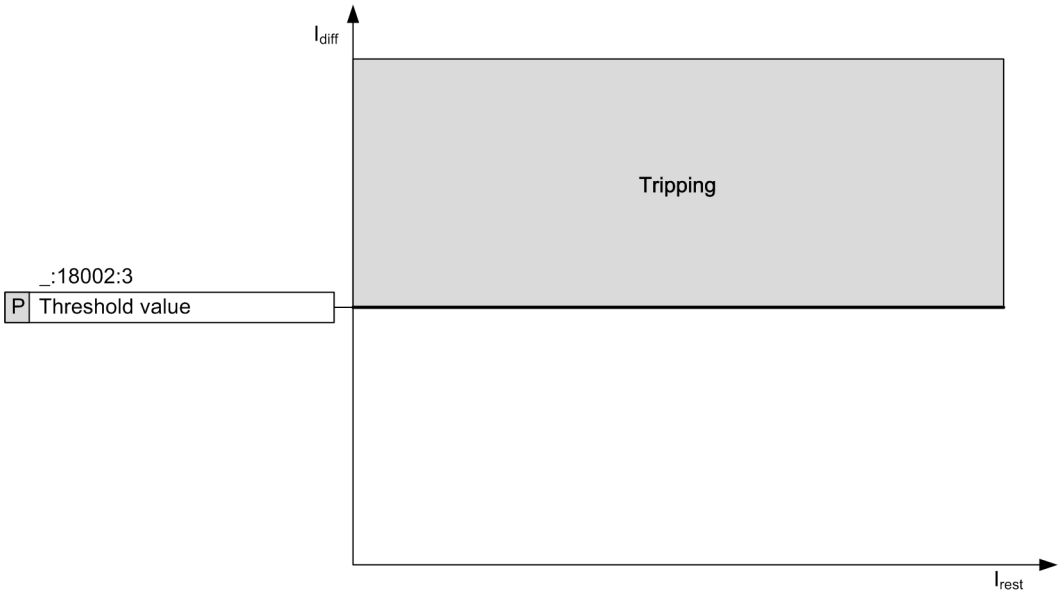
- Instantaneous-value method
- Filter-based method

Instantaneous-Value Method

With the instantaneous-values method, an immediate evaluation of the sampled values of the differential current $i_{Diff}(t)$ occurs. The absolute-value and vector-group adapted currents (i*) are also the basis.

Fundamental-Component Method

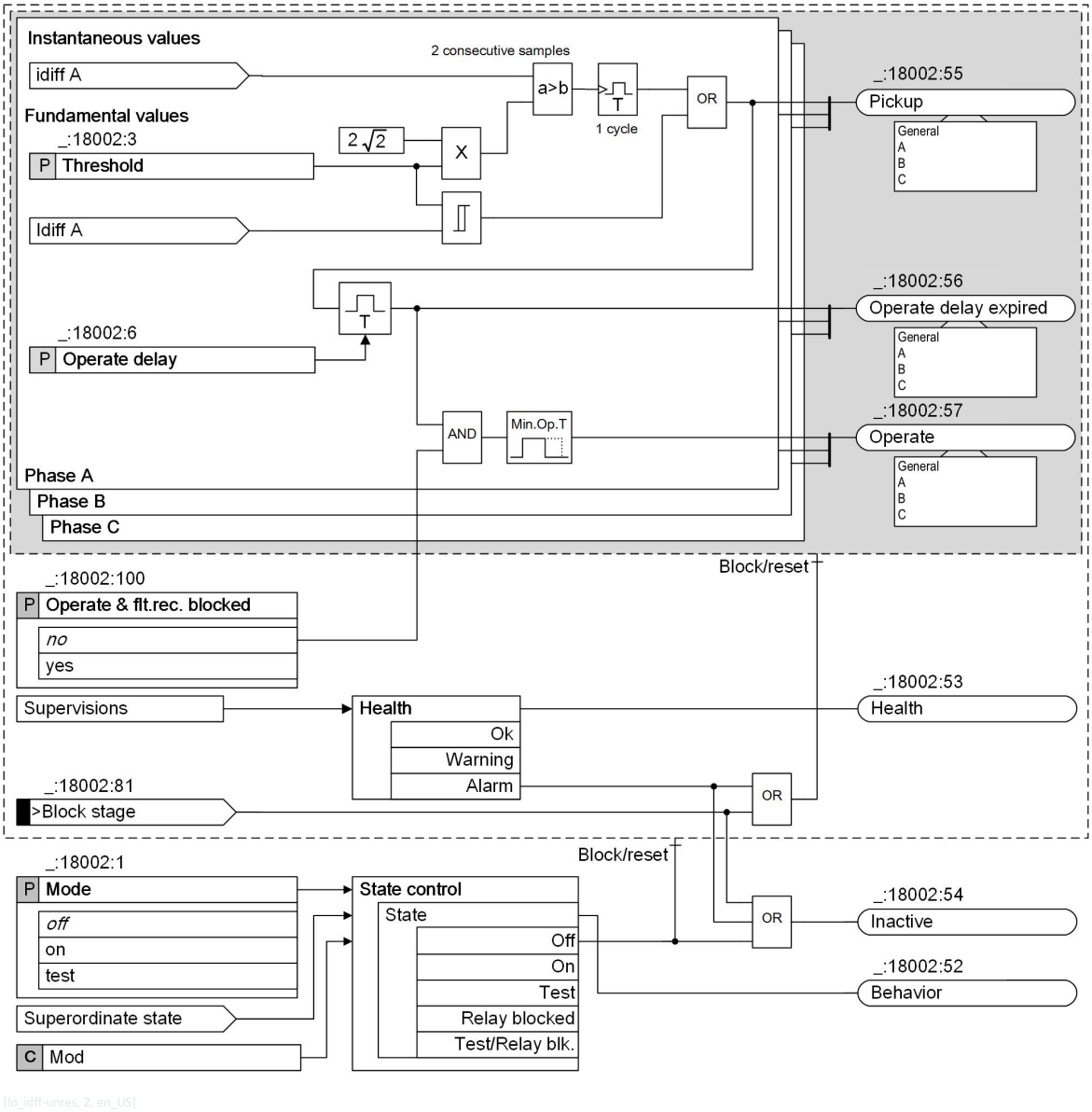
Parallel to the instantaneous-value method, the fundamental component works with a temporal delay. Here, the same measured values are processed as with the I-DIFF method. The fundamental component of the differential current I_{diff} is ordered in the operate curve *Figure 6-112* and the trip decision is made.



[dw_idffunres, 1, en_US]

Figure 6-133 I-DIFF Unrestrained Characteristic Curve

Figure 6-113 shows the overall logic.

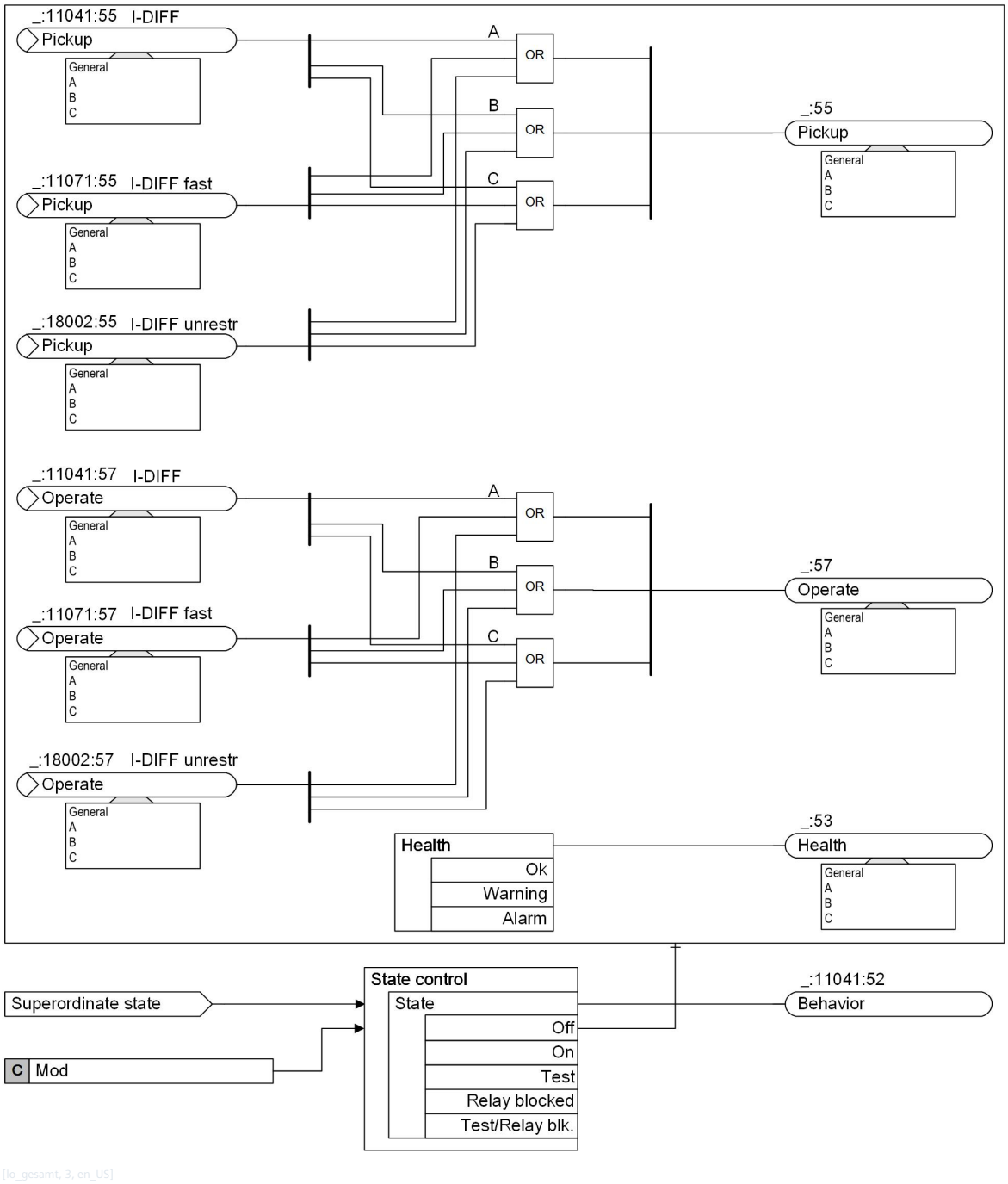


[lo_idff-unres, 2, en_US]

Figure 6-134 Logic of the I-DIFF Unrestrained Differential Protection Function

Trip Logic of the Differential Protection

A common trip signal is formed from the subfunctions I-DIFF, I-DIFF fast, and I-DIFF unrestrained. *Figure 6-114* shows the corresponding logic.



[lo_gesamt, 3, en_US]

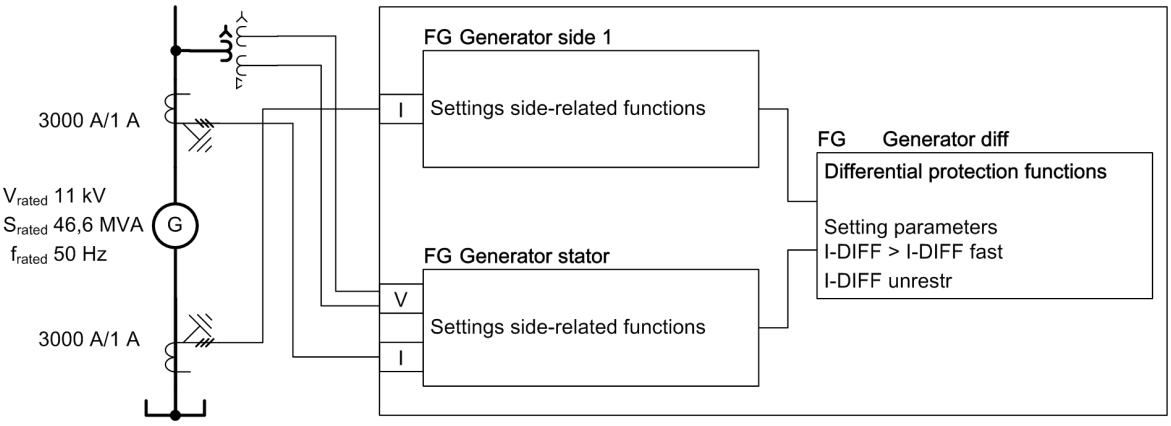
Figure 6-135 Overall Trip Logic

Fault Logging and Fault Recording

A fault is opened with every protection pickup. This means that a fault log and a fault recording are started. Saving of the fault record depends on the setting (see *3.5.3 Function Description*). Since pickup and tripping are the same in differential protection, the recording setting can be used with the pickup function. To enable fault recording even with external errors, along with the exceedance of the characteristic curve, a fault record is opened in case of a blocking by an external error or in case of a characteristic-curve increase through a DC-component detection. This has the advantage that you can evaluate the transformer transfer method of the current transformers very well in case of a fault.

6.6.4 Application and Setting Notes

This chapter provides setting information for the required setting parameters for a typical generator protection application. *Figure 6-136* shows a typical generator protection application. This prevents significant damage to the generator in the event of tripping in case of a short circuit. Therefore, the **Generator differential protection** also makes sense for less powerful generators (< 5 MVA).

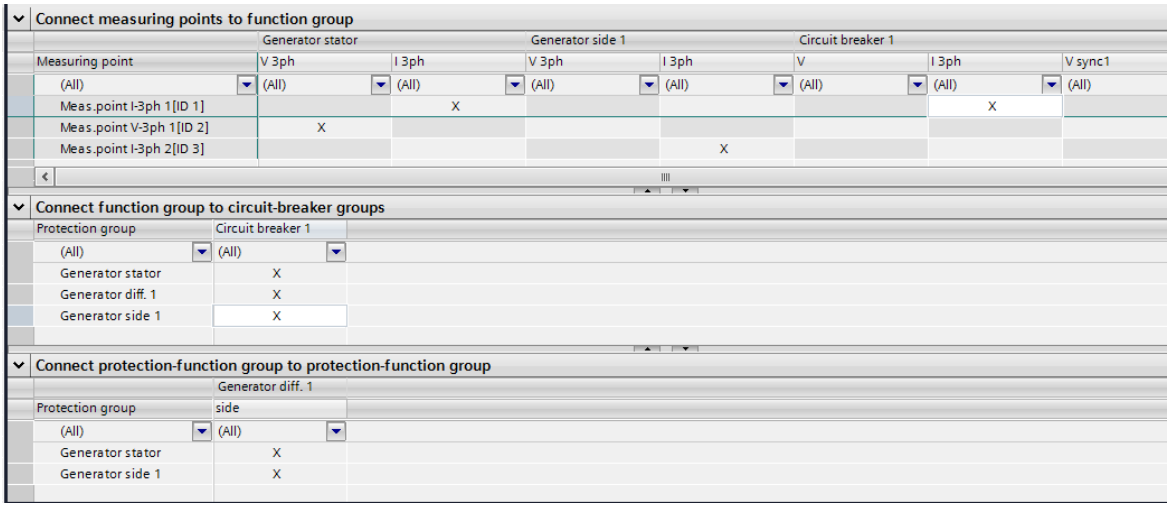


[dw_generator diff connection example, 3, en_US]

Figure 6-136 Connection Example

The connection example refers to an application in the 7UM85. The 3-phase current measuring points are connected to the function groups **Generator side 1** and **Generator stator**. The differential protection function runs in the **Generator diff** function group.

The following screenshot from DIGSI 5 shows the connection of the measuring points as well as the connection of the function groups.



[sc_generator_diff_switch_Digsi, 1, en_US]

Figure 6-137 Internal Interconnection in DIGSI 5

Generator Side and Generator Stator Function Groups

Make the following settings in the function groups **Generator side** and **Generator stator**. They are needed for scaling the currents and processing the differential protection.

NOTE

Ensure that the correct transformer data are set at the measuring points.

The data in the example are for the following current transformers: 3 000 A/1 A

Parameter: `Rated apparent power`

- Default setting **`(_:14671:103) Rated apparent power`** = ***`46.60 MVA`***

  With this parameter, you can set the rated apparent power of the generator. With one generator, the setting value for both function groups (sides) is the same.

Parameter: `Rated voltage`

- Default setting **`(_:14671:102) Rated voltage`** = ***`11 kV`***

  With this parameter, you can set the rated voltage of the generator. The rated voltage is 11 kV in this example. The setting is the same for both function groups.

Generator Diff Function Group

Make the following settings in the **Generator diff** function group for the Idiff function:

Parameter: `Threshold` (Setting the Characteristic-Curve Parameters)

- Default setting **`(_:11041:3) Threshold`** = ***`0.2 I/Irated,obj`***

You set the pickup threshold for the differential current with this parameter. This is the total current flowing into the protection range during a short circuit, regardless of how it is distributed on the sides of the protected object. The pickup value is relative to the rated current of the protected object. The default setting of ***`0.2 I/Irated,obj`*** is a practical value between sensitivity and possible disturbing influence.

Parameter: `Intersection 1 Irest`

- Default setting **`(_:11041:101) Intersection 1 Irest`** = ***`0.67 I/Irated,obj`***

The maximum current of the measuring point is used as restraint current. If you have to expect dynamic transmission faults of the current transformer even with small currents, half of the rated current is an appropriate setting value.

Parameter: `Slope 1`

- Default setting **`(_:11041:100) Slope 1`** = ***`0.3`***

With the **`Slope 1`** you avoid an overfunction of the differential protection with low-current external faults as a consequence of current-transformer transmission faults (stationary and dynamic faults). The default setting of ***`0.3`*** is sufficient for many applications.



NOTE

The stabilization method has been changed from that in SIPROTEC 4 (7UT6x, 7UM62). For this reason, select a higher slope (also see *6.6.3 Function Description*).

Parameter: `Intersection 2 Irest`

- Default setting **`(_:11041:103) Intersection 2 Irest`** = ***`2.5 I/Irated,obj`***

The parameter **`Intersection 2 Irest`** determines from which restraint current the **`Slope 2`** begins. The default setting ***`2.5 I/Irated,obj`*** is a practical value.

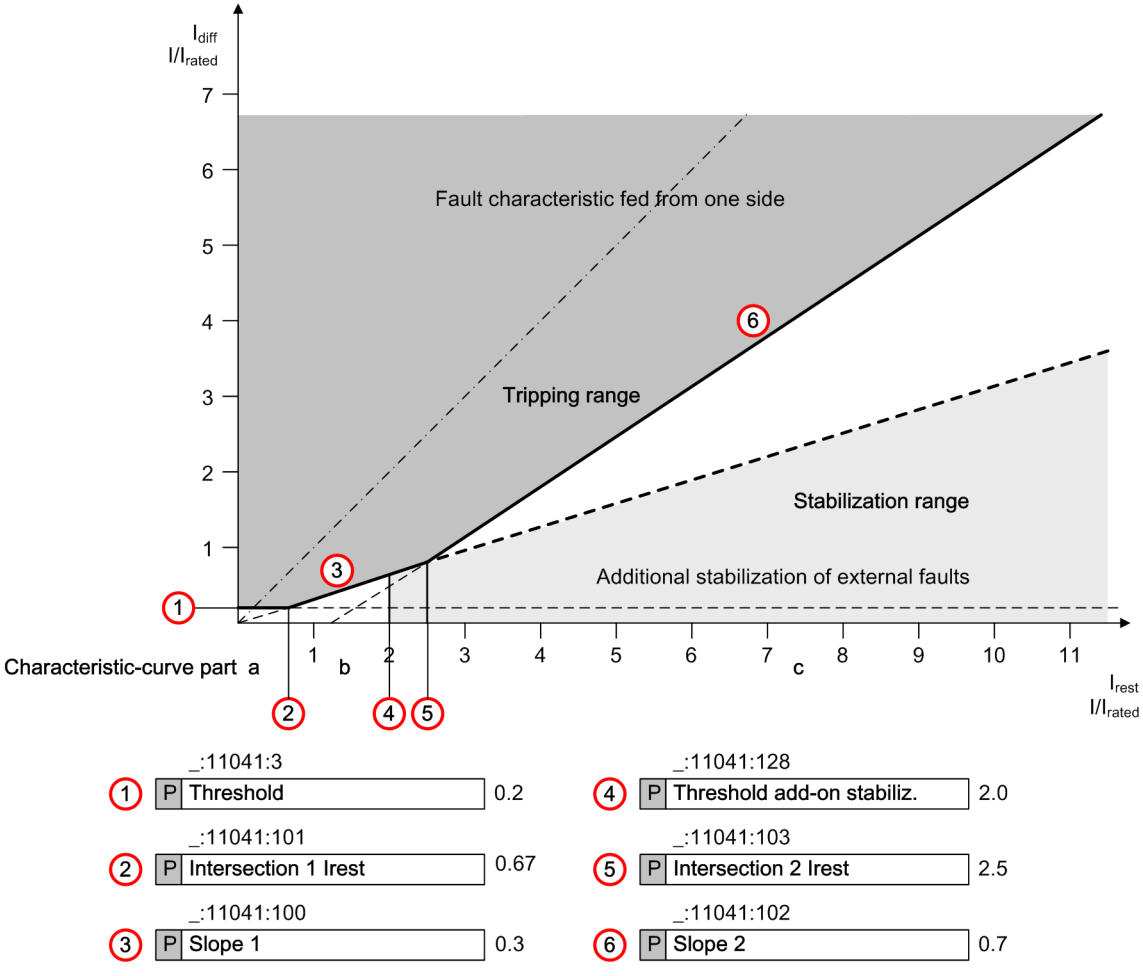
Parameter: `Slope 2`

- Default setting **`(_:11041:102) Slope 2`** = ***`0.7`***

With the **`Slope 2`** parameter, an overfunction of the differential protection is avoided with high-current external faults as a consequence of current-transformer transmission faults (for example, due to saturation). A value greater than or equal to double the value of **`Slope 1`** is practical. As the default setting, ***`0.7`*** was selected.

NOTE

If excessive current flows are cause to expect transmission problems for the current transformers, set the **Slope 2** to a higher value.



[dwdifaus-030912-01.tif, 2, en_US]

Figure 6-138 Characteristic Curve with the Default Settings

Parameter: Starting detection

- Default setting **(_:11041:106) Starting detection** = ***yes***

If the generator feeds into busbars to which motors are also connected, Siemens recommends the activation of the startup detection for generator protection applications, since the motor starting currents can influence the transmission behavior of the current transformers. In this case, set the parameter **Starting detection** to ***yes***.

Parameter: Thresh. startup detection

- Default setting **(_:11041:107) Thresh. startup detection** = ***0.1 I/Irated,obj***

If the restraint current falls below this threshold value, the subsequently set characteristic-curve increase becomes effective with activated function. Increase the default setting of ***0.1 I/Irated,obj*** for generator protection corresponding to your operating conditions. Adjust the parameter **Thresh. startup detection** to the lower load limit (possible order of magnitude, for example, ***0.4 I/Irated,obj***).

Parameter: `Factor increasing char.`

- Default setting **`(_:11041:108) Factor increasing char.`** = ***`1.0`***

Change the default setting value in the case of application. An increase to the value 2.0 has proven itself to be sufficient for many applications.

Parameter: `Max. perm. Start. time`

- Default setting **`(_:11041:109) Max. perm. Start. time`** = ***`5.0 s`***

The setting value must lie above the maximum permissible start time of the connected motor. Refer to the motor data sheets for the start time (for example, **Locked Rotor** time). To guarantee tripping through the motor protection (starting-time supervision) and avoid overfunctions, select a somewhat longer time (factor 1.2 or higher). For the motor in the example, a start time of 6.5 s was assumed at 90 % rated voltage and rated torque. The setting value should be larger than 1.2 * 6.5 s = 7.8 s. Siemens recommends a setting value of 10 s.

Parameter: `Factor increasing char. DC` (DC-Component Detection)

- Default setting **`(_:11041:110) Factor increasing char. DC`** = DC-Component Detection

DC-component detection is always active. As a result of the DC components, transmission problems can arise (for example, phase-angle rotations) in current transformers with small currents flowing. For this reason, the **`Threshold`** and the **`Slope 1`** are increased by the set factor. The default setting of 2.0 has proven itself with numerous applications.

Detection of External Faults

In *Figure 6-138*, the range **Add-on stabilization with external fault** is represented. The range is described by the parameters **`Add-on stabilization threshold value`** and **`Slope 1`**. With an external short circuit, the differential currents can increase beyond this range and reach into the tripping area. With the following parameters, time-limited blocking can be performed.

Parameter: `Threshold add-on stabiliz.`

- Default setting **`(_:11041:128) Threshold add-on stabiliz.`** = ***`2.0`***

The **`Threshold add-on stabiliz.`** parameter allows you to set the pickup value for the additional stabilization. Due to the selected method of measurement, a setting value of 2 is practical. The additional stabilization range is limited by the parameters **`Threshold add-on stabiliz.`** and **`Slope 1`**.

Parameter: `Time of add-on stabiliz.`

- Default setting **`(_:11041:129) Time of add-on stabiliz.`** = ***`0.3 s`***

As orientation for the setting value, you can use the operate time of the external feeder protection. Additionally, take into account the break time of the circuit breaker. Thus, the following calculation method results:

$t_{Z\ rest.} \geq t_{trip,\ ext\ protection} + t_{trip,\ circuit\ breaker}$

The default value is a practical value. You must adapt the value appropriately to use. The value 0 deactivates the detection of external faults.

Parameter: `Crossblk. time add-on st.`

- Default setting **`(_:11041:130) Crossblk. time add-on st.`** = ***`0.3 s`***

The additional stabilization acts separately on each phase. However, it can be extended to block all phases. Siemens recommends the activation of the crossblock function with a corresponding setting of the time. The set time must be identical to the time that is set for the duration of the additional stabilization.

Protection Stage I-DIFF Fast

The task of this protection stage is the fast detection of high-current internal faults (see also *6.6.3 Function Description*). For this reason, the protection stage must always be activated.

Parameter: `Threshold`

- Default setting **`(_:11071:3) Threshold`** = ***`7.5 I/Irated,obj`***

If there are internal faults in the generator with simultaneous network operation, you can assume a current feed from both the generator and the network side. If there is an external fault, current is only fed from the generator. The subtransient and then direct-axis transient reactance takes effect at fault inception. If you assume that the transformers are nearly identical and do not saturate immediately, you can use the direct-axis subtransient reactance to estimate the maximum fault current. The current-transformer design is based on this fault current.

With the assumption described (saturation not the same), you set the stage via the transient short-circuit current.

Idiff fast > 1.1/xd' ·$I_{rated,\ generator}$

Values for xd' from 0.15 through 0.35 result in setting values from approx. 3 $I_{rated,\ generator}$ to 7 $I_{rated,\ generator}$.

Example:

Direct-axis transient reactance xd' (saturated) = 0.19

This results in a transient current of 1.1/0.19 · $I_{rated,\ generator}$ = 5.79 $I_{rated,\ generator}$ = 5.79 $I_{rated,\ obj}$

For the parameter **`(_:11071:3) Threshold`**, you can use the default setting of ***`7.5 I/Irated,obj`***.

Protection Stage I-DIFF Unrestrained

The task of this protection stage is the fast detection of high-current internal faults (see also *I-DIFF Unrestrained Differential Protection Function, Page 682*).

Parameter: `Threshold`

- Default setting **`(_:18002:3) Threshold`** = ***`10.0 I/Irated,obj`***

Use the description of the protection stage **I-DIFF fast** (*Protection Stage I-DIFF Fast, Page 716*) to set the threshold value.

6.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:100	General:Meas. gnd. current side 1		• no • yes	no
_:2311:101	General:Meas. gnd. current side 2		• no • yes	no
_:2311:102	General:Meas. gnd. current side 3		• no • yes	no
_:2311:103	General:Meas. gnd. current side 4		• no • yes	no
_:2311:104	General:Meas. gnd. current side 5		• no • yes	no
_:2311:181	General:Meas. gnd. curr. autosides		• no • with CT 1ph • with CT 3ph	no
_:2311:182	General:Meas. gnd. curr. comp.side		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:105	General:CT mismatch side 1 M3ph 1		0.000 to 100.000	0.000
_:2311:106	General:CT mismatch side 1 M3ph 2		0.000 to 100.000	0.000
_:2311:107	General:CT mismatch side 1 M3ph 3		0.000 to 100.000	0.000
_:2311:108	General:CT mismatch side 1 M3ph 4		0.000 to 100.000	0.000
_:2311:109	General:CT mismatch side 1 M1ph		0.000 to 100.000	0.000
_:2311:110	General:CT mismatch side 2 M3ph 1		0.000 to 100.000	0.000
_:2311:111	General:CT mismatch side 2 M3ph 2		0.000 to 100.000	0.000
_:2311:112	General:CT mismatch side 2 M3ph 3		0.000 to 100.000	0.000
_:2311:113	General:CT mismatch side 2 M3ph 4		0.000 to 100.000	0.000
_:2311:114	General:CT mismatch side 2 M1ph		0.000 to 100.000	0.000
_:2311:115	General:CT mismatch side 3 M3ph 1		0.000 to 100.000	0.000
_:2311:116	General:CT mismatch side 3 M3ph 2		0.000 to 100.000	0.000
_:2311:117	General:CT mismatch side 3 M3ph 3		0.000 to 100.000	0.000
_:2311:118	General:CT mismatch side 3 M3ph 4		0.000 to 100.000	0.000
_:2311:119	General:CT mismatch side 3 M1ph		0.000 to 100.000	0.000
_:2311:120	General:CT mismatch side 4 M3ph 1		0.000 to 100.000	0.000
_:2311:121	General:CT mismatch side 4 M3ph 2		0.000 to 100.000	0.000
_:2311:122	General:CT mismatch side 4 M3ph 3		0.000 to 100.000	0.000
_:2311:123	General:CT mismatch side 4 M3ph 4		0.000 to 100.000	0.000
_:2311:124	General:CT mismatch side 4 M1ph		0.000 to 100.000	0.000
_:2311:125	General:CT mismatch side 5 M3ph 1		0.000 to 100.000	0.000
_:2311:126	General:CT mismatch side 5 M3ph 2		0.000 to 100.000	0.000
_:2311:127	General:CT mismatch side 5 M3ph 3		0.000 to 100.000	0.000
_:2311:128	General:CT mismatch side 5 M3ph 4		0.000 to 100.000	0.000
_:2311:129	General:CT mismatch side 5 M1ph		0.000 to 100.000	0.000
_:2311:183	General:CT mismatch M1ph		0.000 to 100.000	0.000

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:130	General:CT mismatch S1 M3ph 1 N		0.000 to 100.000	0.000
_:2311:131	General:CT mismatch S1 M3ph 2 N		0.000 to 100.000	0.000
_:2311:132	General:CT mismatch S1 M3ph 3 N		0.000 to 100.000	0.000
_:2311:133	General:CT mismatch S1 M3ph 4 N		0.000 to 100.000	0.000
_:2311:134	General:CT mismatch side 1 M1ph N		0.000 to 100.000	0.000
_:2311:176	General:CT mismatch S2 M3ph 1 N		0.000 to 100.000	0.000
_:2311:135	General:CT mismatch S2 M3ph 2 N		0.000 to 100.000	0.000
_:2311:136	General:CT mismatch S2 M3ph 3 N		0.000 to 100.000	0.000
_:2311:137	General:CT mismatch S2 M3ph 4 N		0.000 to 100.000	0.000
_:2311:177	General:CT mismatch side 2 M1ph N		0.000 to 100.000	0.000
_:2311:138	General:CT mismatch S3 M3ph 1 N		0.000 to 100.000	0.000
_:2311:139	General:CT mismatch S3 M3ph 2 N		0.000 to 100.000	0.000
_:2311:140	General:CT mismatch S3 M3ph 3 N		0.000 to 100.000	0.000
_:2311:141	General:CT mismatch S3 M3ph 4 N		0.000 to 100.000	0.000
_:2311:178	General:CT mismatch side 3 M1ph N		0.000 to 100.000	0.000
_:2311:142	General:CT mismatch S4 M3ph 1 N		0.000 to 100.000	0.000
_:2311:143	General:CT mismatch S4 M3ph 2 N		0.000 to 100.000	0.000
_:2311:144	General:CT mismatch S4 M3ph 3 N		0.000 to 100.000	0.000
_:2311:145	General:CT mismatch S4 M3ph 4 N		0.000 to 100.000	0.000
_:2311:179	General:CT mismatch side 4 M1ph N		0.000 to 100.000	0.000
_:2311:146	General:CT mismatch S5 M3ph 1 N		0.000 to 100.000	0.000
_:2311:147	General:CT mismatch S5 M3ph 2 N		0.000 to 100.000	0.000
_:2311:148	General:CT mismatch S5 M3ph 3 N		0.000 to 100.000	0.000
_:2311:149	General:CT mismatch S5 M3ph 4 N		0.000 to 100.000	0.000
_:2311:180	General:CT mismatch side 5 M1ph N		0.000 to 100.000	0.000
_:2311:184	General:CT mismatch M1ph N		0.000 to 100.000	0.000

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:191	General:Reference side is		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	not assigned
_:2311:151	General:MU-ID Side 1 Mp3ph 1		0 to 100	0
_:2311:152	General:MU-ID Side 1 Mp3ph 2		0 to 100	0
_:2311:153	General:MU-ID Side 1 Mp3ph 3		0 to 100	0
_:2311:154	General:MU-ID Side 1 Mp3ph 4		0 to 100	0
_:2311:155	General:MU-ID Side 1 Mp1ph		0 to 100	0
_:2311:156	General:MU-ID Side 2 Mp3ph 1		0 to 100	0
_:2311:157	General:MU-ID Side 2 Mp3ph 2		0 to 100	0
_:2311:158	General:MU-ID Side 2 Mp3ph 3		0 to 100	0
_:2311:159	General:MU-ID Side 2 Mp3ph 4		0 to 100	0
_:2311:160	General:MU-ID Side 2 Mp1ph		0 to 100	0
_:2311:161	General:MU-ID Side 3 Mp3ph 1		0 to 100	0
_:2311:162	General:MU-ID Side 3 Mp3ph 2		0 to 100	0
_:2311:163	General:MU-ID Side 3 Mp3ph 3		0 to 100	0
_:2311:164	General:MU-ID Side 3 Mp3ph 4		0 to 100	0
_:2311:165	General:MU-ID Side 3 Mp1ph		0 to 100	0
_:2311:166	General:MU-ID Side 4 Mp3ph 1		0 to 100	0
_:2311:167	General:MU-ID Side 4 Mp3ph 2		0 to 100	0
_:2311:168	General:MU-ID Side 4 Mp3ph 3		0 to 100	0
_:2311:169	General:MU-ID Side 4 Mp3ph 4		0 to 100	0
_:2311:170	General:MU-ID Side 4 Mp1ph		0 to 100	0
_:2311:171	General:MU-ID Side 5 Mp3ph 1		0 to 100	0
_:2311:172	General:MU-ID Side 5 Mp3ph 2		0 to 100	0

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:173	General:MU-ID Side 5 Mp3ph 3		0 to 100	0
_:2311:174	General:MU-ID Side 5 Mp3ph 4		0 to 100	0
_:2311:175	General:MU-ID Side 5 Mp1ph		0 to 100	0
_:2311:185	General:MU-ID Mp1ph		0 to 100	0
_:2311:187	General:Use tap-changer position		• no • yes	yes
General				
_:11041:1	I-DIFF:Mode		• off • on • test	off
_:11041:2	I-DIFF:Operate & flt.rec. blocked		• no • yes	no
_:11041:6	I-DIFF:Operate delay		0.00 s to 60.00 s	0.00 s
Operate curve				
_:11041:3	I-DIFF:Threshold		0.05 I/IrObj to 2.00 I/IrObj	0.20 I/IrObj
_:11041:100	I-DIFF:Slope 1		0.00 to 0.80	0.30
_:11041:101	I-DIFF:Intersection 1 Irest		0.00 I/IrObj to 5.00 I/IrObj	0.67 I/IrObj
_:11041:102	I-DIFF:Slope 2		0.25 to 0.95	0.70
_:11041:103	I-DIFF:Intersection 2 Irest		1.00 I/IrObj to 20.00 I/IrObj	2.50 I/IrObj
Starting detection				
_:11041:106	I-DIFF:Starting detection		• no • yes	yes
_:11041:107	I-DIFF:Thresh. startup detection		0.1 I/IrObj to 2.0 I/IrObj	0.1 I/IrObj
_:11041:108	I-DIFF:Factor increasing char.		1.0 to 5.0	2.0
_:11041:109	I-DIFF:Max. perm. Start. time		0.1 s to 180.0 s	5.0 s
DC offset detection				
_:11041:110	I-DIFF:Factor increasing char. DC		1.0 to 5.0	2.3
Ext. fault detection				
_:11041:128	I-DIFF:Threshold add-on stabiliz.		1.00 I/IrObj to 20.00 I/IrObj	2.00 I/IrObj
_:11041:129	I-DIFF:Time of add-on stabiliz.		0.00 s to 5.00 s; ∞	0.30 s
_:11041:130	I-DIFF:Crossblk. time add-on st.		0.00 s to 2.00 s; ∞	0.30 s
I-DIFF fast				
_:11071:1	I-DIFF fast:Mode		• off • on • test	off
_:11071:3	I-DIFF fast:Threshold		0.5 I/IrObj to 35.0 I/IrObj	7.5 I/IrObj
_:11071:6	I-DIFF fast:Operate delay		0.00 s to 60.00 s	0.00 s

Addr.	Parameter	C	Setting Options	Default Setting
_:11071:100	I-DIFF fast:Operate & flt.rec. blocked		• no • yes	no
I-DIFF unrestr				
_:18002:1	I-DIFF unrestr:Mode		• off • on • test	off
_:18002:3	I-DIFF unrestr:Threshold		0.5 I/IrObj to 35.0 I/IrObj	10.0 I/IrObj
_:18002:6	I-DIFF unrestr:Operate delay		0.00 s to 60.00 s	0.00 s
_:18002:100	I-DIFF unrestr:Operate & flt.rec. blocked		• no • yes	no

6.6.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:I diff.	WYE	O
_:2311:301	General:I restr.	WYE	O
_:2311:311	General:I diff. operate phA	MV	O
_:2311:312	General:I diff. operate phB	MV	O
_:2311:313	General:I diff. operate phC	MV	O
_:2311:314	General:I restr. operate phA	MV	O
_:2311:315	General:I restr. operate phB	MV	O
_:2311:316	General:I restr. operate phC	MV	O
_:2311:317	General:Adapt. adjustm. inact.	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
I-DIFF			
_:11041:81	I-DIFF:>Block stage	SPS	I
_:11041:51	I-DIFF:Mode (controllable)	ENC	C
_:11041:54	I-DIFF:Inactive	SPS	O
_:11041:52	I-DIFF:Behavior	ENS	O
_:11041:53	I-DIFF:Health	ENS	O
_:11041:55	I-DIFF:Pickup	ACD	O
_:11041:56	I-DIFF:Operate delay expired	ACT	O
_:11041:57	I-DIFF:Operate	ACT	O
_:11041:301	I-DIFF:Slope 1	MV	O
_:11041:302	I-DIFF:Incr. of char. (Start)	SPS	O
_:11041:303	I-DIFF:Increase of char. (DC)	SPS	O
_:11041:312	I-DIFF:Blocked by ext. fault	ACT	O
_:11041:313	I-DIFF:Crossbl. by ext. fault	SPS	O
I-DIFF fast			
_:11071:81	I-DIFF fast:>Block stage	SPS	I
_:11071:51	I-DIFF fast:Mode (controllable)	ENC	C
_:11071:54	I-DIFF fast:Inactive	SPS	O

No.	Information	Data Class (Type)	Type
_:11071:52	I-DIFF fast:Behavior	ENS	O
_:11071:53	I-DIFF fast:Health	ENS	O
_:11071:55	I-DIFF fast:Pickup	ACD	O
_:11071:57	I-DIFF fast:Operate	ACT	O
_:11071:56	I-DIFF fast:Operate delay expired	ACT	O
I-DIFF unrestr			
_:18002:81	I-DIFF unrestr:>Block stage	SPS	I
_:18002:51	I-DIFF unrestr:Mode (controllable)	ENC	C
_:18002:54	I-DIFF unrestr:Inactive	SPS	O
_:18002:52	I-DIFF unrestr:Behavior	ENS	O
_:18002:53	I-DIFF unrestr:Health	ENS	O
_:18002:55	I-DIFF unrestr:Pickup	ACD	O
_:18002:57	I-DIFF unrestr:Operate	ACT	O
_:18002:56	I-DIFF unrestr:Operate delay expired	ACT	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O

6.7 Line Differential Protection

6.7.1 Overview of Functions

Line differential protection (ANSI 87L):

- Is a selective short-circuit protection for overhead lines, cables, and busbars with single-side and multi-side infeed in radial, looped, or meshed systems
- Allows instantaneous tripping on line ends if short circuits occur
- Works strictly phase-selectively
- Becomes more sensitive when using charging-current compensation (Ic compensat.)
- Allows separate protection of the ground path
- Allows separate protection by monitoring the negative-sequence current



NOTE

When using Line differential protection functions in transformer differential protection, the current transformer requirements of the line protection must be considered. These can be found in the Line Protection manual (C53000-G5040-C010).

6.7.2 Structure of the Function

The function **Line differential protection** is used in the function group **Line**.
The function **Line differential protection** is preconfigured at the factory with the function block (FB) **General** , the stage **I-DIFF**, and the stage **I-DIFF fast 2**.
Additional stage types are available in the Global DIGSI 5 library:

- The stage **I-DIFF fast** as an alternative for the stage **I-DIFF fast 2**.
- The stage **IN-DIFF** for separate protection of the ground path.
- The stage **IN-DIFF unrest** for separate protection of the ground path.
- The stage **I2-DIFF** for separate monitoring of the negative-sequence current.



NOTE

Keep in mind that the same stage types must be instantiated in all devices of the device combination. That is, when using the stage **I-DIFF fast**, this stage must be instantiated in all devices of the device combination.

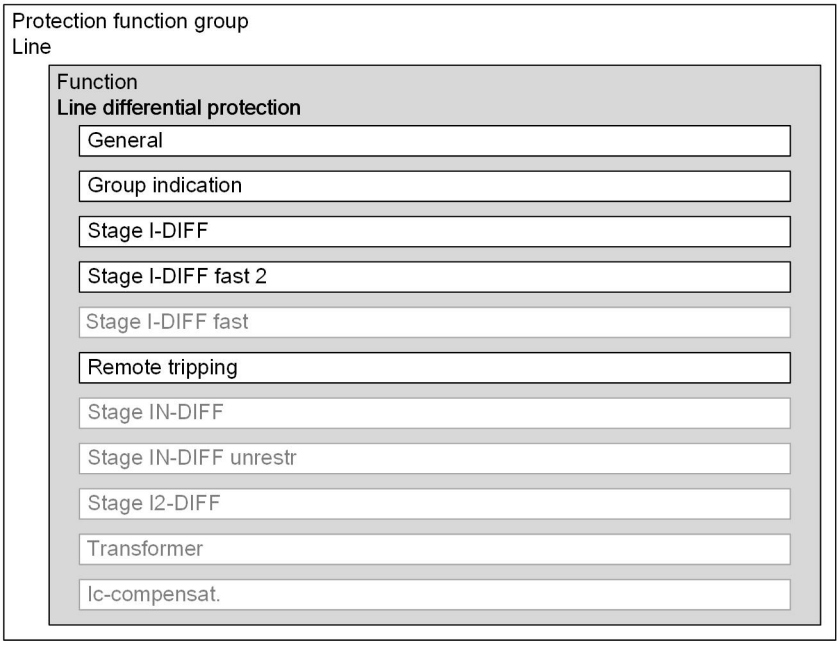
Also note that the devices can be operated either with the stage **I-DIFF fast 2** or with the stage **I-DIFF fast**. Parallel operation of the 2 stages is not possible.

When commissioning communication via the protection interface, it is checked whether the same stage types are instantiated in all devices of the device combination. If different stage types are instantiated in the devices, communication via the protection interface is not possible. In this case, the protection interface issues the diagnostic indication *(_:5161:302) Status of lay. 3 and 4 = Diff. Param. Error* in that case.

For further information, refer to *3.6.5.8 Indications and Measured Values in the Classic Protection Interface* and *3.6.6.6 Indications and Measured Values of the Advanced Protection Interface*.

The function blocks **Ic-compensat.** and **Transformer** are available in the Global DIGSI 5 library for special applications and can be instantiated into the function.

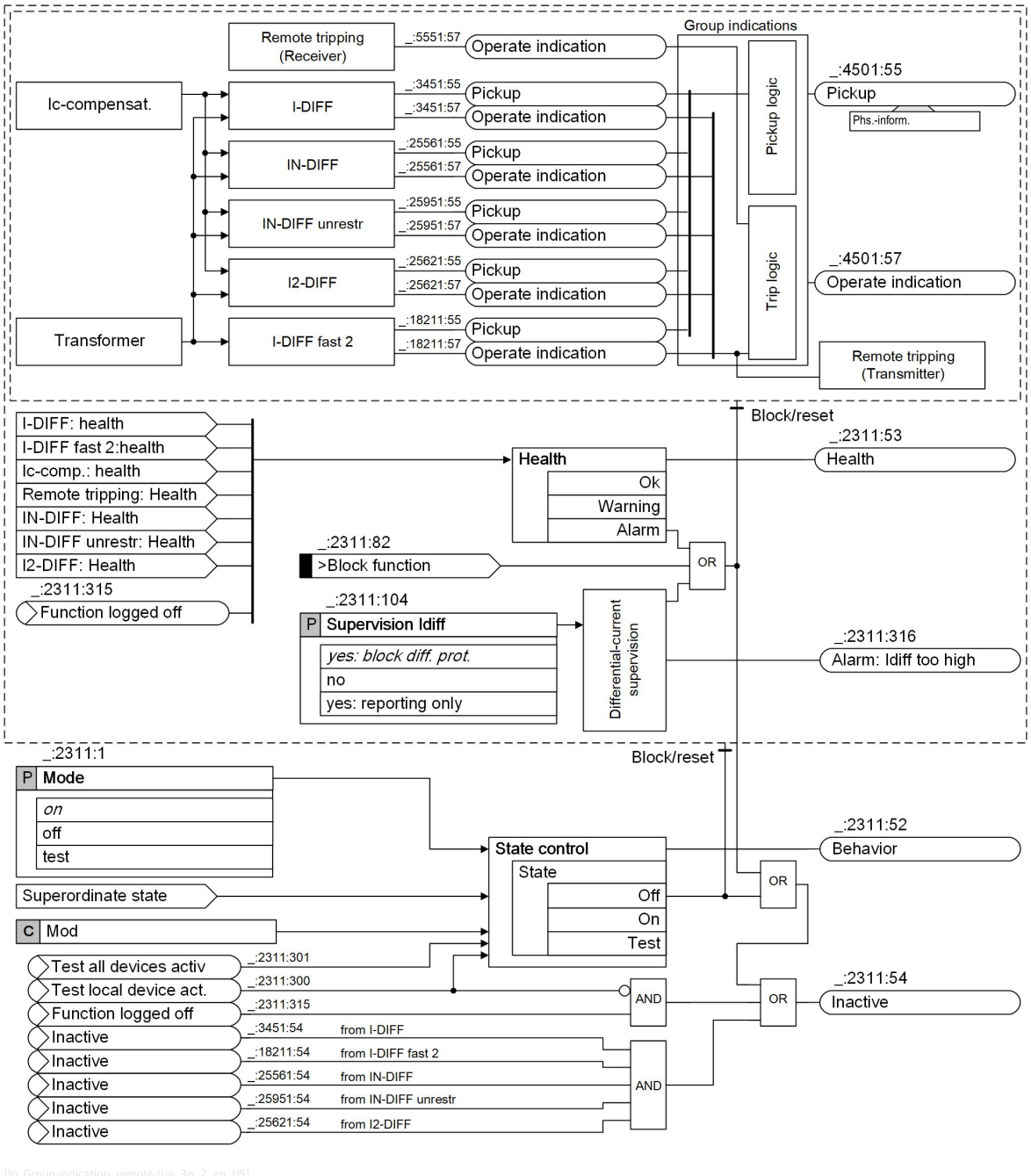
The protection function is structured in that way that the settings in the FB **General** are valid for all stages.



[dw_diff-structur_LP, 1, en_US]

Figure 6-139 Structure/Embedding of the Function

Overall Logic



[lo_Group-indication_remote-trip_3p, 2, en_US]

Figure 6-140 Logic Diagram of the Function Line Differential Protection, Overall Logic

Mode of Operation

The function **Line differential protection** is composed of several subfunctions.

The core of differential protection consists of the 2 stages **I-DIFF** and **I-DIFF fast 2**. Both work in parallel and ensure high sensitivity or fast tripping, depending on the severity of the fault.

For special applications where a ground differential protection is required, the stages **IN-DIFF** and/or **IN-DIFF unrest** can be used.

With the stage **I2-DIFF**, a negative-sequence differential protection can also be used.

The output signals of these stages are pickup and trip signals, which are routed to the pickup logic and the trip logic, resulting in the corresponding protection indications.

The functionality **Remote tripping** transmits the internally generated trip group indication to the remote devices in the device combination. In addition, the functionality **Remote tripping** receives the trip group indications of the remote devices and transmits these indications to the trip logic. For more detailed information, refer to *6.7.13 Remote Tripping*.

The optional FB **Ic-compensat.** contains the charging-current compensation. The FB **Ic-compensat.** is assigned exclusively to the sensitive stage **I-DIFF** and ensures maximum sensitivity even with high capacitive charging currents.

The optional FB **Transformer** is required to protect a transformer in the protection range. The additional FB **Transformer** guarantees that amplitudes and phase angle of the measured currents at the line ends will be evaluated correctly.

6.7.3 Function Description

The line differential protection operates on the basis of current comparison (Kirchhoff's current law). For this a device has to be installed at each end of the area to be protected. The devices exchange their measurands via communication connections. Each device performs the current comparison with these measurands and trips the assigned circuit breaker, if there is a short circuit in the protection range. The current transformers selectively delimit the protection range.

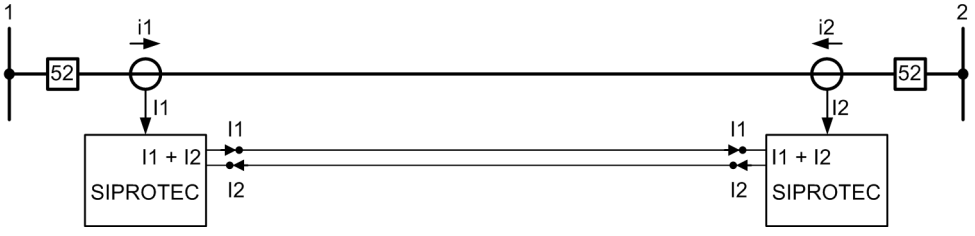
Apart from normal lines, the Line differential protection can also protect lines with a transformer in block connection. By using the function **Inrush-current detection** and the adaptive method of measurement for the line differential protection, the stages can be stabilized to prevent tripping that may be caused by transformer inrush currents.

Measured-Value Transmission

If the protected object is spatially connected – as is the case with generators, transformers, busbars – the measurands can be processed directly. The processing is different for lines where the protection range extends from one station to another. To enable the measurands from all line ends to be processed at each line end, these measurands must be transferred in a suitable form. In this way, the tripping condition can be checked at each line end, and the respective local circuit breaker can be tripped in case of a fault.

The measurands are encrypted and transmitted in digital telegrams via communication channels. For this purpose, each device features at least one interface for protection-data communication, called the protection interface in the following.

Figure 6-141 shows this principle for a line with 2 ends. Each device detects the local current and sends information on its magnitude and phase relation to the opposite end. Thus, each device can add the currents from all ends and further process them.



[dwdiff2e-150211-01.tif, 2, en_US]

Figure 6-141 Differential Protection for a Line with 2 Ends

Measured-Value Synchronization

The devices detect the local currents asynchronously. This means that each device detects, digitizes, and preprocesses the associated currents from the current transformers at its own random processor clock. If the currents of 2 or more line ends are to be compared, all currents must be processed with the same time base. All devices in the device combination exchange their time status with each telegram. The device whose address is entered first in the device-combination configuration in the protection interface functions as **timing master**, meaning it specifies the time frame. Each device can thus calculate the time offset due to the transmission and processing times relative to the **timing master**.

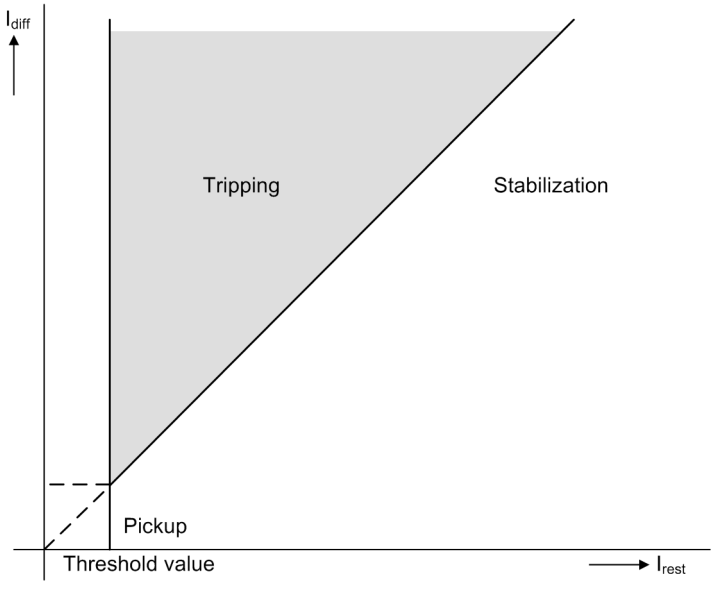
To achieve a sufficiently exact synchronization of the measured values, the current values are additionally provided with a **time stamp** before they are transmitted from one device to the others in digital telegrams. The time stamp allows a statement on the time at which the transmitted current values were valid. The receiving devices can thus carry out a fine synchronization based on the time stamp and their own time management. This means that currents detected at the same time (< 5 µs tolerance) are compared with each other.

The devices use the time stamp in the measured-data telegram to monitor the transfer times in real time and take each of these into account at the respective receiving end. The frequency of the measurands is decisive for precise calculation of the complex phasors. So that the phasor comparison is synchronous, the devices also measure the frequency of the measurands constantly and feed these into the calculation when needed. If the device is connected to voltage transformers and if at least one voltage is available in sufficient magnitude, the frequency is determined from this voltage. Otherwise, the measured currents are used as the basis for frequency determination. The devices exchange the determined frequencies with one another via the communication routes. Under these conditions, all devices operate with the updated frequency.

Adaptive Self-Stabilization

The basic principle of the differential protection is based on the precondition that, during uninterrupted operation, the sum of all currents flowing into the protected object equals 0. This applies to the primary system and only there if the shunt components of current, which occur from the capacitance of the lines or the magnetization currents of the transformers and shunt reactors, are negligible. In contrast, the secondary currents offered to the devices via the current transformers contain measuring fault originating from the measuring fault of the current transformers and the input circuits of the devices themselves. Even transmission faults such as signal jitter can cause measurand deviations.

All these influences mean that even in healthy operation the sum of the currents processed in the devices is not exactly 0. The differential protection is stabilized against these influences. A special method of **Adaptive self-stabilization** is applied in this context to ensure the highest possible sensitivity of the differential protection. The function calculates a restraint current I_{rest} for this purpose.

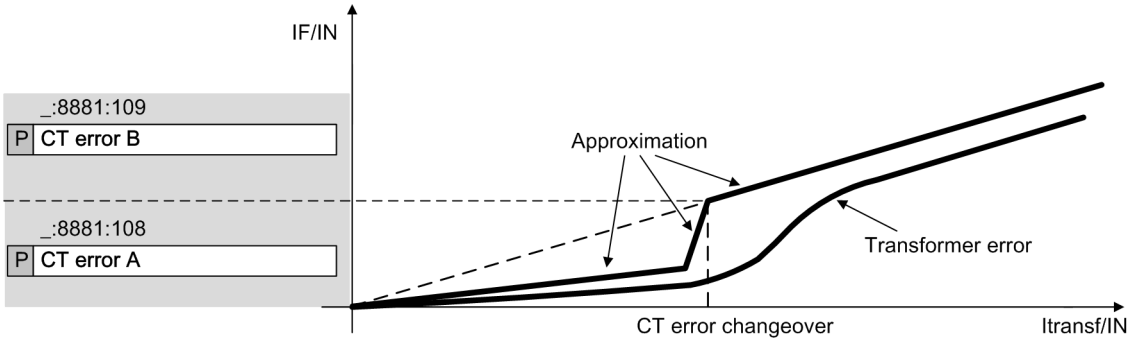


[dwanspre-150211-01.tif, 1, en_US]

Figure 6-142 Operate Curve of the Differential Protection

Current-Transformer Faults

In order to take into account the influences of current-transformer faults, each device calculates the current-transformer fault on an adaptive basis. This value results from an estimated calculation of the possible local transformer faults based on the data of the local current transformers and the magnitude of the locally measured currents.



[dwctfail-310111-01.tif, 2, en_US]

Figure 6-143 Approximation of the Current-Transformer Faults

The basis for this are the transformer data of the connected current transformers that must be entered individually for each device. Since each device transmits its estimated faults to the other devices in the device combination, each device is able to determine the sum of possible faults and use them for stabilization.

Other Measuring Faults

Other measuring faults, which can occur in the device itself due to hardware tolerances, calculation tolerances, time deviations, or the **quality** of the measurands such as harmonics and frequency deviations, are also estimated by the device and automatically increase the local self-stabilization value on an adaptive basis. The permissible variances of the transmission and processing times are also taken into account.

Time deviations are caused by residual faults when performing synchronization of the measurands, runtime variance or similar. GPS synchronization is used to prevent possible increases in self-stabilization in case of runtime jumps.

If an influencing variable cannot be detected – for example, the frequency because no adequate measurands are available – the device assumes the rated values by definition. In the frequency example, this means the following: If the frequency cannot be determined because no sufficient measurands are available, the device uses the rated frequency. But since the actual frequency can deviate from the rated frequency within the permissible range (±20 %), the stabilization is automatically increased correspondingly. As soon as the frequency has been determined (100 ms max. after applying a usable measurand), the stabilization is decreased again. In practice, this has an effect if no measurand is available in the range to be protected before the occurrence of a short-circuit, for example when switching a line with line-side voltage transformers onto a fault. Since the frequency is not yet known at that time, the stabilization is increased at first until the actual frequency is determined. This can lead to a tripping delay, but only at the pickup threshold, for example, in the case of very low-current faults.

Stages of Line Differential Protection

The Line differential protection has 2 preconfigured stages:

- The stage **I-DIFF** works with accurate measurement. Maximum sensitivity can be achieved with this stage. You cannot delete this stage.

  The stage **I-DIFF** can cooperate with the **Current comparison** stage of the Line differential protection of the SIPROTEC 4 devices 7SD5x and 7SD61x.

- The stage **I-DIFF fast 2** works in parallel with the stage **I-DIFF**. A very fast algorithm enables tripping decisions to be made very quickly in the event of high-current faults.

  If the stage **I-DIFF fast 2** is instantiated, the **Saturation detection** block is visible with the parameter **CT saturation threshold** in the **Measuring point Current 3-phase**.

- The stage **I-DIFF fast** is available in the DIGSI 5 library as an alternative to the stage **I-DIFF fast 2**. If you want to instantiate this stage, you must first delete the stage **I-DIFF fast 2**.
  If the stage **I-DIFF fast** is instantiated, the **Saturation detection** block is not visible with the parameter **CT saturation threshold** in the current measuring point.
  The stage **I-DIFF fast** also works in parallel with the stage **I-DIFF**. A very fast algorithm enables tripping decisions to be made very quickly in the event of high-current faults.
  The stage **I-DIFF fast** can cooperate with the stage **Fast charge comparison** of the Line differential protection of the SIPROTEC 4 devices 7SD5x and 7SD61x.
- The stage **IN-DIFF** operates with high-accuracy measurement either with the separately measured ground current I_N or with the calculated zero-sequence current 3I0. With this stage, you can achieve the maximum sensitivity.
- The stage **IN-DIFF unrest** operates with high-accuracy measurement either with the separately measured ground current I_N or with the calculated zero-sequence current 3I0. With this stage, you cannot achieve the maximum sensitivity because the adaptive self-stabilization is not used here.
- The stage **I2-DIFF** operates with high-accuracy measurement with the measured negative-sequence current I2. With this stage, you can achieve the maximum sensitivity.

Inrush-Current Detection

If the protection range extends beyond a transformer, a high inrush current, which flows into the protection range but does not leave it again, has to be expected when connecting the transformer. The inrush current can reach a multiple of the rated current and is characterized by a relatively high content of 2nd harmonic (twice the rated frequency), which is missing almost completely in the case of a short circuit.

The algorithm of the Line differential protection recognizes the inrush currents. Temporarily, the adaptive stabilization function provides an elevated restraint current, preventing any unwanted tripping.

If the function **Inrush-current detection** is present in the device, inrush currents will be detected correctly. For this, the function block **Inrush detect.** from the DIGSI 5 function library must be instantiated and enabled. High inrush currents can lead to an overfunction. Inrush-current detection prevents overfunction by blocking the affected phases or all phases using the crossblock function.

Charging-Current Compensation

Distributed line or phase capacities cause a permanently capacitive charging current. This charging current has to be taken into account by the pickup values of the differential-protection stages. In cables, this charging current can reach considerable values. The charging-current compensation serves to improve the sensitivity so that maximum sensitivity can be protected even at high charging currents. For this, the function block **Ic-compensat.** from the DIGSI 5 function library must be instantiated and enabled.

Monitoring the Differential Current

The process of adaptive self-stabilization is based on the fact that differential current faults that are caused by disturbing influences can be compensated by supplementary restraints. Thus, the process provides the highest possible sensitivity for the differential protection.

The additional dynamic monitoring of the differential current is meaningful, since there are interfering effects that cannot be detected by the device. This includes stationary or slowly building unbalances in the transmission times in the protection interface communication over communication networks. Without external GPS time synchronization, the runtime monitoring function cannot capture the unbalances in transmission times. Therefore, the received measured values cannot be synchronized precisely and high currents passing through may cause tripping.

During operation (load operation), the behavior of the differential and restraint current must be monitored to this effect, and whether in spite of a restraining quantity the differential current approaches the operate curve in an unexpected manner and without recognizing jumps in runtime. Monitoring is based on a characteristic curve located at 80 % of the characteristic curve of the stage **I-DIFF**. If the differential current exceeds the monitoring characteristic curve (parameter **Supervision Idiff** = ***yes: block diff. prot.***) and a current jump is not present, the Line differential protection is blocked after 1 s and the indication *Alarm:*

Idiff too high is output. In addition, a fault record is initiated in all differential protection devices (see *6.7.2 Structure of the Function*).

During commissioning, ensure that the differential current in the operate curve is defined primarily by the charging current and the transformer error (DIGSI 5 Test Suite). If the differential-current supervision function picks up during commissioning, check first whether the setting recommendation for stage **I-DIFF** was followed. If the stage **I-DIFF** is set correctly, pickup indicates a stationary unbalance of the signal-transmission times. It is the responsibility of the network operator to apply suitable measures to eliminate the causes.

Remote Tripping

Additionally to the measured values, the function **Line differential protection** transfers the locally generated operate indication to the Line differential protection functions of the remote devices in the device combination. The remote devices then generate an operate indication if the local **Line differential protection** has not yet generated an operate indication. This can occur under pickup conditions at the pickup threshold (see *6.7.2 Structure of the Function*).

Emergency Mode



NOTE

When the protection device is in emergency mode, the function **Line differential protection** does not work.

If the **Line differential protection** is the main protection function in the protection device, the **Line differential protection** can activate the emergency mode of the device. The emergency mode is activated if one of the following conditions is met:

- Protection-interface communication is disturbed.
- Line differential protection is blocked via the binary input *(_:2311:82) >Block function*.

When emergency mode is active, the function **Overcurrent protection** can work as an emergency function, for example.

If the functions **Line differential protection** and **Distance protection** are instantiated simultaneously, you can set the distance protection zones in such a way that in case of a line differential protection outage, the blocking of the distance protection zones is disabled. The blocking of the distance protection zones is disabled if one of the following conditions is met:

- Protection-interface communication is disturbed.
- Line differential protection is blocked via the binary input *(_:2311:82) >Block function*.
- Line differential protection is disabled.
- Line differential protection is in test operation mode *(_:2311:308) Test all devices*.

Constellation Measured Values

Refer to *Constellation Measured Values , Page 151*

6.7.4 Application and Setting Instructions - General Settings

NOTE

Keep the following hints in mind so that the line differential protection operates correctly on all line ends:

- Set the rated current of the line (parameter **(_:9001:101) Rated current**) to the same value at both ends of the line.
  The rated apparent power is internally calculated for both ends of the line and is displayed as the write-protected parameter **(_:9001:103) Rated apparent power**.
- If you have instantiated the **Transformer** function block in the line differential protection, set the parameter **(_:9001:103) Rated apparent power** to the same value at both ends. The rated current is internally calculated for both ends of the line and is displayed as the write-protected parameter **(_:9001:101) Rated current**.

If the parameters **Rated current** and **Rated apparent power** are set in a different way in the devices of the device combination, the Line differential protection does not operate correctly and the indication *Diff. Param. Err.* is issued.
For further information, refer to *3.6.5.8 Indications and Measured Values in the Classic Protection Interface* and *3.6.6.6 Indications and Measured Values of the Advanced Protection Interface*.

NOTE

To stabilize the line differential protection against current-transformer errors, the parameters for the phase currents **(_:8881:107) CT error changeover**, **(_:8881:108) CT error A** and **(_:8881:109) CT error B** as well as the parameters for the ground current IN **(_:8881:110) CT error changeover**, **(_:8881:111) CT error A** and **(_:8881:147) CT error B** are relevant for the current measuring points in the power-system data. These parameters are used exclusively by the function **Line differential protection**.

Parameter: Min. current for release

- Default setting **(_:2311:102) Min. current for release** = *0.00 A*

With the parameter **Min. current for release**, you specify the minimum local current required for release of the local operate indication.

Parameter: Supervision Idiff

- Recommended setting value **(_:2311:104) Supervision Idiff** = *yes: block diff. prot.*

When using the parameter **Supervision Idiff**, you specify whether the line differential protection function operates with or without differential-current supervision.

Parameter Value	Description
no	The differential current is not monitored.
yes: reporting only	The differential current is monitored. If the differential current exceeds the supervision threshold and a current jump is not present, the indication *Alarm: Idiff too high* is issued after 1 s.
yes: block diff. prot.	The differential current is monitored. If the differential current exceeds the supervision threshold and there is no current jump, the line differential protection is blocked after 1 s and the indication *Alarm: Idiff too high* is issued.

Parameter: Action on Behavior = test

- Default setting **(_:2311:108) Action on Behavior = test** = *Test loc. device autom.*

With the parameter **Action on Behavior = test**, you specify whether the special test mode ***Test local device*** for the function **Line differential protection** is switched on automatically or not after the test mode has been switched on for the entire device via the controllable *Application mode*.

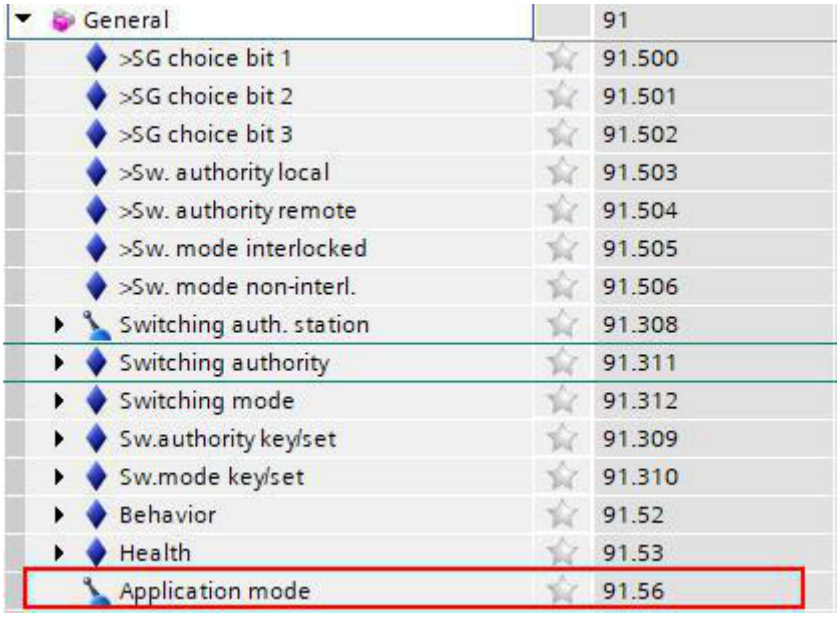
Parameter Value	Description
Test loc. device autom.	If the test mode is switched on for the entire device via the controllable *Application mode*, the special test mode ***Test local device*** is switched on automatically for the function **Line differential protection**. If you use a test switch for testing the local function **Line differential protection** that activates the test mode for the entire device as well as the test mode ***Test local device*** in one switching procedure, this setting option is useful.
Test loc. device man.	With this setting option, the function **Line differential protection** is not automatically switched to the test mode ***Test local device***.

If you switch the entire device to test mode, all protection functions automatically adopt the state ***Test*** or ***Test/Relay blk.***. Protection functions that work only with local measurands can now be tested.

For further information, refer to *Parameter: Activate device test mode , Page 264* and *11.2 Enabling/Disabling the Application/Test Mode for the Entire Device*.

The function **Line differential protection** additionally requires the measurands of the remote devices. Therefore, you must also switch on the test mode for the entire device in the remote devices so that the line differential protection in the remote devices changes to the state ***Test*** or ***Test/Relay blk.***. Only then is it possible to test the entire function **Line differential protection**.

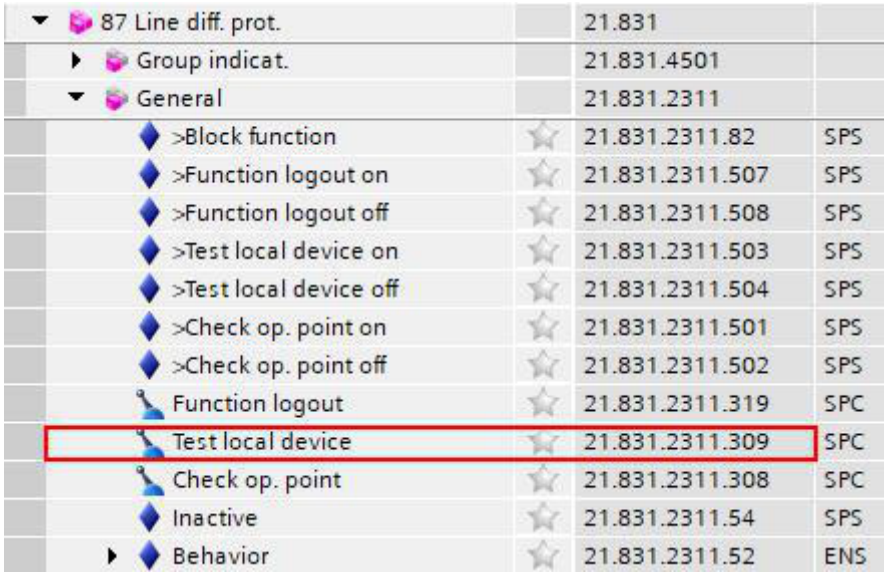
If you want to test the function **Line differential protection** only in the local device, first switch the entire device to test mode using the controllable *(_:56) Application mode*.



[sc_Applicationmode, 1, en_US]

Figure 6-144 Switching on the Test Mode for the Entire Device with the Controllable *Application mode*

Then switch on the special test mode ***Test local device*** with the controllable *(_:2311:309) Test local device* in the function **Line differential protection**.



[sc_Ldiff_testmode_controllable, 1, en_US]

Figure 6-145 Switching on the Special Test Mode for the Function **Line Differential Protection** with the Controllable *Ctrl:Test local device*

In this operating mode, the function **Line differential protection** interprets the local currents as differential currents. These currents are not transmitted to the line differential protection functions of the remote devices. Hence, the line differential protection functions of the remote devices are not effective.

For further information, refer to *11.7 Functional Test Line Differential Protection*.

6.7.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:1	General:Mode		• off • on • test	on
_:2311:102	General:Min. current for release	1 A @ 100 Irated	0.000 A to 35.000 A	0.000 A
		5 A @ 100 Irated	0.00 Ato 175.00 A	0.00 A
		1 A @ 50 Irated	0.000 A to 35.000 A	0.000 A
		5 A @ 50 Irated	0.00 Ato 175.00 A	0.00 A
		1 A @ 1.6 Irated	0.000 A to 1.600 A	0.000 A
		5 A @ 1.6 Irated	0.000 A to 8.000 A	0.000 A
_:2311:104	General:Supervision Idiff		• no • yes: reporting only • yes: block diff. prot.	yes: block diff. prot.
_:2311:108	General:Action on Behavior = test		• Test loc. device man. • Test loc. device autom.	Test loc. device autom.

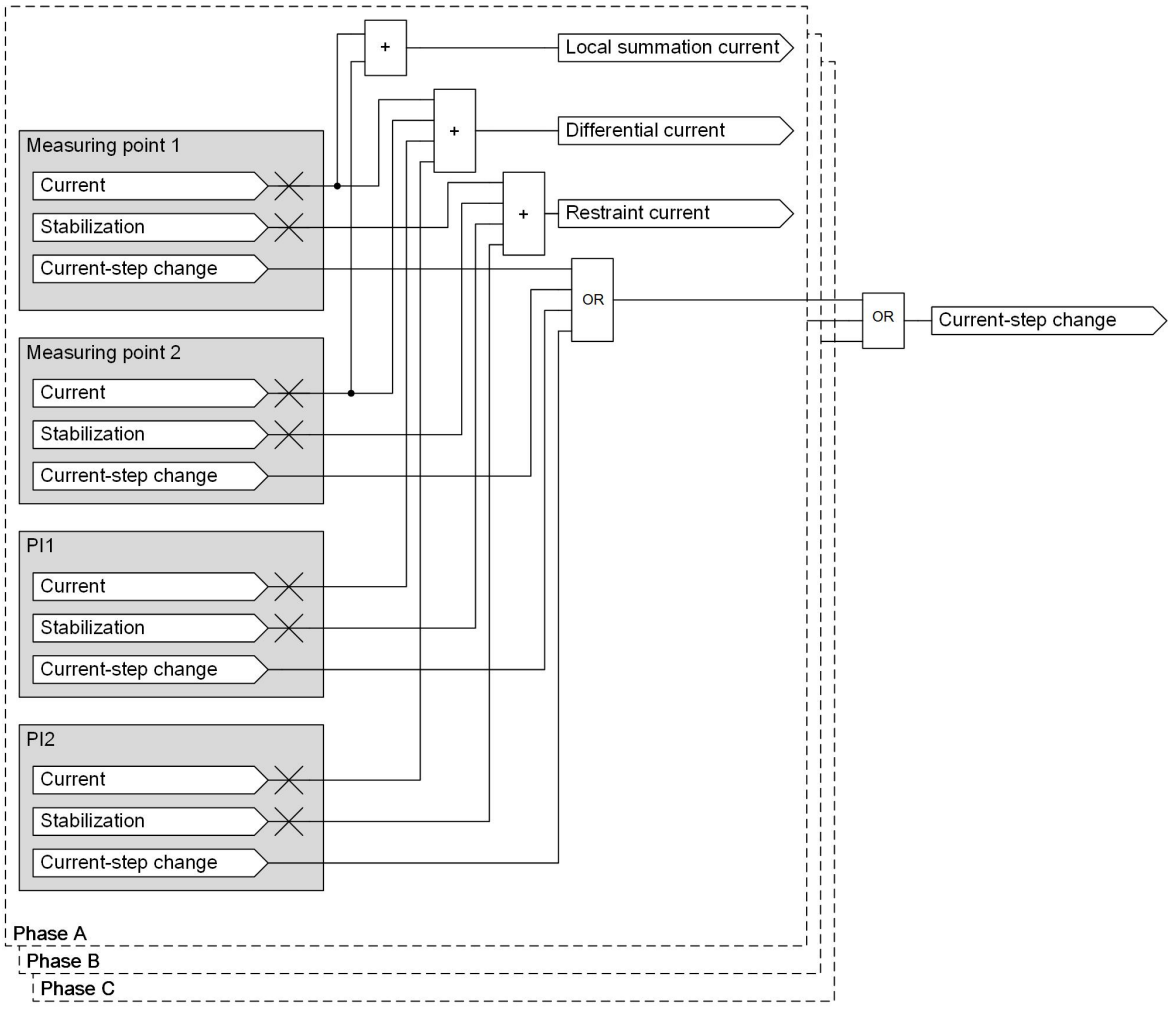
6.7.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:82	General:>Block function	SPS	I
_:2311:507	General:>Function logout on	SPS	I
_:2311:508	General:>Function logout off	SPS	I
_:2311:503	General:>Test local device on	SPS	I
_:2311:504	General:>Test local device off	SPS	I
_:2311:501	General:>Check op. point on	SPS	I
_:2311:502	General:>Check op. point off	SPS	I
_:2311:319	General:Function logout	SPC	C
_:2311:309	General:Test local device	SPC	C
_:2311:308	General:Check op. point	SPC	C
_:2311:51	General:Mode (controllable)	ENC	C
_:2311:54	General:Inactive	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
_:2311:315	General:Function logged off	SPS	O
_:2311:313	General:Logged off via BI	SPS	O
_:2311:314	General:Logged off via control	SPS	O
_:2311:300	General:Test local device act.	SPS	O
_:2311:306	General:BI: Test local device	SPS	O
_:2311:307	General:Ctrl:Test local device	SPS	O
_:2311:301	General:Check op. point active	SPS	O
_:2311:304	General:BI: Check op. point	SPS	O
_:2311:305	General:Ctrl: Check op. point	SPS	O
_:2311:302	General:Test remote device	SPS	O
_:2311:316	General:Alarm: Idiff too high	SPS	O

6.7.7 Stage I-DIFF

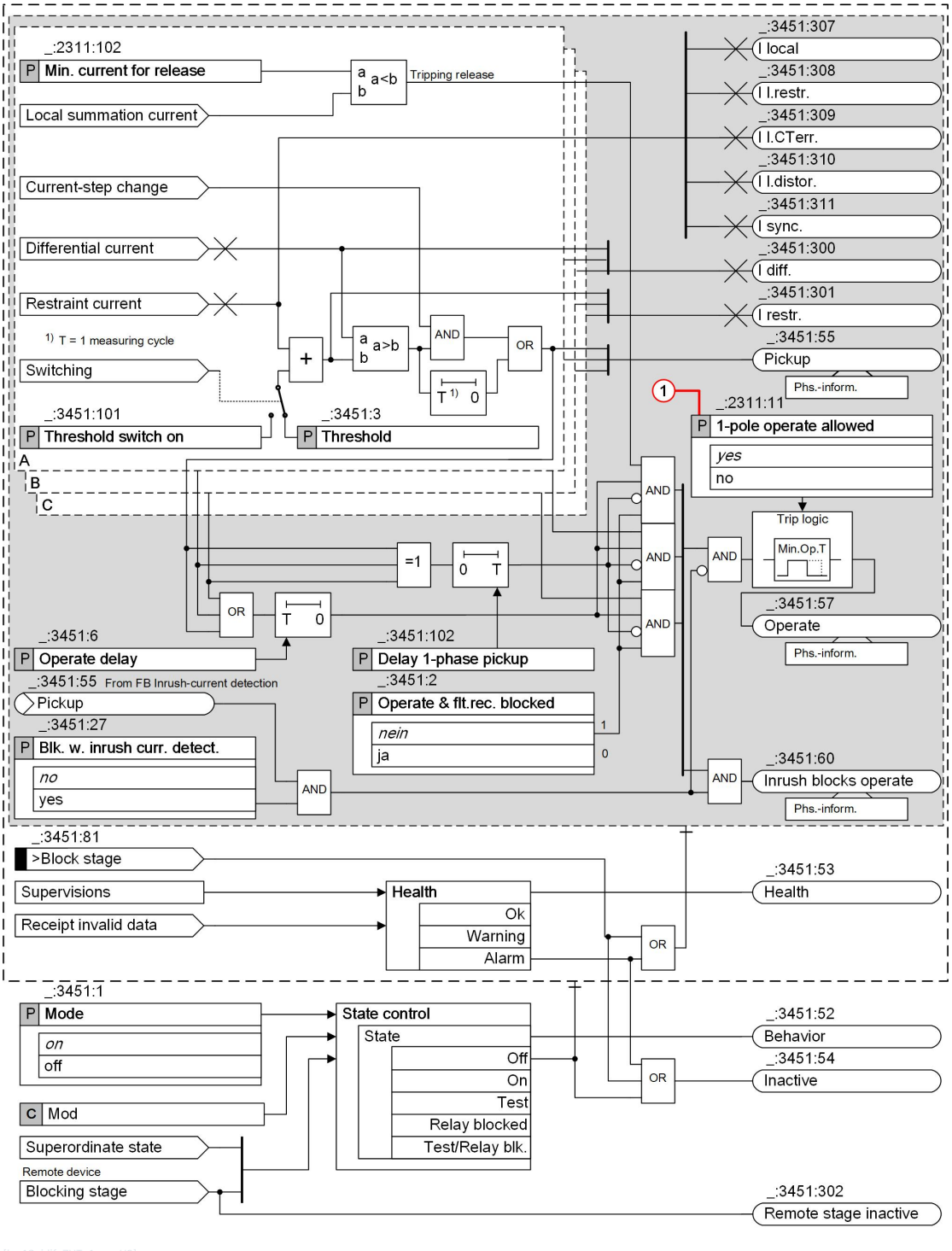
6.7.7.1 Description

Logic of the Stage



[loijump, 2, en_US]

Figure 6-146 Logic of the Stage **I-DIFF**, Part 1



[lo_13_idif_7UT, 1, en_US]

Figure 6-147 Logic of the Stage **I-DIFF**, Part 2

(1) The parameter is only available if the function **Line differential protection 1-pole/3-pole** is instantiated in the device.

Mode of Operation

The stage **I-DIFF** is the sensitive stage of differential protection. The principle of the stage **I-DIFF** is comparison of the current phasor. Usable current phasors are available after 1 period has elapsed following the occurrence

of a fault event. The stage **I-DIFF fast 2**, which operates in parallel, is responsible for fast tripping in the event of high-current faults.

The measurands are analyzed separately for each phase. Each device calculates an I_{diff} differential current from the sum of the current phasors which are calculated at each end of the protected object and transmitted to the other ends. Its value corresponds to the fault current which the differential-protection system sees, ideally that is the short-circuit current. In correct operation, it is small and corresponds to the capacitive charging current in lines in a first approximation. If charging-current compensation is active, the maximum sensitivity is achieved and the pickup value can be set considerably smaller.

The I_{rest} restraint current counteracts the differential current. The restraint current results from the sum of the maximum measuring faults at the ends of the protected object and is calculated adaptively from the current measurands and the set substation settings. To this end, the maximum fault of the current transformers in the rated range or the short-circuit current range is multiplied by the presently flowing current at each end of the protected object and transmitted to the other ends together with the determined internal faults. This means that the restraint current I_{rest} always reflects the maximum possible measuring faults in the differential-protection system.

Optional functions such as **charging-current compensation** (increased sensitivity) and **transformer in the protection range** are automatically considered when the differential and stabilization currents are calculated.

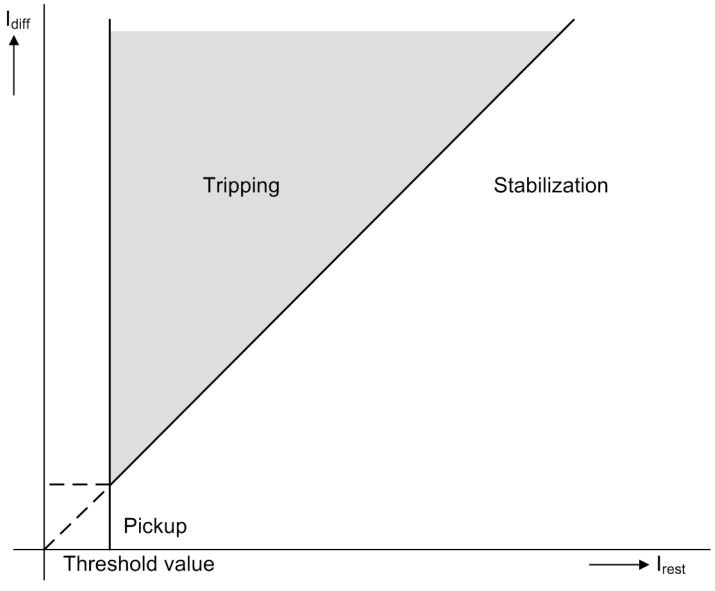
Pickup of the Stage

The pickup characteristic of the differential protection (see *Figure 6-148*) results from the stabilization characteristic curve $I_{diff} = I_{rest}$ (45° line) which is cut below the setting value of the parameter **Threshold**. It complies with the equation

I_{rest} = **Threshold** + Σ (current-transformer error and other measuring errors).

If the measured differential current exceeds the pickup threshold (**Threshold**) and the maximum possible measuring errors, there is an internal fault (dimmed area in *Figure 6-148*).

In case of an internal fault, you can define an additional criterion for local tripping release using the parameter **Min. current for release**.



[dwanspre-150211-01.tif, 1, en_US]

Figure 6-148 Pickup Characteristic of the Stage I-DIFF

Pickup upon Switching

When switching on longer, unloaded cables, overhead lines, and resonant-grounded lines, pronounced higher-frequency compensating processes can occur. These are strongly dampened by digital filters of the differential protection. With the parameter **Thresh. switch onto fault**, you can prevent single-end pickup of the line differential protection in case of switching. The parameter **Thresh. switch onto**

fault always becomes effective as soon as a device in the device combination has detected that its end is switched after a dead time. All devices in the device combination are then changed over to this pickup value for the duration of the closure detection (parameter: **Action time after closure**). For more detailed information, refer to *5.5.4.7 Closure Detection*.

In addition, for the switching of transformers and shunt reactors, the device features an **Inrush-current detection** function via which blocking of the affected phase of the differential protection is possible. For more detailed information, refer to *6.68.1 Inrush-Current Detection*.

Inrush-Current Detection

You can find the **Inrush-current detection** function in the Global DIGSI 5 library under **Line FG** → **Inrush detect.**. Add this functionality to the **Line** function group (under **DIGSI 5 project tree** →**Name of the device** → **Settings** →**Line**).

The parameter **Blk. w. inrush curr. detect.** now also appears in the stage **I-DIFF** of the Line differential protection.

Fault Behavior

The indication *Health* is set to ***Alarm*** when fast measured-value monitoring functions (, fast sum I, analog-digital converter) signal a fault or when invalid data are received via the protection interface. The validity of the currents used as well as the validity of the data received via the protection interface are monitored continuously. If persistent faults are detected, **Health** is set to ***Alarm*** and **Inactive** is set to ***Yes***.

Measured Value of the I-DIFF Stage

In order to clarify failures, the **I-DIFF** stage provides the following measured values:

Measured Value	Description
(_:3451:300) I diff.	Differential current
(_:3451:301) I restr.	Restraint current (overall restraint)
(_:3451:307) I local	Value of local current phasor
(_:3451:308) I l.restr.	Local restraint current
(_:3451:309) I l.cTerr.	Partial component of the local restraint current that considers the transformer fault.
(_:3451:310) I l.distor.	Subcomponent of the local restraint current that considers the fault caused by signal distortion. Each deviation of the signal form from the sinus shape is interpreted as a signal distortion. The deviation between the actual signal form and the sinus shape will be converted to a percentage of the stabilization.
(_:3451:311) I sync.	Subcomponents of the overall restraint that are caused by faults during the time synchronization of the current phasor.

The measured values are available in the fault record. You can read out fault recordings from the device and analyze them afterwards using evaluation tools such as SIGRA. The device display shows only *I diff.* and *I restr.*. In order to find the measured values on the device, go to **Main menu** → **Measurements** → **Line x** → **Functional measured values** → **Line differential protection** → **I-DIFF**.

For detailed information about selecting and deleting fault recordings, refer to the *Operating Manual*.

6.7.7.2 Application and Setting Notes

Parameter: Blk. w. inrush curr. detect.

- Default setting **(_:3451:27) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you determine whether the tripping is blocked during the detection of an inrush current. If the inrush-current detection blocks tripping of the stage **I-DIFF**, the indication *Inrush blocks operate* is generated.

Parameter: `Threshold`

- Recommended setting value **`(_:3451:3) Threshold`** = ***`0.300 A`***

With the **`Threshold`** parameter, you set the pickup threshold for the stage **I-DIFF**. The total current flowing into the protection range during a short circuit is decisive, that is, the total fault current, regardless of how it divides among the ends of the protected object.

Parameter: `Thresh. switch onto fault`

- Recommended setting value **`(_:3451:101) Thresh. switch onto fault`** = ***`0.300 A`***

With the **`Thresh. switch onto fault`** parameter, you set the pickup threshold for the stage **I-DIFF** during a detected connection.

A setting of 3 times to 4 times the stationary charging current generally ensures the stability of the protection when switching.

Approximately at the same time, all devices in the device combination use the pickup threshold increased with the **`Thresh. switch onto fault`** parameter during the set **`(_:4681:102) Action time after closure`**. For further information, refer to *5.5.4.7 Closure Detection*.

If you set the parameter in exactly the same way as the parameter **`Threshold`**, the parameter **`Thresh. switch onto fault`** is ineffective.

Parameter: `Delay 1-phase pickup`

- Recommended setting value **`(_:3451:102) Delay 1-phase pickup`** = ***`0.04 s`***

If the differential protection is used in an isolated or resonant-grounded system, it has to be ensured that tripping due to the fault-ignition oscillation of a simple ground fault is prevented. With the **`Delay 1-phase pickup`** parameter, you delay the pickup in case of a simple ground fault.

In extended, resonant-grounded systems, Siemens recommends using a higher setting value.



NOTE

This parameter is only effective for **resonant-grounded/isolated** neutral-point treatment!

Parameter: `Operate delay`

- Recommended setting value **`(_:3451:6) Operate delay`** = ***`0.00 s`***

In special cases, it can be advantageous to delay the tripping of the differential protection with an additional time stage, for example for reverse interlocking. The time delay is started when the stage **I-DIFF** picks up.

6.7.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`I-DIFF`				
_:3451:1	I-DIFF:Mode		• off • on	on
_:3451:2	I-DIFF:Operate & flt.rec. blocked		• no • yes	no
_:3451:27	I-DIFF:Blk. w. inrush curr. detect.		• no • yes	no
_:3451:3	I-DIFF:Threshold	1 A @ 100 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 100 Irated	0.50 A to 100.00 A	1.50 A
		1 A @ 50 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 50 Irated	0.50 A to 100.00 A	1.50 A

Addr.	Parameter	C	Setting Options	Default Setting
_:3451:101	I-DIFF:Thresh. switch onto fault	1 A @ 100 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 100 Irated	0.50 A to 100.00 A	1.50 A
		1 A @ 50 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 50 Irated	0.50 A to 100.00 A	1.50 A
_:3451:102	I-DIFF:Delay 1-phase pickup		0.00 s to 0.50 s	0.04 s
_:3451:6	I-DIFF:Operate delay		0.00 s to 60.00 s	0.00 s

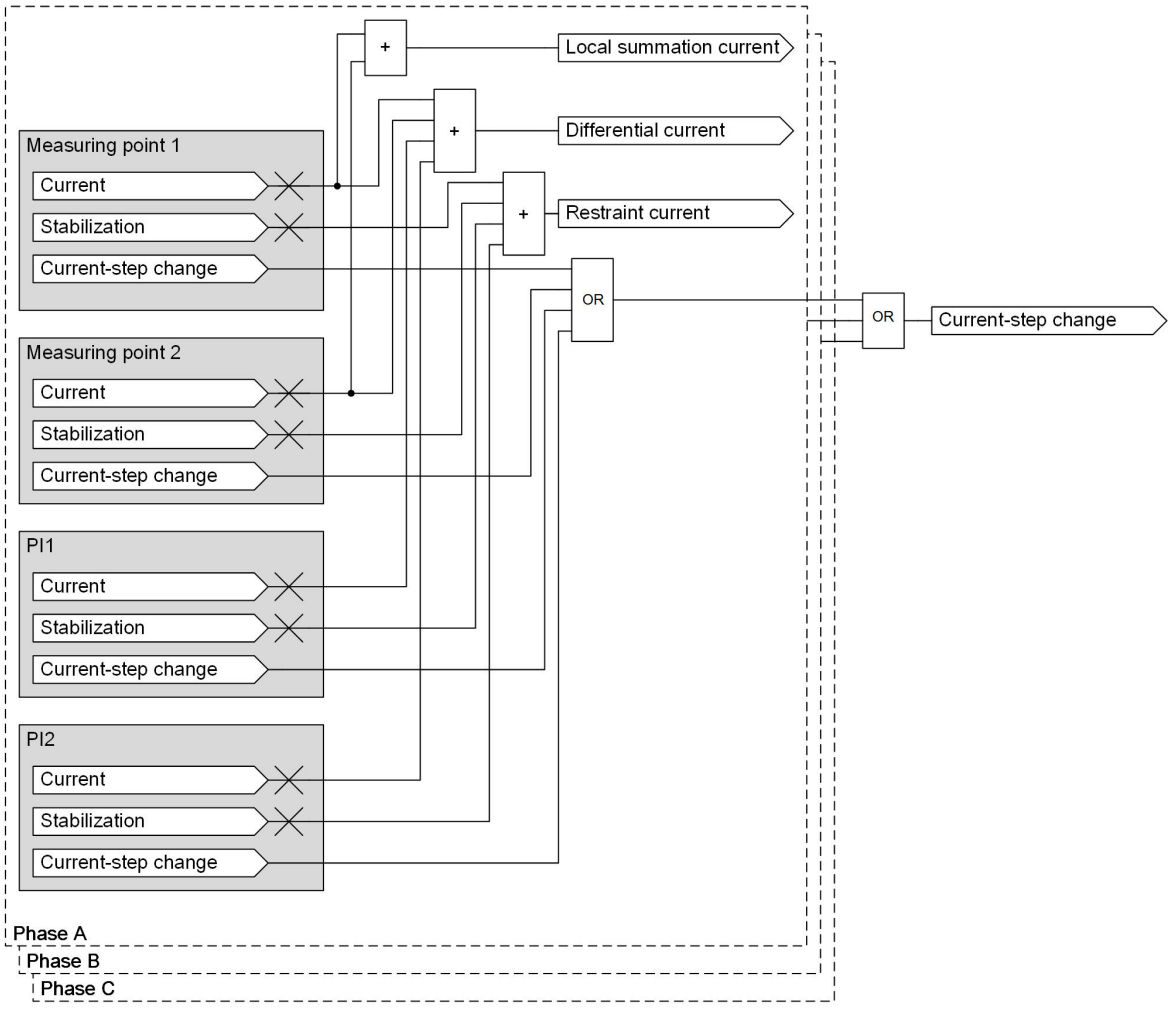
6.7.7.4 Information List

No.	Information	Data Class (Type)	Type
I-DIFF			
_:3451:81	I-DIFF:>Block stage	SPS	I
_:3451:51	I-DIFF:Mode (controllable)	ENC	C
_:3451:54	I-DIFF:Inactive	SPS	O
_:3451:302	I-DIFF:Remote stage inactive	SPS	O
_:3451:52	I-DIFF:Behavior	ENS	O
_:3451:53	I-DIFF:Health	ENS	O
_:3451:55	I-DIFF:Pickup	ACD	O
_:3451:57	I-DIFF:Operate	ACT	O
_:3451:60	I-DIFF:Inrush blocks operate	ACT	O
_:3451:300	I-DIFF:I diff.	WYE	O
_:3451:301	I-DIFF:I restr.	WYE	O
_:3451:307	I-DIFF:I local	WYE	O
_:3451:308	I-DIFF:I l.restr.	WYE	O
_:3451:309	I-DIFF:I l.CTerr.	WYE	O
_:3451:310	I-DIFF:I l.distor.	WYE	O
_:3451:311	I-DIFF:I sync.	WYE	O

6.7.8 Stage I-DIFF Fast 2

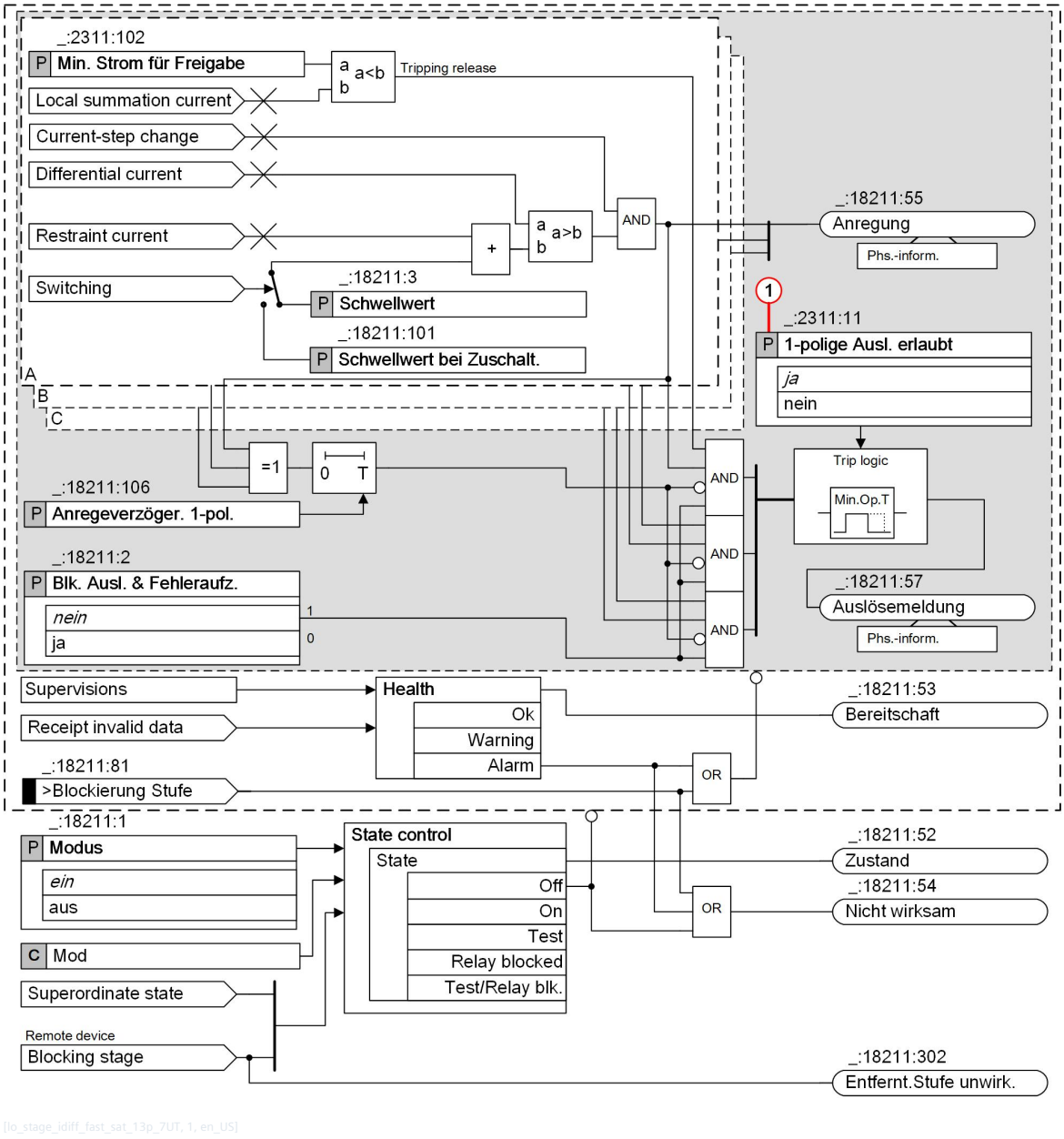
6.7.8.1 Description

Logic of the Stage



[loijump, 2, en_US]

Figure 6-149 Logic of the Stage I-DIFF fast 2, Part 1



[lo_stage_idiff_fast_sat_13p_7UT, 1, en_US]

Figure 6-150 Logic of the Stage I-DIFF fast 2, Continued

(1) The parameter is only available if the function **Line differential protection 1-pole/3-pole** is instantiated in the device.

NOTE

If you want to use the stage **I-DIFF fast 2**, the device must be equipped with the **CP300** CPU printed circuit board assembly.

The differential-protection procedure of the stage **I-DIFF fast 2** has been improved compared to the procedure of the stage **I-DIFF fast**.

The new differential-protection procedure has the following properties:

- The lower limit of the setting range was reduced. As a result, the pickup threshold can be set with more sensitivity.
- Improved stability against transformer-saturation effects during special faults

- Shorter operate times
- Improved behavior during faults with a change from external to internal errors

Mode of Operation

The **I-DIFF fast 2** stage is the differential-protection stage that is optimized for fast tripping times when high-current faults occur. It is superimposed on the **I-DIFF** stage. The measurands are analyzed separately for each phase. Fast tripping for high-current faults is achieved with a procedure based on filtered instantaneous values. During this procedure, stabilization to prevent signal distortion (for example, current-transformer saturation), which can occur during external high-current faults, is not possible. For this reason, a decision for internal or external faults must be made before the potential saturation appears. It is assumed that the current transformers do not yet go into saturation at least for 5 ms after fault inception.

If you use the **I-DIFF fast 2** stage, the **Saturat. det.** block is visible in the measuring point **Current 3-phase** with the **CT saturation threshold** parameter. For this, the **CT saturation threshold** must be set so that transformer saturation does not occur until the currents exceed the setting value.

You can find more detailed information in chapter *8.3.13 Saturation Detection*.

If saturation occurs for one or more current transformers that limit the protection range, the **I-DIFF fast 2** stage is blocked and an erroneous pickup due to transformer saturation is avoided. Normally, the **I-DIFF fast 2** stage is set higher than the rated current. In this way, the influence of charging currents and cross-flow currents of transformers (fixed and transient) is suppressed.

Otherwise, the **I-DIFF fast 2** stage works in the same way as the sensitive **I-DIFF** stage. Each device calculates an I_{diff} differential current for each phase from the sum of the filtered instantaneous values, which are calculated at each end of the protected object and transmitted to the other ends. Its amount corresponds to the fault current calculated by the differential-protection system, ideally that is the short-circuit current. In correct operation, it is small and corresponds to the capacitive charging current in lines in a first approximation.

The I_{rest} restraint current counteracts the differential current. The restraint current results from the sum of the maximum measuring faults at the ends of the protected object and is calculated adaptively from the current measurands and the set substation parameters. To this end, the maximum fault of the current transformers in the rated range or the short-circuit current range is multiplied by the presently flowing current at each end of the protected object and transmitted to the other ends together with the determined internal faults. This means that the restraint current I_{rest} always reflects the maximum possible measuring faults in the differential-protection system.

The option of a transformer in the protection range is automatically considered when the differential and stabilization currents are calculated. An activated charging-current compensation has no effect on the **I-DIFF fast 2** stage.

Pickup of the Stage

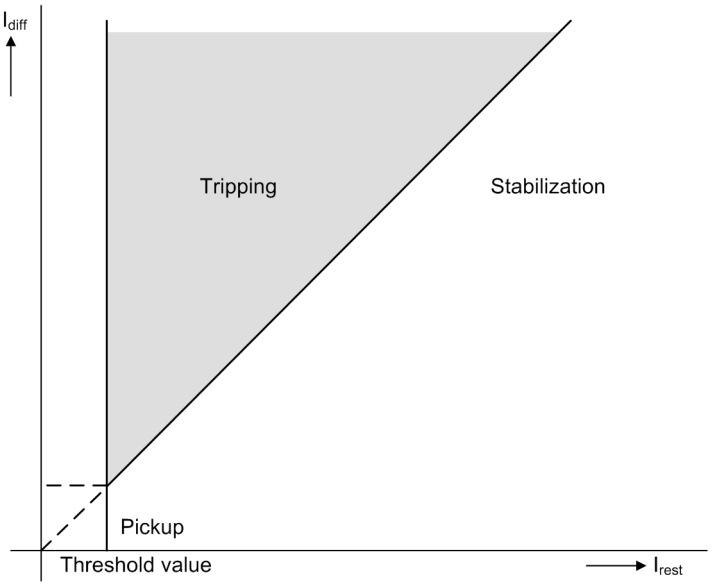
The decisive element is the RMS value of the current. Like for the **I-DIFF** stage, the pickup characteristic (see *Figure 6-151*) results from the stabilization characteristic curve $I_{diff} = I_{rest}$ (45° line) which is cut below the setting value of the parameter **Threshold**. It complies with the equation:

I_{rest} = **Threshold** + Σ(I · **CT error B** + other measuring errors)

For further information, refer to *6.1.7 Application and Setting Notes for Line Differential Protection Settings*.

If the measured differential current exceeds the sum from pickup threshold (**Threshold**) and maximum possible measuring error, there is an internal error (see *Figure 6-151*).

In case of an internal error, you can define an additional criterion for local tripping release using the parameter **Min. current for release**.



[dwanspre-150211-01.tif, 1, en_US]

Figure 6-151 Pickup Characteristic of the I-DIFF fast 2 Stage

Pickup upon Switching

When switching on longer, unloaded cables, overhead lines, and resonant-grounded lines, pronounced higher-frequency compensating processes can occur.

As the **Threshold** of the **I-DIFF fast 2** stage must be set significantly higher than the **Threshold** of the **I-DIFF** stage, switching procedures do not lead to an erroneous pickup of the **I-DIFF fast 2** stage.

For the switching procedures mentioned above, it may be worthwhile to set the **Thresh. switch onto fault** parameter higher than the **Threshold** parameter. This reliably prevents erroneous pickup of the **I-DIFF fast 2** stage. The parameter **Thresh. switch onto fault** always becomes effective as soon as a device in the device combination has detected that its end is switched after a dead time. All devices in the device combination are then changed over to this pickup value for the duration of the closure detection (**Action time after closure** parameter).

You can find more detailed information in chapter *5.5.4.7 Closure Detection*.

Fault Behavior

The indication *Health* is set to ***Alarm*** when fast measured-value monitoring functions (fast sum I, analog-digital converter) signal a fault or when invalid data are received via the protection interface. The validity of the currents used as well as the validity of the data received via the protection interface are monitored continuously. If persistent faults are detected, **Health** is set to ***Alarm*** and **Inactive** is set to ***Yes***.

6.7.8.2 Application and Setting Notes

Parameter: Threshold

- Recommended setting value **(_:3481:3) Threshold** = ***1.000 A***

With the **Threshold** parameter, you set the pickup threshold for the stage **I-DIFF fast 2**.

This stage responds very quickly. For this reason, pickup during capacitive charging currents (in the case of lines) and inductive magnetization currents for transformers or shunt reactors – including during switching procedures - must be excluded. This also applies when charging-current compensation is switched on, because this is not effective for the stage **I-DIFF fast 2**. Set the pickup value to a value greater then the load current ($1.2 \cdot I_{rated}$ to $2 \cdot I_{rated}$).

In resonant-grounded systems, the value must not fall below the value of the not resonant-grounded ground-fault current. This value results from the total capacitive ground-fault current without taking into consideration the arc-suppression coil. Since the arc-suppression coil has to compensate for approximately the total

capacitive ground-fault current, its approximate rated current can be taken as a basis. For transformers, set $I_{rated\ transf.}/V_{k\ transf.}$

A final dynamic check of the pickup thresholds is performed during commissioning.

Parameter: `Thresh. switch onto fault`

- Recommended setting value **`(_:3481:101) Thresh. switch onto fault`** = ***`1.000 A`***

With the **`Thresh. switch onto fault`** parameter, you set the pickup threshold for the stage **`I-DIFF fast 2`** during a detected switching.

If bushing-type transformers are used for a transformer in the line section to be protected, leakage fluxes through the bushing-type transformers can occur during reclosure after an external fault. These leakage fluxes can corrupt the secondary current and lead to an overfunction of the stage **`I-DIFF fast 2`**. If bushing-type transformers are used, Siemens recommends setting the pickup value in the case of switching to 2 to 3 times the setting value of the threshold value of the stage.

Approximately at the same time, all devices in the device combination use the pickup threshold increased with the parameter **`Thresh. switch onto fault`** during the set **`(_:4681:102) Action time after closure`**. For further information, refer to *5.5.4.7 Closure Detection*.

If you set the parameter to the same value as the parameter **`Threshold`**, the parameter **`Thresh. switch onto fault`** is not effective.

Parameter: `Delay 1-phase pickup`

- Recommended setting value **`(_:3481:106) Delay 1-phase pickup`** = ***`0.04 s`***

If the differential protection is used in an isolated or resonant-grounded system, it must be ensured that tripping due to the starting oscillation of a single ground fault is prevented. With the parameter **`Delay 1-phase pickup`**, you delay the pickup in case of a single ground fault.

Siemens recommends a higher setting value in extended resonant-grounded systems.

NOTE

This parameter is only effective for **resonant-grounded or isolated** neutral-point treatment!

6.7.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`I-DIFF fast 2`				
_:18211:1	I-DIFF fast 2:Mode		• off • on	on
_:18211:2	I-DIFF fast 2:Operate & flt.rec. blocked		• no • yes	no
_:18211:3	I-DIFF fast 2:Threshold	1 A @ 100 Irated	0.500 A to 100.000 A	1.000 A
		5 A @ 100 Irated	2.50 A to 500.00 A	5.00 A
		1 A @ 50 Irated	0.500 A to 100.000 A	1.000 A
		5 A @ 50 Irated	2.50 A to 500.00 A	5.00 A
_:18211:101	I-DIFF fast 2:Thresh. switch onto fault	1 A @ 100 Irated	0.500 A to 100.000 A	1.000 A
		5 A @ 100 Irated	2.50 A to 500.00 A	5.00 A
		1 A @ 50 Irated	0.500 A to 100.000 A	1.000 A
		5 A @ 50 Irated	2.50 A to 500.00 A	5.00 A
_:18211:106	I-DIFF fast 2:Delay 1-phase pickup		0.00 s to 0.50 s	0.04 s

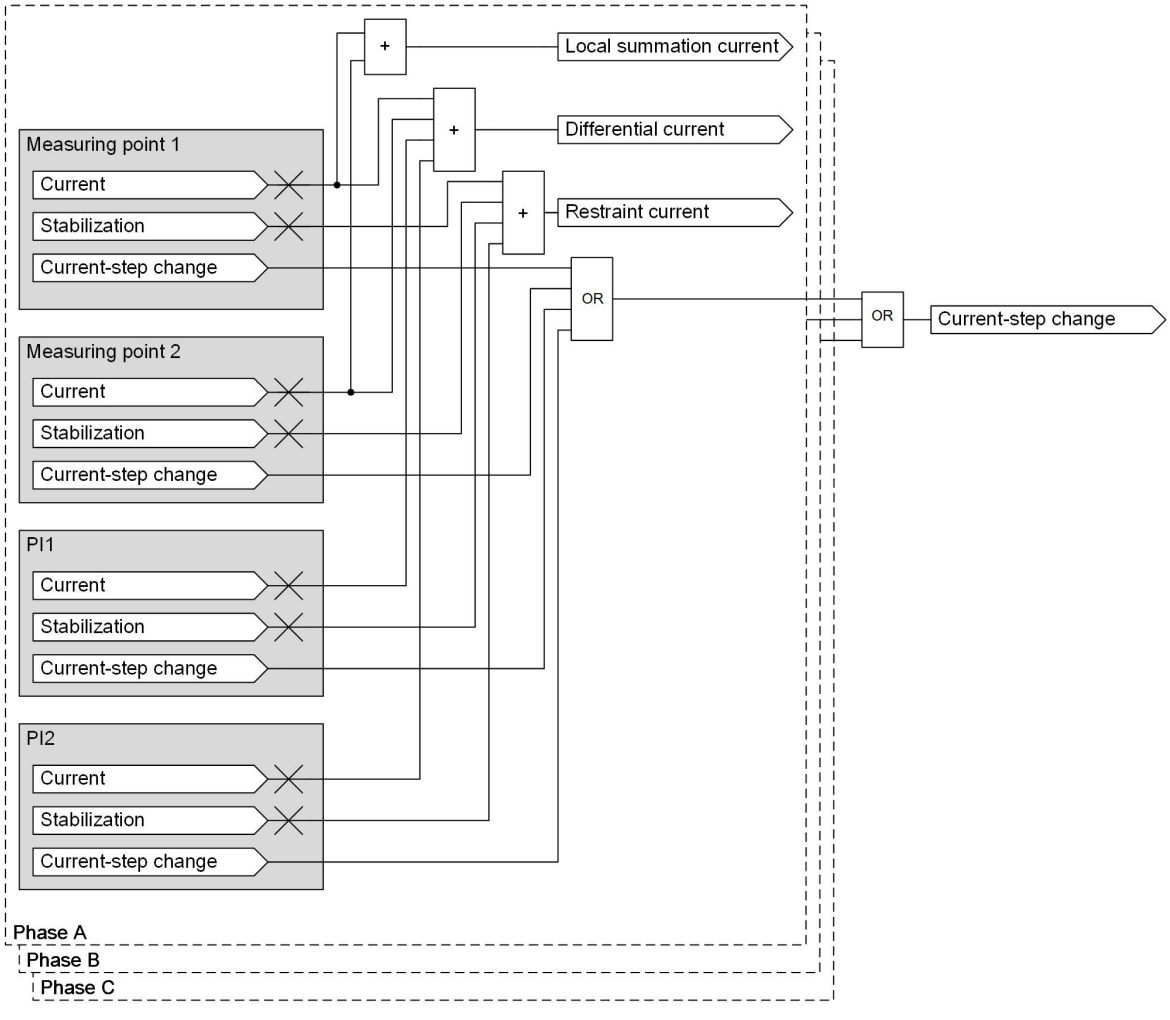
6.7.8.4 Information List

No.	Information	Data Class (Type)	Type
I-DIFF fast 2			
_:18211:81	I-DIFF fast 2:>Block stage	SPS	I
_:18211:51	I-DIFF fast 2:Mode (controllable)	ENC	C
_:18211:54	I-DIFF fast 2:Inactive	SPS	O
_:18211:302	I-DIFF fast 2:Remote stage inactive	SPS	O
_:18211:52	I-DIFF fast 2:Behavior	ENS	O
_:18211:53	I-DIFF fast 2:Health	ENS	O
_:18211:55	I-DIFF fast 2:Pickup	ACD	O
_:18211:57	I-DIFF fast 2:Operate	ACT	O

6.7.9 Stage I-DIFF Fast

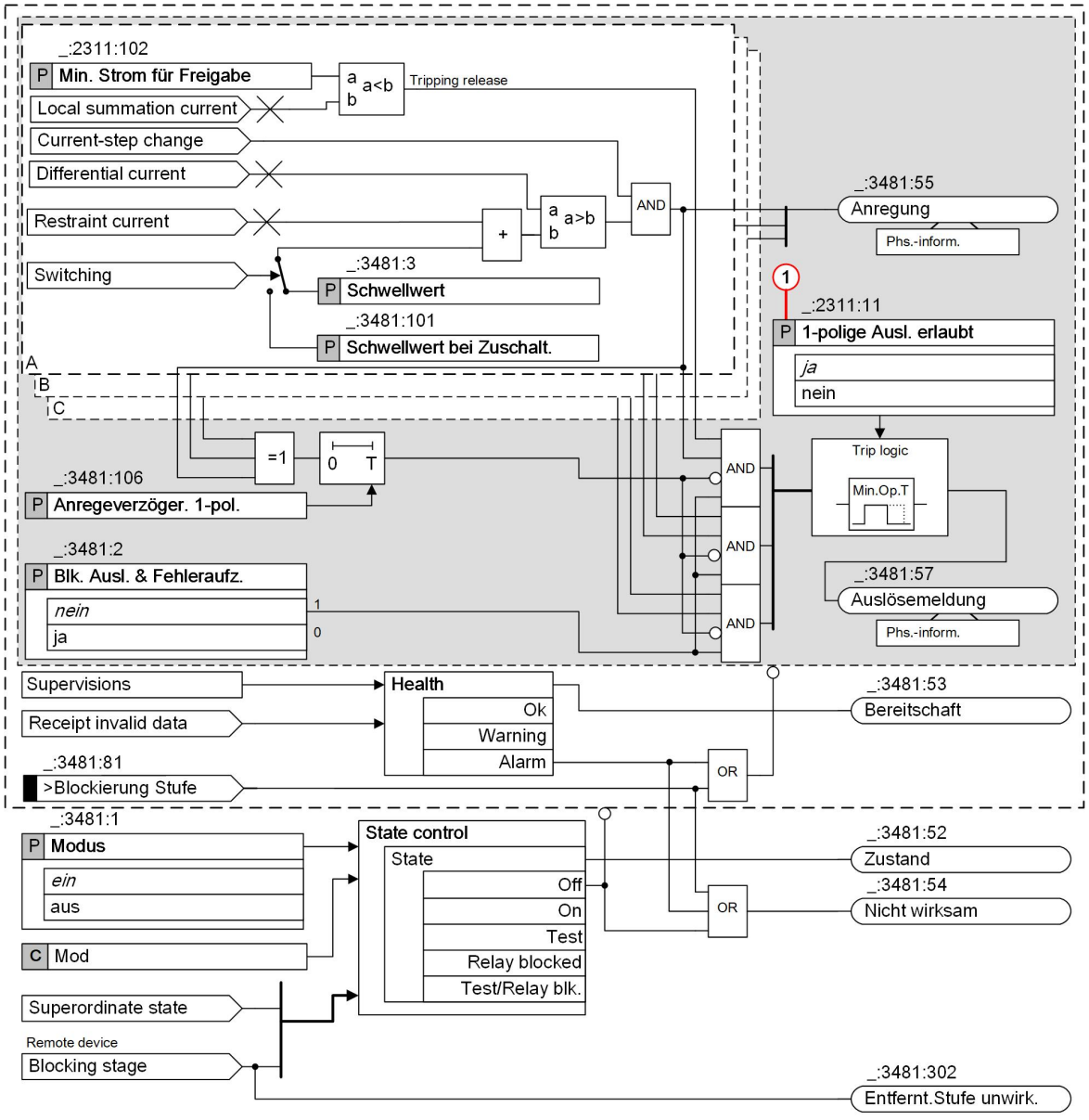
6.7.9.1 Description

Logic of the Stage



[loijump, 2, en_US]

Figure 6-152 Logic of the Stage **I-DIFF fast**, Part 1



[lo_13_idfs_7UT, 1, en_US]

Figure 6-153 Logic of the Stage **I-DIFF**, Part 2

(1) The parameter is only available if the function **Line differential protection 1-pole/3-pole** is instantiated in the device.

NOTE

Siemens recommends:

Use the stage **I-DIFF fast** only if you want to expand an existing line differential protection device combination and you want to retain the existing protection procedure.

NOTE

If you load an application template starting from the **V07.50** platform into a device with the **CP200** CPU printed circuit board assembly, keep the following in mind:

- Starting with the V07.50 platform, the **I-DIFF fast 2** stage is preinstantiated in the **Line differential protection** function.
- The consistency check in DIGSI 5 reports an error for devices with the **CP200** CPU printed circuit board assembly.
- Replace the stage **I-DIFF fast 2** with the stage **I-DIFF fast**.

The stage **I-DIFF fast** is essentially identical to the stage **I-DIFF fast 2**.

In contrast to the differential-protection procedure of the stage **I-DIFF fast 2**, the procedure of the stage **I-DIFF fast** requires a time of at least 5 ms free of saturation from the current transformer. Starting at a certain current flow (> 2.5 · I_{rated}, local measurement), the system immediately determines an external fault and the stage **I-DIFF fast** is blocked. If saturation occurs for one or more current transformers limiting the protection range, the stage **I-DIFF fast** is blocked and unwanted tripping due to transformer saturation is avoided.

6.7.9.2 Application and Setting Notes

The **I-DIFF fast** stage is essentially identical to the **I-DIFF fast 2** stage.

If you want to use the **I-DIFF fast** stage, you must delete the preinstantiated **I-DIFF fast 2** stage if necessary. After this, you can instantiate the **I-DIFF fast** stage.

If you use the **I-DIFF fast** stage, the **Current-transformer saturation** block is not present in the **Measuring point Current 3-phase**.

You can find the application and setting notes for the **I-DIFF fast 2** stage in chapter *6.7.8.2 Application and Setting Notes*.

6.7.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
I-DIFF fast				
_:3481:1	I-DIFF fast:Mode		• off • on	on
_:3481:2	I-DIFF fast:Operate & flt.rec. blocked		• no • yes	no
_:3481:3	I-DIFF fast:Threshold	1 A @ 100 Irated	0.800 A to 100.000 A	1.000 A
		5 A @ 100 Irated	4.000 A to 500.000 A	5.000 A
		1 A @ 50 Irated	0.800 A to 100.000 A	1.000 A
		5 A @ 50 Irated	4.000 A to 500.000 A	5.000 A
_:3481:101	I-DIFF fast:Thresh. switch onto fault	1 A @ 100 Irated	0.800 A to 100.000 A	1.000 A
		5 A @ 100 Irated	4.000 A to 500.000 A	5.000 A
		1 A @ 50 Irated	0.800 A to 100.000 A	1.000 A
		5 A @ 50 Irated	4.000 A to 500.000 A	5.000 A
_:3481:106	I-DIFF fast:Delay 1-phase pickup		0.00 s to 0.50 s	0.04 s

6.7.9.4 Information List

No.	Information	Data Class (Type)	Type
I-DIFF fast 2			
_:18211:81	I-DIFF fast 2:>Block stage	SPS	I

No.	Information	Data Class (Type)	Type
_:18211:51	I-DIFF fast 2:Mode (controllable)	ENC	C
_:18211:54	I-DIFF fast 2:Inactive	SPS	O
_:18211:302	I-DIFF fast 2:Remote stage inactive	SPS	O
_:18211:52	I-DIFF fast 2:Behavior	ENS	O
_:18211:53	I-DIFF fast 2:Health	ENS	O
_:18211:55	I-DIFF fast 2:Pickup	ACD	O
_:18211:57	I-DIFF fast 2:Operate	ACT	O

6.7.10 Stage IN-DIFF

6.7.10.1 Description

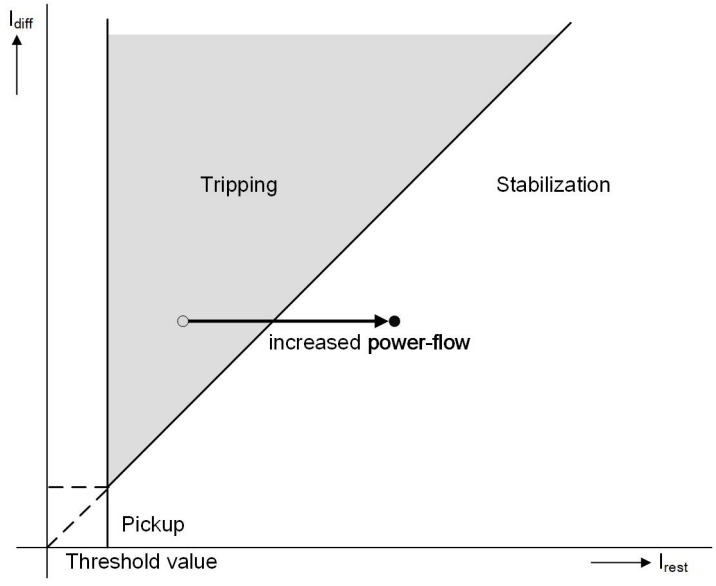
The ground-current differential protection (ANSI 87LN):

- Is a selective ground-fault protection for overhead lines, cables, and busbars with single-side and multi-side infeed in radial, ring, or meshed systems
- Allows fast tripping of short circuits with ground at 2 to 6 line ends
- Allows protection of a transformer in the protection range of the line
- Becomes more sensitive when using the charging-current compensation (Ic compensat.)
- Either the measured ground current IN or the calculated zero-sequence current 3I0 can be set as the leading measured quantity.

NOTE

For the use of the stage **IN-DIFF**, a baud rate of at least 512 Kbit/s is required.

The ground current is independent of balanced power flows that occur. For the stage **I-DIFF**, an increased load current causes an increased restraint, see the following figure. This causes the protection with the stage **I-DIFF** to become more insensitive. If the power flow is high, in rare cases, the stage **I-DIFF** may not reliably detect ground faults with high contact resistance.

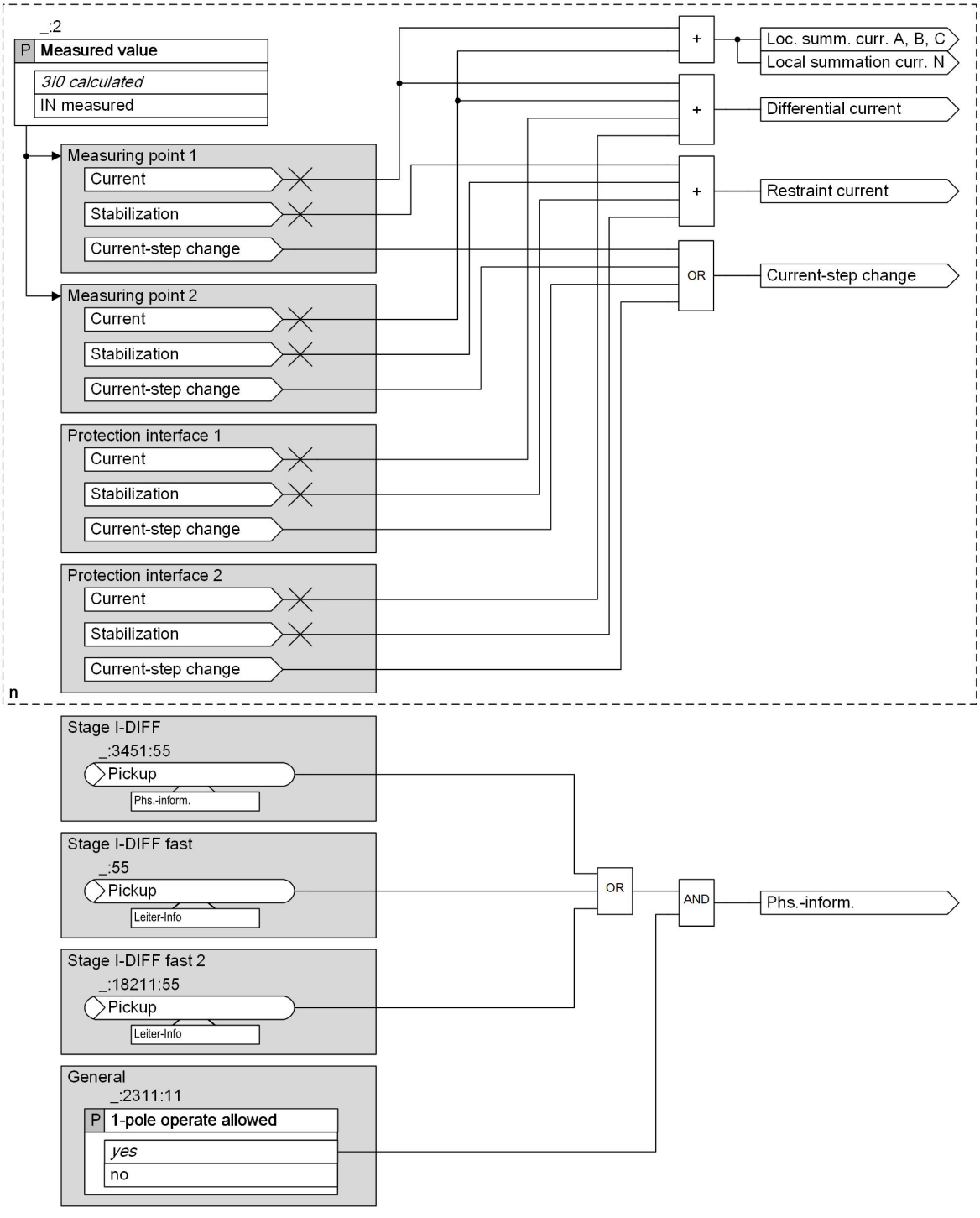


[dw_pickup characteristic_more_load, 2, en_US]

Figure 6-154 Shift of the Operating Point of the Stage **I-DIFF** in Case of a Fault with High Load Current

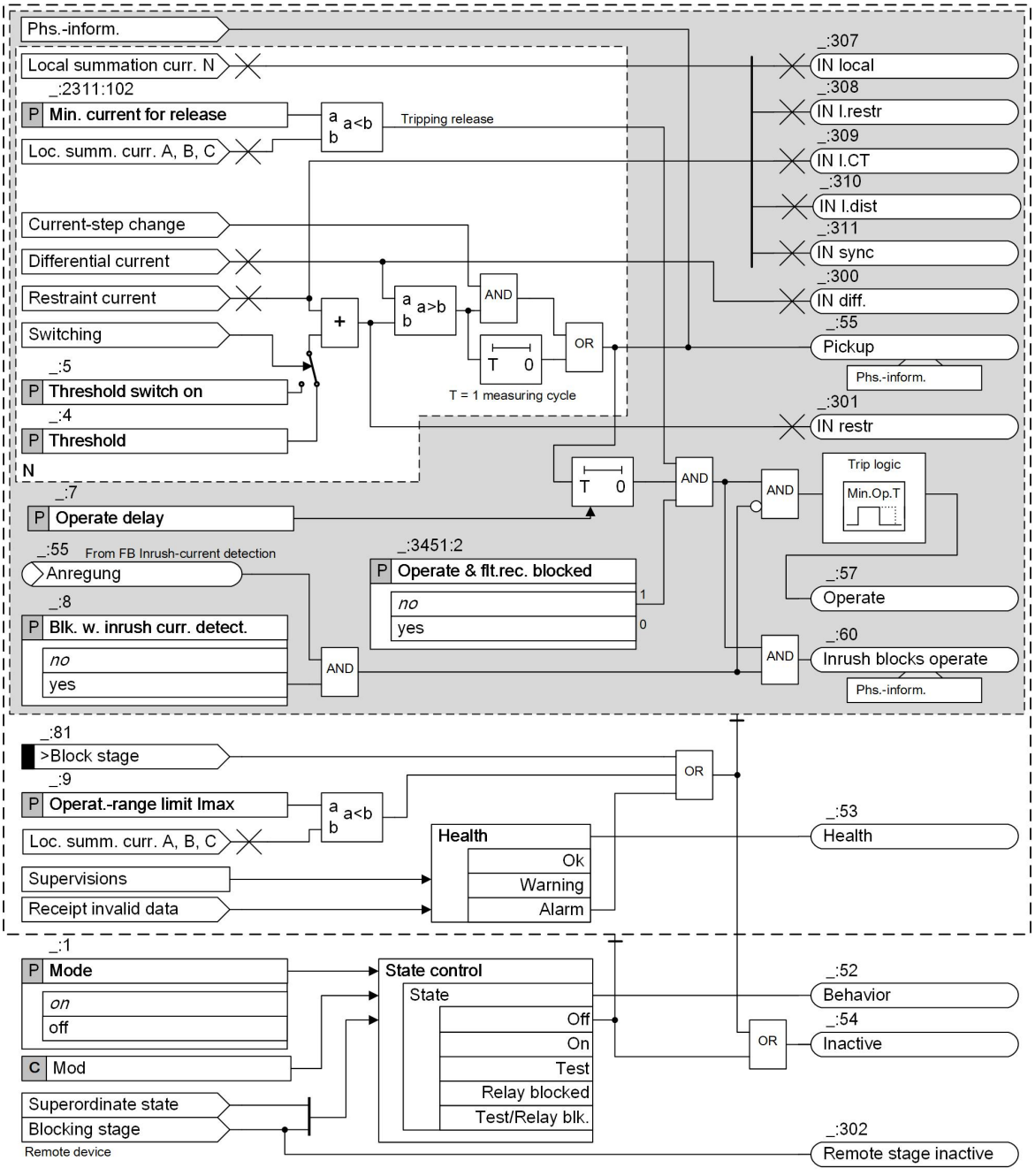
The stage **IN-DIFF** can use the measured ground current IN as the leading measured quantity and thus operate independently of different balanced power flows. The restraining quantity IN_{rest}, derived from the ground current IN, is thus also independent of balanced power-flow changes. In the cases described in the preceding sections, the stage **IN-DIFF** can be more sensitive than the stage **I-DIFF** and reliably detect the fault.

Logic of the Stage



[lo_meas-value_310_2, en_US]

Figure 6-155 Logic of the Stage **IN-DIFF**, Part 1



[lo_stage IN-diff phs-N_part2, 1, en_US]

Figure 6-156 Logic of the Stage **IN-DIFF**, Part 2

Mode of Operation

The stage **IN-DIFF** is the sensitive stage of the differential protection for the ground path. The principle of the stage **IN-DIFF** is a comparison of the ground-current phasors. Each device calculates a differential current IN_{diff} from the sum of the ground-current phasors at each end of the protected object and transmits the calculated value to the remaining ends. The amount corresponds to the fault current which the differential-protection system sees – ideally, this is the short-circuit current. In healthy unbalanced operation, it is small and corresponds to the capacitive charging current to ground in lines in a first approximation. If the charging-current compensation is active, the maximum sensitivity is achieved and the pickup value can be set considerably smaller. The ground differential current is counteracted by the ground restraint current IN_{rest}. The restraint

current results from the sum of the maximum measuring faults at the ends of the protected object and is calculated adaptively from the current measurands and the set substation parameters.

If ***IN measured*** is set as the measured value, the fault of the ground-current transformer in the rated range or in the short-circuit current range is multiplied by the ground current presently flowing at each end of the protected object and transferred to the other ends together with the determined internal faults. If ***3I0 calculated*** is set as the measured value, the fault of the phase current transformers in the rated range and in the short-circuit current range is multiplied by the maximum current presently flowing in one phase at each end of the protected object and transferred to the other ends together with the determined internal faults.

This means that the ground restraint current IN_{rest} is an image of the maximum possible measuring fault of the differential-protection system. Optional functions such as **Charging-current compensation** (increased sensitivity) and the **Transformer in the protection range** are automatically considered when the ground differential currents and the ground restraint currents are calculated.

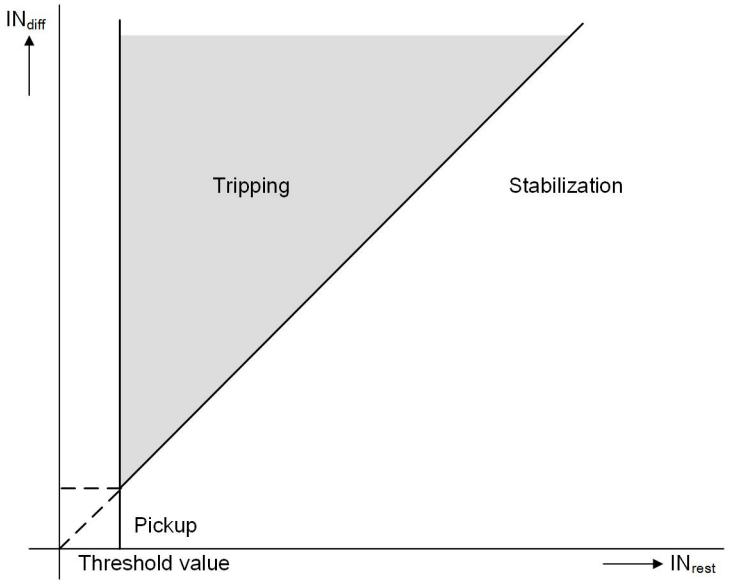
Pickup of the Stage

The pickup characteristic of the differential protection (see *Figure 6-157*) results from the stabilization characteristic curve $I_{diff} = I_{rest}$ (45° line) which is cut below the setting value of the parameter **Threshold**. It corresponds to the following equation:

IN_{rest} = **Threshold** + Σ (current-transformer error and other measuring errors).

If the measured differential current exceeds the sum of the pickup threshold (threshold) and the maximum possible measuring error, there is an internal fault (dimmed area in *Figure 6-157*).

In case of an internal fault, you can define an additional criterion for local tripping release using the parameter **Min. current for release**.



[dw_pickup characteristic_INdiff_INstab, 1, en_US]

Figure 6-157 Pickup Characteristic of the Stage **IN-DIFF**

If the stage **IN-DIFF** detects a fault in the ground path, the stage generates the pickup signal with the ground information. If the ground-current differential protection picks up, the pickup signal of the stage **IN-DIFF** takes over the phase information from the stages **I-DIFF**, **I-DIFF fast 2**, and **I-DIFF fast**.

Pickup upon Switching

When switching on longer, unloaded cables, overhead lines, and resonant-grounded lines, pronounced higher-frequency compensating processes can occur. These are strongly dampened by digital filters of the differential protection. With the parameter **Threshold switch on**, you can prevent a pickup of the line differential protection in case of switching.

The parameter **Threshold switch on** always becomes effective as soon as a device in the device combination has detected that its end is switched after a dead time. All devices in the device combination are then changed over to this pickup value for the duration of the closure detection (parameter: **Action time after closure**).

For more detailed information, refer to *5.5.4.7 Closure Detection*.

In addition, for the switching of transformers and shunt reactors, the device features a function **Inrush-current detection** via which blocking of the affected phase of the differential protection is possible.

For more detailed information, refer to *6.68.1.1 Overview of Functions*.

Inrush-Current Detection

You can find the function **Inrush-current detection** in the DIGSI 5 function library under **Line FG > Inrush detect.**. Add this functionality to the function group **Line** (under **DIGSI 5 project tree > Name of the device > Settings > Line**). The parameter **Blk. w. inrush curr. detect.** now also appears in the stage **IN-DIFF** of the Line differential protection.

Fault Behavior

The indication *Health* is set to ***Alarm*** when fast measured-value monitoring functions (fast sum I, analog-digital converter) signal a fault or when invalid data are received via the protection interface. The validity of the currents used as well as the validity of the data received via the protection interface are monitored continuously. If persistent faults are detected, **Health** is set to ***Alarm*** and **Inactive** is set to ***Yes***.

Measured Values of the Stage IN-DIFF

In order to clarify failures, the stage **IN-DIFF** provides the following measured values:

Measured Value	Description
(_:300) IN diff.	• If the stage **IN-DIFF** operates with the measured ground current IN, the measured value corresponds to the ground differential current. • If the stage **IN-DIFF** operates with the calculated zero-sequence current 3I0, the measured value corresponds to the zero-sequence current difference.
(_:301) IN restr	Ground restraint current (overall restraint)
(_:307) IN local	• If the stage **IN-DIFF** operates with the measured ground current IN, the measured value corresponds to the amount of the local ground current IN. • If the stage **IN-DIFF** operates with the calculated zero-sequence current 3I0, the measured value corresponds to the amount of the local zero-sequence current 3I0.
(_:308) IN l.restr	Local ground restraint current
(_:309) IN l.CT	Partial component of the local ground restraint current that considers the transformer fault. If you set the connection type ***3-phase*** or ***3-phase + IN*** in the measuring-points routing of the **Measuring point I-3ph**, the largest transformer fault occurring in A, B, or C is considered. If you set the connection type ***3-phase + IN-separate*** in the measuring-points routing of the **Measuring point I-3ph**, the transformer fault of the separate ground-current transformer is considered.
(_:310) IN l.dist	Subcomponent of the local ground restraint current that considers the fault caused by signal distortion. Each deviation of the signal form from the sinus shape is interpreted as a signal distortion. The deviation between the actual signal form and the sinus shape will be converted to a percentage of the stabilization.
(_:311) IN sync	Subcomponent of the overall restraint that is caused by faults during the time synchronization of the ground current phasors.

The measured values are available in the fault record. You can read out fault recordings from the device and analyze them afterwards using evaluation tools such as SIGRA. The device display shows only *IN diff.* and *IN restr*. In order to find the measured values on the device, go to **Main menu > Measurements > Line x > Functional measured values > Line differential protection > IN-DIFF**.

For detailed information about selecting and deleting fault recordings, refer to the Operating Manual.

6.7.10.2 Application and Setting Notes

Parameter: `Measured value`

- Default setting **`(_:2) Measured value`** = ***3I0 calculated***

With the parameter **`Measured value`**, you set whether the stage **IN-DIFF** operates with the zero-sequence current 3I0 calculated from the phase currents or with the directly measured ground current IN. Phasor measured values are determined based on the set measured value and transmitted to the opposite ends.

On the other hand, the phasor measured values received from the opposite ends are used to calculate a differential zero-sequence current or a differential ground current. At one end of the line, you can set the parameter **`Measured value`** to ***3I0 calculated*** and at a second end of the line to ***IN measured***.



NOTE

For power systems with isolated neutral point, the setting value of the parameter **`Measured value`** = ***IN measured*** is not possible.

Parameter: `Blk. w. inrush curr. detect.`

- Recommended setting value **`(_:8) Blk. w. inrush curr. detect.`** = ***no***

With the parameter **`Blk. w. inrush curr. detect.`**, you determine whether the tripping is blocked during the detection of an inrush current. If the inrush-current detection blocks tripping of the stage **IN-DIFF**, the indication *Inrush blocks operate* is generated. Inrush-current detection is based on the phase currents.

Parameter: `Threshold`

- Recommended setting value **`(_:4) Threshold`** = ***0.300 A***

With the parameter **`Threshold`**, you set the pickup threshold for the stage **IN-DIFF**. The total current flowing into the protection range during a short circuit is decisive, that is the total fault current. This applies regardless of how it divides among the ends of the protected object.

If you set the parameter **`Measured value`** = ***3I0 calculated***, the stage **IN-DIFF** compares the calculated zero-sequence current 3I0 with the **`Threshold`**.

If you set the parameter **`Measured value`** = ***IN measured***, the stage **IN-DIFF** compares the measured ground current IN with the **`Threshold`**.

Parameter: `Threshold switch on`

- Recommended setting value **`(_:5) Threshold switch on`** = ***0.300 A***

With the parameter **`Threshold switch on`**, you set the pickup threshold for the stage **IN-DIFF** during a detected connection.

A setting of 3 times to 4 times the stationary charging current ensures the stability of the protection when switching.

Approximately at the same time, all devices in the device combination use the pickup threshold increased with the parameter **`Thresh. switch onto fault`** during the set **`(_:4681:102) Action time after closure`**. For more information, refer to *5.5.4.7 Closure Detection*.

If you set the parameter **`Threshold switch on`** in exactly the same way as the parameter **`Threshold`**, the parameter **`Threshold switch on`** is ineffective.

Parameter: **Operate delay**

- Recommended setting value **(_:7) Operate delay** = *0.00 s*

In special cases, it can be advantageous to delay the tripping of the differential protection with an additional time stage, for example for a reverse interlocking. If the stage **IN-DIFF** stage picks up, the time delay starts.

If you set **Operate delay** = ∞, the stage **IN-DIFF** will not trip.

Parameter: **Operat.-range limit Imax**

- Recommended setting value **(_:9) Operat.-range limit Imax** = *2.500 A*

With the parameter **Operat.-range limit Imax**, you set up to which maximum local current the stage **IN-DIFF** operates. In case of local currents above this threshold, the stage is blocked and the indication *Local current too high* is issued.

If the **IN-DIFF** stage has issued an operate indication and the local current subsequently exceeds the set **Operat.-range limit Imax**, the tripping remains in force. The tripping stage will not be blocked.

6.7.10.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
IN-DIFF				
_:1	IN-DIFF:Mode		• off • on	on
_:2	IN-DIFF:Measured value		• 3I0 calculated • IN measured	3I0 calculated
_:3	IN-DIFF:Operate & flt.rec. blocked		• no • yes	no
_:8	IN-DIFF:Blk. w. inrush curr. detect.		• no • yes	no
_:4	IN-DIFF:Threshold	1 A @ 100 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 100 Irated	0.50 A to 100.00 A	1.50 A
		1 A @ 50 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 50 Irated	0.50 A to 100.00 A	1.50 A
_:5	IN-DIFF:Threshold switch on	1 A @ 100 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 100 Irated	0.50 A to 100.00 A	1.50 A
		1 A @ 50 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 50 Irated	0.50 A to 100.00 A	1.50 A
_:7	IN-DIFF:Operate delay		0.00 s to 60.00 s; ∞	0.00 s
_:9	IN-DIFF:Operat.-range limit Imax	1 A @ 100 Irated	0.003 A to 100.000 A	1.500 A
		5 A @ 100 Irated	0.02 A to 500.00 A	7.50 A
		1 A @ 50 Irated	0.003 A to 50.000 A	1.500 A
		5 A @ 50 Irated	0.02 A to 250.00 A	7.50 A

6.7.10.4 Information List

No.	Information	Data Class (Type)	Type
IN-DIFF			
_:81	IN-DIFF:>Block stage	SPS	I
_:51	IN-DIFF:Mode (controllable)	ENC	C
_:54	IN-DIFF:Inactive	SPS	O
_:302	IN-DIFF:Remote stage inactive	SPS	O

No.	Information	Data Class (Type)	Type
_:52	IN-DIFF:Behavior	ENS	O
_:53	IN-DIFF:Health	ENS	O
_:55	IN-DIFF:Pickup	ACD	O
_:57	IN-DIFF:Operate	ACT	O
_:60	IN-DIFF:Inrush blocks operate	ACT	O
_:312	IN-DIFF:Local current too high	SPS	O
_:300	IN-DIFF:IN diff.	MV	O
_:301	IN-DIFF:IN restr	MV	O
_:307	IN-DIFF:IN local	MV	O
_:308	IN-DIFF:IN l.restr	MV	O
_:309	IN-DIFF:IN l.CT	MV	O
_:310	IN-DIFF:IN l.dist	MV	O
_:311	IN-DIFF:IN sync	MV	O

6.7.11 Stage IN-DIFF unrestr

6.7.11.1 Description

The ground current differential protection (ANSI 87LN):

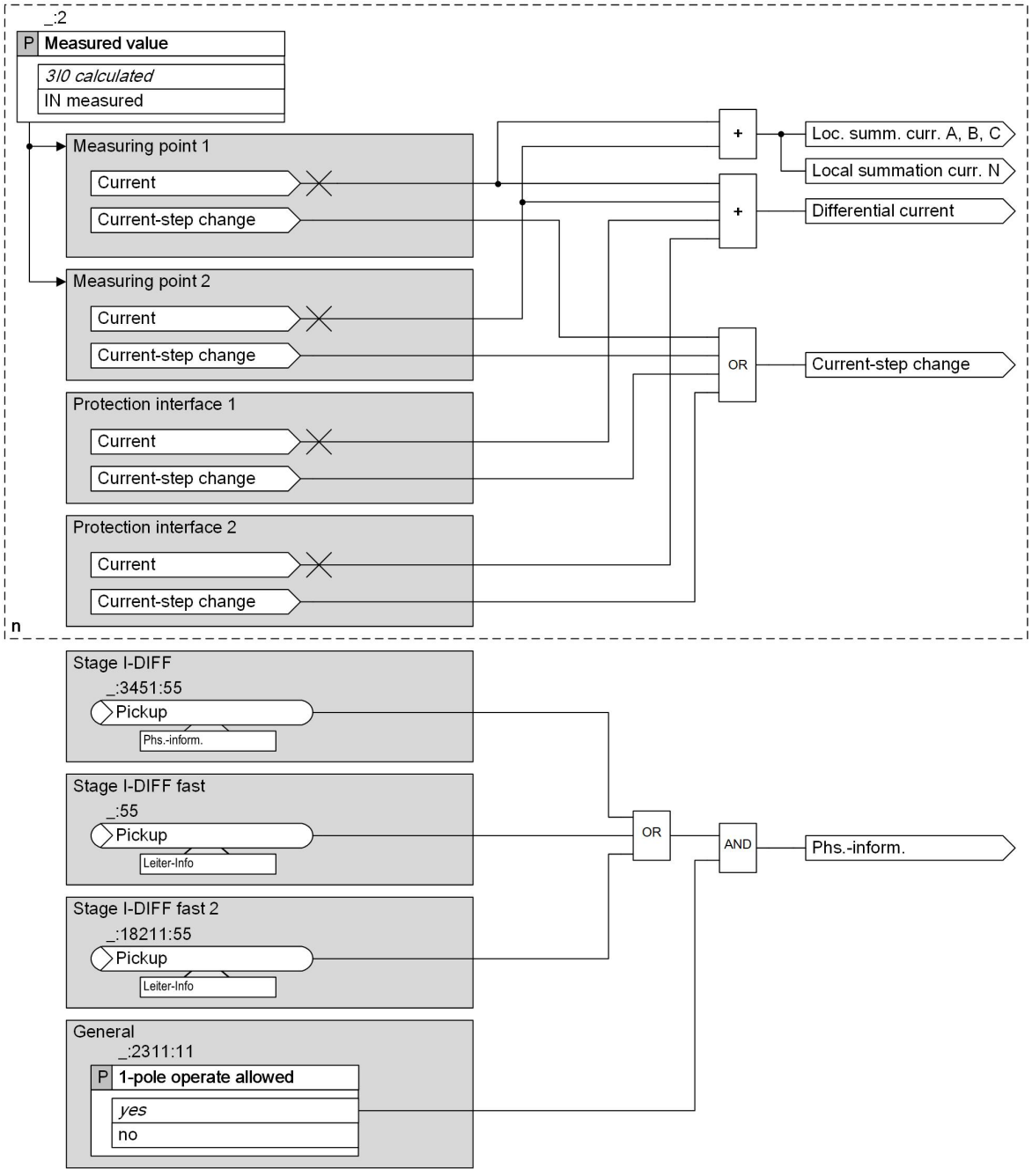
- Is a selective ground-fault protection for overhead lines, cables, and busbars with single-side and multi-side infeed in radial, ring, or meshed power systems
- Allows fast tripping of short circuits with ground at 2 to 6 line ends
- Permits protection of a transformer in the protection range of the line
- Is an unrestraint differential protection that only operates with a parameterizable threshold value
- The charging-current compensation (Ic compensat.) can be used to reduce the differential currents.
- Either the measured ground current IN or the calculated zero-sequence current 3I0 can be set as the leading measured quantity.



NOTE

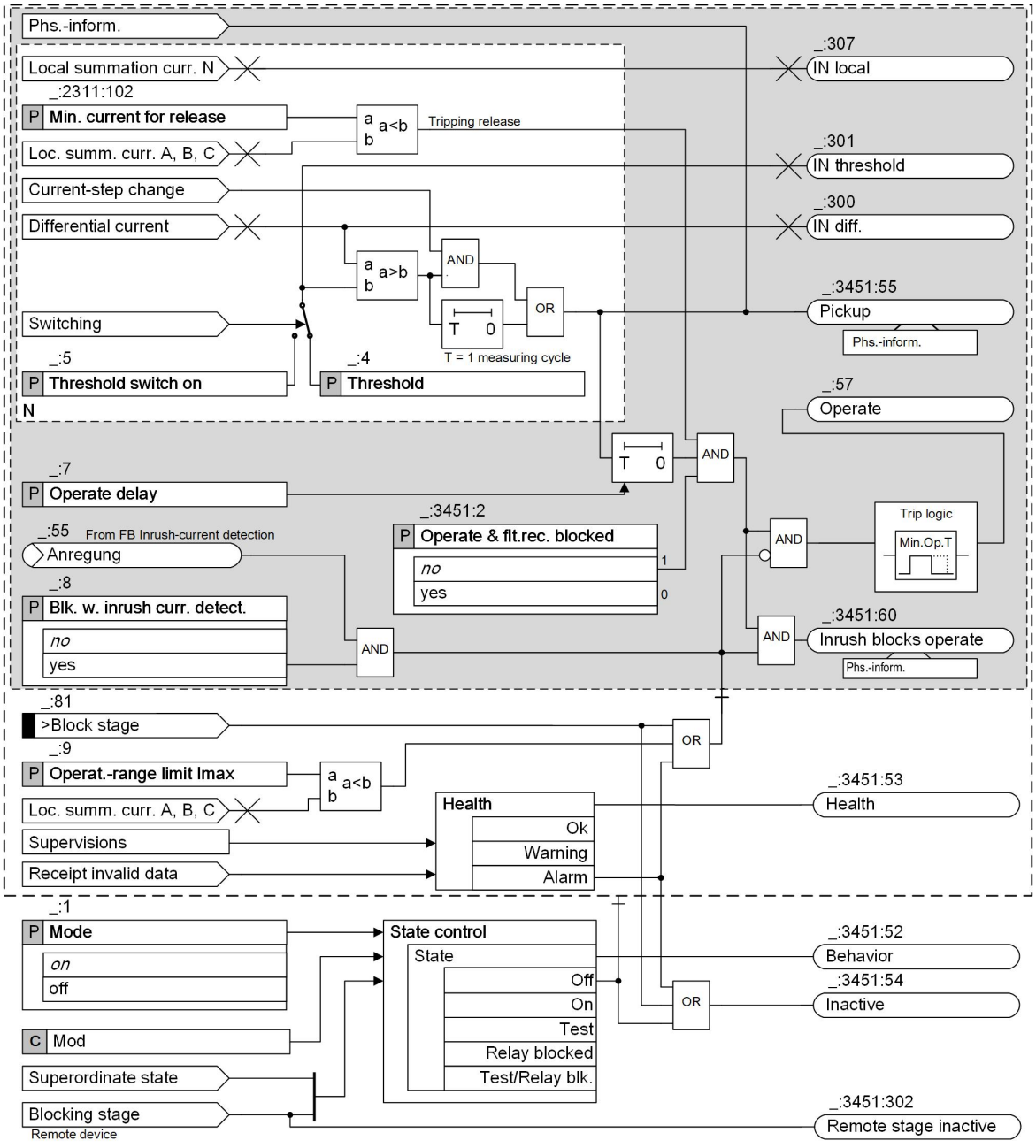
For the use of the stage **IN-DIFF unrest**, a baud rate of at least 512 Kbit/s is required.

Logic of the Stage



[lo_IN-DIFF-unstab, 2, en_US]

Figure 6-158 Logic of the Stage **IN-DIFF unrest**, Part 1



[lo_stage IN-diff-unstab phs-N, 2, en_US]

Figure 6-159 Logic of the Stage **IN-DIFF unrest**, Part 2

Mode of Operation

The stage **IN-DIFF unrest** is the stage of the differential protection for the neutral path. The principle of the stage **IN-DIFF unrest** is a comparison of the ground current phasors. Each device calculates an IN_{diff} differential current from the sum of the ground current phasors which are calculated at each end of the protected object and transmitted to the other ends. The amount of the differential current equals the fault current that the differential protection system sees. In the ideal case, it equals the short-circuit current. In healthy unbalanced operation, the amount of the differential current is small and corresponds to the capacitive charging current to ground in lines in a first approximation. If charging-current compensation is active, the maximum sensitivity is achieved and the pickup value can be set considerably smaller.

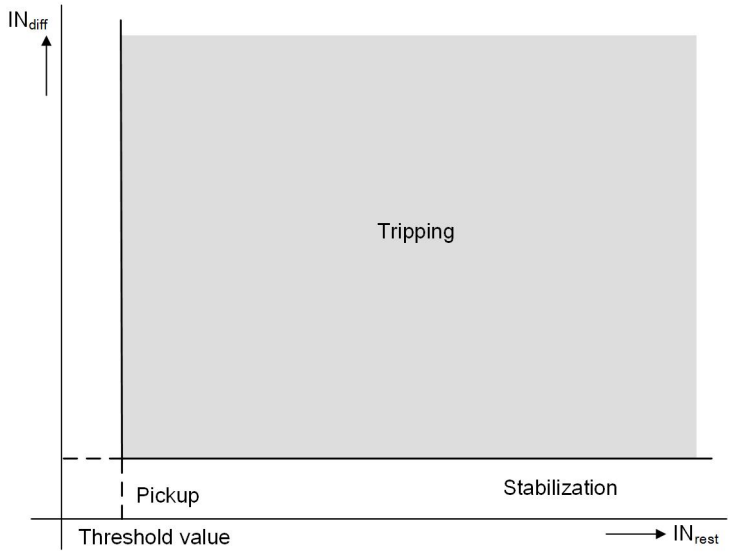
In contrast to the stage **IN-DIFF**, the stage **IN-DIFF unrest** operates without the restraint current I_{rest}. This means, the only criterion for pickup is that the differential current must exceed the parameter **`Threshold`**.

Optional functions such as **Charging-current compensation** (increased sensitivity) and **Transformer in the protection range** are automatically considered when the differential currents are calculated.

Pickup of the Stage

The stage **IN-DIFF unrest** picks up as soon as the differential current exceeds the setting value of the parameter **`Threshold`** (refer to *Figure 6-160*). This means that an internal error has occurred.

In case of an internal error, you can define an additional criterion for local tripping release using the parameter **`Min. current for release`**.



[dw_pickup characteristic_INdiff_INstab_01, 1, en_US]

Figure 6-160 Pickup Characteristic of the Stage **IN-DIFF unrest**

If the stage **IN-DIFF unrest** detects a fault in the neutral path, the stage generates the pickup signal with the ground information. When the ground-current differential protection picks up, the pickup signal of the stage **IN-DIFF unrest** takes over the phase information from the stages **I-DIFF**, **I-DIFF fast 2**, and **I-DIFF fast**.

Pick up upon Switching

When switching on longer, unloaded cables, overhead lines, and resonant-grounded lines, pronounced higher-frequency compensating processes can occur. These are strongly dampened by digital filters of the differential protection. You can ensure the pickup of the line differential protection is prevented when switching using the parameter **`Threshold switch on`**.

The parameter **`Threshold switch on`** always becomes effective as soon as a device in the device combination has detected that its end has been switched after a dead pause. All devices in the device combination are then changed over to this pickup value for the duration of the closure detection (parameter: **`Action time after closure`**).

For more information, refer to *5.5.4.7 Closure Detection*.

In addition, for the switching of transformers and shunt reactors, the device additionally features an **Inrush-current detection** function that can impose the blocking of the differential protection.

For more information, refer to *6.68.1.1 Overview of Functions*.

Inrush-Current Detection

You can find the function **Inrush-current detection** under **Line FG > Inrush-current det.** in the DIGSI 5 function library. Add this functionality to the function group **Line** (under **DIGSI 5 project tree > Name of the device > Parameter > Line**). In the stage **IN-DIFF unrest** of the line differential protection the parameter **`Blk. w. inrush curr. detect.`** now also appears.

Fault Behavior

The indication *Health* is set to ***Alarm*** when fast measured-value monitoring functions (fast sum I, analog-digital converter) signal a fault or when invalid data are received via the protection interface. The validity of the currents used as well as the validity of the data received via the protection interface are monitored continuously. If persistent faults are detected, **Health** is set to ***Alarm*** and **Inactive** is set to ***Yes***.

Measured Values of the Stage IN-DIFF unrest

To clarify faults, the stage **IN-DIFF unrest** provides the following measured values:

Measured Value	Description
(_:300) IN diff.	• If the stage **IN-DIFF unrest** operates with the measured ground current IN, the measured value corresponds to the ground differential current. • If the stage **IN-DIFF unrest** operates with the calculated zero-sequence current 3I0, the measured value corresponds to the zero-sequence current difference.
(_:301) IN threshold	Threshold value (pickup value)
(_:307) IN local	Amount of local ground-current phasor

The measured values are available in the fault record. You can read out the fault recordings from the device and analyze them afterwards using evaluation tools such as SIGRA. Only *IN diff.* and *IN threshold* are visible on the device display. To find the measured values on the device, go to **Main menu > Measured values > Line x > Functional measured values > Line differential protection → IN-DIFF unrest**.

For detailed information about selecting and deleting fault recordings, refer to the Operating Manual.

6.7.11.2 Application and Setting Notes

Parameter: Measured value

- Default setting **(_:2) Measured value** = ***3I0 calculated***

With the parameter **Measured value**, you set whether the stage **IN-DIFF unrest** should operate with the zero-sequence current 3I0 calculated from the phase currents or with the directly measured ground current IN. Phasor measured values are determined based on the set measured value and transmitted to the opposite ends.

On the other hand, the phasor measured values received from the opposite ends are used to calculate a differential zero-sequence current or a differential ground current. At one end of the line, you can set the parameter **Measured value** to ***3I0 calculated*** and at a second end of the line, you can select the setting ***IN measured***.



NOTE

For systems with isolated neutral point, the setting value of the parameter **Measured value** = ***IN measured*** is not possible.

Parameter: Blk. w. inrush curr. detect.

- Recommended setting value **(_:8) Blk. w. inrush curr. detect.** = ***no***

With the parameter **Blk. w. inrush curr. detect.**, you determine whether the tripping is blocked during the detection of an inrush current. If the inrush-current detection blocks tripping of the stage **IN-DIFF unrest**, the indication *Inrush blocks operate* is generated. The inrush-current detection is based on the phase currents.

Parameter: Threshold

- Recommended setting value **(_:4) Threshold** = ***0.300 A***

With the parameter **Threshold**, you set the pickup threshold for the stage **IN-DIFF unrest**. The total current flowing into the protection range during a short circuit, that is the total fault current, is decisive. This applies regardless of how it divides among the ends of the protected object.

Parameter: Threshold switch on

- Recommended setting value **(_:5) Threshold switch on** = *0.300 A*

With the parameter **Threshold switch on**, you set the pickup threshold for the stage **IN-DIFF unrest** during a detected connection.

A setting of 3 times to 4 times the stationary charging current generally ensures the stability of the protection when switching.

Approximately at the same time, all devices in the device combination use the pickup threshold increased with the parameter **Thresh. switch onto fault** during the set **(_:4681:102) Action time after closure**. For further information, refer to *5.5.4.7 Closure Detection*.

If you set the parameter **Threshold switch on** in exactly the same way as the parameter **Threshold**, the parameter **Threshold switch on** is ineffective.

Parameter: Operate delay

- Recommended setting value **(_:7) Operate delay** = *0.00 s*

In special cases, it can be advantageous to delay the tripping of the differential protection with an additional time stage, for example for a reverse interlocking. If the stage **IN-DIFF unrest** picks up, the time delay starts.

If you set the **Operate delay** = ∞, the stage **IN-DIFF unrest** does not trip.

Parameter: Operat.-range limit Imax

- Recommended setting value **(_:9) Operat.-range limit Imax** = *2.500 A*

With this parameter, you set up to which maximum local current the stage **IN-DIFF unrest** operates. In case of local currents above this threshold, the stage is blocked and the indication *Local current too high* is issued.

6.7.11.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
IN-DIFF unrest				
_:1	IN-DIFF unrest:Mode		• off • on	on
_:2	IN-DIFF unrest:Measured value		• 3I0 calculated • IN measured	3I0 calculated
_:3	IN-DIFF unrest:Operate & flt.rec. blocked		• no • yes	no
_:8	IN-DIFF unrest:Blk. w. inrush curr. detect.		• no • yes	no
_:4	IN-DIFF unrest:Threshold	1 A @ 100 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 100 Irated	0.50 A to 100.00 A	1.50 A
		1 A @ 50 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 50 Irated	0.50 A to 100.00 A	1.50 A
_:5	IN-DIFF unrest:Threshold switch on	1 A @ 100 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 100 Irated	0.50 A to 100.00 A	1.50 A
		1 A @ 50 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 50 Irated	0.50 A to 100.00 A	1.50 A
_:7	IN-DIFF unrest:Operate delay		0.00 s to 60.00 s; ∞	0.00 s

Addr.	Parameter	C	Setting Options	Default Setting
_:9	IN-DIFF unrest:Operat.-range limit Imax	1 A @ 100 Irated	0.003 A to 100.000 A	1.500 A
		5 A @ 100 Irated	0.02 A to 500.00 A	7.50 A
		1 A @ 50 Irated	0.003 A to 50.000 A	1.500 A
		5 A @ 50 Irated	0.02 A to 250.00 A	7.50 A

6.7.11.4 Information List

No.	Information	Data Class (Type)	Type
IN-DIFF unrest			
_:81	IN-DIFF unrest:>Block stage	SPS	I
_:51	IN-DIFF unrest:Mode (controllable)	ENC	C
_:54	IN-DIFF unrest:Inactive	SPS	O
_:302	IN-DIFF unrest:Remote stage inactive	SPS	O
_:52	IN-DIFF unrest:Behavior	ENS	O
_:53	IN-DIFF unrest:Health	ENS	O
_:55	IN-DIFF unrest:Pickup	ACD	O
_:57	IN-DIFF unrest:Operate	ACT	O
_:60	IN-DIFF unrest:Inrush blocks operate	ACT	O
_:312	IN-DIFF unrest:Local current too high	SPS	O
_:300	IN-DIFF unrest:IN diff.	MV	O
_:301	IN-DIFF unrest:IN threshold	MV	O
_:307	IN-DIFF unrest:IN local	MV	O

6.7.12 Stage I2-DIFF

6.7.12.1 Description

The negative-sequence differential protection (ANSI 87LQ):

- Is a selective short-circuit protection for overhead lines, cables, and busbars with single-side and multi-side infeed in radial, ring, or meshed systems
- Allows fast tripping of 1-pole or 2-pole short circuits at 2 to 6 line ends
- Allows protection of a transformer in the protection range of the line
- Gets more sensitive when using the charging-current compensation (Ic compensat.)

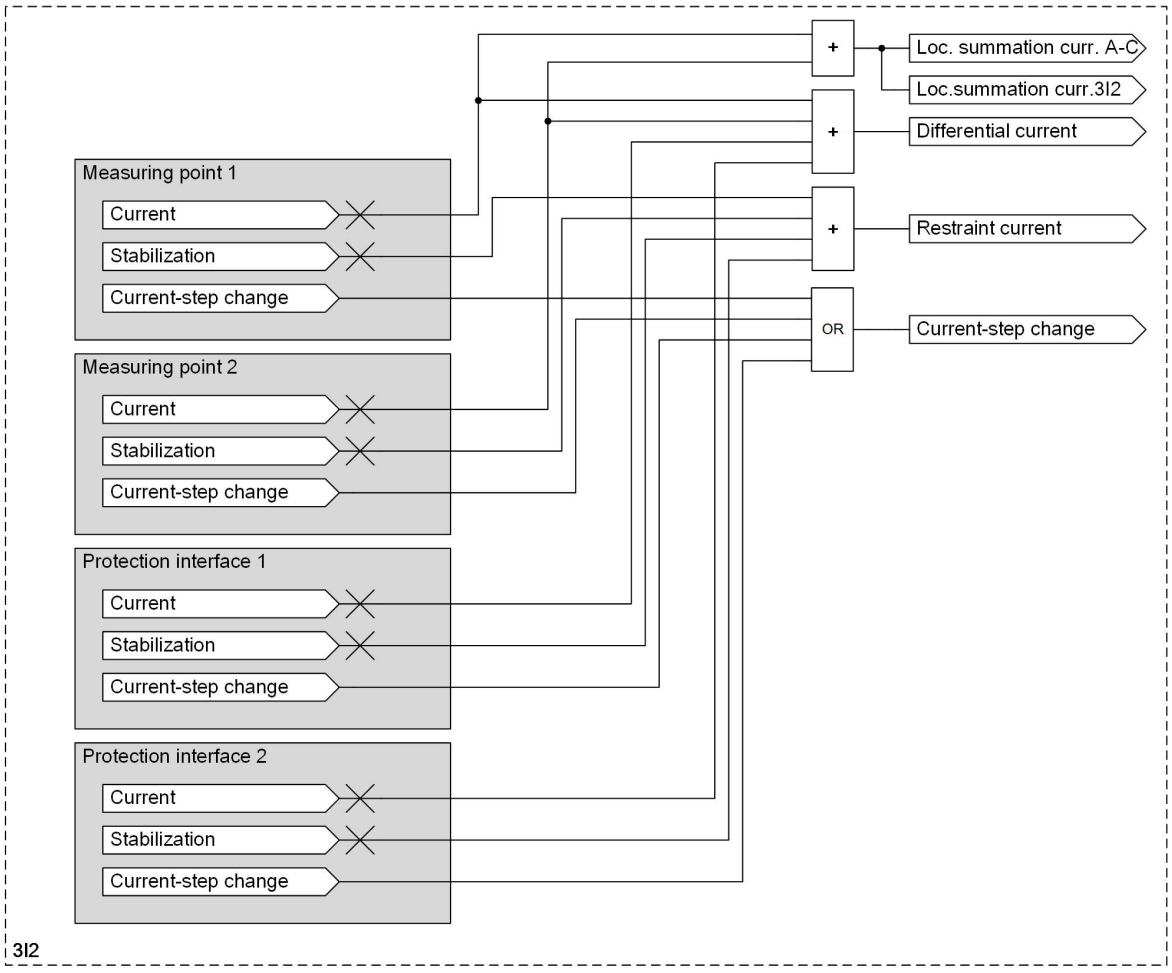


NOTE

For the use of the **I2-DIFF** stage, a baud rate of at least 512 Kbit/s is required.

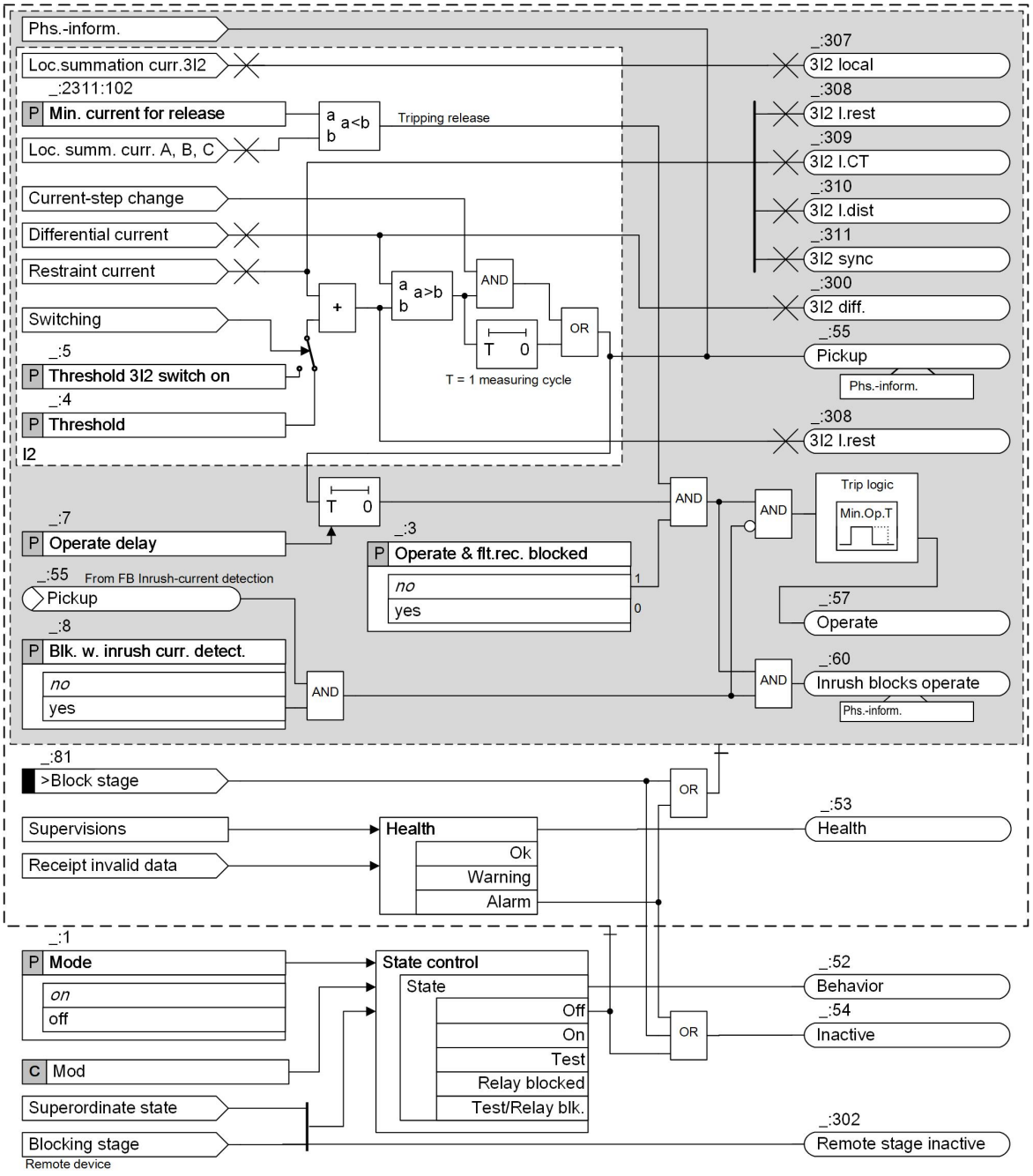
The stage **I2-DIFF** monitors the calculated negative-sequence current I2. As a result, the influence of load currents on the method of measurement is low for all unbalanced errors. Pure phase-to-phase errors have no effect on the ground path and are not detected by the stage **IN-DIFF**. These faults are recorded by the stage **I2-DIFF**.

Logic of the Stage



[lo_meas-value_310_02, 1, en_US]

Figure 6-161 Logic of the Stage **I2-DIFF**, Part 1



[lo_stage 3I2 phs-I2, 2, en_US]

Figure 6-162 Logic of the Stage **I2-DIFF**, Part 2

Mode of Operation

The stage **I2-DIFF** is the sensitive stage of the differential protection using the negative-sequence system. The principle of the stage **I2-DIFF** is a comparison of the negative-sequence current phasors. Each device calculates a differential current $3I2_{diff}$ from the sum of the negative-sequence current phasors which are calculated at each end of the protected object and transmitted to the other ends. The amount of the differential current corresponds to the fault current that the differential-protection system sees. In the ideal case, it corresponds to the short-circuit current. In healthy balanced operation, the differential current is 0. If the charging-current compensation is active, the maximum sensitivity is achieved and the pickup value can be set considerably smaller.

The $3I2_{rest}$ restraint current counteracts the differential current. The restraint current results from the sum of the maximum measuring faults at the ends of the protected object and is calculated adaptively from the current measurands and the set substation settings. To this end, the fault of the phase current transformers in the rated range or the short-circuit current range is multiplied by the maximum presently flowing current in one phase at each end of the protected object and transmitted to the other ends together with the determined internal faults. This means that the restraint current $3I2_{rest}$ reflects the maximum possible measuring fault in the differential-protection system.

Optional functions such as **Charging-current compensation** (increased sensitivity) and **Transformer in the protection range** are automatically considered when the differential currents are calculated.

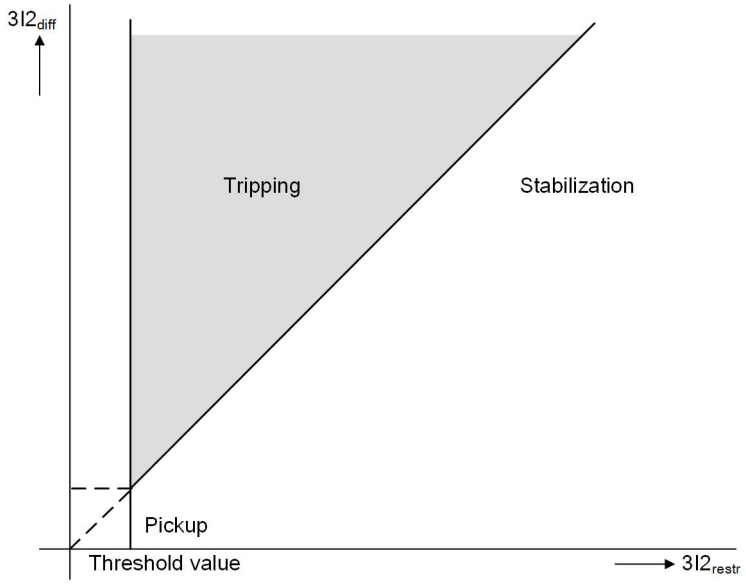
Pickup of the Stage

The pickup characteristic of the differential protection (see *Figure 6-163*) results from the restraint characteristic curve $3I2_{diff} = 3I2_{rest}$ (45 ° line) which is cut below the setting value of the **`Threshold 3I2`** parameter. It corresponds to the following equation:

$3I2_{rest}$ = **`Threshold 3I2`** + Σ(current-transformer error and other measuring errors)

If the measured differential current exceeds the pickup threshold (**`Threshold 3I2`**) and the maximum possible measuring faults, there is an internal fault (dimmed area in *Figure 6-163*).

In case of an internal fault, you can define an additional criterion for local tripping release using the parameter **`Min. current for release`**.



[dw_pickup characteristic_3I2diff_3I2stab_new, 1, en_US]

Figure 6-163 Pickup Characteristic of the Stage **I2-DIFF**

Pickup upon Switching

When switching on longer, unloaded cables, overhead lines, and resonant-grounded lines, pronounced higher-frequency compensating processes can occur. These are strongly dampened by digital filters of the differential protection. With the parameter **`Threshold 3I2 switch on`**, you can prevent a pickup of the line differential protection in case of switching.

The parameter **`Threshold 3I2 switch on`** always becomes effective as soon as a device in the device combination has detected that its end is switched after a dead time. All devices in the device combination are then changed over to this pickup value for the duration of the closure detection (parameter: **`Min. current for release`**).

For more information, refer to *5.5.4.7 Closure Detection*.

In addition, for the switching of transformers and shunt reactors, the device features an **Inrush-current detection** function via which blocking of the differential protection is possible.

For more information, refer to *6.68.1.1 Overview of Functions*.

Inrush-Current Detection

You can find the **Inrush-current detection** function in the Global DIGSI 5 library under **Line FG > Inrush detect.**. Add this functionality to the **Line** function group (under **DIGSI 5 project tree >Name of the device > Settings >Line**). In the stage **I2-DIFF** of the line differential protection, the parameter **Blk. w. inrush curr. detect.** appears additionally.

Fault Behavior

The indication *Health* is set to ***Alarm*** when fast measured-value monitoring functions (fast sum I, analog-digital converter) signal a fault or when invalid data are received via the protection interface. The validity of the currents used as well as the validity of the data received via the protection interface are monitored continuously. If persistent faults are detected, **Health** is set to ***Alarm*** and **Inactive** is set to ***Yes***.

Measured Values of the Stage I2-DIFF

To clarify failures, the stage **I2-DIFF** provides the following measured values:

Measured Value	Description
(_:300) 3I2 diff.	Negative-sequence differential current
(_:301) 3I2 restr	Negative-sequence restraint current (overall restraint)
(_:307) 3I2 local	Amount of local negative-sequence current phasor
(_:308) 3I2 l.rest	Local negative-sequence restraint current
(_:309) 3I2 l.CT	Partial component of the local restraint current that considers the transformer fault.
(_:310) 3I2 l.dist	Subcomponent of the local negative-sequence restraint current that considers the fault caused by signal distortion. Each deviation of the signal form from the sinus shape is interpreted as a signal distortion. The deviation between the actual signal form and the sinus shape will be converted to a percentage of the stabilization.
(_:311) 3I2 sync	Subcomponents of the overall restraint that are caused by faults during the time synchronization of the current phasor.

The measured values are available in the fault record. You can read out fault recordings from the device and analyze them afterwards using evaluation tools such as **SIGRA**. The device display shows only *3I2 diff.* and *3I2 restr*. To find the measured values on the device, go to **Main menu > Measurements > Line x > Functional measured values > Line differential protection > I2-DIFF**.

For detailed information about selecting and deleting fault recordings, refer to the Operating Manual.

6.7.12.2 Application and Setting Notes

Parameter: Blk. w. inrush curr. detect.

- Default setting **(_:8) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you determine whether the tripping is blocked during the detection of an inrush current. If the inrush-current detection blocks tripping of the stage **I2-DIFF**, the indication *Inrush blocks operate* is generated. Inrush-current detection is based on the phase currents.

Parameter: Threshold 3I2

- Recommended setting value **(_:4) Threshold 3I2** = ***0.300 A***

With the **Threshold 3I2** parameter, you set the pickup threshold for the stage **I2-DIFF**. Here, the total current flowing into the protection range during a short circuit is decisive. This applies regardless of how the current is divided among the ends of the protected object.

Parameter: `Threshold 3I2 switch on`

- Recommended setting value **`Threshold 3I2 switch on`** = ***`0.300 A`***

With the **`(_:5) Threshold 3I2 switch on`** parameter, you set the pickup threshold for the stage **I2-DIFF** during a detected connection.

A setting of 3 times to 4 times the stationary charging current ensures the stability of the protection when switching.

Approximately at the same time, all devices in the device combination use the pickup threshold increased with the **`Thresh. switch onto fault`** parameter during the set **`(_:4681:102) Action time after closure`**. For further information, refer to *5.5.4.7 Closure Detection*.

If you set the parameter **`Threshold 3I2 switch on`** exactly in the same way as the parameter **`Threshold 3I2`**, the parameter **`Threshold 3I2 switch on`** is ineffective.

Parameter: `Operate delay`

- Recommended setting value **`(_:7) Operate delay`** = ***`0.00 s`***

In special cases, it can be advantageous to delay the tripping of the differential protection with an additional time stage, for example for a reverse interlocking. The time delay is started when the stage **I2-DIFF** picks up.

If you set **`Operate delay`** = ∞, the **I2-DIFF** stage will not trip.

Example

The ring feeder in the *Figure 6-164* is protected with the sensitive stage **I2-DIFF**. In healthy operation, the negative-sequence differential current **$3I2_{diff}$** occurs at 1st place because of the unbalanced load current in the transformers of the secondary substations. As a rule, the proportion I2 in the load current is less than 5 %.

In the example, the transformers of the secondary substations each have a rated apparent power of 1500 kVA. Thus, the maximum outgoing load current and the negative-sequence differential current **$3I2_{diff}$** are calculated as follows:

$$I_{Load_sum} = 5 \cdot \frac{1500\,\text{kVA}}{\sqrt{3} \cdot 11\,\text{kV}} = 394\,\text{A}$$

[fo_sum_current_i_load, 1, en_US]

Due to unbalance, a maximum of 5 % I2 is assumed:

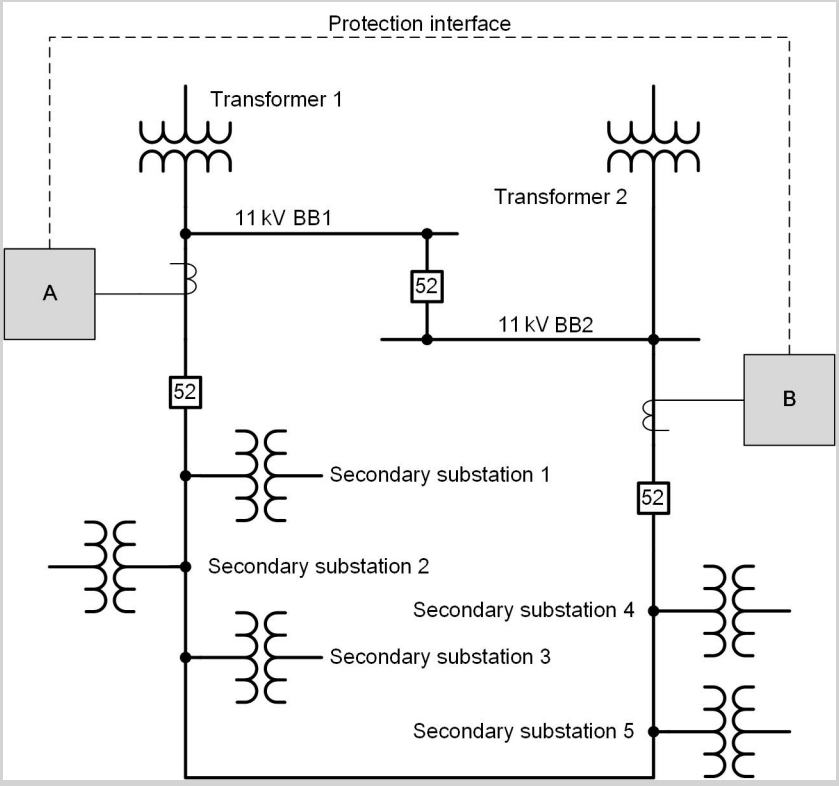
$$3I2_{load} = 3 \cdot 5\,\% \cdot I_{load_{sum}} = 3 \cdot 0.05 \cdot 394\,\text{A} = 59.1\,\text{A}$$

[fo_3I2_Load, 1, en_US]

The **`Threshold 3I2`** with a safety margin of 20 % is set as follows:

$$\text{Threshold } 3I2 = 1.2 \cdot 3I2_{load} = 1.2 \cdot 59.1\,\text{A} = 71\,\text{A prim}$$

[fo_3I2_Load_Thresh, 1, en_US]



[dw_ring-example_1, en_US]

Figure 6-164 Example Ring Feeder

Tripping delay

If a fuse at the secondary substations allows selective fault clearing, the stage **I2-DIFF** must be delayed. A grading time of 300 ms is sufficient:

`Operate delay` = ***`0.30 s`***

When switching on, the inrush current can be higher than the maximum load current. To avoid overfunction, the threshold is adjusted when switching on. Assumed, the maximum inrush current is 400 % of the rated current. The pickup threshold of the stage **I2-DIFF** is increased by 400 %:

`Threshold 3I2 switch on` = ***`400 %`*** · **`Threshold 3I2`** = ***`4`*** · 71 A = 284 A prim

6.7.12.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`I2-DIFF`				
_:1	I2-DIFF:Mode		• off • on	on
_:3	I2-DIFF:Operate & flt.rec. blocked		• no • yes	no
_:8	I2-DIFF:Blk. w. inrush curr. detect.		• no • yes	no
_:4	I2-DIFF:Threshold 3I2	1 A @ 100 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 100 Irated	0.50 A to 100.00 A	1.50 A
		1 A @ 50 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 50 Irated	0.50 A to 100.00 A	1.50 A

Addr.	Parameter	C	Setting Options	Default Setting
_:5	I2-DIFF:Threshold 3I2 switch on	1 A @ 100 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 100 Irated	0.50 A to 100.00 A	1.50 A
		1 A @ 50 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 50 Irated	0.50 A to 100.00 A	1.50 A
_:7	I2-DIFF:Operate delay		0.00 s to 60.00 s; ∞	0.00 s

6.7.12.4 Information List

No.	Information	Data Class (Type)	Type
I2-DIFF			
_:81	I2-DIFF:>Block stage	SPS	I
_:51	I2-DIFF:Mode (controllable)	ENC	C
_:54	I2-DIFF:Inactive	SPS	O
_:302	I2-DIFF:Remote stage inactive	SPS	O
_:52	I2-DIFF:Behavior	ENS	O
_:53	I2-DIFF:Health	ENS	O
_:55	I2-DIFF:Pickup	ACD	O
_:57	I2-DIFF:Operate	ACT	O
_:60	I2-DIFF:Inrush blocks operate	ACT	O
_:300	I2-DIFF:3I2 diff.	MV	O
_:301	I2-DIFF:3I2 restr	MV	O
_:307	I2-DIFF:3I2 local	MV	O
_:308	I2-DIFF:3I2 l.rest	MV	O
_:309	I2-DIFF:3I2 l.CT	MV	O
_:310	I2-DIFF:3I2 l.dist	MV	O
_:311	I2-DIFF:3I2 sync	MV	O

6.7.13 Remote Tripping

6.7.13.1 Description

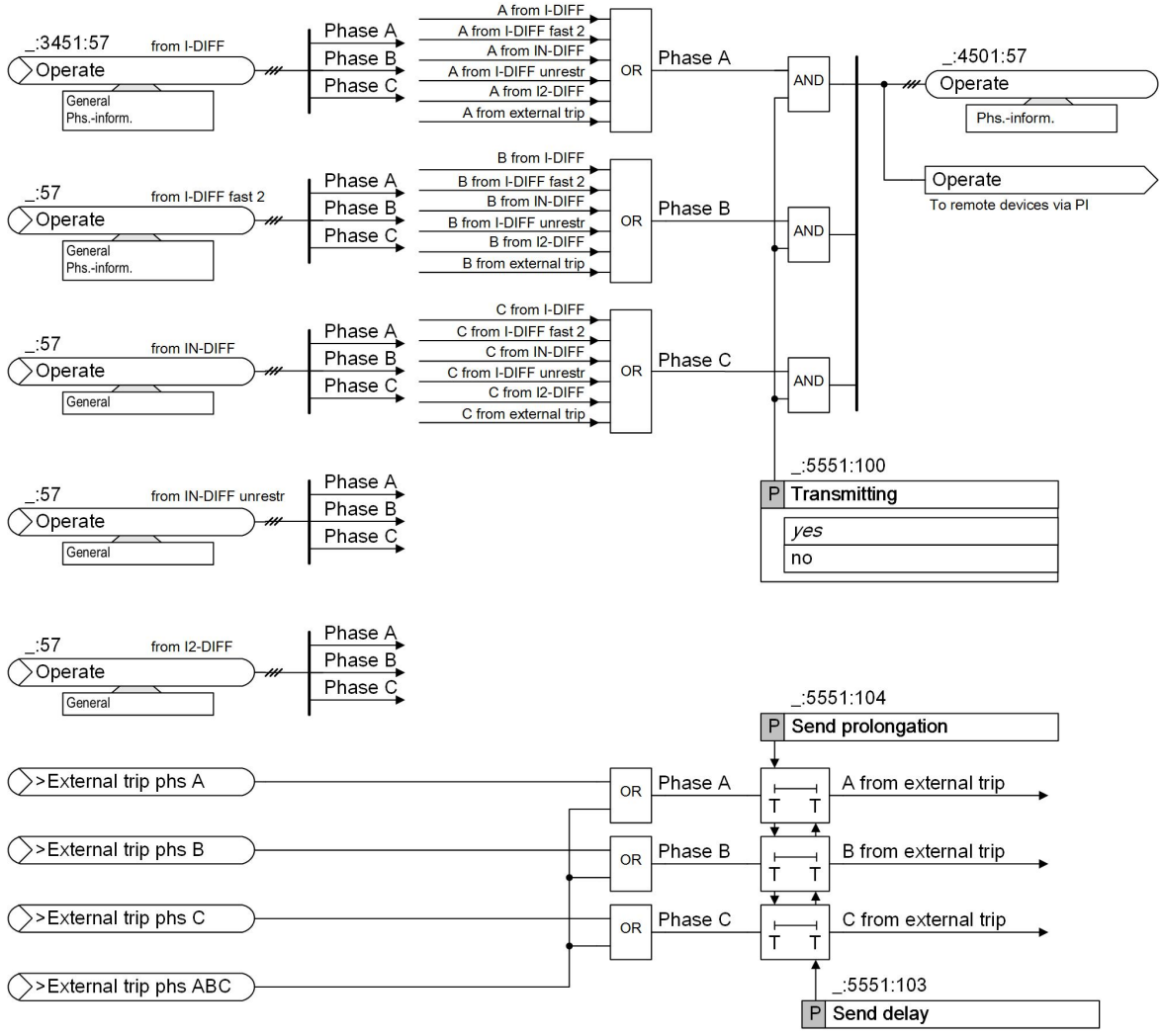
The function **Line differential protection** contains the functionality **remote tripping**.

Remote tripping forms the phase-segregated operate indication *(_:5551:300) Operate transmitted* by the OR operation of the operate indications in the stages **I-DIFF**, **I-DIFF fast 2**, **IN-DIFF**, **IN-DIFF unrest**, and **I2-DIFF** and transmits it to the Line differential protection functions of the remote devices in the device combination

If a device receives a remote operate indication from a remote device, the **remote tripping** functionality generates the indication *(_:5551:57) Operate*.

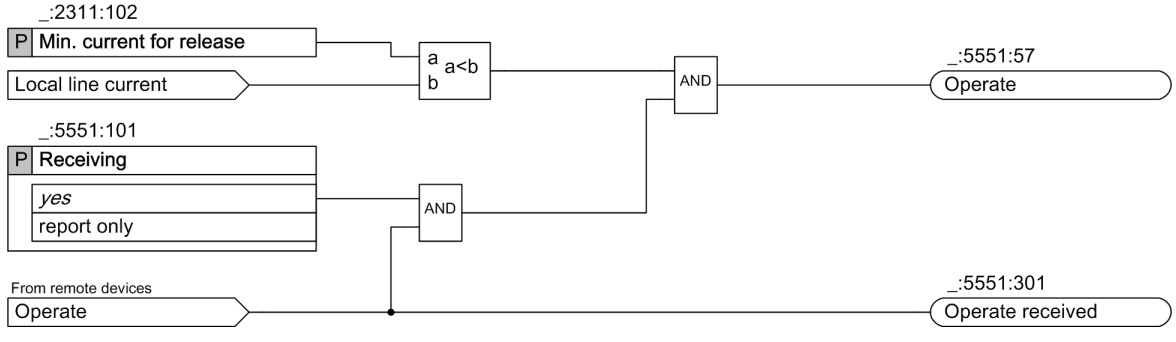
You can find the **remote tripping** indications in the DIGSI 5 information routing under **Line** →**Line differential protection**→ **Remote tripping**.

Logic of the Stage



[lo_Group-indication_operate-send, 1, en_US]

Figure 6-165 Logic of the Transmit Direction



[lo_receive_direction_3pol, 1, en_US]

Figure 6-166 Logic of the Receive Direction

6.7.13.2 Application and Setting Notes for Remote Tripping

Parameter: `Transmitting`

- Recommended setting value **`(_:5551:100) Transmitting`** = ***on***

With the **Transmitting** parameter, you set whether the remote operate indications of the line differential protection are transmitted by way of the protection interface or not.

Parameter Value	Description
on	The functionality **Remote tripping** forms the indication *(_:5551:300) Operate transmitted* by the OR operation of the operate indications of the following stages: • **I-DIFF** • **I-DIFF fast 2** • **I-DIFF fast** • **IN-DIFF** • **IN-DIFF unrest** • **I2-DIFF** The functionality **Remote tripping** sends the indication *Operate transmitted* to the Line differential protection functions of the remote devices in the device combination via the protection interface.
off	The functionality **Remote tripping** does not transmit the remote operate indication via the protection interface.

Parameter: Receiving

- Recommended setting value **(_:5551:101) Receiving** = ***yes***

With the **Receiving** parameter, you control the behavior of the device when a remote operate indication is received from a remote device.

Parameter Value	Description
yes	With this setting option, the indications *(_:5551:301) Operate received* and *(_:5551:57) Operate* are generated.
report only	With this setting option, the *(_:5551:57) Operate* is not generated.

Parameter: Send delay and Send prolongation

- Default setting **(_:5551:103) Send delay** = *0.02 s*
- Default setting **(_:5551:104) Send prolongation** = *0.00 s*

With the routing of the binary signal >External trip phs ABC, you can generate a remote operate indication and transmit it to the remote devices of the device combination.

With the **Send delay** parameter, you delay transmission of the remote operate indication by the set time.

With the **Send prolongation** parameter, you extend transmission of the remote operate indication by the set time.

6.7.13.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:5551:1	Remote trip.:Mode		• off • on	on
_:5551:100	Remote trip.:Transmitting		• no • yes	yes
_:5551:101	Remote trip.:Receiving		• yes • report only	yes

Addr.	Parameter	C	Setting Options	Default Setting
Intertrip				
_:5551:103	Remote trip.:Send delay		0.00 s to 30.00 s	0.02 s
_:5551:104	Remote trip.:Send prolongation		0.00 s to 30.00 s	0.00 s

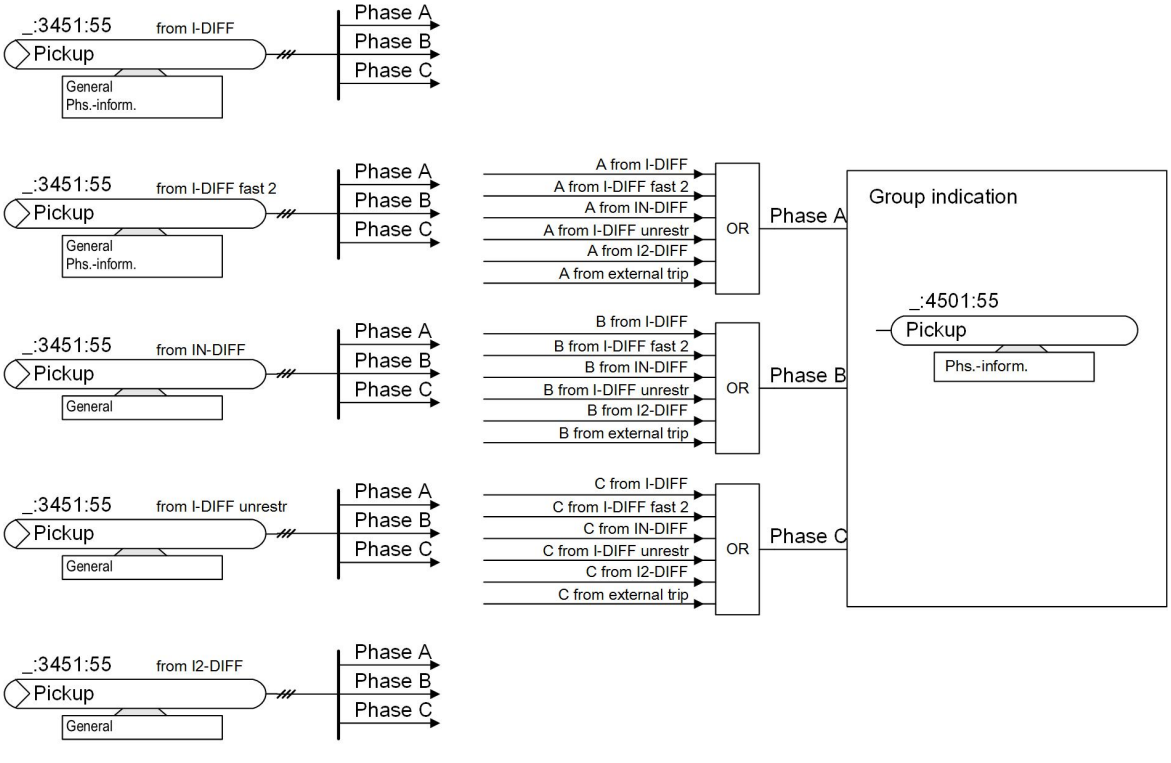
6.7.13.4 Information List

No.	Information	Data Class (Type)	Type
Remote trip.			
_:5551:505	Remote trip.:>External trip phs ABC	SPS	I
_:5551:54	Remote trip.:Inactive	SPS	O
_:5551:52	Remote trip.:Behavior	ENS	O
_:5551:53	Remote trip.:Health	ENS	O
_:5551:57	Remote trip.:Operate	ACT	O
_:5551:300	Remote trip.:Operate transmitted	ACT	O
_:5551:301	Remote trip.:Operate received	ACT	O

6.7.14 Pickup and Tripping

6.7.14.1 Pickup Logic

The pickup logic combines the pickup indications of the stages **I-DIFF**, **I-DIFF fast 2**, **I-DIFF fast**, **IN-DIFF**, **IN-DIFF unrest**, and **I2-DIFF** in a phase-segregated manner and forms the pickup group indication of the function **Line differential protection**.

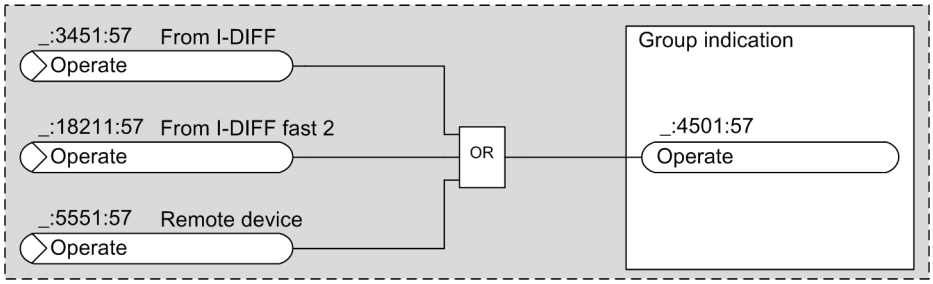


[lo_Group-indication_pickup, 1, en_US]

Figure 6-167 Pickup Logic

6.7.14.2 Trip Logic

The trip logic combines the operate indications of the stages **I-DIFF**, **I-DIFF fast 2**, **IN-DIFF**, **IN-DIFF unrest**, **I2-DIFF** and the **remote tripping** and forms the tripping group indication of the function **Line differential protection**.
If you have instantiated the FG **Circuit breaker**, the function **Line differential protection** trips in a 3-pole way.



[loauslo3-100311-01.tif, 4, en_US]

Figure 6-168 3-Pole Trip Logic

6.7.14.3 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O

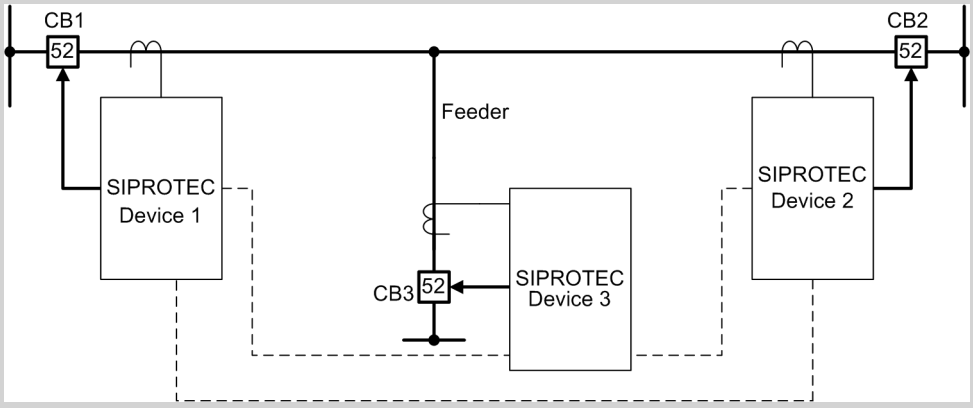
6.7.15 Logging Off the Local Line Differential Protection

For some applications, it may be necessary to remove and log off the local Line differential protection from the device combination of the line differential protection. These applications include, for example:

- Maintenance work
- System expansion
- Testing the local line differential protection

EXAMPLE:

The following line formation is protected by the line differential protection with 3 devices.



[dw_example logoff ldiff, 2, en_US]

Figure 6-169 Differential Protection with 3 Devices for a Line with a Feeder

In the example, the feeder is to be decommissioned for maintenance or modification work. Device 3 should therefore also be switched off. Without additional measures, the line differential protection will no longer function and will send an indication that it is ineffective.

For this use case, the **Line differential protection** function must be logged off in device 3. The Line differential protection in device 3 can only be logged off if no current is flowing through the feeder. During the log-off process, device 3 checks whether the circuit breaker 3 is really open. If the Line differential protection is logged off in device 3, this is saved in the remaining devices 1 and 2 and Kirchhoff's current law will then be calculated only with the currents of the devices 1 and 2.

If device 3 is successfully logged off, you can switch it off. The logoff of device 3 is saved in the remaining devices after it is switched off. If you switch device 3 back on, log on to the device combination again.

NOTE

Before logging off, you must switch off the feeder protected by the local line differential protection.

Logoff Options of the Line Differential Protection

You can log off the **Line differential protection** function as follows:

- In DIGSI online mode via the operating dialog **Online accesses > Interface > Device > Device information, Test and operation, Functional logout**
- Via the on-site operation panel under **Device functions > Line n > Line diff. protection > Log off function**
- Via communication with the controllable *(_:2311:319) Function logout*
- Via the binary inputs *(_:2311:507) >Function logout on* or *(_:2311:508) >Function logout off*

  You can find the binary inputs in the DIGSI information routing at the function **Line differential protection** under **General**.

Conditions for Logging off the Function

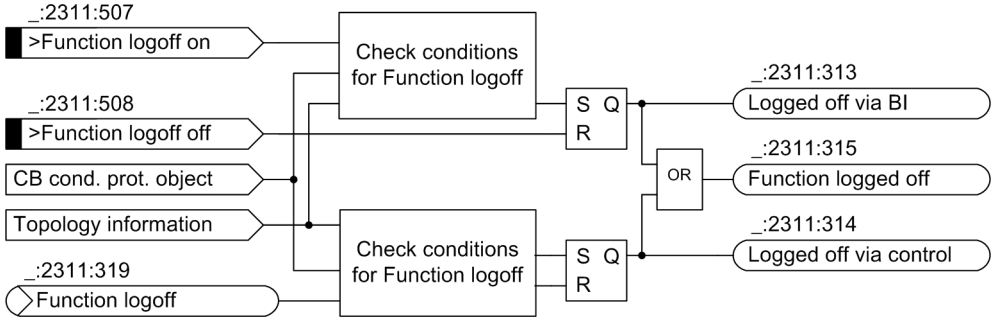


Figure 6-170 Logic for Logging off the Function

The following conditions must be fulfilled before the function is logged off:

- The current flow at the circuit breaker must be stopped. You must switch off the feeder protected by the local line differential protection.

  The locally measured current of the logged-off line end no longer flows into the sum of the currents. The function then only sums up the currents from the line ends that have not been logged off.

- The circuit-breaker position recognition in the **Circuit-breaker** function group (CB) provides the circuit-breaker condition via the internal signal *CB state protected obj.*.

  If a protected object is supplied via 2 circuit breakers (CBs), for example, in case of a breaker-and-a-half layout, then the CB state of the protected object must be determined with both circuit breakers. In this case, the **Circuit-breaker condition for the protected object** function block performs the connection of the individual CB conditions.

  If one of the following 2 conditions is met, the *CB state protected obj.* internal signal is in the ***Open*** state:

  – All connected circuit breakers signal the ***Open*** state.

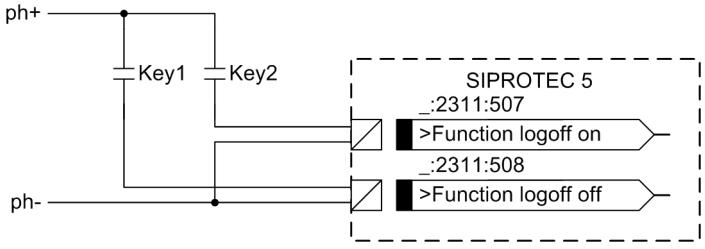
  – The input **>Disconnector open** is active.

  For more detailed information, refer to *5.5.4.6 Circuit-Breaker Condition for the Protected Object*.

- Monitoring the communication topology in the device combination is only important if more than 2 devices are communicating via the protection interface. A function can only be logged off if this does not disturb the communication between the remaining devices in the device combination.

The logged-off local line differential protection can also be activated for test purposes (see *11.7 Functional Test Line Differential Protection*). This has no influence or impact on the running protection interface communication.

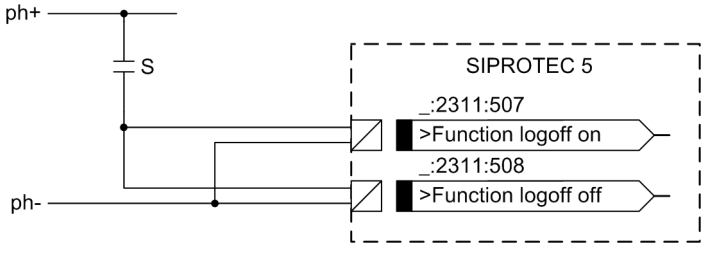
The following diagrams show potential variants on how to control binary inputs. If you would like to use push-buttons, switch on these push-buttons as shown in the following figure. With the push-button **Key2**, you log off the function using; with the push-button **Key1**, you log the function on again.



[loexttx3-140311-01.tif, 1, en_US]

Figure 6-171 External Push-Button Wiring for Logging off the Local Line Differential Protection

If a control switch is used, route the binary input *>Function logout on* as ***H (active with voltage)*** and the binary input *>Function logout off* as ***L (active without voltage)***. If the switch **S** is closed, the function is logged off.



[loextsx4-020412-01.tif, 1, en_US]

Figure 6-172 External Switch Wiring for Logging off the Local Line Differential Protection

Indications

The logged-off function reports the status (*Function logged off*) and the cause of the logoff.

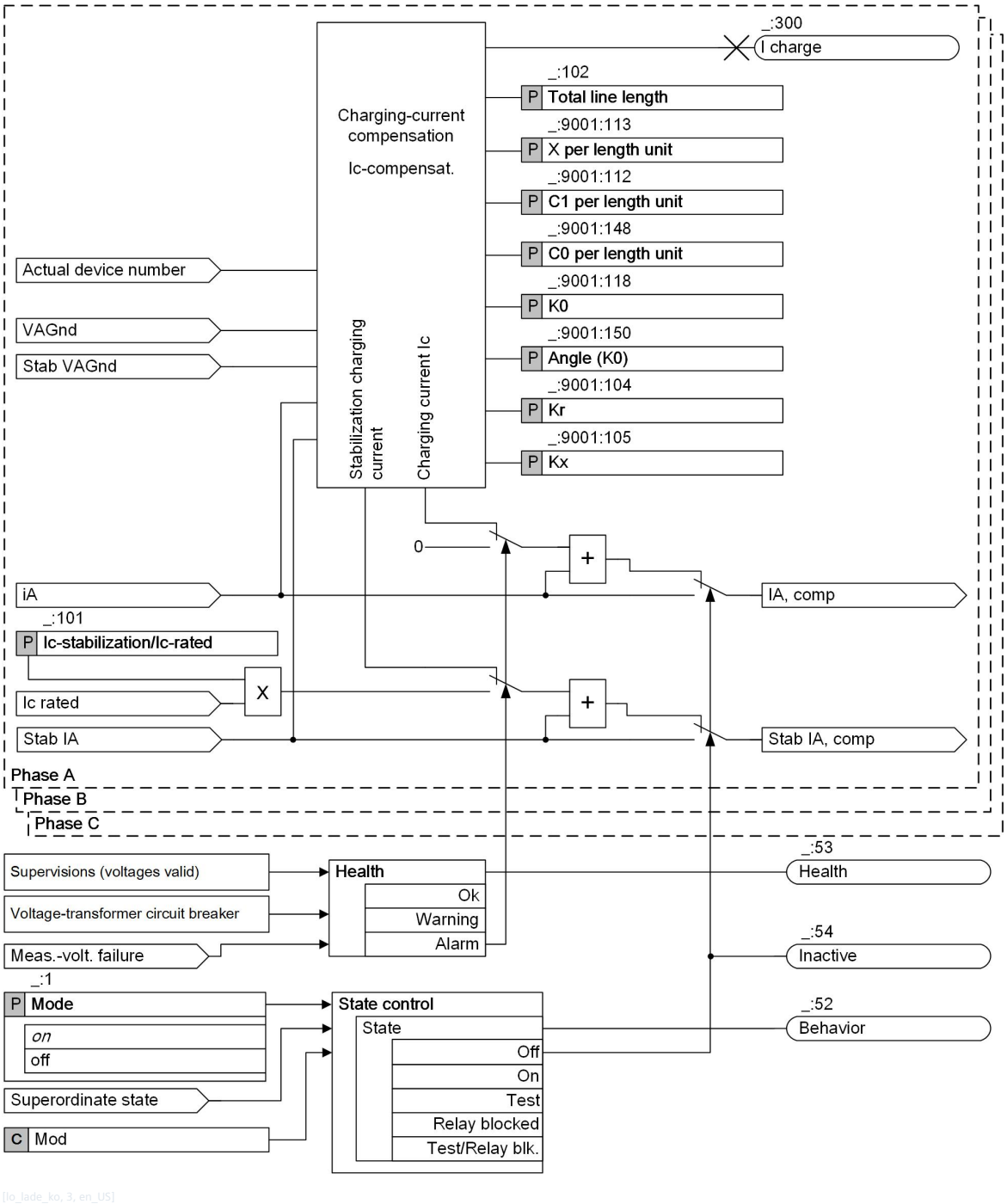
If you have logged off the function via binary inputs, the indication *Logged off via BI* is issued.

If you have logged off the function via on-site operation, DIGSI 5, or the protection interface, the indication *Logged off via control* is issued.

6.7.16 Charging-Current Compensation Ic-Compensation

6.7.16.1 Description

Logic of the Stage



[lo_lade_ko, 3, en_US]

Figure 6-173 Charging-Current Compensation

Mode of Operation

The optional FB **Ic-compensat.** is available for charging-current compensation. The FB **Ic-compensat.** is assigned to the stages **I-DIFF**, **IN-DIFF**, **IN-DIFF unrestr**, and **I2-DIFF** and increases the sensitivity of the stages even with high capacitive charging currents.

The charging current is caused by the capacitances of the overhead line or the cable and flows through the ground capacitance of the line. Due to the phase-to-ground and phase-to-phase capacitances, charging currents are flowing even in correct operation, which cause a difference of the currents at the ends of the protection range. In cables or long lines, the capacitive charging currents can reach considerable values. If the feeder-side transformer voltages are connected to the devices, the influence of the capacitive charging currents can be compensated for by calculation. The charging-current compensation specifies the actual charging current. If there are lines with 2 ends, each device performs half the charging-current compensation. When using .

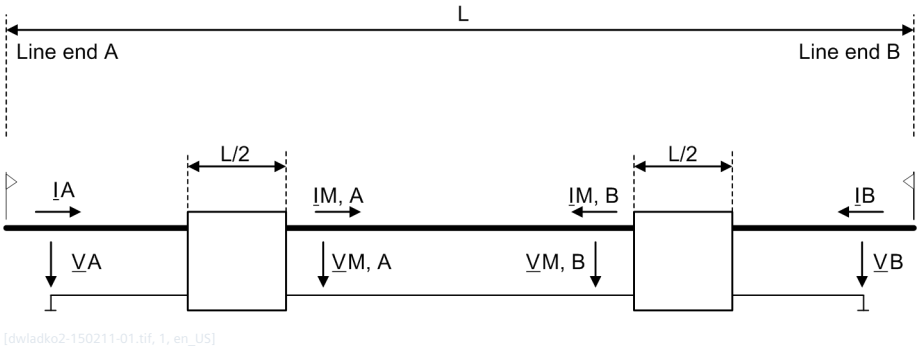


Figure 6-174 Charging-Current Compensation for a Line with 2 Ends (1-Phase System)

For correct operation, stationary charging currents can be regarded as almost constant since they only depend on the voltage and line capacitances. If you are working without charging-current compensation, take into account the charging currents in the pickup value of the **I-DIFF** stage. With charging-current compensation, this does not have to be taken into account here. With charging-current compensation, the stationary magnetizing currents are considered before quadrature-axis reactances. For transient inrush currents, the devices are provided with separate inrush-current detection.

NOTE

If you wish to work with the charging-current compensation, consider the following:

- The local voltage transformers must be connected to the line!
- Monitor the voltage with the **Measuring-voltage failure detection** function. If the **Measuring-voltage failure detection** is not present in the **Line** function group, add the function to the **Line** function group from the Global DIGSI 5 library.

  You can find the **Measuring-voltage failure detection** function in the Global DIGSI 5 library under **FG Line → Supervision of secondary system → Mes.v.fail.det**.

If a transformer or common-mode reactors are located in the line section to be protected, charging-current compensation must not be activated!

6.7.16.2 Application and Setting Notes

The rated current **Ic-rated** is the capacitive charging current to be expected for the entire line and is the result of the setting values of the following parameters:

Parameters	Description
(_:101) Rated frequency	Rated frequency of the device You can find the parameter in DIGSI 5 under **Settings** → **Device settings**.
(_:9001:102) Rated voltage **(_:9001:112) C1 per length unit** **(_:9001:148) C0 per length unit** **(_:9001:113) X per length unit** **(_:9001:104) Kr** **(_:9001:105) Kx** **(_:9001:118) K0** **(_:9001:150) Angle (K0)**	Rated voltage of the line Capacitance per unit length of the line Reactance per unit length of the line Residual compensation factors You can find the parameters in DIGSI 5 under **Settings** → **FG Line** → **General**.
(_:102) Total line length	Overall length of the line as a parameter of the charging-current compensation You can find the parameter in DIGSI 5 under **Settings** → **FG Line** → **Line diff. prot.** in the FB **Ic-compensat.**.

For verification purposes, the rated charging current is displayed as a write-protected parameter in the function block **Ic-compensat.** (**(_:110) Rated charging current**).

In the following cases, no charging current can be calculated:

- The voltages are not connected.
- The voltages are connected, but the internal supervision functions **Voltage-transformer circuit breaker** or **Measuring-voltage failure detection** (Fuse Failure Monitor) detect a loss of voltage.

If one of the 2 cases occurs, the charging-current compensation remains responsible for the line; however, it must return to the conventional stabilization method (see parameter **Ic-stabilization/Ic-rated**).



NOTE

Before switching off the charging-current compensation with the parameter **Mode**, you must increase the **Threshold** of the **I-DIFF** stage to 2 to 3 times **Ic-rated** of the line distance portion. Otherwise, undesired tripping might occur.



NOTE

You must enter additional line parameters for charging-current compensation. These include the following parameters:

- The **Rated frequency**
- The **Rated voltage** of the line
- Capacitance per unit length of the line (**C1 per length unit**, **C0 per length unit**)
- The residual compensation factors (**Kr**, **Kx**, **K0**, **Angle (K0)**)
- The **Total line length**

Parameter: Ic-stabilization/Ic-rated

- Recommended setting value **(_:101) Ic-stabilization/Ic-rated** = *1.5*

It is only possible to set the **I-DIFF** stage more sensitively by using the charging-current compensation (FB **Ic-compensat.**). If you use the charging-current compensation, set the **Threshold** of the **I-DIFF** stage to 1· Ic-rated.

In case of an outage or lack of voltages, it must be ensured that the **Threshold** of the **I-DIFF** stage is increased again to 2 to 3 times Ic-rated. Do this with the parameter **Ic-stabilization/Ic-rated**.

With the **Ic-stabilization/Ic-rated** parameter, you set the stabilization charging current/rated current ratio. The setting value of the parameter **Ic-stabilization/Ic-rated** increases the stabilization of the **I-DIFF** stage by an additional component (stabilization charging current).

EXAMPLE:

In case of an outage or lack of voltages, the **Threshold** of the **I-DIFF** stage is to be increased to 2.5 times Ic-rated. The threshold of the **I-DIFF** stage is set to 1 · Ic-rated.

If you want to increase the threshold of the **I-DIFF** stage to 2.5 times, set the parameter **Ic-stabilization/Ic-rated** = 1.5.

In case of an outage of lack of voltages, both setting values are added to 2.5.

Since the charging current of the device must only be considered for the respective portion of the line, each device will in fact increase its normal stabilization by a value of **Ic-stabilization/Ic-rated** divided by the number of devices.

Parameter: Total line length

- Default setting **(_:102) Total line length** = ***100.0 km***

The parameter **Total line length** considers the entire length of the protected line . Thus, the overall capacity of the line and the resulting charging current of the line can be determined.

6.7.16.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Ic-compensat.				
_:1	Ic-compensat.:Mode		• off • on	on
_:101	Ic-compensat.:Ic-stabilization/Ic-rated		1.0 to 4.0	1.5
_:102	Ic-compensat.:Total line length		0.1 km to 1000.0 km	100.0 km

6.7.16.4 Information List

No.	Information	Data Class (Type)	Type
Ic-compensat.			
_:54	Ic-compensat.:Inactive	SPS	O
_:52	Ic-compensat.:Behavior	ENS	O
_:53	Ic-compensat.:Health	ENS	O
_:300	Ic-compensat.:I charge	WYE	O

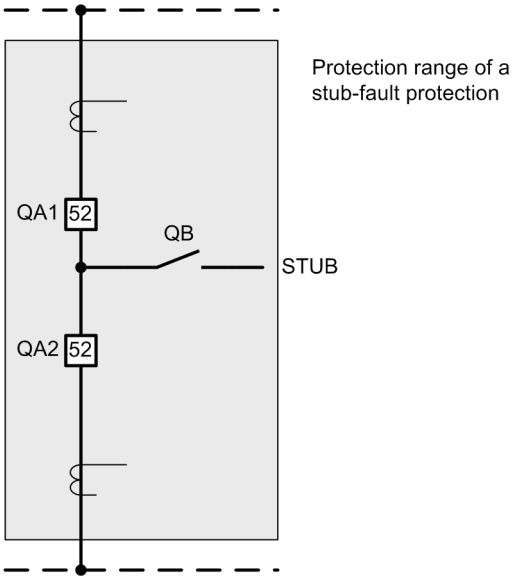
6.8 Stub Differential Protection

6.8.1 Overview of Functions

The Stub differential protection (ANSI 87STUB):

- Is a selective, 2-step short-circuit protection for a line stub that can be tripped by a disconnector switch. It is important in 1 1/2 circuit-breaker layouts.
- Detects short circuits that lie between the current transformers and the feeder disconnector switch QB.
- Operates strictly phase-segregated and permits 3-pole instantaneous high-speed tripping

The stub differential protection operates on the basis of current comparison. To do this, the current transformers that selectively limit the line range are connected to the device using 2 configured, 3-phase current measurement locations. The feedback of the disconnector's position (open) activates the stub differential protection



[dwstubap-150211-01.tif, 1, en_US]

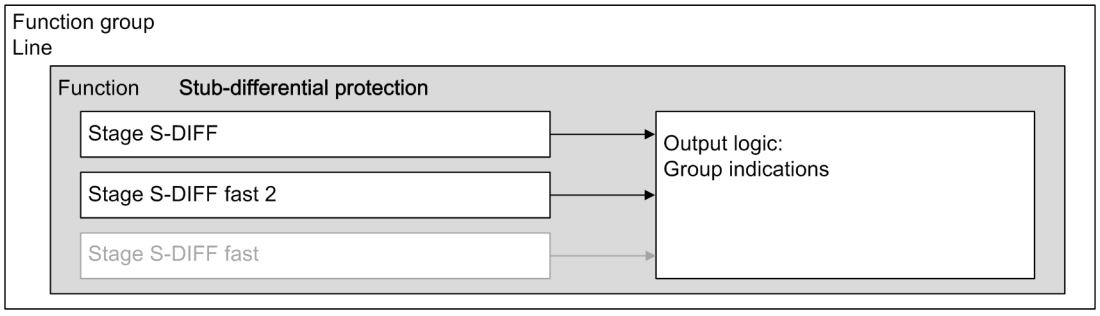
Figure 6-175 Stub Differential Protection on a 1 1/2 Circuit-Breaker Layout

6.8.2 Structure of the Function

The **Stub-differential protection** function is used in the **Line** function group.

The **Stub-differential protection** function is preconfigured at the factory with the **S-DIFF** stage and the **S-DIFF fast 2** stage.

As an alternative to the **S-DIFF fast 2** stage, the **S-DIFF fast** stage is available in the Global DIGSI 5 library.



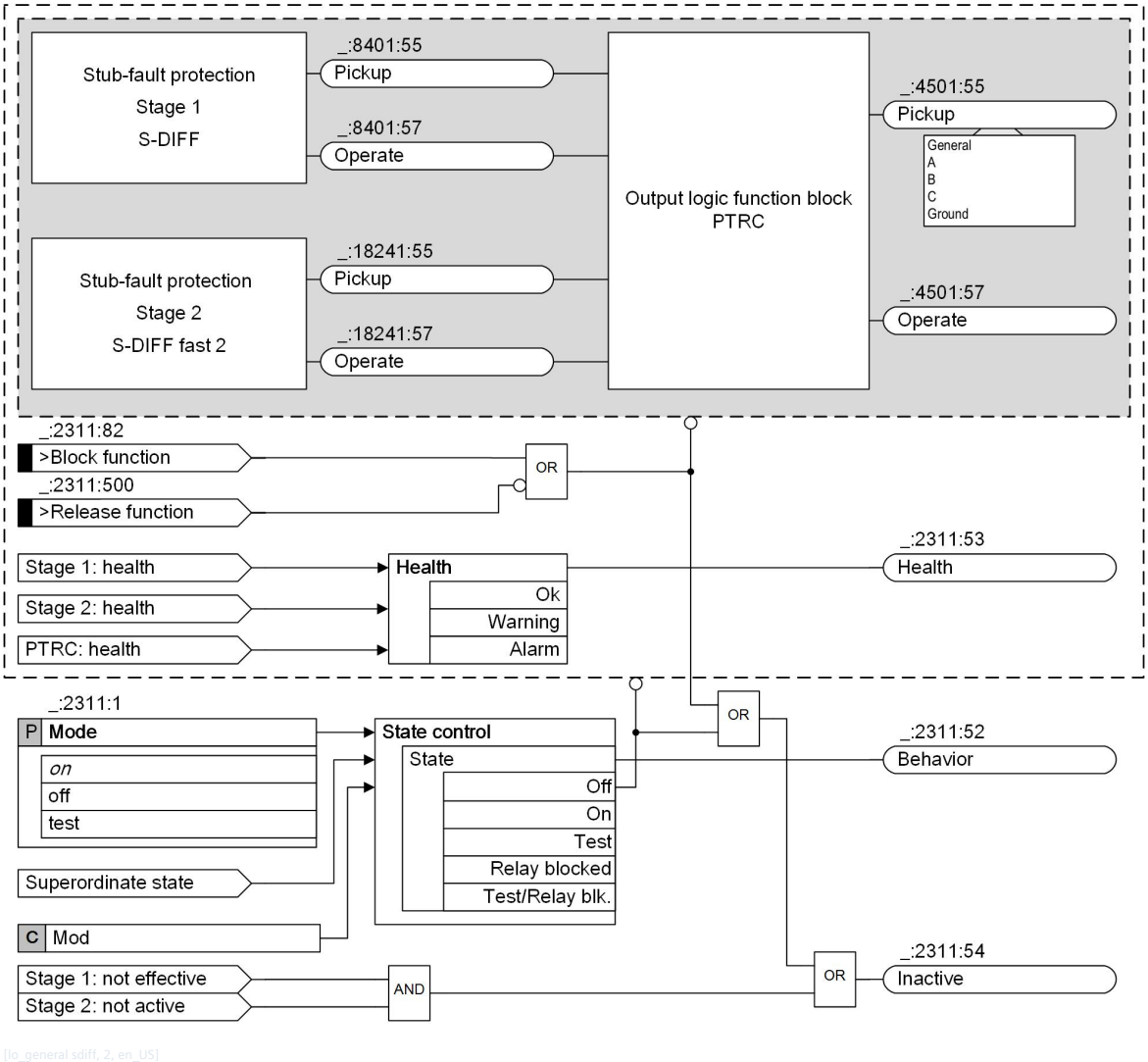
[dwstubeb-150211-01.tif, 2, en_US]

Figure 6-176 Embedding the Stub-Differential Protection

Mode of Operation

The **Stub-differential protection** function is composed of the **S-DIFF** stage and the **S-DIFF fast 2** stage. Both will also be referred to in the following sections as function blocks. Both stages work in parallel and ensure high sensitivity or fast tripping, depending on the severity of the fault. A release binary input (*>Release function*) switches the stub-differential protection to active. This binary input reports the position **open** to the feeder disconnector switch. The output signals of these stages are pickup and operate signals, which are routed to the output logic, resulting in the corresponding protection indications.

Overall Logic



[lo_general sdiff, 2, en_US]

Figure 6-177 General Logic of the Stub-Differential Protection

6.8.3 Function Description

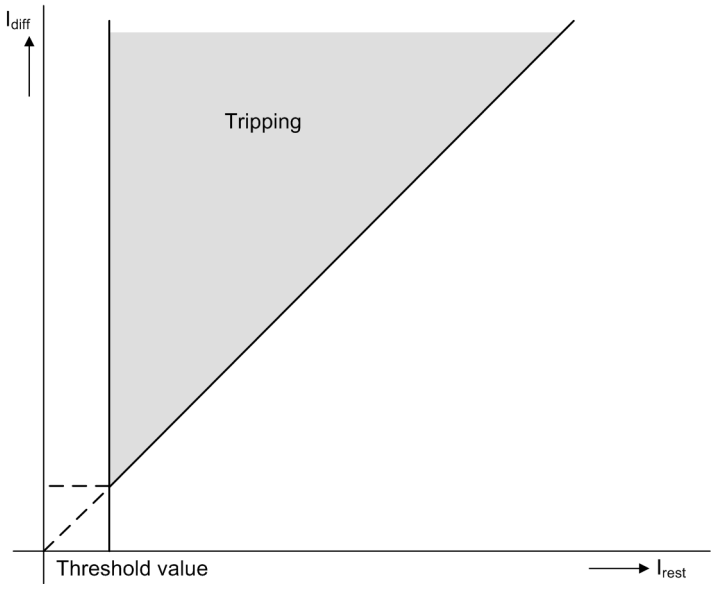
Adaptive Self-Stabilization

The basic principle of differential protection rests on the precondition that, during an uninterrupted operation, the sum of all currents flowing into the protected object equal 0. Secondary currents detected by the device are tainted with measuring errors that are caused by the transmission behavior of the current transformer and the input circuits of the device. All these influences mean that even in healthy operation the sum of the currents processed in the devices is not exactly 0. The differential protection is stabilized against these influences. A special method of adaptive self-stabilization is used in this context to ensure the highest possible sensitivity of the differential protection.

The stabilization variable Irest is calculated from the sum of the potential faults:

Irest = **Threshold** + Σ(current-transformer errors and other measuring errors).

If the measured differential current exceeds the pickup threshold and the maximum possible measuring error, there is an internal fault (shaded area in *Figure 6-178*). With the adaptive approach it is no longer necessary to assign parameters for a characteristic curve.

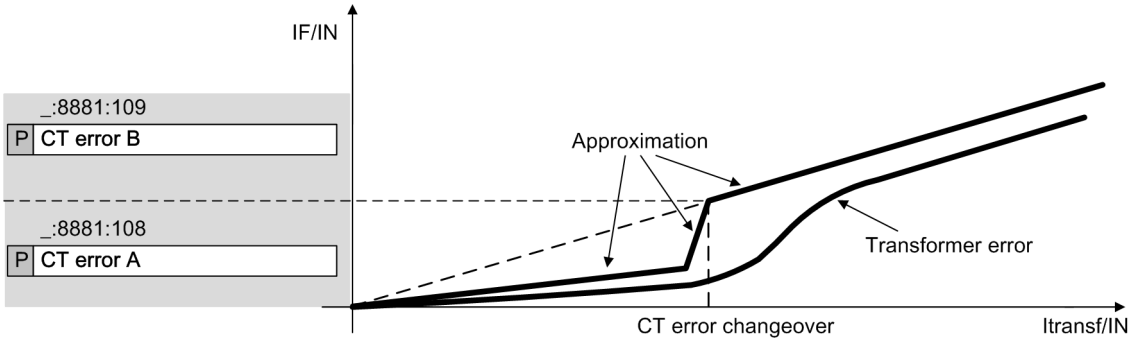


[dwanstub-150211-01.tif, 1, en_US]

Figure 6-178 Operate Curve of the Stub-Differential Protection

Current-Transformer Errors

In order to take into account the influences of current-transformer errors, an adaptive self-stabilization value I_{fault} is calculated for each measuring point. This is the result of the sum of all current-transformer errors, which in turn are the result of the current-transformer data and the degree of currents measured on the transformer.



[dwctfail-310111-01.tif, 2, en_US]

Figure 6-179 Approximation of the Current-Transformer Errors

The set parameters of the transformer data apply to the configured current inputs on the device.

Other Measuring Faults

Additional measuring faults will also be estimated by the device and local self-stabilizing variables will be automatically increased.

Such measuring faults can be caused by

- Hardware and computation tolerances by the device itself
- Based on the **Quality** of the measurands such as harmonic components and frequency deviations.

Stages of the Stub-Differential Protection

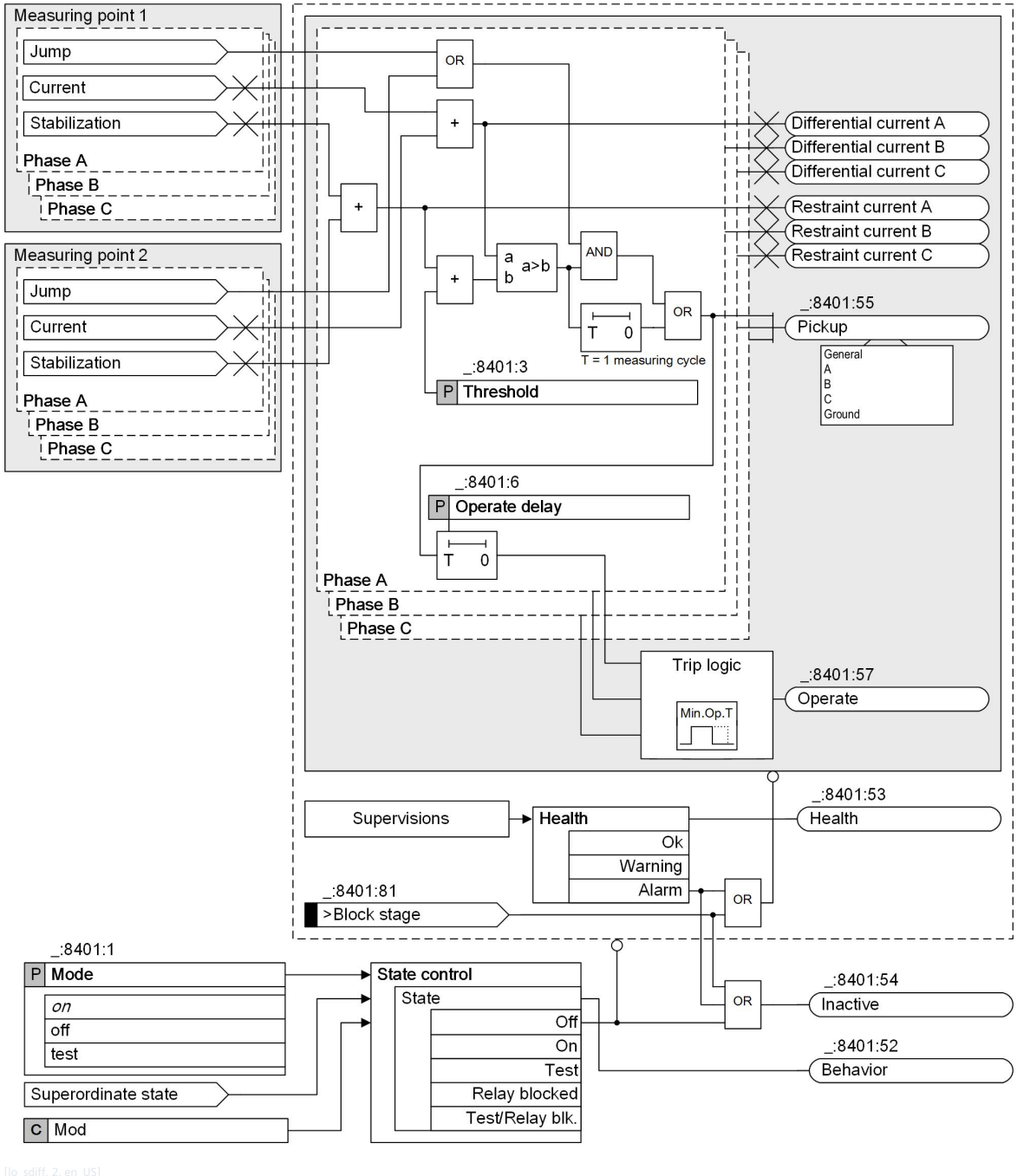
The stub-differential protection has 2 preconfigured stages:

- The **S-DIFF** stage works with very accurate measurement. Maximum sensitivity can be achieved with this stage. You cannot delete this stage.
- The **S-DIFF fast 2** stage works in parallel with the **S-DIFF** stage. A very fast algorithm enables tripping decisions to be made very quickly in the event of high-current faults.
  If the **S-DIFF fast 2** stage is instantiated, the **Saturation detection** block is visible with the **CT saturation threshold** parameter in the **Measuring point Current 3-phase**.
- The **S-DIFF fast** stage is available in the Global DIGSI 5 library as an alternative to the **S-DIFF fast 2** stage. If you want to instantiate this stage, you must first delete the **S-DIFF fast 2** stage.
  If the **S-DIFF fast** stage is instantiated, the **Saturation detection** block is not visible with the **CT saturation threshold** parameter in the current measuring point.
  The **S-DIFF fast** stage also works in parallel with the **S-DIFF** stage. A very fast algorithm enables tripping decisions to be made very quickly in the event of high-current faults.

6.8.4 Stage S-DIFF

6.8.4.1 Description

Logic of the Stage



[lo_sdiff, 2, en_US]

Figure 6-180 Logic of the Stage S-DIFF

Mode of Operation

The stage **S-DIFF** is the sensitive stage of the stub-differential protection. It is based on the principle of current phasor calculation. Usable current phasors are available after 1 period has elapsed following the

occurrence of a fault event. The stage **S-DIFF fast 2**, which operates in parallel, is responsible for fast tripping in the event of high-current errors.

All measurands are evaluated separately for each phase. The device calculates a differential current from the sum of the current phasors on the measuring inputs. The sum of the differential current is equal to the fault current, which is detected by the differential-protection system. Ideally, this is the short-circuit current. In correct operation, it is small and corresponds to the capacitive charging current in a first approximation.

The restraint current counteracts the differential current. The restraint current results from the sum of the maximum measuring errors at the ends of the protected object and is calculated adaptively from the current measurands and the set substation settings. To do this, the maximum error of the current transformers in the rated range or the short-circuit current range is multiplied with the straight flowing currents of the current transformer of the protected object.

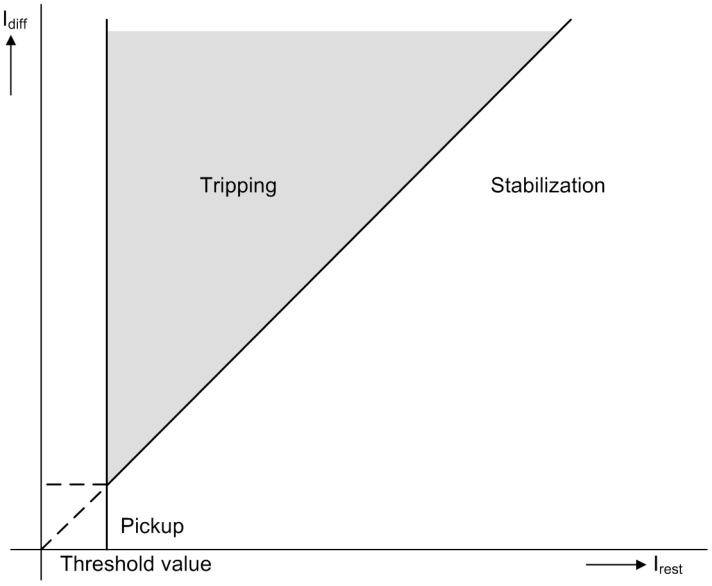
Pickup of the Stage

The pickup characteristic of the stub differential protection (see *Figure 6-181*) results from the stabilization characteristic curve Stubdif = Irest (45° line) which is cut below the setting value of the parameter **(_:8401:3) Threshold**.

It complies with the following equation:

Irest = **Threshold** + Σ(current-transformer errors and other measuring errors).

If the calculated differential current exceeds the pickup threshold and the maximum possible measuring error, there is an internal error (shaded area in *Figure 6-181*).



[dwanspre-150211-01.tif, 1, en_US]

Figure 6-181 Pickup Characteristic of the Stage S-DIFF

Fault Behavior

The indication *Health* is set to ***Alarm*** when fast measured-value monitoring functions (fast sum I, analog-digital converter) signal a fault or when invalid data are received via the protection interface. The validity of the currents used as well as the validity of the data received via the protection interface are monitored continuously. If persistent faults are detected, **Health** is set to ***Alarm*** and **Inactive** is set to ***Yes***.

6.8.4.2 Application and Setting Notes

Parameter: Threshold

- Recommended setting value: **(_:8401:3) Threshold** = ***0.300 A***

  The pickup threshold of the differential current is set using this parameter. The total current flowing into the protection range during a short circuit is the important criterion. This is the overall fault current, regardless how the ends of the protected object are divided.

Parameter: Operate delay

- Recommended setting value: **(_:8401:6) Operate delay** = ***0.00 s***

  In special cases, it can be advantageous to delay the tripping of the stub differential protection with an additional time stage, for example for reverse interlocking. The time delay is started when an internal fault has been detected (***(_:8401:55) Pickup***).

6.8.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:1	General:Mode		• off • on • test	on
S-DIFF				
_:8401:1	S-DIFF:Mode		• off • on • test	on
_:8401:2	S-DIFF:Operate & flt.rec. blocked		• no • yes	no
_:8401:27	S-DIFF:Blk. w. inrush curr. detect.		• no • yes	no
_:8401:3	S-DIFF:Threshold	1 A @ 100 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 100 Irated	0.50 A to 100.00 A	1.50 A
		1 A @ 50 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 50 Irated	0.50 A to 100.00 A	1.50 A
		1 A @ 1.6 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 1.6 Irated	0.500 A to 100.000 A	1.500 A
_:8401:6	S-DIFF:Operate delay		0.00 s to 60.00 s	0.00 s

6.8.4.4 Information List

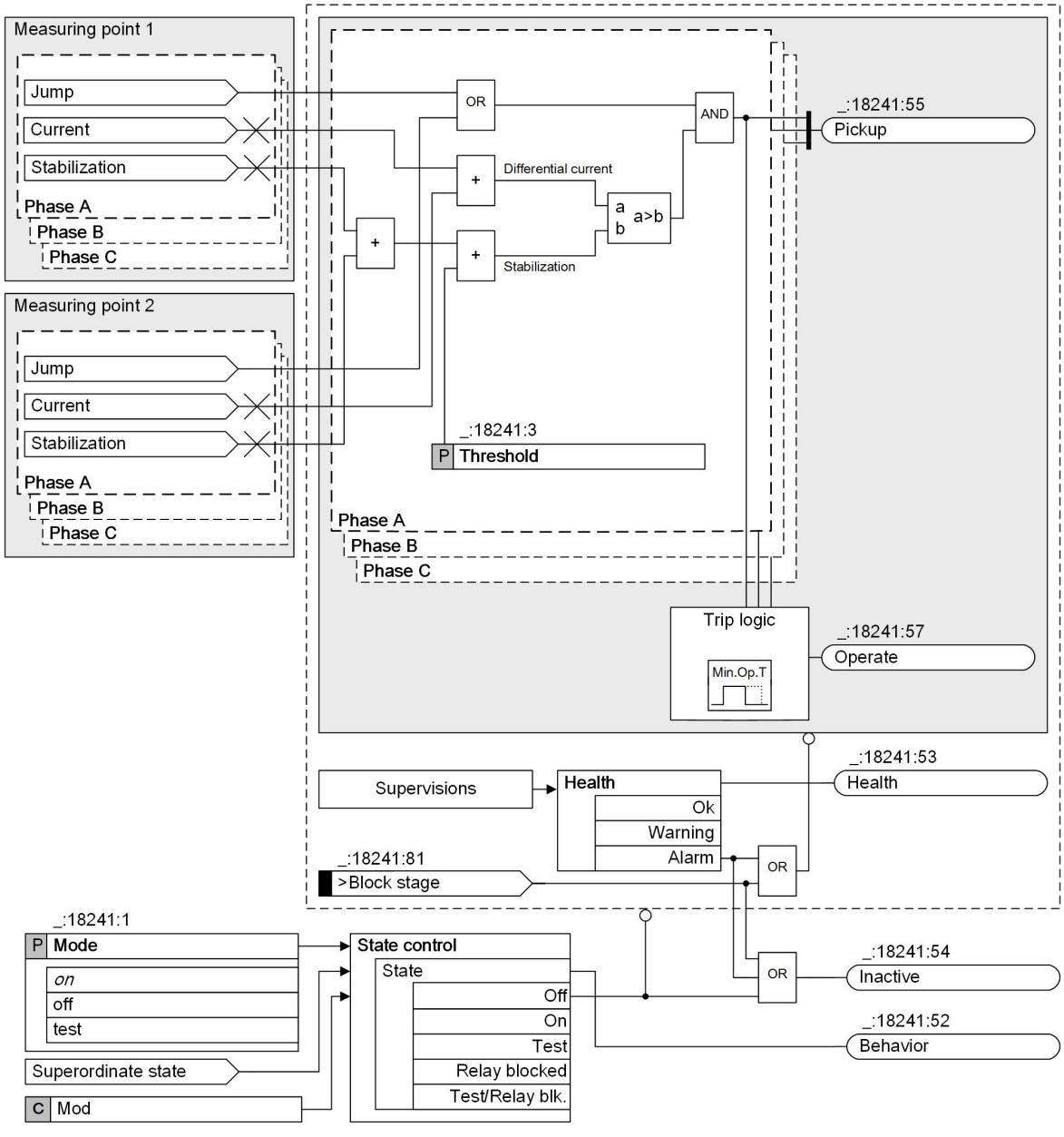
No.	Information	Data Class (Type)	Type
General			
_:2311:82	General:>Block function	SPS	I
_:2311:500	General:>Release function	SPS	I
_:2311:51	General:Mode (controllable)	ENC	C
_:2311:54	General:Inactive	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
S-DIFF			
_:8401:81	S-DIFF:>Block stage	SPS	I

No.	Information	Data Class (Type)	Type
_:8401:51	S-DIFF:Mode (controllable)	ENC	C
_:8401:54	S-DIFF:Inactive	SPS	O
_:8401:52	S-DIFF:Behavior	ENS	O
_:8401:53	S-DIFF:Health	ENS	O
_:8401:55	S-DIFF:Pickup	ACD	O
_:8401:57	S-DIFF:Operate	ACT	O
_:8401:60	S-DIFF:Inrush blocks operate	ACT	O
_:8401:300	S-DIFF:I diff.	WYE	O
_:8401:301	S-DIFF:I restr.	WYE	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O

6.8.5 Stage S-DIFF Fast 2

6.8.5.1 Description

Logic of the Stage



[lo_stage_sdiff_schn2, 2, en_US]

Figure 6-182 Logic of the Stage S-DIFF fast 2

NOTE

If you want to use the **S-DIFF fast 2** stage, the device must be equipped with the **CP300** CPU printed circuit board assembly.

Method of Operation

The stage **S-DIFF fast 2** is optimized for fast operate times during high-current faults. It is superimposed on the stage **S-DIFF**. The measurands are analyzed separately for each phase. Fast tripping for high-current faults is achieved with a procedure based on filtered instantaneous values. During this procedure, stabilization to prevent signal distortion (for example, current-transformer saturation), which may occur during high-current external faults, is not possible. For this reason, a decision for internal or external faults must be made before the potential saturation occurs. It is assumed that the current transformers do not yet go into saturation at least for the duration of one integration interval (5 ms) after fault inception.

If you use the stage **S-DIFF fast 2**, the block **Saturat. det.** is visible with the parameter **CT saturation threshold** in the measuring point **Current 3-phase**. With this, the **CT saturation threshold** must be set so that transformer saturation does not occur until the currents exceed the setting value.

For more detailed information, refer to *8.3.13 Saturation Detection*.

If saturation occurs for one or more current transformers limiting the protection range, the stage **S-DIFF fast 2** is blocked and an erroneous pickup is avoided due to transformer saturation.

Normally, the stage **S-DIFF fast 2** is set higher than the rated current. Otherwise, the stage **S-DIFF fast 2** works in the same way as the sensitive stage **S-DIFF**. Each device calculates a differential current for each phase from the sum of the filtered instantaneous values, which are calculated at each end of the protected object. The value of the differential current corresponds to the fault current, which is detected by the differential-protection system. Ideally, this is the short-circuit current. In correct operation, it is small and corresponds to the capacitive charging current in lines in a first approximation.

The restraint current counteracts the differential current. The restraint current results from the sum of the maximum measuring faults at the ends of the protected object and is calculated adaptively from the current measurands and the set substation parameters. To this end, the maximum error of the current transformers in the rated range or the short-circuit current range is multiplied with the presently flowing currents on each end of the protected object.

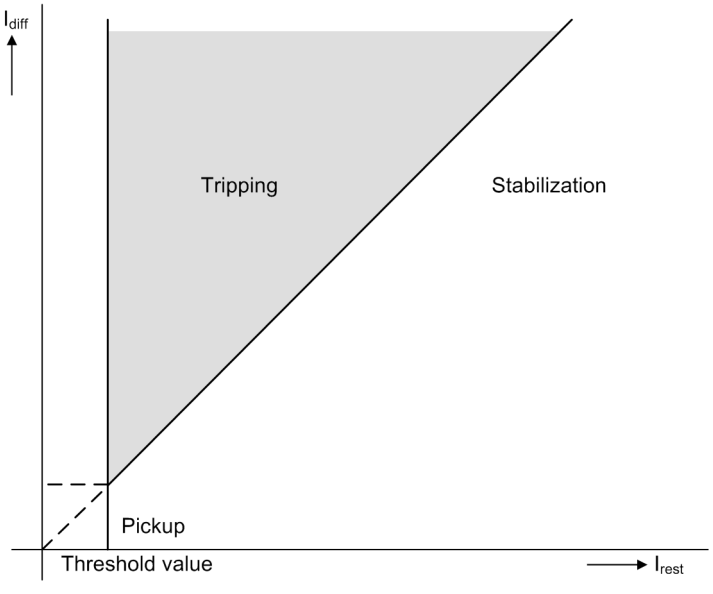
Pickup of the Stage

Like for the stage **S-DIFF**, the pickup characteristic (refer to *Figure 6-183*) results from the stabilization characteristic curve S-DIFF = Irest (45° line), which is cut below the setting value of the parameter **Threshold**.

It complies with the equation

Irest = **Threshold** + Σ(current-transformer errors and other measuring errors).

If the calculated differential current exceeds the pickup threshold and the maximum possible measuring error, there is an internal error (dimmed area in the following figure).



[dwanspre-150211-01.tif, 1, en_US]

Figure 6-183 Pickup Characteristic of the Stage S-DIFF fast 2

Fault Behavior

The indication *Health* is set to ***Alarm*** when fast measured-value monitoring functions (fast sum I, analog-digital converter) signal a fault or when invalid data are received via the protection interface. The validity of the currents used as well as the validity of the data received via the protection interface are monitored continuously. If persistent faults are detected, **Health** is set to ***Alarm*** and **Inactive** is set to ***Yes***.

6.8.5.2 Application and Setting Notes

Parameter: Threshold

- Recommended setting value: **(_:18241:3) Threshold** = ***1.000 A***

  With this parameter, you set the pickup threshold of the differential current. This pickup threshold must be primarily equal on all ends of the protected object.

  This stage responds very quickly. For this reason, a pickup with capacitive charging currents and inductive magnetization currents as with transformers or shunt reactors – including during switching procedures – must be excluded. Set the pickup value to a value greater then the load current ($1.2 \cdot I_{rated}$ to $2 \cdot I_{rated}$).

6.8.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
S-DIFF fast 2				
_:18241:1	S-DIFF fast 2:Mode		• off • on • test	on
_:18241:2	S-DIFF fast 2:Operate & flt.rec. blocked		• no • yes	no
_:18241:3	S-DIFF fast 2:Threshold	1 A @ 100 Irated	0.500 A to 100.000 A	1.000 A
		5 A @ 100 Irated	2.50 A to 500.00 A	5.00 A
		1 A @ 50 Irated	0.500 A to 100.000 A	1.000 A
		5 A @ 50 Irated	2.50 A to 500.00 A	5.00 A

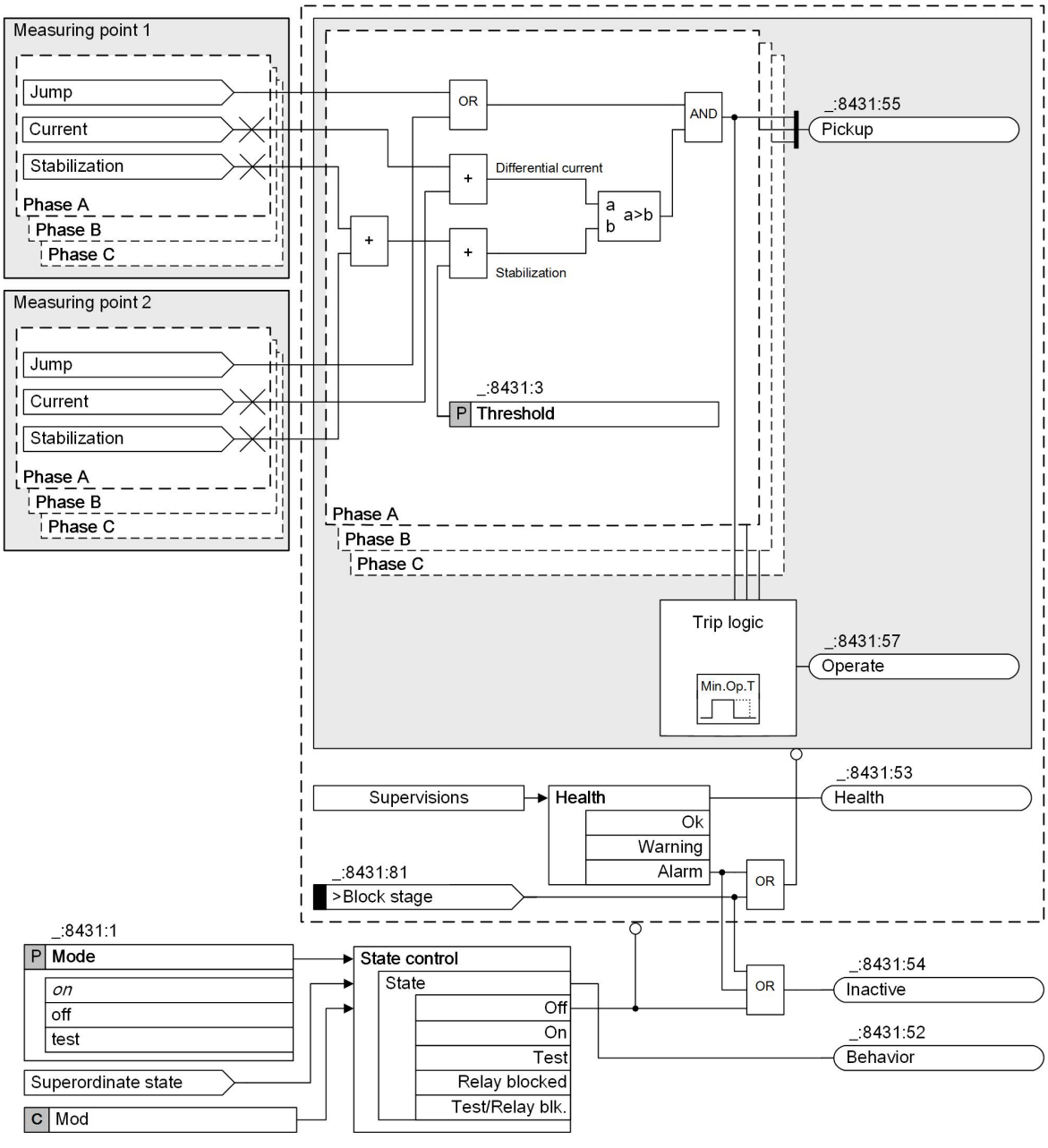
6.8.5.4 Information List

No.	Information	Data Class (Type)	Type
S-DIFF fast 2			
_:18241:81	S-DIFF fast 2:>Block stage	SPS	I
_:18241:51	S-DIFF fast 2:Mode (controllable)	ENC	C
_:18241:54	S-DIFF fast 2:Inactive	SPS	O
_:18241:52	S-DIFF fast 2:Behavior	ENS	O
_:18241:53	S-DIFF fast 2:Health	ENS	O
_:18241:55	S-DIFF fast 2:Pickup	ACD	O
_:18241:57	S-DIFF fast 2:Operate	ACT	O

6.8.6 Stage S-DIFF Fast

6.8.6.1 Description

Logic of the Stage



[lo_stubi2, 2, en_US]

Figure 6-184 Logic of the S-DIFF fast

The **S-DIFF fast** stage is essentially identical to the **S-DIFF fast 2** stage.

If you want to use the **S-DIFF fast** stage, you must delete the preinstantiated **S-DIFF fast 2** stage first. After this, you can instantiate **S-DIFF fast**.

If you use the **S-DIFF fast** stage, the **Saturat. det.** block is not available in the measuring point **Current**.

You can find the description of the **S-DIFF fast 2** in chapter *6.8.5.1 Description*.

6.8.6.2 Application and Setting Notes

The **S-DIFF fast** stage is essentially identical to the **S-DIFF fast 2** stage.

If you want to use the **S-DIFF fast** stage, you must delete the preinstantiated **S-DIFF fast 2** stage first. After this, you can instantiate the **S-DIFF fast** stage.

If you use the **S-DIFF fast** stage, the **Saturat. det.** block is not available in the measuring point **Current**.

You can find the description of the **S-DIFF fast 2** stage in chapter *6.8.5 Stage S-DIFF Fast 2*.

Parameter: Threshold

- Recommended setting value: **(_:8431:3) Threshold** = ***1.000 A***

  This parameter sets the pickup threshold of the differential current, which must be primarily equal on all ends of the protected object.

  This stage responds very quickly. For this reason, pickup during capacitive charging currents and inductive magnetization currents (for transformers or shunt reactors) – including during switching procedures - must be excluded. The pickup value should be set higher than the load current (max. $1.2 \cdot I_{rated}$ to $2 \cdot I_{rated}$).

6.8.6.3 Settings

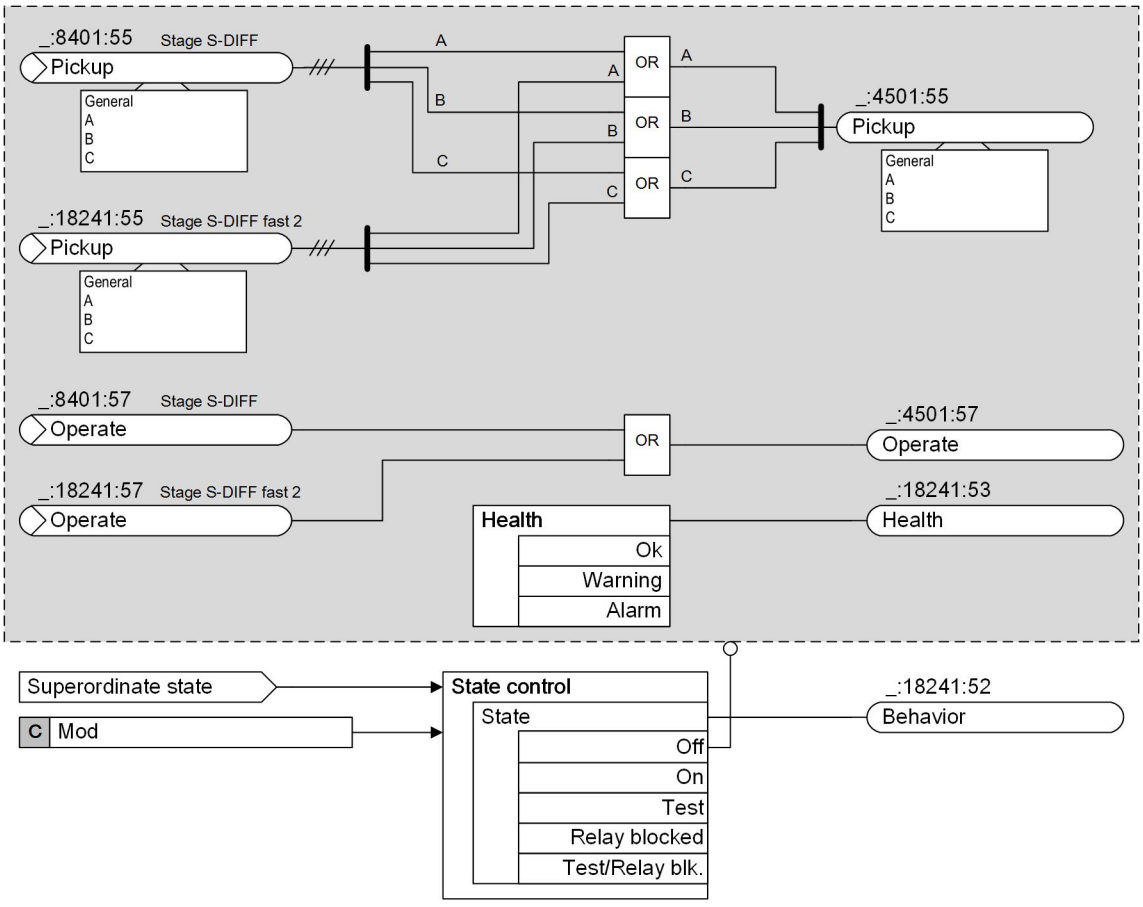
Addr.	Parameter	C	Setting Options	Default Setting
S-DIFF fast				
_:8431:1	S-DIFF fast:Mode		• off • on • test	on
_:8431:2	S-DIFF fast:Operate & flt.rec. blocked		• no • yes	no
_:8431:3	S-DIFF fast:Threshold	1 A @ 100 Irated	0.800 A to 100.000 A	1.000 A
		5 A @ 100 Irated	4.00 A to 500.00 A	5.00 A
		1 A @ 50 Irated	0.800 A to 100.000 A	1.000 A
		5 A @ 50 Irated	4.00 A to 500.00 A	5.00 A
		1 A @ 1.6 Irated	0.800 A to 100.000 A	1.000 A
		5 A @ 1.6 Irated	4.000 A to 500.000 A	5.000 A

6.8.6.4 Information List

No.	Information	Data Class (Type)	Type
S-DIFF fast			
_:8431:81	S-DIFF fast:>Block stage	SPS	I
_:8431:54	S-DIFF fast:Inactive	SPS	O
_:8431:52	S-DIFF fast:Behavior	ENS	O
_:8431:53	S-DIFF fast:Health	ENS	O
_:8431:55	S-DIFF fast:Pickup	ACD	O
_:8431:57	S-DIFF fast:Operate	ACT	O

6.8.7 Stage Description of the Output Logic

Output Logic



[lo_stubag, 3, en_US]

Figure 6-185 Output Logic

6.9 Ground-Fault Protection for High-Resistance Ground Faults in Grounded Systems

6.9.1 Overview of Functions

The **Ground-fault protection for high-resistance ground faults in grounded-neutral systems** function (ANSI 67N):

- Detects high-resistance ground faults in electric equipment in grounded systems
- Detects short circuits phase selectively

6.9.2 Structure of the Function

The **Ground-fault protection for high-resistance ground faults in grounded systems** function is used in the **Line** protection function group. The function is preconfigured at the factory to have 2 stages with definite-time delay (definite time-overcurrent protection stages). Within the function, maximum 6 definite time-overcurrent protection stages can be operated as well as 1 simultaneously by each inverse type. A maximum of 2 functions can be operated within the function group.

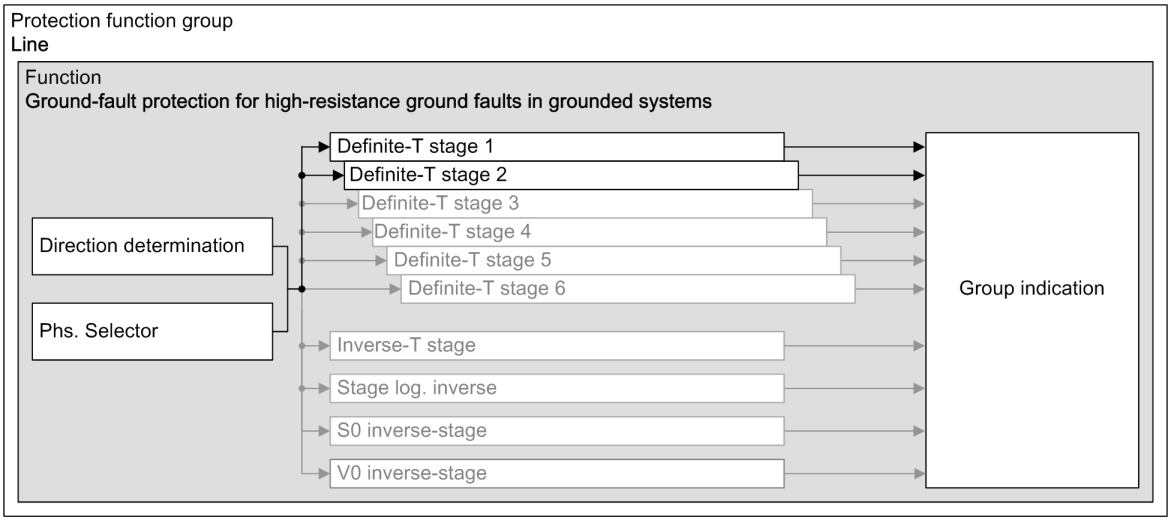
The following stage types are available:

- Ground-fault protection with definite-time delay (definite-time overcurrent protection)
- Ground fault protection with definite-time delay according to IEC and ANSI (AMZ-3I0-IEC/ANSI)
- Ground fault protection with definite-time delay with logarithmic inverse characteristic (AMZ-3I0-log)
- Ground-fault protection with zero-sequence power-dependent delay (S0 inverse)
- Ground-fault protection with zero-sequence voltage-dependent delay (V0 inverse)

The process for direction determination and phase selection is on the function level and has a uniform effect on the stages (see *Figure 6-186* and section *6.9.9.1 Description*). In this way, it is ensured that all stages of a function receive the same direction result. Each stage can be set non-directional or directional – forwards or reverse.

The group-indications output logic (see *Figure 6-186*) generates the following group indications for the entire **Ground-fault protection** function by logic OR from the stage-selective indications:

- **`Pickup`**
- **`Operate delay expired`**
- **`Operate`**



[dwgfpstr-030311-01.tif, 2, en_US]

Figure 6-186 Structure/Embedding of the Function

If the following listed, device-internal functions are present in the device, these functions can influence the pickup values and time delays of the stages or block the stages. The stage can also be affected from outside via a binary input signal.

- Automatic reclosing (AREC)
- Binary input signal

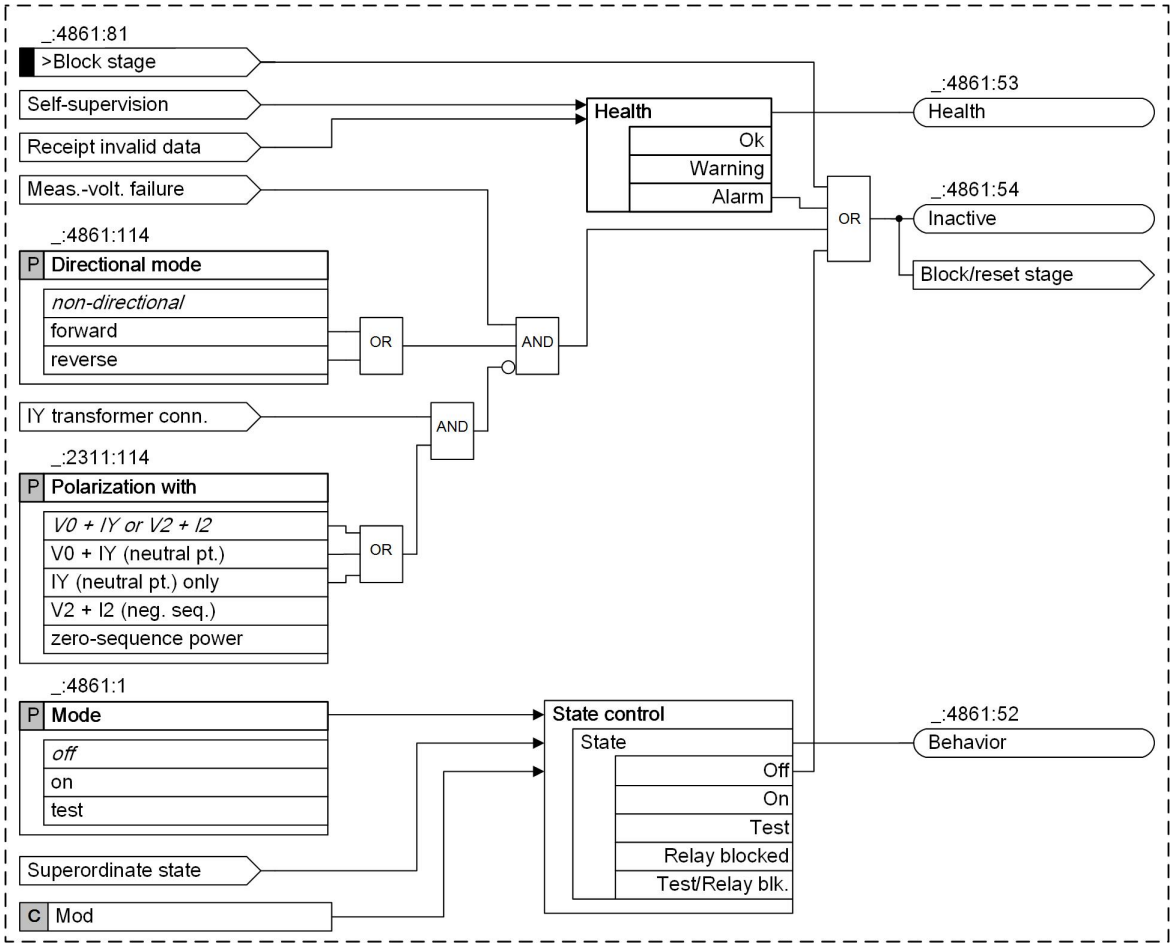
Automatic reclosing (AREC) If the device is equipped with an **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer-inrush currents (see section *6.9.11.1 Description*).

The stages can be used for directional-comparison protection via the **Teleprotection method with ground-fault protection** function, if necessary (see chapter *6.10.1 Overview of Functions*).

6.9.3 Stage Control

Logic

The following figure represents a stage control. It applies for the stage types definite-time overcurrent protection, inverse-time overcurrent protection according to IEC and ANSI and inverse-time overcurrent protection with logarithmic inverse characteristic.

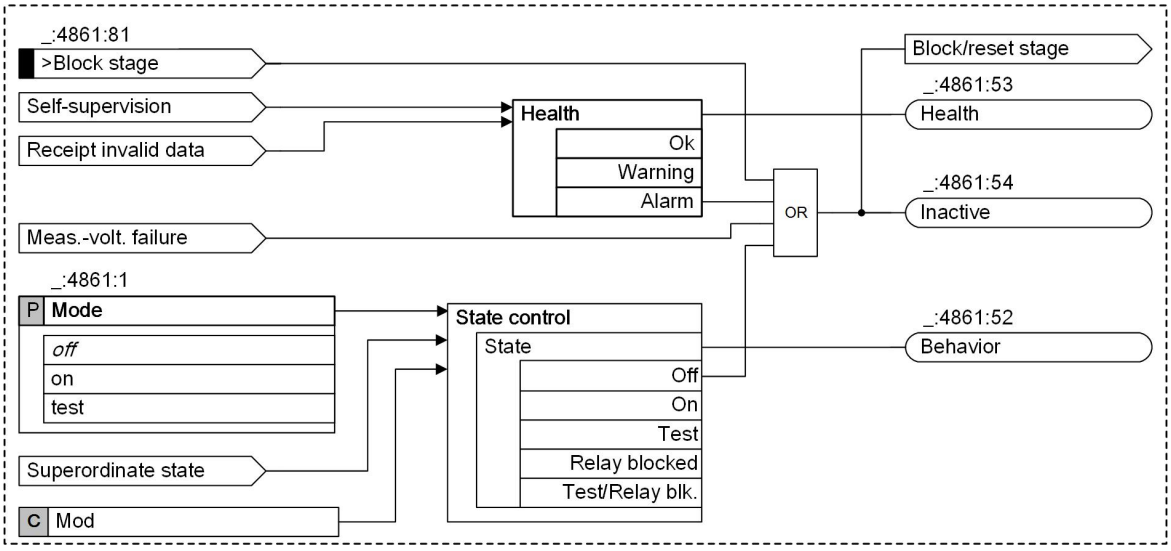


[lo_ggfp_02, 2, en_US]

Figure 6-187 Stage Control for the Stages Types Definite Time-Overcurrent Protection, Inverse-Time Overcurrent Protection, and Logarithmic Inverse

Besides the universally applicable stage control, the stage is blocked in the case of a measuring-voltage failure, insofar as the stage works directionally, and the transformer neutral-point current is not connected.

The following figure shows the stage control for the stage types S0 inverse and V0 inverse.



[lo_ggfp_12, 2, en_US]

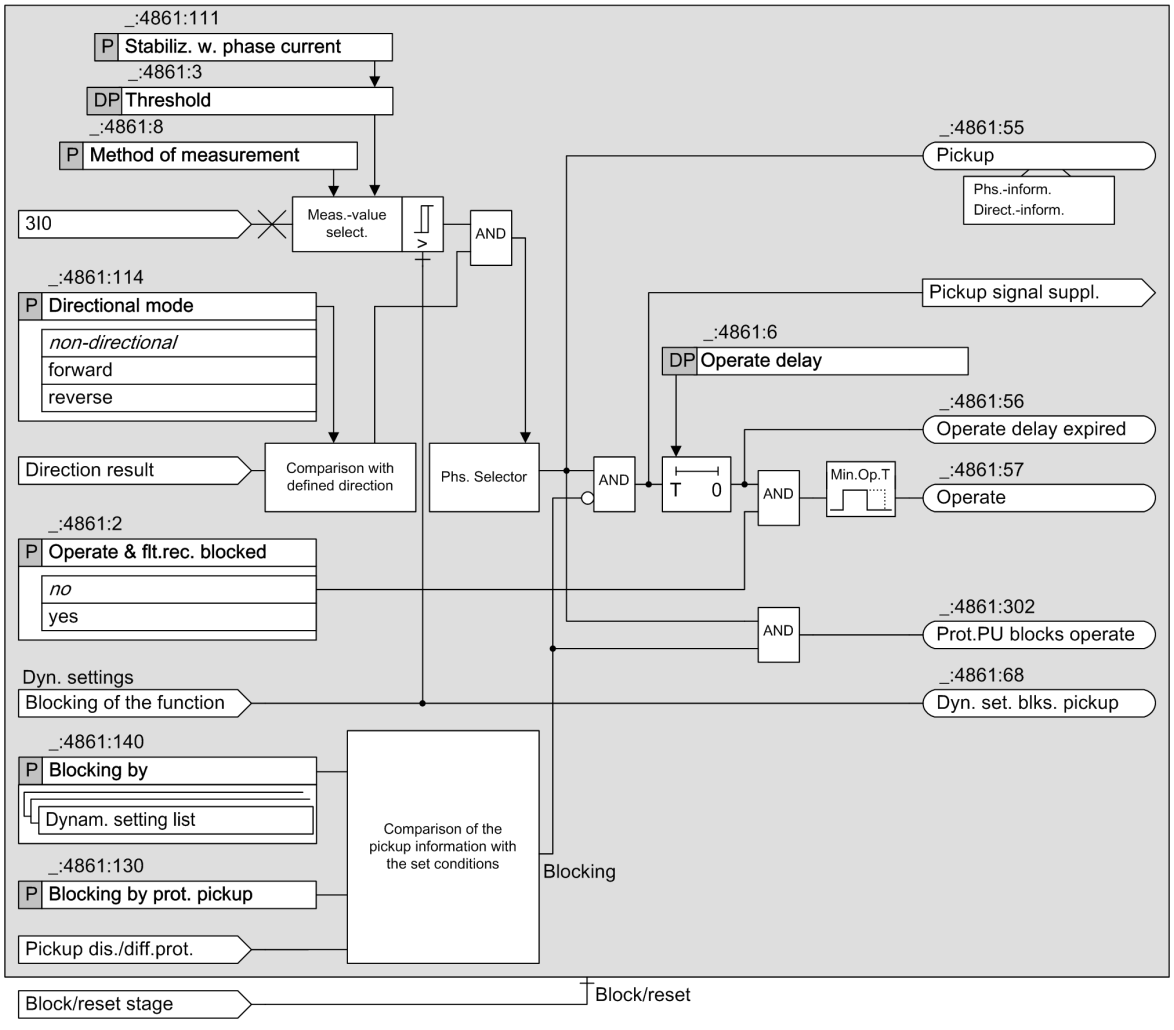
Figure 6-188 Stage Control for the Stage Types S0 Inverse and V0 Inverse

Besides the universally applicable stage control, the stages is also blocked upon a measuring-voltage failure.

6.9.4 Stage with Definite-Time Characteristic Curve

6.9.4.1 Description

Logic of a Stage



[loggfp31-160611-01.tif, 1, en_US]

Figure 6-189 Logic Diagram for Ground-Fault Protection with Definite Time-Overcurrent Protection

Measurand

The residual current is used as a measurand. The residual current is calculated according to its definition equation

$$\underline{3I0} = \underline{I_A} + \underline{I_B} + \underline{I_C}$$

from the sum of the 3 phase currents. Depending on the use of the current inputs of the device, the residual current can be measured or calculated.

If you connect a current input in the neutral-point feed of the current transformer or to a separate ground-current transformer of the line to be protected, the ground current (residual current) will be directly available to the device.

If the device is equipped with a sensitive current input I_{Nsens}, the device will use this ground current (residual current). The linear range of this measuring input ends at an amplitude of approx. 1.5 A. At higher currents, the device automatically switches to analysis of the residual current calculated from the phase currents.

If the ground current is not present in the device as a directly measured variable, the device will calculate the zero current from the conductor currents.

Method of Measurement

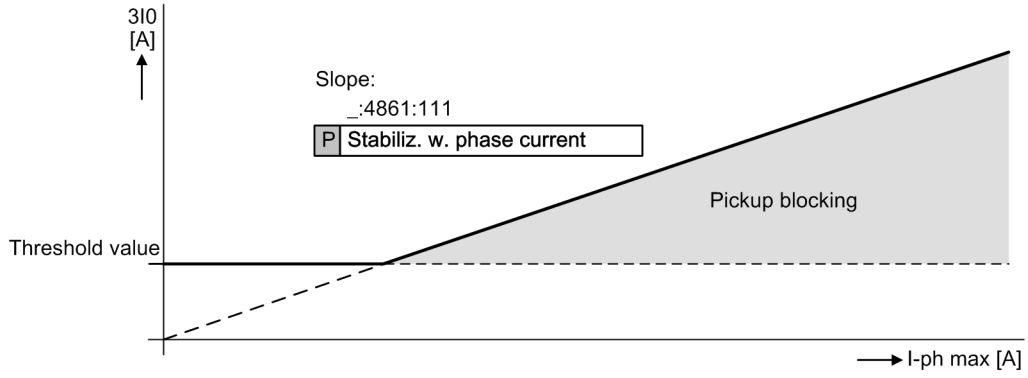
The **Method of measurement** parameter is used to select the relevant measuring procedure, depending on the application:

- Measurement of the fundamental component over 1 cycle filter (standard filter)
  This measuring procedure processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the fundamental component over 2 cycle filters
  This measuring procedure processes the sampled current values and filters out the fundamental component numerically. Harmonics and transient faults are damped particularly strongly over the extended filter length in comparison to the standard filter. The extended filter length causes the pickup time to increase slightly compared to the standard filter (see Technical specifications).

Stabilization with Phase Currents

In grounded systems, unbalanced line and load ratios cause a residual current in normal operational applications. Likewise, different current-transformer faults lead to a secondary residual current. The amplitude of this undesirable residual current increases as the phase current increases. An undesirable residual current can lead to false pickup and unwanted tripping at low setting values for the ground-current stages. To avoid false pickup and unwanted tripping, the ground-current stages are stabilized with the phase currents. The threshold value increases as phase currents rise (see following graphic).

You can change the stabilization factor (= gradient) via the **Stabiliz. w. phase current** parameter.



[logfpsta-030311-01.tif, 1, en_US]

Figure 6-190 Stabilization with Phase Currents

Directional mode

You use the **Directional mode** parameter to define whether the stage works in a forward or reverse direction. Non-directional operation is also possible.

The direction determination works across stages (see chapter *6.9.9.1 Description*).

Phase Selection

Phase Selection Depending on the distribution of the currents and voltages, the phase selection detects if a 1-phase (determination of the affected phase) or multiphase short circuit is present (see Chapter *6.9.10 Phase Selection*).

Pickup for Signal Supplement

The **Teleprotection method with ground-fault protection** function can be used to apply the stage for directional comparison protection as well. The stage provides the internal signal **signal supplement**

pickup for this. Complete the necessary settings in the function **Teleprotection method with ground-fault protection** (see chapter *6.10.1 Overview of Functions*).

Blocking of the Stage Pickup

The following blockings suppress the pickup of the stage and fully reset the picked up stage:

- Externally or internally via the binary input signal **>Block stage** (see also *Figure 6-187* and *Figure 6-188*)
- Via the functionality of the dynamic settings (see section *6.9.13.1 Description*)

The blocking cause is indicated.

Blocking of the Tripping by Pickup of the Distance Protection or Differential Protection Function

The pickup of the main protection function (differential protection) can block the level tripping. You can perform this setting via 2 parameters:

- Parameter **Blocking by**

  This parameter is used to select the differential at whose pickup the blocking is to occur.
- Parameter **Blocking by prot. pickup**

  The parameter is also used to set whether blocking is to occur upon pickup of the main protection. This also applies if you have selected one or more zones/stages from the **Blocking by** parameter.

Blocking of the Tripping via the Device-Internal Inrush-Current Detection Function

Blocking of tripping via the device-internal **Inrush-current detection** function is described in section *6.9.11.1 Description*.

Influence of Other Functions via Dynamic Settings

If the following functions are present in the device, they can affect the dynamic settings **Threshold** and **Operate delay** of the level:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.9.13.1 Description*.

6.9.4.2 Application and Setting Notes

Stage-Type Selection

If the tripping delay is to be independent of the current level, select the stage type Definite time-overcurrent protection.

A multi-stage Definite time-overcurrent protection function is realized by the parallel operation of several definite time-overcurrent protection stages.

Parameter: Blocking by the Main Protection

- Default setting **(_:4861:140) Blocking by** = none
- Default setting **(_:4861:130) Blocking by prot. pickup** = ***every pickup***

If you wish to give the selective fault clarification by the main protection function (for example, differential protection) priority over tripping by ground-fault protection, you can define this via both parameters. The **Blocking by** parameter is used to select the zones or levels of the main protection function(s), upon whose pickup the ground-fault protection is to be blocked.

The **Blocking by prot. pickup** parameter is used to set whether a blocking of the tripping is to be activated upon excitation of the main protection.

Parameter Value	Description
every pickup	Blocking at every pickup
no pickup	No blocking at pickup of the main protection function

Parameter: Directional mode

- Default setting **(_:4861:114) Directional mode** = ***non-directional***

You use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
non-directional	If the stage is to work in the forward and reverse direction (in the direction of the line and busbar), then select this setting. The stage also works with this setting if no direction measurement is possible, for example, owing to lower or no polarization voltage.
forward	Select these settings if the stage is only to work in a forward direction (in direction of the line).
reverse	Select this setting if the level is only to work in the reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value **(_:4861:8) Method of measurement** = ***1-cycle filter***

Use the **Method of measurement** parameter to define whether the measurand is determined via 1 or 2 cycle filters.

Parameter Value	Description
1-cycle filter	This method of measurement suppresses the harmonics or transient voltage peaks. Siemens recommends using this setting as the standard method.
2-cycle filter	To implement a particularly strong attenuation of harmonics and transient faults, select the setting 2 cycle filter. Please note that in this case the pickup time of the tripping level increases slightly (see Technical specifications).

Parameter: Stabilization with phase currents

- Recommended setting value **(_:4861:111) Stabiliz. w. phase current** = ***10 %***

In grounded systems, unbalanced line and load ratios cause a residual current in normal operational applications. Likewise, different current-transformer faults lead to a secondary residual current. The amplitude of this undesirable residual current increases as the phase current increases. An undesirable residual current can lead to false pickup and unwanted tripping at low setting values for the ground-current stages. To avoid false pickup and unwanted tripping, the ground-current stages are stabilized with the phase currents. The threshold value increases as phase currents rise. You can change the stabilization factor (= gradient) via the **Stabiliz. w. phase current** parameter.

Siemens recommends a setting of 10 % under normal conditions.

Dynamic parameter: Threshold

- Default setting **(_:4861:3) Threshold** = ***1500 A***

Define the pickup value corresponding to the application.

At a very sensitive setting, you must ensure that a residual current due to unbalance (for example, untwisted line) does not cause the level to respond.

Dynamic parameter: Operate delay

- Default setting **(_:4861:6) Operate delay** = ***300 ms***

The Operate delay to be set is derived from the time grading chart for ground faults that has been prepared for the network.

When selecting the current and time setting, note whether stage tripping is direction-dependent and whether signal transmission is used. See also chapter *6.10.1 Overview of Functions*.

If you use a stage direction independently and with signal transmission, it can also have a non-delayed effect during the release process. Parameterize a short delay for the blocking method equal to the signal-transmission time plus a reserve of approx. 20 ms.

6.9.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:114	General:Direct. determination with		• V0 + IY or V2 + I2 • V0 + IY (neutral pt.) • IY (neutral pt.) only • V2 + I2 (neg. seq.) • zero-sequence power	V0 + IY or V2 + I2
_:2311:101	General:Angle forward α		0 ° to 360 °	338 °
_:2311:102	General:Angle forward β		0 ° to 360 °	122 °
_:2311:103	General:Min. zero-seq. voltage V0		0.150 V to 34.000 V	1.213 V
_:2311:115	General:Dir.reslt=forw.at V0<min		• no • yes	no
_:2311:104	General:Min.3I0 f.increas.dir.sens.	1 A @ 100 Irated	0.030 A to 10.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.150 A
_:2311:105	General:Min. neutral-point curr. IY	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:2311:107	General:Min. neg.-seq. voltage V2		0.150 V to 34.000 V	1.213 V
_:2311:106	General:Min. neg.-seq. current I2	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:2311:108	General:Compensation angle		0 ° to 360 °	255 °
_:2311:109	General:Forw. dir. power threshold	1 A	0.08 VA to 10.00 VA	0.52 VA
		5 A	0.42 VA to 50.00 VA	2.60 VA
_:2311:116	General:Dir.corr.at ser.comp.lines		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:4861:1	Definite-T 1:Mode		• off • on • test	off
_:4861:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:4861:114	Definite-T 1:Directional mode		• non-directional • forward • reverse	non-directional
_:4861:8	Definite-T 1:Method of measurement		• 1-cycle filter • 2-cycle filter	1-cycle filter
_:4861:116	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:4861:131	Definite-T 1:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:4861:130	Definite-T 1:Blocking by prot. pickup		• every pickup • no pickup	every pickup
_:4861:129	Definite-T 1:Op.mode at 1p dead time		• blocked • non-directional	blocked
_:4861:112	Definite-T 1:Hold mode 1p dead time		0.000 s to 60.000 s	0.040 s
_:4861:115	Definite-T 1:Dynamic settings		• no • yes	no
_:4861:111	Definite-T 1:Stabiliz. w. phase current		0 % to 30 %	10 %
_:4861:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:4861:6	Definite-T 1:Operate delay		0.000 s to 60.000 s	0.300 s
Dyn.s: AR off/n.rdy				
_:4861:117	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:4861:123	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:4861:118	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:4861:124	Definite-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4861:101	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:4861:106	Definite-T 1:Operate delay		0.000 s to 60.000 s	0.300 s
Dyn.set: AR cycle 2				
_:4861:119	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:4861:125	Definite-T 1:Stage blocked		• no • yes	no
_:4861:102	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:4861:107	Definite-T 1:Operate delay		0.000 s to 60.000 s	0.300 s
Dyn.set: AR cycle 3				
_:4861:120	Definite-T 1:Effected by AR cycle 3		• no • yes	no
_:4861:126	Definite-T 1:Stage blocked		• no • yes	no
_:4861:103	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:4861:108	Definite-T 1:Operate delay		0.000 s to 60.000 s	0.300 s
Dyn.s: AR cycle>3				
_:4861:121	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:4861:127	Definite-T 1:Stage blocked		• no • yes	no
_:4861:104	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:4861:109	Definite-T 1:Operate delay		0.000 s to 60.000 s	0.300 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: bin.input				
_:4861:122	Definite-T 1:Effected by binary input		• no • yes	no
_:4861:128	Definite-T 1:Stage blocked		• no • yes	no
_:4861:105	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:4861:110	Definite-T 1:Operate delay		0.000 s to 60.000 s	0.300 s
_:4861:140	Definite-T 1:Blocking by		Setting options depend on configuration	
General				
_:4862:1	Definite-T 2:Mode		• off • on • test	off
_:4862:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:4862:114	Definite-T 2:Directional mode		• non-directional • forward • reverse	non-directional
_:4862:8	Definite-T 2:Method of measurement		• 1-cycle filter • 2-cycle filter	1-cycle filter
_:4862:116	Definite-T 2:Blk. w. inrush curr. detect.		• no • yes	no
_:4862:131	Definite-T 2:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:4862:130	Definite-T 2:Blocking by prot. pickup		• every pickup • no pickup	every pickup
_:4862:129	Definite-T 2:Op.mode at 1p dead time		• blocked • non-directional	blocked
_:4862:112	Definite-T 2:Hold mode 1p dead time		0.000 s to 60.000 s	0.040 s
_:4862:115	Definite-T 2:Dynamic settings		• no • yes	no
_:4862:111	Definite-T 2:Stabiliz. w. phase current		0 % to 30 %	10 %
_:4862:3	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A

Addr.	Parameter	C	Setting Options	Default Setting
_:4862:6	Definite-T 2:Operate delay		0.000 s to 60.000 s	0.300 s
Dyn.s: AR off/n.rdy				
_:4862:117	Definite-T 2:Effect. by AR off/n.ready		• no • yes	no
_:4862:123	Definite-T 2:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:4862:118	Definite-T 2:Effected by AR cycle 1		• no • yes	no
_:4862:124	Definite-T 2:Stage blocked		• no • yes	no
_:4862:101	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:4862:106	Definite-T 2:Operate delay		0.000 s to 60.000 s	0.300 s
Dyn.set: AR cycle 2				
_:4862:119	Definite-T 2:Effected by AR cycle 2		• no • yes	no
_:4862:125	Definite-T 2:Stage blocked		• no • yes	no
_:4862:102	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:4862:107	Definite-T 2:Operate delay		0.000 s to 60.000 s	0.300 s
Dyn.set: AR cycle 3				
_:4862:120	Definite-T 2:Effected by AR cycle 3		• no • yes	no
_:4862:126	Definite-T 2:Stage blocked		• no • yes	no
_:4862:103	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:4862:108	Definite-T 2:Operate delay		0.000 s to 60.000 s	0.300 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.s: AR cycle>3				
_:4862:121	Definite-T 2:Effected by AR cycle gr. 3		• no • yes	no
_:4862:127	Definite-T 2:Stage blocked		• no • yes	no
_:4862:104	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:4862:109	Definite-T 2:Operate delay		0.000 s to 60.000 s	0.300 s
Dyn.set: bin.input				
_:4862:122	Definite-T 2:Effected by binary input		• no • yes	no
_:4862:128	Definite-T 2:Stage blocked		• no • yes	no
_:4862:105	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:4862:110	Definite-T 2:Operate delay		0.000 s to 60.000 s	0.300 s
_:4862:140	Definite-T 2:Blocking by		Setting options depend on configuration	

6.9.4.4 Information List

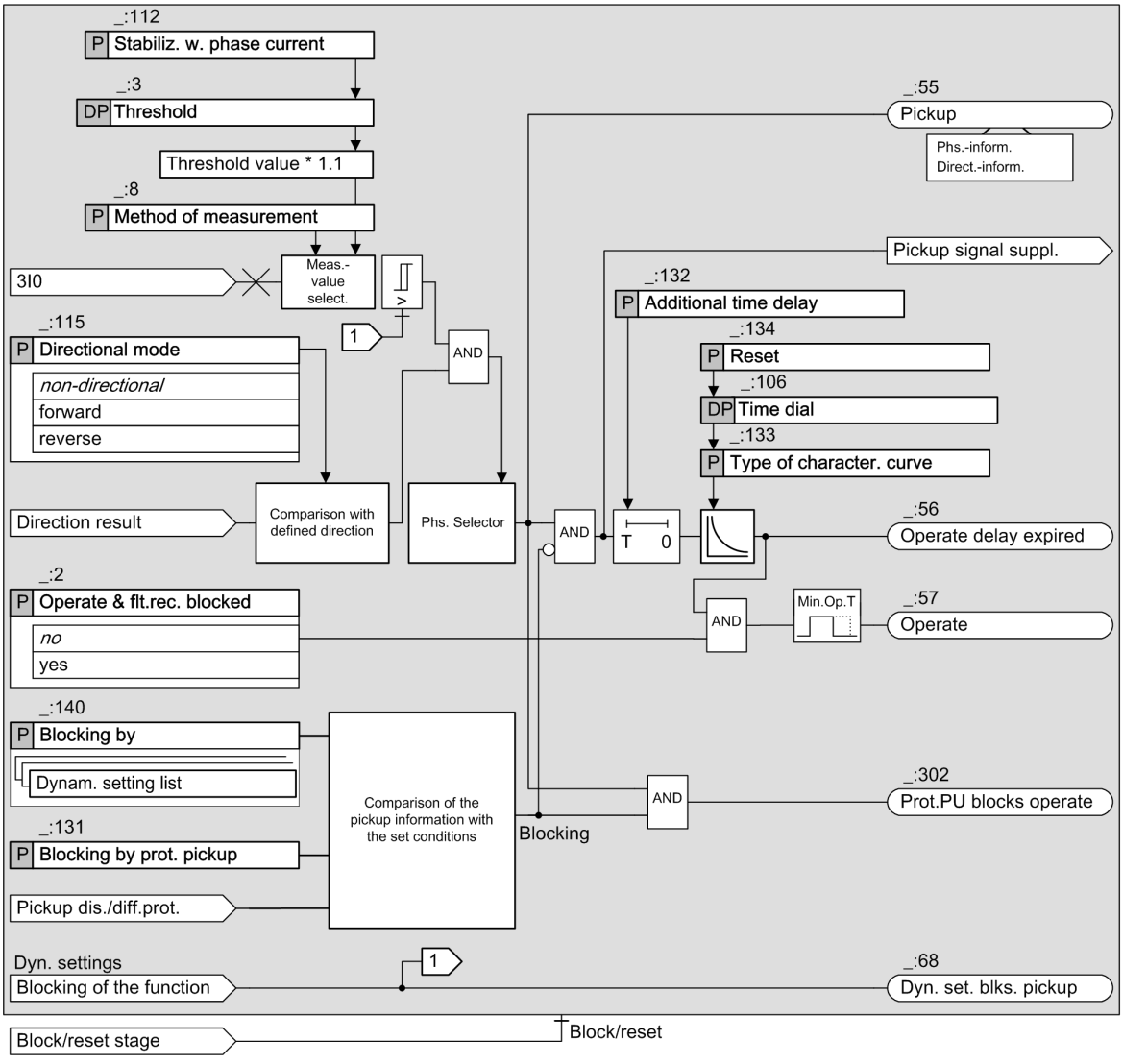
No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Test of direction	SPS	I
_:2311:301	General:Test direction	ACD	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Definite-T 1			
_:4861:81	Definite-T 1:>Block stage	SPS	I
_:4861:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:4861:51	Definite-T 1:Mode (controllable)	ENC	C
_:4861:54	Definite-T 1:Inactive	SPS	O

No.	Information	Data Class (Type)	Type
_:4861:52	Definite-T 1:Behavior	ENS	O
_:4861:53	Definite-T 1:Health	ENS	O
_:4861:60	Definite-T 1:Inrush blocks operate	ACT	O
_:4861:301	Definite-T 1:Mode1p dead-tm.active	SPS	O
_:4861:302	Definite-T 1:Prot.PU blocks operate	SPS	O
_:4861:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:4861:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:4861:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O
_:4861:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:4861:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:4861:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O
_:4861:55	Definite-T 1:Pickup	ACD	O
_:4861:56	Definite-T 1:Operate delay expired	ACT	O
_:4861:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:4862:81	Definite-T 2:>Block stage	SPS	I
_:4862:84	Definite-T 2:>Activ. dyn. settings	SPS	I
_:4862:51	Definite-T 2:Mode (controllable)	ENC	C
_:4862:54	Definite-T 2:Inactive	SPS	O
_:4862:52	Definite-T 2:Behavior	ENS	O
_:4862:53	Definite-T 2:Health	ENS	O
_:4862:60	Definite-T 2:Inrush blocks operate	ACT	O
_:4862:301	Definite-T 2:Mode1p dead-tm.active	SPS	O
_:4862:302	Definite-T 2:Prot.PU blocks operate	SPS	O
_:4862:62	Definite-T 2:Dyn.set. AR cycle1act.	SPS	O
_:4862:63	Definite-T 2:Dyn.set. AR cycle2act.	SPS	O
_:4862:64	Definite-T 2:Dyn.set. AR cycle3act.	SPS	O
_:4862:65	Definite-T 2:Dyn.set. ARcycl.>3act	SPS	O
_:4862:67	Definite-T 2:Dyn.set. BI active	SPS	O
_:4862:68	Definite-T 2:Dyn. set. blks. pickup	SPS	O
_:4862:55	Definite-T 2:Pickup	ACD	O
_:4862:56	Definite-T 2:Operate delay expired	ACT	O
_:4862:57	Definite-T 2:Operate	ACT	O

6.9.5 Stage with Inverse-Time Overcurrent Protection According to IEC and ANSI

6.9.5.1 Description

Logic of the Stage



[loggfp32-300511-01.tif, 1, en_US]

Figure 6-191 Logic Diagram for Ground-Fault Protection with Definite-Time Delay According to IEC and ANSI (AMZ-3I0-IEC/ANSI)

Measurands

The residual current is used as a measurand. The residual current is calculated according to its definition equation

$$\underline{3I0} = \underline{I_A} + \underline{I_B} + \underline{I_C}$$

from the sum of the 3 phase currents. Depending on the use of the current inputs of the device, the residual current can be measured or calculated.

If you connect a current input in the neutral-point feed of the current transformer or to a separate ground-current transformer of the line to be protected, the ground current (residual current) will be directly available to the device.

If the device is equipped with a sensitive current input I_{Nsens}, the device will use this current. The linear range of this measuring input ends at an amplitude of approx. 1.6 A. At higher currents, the device automatically switches to analysis of the residual current calculated from the phase currents.

If the ground current is not present in the device as a directly measured variable, the device will calculate the residual current from the phase currents.

Method of Measurement

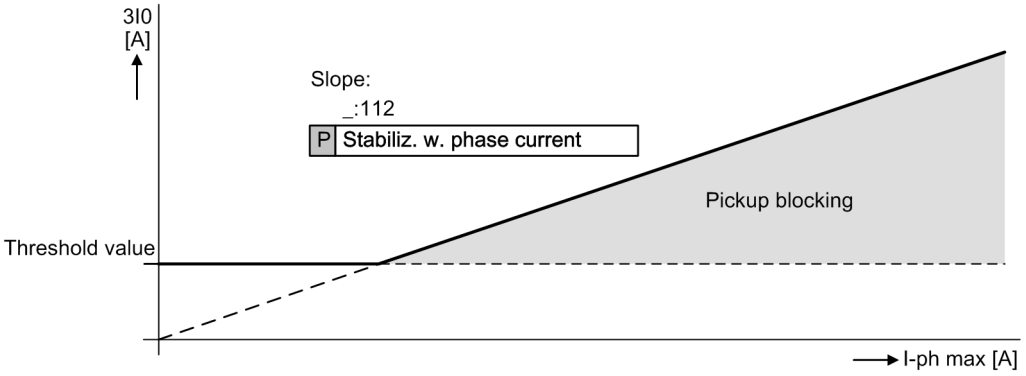
The **Method of measurement** parameter is used to select the relevant method of measurement, depending on the application:

- Measurement of the fundamental component via 1-cycle filter (standard filter)
  This measuring procedure processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the fundamental component via 2-cycle filter
  This measuring procedure processes the sampled current values and filters out the fundamental component numerically. Harmonics and transient faults are damped particularly strongly over the extended filter length in comparison to the standard filter. The extended filter length causes the pickup time to increase slightly compared to the standard filter (see Technical specifications).

Stabilization with Phase Currents

In grounded systems, unbalanced line and load ratios cause a residual current in normal operational applications. Likewise, different current-transformer faults lead to a secondary residual current. The amplitude of this undesirable residual current increases as the phase current increases. An undesirable residual current can lead to false pickup and unwanted tripping at low setting values for the ground-current stages. To avoid false pickup and unwanted tripping, the ground-current stages are stabilized with the phase currents. The threshold value increases as phase currents rise (see following graphic).

You can change the stabilization factor (= gradient) via the **Stabiliz. w. phase current** parameter.



[loggfpst-030810-01.tif, 1, en_US]

Figure 6-192 Stabilization with Phase Currents

Directional mode

You use the **Directional mode** parameter to define whether the stage works in a forward or reverse direction. Non-directional operation is also possible.

The direction determination works across stages (see chapter *6.9.9.1 Description*).

Phase Selection

The phase selection detects whether a 1-pole (determination of the relevant conductor) or a multiphase short circuit is present via the distribution of the currents and voltages (see section *6.9.10 Phase Selection*).

Pickup for Signal Supplement

The **Teleprotection method with ground-fault protection** function can be used to apply the stage for directional comparison protection as well. The stage provides the internal signal **`signal supplement pickup`** for this. Complete the necessary settings in the function **Teleprotection-transmission method with ground-fault protection** (see chapter *6.10.1 Overview of Functions*).

Pickup, Dropout, and Tripping Behavior of the Dependent Characteristic Curve According to IEC and ANSI

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement totalizes the weighted time. This time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between the following options:

- Non-delayed dropout: The summed time is deleted.
- Dropout according to characteristic curve: The summed time is reduced in relation to the characteristic curve.

The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

The execution of the characteristic curve after exceeding 1.1 times the threshold value can be delayed by a constant time (**`Additional time delay`** parameter).

Blocking of the Stage Pickup

The following blockings suppress the pickup of the stage and fully reset the picked up stage:

- Externally or internally via the binary input signal **`>Block stage`** (see also *Figure 6-187* and *Figure 6-187*)
- Via the functionality of the dynamic settings (see section *6.9.13.1 Description*)
  The blocking cause is indicated.

Blocking of the Tripping by Pickup of the Differential Protection Function

The pickup of the main protection function (differential protection) can block the stage tripping. You can perform this setting via 2 parameters:

- Parameter **`Blocking by`**
  This parameter is used to select the differential at whose pickup the blocking is to occur.
- Parameter **`Blocking by prot. pickup`**
  The parameter is also used to set whether blocking is to occur upon pickup of the main protection. This also applies if you have selected one or more zones/stages from the **`Blocking by`** parameter.

Blocking of the Tripping via the Device-Internal Inrush-Current Detection Function

Blocking of the tripping via the device-internal inrush-current detection is described in section *6.9.11.1 Description*.

Influence of Other Functions via Dynamic Settings

If the following functions are present in the device, they can affect the dynamic settings **`Threshold`** and **`Time dial`** of the level:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.9.13.1 Description*.

6.9.5.2 Application and Setting Notes

Stage-Type Selection

If the tripping delay is to be dependent on the current stage according to the IEC or ANSI standard, select this type of stage.

Parameter: Blocking by the Main Protection

- Default setting **(_:140) Blocking by** = none
- Default setting **(_:131) Blocking by prot. pickup** = ***every pickup***

If you wish to give the selective fault clarification by the main protection function (for example, differential protection) priority over tripping by ground-fault protection, you can define this via both parameters. The **Blocking by** parameter is used to select the zones or levels of the main protection function(s), upon whose pickup the ground-fault protection is to be blocked.

The **Blocking by prot. pickup** parameter is used to set whether a blocking of the tripping is to be activated upon excitation of the main protection.

Parameter Value	Description
every pickup	Blocking at every pickup
no pickup	No blocking at pickup of the main protection function

Parameter: Directional mode

- Default setting **(_:115) Directional mode** = ***non-directional***

You use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
non-directional	If the stage is to work in the forward and reverse direction (in the direction of the line and busbar), then select this setting. The stage also works with this setting if no direction measurement is possible, for example, owing to lower or no polarization voltage.
forward	Select these settings if the stage is only to work in a forward direction (in direction of the line).
reverse	Select this setting if the level is only to work in the reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value **(_:8) Method of measurement** = ***1-cycle filter***

Use the **Method of measurement** parameter to define whether the measurand is determined via a 1 or 2 cycle filter.

Parameter Value	Description
1-cycle filter	This method of measurement suppresses the harmonics or transient voltage peaks. Siemens recommends using this setting as the standard method.
2-cycle filter	To implement a particularly strong attenuation of harmonics and transient faults, select the setting 2 cycle filter. Please note that in this case the pickup time of the tripping level increases slightly (see Technical specifications).

Parameter: Stabilization with phase currents

- Recommended setting value **(_:112) Stabiliz. w. phase current** = ***10*** **%**

In grounded systems, unbalanced line and load ratios cause a residual current in normal operational applications. Likewise, different current-transformer faults lead to a secondary residual current. The amplitude of this undesirable residual current increases as the phase current increases. An undesirable residual current can lead to false pickup and unwanted tripping at low setting values for the ground-current stages. To avoid false pickup and unwanted tripping, the ground-current stages are stabilized with the phase currents. The threshold value increases as phase currents rise. You can change the stabilization factor (= gradient) via the **Stabiliz. w. phase current** parameter.

Siemens recommends a setting of 10% under normal conditions.

Dynamic Parameter: Threshold

- Default setting **(_:3) Threshold** = ***1500 A***

Define the pickup value corresponding to the application.

At a very sensitive setting, you must ensure that a residual current due to unbalance (for example, untwisted line) does not cause the level to respond.

Parameter: Type of character. curve

- Default setting **(_:133) Type of character. curve** = ***IEC normal inverse***

Select the type of characteristic curve specified for the system. The characteristic curves and the associated formulas are shown in the Technical Data.

Dynamic Parameter: Time dial

- Default setting **(_:106) Time dial** = ***1.00***

The time multiplier is derived from the grading chart for ground faults established for the system.

When selecting the current and time setting, note whether stage tripping is direction-dependent and whether signal transmission is used. See also section *6.10.2 Structure of the Function*.

If you use a stage direction independently and with signal transmission, it can also have a non-delayed effect during the release process. Parameterize a short delay for the blocking method equal to the signal-transmission time plus a reserve of approx. 20 ms.

Parameter: Additional time delay

- Recommended setting value **(_:132) Additional time delay** = ***0 s***

This additional delay is intended for special applications.

Siemens recommends setting this time to 0 so that it has no effect.

Parameter: Reset

- Default setting **(_:134) Reset** = ***instantaneous***

You use the **Reset** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Use this setting if the device is coordinated with electromechanical devices or other devices, performing a dropout after disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

6.9.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:115	Inverse-T #:Directional mode		• non-directional • forward • reverse	non-directional
_:8	Inverse-T #:Method of measurement		• 1-cycle filter • 2-cycle filter	1-cycle filter
_:117	Inverse-T #:Blk. w. inrush curr. detect.		• no • yes	no
_:135	Inverse-T #:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:131	Inverse-T #:Blocking by prot. pickup		• every pickup • no pickup	every pickup
_:130	Inverse-T #:Op.mode at 1p dead time		• blocked • non-directional	blocked
_:113	Inverse-T #:Hold mode 1p dead time		0.000 s to 60.000 s	0.040 s
_:116	Inverse-T #:Dynamic settings		• no • yes	no
_:112	Inverse-T #:Stabiliz. w. phase current		0 % to 30 %	10 %
_:3	Inverse-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:133	Inverse-T #:Type of character. curve			
_:106	Inverse-T #:Time dial		0.05 to 15.00	1.00
_:132	Inverse-T #:Additional time delay		0.000 s to 60.000 s	1.200 s
_:134	Inverse-T #:Reset		• instantaneous • disk emulation	instantaneous
Dyn.s: AR off/n.rdy				
_:118	Inverse-T #:Effect. by AR off/n.ready		• no • yes	no
_:124	Inverse-T #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 1				
_:119	Inverse-T #:Effected by AR cycle 1		• no • yes	no
_:125	Inverse-T #:Stage blocked		• no • yes	no
_:101	Inverse-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:107	Inverse-T #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:120	Inverse-T #:Effected by AR cycle 2		• no • yes	no
_:126	Inverse-T #:Stage blocked		• no • yes	no
_:102	Inverse-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:108	Inverse-T #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:121	Inverse-T #:Effected by AR cycle 3		• no • yes	no
_:127	Inverse-T #:Stage blocked		• no • yes	no
_:103	Inverse-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:109	Inverse-T #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:122	Inverse-T #:Effected by AR cycle gr. 3		• no • yes	no
_:128	Inverse-T #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:104	Inverse-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:110	Inverse-T #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:123	Inverse-T #:Effected by binary input		• no • yes	no
_:129	Inverse-T #:Stage blocked		• no • yes	no
_:105	Inverse-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:111	Inverse-T #:Time dial		0.05 to 15.00	1.00
_:140	Inverse-T #:Blocking by		Setting options depend on configuration	

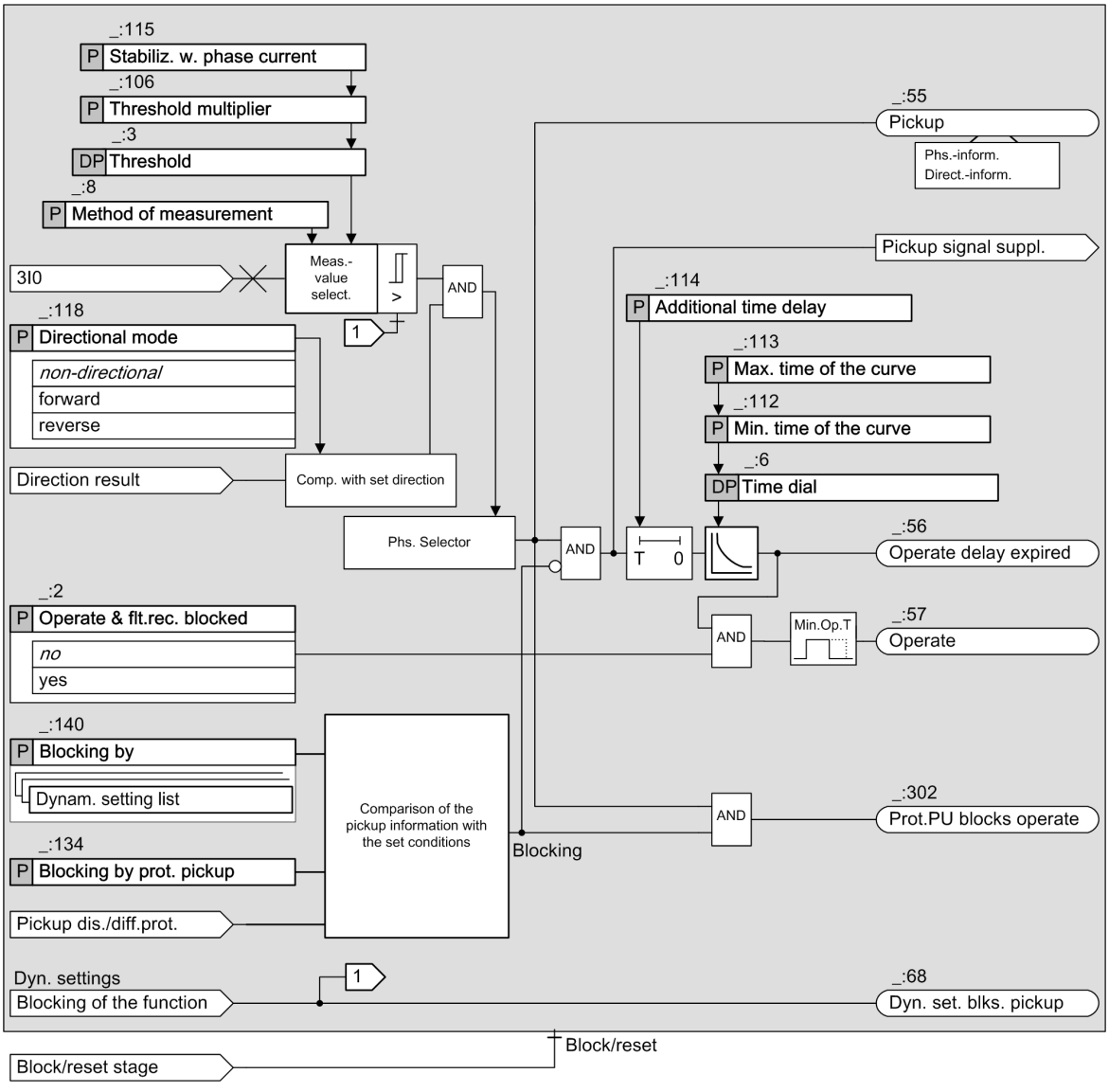
6.9.5.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	Inverse-T #:>Block stage	SPS	I
_:84	Inverse-T #:>Activ. dyn. settings	SPS	I
_:51	Inverse-T #:Mode (controllable)	ENC	C
_:54	Inverse-T #:Inactive	SPS	O
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:60	Inverse-T #:Inrush blocks operate	ACT	O
_:301	Inverse-T #:Mode1p dead-tm.active	SPS	O
_:302	Inverse-T #:Prot.PU blocks operate	SPS	O
_:62	Inverse-T #:Dyn.set. AR cycle1act.	SPS	O
_:63	Inverse-T #:Dyn.set. AR cycle2act.	SPS	O
_:64	Inverse-T #:Dyn.set. AR cycle3act.	SPS	O
_:65	Inverse-T #:Dyn.set. ARcycl.>3act	SPS	O
_:67	Inverse-T #:Dyn.set. BI active	SPS	O
_:68	Inverse-T #:Dyn. set. blks. pickup	SPS	O
_:59	Inverse-T #:Disk emulation running	SPS	O
_:55	Inverse-T #:Pickup	ACD	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:57	Inverse-T #:Operate	ACT	O

6.9.6 Stage with Inverse-Time Overcurrent Protection with Logarithmic-Inverse Characteristic Curve

6.9.6.1 Description

Logic of the Stage



[loggfp33-300511-01.tif, 1, en_US]

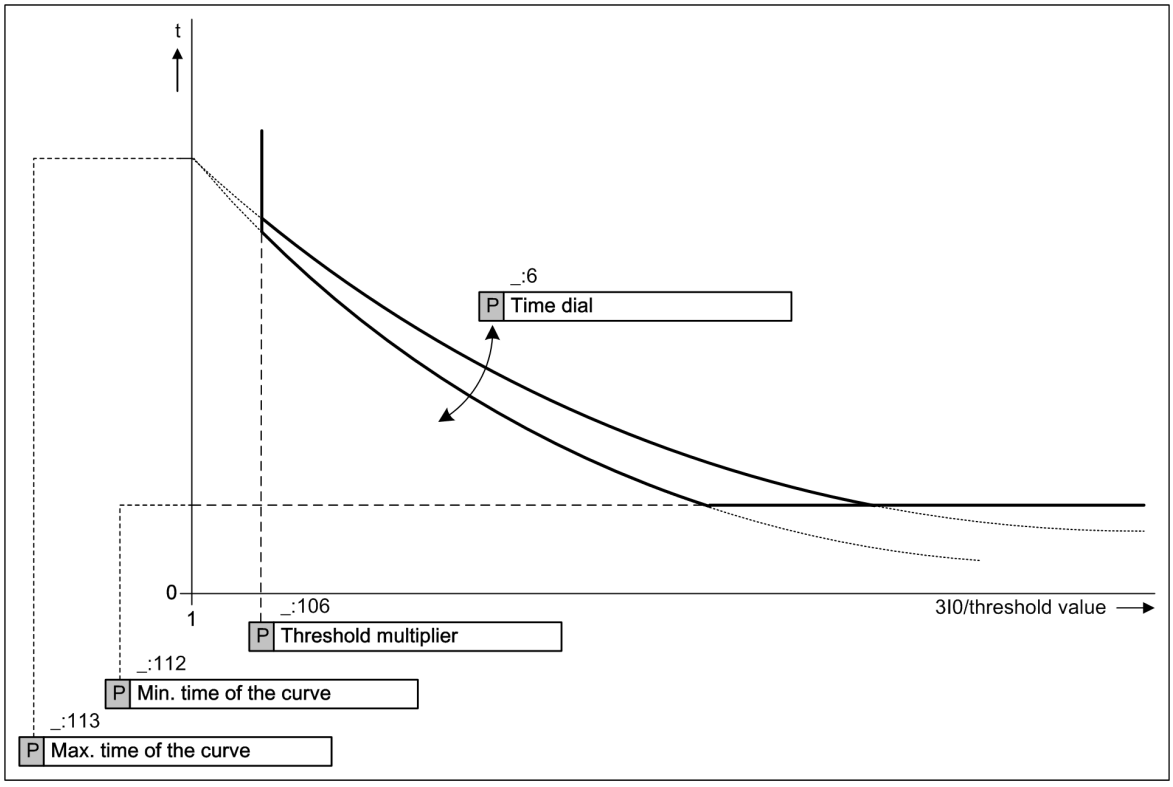
Figure 6-193 Logic Diagram for Ground-Fault Protection with Inverse Time-Overcurrent Protection with Logarithmic Inverse Characteristic Curve (AMZ-3I0-Log)

Apart from the operate curve, this type of stage is identical to the ground-fault protection type with inverse time-overcurrent protection according to IEC and ANSI (AMZ-3I0-IEC/ANSI) (see section *6.9.5.1 Description*). This section will only discuss the nature of the operate curve. For the further functionality, Siemens refers to section *6.9.5.1 Description* .

Operate Curve

Figure 6-194 shows the effect of the characteristic curve parameters qualitatively.

The **Threshold** parameter setting is the reference value for all current values. At the same time, the **Threshold multiplier** parameter maps the beginning of the characteristic curve, that is, the lower operating range on the current axis in relation to the threshold value. The time value **Max. time of the curve** determines the initial value of the characteristic curve (for 3I0 = threshold value). The **Time dial** parameter changes the slope of the characteristic curve. At high currents, the **Min. time of the curve** parameter indicates the lower time limit.



[loggfp04-030810-01.tif, 1, en_US]

Figure 6-194 Operate Curve

6.9.6.2 Application and Setting Notes

Apart from the characteristic curve, this type of stage is identical to the ground-fault protection type with inverse-time delay according to IEC and ANSI (AMZ-3I0-IEC/ANSI) (see section *6.9.5.1 Description*).

This section will only discuss the nature of the operate curve. For the further functionality, Siemens refers to section *6.9.5.2 Application and Setting Notes* .

Stage-Type Selection

If the operate delay is to be dependent on the current stage according to a logarithmic characteristic curve, select this stage type.

Dynamic Parameter: Threshold

- Default setting **(_:3) Threshold** = ***1500 A***

Define the pickup value corresponding to the application. In doing so, for the time-graded stages, the setting for the superordinate and subordinate stages must be taken into account in the grading chart.

Parameter: Threshold multiplier

- Default setting **(_:106) Threshold multiplier** = ***1.1***

You can use the **Threshold multiplier** parameter to define the beginning of the characteristic curve on the current axis (in relation to the threshold value).

General information cannot be provided. Define the value corresponding to the application.

Dynamic Parameter: Time dial

- Default setting **(_:106) Time dial** = ***300 ms***

You can use the **Time dial** parameter to change the slope of the characteristic curve.
General information cannot be provided. Define the value corresponding to the application.

Parameter: Max. time of the curve

- Default setting **(_:113) Max. time of the curve** = ***1.200 s***

The time value **Max. time of the curve** determines the initial value of the characteristic curve (for 3I0 = **Threshold**).
General information cannot be provided. Define the value corresponding to the application.

Parameter: Min. time of the curve

- Default setting **(_:112) Min. time of the curve** = ***1.200 s***

The time value **Min. time of the curve** determines the lower time limit (at high currents).
General information cannot be provided. Define the value corresponding to the application.

6.9.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Log.-inv.-T #:Mode		• off • on • test	off
_:2	Log.-inv.-T #:Operate & flt.rec. blocked		• no • yes	no
_:118	Log.-inv.-T #:Directional mode		• non-directional • forward • reverse	non-directional
_:8	Log.-inv.-T #:Method of measurement		• 1-cycle filter • 2-cycle filter	1-cycle filter
_:120	Log.-inv.-T #:Blk. w. inrush curr. detect.		• no • yes	no
_:135	Log.-inv.-T #:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:134	Log.-inv.-T #:Blocking by prot. pickup		• every pickup • no pickup	every pickup
_:133	Log.-inv.-T #:Op.mode at 1p dead time		• blocked • non-directional	blocked
_:116	Log.-inv.-T #:Hold mode 1p dead time		0.000 s to 60.000 s	0.040 s
_:119	Log.-inv.-T #:Dynamic settings		• no • yes	no
_:115	Log.-inv.-T #:Stabiliz. w. phase current		0 % to 30 %	10 %

Addr.	Parameter	C	Setting Options	Default Setting
_:3	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:106	Log.-inv.-T #:Threshold multiplier		1.00 to 4.00	1.10
_:6	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
_:112	Log.-inv.-T #:Min. time of the curve		0.000 s to 60.000 s	1.200 s
_:113	Log.-inv.-T #:Max. time of the curve		0.000 s to 60.000 s	5.800 s
_:114	Log.-inv.-T #:Additional time delay		0.000 s to 60.000 s	1.200 s
Dyn.s: AR off/n.rdy				
_:121	Log.-inv.-T #:Effect. by AR off/n.ready		• no • yes	no
_:127	Log.-inv.-T #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:122	Log.-inv.-T #:Effected by AR cycle 1		• no • yes	no
_:128	Log.-inv.-T #:Stage blocked		• no • yes	no
_:101	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:107	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.set: AR cycle 2				
_:123	Log.-inv.-T #:Effected by AR cycle 2		• no • yes	no
_:129	Log.-inv.-T #:Stage blocked		• no • yes	no
_:102	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:108	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.set: AR cycle 3				
_:124	Log.-inv.-T #:Effected by AR cycle 3		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:130	Log.-inv.-T #:Stage blocked		• no • yes	no
_:103	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:109	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.s: AR cycle>3				
_:125	Log.-inv.-T #:Effected by AR cycle gr. 3		• no • yes	no
_:131	Log.-inv.-T #:Stage blocked		• no • yes	no
_:104	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:110	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.set: bin.input				
_:126	Log.-inv.-T #:Effected by binary input		• no • yes	no
_:132	Log.-inv.-T #:Stage blocked		• no • yes	no
_:105	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:111	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
_:140	Log.-inv.-T #:Blocking by		Setting options depend on configuration	

6.9.6.4 Information List

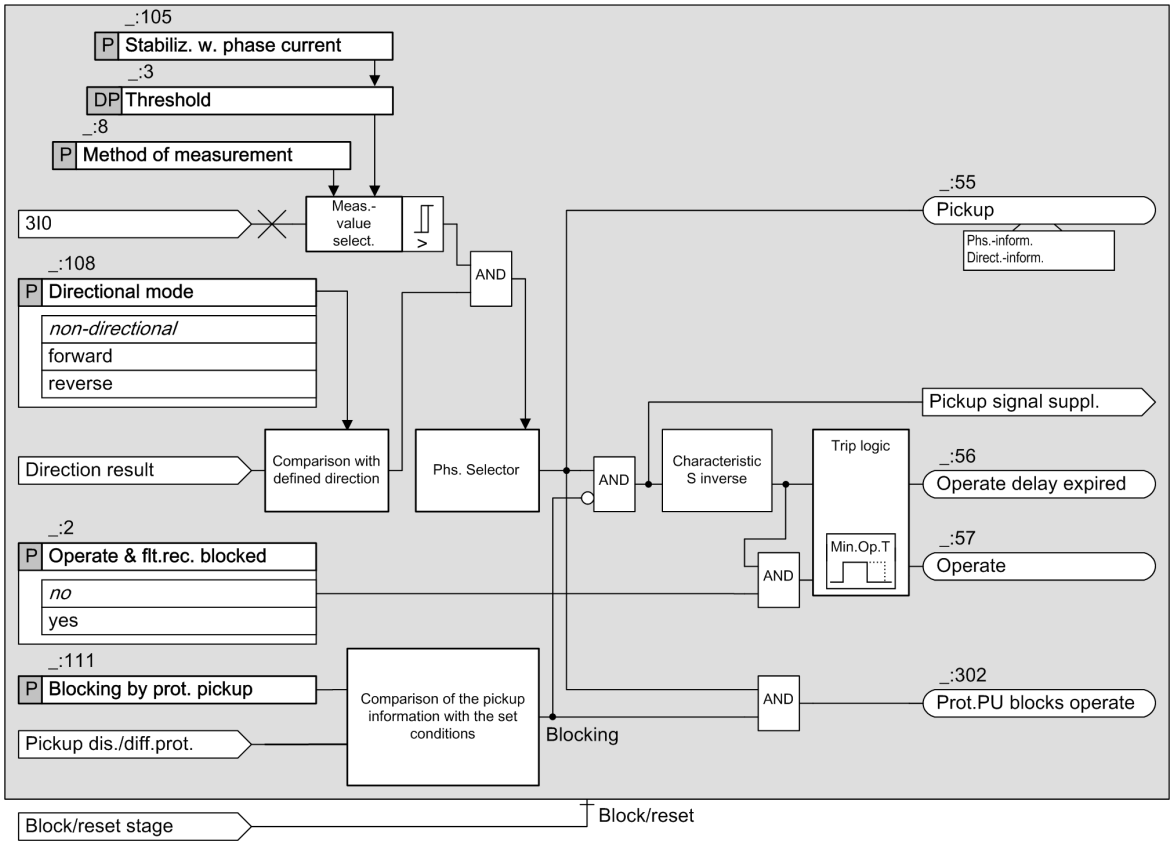
No.	Information	Data Class (Type)	Type
Log.-inv.-T #			
_:81	Log.-inv.-T #:>Block stage	SPS	I
_:84	Log.-inv.-T #:>Activ. dyn. settings	SPS	I
_:51	Log.-inv.-T #:Mode (controllable)	ENC	C
_:54	Log.-inv.-T #:Inactive	SPS	O
_:52	Log.-inv.-T #:Behavior	ENS	O
_:53	Log.-inv.-T #:Health	ENS	O

No.	Information	Data Class (Type)	Type
_:60	Log.-inv.-T #:Inrush blocks operate	ACT	O
_:301	Log.-inv.-T #:Mode1p dead-tm.active	SPS	O
_:302	Log.-inv.-T #:Prot.PU blocks operate	SPS	O
_:62	Log.-inv.-T #:Dyn.set. AR cycle1act.	SPS	O
_:63	Log.-inv.-T #:Dyn.set. AR cycle2act.	SPS	O
_:64	Log.-inv.-T #:Dyn.set. AR cycle3act.	SPS	O
_:65	Log.-inv.-T #:Dyn.set. ARcycl.>3act	SPS	O
_:67	Log.-inv.-T #:Dyn.set. BI active	SPS	O
_:68	Log.-inv.-T #:Dyn. set. blks. pickup	SPS	O
_:55	Log.-inv.-T #:Pickup	ACD	O
_:56	Log.-inv.-T #:Operate delay expired	ACT	O
_:57	Log.-inv.-T #:Operate	ACT	O

6.9.7 Stage with S0 Characteristic Curve

6.9.7.1 Description

Logic of the Stage



[loggfp34-160611-01.tif, 2, en_US]

Figure 6-195 Logic Diagram for Ground-Fault Protection with Zero-Sequence Power-Dependent Delay (S0 Inverse)

Apart from the operate curve, this type of stage is identical to the ground-fault protection type with inverse time-overcurrent protection according to IEC and ANSI (AMZ-3I0-IEC/ANSI) (see section *6.9.5.1 Description*).

This section will only discuss the nature of the operate curve. For the further functionality, Siemens refers to section *6.9.5.1 Description* .

Operate Curve

Figure 6-196 shows the operate curve of the stage.

The zero-sequence system power protection operates according to a power-dependent operate curve.

The zero-sequence system power is calculated from the zero-sequence voltage and the zero-sequence system current. The Sr component in the direction of an adjustable compensation angle φ_{comp} is definitive. This component is designated as a compensated zero power:

$S_r = 3I0 \cdot 3V0 \cdot \cos(\varphi\text{-}\varphi_{comp})$ with $\varphi = \varphi_{V0} - \varphi_{I0}$

φ_{comp} therefore indicates the direction of maximum sensitivity ($\cos(\varphi - \varphi_{comp}) = 1$, if $\varphi = \varphi_{comp}$). The power calculation automatically contains the direction via its sign information. Reversing the signs also allows the power for the reverse direction to be determined. *Figure 6-202* represents the direction-characteristic curve.

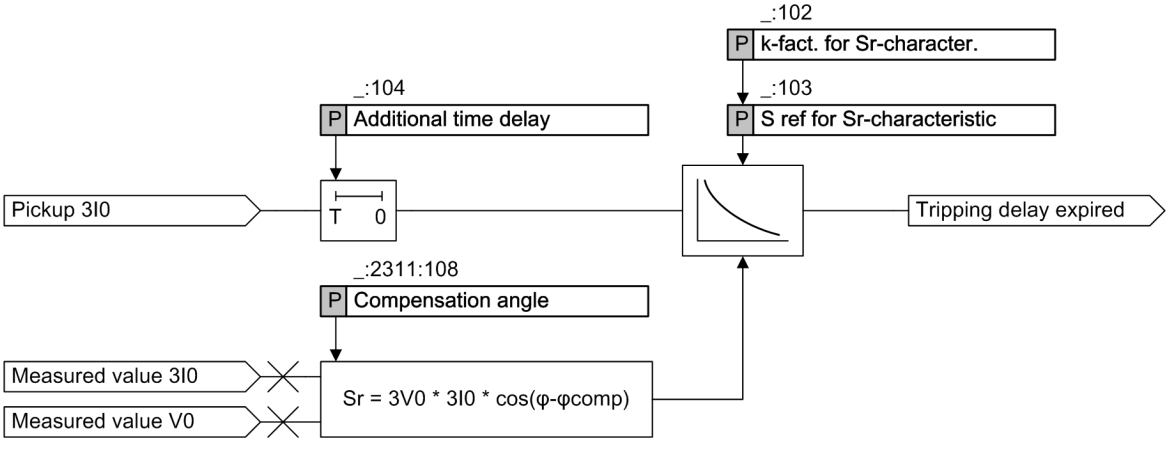
The operate time results according to the equation:

$$t = k \cdot \frac{S_{ref}}{S_r}$$

[fogfp003-300511-01.tif, 1, en_US]

The power-time characteristic curve can be shifted with the reference value S_{ref} (**`S ref for Sr-charac-teristic`** = basic value for the inverse characteristic curve for $\varphi = \varphi_{comp}$) in power direction. The power-time characteristic curve can be shifted in the time direction by the factor **`k-fact. for Sr-character.`**.

You can set additional power-dependent delays with the time setting **`Additional time delay`**.



[loggfp11-250111-01.tif, 1, en_US]

Figure 6-196 Operate Curve

6.9.7.2 Application and Setting Notes

Apart from the characteristic curve, this type of stage is identical to the ground-fault protection type with inverse-time delay according to IEC and ANSI (AMZ-3I0-IEC/ANSI) (see section *6.9.5.1 Description*).

This section will only discuss the nature of the operate curve. For the further functionality, Siemens refers to section *6.9.5.2 Application and Setting Notes* .

Stage-Type Selection

If the tripping delay is to be dependent on the zero power according to an inverse characteristic curve, select this stage type.

Parameter: Compensation angle

- Default setting **`(_:2311:108) Compensation angle`** = ***255°***

The **Compensation angle** setting is used to define the direction of maximum sensitivity.

General information cannot be provided. Define the value corresponding to the application.

Parameter: k-fact. for Sr-character.

- Default setting **(_:102) k-fact. for Sr-character.** = ***0.500 s***

The **k-fact. for Sr-character.** parameter can be used to shift the power-time characteristic curve on the time line.

General information cannot be provided. Define the value corresponding to the application.

Parameter: S ref for Sr-characteristic

- Default setting **(_:103) S ref for Sr-characteristic** = ***10 VA***

The **S ref for Sr-characteristic** parameter can be used to shift the power-time characteristic curve on the power axis.

General information cannot be provided. Define the value corresponding to the application.

Parameter: Additional time delay

- Default setting **(_:104) Additional time delay** = ***1.200 s***

You can set additional power-dependent delays with the **Additional time delay** parameter.

General information cannot be provided. Define the value corresponding to the application.

6.9.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	S0 inverse-T #:Mode		• off • on • test	off
_:2	S0 inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:108	S0 inverse-T #:Direc-tional mode		• non-directional • forward • reverse	non-directional
_:8	S0 inverse-T #:Method of measurement		• 1-cycle filter • 2-cycle filter	1-cycle filter
_:109	S0 inverse-T #:Blk. w. inrush curr. detect.		• no • yes	no
_:112	S0 inverse-T #:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:111	S0 inverse-T #:Blocking by prot. pickup		• every pickup • no pickup	every pickup
_:106	S0 inverse-T #:Hold mode 1p dead time		0.000 s to 60.000 s	0.040 s
_:105	S0 inverse-T #:Stabiliz. w. phase current		0 % to 30 %	10 %

Addr.	Parameter	C	Setting Options	Default Setting
_:3	S0 inverse-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:101	S0 inverse-T #:Threshold multiplier		1.00 to 4.00	1.10
_:102	S0 inverse-T #:k-fact. for Sr-character.		0.000 s to 60.000 s	0.500 s
_:103	S0 inverse-T #:S ref for Sr-characteristic	1 A	0.84 VA to 100.00 VA	17.32 VA
		5 A	4.20 VA to 500.00 VA	86.61 VA
_:104	S0 inverse-T #:Additional time delay		0.000 s to 60.000 s	1.200 s
_:140	S0 inverse-T #:Blocking by		Setting options depend on configuration	

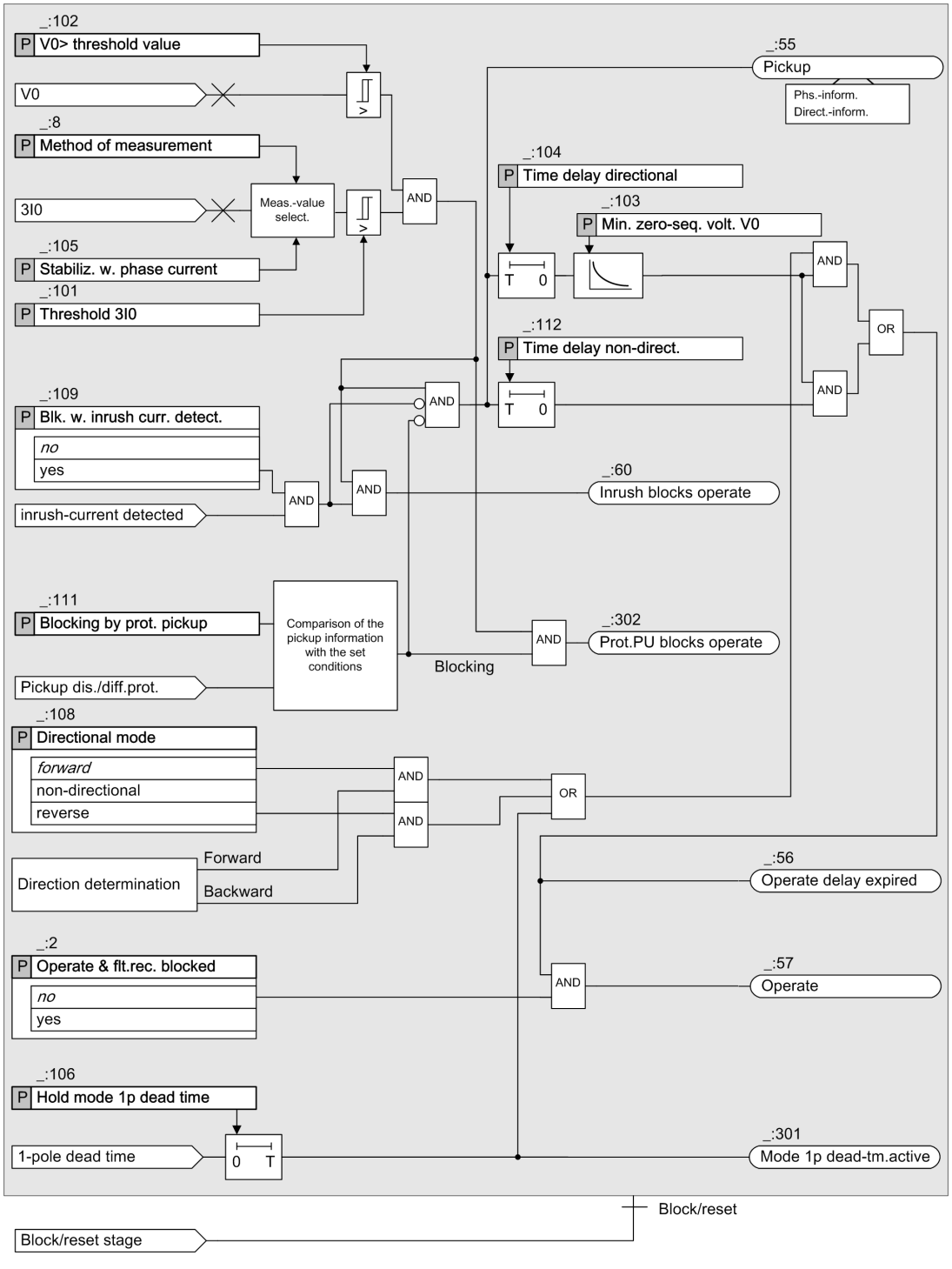
6.9.7.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	S0 inverse-T #:>Block stage	SPS	I
_:51	S0 inverse-T #:Mode (controllable)	ENC	C
_:54	S0 inverse-T #:Inactive	SPS	O
_:52	S0 inverse-T #:Behavior	ENS	O
_:53	S0 inverse-T #:Health	ENS	O
_:60	S0 inverse-T #:Inrush blocks operate	ACT	O
_:301	S0 inverse-T #:Mode1p dead-tm.active	SPS	O
_:302	S0 inverse-T #:Prot.PU blocks operate	SPS	O
_:55	S0 inverse-T #:Pickup	ACD	O
_:56	S0 inverse-T #:Operate delay expired	ACT	O
_:57	S0 inverse-T #:Operate	ACT	O

6.9.8 Stage with U0 Characteristic Curve

6.9.8.1 Description

Logic of the Stage



[lo gfp stage V0 invers 3-ph, 1, en_US]

Figure 6-197 Logic Diagram for Ground-Fault Protection with Zero-Sequence Voltage-Dependent Delay (V0 inverse)

Measurands

The device measures the residual voltage. The measured voltage is converted to the zero-sequence voltage $\underline{V}_0$. If the residual voltage is not available to the device as a measurand from the broken-delta winding, the zero-sequence voltage $\underline{V}_0$ is calculated from the measured phase-to-ground voltages $\underline{V}_A$, $\underline{V}_B$, and $\underline{V}_C$ using the definition equation:

$$\underline{V}0 = \frac{1}{3}\left(\underline{V}_A + \underline{V}_B + \underline{V}_C\right)$$

[fo_U0 nullspannung, 1, en_US]

The zero-sequence current is used as a measurand. Based on its definition equation, the zero-sequence current is derived from the sum of the 3 phase currents:

$$3\underline{I}0 = \underline{I}_A + \underline{I}_B + \underline{I}_C$$

[fo_I0 nullstrom, 1, en_US]

Depending on the use of the current inputs of the device, the zero-sequence current can be measured or calculated.

If you connect a current input to the neutral-point feed of the current transformer or to a separate ground-current transformer of the line to be protected, the ground current (zero-sequence current) will be directly available to the device.

If the device is equipped with a sensitive current input I_{Nsens}, the device will use this current. The linear range of this measuring input ends at an amplitude of approx. 1.6 A. At higher currents, the device automatically switches to analysis of the zero-sequence current calculated from the phase currents.

If the ground current is not present in the device as a directly measured variable, the device will calculate the zero-sequence current from the phase currents.

Method of Measurement

The **`Method of measurement`** parameter is used to select the relevant measuring procedure, depending on the application:

- Measurement of the fundamental component via 1-cycle filter (standard filter)

  This measuring procedure processes the sampled current values and filters out the fundamental component numerically.

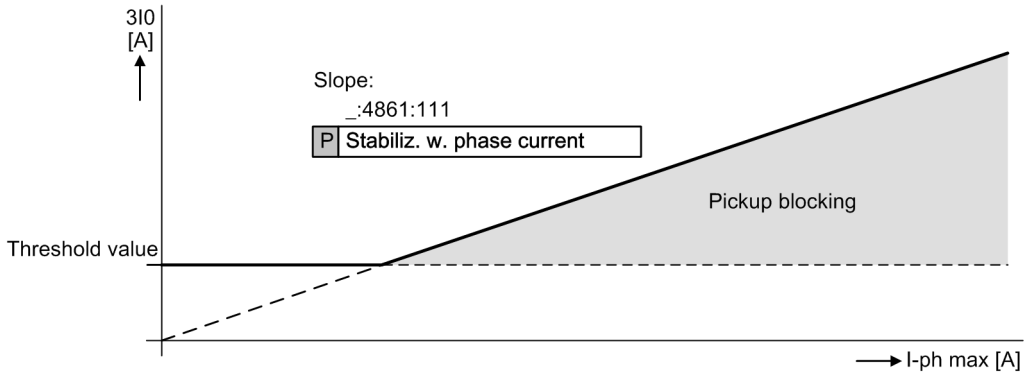
- Measurement of the fundamental component via 2-cycle filter

  This measuring procedure processes the sampled current values and filters out the fundamental component numerically. Harmonics and transient faults are damped particularly strongly over the extended filter length in comparison to the standard filter. The extended filter length causes the pickup time to increase slightly compared to the standard filter (see Technical specifications).

Stabilization with Phase Currents

In grounded systems, unbalanced line and load ratios cause a zero-sequence current in normal operational applications. Likewise, different current-transformer errors lead to a secondary zero-sequence current. The amplitude of this undesirable zero-sequence current increases as the phase current increases. An undesirable zero-sequence current can lead to false pickup and unwanted tripping at low setting values for the ground-current stages. To avoid false pickup and unwanted tripping, the ground-current stages are stabilized with the phase currents. The threshold value increases with rising phase currents (see next figure).

You can change the stabilization factor (= gradient) via the **`Stabiliz. w. phase current`** parameter.



[logfpsta-030311-01.tif, 1, en_US]

Figure 6-198 Stabilization with Phase Currents

Directional mode

You use the **`Directional mode`** parameter to define whether the stage works in a forward or reverse direction. Non-directional operation is also possible.

The direction determination works across stages (see *6.9.9.1 Description*).

Voltage-Dependent Operate Curve

The voltage-dependent operate curve is based on the following formula:

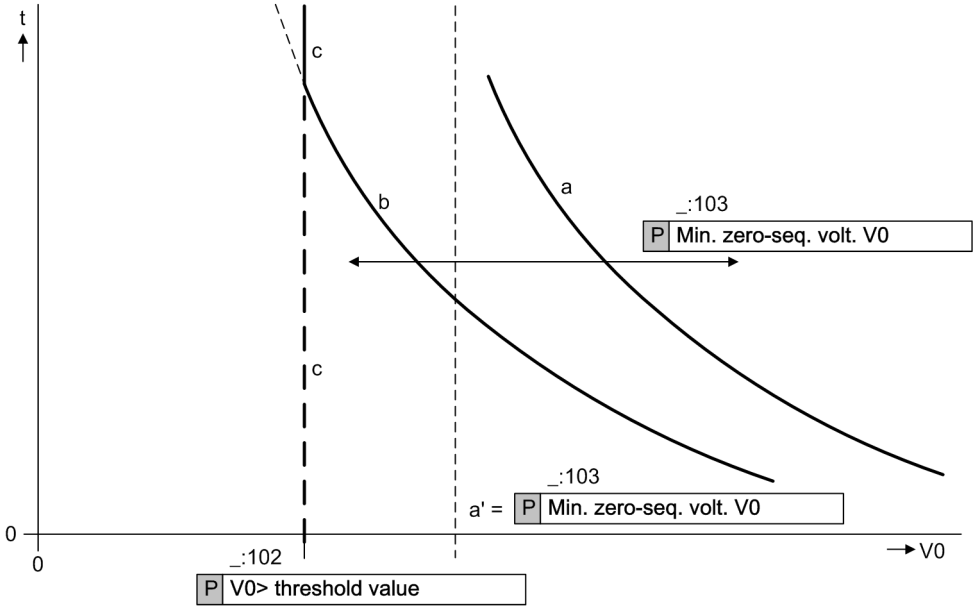
$$t = \frac{2\ s}{0.25 \cdot V_0/[V] - V_{0\,min}/[V]}$$

[fo_U0 kennl, 1, en_US]

with

V_0	Actually occurring zero-sequence voltage
$V_{0\,min}$	Setting value of the parameter **`Min. zero-seq. volt. V0`**

The following figure shows the voltage-dependent characteristic curve of the **V0 inverse** stage:



[dw-GFP-kennl, 1, en_US]

Figure 6-199 Parameter of the Voltage-Dependent Characteristic Curve of the V0 Inverse Stage (without Additional Times)

The operate time depends on the value of the zero-sequence voltage. In meshed, grounded systems, the zero-sequence voltage increases towards the point of the ground fault. Due to the inverse characteristic curve, the operate time decreases with rising zero-sequence voltage.

The **V0> threshold value** parameter defines the lower voltage limit (dotted line **c** in *Figure 6-199*). The lower voltage limit **c** cuts off the characteristic curve **b**.

The **Min. zero-seq. volt. V0** parameter shifts the voltage-dependent characteristic curves in the direction of V0.

The **Time delay directional** parameter shifts the voltage-dependent characteristic curves in the direction of time.

The setting value of the **Min. zero-seq. volt. V0** parameter is the asymptote **a´** of characteristic curve **a** for $t \rightarrow \infty$.

Processing the inverse characteristic curve after exceeding the threshold value **V0> threshold value**, can be delayed by the time set in the **Time delay directional** parameter.

Blocking of the Stage Pickup

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal **>Block stage** (see also *Figure 6-188*).

Blocking the Tripping via the Device-Internal Inrush-Current Detection Function

Blocking of the tripping via the device-internal inrush-current detection is described in *6.9.11.1 Description*.

6.9.8.2 Application and Setting Notes

Stage-Type Selection

If the tripping delay is to be dependent on the zero-sequence voltage according to an inverse characteristic curve, select this stage type.

Parameter: Directional mode

- Default setting **(_:108) Directional mode** = ***forward***

You use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is only to work in a forward direction (in direction of the line).
reverse	Select this setting if the stage is only to work in the reverse direction (in the direction of the busbar).
non-directional	Select this setting if the stage is to work in the forward and reverse direction (in the direction of the line and busbar). The stage also works with this setting if no direction measurement is possible, for example, owing to lower or no polarization voltage.

Parameter: Method of measurement

- Default setting **(_:8) Method of measurement** = ***1-cycle filter***

Use the **Method of measurement** parameter to define whether the measurand is determined via a 1- or 2-cycle filter.

Parameter Value	Description
1-cycle filter	This method of measurement suppresses the harmonics or transient voltage peaks. Siemens recommends using this setting as the standard method.
2-cycle filter	To implement a particularly strong attenuation of harmonics and transient faults, select the setting 2-cycle filter. Note that in this case, the pickup time of the stage increases slightly (see Technical specifications).

Parameter: Blk. w. inrush curr. detect.

- Default setting **(_:109) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you determine whether the **V0-inverse stage** is blocked or not blocked during the detection of the transformer inrush current.

The **Blk. w. inrush curr. detect.** parameter is visible only when the **Inrush-current detection** function is available in the application.

Related Topics

6.9.11.2 Application and Setting Notes

Parameter: Blocking by the Main Protection

- Default setting **(_:140) Blocking by** = none
- Default setting **(_:111) Blocking by prot. pickup** = ***every pickup***

If you wish to give the selective fault clarification by the main protection function (for example, differential or distance protection) priority over tripping by ground-fault protection, you can define this via both parameters. The **Blocking by** parameter is used to select the zones or stages of the main protection function(s), upon whose pickup the ground-fault protection is to be blocked.

The **Blocking by prot. pickup** parameter can be used to define the type of pickup, which leads to the blocking.

Parameter Value	Description
every pickup	Blocking at every pickup
no pickup	No blocking at pickup of the main protection function

Parameter: Hold mode 1p dead time

- Default setting **(_:106) Hold mode 1p dead time** = ***0.040 s***

With the **Hold mode 1p dead time** parameter you define the time by which the behavior during a 1-pole dead time is extended.

At all line ends, there is no simultaneous switch-in after a 1-pole dead time. Thus, the device-internal signal for a 1-pole dead time must be retained for a certain time after the switch-in (end of the 1-pole dead time) until the other end or ends have securely switched in. The time to be set here corresponds to the maximum time between the connection of the 1st circuit breaker and the connection of the last circuit breaker at all ends of the feeder after a 1-pole dead time.

Parameter: Stabiliz. w. phase current

- Default setting **(_:105) Stabiliz. w. phase current** = ***10 %***

In grounded systems, unbalanced line and load ratios cause a residual current in normal operational applications. Likewise, different current-transformer faults lead to a secondary residual current. The amplitude of this undesirable residual current increases as the phase current increases. An undesirable residual current can lead to false pickup and unwanted tripping at low setting values for the ground-current stages. To avoid false pickup and unwanted tripping, the ground-current stages are stabilized with the phase currents. The threshold value increases as phase currents rise. You can change the stabilization factor (= gradient) via the **Stabiliz. w. phase current** parameter.

Siemens recommends a setting of 10 % under normal conditions.

Parameter: Threshold 3I0

- Default setting **(_:101) Threshold 3I0** = ***1.000 A***

With the **Threshold 3I0** parameter, you define the pickup value for the zero-sequence current. Set the **Threshold 3I0** lower than the minimum ground-fault current.
Define the pickup value corresponding to the application.

Parameter: V0> threshold value

- Default setting **(_:102) V0> threshold value** = ***1.667 V***

With the **V0> threshold value** parameter, you set the lower voltage limit of the voltage-dependent operate curve (see *Figure 6-199*). The lower voltage limit cuts off the characteristic curve.

Parameter: Min. zero-seq. volt. V0

- Default setting **(_:103) Min. zero-seq. volt. V0** = ***0.200 V***

With the **Min. zero-seq. volt. V0** parameter, you shift the voltage-dependent characteristic curves in the direction of V0 (see *Figure 6-199*).

Parameter: Time delay directional

- Default setting **(_:104) Time delay directional** = ***0.90 s***

With the **Time delay directional** parameter, you shift the voltage-dependent characteristic curve in the direction of time (see *Figure 6-199*).

Parameter: Time delay non-direct.

- Default setting **(_:112) Time delay non-direct.** = ***1.20 s***

With the **Time delay non-direct.** parameter, you can set additional direction-independent time delays. The level of the zero-sequence voltage does not affect the previously set time delay.
Define the value corresponding to the application.

6.9.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V0 inverse-T #				
_:1	V0 inverse-T #:Mode		• off • on • test	off
_:2	V0 inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:108	V0 inverse-T #:Direc-tional mode		• non-directional • forward • reverse	forward
_:8	V0 inverse-T #:Method of measurement		• 1-cycle filter • 2-cycle filter	1-cycle filter
_:109	V0 inverse-T #:Blk. w. inrush curr. detect.		• no • yes	no
_:113	V0 inverse-T #:Blk. w. 2nd harm. gnd. det.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:111	V0 inverse-T #:Blocking by prot. pickup		• every pickup • no pickup	every pickup
_:106	V0 inverse-T #:Hold mode 1p dead time		0.000 s to 60.000 s	0.040 s
_:105	V0 inverse-T #:Stabiliz. w. phase current		0 % to 30 %	10 %
_:101	V0 inverse-T #:Threshold 3I0	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:102	V0 inverse-T #:V0> threshold value		0.300 V to 200.000 V	1.667 V
_:103	V0 inverse-T #:Min. zero-seq. volt. V0		0.000 V to 200.000 V	0.200 V
_:104	V0 inverse-T #:Time delay directional		0.00 s to 60.00 s	0.90 s
_:112	V0 inverse-T #:Time delay non-direct.		0.00 s to 60.00 s	1.20 s
_:140	V0 inverse-T #:Blocking by		Setting options depend on configuration	

6.9.8.4 Information List

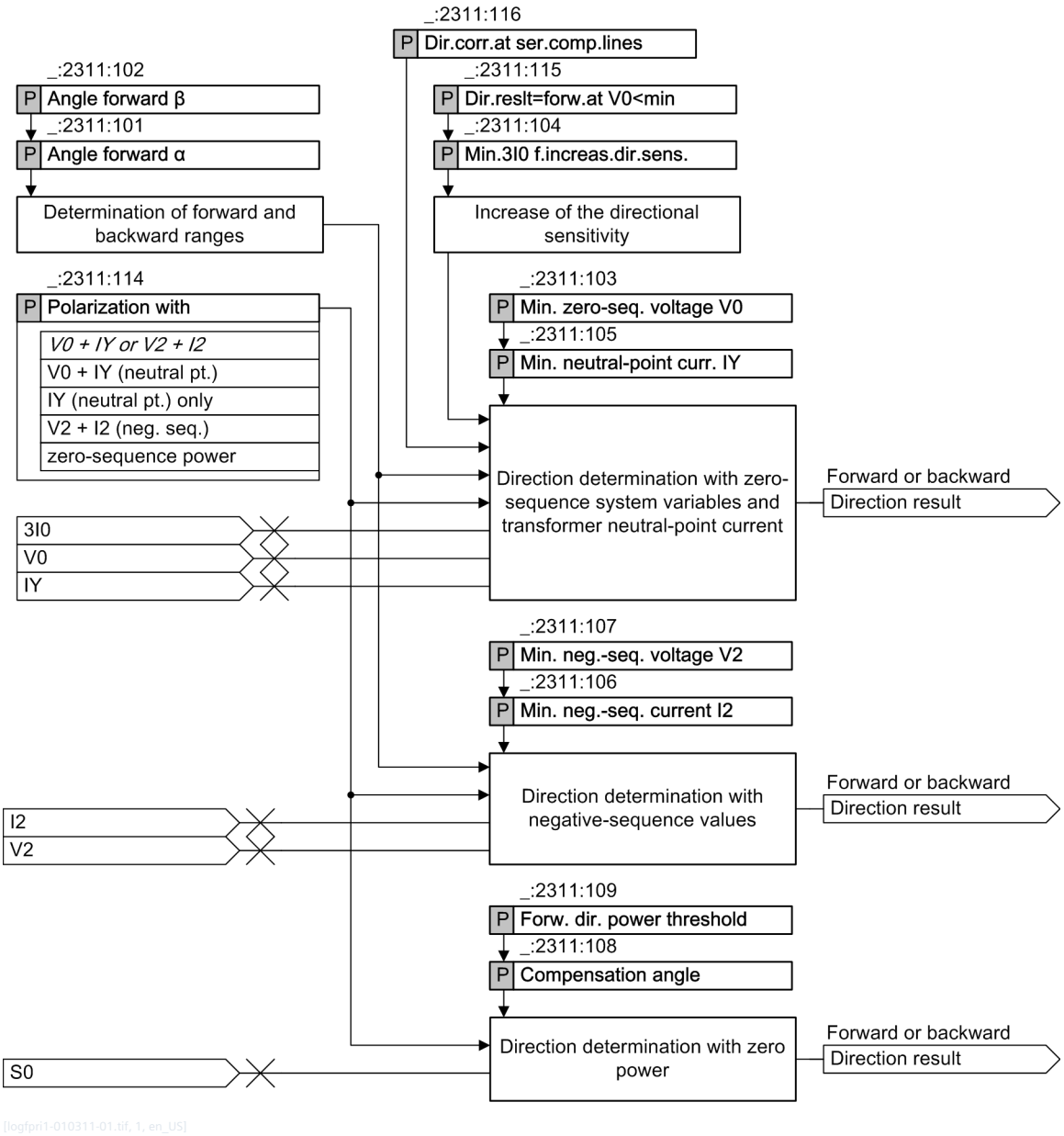
No.	Information	Data Class (Type)	Type
V0 inverse-T #			
_:81	V0 inverse-T #:>Block stage	SPS	I
_:51	V0 inverse-T #:Mode (controllable)	ENC	C
_:54	V0 inverse-T #:Inactive	SPS	O
_:52	V0 inverse-T #:Behavior	ENS	O
_:53	V0 inverse-T #:Health	ENS	O
_:60	V0 inverse-T #:Inrush blocks operate	ACT	O
_:301	V0 inverse-T #:Mode1p dead-tm.active	SPS	O
_:302	V0 inverse-T #:Prot.PU blocks operate	SPS	O
_:55	V0 inverse-T #:Pickup	ACD	O
_:56	V0 inverse-T #:Operate delay expired	ACT	O
_:57	V0 inverse-T #:Operate	ACT	O

6.9.9 Direction Determination

6.9.9.1 Description

The direction determination works across stages. Various methods are available for determining the direction and for increasing the accuracy of the determination.

The following diagram shows which variables and settings are used for direction determination.



[logfpri1-010311-01.tif, 1, en_US]

Figure 6-200 Logic Diagram for Direction Determination

Method for Direction Determination

Use the **Direct. determination with** parameter to define the method and variables with which the direction determination works:

- ***V0 + IY or V2 + I2*** (direction determination with zero-sequence system/transformer neutral-point current or negative-sequence system)
- ***V0 + IY (neutral pt.)*** (direction determination with zero-sequence system/transformer neutral-point current)
- ***IY (neutral pt.) only*** (direction determination with transformer neutral-point current)
- ***V2 + I2 (neg. seq.)*** (direction determination with negative-sequence system)
- ***zero-sequence power*** (direction determination with zero-system power)

The individual methods are described in more detail below.

The device automatically selects a suitable method with the ***V0 + IY or V2 + I2*** setting.

Direction Determination with Current/Voltage Zero-Sequence Variables/Transformer Neutral-Point Current

The forward and backward area is defined by the 2 parameters **Angle forward β** and **Angle forward α** (see also *Figure 6-202*). The reference for the 2 angles that must be set is the positive real axis. The angles are defined positively in a mathematical sense (that is, counterclockwise). The area between the limit angle α, starting in a mathematically positive direction, and the limit angle β is the forward area. The remaining area is the backward area.

The direction is determined from the measuring current I_N and a reference voltage Vp. If no transformer neutral-point current is connected to the device, the reference voltage Vp is the zero-sequence voltage V0.

The zero-sequence voltage is calculated from its definition equation:

$$\underline{V}0 = \frac{1}{3}\left(\underline{V}_A + \underline{V}_B + \underline{V}_C\right)$$

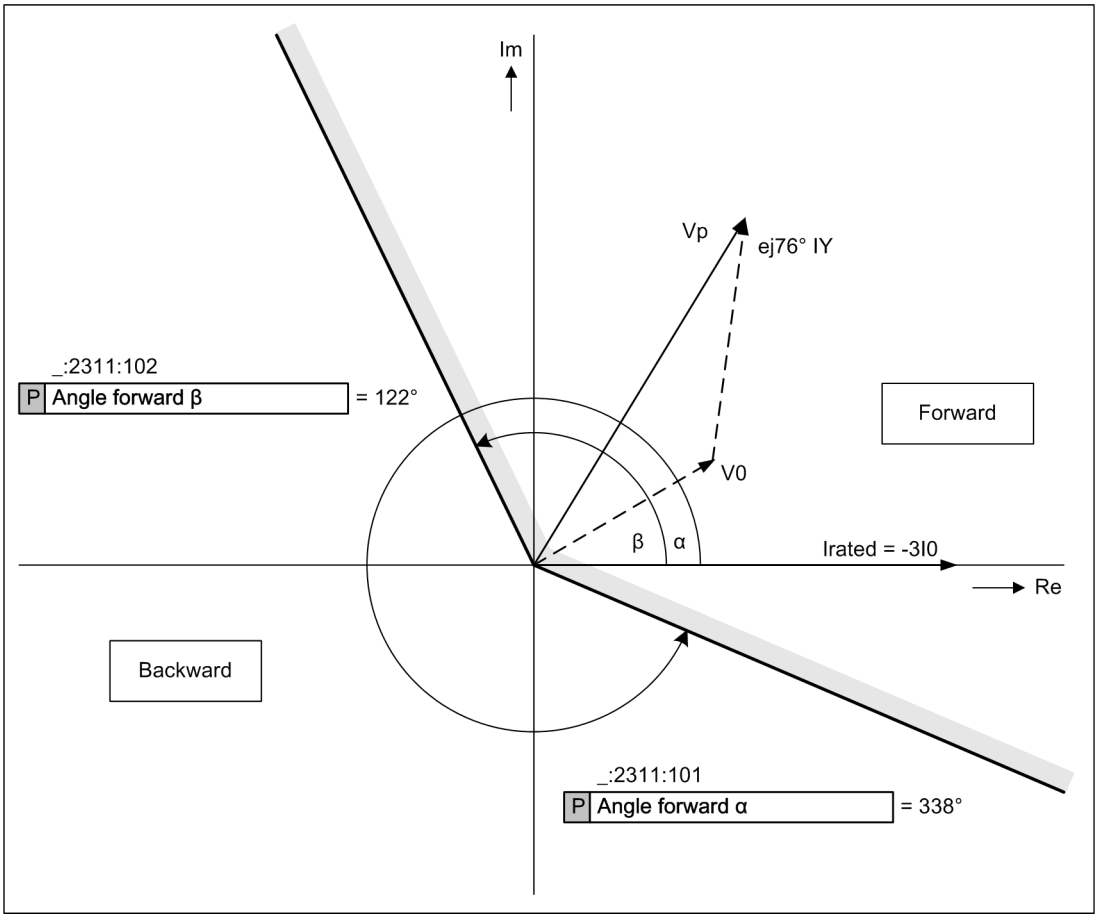
Depending on the device connection, it is measured or calculated. If a voltage input is connected at the broken-delta winding V_{dadn} of a voltage-transformer set, the device will use this voltage with consideration of the **Matching ratio Vph / VN** (see *8.3.7.3 Function Description*). Otherwise the device calculates the zero-sequence voltage from the phase-to-ground voltages.

If the neutral-point current IY of a grounded transformer (supply transformer) is connected, the reference voltage V_P is the sum of the zero-sequence voltage V0 and a variable proportional to the neutral-point current IY (see *Figure 6-201*). This corresponds to 20 V at the rated current. With the setting ***IY (neutral pt.) only***, V_P is only derived from the transformer neutral-point current.

To determine the direction, the device sets the measuring current I_N (= -3I0) to the real axis. If the phasor of the reference voltage V_P is within the defined forward area, the device determines the direction as **forward**. In other cases, the device determines the direction as **backward**.

As a prerequisite for direction determination, the adjustable minimum variables for the zero-sequence voltage or the transformer neutral-point current must be exceeded (parameters **Min. zero-seq. voltage V0** and **Min. neutral-point curr. IY**).

If the device detects a fault in the voltage-transformer secondary circuit, the direction determination is prevented with V0. If the transformer neutral-point current is connected to the device, the direction can be determined via this.



[logfpri2-010311-01.tif, 1, en_US]

Figure 6-201 Phasor Diagram for Direction Determination with Zero-Sequence System Variables

Direction Determination with Negative-Sequence System Variables

This method works in the same way as the direction determination with zero-sequence system current and zero-sequence system voltage. Instead of 3I0 and V0, the negative-sequence system variables I2 and V2 are used for the measurement. These measurands must also have a **`Min. neg.-seq. voltage V2`** and a **`Min. neg.-seq. current I2`**.

Direction Determination with Zero-Sequence System Power

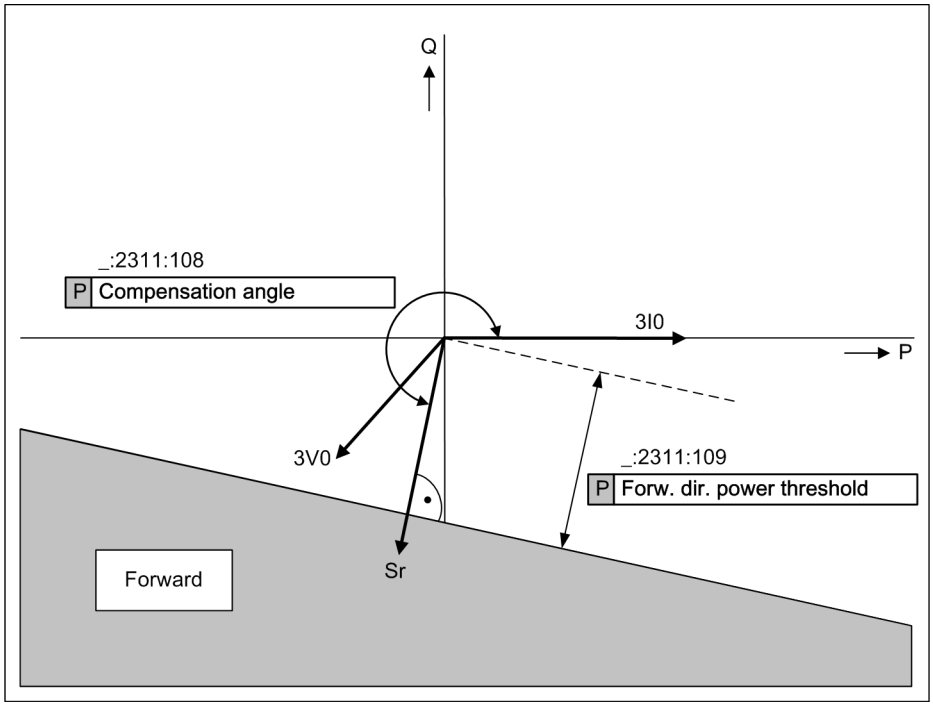
The zero-sequence system power can also be used for the direction determination. The sign of the compensated zero-sequence system power is then crucial. This is the component mentioned in *6.9.7.1 Description* under operate curve S_r of the zero-sequence system power in the direction of an adjustable compensation angle φ_{comp}, that is, $S_r = 3I0 \cdot 3V0 \cdot \cos(\varphi - \varphi_{comp})$.

The direction determination yields:

- Forward, if S_r positive and $|S_r| >$ **`Forw. dir. power threshold`**
- Backward, if S_r negative and $|S_r| >$ **`Forw. dir. power threshold`**

Determining the direction requires a minimum residual voltage that can be set as **`Min. zero-seq. voltage V0`**. Another prerequisite is that the compensated zero power must have an adjustable minimum value (parameter **`Forw. dir. power threshold`**). If the device detects a fault in the voltage-transformer secondary circuit (binary input of voltage transformer miniature circuit breaker dropped out, measuring-voltage failure detection) or a 1-pole dead time, the direction determination is prevented.

The following figure shows an example of the direction-characteristic curve.

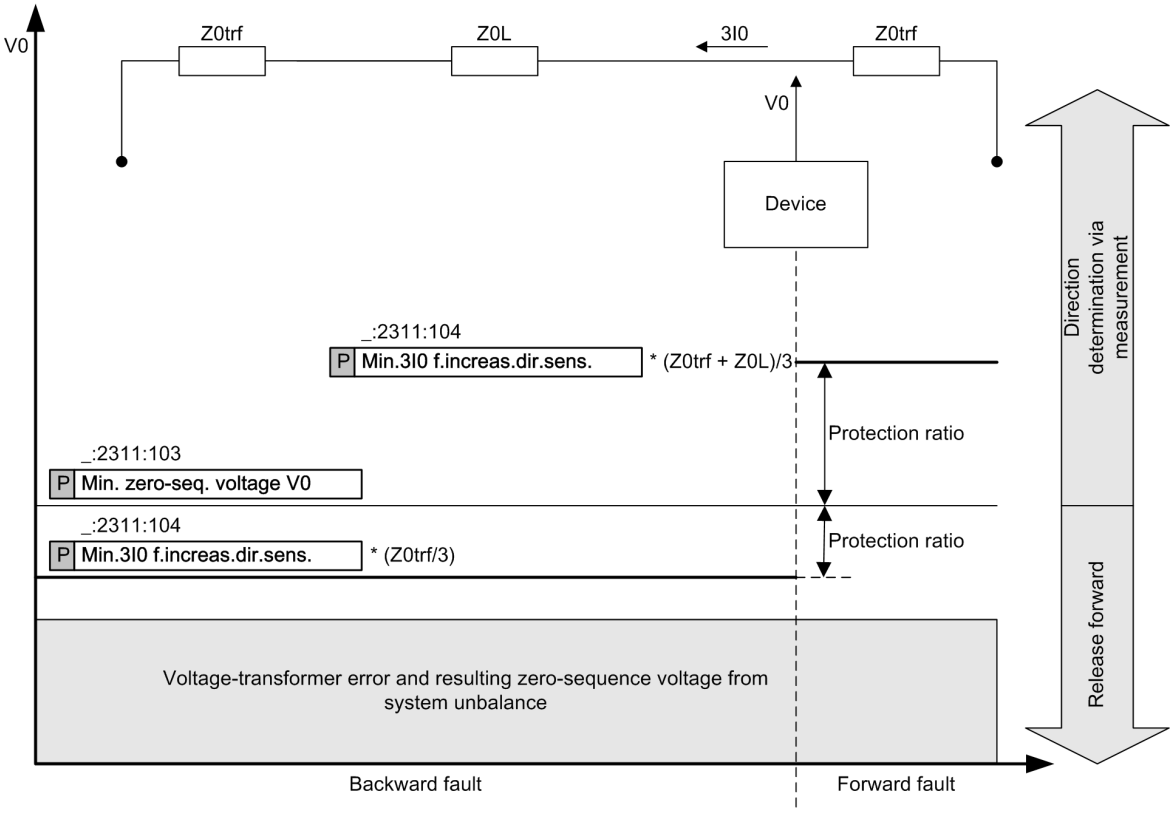


[logfpri4-010311-01.tif, 1, en_US]

Figure 6-202 Direction-Characteristic Curve for Direction Determination with Zero-Sequence System Power

Increased Directional Sensitivity at Low V0 Voltage

The following figure shows the principle for increasing the directional sensitivity.



[logfpri5-010311-01.tif, 1, en_US]

Figure 6-203 Principle of Increased Directional Sensitivity at Low V0 Voltage

The V0 voltage at a ground fault with direction = backward is determined with the following equation:

$V0_{F0=backward} = I0 \cdot (Z0_{trf} + Z0L)$

This equation can be used to determine a I0 threshold with corresponding V0 threshold. If the I0 threshold is exceeded, the measured V0 voltage at a backward fault must exceed the corresponding V0 threshold. If the I0 threshold is exceeded and the measured V0 voltage is less than the V0 threshold, the direction = forward can thus be determined.

The method can improve the directional sensitivity in the case of long lines (large Z0L).

Switch on this functionality via the **`Dir.reslt=forw.at V0<min`** parameter.

If the measured V0 voltage falls below the minimum value **`Min. zero-seq. voltage V0`** and 3I0 exceeds the current threshold **`Min.3I0 f.increas.dir.sens.`**, the decision is for forward.

Direction Determination for Lines with Series Compensation

The direction determination/direction-characteristic curve of the ground-fault protection is based on the assumption of a mainly inductive zero-sequence impedance. In case of a series-compensated line this assumption does not apply anymore. According to the degree of compensation, the zero-sequence impedance is more or less influenced regarding its capacity. If the capacitor is located on the busbar side of the voltage transformer the situation is especially unfavorable.

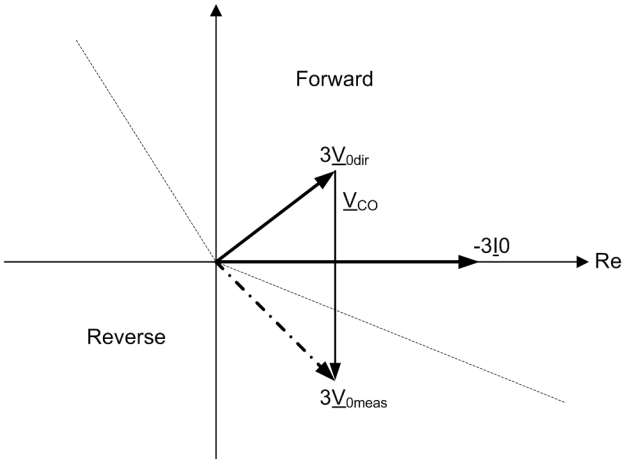
In case of a series compensation on the line you can adjust the direction of the measured zero-sequence voltage V_{0meas}. Perform the adjustment with the **`Dir.corr.at ser.comp.lines`** parameter. Set the data necessary for the adjustment (reactance of the capacitor bank) in the function group **Line** (see chapter *5.5.3 Application and Setting Notes*).

In case of faults on the protected line, the zero-sequence voltage with series compensation consists of 2 components: the voltage drop on the source impedance (mainly inductive) and the voltage drop on the series capacitor.

If the capacity of the series capacitor is known (and constant), the voltage drop on the series capacitor can be determined according to the following formula:

$\underline{V}_{C0} = -jX_{C0} \cdot 3\underline{I}_0$ with

X_{C0} Parameter **`Series capacit. reactance`** in the function group **Line**



[dw_corr_series_comp_direction_with-0, 1, en_US]

Figure 6-204 Adjustment of the Series Compensation for Direction Determination with Zero-Sequence System

The voltage drop on the series capacitor $\underline{V}_{C0}$ is subtracted from the measured voltage $3\underline{V}_{0meas}$. The resulting voltage $3\underline{V}_{0Dir}$ is then assigned to the direction-characteristic curve of the ground-fault protection (see *Figure 6-204*).

6.9.9.2 Application and Setting Notes

Parameter: Direct. determination with

- Recommended setting value **(_:2311:114) Direct. determination with** = ***V0 + IY or V2 + I2***



NOTE

If you use a teleprotection scheme with ground-fault protection, you must ensure that the direction measurement at all line ends is carried out using the same procedure. The setting for parameter **Direct. determination with** must be the same. If a device is used at a line end that does not have all the setting options, then you must limit the direction measurement to a single procedure that is possible at all line ends, for example, only V0 (setting option ***V0 + IY (neutral pt.)***).

Parameter Value	Description
V0 + IY or V2 + I2	The default setting ***V0 + IY or V2 + I2*** is universal. The device automatically selects the best (largest) measured value for direction determination. You can also use this setting if the transformer neutral-point current IY is not connected to the device. Siemens recommends using this setting (see note on Teleprotection Scheme).
V0 + IY (neutral pt.)	If the direction determination is to be deliberately excluded via negative-sequence variables (V2 and I2), select this setting. You can also use this setting irrespective of whether the transformer neutral-point current IY is connected to the device or not. If the transformer neutral-point current is not connected to the device, the direction measurement only operates with V0. For the teleprotection scheme, it can be necessary to carry out the direction measurement with the zero-sequence system alone if a device only provides this option at the opposite end.
IY (neutral pt.) only	This setting can be advisable if a transformer neutral-point current IY is reliably available at the device input at any time. The direction determination is then not affected by faults in the secondary circuit of the voltage converter. It also works if there is a fault in the voltage-transformer secondary circuit. However, this setting requires that ground-fault currents are at least predominantly fed via the transformer whose neutral-point current is measured.
V2 + I2 (neg. seq.)	Select this setting if you only wish to determine the direction with the negative-sequence variables I2 and V2. If zero-sequence voltages occur during ground faults, which are too low for evaluation of the zero-sequence variables, direction determination with negative-sequence variables is advantageous. Direction determination with negative-sequence variables is also advantageous if, for example, parallel lines falsify the zero-sequence variables through mutual coupling. You can also use these settings if the zero-sequence voltage is not available in the device.
zero-sequence power	This setting is intended for special applications.

Parameter: Limit angle of the forwards range

- Recommended setting value **(_:2311:102) Angle forward β** = ***122°***
- Recommended setting value **(_:2311:101) Angle forward α** = ***338°***

You can use the **Angle forward β** and **Angle forward α** parameters to alter the position of the direction-characteristic curve for all methods based on the angular measurement between the measuring and reference value. Only the method for determining the direction via the zero-sequece power is excluded.

Siemens recommends using the default settings, as the function reliably determines the direction of ground faults with this.

Parameter: Directional Correction with Series Compensation

- Recommended setting value **(_:2311:116) Dir.corr.at ser.comp.lines** = ***no***

Parameter Value	Description
no	If no series compensation is used on the line, set this parameter to ***no***.
yes	If a series compensation is used on the line, set this parameter to ***yes***. Direction determination is then corrected using V0.

Parameter: Minimum zero-sequence voltage V0

- Default setting **(_:2311:103) Min. zero-seq. voltage V0** = ***0.15 V***

You can use the **Min. zero-seq. voltage V0** parameter to define the minimum zero-sequence voltage for the direction determination with V0. The minimum zero-sequence voltage V0 must be set greater than the maximum operational unbalance (zero-sequence system) plus voltage-transformer measuring errors. As the measuring error of the individual voltage transformers in the zero-sequence system is not added up, the critical measuring error influence is the unbalance of the primary system.

Siemens recommends observing the operational zero-sequence voltage V0 of the protected object (for example, the line) via the operational measured values of the device and providing the maximum value with a certainty of 20 %.

Min. zero-seq. voltage V0 = 1.2 · max. operational measured value of voltage zero-sequence voltage V0

Example:

Max. operational measured value of voltage zero-sequence voltage V0 = 0.5 Vsec

Min. zero-seq. voltage V0 = 1.2 0.5 V = 0.60 Vsec

The setting value refers to the zero-sequence voltage V0 according to the definition equation and not to 3V0, as with the SIPROTEC 4 devices.

Parameter: Minimum neutral point current IY

- Recommended setting value **(_:2311:105) Min. neutral-point curr. IY** = ***0.05 A***

The **Min. neutral-point curr. IY** parameter is used to set the lower threshold for the reference current from the neutral point of a supply transformer. You can set the value relatively sensitive (see recommended setting value), as the neutral-point current detection is naturally accurate.

Parameter: Minimum negative-sequence variables V2 and I2

- Recommended setting value **(_:2311:107) Min. neg.-seq. voltage V2** = ***0.7 V***
- Recommended setting value **(_:2311:106) Min. neg.-seq. current I2** = ***0.05 A***

You can use the parameters to define the minimum negative-sequence variables for determining the direction with V2 and I2. The set limiting values must not be exceeded by operational unbalances.

Parameter: Compensation angle

- Recommended setting value **(_:2311:108) Compensation angle** = ***255°***

The **Compensation angle** parameter is used to set the angle of the maximum sensitivity, $\cos(\varphi - \varphi_{comp}) = 1$, if $\varphi = \varphi_{comp}$.

The default setting 255° therefore corresponds to a zero-sequence impedance angle of 75° (255° – 180°). Siemens recommends using the default settings, as the direction of ground faults is determined reliably with this.

Parameter: Forward dir. power threshold

- Default setting **(_:2311:109) Forw. dir. power threshold** = ***0.3 VA***

You can use the **Forw. dir. power threshold** parameter to define the value of the compensated zero-sequence power, above which the direction is detected as forward. To ensure direction determination even at low zero-sequence powers, this value is to be below the reference power **S ref for Sr-characteristic** (see chapter *6.9.7.1 Description*).

Parameter: Direction result = forward at V0 < minimum zero-sequence voltage

- Default setting **(_:2311:115) Dir.reslt=forw.at V0<min** = ***no***

With long lines it can be the case that the zero-sequence voltage at a remote fault is too low on the line to be protected. This is due to the high ratio between the zero-sequence impedance of the line and the supply (source). If the setting for the **Min. zero-seq. voltage V0** parameter is fallen below, it will no longer be possible to determine the direction by angular measurement. In the case of reverse faults in long lines, the zero-sequence voltage cannot drop so sharply if the set 3I0 threshold value (**Min.3I0 f.increas.dir.sens.** parameter) is exceeded.

Parameter Value	Description
no	If the direction has to remain undetermined under the described condition and a stage pickup is not therefore possible in a directional stage, you should select the setting ***no***.
yes	If the direction has to be automatically detected as forwards under the described condition, you should select the setting ***yes***.

Parameter: Minimum zero-sequence current 3I0 for increased directional sensitivity

- Default setting **(_:2311:104) Min.3I0 f.increas.dir.sens.** = ***0.05 A***

You only have to set the **Min.3I0 f.increas.dir.sens.** parameter if the **Dir.reslt=forw.at V0<min** parameter has been set to ***yes***.

Then calculate the setting value with the following equation (see also *Figure 6-203*):

$$\text{Min.3I0 f.increas.dir.sens.} = SM \cdot \frac{3 \cdot V0}{(Z0L + Z0_{trf})}$$

[fofrbest-060110-01.tif, 1, en_US]

In this equation, V0 is the setting value for the **Min. zero-seq. voltage V0** parameter. SM is a reserve (for example, 1.2).

6.9.10 Phase Selection

As the ground-fault protection works with the zero-sequence or negative-sequence values, direct determination of the ground fault is not possible. The phase selection detects whether a 1-pole or multiphase short circuit has occurred with the distribution of the currents. The phase selection detects which phase is affected in the case of a 1-phase short circuit. The affected phase is reported via the pickup. The stages always initiate 3-pole tripping.

The phase selection filters the negative-sequence and the zero-sequence out of the phase currents. The fault type, that is, whether a 1-pole or multiphase short circuit has occurred, is determined from the phase displacement between the negative-sequence current and the zero-sequence current. The phase currents, purged of the load current, are also evaluated from this. This utilizes the fact that, in the case of a 1-phase short circuit, the healthy conductors can only conduct either no fault currents at all or only in-phase fault currents.

The phase selection has an action time of approx. 40 ms. If the phase selection is unable to make a decision in this time, 3-phase is signaled.

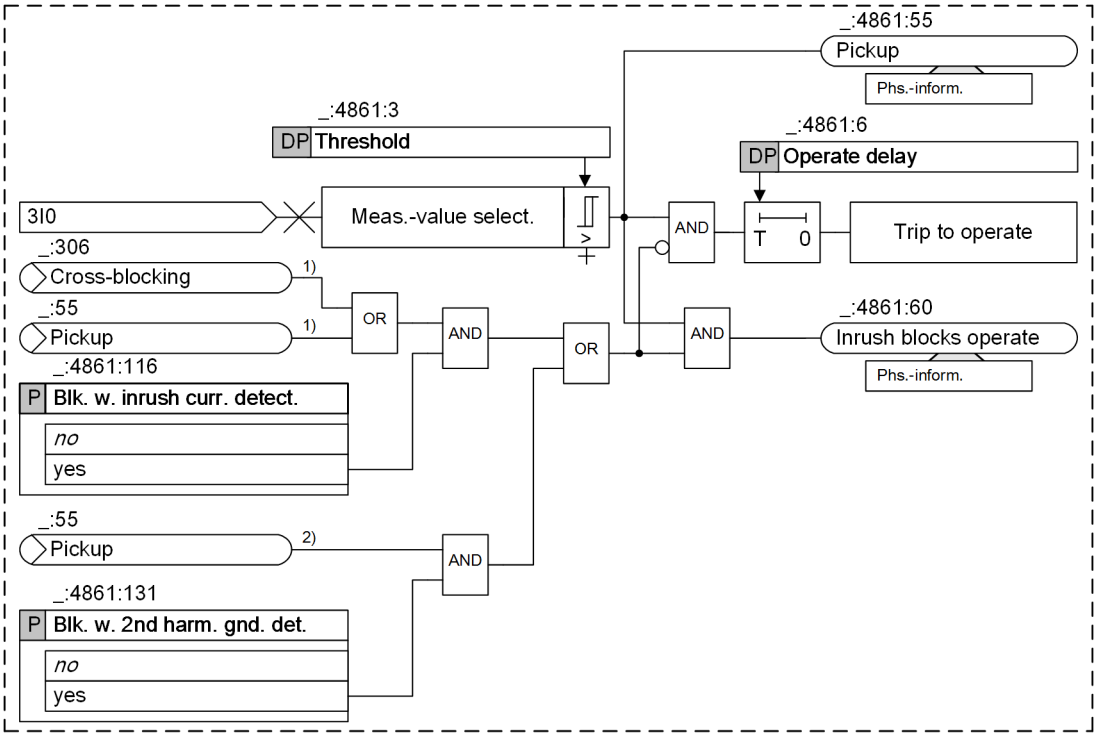
6.9.11 Blocking of the Tripping by Device-Internal Inrush-Current Detection

6.9.11.1 Description

With the **Blk. w. inrush curr. detect.** parameter, you define whether tripping of the stage should be blocked when a threshold-value violation occurs due to an inrush current. In case of a blocking, the stage picks up. The **S0 invers** and the **V0 invers** stages do not pick up. The start of the time delay and tripping are blocked. The stage signals this by way of a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. After that time, the stage operates.

With the **Blk. w. 2nd harm. gnd. det.** parameter, you define whether the operate indication of the stage should be blocked when a threshold value is exceeded due to a detected 2nd harmonic in the ground current. If the conditions for the 2nd harmonic to ground and the start condition for the protection function have been satisfied, inrush-current blocking is active. In case of a blocking and if the start conditions have been satisfied, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started. After that time, the stage operates.

The following figure only shows the part of the stage (exemplified by the 1st definite-time overcurrent protection stage) that illustrates the influence of the inrush-current detection. The blocking can only be adjusted if the **Inrush-current detection** function is active.



[loggfp13-260111-01.tif, 2, en_US]

Figure 6-205 Part of the Logic Diagram on the Influence of Inrush-Current Detection Exemplified by the 1st Definite-Time Overcurrent Protection Stage

(1) From the function block Inrush-current detection

(2) From the function block 2nd harmonic detection ground

6.9.11.2 Application and Setting Notes

Parameter: Blocking w. inrush-current detection

- Default setting **(_:4861:116) Blk. w. inrush curr. detect.** = ***no***

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: 1) In cases where the device is not used on transformers. 2) In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This typically applies for the high-current stage. The high-current stage is set corresponding to the short-circuit voltage V_{sc} of the transformer so that it only responds to high-voltage side faults. The transformer inrush current cannot become larger than the maximum transmittable short-circuit current.
yes	When the transformer inrush-current detection detects an inrush current that can lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: Blk. w. 2nd harm. gnd. det.

- Default setting **(_:4861:131) Blk. w. 2nd harm. gnd. det.** = ***no***

Parameter Value	Description
no	If no 3I0/IN current flow is expected, due to current-transformer saturation above the trip threshold value, select this setting.
yes	If an 3I0/IN current flow is expected due to current-transformer saturation above the trip threshold value, blocking must be activated. This supplies the stability for the following conditions: • Current-transformer saturation without inrush current, because a saturated signal also contains a 2nd harmonic component • Phase inrush current which leads to current-transformer saturation and therefore results in the inrush current of the 2nd harmonic is also being present in the parasitic 3I0 current.

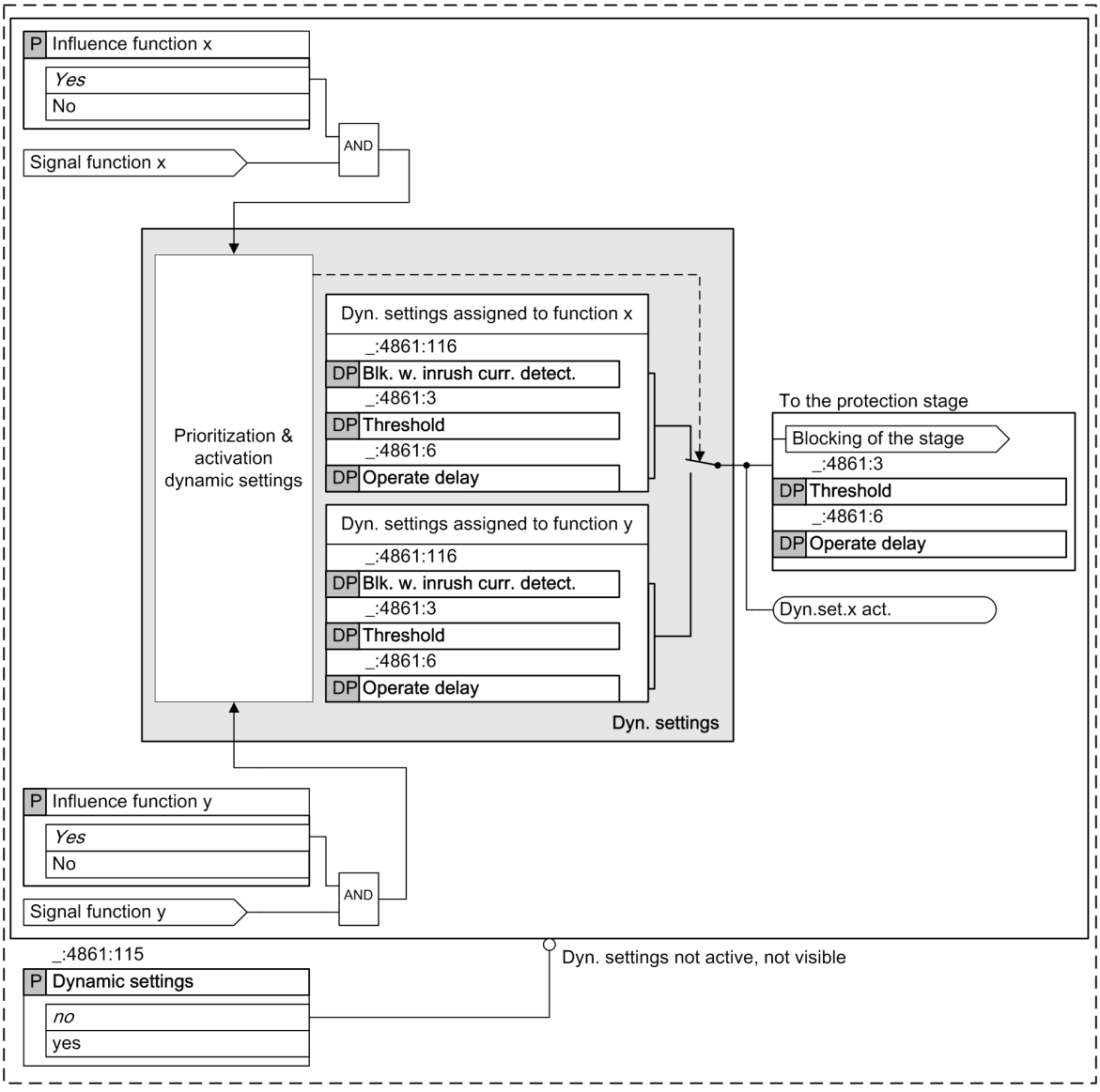
6.9.12 Signal Transmission

You can extend the ground-fault protection by means of the integrated signal-transmission logic for directional comparison protection. You can find more detailed information on the possible transmission methods and their function in section *6.10.2 Structure of the Function*.

6.9.13 Influence of Other Functions via Dynamic Settings

6.9.13.1 Description

The parameters **Threshold** and **Operate delay** of the tripping are so-called dynamic parameters (DP). Depending on other functions, the settings of these parameters can be changed dynamically (see *Figure 6-206*). Depending on other functions, the stage can also be blocked dynamically.



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Figure 6-206 Principle of the Dynamic Parameters in the Example of 1st Definite Time-Overcurrent Protection Stage

If the following functionalities are available in the device, they can affect the overcurrent-protection stages:

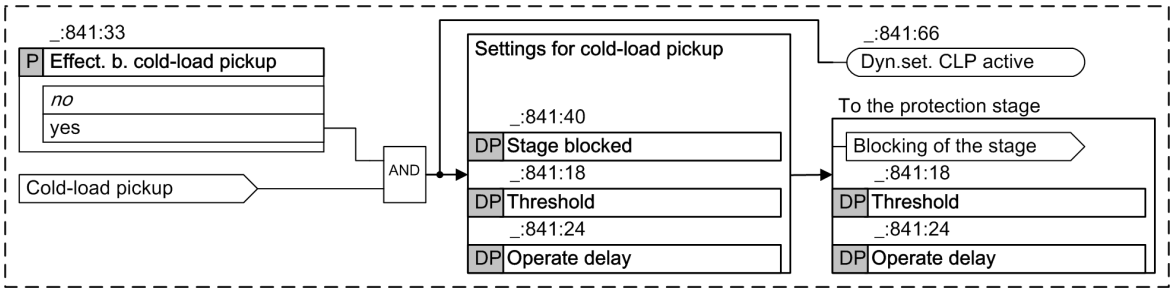
Functionalities	Priority
Automatic reclosing (AREC)	Priority 1
Cold-load pickup detection	Priority 2
Binary input signal	Priority 3

These functionalities generate signals that change the settings of the dynamic settings of the protection stage or block it, if necessary. In the latter case, the settings for the threshold value and time delay are of no relevance. To each of the signals, the overcurrent-protection stage provides a configuration parameter **`Affected by function ...`** and own dynamic parameters (**`Operate delay`** and **`Threshold`**). The configuration parameters are used to set whether the signal shall be active or not, that is, whether the dynamic settings should be activated or not. If one of these signals (for example, signal function x) becomes active and is to take effect, these parameter settings become dynamic, that is, instantly active. This means that the setting assigned to the signal replaces the standard setting. If the signal becomes inactive, the standard settings apply again. The activation of the dynamic parameter is reported.

Where several signals are active in parallel, the specified priority applies. This means that a signal with priority 1 precedes that of priority 2. The parameters assigned to signal 1 become active.

The functionality of the dynamic parameters can be disabled. In this case, the parameters assigned to the signals are not visible and are without effect.

Link to the Device-Internal Function *Cold-Load Pickup Detection*



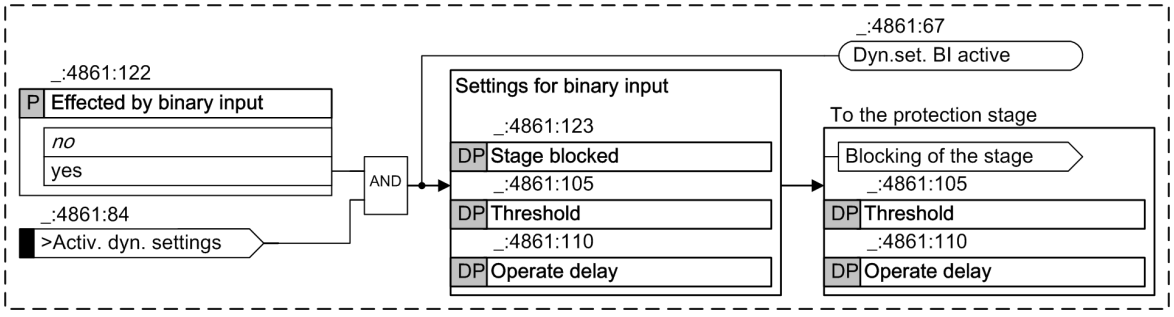
[logfpkal-300511-01.tif, 1, en_US]

Figure 6-207 Influence of the Cold-Load Pickup Detection on the Overcurrent-Protection Stage

In the case of cold-load pickup, you have the option to change the settings for the **Threshold** and **Operate delay** parameters of the protection stage. You can also block the stage. To do so, you must activate the influence of the cold-load pickup. You also have to set the parameters for the **Threshold** and **Operate delay** or **Stage blocked** settings, which take effect when the signal is active.

The way the **Cold-load pickup** signal is generated is described in chapter *5.5.4.1 Overview of Functions*.

Link to an External *Function via a Binary Input Signal*



[loeinbin-270111-01.tif, 1, en_US]

Figure 6-208 Influence of the Binary Input on the Overcurrent-Protection Stage

You can use the binary input signal **>Activ. dyn. settings** to change the settings for the **Threshold** and the **Operate delay** of the protection stage. You can also block the stage. To do so, you must activate the influence of the binary input. You also have to set the parameters for the **Threshold** and **Operate delay** or **Stage blocked** settings, which take effect when the signal is active.

6.9.13.2 Application and Setting Notes

Parameter: Dynamic settings

- Default setting **(_:4861:115) Dynamic settings** = ***no***

Parameter Value	Description
no	The influence on the protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (for example, Automatic reclosing function) or an external function is to affect the protection stage (for example, change to the setting of the threshold value or the time delay, blocking of the stage), it is necessary to set it to ***yes***. In this way, the configuration parameters **Affected by function...** as well as the dynamic settings **Threshold**, **Operate delay** and **Stage blocked** of the stage are visible and you can parameterize the specific influence.

Further application and setting notes can be found in the Overcurrent protection, phases and function in section *6.23.8.2 Application and Setting Notes (Advanced Stage)* .

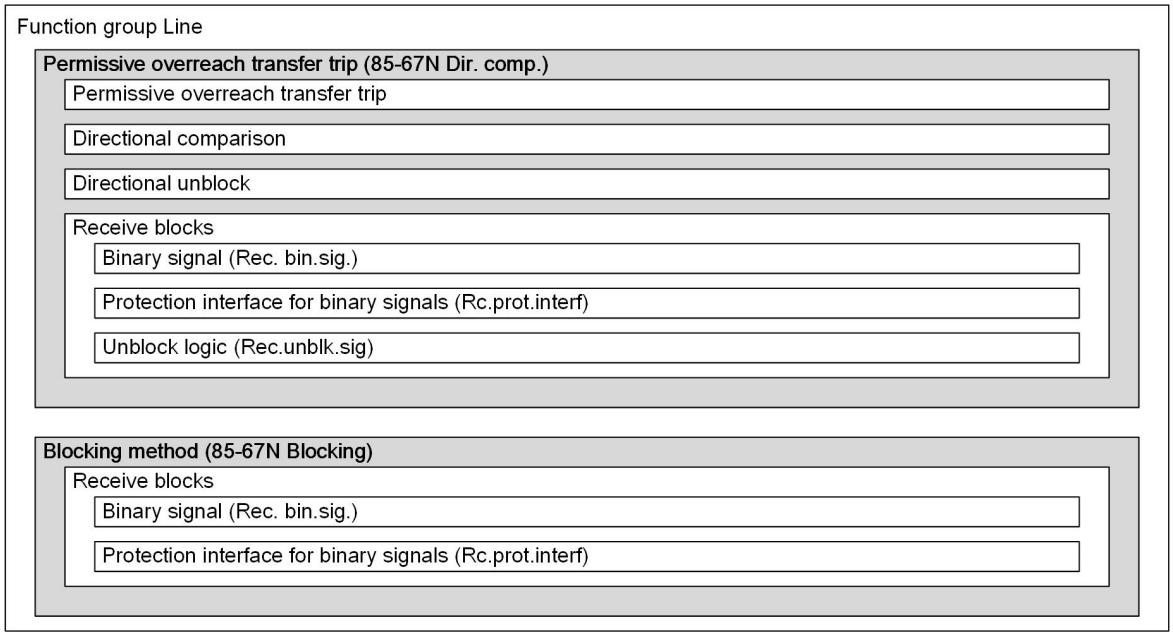
6.10 Teleprotection with Ground-Fault Protection

6.10.1 Overview of Functions

Information is exchanged with the remote station so that the ground-fault protection switches off immediately and selectively on the entire line for all errors. You can implement the teleprotection through reception and transmission contacts or through a digital communication connection.

6.10.2 Structure of the Function

The **Teleprotection schemes** are used in protection function groups with a voltage-measuring point in combination with the Ground-fault protection function. The schemes of the function illustrated in the following figure are available.



[dw_fkt-line_EF_Freigabe-Blockierverfahren, 1, en_US]

Figure 6-209 Structure/Embedding of the Function

Figure 6-210 displays the function control and the function blocks.

The transmission logic analyzes the pickup signals of the ground-fault protection and creates the respective transmission signal for the transmission to the other line end.

The receipt signal from the other line end is coupled either through:

- Binary input (FB **Rec. bin.sig.**)
- Unblock logic (FB **Rec.unblk.sig**)
- Communication (FB **Rec. PI**)

To protect the ends of multi-terminal lines, the function blocks **Rec. bin.sig.** and **Rec.unblk.sig** are available multiple times, once for each removed line end.

The stage parameterized for the teleprotection scheme delivers the pickup information. This pickup information is combined with the reception information for the trip condition. If the trip condition is fulfilled, the teleprotection scheme creates the operate indication.

A trip signal results through the simultaneous presence of a pickup and a release signal.

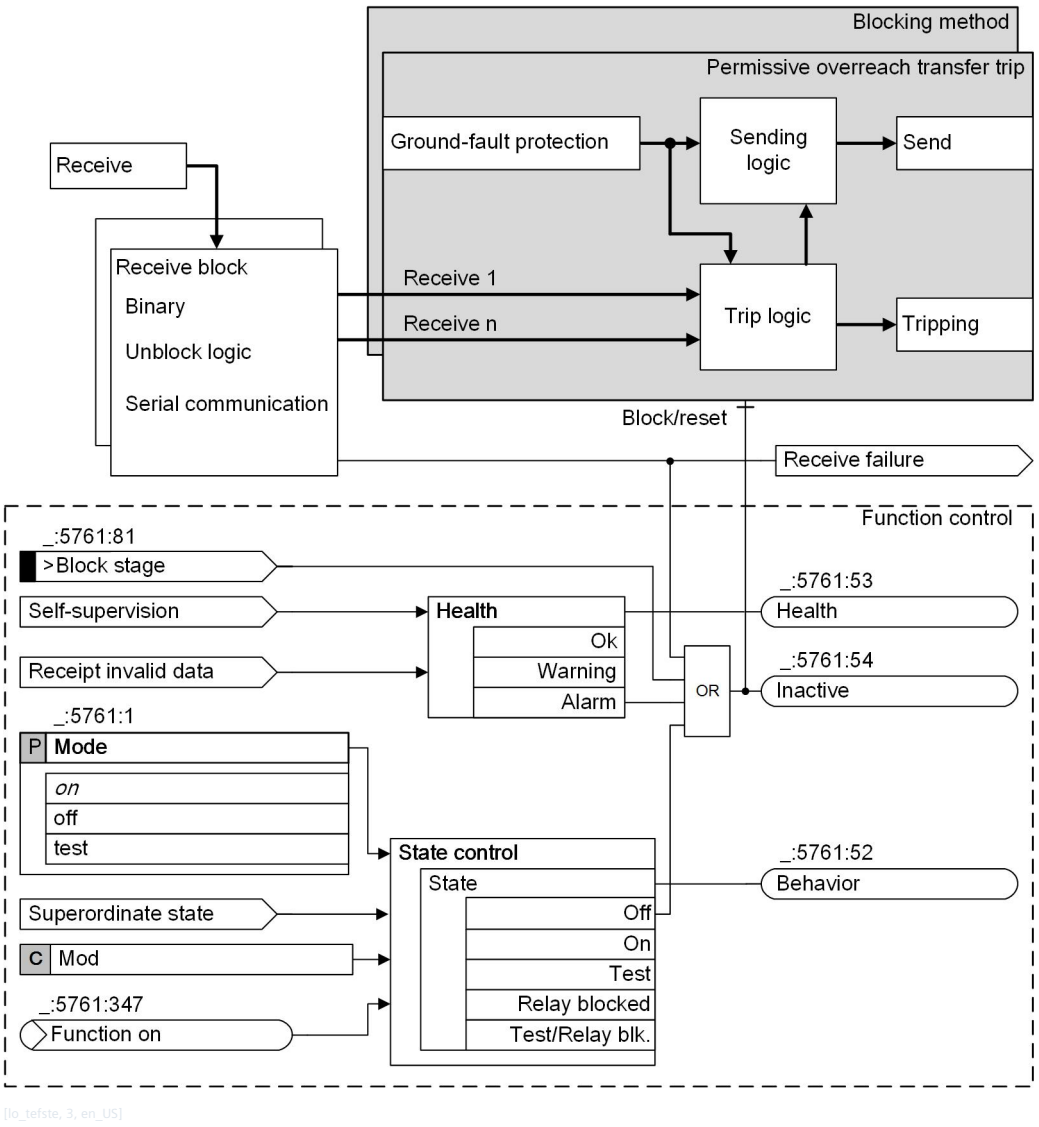


Figure 6-210 Function Blocks and Function Control

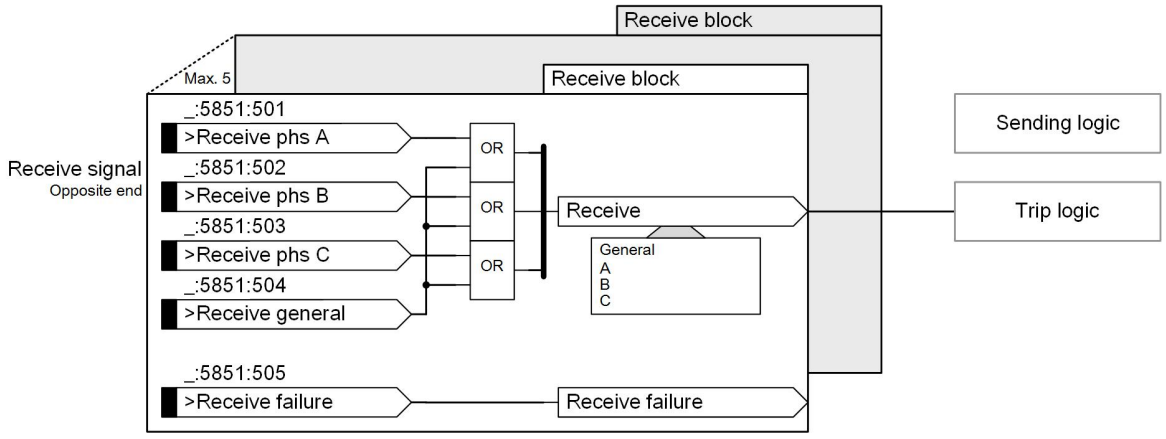
In the following, the individual function blocks for the teleprotection scheme are described. You can find detailed information about function control in *2.3 Function Control*.

6.10.3 Receive Blocks

For the coupling of reception signals from opposite ends, the receive-block types **`Rec. bin.sig.`**, **`Rec.unblk.sig`**, and **`Rec. PI`** are available. The teleprotection schemes described in the following can be operated with the suitable receive blocks as needed.

A mixture between a line end connected through a protection interface and a binary connected line end is not possible.

Binary Receive Block (in DIGSI 5: `Rec. bin.sig.`)



[lotprxbi-100611-01.tif, 2, en_US]

Figure 6-211 Logic Diagram of the Receive Block:`Rec. bin.sig.`

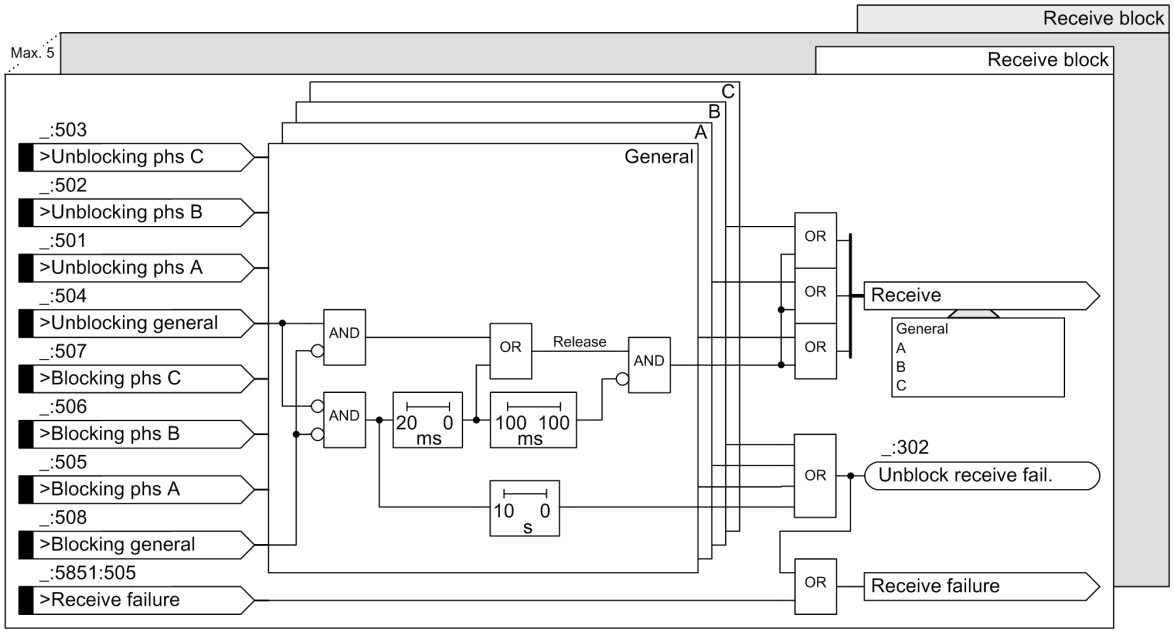
If the communication occurs through binary signals, this reception logic is used. If a teleprotection scheme is configured, for example, with 3 ends in total, 2 function blocks `Rec. bin.sig.` are required.

For applications with 1-pole trip, the selectivity for double ground faults can be improved on parallel lines if 3-phase-selective transmission signals can be transferred per communication direction. The receipt signals can thus be used phase-specifically for A, B, and C or in general as individual signals.

For common-phase teleprotection, the signal **`>Receive general`** is used, for phase-selective teleprotection the 3 signals **`>Receive phs A`**, **`>Receive phs B`**, and **`>Receive phs C`**.

The binary input **`>Receive failure`** affects the status indications of the function control, see *Figure 6-210*.

Receive Block Unblock (in DIGSI 5: `Rec.unblk.sig`)



[lotpsunb-140611-01.tif, 1, en_US]

Figure 6-212 Logic Diagram of the Receive Block: `Rec.unblk.sig`

You can use the teleprotection schemes optionally with the unblocking method. The difference to the conventional binary receipt is that a trip is also then possible if a release signal arrives from the opposite end.

The unblocking method is preferred under the following conditions:

- With long lines
- If the signal is transmitted via PLC (power-line carrier transmission) through the line that is to be protected
- If the attenuation of the transmission signal at the fault location can be so large that the reception from the other line end is not provided

For transmission of the signal, 2 signal frequencies are required, which are sent from the transmission signal of the protection device. If the transmission device has channel monitoring, a monitoring frequency (blocking frequency) can be switched to a working frequency (unblocking frequency). During the idle state or during an external error, the monitoring frequency is transmitted, which signalizes the binary input *>Blocking general* (or during phase-selective teleprotection to the binary inputs *>Blocking phs A*, *>Blocking phs B* and *>Blocking phs C*) of the unblocking logic.

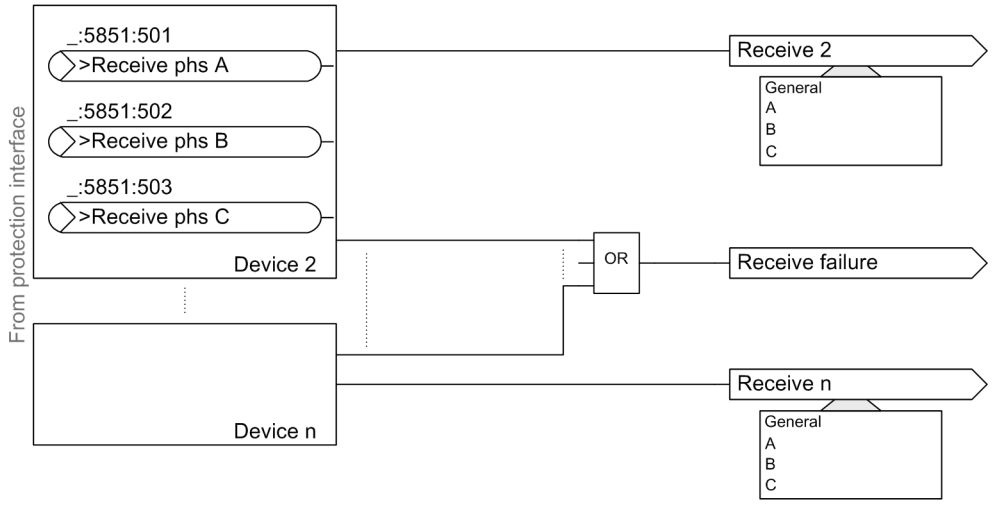
If in the event of a fault due to the transmission signal from the opposite line end the working frequency is received healthy, the receipt signal *>Unblocking general* will appear at the binary input of the unblocking logic. During phase-selective teleprotection, instead of *>Unblocking general* the 3 receive signals *>Unblocking phs A*, *>Unblocking phs B*, and *>Unblocking phs C* are used. Subsequently, the blocking signal *>Blocking general* disappears. During the phase-selective teleprotection, the 3 blocking signals *>Blocking phs A*, *>Blocking phs B*, and *>Blocking phs C* are used. With this, the signal *>Unblocking general* (or the respective signals *>Unblocking phs A*, *>Unblocking phs B*, and *>Unblocking phs C*) are transmitted and the reception of the trip logic of the teleprotection scheme is approved.

A short circuit on the line can cause an attenuation or reflection of the signal and the signal to be transmitted no longer reaches the other line end. In this state both binary inputs *>Unblocking general* and *>Blocking general* are not active. After a time delay of 20 ms, the release is still created and forwarded to the receipt logic. The release is then retracted over the time stage after a further 100 ms.

If the signals continue to receive without disruptions, the release is possible again after a dropout delay of 100 ms.

If the device does not receive any of the signals for 10 s, the indication *Unblock receive fail.* is generated. This indication affects the status indications of the function control, see *Figure 6-210*.

Receive Block Protection Interface (in DIGSI 5: `Rec. PI`)



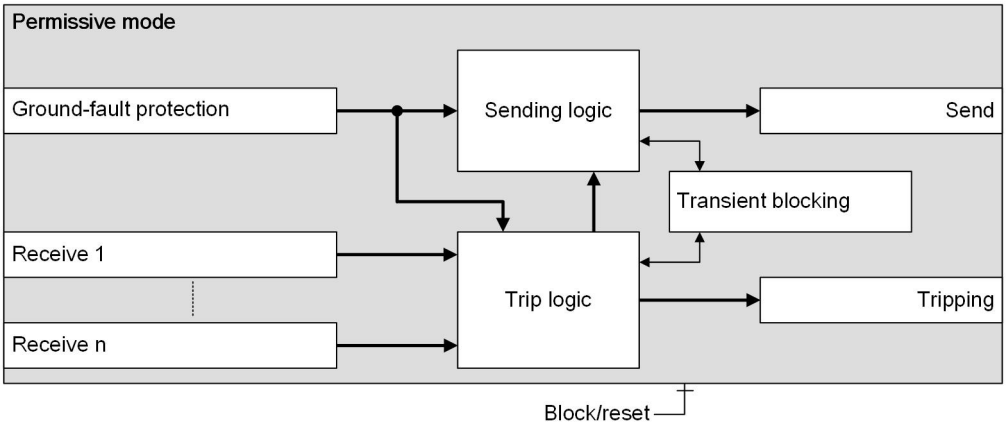
[lotprxws-310511-01.tif, 1, en_US]

Figure 6-213 Logic Diagram of the Receive Block: **`Rec. PI`**

If the communication takes place via a protection interface (digital), this receipt logic is used. Independent of the number of configured devices, only one function block is always **`Rec. PI`** required. The number and the identity of the devices that participate in the teleprotection scheme for protection of the line configuration can be set in the function group **Protection communication** under **System configuration**.

6.10.4 Permissive Overreach Transfer Trip

6.10.4.1 Description

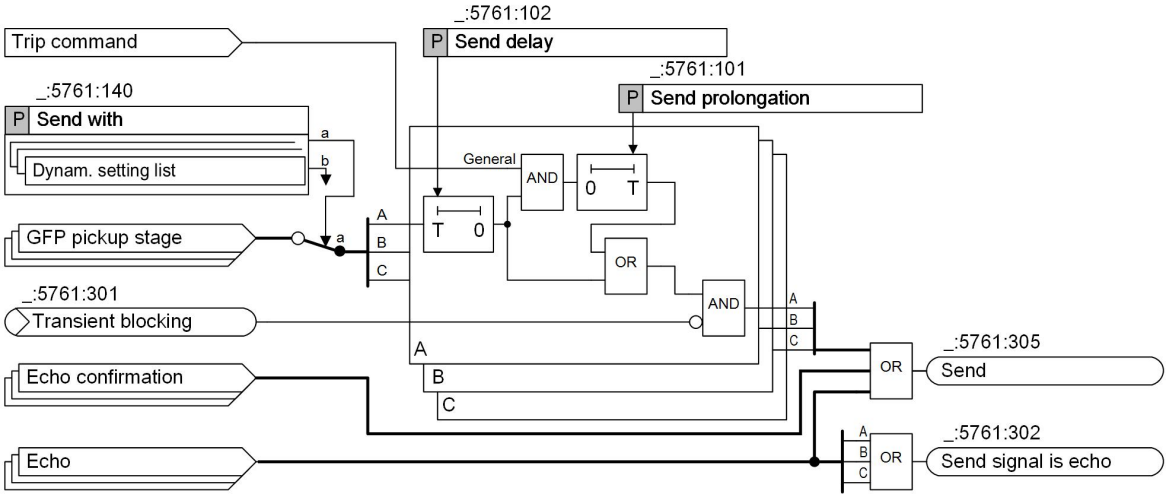


[dwtevgve-100611-01.tif, 2, en_US]

Figure 6-214 Function Block: **85-67N Dir. comp.**

If the ground-fault protection recognizes a fault in a forward direction, a send signal will be sent to the opposite end. If the fault is also recognized in the forward direction, the received signal in the device on the opposite end will lead to an increased trip.

Sending Logic Permissive Mode



[loteseve-310511-01.tif, 3, en_US]

Figure 6-215 Sending Logic for Permissive Mode

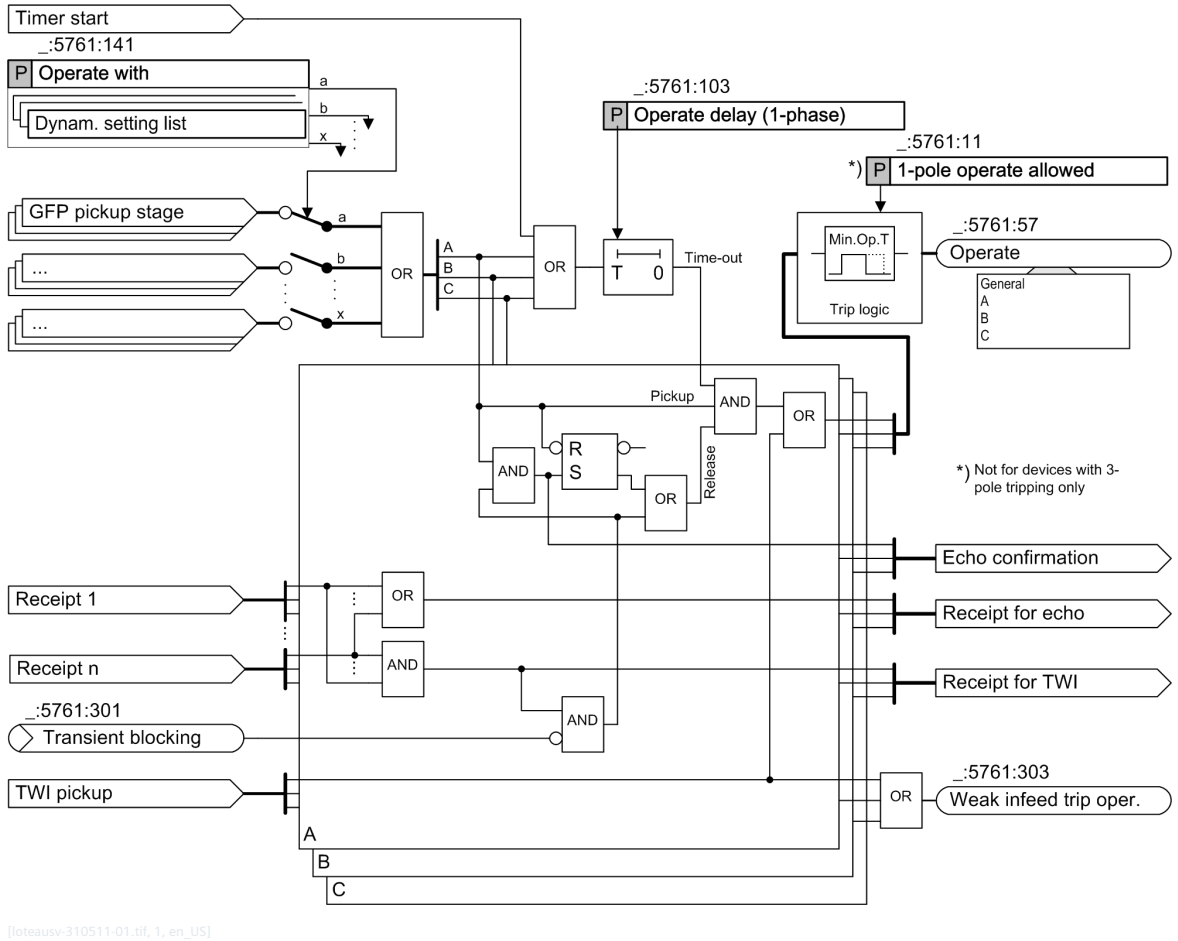
With the parameters **Send with**, you can select which stage of the ground-fault protection affects the send signal. The send condition is fulfilled if the selected stage - or stages - are picked up in a forward direction.
If the protection has already submitted a trip command, the send signal can be prolongated by a set time **(_:5761:101) Send prolongation**. This allows for the release of the other cable end even if the short circuit is very quickly switched off. With this, pickup differences between the cable ends and signal delays can be considered.

If needed, the send signal can be delayed with **(_:5761:102) Send delay**.

The transient blocking (signal *Transient blocking*) provides additional security from fault signals due to transient oscillations caused by a change of direction after disconnection of external faults (for example, on parallel lines). You can find a detailed description in *6.10.6.1 Description*. No send signal is sent in the event of transient blocking.

For applications with 1-pole operate, the selectivity of the permissive mode for double faults can be improved on parallel lines if 3 phase-selective send signals are transmitted per communication direction. Send and reception signals can thus be used phase-specifically for L1, L2 and L3 or phase-jointly as individual signals (general).

Trip Logic Permissive Mode



[loteausv-310511-01.tif, 1, en_US]

Figure 6-216 Trip Logic for Permissive Mode

The ground-fault protection provides the pickup information to the teleprotection scheme. The trip for the affected stage is attended to by that teleprotection scheme with which the ground-fault protection collaborates.

If a reception signal is present, the stage set through the parameter **(_:5761:141) Operate with** will be released for tripping. The trip can be delayed. You can set the time delay under **Send delay**.

With the parameter **(_:5761:11) 1-pole operate allowed**, the tripping logic can allow for 1-pole trip in 1-/3-pole trip devices. This parameter does not apply to devices that only have 3-pole trip.

If the permissive mode for the protection of a line configuration with more than 2 ends is used, the reception signals from all line ends are combined for the operate with AND.

A trip signal results from the simultaneous presence of

- Stage pickup
- Release signal
- Expired time

For applications with delayed trip, a non-recurring receipt signal is only kept until the stage pickup returns. Through this, it is guaranteed that the release signal is also present if the time-out of the corresponding time delay releases the trip and the send signal of the protection of the opposite end is no longer imminent.

The transient blocking (signal *Transient blocking*) prevents the release of the tripping in the permissive mode. It ensures additional security from fault signals due to transient oscillations caused by a change of direction after disconnection of external faults (for example on parallel lines). You can find the detailed description in *6.10.6.1 Description*.

Measures in the Event of Weak Infeed

If no or only a weak infeed is available at a line end, the protection does not pick up the phase information or it does so incorrectly. With this, neither a trip command nor a send signal can be sent. With the permissive mode, the line end cannot be tripped quickly with increased infeed because no release signal is transferred from the end with the weak infeed.

In order to allow for a quick disconnection on both cable ends in such cases, the teleprotection schemes have special measures:

- For the trip of the cable end with a strong infeed, the echo function can be made effective with a weak infeed.
- In order for the cable end to also be tripped with a weak infeed, the teleprotection schemes have a function for trip with weak infeed.

The functions are described in detail in the chapter **Echo and Tripping in the event of weak infeed**.

6.10.4.2 Application and Setting Notes for the Trip Logic of the Permissive Mode

The various permissive modes can be implemented by using both parameters **Send with** and **Operate with** . Additionally, you must observe the selection of the reception block.

The following methods can be ordered:

Methods	Parameter: Send with	Parameter: Operate with
85-67N Dir. comp.	One or multiple stages	One or multiple stages
Ground-fault unblock procedure (Rec.unblk.sig as a reception block)	One or multiple stages	One or multiple stages

Parameter: Send prolongation

- Recommended setting value **(_:5761:101) Send prolongation** = ***0.05 s***

With the parameter **Send prolongation** in the transmission logic, you can compare the differences in the pickup times for both line ends. If SIPROTEC devices are used on all line ends, Siemens recommends the setting value ***0.05 s***.

Parameter: Send delay

- Recommended setting value **(_:5761:102) Send delay** = ***0.00 s***

With the parameter **Send delay**, you can set an additional tripping delay. Since the teleprotection scheme should lead to rapid and selective tripping, Siemens recommends the setting value ***0.00 s***.

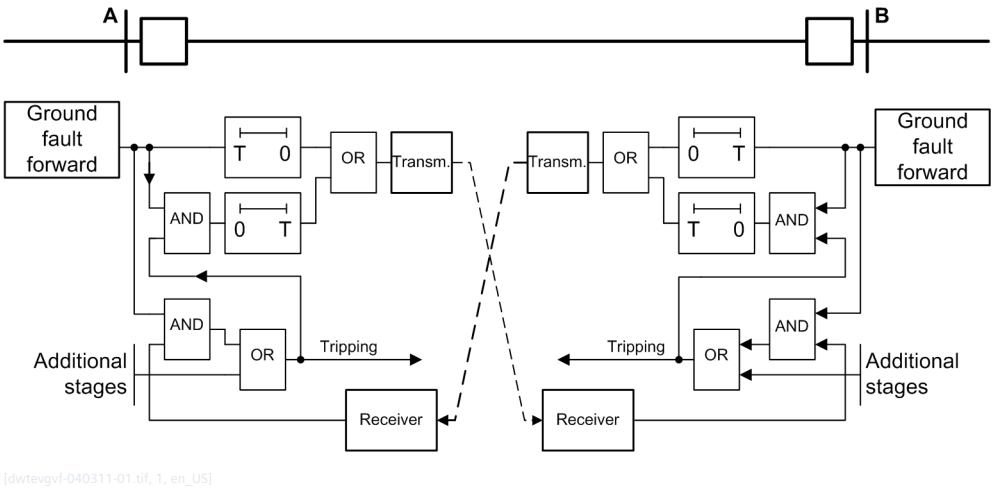
Parameter: 1-pole operate allowed

- Recommended setting value **(_:5761:11) 1-pole operate allowed** = ***yes***

With the parameter **1-pole operate allowed**, you allow 1-pole tripping of the teleprotection scheme for 1-phase faults or multi-phase faults and 1-phase reception. In devices with 1-pole tripping, Siemens recommends the setting ***yes***. In devices with 3-pole trip, this parameter does not apply.

6.10.4.3 Application and Setting Notes for the Permissive Scheme

If the ground-fault protection recognizes an error in the cable direction after a pickup, it will transmit a release signal to the opposite end. If the opposite end receives the release signal and also recognizes a fault in the cable direction, the trip signal is created.



[dwtevgvf-040311-01.tif, 1, en_US]

Figure 6-217 Function Scheme of the Permissive Scheme

With the following settings, you can configure the permissive schemes:

Parameter: `Send with`

- Recommended setting value **`(_:5761:140) Send with`** = ***`ground-fault stage`***

With the parameter **`Send with`**, you select one or multiple stages of the ground-fault protection as transmission criteria. The selection texts of the stages are identical with the labels that you assign to them in the ground-fault protection.

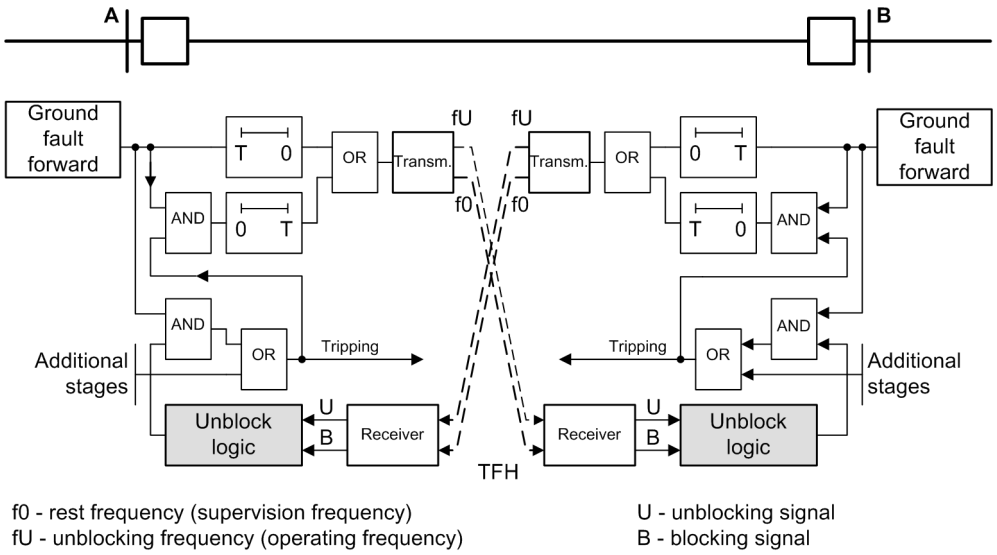
Parameter: `(_:5761:141) Operate with`

- Recommended setting value **`(_:5761:141) Operate with`** = ***`ground-fault stage`***

With the parameter **`Operate with`**, you select the stage or the stages of the ground-fault protection that leads to tripping during signal reception. The selection texts of the stages are identical with the labels that you assign to them in the ground-fault protection.

6.10.4.4 Application and Setting Notes for the Directional-Unblocking Method

The directional-unblocking method corresponds with the permissive scheme with a preset function block **`Rec.unblk.sig`**. Thus, unlike the permissive scheme, tripping is also possible without a permissive signal from the opposite end. The directional-unblocking method cannot be operated with a communication through a protection interface (WS) due to its function.



[dwteublv-040311-01.tif, 1, en_US]

Figure 6-218 Function Scheme of the Directional-Unblocking Method

With the following settings, you can configure the directional-unblocking method:

Parameter: `Send with`

- Recommended setting value **`(_:5761:140) Send with`** = ***`ground-fault stage`***

With the parameter **`Send with`**, you select one or multiple stages of the ground-fault protection as transmission criteria. The selection texts of the stages are identical with the labels that you assign to them in the ground-fault protection.

Parameter: `Operate with`

- Recommended setting value **`(_:5761:141) Operate with`** = ***`ground-fault stage`***

With the parameter **`Operate with`**, you select the stage or the stages of the ground-fault protection that leads to an operate during signal reception. The selection texts of the stages are identical with the labels that you assign to them in the ground-fault protection.

6.10.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
85-67N Dir.com				
_:5761:1	85-67N Dir.com:Mode		• off • on • test	on
_:5761:101	85-67N Dir.com:Send prolongation		0.00 s to 60.00 s	0.05 s
_:5761:102	85-67N Dir.com:Send delay		0.00 s to 60.00 s	0.00 s
_:5761:105	85-67N Dir.com:Trans. blk. pickup delay		0.00 s to 60.00 s	0.04 s
_:5761:106	85-67N Dir.com:Trans. blk. dropout delay		0.00 s to 60.00 s	0.05 s
_:5761:104	85-67N Dir.com:3I0 threshold rev./forw.		0 % to 100 %	75 %
_:5761:11	85-67N Dir.com:1-pole operate allowed		• no • yes	yes

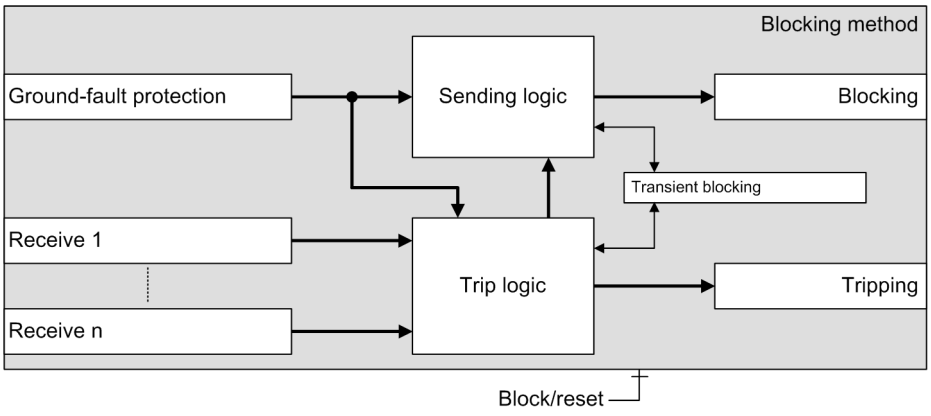
Addr.	Parameter	C	Setting Options	Default Setting
_:5761:103	85-67N Dir.com:Operate delay (1-phase)		0.00 s to 60.00 s	0.00 s
_:5761:140	85-67N Dir.com:Send with		Setting options depend on configuration	
_:5761:141	85-67N Dir.com:Operate with		Setting options depend on configuration	
_:5761:142	85-67N Dir.com:Trans. block. with		Setting options depend on configuration	

6.10.4.6 Information List

No.	Information	Data Class (Type)	Type
85-67N Dir.com			
_:5761:81	85-67N Dir.com:>Block stage	SPS	I
_:5761:501	85-67N Dir.com:>Blocking echo	SPS	I
_:5761:502	85-67N Dir.com:>Blk. weak infeed trip	SPS	I
_:5761:54	85-67N Dir.com:Inactive	SPS	O
_:5761:52	85-67N Dir.com:Behavior	ENS	O
_:5761:53	85-67N Dir.com:Health	ENS	O
_:5761:305	85-67N Dir.com:Send	ACT	O
_:5761:302	85-67N Dir.com:Send signal is echo	SPS	O
_:5761:303	85-67N Dir.com:Weak infeed trip oper.	SPS	O
_:5761:301	85-67N Dir.com:Transient blocking	SPS	O
_:5761:308	85-67N Dir.com:Pickup 3I0	ACD	O
_:5761:56	85-67N Dir.com:Operate delay expired	ACT	O
_:5761:57	85-67N Dir.com:Operate	ACT	O
_:5761:347	85-67N Dir.com:Function on	SPC	C
Rec. bin.sig.1			
_:5851:52	Rec. bin.sig.1:Behavior	ENS	O
_:5851:53	Rec. bin.sig.1:Health	ENS	O
_:5851:501	Rec. bin.sig.1:>Receive phs A	SPS	I
_:5851:502	Rec. bin.sig.1:>Receive phs B	SPS	I
_:5851:503	Rec. bin.sig.1:>Receive phs C	SPS	I
_:5851:504	Rec. bin.sig.1:>Receive general	SPS	I
_:5851:505	Rec. bin.sig.1:>Receive failure	SPS	I

6.10.5 Blocking Method

6.10.5.1 Description

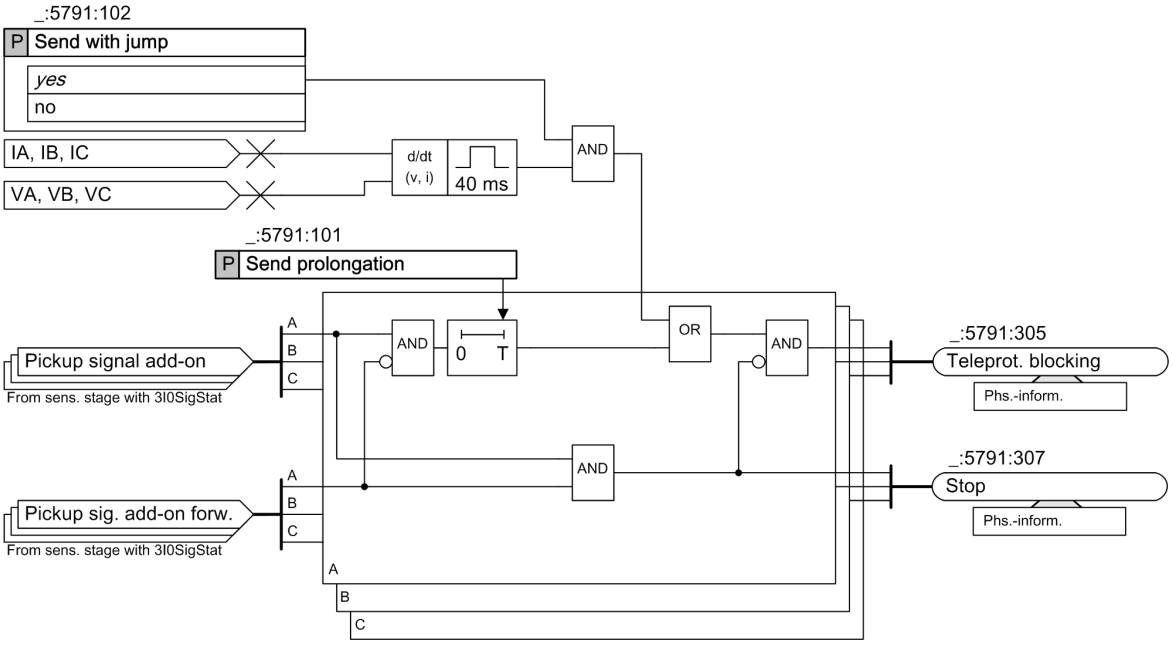


[dwtefblo-100611-01.tif, 1, en_US]

Figure 6-219 Function Block: **85-67N Block.**

If the protection function recognizes a ground fault in the backward direction, the blocking signal is sent to the opposite end (signal **Blocking**). If the protection device does not receive a blocking signal at the receiving line end, it generates the trip signal after a short time delay.

Sending Logic Blocking Method



[lotesblk-040311-01.tif, 1, en_US]

Figure 6-220 Sending Logic for the Blocking Method

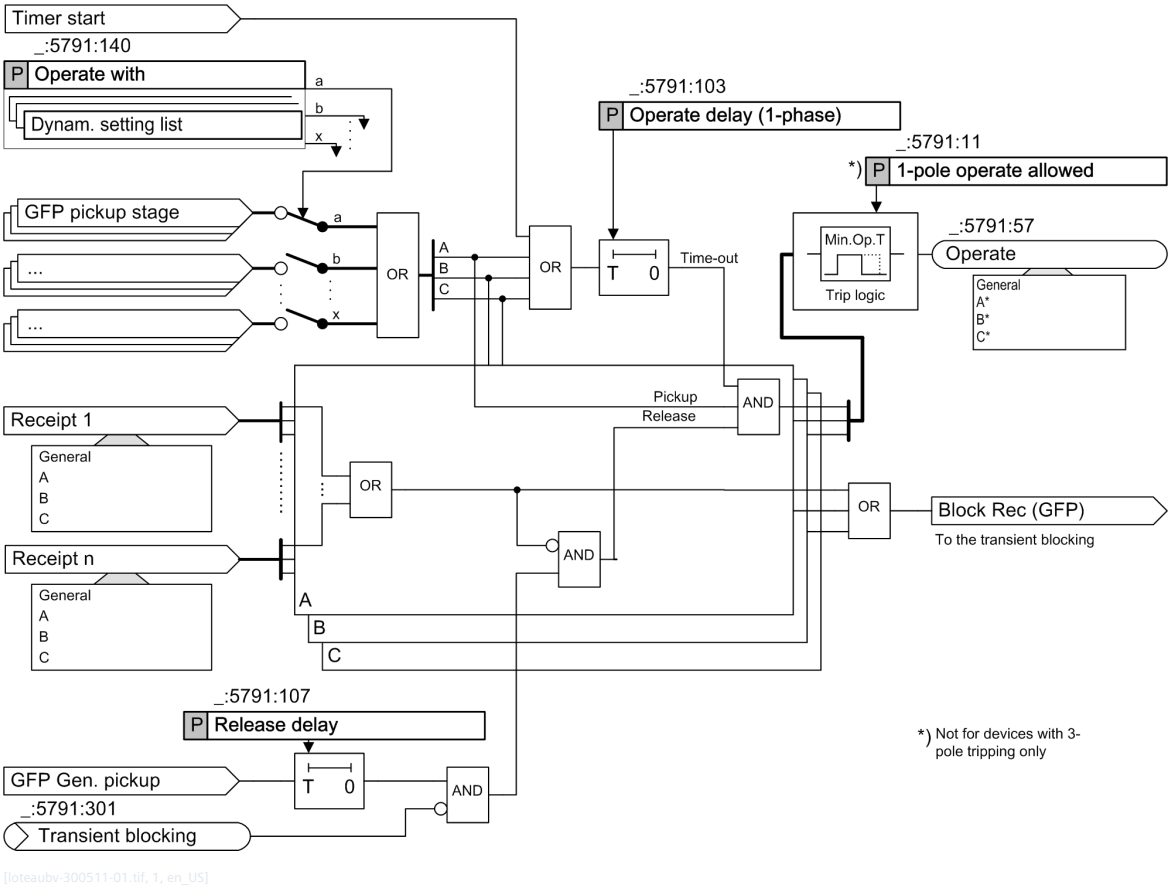
The blocking signal is created in the event of pickup of the ground-fault protection in the **backward** or **non-directional** direction. The threshold value for creation of the blocking signal is the percentage of the threshold value of the level that affects tripping in the blocking procedure. The percentage is set with the parameter **(_:5761:104) 3I0 threshold rev./forw.** in the teleprotection scheme. For further information, refer to *6.10.7.1 Description*.

The logic is designed in a phase-selective manner. With the parameter **(_:5791:101) Send prolongation**, you can extend the blocking signal. Even if the error has already been cleared up locally, the opposite end can continue to be blocked through this.

The blocking signal can also be sent immediately with jump detection (parameter **(_:5791:102) Send with jump**). If the communication channel can react very quickly to the absence of the blocking signal, you can use this jump signal, because the jump signal appears for every jump in the dimensions. If the ground-fault protection detects an error in the forward direction, the blocking signal is immediately stopped and the indication *Stop* is created.

For applications with 1-pole trip, the selectiveness of the blocking method for double faults can be improved on parallel lines if 3 phase-selective transmission signals are transferred per communication direction. Transmission and reception signals can therefore be used phase-specifically for A, B, and C or phase-jointly as individual signals.

Trip Logic Blocking Method



[loteaubv-300511-01.tif, 1, en_US]

Figure 6-221 Trip Logic for the Blocking Method

The ground-fault protection provides the pickup information to the teleprotection scheme. The trip for the affected stage is attended to by that teleprotection scheme with which the ground-fault protection collaborates.

If a reception signal is present, the zone set through the parameter **(_:5791:140) Operate with** will be released for tripping. The trip of the blocking method must be delayed due to possible differences in the pickup times of the devices at both cable ends and because of the transmission time. You can set the time delay with the parameter **(_:5791:107) Release delay**.

The tripping can be delayed. You can set the time delay under **(_:5761:102) Send delay**.

The operate indication results for the simultaneous presence

- of the stage pickup of the ground-fault protection
- of the internal release signal
- of the time expirations

No release of the trip occurs for an upcoming reception signal. In order to make sure that the pickup of the selected stage(s) does not switch the exterior errors on the opposite end, the trip is blocked for upcoming reception signals.

If the blocking method for the protection of a line configuration with more than 2 ends is used, the reception signals from all cable ends are combined with OR.

With the parameter **(_:5791:11) 1-pole operate allowed**, the trip logic can allow for 1-pole trip in 1-/3-pole trip devices. This parameter does not apply to devices that only have 3-pole trip.

Measures in the Event of Weak Infeed

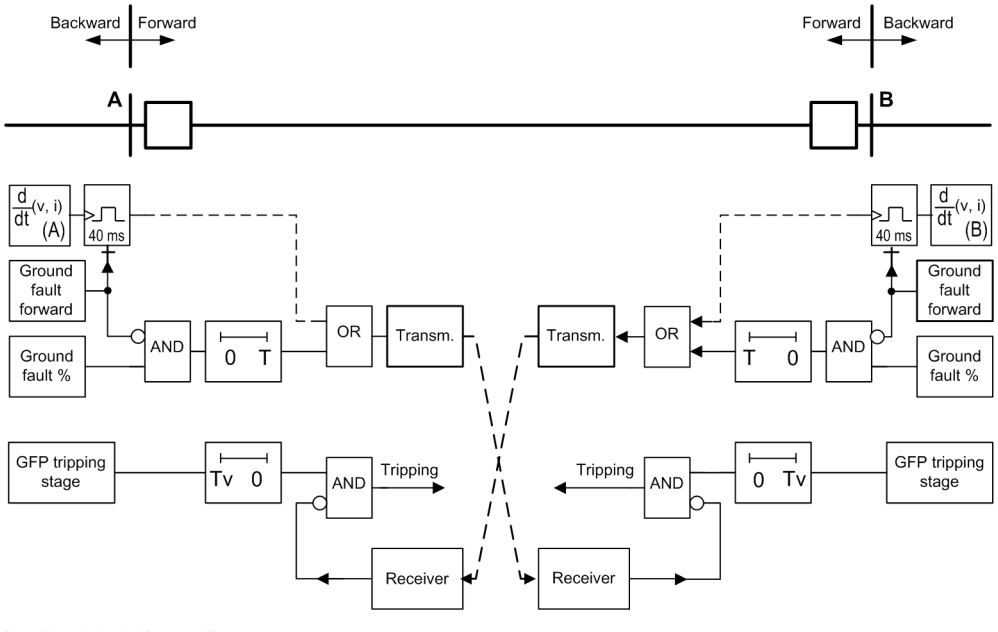
For the blocking procedure, there is not possibility, depending on the procedure, to achieve a trip command release through the opposite end with a weak infeed. The advantage of the blocking procedure is instead that there can be a trip on the infeed end without a release, because the end not being fed in cannot form a blocking signal.

6.10.5.2 Application and Setting Notes for the Blocking Method

The blocking method is often used:

- If the signal is transmitted with TFH through the protected line and if the attenuation of the transmission signal at the fault location is so large that the reception from the other cable end cannot be guaranteed.
- For the protection of line configurations with more than 2 ends with different infeed

If the ground-fault protection recognizes an error in a backward direction, a blocking signal is transmitted. If the other cable end does not receive a blocking signal, the ground-fault protection trips in a forward direction in the case of a ground-fault current. Since no release signal is required by the opposite end, single infeed short circuits are quickly switched off with the blocking method.



[dwteblve-140611-01.tif, 1, en_US]

Figure 6-222 Function Scheme of the Blocking Method

Parameter: Send with jump

- Recommended setting value **(_:5791:102) Send with jump** = ***Yes***

With the parameter **Send with jump**, you can set if the blocking signal is sent without delay with the jump detection. Siemens recommends using the fast blocking with jump and retaining the setting.

Parameter: Send prolongation

- Recommended setting value **(_:5791:101) Send prolongation** = ***0.05 s***

With the settings **T SENDEVERL.** in the transmission logic, you can compare the differences in the pickup times for both cable ends. If SIPROTEC devices are used on all cable ends, Siemens recommends the setting value ***0.05 s***.

Parameter: Operate with

- Recommended setting value **(_:5791:140) Operate with** = ***ground-fault stage***

With the parameter **Operate with**, you can select the ground-fault stage.

Parameter: Release delay

- Recommended setting value **(_:5791:107) Release delay** = ***0.020 s***

With the parameter **Release delay**, you must set the release delay after a pickup. The trip of the blocking method must be delayed due to possible differences in the pickup times of the devices at both cable ends and because of the transmission time. Siemens recommends a setting of ***0.020 s***.

6.10.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
85-67N Block.				
_:5791:1	85-67N Block.:Mode		• off • on • test	on
_:5791:101	85-67N Block.:Send prolongation		0.00 s to 60.00 s	0.05 s
_:5791:102	85-67N Block.:Send with jump		• no • yes	yes
_:5791:108	85-67N Block.:Send phase segregated		• no • yes	no
_:5791:105	85-67N Block.:Trans. blk. pickup delay		0.00 s to 60.00 s	0.02 s
_:5791:106	85-67N Block.:Trans. blk. dropout delay		0.00 s to 60.00 s	0.05 s
_:5791:107	85-67N Block.:Release delay		0.000 s to 60.000 s	0.020 s
_:5791:104	85-67N Block.:3I0 threshold rev./forw.		0 % to 100 %	75 %
_:5791:11	85-67N Block.:1-pole operate allowed		• no • yes	yes
_:5791:103	85-67N Block.:Operate delay (1-phase)		0.00 s to 60.00 s	0.00 s
_:5791:140	85-67N Block.:Operate with		Setting options depend on configuration	
_:5791:141	85-67N Block.:Trans. block. with		Setting options depend on configuration	

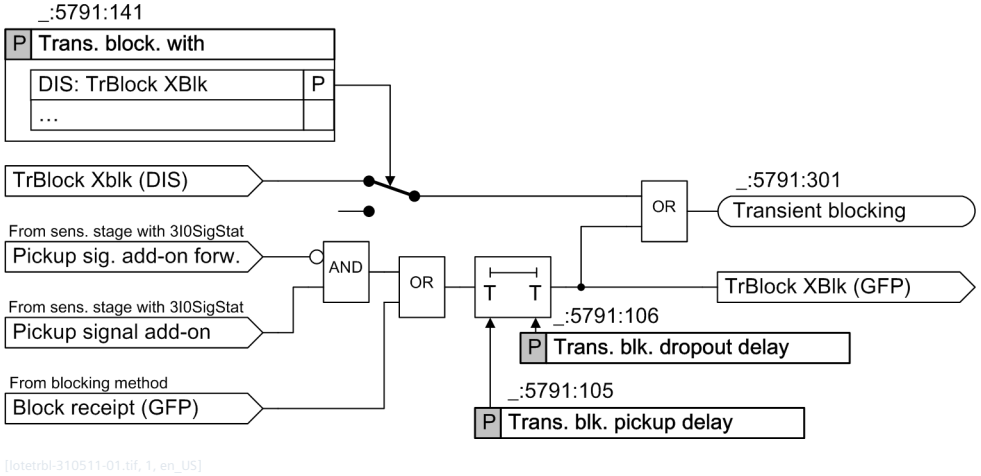
6.10.5.4 Information List

No.	Information	Data Class (Type)	Type
85-67N Block.			
_:5791:81	85-67N Block.:>Block stage	SPS	I
_:5791:54	85-67N Block.:Inactive	SPS	O
_:5791:52	85-67N Block.:Behavior	ENS	O
_:5791:53	85-67N Block.:Health	ENS	O
_:5791:305	85-67N Block.:Teleprot. blocking	ACT	O
_:5791:307	85-67N Block.:Stop	ACT	O
_:5791:301	85-67N Block.:Transient blocking	SPS	O
_:5791:308	85-67N Block.:Pickup 3I0	ACD	O
_:5791:56	85-67N Block.:Operate delay expired	ACT	O
_:5791:57	85-67N Block.:Operate	ACT	O
Rec. bin.sig.1			
_:5851:52	Rec. bin.sig.1:Behavior	ENS	O
_:5851:53	Rec. bin.sig.1:Health	ENS	O
_:5851:501	Rec. bin.sig.1:>Receive phs A	SPS	I
_:5851:502	Rec. bin.sig.1:>Receive phs B	SPS	I
_:5851:503	Rec. bin.sig.1:>Receive phs C	SPS	I
_:5851:504	Rec. bin.sig.1:>Receive general	SPS	I
_:5851:505	Rec. bin.sig.1:>Receive failure	SPS	I

6.10.6 Transient Blocking

6.10.6.1 Description

The transient blocking provides additional security from fault signals due to transient oscillations caused by a change of direction after disconnection of external faults (for example on parallel lines).



[lotetrbl-310511-01.tif, 1, en_US]

Figure 6-223 Logic Diagram of the Transient Blocking

If a pickup in the reverse direction or non-directionally is present (non-forward fault), the transient blocking occurs after a waiting period (**(_:5791:105) Trans. blk. pickup delay**). After the omission of the blocking criteria, the transient blocking will be maintained for a set time (**(_:5791:106) Trans. blk. dropout delay**).

6.10.6.2 Application and Setting Notes for Transient Blocking

Parameter: `Trans. block. with`

- Default setting **`(_:5791:141) Trans. block. with`** = ***`DIS: TrBlock XBlk`***

Set the parameter **`Trans. block. with`** to ***`DIS: TrBlock XBlk`***, if the teleprotection scheme for distance protection works on the same communication channel as a teleprotection scheme for the ground-fault protection. Set the parameter to ***`invalid`*** if you are using separate communication channels. If no teleprotection scheme for distance protection is used, parameter setting will not be possible and the link will be automatically deactivated.

Parameter: `Trans. blk. pickup delay`

- Recommended setting value **`(_:5791:105) Trans. blk. pickup delay`** = ***`0.04 s`***

With the parameter **`Trans. blk. pickup delay`**, you set how long a reverse or non-directional pickup should remain before the transient blocking occurs. Siemens recommends a setting of ***`0.04 s`***.

NOTE

The time **`Trans. blk. pickup delay`** may not be set to 0. This makes sure that the transient-blocking time **`Trans. blk. dropout delay`** is not already started if the directional information comes in a delayed manner compared to the function pickup. Depending on the time of the circuit breaker on the parallel line or the circuit breaker lying in a reverse direction, settings between 10 ms and 40 ms are recommended.

Parameter: `Trans. blk. dropout delay`

- Recommended setting value **`(_:5791:106) Trans. blk. dropout delay`** = ***`0.05 s`***

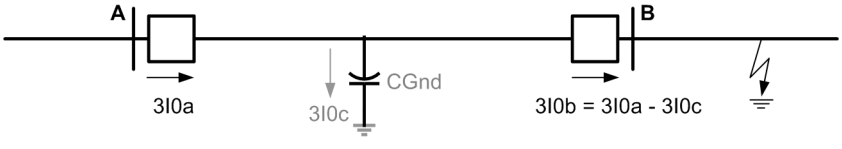
With the parameter **`Trans. blk. dropout delay`**, you determine the duration of the transient blocking. The time must be set longer than the duration of the transient compensation methods for the occurrence or switching of exterior short circuits.

6.10.7 Sensitive Measuring Stage of Ground-Fault Protection

6.10.7.1 Description

In order to avoid a faulty echo during permissive schemes, it must be ensured that an external ground fault with a flowing ground-fault current is detected at both line ends. During the blocking method and for the transient blocking, a secure blocking signal must be created under these conditions.

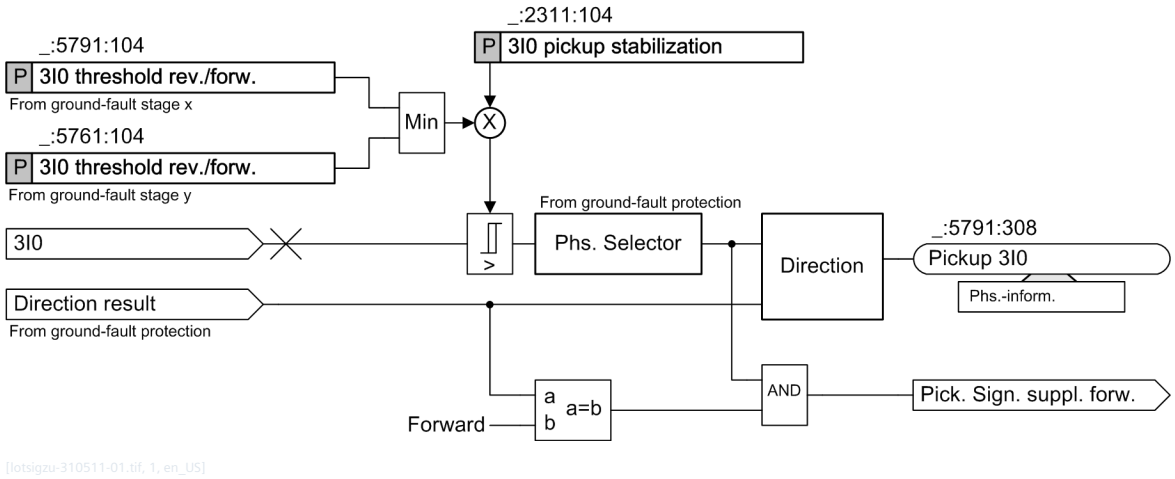
If the error is not detected in a ground fault in accordance with *Figure 6-224* the protection in B, this would be interpreted as an error fed-in from A. With permissive schemes, protection B would send an echo signal. For the blocking procedure and for the transient blocking, the required blocking signal would not be created. The consequence would be a faulty trip of the ground-fault protection in A.



[dwt3i0v1-040311-01.tif, 1, en_US]

Figure 6-224 Possible Current Distribution with an External Ground-Fault

The teleprotection scheme with ground-fault protection therefore has a sensitive ground-current stage **`(_:5791:104) 3I0 threshold rev./forw.`**.



[lotsigzu-310511-01.tif, 1, en_US]

Figure 6-225 Logic of the Sensitive Ground-Fault Protection

With the permissive scheme, the sensitive ground-current stage has an effect on the echo function and the transient blocking. If the stage for the recognition of a backward fault in B is always more sensitive than the stage pickup of the ground-fault protection, which sees an error from the other line end A in a forward direction, no fault echo signal can result and the transient blocking will also work correctly.

With the blocking method, the sensitive ground-current stage is the threshold from which the blocking signal is created if there are reverse errors. For this application, it also applies that the recognition of a reverse error in B must be more sensitive than the stage pickup of the ground-fault protection, which sees the error from the other cable end A in a forward direction. Thus, the blocking signal sent from B leads to the required blocking of the trip ground-current stage on the cable end A.

The setting value for the sensitive ground-current stage is a percent value. For permissive schemes, it automatically relates to the threshold value of the stage or the stages of the ground-fault protection, which are connected with the permissive scheme via the parameter **Send with**.

During the blocking method, the percentage setting value automatically relates to the stage or stages of the ground-fault protection, which are connected with the blocking method via the parameter **Operate with**.

6.10.7.2 Application and Setting Notes for the Sensitive Stage of the Ground-Fault Protection

Parameter: 3I0 threshold rev./forw.

- Default setting **(_:5761:104) 3I0 threshold rev./forw.** and **(_:5791:104) 3I0 threshold rev./forw.** = *75%*

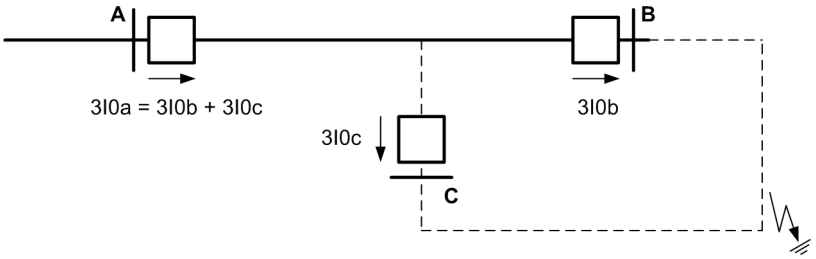
With the parameter **3I0 threshold rev./forw.**, you can set the threshold value for the ground-fault signal addition stage in a ratio to the thresholds of the ground-fault stages selected under **Send with**

The sensitive stage of the ground-fault protection must be more sensitive than the ground-current stage that works with the transmission or trip stage in order for the teleprotection method to function correctly. The sensitive stage must be set in a more sensitive manner depending on the size of the capacitive ground current (3I0c in *Figure 6-224*). Normally, 70 % to 80 % of the setting for the ground-current stage is adequate for overhead lines. Siemens recommends the setting of 75 % for this application.

For cables or very long overhead lines, if the capacitive currents in the event of a ground fault have the same dimensions as the ground-fault currents, the echo function should be avoided or it should only be used for open circuit-breakers; the blocking procedure should then not be used at all.

For lines with 3 ends (feeder), it must be considered that the ground-fault current is unevenly distributed over the ends of the line in the event of an external ground fault. The critical case is illustrated in *Figure 6-226*. In the least favorable case, the ground current flowing from A divides itself half and half over line ends B and C. The setting value **3I0 threshold rev./forw.** significant for the echo or the blocking signal, must therefore be below half of the response value of the ground-current stage used for signal transmission. Additionally, the considerations described above apply with regard to the capacitive ground current, which is not dealt with in *Figure 6-226*. The conditions are more convenient for a ground-current distribution different

than assumed here, because then one of the 2 ground currents 3I0b or 3I0c must be greater than in the previous consideration.



[dwt3i0v2-040311-01.tif, 1, en_US]

Figure 6-226 Possible Inconvenient Current Distribution through a Teed Feeder in the Event of an External Ground Fault

6.11 Directional Intermittent Ground-Fault Protection

6.11.1 Overview of Functions

The function **Directional intermittent ground-fault protection**:

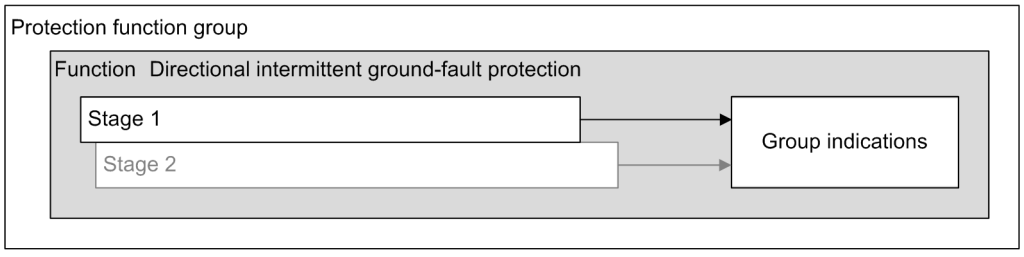
- Detects the intermittent ground faults in grounded, compensated, or isolated cable systems selectively
- Can be operated in 2 different modes:
  - Operate only by counting directional ground-current pulses
  - Operate by integration of the fault current in combination with a directional criterion by counting directional ground-current pulses

The intermittent ground faults in cable systems are frequently caused by weak insulation or water ingress in cable joints. The ground faults are characterized by the following properties:

- Intermittent ground faults show very short high ground-current pulses (up to several hundred amperes) with a duration of less than 1 ms.
- Intermittent ground faults are self-extinguishing and reignite within one half period up to several periods, depending on the power-system conditions and the fault type.
- Intermittent ground faults can persist over longer periods (several seconds to minutes) and develop to static ground faults.

6.11.2 Structure of the Function

The function **Directional intermittent ground-fault protection** can be used in protection function groups with current and voltage measurement. The function is preconfigured by the manufacturer with 1 stage, and a maximum of 2 stages can be operated simultaneously.

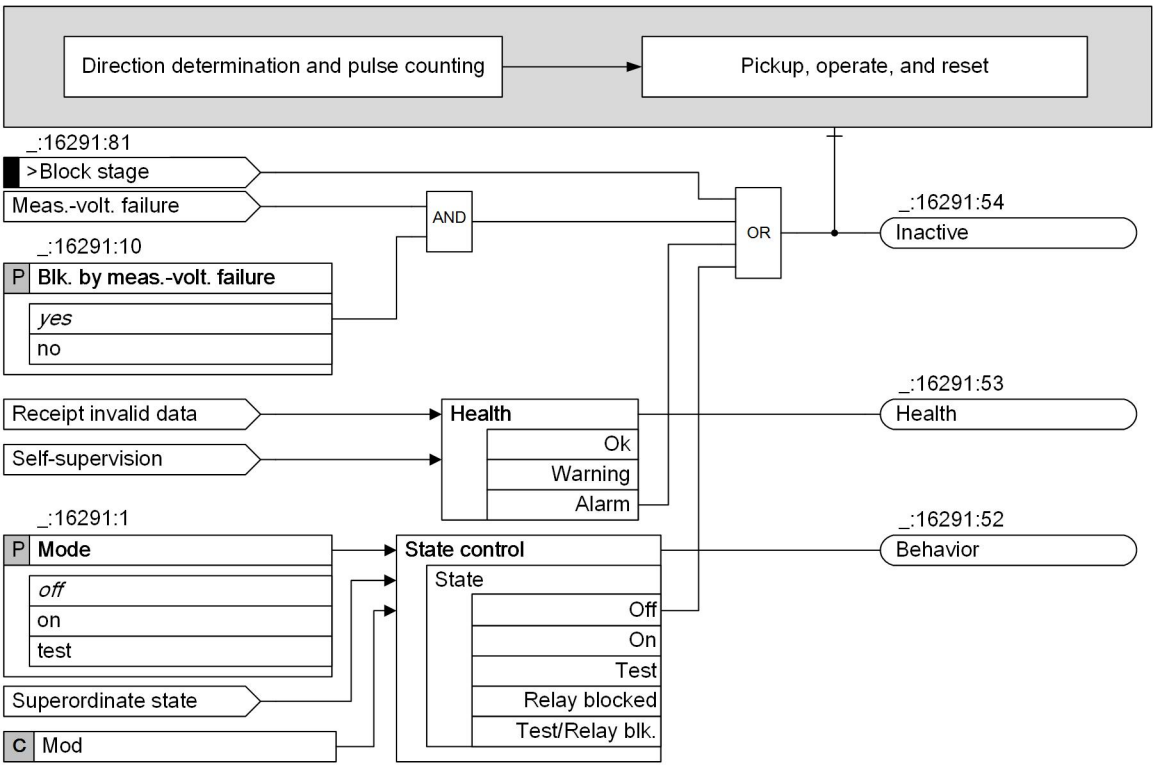


[dw_structure_dirl_GFP, 1, en_US]

Figure 6-227 Structure/Embedding of the Function

6.11.3 Stage Description

Overview



[lo_overview, 2, en_US]

Figure 6-228 Logic of the Directional Intermittent Ground-Fault Protection

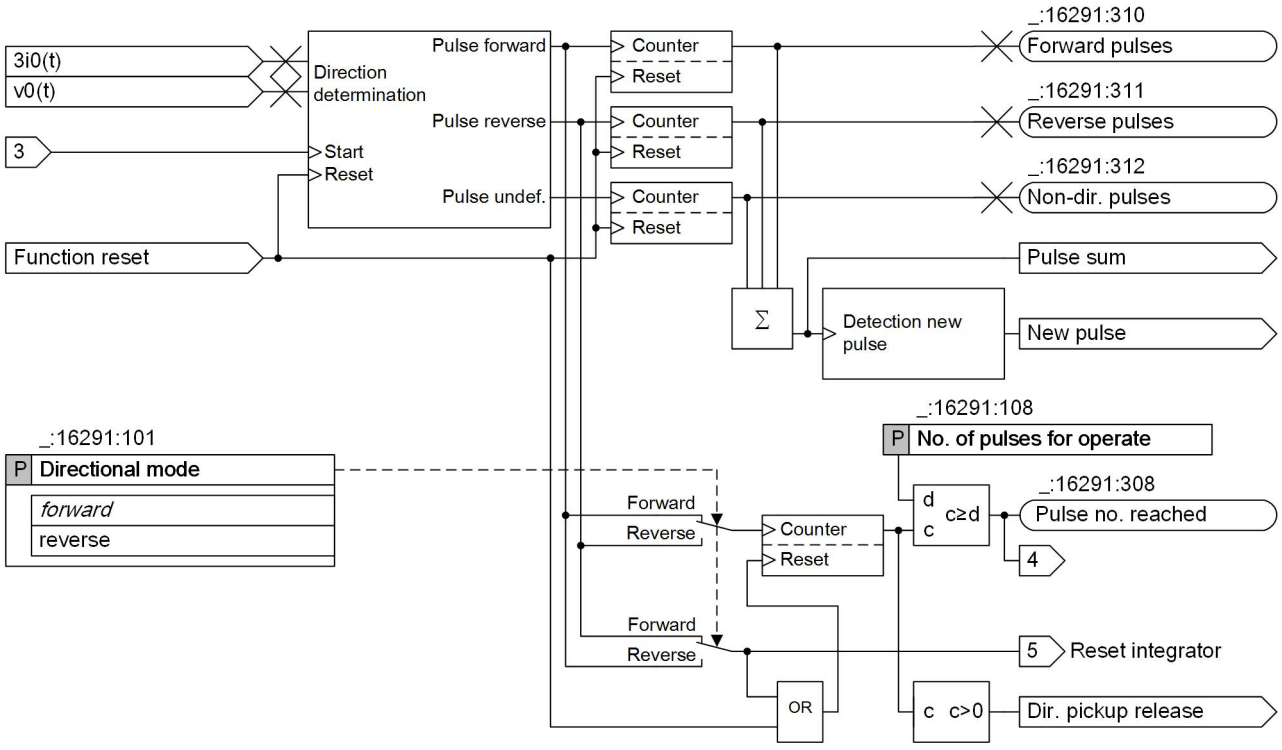
Blocking of the Stage with Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From an internal source upon pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **`Volt.-transf. c. b.`**, which links in the tripping of the voltage-transformer circuit breaker

The **`Blk. by meas.-volt. failure`** parameter can be set so that the measuring-voltage failure detection blocks the stage or does not block it.

Logic for Direction Determination and Pulse Counting



[lo_int_dir1, 3, en_US]

Figure 6-229 Logic Diagram of Direction Determination and Pulse Counting

(1) The input signal 3 is from *Figure 6-230*.

Measurement Values for Direction Determination

The function **Directional intermittent ground-fault protection** determines the direction of the ground-current pulse by comparing the maximum 3I0 and the VN changing trend of the ground-current pulse.

The zero-sequence voltage v0(t) can either be measured via the voltage input VN or can be calculated from the sum of 3 phase-to-ground voltages. The measured value depends on the parameter **Connection type** of the measuring point V-3ph.

The intermittent ground-fault current 3i0(t) can either be measured via the ground-current input IN or via the sensitive ground-current input I_{NS}. It can also be calculated from the sum of the 3 phase currents. The current value and its setting range depend on the parameter **Connection type** of the measuring point I-3ph.

Table 6-2 Threshold Setting Range with Different Connection Types

Connection Type of the Measuring Point I-3ph	Current Threshold 3I0/IN	CT Terminal Type	Threshold Setting Range (Secondary)[36]
3-phase	Calculated 3I0[37]	4 x Protection	0.030 A to 35.000 A
		3 x Protection, 1 x sensitive	0.030 A to 35.000 A
		4 x Measurement	0.001 A to 1.600 A

36 These values apply for a secondary rated current of 1 A. The values need to be multiplied by 5 when the secondary rated current is 5 A.

37 If the connection type is without IN, such as 3-phase, the current threshold value is a calculated 3I0 value.

Connection Type of the Measuring Point I-3ph	Current Threshold 3I0/IN	CT Terminal Type	Threshold Setting Range (Secondary)[36]
3-phase + IN 3-phase + IN-separate	Measured IN[38]	4 x Protection	0.030 A to 35.000 A
		4 x Measurement	0.001 A to 1.600 A
	Measured IN and calculated 3I0 when IN > 1.6 A	3 x Protection, 1 x sensitive	0.001 A to 35.000 A

Direction Determination and Pulse Counting

When the RMS value of 3I0 exceeds the set threshold value (signal no. 3 in *Figure 6-229*), the direction determination process is started and is continuously carried out until the function resets. At first, the current pulse (current peak) detection takes place. If a current pulse is detected, the direction determination for this pulse is carried out.

The direction is determined by the maximum 3I0 and the VN changing trend of the ground-current pulse. The plus or minus sign of the maximum 3I0 is compared to the plus or minus sign of the VN changing trend, resulting in the directional decision ***forward*** or ***reverse***. If the VN changing trend is smaller than 0.03 V_{rated} or if the maximum 3I0 is smaller than 0.1 I_{rated}, the direction is undefined.

During the ongoing intermittent ground fault, the directional results for all current pulses are counted.

Directional Mode and Directional Pulse Counter Criterion

The parameter **Directional mode** defines whether the function operates in ***forward*** or in ***reverse*** direction. The pulses in the specified direction are counted. If the pulse counter reaches the threshold value set in the parameter **No. of pulses for operate**, the signal *Pulse no. reached* is issued. Depending on the operating mode (***Counter*** or ***Integrator and counter***) of the function, the signal can immediately cause the operate of the function (***Counter*** mode) or it is processed as directional release criteria (***Integrator and counter*** operating mode). Refer to the further description in the following sections.

The directional pulse counter is reset when a different direction than the set **Directional mode** is detected. An undefined direction result does not reset the counter.

Operating Mode

2 different functional operating modes are available: ***Counter*** and ***Integrator and counter***. You can select the different operating modes using the parameter **Operating mode**.

- Operating mode ***Counter***:

  Many ground-current pulses of intermittent ground faults can result in a damage of the protected object. In this mode, the criterion for operate is only the number of directional current pulses. This is similar to the SIPROTEC 4 implementation.

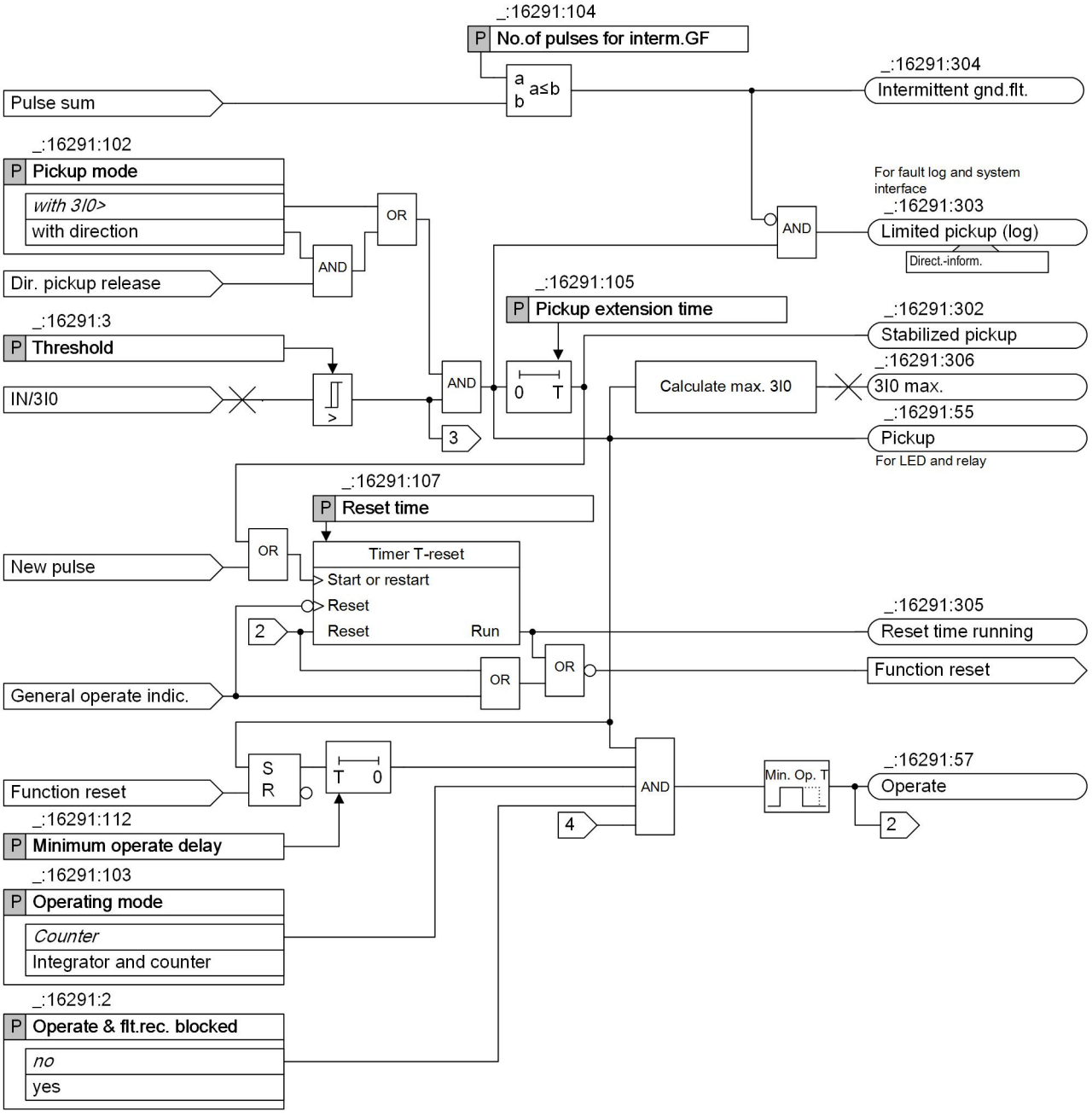
- Operating mode ***Integrator and counter***:

  An intermittent ground fault can result in thermal stress on the protected object. The magnitude and the duration of the ground-current pulses are decisive for the thermal stress. In order to calculate the thermal stress, the stage sums up the duration of the stabilized pickups with an integrator. If the integration value reaches the threshold value, one criterion for the operate is fulfilled. The 2nd criterion for the operate is the ground-fault direction. The ground-fault direction is determined by counting the directional ground-current pulses.

36 These values apply for a secondary rated current of 1 A. The values need to be multiplied by 5 when the secondary rated current is 5 A.

38 If the connection type is with IN, such as 3-phase + IN, the current threshold value is a measured IN value.

Pickup, Operate, and Reset logic for the Counter Mode

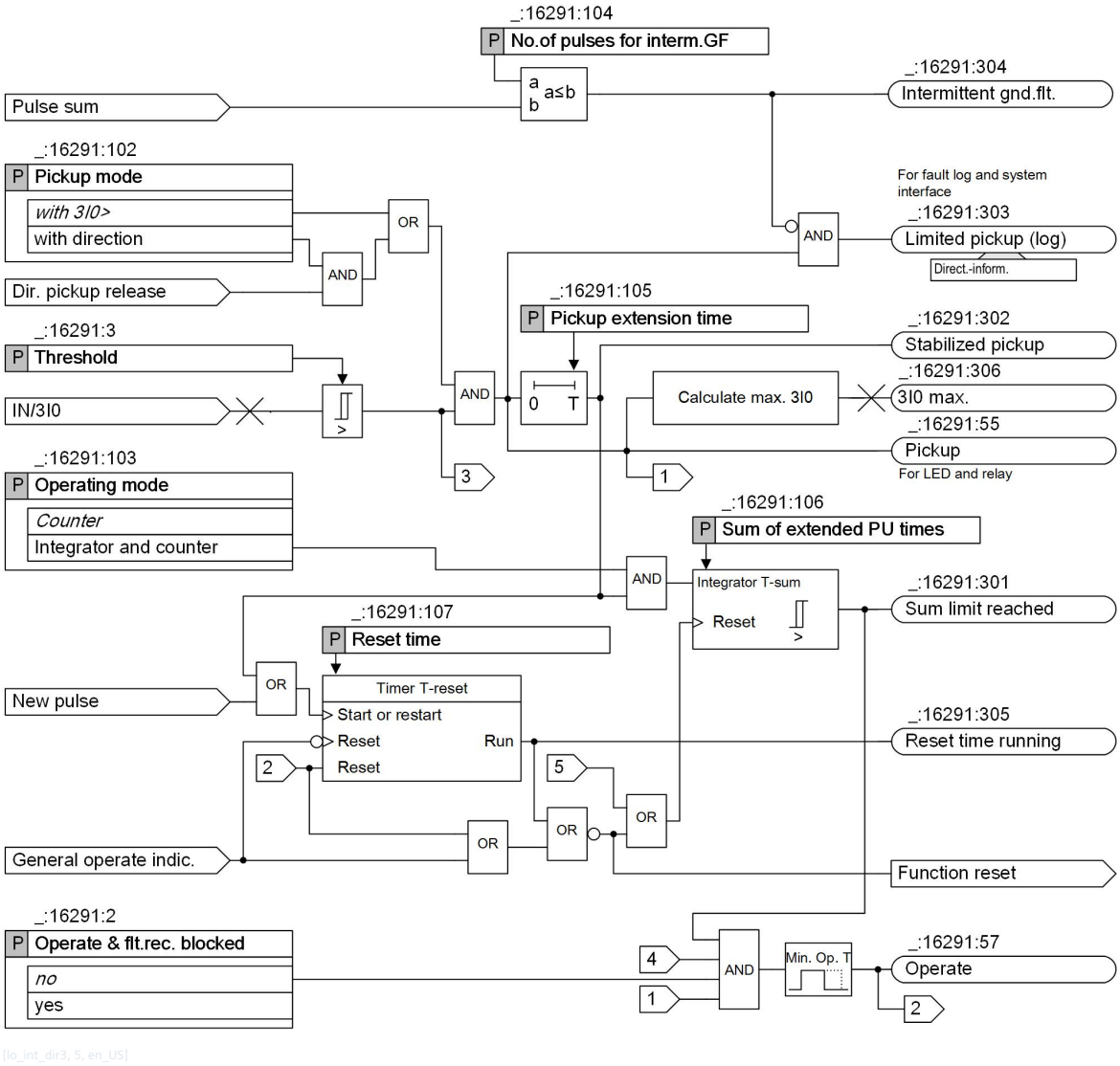


[lo_int_dir2, 4, en_US]

Figure 6-230 Pickup, Operate, and Reset Logic in Operating Mode Counter

(1) The internal signal 4 is from *Figure 6-229*.

Pickup, Operate, and Reset logic for the Integrator and Counter Mode



[lo_int_dir3, 5, en_US]

Figure 6-231 Pickup, Operate, and Reset Logic in Operating Mode Integrator and Counter

(1) The internal signal 4 and 5 are from *Figure 6-229*.

Measurement Value for Pickup and Integration

The stage calculates the RMS value of 3I0 since this value takes into account the higher-order harmonic components and the direct component (DC). Both components contribute to the thermal load.

Pickup, Limited Pickup, and Stabilized Pickup

Whenever 3I0 exceeds **`Threshold`**, the stage issues the signal *`Pickup`*. The signal is intended to be applied for LED and relay output.

`Stabilized pickup` is formed by prolonging the pickup indication by a settable time **`Pickup extension time`**. This stabilization is especially important for the coordination with the existing static or electromechanical overcurrent protection.

The *`Limited pickup (log)`* signal is intend to be applied for logging and communication interface. The *`Limited pickup (log)`* signal will be entered in the fault log and reported via the system interface unless the *`Intermittent gnd.flt.`* indication is given. This behavior prevents a burst of indications.

Intermittent Ground-Fault Indication

The stage counts the 3I0 pulses. If the sum of forward pulse counts, reverse counts, and directional undefined counts is equal to or greater than **No.of pulses for interm.GF**, the signal *Intermittent gnd.flt.* is issued.

If the signal *Intermittent gnd.flt.* is issued, the pickup indications of some protection functions will be restraint to avoid an indication burst during an intermittent ground fault.

Operate

The conditions for issuing the signal *Operate* depend on the operating mode.

Operating Mode	Conditions for Issuing the Operate Signal
Counter	• The current-pulse counter reached the **No. of pulses for operate**, which is signaled via the *Pulse no. reached* indication. • The timer **Minimum operate delay** expired. The timer is started with the first pickup and is reset when the function resets. • The pickup is active, which is signaled via the *Pickup* indication.
Integrator and counter	• The 3I0 current integration value reaches the predefined **Sum of extended PU times**, which is signaled via the *Sum limit reached* indication. • The current-pulse counter reached the **No. of pulses for operate**, which is signaled via the *Pulse no. reached* indication. • The pickup is active, which is signaled via the *Pickup* indication.

When an opposite current pulse against the setting **Directional mode** is detected, the **Integrator T-sum** and the **Counter** are reset.

Reset Time for the Definition of the Interval between Independent Ground Faults

If there is a long interval between independent ground faults or if the ground fault extinguishes and does not restrike again within a long time, the function must not operate. The interval between ground faults is monitored with the reset time. If a ground fault occurs, the **Timer T-reset** with the setting **Reset time** and the **Integrator T-sum** are launched simultaneously. Unlike the integrator, each new ground-current pulse restarts the reset time with its initial value. If the **Timer T-reset** expires, that is, no new ground fault was detected during that period, all memories and the stage logics are reset. The **Timer T-reset** thus determines the time during which the next ground fault must occur to be processed yet as intermittent ground fault in connection with the previous fault. A ground fault that occurs later is considered as a new ground-fault event.

Reset Conditions

Under one of the following 2 conditions, **Timer T-reset** is reset:

- The intermittent ground-fault protection stage operates.
- The general operate indication is going.

Under one of the following conditions, **Integrator T-sum** and **Counter** are reset and the whole stage is reset and returns to its idle state:

- The **Timer T-reset** expires without an operate signal of this stage or another function was issued.
- The operate signal of the intermittent ground-fault protection stage is going.
- The general operate indication is going without the operate signal of the intermittent ground-fault protection stage issued.

Maximum Value 3I0 of the Ground Fault

The stage records the maximum RMS value of 3I0 during the intermittent ground fault.The statistic value *3I0 max.* is a percentage value calculated through dividing the primary maximum RMS value by the rated current value of the protected object. If the function resets or operates, this value is logged via the signal *3I0 max.*.

Fault Log and Fault Recording

You can select between the ground-fault log without fault recording or the normal fault log with fault recording. If you set the parameter **Operate & flt.rec. blocked** to ***yes***, the operate of the stage and fault recording are blocked and the information automatically appears in the ground-fault log. Otherwise, the operate and fault recording are not blocked and the information appears in the normal fault log.

Start and Stop of Fault Recording, Fault Logging, and General Pickup

The *Stabilized pickup* signal initiates fault recording, fault logging, and the general pickup of the function group. The fault recording starts according to the pre-trigger time before the *Stabilized pickup* signal rises.

With the reset condition of this stage, the fault recording, fault logging, and the general pickup of the function group are terminated.

Influence on Other Functions to Avoid a Burst of Indications

In this case, the function uses the same mechanism as the **Non-directional intermittent ground-fault protection**. For more information, refer to chapter *Influence on Other Functions to Avoid a Burst of Signals, Page 882*.

6.11.4 Application and Setting Notes

No Start of the Automatic Reclosing Function

Automatic reclosing is not an effective measure against intermittent ground faults. For this reason, the function **Directional intermittent ground-fault protection** is not intended to start the Automatic reclosing function.

Routing of Pickup Signals

The signal *Pickup* is supposed to be routed to an LED and a relay. The signal *Limited pickup (log)* is only reported to the fault log and communication interface until the signal *Intermittent gnd.flt.* is issued. This scheme prevents a burst of indications.



NOTE

To avoid a burst of indications, do not route the signal *Pickup* to the operational log and to the fault log.

Parameter: Threshold

- Default setting **(_:16291:3) Threshold** = ***1.00 A***

With the parameter **Threshold**, you set the threshold value of the ground current 3I0, measured as RMS value.

A rather sensitive setting is possible to respond also to short ground faults since the pickup time shortens as the ground-fault current increases.

Parameter: Directional mode

- Default setting **(_:16291:101) Directional mode** = ***forward***

With the parameter **Directional mode**, you define if the function operates in *forward* or in *reverse* direction.

Parameter: Pickup mode

- Default setting **(_:16291:102) Pickup mode** = ***with 3I0>***

With the parameter **Pickup mode**, you define under which conditions pickup is detected and fault logging and recording start:

- When the parameter **Pickup mode** is set to ***with 3I0>***, the signal *Pickup* is released without considering the ground fault direction. The signal *Pickup* is issued once the IN/3I0 exceeds the threshold value.
- When the parameter **Pickup mode** is set to ***with direction***, the signal *Pickup* is issued when at least one pulse direction is the same as the direction specified by the set value of parameter **Directional mode**.

Parameter: **Operating mode**

- Default setting **(_:16291:103) Operating mode** = ***Counter***

With the parameter **Operating mode**, you define if the function operates in ***Counter*** or in ***Integrator and counter*** mode.

Operating Mode	Application and Setting Notes
Counter	The number of directional pulses is the determining operate criterion. This is a simple method which is similar to the implementation in the 7SJ SIPROTEC 4 devices. Siemens recommends using this method if no time grading or only simple time grading between protection devices (time grading of only 2 or 3 devices) is required. Time grading is then carried out by increasing the parameter value **No. of pulses for operate** towards the infeed.
Integrator and counter	The integrator and the counter are the determining operate criteria while the counter criterion is only used for the direction determination. The integrator works in the same way as for the non-directional intermittent ground fault function. This allows the same time-grading principles as for the non-directional intermittent ground fault function. Refer to this function for more description.

Parameter: **No.of pulses for interm.GF**

- Default setting **(_:16291:104) No.of pulses for interm.GF** = ***3***

With the parameter **No.of pulses for interm.GF**, you set the total number of pulse counts (***forward***, ***reverse*** and ***non-dir. pulses***) at which the ground fault is considered to be intermittent. Siemens recommends using the default setting.

Parameter: **Pickup extension time**

- Default setting **(_:16291:105) Pickup extension time** = ***0.10 s***

With the parameter **Pickup extension time**, you get a prolonged and thus stabilized pickup signal. This stabilization is especially important for the coordination with existing static or electromechanical overcurrent protections.

Parameter: **No. of pulses for operate**

- Default setting **(_:16291:108) No. of pulses for operate** = ***5***

The pulses in the specified direction from **Directional mode** are counted. If the pulse counter reaches the set value of the parameter **No. of pulses for operate**, the directional counter criterion is fulfilled.

The setting of parameter **No. of pulses for operate** depends on the **Operating mode**.

Operating Mode	Application and Setting Notes
Counter	The number of directional pulses is the determining operate criterion. Thus do not set the value for parameter **No. of pulses for operate** too small. Consider that a permanent intermittent ground fault will cause many current pulses. If no time-grading considerations are required, Siemens recommends using a value in the range of 10 to 20.
Integrator and counter	The integrator and the counter are the determining operate criteria while the counter criterion is only used for the direction determination. The value for parameter **No. of pulses for operate** to fulfill the directional criterion can be set to a rather small value in the range of 3 to 5.

Parameter: Sum of extended PU times

- Default setting **(_:16291:106) Sum of extended PU times** = ***20.00 s***

This parameter is only relevant in the operating mode ***Integrator and counter***.

With the parameter **Sum of extended PU times**, you set the threshold value for the integrator. If the integration reaches **Sum of extended PU times**, the stage operates if the signal *Pulse no. reached* and the pickup state is present.

The parameter **Sum of extended PU times** represents one of the 5 selectivity criteria (ground-fault direction, pickup threshold, pickup extension time, reset time, and integrator threshold value) for coordination of the relays on subordinate devices. It is comparable to the time grading of the overcurrent protection.

The **Sum of extended PU times** has the shortest summation time in the radial system for the device that is closest to the intermittent ground fault and that picks up.

Parameter: Reset time

- Default setting **(_:16291:107) Reset time** = ***300 s***

With the parameter **Reset time**, you can define the maximum interval between 2 adjacent ground faults. If the interval is larger than the **Reset time**, the counter and integrator are reset.

The parameter **Reset time** must be much higher than the operate value of the **Sum of extended PU times**.



NOTE

Siemens recommends setting the parameter **Reset time** to a value not lower than 40 ms. A too low value will lead to a risk that the intermittent ground-fault protection function never picks up.

Parameter: Operate & flt.rec. blocked

- Default setting **(_:16291:2) Operate & flt.rec. blocked** = ***no***

With the parameter **Operate & flt.rec. blocked**, you can block the operate indication, the fault recording, and the fault log. In this case, a ground-fault log is created instead of the fault log.

Parameter: Minimum operate delay

- Default setting **(_:16291:112) Minimum operate delay** = ***0.00 s***

This parameter is only relevant in the operating mode ***Counter***.

The parameter **Minimum operate delay** is used to avoid too fast tripping in case of frequent restriking (for example, restriking occurs every 30 ms).

6.11.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:16291:1	Stage 1:Mode		• off • on • test	off
_:16291:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:16291:10	Stage 1:Blk. by meas.-volt. failure		• no • yes	yes
_:16291:101	Stage 1:Directional mode		• forward • reverse	forward
_:16291:102	Stage 1:Pickup mode		• with 3I0> • with direction	with 3I0>
_:16291:103	Stage 1:Operating mode		• Counter • Integrator and counter	Counter
_:16291:3	Stage 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:16291:105	Stage 1:Pickup extension time		0.00 s to 10.00 s	0.10 s
_:16291:104	Stage 1:No.of pulses for interm.GF		2 to 10	3
_:16291:106	Stage 1:Sum of extended PU times		0.00 s to 180.00 s	20.00 s
_:16291:107	Stage 1:Reset time		0.00 s to 600.00 s	300.00 s
_:16291:108	Stage 1:No. of pulses for operate		2 to 100	5
_:16291:112	Stage 1:Minimum operate delay		0.00 s to 60.00 s	0.00 s

6.11.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Stage 1			
_:16291:81	Stage 1:>Block stage	SPS	I
_:16291:51	Stage 1:Mode (controllable)	ENC	C
_:16291:54	Stage 1:Inactive	SPS	O

No.	Information	Data Class (Type)	Type
_:16291:52	Stage 1:Behavior	ENS	O
_:16291:53	Stage 1:Health	ENS	O
_:16291:55	Stage 1:Pickup	ACD	O
_:16291:302	Stage 1:Stabilized pickup	ACD	O
_:16291:303	Stage 1:Limited pickup (log)	ACD	O
_:16291:304	Stage 1:Intermittent gnd.flt.	SPS	O
_:16291:301	Stage 1:Sum limit reached	SPS	O
_:16291:308	Stage 1:Pulse no. reached	SPS	O
_:16291:305	Stage 1:Reset time running	SPS	O
_:16291:57	Stage 1:Operate	ACT	O
_:16291:306	Stage 1:3I0 max.	MV	O
_:16291:310	Stage 1:Forward pulses	MV	O
_:16291:311	Stage 1:Reverse pulses	MV	O
_:16291:312	Stage 1:Non-dir. pulses	MV	O

6.12 Non-Directional Intermittent Ground-Fault Protection

6.12.1 Overview of Functions

A typical characteristic of intermittent ground faults is that they often extinguish automatically and strike again after some time. The fault duration can last between a few milliseconds and many seconds. Thus, such faults are not detected at all or not selectively by the ordinary overcurrent protection. If pulse durations are extremely short, not all protection devices in a short-circuit path can pick up. Thus, selective tripping is not ensured.

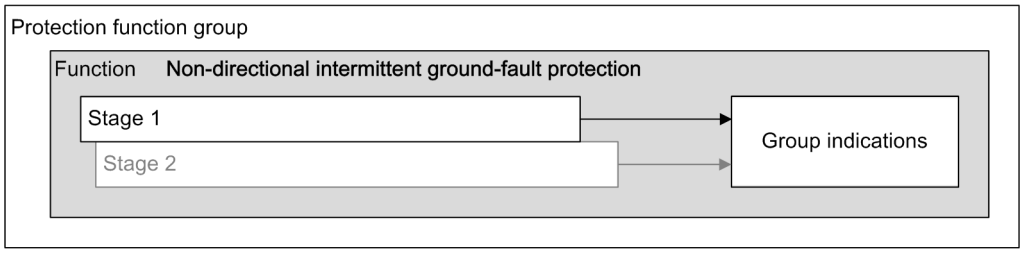
Due to the time delay of the overcurrent protection function, such faults are too short to initiate switching off the faulted cable. The short-circuit protection can clear such ground faults selectively only if the ground faults have become permanent.

But such intermittent ground faults already bear the risk of damaging the equipment thermally. This is why SIPROTEC 5 devices feature a protection function that is able to detect such intermittent ground faults and accumulates their duration. If the sum reaches a configurable value within a certain time, the limit of the thermal rating has been reached. If intermittent ground faults are distributed over a long period or if the ground fault disappears and does not restrike after some time, the equipment under load is expected to cool down. Tripping is not necessary in this case.

The function **Non-directional intermittent ground-fault protection** is used to protect against intermittent ground faults which occur, for example, in cables due to poor insulation or water ingress in cable joints.

6.12.2 Structure of the Function

The function **Non-directional intermittent ground-fault protection** can be used in protection function groups with current measurement. The function comes factory-set with 1 stage, and a maximum of 2 stages can be operated simultaneously. The non-preconfigured stages are shown in gray in the following figure.

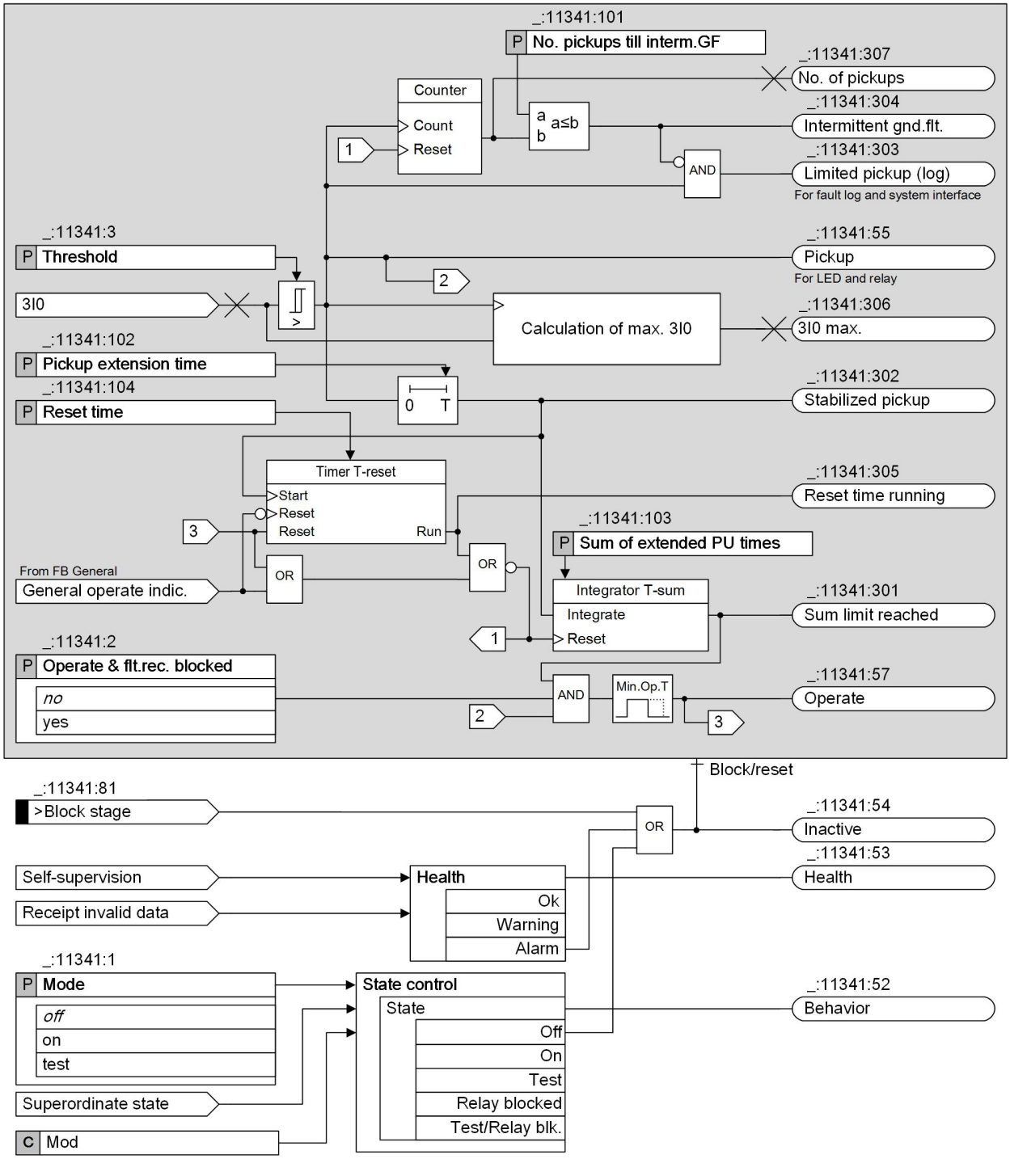


[dw_int_GFP, 1, en_US]

Figure 6-232 Structure/Embedding of the Function

6.12.3 Stage Description

Logic



[lo_Intnon, 2, en_US]

Figure 6-233 Logic of the Non-Directional Intermittent Ground-Fault Protection

Measured Value 3I0

The intermittent ground-fault current 3I0 can either be measured via the standard ground-current input IN or via the sensitive ground-current input I_{NS}. It can also be calculated from the sum of the 3-phase currents. The current value and its setting range depend on the parameter **Connection type** of the measuring point I-3ph.

Table 6-3 Threshold Setting Range with Different Connection Types

Connection Type of the Measuring Point I-3ph	Current Threshold 3I0/IN	CT Terminal Type	Setting Range Threshold Value (Secondary)[39]
3-phase	Calculated 3I0[40]	4 x Protection	0.030 A to 35.000 A
		3 x Protection, 1 x sensitive	0.030 A to 35.000 A
		4 x Measurement	0.001 A to 1.600 A
3-phase + IN 3-phase + IN-separate	Measured IN[41]	4 x Protection	0.030 A to 35.000 A
		4 x Measurement	0.001 A to 1.600 A
	Measured IN and calculated 3I0 when IN > 1.6 A	3 x Protection, 1 x sensitive	0.001 A to 35.000 A

Method of Measurement

The stage calculates the RMS value of 3I0 since this value takes into account the higher-order harmonics components and the direct component (DC). Both components contribute to the thermal load.

Maximum 3I0 of the Fault

The stage records the maximum RMS value of 3I0 during the intermittent ground fault. The statistical value *3I0 max.* is a percentage value calculated through dividing the primary maximum RMS value by the rated current value of the protected object. With the coming operate signal, this value is logged via the information *3I0 max.*.

Pickup and Intermittent Ground-Fault Indication

When 3I0 exceeds the threshold value, the pickup signals *Pickup* and *Limited pickup (log)* are issued. The stage generates the signal *Stabilized pickup* by extending the *Pickup* for a defined time (parameter **Pickup extension time**).

The stage counts the signals *Pickup*. If the counted number reaches the configured **No. pickups till interm.GF**, the signal *Intermittent gnd.flt.* is issued. The signal *Limited pickup (log)* is not issued anymore after the issue of the signal *Intermittent gnd.flt.*.

39 These values apply for a secondary rated current of 1 A. The values need to be multiplied by 5 when the secondary rated current is 5 A.

40 If the connection type is without IN, such as 3-phase, the current threshold value is a calculated 3I0 value.

41 If the connection type is with IN, such as 3-phase + IN, the current threshold value is a measured IN value.

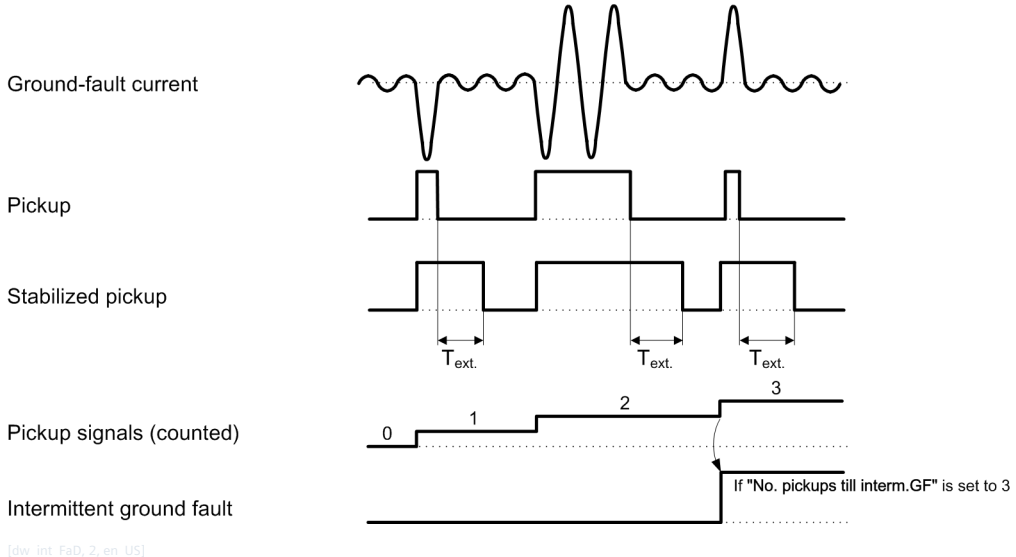


Figure 6-234 Fault Detection of the Intermittent Ground-Fault Protection

$T_{ext.}$ Defined time for extending the signal *Pickup*

Number of Pickups

The stage counts the number of signals *Pickup* during the intermittent ground fault. With the operate of the stage this number is logged via the information *No. of pickups*.

Accumulation of the Intermittent Ground-Fault Current and Issuing the Operate Signal

An intermittent ground fault can result in thermal stress on the protected equipment. The magnitude and the duration of the ground-fault current are decisive for the thermal stress. In order to calculate the thermal stress, the stage sums up the duration of the stabilized pickups with a sum of times. If the integration value reaches the predefined **Sum of extended PU times**, the limit of the thermal load is reached. The stage issues the signal *Sum limit reached* and operates when the signal *Pickup* is active.

Reset Timer for the Definition of the Interval between Independent Ground Faults

If there is a large interval between independent ground faults or if ground fault extinguishes and does not restrike again within a larger time, the stressed equipment can cool down. In this case, an operation is not necessary. The interval between ground faults is monitored with the reset timer. If a ground fault occurs, the **Timer T-reset** with its setting **Reset time** is launched simultaneously with **Integrator T-sum**. Unlike the integrator, each new ground fault restarts the reset timer with its initial value. If **Timer T-reset** expires, that is, no new ground fault was detected during that period, all memories and the stage logics are reset. **Timer T-reset** thus determines the time during which the next ground fault must occur to be processed yet as intermittent ground fault in connection with the previous fault. A ground fault that occurs later is considered as a new fault event.

Reset Conditions

Under one of the following 2 conditions, **Timer T-reset** is reset.

- The Intermittent ground-fault protection stage operates.
- The general operate indication is going.

Under one of the following conditions, **Integrator T-sum** and **Counter** are reset and the whole stage is reset and returns to its idle state.

- **Timer T-reset** expires without an operate signal of this stage or another function was issued.
- The operate signal of the intermittent ground-fault protection stage is going.
- The general operate indication is going without the operate signal of the intermittent ground-fault protection stage issued.

Fault Log and Fault Recording

You can select between the ground-fault log without fault recording or the normal fault log with fault recording. If you set the parameter **Operate & flt.rec. blocked** to ***yes***, the operate of the stage and fault recording are blocked and the information automatically appears in the ground-fault log. Otherwise, the operate and fault recording are not blocked and the information appears in the normal fault log.

Start & Stop of Fault Recording, Fault Logging, and General Pickup

The signal *Stabilized pickup* initiates the fault recording, fault logging, and the general pickup of the function group. The fault recording starts according to the pre-trigger time before the signal *Stabilized pickup* rises.

With the reset condition of this stage, the fault recording, fault logging, and the general pickup of the function group are terminated.

Influence on Other Functions to Avoid a Burst of Signals

Intermittent ground faults may cause other functions, based on overcurrent measurement, to pick up, which may result in a burst of signals. In order to avoid an overflow of the fault log, a special mechanism is applied to the signals of these functions after detection of an intermittent ground fault (signal *Intermittent gnd.flt.*).

The special mechanism is applied for the following listed functions and other functions are not influenced:

- Overcurrent protection, phases
- Overcurrent protection, ground
- Directional overcurrent protection, phases
- Directional overcurrent protection, ground
- Overcurrent protection, 1-phase
- Negative-sequence protection with definite-time characteristic curve
- Directional negative-sequence protection with definite-time delay
- Directional overcurrent-protection stage with cos phi or sin phi measurement
- Directional overcurrent-protection stage with 3I0-phi (V,I) measurement
- Sensitive ground-current protection with 3I0

If a function picks up, normally its output signals are sent directly to the information targets, for example, the pickup signal is written to the fault log. To avoid overflow of logs due to intermittent ground faults, a special log buffer mechanism is used. If one of the preceding functions or stages picks up after an intermittent ground fault has been detected (signal *Intermittent gnd.flt.* has been issued), its output signals are processed as shown in the following 2 tables.

Table 6-4 Processing of the Signal Status Changes

Processing of Signal Status Changes	Description
Special buffering mechanism	The status changes of signals are written to a special buffer. This buffer can store the latest change for each signal. With the pickup signal as example, if one of the preceding protection functions or stages picks up during an active signal *Intermittent gnd.flt.*, the pickup signal is not written in the fault log anymore unless one of the preceding functions operates. After the operation, the buffered signals are written to the information target with the original time stamp. This measure ensures that a pickup signal, although delayed, is always signaled in association with each operate command.
Discard	The signal status changes are discarded.
Pass through	The signal is forwarded to the information target without restriction. Special buffering does not apply for specific information targets as protection measure, for example, reverse interlocking, need these signals for proper operation.

Table 6-5 Information Target with Different Processing of Signal Status Changes

Information Target		Processing of Signal Status Changes
Processing of Signal Status Changes	Operational log Fault log Ground-fault log User-defined log	Special buffering mechanism
Communication interface	IEC 61850-8-1 Client/Server IEC 60870-5-103/104 DNP V3.0	Special buffering mechanism
Automatic reclosing function		Discard
Circuit-breaker failure protection		Discard
Group indications		Discard(1)
Protection interface	PDI	Pass through
IEC 61850-8-1 GOOSE		Pass through
CFC		Pass through
LEDs		Pass through
Binary output		Pass through
Fault recorder		Pass through

(1) Note for reverse-interlocking applications: To ensure that the interlocking signal is not discarded during an intermittent ground fault, Siemens recommends using the individual pickup signals of the function stages instead of the group indications for reverse-interlocking applications in combination with the intermittent ground-fault protection function.

6.12.4 Application and Setting Notes

No Start of the Automatic Reclosing Function

Automatic reclosing is not an effective measure against intermittent ground faults as the protection function only operates after repeated detection of a fault or after the integration value reaches the predefined **Sum of**

extended PU times. Besides this, its basic design is to prevent thermal overload. For these reasons, the intermittent ground-fault protection function is not intended to start the automatic reclosing function.

Rooting of Pickup Signals

The signal *Pickup* is supposed to be routed to LED and relay. The signal *Limited pickup (log)* is only reported to the fault log and communication interface before the signal *Intermittent gnd.flt.* is issued. This scheme prevents a burst of messages.



NOTE

To avoid a burst of messages, do not route the signal *Pickup* to the operational log and fault log.

Parameter: Threshold

- Default setting **(_:11341:3) Threshold** = ***1.00 A***

With the parameter **Threshold**, you set the threshold value of the ground current 3I0, measured as RMS value.
A rather sensitive setting is possible to respond also to short ground faults since the pickup time shortens as the ground-fault current increases.

Parameter: No. pickups till interm.GF

- Default setting **(_:11341:101) No. pickups till interm.GF** = ***3***

With the parameter **No. pickups till interm.GF**, you set the number of counted *Pickup* signals after which the ground fault is considered as intermittent.

Parameter: Pickup extension time

- Default setting **(_:11341:102) Pickup extension time** = ***0.10 s***

You can get a stabilized pickup signal with the parameter **Pickup extension time**. This stabilization is especially important for the coordination with existing static or electromechanical overcurrent protections.

Parameter: Sum of extended PU times

- Default setting **(_:11341:103) Sum of extended PU times** = ***20 s***

With the parameter **Sum of extended PU times**, you set the threshold value for the integrator. If the integration reaches **Sum of extended PU times**, the stage operates if the pickup state is present.
This **Sum of extended PU times** represents one of the 4 selectivity criteria (pickup threshold, pickup extension time, reset time, and integrator threshold value) for coordination of the relays on adjacent feeders. It is comparable to the time grading of the overcurrent protection. The protection in the radial system which is closest to the intermittent fault and picks up, has the shortest summation time **Sum of extended PU times**.

Parameter: Reset time

- Default setting **(_:11341:104) Reset time** = ***300 s***

With the parameter **Reset time**, you can define the maximum interval between 2 adjacent ground faults. If the interval is larger than the **Reset time**, the counter and integrator are reset.
The parameter **Reset time** must be much higher than the operate value of the **Sum of extended PU times**.



NOTE

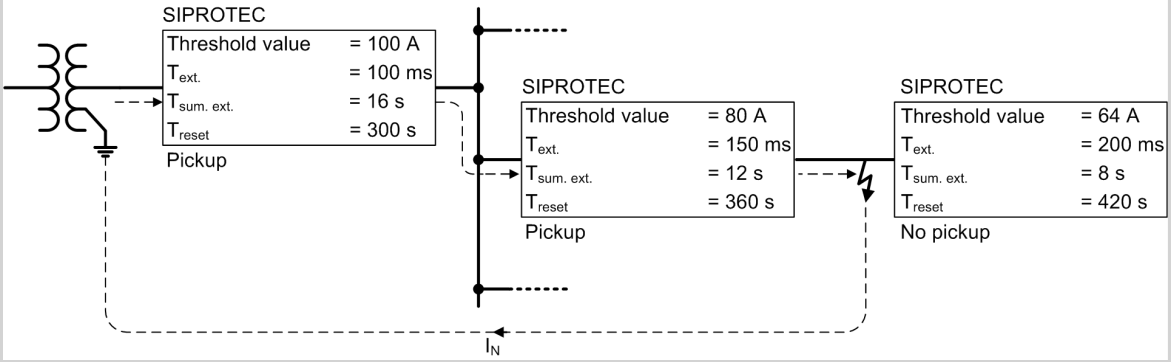
Siemens recommends setting the parameter **Reset time** to a value not lower than 40 ms. A too low value will lead to a risk that the intermittent ground-fault protection function never picks up.

Parameter: `Operate & flt.rec. blocked`

- Default setting **`(_:11341:2) Operate & flt.rec. blocked`** = ***no***

You can block the operate indication, the fault recording, and the fault log with the parameter **`Operate & flt.rec. blocked`**. In this case, a ground-fault log is created instead of the fault log.

EXAMPLE



[TiExaInt, 1, en_US]

Figure 6-235 Example of Selectivity Criteria of the Intermittent Ground-Fault Protection

6.12.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:11341:1	Stage 1:Mode		• off • on • test	off
_:11341:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:11341:3	Stage 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:11341:101	Stage 1:No. pickups till interm.GF		2 to 10	3
_:11341:102	Stage 1:Pickup extension time		0.00 s to 10.00 s	0.10 s
_:11341:103	Stage 1:Sum of extended PU times		0.00 s to 180.00 s	20.00 s
_:11341:104	Stage 1:Reset time		0.00 s to 600.00 s	300.00 s

6.12.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Stage 1			
_:11341:81	Stage 1:>Block stage	SPS	I
_:11341:51	Stage 1:Mode (controllable)	ENC	C
_:11341:54	Stage 1:Inactive	SPS	O
_:11341:52	Stage 1:Behavior	ENS	O
_:11341:53	Stage 1:Health	ENS	O
_:11341:55	Stage 1:Pickup	ACD	O
_:11341:302	Stage 1:Stabilized pickup	ACD	O
_:11341:303	Stage 1:Limited pickup (log)	ACD	O
_:11341:304	Stage 1:Intermittent gnd.flt.	SPS	O
_:11341:301	Stage 1:Sum limit reached	SPS	O
_:11341:305	Stage 1:Reset time running	SPS	O
_:11341:57	Stage 1:Operate	ACT	O
_:11341:306	Stage 1:3I0 max.	MV	O
_:11341:307	Stage 1:No. of pickups	MV	O

6.13 Sensitive Ground-Fault Detection

6.13.1 Overview of Functions

2 functions are available for ground-fault detection: a directional one and a non-directional one.

The **Directional sensitive ground-fault detection** (ANSI 67Ns) serves:

- For directional detection of permanent ground faults in isolated or resonant-grounded systems
- For directional detection of fast extinguishing transient ground faults in isolated or resonant-grounded systems
- For determination of the faulty phase
- For detection of high-impedance ground faults in effectively (solidly) or low-impedance (semi-solidly) grounded systems

The **Non-directional sensitive ground-fault detection** (ANSI 51Ns) serves:

- For ground-fault detection in isolated or resonant-grounded systems
- For detection of high-impedance ground faults in effectively (solidly) or low-impedance (semi-solidly) grounded systems

6.13.2 Structure of the Function

Directional Sensitive Ground-Fault Detection

The **Directional sensitive ground-fault detection** function can be used in protection function groups that make current and voltage zero-sequence systems (3I0 and V0) available. The function comes factory-set with a non-directional **V0> stage with zero-sequence voltage/residual voltage**, a directional **3I0> stage with cos φ or sin φ measurement**, a directional **transient ground-fault stage**, and an **intermittent ground-fault blocking stage**.

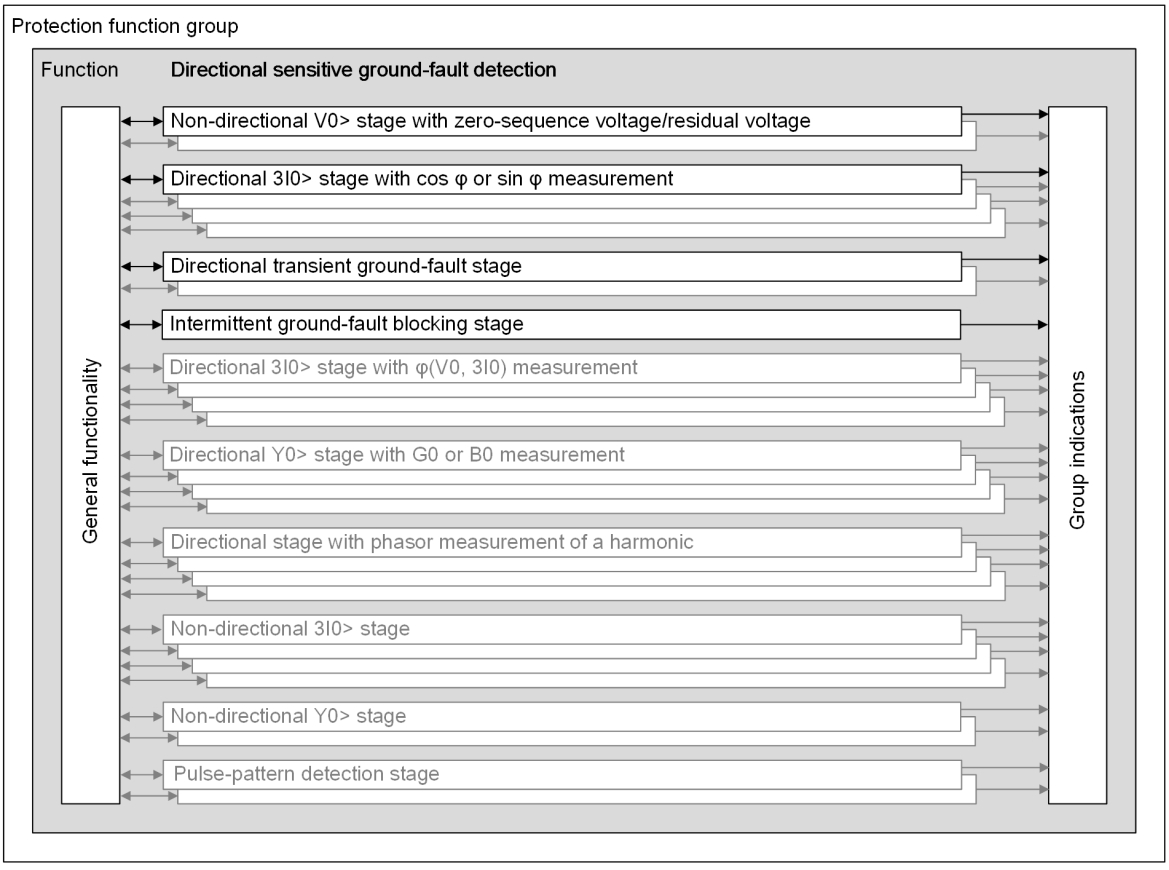
The following stages can be operated simultaneously within the function:

- 2 non-directional **V0> stages with zero-sequence voltage/residual voltage**
- 4 directional **3I0> stages with cos φ or sin φ measurement**
- 2 directional **transient ground-fault stages**
- 4 directional **3I0> stages with φ(V0, 3I0) measurement**
- 4 directional **Y0> stages with G0 or B0 measurement** (admittance method)
- 4 directional **stages with phasor measurement of a harmonic**
- 4 non-directional **3I0> stages**
- 2 non-directional **Y0> stages**
- 2 non-directional **pulse-pattern detection stages**
- 1 **intermittent ground-fault blocking stage**

The general functionality works across stages on the function level.

The group-indications output logic generates the following group indications of the entire function by the logical OR from the stage-selective indications:

- Pickup
- Operate indication



[dw_str_GFP, 6, en_US]

Figure 6-236 Structure/Embedding of the Directional Function in Protection Function Groups

Non-Directional Sensitive Ground-Fault Detection

The **Non-directional sensitive ground-fault detection** function can be used in protection function groups that only make the zero-sequence system (3I0) available. The function comes factory-set with a non-directional **3I0> stage**.

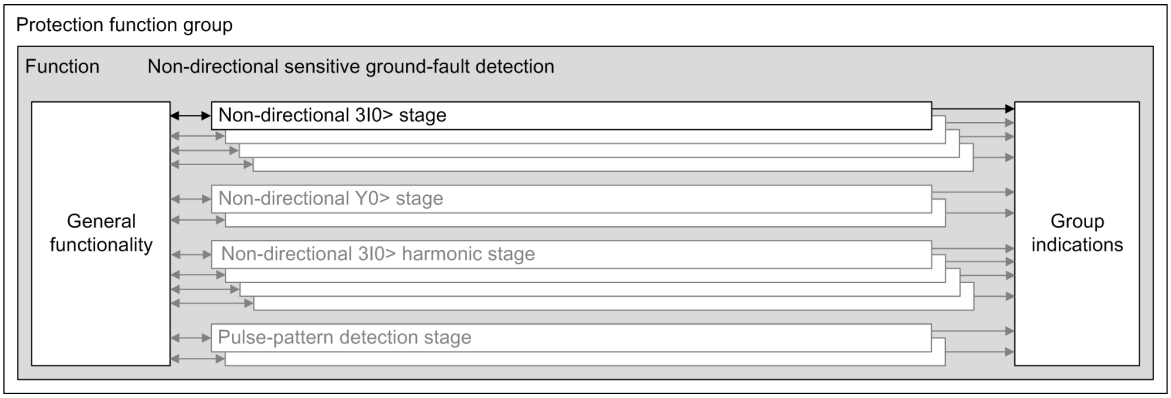
The following stages can be operated simultaneously within the function:

- 4 non-directional **3I0> stages**
- 2 non-directional **Y0> stages**
- 4 non-directional **3I0> harmonic stages**
- 2 non-directional **pulse-pattern detection stages**

The general functionality works across stages on the function level.

The group-indications output logic generates the following group indications of the entire function by the logical OR from the stage-selective indications:

- Pickup
- Operate indication



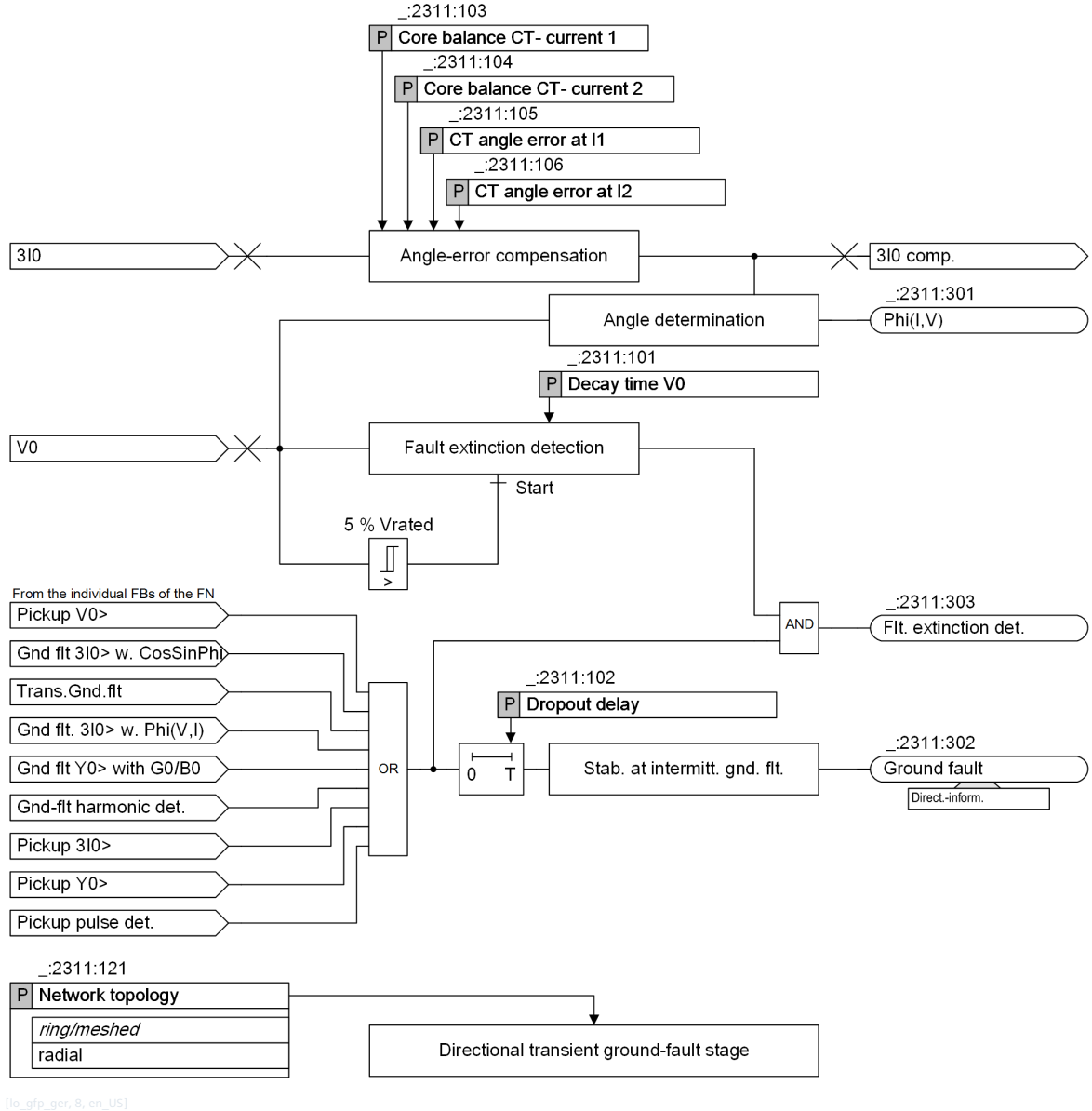
{dw_SGFP_u4, 5, en_US}

Figure 6-237 Structure/Embedding of the Non-Directional Function in Protection Function Groups

6.13.3 General Functionality

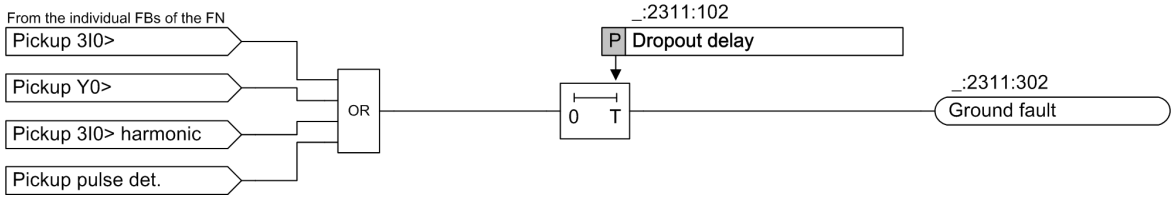
6.13.3.1 Description

Logic



[lo_gfp_ger, 8, en_US]

Figure 6-238 Logic Diagram of the Cross-Stage Functionality of the Directional Function

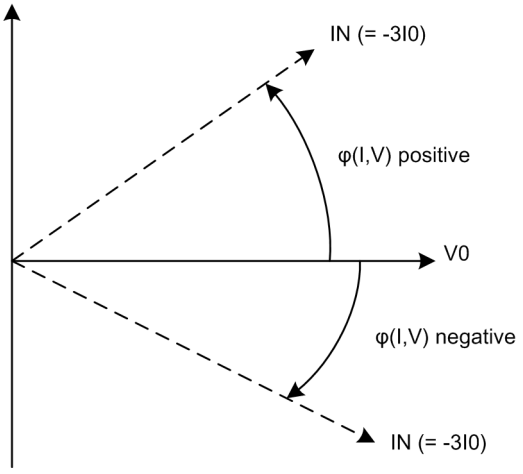


[lo_gfp_non, 6, en_US]

Figure 6-239 Logic Diagram of the Cross-Stage Functionality of the Non-Directional Function

Operational Measured Value φ(I,V)

The function block calculates the angle between IN and V0 and makes the angle available as function measured value *Phi(I,V)*.



[dw_ph_I_N_U0, 1, en_US]

Figure 6-240 Sign Definition for the Measured Value

Network Topology

The parameter **Network topology** parameter is only used in the **Directional transient ground-fault** stage.

With this parameter, the algorithm of the directional transient ground-fault stage adopts its processing of an operational 3I0.

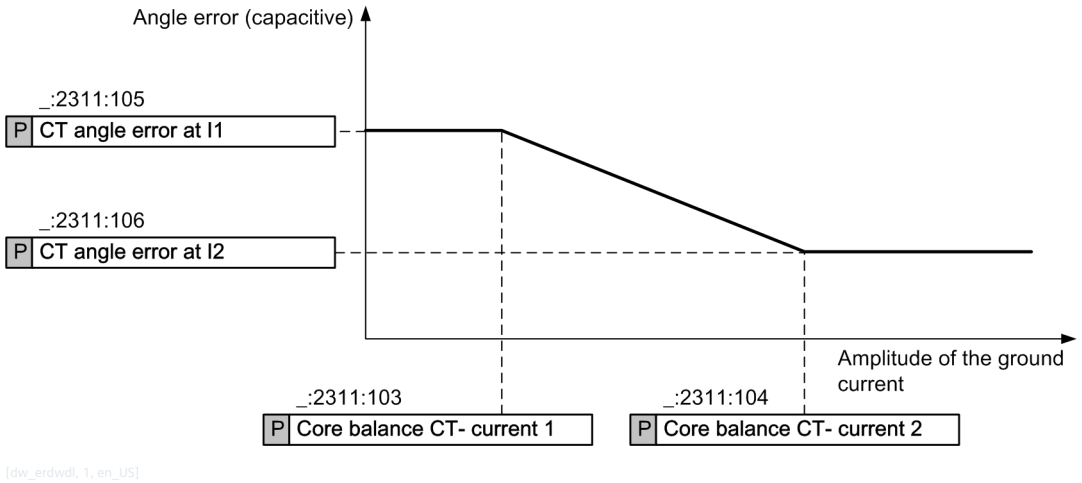
Fault-Extinction Detection

The extinction of the fault is characterized by the fact that the zero-sequence voltage subsides. Depending on the system conditions and fault characteristics, this process can last several 100 ms. If a continuously falling zero-sequence voltage is detected during the set time **Decay time V0**, then the fault is considered extinguished. The signal *Flt. extinction det.* is issued.

Thus, the possibility exists, for example, to block the stage **3I0>** with cos φ or sin φ measurement directly after the fault extinction, in order to avoid an overfunction during the subsiding process with a very sensitive setting of the stage.

Angle-Error Compensation

The high reactive power factor in the arc-suppression-coil-ground system and the unavoidable air-gap of the core balance current transformer often make necessary a compensation of the angle error of the core balance current transformer. Using the characteristic shown in the following figure, the device approaches the angle error of the core balance current transformer with sufficient precision.



[dw_erdwdl, 1, en_US]

Figure 6-241 Correction of the Transmission Characteristic Curve of a Core Balance Current Transformer

Ground-Fault Indication, Stabilization at Intermittent Ground Fault

The indication *Ground fault* indicates the ground fault and manages the ground-fault log (see *Ground-Fault Log, Page 892*). The corresponding information of the stages used is accessed for the generation of this indication.

The indication *Ground fault* contains the direction information, independent of the parameterized working direction of a stage. The indication is thus suited for transfer to a station.

To avoid a flood of indications in case of an intermittent ground fault, a maximum of 30 status changes of this indication is logged per ground fault. An intermittent ground fault must be treated as one ground fault so that the stabilization can take action. This is ensured with the parameter **Dropout delay**, by the dropout of the indication *Ground fault* being delayed. If the next ignition of the ground fault takes place during the dropout delay, the indication does not drop out and the log remains open.

NOTE

The *Ground fault* indication in the general stage must be routed into the ground-fault log. If not, you can meet a flood of ground-fault logs when an intermittent ground fault occurs.

Ground-Fault Log

Ground faults can be recorded in a designated buffer, the ground-fault log. As long as the **Operate & flt.rec. blocked** parameter is set to ***yes***, all indications routed into the ground-fault log are written in the ground-fault log.

The criterion for opening the ground-fault log is the raising of any indication which is routed to the ground-fault log, for example, the indication *Ground fault* . The criterion for closing is the clearing of all routed indications.

Related Topics

You can find general notes on the ground-fault login chapter **Indications** under *3.1.5.4 Ground-Fault Log*.

Value Indications in Log and Real-Time Functional Values

If the value indications listed in *Table 6-6* can be calculated, they are written into the log (ground-fault log or fault log) at the time of the 1st raising ground-fault indication and the 1st operate indication of any stage.

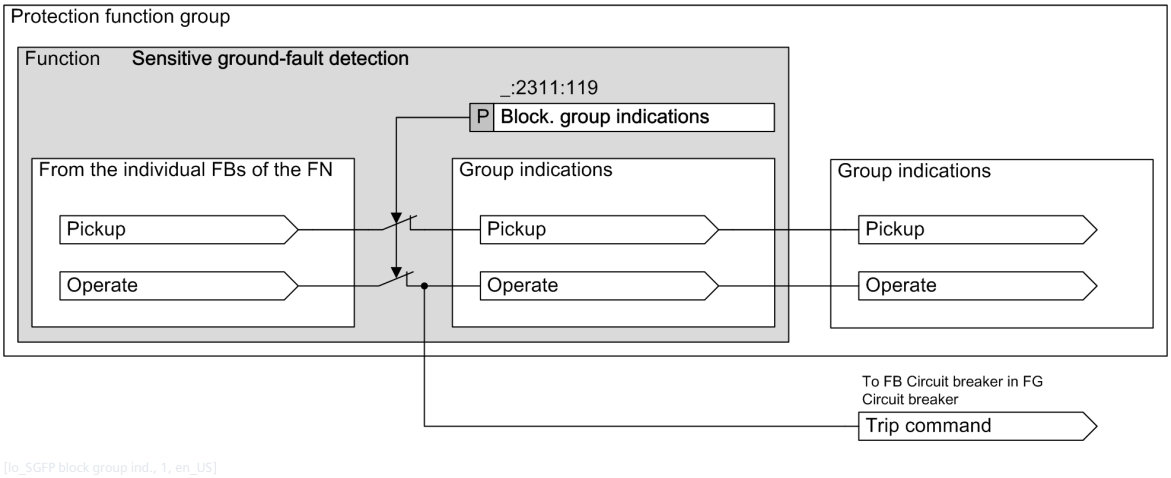
The function also provides some real-time functional values, as described in *Table 6-6*.

Table 6-6 Value Indications in Log and Real-Time Functional Values

Value Indication in Log	Real-Time Functional Value	Description
IN	–	Neutral-point current IN
IN active	IN act.	Active component IN
IN reactive	IN react.	Reactive component IN
V0	–	Zero-sequence voltage V0
Phi(IN, V0)	Phi(I,V)	Angle between IN and V0 Refer to *Operational Measured Value φ(I,V) , Page 891*.

If the ground current is measured via a sensitive input and the measured value exceeds the measuring range of 1.6 · I_{rated}, the function switches from the measured IN value to the calculated 3I0 value and the 3I0 values are displayed.

Group-Indication Blocking



[lo_SGFP block group ind., 1, en_US]

Figure 6-242 Logic Diagram of the Group-Indication Blocking of the Directional and Non-Directional Functions

By setting the **`Block. group indications`** parameter to ***`yes`***, the following indications are blocked:

- The group indications of the function and the corresponding group indications of the function group
- The trip command from the function **Sensitive ground-fault detection** to the FB **Circuit breaker**

Fault recording and logging are not affected by the setting.

6.13.3.2 Application and Setting Notes

Indication: *`Ground fault`*

To indicate the ground fault and its direction via the protocol, Siemens recommends using the indication *`(_:2311:302) Ground fault`*. The indication contains the direction information, independent of the parameterized working direction of a stage. And this indication is also stabilized against a flood of indications in case of an intermittent ground fault.

Parameter: `Decay time V0`

- Recommended setting value **`(_:2311:101) Decay time V0`** = *`0.10 s`*

With the **`Decay time V0`** parameter, you specify the time slot for the detection of a fault extinction. If V0 continuously falls within this time, fault extinction is detected and the indication *`Flt. extinction det.`* is issued.

Siemens recommends using the default setting.

Parameter: `Dropout delay`

- Recommended setting value **`(_:2311:102) Dropout delay`** = ***`1.00 s`***

To avoid chattering of the indication *Ground fault* during an intermittent ground fault and thus a frequent opening and closing of the ground-fault log, the dropout of the indication *Ground fault* (and thus the closing of the log) can be delayed by the **`Dropout delay`**.

Siemens recommends using the default setting.

Using the default setting ensures that no flood of indications arises in case of an intermittent ground fault for the indication *Ground fault*. The intermittent ground fault is then treated as a ground fault, and the stabilization of the indication *Ground fault* can thus take action.

Angle-Error Compensation of the Core Balance Current Transformer

- Default setting **`(_:2311:103) Core balance CT- current 1`** = ***`0.050 A`***
- Default setting **`(_:2311:104) Core balance CT- current 2`** = ***`1.000 A`***
- Default setting **`(_:2311:105) CT angle error at I1`** = ***`0.0°`***
- Default setting **`(_:2311:106) CT angle error at I2`** = ***`0.0°`***

The high reactive-power factor in the arc-suppression-coil-ground system and the unavoidable air gap of the core balance current transformer often make necessary a compensation of the angle error of the core balance current transformer. For the burden actually connected, the maximum angle error **`CT angle error at I1`** and the corresponding secondary current **`Core balance CT- current 1`** as well as a further operating point **`CT angle error at I2`**/**`Core balance CT- current 2`** are entered, from which point the angle error no longer changes appreciably.

In the isolated or grounded system, angle compensation is not necessary.

Parameter: `Block. group indications`

- Default setting **`(_:2311:119) Block. group indications`** = ***`no`***

The **`Block. group indications`** parameter supports in applying the **Sensitive ground-fault detection** function as a supervision function. If you set this parameter to ***`yes`***, the following indications are blocked:

- The group indications of the function and the corresponding group indications of the function group are blocked.

  Consequently, the group-indications of the function group are then related to short-circuit protection functions and can be forwarded to a station controller in the meaning of short-circuit protection.
- The trip command from the **Directional sensitive ground-fault detection** function to the FB **Circuit breaker** is blocked.

Fault recording and logging are not affected by the setting.

Parameter: `Network topology`

- Default setting **`(_:2311:121) Network topology`** = ***`ring/meshed`***

This parameter is only used in the **Directional transient ground-fault** stage.

With the **`Network topology`** parameter, you set the network topology with reference to the network section to be protected by the individual device.

Network Topology	Description
`ring/meshed`	The device is applied in a meshed system or a closed feeder ring.
`radial`	The device is applied in a single feeder with radial topology. This setting has to be also selected if parallel feeders are closed rings, as long as the own feeder is single.

6.13.3.3 Settings

Directional sensitive ground-fault detection

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:121	General:Network topology		• ring/meshed • radial	ring/meshed
_:2311:101	General:Decay time V0		0.03 s to 0.20 s	0.10 s
_:2311:102	General:Dropout delay		0.00 s to 60.00 s	1.00 s
_:2311:103	General:Core balance CT- current 1	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:2311:104	General:Core balance CT- current 2	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:2311:105	General:CT angle error at I1		0.0° to 5.0°	0.0°
_:2311:106	General:CT angle error at I2		0.0° to 5.0°	0.0°
_:2311:119	General:Block. group indications		• no • yes	no

Non-directional sensitive ground-fault detection

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:102	General:Dropout delay		0.00 s to 60.00 s	1.00 s
_:2311:119	General:Block. group indications		• no • yes	no

6.13.3.4 Information List

Directional sensitive ground-fault detection

No.	Information	Data Class (Type)	Type
General			
_:2311:302	General:Ground fault	ACD	O
_:2311:303	General:Flt. extinction det.	SPS	O
_:2311:309	General:Pos. measuring window	SPS	O
_:2311:301	General:Phi(I,V)	MV	O
_:2311:306	General:IN	MV	O
_:2311:307	General:V0	MV	O
_:2311:311	General:IN act.	MV	O

No.	Information	Data Class (Type)	Type
_:2311:312	General:IN react.	MV	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O

Non-directional sensitive ground-fault detection

No.	Information	Data Class (Type)	Type
General			
_:2311:302	General:Ground fault	ACD	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O

6.13.4 Directional 3I0 Stage with Cos φ or Sin φ Measurement

6.13.4.1 Description

Logic

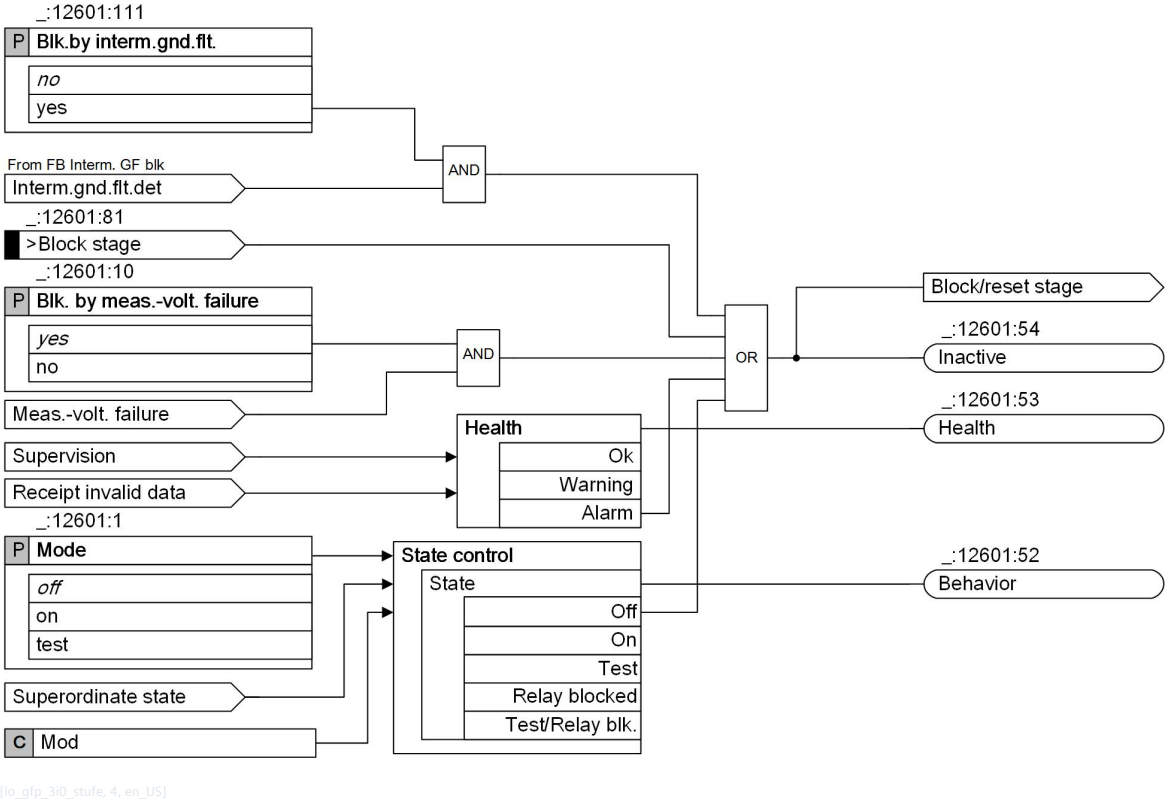
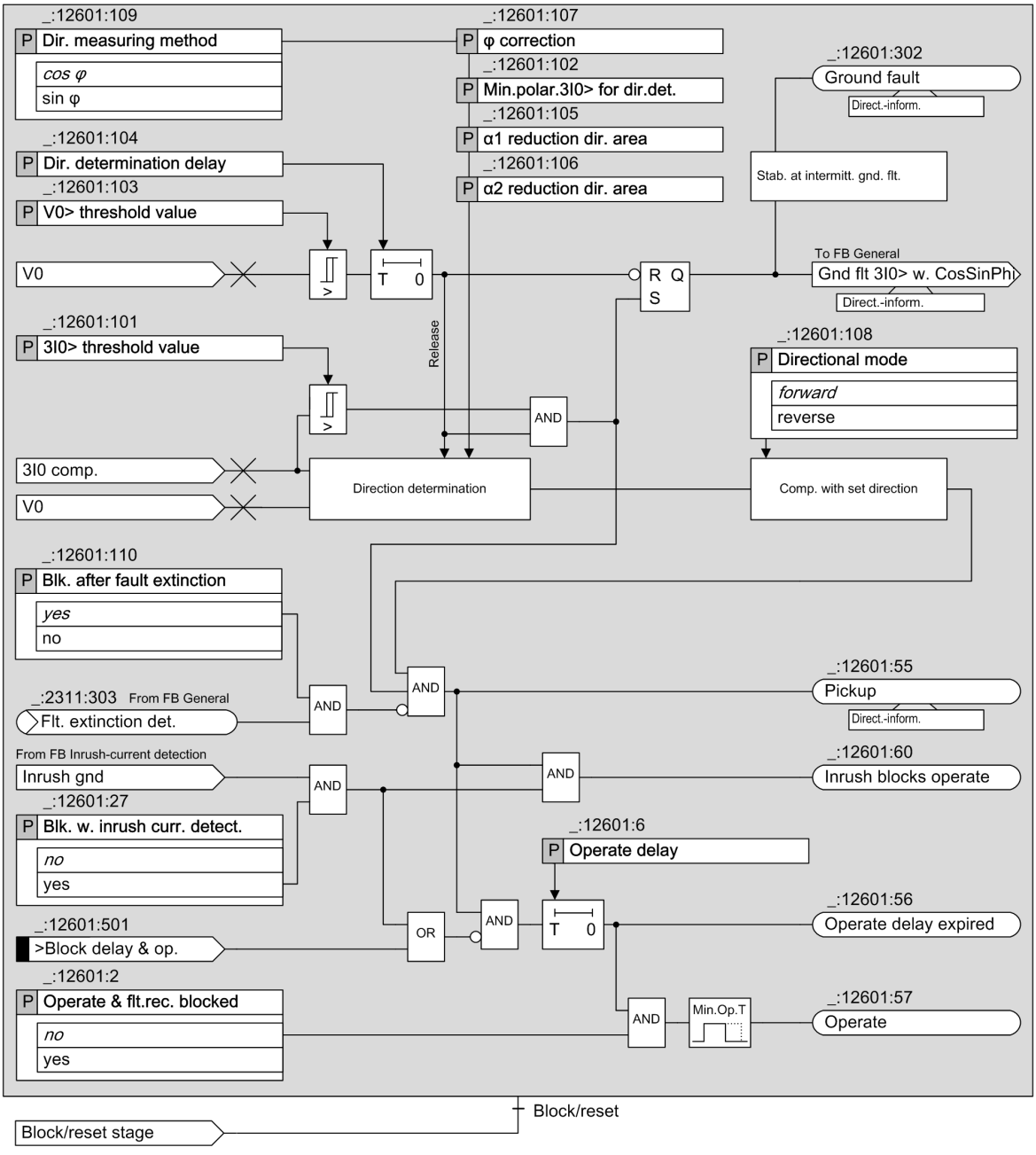


Figure 6-243 Logic Diagram of the Stage Control



[lo_gfp_3i0f, 5, en_US]

Figure 6-244 Logic Diagram of the Directional 3I0 Stage with Cos φ or Sin φ Measurement

Measured Value V0, Method of Measurement

The device can measure the residual voltage at the broken-delta winding. The measured voltage VN is converted to a value with reference to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, Method of Measurement

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary

ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

Depending on the setting of the **Connection type** parameter of the measuring point **I-3ph** as well as the current terminal block used, the following different linearity and settings ranges result in addition to the common application:

Connection Type of the Measuring Point I-3ph	Current Threshold 3I0/IN	Current Terminal Block	3I0 Threshold Value Settings Range (Secondary) [42]
3-phase	Calculated 3I0[43]	4 × protection	0.030 A to 35.000 A
		3 × protection, 1 × sensitive	0.030 A to 35.000 A
		4 × measurement	0.001 A to 1.600 A
3-phase + IN 3-phase + IN-separate 2ph, 2p. CT + 2 IN-sep	Measured IN[44]	4 × protection	0.030 A to 35.000 A
		4 × measurement	0.001 A to 1.600 A
	Measured IN and calculated 3I0 when IN > 1.6 A	3 × protection, 1 × sensitive	0.001 A to 35.000 A
3ph,2prim.CT + IN-sep 2ph, 2p. CT + IN-sep	Measured IN	4 × protection	0.030 A to 35.000 A
		4 × measurement	0.001 A to 1.600 A
		3 × protection, 1 × sensitive	0.001 A to 1.600 A

With the use of the function within a 1-phase function group and therefore at a 1-phase measuring point **I-1ph**, the following different linearity and settings ranges result:

Measuring Point I-1ph	Current Threshold	Current Terminal Block	3I0 Threshold Value Settings Range (Secondary) [45]
	Measured	Sensitive	0.001 A to 1.600 A
		Protection	0.030 A to 35.000 A

The method of measurement processes the sampled current values and filters out the fundamental component numerically.

The methods of measurement are characterized by high accuracy and by insensitivity to harmonics, especially the 3rd and 5th harmonics frequently present in the ground-fault (residual) current.

Ground-Fault Detection, Pickup

If the absolute value of the ground current 3I0 exceeds the threshold value **3I0> threshold value** and the absolute value of the zero-sequence voltage V0 exceeds the threshold value **V0> threshold value**, the stage recognizes the ground fault. The direction determination (see the next paragraph) is started when the V0 threshold value is exceeded. The direction result is indicated via the *Ground fault* signal (in the **General** function block). If the direction result equals the parameterized direction (parameter **Directional mode**), the stage picks up.

Direction Determination

Exceeding the threshold values by the zero-sequence voltage V0 is a criterion for the ground fault. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the **Dir. determination delay** parameter to achieve steady-state measurands. The result form the direction determination is only valid if the absolute value of the ground current 3I0 has also exceeded its threshold value.

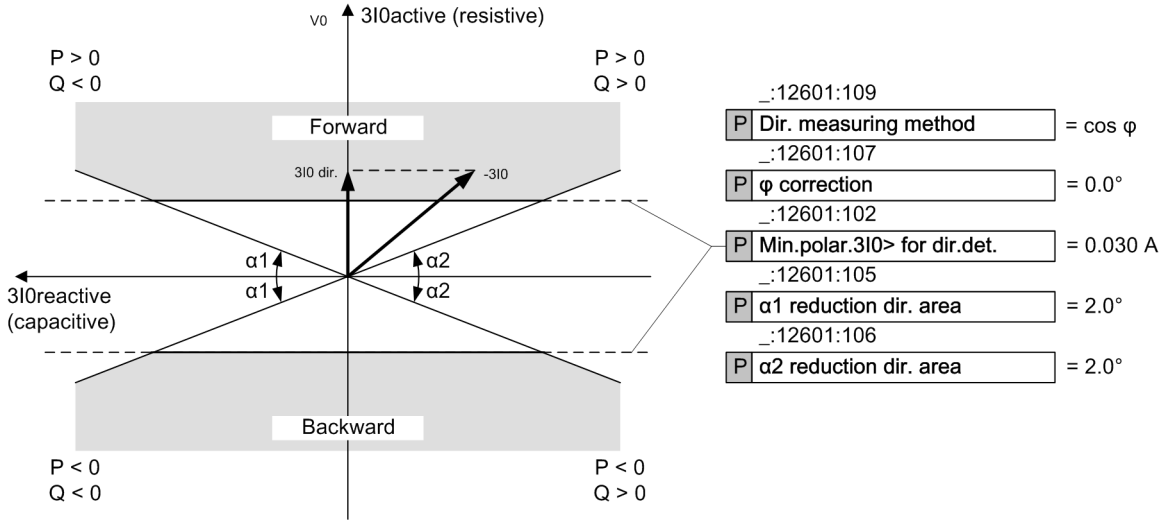
42 These values apply for a secondary rated current of 1 A. For a secondary rated current of 5 A, the values must be multiplied by 5.

43 If the connection type is without IN, such as 3-phase, the current threshold value is a calculated 3I0 value.

44 If the connection type is with IN, such as 3-phase + IN, the current threshold value is a measured IN value.

45 These values apply for a secondary rated current of 1 A. For a secondary rated current of 5 A, the values must be multiplied by 5.

The following figure shows an example of the direction determination in the complex phasor diagram for the cos-φ direction measurement method with a correction value of the direction straight lines from 0 (parameter **φ correction**). The example is suitable for the determination of the ground-fault direction in an arc-suppression-coil-ground system where the variable 3I0 · cos φ is decisive for the direction determination.



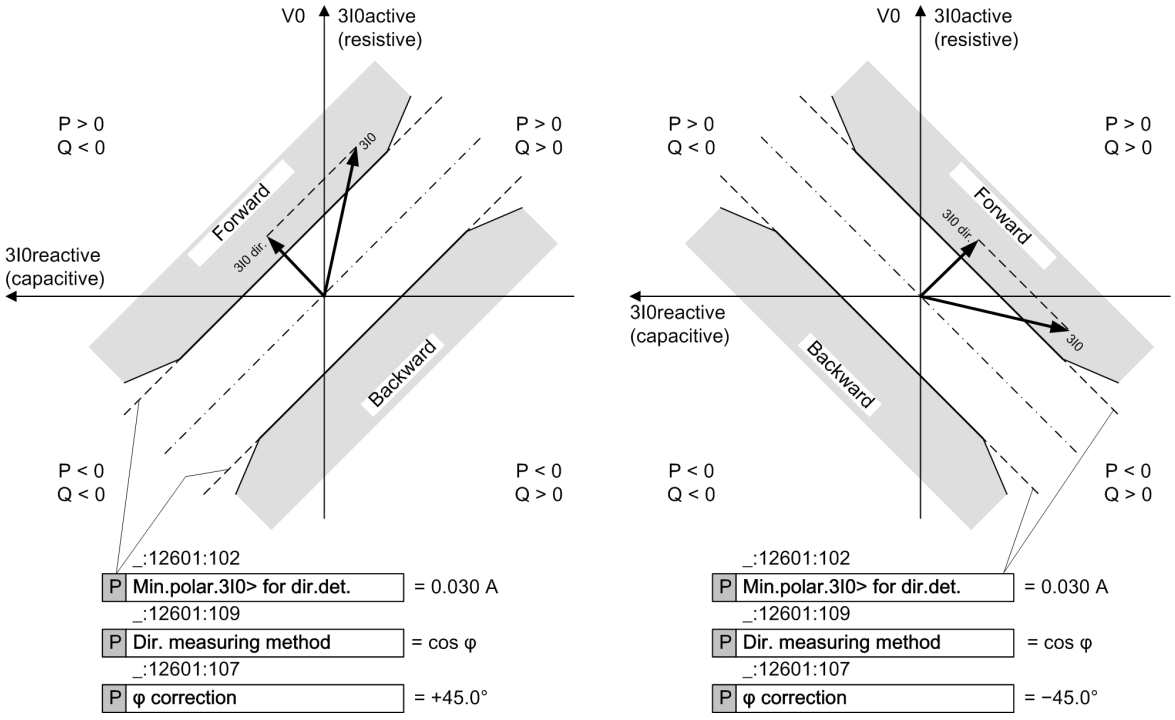
[dw_cosphi, 3, en_US]

Figure 6-245 Direction-Characteristic Curve with Cos φ Measurement

The zero-sequence voltage V0 is basically the reference value for the real axis. The axis of symmetry of the direction-characteristic curve coincides with the 3I0reactive axis for this example. For the direction determination, basically the portion of the current vertical to the set direction-characteristic curve (= axis of symmetry) is decisive (3I0 dir.). In this example, this is the active portion 3I0active of the current 3I0. The current 3I0dir. (here = 3I0active) is calculated and compared with the setting value **Min.polar.3I0> for dir.det.**. If the current 3I0 dir. exceeds the positive setting value, the direction is forward. If the current 3I0 dir. exceeds the negative setting value, the direction is backward. In the range in between, the direction is undetermined.

With the **α1 reduction dir. area** and **α2 reduction dir. area** parameters, you can limit the forward and backward ranges as shown in the figure. With this, the direction determination is secured in case of high currents in the direction of the axis of symmetry.

The symmetry axis can be turned via a correction angle **φ correction** parameter) in a range of ±45°. Through this, it is possible, for example, to attain the greatest sensitivity in grounded systems in the resistive-inductive range with a -45° turn. In the case of electric machines in busbar connection on the isolated system, the greatest sensitivity in the resistive-capacitive range can be attained with a rotation of +45°.

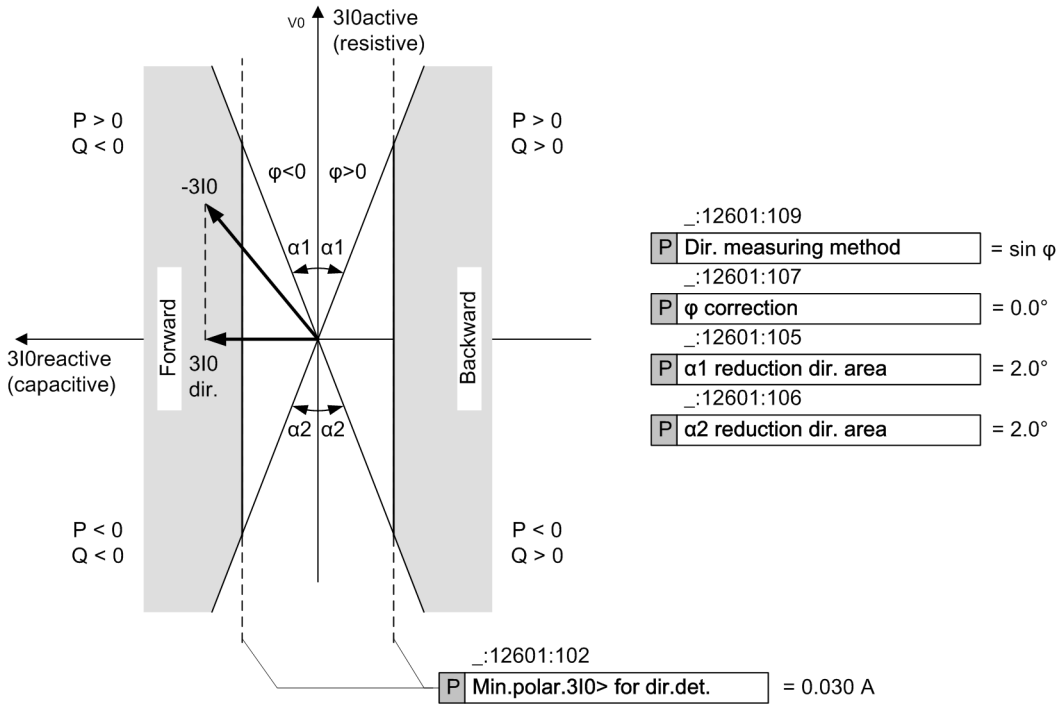


[dw_phicor, 2, en_US]

Figure 6-246 Turning the Direction-Characteristic Curves with Cos φ Measurement with Angle Correction

If you set the **Dir. measuring method** parameter to ***sin φ*** and the **φ correction** parameter to ***0***, the symmetry axis of the direction-characteristic curve coincides with the 3I0active axis and the V0 axis. Since the portion of the current vertical to the direction-characteristic curve (= axis of symmetry) is decisive (3I0dir.), here, the current 3I0reactive is included in the direction determination. If the current 3I0dir. (here = 3I0reactive) exceeds the negative setting value **Min.polar.3I0> for dir.det.**, the direction is forward. If the current 3I0dir. exceeds the positive setting value, the direction is backward. In the range in between, the direction is undetermined.

This direction measurement thus is appropriate for the determination of ground-fault direction in isolated systems.



[dw_sin_phi, 4, en_US]

Figure 6-247 Direction-Characteristic Curve with Sin φ Measurement

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **Voltage-transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker.

The **Blk. by meas.-volt. failure** parameter can be set so that Measuring-voltage failure detection blocks the stage or does not block it.

Blocking the Stage in Case of an Intermittent Ground Fault

In case of an intermittent ground fault, the stage can be blocked upon receiving the internal signal *Interm.gnd.flt.det* from the **Intermittent ground-fault blocking** stage. In the event of blocking, the picked-up stage will be reset.

After the release of the blocking, the timer **Dir. determination delay** is newly started and must expire before a new ground fault or pickup is annunciated.

With the **Blk.by interm.gnd.flt.** parameter, you can enable or disable the blocking of the stage in case of an intermittent ground fault.

Blocking the Pickup with Detection of the Fault Extinction

Using the evaluation of the instantaneous value developing of the zero-sequence voltage, the fault extinction can be recognized faster than via the dropout of the V0 fundamental-component value under the pickup value. The pickup of the stage is blocked with the fast detection of the fault extinction. With this, the pickups

are avoided due to the decay procedure in the zero-sequence system after the fault extinction. With the **Blk. after fault extinction** parameter, you enable or disable this accelerated detection of the fault extinction.

Blocking the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking of the Tripping by Device-Internal Inrush-Current Detection

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started. After that time, the stage operates.

6.13.4.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting **(_:12601:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:12601:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). If V0 is calculated from the phase-to-ground voltages, Siemens recommends using the blocking.
no	The protection stage is not blocked. If V0 is obtained from the VN measurement of a broken-delta winding, Siemens recommends not using the blocking.

Parameter: Blk. w. inrush curr. detect.

- Recommended setting value **(_:12601:27) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you specify whether the operate is blocked during detection of an inrush current.

Siemens recommends disabling the blocking. The fundamental component of the zero-sequence voltage is a reliable criterion for the ground fault and remains unaffected by a switching-on procedure.

Parameter: Blk.by interm.gnd.flt.

- Default setting **(_:12601:111) Blk.by interm.gnd.flt.** = ***no***

With the **Blk.by interm.gnd.flt.** parameter, you specify whether the stage is blocked upon receiving an internal signal *Interm.gnd.flt.det* from the **Intermittent ground-fault blocking** stage.

During intermittent ground faults, stages designed for detecting permanent ground faults (based on continuous RMS measurement) tend to generate a flood of signals and probably even temporary wrong directional information. This can be avoided by blocking these stages in case of an intermittent ground fault.

If intermittent ground faults in your network are probable, Siemens recommends enabling the blocking.

Parameter: `Blk. after fault extinction`

- Recommended setting value **`(_:12601:110) Blk. after fault extinction`** = ***`yes`***

If the **`Blk. after fault extinction`** parameter is set to ***`yes`***, the pickup is blocked after detection of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero-sequence system after the fault extinction. Siemens recommends using the default setting.

Parameter: `Directional mode`

- Default setting **`(_:12601:108) Directional mode`** = ***`forward`***

When a fault is detected, the selection of the parameter **`Directional mode`** defines whether the pickup of the stage occurs in forward or backward direction.

Parameter: `Dir. measuring method, φ correction, Min.polar.3I0> for dir.det., 3I0> threshold value`

- Default setting **`(_:12601:109) Dir. measuring method`** = ***`cos φ`***
- Default setting **`(_:12601:107) φ correction`** = ***`0.0°`***
- Default setting **`(_:12601:102) Min.polar.3I0> for dir.det.`** = ***`0.030 A`***
- Default setting **`(_:12601:101) 3I0> threshold value`** = ***`0.050 A`***

These parameters are used to define the direction characteristic of the stage. The direction characteristic to use is dependent on the neutral-point treatment of the system.

Note that, for the direction determination, basically only a portion of the current vertical to the set direction-characteristic curve (3I0dir.) is decisive, refer to *6.13.4.1 Description*. This portion of the current is compared to the threshold value **`Min.polar.3I0> for dir.det.`**. In contrast, the absolute value of the current 3I0 is compared with the **`3I0> threshold value`** parameter.

System Type/ Neutral-Point Treatment	Description
Arc-suppression coil grounded	In the arc-suppression-coil-ground system, the watt-metric residual current 3I0 · cos φ of the arc-suppression coil is decisive for the direction determination. To evaluate the watt-metric residual current, set the parameters as follows: • **Dir. measuring method** = ***cos φ*** • **φ correction** = ***0.0°*** The direction determination for a ground fault is made more difficult in that a much larger capacitive or inductive reactive current is superimposed on the small watt-metric residual current. Therefore, depending on the system configuration and the fault evaluation, the total ground current supplied to the device can vary considerably in its values regarding the magnitude and the phase angle. However, the device should only evaluate the active component of the ground-fault current. This requires extremely high accuracy, particularly regarding the phase-angle measurement of all the instrument transformers. Furthermore, the device must not be set to operate too sensitively. A reliable direction measurement can only be expected with connection to a core balance current transformer. For the setting of the **Min.polar.3I0> for dir.det.** parameter, the rule of thumb is: Set the pickup value only to half of the expected measuring current as only the watt-metric residual current can be put into use. The **3I0> threshold value** parameter can also be set to half of the expected measuring current, whereby here the entire zero-sequence current can be put to use.
Isolated	In the isolated system, the capacitive ground reactive current 3I0 · sin φ is decisive for the direction determination. To evaluate the capacitive ground reactive current, set the parameters as follows: • **Dir. measuring method** = ***sin φ*** • **φ correction** = ***0.0°*** In an isolated system, the capacitive ground-fault currents of the entire electrically connected system flow through the measuring point in case of a ground fault. The ground current of the faulty feeder is compensated in the measuring point. As the pickup value of the **Min.polar.3I0> for dir.det.** and **3I0> threshold value** parameters, select about half of this capacitive ground-fault current flowing via the measuring point.
Resistance-Grounded	In the resistance-grounded system, the ohmic-inductive ground-fault current is decisive for the direction determination. To evaluate this short-circuit current, set the parameters as follows: • **Dir. measuring method** = ***cos φ*** • **φ correction** = ***-45.0°*** Set the **Min.polar.3I0> for dir.det.** and **3I0> threshold value** parameters to a value below the minimum ground-fault current to be expected.

Parameter: α1 reduction dir. area, α2 reduction dir. area

- Recommended setting value **(_:12601:105) α1 reduction dir. area** = ***2°***
- Recommended setting value **(_:12601:106) α2 reduction dir. area** = ***2°***

With the **α1 reduction dir. area** and **α2 reduction dir. area** parameters, you specify the angle for the limitation of the direction range. Siemens recommends using the default setting of 2°.

In an arc-suppression-coil-ground system in feeders with a very large reactive current, it can be practical to set a somewhat larger angle α1 to avoid a false pickup based on transformer and algorithm tolerances.

Parameter: V0> threshold value

- Default setting **(_:12601:103) V0> threshold value** = ***30.000 V***

The **V0> threshold value** parameter allows you to set the zero-sequence voltage sensitivity of the stage. Set the threshold value smaller than the minimum absolute value of the zero-sequence voltage V0 that must still be detected.

Parameter: Dir. determination delay

- Default setting **(_:12601:104) Dir. determination delay** = ***0.00 s***

The start of the ground fault normally shows a significant transient behavior. This can lead to an incorrect direction decision. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the **Dir. determination delay** parameter to achieve steady-state measurands. The duration of the transient cycle is determined from the system conditions and the respective fault characteristics. If you have no knowledge of a suitable time delay, Siemens recommends keeping the default setting.

Parameter: Operate delay

- Default setting **(_:12601:6) Operate delay** = ***2.0 s***

The **Operate delay** parameter determines the time during which the pickup conditions must be met to issue the operate indication. The operate indication is issued when this time expires.

6.13.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
3I0> cos/sinφ1				
_:12601:1	3I0> cos/sinφ1:Mode		• off • on • test	off
_:12601:2	3I0> cos/sinφ1:Operate & flt.rec. blocked		• no • yes	no
_:12601:10	3I0> cos/sinφ1:Blk. by meas.-volt. failure		• no • yes	yes
_:12601:111	3I0> cos/sinφ1:Blk.by interm.gnd.flt.		• no • yes	no
_:12601:27	3I0> cos/sinφ1:Blk. w. inrush curr. detect.		• no • yes	no
_:12601:110	3I0> cos/sinφ1:Blk. after fault extinction		• no • yes	yes
_:12601:108	3I0> cos/sinφ1:Directional mode		• forward • reverse	forward
_:12601:109	3I0> cos/sinφ1:Dir. measuring method		• cos φ • sin φ	cos φ
_:12601:107	3I0> cos/sinφ1:φ correction		-45° to 45°	0°
_:12601:102	3I0> cos/sinφ1:Min.polar.3I0> for dir.det.	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 35.000 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 35.000 A	0.150 A

Addr.	Parameter	C	Setting Options	Default Setting
_:12601:105	3I0> cos/sinφ1:α1 reduction dir. area		1° to 15°	2°
_:12601:106	3I0> cos/sinφ1:α2 reduction dir. area		1° to 15°	2°
_:12601:101	3I0> cos/sinφ1:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 35.000 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 35.000 A	0.250 A
_:12601:103	3I0> cos/sinφ1:V0> threshold value		0.300 V to 200.000 V	30.000 V
_:12601:104	3I0> cos/sinφ1:Dir. determination delay		0.00 s to 60.00 s	0.10 s
_:12601:6	3I0> cos/sinφ1:Operate delay		0.00 s to 60.00 s	2.00 s

6.13.4.4 Information List

No.	Information	Data Class (Type)	Type
3I0> cos/sinφ1			
_:12601:81	3I0> cos/sinφ1:>Block stage	SPS	I
_:12601:501	3I0> cos/sinφ1:>Block delay & op.	SPS	I
_:12601:54	3I0> cos/sinφ1:Inactive	SPS	O
_:12601:52	3I0> cos/sinφ1:Behavior	ENS	O
_:12601:53	3I0> cos/sinφ1:Health	ENS	O
_:12601:60	3I0> cos/sinφ1:Inrush blocks operate	ACT	O
_:12601:302	3I0> cos/sinφ1:Ground fault	ACD	O
_:12601:55	3I0> cos/sinφ1:Pickup	ACD	O
_:12601:56	3I0> cos/sinφ1:Operate delay expired	ACT	O
_:12601:57	3I0> cos/sinφ1:Operate	ACT	O

6.13.5 Directional Transient Ground-Fault Stage

6.13.5.1 Description

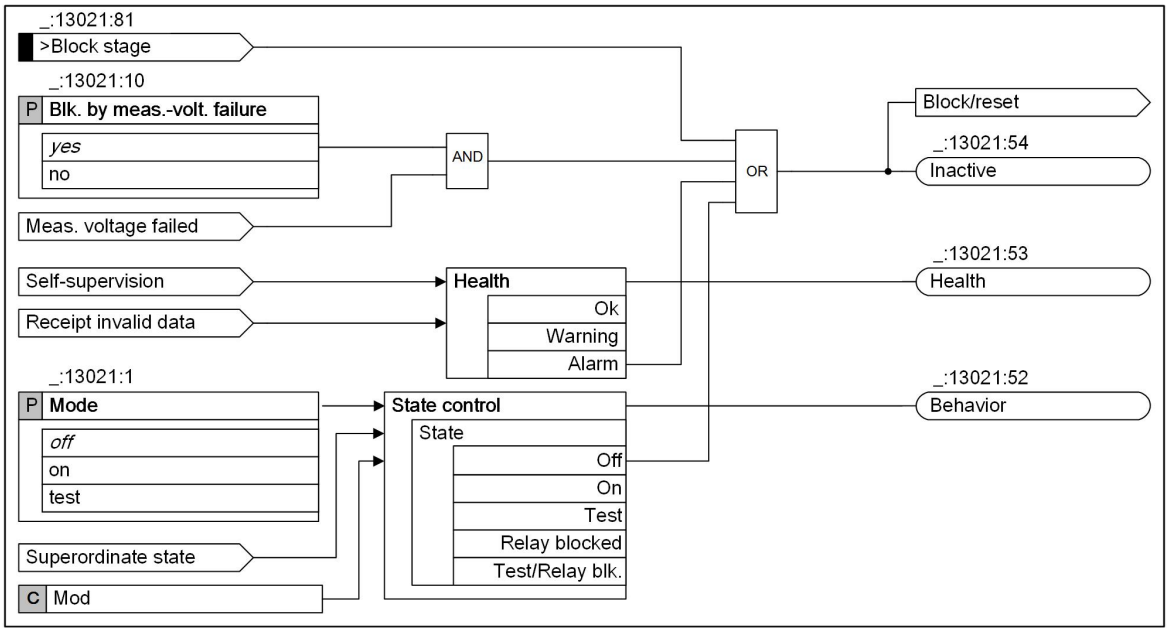
Overview

Ground faults occurring in arc-suppression-coil-ground systems often extinguish a short time after the ignition, mostly within a few milliseconds. Such transient occurrences are called transient ground faults. In order to detect the ground-fault direction, based on these transient occurrences, a special method of measurement is required that can also capture high frequencies. Conventional methods based on phasor calculations are not suitable. Even for ground faults lasting for a short time, usually, a high-frequency charging process occurs in healthy phases. The transient charging process is evaluated by an energy-integrating method to determine the ground-fault direction. This method ensures high sensitivity and positive stability against parasitic signals in the zero-sequence system.

Since permanent ground faults also start with the transient charging process in healthy phases, those errors will be detected as well.

This stage is most suitable for the use in closed loops or meshed systems. Operational, circulating zero-sequence currents are eliminated and therefore, cannot affect the directional result.

Stage-Control Logic



[lo_stu_wis, 3, en_US]

Figure 6-248 Logic Diagram of the Stage Control

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

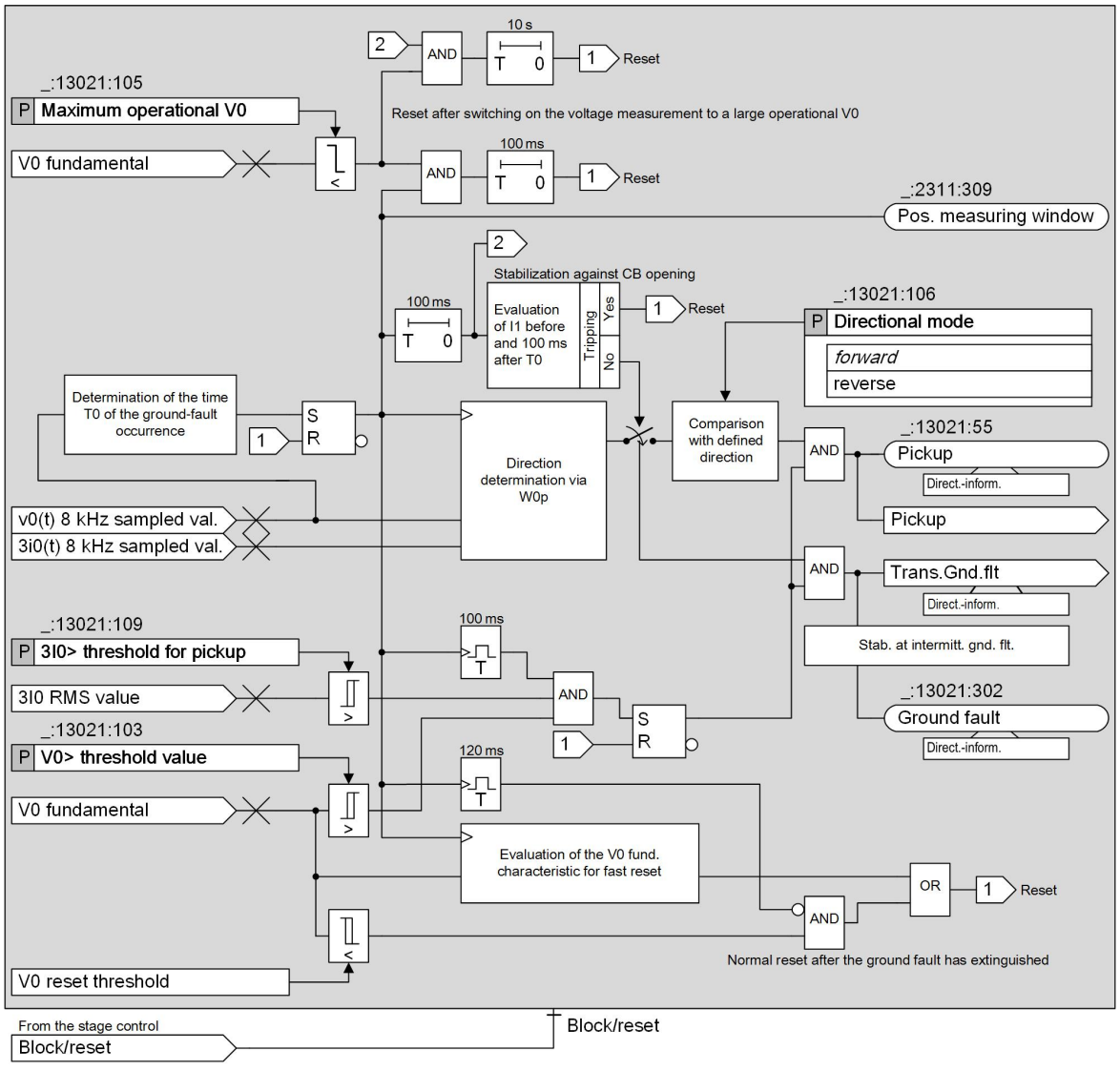
Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker.

The **`Blk. by meas.-volt. failure`** parameter can be set so that **measuring-voltage failure detection** blocks the stage or not.

Logic of the Transient Ground-Fault Functionality



[lo_wisfut, 10, en_US]

Figure 6-249 Logic Diagram of the Directional Transient Ground-Fault Stage

Measured Values, Method of Measurement

The zero-sequence voltage and zero-sequence current are measured directly or calculated from the phase variables. When measuring directly, the following is detected:

- Zero-sequence voltage on the broken-delta winding
- Zero-sequence current via Holmgreen connection or via core balance current transformer

The voltage measured on the broken-delta winding will be converted to the zero-sequence voltage V_0.

The instantaneous values of the zero-sequence voltage v0(t) that are sampled at a high frequency (8 kHz) serve to determine the point in time of the ground fault occurrence T0.

The instantaneous values of the zero-sequence voltage v0(t) and the ground current 3i0(t), which are sampled at a high frequency (8 kHz), are the basis for direction determination.

The fundamental-component values of the zero-sequence voltage V0 serve to release the directional result and the pickup as well as a criterion for the stabilization against switching operations.

The positive-sequence system (if it exists as a measured value) serves as an additional criterion for the stabilization against switching operations.

The fundamental-component value of V0 and the true RMS value of 3I0 will be used for the pickup and the optional trip logic.

Operational, meaning circulating zero-sequence currents, can occur in closed loops or meshed systems. This type of zero-sequence current is also present in case of a failure and can falsify the directional result. Therefore, an operational zero-sequence current is eliminated.

Determining the Time of the Ground-Fault Ignition

The algorithm uses the evaluation of the instantaneous values of the zero-sequence voltage to verify continuously whether a ground fault occurred. This takes place regardless of whether the set threshold value for V0 is exceeded. If a ground fault occurs, the measuring window for determining the direction is positioned and the direction determination is performed. The position of the measuring window is logged via the indication *Pos. measuring window* (in FB **General**). The precise identification of the time T0 at which the ground fault occurs is decisive for the correct direction determination.

Determination of Direction, Method of Measurement

The active energy of the zero-sequence system is calculated for the direction determination. Once the ground-fault occurrence has been detected, the active energy will be calculated across approximately 1 cycle frequency. If the active energy of the zero-sequence system is negative, a forward fault is present; otherwise it is a backward fault.

Directional Ground-Fault Signal, Pickup

Determining the time of the ground-fault ignition and the direction is always done with maximum sensitivity. With the parameters **V0> threshold value** and **3I0> threshold for pickup**, you define the sensitivity for the indication of the direction and the pickup of the stage.

If both of the following conditions are met, the direction result will be reported:

- The fundamental-component value of the zero-sequence voltage V0 exceeds the **V0> threshold value** within 100 ms after detecting the ground-fault ignition.
- The true RMS value of the zero-sequence current 3I0 exceeds the **3I0> threshold for pickup**.

In this way, high-impedance ground faults are also reported in which the zero-sequence system values rise only slowly, and, for this reason, the occurrence of the ground fault is detected noticeably earlier than the exceedance of the parameterized threshold value.

The direction result will be reported to the function via the *(_:2311:302) Ground fault* of the function block **General information**. This indication is reported irrespective of the parameterized direction of the function.

If the determined direction corresponds with the parameterized direction (parameter **Directional mode**), a pickup occurs.

Reset of the Algorithm

To allow a new directional measurement, the algorithm needs to be reset. The normal reset takes place when all the following conditions are met:

- The fundamental component of the zero-sequence voltage V0 drops below the V0 reset threshold. This reset threshold is a small device-internal V0 threshold. It is also depending on an operational V0 and is thus a dynamic threshold. The threshold value is 2.0 V secondary without dynamic influence.
- The duration of 120 ms after T0 has expired.

Stabilization against Switching Operations

Switching operations in the system to be protected can cause transient signals in the zero-sequence system. The stage is stabilized against possible overfunction due to switching operations.

The following mechanisms are applied:

- The fundamental-component value of the zero-sequence voltage V0 is usually only marginal influenced by switching operations and is thus a good criterion for distinguishing the ground fault from a switching operation. The condition that the fundamental-component value must exceed the **`V0> threshold value`** for reporting the direction result effectively suppresses the influence of switching operations.

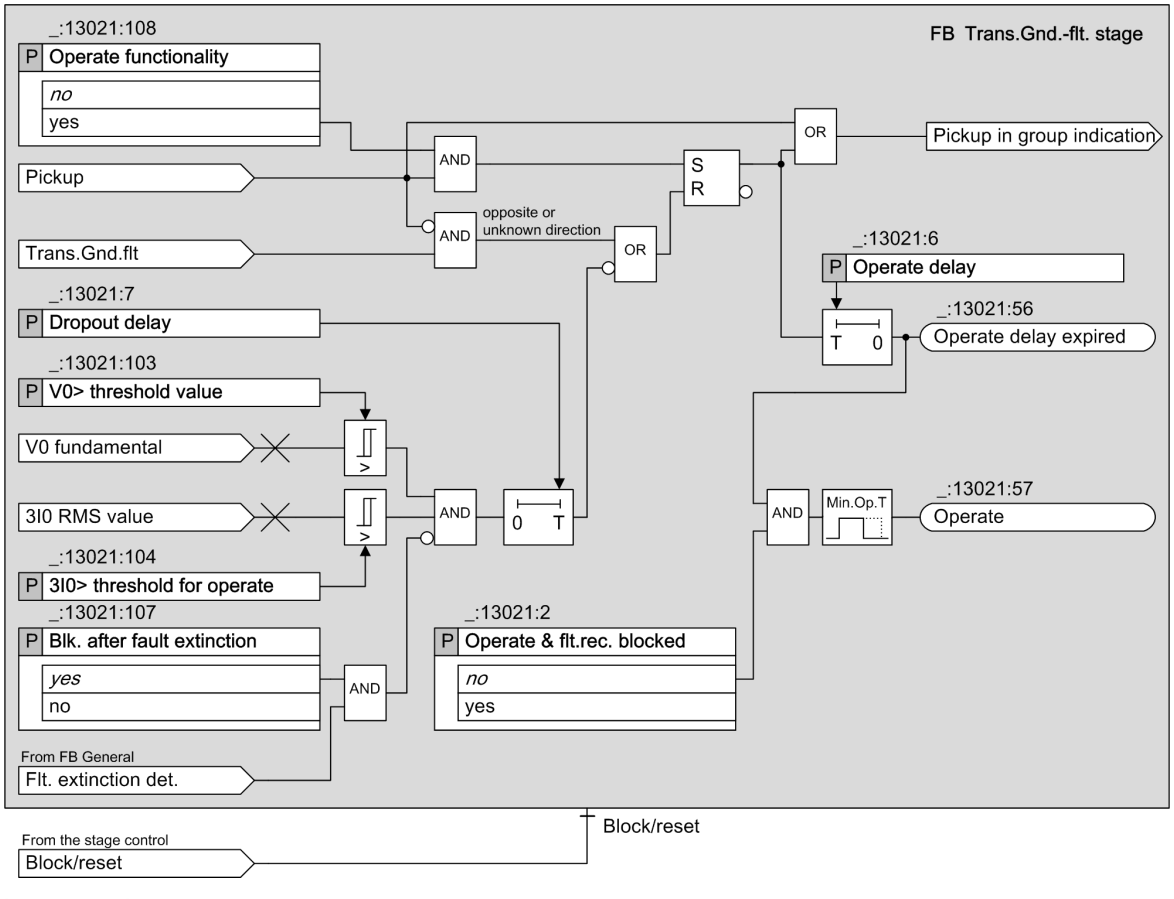
  For rare cases in which high zero-sequence voltages occur over longer time ranges after switching off the feeder or line, a criterion based on the positive-sequence current is also effective. This criterion compares the positive-sequence current before and after the transient event and thus detects a disconnection. In case of disconnection, the direction result is not reported.

  Through stabilization mechanisms, the direction result is reported 100 ms after the ground-fault ignition. Thus a pickup occurs with a 100-ms delay.

  If the stage is used in a 1-phase function group, the additional criterion via the positive-sequence current is not effective.

- The function detects transient ground faults using the zero-sequence voltage. In systems with operational zero-sequence voltages, if the measuring voltage is switched on, the function can internally be started. If the fundamental-component value of the zero-sequence voltage does not exceed the threshold of the **`Maximum operational V0`** parameter in a time slot of 100 ms after the function start, the function is reset internally. For an unexpected case where the function is started due to a switching transient event, a further reset criterion exists to ensure that the function does not permanently remain in the start condition. After the time of 100 ms, if the fundamental-component value is continuously less than the **`Maximum operational V0`** threshold for 10 s, the function is reset as well.

Trip Logic



[lo_auswis, 4, en_US]

Figure 6-250 Trip Logic Diagram

In many applications, the transient ground-fault stage is used only to indicate the direction. In this case, the trip logic is not required and remains disabled. However, this stage can also be used to trip a permanent ground fault. For this, you enable the optional trip logic with the **Operate functionality** parameter. If the fundamental-component value of V0 and the true RMS value of 3I0 exceed the set threshold values, the tripping delay (**Operate delay** parameter) starts with the pickup. If the parameter **Operate & flt.rec. blocked** is set to ***no***, the stage operates when the tripping delay expires.

An intermittent ground fault has the characteristics of periodical extinction and reignition within one half period up to several periods. You can find more information in chapter *6.11.1 Overview of Functions*. Due to the tripping delay and the too short fault durations (contact to ground), reliable tripping is not possible. To ensure reliable tripping under such conditions, the parameter **Dropout delay** can be used. When the fault extinguishes, the fundamental-component value of V0 and the true RMS value of 3I0 drop below the threshold values. A dropout can be delayed for a time specified with the **Dropout delay** parameter. The tripping delay continues to run. If the time delay expires within the dropout delay, the stage operates.
You can set the **Dropout delay** according to the application. The default setting is 0 s. The setting of the dropout delay does not affect the direction determination. When the fault reignites, a new direction determination takes place if the function has dropped out before. If the determined direction is opposite to the parameterized direction or is unknown, the tripping delay is reset immediately.

Blocking the Tripping Delay with Detection of the Fault Extinction

Using the evaluation of the instantaneous value cycle of the zero-sequence voltage, the fault extinction of the ground fault can be detected faster than via the dropout of the V0 fundamental-component value under the pickup value. The fast detection of the fault extinction (see function block **General information**) blocks the tripping delay after the dropout delay expires. With the parameter **Blk. after fault extinction**, this accelerated blocking mechanism can be enabled or disabled.

6.13.5.2 Application and Setting Notes

Parameter: Operate functionality

- Default setting **(_:13021:108) Operate functionality** = ***no***

If the transient ground-fault stage is used only to indicate the direction, this optional trip logic is not required and remains disabled. If the transient ground-fault stage is used to trip permanent faults as well, this optional trip logic must be enabled. Pickup of the stage will initiate the tripping delay.

Parameter: Operate & flt.rec. blocked

- Default setting **(_:13021:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:13021:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.
A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). If V0 is calculated from the phase-to-ground voltages, Siemens recommends using the blocking.
no	The protection stage is not blocked. If V0 is obtained from the VN measurement of a broken-delta winding, Siemens recommends not using the blocking.

Parameter: **Blk. after fault extinction**

- Recommended setting value **(_:13021:107) Blk. after fault extinction** = ***yes***

If the **Blk. after fault extinction** parameter is set to ***yes***, the tripping delay is reset after the detection of the fault extinction. Therefore, if the tripping delay is set for a short time, the possibility of an overfunction is avoided. The reason for an overfunction is a slower attenuation in the zero-sequence system following the fault extinction. Siemens recommends keeping this default setting if the stage is used for tripping.

To protect against intermittent ground faults, the stage uses the parameter **Dropout delay** to delay a dropout due to fault extinction. If you are using the stage for protection against intermittent ground faults, disable the blocking.

Parameter: **Directional mode**

- Default setting **(_:13021:106) Directional mode** = ***forward***

When a fault is detected, the selection of the parameter **Directional mode** defines whether the pickup of the stage occurs in forward or backward direction.

Parameter: **V0> threshold value**

- Default setting **(_:13021:103) V0> threshold value** = ***15.000 V***

With the parameter **V0> threshold value**, you define the sensitivity for the indication of the direction and the pickup of the stage.

Note that the sensitivity of the direction determination itself is not influenced. The direction determination always works with maximum sensitivity.

If high-resistive ground faults must also be reported, very sensitive settings are possible, for example, **V0> threshold value** = ***5 V*** secondary.

Parameter: **Maximum operational V0**

- Recommended setting value **(_:13021:105) Maximum operational V0** = ***3.000 V***

With the parameter **Maximum operational V0**, you define the maximum operational zero-sequence voltage V0. If the fundamental-component value of the zero-sequence voltage V0 does not exceed the parameter **Maximum operational V0** in a time slot of 100 ms after the function has started, the stage is reset.

The setting is made with reference to the zero-sequence voltage V0 according to its definition.

Network Structure	Description
Radial network	In radial networks, operational zero-sequence voltages are rather small. Siemens recommends using the default value of 3.000 V.
Ring network, meshed network	Greater operational zero-sequence voltages can occur in ring or meshed networks. The secondary operational zero-sequence voltages can be determined by reading the residual voltage $V_{N\,sec}$ or the zero-sequence voltage $V_{0\,sec}$ under the symmetrical components from the device or via DIGSI. In case you read the secondary residual voltage $V_{N\,sec}$, you convert it to $V_{0\,sec}$ with the **Matching ratio Vph / VN** parameter. For more information, see also *6.1.4 Application and Setting Notes for Measuring-Point Voltage 3-Phase (V-3ph)*. If $V_{0\,sec}$ is greater than 2.5 V, the value of **Maximum operational V0** shall be increased to $V_{0\,sec} \cdot 1.2$. Example: $V_{N\,sec}$ = 5.000 V **Matching ratio Vph / VN** = $\sqrt{3}$ $V_{0\,sec}$ = 5.000 V · $\sqrt{3}$ / 3 = 2.887 V **Maximum operational V0** = 2.887 V · 1.2 = 3.464 V In most cases, the operational zero-sequence voltages are smaller than 2.500 V. Siemens recommends using the default value of 3.000 V.

Parameter: 3I0> threshold for pickup

- Default setting **(_:13021:109) 3I0> threshold for pickup** = ***0.000 A***

With the parameter **3I0> threshold for pickup**, you define the sensitivity for the indication of the direction and the pickup of the stage.

In ring or meshed systems, you can use this parameter to reduce the number of ground-fault reporting devices. The parameter needs to be set according to the user experience on the specific network. For radial systems, normally you can keep the default value of 0 A which sets this parameter to inactive.

Parameter: 3I0> threshold for operate

- Default setting **(_:13021:104) 3I0> threshold for operate** = ***0.030 A***

The setting is significant only for optional trip logic for switching off permanent ground faults. Select the setting such that the static ground-fault current exceeds the threshold value. You can disable this criterion by setting the value to 0 A.

Parameter: Dropout delay

- Default setting **(_:13021:7) Dropout delay** = ***0.00 s***

The parameter **Dropout delay** allows you to use the function also as a protection against intermittent ground faults. With the parameter **Dropout delay**, the dropout of the pickup state after fault extinction is delayed or held until the next ignition. Thus, the operate delay can go on and trip the fault.

Set the time to a value within which the new ignition can still be assigned to the previous fault. Typical values are in a range between several hundred milliseconds and a few seconds.

Parameter: Operate delay

- Default setting **(_:13021:6) Operate delay** = ***0.50 s***

The **Operate delay** parameter determines the time during which the pickup conditions must be met to issue the operate indication. The operate indication is issued when this time expires.

The setting of the **Operate delay** depends on the specific application. Ensure that the pickup is delayed by 100 ms regarding the time of the ground-fault ignition.

6.13.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Trans.Gnd.flt1				
_:13021:1	Trans.Gnd.flt1:Mode		• off • on • test	off
_:13021:2	Trans.Gnd.flt1:Operate & flt.rec. blocked		• no • yes	no
_:13021:10	Trans.Gnd.flt1:Blk. by meas.-volt. failure		• no • yes	yes
_:13021:107	Trans.Gnd.flt1:Blk. after fault extinction		• no • yes	yes
_:13021:108	Trans.Gnd.flt1:Operate functionality		• no • yes	no
_:13021:106	Trans.Gnd.flt1:Direc-tional mode		• forward • reverse	forward
_:13021:103	Trans.Gnd.flt1:V0> threshold value		0.300 V to 200.000 V	15.000 V
_:13021:105	Trans.Gnd.flt1:Maximum operational V0		0.300 V to 200.000 V	3.000 V
_:13021:109	Trans.Gnd.flt1:3I0> threshold for pickup	1 A @ 100 Irated	0.000 A to 35.000 A	0.000 A
		5 A @ 100 Irated	0.00 A to 175.00 A	0.00 A
		1 A @ 50 Irated	0.000 A to 35.000 A	0.000 A
		5 A @ 50 Irated	0.00 A to 175.00 A	0.00 A
		1 A @ 1.6 Irated	0.000 A to 1.600 A	0.000 A
		5 A @ 1.6 Irated	0.000 A to 8.000 A	0.000 A
_:13021:104	Trans.Gnd.flt1:3I0> threshold for operate	1 A @ 100 Irated	0.000 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.00 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.000 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.00 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.000 A to 1.600 A	0.030 A
		5 A @ 1.6 Irated	0.000 A to 8.000 A	0.150 A
_:13021:6	Trans.Gnd.flt1:Operate delay		0.00 s to 60.00 s	0.50 s
_:13021:7	Trans.Gnd.flt1:Dropout delay		0.00 s to 60.00 s	0.00 s

6.13.5.4 Information List

No.	Information	Data Class (Type)	Type
Trans.Gnd.flt1			
_:13021:81	Trans.Gnd.flt1:>Block stage	SPS	I
_:13021:54	Trans.Gnd.flt1:Inactive	SPS	O
_:13021:52	Trans.Gnd.flt1:Behavior	ENS	O
_:13021:53	Trans.Gnd.flt1:Health	ENS	O
_:13021:302	Trans.Gnd.flt1:Ground fault	ACD	O
_:13021:55	Trans.Gnd.flt1:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:13021:56	Trans.Gnd.flt1:Operate delay expired	ACT	O
_:13021:57	Trans.Gnd.flt1:Operate	ACT	O

6.13.6 Directional 3I0 Stage with φ (V0,3I0) Measurement

6.13.6.1 Description

Logic

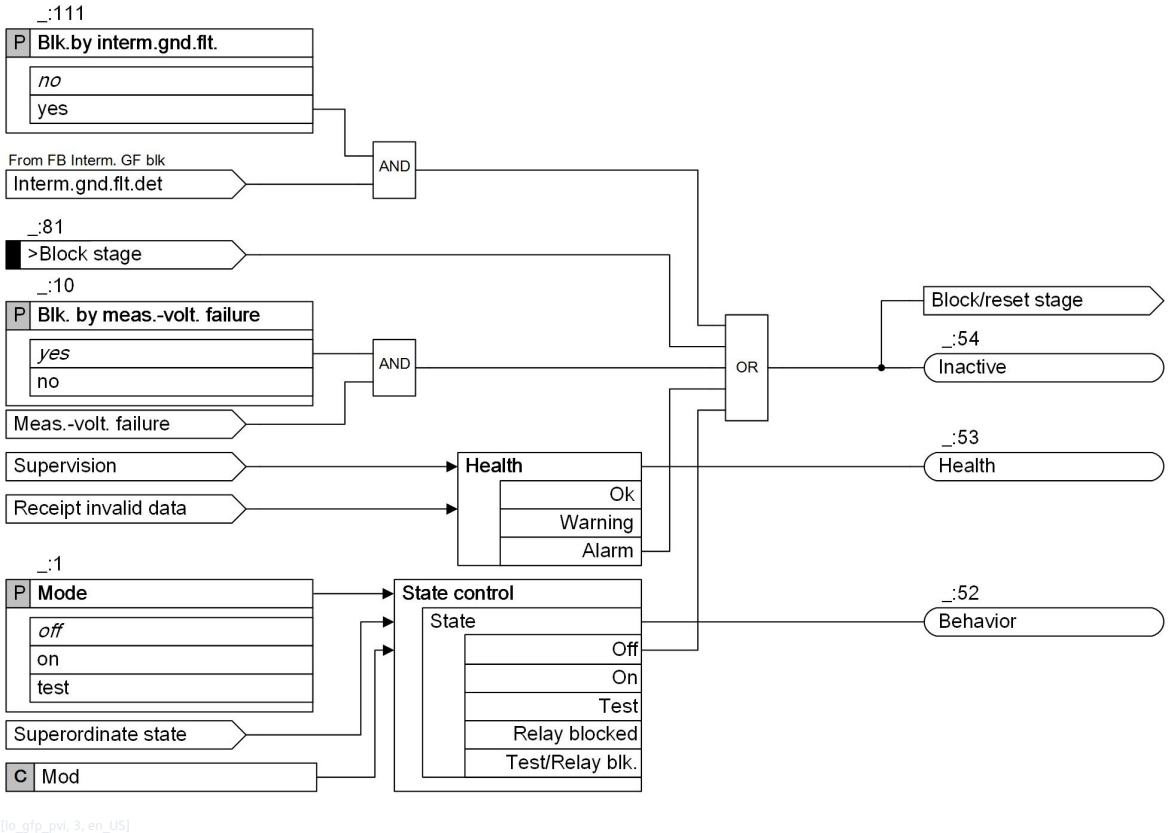
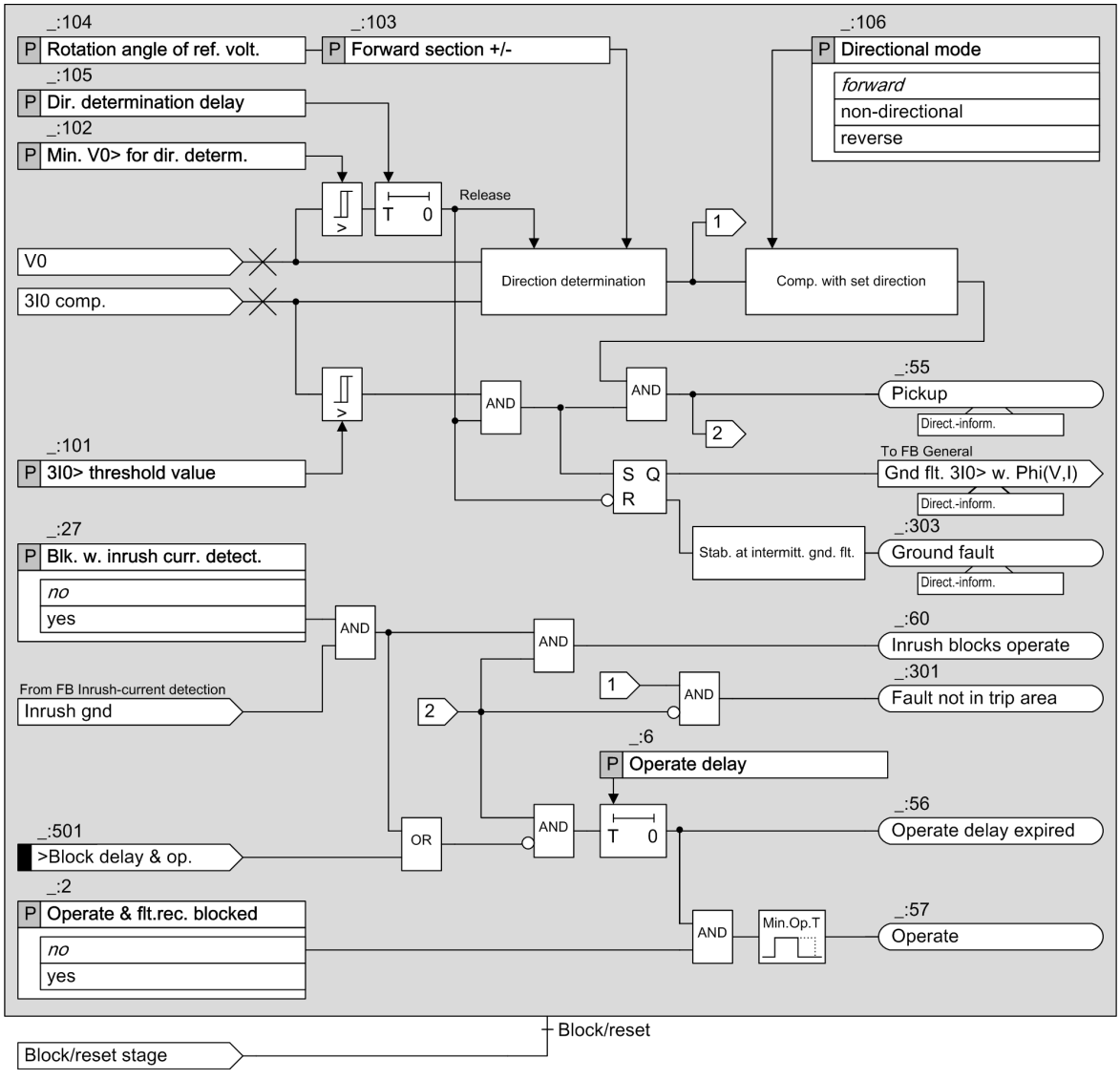


Figure 6-251 Logic Diagram of the Stage Control



[lo_dir sensGFP 3I0 phi VI, 1, en_US]

Figure 6-252 Logic Diagram of the Directional 3I0 Stage with φ (V0,3I0) Measurement

Measured Value V0, Method of Measurement

The device can measure the residual voltage at the broken-delta winding. The measured voltage is converted to a value with reference to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages VA, VB, and VC using the defining equation.

This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, Method of Measurement

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

The method of measurement processes the sampled current values and filters out the fundamental component numerically.

Depending on the connection type of the measuring point and on the current terminal blocks used, different linearity and setting ranges result. You can find more information in chapter *Measured Value 3I0, Method of Measurement , Page 897*.

Ground-Fault Detection, Pickup

If the absolute value of the ground current 3I0 vector exceeds the threshold value **3I0> threshold value** and the absolute value of the zero-sequence voltage V0 vector exceeds the threshold value **Min. V0> for dir. determ.**, the stage detects the ground fault. The direction determination (see in the following paragraph) is started when the zero-sequence voltage exceeds the threshold. The result from the direction determination is only valid if the absolute value of the ground current 3I0 vector has also exceeded its threshold value. The direction result is indicated via the *Ground fault* signal (in the **General** function block).

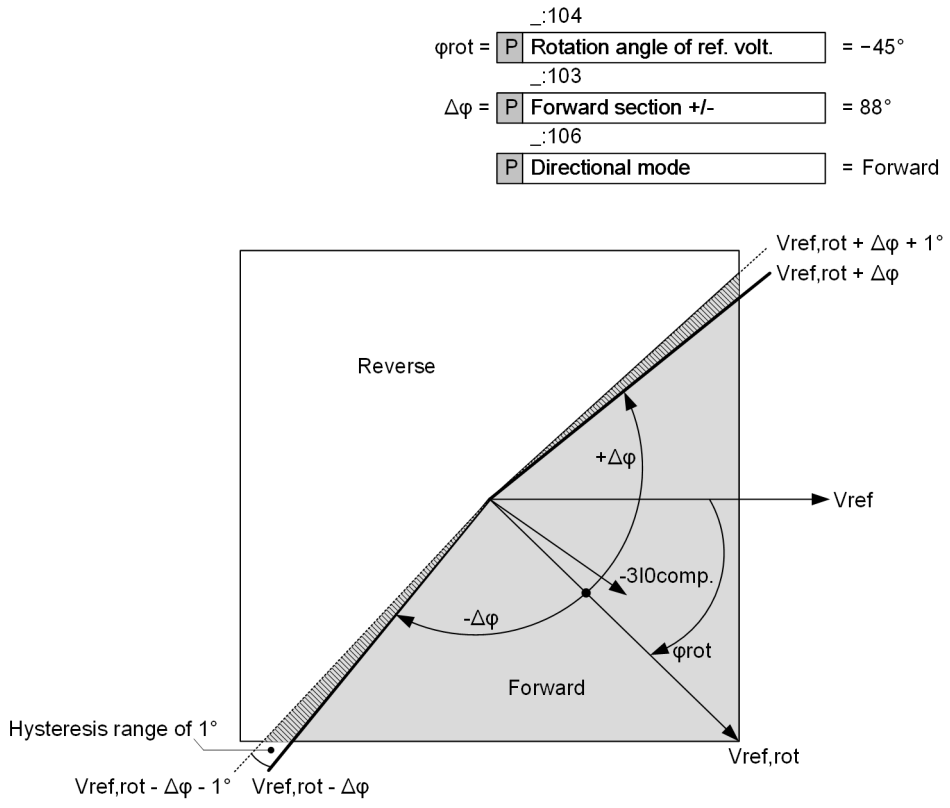
As long as the direction result equals the parameterization direction (parameter **Directional mode**), the stage picks up.

Direction Determination

Exceeding the threshold values by the zero-sequence voltage V0 is a criterion for the ground fault. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the **Dir. determination delay** parameter to achieve steady-state measurands.

The direction is determined via the determination of the phase angle between the angle-error compensated ground current 3I0com. and the rotated zero-sequence voltage V0, indicated in the following as reference voltage $V_{ref,rot}$. To take different system conditions and applications into account, the reference voltage can be rotated through an adjustable angle (**Rotation angle of ref. volt.** parameter). This moves the vector of the rotated reference voltage close to the vector ground current -3I0com. Consequently, the result of direction determination is as reliable as possible.

The rotated reference voltage $V_{ref,rot}$ and the **Forward section +/-** parameter define the forward and reverse area. The forward area results as range ± Δφ around the rotated reference voltage $V_{ref,rot}$. The value ± Δφ is set with the **Forward section +/-** parameter. The remaining area besides the forward area is the reverse area. Between the forward and reverse area, a hysteresis is defined, refer to *Figure 6-253*.



[dw_dirrot, 1, en_US]

Figure 6-253 Directional Characteristic in Forward Mode

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>open* of the function block **Voltage-transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker.

The **Blk. by meas.-volt. failure** parameter can be set so that **measuring-voltage failure detection** blocks the stage or not.

Blocking the Stage in Case of an Intermittent Ground Fault

In case of an intermittent ground fault, the stage can be blocked upon receiving the internal signal *Interm.gnd.flt.det* from the **Intermittent ground-fault blocking** stage. In the event of blocking, the picked-up stage will be reset.

After the release of the blocking, the timer **Dir. determination delay** is newly started and must expire before a new ground fault or pickup is annunciated.

With the **Blk.by interm.gnd.flt.** parameter, you can enable or disable the blocking of the stage in case of an intermittent ground fault.

Blocking the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking of the Tripping by Device-Internal Inrush-Current Detection

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started. After that time, the stage operates.

6.13.6.2 Application and Setting Notes

Parameter: **Operate & flt.rec. blocked**

- Default setting **(_:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: **Blk. by meas.-volt. failure**

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). If V0 is calculated from the phase-to-ground voltages, Siemens recommends using the blocking.
no	The protection stage is not blocked. If V0 is obtained from the VN measurement of a broken-delta winding, Siemens recommends not using the blocking.

Parameter: **Blk. w. inrush curr. detect.**

- Recommended setting value **(_:27) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you specify whether the operate is blocked during detection of an inrush current.

Siemens recommends disabling the blocking. The fundamental component of the zero-sequence voltage is a reliable criterion for the ground fault and remains unaffected by a switching-on procedure.

Parameter: **Blk.by interm.gnd.flt.**

- Default setting **(_:111) Blk.by interm.gnd.flt.** = ***no***

With the **Blk.by interm.gnd.flt.** parameter, you specify whether the stage is blocked upon receiving an internal signal *Interm.gnd.flt.det* from the **Intermittent ground-fault blocking** stage.

During intermittent ground faults, stages designed for detecting permanent ground faults (based on continuous RMS measurement) tend to generate a flood of signals and probably even temporary wrong directional information. This can be avoided by blocking these stages in case of an intermittent ground fault.

If intermittent ground faults in your network are probable, Siemens recommends enabling the blocking.

Parameter: Directional mode

- Default setting **(_:106) Directional mode** = ***forward***

When a fault is detected, the selection of the parameter **Directional mode** defines whether the pickup of the stage occurs in forward or reverse direction.

When the parameter **Directional mode** is set as ***non-directional***, the direction determination is not considered. The pickup condition depends only on the absolute values 3I0 and V0 and the respective thresholds. The forward direction is the direction towards the motor.

Parameter: Rotation angle of ref. volt.,Forward section +/-

- Default setting **(_:104) Rotation angle of ref. volt.** = ***-45°***
- Default setting **(_:103) Forward section +/-** = ***88°***

With the **Rotation angle of ref. volt.** and **Forward section +/-** parameters, you set the direction characteristic, that is, the areas of forward and reverse. With this, you set the direction characteristic according to the system conditions and the neutral-point treatment.

Typical settings for the **Rotation angle of ref. volt.** parameter are:

- Arc-suppression-coil-ground system: 0°
- Isolated system: +45° to +90°
- Grounded system: -45°

The **Forward section +/-** parameter can normally be left at its default setting. A reduction of the forward area by a few degrees is practical, for example, in an arc-suppression-coil-ground system with long cable feeders, that generate high capacitive fault currents.



NOTE

In isolated networks, the setting is near +90°.

The generator protection is also an isolated system. However, to take into account the loading resistor in the busbar connection of the generator, the setting is near +45°.

Parameter: Min. V0> for dir. determ.

- Default setting **(_:102) Min. V0> for dir. determ.** = ***2.000 V***

With the **Min. V0> for dir. determ.** parameter, you determine the minimum voltage V0 necessary for the release of the direction determination that must be attained within the time delay **Dir. determination delay**.

Parameter: 3I0> threshold value

- Default setting **(_:101) 3I0> threshold value** = ***0.050 A***

The **3I0> threshold value** parameter allows you to set the ground-current sensitivity of the stage. Set the threshold value lower than the minimum absolute value of the ground-fault current 3I0 that must still be detected.

Parameter: Dir. determination delay

- Default setting **(_:105) Dir. determination delay** = ***0.10 s***

The start of the ground fault normally shows a significant transient behavior. This can lead to an incorrect direction decision. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the **Dir. determination delay** parameter to achieve steady-state measurands. The duration of the transient cycle is determined from the system conditions and the respective fault characteristics. If you have no knowledge of a suitable time delay, Siemens recommends keeping the default setting.

Parameter: `Operate delay`

- Default setting **`(_:6) Operate delay`** = ***`0.50 s`***

The **`Operate delay`** parameter determines the time during which the pickup conditions must be met to issue the operate indication. The operate indication is issued when this time expires.

6.13.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
3I0> φ(VI) #				
_:1	3I0> φ(VI) #:Mode		• off • on • test	off
_:2	3I0> φ(VI) #:Operate & flt.rec. blocked		• no • yes	no
_:10	3I0> φ(VI) #:Blk. by meas.-volt. failure		• no • yes	yes
_:111	3I0> φ(VI) #:Blk.by interm.gnd.flt.		• no • yes	no
_:27	3I0> φ(VI) #:Blk. w. inrush curr. detect.		• no • yes	no
_:106	3I0> φ(VI) #:Directional mode		• non-directional • forward • reverse	forward
_:104	3I0> φ(VI) #:Rotation angle of ref. volt.		-180° to 180°	-45°
_:103	3I0> φ(VI) #:Forward section +/-		0° to 180°	88°
_:102	3I0> φ(VI) #:Min. V0> for dir. determ.		0.300 V to 200.000 V	2.000 V
_:101	3I0> φ(VI) #:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 35.000 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 35.000 A	0.250 A
_:105	3I0> φ(VI) #:Dir. determination delay		0.00 s to 60.00 s	0.10 s
_:6	3I0> φ(VI) #:Operate delay		0.00 s to 100.00 s	0.50 s

6.13.6.4 Information List

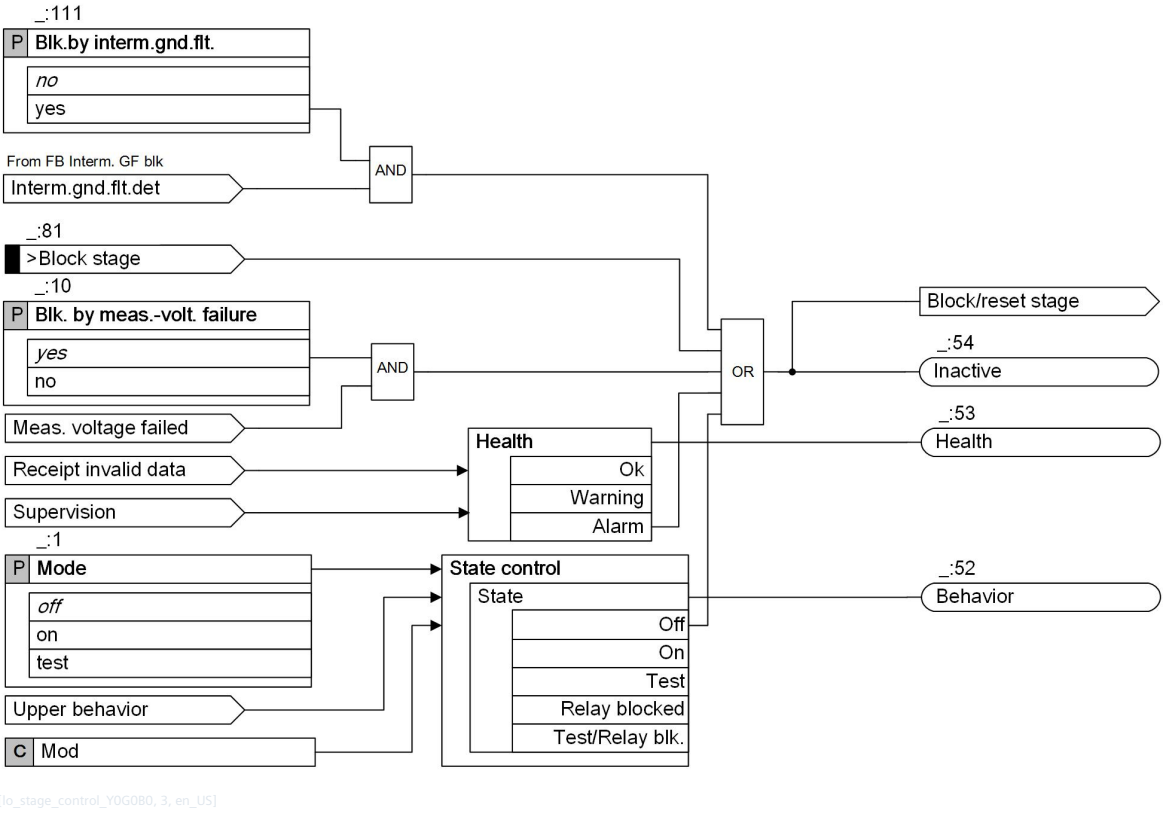
No.	Information	Data Class (Type)	Type
3I0> φ(VI) #			
_:81	3I0> φ(VI) #:>Block stage	SPS	I
_:501	3I0> φ(VI) #:>Block delay & op.	SPS	I
_:54	3I0> φ(VI) #:Inactive	SPS	O
_:52	3I0> φ(VI) #:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:53	3I0> φ(VI) #:Health	ENS	O
_:301	3I0> φ(VI) #:Fault not in trip area	SPS	O
_:60	3I0> φ(VI) #:Inrush blocks operate	ACT	O
_:303	3I0> φ(VI) #:Ground fault	ACD	O
_:55	3I0> φ(VI) #:Pickup	ACD	O
_:56	3I0> φ(VI) #:Operate delay expired	ACT	O
_:57	3I0> φ(VI) #:Operate	ACT	O

6.13.7 Directional Y0 Stage with G0 or B0 Measurement

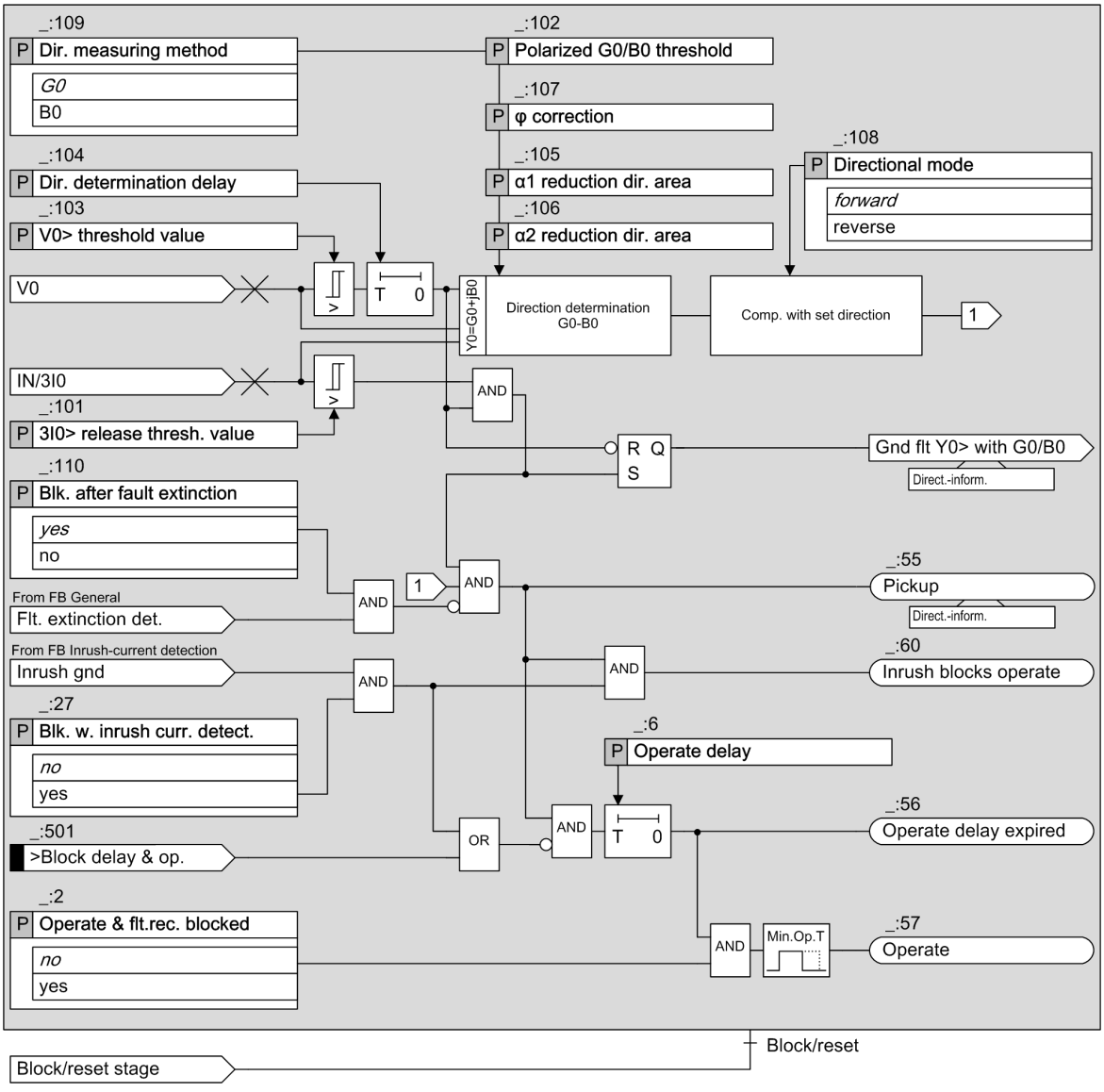
6.13.7.1 Description

Logic



{lo_stage_control_Y0G080, 3, en_US}

Figure 6-254 Logic Diagram of the Stage Control



{lo_Y0_G0_B0, 6, en_US}

Figure 6-255 Logic Diagram of the Directional Y0 Stage with G0 or B0 Measurement

Measured Value V0, Method of Measurement

The device can measure the residual voltage at the broken-delta winding. The measured voltage VN is converted to a value with reference to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages VA, VB, and VC using the definition equation.

The method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, Method of Measurement

The function usually evaluates the ground current 3I0 sensitively measured via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 calculated from the phase currents. This results in a very large linearity and settings range.

The method of measurement processes the sampled current values and filters out the fundamental component numerically. The methods of measurement are characterized by high accuracy and by insensitivity to harmonics, especially the 3rd and 5th harmonics frequently present in the ground-fault (residual) current.

Depending on the connection type of the measuring point as well as the current terminal blocks used, different linearity and setting ranges result. You can find more information in section *Measured Value 3I0, Method of Measurement , Page 897*.

Y0, G0, B0

The fundamental-component values of V0 and 3I0 are used to calculate the admittance Y0 = G0 + jB0. You can choose to use G0 or B0 to determine the direction.

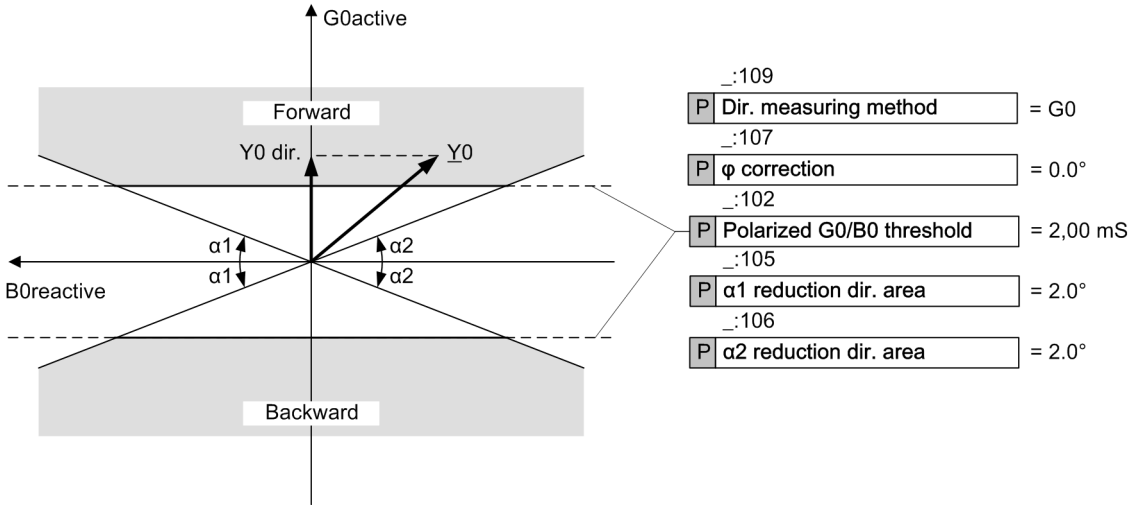
Ground-Fault Detection, Pickup

If the absolute value of the ground current 3I0 exceeds the threshold value **`3I0> release thresh. value`** and the absolute value of the zero-sequence voltage V0 exceeds the threshold value **`V0> threshold value`**, the stage recognizes the ground fault. The calculation of G0 or B0 is started with exceeding the threshold values and then, the direction determination (see the following) is performed. The direction result is indicated via the *`Ground fault`* signal (in the **General** function block). If the direction result equals the parameterized direction (parameter **`Directional mode`**), the stage picks up.

Direction Determination

Exceeding the threshold values by the zero-sequence voltage V0 is a criterion for the ground fault. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the **`Dir. determination delay`** parameter to achieve steady-state measurands. The result from the direction determination is only valid if the absolute value of the ground current 3I0 has also exceeded its release threshold value.

The following figure shows an example of the direction determination in the complex phasor diagram for the G0 direction measurement method with a correction value of the direction straight line from 0 (Parameter **`φ correction`**). The example is suitable for the determination of the ground-fault direction in an arc-suppression-coil-ground system where the value G0 is decisive for the direction determination.



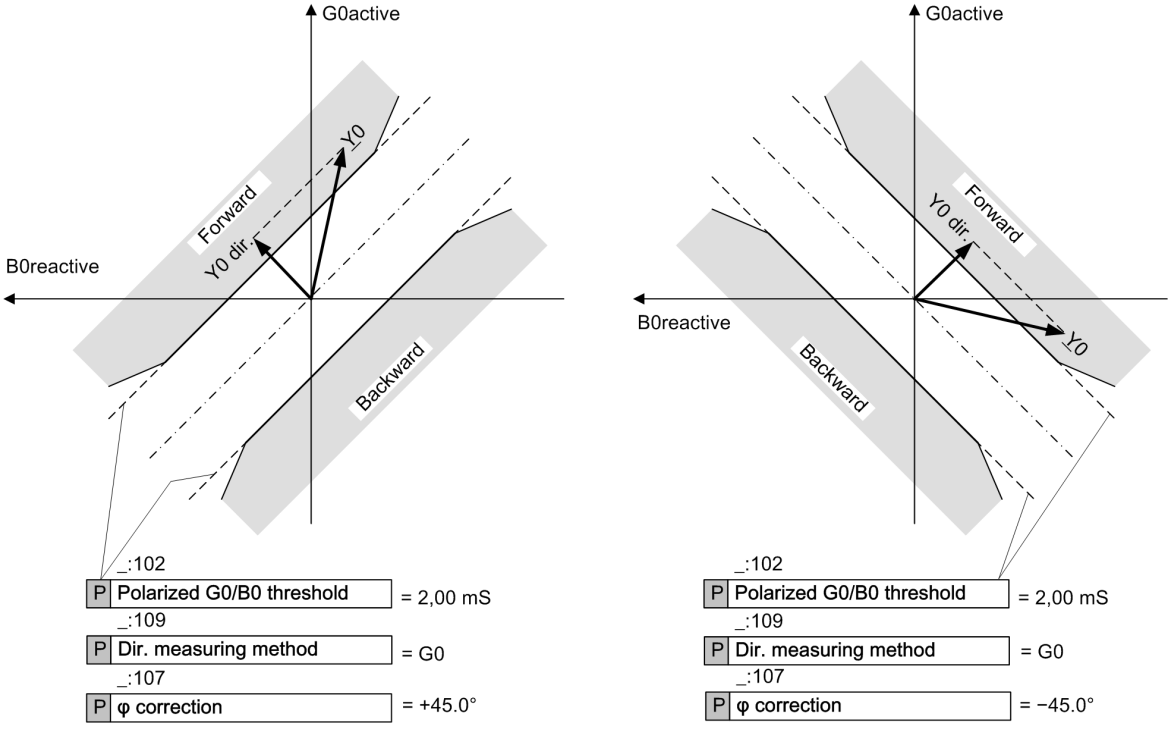
[dw_Y0_dire, 1, en_US]

Figure 6-256 Direction-Characteristic Curve for the G0 Measurement

The zero-sequence voltage V0 is generally the reference value for the real axis and is identical to the G0 axis. The axis of symmetry of the direction-characteristic curve coincides with the B0 (reactive) axis for this example. For the direction determination, the component of the admittance perpendicular to the set direction-characteristic curve (= axis of symmetry) is decisive G0dir (=Y0dir). In this example, this is the active component **G0active** of the admittance Y0. The conductance G0dir. (here = G0active) is calculated and compared with the setting value **`Polarized G0/B0 threshold`**. If the conductance G0dir. exceeds the positive setting value, the direction is forward. If the conductance G0dir. exceeds the negative setting value, the direction is backward. In the range in between, the direction is undetermined.

With the **α1 reduction dir. area** and **α2 reduction dir. area** parameters, you can limit the forward and backward ranges as shown in *Figure 6-257*. With this, the direction determination is secured in case of high currents in the direction of the axis of symmetry.

The symmetry axis can be turned via a correction angle (**φ correction** parameter) in a range of ±45. Through this, it is possible, for example, to attain the greatest sensitivity in grounded systems in the resistive-inductive range with a -45° turn. In the case of electric machines in busbar connection on the isolated system, the greatest sensitivity in the resistive-capacitive range can be attained with a turn of +45° (see following figure).

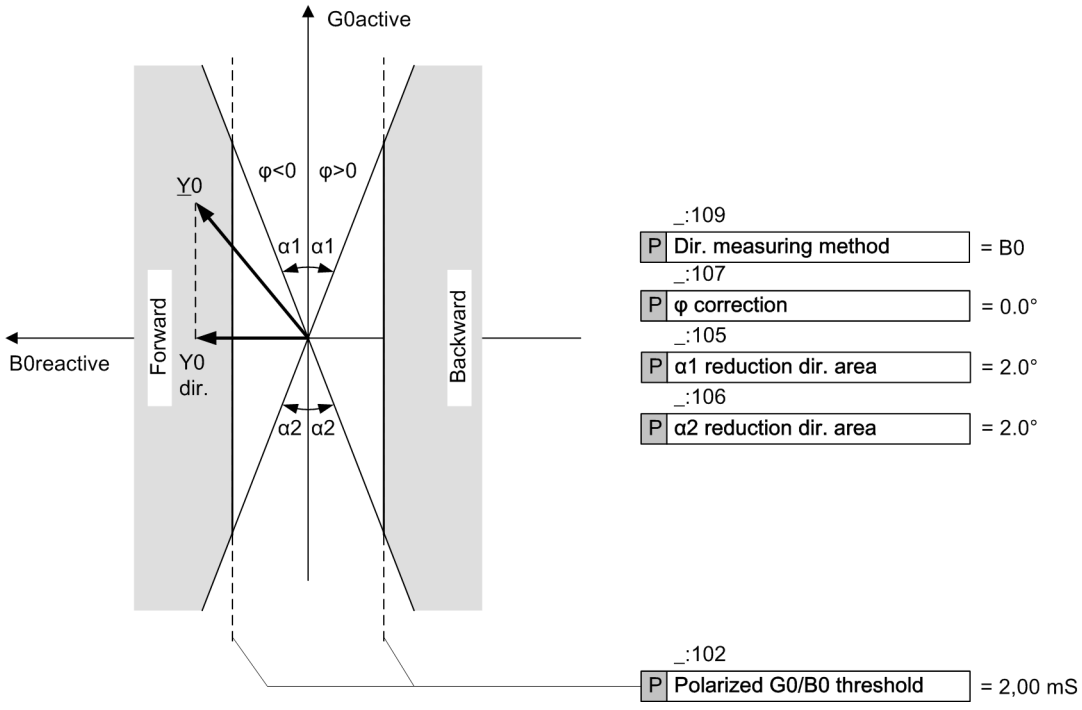


[dw_Y0_meas, 1, en_US]

Figure 6-257 Turning the Direction-Characteristic Curves with G0 Measurement with Angle Correction

If you set the **Dir. measuring method** parameter to B0 and the **φ correction** parameter to ***0***, the axis of symmetry of the direction-characteristic curve coincides with the G0 and V0 axes. Since the component of the admittance Y0 perpendicular to the direction-characteristic curve (= axis of symmetry) is decisive (B0dir. (=Y0dir.)), here, the susceptance B0 (reactive) is used in the direction determination. If the susceptance B0dir. (B0reactive) exceeds the negative setting value **Polarized G0/B0 threshold**, the direction is forward. If the susceptance B0dir. exceeds the positive setting value, the direction is backward. In the range in between, the direction is undetermined.

This direction measurement thus is appropriate for the determination of ground-fault direction in isolated systems.



[dw_si_co_Y0, 1, en_US]

Figure 6-258 Direction-Characteristic Curve for the B0 Measurement

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>open* of the function block **Voltage-transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker.

The **Blk. by meas.-volt. failure** parameter can be set so that Measuring-voltage failure detection blocks the stage or does not block it.

Blocking the Stage in Case of an Intermittent Ground Fault

In case of an intermittent ground fault, the stage can be blocked upon receiving the internal signal *Interm.gnd.flt.det* from the **Intermittent ground-fault blocking** stage. In the event of blocking, the picked-up stage will be reset.

After the release of the blocking, the timer **Dir. determination delay** is newly started and must expire before a new ground fault or pickup is annunciated.

With the **Blk.by interm.gnd.flt.** parameter, you can enable or disable the blocking of the stage in case of an intermittent ground fault.

Blocking the Pickup with Detection of the Fault Extinction

Using the evaluation of the instantaneous value developing of the zero-sequence voltage, the fault extinction can be recognized faster than via the dropout of the V0 fundamental-component value under the pickup value. The pickup of the stage is blocked with the fast detection of the fault extinction. With this, the pickups

are avoided due to the decay procedure in the zero-sequence system after the fault extinction. With the **Blk. after fault extinction** parameter, you enable or disable this accelerated detection of the fault extinction.

Blocking of the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking of the Tripping by Device-Internal Inrush-Current Detection

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started. After that time, the stage operates.

6.13.7.2 Application and Setting Notes

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). If V0 is calculated from the phase-to-ground voltages, Siemens recommends using the blocking.
no	The protection stage is not blocked. If V0 is obtained from the VN measurement of a broken-delta winding, Siemens recommends not using the blocking.

Parameter: Blk. w. inrush curr. detect.

- Recommended setting value **(_:27) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you specify whether the operate is blocked during detection of an inrush current.

Siemens recommends disabling the blocking. The fundamental component of the zero-sequence voltage is a reliable criterion for the ground fault and remains untouched by a switching-on procedure.

Parameter: Blk.by interm.gnd.flt.

- Default setting **(_:111) Blk.by interm.gnd.flt.** = ***no***

With the **Blk.by interm.gnd.flt.** parameter, you specify whether the stage is blocked upon receiving an internal signal *Interm.gnd.flt.det* from the **Intermittent ground-fault blocking** stage.

During intermittent ground faults, stages designed for detecting permanent ground faults (based on continuous RMS measurement) tend to generate a flood of signals and probably even temporary wrong directional information. This can be avoided by blocking these stages in case of an intermittent ground fault.

If intermittent ground faults in your network are probable, Siemens recommends enabling the blocking.

Parameter: **Blk. after fault extinction**

- Recommended setting value **(_:110) Blk. after fault extinction** = ***yes***

If the **Blk. after fault extinction** parameter is set to ***yes***, the pickup is blocked after detection of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero-sequence system after the fault extinction. Siemens recommends using the default setting.

Parameter: **Directional mode**

- Default setting **(_:108) Directional mode** = ***forward***

When a fault is detected, the selection of the parameter **Directional mode** defines whether the pickup of the stage occurs in forward or backward direction.

Parameter: **Dir. measuring method, φ correction, Polarized G0/B0 threshold, 3I0> release thresh. value**

- Default setting **(_:109) Dir. measuring method** = ***G0***
- Default setting **(_:107) φ correction** = ***0.0°***
- Default setting **(_:102) Polarized G0/B0 threshold** = ***2.00 mS***
- Default setting **(_:101) 3I0> release thresh. value** = ***0.002 A***

These parameters are used to define the direction characteristic of the stage. The direction characteristic to use is dependent on the neutral-point treatment of the system.

Note that, for the direction determination, basically only the component of the admittance perpendicular to the set direction-characteristic curve is decisive, see also *6.13.7.1 Description*. This admittance component is compared to the threshold value **Polarized G0/B0 threshold**. In contrast, the absolute value of the current 3I0 is compared with the **3I0> release thresh. value** parameter.

System Type/ Neutral-Point Treatment	Description
Grounded	In the arc-suppression-coil-ground system, the watt-metric residual current 3I0 · cos φ of the arc-suppression coil is decisive for the direction determination. To evaluate the watt-metric residual current, set the parameters as follows: • **Dir. measuring method** = *G0* • **φ correction** = *0.0°* The direction determination for a ground fault is made more difficult in that a much larger reactive current of capacitive or inductive character is superimposed on the small watt-metric residual current. Therefore, depending on the system configuration and the fault evaluation, the total ground current supplied to the device can vary considerably in its values regarding the magnitude and the phase angle. However, the device should only evaluate the active component of the ground-fault current. This requires extremely high accuracy, particularly regarding the phase-angle measurement of all the instrument transformers. Furthermore, the device must not be set to operate too sensitively. A reliable direction measurement can only be expected with connection to a core balance current transformer. For the setting of the **Polarized G0/B0 threshold** parameter, the following formula applies: $G0 > k_s \frac{I_{0active}}{\sqrt{3}V_{rated}} + \frac{I_{0min}}{V0>}$ where: k_s: Safety margin, k_s = 1.2 (cable networks), k_s = 2.0 (overhead lines) $I_{0active}$: Active component of the ground-fault current (watt-metric residual current) of the protected line V_{rated}: Secondary rated voltage in the healthy case I_{0min}: Min. ground current in the healthy case, 5 mA to 10 mA (core balance current transformer), 50 mA to 100 mA (Holmgreen transformer) V0>: Pickup threshold of the residual voltage ≈ $0.1\sqrt{3}V_{rated}$ If a parallel resistor Rp is used on the arc-suppression coil, the threshold value G0 must also be smaller than: $G0 \leq \frac{1}{k_s} \frac{I_{Rp}}{\sqrt{3}V_{rated}}$ where: k_s: Safety margin ≥ 1.5 I_{Rp}: Secondary rated current of the parallel resistor V_{rated}: Secondary rated voltage in the healthy case The **3I0> release thresh. value** parameter can be set to half of the expected measuring current and here, the entire zero-sequence current can be put to use.
Isolated	In the isolated system, the capacitive ground reactive current 3I0 · sin φ is decisive for the direction determination. To evaluate the capacitive ground reactive current, set the parameters as follows: • **Dir. measuring method** = *B0* • **φ correction** = *0.0°* In isolated systems, a ground fault allows the capacitive ground-fault currents of the entire electrically connected system, except for the ground current in the faulty cable itself, to flow through the measuring point as the latter flows directly away from the

System Type/ Neutral-Point Treatment	Description
	fault location (that is, not via the measuring point). The following formula can be used to determine the pickup value of the **Polarized G0/B0 threshold** parameter. $B0 \geq \frac{I_{0min}}{V0>}$ where: I_{0min}: Ground current in the healthy case V0>: Pickup threshold of the residual voltage ≈ $0.02\sqrt{3}V_{rated}$ In healthy operation, B0 ≤ 0. For the **3I0> release thresh. value** parameter, select around half of this capacitive ground-fault current flowing via the measuring point.
Resistance-Grounded	In the resistance-grounded system, the ohmic-inductive ground-fault current is decisive for the direction determination. To evaluate this short-circuit current, set the parameters as follows: • **Dir. measuring method** = *G0* • **φ correction**= *-45.0°* For the setting of the **Polarized G0/B0 threshold** parameter, the rule of thumb is: Set the pickup value according to the following formula where only the active ground-fault current can be put into use. $G0 > k_s \frac{I_{0active}}{\sqrt{3}V_{rated}} + \frac{I_{0min}}{V0>}$ where: k_s: Safety margin, k_s = 1.2 (cable networks), k_s = 2.0 (overhead lines) $I_{0active}$: Active component of the ground-fault current of the protected line V_{rated}: Secondary rated voltage in the healthy case I_{0min}: Min. ground current in the healthy case, 5 mA to 10 mA (core balance current transformer), 50 mA to 100 mA (Holmgreen transformer) V0>: Pickup threshold of the residual voltage ≈ $0.02\sqrt{3}V_{rated}$ The **3I0> release thresh. value** parameter must be set to a value below the minimum expected ground-fault current.

Parameter: **α1 reduction dir. area, α2 reduction dir. area**

- Recommended setting value **(_:105) α1 reduction dir. area** = *2°*
- Recommended setting value **(_:106) α2 reduction dir. area** = *2°*

With the **α1 reduction dir. area** and **α2 reduction dir. area** parameters, you specify the angle for the limitation of the direction range. Siemens recommends using the default setting of 2°.

In an arc-suppression-coil-ground system in feeders with a very large reactive current, it can be practical to set a somewhat larger angle α1 to avoid a false pickup based on transformer and algorithm tolerances.

Parameter: **V0> threshold value**

- Default setting **(_:103) V0> threshold value** = *30.000 V*

The **V0> threshold value** parameter allows you to set the zero-sequence voltage sensitivity of the stage. The threshold value must be smaller than the minimum amount of the zero-sequence voltage V0 which must still be detected.

Parameter: `Dir. determination delay`

- Default setting **`(_:104) Dir. determination delay`** = ***`0.10 s`***

The start of the ground fault normally indicates a significant transient behavior. This can lead to an incorrect direction decision. The direction determination can be delayed for this reason from the occurrence of the zero-sequence voltage with the **`Dir. determination delay`** parameter to achieve steady-state measurands. The duration of the transient cycle is determined from the system conditions and the respective fault characteristics. If you have no knowledge of a suitable time delay, Siemens recommends keeping the default setting.

Parameter: `Operate delay`

- Default setting **`(_:6) Operate delay`** = ***`2.0 s`***

The **`Operate delay`** parameter determines the time during which the pickup conditions must be met to issue the operate indication. The operate indication is issued when this time expires.

6.13.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Y0> G0/B0 #				
_:1	Y0> G0/B0 #:Mode		• off • on • test	off
_:2	Y0> G0/B0 #:Operate & flt.rec. blocked		• no • yes	no
_:10	Y0> G0/B0 #:Blk. by meas.-volt. failure		• no • yes	yes
_:111	Y0> G0/B0 #:Blk.by interm.gnd.flt.		• no • yes	no
_:27	Y0> G0/B0 #:Blk. w. inrush curr. detect.		• no • yes	no
_:110	Y0> G0/B0 #:Blk. after fault extinction		• no • yes	yes
_:108	Y0> G0/B0 #:Directional mode		• forward • reverse	forward
_:109	Y0> G0/B0 #:Dir. measuring method		• G0 • B0	G0
_:107	Y0> G0/B0 #:φ correction		-45° to 45°	0°
_:102	Y0> G0/B0 #:Polarized G0/B0 threshold		0.10 mS to 100.00 mS	2.00 mS
_:105	Y0> G0/B0 #:α1 reduction dir. area		1° to 15°	2°
_:106	Y0> G0/B0 #:α2 reduction dir. area		1° to 15°	2°
_:101	Y0> G0/B0 #:3I0> release thresh. value	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 35.000 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 35.000 A	0.150 A

Addr.	Parameter	C	Setting Options	Default Setting
_:103	Y0> G0/B0 #:V0> threshold value		0.300 V to 200.000 V	30.000 V
_:104	Y0> G0/B0 #:Dir. determination delay		0.00 s to 60.00 s	0.10 s
_:6	Y0> G0/B0 #:Operate delay		0.00 s to 60.00 s	2.00 s

6.13.7.4 Information List

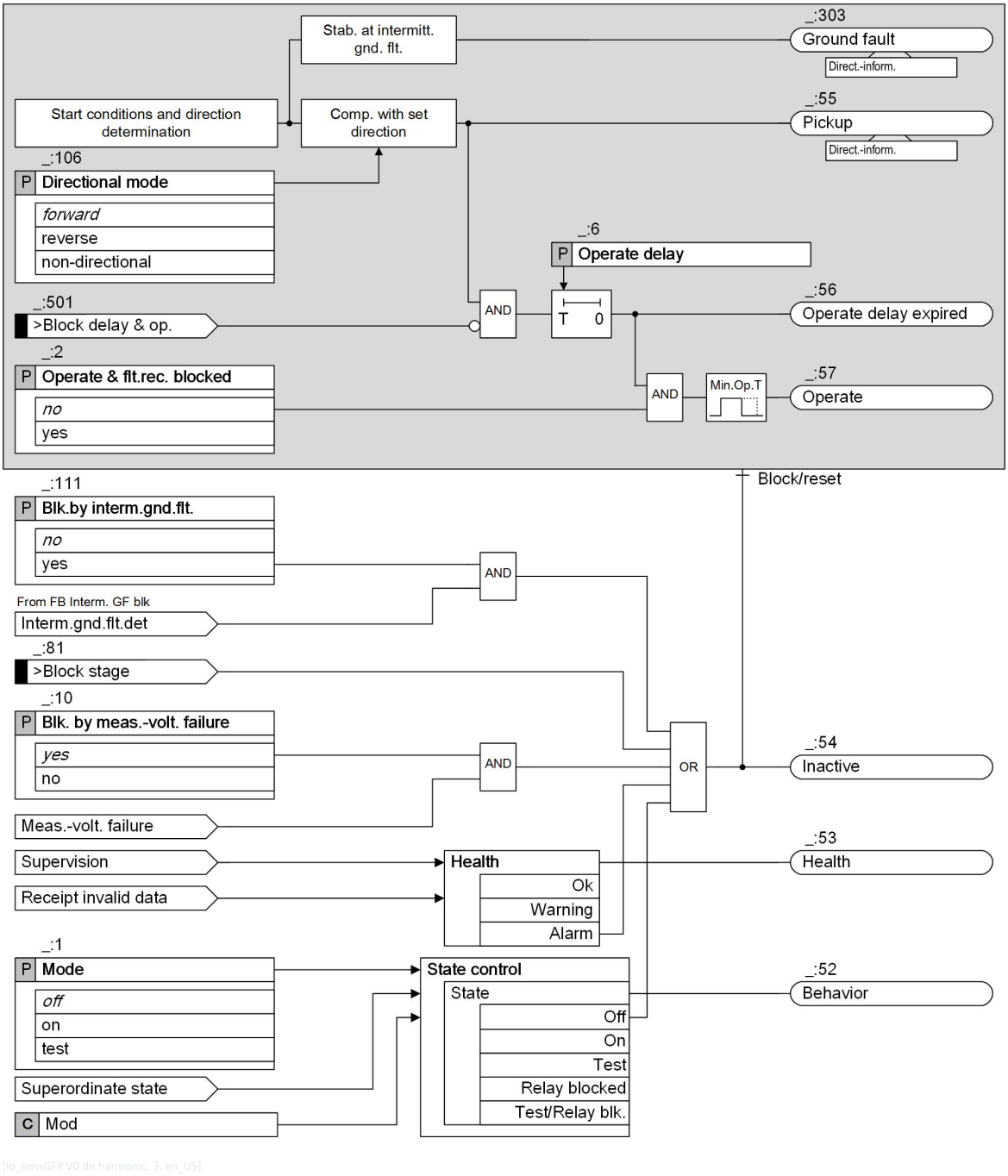
No.	Information	Data Class (Type)	Type
Y0> G0/B0 #			
_:81	Y0> G0/B0 #:>Block stage	SPS	I
_:501	Y0> G0/B0 #:>Block delay & op.	SPS	I
_:54	Y0> G0/B0 #:Inactive	SPS	O
_:52	Y0> G0/B0 #:Behavior	ENS	O
_:53	Y0> G0/B0 #:Health	ENS	O
_:60	Y0> G0/B0 #:Inrush blocks operate	ACT	O
_:55	Y0> G0/B0 #:Pickup	ACD	O
_:56	Y0> G0/B0 #:Operate delay expired	ACT	O
_:57	Y0> G0/B0 #:Operate	ACT	O

6.13.8 Directional Stage with Phasor Measurement of a Harmonic

6.13.8.1 Description

The **Directional stage with phasor measurement of a harmonic** is based on a continuous measuring direction-determination method. The stage determines the direction via the 3rd, 5th, or 7th harmonic phasors of the zero-sequence voltage V0 and current 3I0.

Logic



[lo_sensGFP V0 dir harmonic, 3, en_US]

Figure 6-259 Logic Diagram of the Directional Stage with Phasor Measurement of a Harmonic

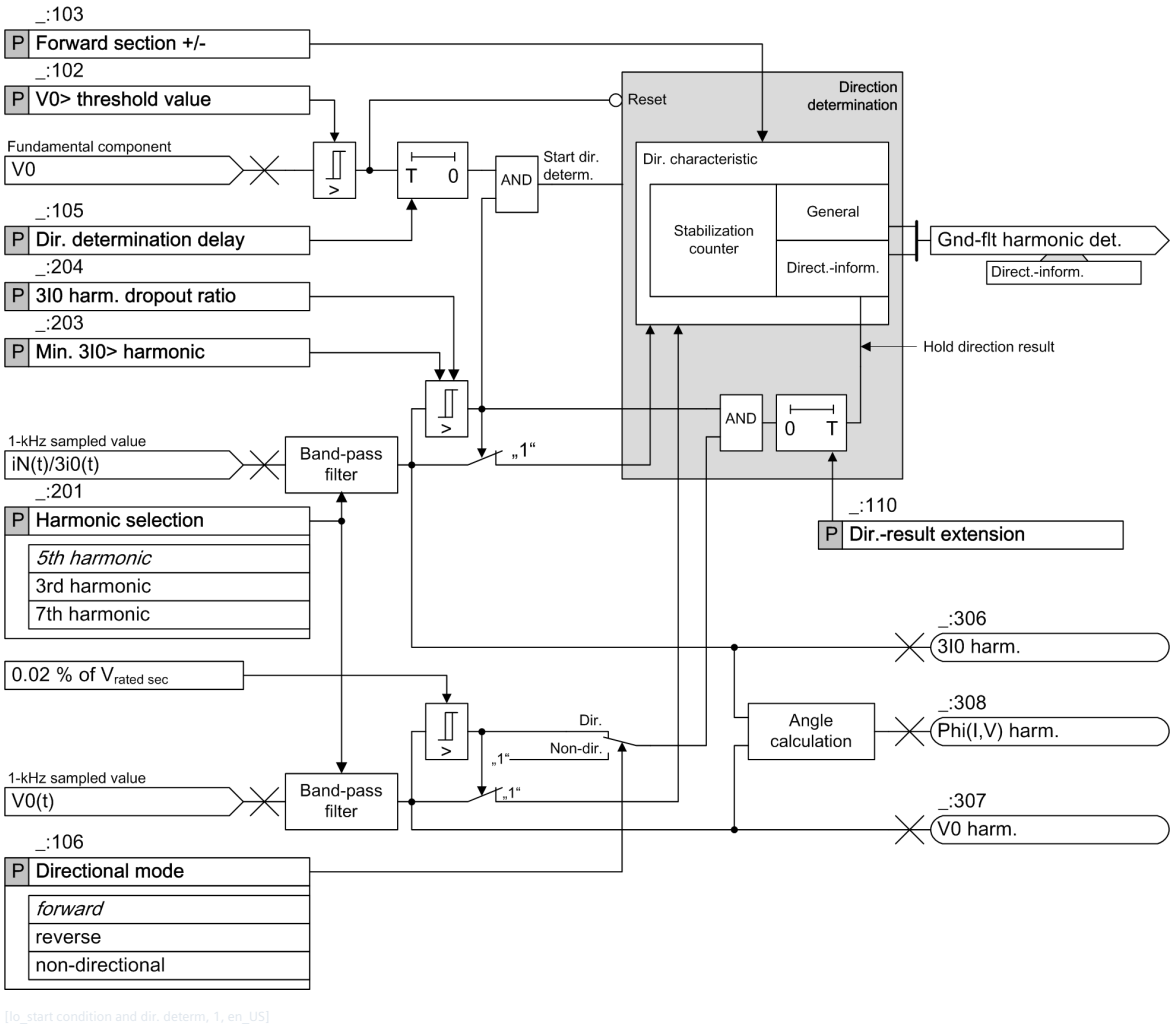


Figure 6-260 Logic Diagram of the Start Conditions and of the Direction Determination

Measured Values, Methods of Measurement

The device can measure the residual voltage at the broken-delta winding. The measured voltage is converted to a value with reference to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

For the measured value 3I0 and the method of measurement, you can find more information in section *Measured Value 3I0, Method of Measurement , Page 897*.

The function uses the fundamental-component value of V0 and the 3rd, 5th, or 7th harmonic phasor of V0 and 3I0 for direction determination. The specific harmonic phasor to be used is determined by the **`Harmonic selection`** setting.

Ground-Fault Detection, Pickup

If the fundamental-component value of the zero-sequence voltage V0 exceeds the threshold **`V0> threshold value`**, the stage detects the ground fault and the timer **`Dir. determination delay`** starts.

If the following 2 conditions are met, the ground-fault signaling and direction determination start:

- The fundamental-component value of the zero-sequence voltage V0 keeps exceeding the threshold **`V0> threshold value`** during the period of the timer **`Dir. determination delay`**.
- The absolute value of the zero-sequence harmonic current 3I0harm. exceeds the threshold **`Min. 3I0> harmonic`** when the timer **`Dir. determination delay`** expires.

To carry out the direction determination, the following condition must also be met in addition to the preceding 2 conditions:

The zero-sequence harmonic voltage V0harm. must exceed the threshold which is 0.02 % of the secondary rated voltage of the voltage transformer. If this condition is not met, the direction result is **unknown**.

The direction result is indicated via the *Ground fault* signal.

The stage pickup depends on the direction result and on the **Directional mode** parameter:

- If the **Directional mode** parameter is set as ***forward*** or ***reverse***, the stage picks up when the direction result equals the parameterized direction, and the *Pickup* is signaled with the determined direction.
- If the **Directional mode** parameter is set as ***non-directional***, the stage picks up regardless of the direction result, and the *Pickup* is signaled with the **unknown** information.

Direction Determination

With the **Harmonic selection** parameter, you can select the 3rd, 5th, or 7th harmonic phasor for direction determination. The direction is determined via the calculation of the phase angle between the following values:

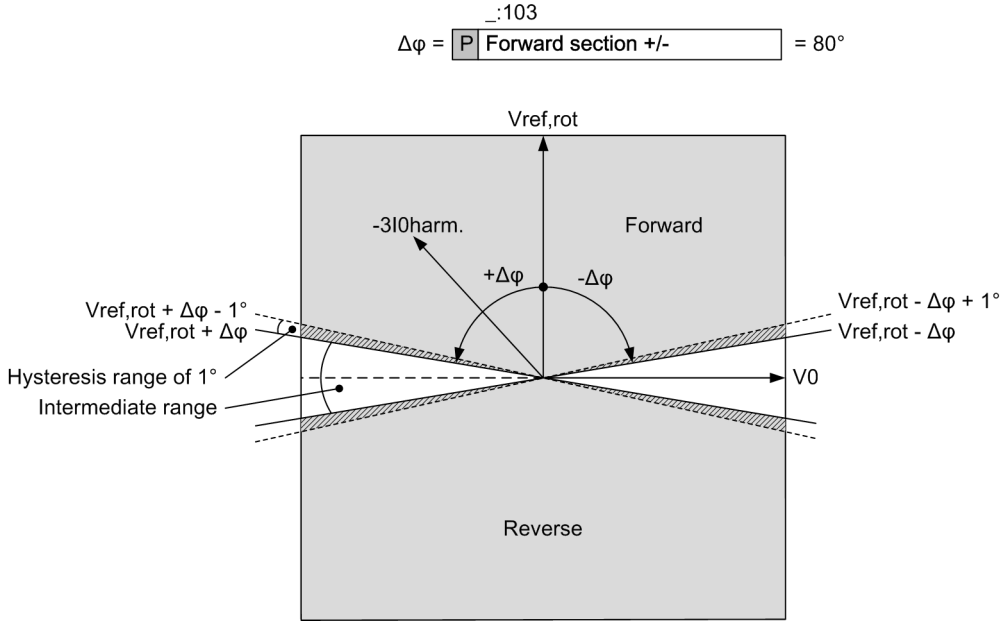
- Zero-sequence harmonic current 3I0harm.
- Rotated zero-sequence harmonic voltage V0harm., indicated in the following as reference voltage $V_{ref,rot}$

The reference voltage is rotated by the angle +90° in relation to V0. This provides the maximum security for the direction determination assuming that 3I0harm. is a reactive current.

The rotated reference voltage $V_{ref,rot}$ and the **Forward section +/-** parameter define the forward and reverse area. For details, refer to *Figure 6-261*.

The areas in the following figure are as follows:

- The forward area results as range ± Δφ around the rotated reference voltage $V_{ref,rot}$. You can set the value ± Δφ with the **Forward section +/-** parameter. If the vector of the secondary ground current -3I0harm. lies within this area, the direction result is forward.
- The mirror area of the forward area is the reverse area. If the vector of the secondary ground current -3I0harm. lies within this area, the direction result is reverse.
- In the intermediate range, the direction is **unknown**.



[dw_sensGFP V0 dir harmonic, 1, en_US]

Figure 6-261 Direction Characteristic

Stabilization Counter

To determine a reliable direction result, the function uses a stabilization counter. For indicating a direction result, the determined direction must be stable for 4 successive measuring cycles. The cycle time is 10 ms.

Direction-Result Extension

With the timer **Dir.-result extension**, you can extend the last determined direction result if the conditions for a further direction determination are no longer met. The last direction result is held until the conditions for a further direction determination are met again (timer is reset) or until the timer expires. The behavior of the direction-result extension varies according to the setting of the **Directional mode** parameter:

- **Directional mode** = ***forward*** or ***reverse***

  As soon as the zero-sequence harmonic current 3I0harm. or the zero-sequence harmonic voltage V0harm. falls below its respective dropout value, the timer **Dir.-result extension** starts. If the direction result equals the setting of the **Directional mode** parameter, the last *Pickup* signal is also extended.

  If both 3I0harm. and V0harm. exceed their thresholds again, the timer **Dir.-result extension** is reset immediately and the direction determination is carried out again.

- **Directional mode** = ***non-directional***

  As soon as the zero-sequence harmonic current 3I0harm. falls below its dropout value, the timer **Dir.-result extension** starts.

  In this directional mode, the *Pickup* is signaled only with the direction information *unknown* regardless of the actual direction that is indicated via the *Ground fault* signal. Therefore, the *Pickup* signal with the *unknown* information is extended.

  If 3I0harm. exceeds its threshold again, the timer **Dir.-result extension** is reset immediately and the direction determination is carried out again.

Measured Value Display

After the timer **Dir. determination delay** expires and the V0 fundamental-component value keeps exceeding the **V0> threshold value**, the following measured values are issued:

- *V0 harm.*
- *3I0 harm.*
- *Phi(I,V) harm.*

These measured values are displayed as **---** if 3I0harm. or V0harm. is smaller than 0.005 % of the rated secondary current or voltage.

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **Voltage-transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker

The **Blk. by meas.-volt. failure** parameter can be set so that the **Measuring-voltage failure detection** blocks the stage or not.

Blocking the Stage in Case of an Intermittent Ground Fault

In case of an intermittent ground fault, the stage can be blocked upon receiving the internal signal *Interm.gnd.flt.det* from the **Intermittent ground-fault blocking** stage. In the event of blocking, the picked-up stage will be reset.

After the release of the blocking, the timer **Dir. determination delay** is newly started and must expire before a new ground fault or pickup is annunciated.

With the **Blk.by interm.gnd.flt.** parameter, you can enable or disable the blocking of the stage in case of an intermittent ground fault.

6.13.8.2 Application and Setting Notes

Parameter: V0> threshold value

- Default setting **(_:102) V0> threshold value** = ***20.000 V***

The **V0> threshold value** parameter allows you to set the zero-sequence (fundamental) voltage sensitivity of the stage. Set the threshold value smaller than the minimum absolute value of the zero-sequence voltage V0 that must still be detected. Typical values are in the range of 15 V to 25 V.

Parameter: Dir. determination delay

- Default setting **(_:105) Dir. determination delay** = ***0.00 s***

The start of the ground fault normally shows a significant transient behavior. This can lead to an incorrect direction decision. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the **Dir. determination delay** parameter to achieve steady-state measurands. The duration of the transient cycle is determined from the system conditions and the respective fault characteristics. If you have no knowledge of a suitable time delay, Siemens recommends keeping the default setting.

Parameter: Forward section +/-

- Default setting **(_:103) Forward section +/-** = ***80°***

With the **Forward section +/-** parameter, you set the direction characteristic, that is, the forward and reverse areas.

The **Forward section +/-** parameter can normally be left at its default setting. With reducing the forward area, you can provide more security for the direction result, but on the other hand, you increase the probability of an underfunction.

Parameter: Dir.-result extension

- Default setting **(_:110) Dir.-result extension** = ***5.00 s***

With the **Dir.-result extension** parameter, you define the time for extending the last determined direction result if the conditions for further direction determination are no longer met.

This timer can be used to generate a stable direction indication under fluctuating zero-sequence harmonics. A stable direction indication again can be required for the implementation of a prioritization schema between different parallel working detection methods (stages).

Parameter: Harmonic selection

- Default setting **(_:201) Harmonic selection** = ***5th harmonic***

With the **Harmonic selection** parameter, you select to use the 3rd, 5th, or 7th harmonic phasor of the zero-sequence voltage V0 and of the zero-sequence current 3I0 for direction determination.

Parameter: Min. 3I0> harmonic

- Default setting **(_:203) Min. 3I0> harmonic** = ***0.030 A***

With the **Min. 3I0> harmonic** parameter, you define the threshold value of the zero-sequence harmonic current 3I0harm. for detecting the ground fault and for starting direction determination. For more information, see also *Ground-Fault Detection, Pickup, Page 934*.

This parameter needs to be set according to the experience from the specific network. This requires the analysis of permanent ground faults from the network. If such information is unavailable, Siemens recommends a rather low setting in the area of 5 mA to 10 mA secondary.

Parameter: 3I0 harm. dropout ratio

- Default setting **(_:204) 3I0 harm. dropout ratio** = ***0.60***

With the **3I0 harm. dropout ratio** parameter, you define the dropout threshold for the **Min. 3I0> harmonic** parameter.

Lowering this dropout threshold enlarges the range and the period of direction determination under fluctuating zero-sequence harmonics. Siemens recommends using the default setting.

Parameter: Directional mode

- Default setting **(_:106) Directional mode** = ***forward***

With the **Directional mode** parameter, you define for which direction result the function generates the pickup state:

- If the **Directional mode** parameter is set as ***forward*** or ***reverse***, the stage picks up when the direction result equals the parameterized direction, and the *Pickup* is signaled with the determined direction.
- If the **Directional mode** parameter is set as ***non-directional***, the stage picks up regardless of the direction result, and the *Pickup* is signaled with the **unknown** information.

Parameter: Operate delay

- Default setting **(_:6) Operate delay** = ***1.00 s***

The **Operate delay** parameter determines the time during which the pickup conditions must be met to issue the operate indication. The operate indication is issued when this time expires.



NOTE

When both the **Operate delay** and the **Dir.-result extension** are applied, the **Operate delay** should usually be set to a considerably greater value than the **Dir.-result extension**. If the **Operate delay** is less than the **Dir.-result extension**, the function will operate for each fault regardless of the fault duration, as long as the fault direction equals the set direction.

Parameter: Operate & flt.rec. blocked

- Default setting **(_:2) Operate & flt.rec. blocked** = ***no***

With the **Operate & flt.rec. blocked** parameter, you block the operate indication, the fault recording, and the fault log. In this case, a ground-fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). If V0 is calculated from the phase-to-ground voltages, Siemens recommends using the blocking.
no	The protection stage is not blocked. If V0 is obtained from the VN measurement of a broken-delta winding, Siemens recommends not using the blocking.

Parameter: **`Blk.by interm.gnd.flt.`**

- Default setting **`(_:111) Blk.by interm.gnd.flt.`** = ***no***

With the **`Blk.by interm.gnd.flt.`** parameter, you specify whether the stage is blocked upon receiving an internal signal *`Interm.gnd.flt.det`* from the **Intermittent ground-fault blocking** stage.

During intermittent ground faults, stages designed for detecting permanent ground faults (based on continuous RMS measurement) tend to generate a flood of signals and probably even temporary wrong directional information. This can be avoided by blocking these stages in case of an intermittent ground fault.

If intermittent ground faults in your network are probable, Siemens recommends enabling the blocking.

6.13.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V0>dir.harm.#				
_:1	V0>dir.harm.#:Mode		• off • on • test	off
_:2	V0>dir.harm.#:Operate & flt.rec. blocked		• no • yes	no
_:10	V0>dir.harm.#:Blk. by meas.-volt. failure		• no • yes	yes
_:111	V0>dir.harm.#:Blk.by interm.gnd.flt.		• no • yes	no
_:106	V0>dir.harm.#:Directional mode		• non-directional • forward • reverse	forward
_:103	V0>dir.harm.#:Forward section +/-		0° to 90°	80°
_:102	V0>dir.harm.#:V0> threshold value		0.300 V to 200.000 V	20.000 V
_:201	V0>dir.harm.#:Harmonic selection		• 3rd harmonic • 5th harmonic • 7th harmonic	5th harmonic

Addr.	Parameter	C	Setting Options	Default Setting
_:203	V0>dir.harm.#:Min. 3I0> harmonic	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 35.000 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 35.000 A	0.150 A
_:204	V0>dir.harm.#:3I0 harm. dropout ratio		0.10 to 0.95	0.60
_:110	V0>dir.harm.#:Dir.-result extension		0.00 s to 60.00 s	5.00 s
_:105	V0>dir.harm.#:Dir. determination delay		0.00 s to 60.00 s	0.00 s
_:6	V0>dir.harm.#:Operate delay		0.00 s to 60.00 s	1.00 s

6.13.8.4 Information List

No.	Information	Data Class (Type)	Type
V0>dir.harm.#			
_:81	V0>dir.harm.#:>Block stage	SPS	I
_:501	V0>dir.harm.#:>Block delay & op.	SPS	I
_:54	V0>dir.harm.#:Inactive	SPS	O
_:52	V0>dir.harm.#:Behavior	ENS	O
_:53	V0>dir.harm.#:Health	ENS	O
_:303	V0>dir.harm.#:Ground fault	ACD	O
_:55	V0>dir.harm.#:Pickup	ACD	O
_:56	V0>dir.harm.#:Operate delay expired	ACT	O
_:57	V0>dir.harm.#:Operate	ACT	O
_:308	V0>dir.harm.#:Phi(I,V) harm.	MV	O
_:307	V0>dir.harm.#:V0 harm.	MV	O
_:306	V0>dir.harm.#:3I0 harm.	MV	O

6.13.9 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage

6.13.9.1 Description

Logic

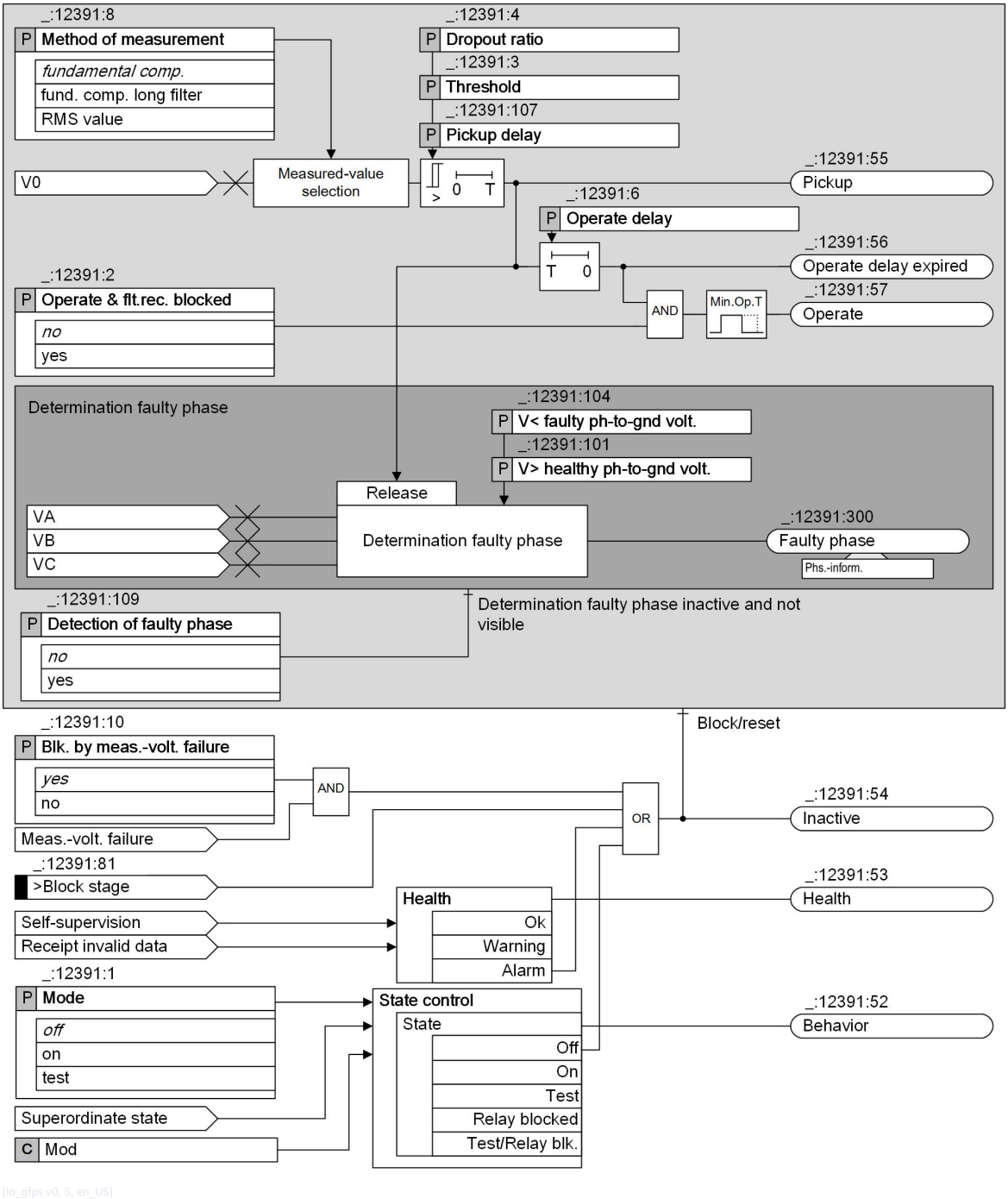


Figure 6-262 Logic Diagram of the Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage

Measured Value, Method of Measurement

The device can measure the residual voltage at the broken-delta winding. The measured voltage VN is converted to a value with reference to the zero-sequence voltage V0. If the residual voltage is not available

to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

Use the **Method of measurement** parameter to select the relevant method of measurement, depending on the application:

- Measurement of the fundamental component (standard filter):
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement of the RMS value (true RMS):
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value.
- Measurement of the fundamental component over 2 cycle filters with triangular window:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically. The extended filter length compared to the standard filter and the use of the triangular window results in a particularly strong attenuation of harmonics and transient faults. The extended filter length causes the pickup time to increase slightly compared to the standard filter (see *12.12.7 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage*).

Pickup, Dropout

The stage compares the **Threshold** with the zero-sequence voltage V0. The **Pickup delay** parameter allows you to delay the pickup of the stage depending on the residual voltage.

With the **Dropout ratio** parameter, you can define the ratio of the dropout value to the **Threshold**.

Determination of the Faulty Phase

With the **Detection of faulty phase** parameter, you can enable or disable the determination of the ground-fault phase. Determining is released when the stage picks up. If 2 phases exceed the threshold value **V> healthy ph-to-gnd volt.** and one phase falls below the threshold value **V< faulty ph-to-gnd volt.**, the last phase is determined to be faulty and is signaled as such.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal **>Block stage** from an external or internal source
- From inside on pickup of the **measuring-voltage failure detection** function. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal *>open* of the function block **Voltage-transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or not.

6.13.9.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:12391:8) Method of measurement** = ***fundamental comp.***

The **Method of measurement** parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

Parameter Value	Description
fundamental comp.	This method of measurement suppresses the harmonics or transient voltage peaks. Siemens recommends using this setting as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks).
fund. comp. long filter	To implement particularly strong damping of harmonics and transient faults, select this method of measurement. At 2 periods, the length of the filter is longer than that of the standard filter. Note that in this case the pickup time of the stage increases slightly (see *12.12.7 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage*).

Parameter: `Pickup delay`

- Recommended setting value **`(_:12391:107) Pickup delay`** = ***`0 ms`***

The **`Pickup delay`** parameter allows you to delay the analysis of the measurand (to generate the pickup) depending on the occurrence of the residual voltage. A pickup delay can be necessary if high transients are anticipated after fault inception due to high line and ground capacitances.

Siemens recommends using the default setting **`Pickup delay`** = ***`0 ms`***.

Parameter: `Threshold`

- Default setting **`(_:12391:3) Threshold`** = ***`30 V`***

The threshold value of the function is set as the zero-sequence voltage V0. The device calculates the zero-sequence voltage V0 either from the residual voltage measured via the broken-delta winding or from the 3 phase-to-ground voltages.

The setting value depends on the system grounding:

- Since virtually the full residual voltage occurs during ground faults in isolated or arc-suppression-coil-grounded systems, the setting value is uncritical there. Siemens recommends setting the value between 20 V and 40 V. A higher sensitivity (= lower threshold value) can be necessary for high fault resistances.
- Siemens recommends setting a more sensitive (smaller) value in grounded systems. This value must be higher than the maximum residual voltage anticipated during operation caused by system unbalances.

EXAMPLE

For an isolated system

The residual voltage is measured via the broken-delta winding:

- If the ground fault is fully unbalanced, a residual voltage of 100 V is present at the device terminals.
- The threshold value should be set so that the stage picks up on 50 % of the full residual voltage.
- At full residual voltage, the zero-sequence voltage is 100 V/$\sqrt{3}$ = 57.7 V
  Setting value: 0.5 · 57.7 V = 28.9 V ≈ 30 V

Parameter: `Dropout ratio`

- Recommended setting value **`(_:12391:4) Dropout ratio`** = ***`0.95`***

The recommended setting value of ***`0.95`*** is appropriate for most applications. To achieve high measurement precision, the dropout ratio can be reduced to 0.98, for example.

Parameter: `Operate delay`

- Default setting **`(_:12391:6) Operate delay`** = ***`3.00 s`***

The **Operate delay** allows you to prevent transient residual voltages from initiating a trip. The setting depends on the specific application.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:12391:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). If V0 is calculated from the phase-to-ground voltages, Siemens recommends using the blocking.
no	The protection stage is not blocked. If V0 is obtained from the VN measurement of a broken-delta winding, Siemens recommends not using the blocking.

Parameter: Detection of faulty phase

- Default setting **(_:12391:109) Detection of faulty phase** = ***no***

The **Detection of faulty phase** parameter controls how the stage responds to determine which phase is affected by the ground fault.

Parameter Value	Description
no	The phase affected by the ground fault is not determined. Select the default setting if you do not want to use the stage to detect ground faults, for example for applications in grounded systems.
yes	After a pickup by the residual voltage, the device tries to determine which phase is affected by the ground fault. Select this setting for applications in isolated or arc-suppression-coil-grounded systems.

Parameter: V< faulty ph-to-gnd volt.

- Default setting **(_:12391:104) V< faulty ph-to-gnd volt.** = ***30 V***

Set the threshold value for determining which phase is affected by the ground fault in the **V< faulty ph-to-gnd volt.** parameter. The setting value is a phase-to-ground quantity.

The set value must be smaller than the minimum phase-to-ground voltage occurring during operation. Siemens recommends using the default setting **V< faulty ph-to-gnd volt.** = ***30 V***.

Parameter: V> healthy ph-to-gnd volt.

- Default setting **(_:12391:101) V> healthy ph-to-gnd volt.** = ***70 V***

Set the threshold value for the 2 healthy phases in the **V> healthy ph-to-gnd volt.** parameter. The setting value is a phase-to-ground measurand.

The set value must be above the maximum phase-to-ground voltage occurring during operation, but below the minimum phase-to-phase voltage present during operation. At V_{rated} = 100 V, the value has to be set to 70 V, for example. Siemens recommends using the default setting **V> healthy ph-to-gnd volt.** = ***70 V***.

Operation as Supervision Function

If you want the stage to have a reporting effect only, the generation of the operate indication and fault logging can be disabled via the **`Operate & flt.rec. blocked`** parameter.

6.13.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V0> 1				
_:12391:1	V0> 1:Mode		• off • on • test	off
_:12391:2	V0> 1:Operate & flt.rec. blocked		• no • yes	no
_:12391:10	V0> 1:Blk. by meas.-volt. failure		• no • yes	yes
_:12391:109	V0> 1:Detection of faulty phase		• no • yes	no
_:12391:8	V0> 1:Method of measurement		• fundamental comp. • fund. comp. long filter • RMS value	fundamental comp.
_:12391:3	V0> 1:Threshold		0.300 V to 200.000 V	30.000 V
_:12391:4	V0> 1:Dropout ratio		0.90 to 0.99	0.95
_:12391:107	V0> 1:Pickup delay		0.00 s to 60.00 s	0.00 s
_:12391:6	V0> 1:Operate delay		0.00 s to 100.00 s	3.00 s
_:12391:101	V0> 1:V> healthy ph-to-gnd volt.		0.300 V to 200.000 V	70.000 V
_:12391:104	V0> 1:V< faulty ph-to-gnd volt.		0.300 V to 200.000 V	30.000 V

6.13.9.4 Information List

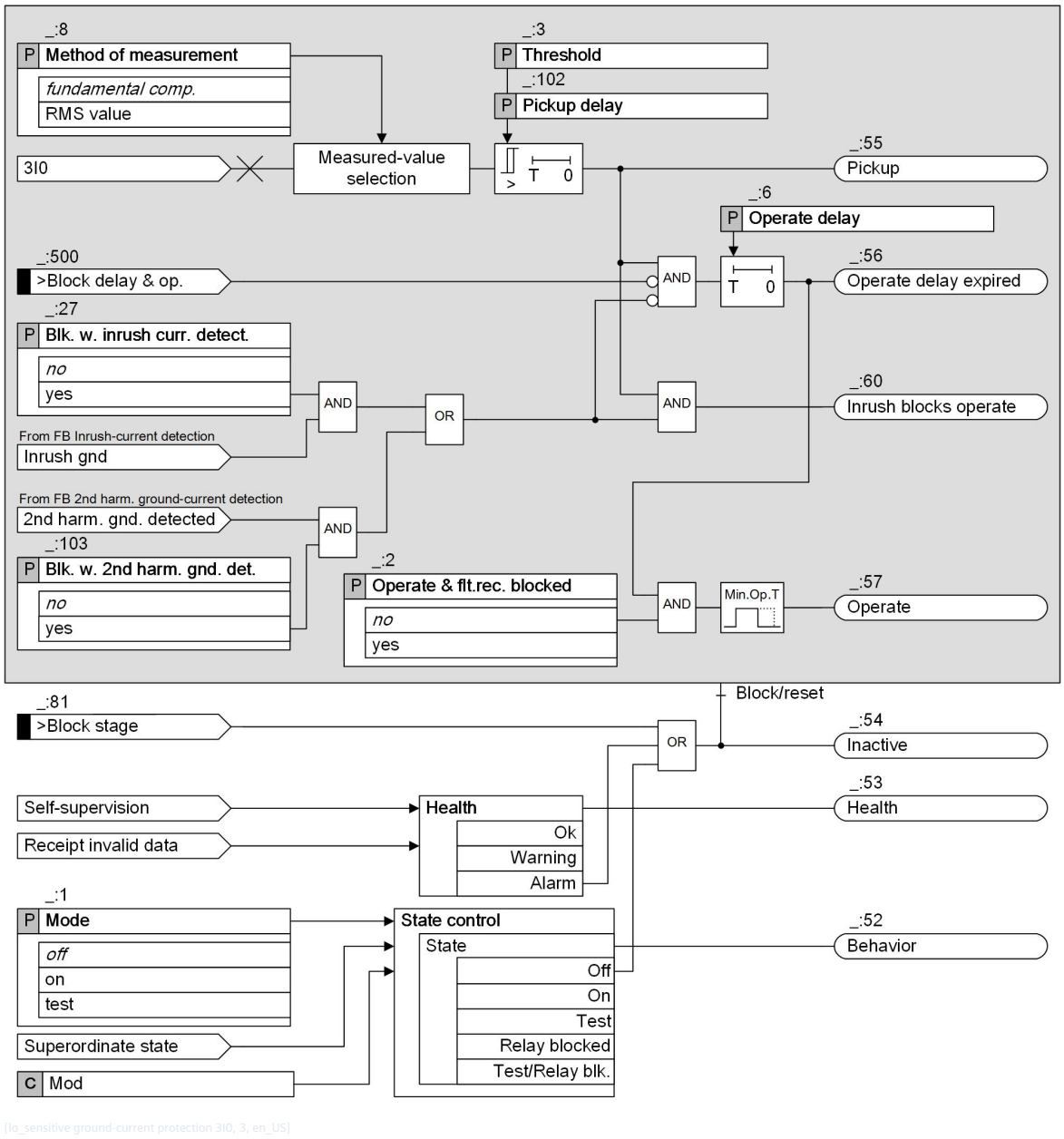
No.	Information	Data Class (Type)	Type
V0> 1			
_:12391:81	V0> 1:>Block stage	SPS	I
_:12391:54	V0> 1:Inactive	SPS	O
_:12391:52	V0> 1:Behavior	ENS	O
_:12391:53	V0> 1:Health	ENS	O
_:12391:300	V0> 1:Faulty phase	ACT	O
_:12391:55	V0> 1:Pickup	ACD	O
_:12391:56	V0> 1:Operate delay expired	ACT	O
_:12391:57	V0> 1:Operate	ACT	O

6.13.10 Non-Directional 3I0 Stage

6.13.10.1 Description

In the **Directional sensitive ground-fault detection** function, the **Non-directional 3I0 stage** also works on demand.

Logic



[lo_sensitive ground-current protection 3I0, 3, en_US]

Figure 6-263 Logic Diagram of the Non-Directional 3I0 Stage

Measured Value 3I0

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

Depending on the connection type of the measuring point as well as the current terminal blocks used, different linearity and setting ranges result. You can find more information in section *Measured Value 3I0, Method of Measurement , Page 897*.

Method of Measurement

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking of the Tripping by Device-Internal Inrush-Current Detection

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started. After that time, the stage operates.

The **Blk. w. 2nd harm. gnd. det.** parameter allows you to define whether the operate indication of the stage should be blocked when the detected 2nd harmonic component of the ground current exceeds a threshold value. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started. After that time, the stage operates.

6.13.10.2 Application and Setting Notes

Parameter: Blk. w. inrush curr. detect.

- Default setting **(_:27) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you determine whether the tripping is blocked during the detection of an inrush current.

Parameter: Blk. w. 2nd harm. gnd. det.

- Default setting **(_:103) Blk. w. 2nd harm. gnd. det.** = ***no***

Parameter Value	Description
no	If no 3I0/IN current flow due to CT saturation with a level above the pickup threshold is expected, select this setting.
yes	If 3I0/IN current flow due to CT saturation with a level above the pickup threshold is expected, the blocking must be activated. This provides stability for the following conditions: • CT saturation without inrush current since a saturated signal also contains 2nd-harmonic content • Phase inrush current that leads to CT saturation and therefore causes 2nd-harmonic inrush current being present also in the parasitic 3I0 current

Parameter: `Method of measurement`

- Recommended setting value **`(_:8) Method of measurement`** = ***`fundamental comp.`***

With the **`Method of measurement`** parameter, you define whether the stage uses the ***`fundamental comp.`*** (standard method) or the calculated ***`RMS value`***.

Parameter Value	Description
`fundamental comp.`	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
`RMS value`	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **`threshold value`** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

Parameter: `Threshold`

- Default setting **`(_:3) Threshold`** = ***`0.050 A`***

The **`Threshold`** parameter allows you to set the threshold value of the ground current 3I0.

Parameter: `Pickup delay`

- Default setting **`(_:102) Pickup delay`** = ***`0.00 s`***

With the parameter **`Pickup delay`** you set whether pickup of the stage is to be delayed or not. If the transient cycle of the ground fault occurrence should not be evaluated, set a delay of 100 ms, for example.

Parameter: `Operate delay`

- Default setting **`(_:6) Operate delay`** = ***`0.30 s`***

The **`Operate delay`** parameter determines the time during which the pickup conditions must be met to issue the operate indication. The operate indication is issued when this time expires.

6.13.10.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
3I0> #				
_:1	3I0> #:Mode		• off • on • test	off
_:2	3I0> #:Operate & flt.rec. blocked		• no • yes	no
_:27	3I0> #:Blk. w. inrush curr. detect.		• no • yes	no
_:103	3I0> #:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:8	3I0> #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	3I0> #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 35.000 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 35.000 A	0.250 A
_:102	3I0> #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:6	3I0> #:Operate delay		0.00 s to 100.00 s	0.30 s

6.13.10.4 Information List

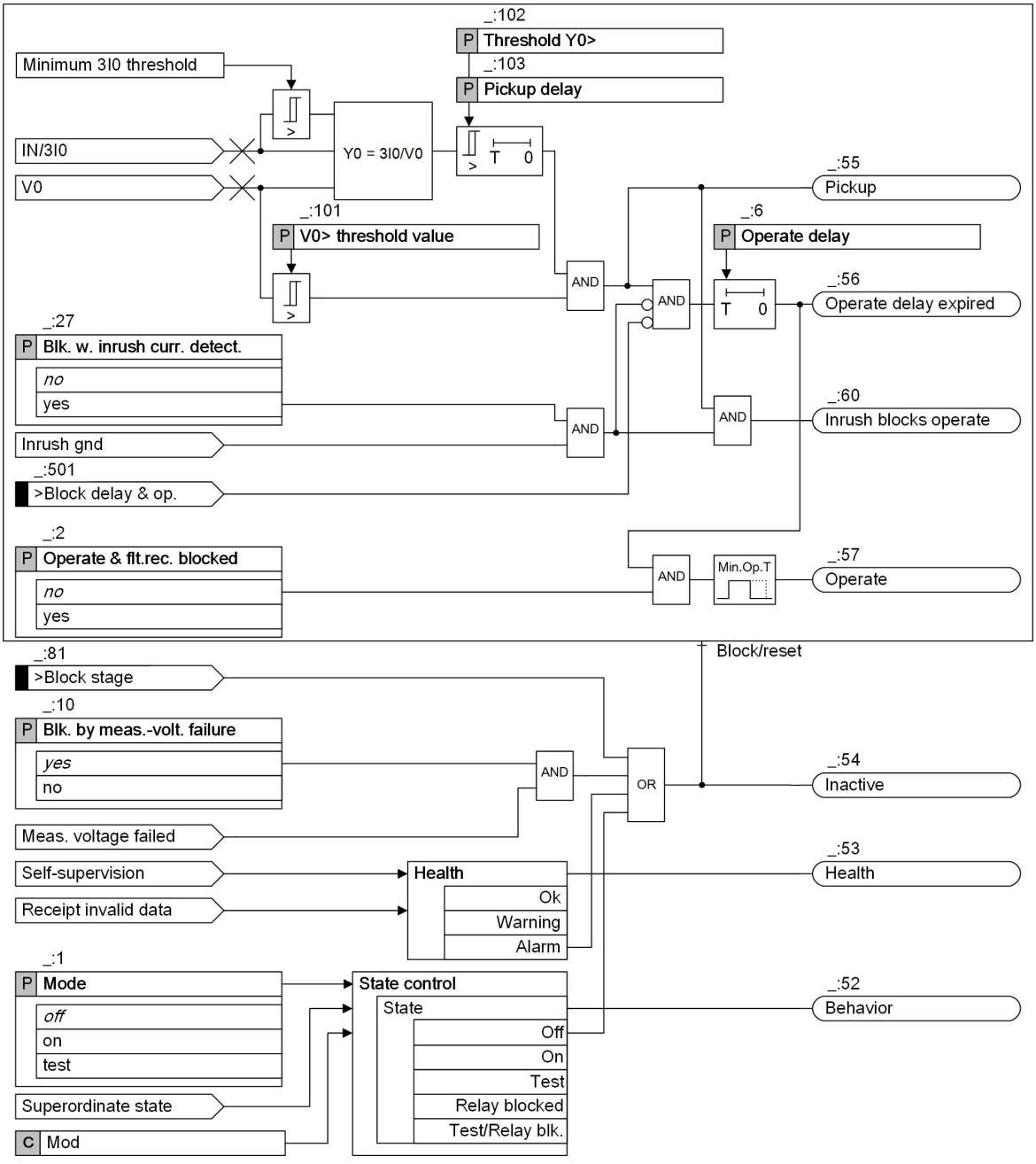
No.	Information	Data Class (Type)	Type
3I0> #			
_:81	3I0> #:>Block stage	SPS	I
_:500	3I0> #:>Block delay & op.	SPS	I
_:54	3I0> #:Inactive	SPS	O
_:52	3I0> #:Behavior	ENS	O
_:53	3I0> #:Health	ENS	O
_:60	3I0> #:Inrush blocks operate	ACT	O
_:55	3I0> #:Pickup	ACD	O
_:56	3I0> #:Operate delay expired	ACT	O
_:57	3I0> #:Operate	ACT	O

6.13.11 Non-Directional Y0 Stage

6.13.11.1 Description

In the **Directional sensitive ground-fault detection** function, the **Non-directional Y0 stage** also works on demand.

Logic



[lo_gfp_sy_0, 3, en_US]

Figure 6-264 Logic Diagram of the Non-Directional Y0 Stage

Measured Value V0, Method of Measurement

The device can measure the residual voltage at the broken-delta winding. The measured voltage VN is converted to a value with reference to the zero-sequence voltage V0. If the residual voltage is not available, the device calculates the zero-sequence voltage V0 from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

The method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, Method of Measurement

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

The method of measurement processes the sampled current values and filters out the fundamental component numerically.

Depending on the connection type of the measuring point as well as the current terminal blocks used, different linearity and setting ranges result. You can find more information in section *Measured Value 3I0, Method of Measurement , Page 897*.

Y0

The fundamental-component values of V0 and 3I0 are used to calculate the admittance Y0 through the formula Y0 = 3I0/V0. This stage uses Y0 as a condition to recognize the ground fault.

Minimum 3I0 Threshold

To start the Y0 calculation, the IN/3I0 value must exceed a minimum 3I0 threshold. For protection-class current transformers, the threshold value is 30 mA ($I_{rated, sec}$ = 1 A) or 150 mA ($I_{rated, sec}$ = 5 A). For sensitive current transformers, the threshold value is 1 mA ($I_{rated, sec}$ = 1 A) or 5 mA ($I_{rated, sec}$ = 5 A).

Ground-Fault Detection, Pickup

If the absolute value of the zero-sequence voltage V0 exceeds the threshold value **`V0> threshold value`** and Y0 exceeds the threshold value **`Threshold Y0>`**, the stage recognizes the ground fault. If the threshold values remain exceeded during the **`Pickup delay`**, the stage picks up.

Blocking the Stage via Binary Input Signal

Blocking of the stage is possible externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pick up of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>open* of the function block **Voltage-transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker.

The **`Blk. by meas.-volt. failure`** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

Blocking of the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking of the Tripping by Device-Internal Inrush-Current Detection

The **`Blk. w. inrush curr. detect.`** parameter allows you to define whether the operate indication of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started. After that time, the stage operates.

6.13.11.2 Application and Setting Notes

Parameter: **Operate & flt.rec. blocked**

- Default setting **(_:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: **Blk. by meas.-volt. failure**

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). If V0 is calculated from the phase-to-ground voltages, Siemens recommends using the blocking.
no	The protection stage is not blocked. If V0 is obtained from the VN measurement of a broken-delta winding, Siemens recommends not using the blocking.

Parameter: **Blk. w. inrush curr. detect.**

- Default setting **(_:27) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you determine whether the operate is blocked during the detection of an inrush current.

Parameter: **V0> threshold value**

- Default setting **(_:101) V0> threshold value** = ***5.000 V***

The **V0> threshold value** parameter allows you to set the zero-sequence voltage sensitivity of the stage. The threshold value must be smaller than the minimum amount of the zero-sequence voltage V0 which must still be detected.

Parameter: **Threshold Y0>**

- Default setting **(_:102) Threshold Y0>** = ***2.00 mS***

With the parameter **Threshold Y0>**, you set the threshold value of the ground admittance Y0. If the ground admittance for the setting value is unknown, you can assume the following relation:

$$Y0 > k_s \frac{I_{c,line}}{3V_{ph-gnd}} + \frac{3I_{0\,min}}{V0>}$$

[fo_se_g_f_Y0, 2, en_US]

k_s	Factor, takes into account the ohmic components of the current (1.2 for overhead lines, 1.0 to 1.05 for cable systems)
$I_{c,line}$	Secondary capacitive ground-fault current for the protected line
V_{ph-gnd}	Secondary phase-to-ground voltage in the healthy case

$3I_{0min}$	Secondary ground current in the healthy case (resulting from transformer error), 5 mA to 10 mA (core balance current transformer), 50 mA to 100 mA (Holmgreen transformer)
V0>	Secondary pickup threshold of the residual voltage

Parameter: `Pickup delay`

- Default setting **`(_:103) Pickup delay`** = ***`0.00 s`***

With the parameter **`Pickup delay`**, you set whether pickup of the stage is to be delayed or not. If the transient cycle of the ground fault occurrence should not be evaluated, set a delay of 100 ms, for example.

Parameter: `Operate delay`

- Default setting **`(_:6) Operate delay`** = ***`0.30 s`***

The **`Operate delay`** parameter determines the time during which the pickup conditions must be met to issue the operate indication. The operate indication is issued when this time expires.

6.13.11.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Y0> #`				
_:1	Y0> #:Mode		• off • on • test	off
_:2	Y0> #:Operate & flt.rec. blocked		• no • yes	no
_:10	Y0> #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	Y0> #:Blk. w. inrush curr. detect.		• no • yes	no
_:101	Y0> #:V0> threshold value		0.300 V to 200.000 V	5.000 V
_:102	Y0> #:Threshold Y0>		0.10 mS to 100.00 mS	2.00 mS
_:103	Y0> #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:6	Y0> #:Operate delay		0.00 s to 60.00 s	0.30 s

6.13.11.4 Information List

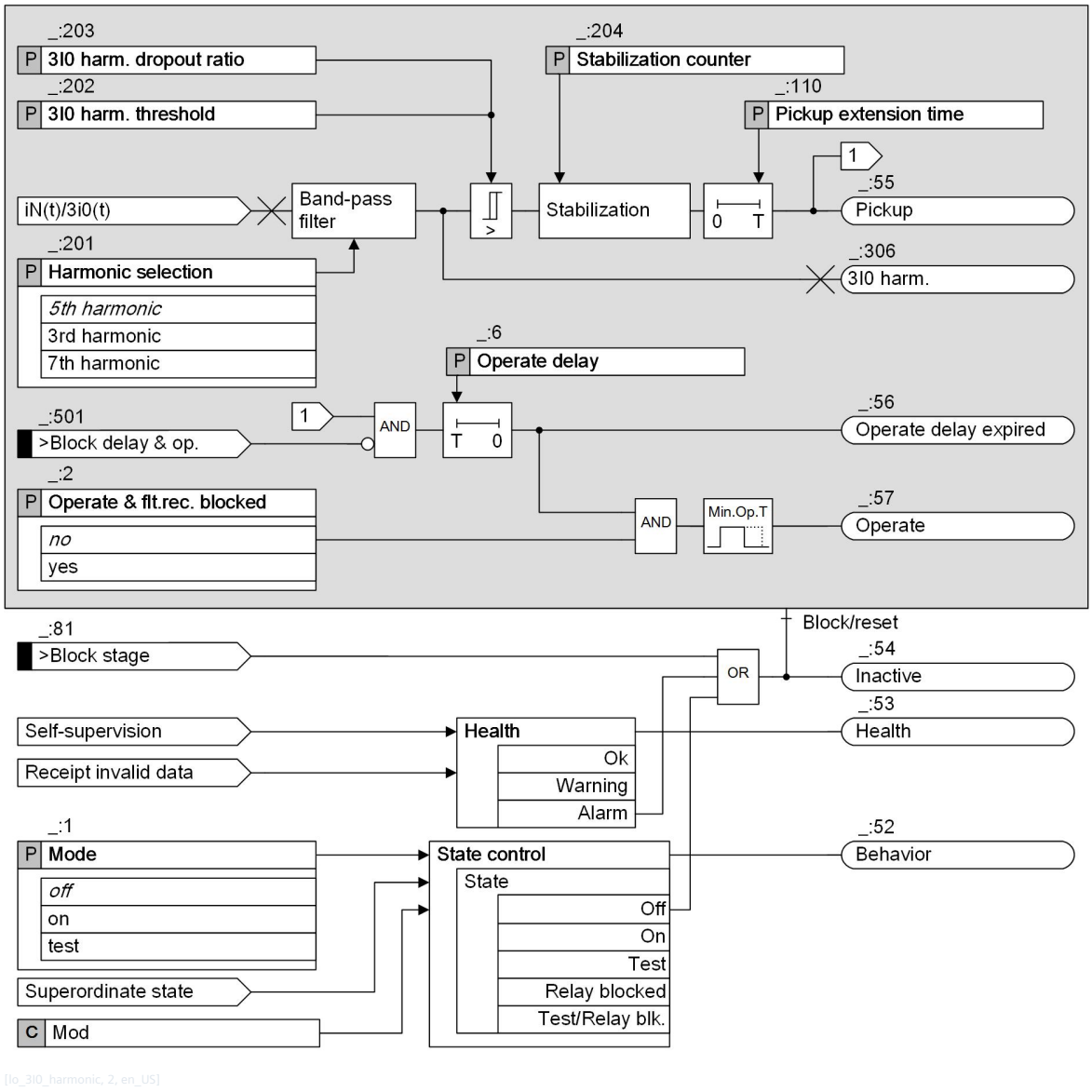
No.	Information	Data Class (Type)	Type
`Y0> #`			
_:81	Y0> #:>Block stage	SPS	I
_:501	Y0> #:>Block delay & op.	SPS	I
_:54	Y0> #:Inactive	SPS	O
_:52	Y0> #:Behavior	ENS	O
_:53	Y0> #:Health	ENS	O
_:60	Y0> #:Inrush blocks operate	ACT	O
_:55	Y0> #:Pickup	ACD	O
_:56	Y0> #:Operate delay expired	ACT	O
_:57	Y0> #:Operate	ACT	O

6.13.12 Non-Directional 3I0 Harmonic Stage

6.13.12.1 Description

The **Non-directional 3I0 harmonic stage** detects ground faults via the 3rd, 5th, or 7th harmonic component of the zero-sequence current 3I0.

Logic



[lo_3I0_harmonic, 2, en_US]

Figure 6-265 Logic Diagram of the Non-Directional 3I0 Harmonic Stage

Measured Value 3I0, Method of Measurement

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

Depending on the connection type of the measuring point and on the current terminal blocks used, different linearity and setting ranges result. You can find more information in chapter *6.13.4.1 Description*.

The function uses the 3rd, 5th, or 7th harmonic component of the ground current 3I0 for detecting the ground fault. The specific harmonic component to be used is determined by the **Harmonic selection** setting.

Stabilization, Pickup

To avoid a wrong pickup in case of transient current peaks, the function uses the **Stabilization counter** parameter. If the magnitude of the zero-sequence harmonic current 3I0harm. exceeds the **3I0 harm. threshold**, the stabilization counter starts. If the 3I0harm. current keeps exceeding the **3I0 harm. threshold** for a specified number of measuring cycles, the stage picks up. You can define the specified number via the **Stabilization counter** parameter.

Pickup Extension

Considering the discontinuity of the 3I0harm. current, the *Pickup* signal does not drop out immediately after the 3I0harm. current falls below the **3I0 harm. threshold**.

When the 3I0harm. current falls below the **3I0 harm. threshold**, the timer **Pickup extension time** starts to hold the *Pickup* signal until the timer expires. The timer resets after the 3I0harm. current exceeds the **3I0 harm. threshold** again during the extension time.

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated. Fault logging and fault recording take place.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
3I0 harm.	3rd, 5th, or 7th harmonic component of the ground current	A	A	Parameter **Rated current**

You can find the parameter **Rated current** in the **FB General** of the function group where the **Sensitive ground-fault detection** function is used. If the 3I0harm. current is smaller than 0.005 % of the rated secondary current, the functional measured value is displayed as ---.

6.13.12.2 Application and Setting Notes

Parameter: Harmonic selection

- Default setting **(_:201) Harmonic selection** = ***5th harmonic***

With the **Harmonic selection** parameter, you select to use the 3rd, 5th, or 7th harmonic component of the zero-sequence current 3I0 for detecting the ground fault.

Parameter: 3I0 harm. threshold

- Default setting **(_:202) 3I0 harm. threshold** = ***0.030 A***

With the **3I0 harm. threshold** parameter, you define the threshold value of the zero-sequence harmonic current 3I0harm. for detecting the ground fault.

This parameter needs to be set according to the experience from the specific network. The experience requires the analysis of permanent ground faults from the network. If such information is unavailable, Siemens recommends a rather low setting between 5 mA and 10 mA secondary.

Parameter: `Stabilization counter`

- Default setting **`(_:204) Stabilization counter`** = ***`4`***

With the **`Stabilization counter`** parameter, you define the number of measuring cycles in which the 3I0harm. current must keep exceeding the **`3I0 harm. threshold`** to meet the pickup condition. With this setting, you can optimize the pickup-condition reliability versus the pickup time.

For example, the **`Stabilization counter`** value is ***`4`***. Then, if the 3I0harm. current exceeds the **`3I0 harm. threshold`** and keeps exceeding the threshold for 4 measuring cycles, the stage picks up. The measuring cycle time is half of the network period. For 50 Hz, the cycle time is 10 ms. To avoid a false pickup due to CB switching operations, Siemens recommends using the default setting.

Parameter: `3I0 harm. dropout ratio`

- Default setting **`(_:203) 3I0 harm. dropout ratio`** = ***`0.60`***

With the **`3I0 harm. dropout ratio`** parameter, you define the dropout threshold for the **`3I0 harm. threshold`** parameter. Siemens recommends using the default setting.

Parameter: `Pickup extension time`

- Default setting **`(_:110) Pickup extension time`** = ***`0.00 s`***

With the **`Pickup extension time`** parameter, you define the time for extending the *Pickup* signal if the zero-sequence harmonic current 3I0harm. falls below the **`3I0 harm. threshold`**.

This extension time can be used to generate a stable pickup indication under fluctuating zero-sequence harmonics.

Parameter: `Operate delay`

- Default setting **`(_:6) Operate delay`** = ***`1.00 s`***

With the **`Operate delay`** parameter, you determine the time during which the pickup conditions must be met to issue the operate indication. The operate indication is issued when this time expires.

Parameter: `Operate & flt.rec. blocked`

- Default setting **`(_:2) Operate & flt.rec. blocked`** = ***`no`***

With the **`Operate & flt.rec. blocked`** parameter, you block the operate indication, the fault recording, and the fault log. In this case, a ground-fault log is created instead of the fault log.

6.13.12.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`3I0> harmonic#`				
_:1	3I0> harmonic#:Mode		• off • on • test	off
_:2	3I0> harmonic#:Operate & flt.rec. blocked		• no • yes	no
_:201	3I0> harmonic#:Harmonic selection		• 3rd harmonic • 5th harmonic • 7th harmonic	5th harmonic

Addr.	Parameter	C	Setting Options	Default Setting
_:202	3I0> harmonic#:3I0 harm. threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 35.000 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 35.000 A	0.150 A
_:203	3I0> harmonic#:3I0 harm. dropout ratio		0.10 to 0.95	0.60
_:204	3I0> harmonic#:Stabilization counter		1 to 10	4
_:110	3I0> harmonic#:Pickup extension time		0.00 s to 60.00 s	0.00 s
_:6	3I0> harmonic#:Operate delay		0.00 s to 60.00 s	1.00 s

6.13.12.4 Information List

No.	Information	Data Class (Type)	Type
3I0> harmonic#			
_:81	3I0> harmonic#:>Block stage	SPS	I
_:501	3I0> harmonic#:>Block delay & op.	SPS	I
_:54	3I0> harmonic#:Inactive	SPS	O
_:52	3I0> harmonic#:Behavior	ENS	O
_:53	3I0> harmonic#:Health	ENS	O
_:55	3I0> harmonic#:Pickup	ACD	O
_:56	3I0> harmonic#:Operate delay expired	ACT	O
_:57	3I0> harmonic#:Operate	ACT	O
_:306	3I0> harmonic#:3I0 harm.	MV	O

6.13.13 Pulse-Pattern Detection Stage

6.13.13.1 Description

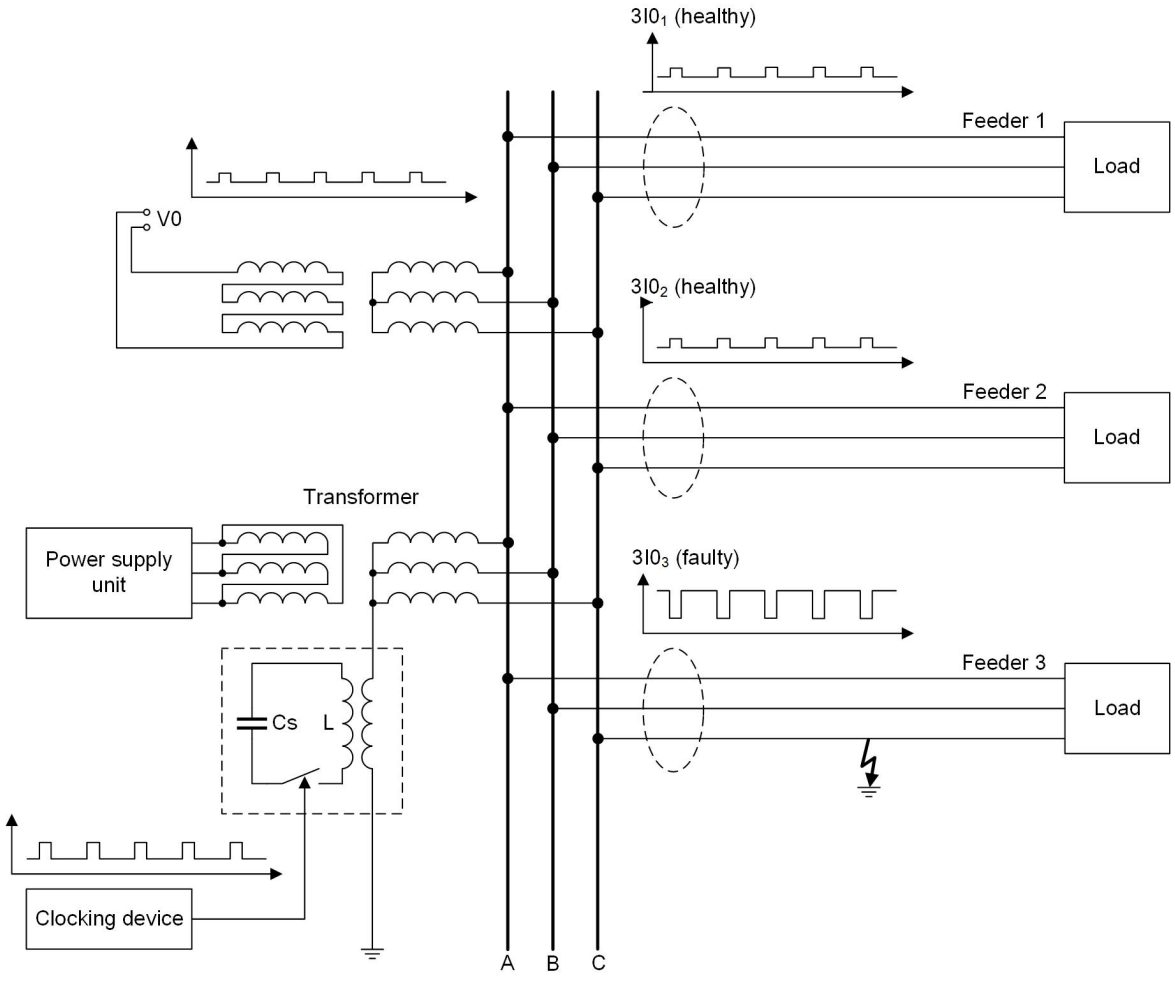
Overview

The **Pulse-pattern detection** stage detects a faulty feeder during a permanent ground fault in overcompensated systems. This method is not reliably applicable to undercompensated systems.

The following figure shows a simplified network that applies the pulse-pattern detection method.

The pulse pattern in the ground current 3I0 is generated by switching on and off a capacitor in parallel to the arc-suppression coil:

- When the capacitor is switched on, an additional capacitive ground current is generated and the 3I0 compensation changes.
- When the capacitor is switched off, the additional capacitive ground current is vanished and the 3I0 compensation returns to the normal state.



[dw_pulse detection network, 2, en_US]

Figure 6-266 Network that Uses the Pulse-Pattern Detection

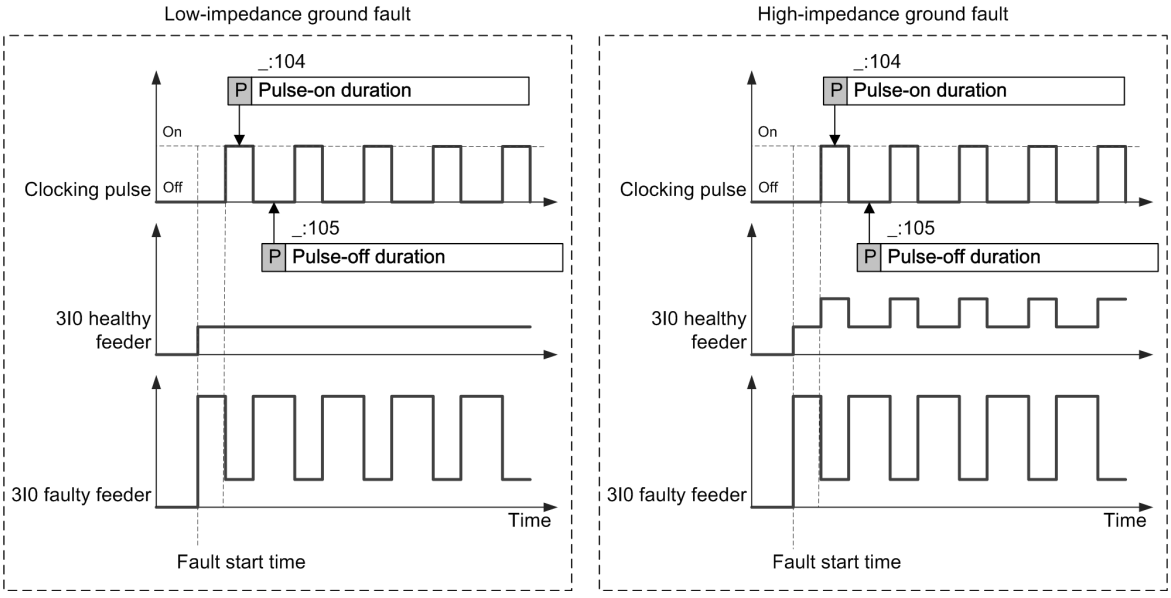
Cs	Capacitance of the switched capacitor
L	Inductance of the arc-suppression coil

Pulse Pattern during a Ground Fault

The following figure shows the 3I0 pulse pattern in an overcompensated system for a low-impedance ground fault and a high-impedance ground fault.

- For low-impedance ground faults, the 3I0 pulse pattern exists only in the faulty feeder.
- For high-impedance ground faults, the pulse pattern is also present in the healthy feeders with lower amplitude but in phase opposition to the faulty feeder.

  Applying a different switch-on/switch-off duration allows distinguishing between faulty and healthy feeders in case of high-impedance ground faults.



[dw_pulse pattern in overcompensation network, 1, en_US]

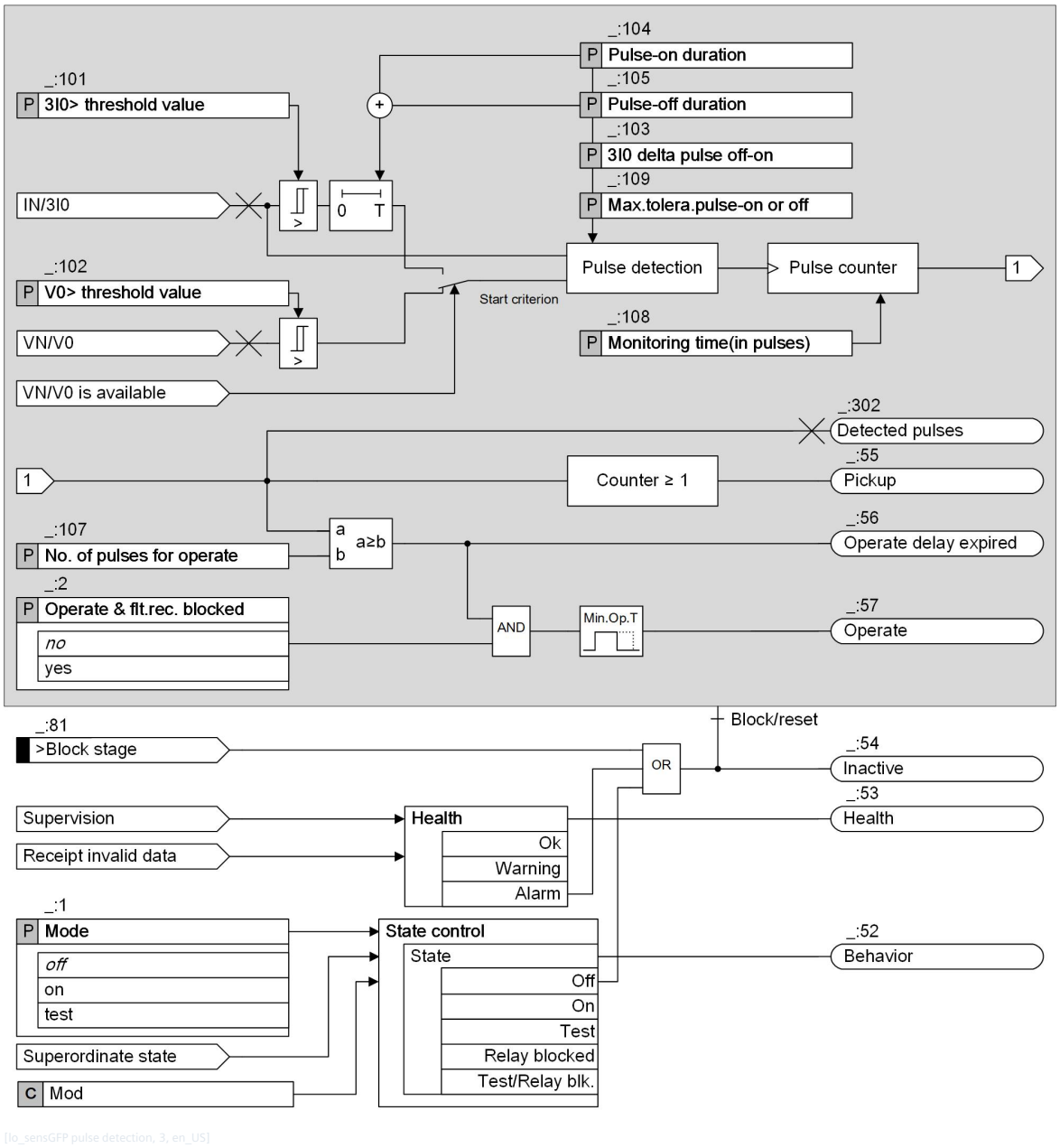
Figure 6-267 Current Pulse Pattern in the Overcompensated System

For the faulty feeder, the current pulse pattern is as follows:

- When the clocking pulse is on, the capacitor is switched on, the zero-sequence current 3I0 in the faulty feeder is reduced, and the corresponding current pulse pattern is off.
- When the clocking pulse is off, the capacitor is switched off, 3I0 in the faulty feeder is increased, and the current pulse pattern is on.

Clocking Pulse	Capacitor	3I0 in the Faulty Feeder	Current Pulse Pattern of the Faulty Feeder
On	On	Reduced	Off
Off	Off	Increased	On

Logic



[lo_sensGFP pulse detection, 3, en_US]

Figure 6-268 Logic Diagram of the Pulse-Pattern Detection Stage

Measured Value V0, Method of Measurement

The device can measure the residual voltage at the broken-delta winding. The measured voltage VN is converted to a value with reference to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, Method of Measurement

The function usually evaluates the ground current 3I0 sensitively measured via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary

ground currents, the function switches to the 3I0 calculated from the phase currents. This results in a very large linearity and settings range.

The method of measurement processes the sampled current values and filters out the fundamental component numerically.

Depending on the connection type of the measuring point as well as the current terminal blocks used, different linearity and setting ranges result. You can find more information in *Measured Value 3I0, Method of Measurement , Page 897*.

Pulse Detection, Pulse Counter

For this stage, voltage routing is optional and current routing is mandatory.

- If VN or V0 is available, the voltage is the only criterion for starting the pulse-detection logic. When the fundamental-component value of V0 exceeds the **V0> threshold value**, the pulse-detection logic is started.
- If VN or V0 is not available, the current is the only criterion for starting the pulse-detection logic. When the fundamental-component value of the zero-sequence current 3I0 exceeds the **3I0> threshold value**, the pulse-detection logic is started.

If the measured current pulse-off duration equals to the value of the **Pulse-on duration** parameter and the measured current pulse-on duration equals to the value of the **Pulse-off duration** parameter, a valid pulse is detected.

After the first valid pulse is detected, the pulse counter is started to count the number of pulses continuously until the stage resets.

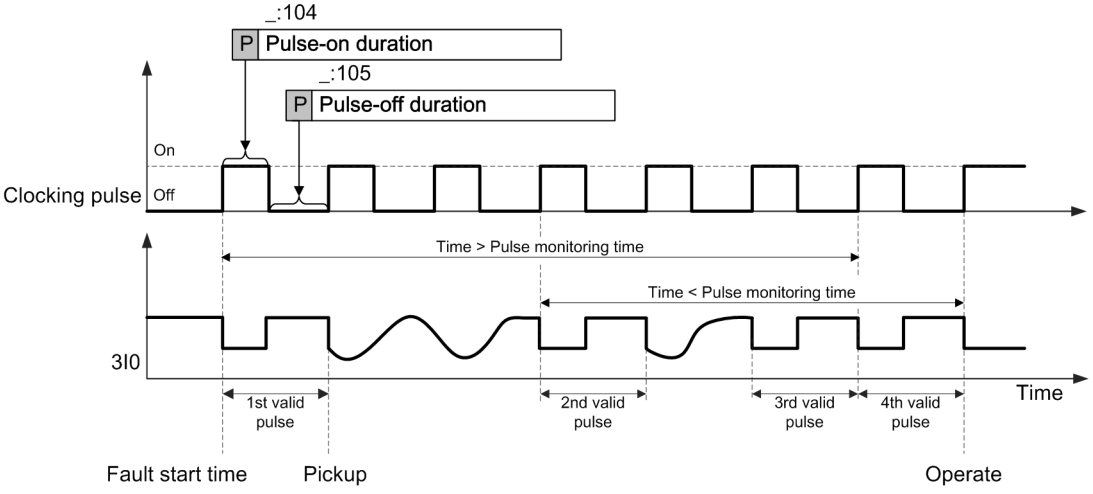
Pickup, Operate

After the first valid pulse is detected, the stage picks up.

If the number of detected pulses within the pulse monitoring time reaches the setting of the **No. of pulses for operate** parameter, the stage operates. The pulse monitoring time is calculated via the following formula:

Pulse monitoring time = Value **Monitoring time(in pulses)** · (Value **Pulse-on duration** + Value **Pulse-off duration**)

For example, the value of the **No. of pulses for operate** parameter is ***3***, and the value of the **Monitoring time(in pulses)** is ***5***. Then the pickup and operate time diagram is as follows:



[dw_pulse pickup and operate, 1, en_US]

Figure 6-269 Pickup and Operate Time

- After the 3rd valid pulse is detected, the stage does not operate because the time between the 1st and the 3rd valid pulses is greater than the pulse monitoring time which is 5 clocking pulses.
- After the 4th valid pulse is detected, the stage operates because the time between the 2nd and the 4th valid pulses is within the pulse monitoring time which is 5 clocking pulses.

Dropout Delay

Switching on the capacitor usually causes 3I0 to decrease in the faulty feeder. This must not cause the stage to drop out. For that reason, a dropout delay is active for the sum of the **Pulse-on duration** and **Pulse-off duration** values.

Detected Pulses of the Ground Fault

The stage records the total number of detected pulses during the permanent ground fault. If the function resets or the operate condition is met, this number is issued via the signal *Detected pulses*.

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

6.13.13.2 Application and Setting Notes

Parameter: V0> threshold value

- Default setting **(_:102) V0> threshold value** = *30.000 V*

The **V0> threshold value** parameter allows you to set the zero-sequence (fundamental) voltage sensitivity of the stage. Set the threshold value smaller than the minimum absolute value of the zero-sequence voltage V0 that must still be detected.

If VN or V0 is not available, the **V0> threshold value** parameter is hidden and the **3I0> threshold value** parameter is visible and used.

Parameter: 3I0> threshold value

- Default setting **(_:101) 3I0> threshold value** = *0.200 A*

If VN or V0 is not available, the **3I0> threshold value** parameter is visible and used.

The **3I0> threshold value** parameter allows you to set the zero-sequence (fundamental) current sensitivity of the stage. Set the threshold value smaller than the minimum absolute value of the zero-sequence current 3I0 that must still be detected.

Parameter: Pulse-on duration, Pulse-off duration

- Default setting **(_:104) Pulse-on duration** = *1.00 s*
- Default setting **(_:105) Pulse-off duration** = *1.50 s*

With the **Pulse-on duration** and **Pulse-off duration** parameters, you define the switch-on and switch-off duration of the capacitor.

These values must be set according to the operation of the clocking device that determines the switch-on and switch-off duration of the capacitor. If you set these 2 parameters to the same or similar values, there is a risk of failure because the stage cannot distinguish the healthy and faulty feeders by only evaluating the ground current during a high-impedance ground fault.

Parameter: Max.tolera.pulse-on or off

- Default setting **(_:109) Max.tolera.pulse-on or off** = *0.15 s*

With the **Max.tolera.pulse-on or off** parameter, you define the tolerance for the measured pulse-on/pulse-off duration. The tolerance is the maximum deviation from the set values for the **Pulse-on duration** and **Pulse-off duration** parameters.

The recommended setting for this parameter is the maximum tolerance of the clocking device plus 40 ms (tolerance of the SIPROTEC 5 device). For the tolerance of the clocking device, you have to consider the tolerances of the pulse-on and pulse-off durations individually and select the larger tolerance of both.

EXAMPLE

Clocking device:

Set pulse-on duration for the clocking device	1.00 s
Max. tolerance pulse-on duration of the clocking device	70 ms
Set pulse-off duration for the clocking device	1.50 s
Max. tolerance pulse-off duration of the clocking device	110 ms
Larger tolerance of both	110 ms

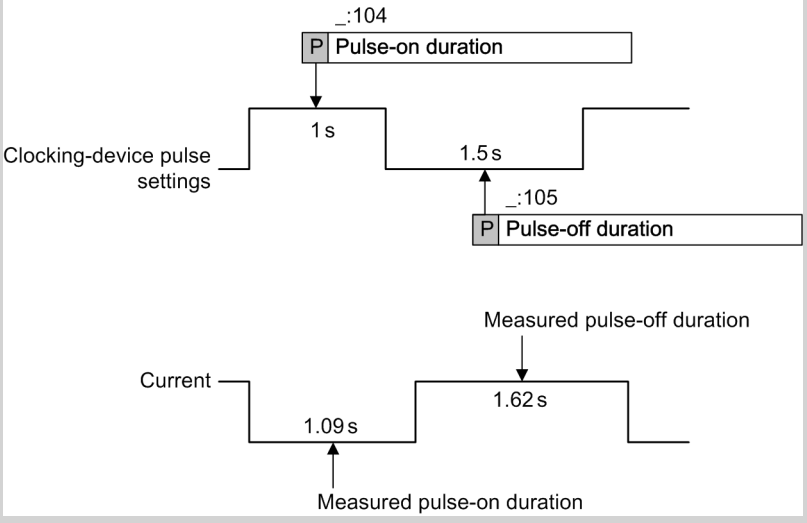
Tolerance to be set:

Tolerance of the SIPROTEC 5 device	40 ms
Total tolerance to be set	110 ms + 40 ms = 150 ms

Consequently, you must set the respective device settings as:

- **`Pulse-on duration`** = 1.00 s
- **`Pulse-off duration`** = 1.50 s
- **`Max.tolera.pulse-on or off`** = 0.15 s

The following figure shows the measured pulse durations which are within the maximum stated tolerances of the example.



[dw_tolerance, 1, en_US]

If you have no information about the tolerance of the clocking device, you can carry out a test recording while the clocking device is in operation. From the test recording, you can read the inaccuracy of the pulse-on/ pulse-off durations. Add a safety margin of 20 ms on the read inaccuracy and consider this as the maximum tolerance of the clocking device. For the setting, add another 40 ms for the tolerance of the SIPROTEC 5 device.

Parameter: `3I0 delta pulse off-on`

- Default setting **`(_:103) 3I0 delta pulse off-on`** = ***`10 %`***

With the **3I0 delta pulse off-on** parameter, you define the minimum percentage value of the ground-current delta between the capacitor switched-on and capacitor switched-off states to detect the pulse pattern. That is, to detect the pulse pattern, the following condition must be met:

$$\frac{3I0_{\text{switched-off}} - 3I0_{\text{switched-on}}}{3I0_{\text{switched-off}}} \cdot 100\ \% \ \geq\ 3I0\ \text{delta pulse off-on}$$

[fo_delta ratio, 1, en_US]

To prevent minor current fluctuations from leading to a maloperation of the function, the setting of the **3I0 delta pulse off-on** parameter cannot be less than 2 %.

The setting of the **3I0 delta pulse off-on** parameter can be calculated with the following formula:

$$3I0\ \text{delta pulse off-on}\ =\ \frac{K_f C_s}{\frac{1}{\omega^2 L} - 3(C_{0\Sigma} - C_{0i})} \cdot\ 100\ \%$$

[fo_3I0_delta_pulse_off-on, 1, en_US]

Where

K_f	Safety factor Siemens recommends applying the factor 0.6 to also detect high-impedance ground faults.
C_s	Capacitance of the switched capacitor
ω	Angular frequency, which equals to 2πf, where f is the power frequency
L	Inductance of the arc-suppression coil
$C_{0\Sigma}$	Zero-sequence capacitance of the whole network
C_{0i}	Zero-sequence capacitance of the protected feeder

EXAMPLE

K_f	0.6
C_s	$1.1 \cdot 10^{-6}$ F
ω	314 rad/s
L	0.577 H
$C_{0\Sigma}$	$5.4297 \cdot 10^{-6}$ F
C_{0i}	$1.5502 \cdot 10^{-6}$ F

Then the setting of the **3I0 delta pulse off-on** parameter is calculated as follows:

$$3I0\ \text{delta pulse off-on}\ =\ \frac{0.6 \cdot 1.1 \cdot 10^{-6}}{\frac{1}{314^2 \cdot 0.577} - 3(5.4297 \cdot 10^{-6} - 1.5502 \cdot 10^{-6})} \cdot\ 100\ \% \ = 11\ \%$$

[fo_delta calculate, 1, en_US]

If the network information for the setting calculation is not available, Siemens recommends using the default setting of ***10 %***.

Parameter: No. of pulses for operate, Monitoring time(in pulses)

- Default setting **(_:107) No. of pulses for operate** = ***3***
- Default setting **(_:108) Monitoring time(in pulses)** = ***5***

With the **No. of pulses for operate** parameter, you determine the number of pulses to be detected within the pulse monitoring time, so that the stage operates.

With the **Monitoring time(in pulses)** parameter, you define the pulse monitoring time, which is calculated via the following formula:

Pulse monitoring time = Value **`Monitoring time(in pulses)`** · (Value **`Pulse-on duration`** + Value **`Pulse-off duration`**)

6.13.13.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Pulse detect.#				
_:1	Pulse detect.#:Mode		• off • on • test	off
_:2	Pulse detect.#:Operate & flt.rec. blocked		• no • yes	no
_:102	Pulse detect.#:V0> threshold value		0.300 V to 200.000 V	30.000 V
_:101	Pulse detect.#:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.00 A
		1 A @ 1.6 Irated	0.001 A to 35.000 A	0.200 A
		5 A @ 1.6 Irated	0.005 A to 35.000 A	1.000 A
_:103	Pulse detect.#:3I0 delta pulse off-on		2 % to 50 %	10 %
_:104	Pulse detect.#:Pulse-on duration		0.20 s to 10.00 s	1.00 s
_:105	Pulse detect.#:Pulse-off duration		0.20 s to 10.00 s	1.50 s
_:109	Pulse detect.#:Max.tolera.pulse-on or off		0.02 s to 2.00 s	0.15 s
_:107	Pulse detect.#:No. of pulses for operate		2 to 100	3
_:108	Pulse detect.#:Monitoring time(in pulses)		2 to 100	5

6.13.13.4 Information List

No.	Information	Data Class (Type)	Type
Pulse detect.#			
_:81	Pulse detect.#:>Block stage	SPS	I
_:54	Pulse detect.#:Inactive	SPS	O
_:52	Pulse detect.#:Behavior	ENS	O
_:53	Pulse detect.#:Health	ENS	O
_:302	Pulse detect.#:Detected pulses	MV	O
_:55	Pulse detect.#:Pickup	ACD	O
_:56	Pulse detect.#:Operate delay expired	ACT	O
_:57	Pulse detect.#:Operate	ACT	O

6.13.14 Intermittent Ground-Fault Blocking Stage

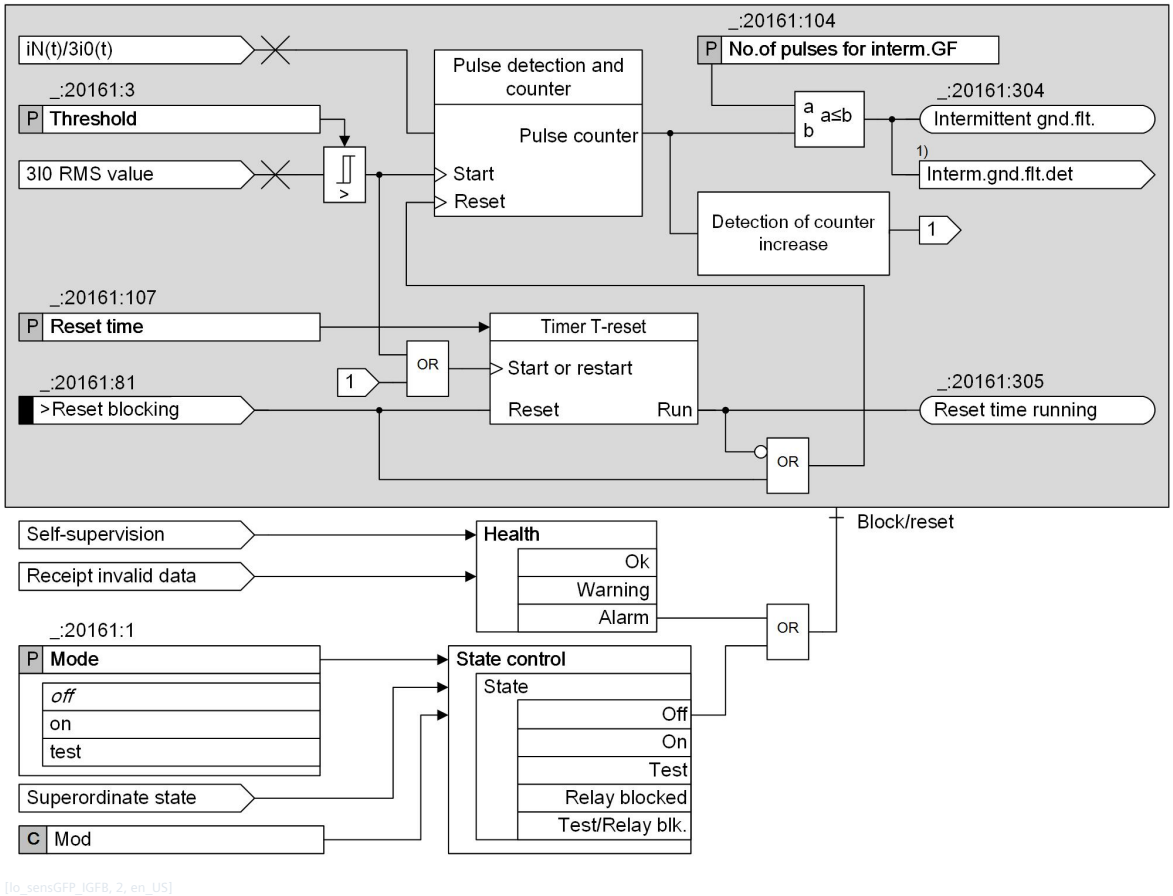
6.13.14.1 Description

Most functions designed for the detection of permanent ground faults may show a disadvantageous behavior in case of intermittent ground faults. An example of these functions is the **3I0> stage with cos φ or sin φ measurement**. In case of an intermittent ground fault, these functions may cause a flood of information due to continuously exceeding and dropping below thresholds. Also short-term wrong directional results are possible due to the nature of the intermittent signals. To avoid this disadvantage, these functions should be blocked in case of intermittent grounds faults.

The **Intermittent ground-fault blocking** stage detects and classifies a ground fault as intermittent and sends a blocking signal to the following stages:

- Directional **3I0> stage with cos φ or sin φ measurement**
- Directional **3I0> stage with φ(V0, 3I0) measurement**
- Directional **Y0> stage with G0 or B0 measurement**
- Directional **stage with phasor measurement of a harmonic**

Logic



[lo_sensGFP_IGFB, 2, en_US]

Figure 6-270 Logic Diagram of the Intermittent Ground-Fault Blocking Stage

(1) This signal is sent to the protection stages described in the preceding sections.

Measured Value 3I0

The algorithm evaluates the true RMS value of the ground current to ensure that ground-current pulses are considered.

You can find more information about possible connection types and measuring angles in chapter *Measured Value 3I0, Method of Measurement , Page 897*.

Pulse Counting and Intermittent Ground-Fault Indication

If the true RMS value of 3I0 exceeds the **Threshold** value, the current-pulse (current-peak) detection takes place. During the ongoing intermittent ground fault, all current pulses are counted.

If the pulse count reaches the threshold value set in the parameter **No.of pulses for interm.GF**, the signal *Intermittent gnd.flt.* is issued. At once, the internal signal *Interm.gnd.flt.det* is sent to the following stages:

- Directional **3I0> stage with cos φ or sin φ measurement**
- Directional **3I0> stage with φ(V0, 3I0) measurement**
- Directional **stage with phasor measurement of a harmonic**
- Directional **Y0> stage with G0 or B0 measurement**

If the **Blk.by interm.gnd.flt.** parameter in one of these stages is set to ***yes***, the stage is blocked.

Reset Time for the Definition of the Interval between Independent Ground Faults

If there is a large interval between independent ground faults or if the ground fault extinguishes and does not restrike within a large time, an intermittent ground fault can be considered as definitely disappeared.

The interval between ground faults is monitored with the reset time. If a ground fault occurs, the **Timer T-reset** with the setting **Reset time** is launched. Each new ground-current pulse restarts the **Reset time** with its initial value. If the **Timer T-reset** expires, that is, if no new ground fault was detected during that period, all memories and the stage logics are reset.

The **Timer T-reset** thus determines the time during which the next ground fault must occur to be processed yet as an intermittent ground fault in connection with the previous fault. A ground fault that occurs later is considered as a new ground-fault event.

Start and Reset Conditions of the Timer T-reset

The **Timer T-reset** is started if one of the following conditions is fulfilled:

- The true RMS value of 3I0 exceeds the **Threshold** value.
- A new pulse is detected. That is, with each new pulse, the timer starts again with its initial value.

The **Timer T-reset** can be reset via the binary input signal *>Reset blocking*.

Reset Conditions of the Counter and the Protection-Stage Blocking

The whole stage, including the counter and protection-stage blocking signal, is reset if one of the following conditions is fulfilled:

- The **Timer T-reset** expires.
- The binary input signal *>Reset blocking* is activated.

6.13.14.2 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:20161:3) Threshold** = ***1.000 A***

With the parameter **Threshold**, you set the intermittent ground-fault pickup threshold. This setting must be coordinated with the applied protection stage for detecting a permanent ground fault, which shall be blocked for an intermittent fault, for example, the **3I0> stage with cos φ or sin φ measurement**.

The parameter **Threshold** must be set to the same value as the respective **3I0> threshold value** of the protection stage. For example, in case of the **3I0> stage with cos φ or sin φ measurement**, the value from the parameter **(_:12601:101) 3I0> threshold value** must be applied for the parameter **Threshold**. It is not required to set a lower value than the respective **3I0> threshold value** of the protection stage.

If the **3I0> threshold value** of the protection stage is set to a higher value than the setting range for the parameter **Threshold**, set the maximum setting value for the parameter **Threshold**.

Parameter: No.of pulses for interm.GF

- Default setting **(_:20161:104) No.of pulses for interm.GF** = ***3***

With the parameter **No.of pulses for interm.GF**, you set the total number of pulse counts at which the ground fault is considered to be intermittent. Siemens recommends using the default setting.

Parameter: Reset time

- Default setting **(_:20161:107) Reset time** = ***5.00 s***

With the parameter **Reset time**, you define the minimum time between 2 adjacent ground faults/impulses. If the time is larger than the **Reset time**, the intermittent ground fault is considered as disappeared. This can mean that the ground fault has disappeared or that the intermittent ground fault has changed to a static ground fault. The function resets and a blocking is cleared.

Siemens recommends using the default setting.

6.13.14.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Blk.interm.GF				
_:20161:1	Blk.interm.GF:Mode		• off • on • test	off
_:20161:3	Blk.interm.GF:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:20161:104	Blk.interm.GF:No.of pulses for interm.GF		2 to 50	3
_:20161:107	Blk.interm.GF:Reset time		1.00 s to 600.00 s	5.00 s

6.13.14.4 Information List

No.	Information	Data Class (Type)	Type
Blk.interm.GF			
_:20161:81	Blk.interm.GF:>Reset blocking	SPS	I
_:20161:304	Blk.interm.GF:Intermittent gnd.flt.	SPS	O
_:20161:305	Blk.interm.GF:Reset time running	SPS	O

6.14 Echo and Tripping in the Event of Weak Infeed

6.14.1 Overview of Functions

The **Echo and tripping on weak infeed** function is used to support the teleprotection schemes for distance protection and ground-fault protection. Its use is only advisable, therefore, if you are using an appropriate teleprotection scheme.

In the following situations, a permissive overreach transfer trip (permissive overreach transfer trip scheme, directional comparison and directional unblock method) does not receive a release signal from the opposite line end:

- Lines with single-side infeed, from the end of the line without infeed
- Neutral-point grounding at only one line end, from the end of the line without zero-sequence current
- From the line end with no or weak infeed

To accelerate tripping at both ends of the line in these situations, the **Echo and tripping on weak infeed** function supports the Echo function and the TWI function (TWI = tripping on weak infeed).

To trip the end of the line with a strong infeed, the echo function can be implemented at the end of the line with a weak infeed. In the absence of pickup at one end of the line, the echo function sends the received signal back to the other end of the line as an echo, so that the trip command can be enabled there.

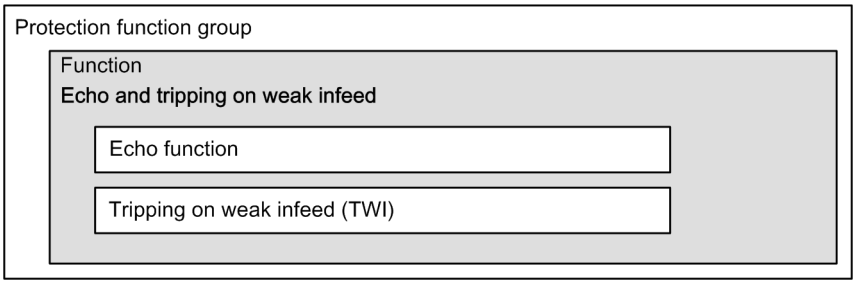
The Echo function can also be used to test the signal connection between the protection devices in the context of permissive underreach transfer trip.

You can also use the TWI function to trip the end of the line with missing or weak infeed. You can use the TWI function together with permissive overreach transfer trips and permissive underreach transfer trip.

Please note that the function must not be used in conjunction with blocking methods.

6.14.2 Structure of the Function

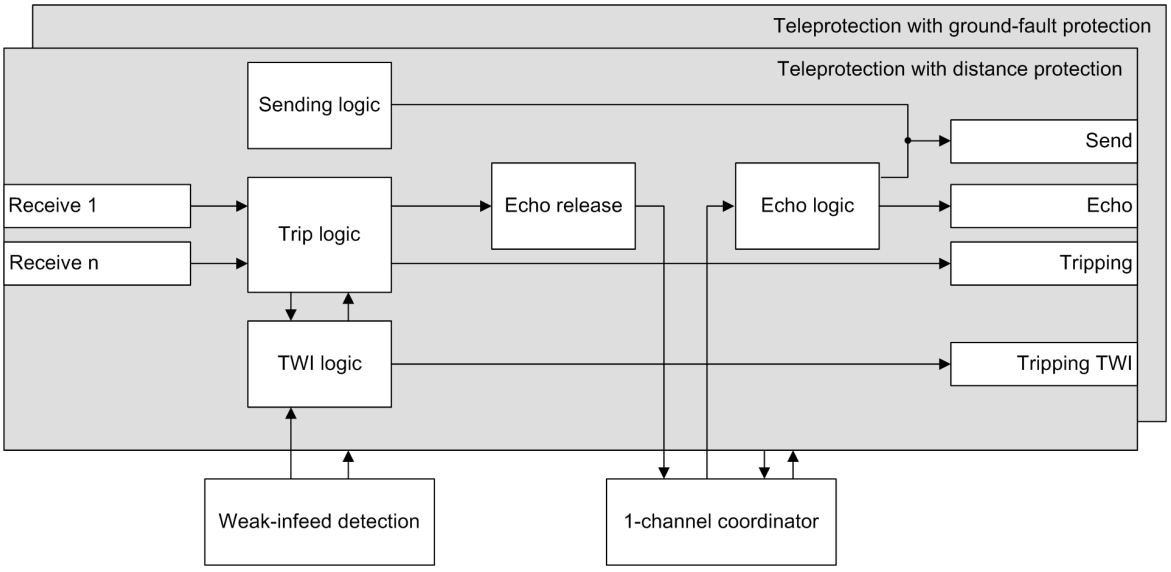
The **Echo and tripping on weak infeed** function comprises the subfunctions shown in the following figure. The function is used in the function group **Line**.



[dwwnstru-070311-01.tif, 1, en_US]

Figure 6-271 Structure/Embedding of the Function

The 2 subfunctions **Echo** and **Tripping on weak infeed** receive control signals from the teleprotection scheme for distance protection and ground-fault protection in the local device, see the following figure.



[dwwnfblk-070311-01.tif, 1, en_US]

Figure 6-272 Function Blocks

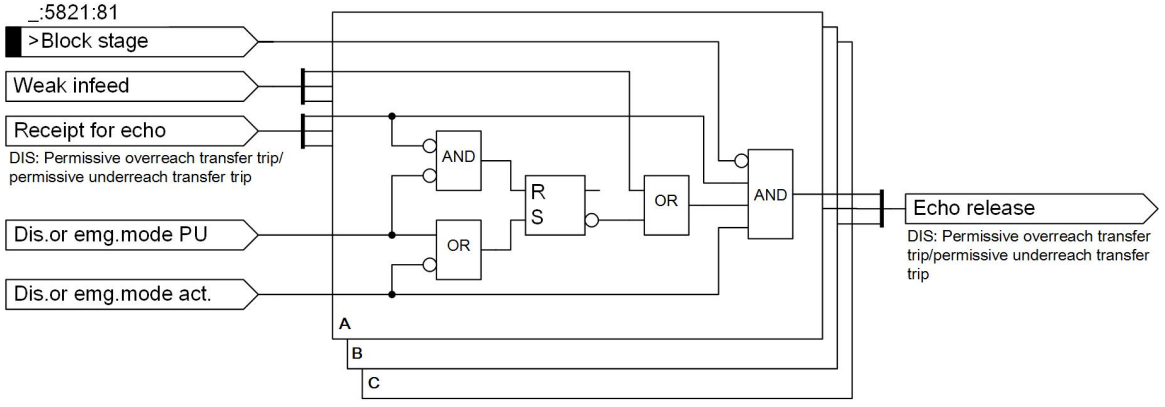
In the following, the individual function blocks are described.

6.14.3 Echo Function

In the absence of pickup at one end of the line, the echo function sends the received signal back to the other end of the line as an echo, so that the trip command can be released there.

Echo Release

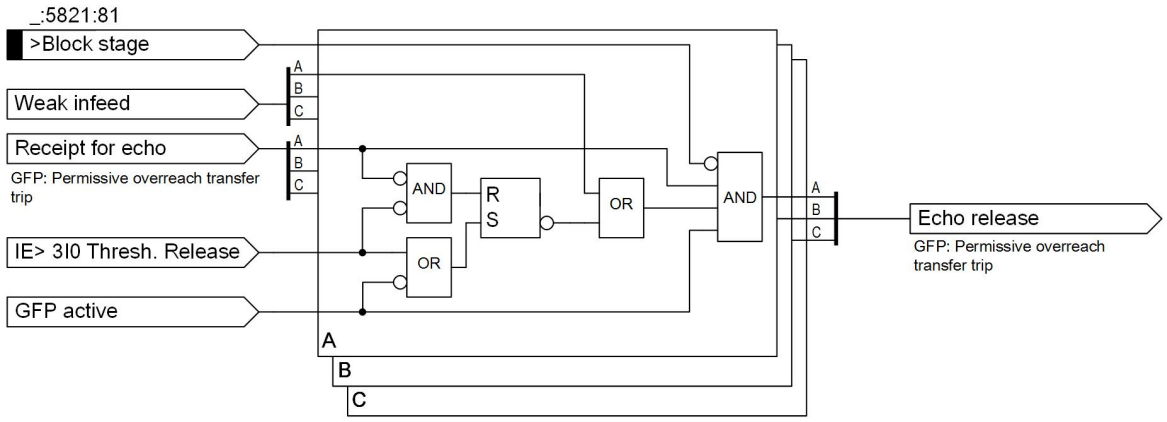
The release signal for the echo function in the teleprotection with distance protection is generated as follows:



[lodisecf-070311-01.tif, 1, en_US]

Figure 6-273 Release Logic for the Echo Function with Distance Protection

The release signal for the echo function in the teleprotection scheme with ground-fault protection is generated as follows:

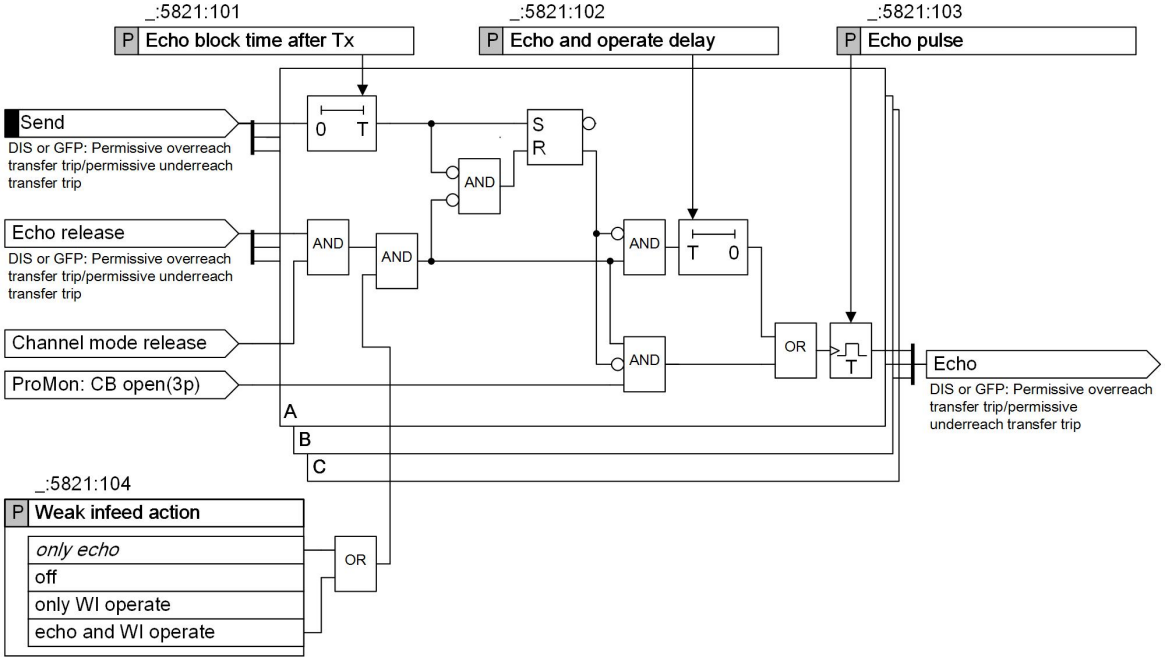


[loeksecf-070311-01.tif, 2, en_US]

Figure 6-274 Release Logic for the Echo Function with Ground-Fault Protection

Echo Logic

There are 2 structurally identical echo logics assigned to the functions Distance protection and Ground-fault protection. The echo logic is shown in the following figure.



[lodisecl-070311-01.tif, 1, en_US]

Figure 6-275 Logic Diagram for the Echo Function

The time delay **(_:5821:102) Echo and operate delay** takes effect when the echo release for distance protection or ground-fault protection is set. This time delay is necessary if the pickup time for the protection function at the weak line end is higher for a reverse fault or if the protection function picks up later due to unfavorable short circuit or ground-current distribution. The echo is transmitted at the end of the time delay. If the circuit breaker at the line end without infeed is 3-pole open, the echo time delay is not necessary. The echo time delay is bypassed.

You can set the length of the echo pulse with the **(_:5821:103) Echo pulse** parameter.

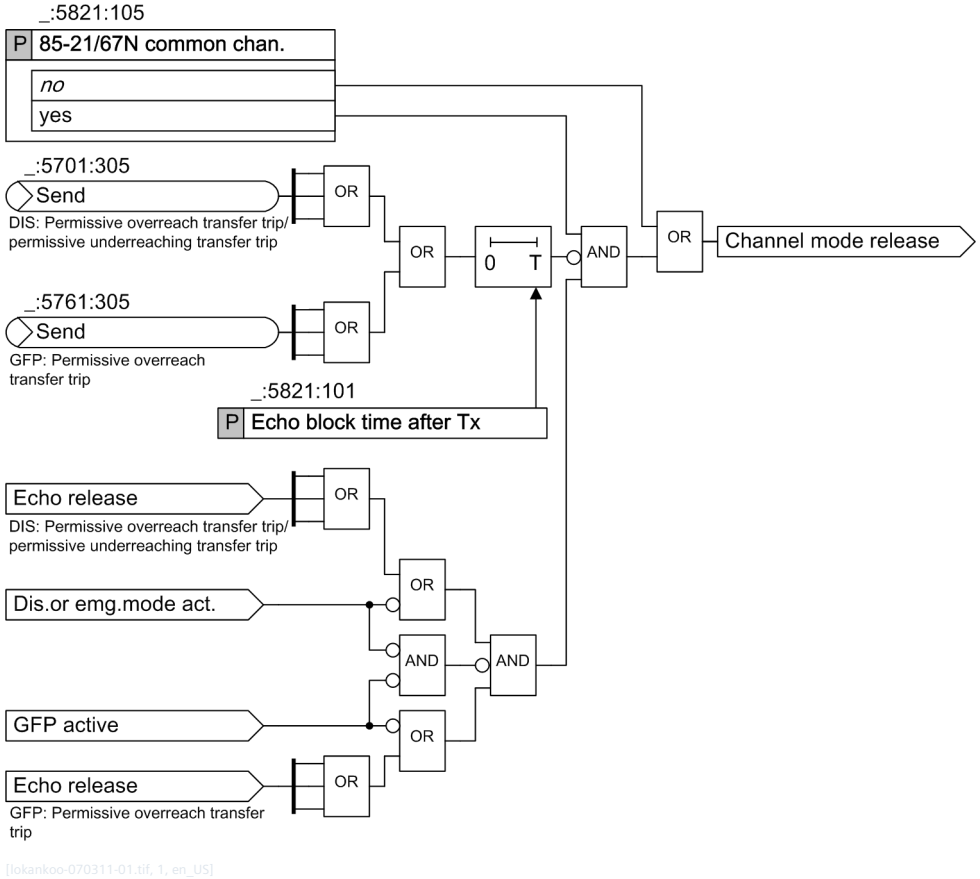
The circuit-breaker switch position is signaled centrally by the process monitor.

A new echo cannot be transmitted for at least 50 ms (default setting of the parameter **(_:5821:101) Echo block time after Tx**) once the echo pulse has been released, or for the duration of the send signal

associated with the release method currently in use. This prevents the echo from being repeated immediately after the line is disconnected.

Common Communication Channel

If the teleprotection scheme with distance protection and ground-fault protection are used in parallel and a common communication channel is used for the send signals, it is no longer possible at the remote end of the line to tell whether the original echo signal is coming from distance protection or from ground-fault protection. The 1-channel coordinator ensures that an echo is only transmitted if an echo release is pending for both protection functions: in other words, if neither protection function picks up.



[lokankoo-070311-01.tif, 1, en_US]

Figure 6-276 Logic of the 1-Channel Coordinator

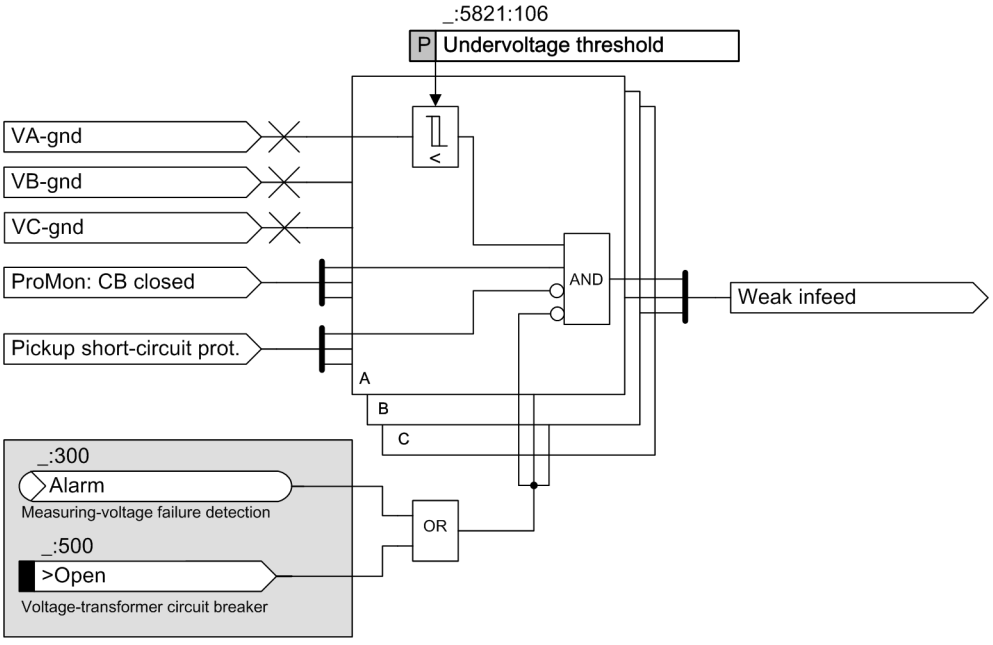
Detection of Weak Infeed

If there is a short-circuit, it has to be assumed that there is only a low voltage at the end of the line with weak infeed, as the weak short-circuit current can only induce a low voltage drop in the short-circuit loop. If there is no infeed, the loop voltage is close to zero. For this reason, tripping with weak infeed depends on the measured undervoltage **V<**. The measured undervoltage also makes it possible to the determine the faulty phase.

For supply systems with grounded neutral point, detection of the weak infeed is phase-selective. The infeed is assumed to be weak in the absence of pickup in the appropriate phase and if undervoltage (**(_:5821:106) Undervoltage threshold** parameter) is detected when the circuit breaker is closed. The information about the circuit-breaker position is supplied by the process monitor.

NOTE

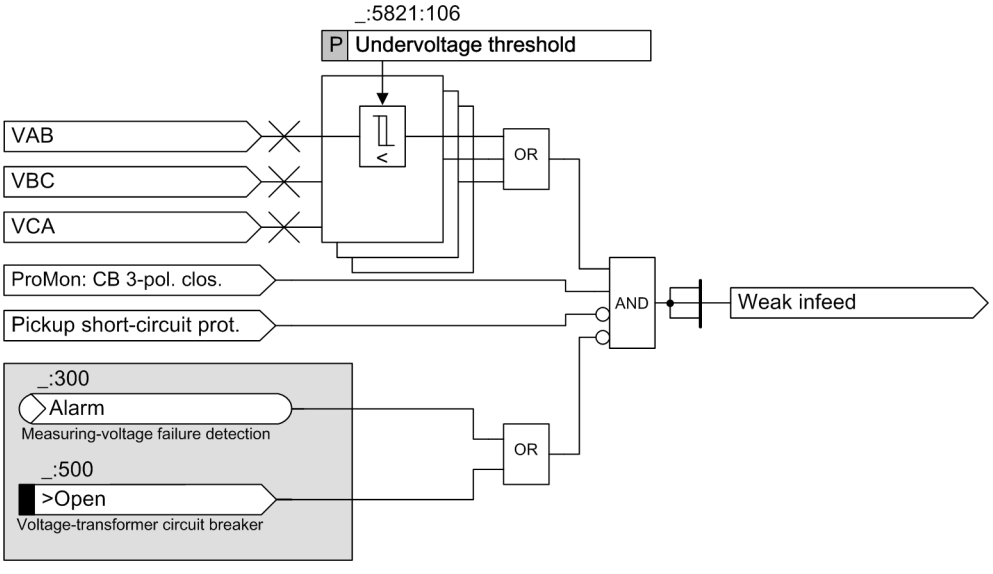
If no circuit-breaker auxiliary contacts are routed and there is an operating condition without current flow, the logic of the process monitor cannot detect the circuit-breaker position. In such cases, you can influence the behavior of the logics in *Figure 6-277* and *Figure 6-278* with the parameter **`CB closed on I=0`** (see *6.14.5 Application and Setting Notes*).



[loasephe-070311-01.tif, 1, en_US]

Figure 6-277 Detection of Weak Infeed for Phase-to-Ground Voltages (Grounded Systems)

For systems with isolated or resonant-grounded neutral point, the phase-to-phase voltages are used as the criteria for undervoltage detection. Phase-selective detection of weak infeed is not possible.



[loasephp-170912-01.tif, 1, en_US]

Figure 6-278 Detection of Weak Infeed for Phase-to-Phase Voltages (Isolated or Resonant-Grounded Systems)

6.14.4 Tripping on Weak Infeed (TWI Function)

The TWI function is used to trip the circuit breaker at the end of the line with missing or weak infeed.

Logic for TWI

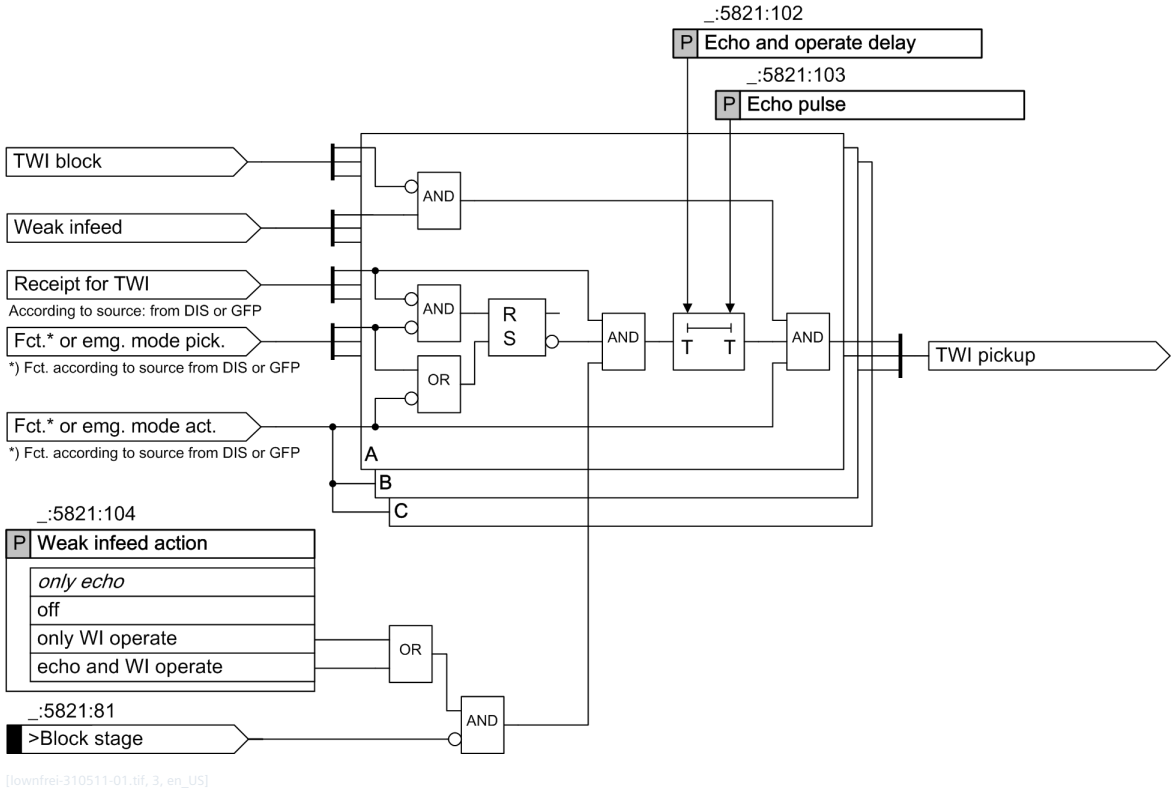


Figure 6-279 Release Logic for Tripping on Weak Infeed

If a weak infeed is detected and a receive signal from the teleprotection scheme for distance protection or ground-fault protection is pending at the same time, phase-selective TWI pickup is triggered. On TWI pickup, the trip logic of the associated method triggers the trip signal.

TWI pickup and thus tripping can be delayed with the parameterizable time **(_:5821:102) Echo and operate delay**. TWI pickup is also delayed by the release time **(_:5821:103) Echo pulse**. Synchronization between echo and TWI is achieved by both functions using the same time parameters.

The TWI function can be blocked via the phase-selective signals *TWI block*. This prevents false pickups, for example, due to switch-off processes on the line in question or on the parallel line. All phases not picked up for a 3-pole TWI operate are blocked for 250 ms. If another protection function trips, all 3 phases are blocked for 250 ms. In the event of a cleared reverse pickup of 1 phase of the corresponding function (depending on the source of Dis or EF), all 3 phases are blocked for 50 ms.

6.14.5 Application and Setting Notes

To select the function **Echo and tripping on weak infeed**, use the function library with DIGSI.

The function is designed for cooperation with permissive underreach transfer trip and permissive overreach transfer trips. The function must not be used in conjunction with blocking methods.

The function contains the following parameters:

Parameter: Weak infeed action

- Recommended setting value **(_:5821:104) Weak infeed action** = ***only echo***

The basic operating mode is set with the **Weak infeed action** parameter.

Parameter Value	Description
only echo	The echo function is active. There is no tripping on short circuits with missing or weak infeed.
off	A missing or weak infeed does not induce echo or tripping.
echo and WI operate	The echo function and tripping on short circuits with missing or weak infeed are active.
only WI operate	Only tripping on short circuits with missing or weak infeed is active.

Parameter: 85-21/67N common chan.

- Default setting **(_:5821:105) 85-21/67N common chan.** = ***no***

If distance protection and ground-fault protection are using the same communication channel and generate an echo independently of one another, you must set the **85-21/67N common chan.** parameter to ***yes*** to avoid unwanted tripping.

Parameter: Echo and operate delay

- Recommended setting value **(_:5821:102) Echo and operate delay** = ***0.04 s***

The length of the echo time delay **Echo and operate delay** must be set so that different pickup response times for distance-protection functions or ground-fault protection functions at all line ends cannot lead to an unwanted echo if faults occur outside the system.

Parameter: Echo pulse

- Recommended setting value **(_:5821:103) Echo pulse** = ***0.05 s***

The echo pulse duration **Echo pulse** can be adapted to transmission system conditions. It must be long enough to ensure that the receive signal is detected even if the movement delays of the protection and transmission devices at the ends of the line are not the same.

Parameter: Echo block time after Tx

- Recommended setting value **(_:5821:101) Echo block time after Tx**= ***0.05 s***

To avoid an infinite echo between the ends of the line, a new echo cannot be sent for a period of **(_:5821:101) Echo block time after Tx** after an echo signal has been sent. An infinite echo could otherwise be triggered by interference coupling on the signal path, for example. The echo is also blocked for this time once distance protection or ground-fault protection has been sent.

Parameter: Undervoltage threshold

- Default setting **(_:5821:106) Undervoltage threshold** = ***25,000 V***

This parameter is relevant only if you are using the TWI function (tripping on missing or weak infeed).

The upper limit for this threshold value **Undervoltage threshold** must be below the minimum voltage expected during operation. The maximum voltage drop to be expected at the end of the line with weak infeed if there is a short circuit on the line to be protected, at which distance protection might no longer pick up, applies as the lower limit.

In systems with grounded neutral point, phase-to-ground voltages apply as reference values; in systems with isolated or resonant-grounded neutral point, phase-to-phase voltages apply.

Parameter: CB closed on I=0

- Default setting **(_:5821:108) CB closed on I=0** = ***no***

With the **CB closed on I=0** parameter, you can influence the behavior of the logic for echo and tripping in the event of weak infeed, when no circuit-breaker auxiliary contacts are routed and there is an operating

condition without current flow. In such operating conditions, the logic of the process monitor is unable to detect the circuit-breaker position.

Parameter Value	Description
no	When you set the parameter **CB closed on I=0** = ***no***, the logics work to detect the weak infeed into the *Figure 6-277* and *Figure 6-278*, as if the circuit breaker were open. In this case, no *Weak infeed* is detected and tripping at weak infeed is not possible.
yes	When you set the parameter **CB closed on I=0** = ***yes***, the logics work to detect the weak infeed into *Figure 6-277* and *Figure 6-278* as if the circuit breaker were closed. In this case, the *Weak infeed* is detected and tripping at weak infeed is possible.

If the circuit-breaker auxiliary contacts are routed, or current flow is detected, the circuit-breaker switch position is detected based on this information.

You can find more detailed information in *6.14.3 Echo Function* in *Detection of Weak Infeed, Page 972*.

6.14.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Weak infeed				
_:5821:101	Weak infeed:Echo block time after Tx		0.00 s to 60.00 s	0.05 s
_:5821:102	Weak infeed:Echo and operate delay		0.00 s to 60.00 s	0.04 s
_:5821:103	Weak infeed:Echo pulse		0.00 s to 60.00 s	0.05 s
_:5821:104	Weak infeed:Weak infeed action		• off • only WI operate • only echo • echo and WI operate	only echo
_:5821:105	Weak infeed:85-21/67N common chan.		• no • yes	no
_:5821:106	Weak infeed:Under-voltage threshold		0.300 V to 200.000 V	25.000 V
_:5821:108	Weak infeed:CB closed on I=0		• no • yes	no

6.14.7 Information List

No.	Information	Data Class (Type)	Type
Weak infeed			
_:5821:52	Weak infeed:Behavior	ENS	O
_:5821:53	Weak infeed:Health	ENS	O
_:5821:81	Weak infeed:>Block stage	SPS	I

6.15 Distance Protection

6.15.1 Overview of Functions

The **Distance protection** (ANSI 21, 21N) function is available in 2 variants:

- Distance protection for grounded systems with 3-phase tripping
- Distance protection for isolated/resonant-grounded systems with 3-phase tripping



NOTE

This section explains the basic design of the distance protection function. Descriptions of the 5 listed functions can be found in the line protection manual (C53000-G5000-C010).

- Distance protection with reactance method (RMD)
- Teleprotection with distance protection
- Teleprotection with ground-fault protection
- Echo and tripping in the event of weak infeed
- Automatic reclosing function



NOTE

When using line distance protection functions in transformer differential protection, the current-transformer requirements of the line protection must be considered. You can find these in the line protection manual (C53000-G5040-C010).

6.15.2 Distance Protection for Grounded Systems

6.15.2.1 Overview of Functions

The function **Distance protection for grounded systems** (ANSI 21 N):

- Is a form of selective short-circuit protection for lines and cables supplied from one or more end(s) in radial, looped or meshed systems,
- Used as backup protection for busbars, transformers and other lines
- Works only in systems with grounded neutral point
- Trips 3-phase
- Suitable for use in all voltage levels

6.15.2.2 Structure of the Function

The function **Distance protection for grounded systems** can be placed in function groups that provide voltage and current measured values as well as line parameters.

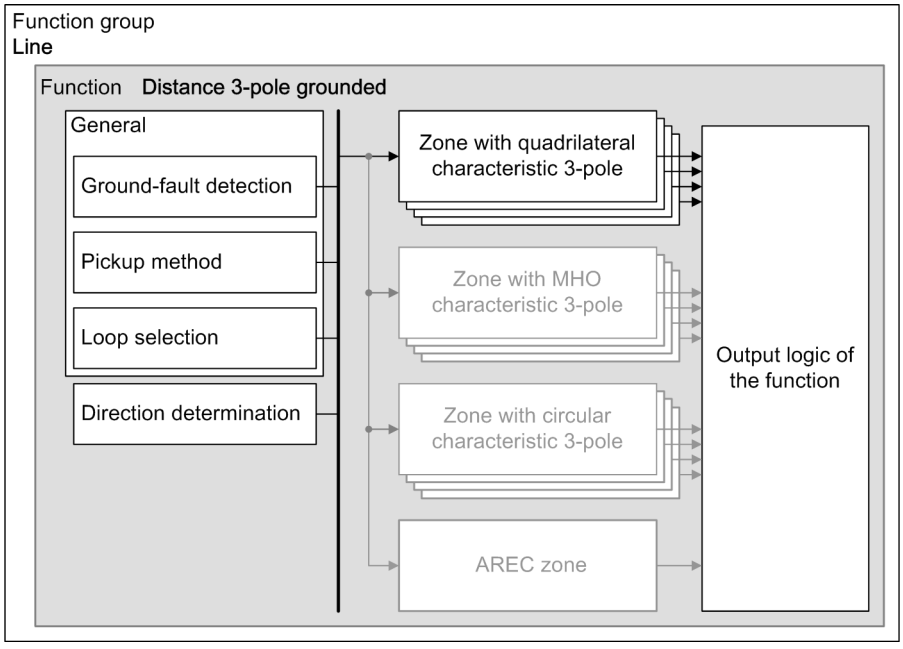
The function **Distance protection for grounded systems** consists of the following blocks:

- General
- Pickup method
- Distance zones (preconfigured quadrilateral characteristic)
- Output logic 3-phase

The function **Distance protection for grounded systems** is preconfigured with 4 zones at the factory. The zones are structured identically. In the function **Distance protection for grounded systems**, a maximum of

16 zones with quadrilateral characteristic curve and 16 zones with MHO characteristic curve can be operated simultaneously.

The following figure shows the structural principles of the function **Distance protection for grounded systems**.



[dwstrg3p-090212-01.tif, 1, en_US]

Figure 6-280 Structure/Embedding of the Function

Mode of Operation

Ground-fault detection determines whether a ground fault has occurred. The pickup method releases the measurement loops. The impedance is calculated for the released loops. The calculated impedance is assigned to the operate curves (quadrilateral, MHO or circular characteristic) of the zones.

In the **Impedance pickup** method, the load cutout is then analyzed and the apparent impedances eliminated. For all picked up loops, the direction to the short-circuit location is then determined. The loop selection determines for which of the picked up loops assignment in the defined zones is done. The loop elimination removes all loops that are no longer picked up after direction determination and querying the load cutout. For the picked up loops, the time delay in the zone logic is started. The zone logic forms the pickup and trip signals of the loops and phases for the zone. The output logic processes the pickup and trip signals of the zones and forms the pickup and trip signals of the distance protection.

Ground-Fault Detection

Ground-fault detection checks whether a ground fault has occurred. If a ground fault has occurred, the measuring elements for the phase-to-ground loops are released.

For ground-fault detection, the following criteria are available:

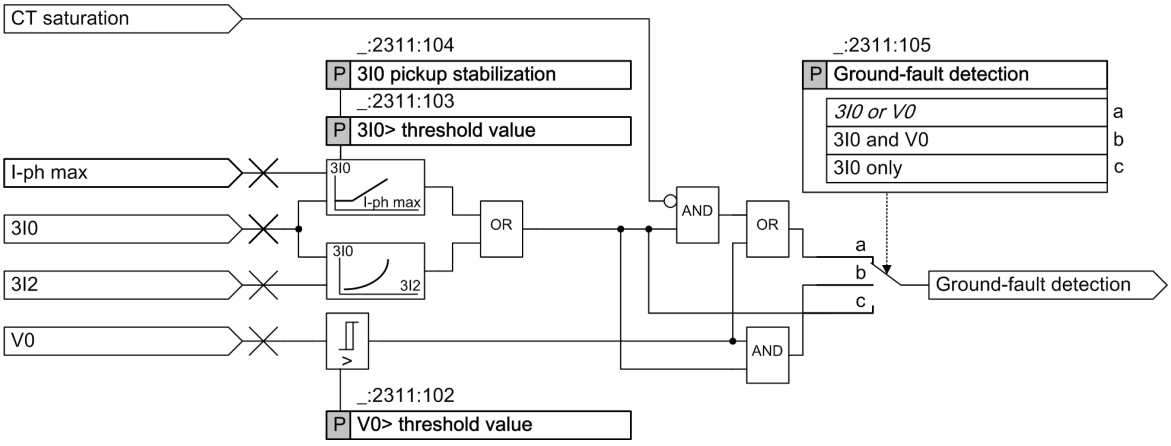
- Monitoring of the zero-sequence current $3I_0$
- Monitoring of the ratio of the zero-sequence current and negative-sequence current ($3I_0/3I_2$)
- Monitoring of the zero-sequence voltage V_0

Current and voltage criteria complement one another (see *Figure 6-281*). If the ratio of zero-sequence impedance to positive-sequence impedance is greater, zero voltage increases. If the ratio of zero-sequence impedance to positive-sequence impedance is small, the ground current increases. The **`Ground-fault detection`** parameter determines the criterion used to perform ground fault recognition.

If a phase current leads to current-transformer saturation, the voltage criterion **must** be met for ground-fault detection. Uneven saturation of current transformers can lead to a secondary zero-sequence current without

a primary zero-sequence current flowing. Automatic scanning of the voltage criterion in the event of current-transformer saturation prevents unwanted ground-fault detections.

Ground-fault detection alone does not lead to the general pickup of the distance protection; it only controls other pickup modules. Ground-fault detection is also not indicated on its own.



[loerdfeh-240511-01.tif, 1, en_US]

Figure 6-281 Logic of Ground-Fault Detection for Grounded Systems

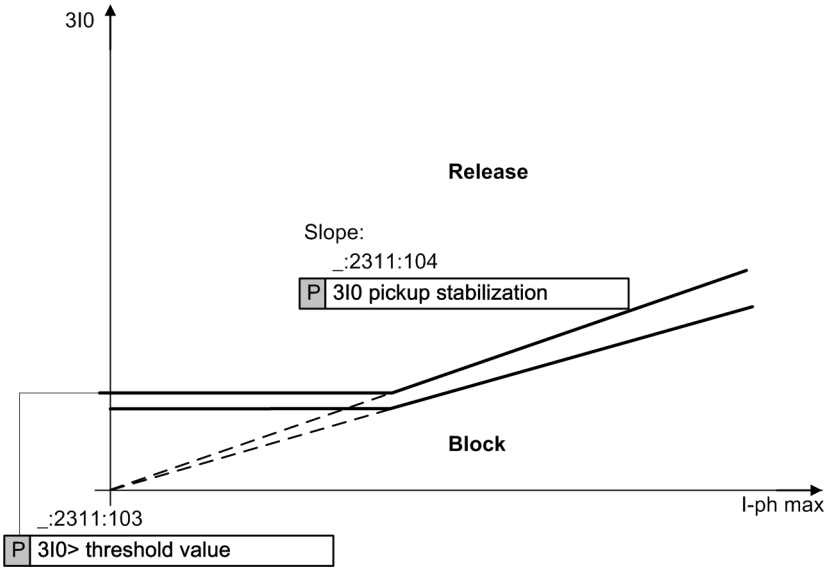
Ground-Fault Detection: Zero-Sequence Current $3I_0$

The zero-sequence current criterion monitors the fundamental component of the sum of phase currents for exceeding a settable value (parameter **`3I0> threshold value`**).

The residual-current criterion is stabilized against unwanted pickup for the following cases:

- Zero-sequence currents due to unbalanced load conditions
- zero-sequence currents in the event of faults without ground contact due to differing saturation of phase-current transformers
- For detected current-transformer saturation (see *Figure 6-281*)

Figure 6-282 shows the pickup characteristic of the residual-current criterion. As phase currents increase, the actual pickup value rises automatically. The dropout threshold is about 95 % of the pickup value.

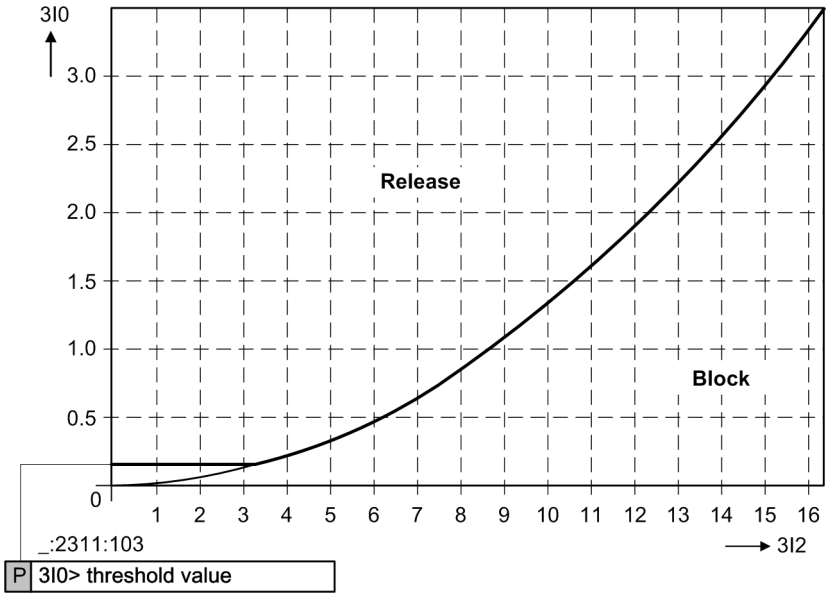


[dwklerds-060611-01.tif, 1, en_US]

Figure 6-282 Zero-Sequence Current Criterion: Pickup Characteristic

Ground-Fault Detection: Zero-Sequence Current/Negative-Sequence Current ($3I_0/3I_2$)

For long, highly loaded lines, high load currents can lead to destabilization of the residual-current criterion (see *Figure 6-282*). For the detection of ground faults, the load-independent negative-sequence current criterion is extended. In addition to the zero-sequence current, the ratio of zero-sequence current to negative-sequence current is also monitored. In a 1-phase short circuit, the negative-sequence current I_2 is approximately as high as the zero-sequence current I_0. If the ratio of zero-sequence current to negative-sequence current exceeds a preset limit, the criterion is released. The zero-sequence current/negative-sequence current criterion is stabilized for high negative-sequence currents using a parabolic characteristic. *Figure 6-283* shows the connection. A prerequisite for release of the zero-sequence current/negative-sequence current criterion is a minimum current of $0.2 \cdot I_{rated}$ for $3I_0$.



[dwkdi0i2-140611-01.tif, 1, en_US]

Figure 6-283 I0/I2 Criterion: Pickup Characteristic

Ground-Fault Detection: Zero-Sequence Voltage V_0

The zero voltage is monitored for exceeding a set value (parameter **`V0> threshold value`**). The dropout threshold is about 95 % of the pickup value. In grounded systems, monitoring of the zero voltage can be used as an additional ground-fault criterion.

Pickup Method

The pickup method selects the fault loops to be measured. The following pickup methods are available:

- Impedance pickup
- Overcurrent pickup
- V-/I pickup
- V-/I-φ pickup

Impedance pickup is preconfigured as the pickup method. You can use different pickup methods in parallel.

Zone Assignment

The calculated impedance phasors for the fault loops are assigned to the zones. For each zone, an operate curve is defined in the R-X plane. The following operate curves are available:

- Quadrilateral characteristic
- MHO characteristic curve

You can find the description of operate curves in the chapters *6.15.6 Zone with Quadrilateral Characteristic Curve* and *6.15.8 Zone with MHO Characteristic Curve*.

Direction Determination

You can define for each zone whether the zone should work ***forwards***, ***backwards***, or ***non-directional***. For directional zones, you define the direction in the R-X plane. When assigning the impedance phasors in the R-X plane, the direction is then additionally analyzed. The description can be found in chapter *6.15.4 Direction Determination*.

Loop Selection in the Grounded System

In systems with effective or low-impedance grounded neutral point, each contact of a phase with ground is a short-circuit-like process. The closest protection equipment must switch off the fault immediately.

For double ground-fault protection, 2 phase-to-ground loops generally pick up. If both ground faults are in the same direction, this can also lead to pickup in the associated phase-to-phase loop. The **Loop select. with ph-ph-g** parameter is used to restrict analysis to certain loops.

In a 3-phase short circuit, all phase-to-phase loops generally pick up. In this case, the 3 phase-to-phase loops are analyzed. If a ground fault is detected, the phase-to-ground loops are also analyzed.

Output Logic

The output logic of the function **Distance protection for grounded systems** links the output indications of the zones and forms the group trip signal of the function.

You can find the description of the output logic in chapter *6.15.11 Output Logic of the Distance Protection*.

Influence of the Inrush-Current Detection

If the device is equipped with the **Inrush-current detection** function, the distance protection can be stabilized against tripping due to transformer-inrush currents. In case of interaction with the inrush-current detection the following configurations are possible:

- Blocking of the pickup for the overcurrent pickup method, V-/I-pickup and V-/I-/ϕ-pickup
- Blocking of individual distance zones
- Blocking of the pickup during impedance pickup by blocking the external distance zone(s)

The **Inrush-current detection** can be configured individually for the blocking of the mentioned pickup methods and distance zones. In case of blocking, the distance zone that is linked to the inrush-current detection or the pickup method will not pick up. The function **Inrush-current detection** signals the blocking through a corresponding indication. Once the blocking drops out and the pickup condition for the respective method or the linked distance zone is met, the pickup is signaled and the corresponding time delay will start. After that time, the operate indication will be generated. Only if the central function **Inrush-current detection** (see section *6.68.1 Inrush-Current Detection*) is in effect can the blocking be set.

6.15.2.3 Application and Setting Notes - General Settings

Set the following settings under **General** in the function **Distance protection for grounded systems**. The setting values are valid for all zones in the distance protection.

Parameter: Zone timer start

- Recommended setting value **(_:2311:110) Zone timer start** = ***on dist. pickup***

The **Zone timer start** parameter is used to determine the time at which the time delays of the zones start.

Parameter Value	Description
on dist. pickup	If the time delays of all zones start simultaneously, select this setting. If the fault type or measurement loop selection changes, all time delays continue to run. Siemens recommends using this setting.
on zone pickup	The time delay for the zone starts with zone pickup. If you need to coordinate the function with other distance or overcurrent protection functions, select this setting.

Parameter: Dist. characteristic angle

- Default setting **(_:2311:107) Dist. characteristic angle** = ***85.0°***

The **Dist. characteristic angle** parameter allows you to set the inclination angle of the distance protection characteristic curve (see *Figure 6-297*). The inclination angle set here for the distance protection characteristic curve applies to all zones in the function.

Siemens recommends setting the **Dist. characteristic angle** parameter to the line angle.

EXAMPLE:

Calculate the line angle from the data of the positive-sequence impedance on the line to be protected:

$$Z_1 = R_L + jX_L = (0.025 + j0.21)\Omega$$

[fo1 line angle, 1, en_US]

$$\text{Line angle} = \arctan\left(\frac{X_L}{R_L}\right)$$

[fo2 line angle, 1, en_US]

$$\text{Line angle} = 83.2°$$

[fo3 line angle, 1, en_US]

If you need to coordinate the function with other equipment, you can also set the inclination angle of the distance protection characteristic differently.

Parameter: Ground-fault detection

- Recommended setting value **(_:2311:105) Ground-fault detection** = ***3I0 or V0***

The **Ground-fault detection** parameter determines the criteria used to perform ground-fault detection.

Parameter Value	Description
3I0 or V0	If either the zero-sequence current criterion (3I0>) or the zero-sequence voltage criterion (V0>) leads to ground-fault detection, select this setting. For grounded systems, the OR operation of the criteria 3I0> and V0> is a reliable criterion for ground-fault detection. The criteria complement one another. For a weak infeed, the zero-sequence current is low and the zero-sequence voltage high. For a strong infeed, the conditions are reversed. Siemens recommends this setting for grounded systems.
3I0 and V0	If you wish to use both criteria for ground-fault detection (logical AND operation of zero-sequence current and zero-sequence voltage criteria), select this setting.
3I0 only	If only the zero-sequence current criterion is to be used for ground-fault detection, select this setting.

Parameter: 3I0> threshold value

- Recommended setting value **(_:2311:103) 3I0> threshold value** = ***0.10 A***

The **3I0> threshold value** parameter is used to define the zero-sequence current limit for ground-fault detection.

The parameter **3I0> threshold value** must be set to a value less than the lowest expected ground current in ground faults on the protected feeder. For the distance protection to trigger for external remote faults as backup protection, set the **3I0> threshold value** parameter to a more sensitive value than that necessary for internal faults. Siemens recommends keeping the setting value of ***0.10°A***.

Parameter: V0> threshold value

- Recommended setting value **(_:2311:102) V0> threshold value** = ***1.66 V***

The **V0> threshold value** parameter is used to define the zero-sequence voltage limit for ground-fault detection.

For ground faults in a grounded system, there is a zero-sequence voltage. The zero-sequence voltage drops as the distance between the fault location and the measuring point increases. Siemens recommends maintaining a default setting of ***1.66 V***. If power-system unbalances can cause higher zero-sequence voltages to occur during operation, you can increase the default setting.

Parameter: 3I0 pickup stabilization

- Recommended setting value **(_:2311:104) 3I0 pickup stabilization** = ***0.10***

The **3I0 pickup stabilization** parameter is used to set the inclination of the 3I0> characteristic curve for ground-fault detection.

Power-system unbalance (for example, untwisted lines) and current-transformer errors can cause a zero-sequence current flow at the protection device in the case of higher phase currents, even if there is no ground fault. The **3I0 pickup stabilization** parameter is used to avoid unwanted ground activation. If no extreme power-system unbalance and unusually large current-transformer errors are expected, Siemens recommends keeping the default value of ***0.10***.

Parameter: Loop select. with ph-ph-g

- Default setting **(_:2311:108) Loop select. with ph-ph-g** = ***block leading phase***

The **Loop select. with ph-ph-g** parameter is used to determine which loops will be analyzed by the distance protection in the event of double ground faults. You can restrict the analysis to certain loops. If you wish to restrict analysis to certain loops, they must have the same direction.

In the case of a bilateral infeed to one common fault resistance with respect to ground, the phase-to-ground loop of the leading phase tends to overreach, that is, the leading phase-to-ground loop is measured too small. If you set the parameter **Loop select. with ph-ph-g** = ***block leading phase***, these loops will not be analyzed.

The following table shows which loops are analyzed for different settings of the **Loop select. with ph-ph-g** parameter:

Parameter Value	Picked Up Loops	Analyzed Loop(s)
block leading phase	A-gnd, B-gnd, A-B B-gnd, C-gnd, B-C A-gnd, C-gnd, C-A	B-gnd, A-B C-gnd, B-C A-gnd, C-A
block lagging phase	A-gnd, B-gnd, A-B B-gnd, C-gnd, B-C A-gnd, C-gnd, C-A	A-gnd, A-B B-gnd, B-C C-gnd, C-A
all	A-gnd, B-gnd, A-B B-gnd, C-gnd, B-C A-gnd, C-gnd, C-A	A-gnd, B-gnd, A-B B-gnd, C-gnd, B-C A-gnd, C-gnd, C-A

Parameter Value	Picked Up Loops	Analyzed Loop(s)
ph-ph only	A-gnd, B-gnd, A-B	A-B
	B-gnd, C-gnd, B-C	B-C
	A-gnd, C-gnd, C-A	C-A
ph-gnd only	A-gnd, B-gnd, A-B	A-gnd, B-gnd
	B-gnd, C-gnd, B-C	B-gnd, C-gnd
	A-gnd, C-gnd, C-A	A-gnd, C-gnd

In a double line, ground faults may occur simultaneously on both lines. To avoid blocking of the internal fault loop, you must set the parameter **Loop select. with ph-ph-g** to ***ph-gnd only*** or ***all*** for this application. To ensure the selectivity of protection, reduce the range of the underreaching zone.

Parameter: Parallel-line compensat.

- Default setting: **(_:2311:106) Parallel-line compensat.** = ***no***

The **Parallel-line compensat.** parameter is used to determine for double circuit lines whether you wish to take into account the influence of the coupling impedance on the loop impedance or not.

NOTE

You see the parameter **Parallel-line compensat.** only if the ground current of the parallel line is available in the **Line** function group. To do this, connect the measuring point **I-1ph** (ground current of the parallel line) to the **Line** function group in DIGSI 5.

NOTE

The following parameters will be visible only if you are working with MHO characteristic curves:

- **Mem. polarization(ph-g)**
- **Mem. polarization(ph-ph)**
- **Cross polarization(ph-g)**
- **Cross polarization(ph-ph)**

The parameters apply to all MHO zones!

Parameter: Mem. polarization(ph-g)

- Default setting **(_:2311:111) Mem. polarization(ph-g)** = ***15.0*** **%**

With the **Mem. polarization(ph-g)** parameter, you can specify the degree of polarization with a buffered voltage for phase-to-ground loops. This parameter influences the extension of the MHO characteristic curve depending on the source impedance. If you wish to work with the basic characteristic curve without extension, set the **Mem. polarization(ph-g)** parameter to ***0.0*** **%**.

Parameter: Mem. polarization(ph-ph)

- Default setting **(_:2311:112) Mem. polarization(ph-ph)** = ***15.0*** **%**

With the **Mem. polarization(ph-ph)** parameter, you can specify the degree of polarization with a buffered voltage for phase-to-phase loops. This parameter influences the extension of the MHO characteristic curve depending on the source impedance. If you wish to work with the basic characteristic curve without extension, set the **Mem. polarization(ph-ph)** parameter to ***0.0*** **%**.

Parameter: Cross polarization(ph-g)

- Default setting **(_:2311:113) Cross polarization(ph-g)** = ***15.0*** **%**

With the **Cross polarization(ph-g)** parameter, you can specify the degree of polarization with an external-fault voltage for phase-to-ground loops. This parameter influences the extension of the MHO charac-

teristic curve depending on the source impedance. If you wish to work with the basic characteristic curve without extension, set the **Cross polarization(ph-g)** parameter to ***0.0 %***.

Parameter: Cross polarization(ph-ph)

- Default setting **(_:2311:114) Cross polarization(ph-ph)** = ***15.0 %***

With the **Cross polarization(ph-ph)** parameter, you can specify the degree of polarization with an external-fault voltage for phase-to-phase loops. This parameter influences the extension of the MHO characteristic curve depending on the source impedance. If you wish to work with the basic characteristic curve without extension, set the **Cross polarization(ph-ph)** parameter to ***0.0 %***.

6.15.2.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:110	General:Zone timer start		• on zone pickup • on dist. pickup	on dist. pickup
_:2311:107	General:Dist. characteristic angle		30.0 ° to 90.0 °	85.0 °
_:2311:105	General:Ground-fault detection		• 3I0 or V0 • 3I0 and V0 • 3I0 only	3I0 or V0
_:2311:103	General:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
_:2311:102	General:V0> threshold value		0.300 V to 200.000 V	1.667 V
_:2311:104	General:3I0 pickup stabilization		0.05 to 0.30	0.10
_:2311:108	General:Loop select. with ph-ph-g		• block leading phase • block lagging phase • all • ph-ph only • ph-gnd only	block leading phase
_:2311:106	General:Parallel-line compensat.		• no • yes	no
_:2311:111	General:Mem. polarization(ph-g)		0.0 % to 100.0 %	15.0 %
_:2311:112	General:Mem. polarization(ph-ph)		0.0 % to 100.0 %	15.0 %
_:2311:113	General:Cross polarization(ph-g)		0.0 % to 100.0 %	15.0 %
_:2311:114	General:Cross polarization(ph-ph)		0.0 % to 100.0 %	15.0 %
Pickup Z<				
_:3661:101	Pickup Z<:Min. phase-current thresh	1 A @ 100 Irated	0.050 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.25 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.050 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.25 A to 175.00 A	0.50 A

Addr.	Parameter	C	Setting Options	Default Setting
_:3661:102	Pickup Z<:Use ph-g load cutout		• no • yes	no
_:3661:103	Pickup Z<:R load cutout (ph-g)	1 A	0.050 Ω to 600.000 Ω	25.000 Ω
		5 A	0.010 Ω to 120.000 Ω	5.000 Ω
_:3661:104	Pickup Z<:Angle load cutout (ph-g)		20.0 ° to 60.0 °	45.0 °
_:3661:105	Pickup Z<:Use ph-ph load cutout		• no • yes	no
_:3661:106	Pickup Z<:R load cutout (ph-ph)	1 A	0.050 Ω to 600.000 Ω	20.000 Ω
		5 A	0.010 Ω to 120.000 Ω	4.000 Ω
_:3661:107	Pickup Z<:Angle load cutout (ph-ph)		20.0 ° to 60.0 °	45.0 °
Z 1				
_:3571:1	Z 1:Mode		• off • on • test	off
_:3571:2	Z 1:Operate & flt.rec. blocked		• no • yes	no
_:3571:121	Z 1:Blocked if diff.prot.active		• no • yes	no
_:3571:27	Z 1:Blk. w. inrush curr. detect.		• no • yes	no
_:3571:101	Z 1:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:3571:114	Z 1:Zone-spec. residu. comp.		• no • yes	no
_:3571:109	Z 1:Directional mode		• non-directional • forward • reverse	forward
_:3571:102	Z 1:X reach	1 A	0.050 Ω to 600.000 Ω	2.500 Ω
		5 A	0.010 Ω to 120.000 Ω	0.500 Ω
_:3571:103	Z 1:R (ph-g)	1 A	0.050 Ω to 600.000 Ω	2.500 Ω
		5 A	0.010 Ω to 120.000 Ω	0.500 Ω
_:3571:104	Z 1:R (ph-ph)	1 A	0.050 Ω to 600.000 Ω	1.250 Ω
		5 A	0.010 Ω to 120.000 Ω	0.250 Ω
_:3571:113	Z 1:Zone-inclination angle		0 ° to 45 °	0 °
_:3571:110	Z 1:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.00 s
_:3571:112	Z 1:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.00 s
_:3571:105	Z 1:Kr		-0.33 to 11.00	1.00
_:3571:106	Z 1:Kx		-0.33 to 11.00	1.00
_:3571:107	Z 1:K0		0.000 to 11.000	1.000
_:3571:108	Z 1:Angle (K0)		-180.00 ° to 180.00 °	0.00 °

Addr.	Parameter	C	Setting Options	Default Setting
Z 2				
_:3572:1	Z 2:Mode		• off • on • test	off
_:3572:2	Z 2:Operate & flt.rec. blocked		• no • yes	no
_:3572:121	Z 2:Blocked if diff.prot.active		• no • yes	no
_:3572:27	Z 2:Blk. w. inrush curr. detect.		• no • yes	no
_:3572:101	Z 2:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:3572:114	Z 2:Zone-spec. residu. comp.		• no • yes	no
_:3572:109	Z 2:Directional mode		• non-directional • forward • reverse	forward
_:3572:102	Z 2:X reach	1 A	0.050 Ω to 600.000 Ω	5.000 Ω
		5 A	0.010 Ω to 120.000 Ω	1.000 Ω
_:3572:103	Z 2:R (ph-g)	1 A	0.050 Ω to 600.000 Ω	5.000 Ω
		5 A	0.010 Ω to 120.000 Ω	1.000 Ω
_:3572:104	Z 2:R (ph-ph)	1 A	0.050 Ω to 600.000 Ω	2.500 Ω
		5 A	0.010 Ω to 120.000 Ω	0.500 Ω
_:3572:113	Z 2:Zone-inclination angle		0 ° to 45 °	0 °
_:3572:110	Z 2:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.30 s
_:3572:112	Z 2:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.30 s
_:3572:105	Z 2:Kr		-0.33 to 11.00	1.00
_:3572:106	Z 2:Kx		-0.33 to 11.00	1.00
_:3572:107	Z 2:K0		0.000 to 11.000	1.000
_:3572:108	Z 2:Angle (K0)		-180.00 ° to 180.00 °	0.00 °
Z 3				
_:3573:1	Z 3:Mode		• off • on • test	off
_:3573:2	Z 3:Operate & flt.rec. blocked		• no • yes	no
_:3573:121	Z 3:Blocked if diff.prot.active		• no • yes	no
_:3573:27	Z 3:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:3573:101	Z 3:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:3573:114	Z 3:Zone-spec. residu. comp.		• no • yes	no
_:3573:109	Z 3:Directional mode		• non-directional • forward • reverse	forward
_:3573:102	Z 3:X reach	1 A	0.050 Ω to 600.000 Ω	10.000 Ω
		5 A	0.010 Ω to 120.000 Ω	2.000 Ω
_:3573:103	Z 3:R (ph-g)	1 A	0.050 Ω to 600.000 Ω	10.000 Ω
		5 A	0.010 Ω to 120.000 Ω	2.000 Ω
_:3573:104	Z 3:R (ph-ph)	1 A	0.050 Ω to 600.000 Ω	5.000 Ω
		5 A	0.010 Ω to 120.000 Ω	1.000 Ω
_:3573:113	Z 3:Zone-inclination angle		0 ° to 45 °	0 °
_:3573:110	Z 3:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.60 s
_:3573:112	Z 3:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.60 s
_:3573:105	Z 3:Kr		-0.33 to 11.00	1.00
_:3573:106	Z 3:Kx		-0.33 to 11.00	1.00
_:3573:107	Z 3:K0		0.000 to 11.000	1.000
_:3573:108	Z 3:Angle (K0)		-180.00 ° to 180.00 °	0.00 °
Z 4				
_:3574:1	Z 4:Mode		• off • on • test	off
_:3574:2	Z 4:Operate & flt.rec. blocked		• no • yes	no
_:3574:121	Z 4:Blocked if diff.prot.active		• no • yes	no
_:3574:27	Z 4:Blk. w. inrush curr. detect.		• no • yes	no
_:3574:101	Z 4:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:3574:114	Z 4:Zone-spec. residu. comp.		• no • yes	no
_:3574:109	Z 4:Directional mode		• non-directional • forward • reverse	non-directional
_:3574:102	Z 4:X reach	1 A	0.050 Ω to 600.000 Ω	12.000 Ω
		5 A	0.010 Ω to 120.000 Ω	2.400 Ω
_:3574:103	Z 4:R (ph-g)	1 A	0.050 Ω to 600.000 Ω	12.000 Ω
		5 A	0.010 Ω to 120.000 Ω	2.400 Ω

Addr.	Parameter	C	Setting Options	Default Setting
_:3574:104	Z 4:R (ph-ph)	1 A	0.050 Ω to 600.000 Ω	12.000 Ω
		5 A	0.010 Ω to 120.000 Ω	2.400 Ω
_:3574:113	Z 4:Zone-inclination angle		0 ° to 45 °	0 °
_:3574:110	Z 4:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.90 s
_:3574:112	Z 4:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.90 s
_:3574:105	Z 4:Kr		-0.33 to 11.00	1.00
_:3574:106	Z 4:Kx		-0.33 to 11.00	1.00
_:3574:107	Z 4:K0		0.000 to 11.000	1.000
_:3574:108	Z 4:Angle (K0)		-180.00 ° to 180.00 °	0.00 °

6.15.2.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:82	General:>Block function	SPS	I
_:2311:54	General:Inactive	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:301	Group indicat.:Selected loop AG	ACD	O
_:4501:302	Group indicat.:Selected loop BG	ACD	O
_:4501:303	Group indicat.:Selected loop CG	ACD	O
_:4501:304	Group indicat.:Selected loop AB	ACD	O
_:4501:305	Group indicat.:Selected loop BC	ACD	O
_:4501:306	Group indicat.:Selected loop CA	ACD	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Pickup Z<			
_:3661:52	Pickup Z<:Behavior	ENS	O
_:3661:53	Pickup Z<:Health	ENS	O
Z 1			
_:3571:81	Z 1:>Block stage	SPS	I
_:3571:500	Z 1:>Block ph-g loops	SPS	I
_:3571:501	Z 1:>Block ph-ph loops	SPS	I
_:3571:51	Z 1:Mode (controllable)	ENC	C
_:3571:54	Z 1:Inactive	SPS	O
_:3571:52	Z 1:Behavior	ENS	O
_:3571:53	Z 1:Health	ENS	O
_:3571:55	Z 1:Pickup	ACD	O
_:3571:300	Z 1:Pickup loop AG	ACD	O
_:3571:301	Z 1:Pickup loop BG	ACD	O
_:3571:302	Z 1:Pickup loop CG	ACD	O

No.	Information	Data Class (Type)	Type
_:3571:303	Z 1:Pickup loop AB	ACD	O
_:3571:304	Z 1:Pickup loop BC	ACD	O
_:3571:305	Z 1:Pickup loop CA	ACD	O
_:3571:56	Z 1:Operate delay expired	ACT	O
_:3571:57	Z 1:Operate	ACT	O
Z 2			
_:3572:81	Z 2:>Block stage	SPS	I
_:3572:500	Z 2:>Block ph-g loops	SPS	I
_:3572:501	Z 2:>Block ph-ph loops	SPS	I
_:3572:51	Z 2:Mode (controllable)	ENC	C
_:3572:54	Z 2:Inactive	SPS	O
_:3572:52	Z 2:Behavior	ENS	O
_:3572:53	Z 2:Health	ENS	O
_:3572:55	Z 2:Pickup	ACD	O
_:3572:300	Z 2:Pickup loop AG	ACD	O
_:3572:301	Z 2:Pickup loop BG	ACD	O
_:3572:302	Z 2:Pickup loop CG	ACD	O
_:3572:303	Z 2:Pickup loop AB	ACD	O
_:3572:304	Z 2:Pickup loop BC	ACD	O
_:3572:305	Z 2:Pickup loop CA	ACD	O
_:3572:56	Z 2:Operate delay expired	ACT	O
_:3572:57	Z 2:Operate	ACT	O
Z 3			
_:3573:81	Z 3:>Block stage	SPS	I
_:3573:500	Z 3:>Block ph-g loops	SPS	I
_:3573:501	Z 3:>Block ph-ph loops	SPS	I
_:3573:51	Z 3:Mode (controllable)	ENC	C
_:3573:54	Z 3:Inactive	SPS	O
_:3573:52	Z 3:Behavior	ENS	O
_:3573:53	Z 3:Health	ENS	O
_:3573:55	Z 3:Pickup	ACD	O
_:3573:300	Z 3:Pickup loop AG	ACD	O
_:3573:301	Z 3:Pickup loop BG	ACD	O
_:3573:302	Z 3:Pickup loop CG	ACD	O
_:3573:303	Z 3:Pickup loop AB	ACD	O
_:3573:304	Z 3:Pickup loop BC	ACD	O
_:3573:305	Z 3:Pickup loop CA	ACD	O
_:3573:56	Z 3:Operate delay expired	ACT	O
_:3573:57	Z 3:Operate	ACT	O
Z 4			
_:3574:81	Z 4:>Block stage	SPS	I
_:3574:500	Z 4:>Block ph-g loops	SPS	I
_:3574:501	Z 4:>Block ph-ph loops	SPS	I
_:3574:51	Z 4:Mode (controllable)	ENC	C
_:3574:54	Z 4:Inactive	SPS	O
_:3574:52	Z 4:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:3574:53	Z 4:Health	ENS	O
_:3574:55	Z 4:Pickup	ACD	O
_:3574:300	Z 4:Pickup loop AG	ACD	O
_:3574:301	Z 4:Pickup loop BG	ACD	O
_:3574:302	Z 4:Pickup loop CG	ACD	O
_:3574:303	Z 4:Pickup loop AB	ACD	O
_:3574:304	Z 4:Pickup loop BC	ACD	O
_:3574:305	Z 4:Pickup loop CA	ACD	O
_:3574:56	Z 4:Operate delay expired	ACT	O
_:3574:57	Z 4:Operate	ACT	O

6.15.3 Distance Protection for Isolated/Resonant-Grounded Systems

6.15.3.1 Overview of Functions

The function **Distance protection for isolated or resonant-grounded systems** (ANSI 21 N):

- Is a form of selective short-circuit protection for lines and cables supplied from one or more end(s) in radial, looped or meshed systems,
- Works only in isolated or resonant-grounded systems via an arc-suppression coil
- Trips 3-phase
- Suitable for use in all voltage levels

6.15.3.2 Structure of the Function

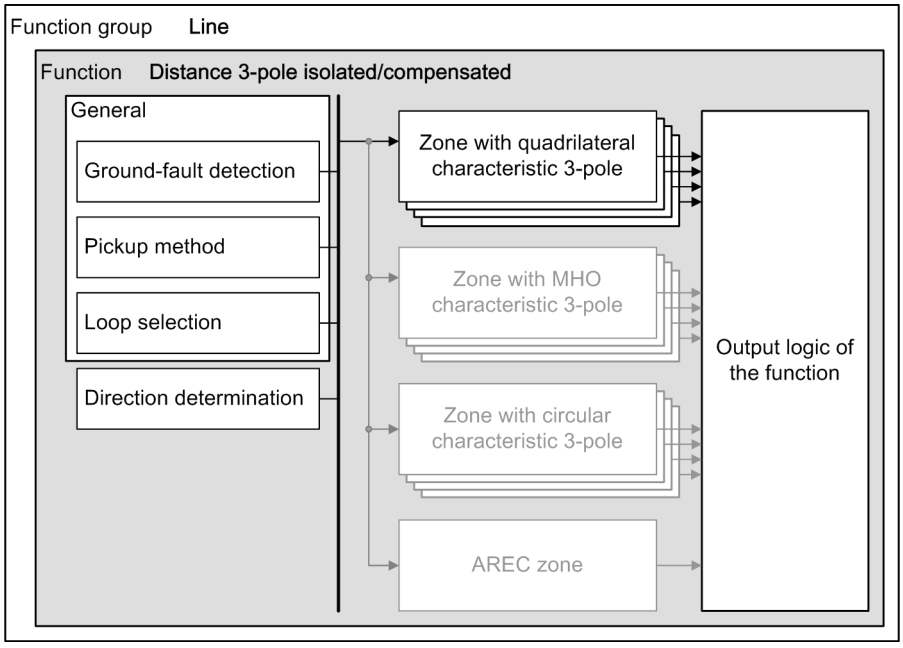
The function **Distance protection for isolated or resonant-grounded systems** can be placed in function groups that provide voltage and current measured values as well as line parameters.

The function **Distance protection for isolated or resonant-grounded systems** consists of the following blocks:

- General information
- Pickup method
- Distance zones (preconfigured quadrilateral characteristic)
- AREC zones (not preconfigured)
- Output logic 3-phase

The function **Distance protection for isolated or resonant-grounded systems** is preconfigured with 4 zones at the factory. The zones are structured identically. In the function **Distance protection for isolated or resonant-grounded systems**, maximum of 16 zones with quadrilateral characteristic curves and 16 zones with MHO characteristic curves can be operated simultaneously.

The following figure shows the structural principles of the function **Distance protection for isolated or resonant-grounded systems**.



[dwstriso-090212-01.tif, 1, en_US]

Figure 6-284 Structure/Embedding of the Function

Mode of Operation

Ground-fault detection determines whether a ground fault has occurred. The pickup method releases the measurement loops. The impedance is calculated for the released loops. The calculated impedance is assigned to the operate curves (quadrilateral, MHO, or circular characteristic [46]) of the zones. In the **Impedance pickup** method, the load cutout is then analyzed and the apparent impedances eliminated. For all picked up loops, the direction to the short-circuit location is then determined. The loop selection determines for which of the picked up loops assignment in the defined zones is done. The loop elimination removes all loops that are no longer picked up after direction determination and querying the load cutout. For the picked up loops, the time delay in the zone logic is started. The zone logic forms the pickup and trip signals of the loops and phases for the zone. The output logic processes the pickup and trip signals of the zones and forms the pickup and trip signals of the distance protection.

Ground-Fault Detection

Ground-fault detection checks whether a ground fault has occurred. If a ground fault has occurred, the measuring elements for the phase-to-ground loops are released.

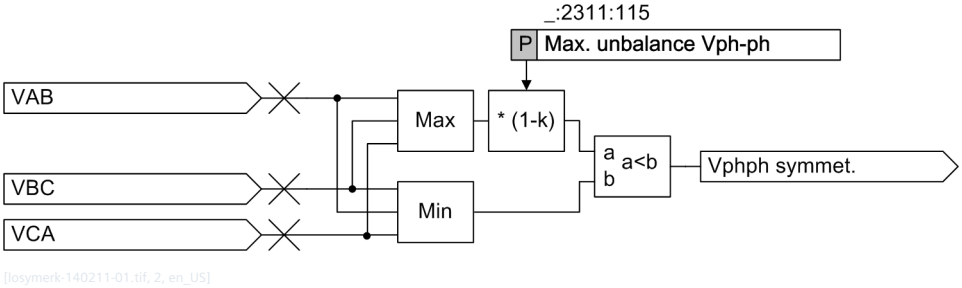
For ground-fault detection, the following criteria are available:

- Monitoring of the zero-sequence current $3I_0$
- Monitoring of the ratio of the zero-sequence current and negative-sequence current ($3I_0/3I_2$)
- Monitoring of the zero-sequence voltage V_0
- Monitoring of the balance of phase-to-phase voltages

In isolated/resonant-grounded systems, the pickup of ground-fault detection is unwanted for simple ground faults. In the event of 1-phase pickup, a simple ground fault is initially presumed. So that the starting oscillation upon occurrence of the ground fault does not lead to unwanted pickup of the function, the pickup is suppressed for a settable time. After the **`Delay 1-phase pickup`** time has expired, the pickup is released. This is necessary so that the distance protection can still detect a double ground fault with a base point on a stub-end feeder. If phase-to-phase voltages are unbalanced, a double ground fault can be assumed. In that case, pickup is released immediately. The balance criterion prevents unwanted pickup for a simple ground

[46] in preparation

fault or unbalanced load conditions (see *Figure 6-285*). The **`Max. unbalance Vph-ph`** parameter specifies the maximum permitted unbalance for the load case, or in the event of a simple ground fault.



[losymerk-140211-01.tif, 2, en_US]

Figure 6-285 Balance Detection for Phase-to-Phase Voltages

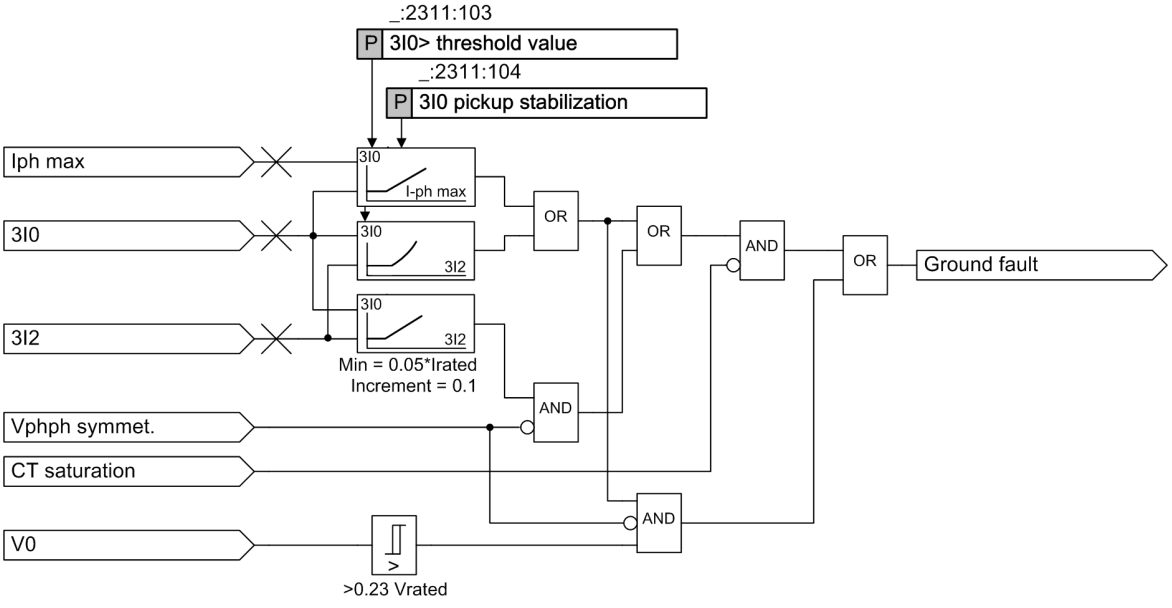
Figure 6-286 shows the logic of the ground-fault detection in isolated or resonant-grounded systems.

If the following conditions are met, the ground-fault detection responds for double ground faults with very low ground currents:

- The zero-sequence current is 10 % of the measured negative-sequence current I_2
- The zero-sequence current is at least 5 % of the secondary rated current
- The phase-to-phase voltages are unbalanced

Monitoring of the balance in phase-to-phase voltages prevents unwanted pickup in the event of simple ground faults.

Only for current-transformer saturation, the zero-sequence voltage criterion is taken into account for the release of the ground-fault detection for double ground faults. If V0 exceeds the firmly set threshold of 0.23 V · V_{rated}, the zero-sequence voltage criterion is released.



[loisolie-140211-01.tif, 1, en_US]

Figure 6-286 Ground-Fault Detection in Isolated or Resonant-Grounded Systems

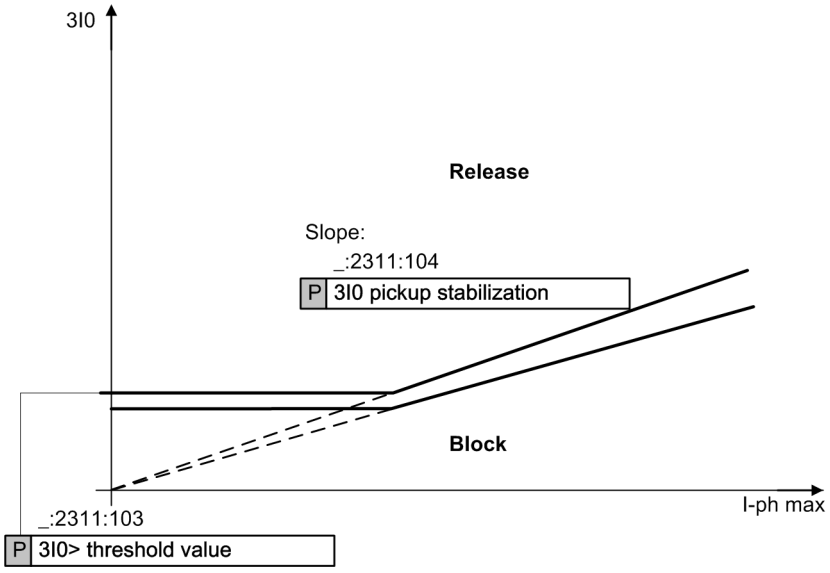
Ground-Fault Detection: Zero-Sequence Current $3I_0$

The zero-sequence current criterion monitors the fundamental component of the sum of phase currents for exceeding a settable value (parameter **`3I0> threshold value`**).

The zero-sequence current criterion is stabilized against unwanted pickup for the following cases:

- Zero-sequence currents due to unbalanced load conditions
- Zero-sequence currents in the event of faults without ground contact due to differing saturation of phase-current transformers
- For detected current-transformer saturation (see *Figure 6-286*)

Figure 6-287 shows the pickup characteristic of the zero-sequence current criterion. As phase currents increase, the actual pickup value rises automatically. The dropout threshold is about 95 % of the pickup value.

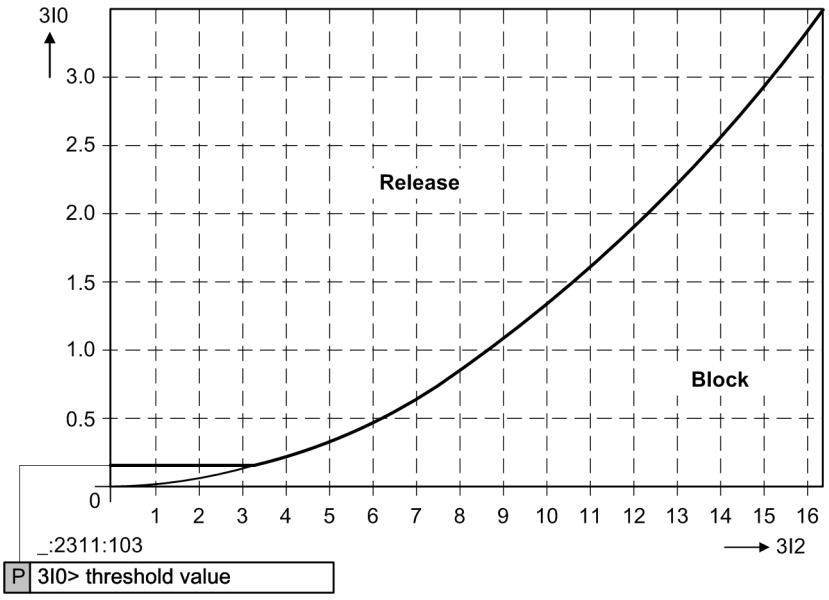


[dwklerds-060611-01.tif, 1, en_US]

Figure 6-287 Zero-Sequence Currents Criterion: Pickup Characteristic:

Ground-Fault Detection: Zero-Sequence Current/Negative-Sequence Current ($3I_0/3I_2$)

For long lines, high load currents can lead to destabilization of the residual-current criterion (see *Figure 6-287*). For the detection of double ground faults, the load-independent negative-sequence current criterion is extended. In addition to the zero-sequence current, the ratio of zero-sequence current to negative-sequence current is also monitored. If the ratio of zero-sequence current to negative-sequence current exceeds a preset limit, the criterion is released. The zero-sequence current/negative-sequence current criterion is stabilized for high negative-sequence currents using a parabolic characteristic. *Figure 6-288* shows the connection. A prerequisite for release of the zero-sequence current/negative-sequence current criterion is a minimum current of $0.2 \cdot I_{rated}$ for $3I_0$.



[dwkli0i2-140611-01.tif, 1, en_US]

Figure 6-288 I0/I2 Criterion: Pickup Characteristic

Ground-Fault Detection: Zero-Sequence Voltage V_0

Only for current-transformer saturation, the zero-sequence voltage criterion is taken into account for the release of the ground-fault detection for double ground faults. If V0 exceeds the firmly set threshold of 0.23 V V_{rated}, the zero-sequence voltage criterion is released.

Pickup Method

The pickup method selects the fault loops to be measured. The following pickup methods are available:

- Impedance pickup
- Overcurrent pickup
- V-/I pickup
- V-/I-φ pickup

Impedance pickup is preconfigured as the pickup method. You can use different pickup methods in parallel.

Zone Assignment

The calculated impedance phasors for the fault loops are assigned to the zones. For each zone, an operate curve is defined in the R-X plane. The following operate curves are available:

- Quadrilateral characteristic (preconfigured)
- MHO characteristic curve

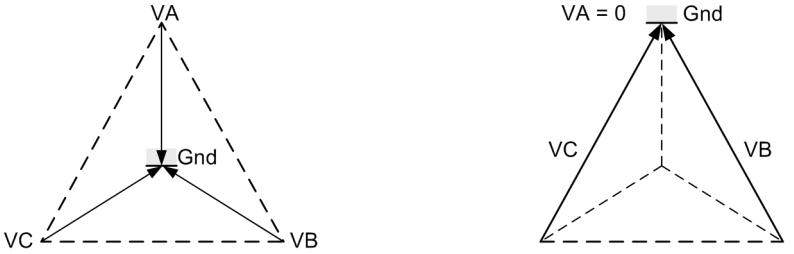
You can find the description of operate curves in the chapters *6.15.6 Zone with Quadrilateral Characteristic Curve* and *6.15.8 Zone with MHO Characteristic Curve*.

Direction Determination

You can define for each zone whether the zone should work ***forwards***, ***backwards***, or ***non-directional***. For directional zones, you define the direction in the R-X plane. When assigning the impedance phasors in the R-X plane, the direction is then additionally analyzed. The description can be found in chapter *6.15.4 Direction Determination*.

Loop Selection for Double Faults in Isolated/Resonant-Grounded Systems

In isolated or resonant-grounded systems, no short-circuit-like currents flow in the event of a 1-phase-to-ground fault. There is only a shift of the voltage triangle (see *Figure 6-289*). For system operation, this state is not an immediate danger. In the entire galvanically connected system, the voltage of the phase affected by the ground fault is approximately 0 V. Thus each load current gives an impedance of approximately 0 Ω. The distance protection may not respond in this case. A 1-phase phase-to-ground pickup without ground-current pickup is thus prevented.



a) Healthy power system, without ground fault

b) Ground fault in phase A

[dwerdslu-100611-01.tif, 1, en_US]

Figure 6-289 Ground Fault in the Non-Grounded System

If a ground fault occurs, a significant starting current can flow in an extended resonant-grounded system. This can result in a pickup of the ground-current pickup. Special measures must be taken to prevent unwanted pickups when a ground fault occurs.

Specify a uniform double ground-fault preference for the galvanically contiguous system. This specifies which fault will be switched off.

For a double ground fault in the isolated or resonant-grounded system, it is enough to switch off one base point. The 2nd fault can remain in the system as a simple ground fault. Specify a uniform double ground-fault preference for the galvanically contiguous system. This specifies which fault will be switched off. The **`Phase preferen. (ph-ph-g)`** parameter is used to define the order of preference. The following double ground-fault preferences can be selected.

Setting for Parameter `Phase preferen. (ph-ph-g)`	Principle of Preference
C(A) acyclical	Acyclical C before A before B
A(C) acyclical	Acyclical A before C before B
B(A) acyclical	Acyclical B before A before C
A(B) acyclical	Acyclical A before B before C
C(B) acyclical	Acyclical C before B before A
B(C) acyclical	Acyclical B before C before A
C(A) cyclical	Cyclical C before A before B before C
A(C) cyclical	Cyclical A before C before B before A

In the 8 preference cases, a ground fault will be switched off according to the preference program. The 2nd fault remains as a simple ground fault in the system and can be detected using the **Ground-fault detection** function.

Influence of the Inrush-Current Detection

If the device is equipped with the **Inrush-current detection** function, the distance protection can be stabilized against tripping due to transformer-inrush currents. In case of interaction with the inrush-current detection the following configurations are possible:

- Blocking of the pickup for the overcurrent pickup method, V-/I-pickup and V-/I-/ϕ-pickup
- Blocking of individual distance zones
- Blocking of the pickup during impedance pickup by blocking the external distance zone(s)

The **Inrush-current detection** can be configured individually for the blocking of the mentioned pickup methods and distance zones. In case of blocking, the distance zone that is linked to the inrush-current detection or the pickup method will not pick up. The function **Inrush-current detection** signals the blocking through a corresponding indication. Once the blocking drops out and the pickup condition for the respective method or the linked distance zone is met, the pickup is signaled and the corresponding time delay will start. After that time, the operate indication will be generated. Only if the central function **Inrush-current detection** (see section *6.68.1 Inrush-Current Detection*) is in effect can the blocking be set.

6.15.3.3 Application and Setting Notes - General Settings

Parameter: Zone timer start

- Recommended setting value **(_:2311:110) Zone timer start** = ***on dist. pickup***

The **Zone timer start** parameter is used to determine the time at which the time delays of the zones start.

Parameter Value	Description
on dist. pickup	If the time delays of all zones start simultaneously, select this setting. If the fault type or measurement loop selection changes, all time delays continue to run. Siemens recommends using this setting.
on zone pickup	The time delay for the zone starts with zone pickup. If you need to coordinate the function with other distance or overcurrent protection functions, select this setting.

Parameter: Dist. characteristic angle

- Default setting **(_:2311:107) Dist. characteristic angle** = ***85.0°***

The **Dist. characteristic angle** parameter allows you to set the inclination angle of the distance protection characteristic curve (see *Figure 6-297*). The inclination angle set here for the distance protection characteristic curve applies to all zones in the function.
Siemens recommends setting the **Dist. characteristic angle** parameter to the line angle.

EXAMPLE:

Calculate the line angle from the data of the positive-sequence impedance (Z_1) on the line to be protected in the following way:

$$Z_1 = R_L + jX_L = (0.025 + j0.21)\Omega$$

[fo1 line angle, 1, en_US]

$$\text{Line angle} = \arctan\left(\frac{X_L}{R_L}\right)$$

[fo2 line angle, 1, en_US]

$$\text{Line angle} = 83.2°$$

[fo3 line angle, 1, en_US]

If you need to coordinate the function with other equipment, you can also set the inclination angle of the distance protection characteristic differently.

Parameter: 3I0> threshold value

- Recommended setting value **(_:2311:103) 3I0> threshold value** = ***0.10 A***

The **3I0> threshold value** parameter is used to define the zero-sequence current limit for ground-fault detection.

Determine the maximum ground current for a simple ground fault. Set the parameter **3I0> threshold value** to a slightly higher value.

Parameter: 3I0 pickup stabilization

- Recommended setting value **(_:2311:104) 3I0 pickup stabilization** = ***0.10***

The **3I0 pickup stabilization** parameter is used to set the inclination of the 3I0> characteristic curve for ground-fault detection.

Power-system unbalance (for example, untwisted lines) and current-transformer errors can cause a zero-sequence current flow at the protection device in the case of higher phase currents, even if there is no ground fault. The **3I0 pickup stabilization** parameter is used to avoid unwanted ground activation. If no extreme power-system unbalance and extraordinary current-transformer faults are expected, Siemens recommends keeping the recommended setting value of ***0.10***.

Parameter: Delay 1-phase pickup

- Default setting **(_:2311:108) Delay 1-phase pickup** = ***0.04 s***

The **Delay 1-phase pickup** parameter is used to delay pickup in the event of simple ground faults in the isolated/resonant-grounded system for the duration of the transient.

In resonant-grounded systems (neutral point grounding through an arc-suppression coil), when a ground fault occurs, it leads to non-system-frequency transients. The starting oscillation can lead to pickup of the I0> criterion. The **Delay 1-phase pickup** parameter is used to delay the pickup.

Parameter: Phase preferen. (ph-ph-g)

- Default setting **(_:2311:116) Phase preferen. (ph-ph-g)** = ***C (A) acyclic***

The **Phase preferen. (ph-ph-g)** parameter is used to define the order of preference for double ground faults.

The following table shows which loops are analyzed for different settings of the **Phase preferen. (ph-ph-g)** parameter:

Parameter Value	Picked Up Loop(s)	Analyzed Loop(s)
C (A) acyclic	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	A-gnd C-gnd C-gnd
A (C) acyclic	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	A-gnd C-gnd A-gnd
B (A) acyclic	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	B-gnd B-gnd A-gnd
A (B) acyclic	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	A-gnd B-gnd A-gnd
C (B) acyclic	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	B-gnd C-gnd C-gnd
B (C) acyclic	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	B-gnd B-gnd C-gnd
C (A) cyclic	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	A-gnd B-gnd C-gnd

Parameter Value	Picked Up Loop(s)	Analyzed Loop(s)
A (C) cyclic	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	B-gnd C-gnd A-gnd
all	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	A-gnd, B-gnd B-gnd, C-gnd C-gnd; A-gnd

If you wish to switch off both base points of a ground fault, set the parameter **Phase preferen. (ph-ph-g)** = ***all***.

Parameter: Max. unbalance Vph-ph

- Default setting **(_:2311:115) Max. unbalance Vph-ph** = ***25 %***

The parameter **Max. unbalance Vph-ph** can be used to specify the maximum permitted unbalance for phase-to-phase voltages in the healthy condition. Determine the setting value for the specific application.



NOTE

The following parameters will be visible only if you are working with MHO characteristic curves:

- **Mem. polarization(ph-g)**
- **Mem. polarization(ph-ph)**
- **Cross polarization(ph-g)**
- **Cross polarization(ph-ph)**

The parameters apply to all MHO zones!

Parameter: Mem. polarization(ph-g)

- Default setting (:_2310:_111) **Mem. polarization(ph-g)** = ***15.0 %***

With the **Mem. polarization(ph-g)** parameter, you can specify the degree of polarization with an external-fault voltage for phase-to-ground loops. This parameter influences the extension of the MHO characteristic curve depending on the source impedance. If you wish to work with the basic characteristic curve without extension, set the **Mem. polarization(ph-g)** parameter to ***0.0 %***.

Parameter: Mem. polarization(ph-ph)

- Default setting (:_2310:_112) **Mem. polarization(ph-ph)** = ***15.0 %***

With the **Mem. polarization(ph-ph)** parameter, you can specify the degree of polarization with an external-fault voltage for phase-to-phase loops. This parameter influences the extension of the MHO characteristic curve depending on the source impedance. If you wish to work with the basic characteristic curve without extension, set the **Mem. polarization(ph-ph)** parameter to ***0.0 %***.

Parameter: Cross polarization(ph-g)

- Default setting (:_2310:_113) **Cross polarization(ph-g)** = ***15.0 %***

With the **Cross polarization(ph-g)** parameter, you can specify the degree of polarization with an external-fault voltage for phase-to-ground loops. This parameter influences the extension of the MHO characteristic curve depending on the source impedance. If you wish to work with the basic characteristic curve without extension, set the **Cross polarization(ph-g)** parameter to ***0.0 %***.

Parameter: Cross polarization(ph-ph)

- Default setting (:_2310:_114) **Cross polarization(ph-ph)** = ***15.0 %***

With the **Cross polarization(ph-ph)** parameter, you can specify the degree of polarization with an external-fault voltage for phase-to-phase loops. This parameter influences the extension of the MHO characteristic curve depending on the source impedance. If you wish to work with the basic characteristic curve without extension, set the **Cross polarization(ph-ph)** parameter to ***0.0 %***.

6.15.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:110	General:Zone timer start		• on zone pickup • on dist. pickup	on dist. pickup
_:2311:107	General:Dist. characteristic angle		30.0 ° to 90.0 °	85.0 °
_:2311:103	General:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
_:2311:104	General:3I0 pickup stabilization		0.05 to 0.30	0.10
_:2311:108	General:Delay 1-phase pickup		0.00 s to 0.50 s	0.04 s
_:2311:116	General:Phase preferen. (ph-ph-g)		• C (A) acyclic • A (C) acyclic • C (B) acyclic • B (C) acyclic • A (B) acyclic • B (A) acyclic • C (A) cyclic • A (C) cyclic • all	C (A) acyclic
_:2311:115	General:Max. unbalance Vph-ph		5 % to 50 %	25 %
_:2311:111	General:Mem. polarization(ph-g)		0.0 % to 100.0 %	15.0 %
_:2311:112	General:Mem. polarization(ph-ph)		0.0 % to 100.0 %	15.0 %
_:2311:113	General:Cross polarization(ph-g)		0.0 % to 100.0 %	15.0 %
_:2311:114	General:Cross polarization(ph-ph)		0.0 % to 100.0 %	15.0 %
Pickup Z<				
_:3661:101	Pickup Z<:Min. phase-current thresh	1 A @ 100 Irated	0.050 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.25 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.050 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.25 A to 175.00 A	0.50 A
_:3661:102	Pickup Z<:Use ph-g load cutout		• no • yes	no
_:3661:103	Pickup Z<:R load cutout (ph-g)	1 A	0.050 Ω to 600.000 Ω	25.000 Ω
		5 A	0.010 Ω to 120.000 Ω	5.000 Ω

Addr.	Parameter	C	Setting Options	Default Setting
_:3661:104	Pickup Z<:Angle load cutout (ph-g)		20.0 ° to 60.0 °	45.0 °
_:3661:105	Pickup Z<:Use ph-ph load cutout		• no • yes	no
_:3661:106	Pickup Z<:R load cutout (ph-ph)	1 A	0.050 Ω to 600.000 Ω	20.000 Ω
		5 A	0.010 Ω to 120.000 Ω	4.000 Ω
_:3661:107	Pickup Z<:Angle load cutout (ph-ph)		20.0 ° to 60.0 °	45.0 °
Z 1				
_:3571:1	Z 1:Mode		• off • on • test	off
_:3571:2	Z 1:Operate & flt.rec. blocked		• no • yes	no
_:3571:121	Z 1:Blocked if diff.prot.active		• no • yes	no
_:3571:27	Z 1:Blk. w. inrush curr. detect.		• no • yes	no
_:3571:101	Z 1:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:3571:114	Z 1:Zone-spec. residu. comp.		• no • yes	no
_:3571:109	Z 1:Directional mode		• non-directional • forward • reverse	forward
_:3571:102	Z 1:X reach	1 A	0.050 Ω to 600.000 Ω	2.500 Ω
		5 A	0.010 Ω to 120.000 Ω	0.500 Ω
_:3571:103	Z 1:R (ph-g)	1 A	0.050 Ω to 600.000 Ω	2.500 Ω
		5 A	0.010 Ω to 120.000 Ω	0.500 Ω
_:3571:104	Z 1:R (ph-ph)	1 A	0.050 Ω to 600.000 Ω	1.250 Ω
		5 A	0.010 Ω to 120.000 Ω	0.250 Ω
_:3571:113	Z 1:Zone-inclination angle		0 ° to 45 °	0 °
_:3571:110	Z 1:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.00 s
_:3571:112	Z 1:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.00 s
_:3571:105	Z 1:Kr		-0.33 to 11.00	1.00
_:3571:106	Z 1:Kx		-0.33 to 11.00	1.00
_:3571:107	Z 1:K0		0.000 to 11.000	1.000
_:3571:108	Z 1:Angle (K0)		-180.00 ° to 180.00 °	0.00 °
Z 2				
_:3572:1	Z 2:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:3572:2	Z 2:Operate & flt.rec. blocked		• no • yes	no
_:3572:121	Z 2:Blocked if diff.prot.active		• no • yes	no
_:3572:27	Z 2:Blk. w. inrush curr. detect.		• no • yes	no
_:3572:101	Z 2:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:3572:114	Z 2:Zone-spec. residu. comp.		• no • yes	no
_:3572:109	Z 2:Directional mode		• non-directional • forward • reverse	forward
_:3572:102	Z 2:X reach	1 A	0.050 Ω to 600.000 Ω	5.000 Ω
		5 A	0.010 Ω to 120.000 Ω	1.000 Ω
_:3572:103	Z 2:R (ph-g)	1 A	0.050 Ω to 600.000 Ω	5.000 Ω
		5 A	0.010 Ω to 120.000 Ω	1.000 Ω
_:3572:104	Z 2:R (ph-ph)	1 A	0.050 Ω to 600.000 Ω	2.500 Ω
		5 A	0.010 Ω to 120.000 Ω	0.500 Ω
_:3572:113	Z 2:Zone-inclination angle		0 ° to 45 °	0 °
_:3572:110	Z 2:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.30 s
_:3572:112	Z 2:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.30 s
_:3572:105	Z 2:Kr		-0.33 to 11.00	1.00
_:3572:106	Z 2:Kx		-0.33 to 11.00	1.00
_:3572:107	Z 2:K0		0.000 to 11.000	1.000
_:3572:108	Z 2:Angle (K0)		-180.00 ° to 180.00 °	0.00 °
Z 3				
_:3573:1	Z 3:Mode		• off • on • test	off
_:3573:2	Z 3:Operate & flt.rec. blocked		• no • yes	no
_:3573:121	Z 3:Blocked if diff.prot.active		• no • yes	no
_:3573:27	Z 3:Blk. w. inrush curr. detect.		• no • yes	no
_:3573:101	Z 3:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:3573:114	Z 3:Zone-spec. residu. comp.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:3573:109	Z 3:Directional mode		• non-directional • forward • reverse	forward
_:3573:102	Z 3:X reach	1 A	0.050 Ω to 600.000 Ω	10.000 Ω
		5 A	0.010 Ω to 120.000 Ω	2.000 Ω
_:3573:103	Z 3:R (ph-g)	1 A	0.050 Ω to 600.000 Ω	10.000 Ω
		5 A	0.010 Ω to 120.000 Ω	2.000 Ω
_:3573:104	Z 3:R (ph-ph)	1 A	0.050 Ω to 600.000 Ω	5.000 Ω
		5 A	0.010 Ω to 120.000 Ω	1.000 Ω
_:3573:113	Z 3:Zone-inclination angle		0 ° to 45 °	0 °
_:3573:110	Z 3:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.60 s
_:3573:112	Z 3:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.60 s
_:3573:105	Z 3:Kr		-0.33 to 11.00	1.00
_:3573:106	Z 3:Kx		-0.33 to 11.00	1.00
_:3573:107	Z 3:K0		0.000 to 11.000	1.000
_:3573:108	Z 3:Angle (K0)		-180.00 ° to 180.00 °	0.00 °
Z 4				
_:3574:1	Z 4:Mode		• off • on • test	off
_:3574:2	Z 4:Operate & flt.rec. blocked		• no • yes	no
_:3574:121	Z 4:Blocked if diff.prot.active		• no • yes	no
_:3574:27	Z 4:Blk. w. inrush curr. detect.		• no • yes	no
_:3574:101	Z 4:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:3574:114	Z 4:Zone-spec. residu. comp.		• no • yes	no
_:3574:109	Z 4:Directional mode		• non-directional • forward • reverse	non-directional
_:3574:102	Z 4:X reach	1 A	0.050 Ω to 600.000 Ω	12.000 Ω
		5 A	0.010 Ω to 120.000 Ω	2.400 Ω
_:3574:103	Z 4:R (ph-g)	1 A	0.050 Ω to 600.000 Ω	12.000 Ω
		5 A	0.010 Ω to 120.000 Ω	2.400 Ω
_:3574:104	Z 4:R (ph-ph)	1 A	0.050 Ω to 600.000 Ω	12.000 Ω
		5 A	0.010 Ω to 120.000 Ω	2.400 Ω
_:3574:113	Z 4:Zone-inclination angle		0 ° to 45 °	0 °

Addr.	Parameter	C	Setting Options	Default Setting
_:3574:110	Z 4:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.90 s
_:3574:112	Z 4:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.90 s
_:3574:105	Z 4:Kr		-0.33 to 11.00	1.00
_:3574:106	Z 4:Kx		-0.33 to 11.00	1.00
_:3574:107	Z 4:K0		0.000 to 11.000	1.000
_:3574:108	Z 4:Angle (K0)		-180.00 ° to 180.00 °	0.00 °

6.15.3.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:82	General:>Block function	SPS	I
_:2311:54	General:Inactive	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:301	Group indicat.:Selected loop AG	ACD	O
_:4501:302	Group indicat.:Selected loop BG	ACD	O
_:4501:303	Group indicat.:Selected loop CG	ACD	O
_:4501:304	Group indicat.:Selected loop AB	ACD	O
_:4501:305	Group indicat.:Selected loop BC	ACD	O
_:4501:306	Group indicat.:Selected loop CA	ACD	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Pickup Z<			
_:3661:52	Pickup Z<:Behavior	ENS	O
_:3661:53	Pickup Z<:Health	ENS	O
Z 1			
_:3571:81	Z 1:>Block stage	SPS	I
_:3571:500	Z 1:>Block ph-g loops	SPS	I
_:3571:501	Z 1:>Block ph-ph loops	SPS	I
_:3571:51	Z 1:Mode (controllable)	ENC	C
_:3571:54	Z 1:Inactive	SPS	O
_:3571:52	Z 1:Behavior	ENS	O
_:3571:53	Z 1:Health	ENS	O
_:3571:55	Z 1:Pickup	ACD	O
_:3571:300	Z 1:Pickup loop AG	ACD	O
_:3571:301	Z 1:Pickup loop BG	ACD	O
_:3571:302	Z 1:Pickup loop CG	ACD	O
_:3571:303	Z 1:Pickup loop AB	ACD	O
_:3571:304	Z 1:Pickup loop BC	ACD	O
_:3571:305	Z 1:Pickup loop CA	ACD	O
_:3571:56	Z 1:Operate delay expired	ACT	O

No.	Information	Data Class (Type)	Type
_:3571:57	Z 1:Operate	ACT	O
Z 2			
_:3572:81	Z 2:>Block stage	SPS	I
_:3572:500	Z 2:>Block ph-g loops	SPS	I
_:3572:501	Z 2:>Block ph-ph loops	SPS	I
_:3572:51	Z 2:Mode (controllable)	ENC	C
_:3572:54	Z 2:Inactive	SPS	O
_:3572:52	Z 2:Behavior	ENS	O
_:3572:53	Z 2:Health	ENS	O
_:3572:55	Z 2:Pickup	ACD	O
_:3572:300	Z 2:Pickup loop AG	ACD	O
_:3572:301	Z 2:Pickup loop BG	ACD	O
_:3572:302	Z 2:Pickup loop CG	ACD	O
_:3572:303	Z 2:Pickup loop AB	ACD	O
_:3572:304	Z 2:Pickup loop BC	ACD	O
_:3572:305	Z 2:Pickup loop CA	ACD	O
_:3572:56	Z 2:Operate delay expired	ACT	O
_:3572:57	Z 2:Operate	ACT	O
Z 3			
_:3573:81	Z 3:>Block stage	SPS	I
_:3573:500	Z 3:>Block ph-g loops	SPS	I
_:3573:501	Z 3:>Block ph-ph loops	SPS	I
_:3573:51	Z 3:Mode (controllable)	ENC	C
_:3573:54	Z 3:Inactive	SPS	O
_:3573:52	Z 3:Behavior	ENS	O
_:3573:53	Z 3:Health	ENS	O
_:3573:55	Z 3:Pickup	ACD	O
_:3573:300	Z 3:Pickup loop AG	ACD	O
_:3573:301	Z 3:Pickup loop BG	ACD	O
_:3573:302	Z 3:Pickup loop CG	ACD	O
_:3573:303	Z 3:Pickup loop AB	ACD	O
_:3573:304	Z 3:Pickup loop BC	ACD	O
_:3573:305	Z 3:Pickup loop CA	ACD	O
_:3573:56	Z 3:Operate delay expired	ACT	O
_:3573:57	Z 3:Operate	ACT	O
Z 4			
_:3574:81	Z 4:>Block stage	SPS	I
_:3574:500	Z 4:>Block ph-g loops	SPS	I
_:3574:501	Z 4:>Block ph-ph loops	SPS	I
_:3574:51	Z 4:Mode (controllable)	ENC	C
_:3574:54	Z 4:Inactive	SPS	O
_:3574:52	Z 4:Behavior	ENS	O
_:3574:53	Z 4:Health	ENS	O
_:3574:55	Z 4:Pickup	ACD	O
_:3574:300	Z 4:Pickup loop AG	ACD	O
_:3574:301	Z 4:Pickup loop BG	ACD	O

No.	Information	Data Class (Type)	Type
_:3574:302	Z 4:Pickup loop CG	ACD	O
_:3574:303	Z 4:Pickup loop AB	ACD	O
_:3574:304	Z 4:Pickup loop BC	ACD	O
_:3574:305	Z 4:Pickup loop CA	ACD	O
_:3574:56	Z 4:Operate delay expired	ACT	O
_:3574:57	Z 4:Operate	ACT	O

6.15.4 Direction Determination

To determine the direction of a short circuit, an impedance phasor is used for each loop.

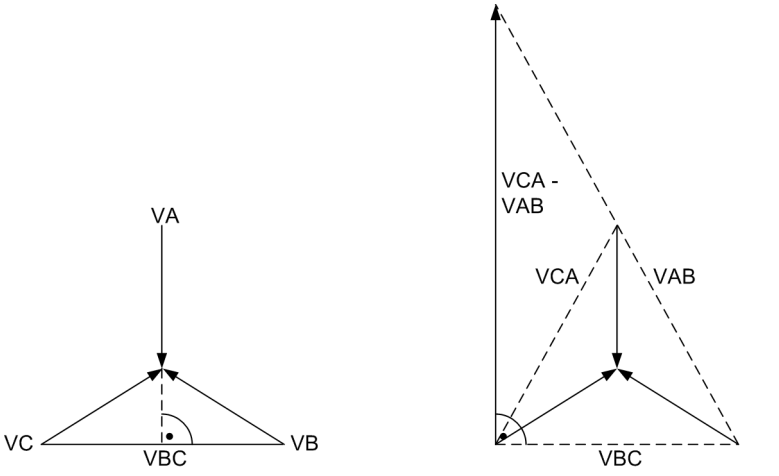
Different methods are implemented for direction determination. The function selects the most appropriate method depending on the available input variables when a short circuit occurs.

The following factors during short-circuit occurrence influence, for example, the method selection:

- Existing measurands
- Existing storage capacities
- Current system constellation

The following table shows the different input variables of the methods and their properties:

Input Variables for Direction Determination	Feature
Current, actual short-circuit voltage	This method determines the ratio between the instantaneous voltage phasor and the instantaneous current phasor. The calculated impedance provides information on the direction of the short circuit. The method functions with all short-circuit types and is loop-selective.
Saved, actual short-circuit voltage	The method determines the ratio between the saved voltage phasor and the instantaneous current phasor. The voltage phasor adapted to the instantaneous phase situation is used. The calculated impedance provides information on the direction of the short circuit. It is the preferred application for series-compensated systems. The method functions with all short-circuit types and is loop-selective.

Input Variables for Direction Determination	Feature
Current quadrature voltage	The method determines the ratio between the instantaneous healthy voltage phasor turned by 90° and the instantaneous current phasor.  a) Phase-to-ground loop (A-gnd) b) Phase-to-phase loop (phsBC) Figure 6-290 Direction Determination with Quadrature Voltages The calculated impedance provides information on the direction of the short circuit. The method functions only with 1-phase and 2-phase short circuits without ground contact and is loop-selective.
Saved quadrature voltage	The method determines the ratio between the saved healthy voltage phasor turned by 90° and the instantaneous current phasor. The calculated impedance provides information on the direction of the short circuit. The method functions only with 1-phase and 2-phase short circuits without ground contact and is loop-selective.
Delta variables	Direction determination works with static delta variables. The method uses the delta phasors of current and voltage. The delta phasors of current and voltage are calculated from the difference between the instantaneous measured phasor and the phasor saved before the fault. The ratio between the delta voltage phasor and the delta current phasor provides information on the direction of the short circuit. The method functions with all short-circuit types and is loop-selective.
Symmetrical components	The direction determination is based on the symmetrical components. • The direction determination with zero-sequence variables determines the zero-sequence impedance from the voltage and current phasors of the zero-sequence system. The calculated impedance provides information on the direction of the short circuit. The method functions only with short circuits with ground contact and is not loop-selective. • The direction determination with negative-sequence variables determines the negative-sequence impedance from the voltage and current phasors of the negative-sequence system. The calculated impedance provides information on the direction of the short circuit. It is the preferred application for short circuits during power swing. It functions only with unbalanced short circuits and is not loop-selective.

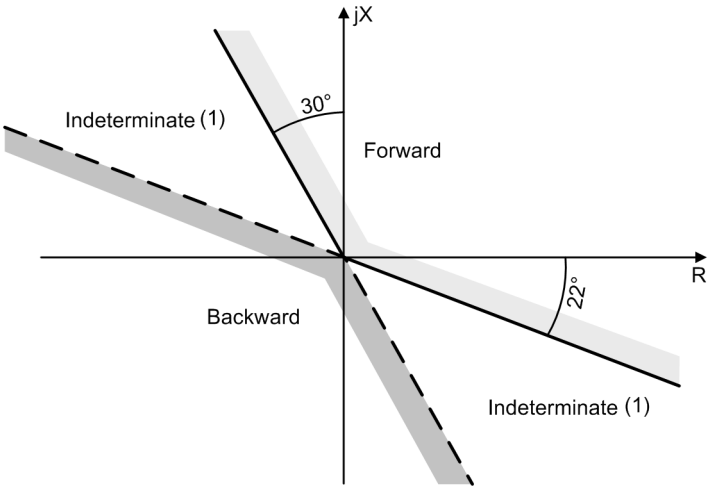
Direction-Characteristic Curve

The theoretical steady-state direction-characteristic curve is shown in *Figure 6-291*.

If buffered voltages are used, the following factors influence the position of the direction-characteristic curve:

- Source impedance
- Power transported on the line before occurrence of the short circuit

For this reason, the direction-characteristic curve (forwards) has a reserve distance to the limits of the 1st quadrant in the R-X diagram:



[dw_ritgkl, 2, en_US]

Figure 6-291 Direction-Characteristic Curve in the R-X Diagram

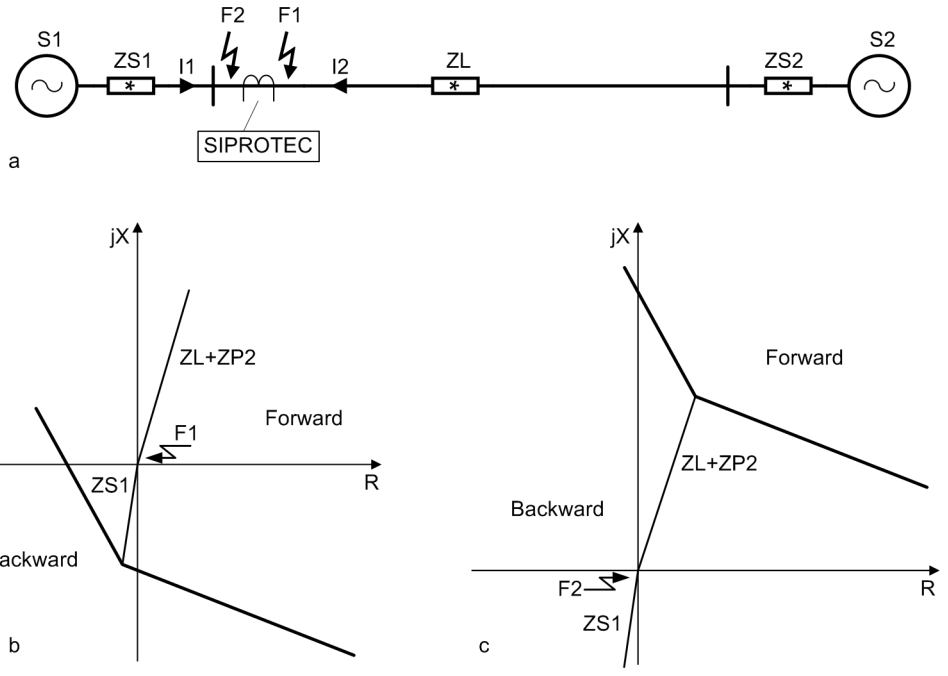
(1) Also valid for non-directional

Since each zone can be set to **forward**, **backward**, or **non-directional**, different direction-characteristic curves are used for **forward** and **backward**. A non-directional zone has no direction-characteristic curve. The entire tripping range applies to it.

Features of Direction Determination

The theoretical steady-state direction-characteristic curve in *Figure 6-291* applies to actual short-circuit voltages.

Figure 6-292 shows the direction-characteristic curve, taking the source impedance into consideration for external short-circuit or buffered voltages (without load transport). Since these voltages are equal to the corresponding generator voltage E, and they also do not change after the short circuit occurs, the direction-characteristic curve appears in the impedance diagram shifted by the source impedance ZS1 = E1/I1. For fault location F1 (*Figure 6-292*a), the short circuit lies in the forward direction, and the source impedance is in the backward direction. For all fault locations up to directly where the device is installed (current transformer), there is a consensus for forward (*Figure 6-292*b). If the current reverses, the orientation of the direction-characteristic curve changes suddenly (*Figure 6-292*c). A reversed current I2 now flows through the measuring point (current transformer). The source impedance ZS2 + ZL determines the value of I2. During load transport on the line, the direction-characteristic curve can also rotate by the load angle.

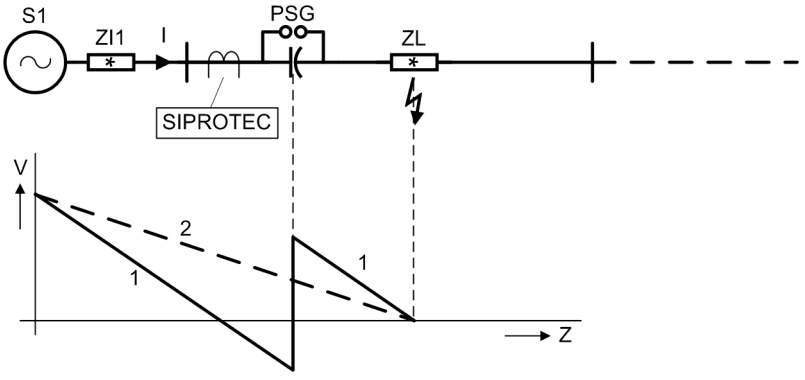


[dwrspeiu-140211-01.tif, 1, en_US]

Figure 6-292 Direction-Characteristic Curve with Quadrature or Buffered Voltages

Direction Determination for Series-Compensated Lines

The direction-characteristic curves and their shift by the source impedance also apply for lines with series capacitors. For a short circuit upstream of the local series capacitor, however, the short-circuit voltage reverses if the protective spark gap SF has not picked up (see *Figure 6-293*).



[dwrserko-140211-01.tif, 1, en_US]

Figure 6-293 Voltage Characteristic for a Short Circuit Upstream of a Series Capacitor

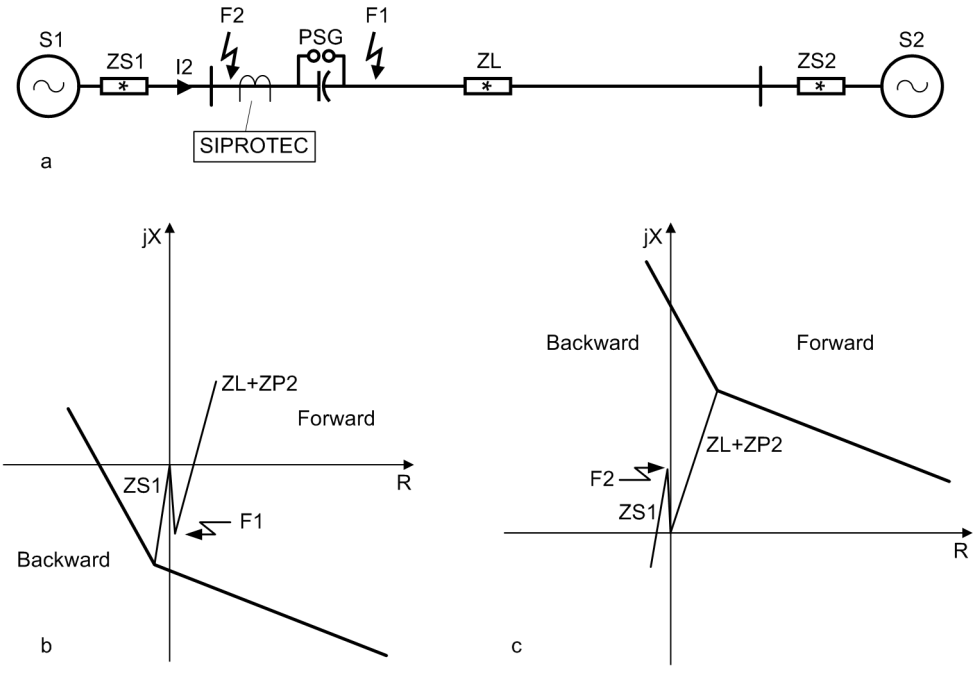
(1) Without pickup of the protective spark gap

(2) With pickup of the protective spark gap

The distance protection thus senses a false fault direction. But in this case as well, direction measurement is correct due to the use of buffered voltages (see *Figure 6-294*a).

For direction determination, the voltage before the occurrence of the fault is used. Thus the peaks of the direction-characteristic curves, depending on the source impedance and load conditions before occurrence of the fault, appear shifted so far that the capacitor reactance does not lead to apparent reversal of direction (*Figure 6-294*b). The capacitor reactance is always lower than the source reactance.

If the short circuit is downstream of the capacitor – thus in reverse direction from where the device is installed (current transformer) – the peaks of the direction-characteristic curve are shifted in the other direction (*Figure 6-294*c). This also ensures a correct direction determination in this case.



[dwrklser-140211-01.tif, 1, en_US]

Figure 6-294 Direction-Characteristic Curves for Series-Compensated Lines

So that the direction determination for lines with series compensation functions correctly, you must set the parameter **`Series compensation`** = ***`yes`*** in the **Line** function group.

6.15.5 Pickup Method: Impedance Pickup

6.15.5.1 Description

In impedance pickup, the phase currents are monitored. If the phase currents exceed the set **`Min. phase-current thresh`**, the impedances between the phase-to-phase loops are calculated. If a ground fault is detected, the impedances of the phase-to-ground loops are also calculated.

Impedance pickup includes the elimination of apparent impedance and – if activated – monitoring of the load cutout.

Healthy Loops

In impedance pickup, all 6 line loops are calculated. Here, the short-circuit currents and voltages of short-circuited lines also influence the impedances of the healthy loops. For an A-gnd fault, for example, the short-circuit current in line A also influences the measured values in measurement loops A-B and C-A. The ground current is also measured in loops B-gnd and C-gnd. Together with load currents flowing, so-called "apparent impedances" occur in the healthy loops. These have nothing to do with the actual troubleshooting.

These apparent impedances in the healthy loops are typically greater than the fault impedance of the short-circuit loop. The healthy loops contain only part of the short-circuit current, and always have a higher voltage than the faulty loop. They are therefore of no significance for the zone selectivity of the protection.

In addition to zone selectivity, phase selectivity is also important. Phase selectivity includes the identification of the faulty phase, the generation of phase-selective indications, and the possibility of executing a 1-pole automatic reclosing function (AREC). Depending on the infeed conditions, short circuits near the station may have the result that the healthy loops see the short circuit at a greater distance, but they still see it within a tripping area. This case leads to a disconnection without the option of a 1-pole AREC. The 3-pole disconnection of the line then results.

Inspecting the loops reliably assures zone and phase selectivity. Loops are inspected in 2 steps.

- From the calculated loop impedance and their partial impedances (phase or ground), a replication of the line is first simulated.
- If the replication is plausible, the corresponding loop activation is categorized as valid.

If the impedances of more than one loop lie within the zone range, the smallest is still declared valid. Furthermore, all loops are declared valid whose impedance is greater than the lowest impedance by not more than 50 %. Loops with greater impedances are eliminated. The exception is any loop declared plausible in the first step. These can then no longer be eliminated.

This eliminates healthy apparent impedances on the one hand, but on the other hand simultaneously detects unbalanced multiphase short circuits and multiple faults correctly. The loops found valid are converted into phase information. This allows the pickup to be signaled in a phase-selective manner.

Load Cutout

For long lines with high loads, there is a risk that the load impedance will be reflected in the operate curve of the distance protection. For operate curves with high R segments, a load cutout can be configured that eliminates unwanted pickups due to overload. The load cutout (see *Figure 6-295* can be configured for phase-to-phase loops and for phase-to-ground loops.

The parameters are explained in chapter *6.15.5.2 Application and Setting Notes*.

6.15.5.2 Application and Setting Notes

Parameter: Min. phase-current thresh

- Recommended setting value **(_:101) Min. phase-current thresh** = ***0.10 A***

Set the **Min. phase-current thresh** parameter to a very sensitive value (10 % of I_{rated}). If the minimum phase current is exceeded, the distance protection calculates the impedance. The sensitive setting allows you to ensure the backup function of the distance protection in case of remote faults in other feeders. If the minimum phase current in some short circuits – depending on system conditions – is not exceeded, you will have to take special measures for the weak infeed. Siemens recommends using the default setting **Min. phase-current thresh** = ***0.10 A***.

Load Cutout

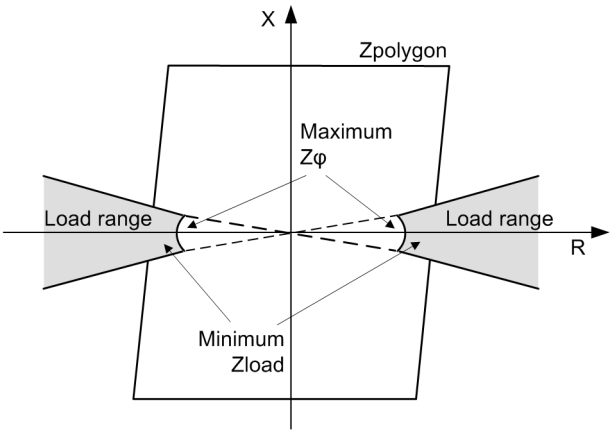
The load cutout can be set using the following parameters:

- Default setting **(_:102) Use ph-g load cutout** = ***Yes***
- Default setting **(_:103) R load cutout (ph-g)** = ***20.000 Ω***
- Default setting **(_:104) Angle load cutout (ph-g)** = ***45.0°***
- Default setting **(_:105) Use ph-ph load cutout** = ***Yes***
- Default setting **(_:106) R load cutout (ph-ph)** = ***25.000 Ω***
- Default setting **(_:107) Angle load cutout (ph-ph)** = ***45.0°***

The load cutout is set separately for phase-to-ground loops (ph-gnd) and phase-to-phase loops (ph-ph). Using the parameters **Use ph-g load cutout** and **Use ph-ph load cutout**, you specify whether the load range is cut out of the impedance level or not. The load cutout parameters are visible only if you set the parameters **Use ph-g load cutout** = ***yes*** and **Use ph-ph load cutout** = ***yes*** .

Since there is no zero-sequence current in the load, load conditions cannot lead to a ground pickup. In the event of a 1-pole tripping of neighboring circuits, there may simultaneously be a ground pickup and an increased load current. For these cases, the load cutout must be set for the ground characteristic.

In the impedance level, the load range must be separate from the tripping area of the distance zone. The zone may only respond under fault conditions, not under load conditions. For the specific application, calculate the smallest load impedance and the greatest load impedance angle under heavy load (see *Figure 6-295*).



[dwlastke-140211-01.tif, 1, en_US]

Figure 6-295 Load Cutout

The values should be set a little smaller (about 10 %) than the minimum load impedance expected. The minimum load impedance results at maximum load current and minimum operating voltage.

EXAMPLE

Calculation of load-cutout parameters in balanced load conditions

110-kV overhead line, 150 mm^2, with the data:

Maximum transmittable power	
P_{max}	= 100 MVA
I_{max}	= 525 A
Minimum operating voltage	
V_{min}	= 0.9 V_{rated}
Current transformer	600 A/5 A
Voltage transformer	110 kV/0.1 kV

The primary minimum load impedance is then calculated as follows:

$$R_{Lprim} = \frac{V_{min}}{I_{max}} = \frac{0.9 \cdot 110\ kV}{525\ A \cdot \sqrt{3}} = 108.9\ \Omega$$

[fo_ltber1-210514, 1, en_US]

The secondary minimum load impedance is then:

$$R_{Lsec} = \frac{Ratio_I}{Ratio_U} \cdot R_{Lprim} = \frac{600\ A/5\ A}{110\ kV/0.1\ kV} \cdot 108.9\ \Omega = 11.9\ \Omega$$

[fo_ltber2-210514, 1, en_US]

With a safety margin of 10 %, the following setting values result for setting the primary and secondary values:
Primary: **`R load cutout (ph-ph)`** = 108.9 Ω or
Secondary: **`R load cutout (ph-ph)`** = 11.9 Ω

Set the opening angle of the load cutout (parameters **`Angle load cutout (ph-ph)`** and **`Angle load cutout (ph-g)`**) greater (approx. 5°) than the maximum occurring load angle (corresponding to the minimum power factor cos φ).

EXAMPLE

Minimum power factor under heavy load $(\cos \varphi_{max})_{min} = 0.8$

$\varphi_{max} = 36.9°$

Setting value **`Angle load cutout (ph-ph)`** $= \varphi_{max} + 5° = 41.9°$

You can find additional setting notes in *Example application high voltage overhead line* in *6.15.5.2 Application and Setting Notes*

When, with double lines, 2 line systems are on a single tower, there is a significant coupling between the 2 line systems. In the event of a 1-pole tripping of neighboring circuits, increased load currents and coupled ground currents can cause a ground pickup. This pickup can be prevented by separate setting of the load cutout for phase-to-ground loops.

During the 1-pole dead time on the parallel line, a significant ground current flows on the intact line. This ground current is caused by the coupling in the zero-sequence system. The ground current during the 1-phase pause on the parallel line must be considered when setting the **`R load cutout (ph-g)`** parameter.

EXAMPLE

Calculation of the load-cutout parameters for an application on a double line

This example applies to a double line with zero-sequence system coupling of both line systems and 1-pole tripping on one system in the double line.

The set values for the load cutout parameters are calculated for a 400-kV overhead line with the following data:

220-km double line on one tower (zero-sequence system coupling of both line systems)

Maximum power flow per line with both lines in operation:

P_{max}	= 1200 MVA
I_{max}	= 1732 A
Minimum operating voltage V_{min}	= 0.9 V_{rated}
Current transformer	2000 A/5 A
Voltage transformer	400 kV/100 V
Parameter **`kr`**	= 1.54

The minimum load impedance results in:

$$Z_{L\ prim} = \frac{V_{min}}{\sqrt{3} \cdot I_{max}} = \frac{0.9 \cdot 400\ kV}{\sqrt{3} \cdot 1732\ A} = 120\ \Omega$$

[fo_zl prim, 1, en_US]

This calculated value applies to phase-to-phase loops. For double lines, the 1-pole dead time on the parallel line must also be considered for phase-to-ground loops. During the 1-pole dead time, the load current on the intact line increases. At the same time, a load current flows in the ground path on the parallel line in the 1-pole dead time. Calculate the minimum load impedance for phase-to-ground loops with the load current in the ground path. For the calculation in this example, this ground current is given as a value relative to the load current I_{max}.

For the ratio of Ignd on the healthy line to I_{max} in the 1-phase pause on the parallel line, the following value is assumed:

$$\frac{I_{gnd\ 1phase\ Pause}}{I_{max}} = 0.4$$

[fo_je 1pol imax, 1, en_US]

The line length as well as the source impedance and line impedance have an influence on this ratio. If you cannot determine the value using a power-system simulation, you can assume the following approximate values:

Long lines (about 200 km)	$I_{gnd1pol:Pause}/I_{max}$: approximately 0.4
Short lines (about 25 km)	$I_{gnd1pol:Pause}/I_{max}$: approximately 0.6

The minimum load impedance for phase-to-ground loops results in the following for the calculation example:

$$R_{L\ prim\ (ph-gnd)} = \frac{R_{L\ prim}}{1 + \frac{I_{gnd\ 1phase\ \ Pause}}{I_{max}} \cdot (1 + kr)} = \frac{120\ \Omega}{1 + 0.4 \cdot (1 + 1.54)} = 59.5\ \Omega$$

[fo_rl prim L-E, 1, en_US]

When parameterizing using PC and DIGSI, you can select to enter the values as the primary or secondary variables. Conversion into secondary values yields:

$$R_{L\ sec} = \frac{Ratio_I}{Ratio_V} \cdot R_{L\ prim} = \frac{2000\ A/5\ A}{400\ kV/0.1\ kV} \cdot 120\ \Omega = 12\ \Omega$$

[fo_rl sek, 1, en_US]

$$R_{L\ sec\ (ph-gnd)} = \frac{Ratio_I}{Ratio_V} \cdot R_{L\ prim\ (ph-gnd)} = \frac{2000\ A/5\ A}{400\ kV/0.1\ kV} \cdot 59.5\ \Omega = 5.95\ \Omega$$

[fo_rl sek L-E, 1, en_US]

With a safety margin of 10%, these settings are used:

R load cutout (ph-ph)	= 108 Ω	(primary)	= 10.8 Ω	(secondary)
R load cutout (ph-g)	= 53.5 Ω	(primary)	= 5.35 Ω	(secondary)

The opening angle of the load cutout, as in the 1st example for the single line, is calculated using the minimum power factor.

6.15.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Pickup Z<				
_:101	Pickup Z<:Min. phase-current thresh	1 A @ 100 Irated	0.050 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.25 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.050 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.25 A to 175.00 A	0.50 A
_:102	Pickup Z<:Use ph-g load cutout		• no • yes	no
_:103	Pickup Z<:R load cutout (ph-g)	1 A	0.100 Ω to 600.000 Ω	25.000 Ω
		5 A	0.020 Ω to 120.000 Ω	5.000 Ω
_:104	Pickup Z<:Angle load cutout (ph-g)		20.0 ° to 60.0 °	45.0 °
_:105	Pickup Z<:Use ph-ph load cutout		• no • yes	no
_:106	Pickup Z<:R load cutout (ph-ph)	1 A	0.100 Ω to 600.000 Ω	20.000 Ω
		5 A	0.020 Ω to 120.000 Ω	4.000 Ω
_:107	Pickup Z<:Angle load cutout (ph-ph)		20.0 ° to 60.0 °	45.0 °

6.15.5.4 Information List

No.	Information	Data Class (Type)	Type
Pickup Z<			
_:52	Pickup Z<:Behavior	ENS	O
_:53	Pickup Z<:Health	ENS	O

6.15.6 Zone with Quadrilateral Characteristic Curve

6.15.6.1 Description

Logic of a Zone

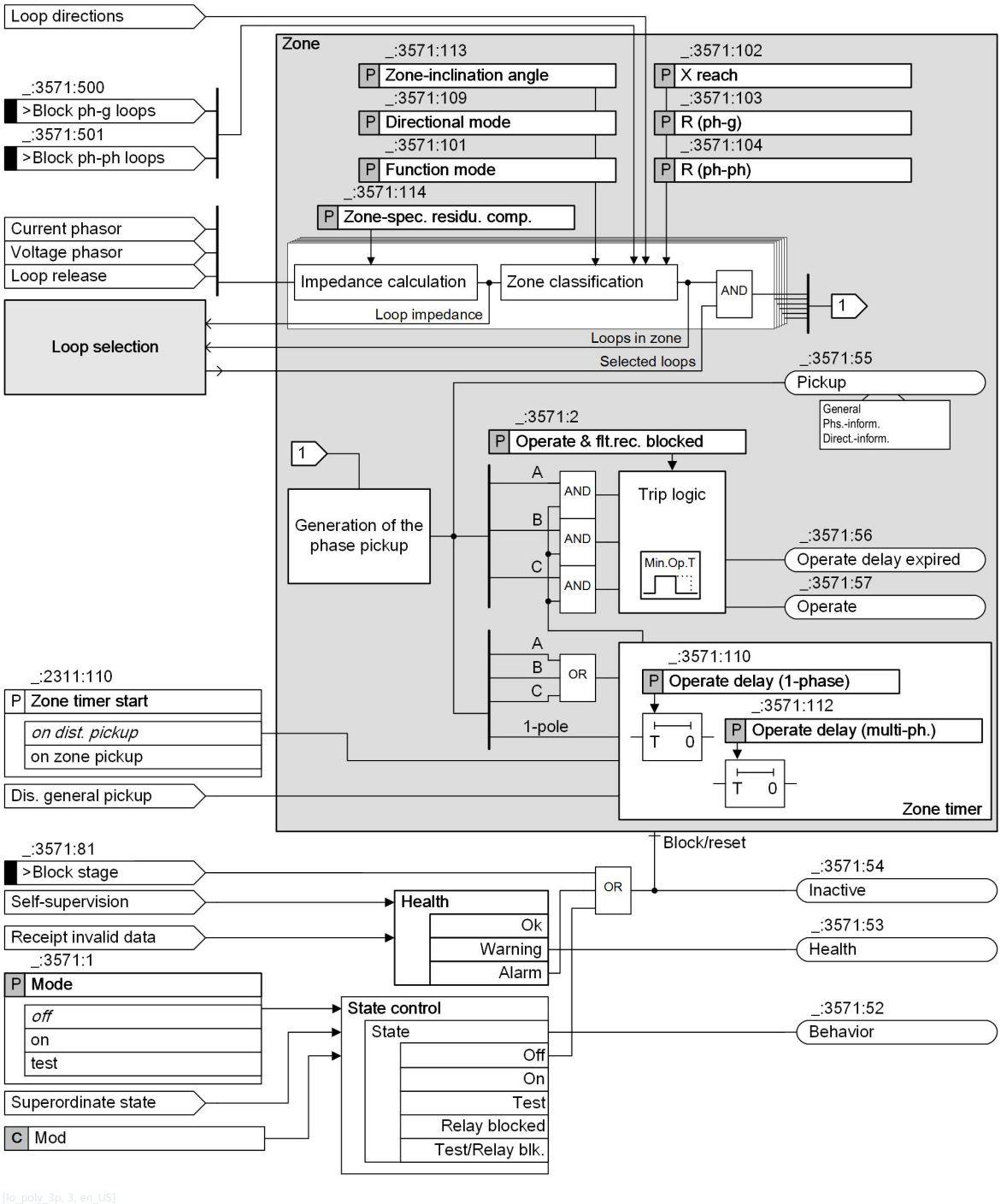


Figure 6-296 Logic Diagram of a Zone with a Quadrilateral Characteristic Curve

Mode of Operation

The zone handles the following tasks:

- Impedance calculation from the measured current and voltage values
- Placement of the impedance into the zone
- Generation of pickup and tripping for the zone

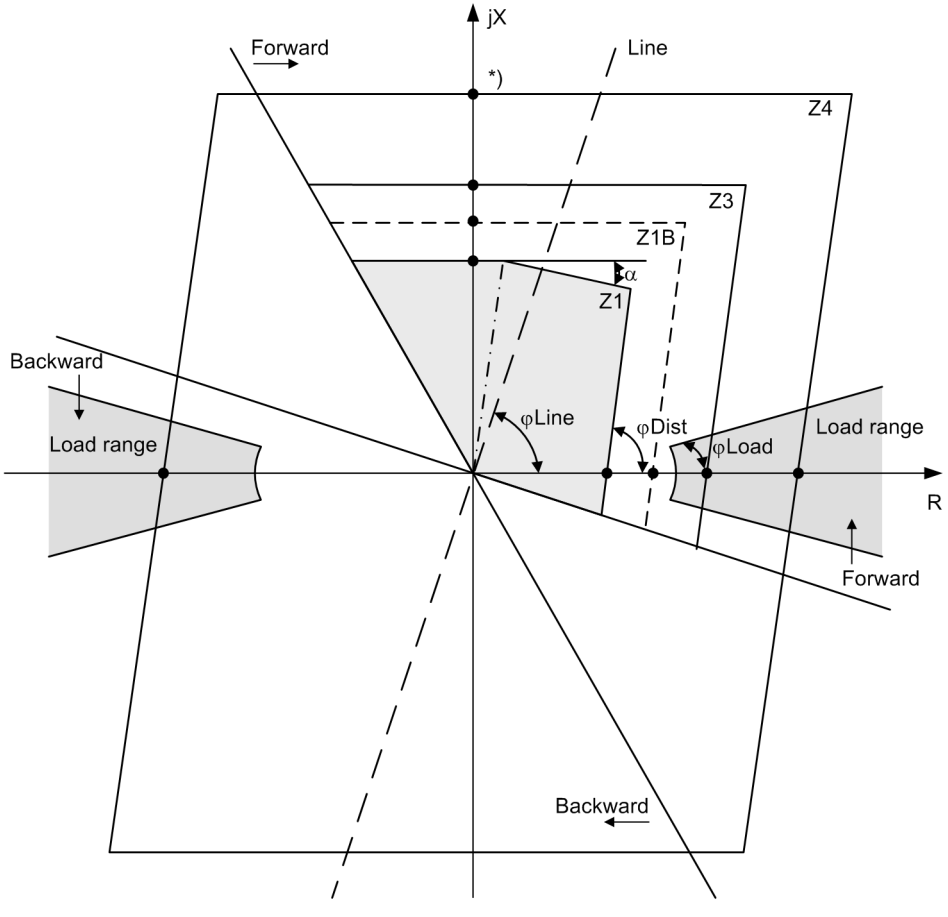
If the fault impedance of a loop lies well within the operating polygon of a distance zone, and the direction of the impedance phasor matches the directionality of the zone, the zone picks up. The loop information is converted into phase-selective pickup indications. The phase-selective pickup indications of the zones are processed further in the output logic of the distance protection and by external additional functions (for example, teleprotection scheme). The output logic of the distance protection is described in chapter *6.15.11 Output Logic of the Distance Protection*.

Operating Polygon

The quadrilateral characteristic (operating polygon) of the zone is an inclined parallelogram in the R-X plane. The operating polygon is defined by the parameters **`X reach`**, **`R (ph-ph)`**, **`R (ph-g)`** and **`Zone-inclination angle`**.

To stabilize the polygon limits, the characteristics have a hysteresis of 5 %. If the fault impedance lies within a polygon, the limits are increased by 5 % in all directions.

The following figure shows an example with 4 zones for the distance protection with quadrilateral operate curve.



*) Setting values are marked by points

[dwklpoly-060611-01.tif, 1, en_US]

Figure 6-297 Operate Curve with Quadrilateral Characteristic

NOTE

You can rename or delete the zones in DIGSI. You can also add additional zones from the DIGSI function library.

6.15.6.2 Impedance Calculation

There is an impedance measuring element available for each of the 6 possible phase loops A-gnd, B-gnd, C-gnd, A-B, B-C, C-A.

A jump detection synchronizes all calculations to the occurrence of the fault. Synchronization enables minimum and repeatable operate times to be achieved. If another fault occurs during analysis, the impedances are calculated using the current cyclical measurands. The analysis thus always works with the measurands of the current fault condition.

Impedance Calculation for Phase-to-Phase Loops

For calculation of a phase-to-phase loop, for example, for a 2-phase A-B short circuit (*Figure 6-298*), the loop equation is:

$$\underline{I}_A \cdot \underline{Z}_L - \underline{I}_B \cdot \underline{Z}_L = \underline{V}_{A-gnd} - \underline{V}_{B-gnd}$$

[foflschl-160909-01.tif, 1, en_US]

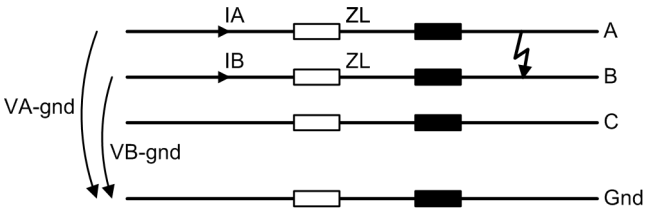
with

$\underline{V}, \underline{I}$	(complex) measurands
$\underline{Z}_L = R + jX$	(complex) line impedance

The line impedance is calculated as follows:

$$\underline{Z}_L = \frac{\underline{V}_{A-gnd} - \underline{V}_{B-gnd}}{\underline{I}_A - \underline{I}_B}$$

[folimped-240609-01.tif, 1, en_US]



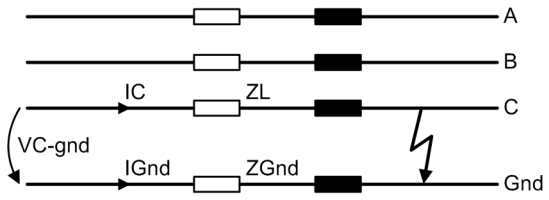
[dwllschl-140211-01.tif, 1, en_US]

Figure 6-298 Short Circuit of a Phase-to-Phase Loop

As long as one of the lines involved is switched off, for example, during the 1-pole dead time of the automatic reclosing, the phase-to-phase loops involved are not calculated. During the 1-pole dead time of the automatic reclosing in A, for example, the loops A-B and C-A are blocked. This prevents an incorrect measurement with undefined measurands. The process monitor in the **Line** function group observes the state of the automatic reclosing and provides the blocking signal.

Impedance Calculation for Phase-to-Ground Loops

For calculation of a phase-to-ground loop, it must be considered that the impedance of the ground-return path generally does not match the impedance of the phases. This is the case, for example, for an C-gnd (*Figure 6-299*) short circuit.



[dwleschl-140211-01.tif, 1, en_US]

Figure 6-299 Short Circuit of a Phase-to-Ground Loop

The voltage $V_{C\text{-}gnd}$, the phase current I_C, and the ground current I_{gnd} of the faulty loop are measured.

$$V_{C-gnd} = I_C \cdot \left(R_{ph} + jX_{ph}\right) - I_{gnd} \cdot \left(kr \cdot R_{ph} + j\left(kx \cdot X_{ph}\right)\right)$$

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The impedance at the location of the fault is calculated as:

$$R_{C-gnd} = \frac{V_{C-gnd}}{I_C} \cdot \frac{\cos(\varphi_V - \varphi_{ph}) - \frac{I_{gnd}}{I_C} \cdot kx \cdot \cos(\varphi_V - \varphi_{gnd})}{1 - (kx + kr) \cdot \frac{I_{gnd}}{I_C} \cdot \cos(\varphi_{gnd} - \varphi_{ph}) + kr \cdot kx \cdot \left(\frac{I_{gnd}}{I_C}\right)^2}$$

[foreform-240609-01.tif, 1, en_US]

and

$$X_{C-gnd} = \frac{U_{C-gnd}}{I_C} \cdot \frac{\sin(\varphi_V - \varphi_{ph}) - \frac{I_{gnd}}{I_C} \cdot kr \cdot \sin(\varphi_V - \varphi_{gnd})}{1 - (kx + kr) \cdot \frac{I_{gnd}}{I_C} \cdot \cos(\varphi_{gnd} - \varphi_{ph}) + kr \cdot kx \cdot \left(\frac{I_{gnd}}{I_C}\right)^2}$$

[foxeform-240609-01.tif, 1, en_US]

with

$V_{C\text{-}gnd}$	Short-circuit voltage phasor
I_C	Short-circuit current phasor (phase C)
I_{gnd}	Ground-fault current phasor
φ_V	Phase angle of the short-circuit voltage
φ_{ph}	Phase angle of the short-circuit current (phase C)
φ_{gnd}	Phase angle of the ground-fault current

The factors $Kr = R_{gnd}/R_{ph}$ and $Kx = X_{gnd}/X_{ph}$ depend only on the line constants and not on the distance to the fault.

NOTE

In the impedance calculation, the factors **Kr** and **Kx** are used for residual compensation. If you enter the grounding resistance factors in the format **k0** with **Phi(k0)**, they are automatically converted into **Kr** and **Kx**. Conversion is performed under consideration of the line angle. For this reason, pay attention to the correct setting of the line angle in the general data of the **Line** function group (parameter **(_:9001:108) Line angle**).

As long as one of the phases involved is switched off, for example, during the 1-pole dead time of the automatic reclosing, the phase-to-ground loops involved are not calculated. During the 1-pole dead time in the automatic reclosing in C, the C-gnd loop is blocked, for example. This prevents an incorrect measurement

with undefined measurands. The process monitor observes the state of the automatic reclosing and provides the blocking signal.

Measured-Value Correction for Parallel Lines

For double lines, both line systems are influenced by mutual coupling impedances (see *Figure 6-300*). With ground faults, errors in the results of the impedance calculation occur unless particular measures are taken. You can therefore effectively connect parallel-line compensation. This takes the ground current of the parallel line into consideration in the line equation, compensating for the coupling influence. This ground current must be applied to the device for this purpose. The loop equation in this case is similar to that of *Figure 6-299*:

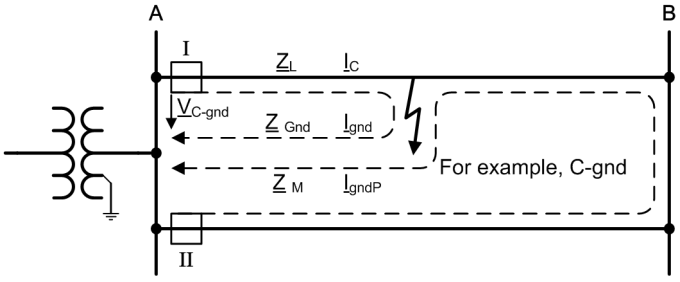
$$\underline{I}_C \cdot \underline{Z}_L - \underline{I}_{gnd} \cdot \underline{Z}_{gnd} - \underline{I}_{gndP} \cdot \left(\underline{Z}_{0M}/3\right) = \underline{V}_{C-gnd}$$

[fofokpl1-150909-01.tif, 1, en_US]

$$\underline{I}_C \cdot \left(R_L + jX_L\right) - \underline{I}_{gnd} \cdot \left(kr \cdot R_L + j\,kx \cdot X_L\right) - \underline{I}_{gndP} \cdot \left(kmR \cdot R_L + j\,kmX \cdot X_L\right) = \underline{V}_{C-gnd}$$

[fofokpl2-150909-01.tif, 1, en_US]

I_{gndP} is the ground current of the parallel line. The ratios $R_{0M}/3R_{ph}$ and $X_{0M}/3X_{ph}$ are line constants that result from the geometry of the double line and the suitability of the grounding.



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Figure 6-300 Ground Fault on a Double Line

Without parallel-line compensation, the ground current of the parallel line typically results in the under-reaching of the distance protection (the loop impedance seen by the distance protection appears to be larger). If both lines end on different busbars and the grounding point is on a remote busbar (at B in *Figure 6-300*), overreach can result.

The parallel-line compensation applies only to faults on the line to be protected. Compensation may not be carried out for faults on the parallel line, since it would cause significant overreach. At installation point II in *Figure 6-300*, there must be no compensation for this fault situation.

The device thus receives an additional ground-current balance to perform a cross-comparison of the ground currents in both lines. The compensation is only connected for those line ends where the ground current of the parallel line is less than that of the end's own line. In example *Figure 6-300*, Ignd is greater than Ignd-P: There is compensation in I in that ZM · Ignd-P is coupled in; in II there is no compensation.

6.15.6.3 Application and Setting Notes

Parameter: Blocked if diff.prot.active

- Recommended setting value **`(_:121) Blocked if diff.prot.active`** = ***no***

The **`Blocked if diff.prot.active`** parameter is visible only when the **Line differential protection** function is available in the application.

Using the **`Blocked if diff.prot.active`** parameter, you establish whether the distance protection zone is blocked or not as long as the **Line differential protection** function is active.

Parameter Value	Description
no	If the zone is switched on (parameter **Mode** = ***on***) and the parameter **Blocked if diff.prot.active** = ***no*** is set, the zone will run regardless of the line differential protection. If the zone picks up, it will generate an operate indication after the time delay has elapsed.
yes	If the zone is switched on (parameter **Mode** = ***on***) and the **Blocked if diff.prot.active** = ***yes*** parameter is set, the zone is blocked as long as the line differential protection function is working. If the line differential protection is blocked, then the zone is **not** blocked.

Parameter: Blk. w. inrush curr. detect.

- Default setting **(_:27) Blk. w. inrush curr. detect.** = ***no***

The **Blk. w. inrush curr. detect.** parameter is visible only when the **Inrush-current detection** function is available in the application. With the **Blk. w. inrush curr. detect.** parameter, you determine whether the distance protection zone is blocked or not during the detection of a transformer inrush current.



NOTE

With the parameter **Blk. w. inrush curr. detect.** = ***yes*** set, the minimum pickup and operate time for this distance protection zone is about 1.5 system cyles even if no transformer inrush current is detected. Set the parameter **Blk. w. inrush curr. detect.** = ***yes*** only if you really need blocking on the basis of **inrush-current detection**.

Parameter: Function mode

- Recommended setting value **(_:101) Function mode** = ***ph-gnd and ph-ph***

You can use the **Function mode** parameter to determine which measuring element the zone will work with. The possible alternatives are ***ph-gnd and ph-ph***, ***ph-gnd only*** and ***ph-ph only***.

Parameter Value	Description
ph-gnd and ph-ph	The zone works with phase-to-ground and phase-to-phase measuring elements. Siemens recommends using the default setting.
ph-gnd only	The zone works only with the phase-to-ground measuring element.
ph-ph only	The zone works only with the phase-to-phase measuring element.

Parameter: Directional mode

- Default setting **(_:109) Directional mode** = ***forward***

You can use the **Directional mode** parameter to define whether the zone operates ***forward***, ***reverse***, or ***non-directional***. Set the parameter **Directional mode** for the specific application.

Parameter: X reach

- Default setting **(_:102) X reach** = ***2.500 Ω***

You can use the **X reach** parameter to set the limit of the polygon in the X direction. Determine the setting value for the specific application.

First, create a time-grading schedule for the entire galvanically connected system. Enter the section lengths with their reactances X in Ω/km into the time-grading schedule. The reactances X then define the range of the distance zones.

Under *Notes on the R/X Ratio in the Zone Setting* at the end of the section, you will find notes on the R/X setting.

You can find additional setting notes in *Example application: High-voltage overhead line*.

Parameter: R (ph-g)

- Default setting **(_:103) R (ph-g)** = ***2.500 Ω***

You can use the **R (ph-g)** parameter to set the polygon limits in the R direction for phase-to-ground loops. The R radius for ground faults is calculated in a manner similar to that used for **R (ph-ph)** setting value for phase-to-phase faults. For phase-to-ground faults, the fault resistance is greater than that for phase-to-phase faults. For overhead lines, not only the arc resistance must be taken into consideration for a ground fault, but also the tower-grounding resistance.

Under *Notes on the R/X Ratio in the Zone Setting* at the end of the section, you will find notes on the R/X setting.

You can find additional setting notes in *Example application: High-voltage overhead line*.

Parameter: R (ph-ph)

- Default setting **(_:104) R (ph-ph)** = ***1.250 Ω***

You can use the **R (ph-ph)** parameter to set the polygon limits in the R direction for phase-to-phase loops. The **R (ph-ph)** setting value considers the fault resistance at the fault location. The fault resistance is added to the impedance of the fault loop as an additional effective resistance. This fault resistance is, for example, the arc resistance or the dissipation resistance of ground phases. Do not set the reserve resistance any larger than necessary. For long, heavily loaded lines, the setting value may enter the load range. A configurable load cutout prevents the activation of the zone in the event of overload (see *Load cutout* in chapter *6.15.5 Pickup Method: Impedance Pickup*.

For overhead lines, the setting value is determined primarily by the arc resistance. No significant arc is possible in cables. With very short cables, ensure that the arc flashover at the local cable box is included in the set resistance for Zone 1.

Under *Notes on the R/X Ratio in the Zone Setting* at the end of the section, you will find notes on the R/X setting.

You can find additional setting notes in *Example application: High-voltage overhead line*.

Parameter: Operate delay (1-phase)

- Default setting **(_:110) Operate delay (1-phase)** = ***0.00 s***

You can use the **Operate delay (1-phase)** parameter to set the grading time of the zone for 1-phase short circuits. The **Operate delay (1-phase)** must be set for the specific application.

Parameter: Operate delay (multi-ph.)

- Default setting **(_:112) Operate delay (multi-ph.)** = ***0.00 s***

You can use the **Operate delay (multi-ph.)** parameter to set the grading time of the zone for multi-phase short circuits. The **Operate delay (multi-ph.)** must be set for the specific application.

Parameter: Zone-inclination angle

- Default setting **(_:113) Zone-inclination angle** = ***0.0°***

The **Zone-inclination angle** parameter is used to set the angle by which the upper limit of the polygon is inclined in the first quadrant.

Under no circumstances may Zone 1 respond in the event of external faults, since this represents a loss of selectivity. To prevent the loss of selectivity, the limit of the X setting for Zone 1 is inclined downwards by the set angle. The default angle of 0° is typically retained for greater distance zones.

You can find additional setting notes in *Example application: High-voltage overhead line*.

Parameter: Zone-spec. residu. comp.

- Default setting **(_:114) Zone-spec. residu. comp.** = ***no***

You can use the **Zone-spec. residu. comp.** parameter to determine whether the zone operates with its own, specific residual compensation factors or not.

Parameter Value	Description
no	The zone works with the residual compensation factors set in the **Line** function group.
yes	The zone works with the specific residual compensation factors of the zone.



NOTE

Only if you set the parameter **Zone-spec. residu. comp.** = ***yes*** in the zone will the residual compensation factors set here be valid and visible. If you set the parameter **Zone-spec. residu. comp.** = ***no***, the residual compensation factors set for the device apply.

Parameter: Kr and Kx

- Default setting **(_:105) Kr** = ***1.00***
- Default setting **(_:106) Kx** = ***1.00***

You can use the **Kr** and **Kx** parameters to set the residual compensation with scalar factors.



NOTE

The parameters **Kr** and **Kx** are visible in the zone only if you have set the parameter **Zone-spec. residu. comp.** = ***yes*** in the zone and the parameter **Set. format residu. comp.** = ***Kr, Kx*** for the device. You can only change the setting value of the parameter **Set. format residu. comp.** in DIGSI 5 under **Device settings**.

Parameter: K0 and Angle (K0)

- Default setting **(_:3571:107) K0** = ***1.000***
- Default setting **(_:3571:108) Angle (K0)** = ***0.00°***

You can use the **K0** and **Angle (K0)** parameters to set the residual compensation with the complex residual compensation factor.



NOTE

The parameters **K0** and **Angle (K0)** are visible in the zone only if you have set the parameter **Zone-spec. residu. comp.** = ***yes*** in the zone and the parameter **Set. format residu. comp.** = ***K0*** for the device. You can only change the setting value of the parameter **Set. format residu. comp.** in DIGSI 5 under **Device settings**.

Notes on the R/X Ratio in the Zone Setting

In practice, the ratio of the resistance to the reactance setting lies in the following ranges:

Section Type	R/X Ratio in the Zone Setting
Short cable sections (about 0.5 km to 3 km)	3 to 5
Longer cable sections (> 3 km)	2 to 3
Short overhead-line sections < 10 km	2 to 5
Overhead lines < 100 km	1 to 2
Long overhead lines 100 km to 200 km	0,5 to 1
Long extra-high voltage lines > 200 km	≤ 0.5

NOTE

For short lines with large R/X ratios, note the following during zone setting: The angle errors of the current and voltage transformers cause a rotation of the impedance measured in the direction of the R axis. The risk that external faults will be shifted into the first zone increases if, because of the settings for the polygon, kr and kx, the loop range is large in the R direction in relation to the X direction for Zone 1. Use the grading factor of 85 % only up to an R/X ratio ≤ 1 (loop range).

For larger R/X settings, you can calculate a reduced grading factor for Zone 1 using the following formula:

STF	Grading factor = range of Zone 1 relative to the line length
R	Loop range in the direction R for Zone 1 = R1· (1 + kr)
X	Loop range in the direction X for Zone 1 = X1· (1 + kx)
δ_V	Angle error of the voltage transformer (typically 1°) 1°)
δ_I	Angle error of the current transformer (typically 1°) 1°)

$$STF \leq \left[1 - \frac{R}{X} \cdot \tan\left(\delta_V + \delta_I\right)\right] \cdot 88.5\ \%$$

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Alternatively or additionally, you can use the **Zone-inclination angle** parameter to incline the polygon of Zone 1 in the first quadrant. This also prevents overreach (see *Figure 6-297*).

6.15.6.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Z #				
_:1	Z #:Mode		• off • on • test	off
_:2	Z #:Operate & flt.rec. blocked		• no • yes	no
_:121	Z #:Blocked if diff.prot.active		• no • yes	no
_:27	Z #:Blk. w. inrush curr. detect.		• no • yes	no
_:101	Z #:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:114	Z #:Zone-spec. residu. comp.		• no • yes	no
_:109	Z #:Directional mode		• non-directional • forward • reverse	forward
_:102	Z #:X reach	1 A	0.100 Ω to 600.000 Ω	2.500 Ω
		5 A	0.020 Ω to 120.000 Ω	0.500 Ω
_:103	Z #:R (ph-g)	1 A	0.100 Ω to 600.000 Ω	2.500 Ω
		5 A	0.020 Ω to 120.000 Ω	0.500 Ω
_:104	Z #:R (ph-ph)	1 A	0.100 Ω to 600.000 Ω	1.250 Ω
		5 A	0.020 Ω to 120.000 Ω	0.250 Ω

Addr.	Parameter	C	Setting Options	Default Setting
_:113	Z #:Zone-inclination angle		0 ° to 45 °	0 °
_:110	Z #:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.30 s
_:112	Z #:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.30 s
_:105	Z #:Kr		-0.33 to 11.00	1.00
_:106	Z #:Kx		-0.33 to 11.00	1.00
_:107	Z #:K0		0.000 to 11.000	1.000
_:108	Z #:Angle (K0)		-180.00 ° to 180.00 °	0.00 °

6.15.6.5 Information List

No.	Information	Data Class (Type)	Type
Z #			
_:81	Z #:>Block stage	SPS	I
_:500	Z #:>Block ph-g loops	SPS	I
_:501	Z #:>Block ph-ph loops	SPS	I
_:54	Z #:Inactive	SPS	O
_:52	Z #:Behavior	ENS	O
_:53	Z #:Health	ENS	O
_:55	Z #:Pickup	ACD	O
_:300	Z #:Pickup loop AG	ACD	O
_:301	Z #:Pickup loop BG	ACD	O
_:302	Z #:Pickup loop CG	ACD	O
_:303	Z #:Pickup loop AB	ACD	O
_:304	Z #:Pickup loop BC	ACD	O
_:305	Z #:Pickup loop CA	ACD	O
_:56	Z #:Operate delay expired	ACT	O
_:57	Z #:Operate	ACT	O

6.15.7 Zone with Quadrilateral Characteristic Curve and Adaptive Pickup

6.15.7.1 Description

The **Zone with quadrilateral characteristic curve and adaptive pickup** is essentially the same as the **Zone with quadrilateral characteristic curve**.

The chapter describes only the extensions of the **Zone with quadrilateral characteristic curve and adaptive pickup**.

You can find the description for the **Zone with quadrilateral characteristic curve** beginning with chapter *6.15.6.1 Description*.

The **Zone with quadrilateral characteristic curve and adaptive pickup** has the following extensions:

- You set the load cutout directly in the zone. The load cutout applies for all the additional zones in the **Distance protection for grounded systems** function.
- The load cutout applies to both the phase-to-phase and the phase-to-ground loops.
- You can additionally limit the load cutout by user-specific minimum/maximum values.
  In that way, you can adapt the load cutout better to the load curve.
- The load-cutout settings are available as measured values *R load cutout* and *Angle load cutout*.

You can define multiple characteristic curves with different load cutouts and store them in different settings groups. If you switch the settings group, you can adapt the load cutout in the operate curve of the **Distance protection** quickly and flexibly to different load conditions. This increases the safety against erroneous pickups due to overloads.

For more detailed information regarding settings group switching, refer to *3.11.1 Settings-Group Switching*.

Measured Values of the Zone with Quadrilateral Characteristic Curve and Adaptive Pickup

The measured values are prerouted to the operational and fault log. This supports fault analysis if the function trips.

Measured Value	Description
(_:306) R load cutout	Resistance for defining the load cutout in the R-X plane
(_:307) Angle load cutout	Opening angle of the load cutout

6.15.7.2 Application and Setting Notes

NOTE

If you insert a **Zone with quadrilateral characteristic curve and adaptive pickup** into the **Distance protection** function, the load-cutout settings migrate from the impedance pickup into this zone.

If you delete this zone in the function, you must again set the load-cutout settings in the impedance pickup.

In the impedance pickup, you can again set the load cutout separately for phase-to-phase and phase-to-ground loops.

NOTE

If you set the load cutout in the **Quadrilateral zone with adaptive pickup**, the load cutout applies for all zones, both for phase-to-phase and for phase-to-ground loops.

Load Cutout

The load cutout can be set using the following parameters:

- Default setting **(_:122) R load cutout** = *25.000 Ω*
- Default setting **(_:123) Max. R load cutout** = *600.000 Ω*
- Default setting **(_:124) Min. R load cutout** = *0.050 Ω*
- Default setting **(_:125) Angle load cutout** = *45.0°*
- Default setting **(_:126) Max. Angle load cutout** = *60.0°*
- Default setting **(_:127) Min. Angle load cutout** = *20.0°*

The load cutout is set jointly for phase-to-ground loops (ph-gnd) and phase-to-phase loops (ph-ph).

You can find application and setting notes for the **R load cutout** and **Angle load cutout** parameters in the description of impedance pickups in chapter *6.15.5.2 Application and Setting Notes*.

Parameters: Max. R load cutout, Min. R load cutout

- Default setting **(_:123) Max. R load cutout** = *600.000 Ω*
- Default setting **(_:124) Min. R load cutout** = *0.050 Ω*

With the **Max. R load cutout** and **Min. R load cutout** parameters, you can define an upper and a lower limiting value for the **R load cutout** parameter. This allows you to additionally limit the setting range of the **R load cutout** parameter and adapt it to specific load conditions. If you set the **Max. R load**

cutout and **Min. R load cutout** parameters to the same value, the parameter **R load cutout** cannot take on a different value.

Parameters: Max. Angle load cutout, Min. R load cutout

- Default setting **(_:126) Max. Angle load cutout** = ***60.0°***
- Default setting **(_:127) Min. Angle load cutout** = ***20.0°***

With the **Max. Angle load cutout** and **Min. Angle load cutout** parameters, you can define an upper and a lower limiting value for the **Angle load cutout** parameter. This allows you to additionally limit the setting range of the **Angle load cutout** parameter and adapt it to specific load conditions. If you set the **Max. Angle load cutout** and **Min. Angle load cutout** parameters to the same value, the parameter **Angle load cutout** cannot take on a different value.

6.15.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Z adapt.pickup				
_:1	Z adapt.pickup:Mode		• off • on • test	off
_:2	Z adapt.pickup:Operate & flt.rec. blocked		• no • yes	no
_:121	Z adapt.pickup:Blocked if diff.prot.active		• no • yes	no
_:27	Z adapt.pickup:Blk. w. inrush curr. detect.		• no • yes	no
_:11	Z adapt.pickup:1-pole operate allowed		• no • yes	yes
_:101	Z adapt.pickup:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:114	Z adapt.pickup:Zone-spec. residu. comp.		• no • yes	no
_:109	Z adapt.pickup:Directional mode		• non-directional • forward • reverse	forward
_:102	Z adapt.pickup:X reach	1 A	0.100 Ω to 600.000 Ω	25.000 Ω
		5 A	0.020 Ω to 120.000 Ω	5.000 Ω
_:103	Z adapt.pickup:R (ph-g)	1 A	0.100 Ω to 600.000 Ω	25.000 Ω
		5 A	0.020 Ω to 120.000 Ω	5.000 Ω
_:104	Z adapt.pickup:R (ph-ph)	1 A	0.100 Ω to 600.000 Ω	12.500 Ω
		5 A	0.020 Ω to 120.000 Ω	2.500 Ω
_:113	Z adapt.pickup:Zone-inclination angle		0 ° to 45 °	0 °
_:110	Z adapt.pickup:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.30 s
_:112	Z adapt.pickup:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.30 s
_:105	Z adapt.pickup:Kr		-0.33 to 11.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
_:106	Z adapt.pickup:Kx		-0.33 to 11.00	1.00
_:107	Z adapt.pickup:K0		0.000 to 11.000	1.000
_:108	Z adapt.pickup:Angle (K0)		-180.00 ° to 180.00 °	0.00 °
_:122	Z adapt.pickup:R load cutout	1 A	0.100 Ω to 600.000 Ω	25.000 Ω
		5 A	0.020 Ω to 120.000 Ω	5.000 Ω
_:123	Z adapt.pickup:Max. R load cutout	1 A	0.100 Ω to 600.000 Ω	300.000 Ω
		5 A	0.020 Ω to 120.000 Ω	60.000 Ω
_:124	Z adapt.pickup:Min. R load cutout	1 A	0.100 Ω to 600.000 Ω	0.100 Ω
		5 A	0.020 Ω to 120.000 Ω	0.020 Ω
_:125	Z adapt.pickup:Angle load cutout		20.0 ° to 60.0 °	45.0 °
_:126	Z adapt.pickup:Max. Angle load cutout		20.0 ° to 60.0 °	60.0 °
_:127	Z adapt.pickup:Min. Angle load cutout		20.0 ° to 60.0 °	20.0 °

6.15.7.4 Information List

No.	Information	Data Class (Type)	Type
Z adapt.pickup			
_:81	Z adapt.pickup:>Block stage	SPS	I
_:500	Z adapt.pickup:>Block ph-g loops	SPS	I
_:501	Z adapt.pickup:>Block ph-ph loops	SPS	I
_:54	Z adapt.pickup:Inactive	SPS	O
_:52	Z adapt.pickup:Behavior	ENS	O
_:53	Z adapt.pickup:Health	ENS	O
_:55	Z adapt.pickup:Pickup	ACD	O
_:300	Z adapt.pickup:Pickup loop AG	ACD	O
_:301	Z adapt.pickup:Pickup loop BG	ACD	O
_:302	Z adapt.pickup:Pickup loop CG	ACD	O
_:303	Z adapt.pickup:Pickup loop AB	ACD	O
_:304	Z adapt.pickup:Pickup loop BC	ACD	O
_:305	Z adapt.pickup:Pickup loop CA	ACD	O
_:56	Z adapt.pickup:Operate delay expired	ACT	O
_:57	Z adapt.pickup:Operate	ACT	O
_:306	Z adapt.pickup:R load cutout	MV	O
_:307	Z adapt.pickup:Angle load cutout	MV	O

6.15.8 Zone with MHO Characteristic Curve

6.15.8.1 Description

Logic of a Zone

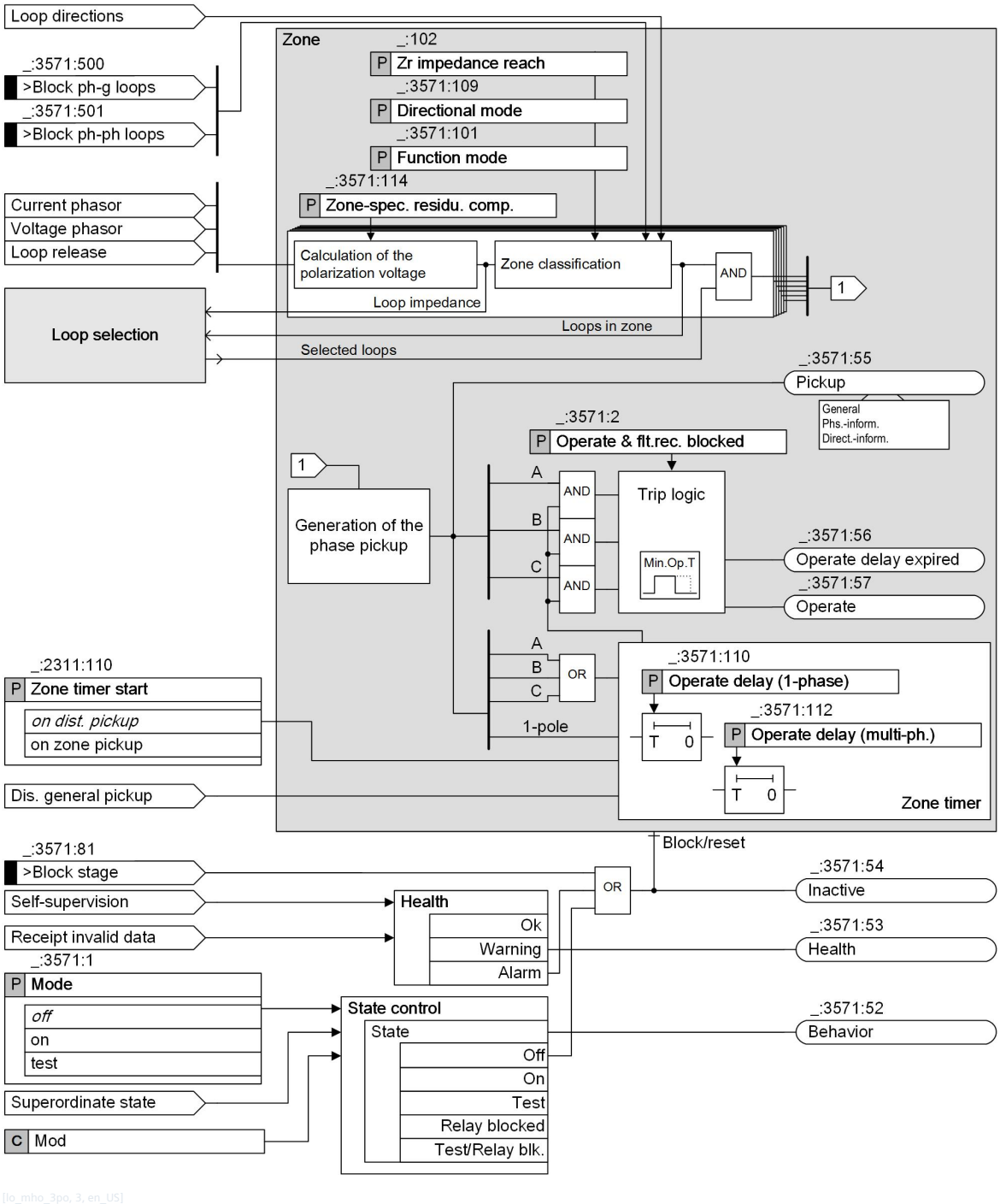


Figure 6-301 Logic Diagram of a Zone with MHO Characteristic Curve

Mode of Operation

The zone handles the following tasks:

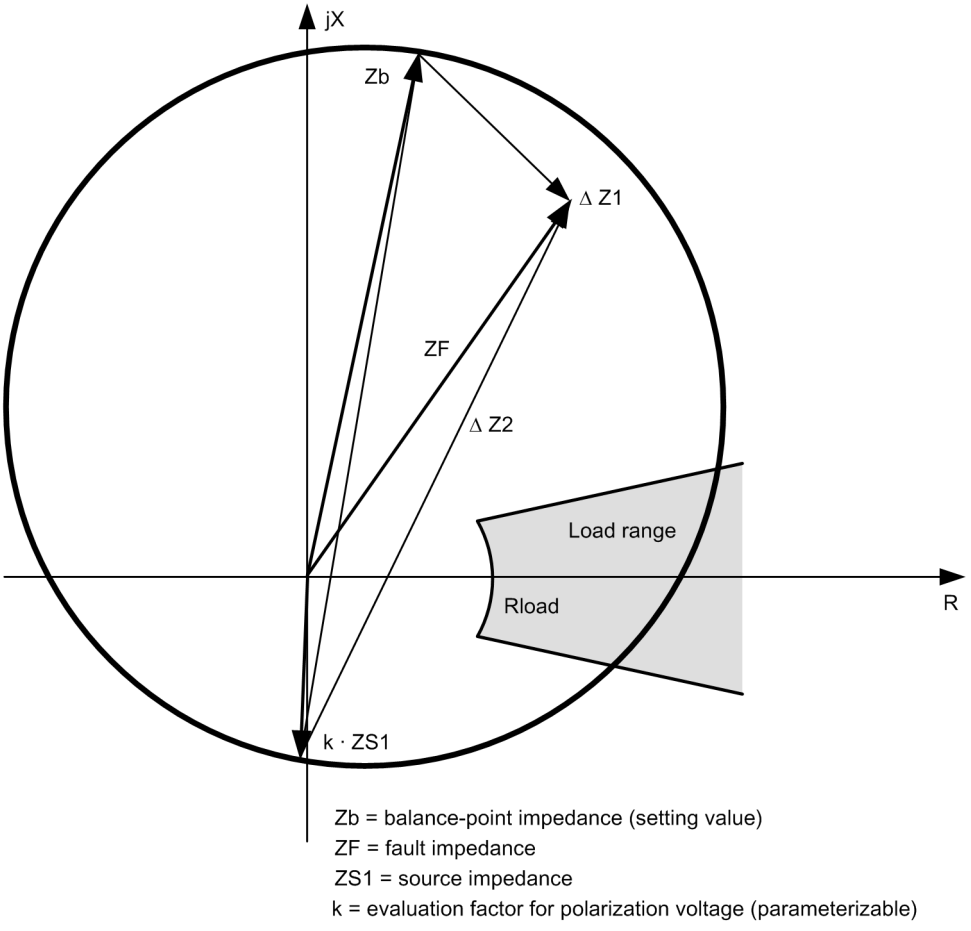
- Calculation of the polarization voltage from the measured current values
- Placement of the polarization and loop voltage into the zone
- Generation of pickup and tripping for the zone

To arrange the measurands in the tripping level of the MHO characteristic curve, the angle between 2 difference vectors ΔZ1 and ΔZ2 is determined (see *Figure 6-302*). These vectors are calculated from the difference between the 2 peaks of the circle diameter and the fault impedance. The peak Zr corresponds to the setting value of the zone (parameter **`Zr impedance reach`** and φ as in *Figure 6-303*); the peak k·ZV corresponds to the polarization value. The difference vectors are calculated as follows:

$$\Delta \underline{Z}_1 = \underline{Z}_F - \underline{Z}_r$$
$$\Delta \underline{Z}_2 = \underline{Z}_F - k \cdot \underline{Z}_V$$

[fofdltzr-130709-01.tif, 1, en_US]

In the boundary case, ZF is on the periphery of the circle. Then, the angle between the 2 difference vectors is 90° (Thales' theorem). Within the characteristic, the angle is greater than 90°; outside the characteristic, it is less than 90°.



[dwmhomes-140211-01.tif, 1, en_US]

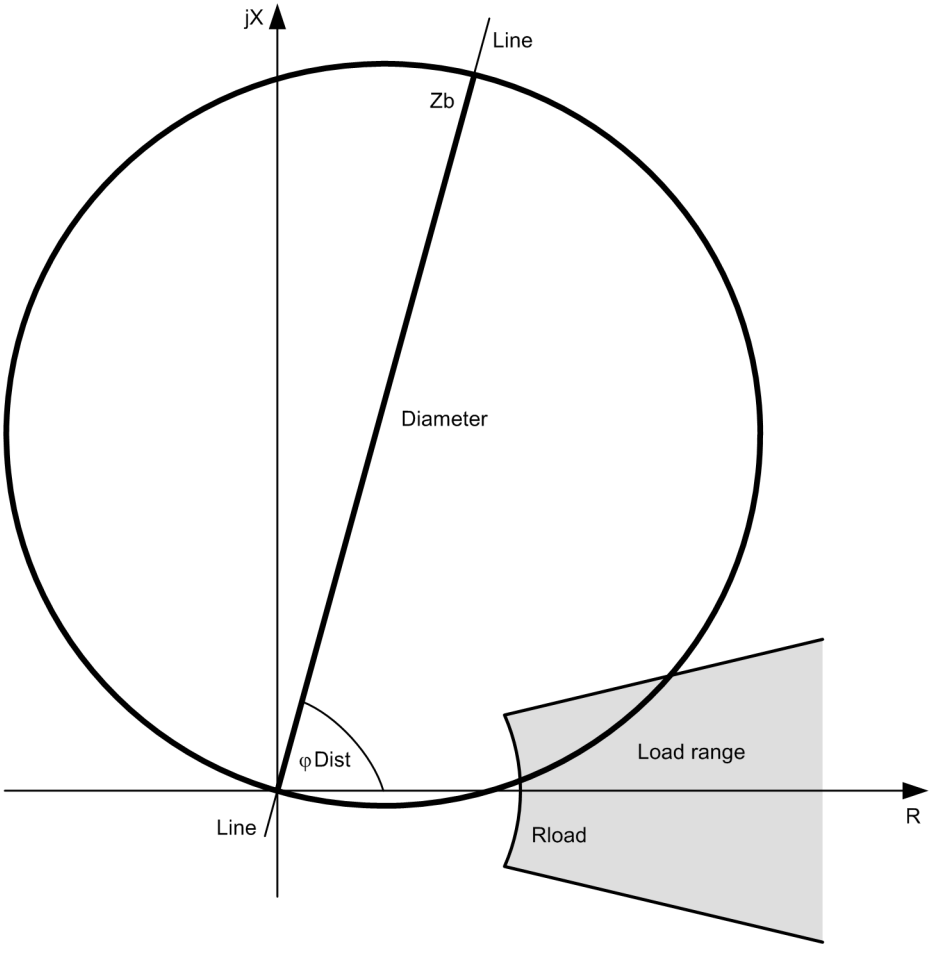
Figure 6-302 Vector Diagram of the Measurands for the MHO Characteristic Curve

The **`Zr impedance reach`** parameter is used to define the zone. With the parameter **`Directional mode`**, you can specify whether the zone works ***`forward`*** or ***`reverse`*** directed. In the reverse direction, the MHO characteristic curve is reflected across the coordinate origin. Once the fault impedance of a loop lies well

within the MHO characteristic curve of a distance zone, the zone picks up. The loop information is converted into phase-selective pickup indications. The phase-selective pickup indications of the zones are processed further in the output logic of the distance protection and by external additional functions (for example, teleprotection scheme). The output logic of the distance protection is described in chapter *6.15.11 Output Logic of the Distance Protection*.

Basic Characteristic Curve of the MHO Circuit

The basic form of the MHO characteristic curve is shown in *Figure 6-303*. The MHO characteristic curve of the zone is a circle through the coordinate origin in the R-X plane. The diameter is defined by the parameter **`Zr impedance reach`**. The inclination is defined by the parameter **`Dist. characteristic angle`**.

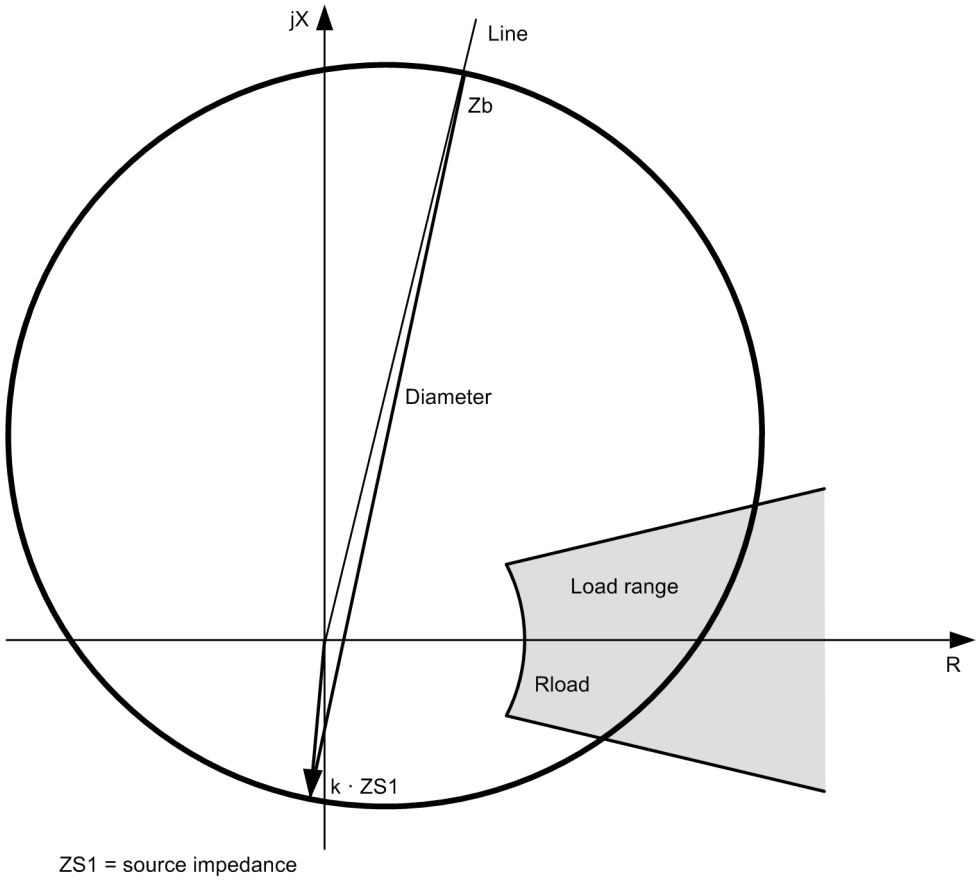


[dwmhogru-140211-01.tif, 1, en_US]

Figure 6-303 Basic Form of the MHO Characteristic Curve

Polarized MHO Characteristic Curve

The MHO characteristic curve passes through the coordinate origin. The boundary around the origin is undefined, since the measuring voltage there is too small for reliable analysis. The MHO characteristic curve is thus polarized. The polarization determines the lower peak of the circle, that is, the lower intersection of the diameter line on the circle circumference. The upper peak remains unchanged. It is defined by the parameter **`Zr impedance reach`**. Immediately after a fault occurs, the short-circuit voltage is influenced by the compensation procedure. Hence, the voltage buffered before the occurrence of the short circuit is used to perform the polarization. This shifts the lower peak by the impedance corresponding to the buffer voltage (see *Figure 6-304*). If the buffered short-circuit voltage is too small, a cross-polarized voltage is used. Theoretically, this is perpendicular to the actual short-circuit voltages for both the phase-to-ground loops and the phase-to-phase loops. This is taken into consideration with a 90° rotation during the calculation. The quadrature voltage also shifts the lower peak of the MHO characteristic curve.

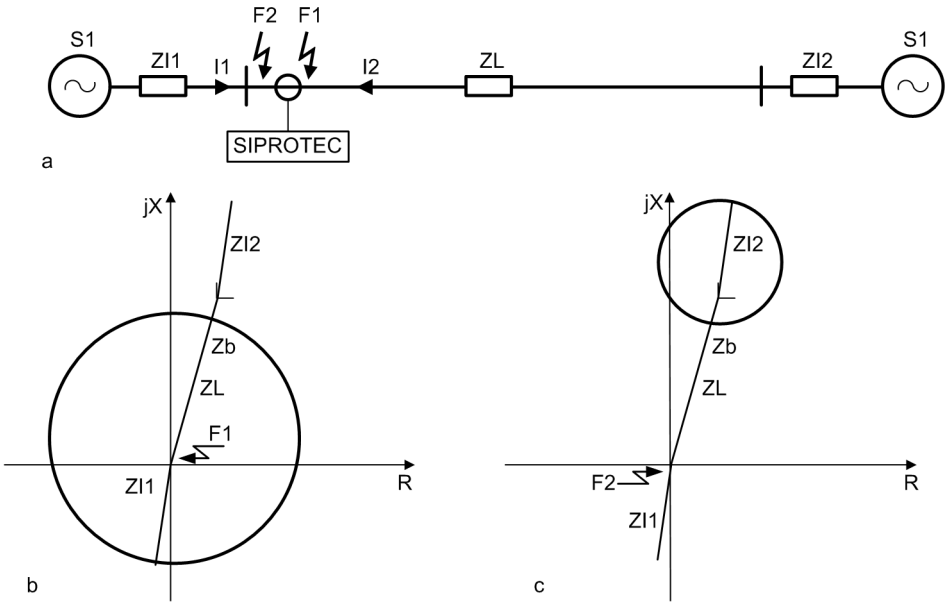


[dwmhopol-140211-01.tif, 1, en_US]

Figure 6-304 Polarized MHO Characteristic Curve

Properties of the MHO Characteristic Curve

The cross-polarized or buffered voltage (without load transport) is equal to the corresponding generator voltage E. After the short circuit, it does not change (see also *Figure 6-305*). The lower peak of the circle diameter thus appears shifted in the impedance diagram by the polarization value k·ZV1 = k·E1/I1. The upper peak remains defined by the setting value **`Zr impedance reach`**. For fault location F1 (*Figure 6-305*a), the short circuit lies in the forward direction, and the source impedance is in the reverse direction. All fault locations up to directly where the device is installed (current transformer) are unambiguously within the MHO characteristic curve (*Figure 6-305*b). If the current reverses, the peak of the circle diameter changes suddenly (*Figure 6-305*c). A reversed current I2 now flows through the measuring point (current transformer). The source impedance ZV2 + ZL determines the current I2. The peak Zr remains unchanged. It is now the lower limit of the diameter of the circle. During load transport on the line, the peak phasor can also rotate by the load angle.



[dwksfrsp-140211-01.tif, 1, en_US]

Figure 6-305 Polarized MHO Characteristic Curve with Cross-Polarized or Buffered Voltages

Selecting the Polarization

For short lines, the range of the zone must be set as a small value. For small loop voltages, the phase angle comparison between the differential voltage and the loop voltage is not secure. This can lead to incorrect directional decisions (tripping or blocking despite reverse faults). If a polarization voltage is used for the phase angle comparison, these problems are avoided. The polarization voltage is proportionally composed of the loop voltage buffered before the fault occurred and the present loop voltage. The following equation shows the polarization voltage V_P for a phase-to-ground loop:

$$\underline{V}_P = (1 - k_{pre}) \cdot \underline{V}_{ph-gnd} + k_{pre} \cdot \underline{V}_{ph-gnd\ memory}$$

[fofuspch-090709-01.tif, 1, en_US]

A value (factor k_{pre}) for the prefault voltage can be set separately for phase-to-ground and phase-to-phase loops. Memory polarization is only carried out when the RMS value of the corresponding buffer voltage for phase-to-ground loops is greater than 40 % of the rated voltage (V_{rated}). For phase-to-phase loops, the RMS value of the buffer voltage must be greater than 70 % of V_{rated}.

For a subsequent fault or after switching onto a fault, the prefault voltage can be missing. In this case, the buffer voltage can only be used for a limited time, for reasons of accuracy. For 1-phase short circuits and 2-phase short circuits without ground contact, you can use a voltage not involved in the fault for polarization. This voltage is rotated by 90° in relation to the actual fault voltage (cross polarization). The polarization voltage V_P is a mixture of the present voltage and the corresponding external-fault voltage. The following equation shows the polarization voltage V_P for a phase-to-ground loop:

$$\underline{V}_P = (1 - k_{cross}) \cdot \underline{V}_{ph-gnd} + k_{cross} \cdot \underline{V}_{ph-gnd\ healthy}$$

[fofukrzp-090709-01.tif, 1, en_US]

If the buffer voltage is not available, then cross polarization can be used. An evaluation (factor k_{cross}) for the voltage can be set separately for phase-to-ground and phase-to-phase loops.

NOTE

The following parameters are available as evaluation factors for polarization:

- **Mem. polarization(ph-g)**
- **Mem. polarization(ph-ph)**
- **Cross polarization(ph-g)**
- **Cross polarization(ph-ph)**

Set the parameters for all zones in the general parameters of the Distance protection function.

6.15.8.2 Application and Setting Notes

Parameter: Blocked if diff.prot.active

- Recommended setting value **(_:121) Blocked if diff.prot.active** = ***no***

The **Blocked if diff.prot.active** parameter is visible only when the **Line differential protection** function is available in the application.
You can use the **Blocked if diff.prot.active** parameter to establish whether the distance protection zone is blocked or not as long as the **Line differential protection** function is active.

Parameter Value	Description
no	If the zone is switched on (parameter **Mode** = ***on***) and the parameter **Blocked if diff.prot.active** = ***no*** is set, the zone will run regardless of the line differential protection. If the zone picks up, it will generate an operate indication after the time delay has elapsed.
yes	If the zone is switched on (parameter **Mode** = ***on***) and the **Blocked if diff.prot.active** = ***yes*** parameter is set, the zone is blocked as long as the line differential protection function is working. If the line differential protection is blocked, then the zone is **not** blocked.

Parameter: Blk. w. inrush curr. detect.

- Default setting **(_:27) Blk. w. inrush curr. detect.** = ***no***

The **Blk. w. inrush curr. detect.** parameter is visible only when the **Inrush-current detection** function is available in the application. You can use the **Blk. w. inrush curr. detect.** parameter to determine whether the distance protection zone is blocked or not during the detection of a transformer inrush current.

NOTE

With the parameter **Blk. w. inrush curr. detect.** = ***yes*** set, the minimum pickup and operate time for this distance protection zone is 1.5 power-system cyles even if the transformer inrush current is detected. Set the parameter **Blk. w. inrush curr. detect.** = ***yes*** only if you really need blocking on the basis of **inrush-current detection**.

Parameter: Function mode

- Recommended setting value **(_:101) Function mode**= ***ph-gnd and ph-ph***

You can use the **Function mode** parameter to determine which measuring element the zone will work with. The possible alternatives are ***ph-gnd and ph-ph***, ***ph-gnd only*** and ***ph-ph only***.

Parameter Value	Description
ph-gnd and ph-ph	The zone works with phase-to-ground and phase-to-phase measuring elements. Siemens recommends using the default setting.
ph-gnd only	The zone works only with the phase-to-ground measuring element.
ph-ph only	The zone works only with the phase-to-phase measuring element.

Parameter: Directional mode

- Recommended setting value **(_:109) Directional mode**= ***forward***

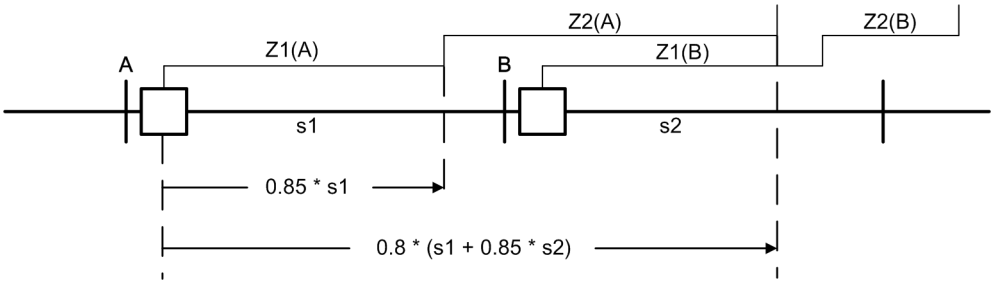
You can use the **Directional mode** parameter to specify whether the zone works ***forward*** or ***reverse***. Set the parameter **Directional mode** for the specific application.

Parameter: Zr impedance reach

- Recommended setting value **(_:102) Zr impedance reach**= ***2.500 Ω***

You can use the **Zr impedance reach** parameter to define the reach of the zone. Determine the setting value for the specific application.

First, create a time-grading schedule for the entire galvanically connected system. Enter the section lengths with their primary reactances X in Ω/km into the time-grading schedule. The reactances X then define the range of the distance protection zones.



[dwstaffz-140211-01.tif, 1, en_US]

Figure 6-306 Setting of the Range – Example for Device A

Set the range of Zone Z1 to about 85 % of the line section to be protected. Zone Z1 should trip quickly. Set the time delay of Zone Z1 to 0.00 s. The protection then switches off faults at this distance with its operating time. For higher levels, increase the time delay by 1 grading time increment.

The grading time must take the following factors into consideration:

- Circuit-breaker opening time including variation
- Dropout time for protection systems
- Variation in time delays

The usual grading times are 0.2 s to 0.4 s. Set the range of Zone Z2 to a value that extends to about 80 % of the lower-level zone of the protection for the shortest subsequent line (see *Figure 6-306*).

When parameterizing using PC and DIGSI, you can select to enter the values in either primary or secondary variables. If you wish to enter secondary variables during parameterization, convert the primary values from the time-grading schedule into secondary values as follows:

$$Z_{secondary} = \frac{Ratio_I}{Ratio_V} \cdot Z_{primary}$$

[fofpmsek-140409-01.tif, 1, en_US]

6.15.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Z (MHO) #				
_:1	Z (MHO) #:Mode		• off • on • test	off
_:2	Z (MHO) #:Operate & flt.rec. blocked		• no • yes	no
_:121	Z (MHO) #:Blocked if diff.prot.active		• no • yes	no
_:27	Z (MHO) #:Blk. w. inrush curr. detect.		• no • yes	no
_:101	Z (MHO) #:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:114	Z (MHO) #:Zone-spec. residu. comp.		• no • yes	no
_:109	Z (MHO) #:Directional mode		• forward • reverse	forward
_:102	Z (MHO) #:Zr impedance reach	1 A	0.100 Ω to 600.000 Ω	2.500 Ω
		5 A	0.020 Ω to 120.000 Ω	0.500 Ω
_:110	Z (MHO) #:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.30 s
_:112	Z (MHO) #:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.30 s
_:105	Z (MHO) #:Kr		-0.33 to 11.00	1.00
_:106	Z (MHO) #:Kx		-0.33 to 11.00	1.00
_:107	Z (MHO) #:K0		0.000 to 11.000	1.000
_:108	Z (MHO) #:Angle (K0)		-180.00 ° to 180.00 °	0.00 °

6.15.8.4 Information List

No.	Information	Data Class (Type)	Type
Z (MHO) #			
_:81	Z (MHO) #:>Block stage	SPS	I
_:500	Z (MHO) #:>Block ph-g loops	SPS	I
_:501	Z (MHO) #:>Block ph-ph loops	SPS	I
_:54	Z (MHO) #:Inactive	SPS	O
_:52	Z (MHO) #:Behavior	ENS	O
_:53	Z (MHO) #:Health	ENS	O
_:55	Z (MHO) #:Pickup	ACD	O
_:300	Z (MHO) #:Pickup loop AG	ACD	O
_:301	Z (MHO) #:Pickup loop BG	ACD	O
_:302	Z (MHO) #:Pickup loop CG	ACD	O
_:303	Z (MHO) #:Pickup loop AB	ACD	O
_:304	Z (MHO) #:Pickup loop BC	ACD	O
_:305	Z (MHO) #:Pickup loop CA	ACD	O

No.	Information	Data Class (Type)	Type
_:56	Z (MHO) #:Operate delay expired	ACT	O
_:57	Z (MHO) #:Operate	ACT	O

6.15.9 Zone with Circular Characteristic Curve

6.15.9.1 Description

Logic of a Zone

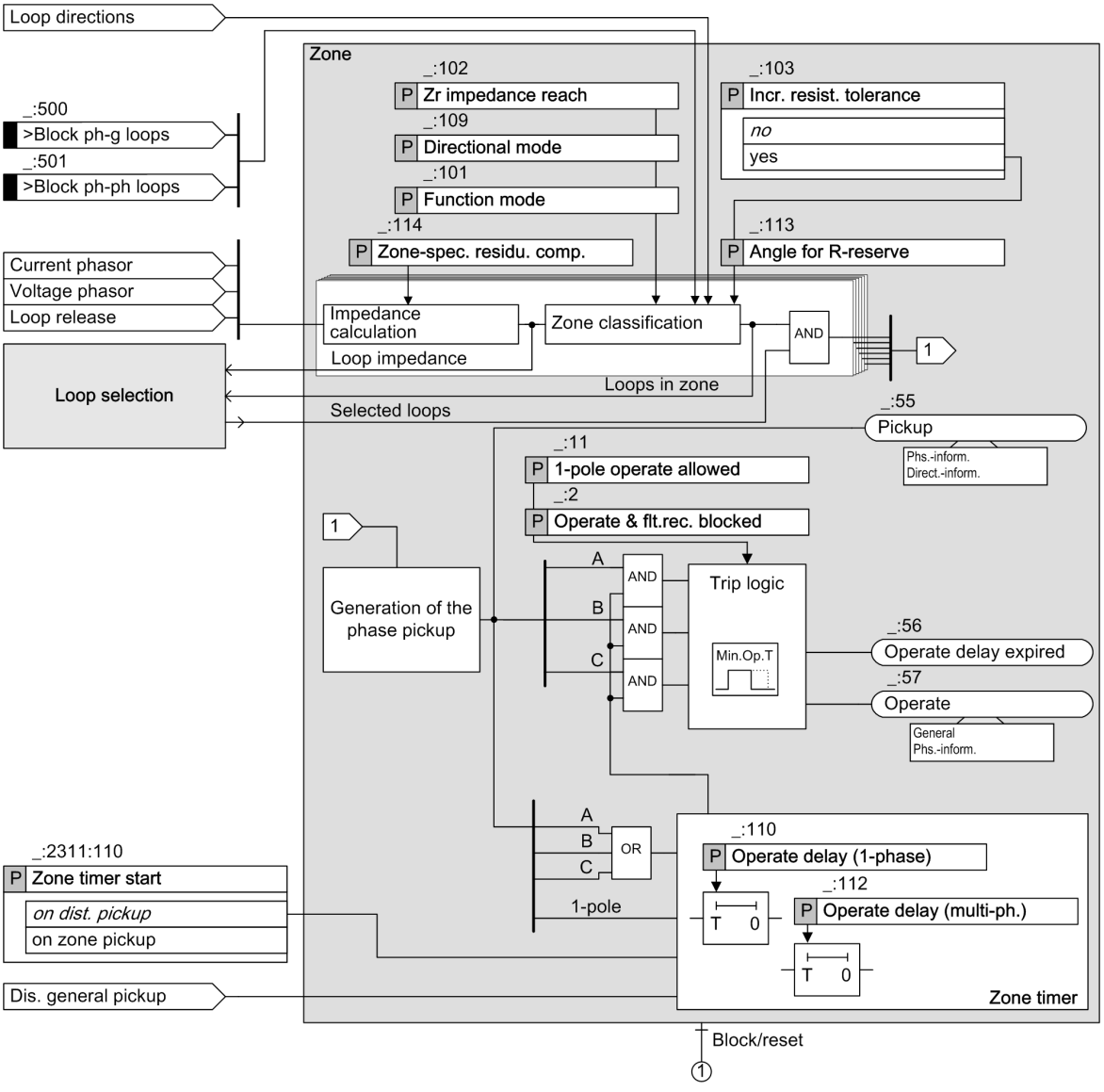
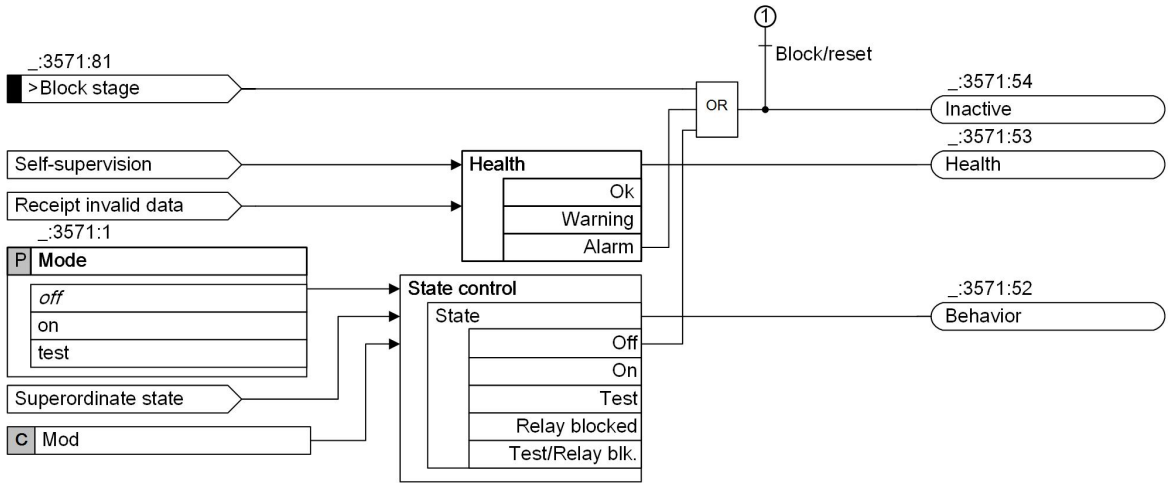


Figure 6-307 Logic Diagram of a Zone with Circular Characteristic Curve



[lo_block_i, 3, en_US]

Figure 6-308 Logic Diagram of a Zone with Circular Characteristic Curve (Continuation)

Mode of Operation

The zone handles the following tasks:

- Placement of the calculated impedance into the zone
- Generation of pickup and tripping for the zone

If the fault impedance of a loop lies well within the circular characteristic curve of a distance zone, and the direction of the impedance phasor matches the directionality of the zone, the zone picks up. The loop information is converted into phase-selective pickup indications. The phase-selective pickup indications of the zones are processed further in the output logic of the distance protection and by external additional functions (for example, teleprotection scheme). The output logic of the distance protection is described in chapter *6.15.11 Output Logic of the Distance Protection*.

Base Circle

The operate curve of the zone is a centered impedance circle around the origin of the R-X coordinate system. The base circle of the circular characteristic curve is defined by the parameter **`Zr impedance reach`**.

Since the circle cannot distinguish between positive impedance (forward direction) and negative impedance (reverse direction), direction-characteristic curves delimit the operating zones to the desired quadrant.

You can find more detailed information regarding the direction determination in chapter *6.15.4 Direction Determination*.

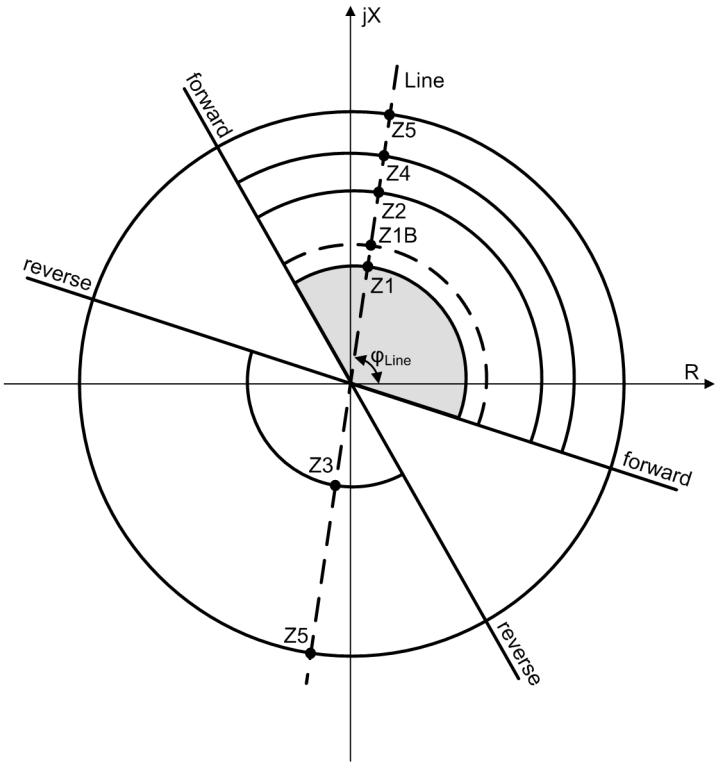
Figure 6-309 shows an example of the shape of the impedance circles. The circle for the first zone as a forward-directed zone is shaded. The third zone is shown as a reverse-directed zone. Zone Z5 is non-directional.

The impedance circle is defined by its radius and it forms the local curve of constant impedance.

$$Z = \sqrt{R^2 + X^2}$$

[fo_7sa6_fkt-beschr-Grundkreis, 1, en_US]

The radius thus determines the reach of a distance-protection zone in the R-X diagram and is independent of the short-circuit angle φ_{SC}.



[dw_kreis-charakteristik, 1, en_US]

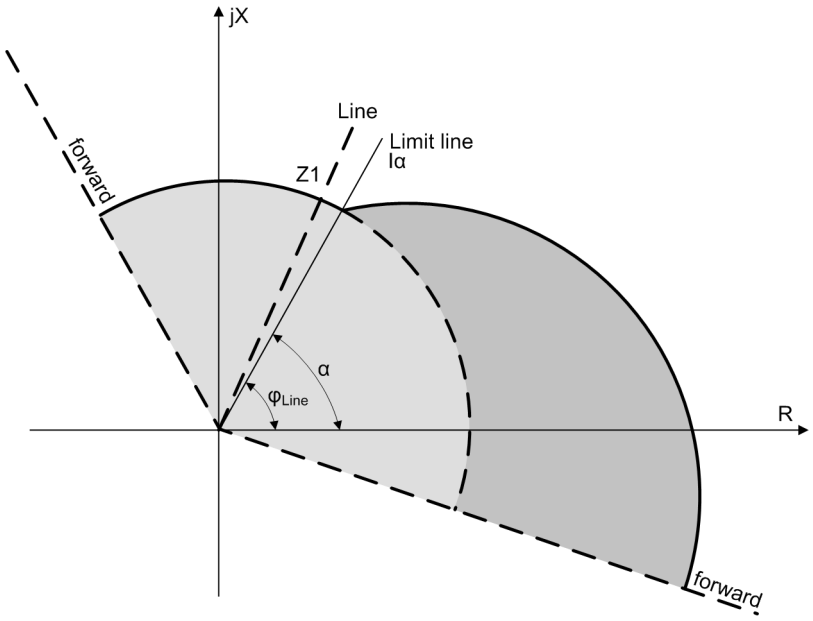
Figure 6-309 Example of Zones with Circular Characteristic Curve

Increased Resistance Reserve

Due to its centered symmetry, the circular characteristic curve includes only a limited resistance reserve for faults near the zone reach limit. This means that – for overhead lines – arc resistances can only be taken into consideration to a limited extent. For local faults (X ≈ 0), fault resistances R up to the magnitude of the set impedance Z (parameter: **(_:102) Zr impedance reach**) can be detected. For relatively long cables, this is sufficient if the arc resistance at the local sealing end is covered by the R-segment of the circle. In the cable itself, no significant arc resistance is possible.

In order to achieve a sufficient resistance reserve for overhead lines, even in the vicinity of the zone reach limit, an extension of the operate curve in the R-direction can be set. This also makes sense if an increased resistance reserve is necessary for short cables. This is the case if the resistance of an arc fault at the local sealing end of the cable is greater than the cable impedance at the zone reach limit of the first distance protection zone.

The increase of the resistance reserve takes effect below an adjustable limit angle α (parameter: **(_:113) Angle for R-reserve**), which should correspond approximately to the line angle. The following figure shows an example for the 1st zone and α = 60°. The somewhat more darkly shaded section is the increased resistance relative to the more lightly shaded impedance circle.



[dw_bsp-erhoehte-resistanzreserve, 1, en_US]

Figure 6-310 Example of Increased Resistance Reserve

The limit angle α can be set separately for each zone. If a zone is set in the reverse direction, the section of the increased resistance reserve is mirrored at the coordinate origin.

The resistance reserve is increased according to the following equation

$$\frac{Z_{Break}}{Z_r} = 1 + \sin(\alpha - \varphi_{sc})$$

[fo_resist_up_circlezone, 1, en_US]

with

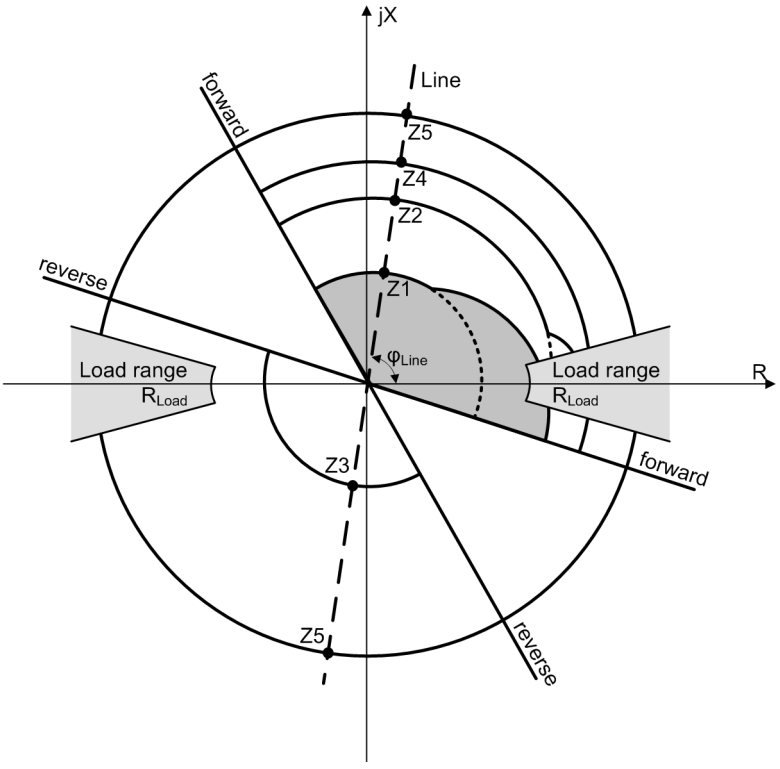
Z_{Break}	Balance-point impedance = actual limit of the zone
Z_r	Set impedance (parameter **`Zr impedance reach`**) = radius of the base circle
α	Set limit angle (parameter **`Angle for R-reserve`**) = angle below which the increased resistance reserve takes effect
φ_{sc}	Actual short-circuit angle = angle of the calculated short-circuit impedance

At the set limit angle α, the zone reach limit is therefore still on the impedance circle: because $\varphi_{sc} = \alpha$, $\sin(\alpha - \alpha) = 0$, and thus $Z_{Break} = Z_r$. If φ_{sc} is greater than the set limit angle α, then the impedance circle takes effect by definition and the increase of the resistance reserve makes no sense and is ineffective. For smaller angles up to -45°, the resistance reserve is increased by the expression $\sin(\alpha - \varphi_{sc})$, thus by $\sin(\alpha)$ at $\varphi_{sc} = 0°$.

Load Range

If the impedance circle is used as an implicit pickup method, there is a danger on long, heavily loaded lines that the load impedance may extend into the operate curves of the distance protection. In order to avoid faulty pickups of the distance protection in case of high power transmission, you can adjust a load cutout here. For operate curves with a high R-range, the load cutout excludes faulty pickups due to overload. For other pickup methods, this load cutout is unnecessary since the distance zones are only enabled after a pickup has taken place. In other words, the pickup in those cases distinguishes between load operation and short circuit.

The load cutout cuts the section of the load impedance from the circular characteristic curves (*Figure 6-311*). It also acts on the section of increased resistance reserve, as shown in the figure for the 1st zone. The shape of the load cutout is determined by the load section R_{load} and the load-range angle φ_{load}. These values apply to all zones.



[dw_kreis-charakteristik-mit-lastk, 1, en_US]

Figure 6-311 Circular Characteristic Curve with Load Cutout – Example

Direction Determination

Since each zone can be set to ***forward***, ***reverse***, or ***non-directional***, there are different (centrally mirrored) direction-characteristic curves for ***forward*** and ***reverse***. A non-directional zone has no direction-characteristic curve. For such a zone, the entire trip region applies.

6.15.9.2 Application and Setting Notes

Parameter: Blocked if diff.prot.active

- Recommended setting value **(_:121) Blocked if diff.prot.active** = ***no***

The **Blocked if diff.prot.active** parameter is visible only when the **Line differential protection** function is available in the application.

With the **Blocked if diff.prot.active** parameter, you determine whether the distance protection zone is blocked or not as long as the **Line differential protection** function is active.

Parameter Value	Description
no	If the zone is switched on (parameter **Mode** = ***on***) and the parameter **Blocked if diff.prot.active** = ***no*** the zone will run regardless of the line differential protection. If the zone picks up, it will generate an operate indication after the time delay has elapsed.
yes	If the zone is switched on (parameter **Mode** = ***on***) and the parameter **Blocked if diff.prot.active** = ***yes*** the zone is blocked as long as the line differential protection function is operating. If the line differential protection is blocked, then the zone is **not** blocked.

Parameter: Blk. w. inrush curr. detect.

- Default setting **(_:27) Blk. w. inrush curr. detect.** = ***no***

The **Blk. w. inrush curr. detect.** parameter is visible only when the **Inrush-current detection** function is available in the application. With the **Blk. w. inrush curr. detect.** parameter, you determine whether the distance-protection zone is blocked or not during the detection of a transformer inrush current.



NOTE

If you have set the parameter **Blk. w. inrush curr. detect.** = ***yes***, the minimum pickup and operate time for this distance-protection zone is 1.5 power-system cycles even if no transformer inrush current is detected. Set the parameter **Blk. w. inrush curr. detect.** = ***yes*** only if you really need the blocking by **Inrush-current detection**.

Parameter: 1-pole operate allowed

- Default setting **(_:11) 1-pole operate allowed** = ***yes***

With the **1-pole operate allowed** parameter, you specify whether the zone may execute 1-pole tripping or not. If the circuit breaker can do 1-phase switching, then 1-pole tripping is allowed on overhead lines. For practical applications, only the 1st distance zone and the overreaching zone shall trip in a 1-pole way. Set the parameter **1-pole operate allowed** = ***yes*** for the 1st distance zone and the overreaching zone. For all higher zones, set the parameter **1-pole operate allowed** = ***no***.

Parameter: Function mode

- Recommended setting value **(_:101) Function mode**= ***ph-gnd and ph-ph***

With the **Function mode** parameter, you can determine which measuring element the zone will work with. Possible alternatives are ***ph-gnd and ph-ph***, ***ph-gnd only*** and ***ph-ph only***.

Parameter Value	Description
ph-gnd and ph-ph	The zone works with phase-to-ground and phase-to-phase measuring elements. Siemens recommends using the default setting.
ph-gnd only	The zone works only with the phase-to-ground measuring element.
ph-ph only	The zone works only with the phase-to-phase measuring element.

Parameter: Zone-spec. residu. comp.

- Default setting **(_:114) Zone-spec. residu. comp.** = ***no***

You can use the **Zone-spec. residu. comp.** parameter to determine whether the zone operates with its own, specific residual compensation factors or not.

Parameter Value	Description
no	The zone works with the residual compensation factors set in the **Line** function group.
yes	The zone works with the specific residual compensation factors of the zone.



NOTE

The residual compensation factors set here will be valid and visible only if you have set the parameter **Zone-spec. residu. comp.** = ***yes*** in the zone. If you have set the parameter **Zone-spec. residu. comp.** = ***no***, the residual compensation factors set for the device apply.

Parameter: Directional mode

- Recommended setting value **(_:109) Directional mode**= ***forward***

You can use the **Directional mode** parameter to define whether the zone operates ***forward***, ***reverse*** or ***non-directional***. Set the parameter **Directional mode** for the specific application.

Parameter: Incr. resist. tolerance

- Default setting **(_:103) Incr. resist. tolerance** = ***no***

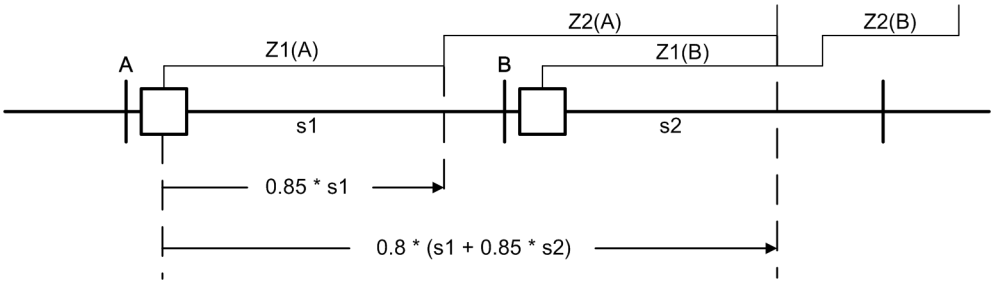
With the **Incr. resist. tolerance** parameter, you can set whether the zone is to have an increased resistance reserve (= ***yes***) or not (= ***no***).

Parameter: Zr impedance reach

- Default setting **(_:102) Zr impedance reach**= ***2.500 Ω***

You can use the **Zr impedance reach** parameter to define the reach of the zone. Determine the setting value for the specific application.

First, create a time-grading schedule for the entire galvanically connected system. Enter the section lengths with their primary reactances X in Ω/km into the time-grading schedule. The reactances X then define the range of the distance-protection zones.



[dwstaffz-140211-01.tif, 1, en_US]

Figure 6-312 Setting of the Range – Example for Device A

Set the reach of Zone Z1 to about 85 % of the line section to be protected. Zone Z1 should trip without delay. Set the time delay of Zone Z1 to 0.00 s. The protection then switches off faults at this distance with its operating time. For higher levels, increase the time delay by 1 grading time increment.

The grading time must take the following factors into consideration:

- Circuit-breaker opening time including variation
- Dropout time for protection systems
- Variation in time delays

The usual grading times are 0.2 s to 0.4 s. Set the reach of Zone Z2 to a value that extends to about 80 % of the lower-level zone of the protection for the shortest subsequent line (see *Figure 6-312*).

When parameterizing using PC and DIGSI, you can select to enter the values in either primary or secondary variables. If you wish to enter secondary variables during parameterization, convert the primary values from the time-grading schedule into secondary values as follows:

$$Z_{secondary} = \frac{Ratio_I}{Ratio_V} \cdot Z_{primary}$$

[fofpmsek-140409-01.tif, 1, en_US]

EXAMPLE:

Belted cable 10 kV with Al jacket 3 x 120 mm² and the data:

s (length)	8.5 km
R_1/s	0.15 Ω/km
X_1/s	0.10 Ω/km
R_0/s	0.83 Ω/km
X_0/s	0.31 Ω/km

Current transformer	500 A/5 A
Voltage transformer	10 kV/0.1 kV

Use the data to calculate the line impedance as follows

$$Z_L = \sqrt{0.15^2 + 0.10^2} \cdot \frac{\Omega}{\text{km}} \cdot 8.5\ \text{km} = 0.18 \frac{\Omega}{\text{km}} \cdot 8.5\ \text{km} = 1.53\ \Omega$$

[fo_zl_circlezone, 1, en_US]

If you set the first zone to 85 % of the line length, the following setting values result:

Primary:

$$Z1_{prim} = 0.85 \cdot Z_L = 0.85 \cdot 1.53\ \Omega = 1.30\ \Omega$$

Secondary:

$$Z1_{sec} = \frac{Ratio_I}{Ratio_V} \cdot Z1_{prim} = \frac{500\ \text{A}/5\ \text{A}}{10\ \text{kV}/0.1\ \text{kV}} \cdot 1.30\ \Omega = 1.30\ \Omega$$

Parameter: Angle for R-reserve

- Default setting **(_:113) Angle for R-reserve** = ***60.0°***

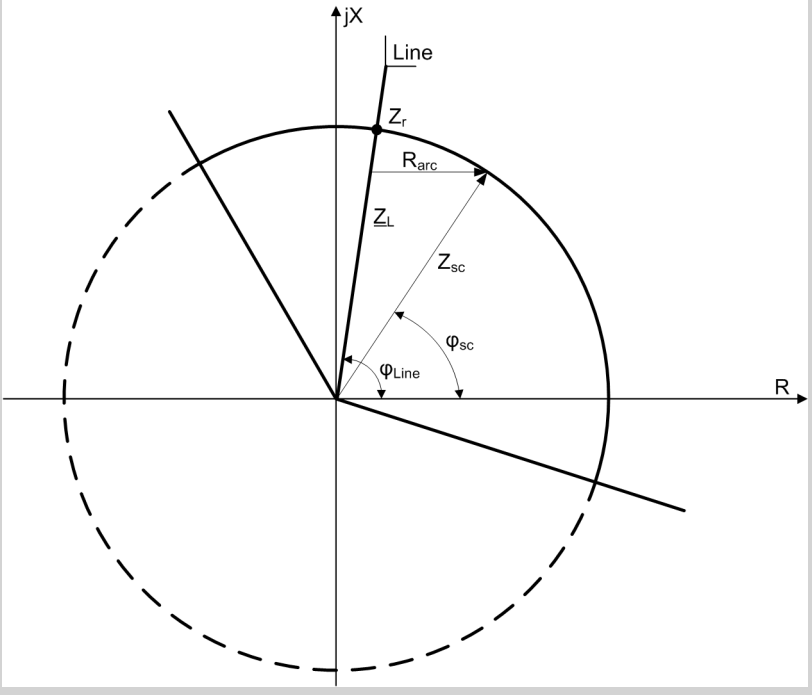
With the **Angle for R-reserve** parameter, you define the transition from the impedance circle to the curve of the increased resistance reserve (see *Figure 6-316*).

The natural resistance reserve of the impedance circle consists in the horizontal distance between the line and the periphery of the circle.

EXAMPLE:

Resistance reserve for overhead lines

For overhead lines, the presence of a fault resistance (arc) causes underreaching of the distance zones because the resistance reserve at the breakdown point is 0, but then increases sharply in the direction of the coordinate origin (see the following figure).



[dw_resistanzreserve-impedanzkreis-bei-freiltg, 1, en_US]

Figure 6-313 Resistance Reserve of the Impedance Circle for Overhead Lines

Z_r	Set reach
$\underline{Z}_L$	Line impedance
φ_{line}	Line angle
R_{arc}	Arc resistance
Z_{sc}	Short-circuit impedance
φ_{sc}	Short-circuit angle

The resistance reserve R_{arc} in this case depends on the line angle and on the underreaching of the distance zone that is to be tolerated. For a line angle of $\varphi_{line} = 80°$ and 10 % underreaching, for example, the resistance reserve is 30 % of the balance-point impedance.

The following table shows additional values for the resistance reserve at the impedance circle:

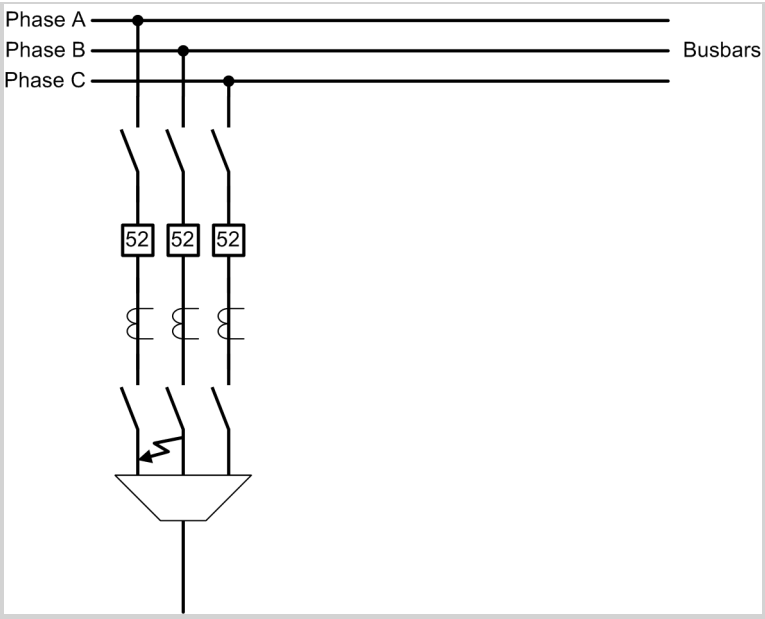
Line Angle φ_{line}	Resistance Reserve R_{arc} for Tolerable Underreaching of		
	10 %	**15 %**	**20 %**
85°	36 %	45 %	53 %
80°	30 %	40 %	47 %
75°	26 %	35 %	42 %
70°	22 %	31 %	38 %
65°	19 %	27 %	35 %
60°	17 %	25 %	32 %
All percentage values relate to the balance-point impedance (= circle radius)			

EXAMPLE:

Resistance reserve for cables

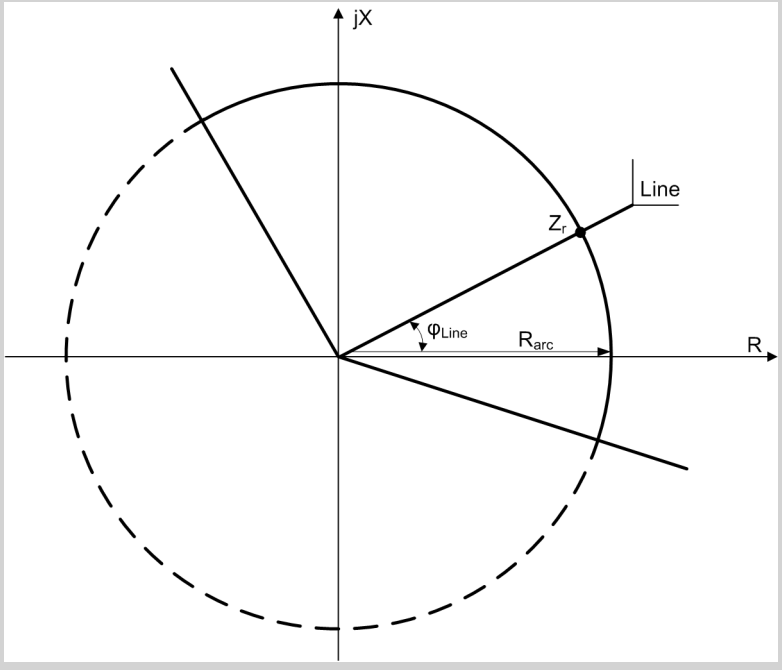
For cables, the resistance reserve in the vicinity of the breakdown point is not relevant, but rather the local resistance reserve. Since an arc is practically impossible in the cable itself, the resistance reserve only has to take account of the arc faults in the vicinity of the local sealing end (*Figure 6-314*).

The impedance circle here covers fault resistances up to the absolute value of the balance-point impedance (*Figure 6-315*).



[dw_kabelabg-mit-lichtbogenfehler-am-oertl-endverschluss, 1, en_US]

Figure 6-314 Outgoing Cable with Arc Fault at Local Sealing End



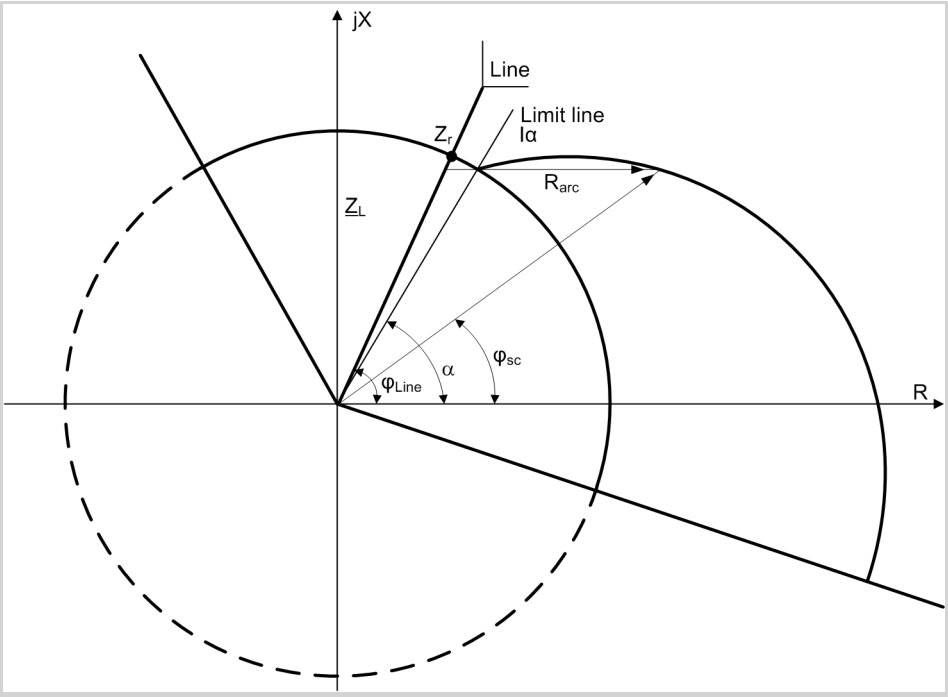
[dw_oertl-resistanzreserve-impedanzkreis-bei-kabel, 1, en_US]

Figure 6-315 Local Resistance Reserve of the Impedance Circle for Cables

EXAMPLE:

Increased resistance reserve

If you wish to increase the reserve for fault resistances, you must set the parameter **`Incr. resist. tolerance`** = ***`yes`***. In this case, the impedance circle is increased by an extension in the R direction (*Figure 6-316*). The angle α in this case determines the transition from the impedance circle to the curve of the increased resistance reserve.

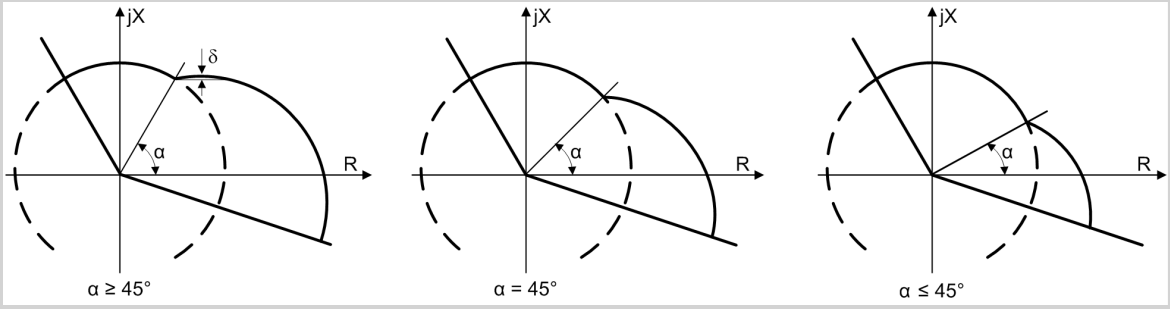


[dw_bsp-eine-erhoehte-resistanzreserve-mit-erweiterung, 1, en_US]

Figure 6-316 Example of Increased Resistance Reserve

This extension leads to an increased resistance reserve both in the vicinity of the breakdown limit and in the vicinity of the installation location. The curvature of the extension curve in the X direction can determine an overreaching. This overreaching can be tolerated within certain limits, however, because the breakdown limit in any case normally has a 15 % reserve distance from the next station, that is from the end of the line.

There is no extension-induced overreaching for limit angles α (for example, parameter **(_:113) Angle for R-reserve** for the 1st zone) of 45° or less. The greater the set value of α, the greater the possible overreaching. The following figure qualitatively shows the shape of the operate curve for different angles α.



[dw_quali-verlauf-ausloesekennl-erhoeht-resistanzreserve, 1, en_US]

Figure 6-317 Qualitative Plot of the Operate Curve for Increased Resistance Reserve

Since the overreaching and the resistance reserve both depend on the line angle φ_{line} and on the set limit angle α, a few reference values are listed in the following sections.

The resistance reserve for short-circuits through an arc near of the breakdown point is primarily relevant for overhead lines. Select the limit angle α (for example, parameter **(_:113) Angle for R-reserve** for the 1st zone) so that a high resistance reserve goes into effect without impermissibly high overreaching.

Note the following:

- Do not set the parameter **Angle for R-reserve** to a value greater than the line angle.
- Do not set the parameter **Angle for R-reserve** above 75°.

Otherwise, increased overreaching may occur in the event of arc faults. The following table shows the conditions for some examples of the approximate overreaching caused by setting an increased resistance reserve.

α	Possible Overreaching Values Due to Arc Faults for a Line Angle of								
	90°	**85°**	**80°**	**75°**	**70°**	**65°**	**60°**	**55°**	**50°**
75°	10 %	11 %	12 %	14 %	-[47]	-[47]	-[47]	-[47]	-[47]
70°	3 %	4 %	5 %	7 %	10 %	-[47]	-[47]	-[47]	-[47]
65°	0 %	0 %	0 %	0 %	3 %	7 %	-[47]	-[47]	-[47]
60°	0 %	0 %	0 %	0 %	0 %	0 %	4 %	-[47]	-[47]
55°	0 %	0 %	0 %	0 %	0 %	0 %	0 %	2 %	-[47]
50°	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	1 %

As with the base circle, the level of the resistance reserve R_{arc} depends on the line angle and on the tolerable underreaching of the distance zone (also see *Figure 6-316*). The following table shows the approximate resistance reserve for tolerable underreaching of 15 %.

α	Resistance Reserve R_{arc} for Tolerable Underreaching of 15 % at a Line Angle of								
	90°	**85°**	**80°**	**75°**	**70°**	**65°**	**60°**	**55°**	**50°**
75°	148 %	141 %	135 %	129 %	-[47]	-[47]	-[47]	-[47]	-[47]
70°	137 %	131 %	125 %	120 %	116 %	-[47]	-[47]	-[47]	-[47]
65°	125 %	118 %	112 %	108 %	105 %	102 %	-[47]	-[47]	-[47]
60°	107 %	100 %	96 %	93 %	91 %	90 %	89 %	-[47]	-[47]
55°	-[48]	-[48]	59 %	86 %	71 %	73 %	75 %	77 %	-[47]
50°	-[48]	-[48]	-[48]	-[48]	-[48]	36 %	55 %	61 %	65 %

The resistance reserve in the near the breakdown point is not relevant for cables but rather the local resistance reserve, that is for $\varphi_{sc} = 0°$. To avoid overreaching, do not set the parameter **`Angle for R-reserve`** to a value greater than the line angle here either. The resistance reserve is derived from the R axis segment (X = 0) of the expanded operate curve. The following table shows some values for various setting values of the parameter **`Angle for R-reserve`**:

α	Resistance Reserve R_{arc} for X = 0
65°	190 %
60°	186 %
55°	181 %
50°	176 %
45°	170 %
40°	164 %
35°	157 %
30°	150 %
25°	142 %
20°	134 %
15°	125 %
10°	117 %
All percentage values relate to the balance-point impedance (= circle radius)	

For the higher zones, a resistance reserve lower than that for the 1st zone makes sense (relative to the impedance reach in each case). To do this, adjust the parameter **`Angle for R-reserve`** to a lower value.

47 The condition $\alpha \leq \varphi_{line}$ is not fulfilled here.

48 Underreaching greater than 15 %

Parameter: Operate delay (1-phase)

- Default setting **(_:110) Operate delay (1-phase)** = ***0.00 s***

With the **Operate delay (1-phase)** parameter, you set the grading time of the zone for 1-pole short circuits. Set the **Operate delay (1-phase)** for the specific application.

Parameter: Operate delay (multi-ph.)

- Default setting **(_:112) Operate delay (multi-ph.)** = ***0.00 s***

With the **Operate delay (multi-ph.)** parameter, you set the grading time of the zone for multi-phase faults. Set the **Operate delay (multi-ph.)** for the specific application.

Parameter: Kr and Kx

- Default setting **(_:105) Kr** = ***1,00***
- Default setting **(_:106) Kx** = ***1,00***

With the **Kr** and **Kx** parameters, you set the residual compensation with scalar factors.

NOTE

The parameters **Kr** and **Kx** are visible in the zone only if you have set the parameter**Zone-spec. residu. comp.** = ***yes*** in the zone and the parameter **Set. format residu. comp.** = ***Kr, Kx*** for the device. You can only change the setting value of the parameter **Set. format residu. comp.** in DIGSI 5 under **Device settings**.

Parameter: K0 and Angle (K0)

- Default setting **K0** = ***1.000***
- Default setting **Angle (K0)** = ***0.00°***

You can use the **K0** and **Angle (K0)** parameters to set the residual compensation with the complex residual compensation factor.

NOTE

The parameters **K0** and **Angle (K0)** are visible in the zone only if you have set the parameter **Zone-spec. residu. comp.** = ***yes*** in the zone and the parameter **Set. format residu. comp.** = ***K0*** for the device. You can only change the setting value of the parameter **Set. format residu. comp.** in DIGSI 5 under **Device settings**.

6.15.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Z (circle) #				
_:1	Z (circle) #:Mode		• off • on • test	off
_:2	Z (circle) #:Operate & flt.rec. blocked		• no • yes	no
_:121	Z (circle) #:Blocked if diff.prot.active		• no • yes	no
_:27	Z (circle) #:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:11	Z (circle) #:1-pole operate allowed		• no • yes	yes
_:101	Z (circle) #:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:114	Z (circle) #:Zone-spec. residu. comp.		• no • yes	no
_:109	Z (circle) #:Directional mode		• non-directional • forward • reverse	forward
_:103	Z (circle) #:Incr. resist. tolerance		• no • yes	no
_:102	Z (circle) #:Zr impedance reach	1 A	0.100 Ω to 600.000 Ω	2.500 Ω
		5 A	0.020 Ω to 120.000 Ω	0.500 Ω
_:113	Z (circle) #:Angle for R-reserve		10 ° to 90 °	60 °
_:110	Z (circle) #:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.30 s
_:112	Z (circle) #:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.30 s
_:105	Z (circle) #:Kr		-0.33 to 11.00	1.00
_:106	Z (circle) #:Kx		-0.33 to 11.00	1.00
_:107	Z (circle) #:K0		0.000 to 11.000	1.000
_:108	Z (circle) #:Angle (K0)		-180.00 ° to 180.00 °	0.00 °

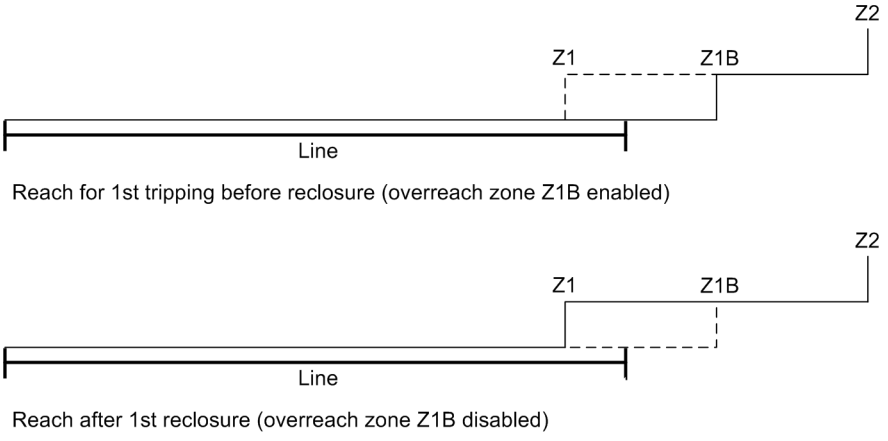
6.15.9.4 Information List

No.	Information	Data Class (Type)	Type
Z (circle) #			
_:81	Z (circle) #:>Block stage	SPS	I
_:500	Z (circle) #:>Block ph-g loops	SPS	I
_:501	Z (circle) #:>Block ph-ph loops	SPS	I
_:54	Z (circle) #:Inactive	SPS	O
_:52	Z (circle) #:Behavior	ENS	O
_:53	Z (circle) #:Health	ENS	O
_:55	Z (circle) #:Pickup	ACD	O
_:300	Z (circle) #:Pickup loop AG	ACD	O
_:301	Z (circle) #:Pickup loop BG	ACD	O
_:302	Z (circle) #:Pickup loop CG	ACD	O
_:303	Z (circle) #:Pickup loop AB	ACD	O
_:304	Z (circle) #:Pickup loop BC	ACD	O
_:305	Z (circle) #:Pickup loop CA	ACD	O
_:56	Z (circle) #:Operate delay expired	ACT	O
_:57	Z (circle) #:Operate	ACT	O

6.15.10 Release of Tripping through AREC Zone

6.15.10.1 Description

The AREC zone works together with the **Automatic reclosing** function. In order for automatic reclosing to be successful, short circuits on the entire transmission route to all line ends must be switched off at the same time and with as little delay as possible. In addition, with distance protection, the AREC zone may be functioning as an overreaching distance zone, or example, Zone Z1B, prior to automatic reclosing. After automatic reclosing, the AREC zone is typically no longer in effect. For the relevant AREC cycle, short circuits up to the breakdown point of the AREC zone can be switched off quickly (see following figure). Before automatic reclosing, limited non-selectivity in favor of fast simultaneous disconnection is acceptable. Automatic reclosing will be performed in any case. The normal stages of the distance protection (Z1, Z2, etc.) are typically operated independently of the automatic reclosing function.

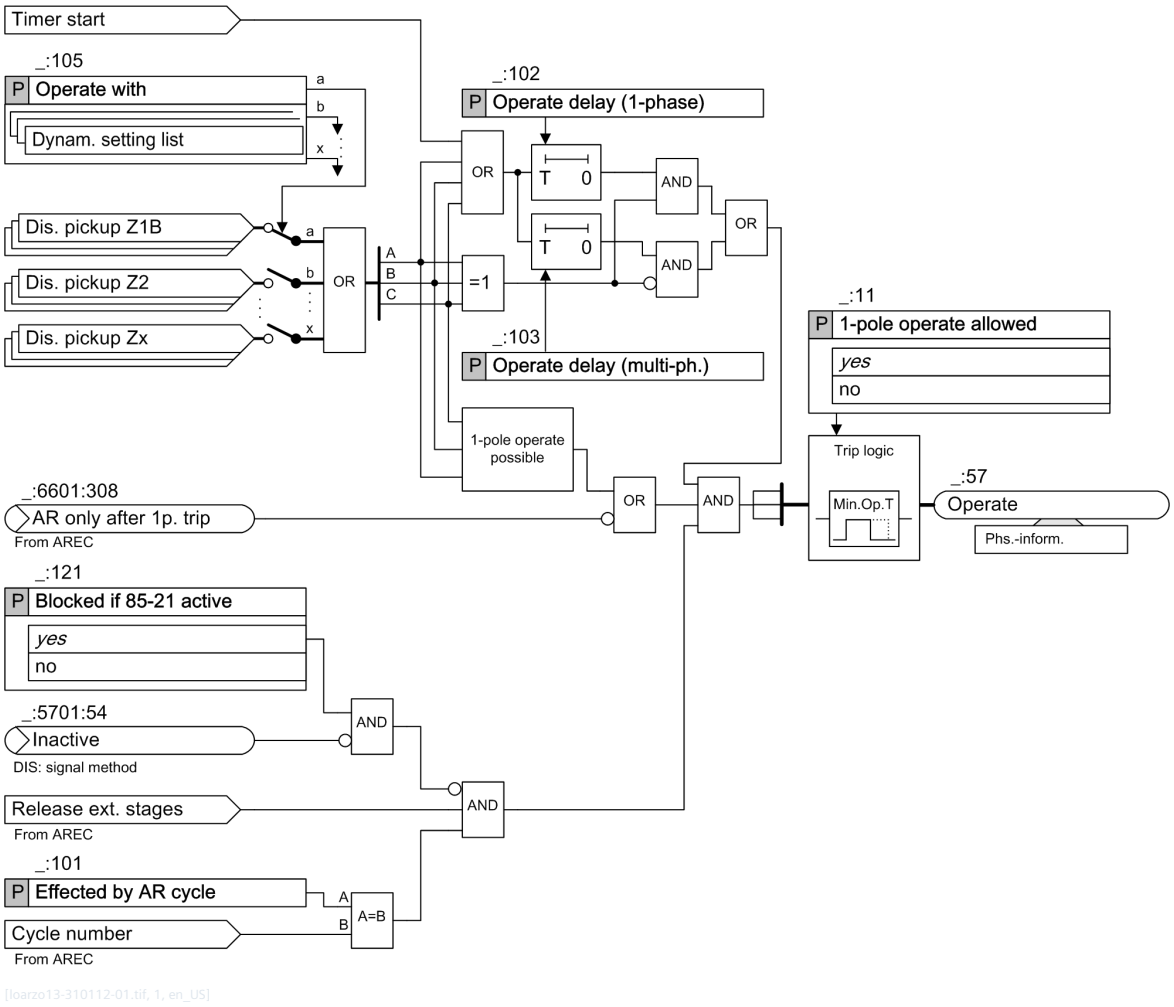


[dw_reichweite_ar_zone, 1, en_US]

Figure 6-318 Reach Control Before 1st Reclosure for Distance Protection

The automatic reclosing zone is available in the function library in DIGSI (in **Line function group** → **Distance protection** → **Zone types**). If necessary you can insert the automatic reclosing zone into the **Distance protection** function. The automatic reclosing zone can be controlled from the internal automatic reclosing function and also externally via the automatic reclosing function type **Operation with external automatic reclosing function**.

Logic



[loarzo13-310112-01.tif, 1, en_US]

Figure 6-319 Logic of the Automatic Reclosing Zone

Mode of Operation

The automatic reclosing zone is an instance of controlled trip logic. You use the parameter **Operate with** to select which distance zones will deliver the pickup information. If the selected distance zones have picked up and a release from the automatic reclosing function is present, the automatic reclosing zone generates an operate indication.

You use the parameter **Effected by AR cycle** to select the automatic reclosing cycle for the release of tripping. If you wish to have a zone release in several automatic reclosing cycles, you must instantiate several automatic reclosing zones and select a different automatic reclosing cycle for each zone. If the selected automatic reclosing cycle is only parameterized for 1-pole tripping (indication *(_:6601:308) AR only after 1p. trip*), the automatic reclosing zone only trips if this operate indication leads to a 1-pole trip command in the trip logic of the Circuit breakers function group.

The, both the 3-pole coupling via pickup or trip command and the handling of 2-pole phase-to-phase short circuits are considered.

If the selected automatic reclosing cycle is parameterized for 1-pole operation and the parameter **1-pole operate allowed** is set to ***no*** , the automatic reclosing zone indicates *Inactive* .

If the function **teleprotection with distance protection** is present and in effect, you can block the automatic reclosing zone with the parameter **Blocked if 85-21 active** . The AREC zone is active only if the teleprotection with distance protection is not in effect, for example, with a communication failure. If the teleprotection with distance protection is in effect, you achieve 100% selectivity through the teleprotection method as distance protection only if the comprehensive AR zone is blocked.

6.15.10.2 Application and Setting Notes

Parameter: Operate with

- Recommended setting value **(_:105) Operate with** = ***Z1B***

You use the parameter **Operate with** to specify which distance zones will generate an operate indication when pickup occurs while an automatic reclosing release is present. Typically, you use an overreaching distance zone. This is called Z1B in the application templates.

The selection texts for the parameter **Operate with** are identical to the texts you assign during zone configuration in the **Distance protection** function.

Parameter: Operate delay (1-phase)

- Recommended setting value **(_:102) Operate delay (1-phase)** = ***0.00 s***

The **Operate delay (1-phase)** parameter is used to set the tripping delay of the automatic reclosing zone for 1-phase short circuits. Set the parameter **Operate delay (1-phase)** for the specific application. If the distance zone selected with the parameter **Operate with** picks up and all release conditions are met, the distance zone trips with the **Operate delay (1-phase)** set here.

Parameter: Operate delay (multi-ph.)

- Recommended setting value **(_:103) Operate delay (multi-ph.)** = ***0.00 s***

You can use the **Operate delay (multi-ph.)** parameter to set the tripping delay for multi-phase short circuits. Set the parameter **Operate delay (multi-ph.)** for the specific application. If the distance zone selected with the parameter **Operate with** picks up and all release conditions are met, the distance zone trips with the **Operate delay (multi-ph.)** set here.

Parameter: Effected by AR cycle

- Recommended setting value **(_:101) Effected by AR cycle** = ***1***

You use the parameter **Effected by AR cycle** to select the automatic reclosing cycle for the release of tripping. If you wish to have a zone release in several automatic reclosing cycles, you must instantiate several automatic reclosing zones and select a different automatic reclosing cycle for each zone. If you use the **automatic reclosing** function with the **operation with external reclosing system** or **automatic reclosing with adaptive dead time (ADT)** function type, you must retain the default setting ***1***.

If the selected automatic reclosing cycle is only parameterized for 1-pole tripping (indication *(_:6601:308) AR only after 1p. trip*), the automatic reclosing zone only trips if this operate indication leads to a 1-pole trip command in the trip logic of the Circuit breakers function group. If you do not use the **Automatic reclosing** function, you must delete the automatic reclosing zone in the **Distance protection** function in order to ensure consistent parameterization in DIGSI.

Parameter: Blocked if 85-21 active

- Recommended setting value **(_:121) Blocked if 85-21 active** = ***yes***

The **Blocked if 85-21 active** parameter is used to block the automatic reclosing zone with the teleprotection method in effect. If the function **teleprotection with distance protection** is present and in effect, Siemens recommends blocking the automatic reclosing zone. To do this, set the parameter **Blocked if 85-21 active** = ***yes***. If the parameter **Blocked if 85-21 active** = ***yes*** is set, the AR zone is active only if the teleprotection with distance protection is no in effect (for example, in the case of a communication failure).

6.15.10.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
AR zone #				
_:1	AR zone #:Mode		• off • on • test	on
_:11	AR zone #:1-pole operate allowed		• no • yes	yes
_:102	AR zone #:Operate delay (1-phase)		0.00 s to 60.00 s	0.00 s
_:103	AR zone #:Operate delay (multi-ph.)		0.00 s to 60.00 s	0.00 s
_:101	AR zone #:Effected by AR cycle		1 to 1	1
_:121	AR zone #:Blocked if 85-21 active		• no • yes	yes
_:105	AR zone #:Operate with		Setting options depend on configuration	

6.15.10.4 Information List

No.	Information	Data Class (Type)	Type
AR zone #			
_:81	AR zone #:>Block stage	SPS	I
_:54	AR zone #:Inactive	SPS	O
_:52	AR zone #:Behavior	ENS	O
_:53	AR zone #:Health	ENS	O
_:56	AR zone #:Operate delay expired	ACT	O
_:57	AR zone #:Operate	ACT	O

6.15.11 Output Logic of the Distance Protection

Mode of Operation

The output logic treats the pickup and trip signals of the distance zones separately, in one pickup logic and one trip logic each. The pickup and trip logic generate the superordinate indications of the distance protection.

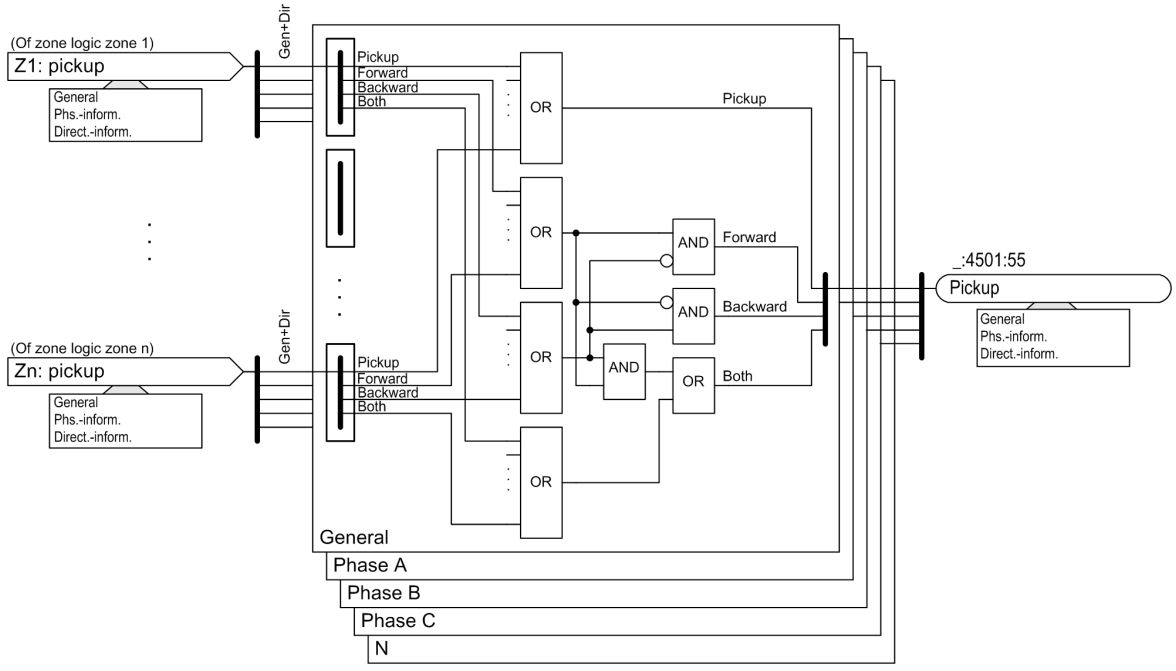
General Pickup

In impedance pickup, the signal *General* is generated once a fault is reliably detected in the working area of a zone. In the pickup methods I>, V, and V/Phi, the signal *General* is generated when a pickup condition is met.

The signal *General* is indicated and can be further processed by internal and external additional functions, for example, teleprotection scheme or automatic reclosing.

Pickup Logic

The distance zone pickups are combined phase-selectively and output as indications.

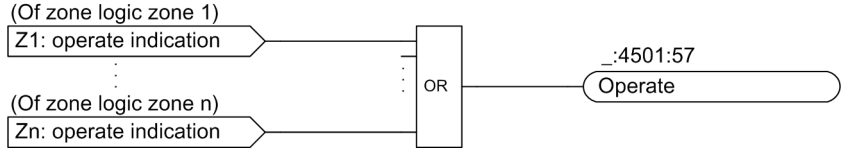


[loanrdis-140211-01.tif, 2, en_US]

Figure 6-320 Pickup Logic

Trip Logic

The trip signals of the distance zones always lead to a 3-phase operate indication of the distance protection.



[loaus3po-140211-01.tif, 1, en_US]

Figure 6-321 3-Phase Trip Logic

6.16 Impedance Protection

6.16.1 Overview of Functions

The **Impedance protection** function (ANSI 21):

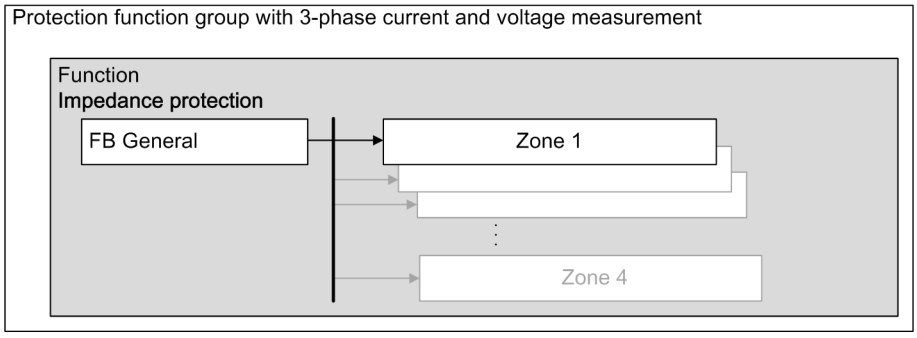
- Protects transformers as backup protection for transformer differential protection
- Is used as a backup protection for the transformer and the generator in the block units of power stations
- Functions as backup protection in the event of energy recovery to faults in the upstream electrical power system beyond a transformer

6.16.2 Structure of the Function

The **Impedance protection** function is used in protection function groups which provide current and voltage measurement values.

The **Impedance protection** function is preconfigured at the factory with the function block (FB) **General** and **one** zone. A maximum of **4** zones can be operated simultaneously in the function. The zones are structured identically.

The protection function is structured in that way that the settings in the FB **General** are valid for all zones.



[dw_strimpedanceprot, 3, en_US]

Figure 6-322 Structure/Embedding of the Function

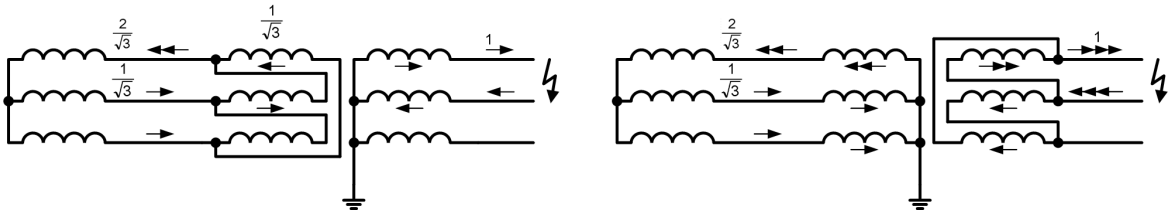
6.16.3 Description

Impedance Measurement via the Transformer

Pay attention to the following features when measuring impedance in or via transformers:

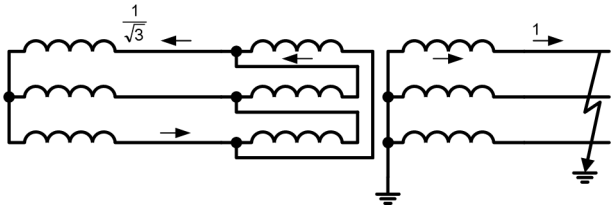
- Impedance is transferred to the side to be measured using the quadrant of the transformer ratio.
- For star-delta transformers, an opposite phase rotation occurs in the positive-sequence and negative-sequence system, depending on the vector group. This changes the fault situation on the other side. A 2-phase short circuit on the star side appears as a 3-phase short circuit with different current distribution on the delta side (see *Figure 6-323*).

  Since star-delta transformers do not permit the zero-sequence system to be transferred, a 1-phase ground fault on the star side appears as a 2-phase short circuit on the delta side (see *Figure 6-324*).
- In the case of auto transformers and transformers grounded on both sides in the star-star connection, measurement through the transformer is possible. Here, distance protection for lines can be used without any problems.



[dw_ratio-2pol-ifault, 2, en_US]

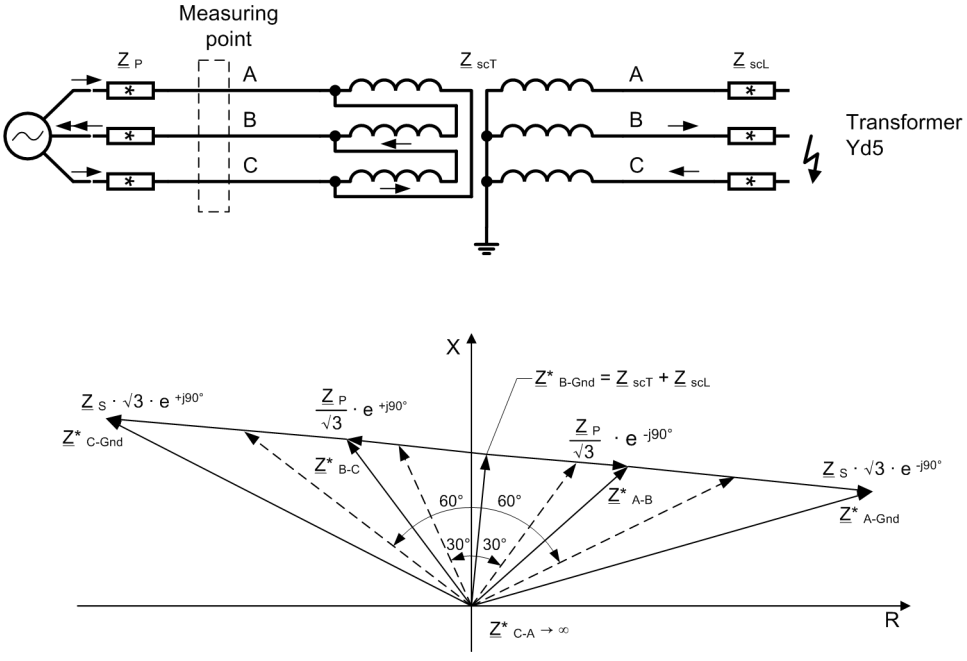
Figure 6-323 Transformation of a 2-Phase Short-Circuit Current



[dw_ratio-1pol-fault, 2, en_US]

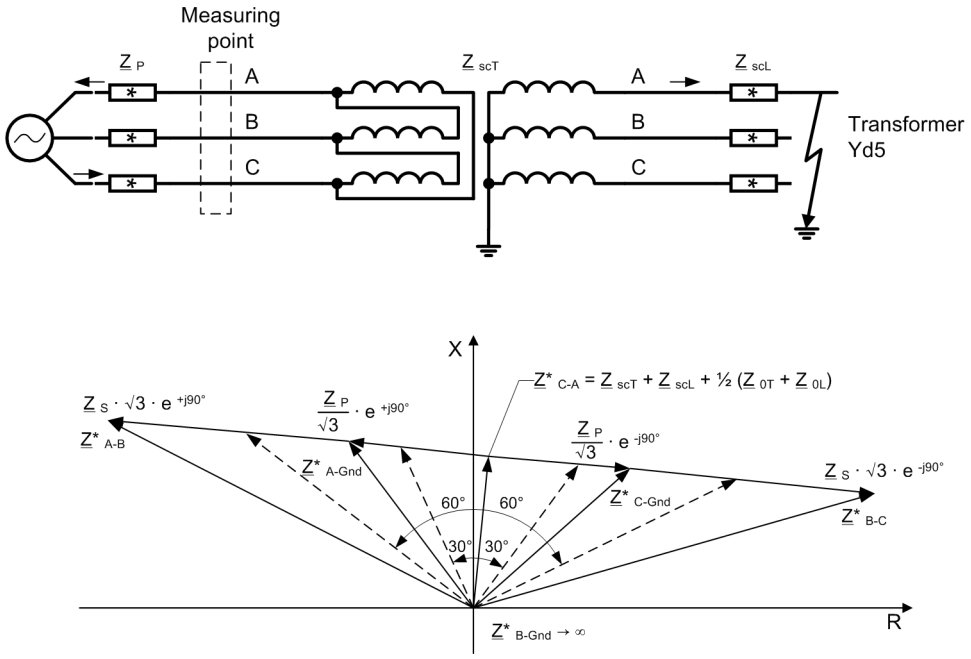
Figure 6-324 Transformation of a 1-Phase Short-Circuit Current

The changed measurand mapping also leads to a different impedance mapping. *Figure 6-325* and *Figure 6-326* show, for example, for a 2-phase or 1-phase short circuit on the star side, the resulting phasors on the delta side. To simplify it, the transformer ratio was assumed to be **1**.



[dw_imp-2pol-short-ciruit, 2, en_US]

Figure 6-325 Impedance Measurement with a 2-Phase Short Circuit



[dw_imp-1pol-short-ciruit, 2, en_US]

Figure 6-326 Impedance Measurement with a 1-Phase Short Circuit

With a 2-phase short circuit, the phase-to-ground impedance of the phase corresponds to the double phase current of the actual fault impedance via the transformer. The impedance is correctly measured. All other impedances are measured as considerably larger. Subtracting the currents results in an infinite impedance measured value for the C-A loop.

A 1-phase ground fault results in the smallest impedance value based on the calculation with phase-to-phase voltages (in the example, C-A). Because the zero-sequence system cannot be transferred via a star-delta transformer, an impedance is measured that is too large by the amount of the zero-sequence impedances (transformer, line). The actual fault location is seen as being farther away.

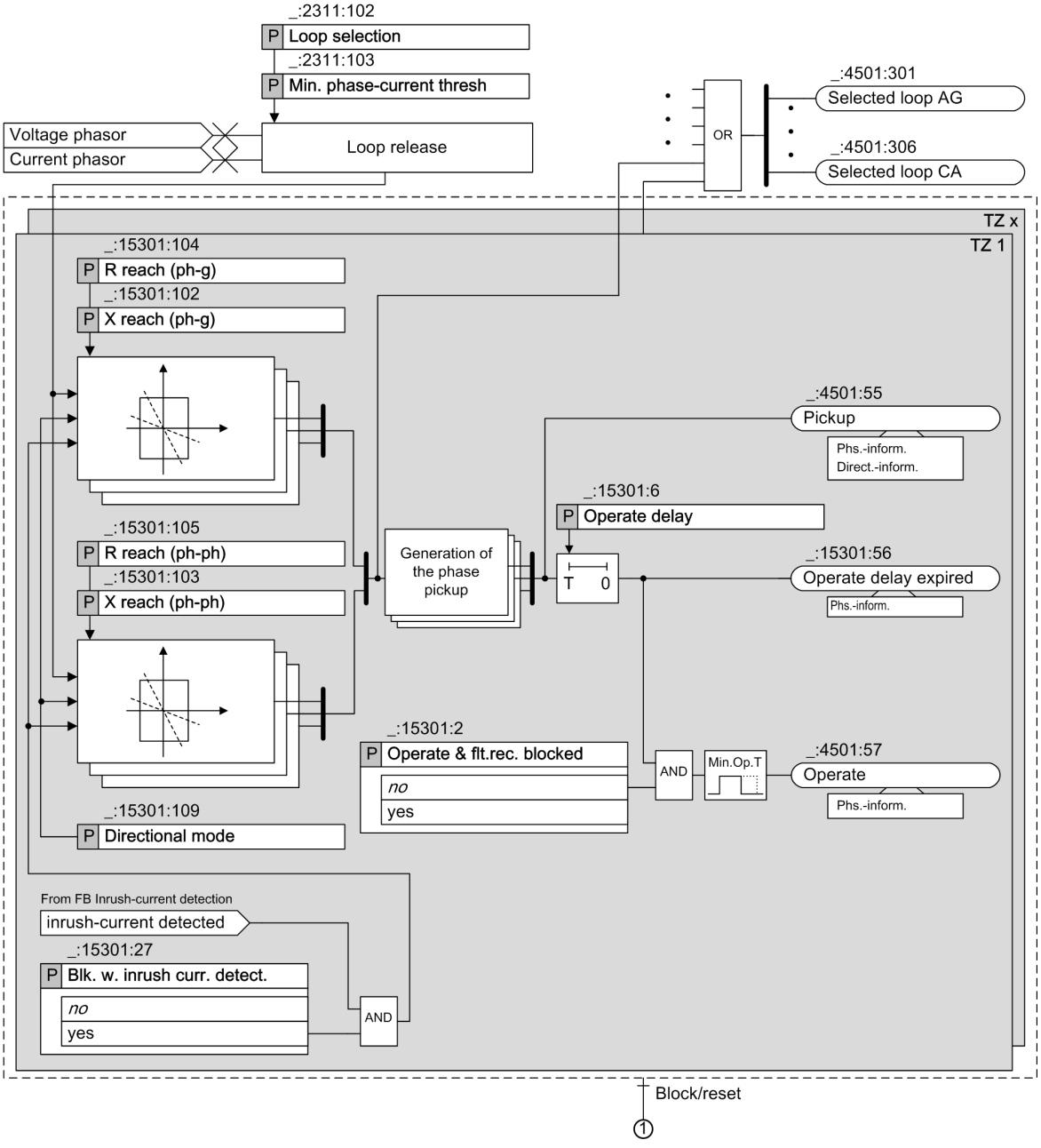
With a 3-phase short circuit, the impedance measurement for all measuring loops is correct.

The following table summarizes the results of the impedance measurement for a star-delta transformer:

Table 6-7 Fault Mapping and Measuring Errors during the Impedance Measurement of a Star-Delta Transformer

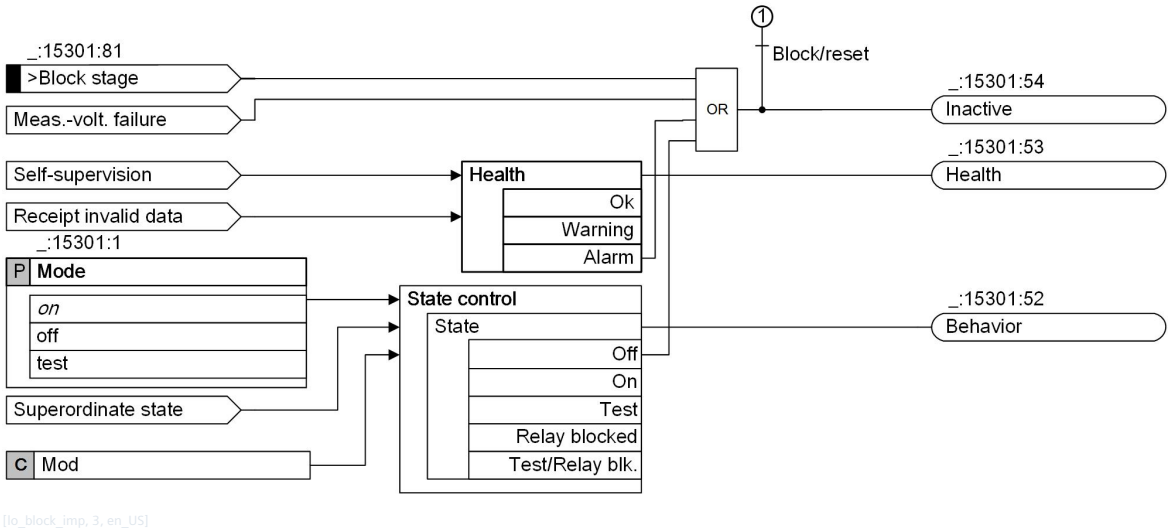
Power-System Incident on the Star Side	Fault Mapping on the Delta Side	Correct Impedance Loop	Measuring Error
3-phase short circuit	3-phase short circuit	Phase-to-ground and phase-to-phase loop	Correct measurement
2-phase short circuit	3-phase short circuit, different fault-current distribution	Phase-to-ground loop with largest fault current	Correct measurement
1-phase ground fault	2-phase short circuit	Phase-to-phase loop, but with measuring error	Impedance measured too large by the amount of the zero-sequence impedance (0.5 Z0)

Logic of the Function



[lo_dis-impedance-protection, 3, en_US]

Figure 6-327 Logic Diagram for Impedance Protection



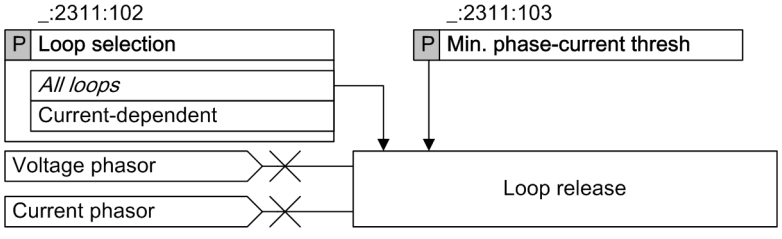
[lo_block_imp, 3, en_US]

Figure 6-328 Logic Diagram for Impedance Protection (Continued)

Loop Selection

The function **Impedance protection** can be used in electrical power systems and plants with different neutral points. With the **`Loop selection`** parameter, you control which parameters influence the loop release.

In power systems with effective neutral point grounding – solidly or low-impedance grounded neutral point – all impedance loops (phase-to-ground and phase-to-phase loops) can work parallel to each other. When all loops are working in parallel, the loop release is controlled by the parameter **`Min. phase-current thresh`** (see following figure).



[lo_loopselect1 impprot, 3, en_US]

Figure 6-329 Effective Parameter for Loop Release for All Loops

In power systems with a non-effective neutral point grounding – isolated, grounded, or high-impedance grounded neutral point – the control for the loop selection is necessary to avoid an overfunction, for example, a ground fault. The loop selection is controlled by the ***`Current-dependent`*** parameter. The following figure shows which parameter controls the loop selection.

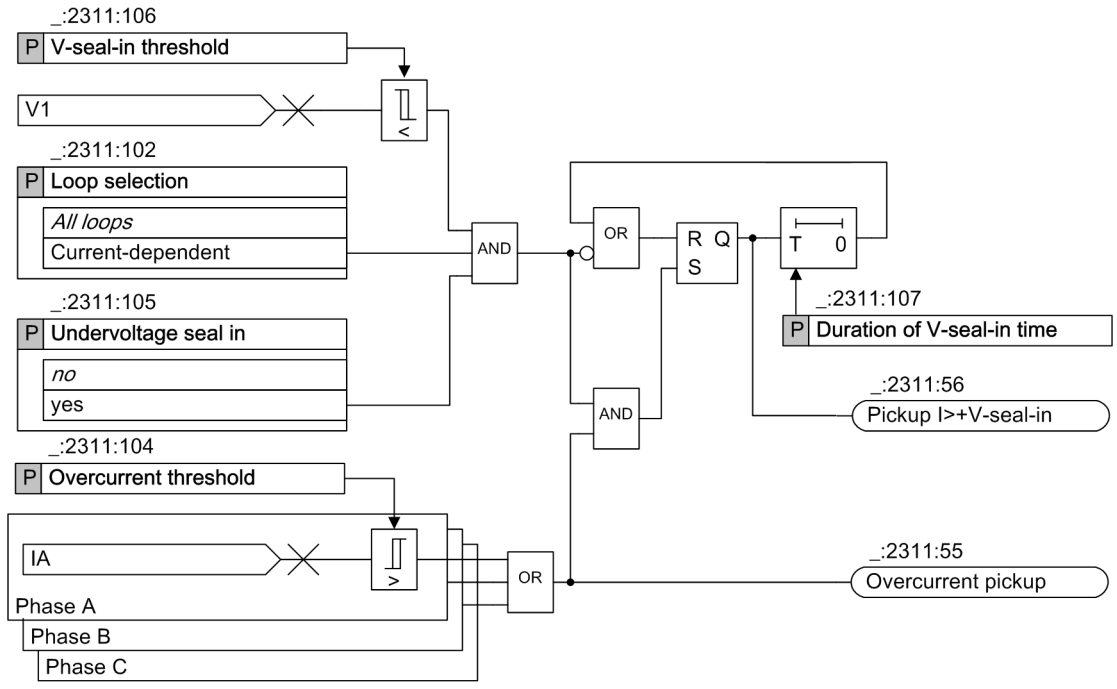


Figure 6-330 Effective Parameter in Current-Dependent Loop Release

In case of a ground fault, the voltage collapsed – ideally to 0 – and the phase-to-ground loop measures either a small impedance or 0 Ω. The phase-selective overcurrent detection releases the loops (parameter **Overcurrent threshold**). The undervoltage seal-in (parameter **Undervoltage seal in**) keeps the overcurrent erect. The undervoltage seal-in is necessary for use in power plants when an exciting transformer is connected to the generator bus. During a near short circuit, the excitation voltage collapses and results in a decreased synchronous generated voltage. Thereby the fault current sinks below the rated current and thereby the current threshold value (parameter **Overcurrent threshold**). The parameter **V-seal-in threshold** monitors the positive-sequence voltage. The undervoltage seal-in drops out when the threshold value **V-seal-in threshold** is topped or the undervoltage seal-in time (parameter **Duration of V-seal-in time**) runs out.

The following rules apply for loop selection:

- In the event of 1-phase pickup, an associated phase-to-ground loop is used.
- In the event of 2-phase pickup, an associated phase-to-phase loop with the applicable phase-to-phase voltage is used for the impedance calculation.
- In the event of a 3-phase pickup, the loop selection is dependent on the ratio of the current amplitudes of the phases to one another.

The following table shows the measuring-loop selection:

Pickup		Measuring Loops	
1-phase	A B C	Phase-to-ground	A-gnd B-gnd C-gnd
2-phase	A, B B, C C, A	Phase-to-phase	A-B B-C C-A

Pickup		Measuring Loops	
3-phase with unequal phase current amplitudes	A, 2· B, C B, 2· C, A C, 2· A, B	When the current in 1 phase is double the size, the phase-to-ground loops are measured.	B-gnd C-gnd A-gnd
	(A, B) ≈ 2 · C (B, C) ≈ 2 · A (C, A) ≈ 2 · B	When the current in 2 phases is double the size, the phase-to-phase loops are measured.	A-B B-C C-A
3-phase with equal amplitudes	A, B, C	When all voltages are almost equal, the phase-to-phase loops are measured. All 3 loops are released.	A-B B-C C-A

Impedance Measurement

From the sampled values of the phase currents and the phase-to-ground voltages, the fundamental phasors are determined per period using an FIR filter (FIR = Finite Impulse Response). The impedances are calculated from the fundamental phasors. By using the frequency-tracking sampled values, the impedance is measured using another frequency range. This is advantageous for island networks or block-unit power plants, for example, for start-up processes.

There is an impedance measuring element available for each of the 6 possible phase loops A-gnd, B-gnd, C-gnd, A-B, B-C, C-A. If another fault occurs during analysis, the impedances are calculated using the current cyclical measurands. The analysis thus always works with the measurands of the current fault condition.

The impedance for phase-to-phase loops is calculated as follows:

$$\underline{Z}_{ph-ph} = \frac{\underline{V}_{phx\ phy}}{\underline{I}_{phx} - \underline{I}_{phy}}$$

[fo_loop_ZLL, 2, en_US]

The impedance of phase-to-ground loops is calculated as follows:

$$\underline{Z}_{Ph-gnd} = \frac{\underline{V}_{Phx}}{\underline{I}_{Phx}}$$

[fo_loop_ZLE, 2, en_US]

Mode of Operation

If the phase currents exceed the set **`Min. phase-current thresh`**. All released impedance loops are calculated.

To release phase-to-ground loops, it is sufficient if the corresponding phase current exceeds the **`Min. phase-current thresh`**. For phase-to-phase loops, both phase currents and the loop current must exceed the **`Min. phase-current thresh`**.

There is no special ground-fault detection, such as distance protection for lines.

If the released impedance loop(s) lie in one zone, the **Impedance protection** function generates a pickup indication with loop information. At the same time, a pickup indication in the picked up zone occurs with specification of the relevant phase and direction. The direction is subsequently determined for all picked up impedance loops and the associated time delay started. The output logic processes the pickup and trip signals of the zones and forms the pickup and trip signals of the function.

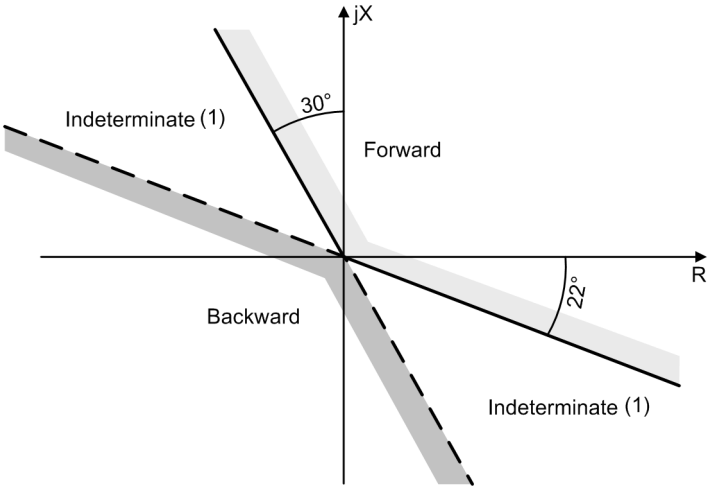
Direction Determination

The direction is determined either using a stored prefault voltage or negative-sequence system variables. If the measured negative-sequence voltage or the negative-sequence current exceed 10 % of the rated values of the device, the variables of the negative-sequence system are used exclusively. For the direction decision, the angle between the negative-sequence current I_2 and the negative-sequence voltage V_2 is evaluated.

Figure 6-331 shows the defined directional areas on impedance level.

For 3-phase symmetrical short circuits, there is no negative-sequence system. In this case, the memory voltage is used. If the memory voltage is not available either, for example when switching onto a fault, all zones – regardless of their parameterized direction – pick up and generate an operate indication after the time delay has expired.

Optionally, you can link the **Impedance protection** function with the **Instantaneous tripping at switch onto fault** function (see chapter *6.16.4 Application and Setting Notes*). This enables the selected **Impedance-protection** zones to trip without delay.



[dw_ritgkl, 2, en_US]

Figure 6-331 Direction-Characteristic Curve in the R-X Diagram

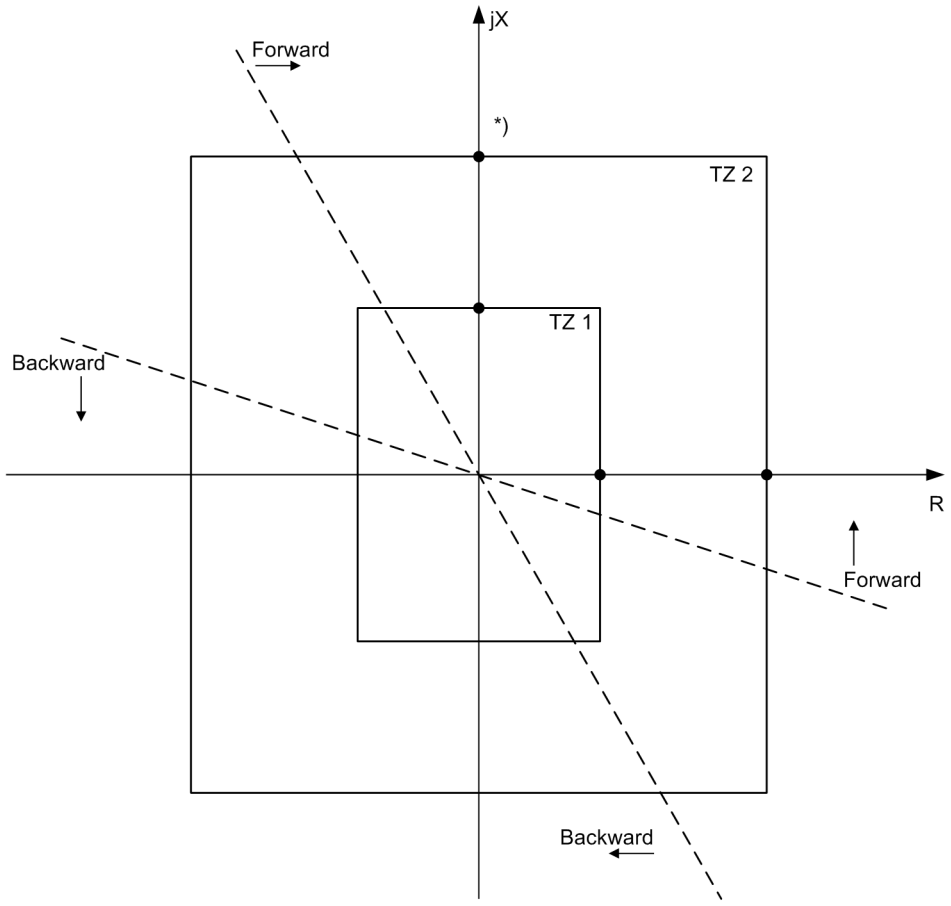
Inrush-Current Detection

If the device is equipped with the **Inrush-current detection** function, you can stabilize the zones against tripping due to transformer inrush currents.

Impedance Polygon

The quadrilateral operate curve (impedance polygon) in the zone is a rectangle in the R-X plane. The polygon is defined by the parameters **`X reach (ph-g)`**, **`X reach (ph-ph)`**, **`R reach (ph-g)`**, and **`R reach (ph-ph)`** and the **`Directional mode`**. This means that, in special situations, a different setting is possible for phase-to-phase and phase-to-ground loops.

To stabilize the quadrilateral limits, the characteristics have a hysteresis of 5 %. If the fault impedance lies within a polygon, the limits are increased by 5 % in all directions. The following figure shows an example with 2 non-directional zones:



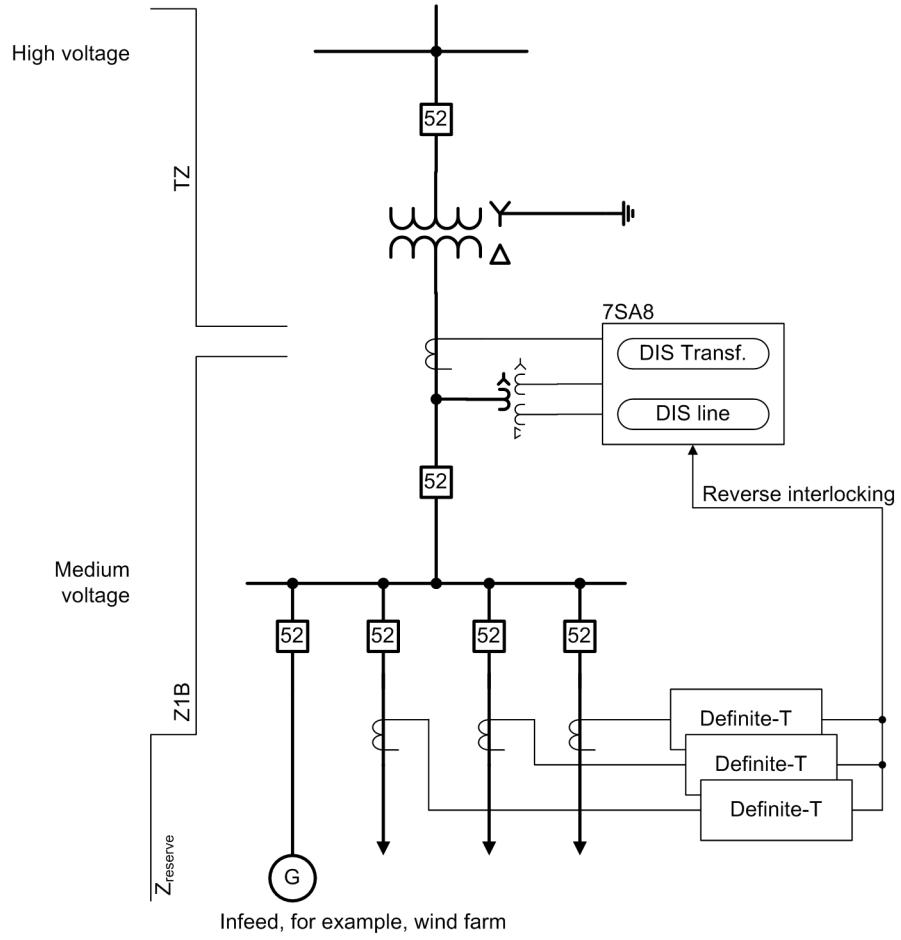
[dw_klpoly-impedanceprot, 2, en_US]

Figure 6-332 Operate Curve with Quadrilateral Characteristic

6.16.4 Application and Setting Notes

Sample Configuration

The following figure is an example of how the **Impedance protection** function is used at a feeder point in a medium-voltage power system.



[dw_example-protection, 1, en_US]

Figure 6-333 Example of a Network Protection Application

The medium-voltage power system is fed on the high-voltage side with a YNd5 transformer. In addition, there is an infeed that enables energy recovery to faults occurring on the high-voltage side.

The protection device installed on the delta side of the transformer functions as **distance protection**, which is the backup protection for the medium-voltage power system.

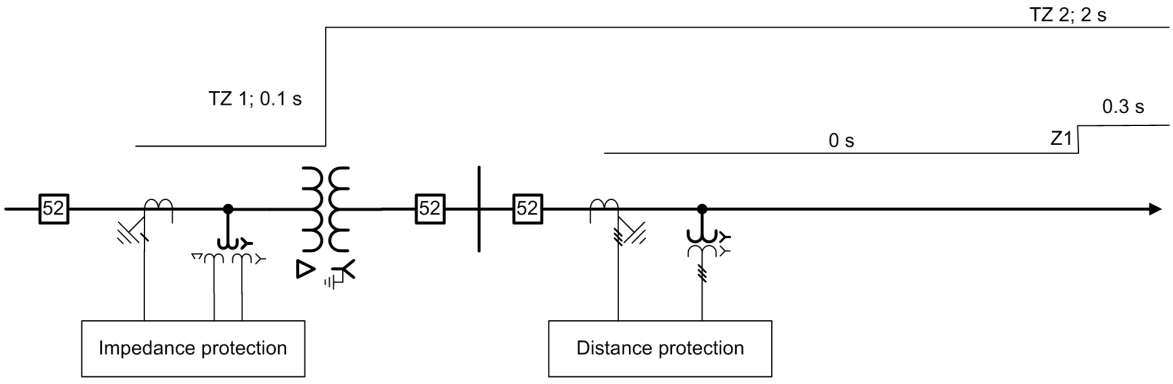
In addition to distance protection, the protection device on the delta side functions as **impedance protection**, which looks in the transformer direction. The power system on the high-voltage side is a meshed system and also contains distance protection devices.

In the following, you can find recommendations for the protection setting values and a view of the setting problems. *Figure 6-334* shows a possible setting approach.

Zone **TZ 1** should be coordinated with the protection system and delayed by approx. 100 ms. The delay makes preferred tripping possible due to the differential protection and a dropout of the zone.

Zone **TZ 2** is intended as a directional reserve stage, whose time must, without fail, be coordinated with the protection system. At the same time, this stage can be used if, when switching the transformer on, it switches onto a fault.

In exchange, the function **Instantaneous tripping at switch onto fault** must be present and set accordingly (see function description in chapter *6.56 Instantaneous Tripping at Switch onto Fault*).



[dw_config-staffel, 1, en_US]

Figure 6-334 System Configuration and Possible Time Grading

For this example, the following data apply:

Table 6-8 Data for Sample Calculations

Transformer	Vector group		YNd5
	Rated voltages	Upper-voltage side	$V_{rated, UV}$ = 230 kV
		Undervoltage side	$V_{rated, LV}$ = 20 kV
	Rated power		S_{rated} = 50 MVA
	Short-circuit voltage		V_{sc} = 12 %
Overhead line	Reactance per unit length		X´ = 0.3 Ω/km
	Length up to $Z_{1, Dis}$		L = 50 km
Transducer	Voltage transformer		20 kV/√3 /100 V/√3 / 100V/3
	Current transformer, Undervoltage side		1500 A/1 A

The primary side reactances are calculated as follows:

Transformer:

$$X_{Tr} = \frac{V_{sc} \cdot V_{rated}^2}{100\ \% \cdot S_{rated}} = \frac{12\ \% \cdot 20^2 kV^2}{100\ \% \cdot 50\ MVA} = 0.96\ \Omega$$

Line (transformed to 20 kV):

$$X_{Ph} = l \cdot X' \cdot \left(\frac{V_{rated\ ,\ UV}}{V_{rated\ ,\ LV}}\right)^2 = 50\ km \cdot 0.3 \frac{\Omega}{km} \cdot \left(\frac{20\ kV}{230\ kV}\right)^2 = 1.5\ \Omega \cdot 0.0756 = 0.011\ \Omega$$

The sample calculation clearly shows that the line reactance can be disregarded compared to transformer reactance due to the quadratic transformation.

To avoid overfunction, select the following setting values for the 1st zone (**TZ 1)**

$X_1 = 0.9 \cdot X_{Tr} = 0.9 \cdot 0.96\ \Omega = 0.864\ \Omega$

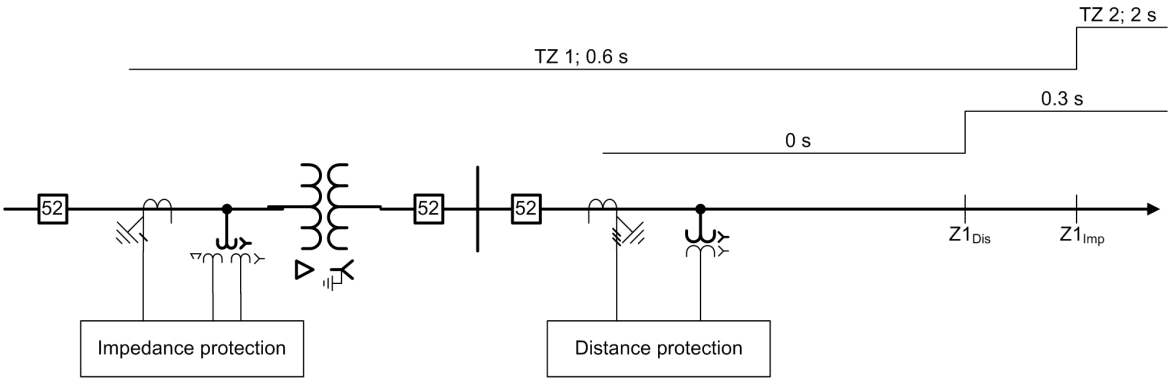
For the 2nd zone, select the double transformer impedance and set the time delay correspondingly high.

$X_2 = 2 \cdot X_{Tr} = 2 \cdot 0.96\ \Omega = 1.92\ \Omega$.

With the selected setting, Zone **TZ 1** does not protect the transformer completely, especially if you take into account the incorrect measurement for a 1-phase short circuit.

If you want to achieve a reliable tripping for all fault situations (see *Table 6-7*), the setting value must extend far beyond the transformer. One possible strategy for the time grading is a setting value of approx. 1.5 X_{Tr}.

You must guarantee the selectivity using the **Time** criterion. The following figure shows the time-grading chart:



[dw_grading-x1-xtr, 3, en_US]

Figure 6-335 System Configuration and Possible Time Grading

The zone range in the R direction must take into account the fault resistance on the fault location. The fault resistance is added to the impedance of the fault loop as an additional effective resistance. This fault resistance is, for example, the arc resistance or the dissipation resistance of ground phases. For the zone range in the R direction, you do not have to take the fault resistance on the upper-voltage side and the line resistance into account. These are also divided by the transformer-ratio quadrant and can be mostly disregarded. However, fault resistances on the upper-voltage side during high-current feed on the upper-voltage side also impact the reactance and resistance measurement on the undervoltage side. This impact is unavoidable and can result in a short circuit with fault resistance on the upper-voltage side not being detected by the undervoltage side until the high-current feed on the upper-voltage side is cleared. Do not set the reserve resistance any larger than necessary. The setting can be adjusted to the maximum load in the direction of the line section to be protected, in other words, in the transformer direction. The setting value for the R range must be lower than the resistance under maximum load conditions ($R_{L\,max}$). For a sufficient distance to the load range, Siemens recommends a value of about 20 % to 50 % $R_{L\,max}$. This means an incorrect measurement is avoided by the apparent impedances (see*Figure 6-325* and *Figure 6-326*).

Parameter: Loop selection

- Default setting **(_:2311:102) Loop selection** = ***All loops***

With the parameter **Loop selection**, you control the measuring-loop selection.

Parameter Value	Description
All loops	The function evaluates all 6 impedance loops. Siemens recommends using this setting value for electrical power systems or plants with an effective neutral-point grounding. For effective neutral-point grounding the neutral point is either fixed or low-impedance grounded.
Current-dependent	Use this setting value for electrical power systems or plants with a non-effective neutral-point grounding. For non-effective neutral-point grounding the neutral point is isolated, grounded or high-impedance grounded. Siemens recommends this setting value for generator-protection applications.

Parameter: Min. phase-current thresh

- Default setting **(_:2311:103) Min. phase-current thresh** = ***0.100 A***

With the parameter **Min. phase-current thresh**, you set the lower pickup threshold for the current.

Set the **Min. phase-current thresh** parameter under the load current. A practical setting value is approximately 10 % to 20 % of the rated current of the protected object.

NOTE

The parameter **(_:2311:102) Loop selection** = ***All loops*** is visible only if you set the parameter **Min. phase-current thresh**.

Parameter: Overcurrent threshold

- Default setting **(_:2311:104) Overcurrent threshold** = ***1.300 A***

With the parameter **Overcurrent threshold**, you set the lower pickup threshold for the overcurrent.
Set the **Overcurrent threshold** parameter above the maximum possible load current. A practical setting value is approximately 1.2 to 1.4 times the generator rated current.

EXAMPLE:

The rated generator current is calculated as:

$$I_{\text{rated, Gen prim}} = \frac{S_{\text{rated}}}{V_{\text{rated}}} = \frac{100\ \text{MVA}}{15.75\ \text{kV} \cdot \sqrt{3}} = 3666\ \text{A}$$

[fo_1 irated gen, 2, en_US]

The primary setting value is calculated as follows:

$$I_{\text{Threshold value ,prim}} = 1.4 \cdot I_{\text{rated ,Gen .prim}} = 1.4 \cdot 3666\ \text{A} = 5132.4\ \text{A}$$

[fo_2 irated gen, 3, en_US]

Taking into account the transformer ratios, the secondary setting value is calculated as follows:

$$I_{\text{Threshold value , sec}} = \frac{I_{\text{Threshold value , prim}}}{\text{Ratio}_I} = \frac{5132.4\ \text{A}}{4000\ \text{A}/1\ \text{A}} = 1.283\ \text{A}$$

[fo_3 irated gen, 3, en_US]

Parameter: Undervoltage seal in

- Default setting **(_:2311:105) Undervoltage seal in** = ***no***

With the parameter **Undervoltage seal in**, you specify whether you would like to maintain pickup from undervoltage.

Parameter Value	Description
no	If the fault current is above the setting value of the parameter **Overcurrent threshold** during the entire error Fault duration, then keep the default setting.
yes	Siemens recommends using this setting value for generator-protection applications, if during static excitation the exciting transformer is connected to the generator bus. In this situation, the excitation voltage dips in case of a near short circuit. Thereby reducing the synchronous generated voltage, the fault current can sink after an extended period of time after the fault occurred below the generator rated current. If a fault occurs the fault current is noticeably greater than the rated current. The undervoltage seal-in maintains the pickup. When selecting this setting value, the following parameters are visible: • **(_:2311:106) V-seal-in threshold** • **(_:2311:107) Duration of V-seal-in time**

Parameter: V-seal-in threshold

- Default setting **(_:2311:106) V-seal-in threshold** = ***46.200 V***

With the parameter **V-seal-in threshold**, you set the lower pickup threshold for the undervoltage seal-in.

80 % of the generator rated voltage is a typical setting value. As the voltage transformers are precisely adapted to the object rated voltage, you can set 80 % of the secondary rated voltage. The parameter **V-seal-in threshold** evaluates the positive-sequence voltage. With a secondary rated voltage $V_{rated, sec}$ = 100 V, the setting value is determined as follows:

$$0.8 \cdot \frac{V_{rated\ ,sec}}{\sqrt{3}} = 0.8 \cdot \frac{100\ V}{\sqrt{3}} = 46.2\ V$$

[fo_undervolt pickup, 2, en_US]

Parameter: Duration of V-seal-in time

- Default setting **(_:2311:107) Duration of V-seal-in time** = ***4.00 s***

With the **Duration of V-seal-in time** parameter, you set how long the pickup must persist. If the **Duration of V-seal-in time** is exceeded, the pickup drops off. If the fault is cleared before the end of the **Duration of V-seal-in time**, the **Undervoltage seal in** drops off. If the voltage exceeds setting **V-seal-in threshold** again before the end of the **Duration of V-seal-in time**, the **Undervoltage seal in** also drops.

Set the **Duration of V-seal-in time** above the maximum **Operate delay**. The default setting 4 s is a practicable value.

Parameter: Blk. w. inrush curr. detect.

- Default setting **(_:15301:27) Blk. w. inrush curr. detect.** = ***no***

The parameter is only visible when the **Inrush-current detection** function is present in the application. Use the parameter to define whether the zone is blocked or not during transformer inrush-current detection.

Parameter: X reach (ph-g)

- Default setting **(_:15301:102) X reach (ph-g)** = ***2.500 Ω***

With the parameter **X reach (ph-g)**, you set the polygon limit in the X direction for phase-to-ground impedance loops. Determine the setting value for the specific application.

If the impedance protection has to be measured well beyond the transformer into the upstream power system, Siemens recommends, as a setting value for the **X reach (ph-g)**, approx. 1.5 times the transformer reactance. Adjust the associated delay time high enough so that short circuits downstream from the transformer can be initially cleared selectively.

EXAMPLE:

For the calculation, the data from *Table 6-8* apply.

X range = 150 %

The primary setting value is calculated as follows:

X_{prim} = 150 %/100 % · Z_{KT} = 1.5 · 0.96 Ω = 1.44 Ω (primary)

Taking into account the transformer ratios, the secondary setting value is calculated as follows:

$$X_{sec} = \frac{I_{prim}/I_{sec}}{V_{prim}/V_{sec}} \cdot X_{prim} = \frac{1500\ A/1\ A}{20\ kV/100\ V} \cdot 1.44\ \Omega = 7.5 \cdot 1.44\ \Omega = 10.8\ \Omega$$

[fo_Xrange_sec, 2, en_US]

Parameter: X reach (ph-ph)

- Default setting **(_:15301:103) X reach (ph-ph)** = ***2.500 Ω***

With the parameter **X reach (ph-ph)**, you set the polygon limit in the X direction for phase-to-phase impedance loops. Determine the setting value for the specific application.

If the impedance protection has to be measured well beyond the transformer into the upstream power system, Siemens recommends, as a setting value for the **X reach (ph-ph)**, approx. 1.5 times the transformer reactance. Adjust the associated delay time high enough so that short circuits downstream from the transformer can be initially cleared selectively.

Because the phase-to-phase loop applies both to a 3-phase short circuit as well as a 1-phase short circuit, the 3-phase short circuit is taken as the basis.

You can estimate the range for 1-phase short circuits by taking into account the zero-sequence impedance (reactance). The following applies:

$Z_{SC} = (Z_{KT} + 0.5 \cdot Z_{0T})$

For star-delta transformers, the zero-sequence impedance amounts to approx. $0.8 \cdot Z_{KT}$. This results in the following impedance measured value:

$Z_{SC} = (Z_{KT} + 0.5 \cdot Z_{0T}) = (Z_{KT} + 0.5 \cdot 0.8 \cdot Z_{KT}) = 1.4\ Z_{KT}$

With a time grading of $1.5\ Z_{KT}$, measure the entire transformer winding for a 1-phase ground fault.

In the example, the same setting values apply for the phase-to-phase loops as for the phase-to-ground loops.

Parameter: R reach (ph-g)

- Default setting **(_:15301:104) R reach (ph-g)** = ***2.500 Ω***

With the parameter **R reach (ph-g)**, you set the polygon limit in the R direction for phase-to-ground loops. For phase-to-ground faults, the fault resistance can be greater than that of phase-to-phase faults.

EXAMPLE:

For the calculation, the data from *Table 6-8* apply.

The rated transformer current is assumed as the rated load current. The current is 1443 A on the 20 kV side.

The smallest impedance measured under maximum load conditions (Z_{max}) is calculated as follows assuming 10 % undervoltage and 10 % overcurrent:

$$Z_{max} = \frac{0.9 \cdot V_{rated}}{1.1 \cdot \sqrt{3} \cdot I_{rated\ load}} = \frac{0.9 \cdot 20\ kV}{1.1 \cdot \sqrt{3} \cdot 1443\ A} = 6.55\ \Omega$$

[fo_Zmax_trafo_RLE_2_en_US]

For the R reach, $20\ \% \cdot Z_{max}$ is specified. This means the primary setting value of the **R reach (ph-g)** parameter is calculated as follows:

R reach (ph-g) = $0.2 \cdot 6.55\ \Omega = 1.31\ \Omega$

This value corresponds to approx. the X value so that you can select, as a practical setting, R range = X range.

Taking into account the transformer ratios, the secondary setting value is calculated as follows:

$$R_{sec} = \frac{I_{prim}/I_{sec}}{V_{prim}/V_{sec}} \cdot R_{reach\ (ph-g)} = \frac{1500\ A/1\ A}{20\ kV/100\ V} \cdot 1.31\ \Omega = 7.5 \cdot 1.31\ \Omega = 9.82\ \Omega$$

[fo_r_range_sek_2_en_US]

Parameter: R reach (ph-ph)

- Default setting **(_:15301:105) R reach (ph-ph)** = ***1.250 Ω***

With the parameter **R reach (ph-ph)**, you set the polygon limits in the R direction for phase-to-phase loops.

EXAMPLE:

For the calculation, the data from *Table 6-8* apply.

Set the range for phase-to-phase loops just like for phase-to-ground loops. This results in the following setting values:

R reach (ph-ph) = **R reach (ph-g)** = 1.45 Ω (primary)

R reach (ph-ph) = **R reach (ph-g)** = 10.9 Ω (secondary)

Parameter: Directional mode

- Default setting **(_:15301:109) Directional mode** = ***reverse***

With the parameter **Directional mode**, you can specify whether the zone operates ***forward***, ***reverse***, or ***non-directional***. Set the parameter **Directional mode** for the specific application.

If the **Impedance protection** function is present in a power-system protection device, the directional mode is in the direction of the line ***forward***. If you want to use the impedance zone as backup protection for a transformer, you have to set the parameter **Directional mode** = ***reverse***.

Parameter: Operate delay

- Default setting **(_:15301:6) Operate delay** = ***0.30 s***

With the parameter **Operate delay**, your set the grading time of the zone. Set the parameter **Operate delay** for the specific application.

Select the associated time stage for Zone TZ so that it staggers the power-system protection devices of the following lines. Therefore, check the grading times in the superposed power system as well as the range in the power system if 1.5 Z_{KT} is set.

6.16.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:1	General:Mode		• off • on • test	on
_:2311:102	General:Loop selection		• All loops • Current-dependent	All loops
_:2311:103	General:Min. phase-current thresh	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2311:104	General:Overcurrent threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.300 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.300 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.300 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.500 A
_:2311:105	General:Undervoltage seal in		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:106	General:V-seal-in threshold		0.300 V to 340.000 V	80.019 V
_:2311:107	General:Duration of V-seal-in time		0.00 s to 60.00 s	4.00 s
TZ 1				
_:15301:1	TZ 1:Mode		• off • on • test	on
_:15301:2	TZ 1:Operate & flt.rec. blocked		• no • yes	no
_:15301:27	TZ 1:Blk. w. inrush curr. detect.		• no • yes	no
_:15301:102	TZ 1:X reach (ph-g)	1 A	0.100 Ω to 600.000 Ω	2.500 Ω
		5 A	0.020 Ω to 120.000 Ω	0.500 Ω
_:15301:103	TZ 1:X reach (ph-ph)	1 A	0.100 Ω to 600.000 Ω	2.500 Ω
		5 A	0.020 Ω to 120.000 Ω	0.500 Ω
_:15301:104	TZ 1:R reach (ph-g)	1 A	0.100 Ω to 600.000 Ω	2.500 Ω
		5 A	0.020 Ω to 120.000 Ω	0.500 Ω
_:15301:105	TZ 1:R reach (ph-ph)	1 A	0.100 Ω to 600.000 Ω	1.250 Ω
		5 A	0.020 Ω to 120.000 Ω	0.250 Ω
_:15301:109	TZ 1:Directional mode		• non-directional • forward • reverse	reverse
_:15301:6	TZ 1:Operate delay		0.00 s to 60.00 s; ∞	0.30 s

6.16.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:82	General:>Block function	SPS	I
_:2311:51	General:Mode (controllable)	ENC	C
_:2311:54	General:Inactive	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
_:2311:55	General:Overcurrent pickup	ACT	O
_:2311:56	General:Pickup I>+V-seal-in	ACT	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:301	Group indicat.:Selected loop AG	ACD	O
_:4501:302	Group indicat.:Selected loop BG	ACD	O
_:4501:303	Group indicat.:Selected loop CG	ACD	O
_:4501:304	Group indicat.:Selected loop AB	ACD	O
_:4501:305	Group indicat.:Selected loop BC	ACD	O
_:4501:306	Group indicat.:Selected loop CA	ACD	O

No.	Information	Data Class (Type)	Type
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
TZ 1			
_:15301:81	TZ 1:>Block stage	SPS	I
_:15301:51	TZ 1:Mode (controllable)	ENC	C
_:15301:54	TZ 1:Inactive	SPS	O
_:15301:52	TZ 1:Behavior	ENS	O
_:15301:53	TZ 1:Health	ENS	O
_:15301:55	TZ 1:Pickup	ACD	O
_:15301:56	TZ 1:Operate delay expired	ACT	O
_:15301:57	TZ 1:Operate	ACT	O

6.17 Power-Swing Blocking

6.17.1 Overview of Functions

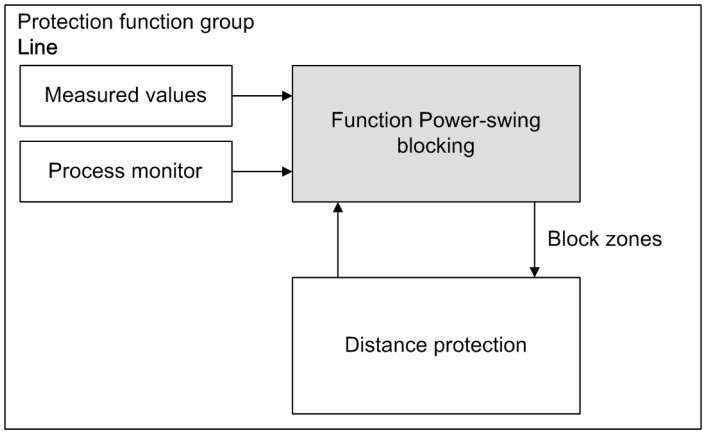
Power-swing blocking

- Detects power swings
- Evaluates the impedances per phase accordingly
- Checks the impedance trajectory on a continual basis
- Reports the power-swing detection per phase
- Blocks the selected zones of the distance protection in case of power swings
- Detects 1-phase, 2-phase, and 3-phase short circuits during a power swing and then cancels the blocking for the specific phase
- Works during a 1-pole dead time
- Activates only when the distance-protection function is active
- Does not generate tripping of the out-of-step condition; a separate out-of-step protection function is available for this purpose

6.17.2 Structure of the Function

The Power-swing blocking function is a supplementary function to the distance protection. It only works if the distance-protection function is activated. If a power swing is detected, power-swing blocking blocks the pickup and tripping through the distance protection. Each distance-protection zone can be blocked separately.

The Power-swing blocking function is included in a function group with at least 3 voltage inputs and current inputs. The process monitor delivers status information to the function regarding the protected object (open poles in particular).



[dwpsdstr-010612-01.tif, 1, en_US]

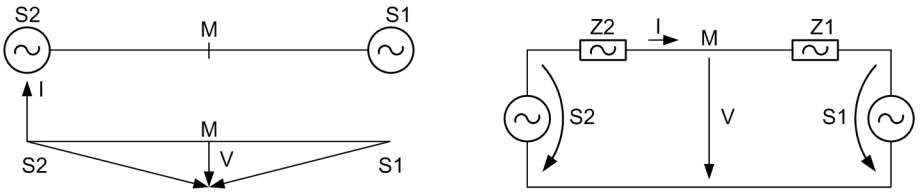
Figure 6-336 Power-Swing Blocking Works Together with the Distance-Protection Function

6.17.3 Function Description

Power-Swing Event

After dynamic events such as load jumps, short circuits, automatic reclosing functions, or switching operations, the generators exposed to the oscillations may have to respond to the new power balance of the system. In case of power swings, the distance-protection function is fed with high compensating currents and – especially at the electrical center – low voltages (*Figure 6-337*). Low voltages combined with high currents

represent apparently small impedances that can lead to tripping by the distance protection. Power-swing blocking prevents tripping by the distance protection in case of power swings.



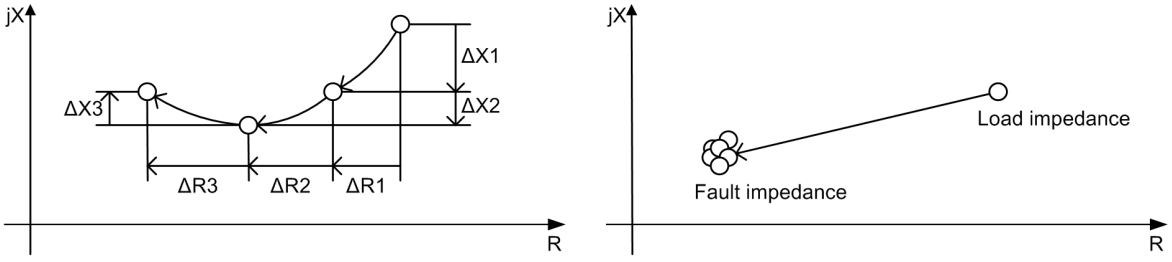
[dwpendel-160211-01.tif, 1, en_US]

Figure 6-337 Power Swings

Power swings are 3-phase symmetrical events. As a rule, a certain symmetry of the measurands can be assumed. Power swings may also occur during unsymmetrical events, such as short circuits or during a 1-pole dead time. For this reason, power-swing detection is structured to use 3 measuring systems. One measuring system is available for each phase, which warrants phase-selective power-swing detection. If short circuits occur, the power swing detected in the respective phase will be discarded, which enables the distance-protection function to initiate selective tripping.

Functionality

In order to detect the power swing, the rate of change will be adjusted to the impedance phasor.



[dwzvekto-220311-01.tif, 1, en_US]

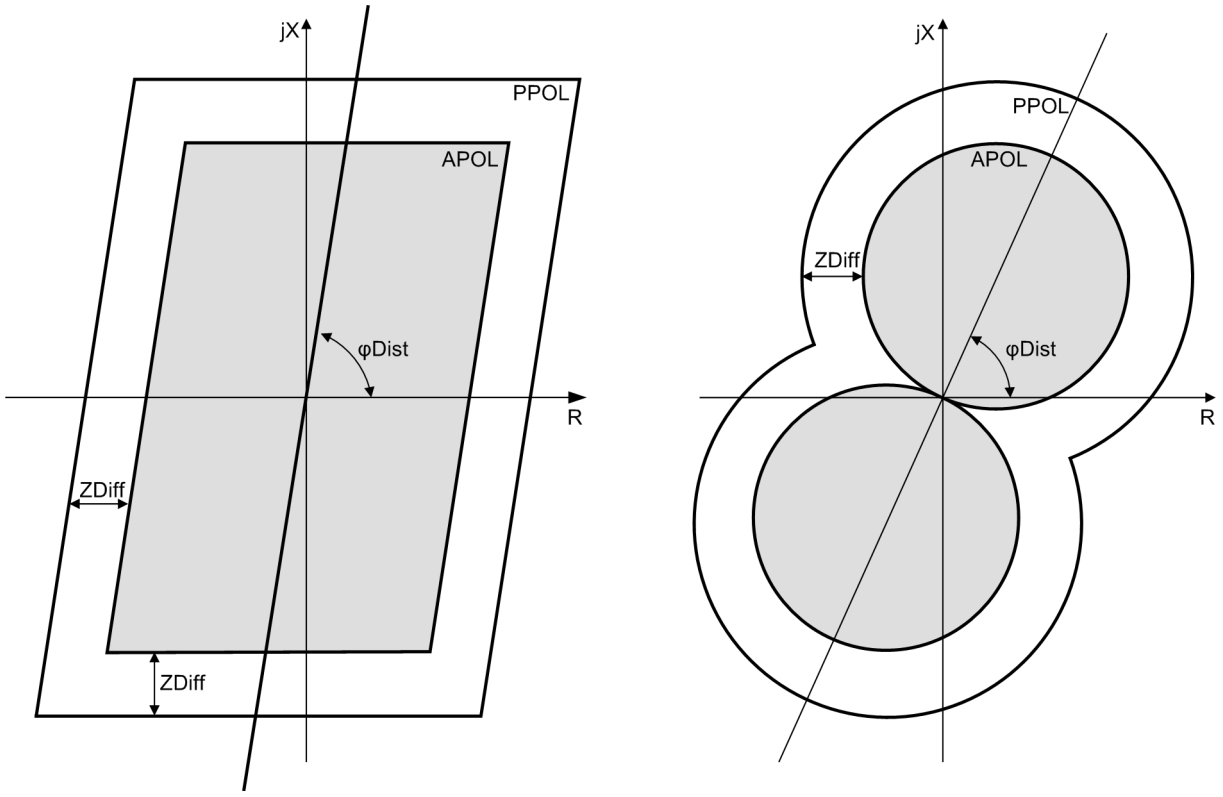
Figure 6-338 Impedance Vectors During a Power Swing and During a Short Circuit

In order to warrant all functions of the power-swing detection are stable and secure, without the risk of overfunction during a short circuit, the following measurement criteria are used:

- **Trajectory monotony:**
  During a power swing, the measured impedance indicates a directional path of movement. This path occurs precisely if within the measurement window one of the components ΔR and ΔX at the most indicates a change of directions. As a rule, if a short circuit occurs, it causes a directional change in ΔR as well as in ΔX within the measured value window.
- **Trajectory continuity:**
  The spacing of 2 consecutive impedance values will clearly indicate a change of ΔR or ΔX during a power swing. If a short circuit occurs, the impedance vector skips to the short-circuit impedance and remains motionless.
- **Trajectory uniformity**:
  During a power swing the ratio between 2 consecutive changes of ΔR or ΔX do not overshoot a threshold. As a rule, if a short circuit occurs, it will cause an erratic movement since the impedance phasor abruptly skips from load impedance to short-circuit impedance.

The indication of a power swing is triggered when the impedance vector enters the PPOL power swing measuring range (see the following figure) and the criteria for power-swing detection are met. With the quadrilateral characteristic, the APOL pickup range is composed of the largest quantitative values set for R and X of all active zones. The power swing measuring range has a minimum distance $Z_{Diff}$of 5 Ω (at I_N = 1 A) or 1 Ω (at I_N = 5 A) in all directions from the pickup range. The same applies to the MHO characteristic. The power

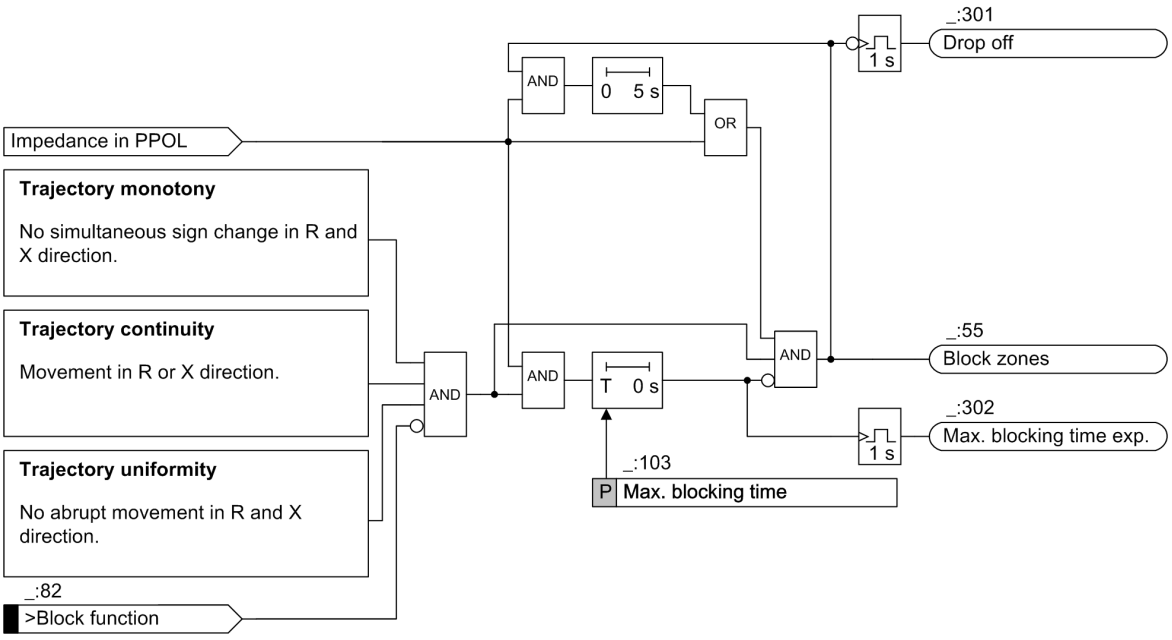
swing measuring range also has a distance of 5 Ω (at II_N = 1 A) or 1 Ω (at II_N = 5 A) from the largest pickup circuit. The power swing measuring range has no load trapezoid cut-out.



[arbeitsbereich-21062010, 1, en_US]

Figure 6-339 Operating Range for the Power-Swing Detection for Polygonal and MHO Characteristic

Figure 6-340 shows a simplified logic diagram of the power-swing detection function. The measurement is executed per phase. A power swing signal (*(_:55) Block zones*) will be generated if the measured impedance is inside the power swing measuring range (PPOL). If a power-swing detection signal is initiated, it remains active until a short circuit occurs or the power swing has decayed. The power-swing detection can be blocked via the binary input *>Block function*.



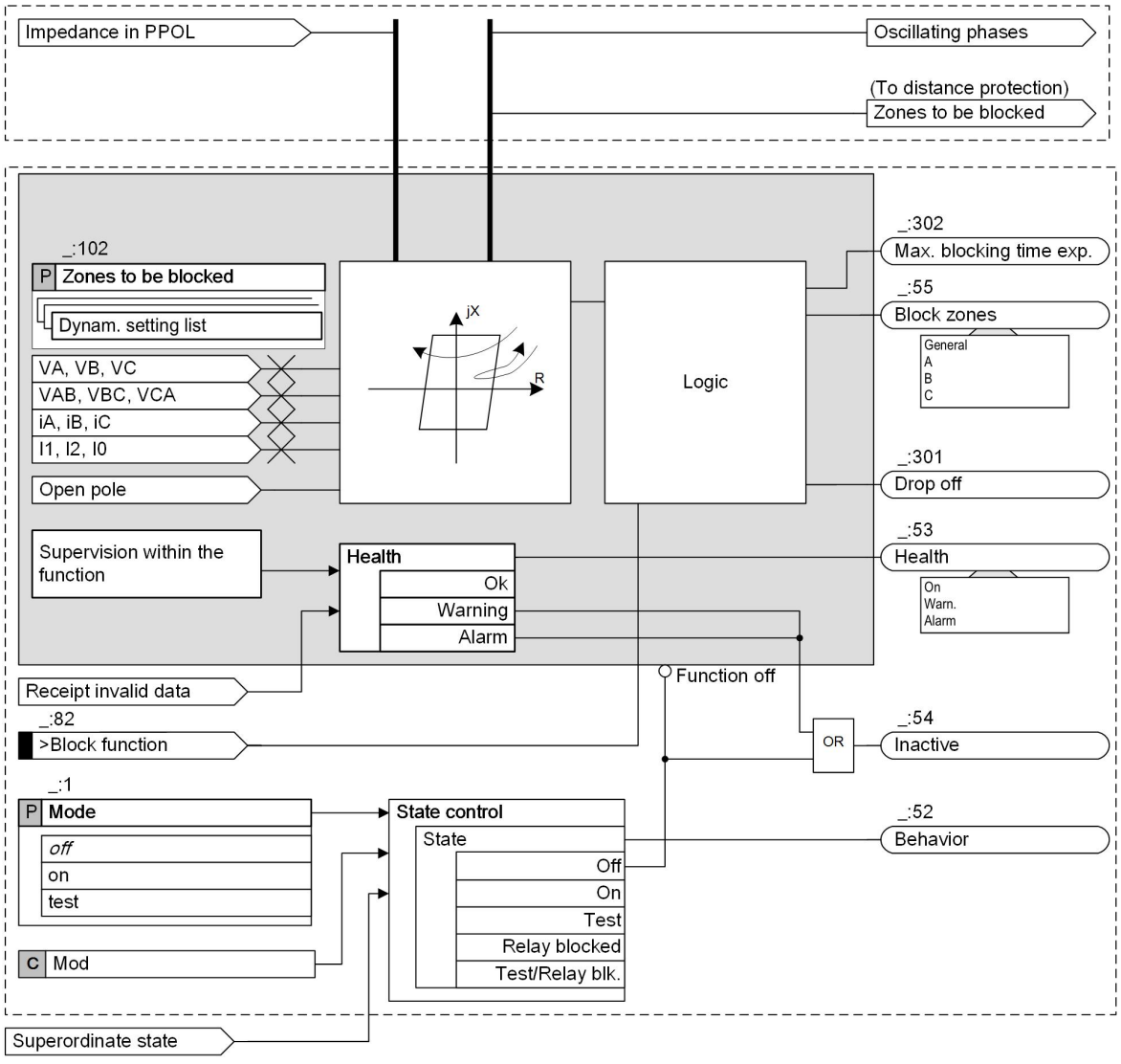
[lopendel-190413-01.tif, 3, en_US]

Figure 6-340 Power-Swing Blocking Logic

With the **`Max. blocking time`** parameter, you can place a time limit on the blocking effect of the power-swing blocking. In this way, for instance, the power-swing blocking can be eliminated when using systems that are slowly drifting apart.

When the impedance enters the power swing measuring range PPOL, the maximum blocking time will be started. When the impedance exits the power swing measuring range PPOL while the maximum blocking time is running, the maximum blocking time will be reset.

Logic



[lo_psd_log_3_en_US]

Figure 6-341 Functionality of Power-Swing Blocking

The distance protection delivers information about the loops contained in its zones to the power-swing blocking. If the power-swing blocking detects power swings in the activated loops, it delivers phase-selective information about the zones to be blocked to the distance protection. The actual blocking is carried out in the distance protection.

6.17.4 Application and Setting Notes

Selection of the Distance Zones to be Blocked

- Recommended setting value **(_:102) Zones to be blocked** = ***Zone x***

Parameter Value	Description
Zones to be blocked	Via a parameter, the user can individually select each zone present in the distance-protection function that is to be blocked during a power swing.

Maximum Blocking Time

- Default setting **(_:103) Max. blocking time** = ∞

When using the **Max. blocking time** parameter, you can limit the maximum blocking time of the distance protection during the power swing. In this way, for instance, the power-swing blockage can be eliminated when using networks that are slowly drifting apart.

For tripping during an asynchronous long-lasting power swings, **Max. blocking time** is not relevant. For this application, use the function **Out-of-step protection**.

If there is no operational requirement with regards to a time limit of the power-swing blocking, Siemens recommends the default setting ∞ (= not in effect).

Further Application Notes

The following table provides application notes for the interaction with other internal or external functions.

Interaction with Other Functions:	Note
Distance Protection	Distance protection delivers information about which impedance loops picked up. If power swings occur, pickup and tripping of the distance protection are blocked for the specific phases and zones. Power-swing blocking only works if the distance-protection function is activated.

6.17.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
68 P.swing blk				
_:1	68 P.swing blk:Mode		• off • on • test	off
_:103	68 P.swing blk:Max. blocking time		0.00 s to 60.00 s; ∞	∞
_:102	68 P.swing blk:Zones to be blocked		Setting options depend on configuration	

6.17.6 Information List

No.	Information	Data Class (Type)	Type
68 P.swing blk			
_:82	68 P.swing blk:>Block function	SPS	I
_:54	68 P.swing blk:Inactive	SPS	O
_:52	68 P.swing blk:Behavior	ENS	O
_:53	68 P.swing blk:Health	ENS	O
_:55	68 P.swing blk:Block zones	ACD	O
_:301	68 P.swing blk:Drop off	SPS	O
_:302	68 P.swing blk:Max. blocking time exp.	SPS	O

6.18 Teleprotection with Distance Protection

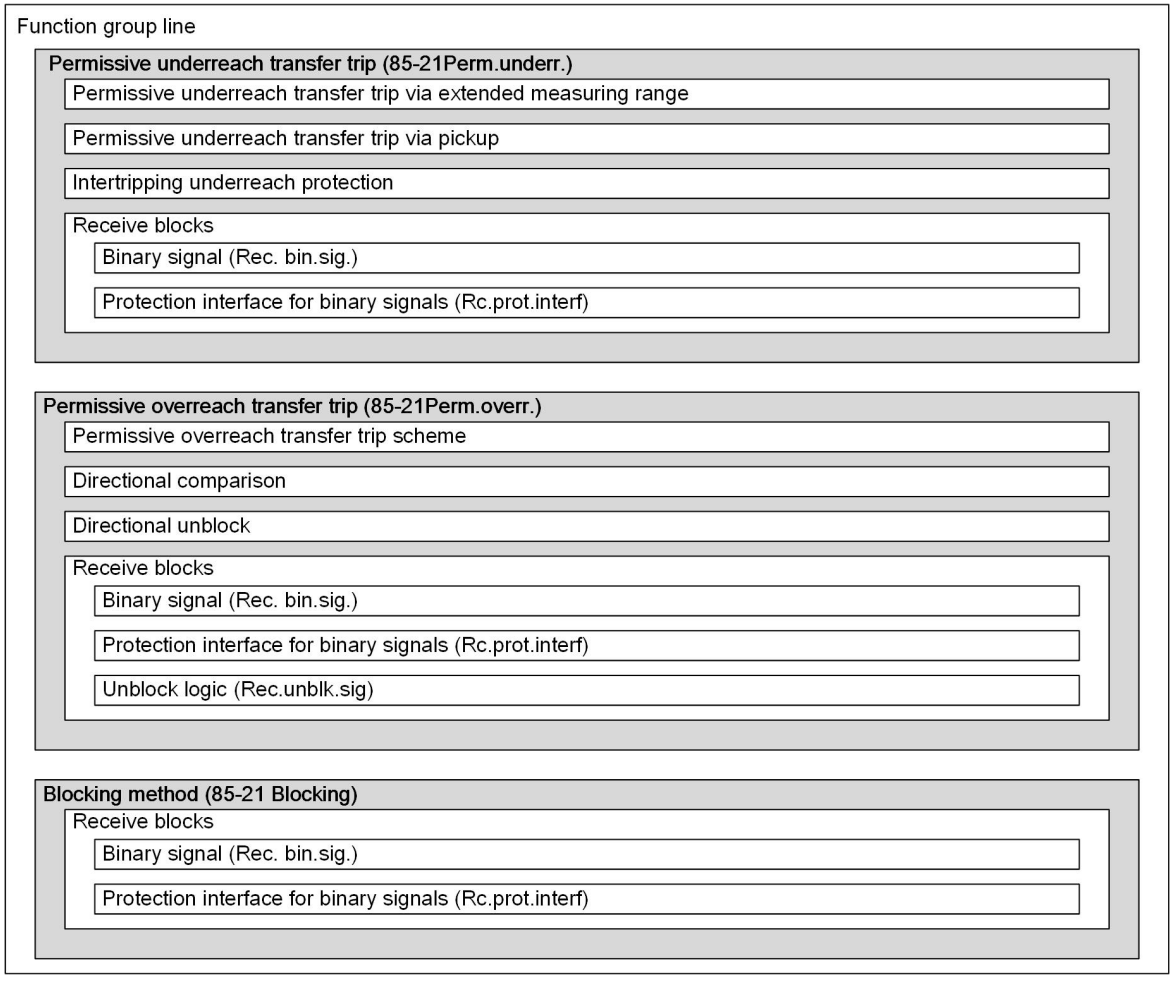
6.18.1 Overview of Functions

To enable selective and non-delayed fault clearance of all faults, on the entire line length, information exchange with the remote line end is applied. You can implement teleprotection using binary inputs and outputs (transmission and reception contacts) or using a digital communication connection.

6.18.2 Structure of the Function

The **Teleprotection schemes** is used in the protection function group **Line** in combination with the function Distance protection.

The functions shown in the following figure are available:



[dw_fkt-line_DIS_Mitnahme-Freigabe-Blockierverfahren, 1, en_US]

Figure 6-342 Structure/Embedding of the Function

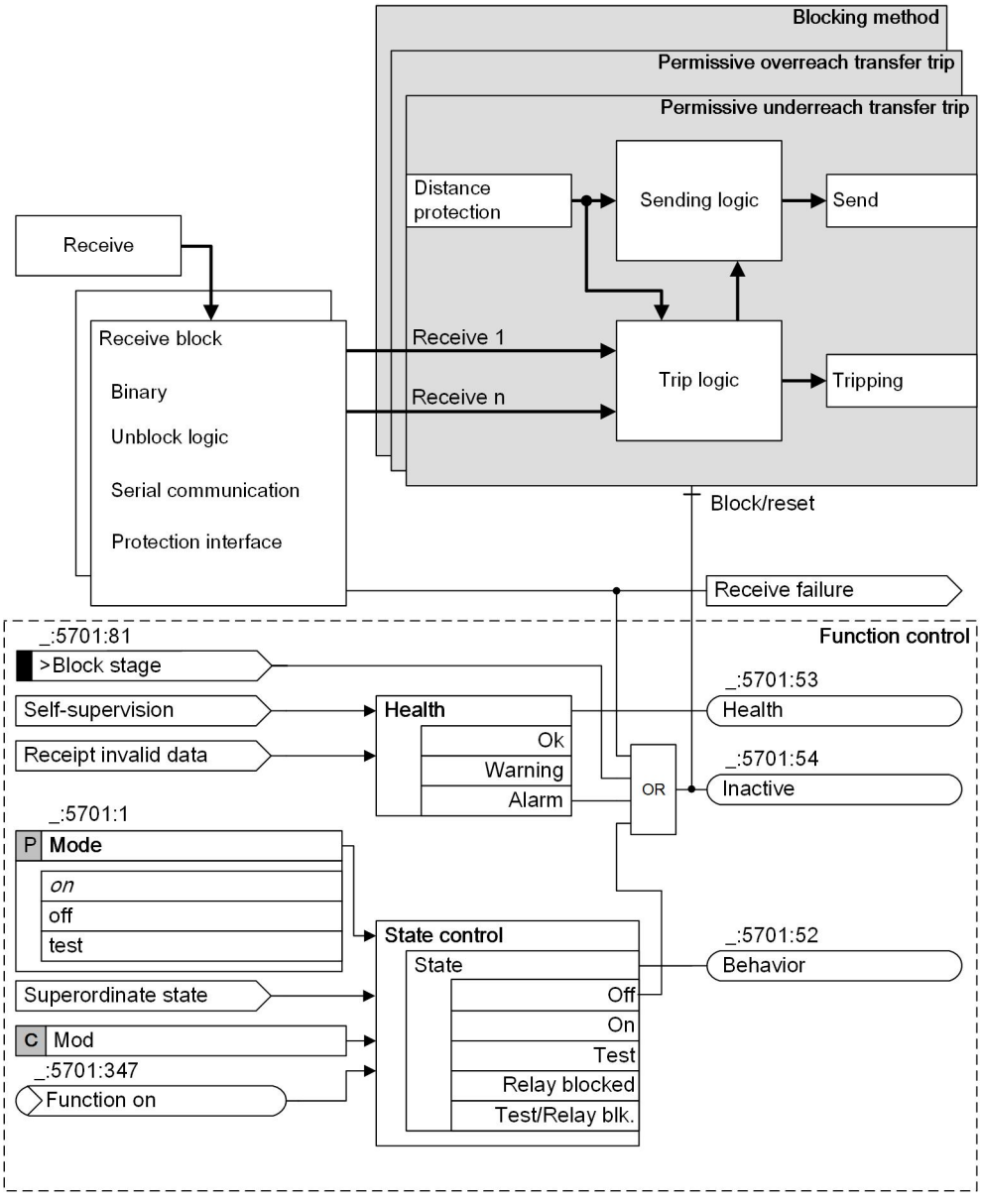
Figure 6-343 shows the function control and the function blocks.

The transmission logic analyzes the pickup signals of the distance protection and generates the associated transmission signal for transmission to the other line end.

The receive signal from the other line end is optionally coupled via a binary input, via the unblock logic or via the communication. For protection of the ends of multi-terminal lines, the function blocks **`Rec. bin.sig.`** and **`Rec.unblk.sig`** are available multiple times, once for each removed line end.

The distance zone parameterized for the teleprotection scheme provides the pickup information. This pickup information is combined with the reception information for the trip condition. If the trip condition is fulfilled, the teleprotection scheme creates the operate indication.

A trip signal results from the simultaneous presence of a pickup and a release signal.



[lo_struct_teleprot-wth_des-protec, 4, en_US]

Figure 6-343 Function Blocks and Function Control

In the following, the individual function blocks for the teleprotection scheme are described.

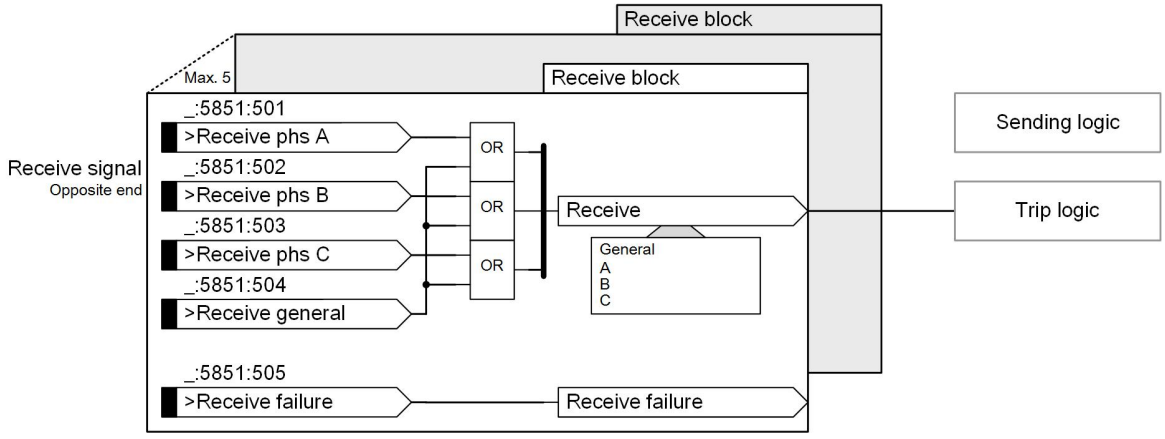
For more information, see *2.3 Function Control*.

6.18.3 Receive Blocks

For the coupling of receive signals from the opposite end, the receive block types **`Rec. bin.sig.`**, **`Rec.unblk.sig`** and **`Rec. PI`** are available. The teleprotection scheme described below can be operated with the suitable receive blocks if required.

A mixture between a line end connected through a protection interface and a binary connected line end is not possible.

Receive Block, Binary (in DIGSI 5: `Rec. bin.sig.`)



[lotprxbi-100611-01.tif, 2, en_US]

Figure 6-344 Logic Diagram of the Receive Block: `Rec. bin.sig.`

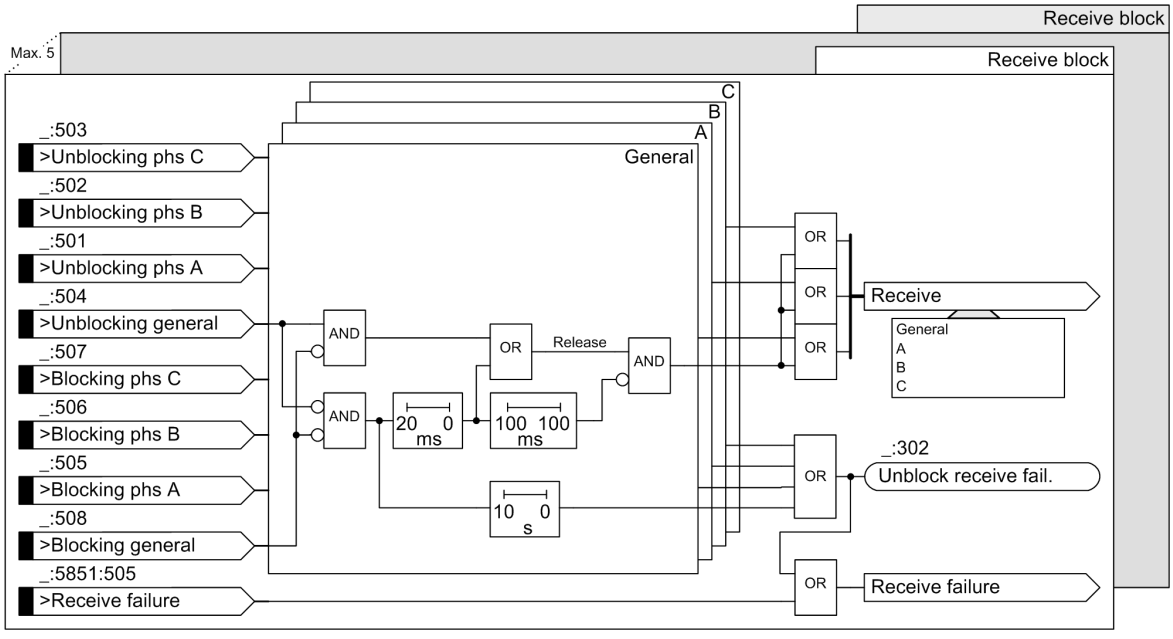
This receipt logic is used if the communication takes place via binary signals. If a teleprotection scheme is configured with a total of 3 ends, for example, 2 function blocks `Rec. bin.sig.` are required.

For applications with 1-pole tripping, the selectivity of the permissive underreach transfer trip for double ground faults on parallel lines can be improved, if 3 phase-selective send signals are transmitted per communication direction. The receipt signals can thus be used phase-specifically for A, B, and C or in general as individual signals.

For common-phase teleprotection, the signal **`>Receive general`** is used, for phase-selective teleprotection the 3 signals **`>Receive phs A`**, **`>Receive phs B`** and **`>Receive phs C`**.

The binary input **`>Receive failure`** affects the status indications of the function control, see *Figure 6-343*.

Receive Block, Unblock (in DIGSI 5: `Rec.unblk.sig`)



[lotpsunb-140611-01.tif, 1, en_US]

Figure 6-345 Logic Diagram of the Receive Block: `Rec.unblk.sig`

The teleprotection scheme can optionally be used with the unblock method. The difference to the conventional binary receipt is that a trip is also then possible if a release signal arrives from the opposite end.

The unblocking method is preferred under the following conditions:

- With long lines
- If the signal is transmitted via PLC (power-line carrier transmission) through the line that is to be protected
- If the attenuation of the transmission signal at the fault location can be so great that reception by the other line end is not ensured.

For transmission of the signal, 2 signal frequencies are required, which are sent from the transmission signal of the protection device. If the transmission device has channel monitoring, a monitoring frequency (blocking frequency) can be switched to a working frequency (unblocking frequency). During the idle state or during an external error, the monitoring frequency is transmitted, which signalizes the binary input *>Blocking general* (or during phase-selective teleprotection to the binary inputs *>Blocking phs A*, *>Blocking phs B*, and *>Blocking phs C*) of the unblock logic.

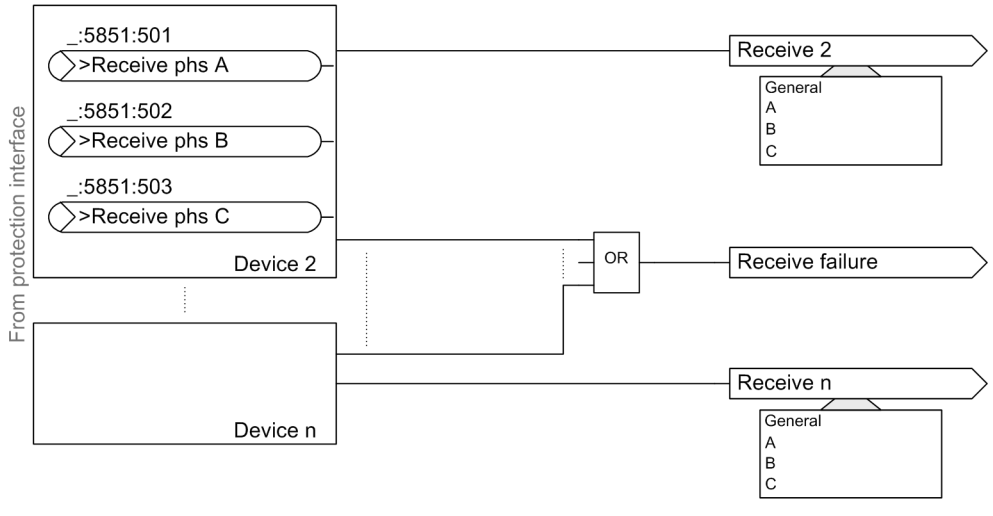
If in the event of a fault due to the transmission signal from the opposite line end the working frequency is received healthy, the receipt signal *>Unblocking general* will appear at the binary input of the unblock logic. During phase-selective teleprotection, instead of *>Unblocking general* the 3 receipt signals *>Unblocking phs A*, *>Unblocking phs B*, and *>Unblocking phs C* are used. Subsequently, the blocking signal *>Blocking general* disappears. During the phase-selective teleprotection, the 3 blocking signals *>Blocking phs A*, *>Blocking phs B* and *>Blocking phs C* are used. With this, the signal *>Unblocking general* (or the respective signals *>Unblocking phs A*, *>Unblocking phs B*, and *>Unblocking phs C*) are transmitted and the receipt of the trip logic of the teleprotection scheme is approved.

A short circuit on the line can cause an attenuation or reflection of the signal and the signal to be transmitted no longer reaches the other line end. In this state, both binary inputs *>Unblocking general* and *>Blocking general* are not active. After a time delay of 20 ms, the release is still created and forwarded to the receipt logic. The release is then retracted over the time stage after a further 100 ms.

If the signals continue to receive without disruptions, the release is possible again after a dropout delay of 100 ms.

If the device does not receive any of the signals for 10 s, the indication *Unblock receive fail.* is generated. This indication affects the status indications of the function control, see *Figure 6-343*.

Receive Block, Protection Interface (in DIGSI 5: `Rec. PI`)



[lotprxws-310511-01.tif, 1, en_US]

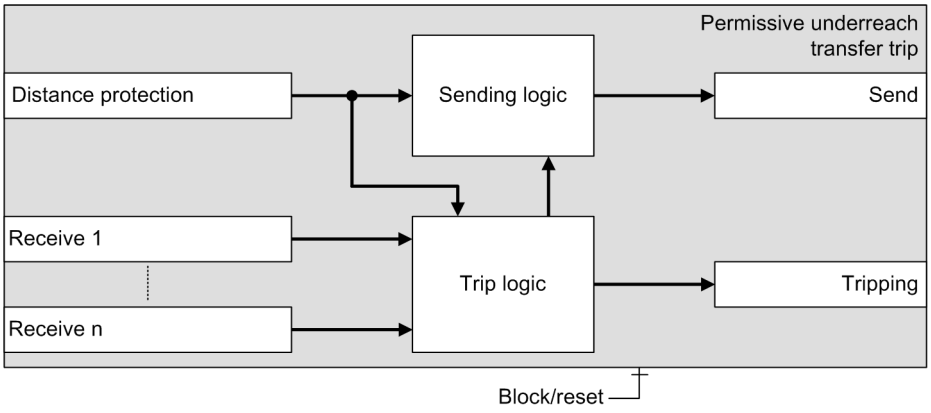
Figure 6-346 Logic Diagram of the Receive Block: **`Rec. PI`**

This receipt logic is used if the communication takes place via a protection interface (digital). Independent of the number of configured devices, only one function block **`Rec. PI`** is required at a time. The number and

the identity of devices participating in the teleprotection scheme for the protection of the line configuration are set by using the configuration of the protection interface, see *3.6.5.4 Configuration of the Protection Interface in DIGSI 5*.

6.18.4 Permissive Underreach Transfer Trip

6.18.4.1 Description

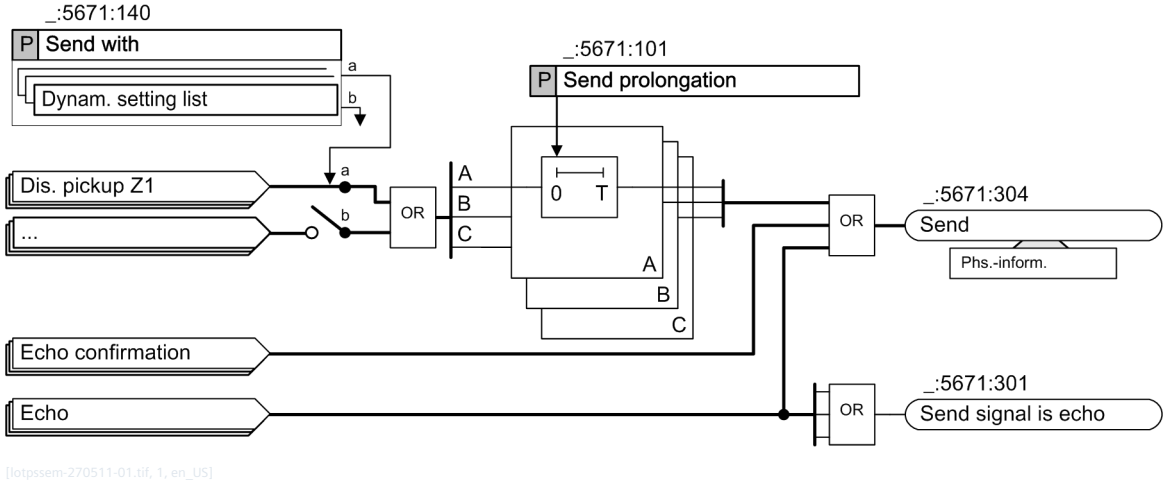


[dwtpsmit-100611-01.tif, 1, en_US]

Figure 6-347 Function Block: Permissive Underreach Transfer Trip (85-21 Perm. underr.)

If a fault occurs within the underreaching zone - this is usually zone Z1 for the distance protection - a transfer-trip signal is sent to the remote end. The receive signal leads to accelerated tripping in the device at the remote end.

Sending Logic Permissive Underreach Transfer Trip



[lotpssem-270511-01.tif, 1, en_US]

Figure 6-348 Sending Logic for Permissive Underreach Transfer Trip

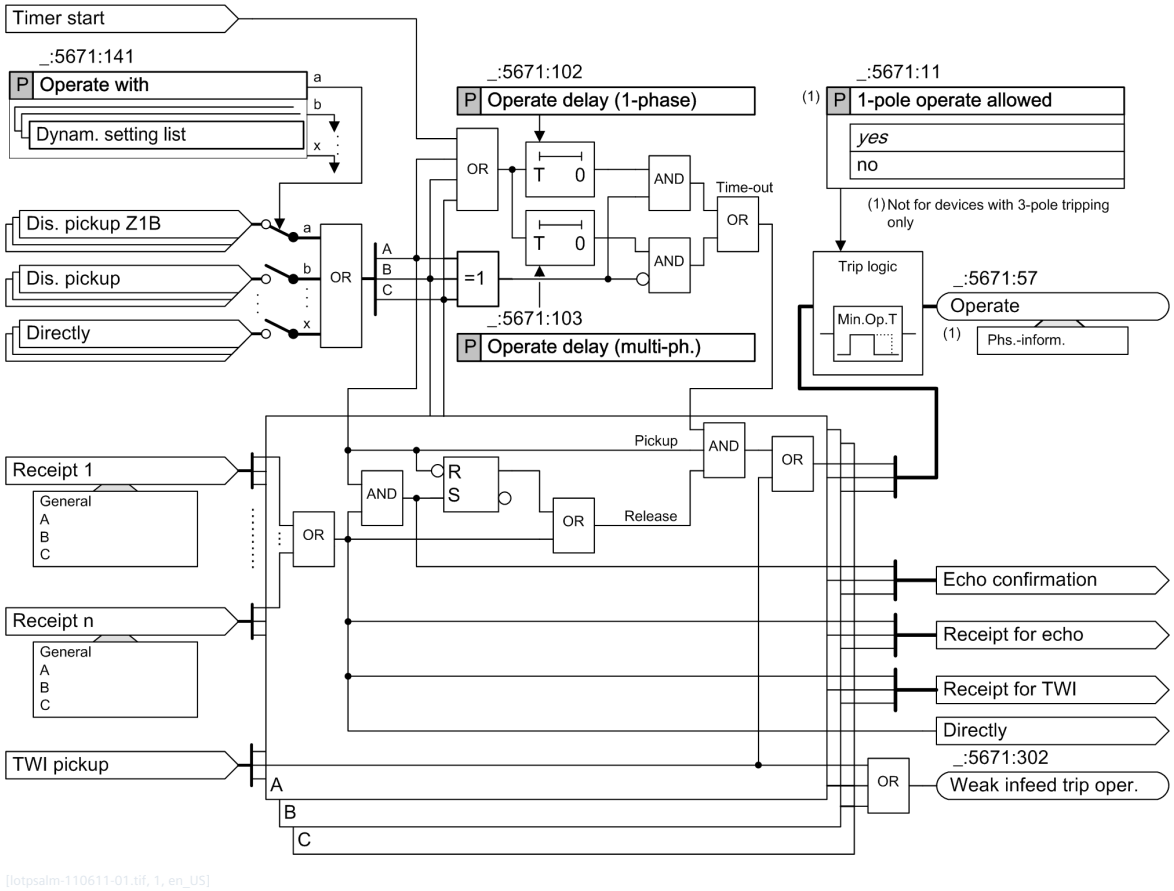
Sending takes place upon pickup in the distance zone selected as a send condition. You can use the **(_:5671:101) Send prolongation** parameter to compensate the differences in the pickup times at both line ends.

For applications with 1-pole tripping, the selectivity of the permissive underreach transfer trip for double ground faults on parallel lines can be improved, if 3 phase-selective send signals are transmitted per communication direction. Transmission and reception signals can thus be used phase-specifically for L1, L2 and L3 or phase-jointly as individual signals (general).

If the internal indication *Echo confirmation* from the trip logic is present, the sending logic also generates the *Send* signal. If, with a present receive signal, an **Operate with** parameterized zone has picked up, the

Echo Confirmation raises. Even if the **Send zone** is set below the **operate zone**, a definite tripping is possible for all line ends.

Trip Logic Permissive Underreach Transfer Trip



[lotpsalm-110611-01.tif, 1, en_US]

Figure 6-349 Trip Logic for Permissive Underreach Transfer Trip

The distance protection provides the pickup information to the teleprotection scheme. The tripping for the relevant zone is undertaken by that teleprotection scheme with which the distance protection works together.

If a receive signal is present, the zone set through the parameter **`Operate with`** will be released for tripping. The trip can be delayed. For 1-phase faults, set the time delay under **`(_:5671:102) Operate delay (1-phase)`**; for multi-phase faults, use the parameter **`(_:5671:103) Operate delay (multi-ph.)`**.

If the permissive underreach transfer trip is used to protect a line configuration with more than 2 ends, the receive signals from all line ends are linked with OR.

A trip signal results from a simultaneous presence of the distance zone pickup, the release signal, and the time sequence. The **`(_:5671:11) 1-pole operate allowed`** parameter can be used by the trip logic to allow 1-pole tripping in 1-pole/3-pole tripping devices. This parameter does not apply to devices that only have 3-pole trip.

For applications with time-delayed tripping, a receive signal once received is retained until the distance zone pickup drops out. This ensures that the release signal is still present if the expiration of the corresponding time delay releases the tripping, and the transmission signal of the protection from the remote end is no longer present.

Measures in the Event of Weak Infeed

If no or only a weak infeed is available at a line end, the protection does not pick up the phase information or it does so incorrectly. No trip command can therefore be issued there. In SIPROTEC 5 devices tripping can also be used together with the permissive underreach transfer trip in the event of weak infeed.

With the permissive underreach transfer trip, the protection trips parallel to the send signal with the underreaching distance zone at the line end with strong infeed. An echo from the line end with weak infeed is therefore unnecessary as a release signal. However, the echo is advisable for manually testing the signal connection between the protection devices.

The functions are described in more detail in *6.14.4 Tripping on Weak Infeed (TWI Function)*.

6.18.4.2 Application and Setting Notes for Permissive Underreach Transfer Trip, General

Setting the Process

The various permissive underreach transfer trip methods can be implemented by using both parameters **Send with** and **Operate with** (see *Figure 6-348* and *Figure 6-349*). In addition, the selection of the reception block must be observed.

The following methods can be ordered:

Methods	Parameter: Send with	Parameter: Operate with
DIS permissive underreach transfer trip via pickup, non-directional	Underreaching zone, type Z1	Pickup, general
DIS intertrip process via extended range	Underreaching zone, type Z1	Overreaching zone, type Z1B
DIS intertrip process direct	Underreaching zone, type Z1	Permissive underreach transfer trip, reception (direct tripping)

The selection texts are identical to the designations which you specify during the zone configuration in the distance protection function. The selection text for the underreaching distance zone can therefore also be different from Z1.

Parameter: Send prolongation

- Recommended setting value **(_:5671:101) Send prolongation** = ***0.05 s***

With the parameter **Send prolongation** in the transmission logic, you can compare the differences in the pickup times for both line ends. If SIPROTEC distance protection devices are used at all line ends, Siemens recommends the setting value ***0.05 s***.

Parameter: Operate delay (1-phase)

- Recommended setting value **(_:5671:102) Operate delay (1-phase)** = ***0.00 s***

With the parameter **Operate delay (1-phase)**, you set the operate delay for 1-phase ground faults. Since the teleprotection scheme should lead to a fast and selective operate, Siemens recommends the setting value ***0.00 s***.

Parameter: Operate delay (multi-ph.)

- Recommended setting value **(_:5671:103) Operate delay (multi-ph.)** = ***0.00 s***

With the parameter **Operate delay (multi-ph.)**, you set the operate delay for multi-phase faults. Since the teleprotection scheme should lead to a fast and selective operate, Siemens recommends the setting value ***0.00 s***.

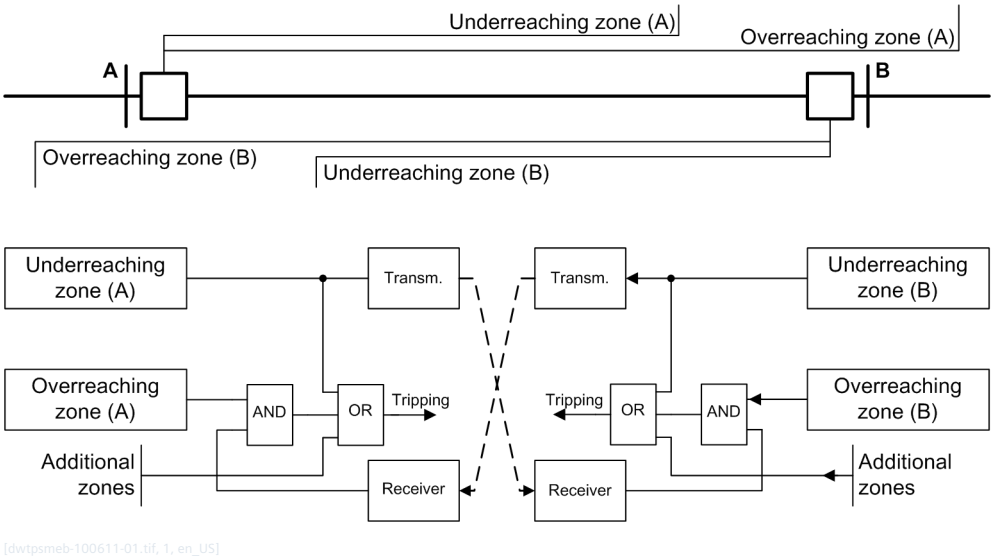
Parameter: 1-pole operate allowed

- Recommended setting value **(_:5671:11) 1-pole operate allowed** = ***Yes***

This parameter allows 1-pole tripping of the teleprotection scheme in the event of 1-phase short circuits or multiphase short circuits and 1-phase reception. In devices with 1-pole tripping, Siemens recommends the setting ***Yes***. In devices with 3-pole trip, this parameter does not apply.

6.18.4.3 Application and Setting Notes for the Permissive Underreach Transfer Trip via an Extended Measuring Range (Distance Protection with Underreaching and Grading-Time Shortening)

A transfer-trip signal is transmitted to the remote end in the event of a fault within the underreaching zone. If the fault is detected there within the overreaching zone, the receive signal leads to tripping.



[dwtpsmeb-100611-01.tif, 1, en_US]

Figure 6-350 Function Diagram of the Permissive Underreach Transfer Trip via Extended Measuring Range

You can configure the Permissive Underreach Transfer Trip via an extended measuring range with the following settings:

Transmit with

- Recommended setting value **(_:5671:140) Send with** = ***Z1***

With the parameter **Send with**, you select the underreaching distance zone. The underreaching distance zone is typically designated with Z1. The selection texts are identical to the designations which you specify during the zone configuration in the distance protection function. The selection text for the underreaching distance zone can therefore also be different from Z1.

Operate with

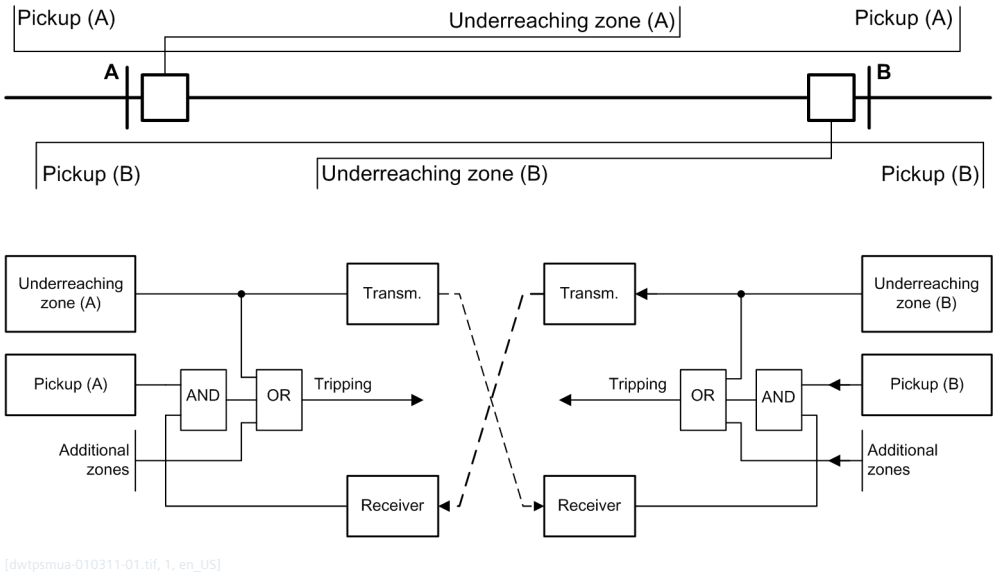
- Recommended setting value **(_:5671:141) Operate with** = ***Dis Z1B***

With the parameter **Operate with**, you select the overreaching distance zone Z1B. The selection texts are identical to the designations which you specify during the zone configuration in the distance protection function. The selection text for the overreaching distance zone can therefore also be different from Z1B.

For applications in which the ranges for phase and ground faults are to be set differently, there are 2 underreaching or 2 overreaching distance zones. For example Z1(Ph-gnd) then takes effect for ground faults and Z1(Ph-Ph) for phase faults. In this case, you must select both zones as send or tripping zones in the teleprotection scheme. This applies to parameters **Send with** and **Operate with**.

6.18.4.4 Application and Setting Notes for the Permissive Underreach Transfer Trip via Pickup (Distance Protection with Underreaching and Remote Tripping with Release)

A transfer-trip signal is transmitted to the remote end in the event of a fault in the underreaching zone. If the distance-protection function picks up at the remote end, the signal received there leads to tripping.



[dwtpsmua-010311-01.tif, 1, en_US]

Figure 6-351 Function Diagram of the Permissive Underreach Transfer Trip via Pickup

You can configure the permissive underreach transfer trip via pickup with the following settings:

Parameter: Send with

- Recommended setting value **(_:5671:140) Send with** = ***Z1***

With the parameter **Send with**, you select the underreaching distance zone. The underreaching distance zone is typically designated with Z1. The selection texts are identical to the designations which you specify during the zone configuration in the distance protection function. The selection text for the underreaching distance zone can therefore also be different from Z1.

Parameter: Operate with

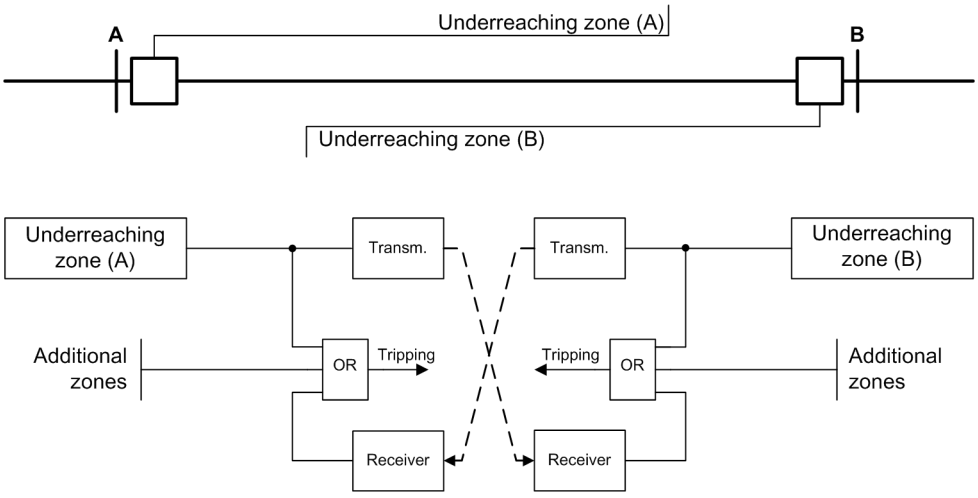
- Default setting **(_:5671:141) Operate with** = ***Pickup, general***

With the parameter **Operate with**, you set the pickup for the accelerated tripping.

Parameter Value	Description
Pickup, general	Select this setting value for the non-directional permissive underreach transfer trip via pickup.
Reception (direct tripping)	Select this setting value for direct tripping with the received signal.

6.18.4.5 Application and Setting Notes for the Direct Permissive Underreach Transfer trip

A transfer-trip signal is transmitted to the remote end in the event of a fault in the underreaching zone. The signal received there leads directly to the tripping.



[dwtpsdim-100611-01.tif, 1, en_US]

Figure 6-352 Function Diagram for the Direct Permissive Underreach Transfer Trip

Parameter: Send with

- Recommended setting value **(_:5671:140) Send with** = ***Z1***

With the parameter **Send with**, you can select the underreaching distance zone. The underreaching distance zone is typically designated with Z1. The selection texts are identical to the designations which you specify during the zone configuration in the distance protection function. The selection text for the underreaching distance zone can therefore also be different from Z1.

Parameter: Operate with

- Recommended setting value **(_:5671:141) Operate with** = ***direct***

For the direct permissive underreach transfer trip, set the parameter to ***direct***.

6.18.4.6 Settings

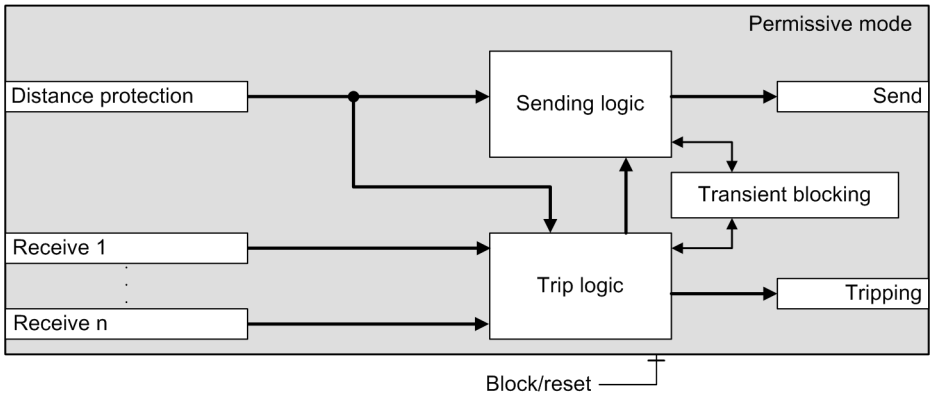
Addr.	Parameter	C	Setting Options	Default Setting
85-21Perm.unde				
_:5671:1	85-21Perm.unde:Mode		• off • on • test	on
_:5671:101	85-21Perm.unde:Send prolongation		0.00 s to 60.00 s	0.05 s
_:5671:11	85-21Perm.unde:1-pole operate allowed		• no • yes	yes
_:5671:102	85-21Perm.unde:Operate delay (1-phase)		0.00 s to 60.00 s	0.00 s
_:5671:103	85-21Perm.unde:Operate delay (multi-ph.)		0.00 s to 60.00 s	0.00 s
_:5671:140	85-21Perm.unde:Send with		Setting options depend on configuration	
_:5671:141	85-21Perm.unde:Operate with		Setting options depend on configuration	

6.18.4.7 Information List

No.	Information	Data Class (Type)	Type
85-21Perm.unde			
_:5671:81	85-21Perm.unde:>Block stage	SPS	I
_:5671:501	85-21Perm.unde:>Blocking echo	SPS	I
_:5671:502	85-21Perm.unde:>Blk. weak infeed trip	SPS	I
_:5671:54	85-21Perm.unde:Inactive	SPS	O
_:5671:52	85-21Perm.unde:Behavior	ENS	O
_:5671:53	85-21Perm.unde:Health	ENS	O
_:5671:304	85-21Perm.unde:Send	ACT	O
_:5671:301	85-21Perm.unde:Send signal is echo	SPS	O
_:5671:302	85-21Perm.unde:Weak infeed trip oper.	SPS	O
_:5671:56	85-21Perm.unde:Operate delay expired	ACT	O
_:5671:57	85-21Perm.unde:Operate	ACT	O
Rec. bin.sig.1			
_:5851:52	Rec. bin.sig.1:Behavior	ENS	O
_:5851:53	Rec. bin.sig.1:Health	ENS	O
_:5851:501	Rec. bin.sig.1:>Receive phs A	SPS	I
_:5851:502	Rec. bin.sig.1:>Receive phs B	SPS	I
_:5851:503	Rec. bin.sig.1:>Receive phs C	SPS	I
_:5851:504	Rec. bin.sig.1:>Receive general	SPS	I
_:5851:505	Rec. bin.sig.1:>Receive failure	SPS	I

6.18.5 Permissive Overreach Transfer Trip

6.18.5.1 Description

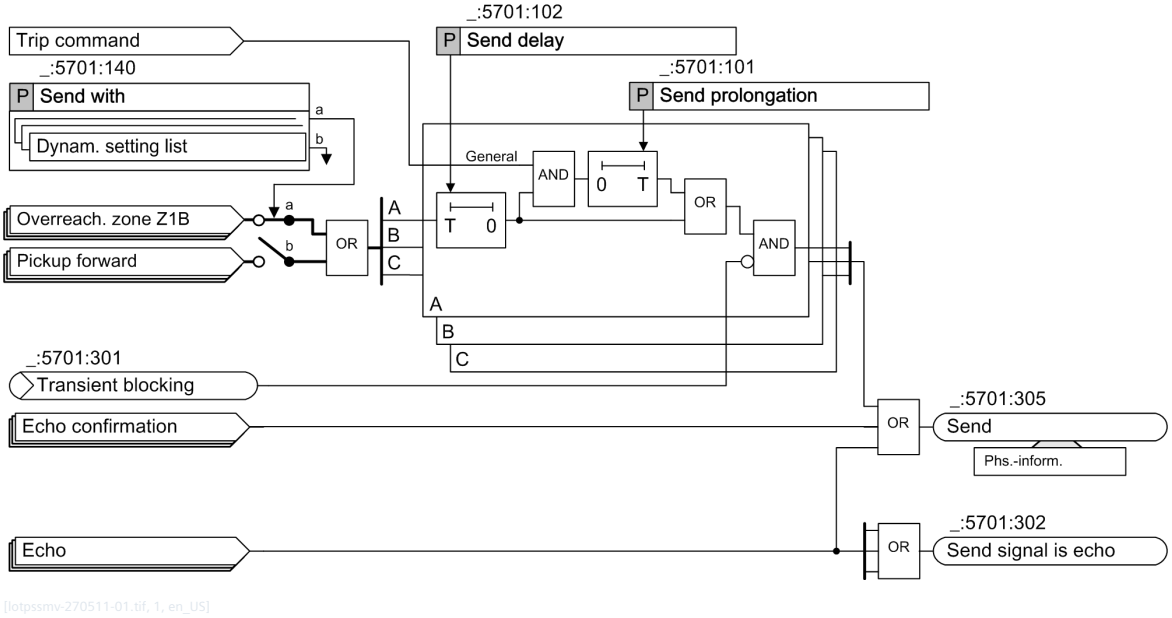


[dwtpsver-010612-01.tif, 1, en_US]

Figure 6-353 Function Block: Permissive Schemes (85-21 Perm. overr.)

If a fault occurs within the overreaching zone, for example zone Z1B for the distance protection, a send signal is sent to the opposite end. In the distance protection device, the received signal leads to accelerated tripping if the fault is also detected in the forward direction.

Sending Logic, Permissive Schemes



[lotpssmv-270511-01.tif, 1, en_US]

Figure 6-354 Sending Logic for Permissive Schemes

Sending takes place upon pickup in the selected overreaching zone or optionally upon pickup in the forward direction. The send signal can be extended by a parameterizable time **(_:5701:101) Send prolongation** if the protection has already issued a trip command. This allows for the release of the other line end even if the short circuit there only leads to pickup after the short-circuit current at the opposite end has been deactivated. With this, pickup differences between the cable ends and signal delays can be considered.

If needed, the transmission signal can be delayed with **(_:5701:102) Send delay**.

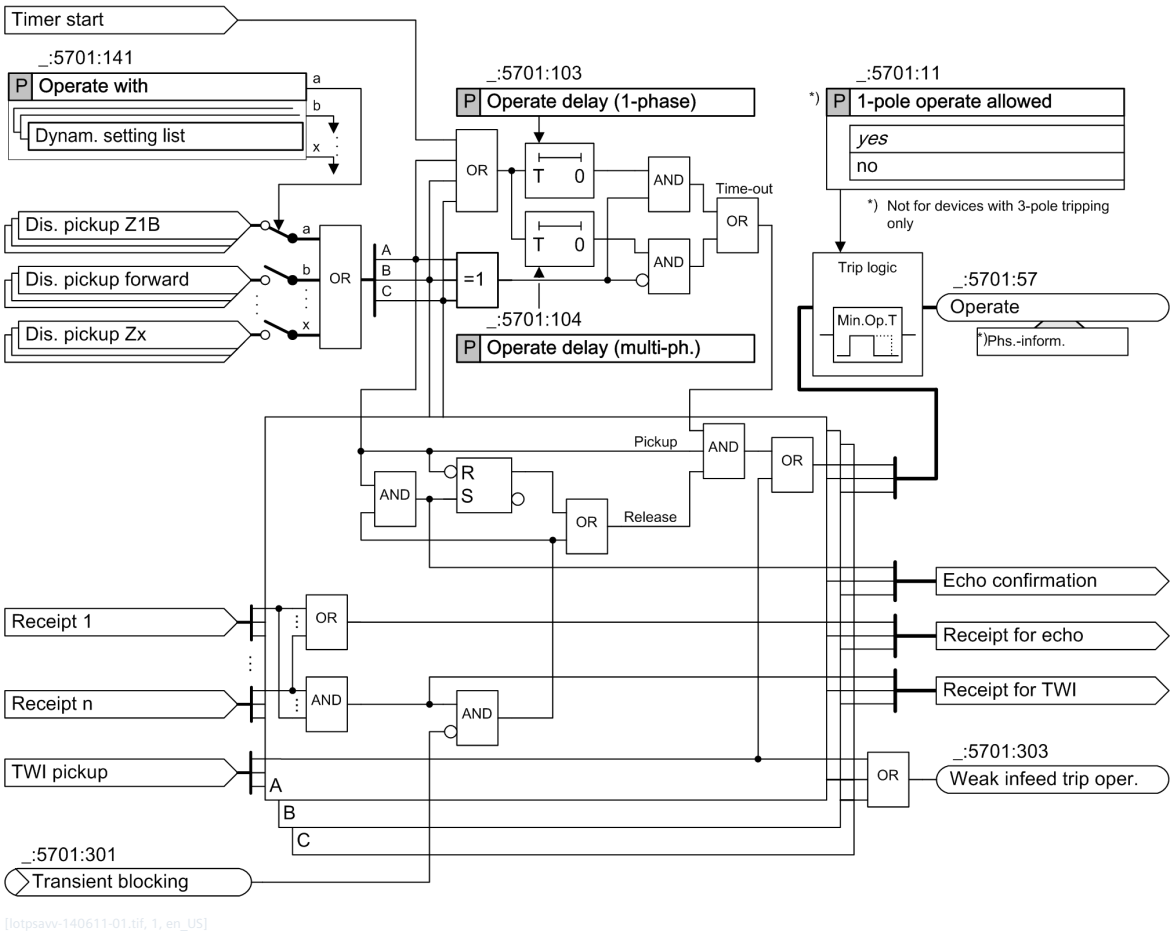
Transient blocking (signal **Transient blocking**) provides additional security against false signals caused by a change of direction after disconnection of external faults (for example, on parallel lines). No transmission signal is sent in the event of transient blocking.

For applications with 1-pole tripping, the selectivity of the permissive scheme for double faults can be improved on parallel lines if 3 phase-selective transmission signals are transmitted per communication direction. Transmission and reception signals can thus be used phase-specifically for L1, L2 and L3 or phase-jointly as individual signals (general).

Related Topics

6.18.8.1 Description

Trip Logic, Permissive Schemes



[lotpsavv-140611-01.tif, 1, en_US]

Figure 6-355 Trip Logic for Permissive Schemes

The distance protection provides the pickup information to the teleprotection scheme. The tripping for the relevant zone is undertaken by that teleprotection scheme with which the distance protection works together.

If a receive signal is present, the zone set through the parameter **(_:5701:141) Operate with** will be released for tripping. The trip can be delayed. For 1-phase faults, set the time delay under **(_:5701:103) Operate delay (1-phase)**. For multi-phase faults, use the parameter **(_:5701:104) Operate delay (multi-ph.)**.

The parameter **(_:5701:11) 1-pole operate allowed** can be used by the trip logic to allow 1-pole tripping in 1-pole/3-pole tripping devices. This parameter does not apply to devices that only have 3-pole trip.

If the permissive scheme for the protection of a line configuration with more than 2 ends is used, the reception signals from all line ends are combined for the tripping with AND.

A trip signal results from simultaneous presence of the distance zone activation, the release signal and the time sequence. For applications with time-delayed tripping, a receipt signal once received is retained until the distance zone pickup drops out. This ensures that the release signal is still present if the expiration of the corresponding time delay releases the tripping, and the transmission signal of the protection from the remote end is no longer present.

The transient blocking (signal *Transient blocking*) prevents the release of the tripping in the permissive scheme. It ensures additional security from false signals caused by a change of direction after disconnection of external faults (for example on parallel lines).

Related Topics

6.18.8.1 Description

Measures in the Event of Weak Infeed

If no or only a weak infeed is available at a line end, the protection does not pick up the phase information or it does so incorrectly. With this, neither a trip command nor a transmission signal can be sent. With the permissive scheme, the line end cannot be tripped quickly with increased infeed because no release signal is transferred from the end with the weak infeed.

The teleprotection schemes have special measures to enable a rapid trip at both line ends in such cases:

- For the trip of the cable end with a strong infeed, the echo function can be made effective with a weak infeed.
- In order for the cable end to also be tripped with a weak infeed, the teleprotection scheme has a function for trip with weak infeed.

Related Topics

6.14.4 Tripping on Weak Infeed (TWI Function)

6.18.5.2 Application and Setting Notes for Permissive Schemes, General

Setting the Process

The various permissive schemes can be implemented using the 2 parameters **`Send with`** and **`Operate with`** (see *Figure 6-354* and *Figure 6-355*). In addition, the selection of the receive block must be observed.

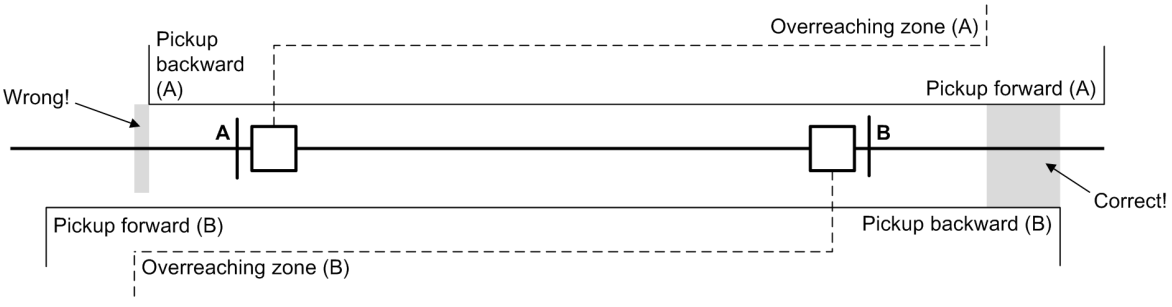
The following methods can be set:

Methods	Parameter: Send with	Parameter: Operate with
Signal permissive overreach transfer trip	Overreaching zone, type Z1B	Overreaching zone, type Z1B
Directional permissive overreach transfer trip	Pickup forward	Pickup forward
Direction unblock process	Overreaching zone, type Z1B	Overreaching zone, type Z1B

However, the selection texts are identical to the designations which you specify during the zone configuration in the distance protection function. The selection text for the overreaching distance zone can therefore also be different from Z1B.

Requirements during Distance Protection

When using any kind of permissive overreach transfer trip, make sure that the pickup of the distance protection in the backward direction reaches further than the overreaching zone of the opposite end (see the shaded areas in the following figure on the right)! For this purpose, at least one of the distance-protection stages must be set to *backward* or *non-directional*. In case of a fault occurring in Z1B of the protection in B due to an incorrect setting in the shaded area (left in the figure), the distance protection would pick up. Since an echo function is typically used, an undesired echo signal would be sent from protection A and protection B would trip in an unselective way.



[dw_Dis-prot-vergleich-200314-01.vsd, 1, en_US]

Figure 6-356 Distance-Protection Setting with Permissive Overreach Transfer Trip

Parameter: Send prolongation

- Recommended setting value **(_:5701:101) Send prolongation** = ***0.05 s***

With the parameter **Send prolongation** in the transmission logic, you compensate the differences in the pickup times for both line ends. If SIPROTEC distance protection devices are used at all line ends, Siemens recommends the setting value ***0.05 s***.

Parameter: Send delay

- Recommended setting value **(_:5701:102) Send delay** = ***0.00 s***

With the parameter **Send delay**, you set an additional tripping delay. Since the teleprotection scheme should lead to a fast and selective tripping, Siemens recommends the setting value ***0.00 s***.

Parameter: Operate delay (1-phase)

- Recommended setting value **(_:5701:103) Operate delay (1-phase)** = ***0.00 s***

With the parameter **Operate delay (1-phase)**, you set the tripping delay for 1-phase ground faults. Since the teleprotection scheme should lead to a rapid and selective tripping, Siemens recommends the setting value ***0.00 s***.

Parameter: Operate delay (multi-ph.)

- Recommended setting value **(_:5701:104) Operate delay (multi-ph.)** = ***0.00 s***

With the parameter **Operate delay (multi-ph.)**, you set the tripping delay for multi-phase faults. Since the teleprotection scheme should lead to a fast and selective tripping, Siemens recommends the setting value ***0.00 s***.

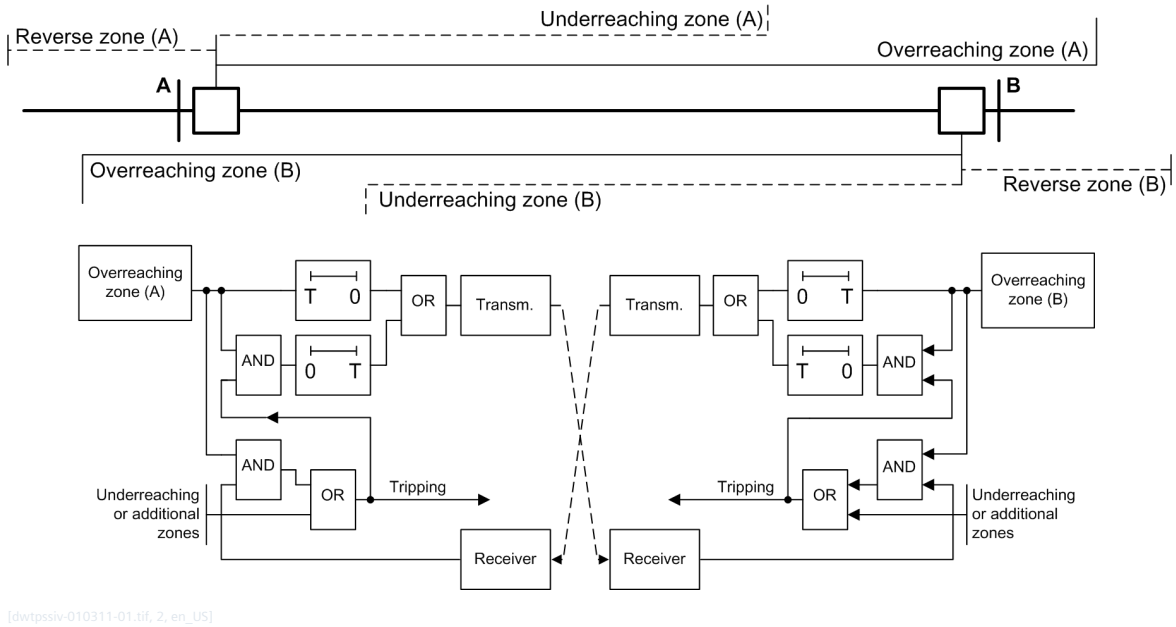
Parameter: 1-pole operate allowed

- Recommended setting value **(_:5701:11) 1-pole operate allowed** = ***Yes***

This parameter allows 1-pole tripping of the teleprotection scheme in the event of 1-phase short circuits or multiphase short circuits and 1-phase reception. In devices with 1-pole tripping, Siemens recommends the setting ***Yes***. In devices with 3-pole trip, this parameter does not apply.

6.18.5.3 Application and Setting Notes for the Permissive Overreach Transfer Trip Scheme (Distance Protection with Overreaching and Release)

A send signal is sent to the remote end in the event of a fault in the overreaching zone. If the fault is also detected there in the overreaching zone, the received signal leads to tripping.



[dwtpssiv-010311-01.tif, 2, en_US]

Figure 6-357 Function Diagram of the Permissive Overreach Transfer Trip Scheme

You can use the following settings to configure the permissive overreach transfer trip scheme:

Parameter: `Send with`

- Recommended setting value **`(_:5701:140) Send with`** = ***Z1B***

With the parameter **`Send with`**, you select the overreaching distance zone. The overreaching distance zone is typically designated with Z1B. The selection texts are identical to the designations which you specify during the zone configuration in the distance protection function. The selection text for the overreaching distance zone can therefore also be different from Z1B.

Parameter: `Operate with`

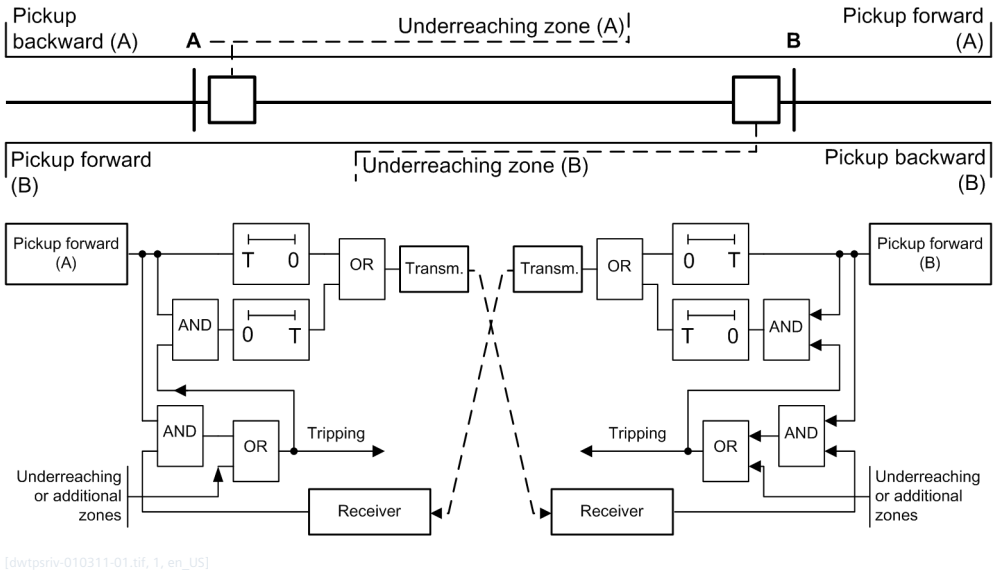
- Recommended setting value **`(_:5701:141) Operate with`** = ***Z1B***

With the parameter **`Operate with`**, you select the overreaching distance zone. The overreaching distance zone is typically designated with Z1B. The selection texts are identical to the designations which you specify during the zone configuration in the distance protection function. The selection text for the overreaching distance zone can therefore also be different from Z1B.

For applications in which the ranges for phase and ground faults are to be set differently, there are 2 overreaching distance zones. For example Z1B(Ph-gnd) then takes effect for ground faults and Z1B(Ph-Ph) for phase faults. In this case, you must select both zones as send zones or tripping zones in the teleprotection scheme. This applies to parameters **`Send with`** and **`Operate with`**.

6.18.5.4 Application and Setting Notes for the Directional-Comparison Method

If the distance protection detects a fault in the line direction after an activation, it sends a release signal to the remote end. If the opposite end receives the release signal and also recognizes an error in the cable direction, the trip signal is created.



[dwtpsriv-010311-01.tif, 1, en_US]

Figure 6-358 Function Scheme of the Directional Comparison Procedure

With the following settings, you can configure the directional comparison:

Parameter: **Send with**

- Recommended setting value **(_:5701:140) Send with** = ***Dis pickup fwd***

The parameter **Send with** is used to set the send condition to ***Dis pickup fwd.***.

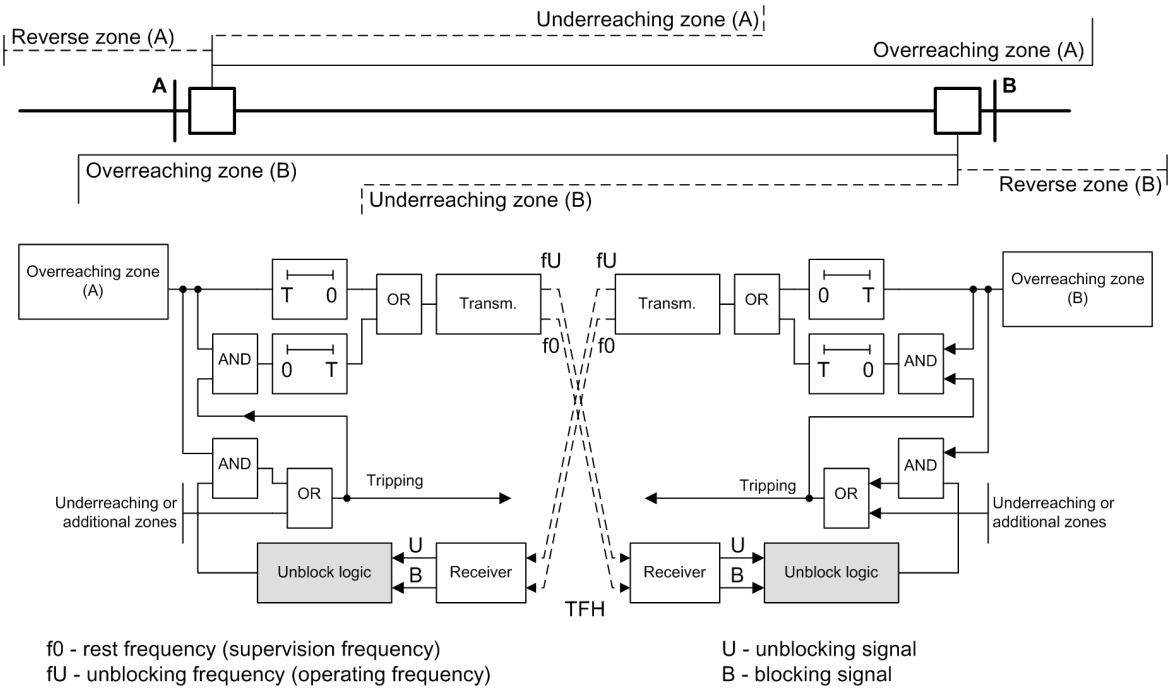
Parameter: **Operate with**

- Recommended setting value **(_:5701:141) Operate with** = ***Dis pickup fwd.***

The parameter **Operate with** is used to set the trip condition to ***Dis pickup fwd.***.

6.18.5.5 Application and Setting Notes for the Directional Unblocking Method (Distance Protection with Overreaching and Unblocking)

The directional unblocking method corresponds with the permissive overreach transfer trip with a preceding function block **Rec.unblk.sig**. Thus, compared to the permissive overreach transfer trip, a tripping is also possible without a release signal from the opposite end. The directional unblocking method cannot be operated with a communication via a protection interface owing to the way it functions.



[dwtpsubl-010311-01.tif, 2, en_US]

Figure 6-359 Function Scheme of the Directional Unblocking Method

With the following settings, you can configure the directional unblocking method:

Parameter: `Send with`

- Recommended setting value **`(_:5701:140) Send with`** = ***`Z1B`***

With the parameter **`Send with`**, you select the overreaching distance zone. The overreaching distance zone is typically designated with Z1B. The selection texts are identical to the designations you specify during the zone configuration in the distance protection function. The selection text for the overreaching distance zone can therefore also be different from Z1B.

Parameter: `Operate with`

- Recommended setting value **`(_:5701:141) Operate with`** = ***`Z1B`***

With the parameter **`Operate with`**, you select the overreaching distance zone. The overreaching distance zone is typically designated with Z1B. The selection texts are identical to the designations you specify during the zone configuration in the distance protection function. The selection text for the overreaching distance zone can therefore also be different from Z1B.

For applications in which the ranges for phase and ground faults are to be set differently, there are 2 overreaching distance zones. For example Z1B(Ph-Gnd) then takes effect for ground faults and Z1B(Ph-Ph) for phase faults. In this case, you must select both zones as send or tripping zones in the teleprotection scheme. This applies to the parameters **`Send with`** and **`Operate with`**.

6.18.5.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
85-21Perm.over				
_:5701:1	85-21Perm.over:Mode		• off • on • test	on
_:5701:101	85-21Perm.over:Send prolongation		0.00 s to 60.00 s	0.05 s

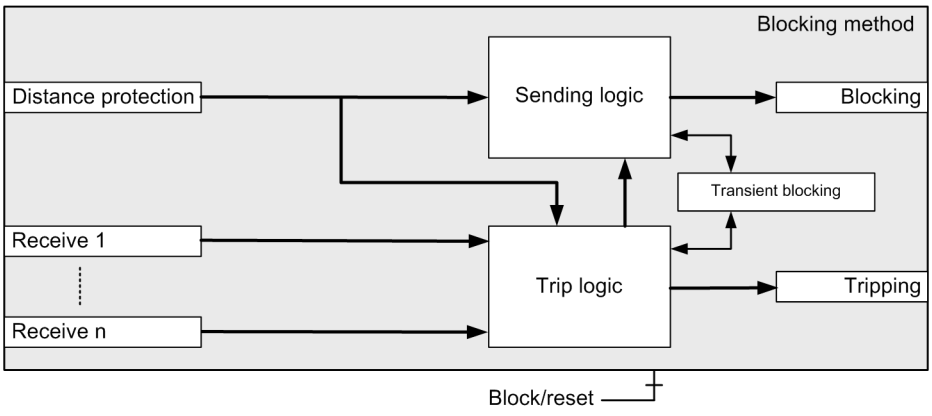
Addr.	Parameter	C	Setting Options	Default Setting
_:5701:102	85-21Perm.over:Send delay		0.00 s to 60.00 s	0.00 s
_:5701:105	85-21Perm.over:Trans. blk. pickup delay		0.00 s to 60.00 s	0.04 s
_:5701:106	85-21Perm.over:Trans. blk. dropout delay		0.00 s to 60.00 s	0.05 s
_:5701:11	85-21Perm.over:1-pole operate allowed		• no • yes	yes
_:5701:103	85-21Perm.over:Operate delay (1-phase)		0.00 s to 60.00 s	0.00 s
_:5701:104	85-21Perm.over:Operate delay (multi-ph.)		0.00 s to 60.00 s	0.00 s
_:5701:140	85-21Perm.over:Send with		Setting options depend on configuration	
_:5701:141	85-21Perm.over:Operate with		Setting options depend on configuration	
_:5701:142	85-21Perm.over:Trans. block. with		Setting options depend on configuration	

6.18.5.7 Information List

No.	Information	Data Class (Type)	Type
85-21Perm.over			
_:5701:81	85-21Perm.over:>Block stage	SPS	I
_:5701:501	85-21Perm.over:>Blocking echo	SPS	I
_:5701:502	85-21Perm.over:>Blk. weak infeed trip	SPS	I
_:5701:54	85-21Perm.over:Inactive	SPS	O
_:5701:52	85-21Perm.over:Behavior	ENS	O
_:5701:53	85-21Perm.over:Health	ENS	O
_:5701:305	85-21Perm.over:Send	ACT	O
_:5701:302	85-21Perm.over:Send signal is echo	SPS	O
_:5701:303	85-21Perm.over:Weak infeed trip oper.	SPS	O
_:5701:301	85-21Perm.over:Transient blocking	SPS	O
_:5701:56	85-21Perm.over:Operate delay expired	ACT	O
_:5701:57	85-21Perm.over:Operate	ACT	O
_:5701:347	85-21Perm.over:Function on	SPC	C
Rec. bin.sig.1			
_:5851:52	Rec. bin.sig.1:Behavior	ENS	O
_:5851:53	Rec. bin.sig.1:Health	ENS	O
_:5851:501	Rec. bin.sig.1:>Receive phs A	SPS	I
_:5851:502	Rec. bin.sig.1:>Receive phs B	SPS	I
_:5851:503	Rec. bin.sig.1:>Receive phs C	SPS	I
_:5851:504	Rec. bin.sig.1:>Receive general	SPS	I
_:5851:505	Rec. bin.sig.1:>Receive failure	SPS	I

6.18.6 Blocking Method

6.18.6.1 Description

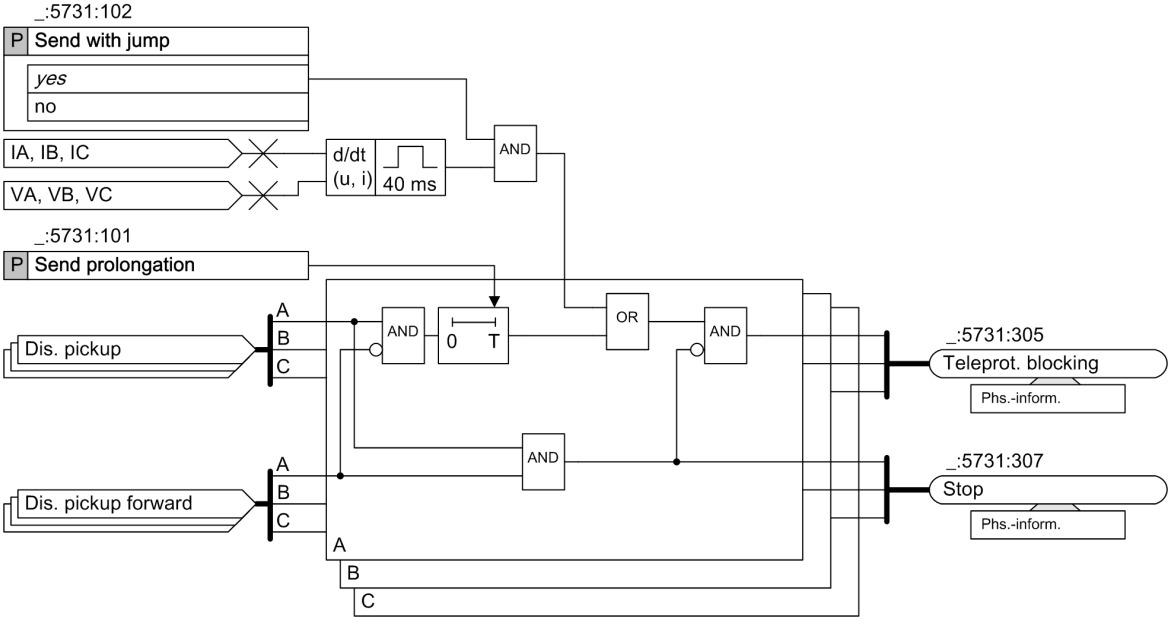


[dwtpsblo-040311-01.tif, 1, en_US]

Figure 6-360 Function Block: Blocking Method (85-21 Blocking)

If the protection function recognizes a fault in the reverse direction, the blocking signal is sent to the opposite end. If the protection device does not receive a blocking signal at the receiving line end, it generates the trip signal after a short time delay.

Sending Logic Blocking Method



[lotpssbl-040311-01.tif, 1, en_US]

Figure 6-361 Sending Logic for the Blocking Method

The blocking signal is generated on the activation of the distance protection in the **reverse** direction or **non-directionally**. The logic is designed in a phase-selective manner. With the parameter **(_:5731:101) Send prolongation**, you can extend the blocking signal. In this way, the opposite end can continue to be blocked, even if the fault has already been cleared locally.

The blocking signal can also be sent immediately with jump detection (parameter **(_:5731:102) Send with jump**). If the communication channel can react very quickly to the absence of the blocking signal, you can use this jump signal, because the jump signal appears for every jump in the dimensions. If the

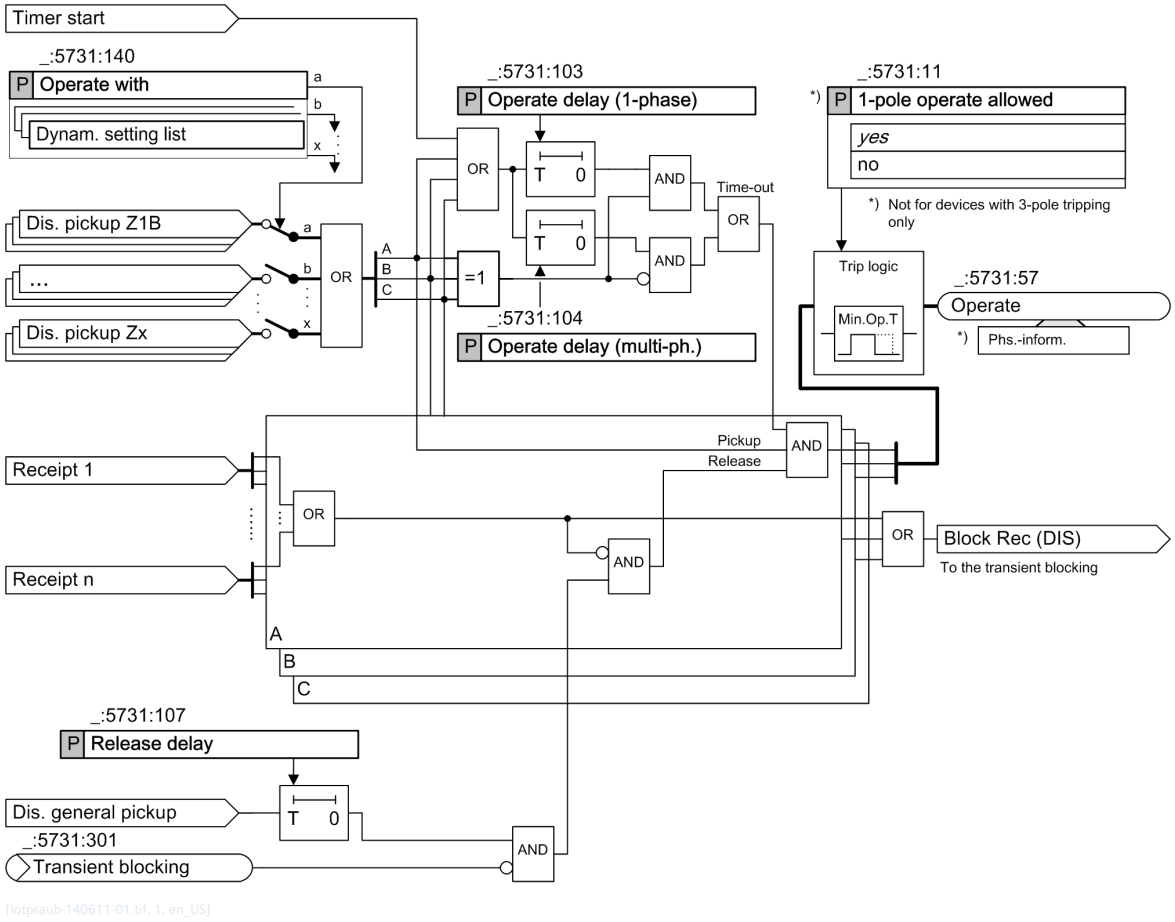
distance protection detects a fault in the forward direction, the blocking signal is stopped immediately and the indication **Stop** is generated.

For applications with 1-pole trip, the selectiveness of the blocking method for double faults can be improved on parallel lines if 3 phase-selective transmission signals are transferred per communication direction. Transmission and reception signals can therefore be used phase-specifically for A, B, and C or phase-jointly as individual signals.

Related Topics

6.18.8.1 Description

Trip Logic Blocking Method



[lotpsaub-140611-01.tif, 1, en_US]

Figure 6-362 Trip Logic for the Blocking Method

The distance protection provides the pickup information to the teleprotection scheme. The tripping for the relevant zone is undertaken by that teleprotection scheme with which the distance protection works together.

If a receive signal is not present, the zone that is set through the parameter **(_:5731:140) Operate with** will be released for tripping. The trip of the blocking method must be delayed due to possible differences in the pickup times of the devices at both cable ends and because of the transmission time. The time delay is set with the **(_:5731:107) Release delay** parameter.

Tripping can also be delayed . For 1-phase faults, set the time delay under **Operate delay (1-phase)**; for multi-phase faults, use the parameter **Operate delay (multi-ph.)**.

The trip indication therefore results when there is a simultaneous presence of the distance zone activation, the internal release signal and the time sequences.

No release of the trip occurs for an upcoming reception signal. The trip is blocked so that an activation in the selected overreaching zone in the forward direction does not quickly shut down the external fault at the remote end.

If the blocking method for the protection of a line configuration with more than 2 ends is used, the reception signals from all cable ends are combined with OR.

The **(_:5731:11) 1-pole operate allowed** parameter can be used to allow 1-pole tripping in 1-pole/3-pole tripping devices. This parameter does not apply to devices that only have 3-pole trip.

Measures in the Event of Weak Infeed

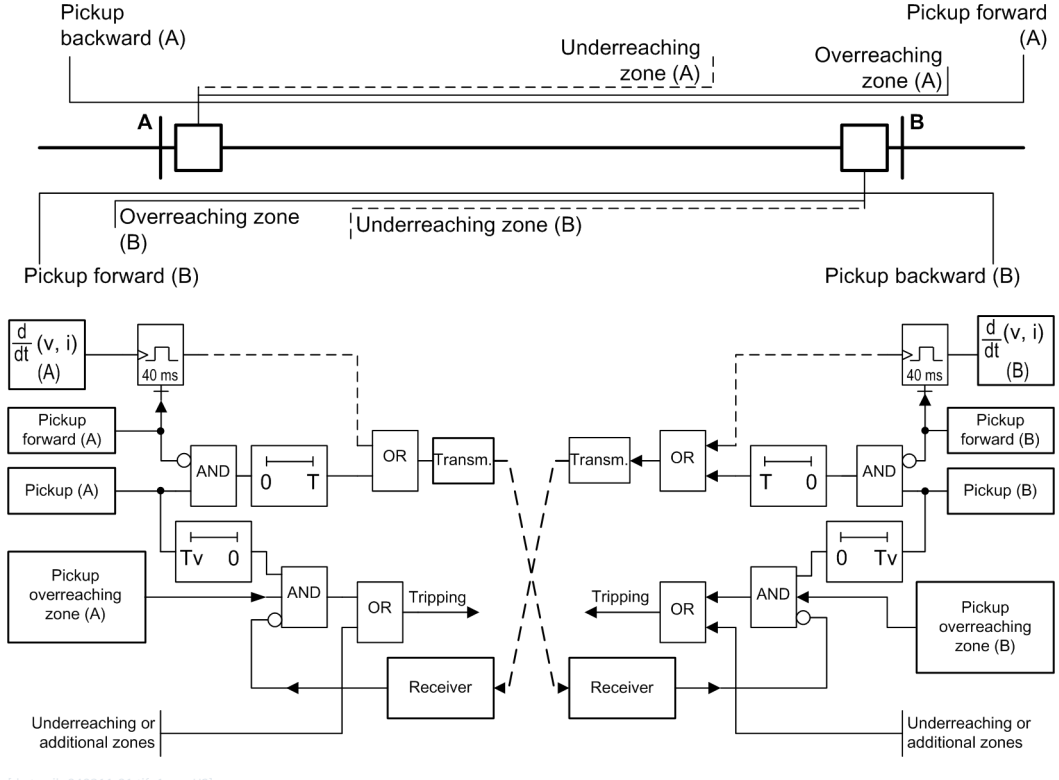
Owing to the process, there is no option in the blocking method for achieving a trip command release at weak infeed by the opposite end. Rather, the advantage of the blocking method lies in the fact that tripping can also occur rapidly at the infeed end without release, as no blocking signal can be formed from the non-feeding end.

6.18.6.2 Application and Setting Notes for the Blocking Method

The blocking method is used frequently:

- If the signal is transmitted with PLC[49] through the protected line and if the attenuation of the transmission signal at the fault location is so large that reception from the other line end cannot be guaranteed.
- For the protection of line configurations with more than 2 ends with different infeed

If the protection function detects a fault in the backward direction, a blocking signal is generated. If the other line end does not receive a blocking signal, the protection function trips in the event of a fault in the overreaching zone. For this, the overreaching zone must be set to approximately 120 % of the line length. In the case of multi-terminal lines, the overreach zone must extend over the longer line section, regardless of whether or not an additional infeed is possible via the branching point. Since no release signal is required from the opposite end, single infeed short circuits are quickly switched off with the blocking method.



[dwtpsrib-040311-01.tif, 1, en_US]

Figure 6-363 Function Diagram of the Direction Blocking Method

49 PLC = power-line carrier transmission

Requirements during Distance Protection

When using the blocking method, observe that the pickup of the distance protection in the backward direction must reach further than the overreach zone of the opposite end! For this purpose, at least one of the distance-protection stages must be set to *backward* or *non-directional*. If a fault has been removed in Z1B (after B) of the protection in A *Figure 6-363*, the distance protection in B must safely pick up in the backward direction, in order to be able to send a blocking signal from protection B to protection in A.

Parameter: Send with jump

- Recommended setting value **(_:5731:102) Send with jump** = ***Yes***

With the parameter **Send with jump**, you set whether the blocking signal is sent without delay with the jump detection. Siemens recommends using the fast blocking with jump and retaining the setting.

Parameter: Send prolongation

- Recommended setting value **(_:5731:101) Send prolongation** = ***0.05 s***

With the parameter **Send prolongation** in the transmission logic, you compensate the differences in the pickup and dropout times at both line ends. If SIPROTEC distance protection devices are used at all line ends, Siemens recommends the setting value ***0.05 s***.

Parameter: Operate delay (1-phase)

- Recommended setting value **(_:5731:103) Operate delay (1-phase)** = ***0.00 s***

With the parameter **Operate delay (1-phase)**, you set the tripping delay for 1-phase ground faults. Since the teleprotection scheme should lead to fast and selective tripping, Siemens recommends the setting value ***0.00 s***.

Parameter: Operate delay (multi-ph.)

- Recommended setting value **(_:5731:104) Operate delay (multi-ph.)** = ***0.00 s***

With the parameter **Operate delay (multi-ph.)**, you set the tripping delay for multi-phase faults. Since the teleprotection scheme should lead to fast and selective tripping, Siemens recommends the setting value ***0.00 s***.

Parameter: Operate with

- Recommended setting value **(_:5731:140) Operate with** = ***Z1B***

With the parameter **Operate with**, you select the overreaching distance zone. The overreaching distance zone is typically designated with Z1B. The selection texts are identical to the designations which you specify during the zone configuration in the function Distance protection. The selection text for the overreaching distance zone can therefore also be different from Z1B.

For applications in which the ranges for phase and ground faults are to be set differently, there are 2 overreaching distance zones. For example Z1B(Ph-E) then takes effect for ground faults and Z1B(Ph-Ph) for phase faults. In this case, you must select both zones as tripping zones.

Parameter: Release delay

- Recommended setting value **(_:5731:107) Release delay** = ***0.020 s***

With the parameter **Release delay**, you must set the release delay after a pickup. The trip of the blocking method must be delayed due to possible differences in the pickup times of the devices at both cable ends and because of the transmission time. Siemens recommends a setting value of ***0.020 s***.

6.18.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
85-21 Blocking				
_:5731:1	85-21 Blocking:Mode		• off • on • test	on
_:5731:101	85-21 Blocking:Send prolongation		0.00 s to 60.00 s	0.05 s
_:5731:102	85-21 Blocking:Send with jump		• no • yes	yes
_:5731:108	85-21 Blocking:Send phase segregated		• no • yes	no
_:5731:105	85-21 Blocking:Trans. blk. pickup delay		0.00 s to 60.00 s	0.02 s
_:5731:106	85-21 Blocking:Trans. blk. dropout delay		0.00 s to 60.00 s	0.05 s
_:5731:107	85-21 Blocking:Release delay		0.000 s to 60.000 s	0.020 s
_:5731:11	85-21 Blocking:1-pole operate allowed		• no • yes	yes
_:5731:103	85-21 Blocking:Operate delay (1-phase)		0.00 s to 60.00 s	0.00 s
_:5731:104	85-21 Blocking:Operate delay (multi-ph.)		0.00 s to 60.00 s	0.00 s
_:5731:140	85-21 Blocking:Operate with		Setting options depend on configuration	
_:5731:141	85-21 Blocking:Trans. block. with		Setting options depend on configuration	

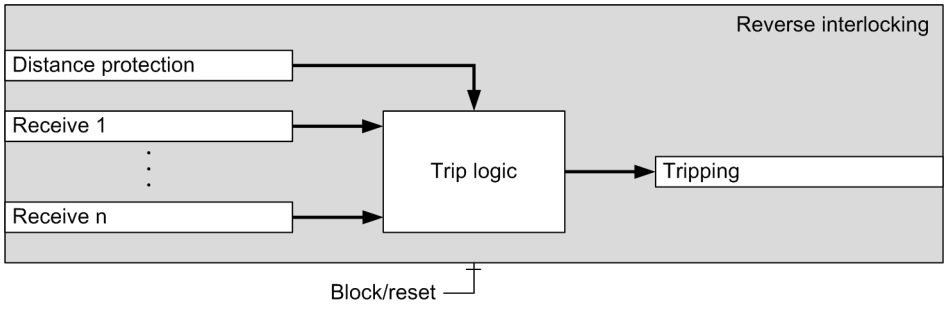
6.18.6.4 Information List

No.	Information	Data Class (Type)	Type
85-21 Blocking			
_:5731:81	85-21 Blocking:>Block stage	SPS	I
_:5731:54	85-21 Blocking:Inactive	SPS	O
_:5731:52	85-21 Blocking:Behavior	ENS	O
_:5731:53	85-21 Blocking:Health	ENS	O
_:5731:305	85-21 Blocking:Teleprot. blocking	ACT	O
_:5731:307	85-21 Blocking:Stop	ACT	O
_:5731:301	85-21 Blocking:Transient blocking	SPS	O
_:5731:56	85-21 Blocking:Operate delay expired	ACT	O
_:5731:57	85-21 Blocking:Operate	ACT	O
Rec. bin.sig.1			
_:5851:52	Rec. bin.sig.1:Behavior	ENS	O
_:5851:53	Rec. bin.sig.1:Health	ENS	O
_:5851:501	Rec. bin.sig.1:>Receive phs A	SPS	I
_:5851:502	Rec. bin.sig.1:>Receive phs B	SPS	I
_:5851:503	Rec. bin.sig.1:>Receive phs C	SPS	I

No.	Information	Data Class (Type)	Type
_:5851:504	Rec. bin.sig.1:>Receive general	SPS	I
_:5851:505	Rec. bin.sig.1:>Receive failure	SPS	I

6.18.7 Reverse Interlocking

6.18.7.1 Description

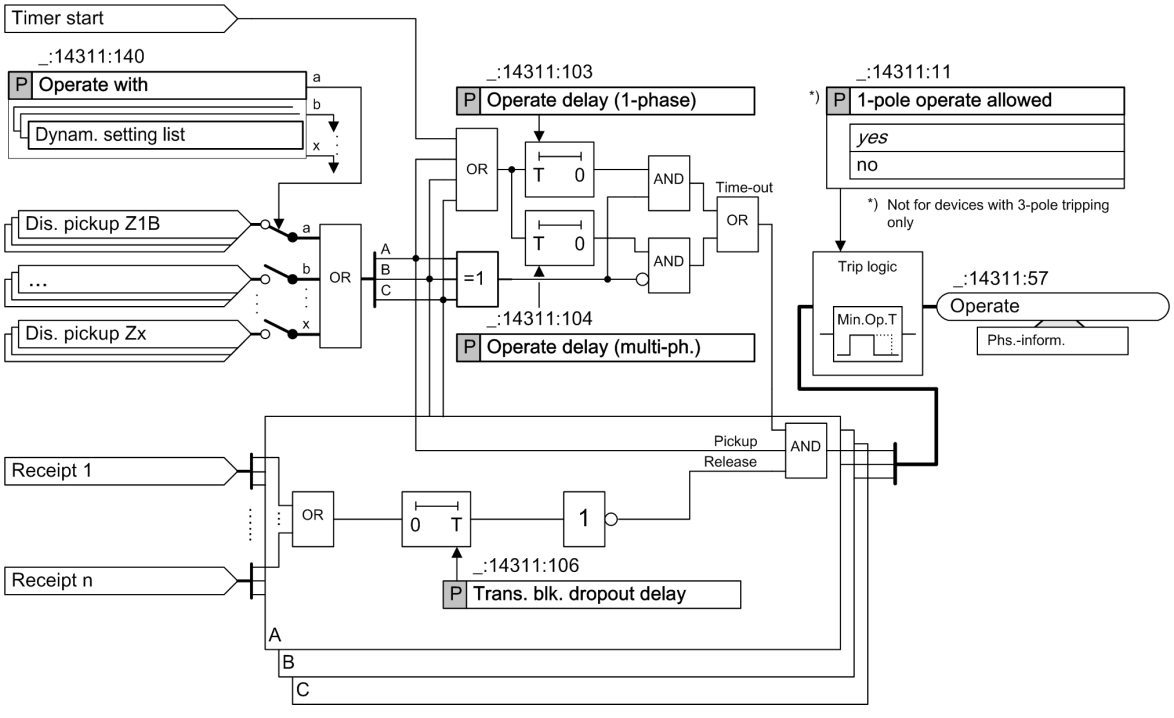


[dwtpsrwv-260613-01.tif, 2, en_US]

Figure 6-364 Function Block: Reverse Interlocking (85-21 Rev. interlock.)

If a fault occurs within the crossover zone and none of the subordinate protection devices transmits a blocking signal, this will initiate tripping of reverse interlocking.

Trip Logic Reverse Interlocking



[loruever-260613-01.tif, 1, en_US]

Figure 6-365 Trip Logic for Reverse Interlocking

The distance protection provides the pickup information to the teleprotection scheme. The tripping for the relevant zone is undertaken by that teleprotection scheme with which the distance protection works together.

If a receive signal is not present, the zone that is set through the parameter **(_:14311:140) Operate with** will be released for tripping.

The tripping can be delayed. For 1-phase faults, set the time delay under **Operate delay (1-phase)**; for multi-phase faults, use the **Operate delay (multi-ph.)** parameter.

The trip indication therefore results when there is a simultaneous presence of the distance zone activation, the internal release signal and the time sequences.

If a receiving signal is pending, tripping will be blocked in order to ensure that a pickup in the selected crossover zone does not disconnect quickly the short circuit on the outbound line.

If the Reverse interlocking function is used with several receiving blocks, the receiving signals from all receiving blocks will be linked with OR.

The **(_:14311:11) 1-pole operate allowed** parameter can be used by the trip logic to allow 1-pole tripping in 1-pole/3-pole tripping devices. If the device is capable of only 3-pole tripping, the parameter **1-pole operate allowed** does not apply and is not visible.

6.18.7.2 Application and Setting Notes for Reverse Interlocking

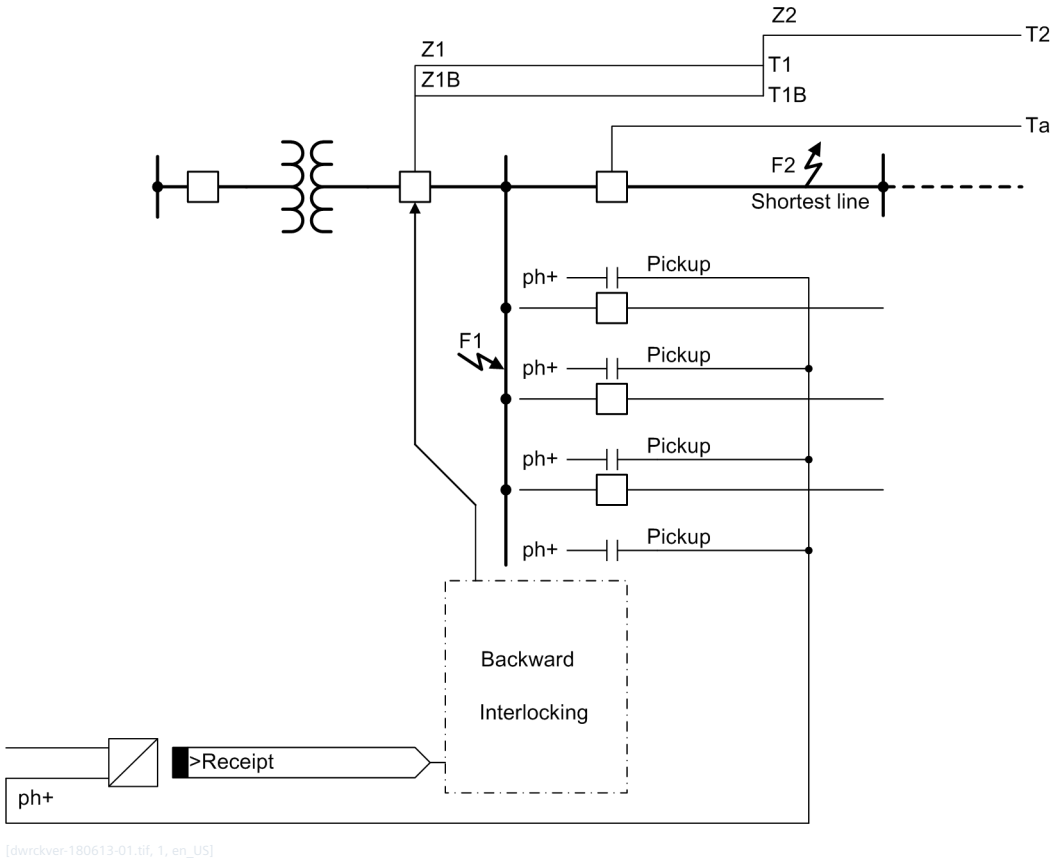
If the distance protection is used as backward protection at a transformer tap fed in from one side, you can protect the busbar via reverse interlocking via quick-operating time. The selectivity of the distance protection for faults on outgoing lines will not be jeopardized.

The distance zones **Z1** and **Z2** according to *Figure 6-366* serve as reserve stage for errors on the out-bound lines, for example, in **F2**. Consider the shortest following line for distance staggering.

Typically, the crossover zone **Z1B** provides the pickup information for the reverse interlocking. The time delay for the reverse interlocking must be set higher than the pickup time **Ta** of the protection devices on the out-bound lines. In the event of subordinate protection pickup, tripping of the reverse interlocking is blocked. The pickup signals of the subordinate protection devices will be transmitted as receiving signal to reverse interlocking (see *Figure 6-366*). If none of the subordinate protection devices picks up, reverse interlocking generates a operate indication. This enables quick disconnection in the following scenarios:

- Short circuit on the busbar, for example, in **F1**
- If the circuit breaker fails during a fault in **F2**.

If the pickup signals of the subordinate protection devices drop faster than the pickup of the selected cross-over zones, the transient blocking time prevents an unwanted tripping of the reverse interlocking.



[dwrckver-180613-01.tif, 1, en_US]

Figure 6-366 Functional Schematic of Reverse Interlocking

Parameter: Operate delay (1-phase)

- Recommended setting value **(_:14311:103) Operate delay (1-phase)** = ***0.04 s***

You can use the **Operate delay (1-phase)** parameter to set the tripping delay for 1-phase ground faults. Due to possible differences in the pickup times of the devices and due to signal transmission times, tripping of the reverse interlocking must be delayed. Siemens recommends a setting of ***0.04 s***.

Parameter: Operate delay (multi-ph.)

- Recommended setting value **(_:14311:104) Operate delay (multi-ph.)** = ***0.04 s***

You can use the **Operate delay (multi-ph.)** parameter to set the tripping delay for multi-phase faults. Due to possible differences in the pickup times of the devices and due to signal transmission times, tripping of the reverse interlocking must be delayed. Siemens recommends a setting of ***0.04 s***.

Parameter: Operate with

- Recommended setting value **(_:14311:140) Operate with** = ***Z1B***

With the **Operate with** parameter, you can select the overreaching distance zone. The overreaching distance zone is typically designated with Z1B. The selection texts are identical to the designations which you specify during the zone configuration in the distance protection function. The selection text for the overreaching distance zone can therefore also be different from Z1B.

For applications in which the ranges for phase and ground faults are to be set differently, there are 2 overreaching distance zones. For example, Z1B(L-E) takes effect for ground faults and Z1B(L-L) for phase faults. In this case, you must select both zones as tripping zones.

Parameter: Trans. blk. dropout delay

- Recommended setting value **(_:14311:106) Trans. blk. dropout delay** = ***0.05 s***

With the **Trans. blk. dropout delay** parameter, you can determine the duration of the transient blocking. Set the **Trans. blk. dropout delay** to prevent an unwanted tripping of the reverse interlocking during a fast dropout of the pickup signal of the protection devices. Siemens recommends a setting of ***0.05 s***.

6.18.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
85-21Rev.interlock				
_:14311:1	85-21Rev.interlock:Mode		• off • on • test	on
_:14311:106	85-21Rev.interlock:Trans. blk. dropout delay		0.00 s to 60.00 s	0.05 s
_:14311:11	85-21Rev.interlock:1-pole operate allowed		• no • yes	yes
_:14311:103	85-21Rev.interlock:Operate delay (1-phase)		0.00 s to 60.00 s	0.04 s
_:14311:104	85-21Rev.interlock:Operate delay (multi-ph.)		0.00 s to 60.00 s	0.04 s
_:14311:140	85-21Rev.interlock:Operate with		Setting options depend on configuration	

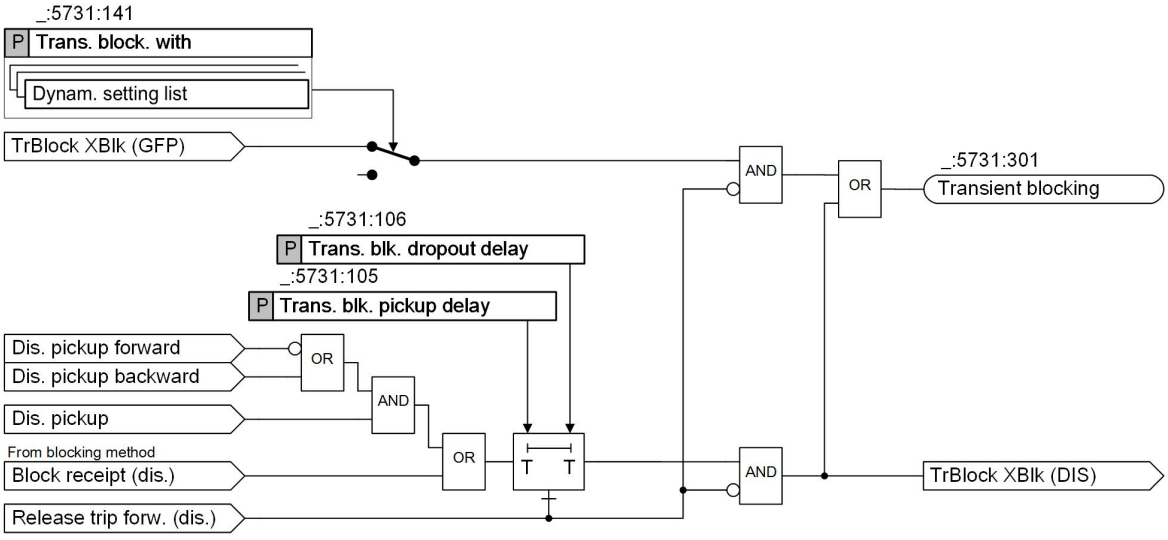
6.18.7.4 Information List

No.	Information	Data Class (Type)	Type
85-21Rev.interlock			
_:14311:81	85-21Rev.interlock:>Block stage	SPS	I
_:14311:54	85-21Rev.interlock:Inactive	SPS	O
_:14311:52	85-21Rev.interlock:Behavior	ENS	O
_:14311:53	85-21Rev.interlock:Health	ENS	O
_:14311:56	85-21Rev.interlock:Operate delay expired	ACT	O
_:14311:57	85-21Rev.interlock:Operate	ACT	O
_:14311:347	85-21Rev.interlock:Function on	SPC	C
Rec. bin.sig.1			
_:5851:52	Rec. bin.sig.1:Behavior	ENS	O
_:5851:53	Rec. bin.sig.1:Health	ENS	O
_:5851:501	Rec. bin.sig.1:>Receive phs A	SPS	I
_:5851:502	Rec. bin.sig.1:>Receive phs B	SPS	I
_:5851:503	Rec. bin.sig.1:>Receive phs C	SPS	I
_:5851:504	Rec. bin.sig.1:>Receive general	SPS	I
_:5851:505	Rec. bin.sig.1:>Receive failure	SPS	I

6.18.8 Transient Blocking

6.18.8.1 Description

Transient blocking provides additional security from fault signals caused by a change of direction after disconnection of external faults, on parallel lines for example. The transient blocking is used for blocking and permissive overreach transfer trips, but not for a permissive underreach transfer trip.



[lotpstrb-310511-01.tif, 3, en_US]

Figure 6-367 Logic Diagram of the Transient Blocking

If a pickup in the reverse direction or non-directionally is present (non-forward fault), the transient blocking occurs after a waiting period **`Trans. blk. pickup delay`**. The *`Transient blocking`* signal has an effect on send and trip logic of the permissive overreach transfer trips as well as on the trip logic of the blocking method. After the elimination of the blocking criterion, the transient blocking will be maintained for a set time **`Trans. blk. dropout delay`**. If a trip command is generated in the underreaching zone during a transient blocking (signal **Release Trip forward (DIS)**, the transient blocking time is triggered. In this way, the blocking of the teleprotection in the event of an internal fault is prevented.

The teleprotection schemes for distance protection and ground-fault protection can affect one another. Use the **`Trans. block. with`** parameter to set whether the transient blocking of the teleprotection scheme for the ground-fault protection is to affect that of the distance protection. The reciprocal influence is advisable if the teleprotection schemes for distance protection and ground-fault protection work with a common communication channel.

6.18.8.2 Application and Setting Notes for Transient Blocking

Trans. Block through

- Default setting **`(_:5731:141) Trans. block. with`** = ***`EF: TrBlock XBlk`***

Set the parameter **`Trans. block. with`** to ***`EF: TrBlock XBlk`***, if the teleprotection scheme for the distance protection works on the same communication channel as a teleprotection scheme for the ground-fault protection. Set the parameter to ***`invalid`*** if you are using separate communication channels. If no teleprotection scheme is used for the ground-fault protection, it will not be possible to set the settings and the link will be automatically deactivated.

Parameter: Trans. blk. pickup delay

- Recommended setting value **`(_:5731:105) Trans. blk. pickup delay`** = ***`0.02 s`***

With the parameter **`Trans. blk. pickup delay`**, you set how long a reverse or non-directional pickup should remain before the transient blocking occurs. Siemens recommends a setting value of ***`0.02 s`***.

NOTE

The time **Trans. blk. pickup delay** may not be set to zero. This makes sure that the transient-blocking time **Trans. blk. dropout delay** is not already started if the directional information comes in a delayed manner compared to the function pickup. Depending on the time of the circuit breaker on the parallel line or the circuit breaker lying in a reverse direction, settings between 10 ms and 20 ms are recommended.

Parameter: Trans. blk. dropout delay

- Recommended setting value **(_:5731:106) Trans. blk. dropout delay** = ***0.05 s***

With the parameter **Trans. blk. dropout delay**, you determine the duration of the transient blocking. The time must be set longer than the duration of the transient compensation methods for the occurrence or switching of exterior short circuits.

6.19 Universal Teleprotection with Distance Protection

6.19.1 Overview of Functions

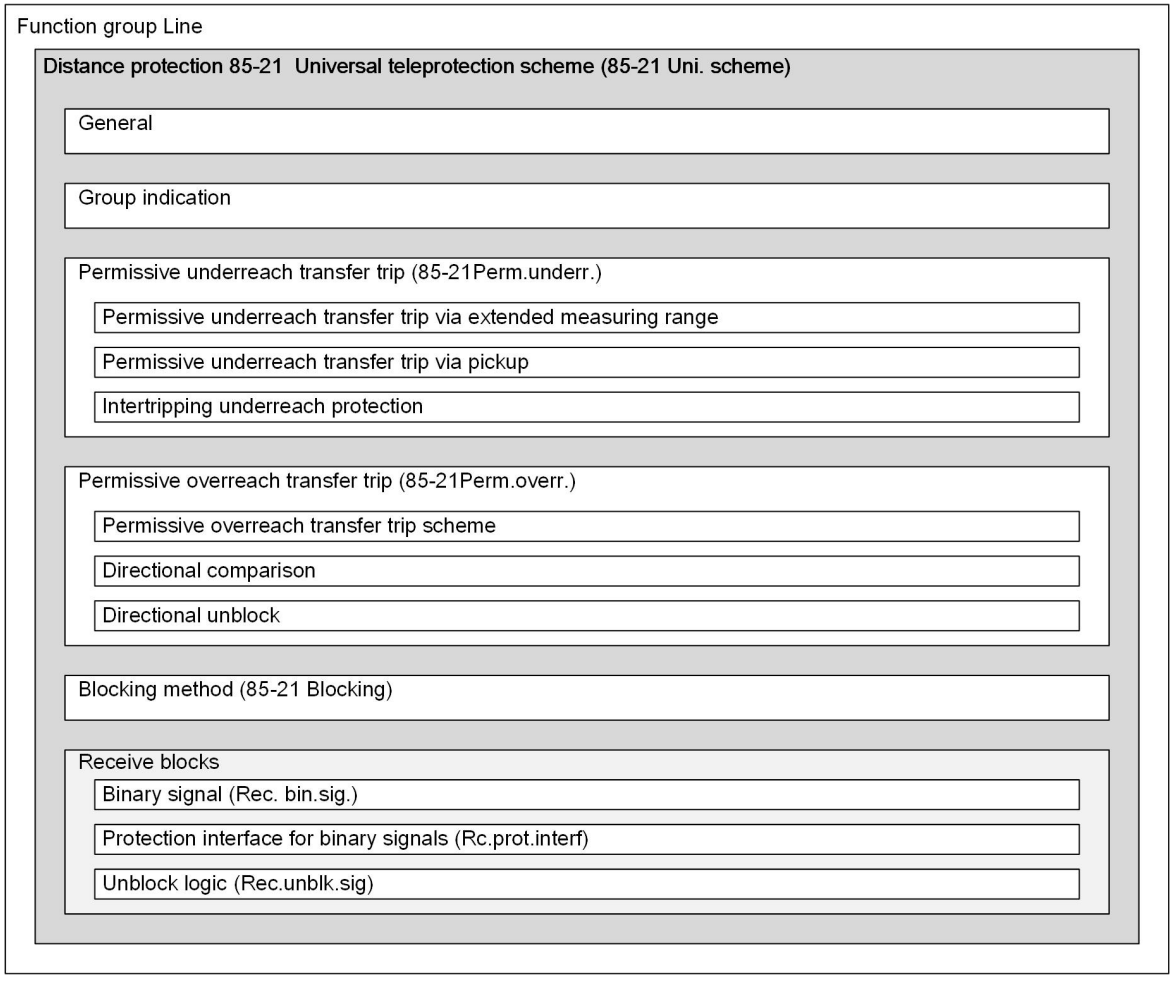
The universal teleprotection with distance protection (**85-21 Uni. scheme**) include the same functionalities as described in *6.18 Teleprotection with Distance Protection*. The difference is that all functionalities, except the scheme **85-21 Rev. interlock.**, are compactly grouped together within the function **85-21 Uni. scheme**. This can be an advantage if a switchover of the functionalities using settings changes is desired.

Since there are no functional differences between the teleprotection scheme with distance protection, only the special features are described in the following.

6.19.2 Structure of the Function

The function **85-21 Uni. scheme** is used in the function group **Line** in combination with the function Distance protection.

The functions shown in the following figure are available:



[dw_funct-line_universal, 1, en_US]

Figure 6-368 Structure/Embedding of the Function

In addition to the individual teleprotection with distance protection schemes, the universal teleprotection schemes contain the function blocks (FBs) **General** and **Group indicat.**.

You will find the function **85-21 Uni. scheme** in the DIGSI library under **FG Line** > **Teleprotection scheme** > **DIS universal scheme**.

The following functionalities are preinstantiated when the function **85-21 Uni. scheme** is instantiated:

- FB **General**
- FB **Group indicat.**
- FB **Permissive underreach transfer trip** (**85-21Perm.unde**)
- FB **Permissive scheme** (**85-21Perm.over**)
- FB **Blocking method** (**85-21 Blocking**)
- FB **Receive block for binary signal 1** (**Rec. bin.sig.** 1)
- FB **Receive block for binary signal 2** (**Rec. bin.sig.** 2)
- FB **Receive block, protection interface for binary signals** (**Rec. PI**)

The function blocks have the following properties:

Function Block	Deletable	Number of Instances	Default Setting, Mode
General	No	1	On
Group indicat.	No	1	On (cannot be changed)
85-21Perm.unde	Yes	5	Off
85-21Perm.over	Yes	5	Off
85-21 Blocking	Yes	5	Off
Rec. bin.sig.	Yes	5	Off
Rec. PI	Yes	1	Off
Rec.unblk.sig	Yes	5	Off

NOTE

As most function blocks are deactivated following preinstantiation, Siemens recommends checking these default settings.

NOTE

In contrast to the individual teleprotection schemes with distance protection, the function blocks **Rec. bin.sig.**, **Rec. PI** and **Rec.unblk.sig** have the parameter **Mode** and appear for this reason in the configuration view.

FB General

With the parameter **General** FB, you can power the function **85-21 Uni. scheme** on and off via the **Mode** parameter or the **Mode (controllable)** controllable.

In addition, the general indications of the function **85-21 Uni. scheme** are made available.

FB Group indicat.

The FB **Group indicat.** the information of all permissive underreach transfer trips, permissive schemes and blocking methods in one central location. If you are using several teleprotection schemes and you can switch between them using parameter changes, you can simplify the routing of indications in this way.

For more information about the teleprotection scheme, see:

- *6.18.4 Permissive Underreach Transfer Trip*
- *6.10.4 Permissive Overreach Transfer Trip*

- *6.10.5 Blocking Method*
- *6.19.3 Receive Blocks*

6.19.3 Receive Blocks

Several receive blocks **Rec. bin.sig.** as well as the receive block **Rec. PI** can be present at the same time.

If the line ends communicate using binary signals, the necessary receive blocks are connected to ***on*** via the **Mode** parameter. If a teleprotection scheme is configured, for example, with a total of 3 ends, exactly 2 receive blocks must be activated. All additional receive blocks that can be installed, even the **Rec. PI** receive block, must be deactivated.

If the line ends are to communicate via a protection interface, you must activate the **Rec. PI** receive block. All other receive blocks must be deactivated. A mixture of communication to the line ends using a protection interface and binary signals is not possible.

For more information on the operation of receive blocks, see *6.18.3 Receive Blocks*.

6.19.4 Application

The universal teleprotection with distance protection allows you to create a common configuration for several use cases. If, for example, you want to use permissive underreach transfer trip across an expanded measuring range and permissive underreach transfer trip by way of pickup in your plants, you can instantiate the permissive underreach transfer trip twice in the universal teleprotection scheme and configure it appropriately for each application. For the specific use in a plant, you simply need to switch the desired scheme to ***on*** via the **Mode** parameter.

It is equally possible to create a common configuration for the different options of communication with the other line ends. If you have plants with, for example, both 2 and 3 ends and either binary signals or a protection interface are used for communication, you can create 2 **Rec. bin.sig.** receive blocks as well as one **Rec. PI** receive block for this purpose, set their parameters appropriately and route the indications. The receive blocks needed for the specific use are switched to ***on*** via the **Mode** parameter.

For communication using the protection interface, you set the identity and the number of devices participating in the teleprotection scheme for the protection of the line configuration by using the configuration of the protection interface. For more information, see *3.6.5.4 Configuration of the Protection Interface in DIGSI 5* or *3.6.6.4 Configuration of the Advanced Protection Communication in DIGSI 5*.

6.19.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:25111:1	General:Mode		• off • on • test	on
85-21 Blocking				
_:5731:1	85-21 Blocking:Mode		• off • on • test	off
_:5731:101	85-21 Blocking:Send prolongation		0.00 s to 60.00 s	0.05 s
_:5731:102	85-21 Blocking:Send with jump		• no • yes	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:5731:108	85-21 Blocking:Send phase segregated		• no • yes	no
_:5731:105	85-21 Blocking:Trans. blk. pickup delay		0.00 s to 60.00 s	0.02 s
_:5731:106	85-21 Blocking:Trans. blk. dropout delay		0.00 s to 60.00 s	0.05 s
_:5731:107	85-21 Blocking:Release delay		0.000 s to 60.000 s	0.020 s
_:5731:11	85-21 Blocking:1-pole operate allowed		• no • yes	yes
_:5731:103	85-21 Blocking:Operate delay (1-phase)		0.00 s to 60.00 s	0.00 s
_:5731:104	85-21 Blocking:Operate delay (multi-ph.)		0.00 s to 60.00 s	0.00 s
_:5731:140	85-21 Blocking:Operate with		Setting options depend on configuration	
_:5731:141	85-21 Blocking:Trans. block. with		Setting options depend on configuration	
85-21Perm.over				
_:5701:1	85-21Perm.over:Mode		• off • on • test	off
_:5701:101	85-21Perm.over:Send prolongation		0.00 s to 60.00 s	0.05 s
_:5701:102	85-21Perm.over:Send delay		0.00 s to 60.00 s	0.00 s
_:5701:105	85-21Perm.over:Trans. blk. pickup delay		0.00 s to 60.00 s	0.02 s
_:5701:106	85-21Perm.over:Trans. blk. dropout delay		0.00 s to 60.00 s	0.05 s
_:5701:11	85-21Perm.over:1-pole operate allowed		• no • yes	yes
_:5701:103	85-21Perm.over:Operate delay (1-phase)		0.00 s to 60.00 s	0.00 s
_:5701:104	85-21Perm.over:Operate delay (multi-ph.)		0.00 s to 60.00 s	0.00 s
_:5701:140	85-21Perm.over:Send with		Setting options depend on configuration	
_:5701:141	85-21Perm.over:Operate with		Setting options depend on configuration	
_:5701:142	85-21Perm.over:Trans. block. with		Setting options depend on configuration	
85-21Perm.unde				
_:5671:1	85-21Perm.unde:Mode		• off • on • test	off
_:5671:101	85-21Perm.unde:Send prolongation		0.00 s to 60.00 s	0.05 s

Addr.	Parameter	C	Setting Options	Default Setting
_:5671:11	85-21Perm.unde:1-pole operate allowed		• no • yes	yes
_:5671:102	85-21Perm.unde:Operate delay (1-phase)		0.00 s to 60.00 s	0.00 s
_:5671:103	85-21Perm.unde:Operate delay (multi-ph.)		0.00 s to 60.00 s	0.00 s
_:5671:140	85-21Perm.unde:Send with		Setting options depend on configuration	
_:5671:141	85-21Perm.unde:Operate with		Setting options depend on configuration	
Rec. bin.sig.1				
_:5851:1	Rec. bin.sig.1:Mode		• off • on • test	off
Rec. bin.sig.2				
_:5852:1	Rec. bin.sig.2:Mode		• off • on • test	off
Rec. PI1				
_:5911:1	Rc.prot.interf:Mode		• off • on • test	off

6.19.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:25111:81	General:>Block stage	SPS	I
_:25111:51	General:Mode (controllable)	ENC	C
_:25111:54	General:Inactive	SPS	O
_:25111:52	General:Behavior	ENS	O
_:25111:53	General:Health	ENS	O
Group indicat.			
_:9061:303	Group indicat.:Operate	ACT	O
_:9061:302	Group indicat.:Operate delay expired	ACT	O
_:9061:304	Group indicat.:Teleprot. blocking	ACT	O
_:9061:305	Group indicat.:Stop	ACT	O
_:9061:301	Group indicat.:Transient blocking	SPS	O
_:9061:308	Group indicat.:Send	ACT	O
_:9061:306	Group indicat.:Send signal is echo	SPS	O
_:9061:307	Group indicat.:Weak infeed trip oper.	SPS	O
_:9061:52	Group indicat.:Behavior	ENS	O
_:9061:53	Group indicat.:Health	ENS	O
85-21 Blocking			
_:5731:81	85-21 Blocking:>Block stage	SPS	I
_:5731:51	85-21 Blocking:Mode (controllable)	ENC	C

No.	Information	Data Class (Type)	Type
_:5731:54	85-21 Blocking:Inactive	SPS	O
_:5731:52	85-21 Blocking:Behavior	ENS	O
_:5731:53	85-21 Blocking:Health	ENS	O
_:5731:305	85-21 Blocking:Teleprot. blocking	ACT	O
_:5731:307	85-21 Blocking:Stop	ACT	O
_:5731:301	85-21 Blocking:Transient blocking	SPS	O
_:5731:56	85-21 Blocking:Operate delay expired	ACT	O
_:5731:57	85-21 Blocking:Operate	ACT	O
_:5731:347	85-21 Blocking:Function on	SPC	C
85-21Perm.over			
_:5701:81	85-21Perm.over:>Block stage	SPS	I
_:5701:501	85-21Perm.over:>Blocking echo	SPS	I
_:5701:502	85-21Perm.over:>Blk. weak infeed trip	SPS	I
_:5701:51	85-21Perm.over:Mode (controllable)	ENC	C
_:5701:54	85-21Perm.over:Inactive	SPS	O
_:5701:52	85-21Perm.over:Behavior	ENS	O
_:5701:53	85-21Perm.over:Health	ENS	O
_:5701:305	85-21Perm.over:Send	ACT	O
_:5701:302	85-21Perm.over:Send signal is echo	SPS	O
_:5701:303	85-21Perm.over:Weak infeed trip oper.	SPS	O
_:5701:301	85-21Perm.over:Transient blocking	SPS	O
_:5701:56	85-21Perm.over:Operate delay expired	ACT	O
_:5701:57	85-21Perm.over:Operate	ACT	O
_:5701:347	85-21Perm.over:Function on	SPC	C
85-21Perm.unde			
_:5671:81	85-21Perm.unde:>Block stage	SPS	I
_:5671:501	85-21Perm.unde:>Blocking echo	SPS	I
_:5671:502	85-21Perm.unde:>Blk. weak infeed trip	SPS	I
_:5671:51	85-21Perm.unde:Mode (controllable)	ENC	C
_:5671:54	85-21Perm.unde:Inactive	SPS	O
_:5671:52	85-21Perm.unde:Behavior	ENS	O
_:5671:53	85-21Perm.unde:Health	ENS	O
_:5671:304	85-21Perm.unde:Send	ACT	O
_:5671:301	85-21Perm.unde:Send signal is echo	SPS	O
_:5671:302	85-21Perm.unde:Weak infeed trip oper.	SPS	O
_:5671:56	85-21Perm.unde:Operate delay expired	ACT	O
_:5671:57	85-21Perm.unde:Operate	ACT	O
_:5671:347	85-21Perm.unde:Function on	SPC	C
Rec. bin.sig.1			
_:5851:52	Rec. bin.sig.1:Behavior	ENS	O
_:5851:53	Rec. bin.sig.1:Health	ENS	O
_:5851:301	Rec. bin.sig.1:Received	ACT	O
_:5851:501	Rec. bin.sig.1:>Receive phs A	SPS	I
_:5851:502	Rec. bin.sig.1:>Receive phs B	SPS	I
_:5851:503	Rec. bin.sig.1:>Receive phs C	SPS	I
_:5851:504	Rec. bin.sig.1:>Receive general	SPS	I

No.	Information	Data Class (Type)	Type
_:5851:505	Rec. bin.sig.1:>Receive failure	SPS	I
Rec. bin.sig.2			
_:5852:52	Rec. bin.sig.2:Behavior	ENS	O
_:5852:53	Rec. bin.sig.2:Health	ENS	O
_:5852:301	Rec. bin.sig.2:Received	ACT	O
_:5852:501	Rec. bin.sig.2:>Receive phs A	SPS	I
_:5852:502	Rec. bin.sig.2:>Receive phs B	SPS	I
_:5852:503	Rec. bin.sig.2:>Receive phs C	SPS	I
_:5852:504	Rec. bin.sig.2:>Receive general	SPS	I
_:5852:505	Rec. bin.sig.2:>Receive failure	SPS	I
Rec. PI1			
_:5911:52	Rc.prot.interf:Behavior	ENS	O
_:5911:53	Rc.prot.interf:Health	ENS	O
_:5911:301	Rc.prot.interf:Rec. from device 1	ACT	O
_:5911:302	Rc.prot.interf:Rec. from device 2	ACT	O
_:5911:303	Rc.prot.interf:Rec. from device 3	ACT	O
_:5911:304	Rc.prot.interf:Rec. from device 4	ACT	O
_:5911:305	Rc.prot.interf:Rec. from device 5	ACT	O
_:5911:306	Rc.prot.interf:Rec. from device 6	ACT	O
_:5911:307	Rc.prot.interf:Receive failure	SPS	O

6.20 External Trip Initiation 3-Pole

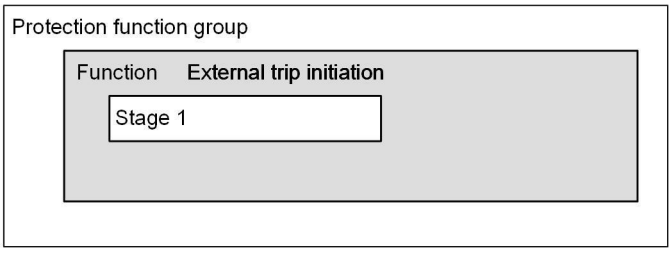
6.20.1 Overview of Functions

The **External trip initiation** function:

- Processes any signals from external protection or supervision devices
- Enables the integration of any signals from external protection equipment in the indication and tripping processing, for example from transient ground-fault relays or Buchholz protection
- Enables direct tripping of the circuit breaker in conjunction with busbar-protection applications
- Enables direct tripping of the circuit breaker in the case of circuit-breaker failure at the other line end

6.20.2 Structure of the Function

The function **External trip initiation** includes one stage. You can instantiate the **External trip initiation** function in DIGSI 5 multiple times.

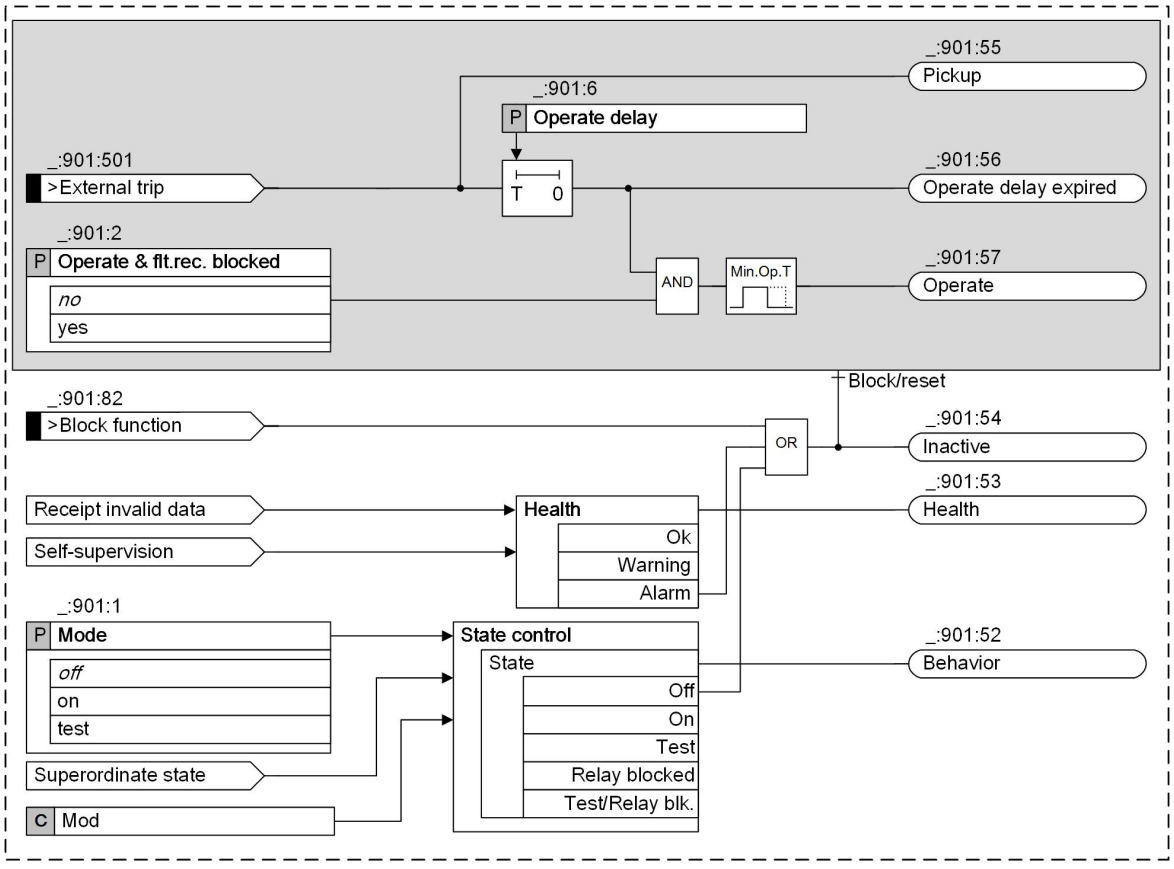


[dw_strext, 2, en_US]

Figure 6-369 Structure/Embedding of the Function

6.20.3 Stage Description

Logic of the Stage



[lo_ext-trip-initiation, 3, en_US]

Figure 6-370 Logic Diagram for the External Trip-Initiation Stage

Binary Input Signal >External Trip

The binary input signal **>External trip** starts the **Pickup** and the **Operate delay**.

Blocking the Stage

The stage can be switched to ineffective via a number of signals. If the stage is in the pickup state at the time of blocking, it will be immediately reset. However, the operate indication remains stopped for the minimum operating time **(_:102) Minimum operate time**.

6.20.4 Application and Setting Notes

Parameter: Operate delay

- Recommended setting value **(_:901:6) Operate delay** = ***0.00 s***

The **Operate delay** parameter must be set for the specific application. After expiry of the **Operate delay** the time-out and tripping are signaled. The duration of the initiation signal as well as the adjustable minimum command time determine the signal duration of the **Operate**.

6.20.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:901:1	Stage 1:Mode		• off • on • test	on
_:901:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:901:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.00 s

6.20.6 Information List

No.	Information	Data Class (Type)	Type
Stage 1			
_:901:82	Stage 1:>Block function	SPS	I
_:901:501	Stage 1:>External trip	SPS	I
_:901:54	Stage 1:Inactive	SPS	O
_:901:52	Stage 1:Behavior	ENS	O
_:901:53	Stage 1:Health	ENS	O
_:901:55	Stage 1:Pickup	ACD	O
_:901:56	Stage 1:Operate delay expired	ACT	O
_:901:57	Stage 1:Operate	ACT	O

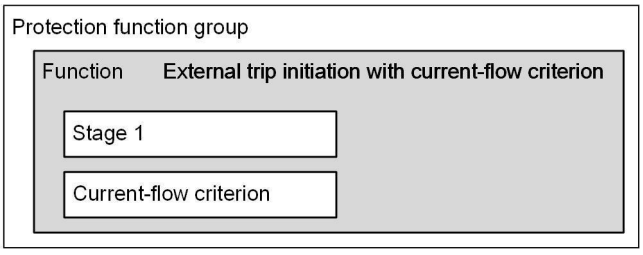
6.21 External Trip Initiation with Current-Flow Criterion 3-Pole

6.21.1 Overview of Functions

The **External trip initiation with current-flow criterion** function enables the use of a current-flow criterion. Otherwise, the function operates as the **External trip initiation** (see *6.20.1 Overview of Functions*).

6.21.2 Structure of the Function

The **External trip initiation with current-flow criterion** function contains 2 fixed steps. You can instantiate the **External trip initiation with current-flow criterion** function in DIGSI 5 multiple times.

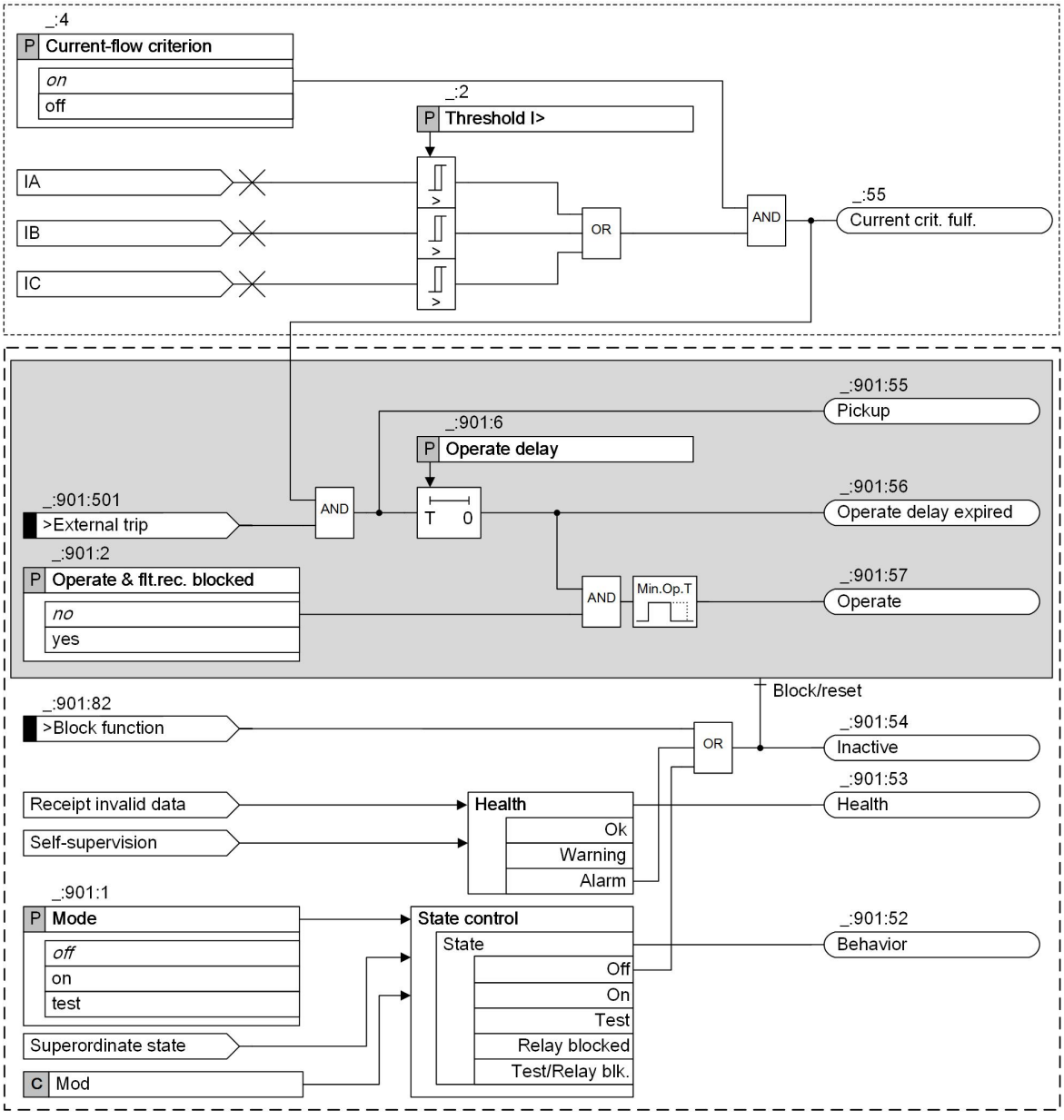


[dw_strext_CfC-051021, 1, en_US]

Figure 6-371 Structure/Embedding of the Function

6.21.3 Stage Description

Stage Logic



[lo_ext-trip-initiation_CFC, 1, en_US]

Figure 6-372 Logic Diagram of the Stage External Trip Initiation with Threshold Value I>

Binary Input Signal >External Trip

The binary input signal **>External trip** starts the **Pickup** and the **Operate delay**.

Blocking the Stage

The stage can be switched to ineffective via a number of signals. If the stage is in the activate state at the time of blocking, it will be immediately reset. However, the operate indication remains for the minimum operating time **(_:102) Minimum operate time**.

6.21.4 Application and Setting Notes

Parameter: Operate delay

- Recommended setting value **(_:901:6) Operate delay** = *0.00 s*

The **Operate delay** parameter must be set for the specific application. After the expiry of the **Operate delay**, the time-out and tripping are signaled. The duration of the initiation signal and the adjustable minimum command time determine the signal duration of the **Operate**.

Parameter: Current-flow criterion

- Recommended setting value **(_:4) Current-flow criterion** = *on*

With the parameter **Current-flow criterion**, you can switch off the stage. When switched off, the external trip initiation can work without current criterion.

Parameter: Threshold I>

- Recommended setting value **(_:2) Threshold I>** = *0.05 A*

The **Threshold I>** parameter must be set for the specific application. The tripping is only output if the current exceeds the **threshold value I>**. This is also signaled by *(_:55) Current crit. fulf.*.

6.21.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:901:1	Stage 1:Mode		• off • on • test	on
_:901:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:901:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.00 s
Curr.criterion				
_:4	Curr.criterion:Current-flow criterion		• off • on	on
_:2	Curr.criterion:Threshold I>	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A

6.21.6 Information List

No.	Information	Data Class (Type)	Type
Stage 1			
_:901:82	Stage 1:>Block function	SPS	I
_:901:501	Stage 1:>External trip	SPS	I
_:901:51	Stage 1:Mode (controllable)	ENC	C
_:901:54	Stage 1:Inactive	SPS	O

No.	Information	Data Class (Type)	Type
_:901:52	Stage 1:Behavior	ENS	O
_:901:53	Stage 1:Health	ENS	O
_:901:55	Stage 1:Pickup	ACD	O
_:901:56	Stage 1:Operate delay expired	ACT	O
_:901:57	Stage 1:Operate	ACT	O
Curr.criterion			
_:51	Curr.criterion:Mode (controllable)	ENC	C
_:52	Curr.criterion:Behavior	ENS	O
_:53	Curr.criterion:Health	ENS	O
_:55	Curr.criterion:Current crit. fulf.	SPS	O

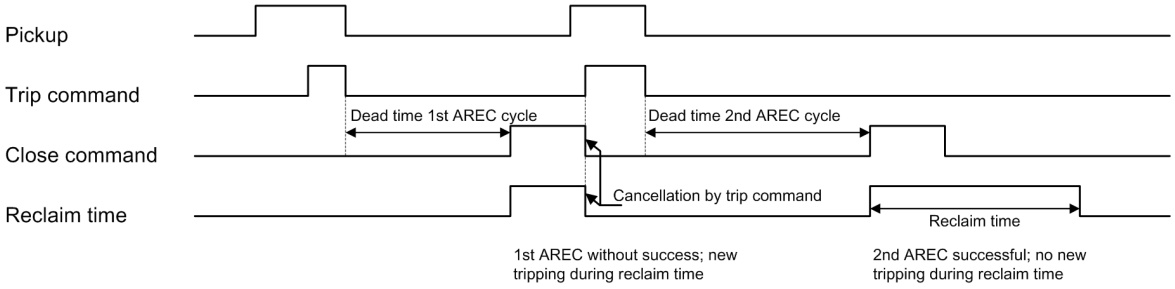
6.22 Automatic Reclosing Function

6.22.1 Overview of Functions

The Automatic reclosing function (ANSI 79/RREC)

- Automatically closes overhead lines after arc short-circuits
- Is only permissible for overhead lines, because only the possibility of self-activated extinguishing of an arc short-circuit exists here
- Can be controlled by integrated protection functions and by external protection devices
- The automatic reclosing can be controlled via an external automatic reclosing function via binary input signals.

The automatic reclosing function (AREC) takes over automatic reclosing after a switch off via a short-circuit protection. The following figure shows an example for the normal procedure with a two-time automatic reclosing where the 2nd automatic reclosing attempt is successful.

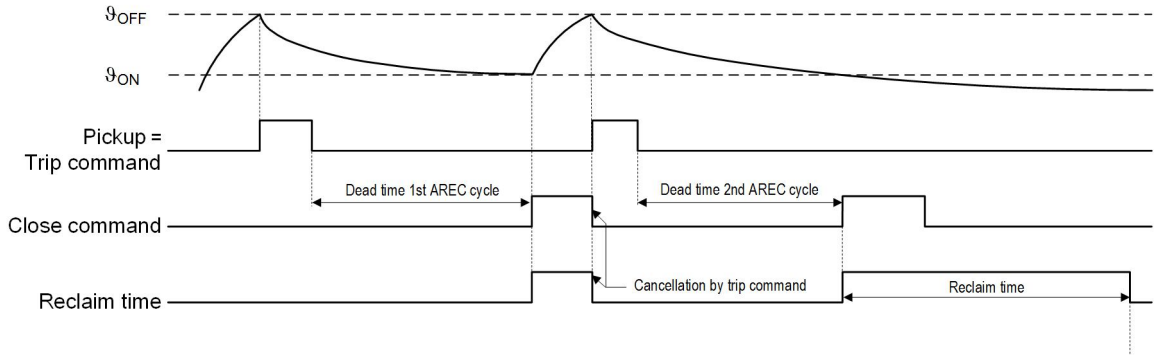


[dw_2awewz, 1, en_US]

Figure 6-373 Process Diagram of a Two-Time Reclosing with Action Time (2nd AREC Successful)

The integrated Automatic reclosing function allows up to 8 reclosing attempts. Each of the 8 disruption cycles can work with different parameters.

The following figure shows an example for normal procedure with a two-time automatic reclosing after disconnection via the internal overload protection. The 2nd automatic reclosing attempt is successful.



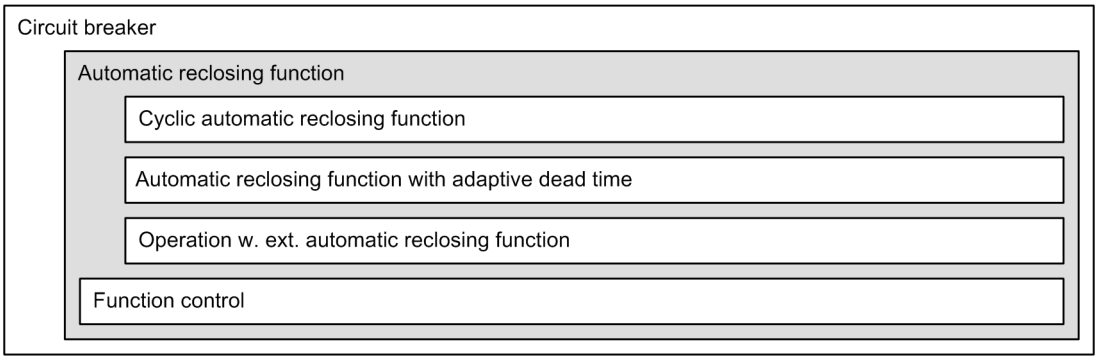
[dw_ablaufdiagramm_2-AWE-nach Abschalt-Thermo, 1, en_US]

Figure 6-374 Process Diagram of a Two-Time Reclosing after Disconnection via Overload Protection

The integrated Automatic reclosing function allows up to 8 reclosing attempts here as well. In contrast to disconnection through the short-circuit protection, each of the 8 disruption cycles can work with its own parameters that are the same for all cycles.

6.22.2 Structure of the Function

The Automatic reclosing function is used in function groups for circuit breakers. In a function group for circuit breakers, one of the 3 types of functions illustrated in the following figures can be used. The Automatic reclosing function has a central function control.



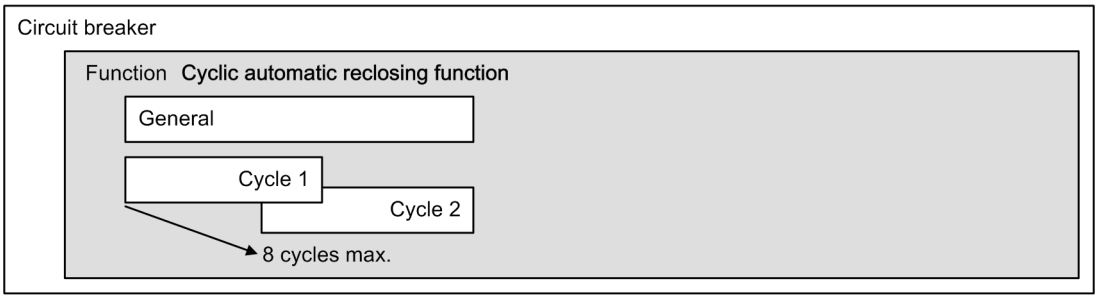
[dw_fkt_awe, 1, en_US]

Figure 6-375 Structure/Embedding of the Function

Cyclic Automatic Reclosing Function

The Cyclic automatic reclosing function (*Figure 6-376*) allows up to 8 reclosing attempts. Here each disruption cycle can work with different settings.

For the Cyclic automatic reclosing function, 1 cycle is preset. The preset cycle cannot be deleted. You can add and delete additional cycles from the function library in DIGSI 5.

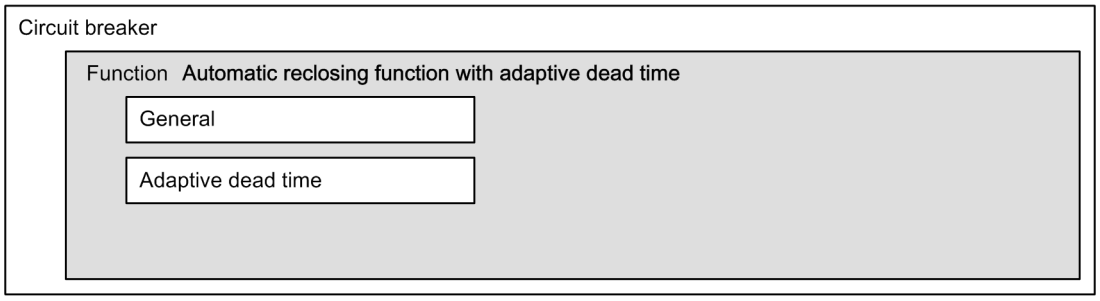


[dw_zyk_awe, 1, en_US]

Figure 6-376 Structure/Embedding of the Cyclic Automatic Reclosing Function

Automatic Reclosing Function with Adaptive Dead Time

The Automatic reclosing function with adaptive dead time (ADT) works without set disruption cycles (*Figure 6-377*). The requirement for the usage of ADT is that voltage transformers on the line-side are connected or there is a possibility for the transmission of a close command to a remote line end. With the ADT, the Automatic reclosing function decides independently if and when an automatic reclosing is reasonable and permissible and when it is not. The criteria is the phase-to-ground voltage, which is switched through after reclosing from the opposite line end. The Automatic reclosing function with ADT occurs as soon as it is known that the line from the opposite end has been placed back under voltage.

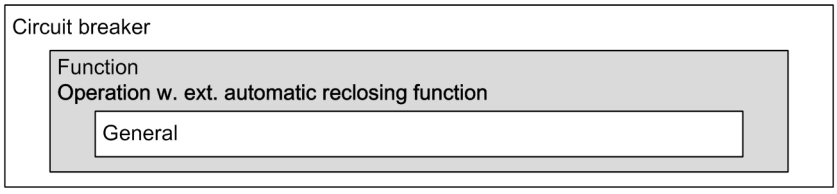


[dw_aweasp, 1, en_US]

Figure 6-377 Structure/Embedding of the Automatic Reclosing Function With Adaptive Dead Time (ADT)

Operation with External Automatic Reclosing Function

If an external reclosing device operates together with the SIPROTEC protection device, use the function type **Operation with external automatic reclosing function** (*Figure 6-378*). The function only provides binary inputs for the influence of the protection functions in the SIPROTEC protection device. The external reclosing device delivers the close command. The SIPROTEC protection functions then provide for the trip commands.

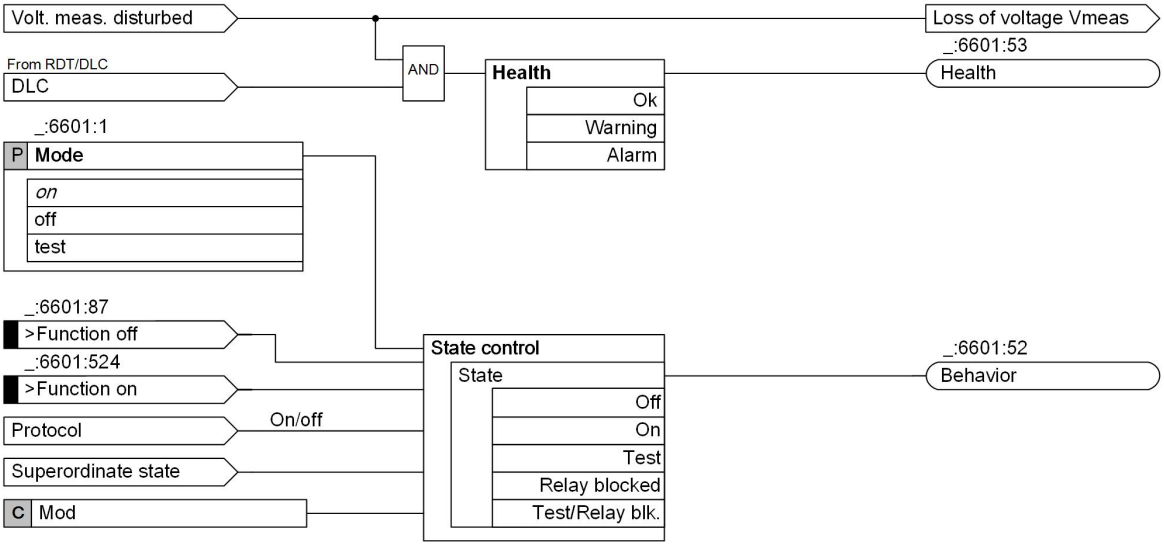


[dw_extawe, 1, en_US]

Figure 6-378 Structure/Embedding of the Operating Function With External Automatic Reclosing Function

Function Control

The Automatic reclosing function contains a central function control, see the following figure. You can find detailed information on the function control in the chapter **Function/Stage Control**.



[lo_arc_fkt, 2, en_US]

Figure 6-379 Function Control for the Automatic Reclosing Function

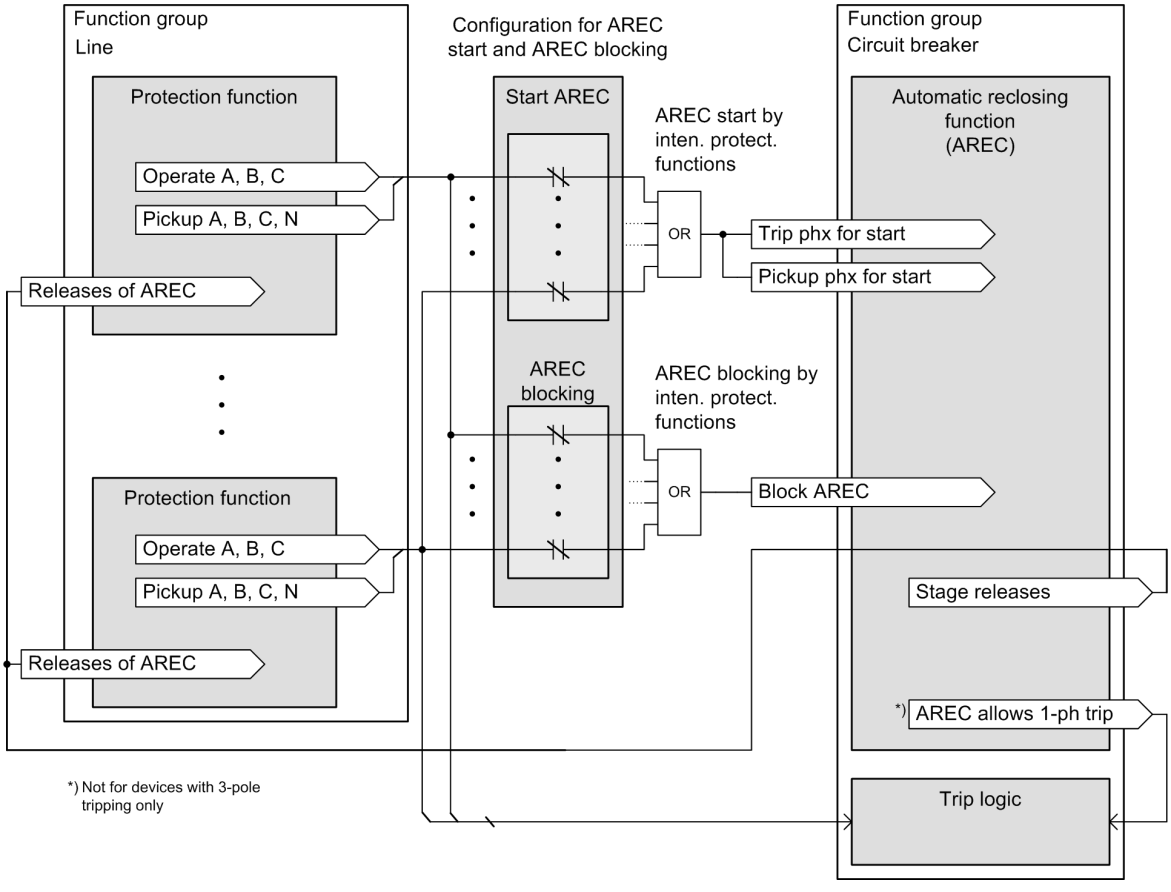
6.22.3 Cooperation of the Automatic Reclosing Function and Protection Functions

The automatic reclosing function (AREC) can be influenced by the protection functions in the following way:

- The AREC is started through pickup indications and operate indications by the selected protection functions or protection stages. The start is independent of the set operating mode for the AREC.
- Individual protection functions or protection stages can be configured so that their operate indication blocks the AREC. If such a blocking exists, the AREC cannot be started. If the AREC is already started, the blocking will lead to the cancellation of the AREC.

The automatic reclosing device can thus have an influence on the effects of the protection functions. The following influence possibilities exist:

- The AREC provides signals that can be used by protection functions for the blocking or release of special stages or zones. An example is the release of overreaching zones with distance protection.
- For applications with 1-pole tripping, the automatic reclosing function provides a signal, based on which the protection functions can turn off the 1-pole circuit breaker.
- For the application with 1-pole tripping and stage or zone release through the automatic reclosing function, this function provides a signal that uses the protection functions that lets the stage and zone release act only if a 1-pole faults occurs.



[loawesig-160611-01.tif, 1, en_US]

Figure 6-380 Signals between Protection Functions and Automatic Reclosing Functions

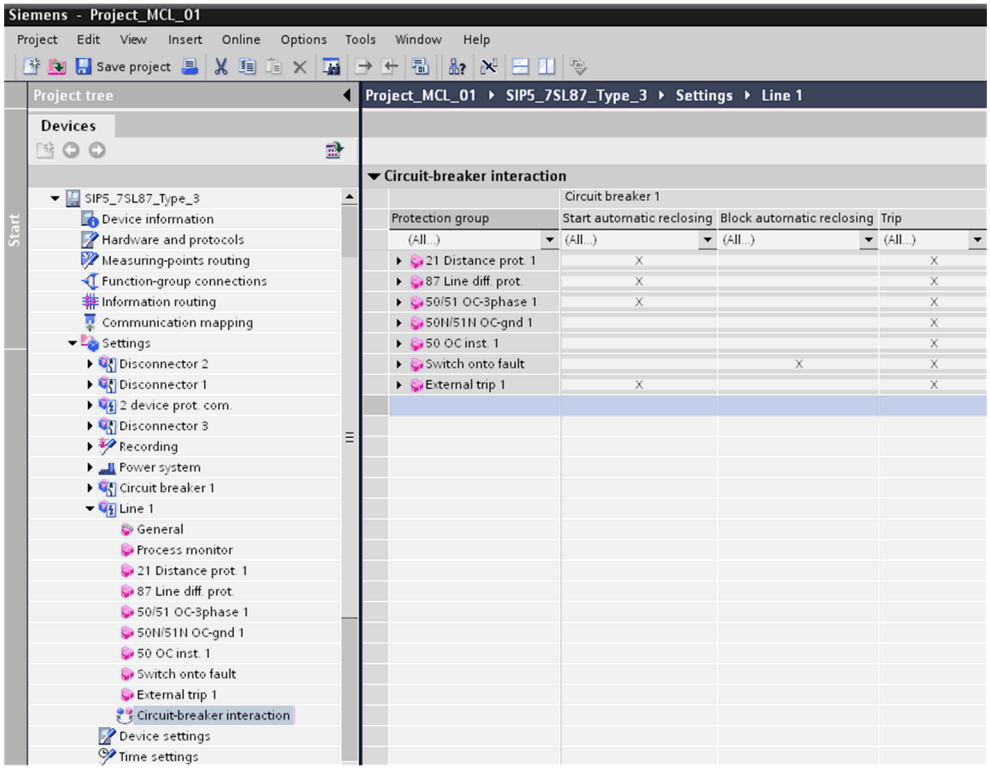
The configuration of the interaction between internal protection functions and automatic reclosing functions can be set separately for each protection function, see *Figure 6-380*. The configuration occurs in a matrix view in DIGSI, see *Figure 6-381*.

If a protection function or the stage of a protection function is connected with the AREC through the matrix, this means that the respective pickup and operate indications are forwarded to the AREC.

The links can be created separately

- For starting the automatic reclosing function and
- For the blocking of the automatic reclosing function.

The automatic reclosing function also has the corresponding binary inputs and binary outputs through which the external protection devices can be connected to the internal automatic reclosing function.



[scdigsia-080311-01.tif, 1, en_US]

Figure 6-381 Configuration of the Protection Functions for Starting and Blocking the Automatic Reclosing Function in DIGSI 5

6.22.4 Cyclic Automatic Reclosing Function

6.22.4.1 Operating Modes for Cyclic Automatic Reclosing Function

For the cyclic automatic reclosing function, there are 4 operating modes, from which one can be selected for the parameterization (parameter **(_:6601:101) 79 operating mode**).

The selection of the operating mode is dependent on the tripping behavior of the protection functions and the circuit breaker.

For applications with 3-pole tripping, all 4 operating modes are available. For applications with 1- and 3-pole tripping, one can select between 2 operating modes.

Their connections are displayed in the following table.

Table 6-9 Operating modes of the cylindrical automatic reclosing function in accordance with tripping behaviors

Operating Mode of the Cyclic Automatic Reclosing Function (AREC)	Tripping Behavior	
	3-Pole Tripping	1-Pole and 3-Pole Tripping
Operating mode 1 ***with op., with act. time***	X	X
Operating mode 2 ***w.pickup, w. action time***	X	-
Operating mode 3 ***with op., w/o act. time***	X	X
Operating mode 4 ***w.pickup, w/o act. time***	X	-

Operating mode 1: with op., with act. time

The operating mode ***with op., with act. time*** allows different automatic reclosing cycles depending on the tripping type and operate time of the protection function(s). With this operating mode, the automatic reclosing must be started with the operate indications. Additionally, the general pickup must also be considered.

With raising general pickup, the action times of the configured automatic reclosing cycles start. The general pickup is in this connection the group indication of all internal protection functions configured for starting the automatic reclosing and the external binary input for general pickup *>Gen. pickup for start*.

Through the time between the raising general pickup and clearing operate indication, the automatic reclosing cycle to be started will be determined. Here for multiple automatic reclosing cycles, the sequence of the expiring automatic reclosing cycles is not fixed, like the operating modes without action time.

- During a 3-pole trip indication, the automatic reclosing cycle(s) start(s), for which 3-pole dead times are set.
- During a 1-pole trip indication, the automatic reclosing cycle(s) start(s), for which 1-pole dead times are set.

The following example in *Figure 6-382* shows a 1-pole tripping that comes after expiration of the action time of cycle 1, but still before the expiration of the action times from cycle 2 and cycle 3. Cycle 2 is set to make a 1-pole tripping possible. Cycle 2 will now become active with the settings for 1-pole tripping.

Within the following reclaim time, there will be another pickup and a 3-pole tripping. Since cycle 2 is already complete, these and all lower cycles are no longer able to expire. The second trip command comes during the current action time of cycle 3. Thus, cycle 3 becomes active with the settings for 3-phase trippings.

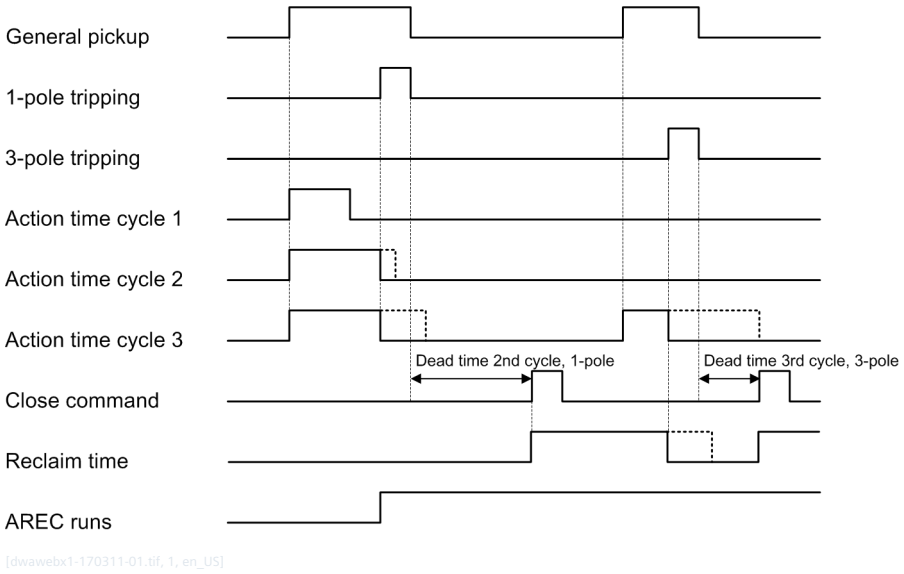


Figure 6-382 Operating-Mode Signal Examples: With Tripping/With Action Time

Through the action time, there is a direct influence on the dead time behavior of the automatic reclosing function. With faults with short operate times, other dead times can be realized than for removed faults with longer tripping time. With faults with short operate time, an automatic reclosing is executed, with removed faults this does not occur with longer operate time. The operating mode ***with op., with act. time*** allows for different automatic reclosing cycles depending on 1- or 3-pole tripping and the trip time of the protection function(s).

Operating mode 2: w.pickup, w. action time

The operating mode ***w.pickup, w. action time*** allows different automatic reclosing cycles depending on the operate time and type of fault. It is only suitable and applicable for applications with 3-pole tripping.

With this operating mode, the automatic reclosing must be started with the operate indications from the protection functions. Additionally, the pickup sample from the conductor pickups and the general pickup are considered:

- With 1-phase pickup, the automatic reclosing cycles set for 1-phase dead times are activated. 1-phase pickup includes both pickup samples **phase-to-ground** and **only grounding**.
- With 2-phase pickup, the automatic reclosing cycles set for 2-phase dead times are activated.
- With 3-phase pickup, the automatic reclosing cycles set for 3-phase dead times are activated.

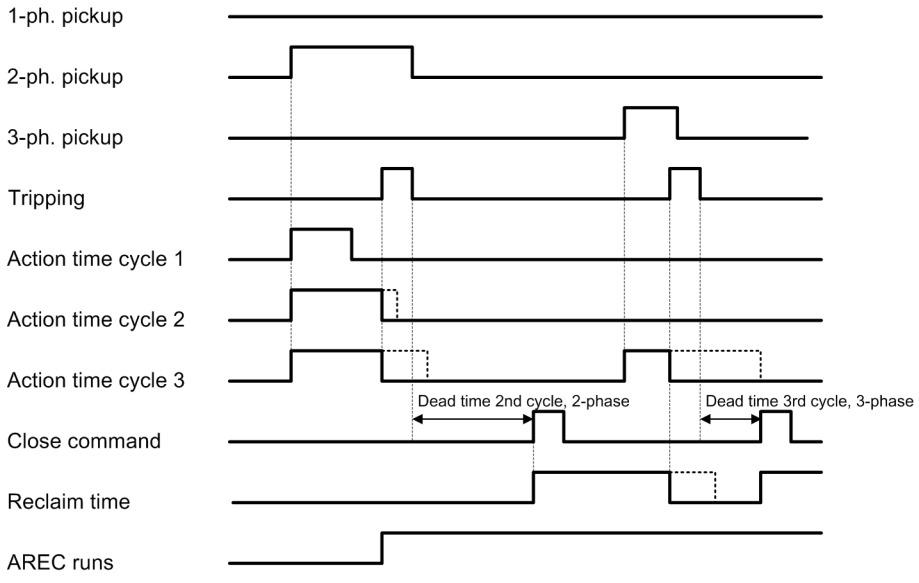
With each automatic reclosing cycle, it is checked to see if it is a 1-phase, 2-phase or 3-phase pickup.

With raising general pickup, the action times of the configured automatic reclosing cycles start. The general pickup is in this connection the group indication of all internal protection functions configured for starting the automatic reclosing and the external binary input for general pickup *>Gen. pickup for start*.

Through the time between the raising general pickup and raising trip command, the automatic reclosing cycle to be started will be determined. Here for multiple automatic reclosing cycles, the sequence of the expiring automatic reclosing cycles is not fixed, like the operating modes without action time.

The following example shows a tripping that comes after expiration of the action time of cycle 1, but still before the expiration of the action times from cycle 2 and cycle 3. Since it is a 2-phase pickup, cycle 2 is active with the dead-time setting for 2-phase faults.

After reclosing, there will be another, this time 3-phase, pickup and tripping within the following reclaim time. Since cycle 2 is already complete, these and all lower cycles are no longer able to expire. The trip command comes during the current action time of cycle 3. Thus, cycle 3 is active, with the dead time setting for 3-phase faults.

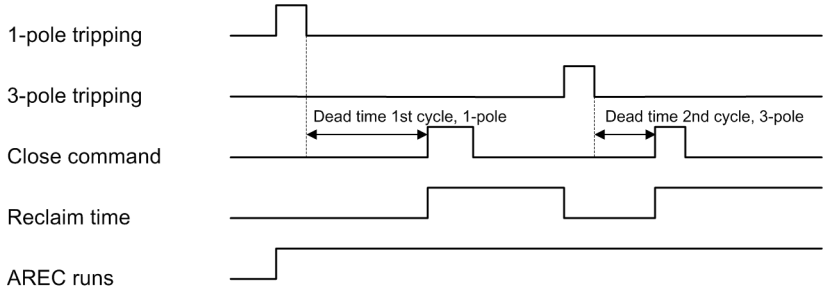


[dw_arcbm2, 1, en_US]

Figure 6-383 Operating-Mode Signal Examples: With Pickup/With Action Time

Operating mode 3: with op., w/o act. time

With the operating mode ***with op., w/o act. time***, the respective dead time is started after each trip command. The sequence of the automatic reclosing function is exclusively control by the operate indications. The pickups are not considered. Unless parameters are not set otherwise, a 3-pole operate indication initiates the 3-pole dead time start, a 1-pole operate indication initiates the 1-pole dead time start. If more than one automatic reclosing cycle is configured, the sequence of the expiring automatic reclosing cycles is identical with the cycle number (1, 2, and 3.).



[dwawebs3-010612-01.tif, 1, en_US]

Figure 6-384 Operating-Mode Signal Examples: With Tripping/Without Action Time

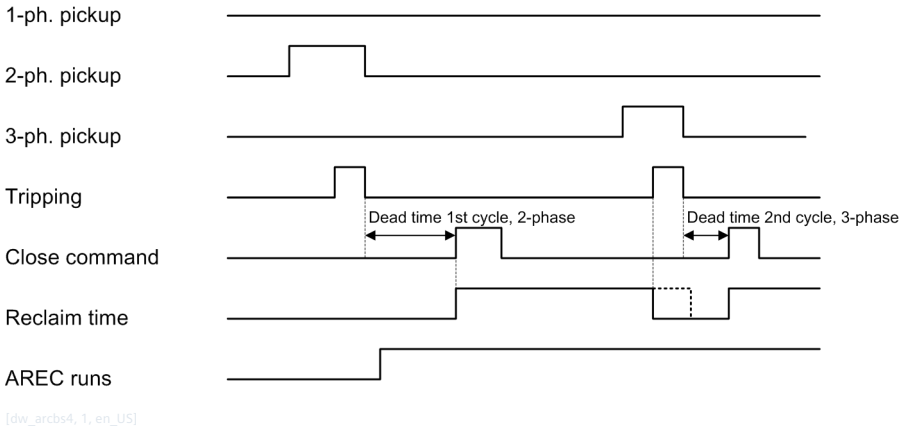
Operating mode 4: w.pickup, w/o act. time

With the operating mode ***w.pickup, w/o act. time***, the automatic reclosing must be started with the operate indications from the protection functions. It is only suitable and applicable for applications with 3-pole tripping.

The start of the dead time occurs after each trip command. Additionally, the pickup sample from the conductor pickups is considered:

- With 1-phase pickup, the automatic reclosing cycles set for 1-phase dead times are activated. 1-phase pickup includes both pickup samples **phase-to-ground** and **only grounding**.
- With 2-phase pickup, the automatic reclosing cycles set for 2-phase dead times are activated.
- With 3-phase pickup, the automatic reclosing cycles set for 3-phase dead times are activated.

With each automatic reclosing cycle, it is checked to see if it is a 1-phase, 2-phase or 3-phase pickup. If more than one automatic reclosing cycle is configured, the sequence of the expiring automatic reclosing cycles is identical with the cycle number (1, 2, 3, etc.).



[dw_arcbs4, 1, en_US]

Figure 6-385 Operating-Mode Signal Examples: With Pickup/Without Action Time

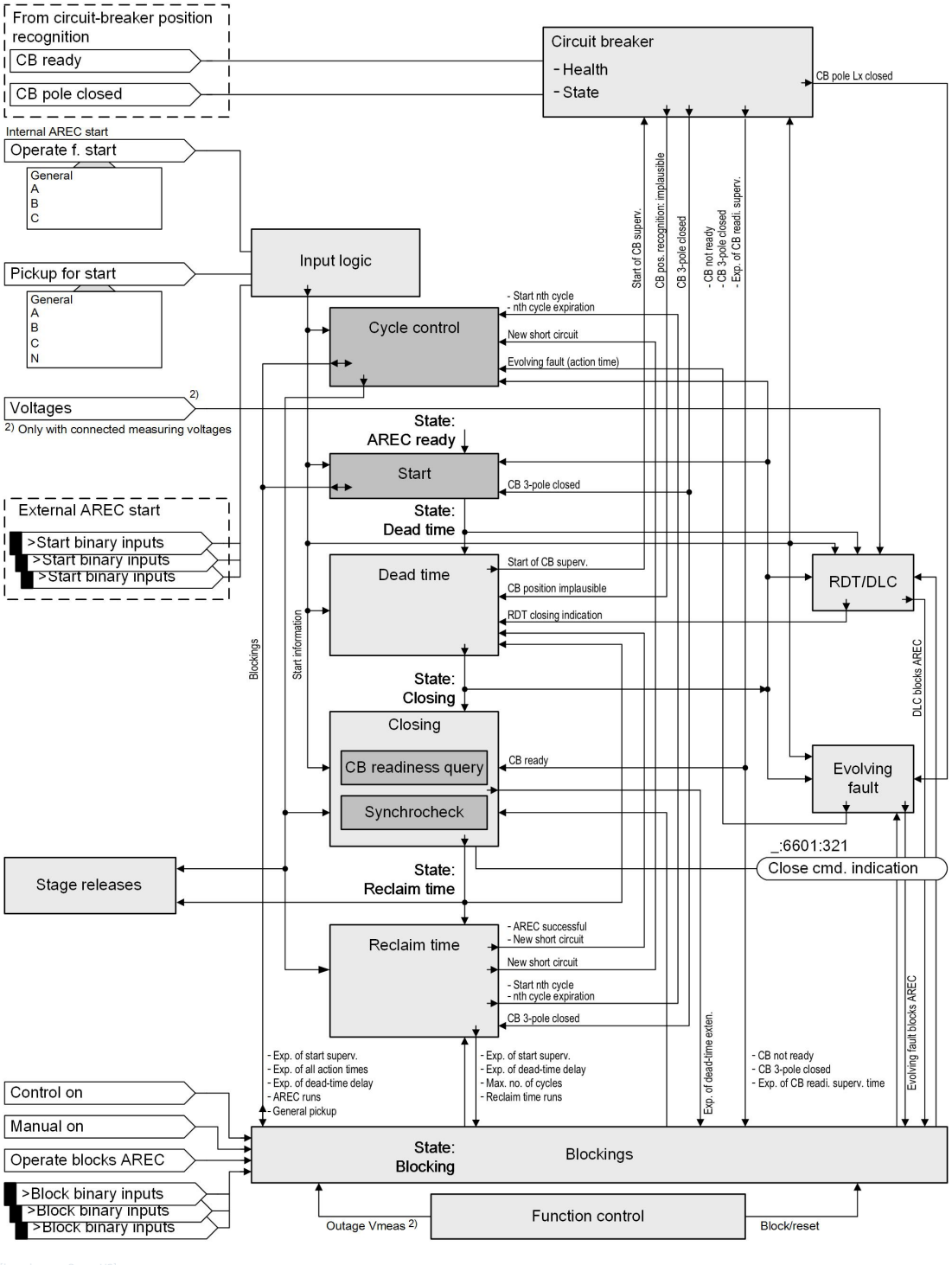
6.22.4.2 Structure of the Cyclic Automatic Reclosing Function

In *Figure 6-386*, the functional structure of the cyclic automatic reclosing function is illustrated as a block diagram. The figure displays the important signals, coming from outside of the cyclic automatic reclosing function, and the most important signals between the individual function blocks.

The automatic reclosing function works as a state machine. From the idle state **AREC ready**, the automatic reclosing function gets through the tripping or pickup indications of the protection functions to the **Dead time** state. After expiration of the dead time, the subsequent state is reached with the closing indication. The reclaim time is also started together with the closing indication. If the reclaim time can expire without further operate or pickup indications, the automatic reclosing is successful and the automatic reclosing function turns back to idle state.

If the automatic reclosing function is restarted during the current reclaim time, there will be either a dynamic blocking or other reclosing cycles will be executed. If other reclosing cycles are possible, there will be a dead time start and the described process starts again.

After the end of a dynamic blocking, the automatic reclosing function switches back to idle state or it goes into the state **Static Blocking** if the blocking condition is permanently present. In the following sections, the individual function blocks are described in detail.



[lo_zyk_awe, 2, en_US]

Figure 6-386 Cyclic Reclosing Function: Block Diagram of Automatic Reclosing

6.22.4.3 Input Logic for Operating Modes with Tripping

The operate indications are used as starting signals. For operating modes **with action time**, the start of the action time(s) occurs with the pickup indications. During all operating modes, the pickup indications are also required during the processing of faults and for supervision during the reclaim time.

Applications with 3-Pole Tripping

For applications with only 3-pole tripping options, the internal operate indications are always 3-pole. For external starts, there is a binary input, which signalizes a 3-pole tripping of the external protection device.

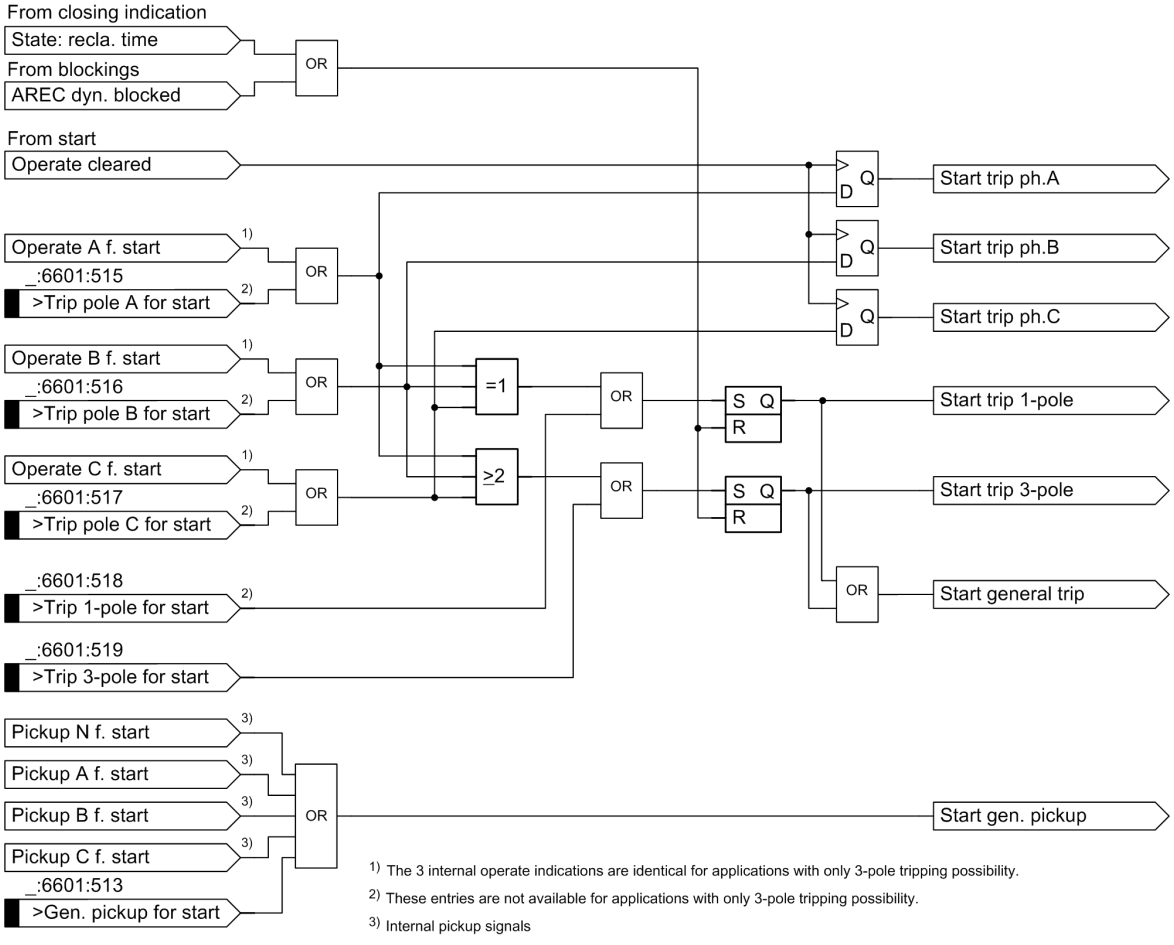
The outputs of the input logic signalize that the reclosing start has occurred through a 3-pole operate indication.

Application with 1-Pole and 3-Pole Tripping

Depending on the generated protection function, during the application with 1-pole and 3-pole tripping options, the internal trip indication may be phase-selective or 3-phase. If an external start via binary input is selected, phase-selective inputs as well as inputs for 3-pole start are available.

The outputs of the input logic indicate whether the reclosing start has occurred through a 1-pole or 3-pole operate indication. A start initiated by a 3-pole tripping is recognized if more than 1 pole signaled a tripping during at least one time lapse within the period from the first incoming operate indication up to the last outgoing operate indication.

At the time of the outgoing operate indication, all tripped poles will be stored. This information is used for the plausibility check between the auxiliary contacts of the circuit breaker and assigned operate indication, see chapter *6.22.4.11 Dead Time for Operating Modes with Tripping*.



[lo_bta_aus, 2, en_US]

Figure 6-387 Input Logic for Operating Modes: With Tripping

6.22.4.4 Input Logic for Operating Modes with Pickup

The operate indications and the pickup indications are used as starting signals. The internal pickup indications are processed selective to the phase. Through binary inputs, the pickup information can also be coupled by external protection devices (*>Pickup A for start*, *>Pickup B for start* and *>Pickup C for*

start). Optionally, the pickup information can be externally captured as a pickup sample, thus, as a 1-phase, 2-phase and 3-phase pickup.

The outputs of the input logic signalize if the automatic reclosing start occurs through a 1-phase, 2-phase, or 3-phase pickup:

- On **Start with 3-phase pickup**, it is recognized if all 3 phases were picked up in the period from the first raising pickup indication up to the last clearing outgoing pickup indication.
- On **Start with 2-phase pickup**, it is recognized if all 2 phases were picked up in the period from the first raising pickup indication up to the last clearing pickup indication and at no time 3 phases.
- On **Start with 1-phase pickup**, it is recognized if only 1 phase was picked up in the period from the first raising pickup indication up to the last clearing pickup indication.

For operating modes **with action time**, the start of the action time(s) occurs with the pickup indications. During operating modes **with pickup**, the pickup indications affect the selection of the dead times. During all operating modes, the pickup indications are also required during the processing of faults and for supervision during the reclaim time.

The automatic reclosing operating modes **with pickup** are only ideal for applications with 3-pole tripping. Therefore, the outputs of the input logic always signal 3-pole operate indications.

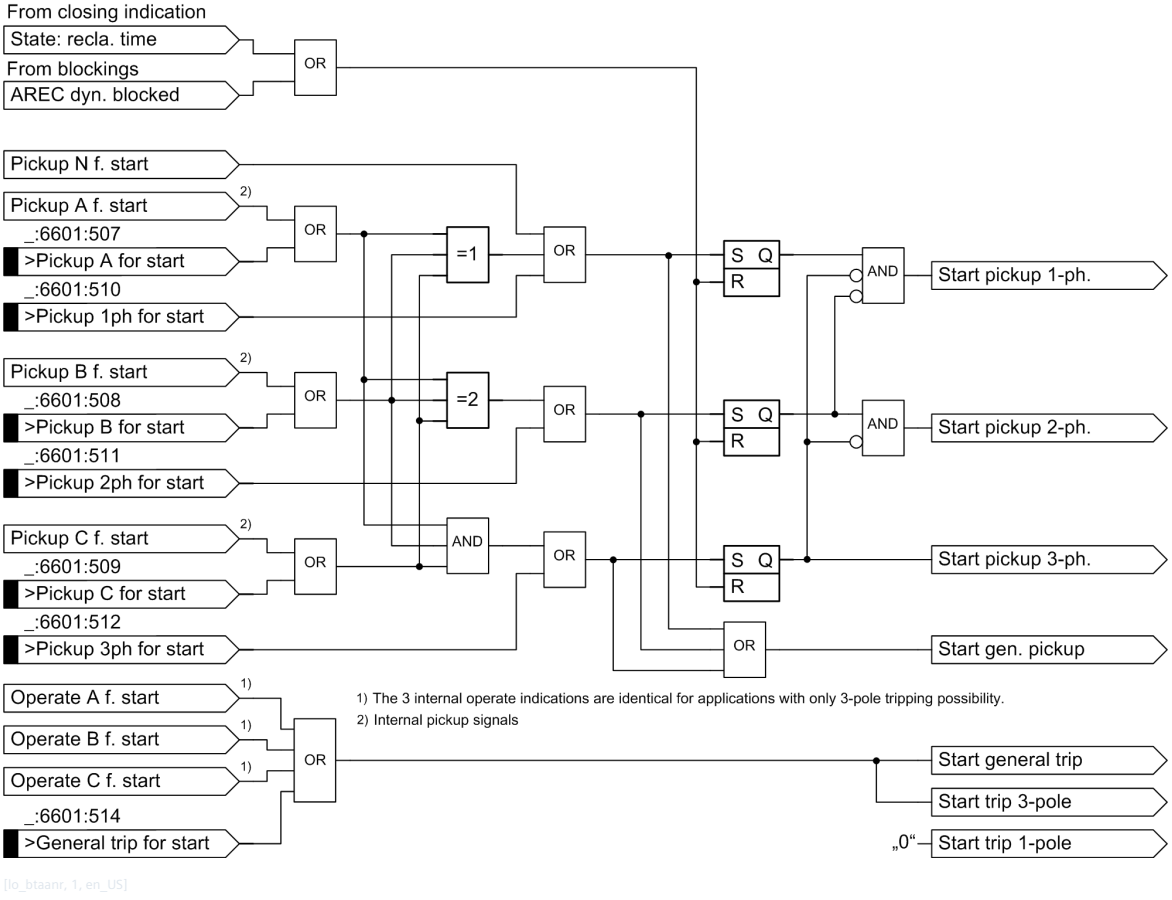


Figure 6-388 Input Logic for Operating Modes: with Pickup

6.22.4.5 Start

In the **Start** function block, the automatic reclosing function is switched from the idle state **AREC ready** to the state **Dead time**, see *Figure 6-389*. The length of the starting signals is controlled with a supervision time.

Start-Signal Supervision Time

The start-signal supervision stops the automatic reclosing if the short circuit is not switched off within the normal time; for example, in the case of a circuit-breaker failure.

With the first raising operate indication, the start-signal supervision time is initiated, parameter **`Start signal supervis.time`**. The time is stopped as soon as no operate indication is active.

The automatic reclosing function is blocked if there is an expiration of the start-signal supervision time through a long operate indication. The blocking lasts until the operate indication stops, extended by a further 0.5 s.

Transition to the Dead-Time State

The transition of the automatic reclosing function to the **dead-time** state occurs for:

- Clearing operate indications if none of the signal inputs for operate indications are active
- Or if the circuit breaker can no longer be recognized as 3-pole closed
- And the start-signal supervision time is not expired

Additionally, the following conditions must be fulfilled:

- The circuit breaker signalizes the readiness for automatic reclosing typically through a binary input. If the circuit breaker is not ready, the automatic reclosing function can be statically blocked. In this situation, the automatic closing function is not in idle state **automatic closing function ready**. The control of the circuit-breaker readiness is optional and can be turned off through settings, see also chapter *6.22.4.16 Circuit-Breaker Readiness and Circuit-Breaker Condition* and *6.22.4.17 Blockings*.
- The circuit breaker must be 3-pole closed before the trip command. This condition is not considered if the circuit-breaker auxiliary contacts are not connected to the protection device.

You can delay the transition to the **dead-time** state through the binary input **>Dead Time Start Delay.** As long the corresponding binary signal is present, the dead time of the automatic reclosing function will not be started. The maximum duration of this binary signal is monitored through a time stage that can be set, parameter **`Max. dead-time delay`**. Upon expiration of this time stage, that is, if the binary signal is present longer than permitted, the automatic reclosing function will be blocked until the end of the binary signal, additionally extended by another 0.5 s. See also chapter *6.22.4.17 Blockings*.

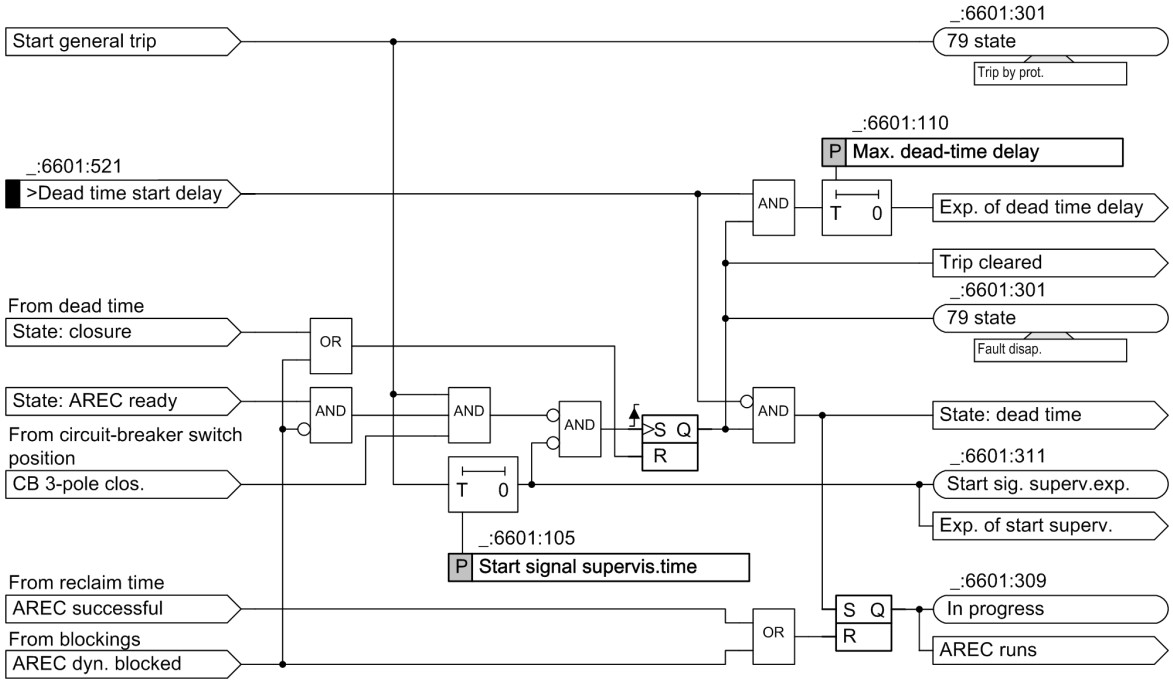


Figure 6-389 Logic for Function-Block Start

6.22.4.6 Cycle Control with Operating Mode 1: with Tripping/with Action Time

The cycle control checks the readiness for each automatic reclosing cycle and controls the process of the action time(s). In *Figure 6-390*, the cycle control is illustrated.

Cycle Availability

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter **Dead time aft. 3-pole trip** to ***invalid*** avoids an automatic reclosing after 3-pole tripping. Accordingly, the automatic reclosing does not occur if **Dead time aft. 1-pole trip** is set to ***invalid***. If both dead times are set to ***invalid***, the respective automatic reclosing cycle will be completely blocked. With the binary input *>Block 79 cycle*, you can block the associated automatic reclosing cycle.

For applications with 1-pole tripping, the cycle control provides a signal, based on which the protection functions can recognize that the automatic reclosing function only occurs after 1-pole tripping (*AR only after 1p. trip*). The approval or switch over of special protection stages only occurs for types of faults that lead to 1-pole tripping.

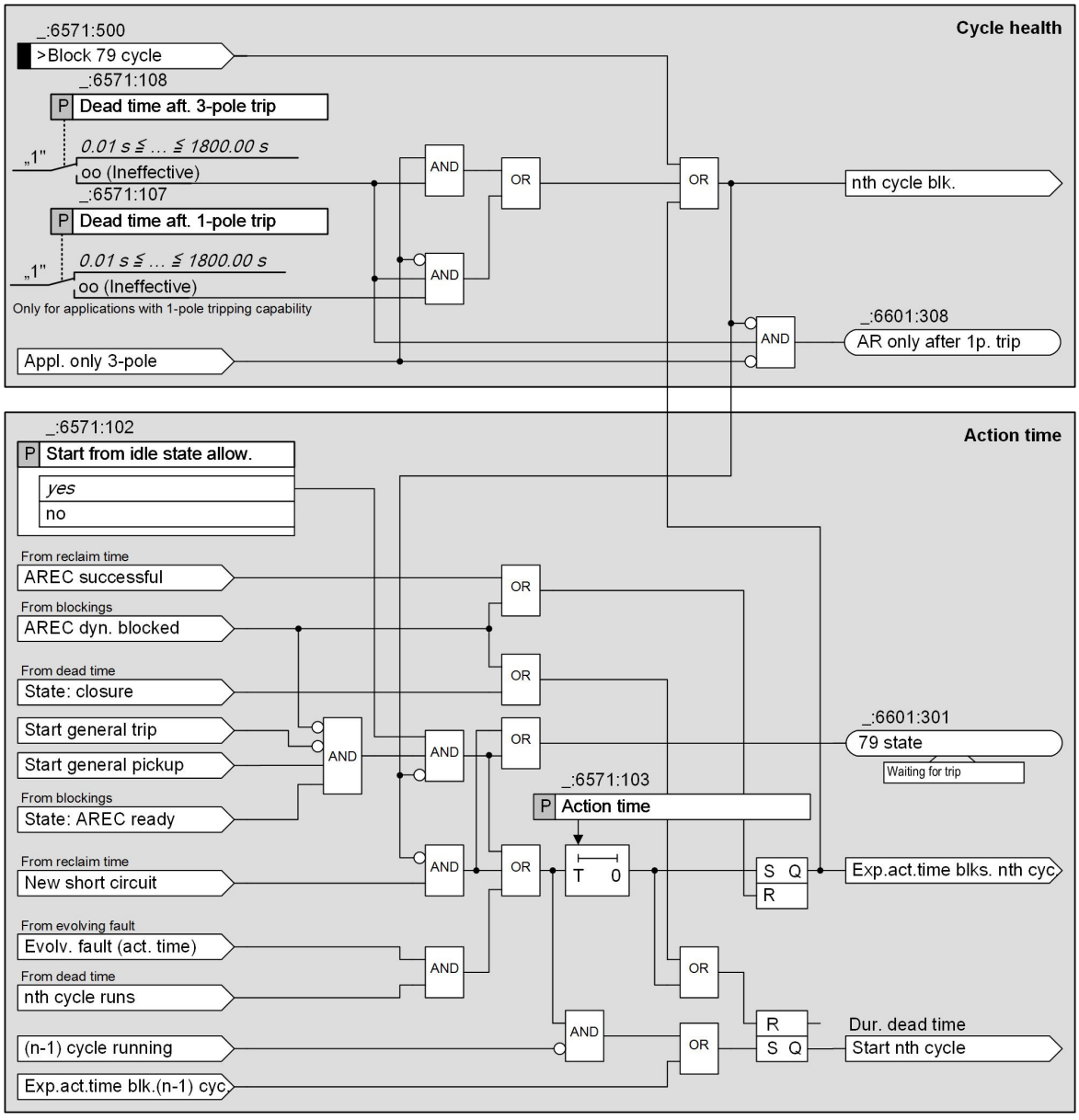
Action Time

If the automatic reclosing function is in the idle state **automatic reclosing function ready**, an incoming general pickup will affect the start of the action time. This applies for the reclosing function cycles that are released through the parameter **Start from idle state allow.** and not blocked.

During one of the started action times, the corresponding reclosing cycle is blocked and the reclosing cycle is assigned the next highest cycle number, whose action time is running and is not blocked.

With raising trip commands, the action times are stopped and reset. The process state of the action times existing at this moment determines the automatic reclosing cycle that should be started.

If all initiated action times expire without capturing a tripping, the automatic reclosing function does not take place. However, if a tripping function is initiated after expiry of the action time, the automatic closing function is blocked for 3 seconds. A new start of the reclosing function is only possible if the general pickup is no longer active.



[lo_auswir, 2, en_US]

Figure 6-390 Cycle Control with Operating Mode: With Tripping/With Action Time

6.22.4.7 Cycle Control with Operating Mode 2: With Pickup/With Action Time

The cycle control checks the readiness for each automatic reclosing cycle and controls the process of the action time(s). In *Figure 6-391*, the cycle control is illustrated.

Cycle Availability

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter **Dead time aft.1ph. pickup** to ***invalid*** avoids an automatic reclosing after 3-pole tripping due to 1-phase short circuits. This also applies to **Dead time aft.2ph. pickup** and **Dead time aft.3ph. pickup**. If all 3 dead times are set to ***invalid***, the respective reclosing cycle will be completely blocked. With the binary input *>Block 79 cycle*, you can block the associated automatic reclosing cycle.

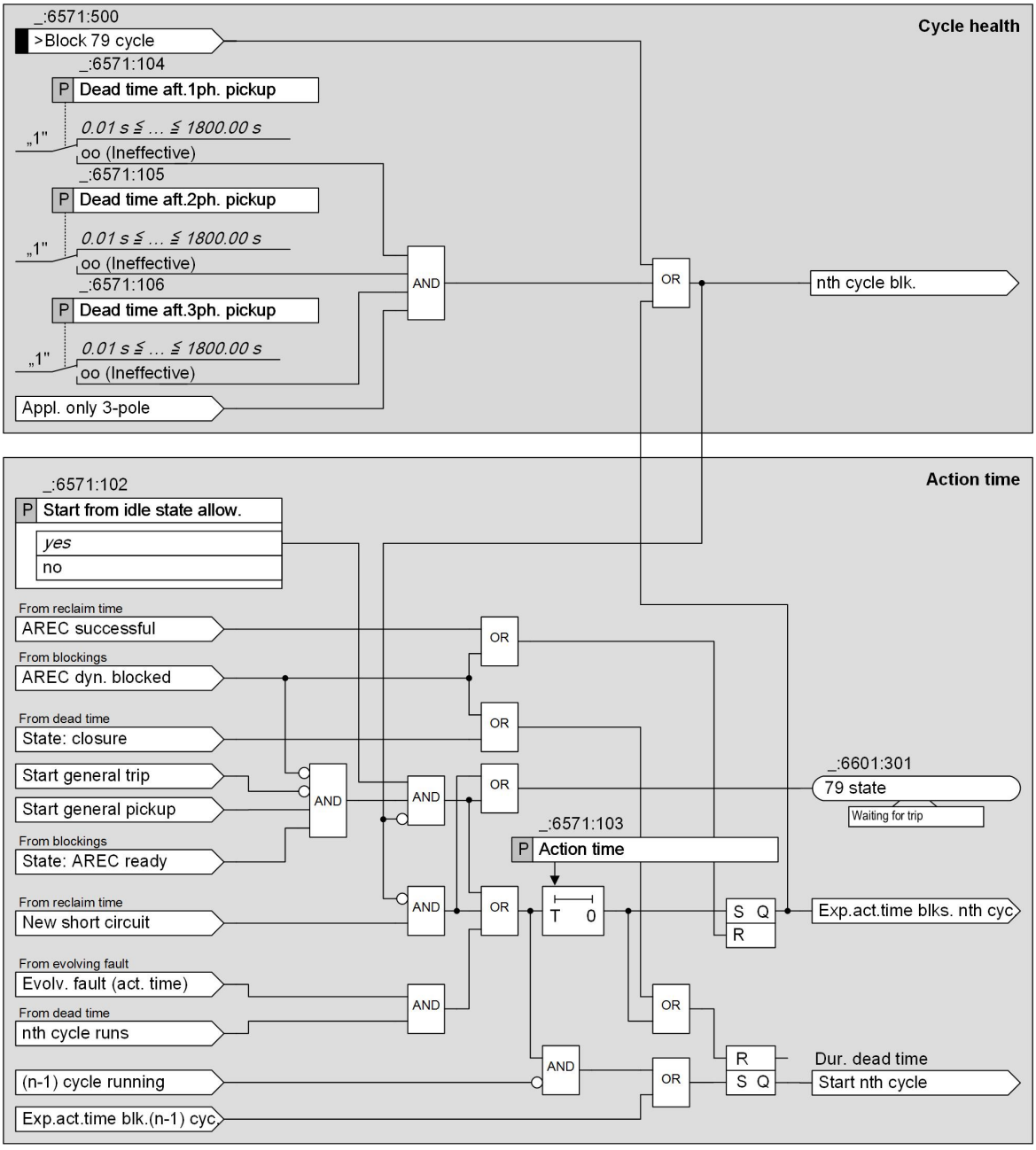
Action Time

If the automatic reclosing function is in the idle state **automatic reclosing function ready**, an incoming general pickup will affect the start of the action time. This applies for the reclosing function cycles that are released through the parameter **`Start from idle state allow.`** and not blocked.

During one of the started action times, the corresponding reclosing cycle is blocked and the reclosing cycle is assigned the next highest cycle number, whose action time is running and is not blocked.

With raising trip commands, the action times are stopped and reset. The process state of the action times existing at this moment determines the automatic reclosing cycle that should be started.

If all initiated action times expire without capturing a tripping, the automatic reclosing function does not take place. However, if a tripping function is initiated after expiry of the action time, the automatic closing function is blocked for 3 seconds. A new start of the reclosing function is only possible if the general pickup is no longer active.



[lo_anrwir, 2, en_US]

Figure 6-391 Cycle Control with Operating Mode: With Pickup/With Action Time

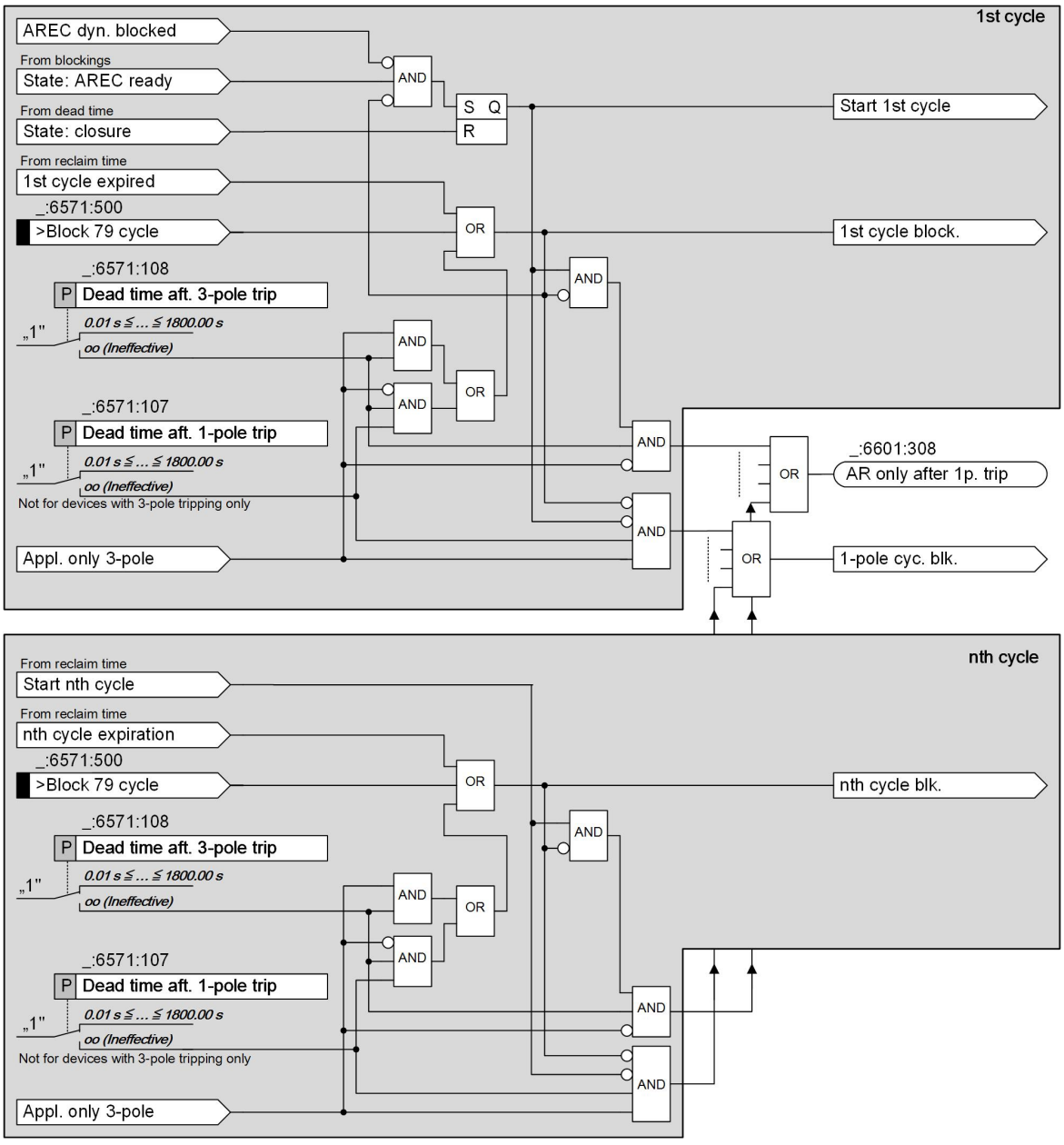
6.22.4.8 Cycle Control with Operating Mode 3: With Tripping/Without Action Time

The cycle control checks the availability for each automatic reclosing cycle. In *Figure 6-392*, the cycle control for the 1st automatic reclosing cycle and other reclosing cycles is illustrated. The further automatic reclosing cycles are generally described with the cycle number **n** and apply for all other configured automatic reclosing cycles.

The cycle availability is influenced through the parameterization of the dead time and through a binary input.

In this way, setting the parameter **Dead time aft. 3-pole trip** to ***invalid*** avoids an automatic reclosing after 3-pole tripping. Correspondingly, there is no automatic reclosing after 1-pole tripping if **Dead time aft. 1-pole trip** is set to ***invalid***. If both dead times are set to ***invalid***, the respective automatic reclosing cycle will be completely blocked. With the binary input *>Block 79 cycle*, you can block the associated automatic reclosing cycle.

For applications with 1-pole tripping, the cycle control provides a signal, based on which the protection functions can recognize that the automatic reclosing function only occurs after 1-pole tripping (*AR only after 1p. trip*). The approval or switch over of special protection stages only occurs for types of faults that lead to 1-pole tripping.



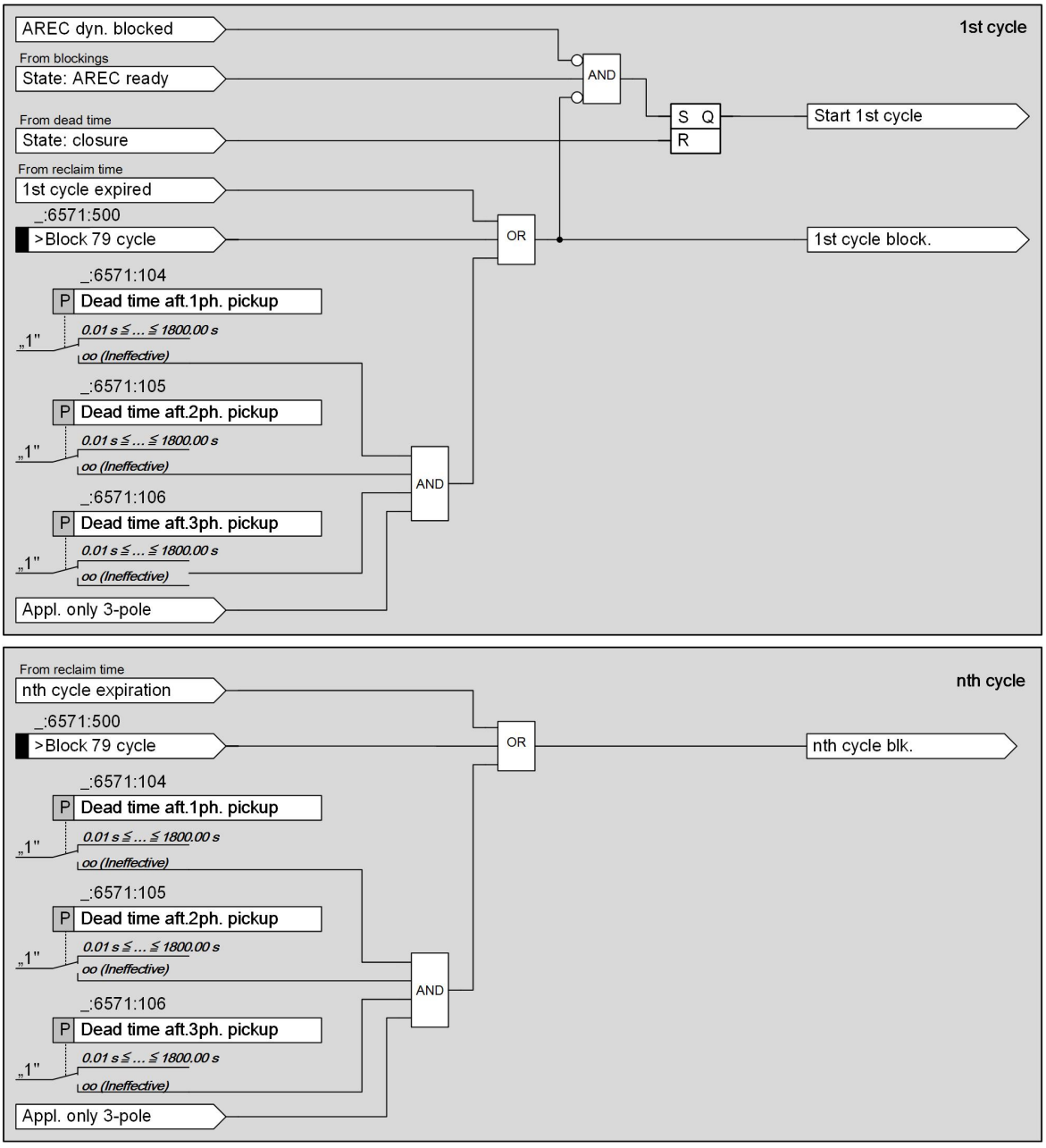
[lo_auowrk, 2, en_US]

Figure 6-392 Cycle Control with Operating Mode: With Tripping/Without Action Time

6.22.4.9 Cycle Control with Operating Mode 4: with Pickup/without Action Time

The cycle control checks the availability for each automatic reclosing cycle. In *Figure 6-393*, the cycle control for the 1st automatic reclosing cycle and other reclosing cycles is illustrated. The further automatic reclosing cycles are generally described with the cycle number **n** and apply for all other configured automatic reclosing cycles.

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter **`Dead time aft.1ph. pickup`** to ***`invalid`*** avoids an automatic reclosing after 3-pole tripping due to 1-phase short circuits. This also applies to **`Dead time aft.2ph. pickup`** and **`Dead time aft.3ph. pickup`**. If all 3 dead times are set to ***`invalid`***, the respective reclosing cycle will be completely blocked. With the binary input *`>Block 79 cycle`*, you can block the associated automatic reclosing cycle.



[lo_anowrk, 2, en_US]

Figure 6-393 Cycle Control with Operating Mode: with Pickup/without Action Time

6.22.4.10 Stage Release

The function block **Stage release** creates output indications for the release or switching over of special stages for protection functions (stage release in the 1st cycle or stage release in the n. cycle). Examples for this are the release of overreaching zones with distance protection and the dynamic adjustment of delays or threshold values with overcurrent protection.

Figure 6-394 shows the tripping stage release for the 1st automatic reclosing cycle. With available automatic reclosing functions, the tripping stage release typically occurs up to the expiration of the dead time. In this state, the cycle number is 1. However, if the automatic reclosing function cycle is only set to 1-pole, the stage release will be returned at the start of the 1-pole dead time. This is necessary, since every additional evolving fault that occurs within the dead time causes a 3-pole cut-off, and subsequently, the automatic reclosing function can no longer take place.

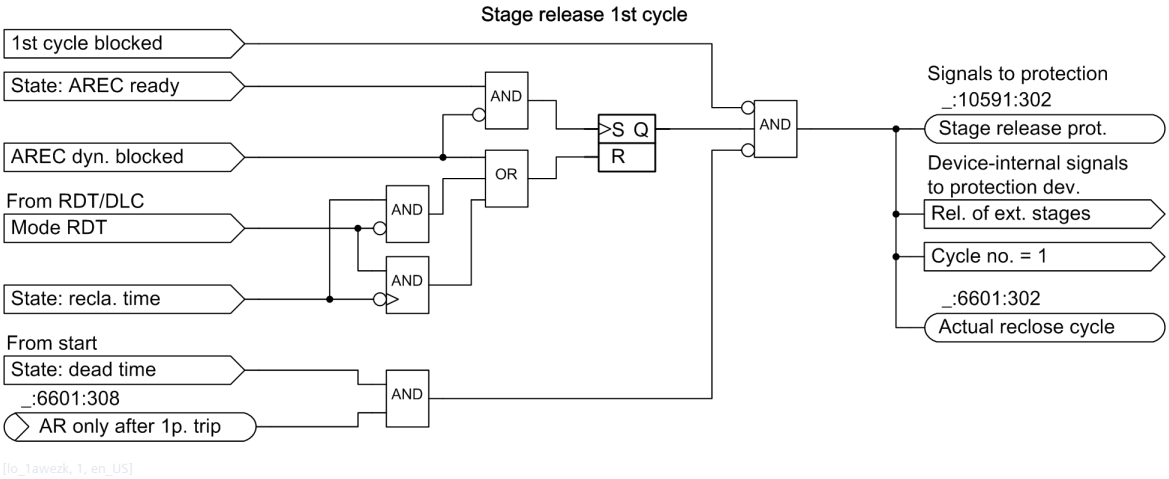


Figure 6-394 Stage Release for Protection Functions in the 1st Automatic Reclosing Cycle

The tripping stage release for higher automatic reclosing cycles is set to the beginning of the reclaim time for rising edge close commands. Simultaneously, the cycle number is increased. The reset condition is identical to the condition for the 1st automatic reclosing cycle. If the reduced dead time (RDT) mode is selected and no additional reduced dead time occurs, the release of the 2nd cycle will be maintained, since it can be assumed that the opposite end is open.

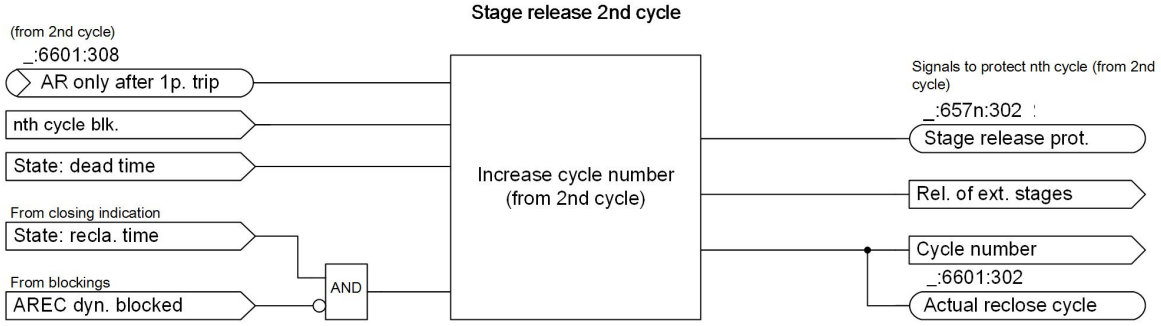


Figure 6-395 Stage Release for Protection Functions Starting with the 2nd Automatic Reclosing Cycle

6.22.4.11 Dead Time for Operating Modes with Tripping

In the **Dead-time** function block, the dead time which corresponds with the previous trip command is started. After expiration of the dead time, the automatic reclosing function changes to the status **Switch on**. *Figure 6-396* shows the dead time logic.

There are 3 time stages that can be set differently:

- Dead time after 3-pole tripping
- Dead time after 1-pole tripping (only available for applications with 1-pole tripping)
- Dead time after evolving fault

In this way, setting the parameter **`Dead time aft. 3-pole trip`** to ***`invalid`*** avoids an automatic reclosing after 3-pole tripping. Correspondingly, if after 1-pole tripping there is no automatic reclosing if **`Dead time aft. 1-pole trip`** is set to ***`invalid`***.

As soon as an evolving fault is recognized (see chapter *6.22.4.13 Evolving-Fault Detection During the Dead Time*), switching to an automatic reclosing cycle for 3-pole interruption occurs. With the 3-pole cut-off of the evolving fault, a separate adjustable dead time for the evolving fault begins. The total dead time is composed of the part of the dead time that expired until the evolving fault was stopped for the first disruption plus the dead time for the evolving fault.

3-Pole Coupling of the Circuit-Breaker with 1-Pole Tripping and Implausible Circuit-Breaker Condition

With applications with 1-pole tripping, during the dead time there is a plausibility check between the assigned trip command and the current flow in the open conductor. If the circuit-breaker auxiliary contacts are connected pole-selectively, the plausibility check also occurs with the circuit-breaker auxiliary contacts. More information can be found in the chapter *6.22.4.16 Circuit-Breaker Readiness and Circuit-Breaker Condition*.

The plausibility check determines whether the circuit-breaker poles that have not been switched off after a 1-pole trip command remain closed.

For an implausible circuit-breaker condition, a 3-pole coupling of the trip command for the circuit breaker is executed, provided the 3-pole coupling of the trip command is permitted through the parameter (parameter **`3-pole operate by 79`**). After this 3-pole tripping, if set and not blocked, more 3-pole automatic reclosing cycles may follow.

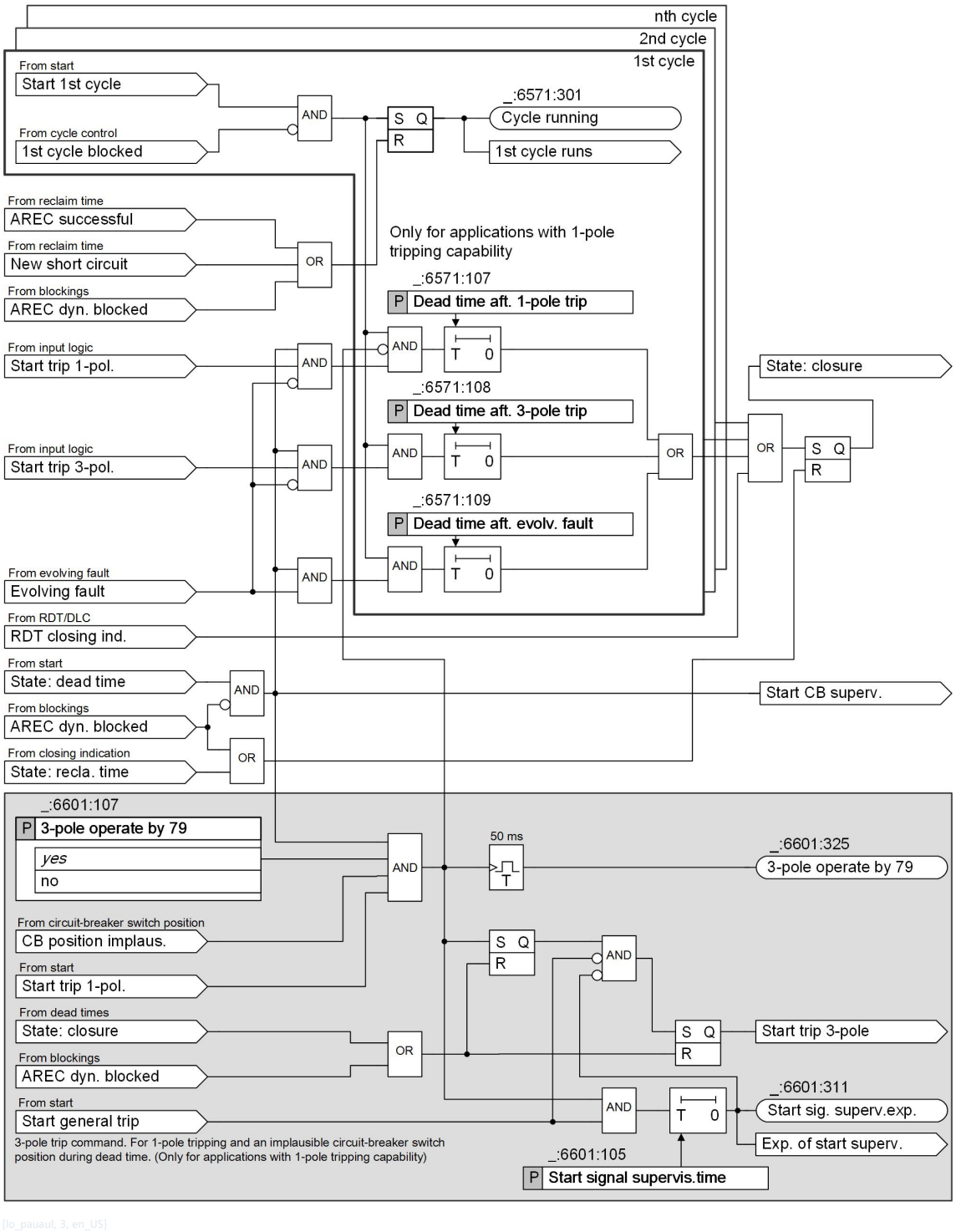


Figure 6-396 Cyclic Automatic Reclosing Function - Logic of the Dead Time for the Operating Modes: With Tripping

6.22.4.12 Dead Time for Operating Modes with Pickup

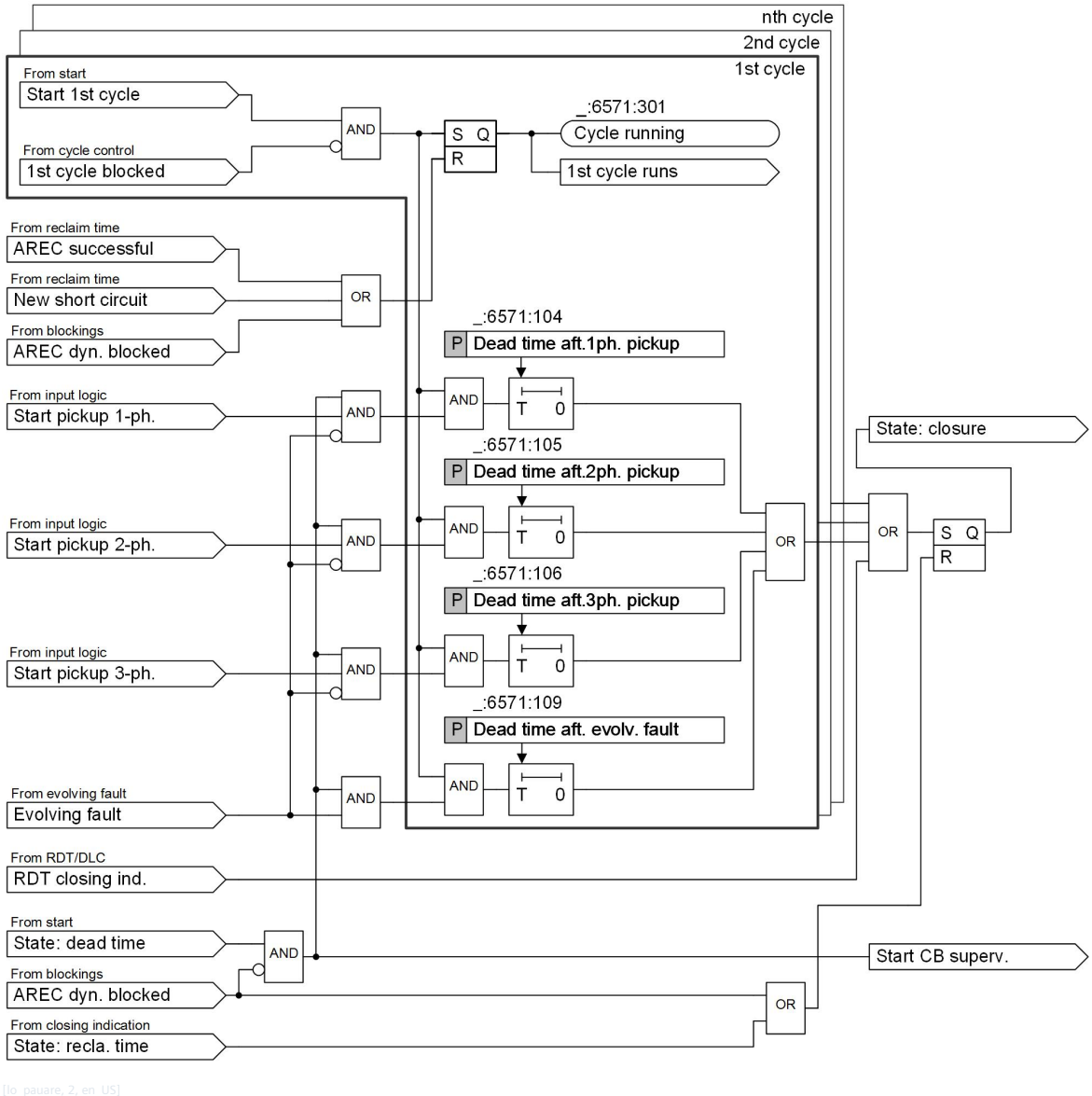
In the **dead time** function block, the dead time corresponding to the type of short circuit that led to the trip command is started. The automatic reclosing operating modes **with pickup** are only ideal for applications with 3-pole tripping. After expiration of the dead time, the automatic reclosing function changes to the status **Switch on**. *Figure 6-397* shows the dead time logic.

There are 4 time stages that can be set differently:

- Dead time after 1-phase short circuits
- Dead time after 2-phase short circuits
- Dead time after 3-phase short circuits
- Dead time for evolving faults

In this way, setting the parameter **Dead time aft.1ph. pickup** to ***invalid*** avoids an automatic reclosing after 3-pole tripping due to 1-phase short circuits. This also applies to **Dead time aft.2ph. pickup** and **Dead time aft.3ph. pickup**.

As soon as an evolving fault is recognized (see chapter *6.22.4.13 Evolving-Fault Detection During the Dead Time*), a separate dead time for faults begins with the stopping of the fault. The total dead time is composed of the part of the dead time that expired until the evolving fault was stopped for the 1st disruption plus the dead time for the evolving fault. With the setting of the **Dead time aft. evolv. fault** to ***invalid***, no other automatic reclosing cycle is executed after tripping through the evolving fault. The tripping through evolving faults is then finished.



[lo_pauare, 2, en_US]

Figure 6-397 Cyclic Automatic Reclosing Function - Logic of the Dead Time for the Operating Modes: with Pickup

6.22.4.13 Evolving-Fault Detection During the Dead Time

Evolving faults are short circuits, which occur after switching off a short circuit during dead time. This may be the case during 1-pole tripping and there is a short circuit in the non-switched conductors after this.

After 3-pole tripping there may also be evolving faults if the line is fed through a second (non-3-pole) opened circuit breaker, for example, for systems with a 1 1/2 circuit breaker layout. Evolving-fault detection does not start until 50 ms after the dead time starts.

The evolving-fault detection is divided into components:

- Detection of evolving faults
- Evolving faults processing
- 3-pole coupling of the circuit breaker during evolving faults

The procedure during evolving faults is illustrated in *Figure 6-398*.

Detection of Evolving Faults

For the detection of an evolving fault, the following criteria can be selected through parameters:

- Parameter **Evolving-fault detection** = ***with trip***

  For this setting, **any tripping** during the dead time leads to evolving-fault detection. At **any tripping** it is decided if an internal protection function is tripped or if the tripping is signaled through a binary input. Thus, it does not matter if the tripping-protection function is configured for the start of the automatic reclosing function or not.

- Parameter **Evolving-fault detection** = ***with pickup***

  Evolving faults are detected if during the dead time a protection function configured for the automatic reclosing function start is picked up or if an external pickup is recognized through a binary input.

- Binary input *>Evolving fault start*

  The evolving-fault detection can also be introduced through a binary input without an internal protection pickup being available.

Reaction to Evolving Faults

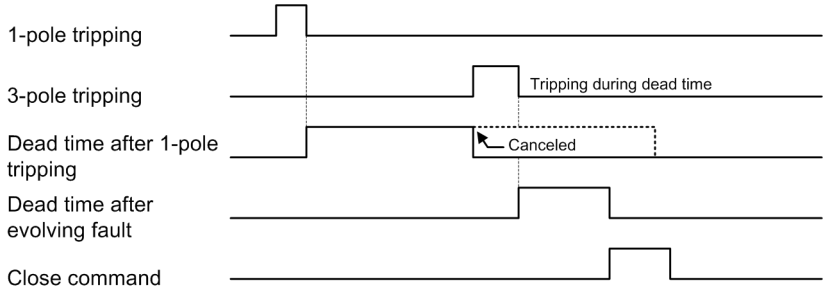
After a recognized evolving fault, the automatic reclosing function can be influenced in 2 ways.

- Parameter **Response to evolv. faults** = ***blocks 79***

  As soon as an evolving fault is recognized, the reclosing function will be blocked. There are no other reclosing attempts and the automatic reclosing function is blocked until the pickup and operate indications causing the evolving fault disappear.

- Parameter **Response to evolv. faults** = ***strt. evol.flt.dead time***

  As soon as an evolving fault is recognized, an automatic reclosing cycle for 3-pole interruption is switched to. The automatic reclosing function does not allow any 1-pole tripping until the fault is solved or there is a final switch off; thus, every following trip command will be 3-pole. When the evolving fault is fixed, the separate dead time for faults will start, see also chapter **Dead time**. The further process is as by 3-pole cycles.



[dw_bspffe, 1, en_US]

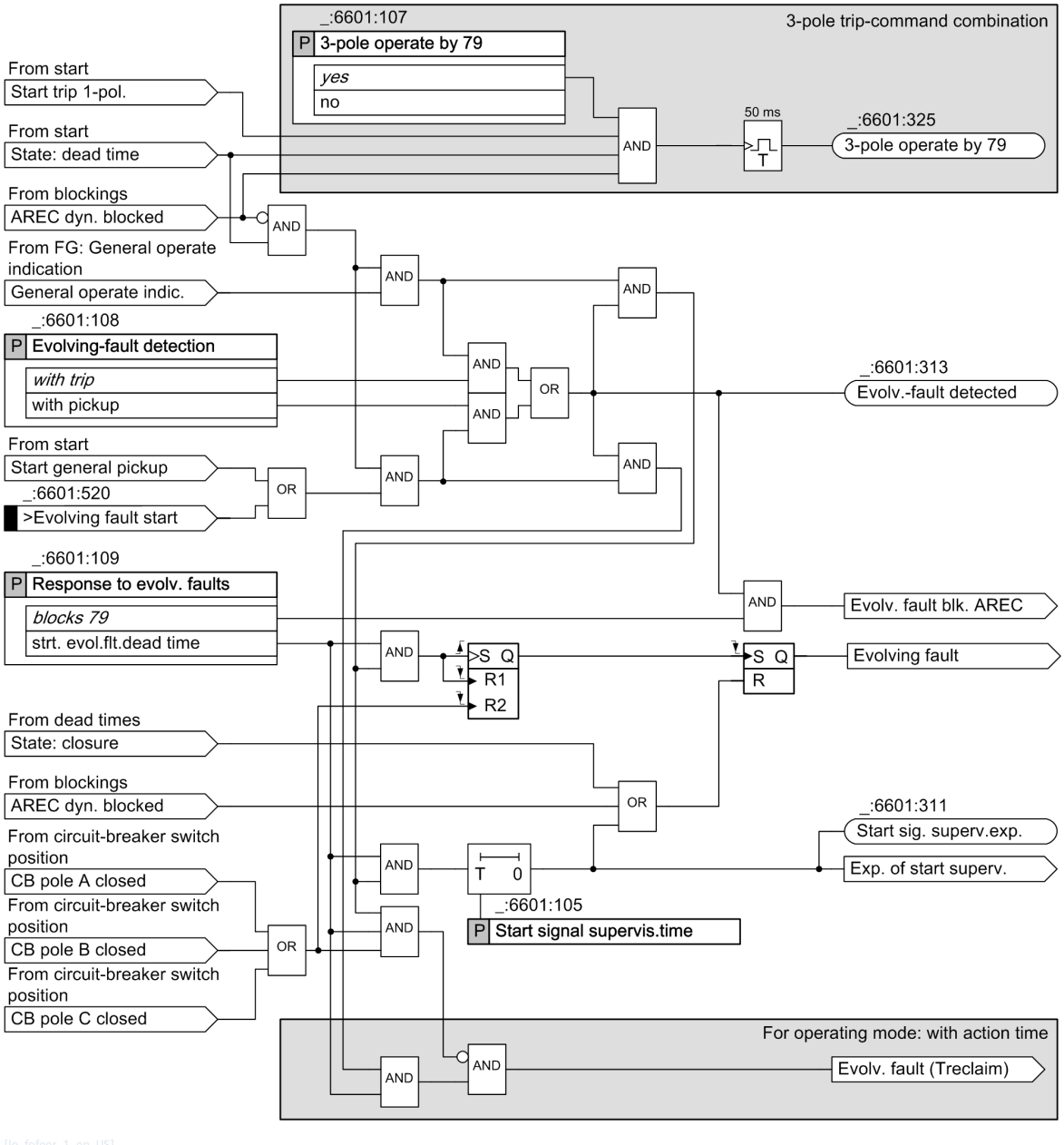
Figure 6-398 Cyclic Automatic Reclosing Function - Example for an Evolving Fault

For tripping through evolving faults, the entire dead time consists of the part of the dead time expired until disconnecting the evolving fault for the 1-pole interruption plus the dead time for the fault together, see *Figure 6-399*.

The dead time for evolving faults is started with the return of the operate indication or with the opening of all 3 circuit-breaker poles, provided the circuit-breaker auxiliary contacts are connected.

3-Pole Tripping of the Circuit Breaker for Automatic Reclosing Function Blocking through Evolving Faults in a 1-Pole Dead Time

If due to an evolving fault there is a blocking of the automatic reclosing function in the 1-pole dead time without a protection function submitting a 3-pole trip command, for example, during an evolving-fault detection with pickup, the automatic reclosing function can create a 3-pole trip command. Thus, the circuit breaker will have 3-pole tripping in which the blocking of the automatic reclosing function will occur.



[lo_fofeer, 1, en_US]

Figure 6-399 Cyclic Automatic Reclosing Function – Logic of Evolving-Fault Detection

6.22.4.14 Closing Indication and Close Command

After the expiration of the dead time, the Automatic reclosing function will be in the **closing** state.

The **closing** state can depend on the following influences, see *Figure 6-400*:

- through a synchrocheck if the circuit breaker was opened during the 3-pole dead time
- Through the readiness of the circuit breaker signaled through the binary input
- Through a binary input for delaying the close command (*>Delay close cmd.*)

The *Close cmd. indication* is a requirement for the assignment of the actual close command to the circuit breaker.

The mentioned criteria must not be fulfilled directly after expiration of the dead time. If a dead-time prolongation is set, the mentioned criteria will be checked during the prolongation. With the release of the closing indication, the automatic reclosing function will switch to the **reclaim time** state.

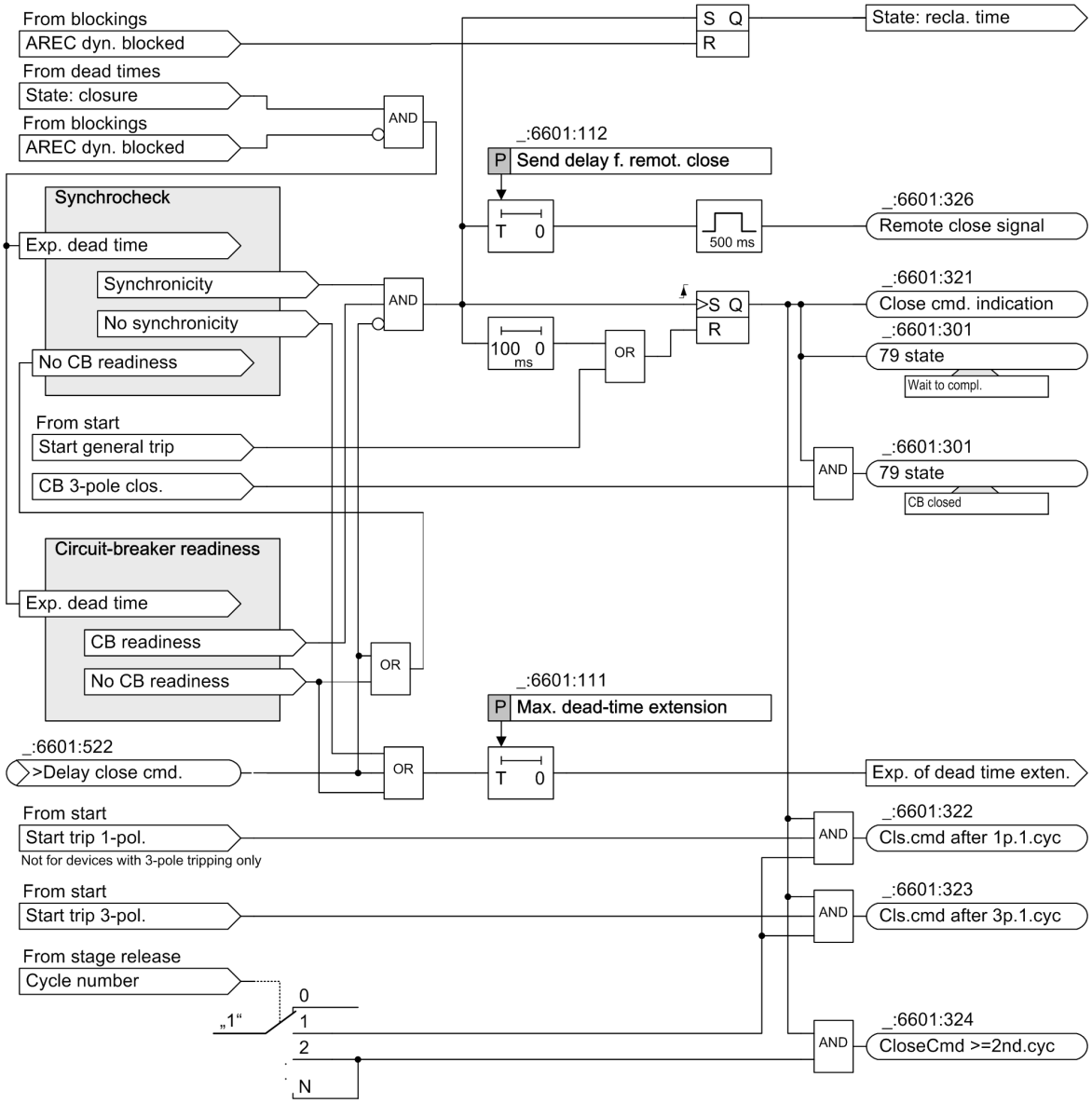


Figure 6-400 Cyclic Reclosing Function: Logic for the Closing Indication

Testing the Circuit-Breaker Readiness Directly before Closing

For each of the automatic reclosing cycles, you can set if a test of the circuit-breaker readiness should occur directly before closing (parameters **`CB ready check bef.close`**, *Figure 6-401*). Independent of this, a test of the circuit-breaker readiness before the start of the 1st automatic reclosing cycle can be set, see Chapter *6.22.4.5 Start* and chapter *6.22.4.16 Circuit-Breaker Readiness and Circuit-Breaker Condition*.

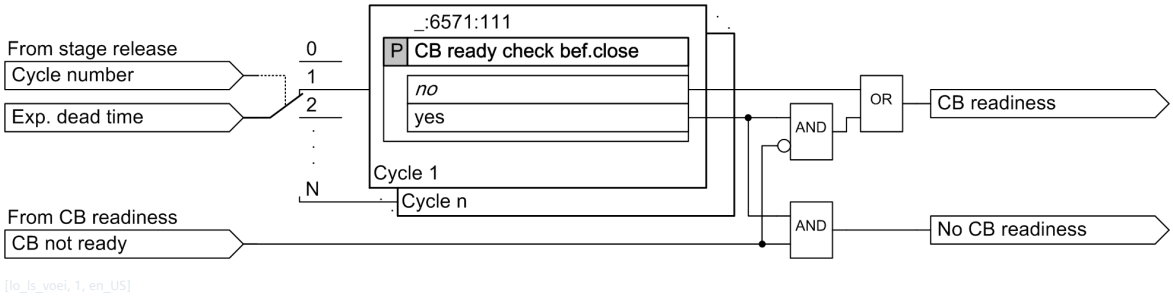


Figure 6-401 Cyclic Reclosing Function: Logic for the Query of the Circuit-Breaker Readiness Directly before Closing

Synchrocheck

For each of the configured automatic reclosing cycles, you can set if a synchrocheck should be executed and which functionality should be used here, see *Figure 6-402*. You may only use the internal synchrocheck if the device is connected to a voltage transformer.

Alternatively, you can also connect an external device with synchrocheck through a binary input.

The measuring request for the synchrocheck is placed if the optional test of the circuit-breaker readiness was positive. The measuring request for the synchrocheck exists until the synchrocheck assigns the allowance for the closure. If the allowance is not given within the set maximum dead time extension, the closure will be cancelled through the blocking of the automatic reclosing function. The minimum duration of the measuring request is 50 ms.

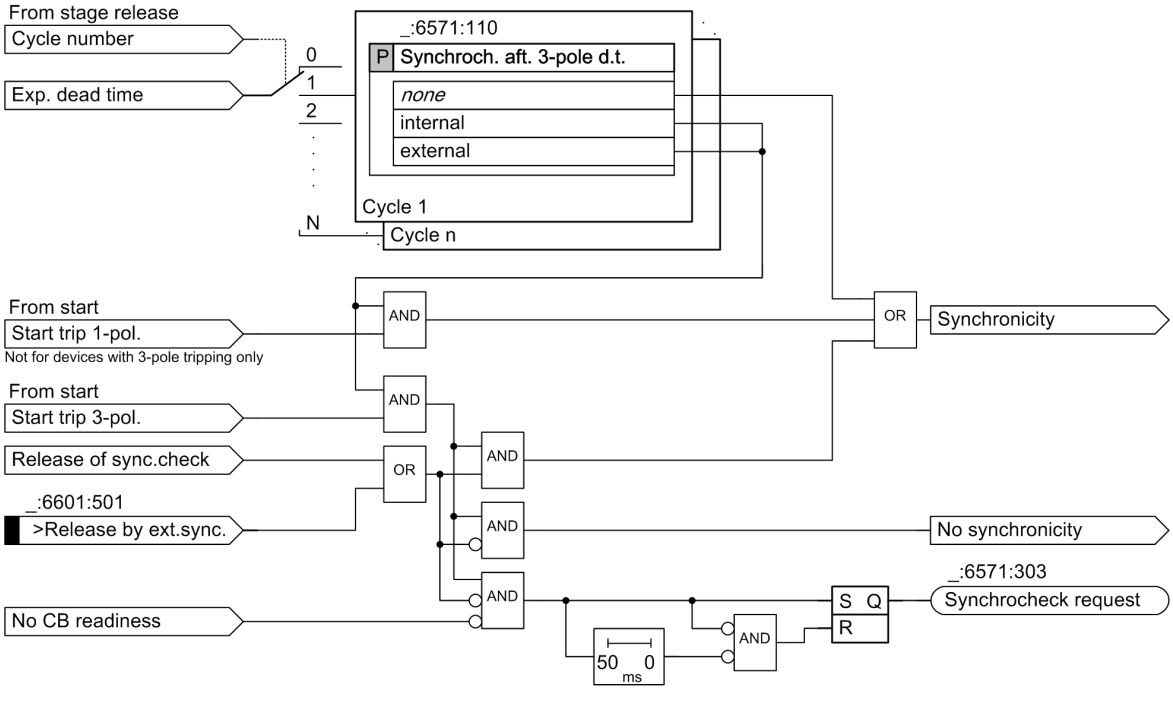


Figure 6-402 Cyclic Reclosing Function: Logic for the Inquiry of the Synchronism

Close Command

As soon as the test of the circuit-breaker readiness and the synchrocheck deliver a positive result, the closing indication will be created. It will be assigned for 100 ms. The actual close command is not created by the automatic reclosing function, but rather from the circuit-breaker function block outside of the automatic reclosing function. Here the set maximum duration of the close command is also considered.

In addition to the closing indication, additional indications will be created that describe the type of closure. These include:

- Close command after 1-pole tripping in the 1st cycle (*Cls.cmd after 1p.1.cyc*)
- Close command after 3-pole tripping in the first cycle (*Cls.cmd after 3p.1.cyc*)
- Close command after 1-pole or 3-pole tripping starting with the second cycle (*CloseCmd >=2nd.cyc*)

Creation of the Signal Remote close signal

The cyclic automatic reclosing function can create information *Remote close signal*. This information can be transferred to the protection device as a binary signal on the line that is to be protected on the opposite end. From the automatic reclosing function, it can be processed in the operating mode **adaptive dead time**. Furthermore, the binary signal may be arranged as data for transmission via an existing protection interface.

The information *Remote close signal* is created by the closing logic. It can be delayed by a set time over the local close indication. With this delay, you can make sure that information is only set if the automatic reclosing was successful and there was no further tripping. The pulse duration of the inter-close signal has a fixed length of 500 ms.

6.22.4.15 Reclaim Time

With the assignment of the close command, the automatic reclosing function goes into the **reclaim time** state. During this time, it is decided if the current reclosing cycle was successful or not.

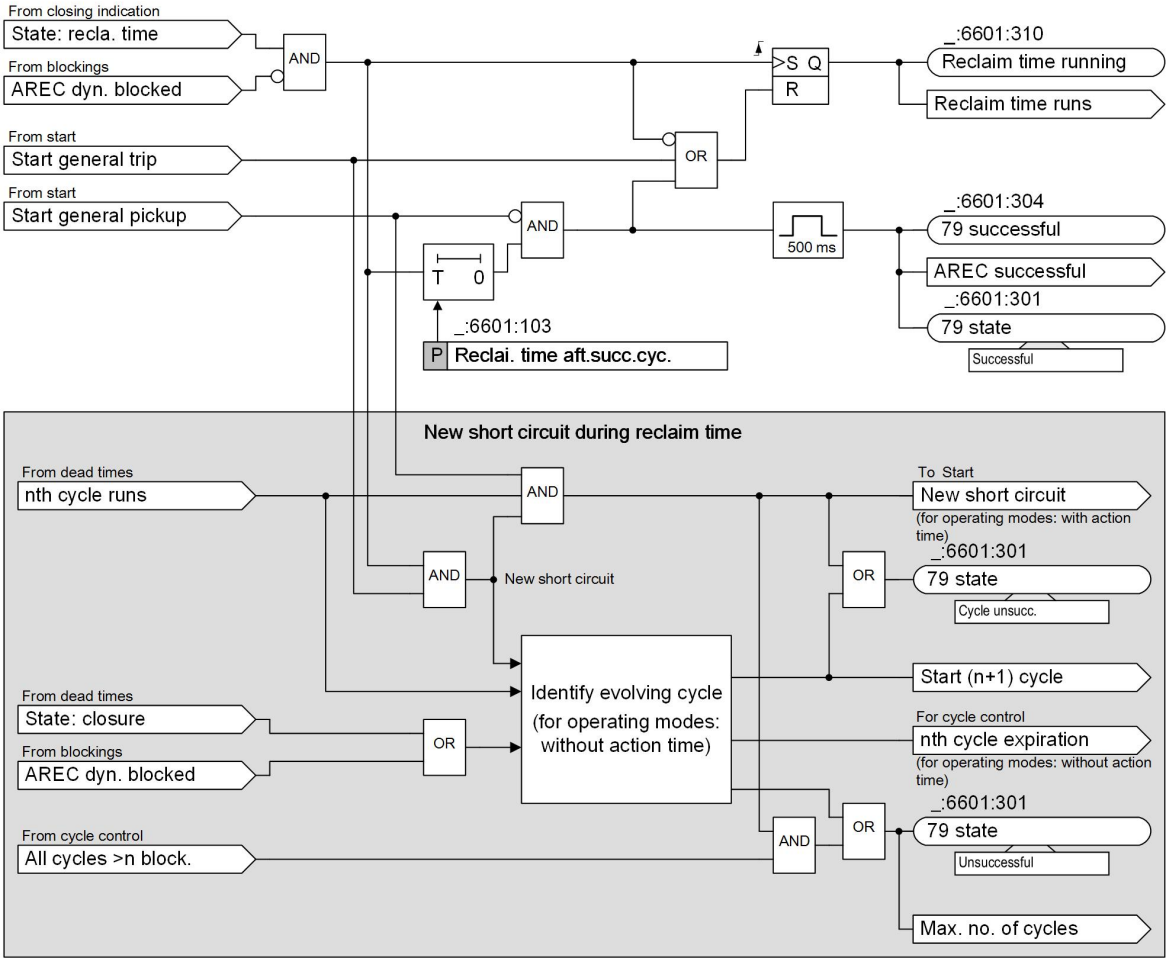
- If during the reclaim time no further tripping occurs, the currently running automatic reclosing cycle, and thus the entire automatic reclosing, was successful.
- If during the reclaim time another tripping occurs, the currently running automatic reclosing cycle was not successful. If other automatic reclosing cycles are permitted, one of these cycles will be used to continue the process. If, in contrast, the currently executed cycle was the last permissible cycle, the automatic reclosing process will end and be reported as unsuccessful.

In both cases, the automatic reclosing function switches back to the idle state **automatic reclosing function ready**.

Short Circuits during Running Reclaim Time

A trip command that occurs during a reclaim time leads to a cancelation of the reclaim time. If further automatic reclosing cycles are allowed, the regulation of the next cycle depends on whether the automatic reclosing function is executed in an operating mode **with action times** or **without action times**, see *Figure 6-403*.

- With operating modes **with action time**, the action times of all higher cycles are started with the beginning of the new general pickup if these are not blocked. The cycle with the lowest cycle number is selected, whose action time is not yet expired with the incoming operate indication. If no further cycles are possible or if the action times of all possible cycles are expired before the operate indication, there will be no further reclosing.
- With the operating modes **without action time**, the cycle following the current cycle will always be selected in the set cycle. If this is blocked, the cycle following this one will be selected, etc. If no higher cycles exist or if they are all blocked, there will be no further automatic reclosing.



[lo_sperre, 2, en_US]

Figure 6-403 Cyclic Reclosing Function: Logic for the Reclaim Time

6.22.4.16 Circuit-Breaker Readiness and Circuit-Breaker Condition

The automatic reclosing function requires the readiness of the circuit breaker for the following purposes, see *Figure 6-404*:

- Recognition of the circuit-breaker readiness from the beginning:
  In idle state of the automatic reclosing function, an unavailable circuit breaker leads to the blocking of the automatic reclosing function. This monitoring is optional and must be switched off through settings if the readiness signal is not available for the protection device.
- Analysis of the circuit-breaker readiness directly before the close command:
  For each of the configured automatic reclosing cycles, it can be set whether the circuit-breaker readiness is a requirement for the assignment of the close command. This monitoring is also optional.

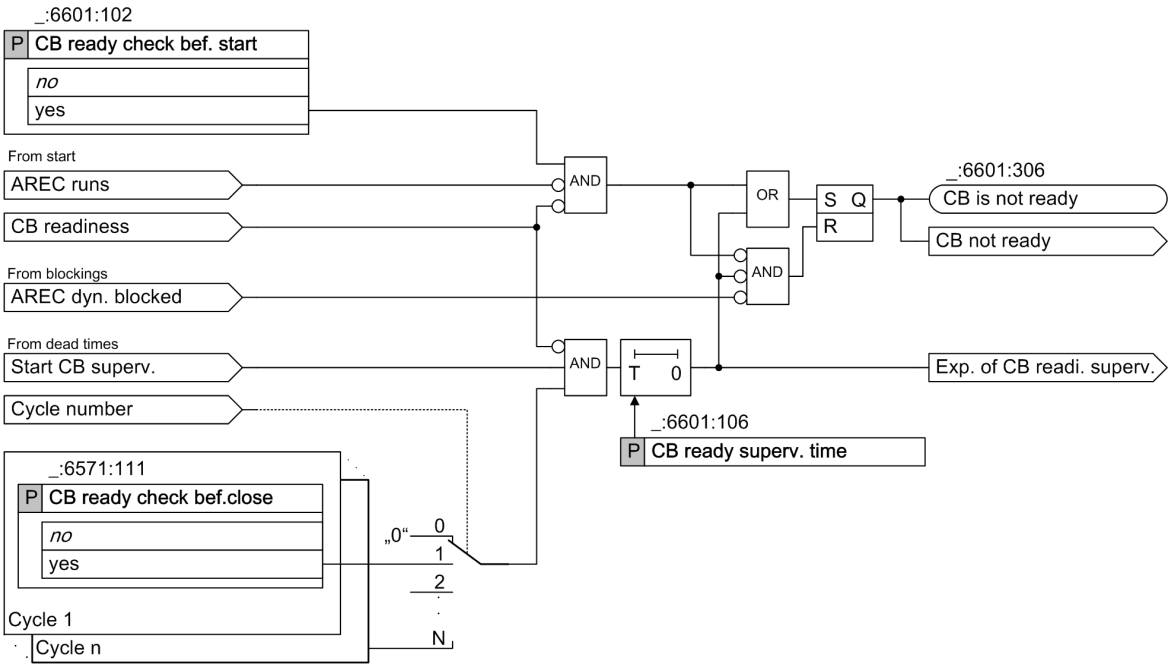


Figure 6-404 Cyclic Reclosing Function: Logic for the Circuit-Breaker Readiness

The automatic reclosing function uses the information from the circuit breaker for the following purposes (see *Figure 6-405*):

- Detection of a non-closed circuit breaker before the start:

  In idle state of the automatic reclosing function, a non-3-pole closed circuit breaker leads to the blocking of the automatic reclosing function, see also chapter *6.22.4.17 Blockings*. This monitoring is not needed if the auxiliary-contact signals are not available.

- Detection of the reaction of the circuit breaker after a trip command:

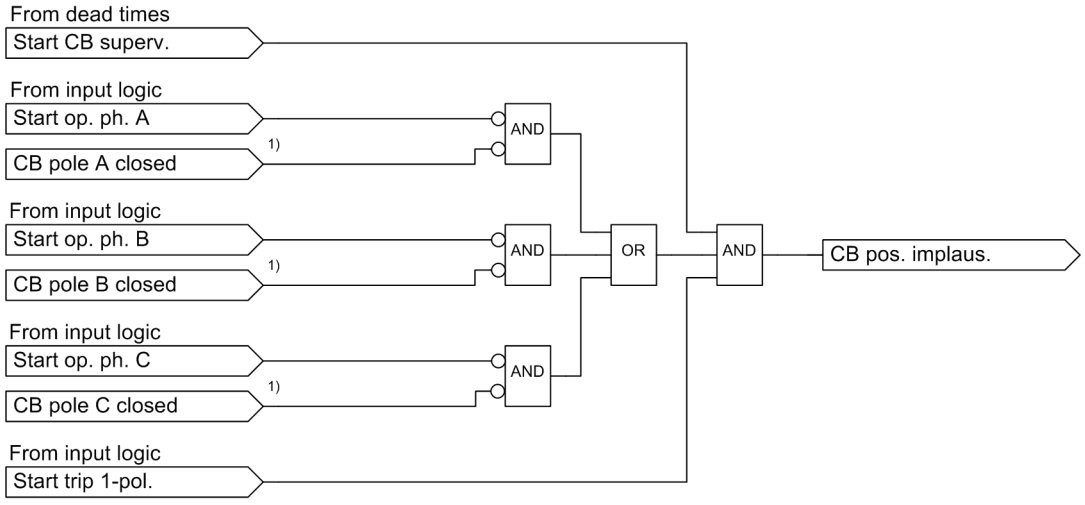
  The automatic reclosing function dead time is started immediately with the opening of the circuit breaker if the circuit-breaker auxiliary contacts are connected. Here a decision is made based on the opening of the circuit breaker if the circuit breaker is no longer 3-pole closed.

  An exception is the reaction to an evolving fault. As the circuit breaker already has 1 pole open before the occurrence of an evolving fault, the dead time is started if the circuit breaker is detected as having 3 poles open.

  If the circuit-breaker auxiliary contacts are not connected, the automatic reclosing function dead time will start with the dropout of the operate indication.

- After a 1-pole trip, a check is done during the dead time to determine whether the circuit-breaker poles that were not switched off remain closed. The circuit-breaker position recognition is delivered from the central circuit-breaker position recognition of the Circuit-breaker function group.

  For implausible circuit-breaker condition, a 3-pole coupling of the trip command for the circuit breaker is executed provided the settings allows this. After this 3-pole tripping, if set and not blocked, more 3-pole automatic reclosing cycles may follow, see also chapter *6.22.4.11 Dead Time for Operating Modes with Tripping*.



1) From circuit-breaker position recognition

[lo_lsuebe, 1, en_US]

Figure 6-405 Cyclic Reclosing Function: Logic for Circuit-Breaker Condition and Supervision

6.22.4.17 Blockings

The Automatic reclosing function differentiates between 2 types of blockings, see *Figure 6-406*:

- Static blocking
- Dynamic blocking

Static Blocking

The Automatic reclosing function is statically blocked if the function is switched on, but is not ready for reclosing and also cannot be started as long as this blocking is present. The static blocking is signaled with the indication *Inactive*.

The following conditions lead to static blocking:

Condition	Indication
Manual closing of the circuit breaker, recognition through binary input or internal device control. The blocking is temporary, the duration can be set with the parameter **Block. time aft. man.close**.	Inactive
Circuit breaker not available for AREC, recognition through binary input. This cause can be switched on or off via the parameter **CB ready check bef.close**.	Inactive

Condition	Indication
Circuit breaker not closed on 3-poles, recognition through binary input. This criteria is used if the circuit-breaker auxiliary contacts are connected.	Inactive
No reclosing cycle possible Recognition due to the following causes: • AREC cycle is not set. • AREC cycles are set, but all are blocked, for example, via binary input. • There is no device-internal function and no binary input configured for starting the Automatic reclosing function. • With operating modes **with tripping**: – both 1-pole and 3-pole cycles are blocked via binary inputs • With operating modes **with pickup**: – 1-phase, 2-phase and 3-phase AREC cycles are blocked via binary inputs. • With operating modes **without action time**: – the first automatic reclosing cycle is blocked via binary input. • With the **dead-line check** functionality: – if the voltage measurement is not available or is disrupted	Inactive

Dynamic Blocking

The Automatic reclosing function is **blocked dynamically** if a blocking condition occurs while an Automatic reclosing function is running. The dynamic blocking is signalized with the indication *Not ready*.

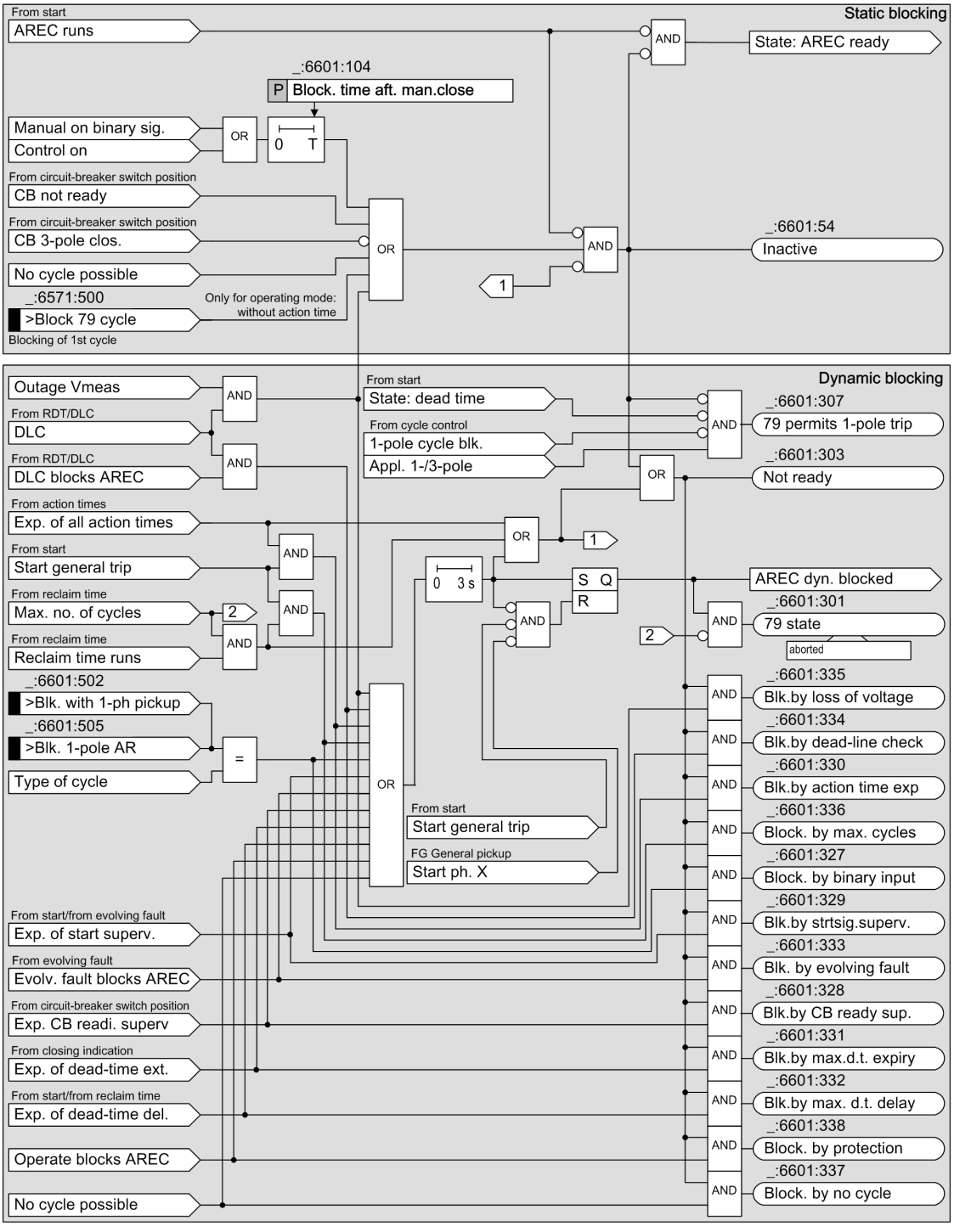
After the occurrence of a dynamic blocking, it is checked in intervals of 0.5 s to see if the blocking can be removed. If the blocking condition remains or if a different blocking condition occurs in the meantime, the blocking will remain. If, in contrast, the cause of the blocking disappears, the dynamic blocking will be removed if no general pickup or no tripping configured for the Automatic reclosing function start is available.

A separate indication for logging exists for each individual blocking cause.

The following conditions lead to the dynamic blocking:

Condition	Indication
If no reclosing cycle fitting the fault type is released: • With operating modes **with tripping**: If a 1-pole or 3-pole operate indication occurs at the automatic reclosing function starting process, however, the Automatic reclosing function does not start in accordance with the parameterization for this type of tripping, the respective dead time will be set to ***invalid***. • With operating modes **with pickup**: If a 1-phase, 2-phase or 3-phase pickup indication occurs at the automatic reclosing function starting process, but the Automatic reclosing function may not be started in accordance with the parameterization for this type of pickup.	*Not ready* Block. by no cycle
If a protection function causes the Automatic reclosing function to be blocked in accordance with the configuration	*Not ready* Block. by protection

Condition	Indication
If the maximum set waiting time for the delay of the start of the dead time through the binary input *>Dead time start delay* expires without the binary input becoming inactive during this period of time	*Not ready* Blk.by max. d.t. delay
If the synchrocheck is set and the synchronism conditions after the expiration of the maximum dead-time extension are not fulfilled before the assignment of the close command	*Not ready* *Blk.by max.d.t. expiry*
If the query of the circuit-breaker readiness is switched on directly before the close command through the parameter and the maximum dead-time extension expires	*Not ready* *Blk.by CB ready sup.* *Blk.by max.d.t. expiry*
If the closing indication is delayed through the binary input *>Delay close cmd.* for so long until the maximum dead time extension is exceeded before the assignment of the close command	*Not ready* *Blk.by max.d.t. expiry*
If an evolving fault occurs and the parameter **Response to evolv. faults** is set to ***blocks 79***	*Not ready* *Blk. by evolving fault*
If the starting-signal supervision time for the operate indication starting from the AREC or the starting binary input expires. In this case, a circuit-breaker failure is assumed.	*Not ready* *Blk.by strtsig.superv.*
If after the start of the AREC a dead time is already running and a blocking binary input is active, with the following binary inputs: *>Blk. 1-pole AR*, *>Blk. 3-pole AR*, *>Blk. with 1-ph pickup*, *>Blk. with 2-ph pickup*, >Blk. with 3-ph pickup	*Not ready* *Block. by binary input*
If the maximum number of Automatic reclosing attempts is reached and there is a trip command within the reclaim time	*Not ready* *Block. by max. cycles*
With operating modes **with action time**: If the action times of all released automatic reclosing cycles expire without a trip command	*Not ready* *Blk.by action time exp*
For applications with voltage measurement and switched on functionalities with **dead-line check**: If during the dead time the required voltage criteria is not fulfilled	*Not ready* *Blk.by dead-line check*
For applications with voltage measurement and switched on functionalities with **dead-line check**: If during a running automatic reclosing cycle a failure of the measuring voltage is determined. After the completion of the automatic reclosing cycle, the dynamic blocking becomes static blocking if there is a continued failure of the measuring voltage.	*Not ready* *Blk.by loss of voltage*



[lo_blo_awe, 3, en_US]

Figure 6-406 Cyclic Automatic Reclosing: Blocking Logic as an Example for a 1-Pole Cycle (Static and Dynamic Blocking)

6.22.4.18 1-/3-pole Tripping of the Circuit Breaker

During short circuits, a 1-pole may shut off the circuit breaker if the corresponding protection functions generate trip indications in accordance with the parameterization and short circuit type, and the automatic reclosing function is parameterized such that 1-pole reclosing cycles are allowed.

By displaying the message *79 permits 1-pole trip* (see *Figure 6-406* in Section *6.22.4.17 Blockings*) the automatic reclosing function signals the 1-pole tripping option of the circuit breaker within the associated function group of the circuit breaker.

Subject to the following conditions, the message *79 permits 1-pole trip* will neither be generated nor reset:

- during the current 1-pole automatic reclosing function cycle if a blocking of the automatic reclosing function occurs prior to the reclosing
- If an automatic reclosing function start is signaled with 2-pole tripping, for example, through external binary inputs
- During operating modes **with tripping**, if there is a 1-pole trip indication and the automatic reclosing function does not allow for 1-pole cycles in accordance with their parameterization.
- If during a 1-pole automatic reclosing function cycle the monitoring of the circuit-breaker pole recognizes an implausible condition.

The automatic reclosing function may generate a 3-pole trip command (3-pole intertrip), if a blocking of the automatic reclosing function occurs based on the above-mentioned causes, e.g., during the detection of an evolving fault with pickup and blocking of evolving faults. Thus, the circuit breaker will have 3-pole tripping in which the blocking of the automatic reclosing function will occur, see also Chapter *6.22.4.11 Dead Time for Operating Modes with Tripping*.

6.22.4.19 Dead-Line Check (DLC) and Reduced Dead Time (RDT)

The additional functions **Dead-line check (DLC)** and **Reduced dead time (RDT)**, are only possible for applications with a voltage-transformer connection. Another requirement is that the voltage of the line being switched on can be correctly measured with an open circuit breaker. This is only possible if the voltage transformer is aligned on the line-side - seen from the circuit breaker.

Both additional functions DLC and RDT are mutually exclusive, because the DLC checks if the value falls below a voltage threshold, while the RDT checks if the value exceeds the voltage threshold.

The respectively selected additional function runs in the automatic reclosing state **dead time**.

Reduced Dead Time (RDT)

With the **Reduced dead time**, a close command can be assigned before the expiration of the set dead times if the line to switch on is recognized as fault-free through the measurement of the line voltage.

The voltage measurement occurs with the 3 phase-to-phase-voltages.

In systems with a grounded neutral point, the 3 phase-to-ground voltages are additionally observed.

In systems with compensated or with isolated neutral points, the largest 2 of the 3 phase-to-ground voltages are additionally considered. Through this, a RDT can also be executed with 1-phase ground connections.

For the approval of the close command with RDT, the following conditions apply:

- The automatic reclosing function is in the state **dead time**.
- Each measured voltage is above the set threshold values **`Volt. thres.f. live line/bus`**
  The phase-to-phase voltages are divided by √3 prior to comparison with the threshold value. Thus, the phase-to-ground voltage $U_N\sqrt{3}$ applies as the reference size for the parameterization.
- Exceeding the threshold is fulfilled for the set duration **`Voltage supervision time`**.

Dead-Line Check (DLC)

If after switching off a short-circuit the voltage on the switched off line does not disappear, the automatic reclosing function can be avoided with the **dead-line check (DLC)**.

The voltage measurement occurs with the 3 phase-to-ground voltages.

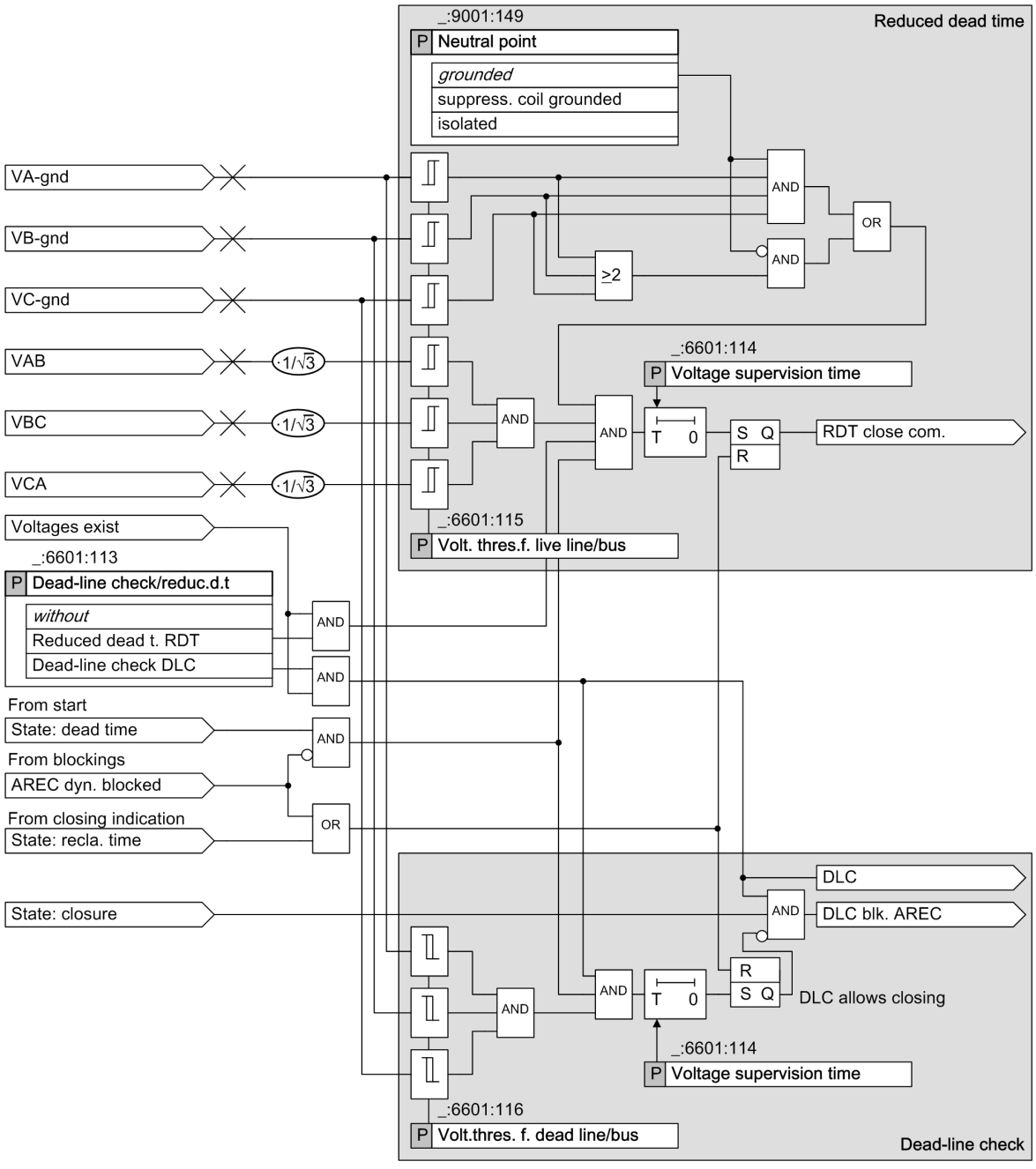
For the release of the close command with DLC, the following conditions apply:

- The automatic reclosing function is in the state **dead time**.
- All measured voltages for the set duration **Voltage supervision time** are below the set threshold **Volt. thres.f. live line/bus**.
- The set dead time is expired.

As soon as the voltages fall below the threshold value for the set duration, the allowance for automatic reclosing with DLC is assigned. This also applies if the values are not below the voltage threshold until the expiration of the set dead time. In this way, an automatic reclosing is executed if the automatic reclosing function is first switched to at the end of the protected line and thus, the line is exposed to voltage again.

The automatic reclosing function is blocked by the DLC under the following conditions:

- The automatic reclosing function is in the **Closure** state, the dead time has expired
- All measured voltages were not simultaneously below the set threshold values **Voltage supervision time** for the set duration**Volt.thres. f. dead line/bus** during the dead time.



[lo_vrkarc, 1, en_US]

Figure 6-407 Cyclic Reclosing Function: Logic for the Functions of Reduced Dead Time and Dead-Line Check

6.22.4.20 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:6601:1	General:Mode		• off • on • test	on

Addr.	Parameter	C	Setting Options	Default Setting
_:6601:101	General:79 operating mode		• with op., w/o act. time • with op., with act. time • w.pickup, w/o act. time • w.pickup, w. action time	with op., with act. time
_:6601:102	General:CB ready check bef. start		• no • yes	no
_:6601:103	General:Reclai. time aft.succ.cyc.		0.50 s to 300.00 s	3.00 s
_:6601:104	General:Block. time aft. man.close		0.00 s to 300.00 s	1.00 s
_:6601:105	General:Start signal supervis.time		0.01 s to 300.00 s	0.13 s
_:6601:106	General:CB ready superv. time		0.01 s to 300.00 s	3.00 s
_:6601:107	General:3-pole operate by 79		• no • yes	yes
_:6601:108	General:Evolving-fault detection		• with trip • with pickup	with trip
_:6601:109	General:Response to evolv. faults		• strt. evol.flt.dead time • blocks 79	blocks 79
_:6601:110	General:Max. dead-time delay		0.01 s to 300.00 s	0.50 s
_:6601:111	General:Max. dead-time extension		0.00 s to 300.00 s; ∞	1.20 s
_:6601:112	General:Send delay f. remot. close		0.00 s to 300.00 s; ∞	∞
DLC, RDT				
_:6601:113	General:Dead-line check/ reduc.d.t		• without • Reduced dead t. RDT • Dead-line check DLC	without
_:6601:114	General:Voltage supervision time		0.10 s to 30.00 s	0.10 s
_:6601:115	General:Volt. thres.f. live line/bus		0.300 V to 340.000 V	48.000 V
_:6601:116	General:Volt.thres. f. dead line/bus		0.300 V to 340.000 V	30.000 V
Cycle 1				
_:6571:102	Cycle 1:Start from idle state allow.		• no • yes	yes
_:6571:103	Cycle 1:Action time		0.00 s to 300.00 s; ∞	0.20 s
_:6571:108	Cycle 1:Dead time aft. 3-pole trip		0.00 s to 1800.00 s; ∞	0.50 s
_:6571:107	Cycle 1:Dead time aft. 1-pole trip		0.00 s to 1800.00 s; ∞	1.20 s
_:6571:104	Cycle 1:Dead time aft.1ph. pickup		0.00 s to 1800.00 s; ∞	1.20 s
_:6571:105	Cycle 1:Dead time aft.2ph. pickup		0.00 s to 1800.00 s; ∞	1.20 s

Addr.	Parameter	C	Setting Options	Default Setting
_:6571:106	Cycle 1:Dead time aft.3ph. pickup		0.00 s to 1800.00 s; ∞	0.50 s
_:6571:109	Cycle 1:Dead time aft. evolv. fault		0.01 s to 1800.00 s	1.20 s
_:6571:111	Cycle 1:CB ready check bef.close		• no • yes	no
_:6571:110	Cycle 1:Synchroch. aft. 3-pole d.t.		• none • internal • external	none
_:6571:112	Cycle 1:Intern. synchro-check with		Setting options depend on configuration	

6.22.4.21 Information List

No.	Information	Data Class (Type)	Type
General			
_:6601:51	General:Mode (controllable)	ENC	C
_:6601:87	General:>Function off	SPS	I
_:6601:524	General:>Function on	SPS	I
_:6601:347	General:Function on	SPC	C
_:6601:82	General:>Block function	SPS	I
_:6601:501	General:>Release by ext.sync.	SPS	I
_:6601:502	General:>Blk. with 1-ph pickup	SPS	I
_:6601:503	General:>Blk. with 2-ph pickup	SPS	I
_:6601:504	General:>Blk. with 3-ph pickup	SPS	I
_:6601:505	General:>Blk. 1-pole AR	SPS	I
_:6601:506	General:>Blk. 3-pole AR	SPS	I
_:6601:507	General:>Pickup A for start	SPS	I
_:6601:508	General:>Pickup B for start	SPS	I
_:6601:509	General:>Pickup C for start	SPS	I
_:6601:510	General:>Pickup 1ph for start	SPS	I
_:6601:511	General:>Pickup 2ph for start	SPS	I
_:6601:512	General:>Pickup 3ph for start	SPS	I
_:6601:513	General:>Gen. pickup for start	SPS	I
_:6601:514	General:>General trip for start	SPS	I
_:6601:515	General:>Trip pole A for start	SPS	I
_:6601:516	General:>Trip pole B for start	SPS	I
_:6601:517	General:>Trip pole C for start	SPS	I
_:6601:518	General:>Trip 1-pole for start	SPS	I
_:6601:519	General:>Trip 3-pole for start	SPS	I
_:6601:520	General:>Evolving fault start	SPS	I
_:6601:521	General:>Dead time start delay	SPS	I
_:6601:522	General:>Delay close cmd.	SPS	I
_:6601:52	General:Behavior	ENS	O
_:6601:53	General:Health	ENS	O
_:6601:54	General:Inactive	SPS	O
_:6601:301	General:79 state	ENS	O

No.	Information	Data Class (Type)	Type
_:6601:302	General:Actual reclose cycle	INS	O
_:6601:303	General:Not ready	SPS	O
_:6601:304	General:79 successful	SPS	O
_:6601:305	General:CB ready superv.expir	SPS	O
_:6601:306	General:CB is not ready	SPS	O
_:6601:307	General:79 permits 1-pole trip	SPS	O
_:6601:308	General:AR only after 1p. trip	SPS	O
_:6601:309	General:In progress	SPS	O
_:6601:310	General:Reclaim time running	SPS	O
_:6601:311	General:Start sig. superv.exp.	SPS	O
_:6601:313	General:Evolv.-fault detected	SPS	O
_:6601:314	General:RDT CloseCmd indicat.	SPS	O
_:6601:315	General:Dead t. aft.1pole trip	SPS	O
_:6601:316	General:Dead t. aft.3pole trip	SPS	O
_:6601:317	General:Dead t. aft.1ph pickup	SPS	O
_:6601:318	General:Dead t. aft.2ph pickup	SPS	O
_:6601:319	General:Dead t. aft.3ph pickup	SPS	O
_:6601:320	General:Dead t. aft.evolv.flt.	SPS	O
_:6601:321	General:Close cmd. indication	ACT	O
_:6601:322	General:Cls.cmd after 1p.1.cyc	SPS	O
_:6601:323	General:Cls.cmd after 3p.1.cyc	SPS	O
_:6601:324	General:CloseCmd >=2nd.cyc	SPS	O
_:6601:325	General:3-pole operate by 79	SPS	O
_:6601:326	General:Remote close signal	SPS	O
_:6601:327	General:Block. by binary input	SPS	O
_:6601:328	General:Blk.by CB ready sup.	SPS	O
_:6601:329	General:Blk.by strtsig.superv.	SPS	O
_:6601:330	General:Blk.by action time exp	SPS	O
_:6601:331	General:Blk.by max.d.t. expiry	SPS	O
_:6601:332	General:Blk.by max. d.t. delay	SPS	O
_:6601:333	General:Blk. by evolving fault	SPS	O
_:6601:337	General:Block. by no cycle	SPS	O
_:6601:338	General:Block. by protection	SPS	O
_:6601:334	General:Blk.by dead-line check	SPS	O
_:6601:335	General:Blk.by loss of voltage	SPS	O
_:6601:336	General:Block. by max. cycles	SPS	O
_:6601:339	General:Cyc1 1p AR	INS	O
_:6601:340	General:Cyc1 3p AR	INS	O
_:6601:341	General:Cyc2+ 1p AR	INS	O
_:6601:342	General:Cyc2+ 3p AR	INS	O
Cycle 1			
_:6571:51	Cycle 1:Mode (controllable)	ENC	C
_:6571:500	Cycle 1:>Block 79 cycle	SPS	I
_:6571:52	Cycle 1:Behavior	ENS	O
_:6571:53	Cycle 1:Health	ENS	O
_:6571:301	Cycle 1:Cycle running	SPS	O

No.	Information	Data Class (Type)	Type
_:6571:302	Cycle 1:Stage release prot.	SPS	O
_:6571:303	Cycle 1:Synchrocheck request	SPS	O

6.22.5 Automatic Reclosing Function with Adaptive Dead Time (ADT)

6.22.5.1 Description

Description

It is also possible to set the dead times only at one line end and to configure the adaptive dead time at the other end or ends. The requirements for this is that the voltage transformer aligned on the line side or a possibility to transfer a close command to a remote line end exists.

Figure 6-408 shows an example with a voltage measurement. It is assumed that device I works with defined dead times, while the adaptive dead time is configured in device II. It is important that the line is at least fed from busbar A, so from the side with the defined dead times.

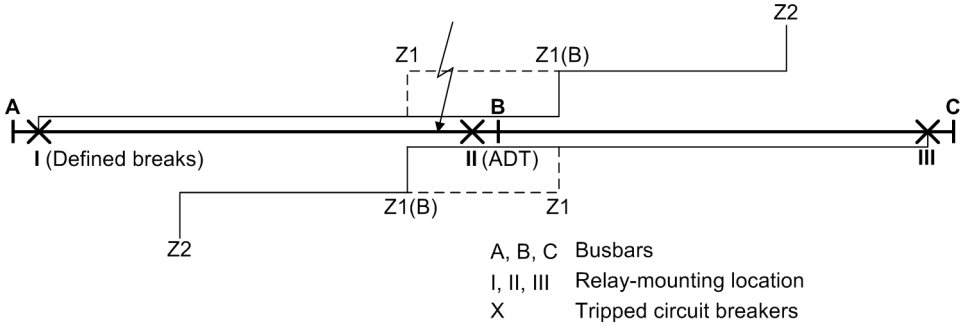
With the adaptive dead time, the automatic reclosing function at the line end II decides independently if and when a reclosing is reasonable and permissible and when it is not. The criteria is the voltage of the line at the end II, which is switched through after reclosing from end I. The reclosing at end II occurs, as soon as it exists, so that the line from end I is set back under voltage. Basically, all phase-to-phase and phase-to-ground voltages are monitored.

With an implied short-circuit, the lines at the positions I, II, and III in the example are switched off. Position I is switched on again after the dead time set there. At position III the reduced dead time (RDT) can be executed with the appropriate configuration (see chapter) if an infeed is also available on busbar B.

If the short circuit has been cleared after successful reclosing, the line A-B from the busbar A will be set under voltage through the position I. Device II recognizes this voltage and switches on to warrant adequate voltage measurement time after a short delay The system incident is thus successfully cleared.

If the short circuit is not cleared after closure at position I, I will be switched to the fault again. At line end II, now no healthy voltage will appear. The device here recognizes this and does not close again.

With multiple reclosing, the process may repeat if the reclosing is unsuccessful until one of the reclosings is successful or a final disconnection occurs.



[dw_arcasp, 1, en_US]

Figure 6-408 Example for Adaptive Dead Time (ADT)

As the example shows, the adaptive dead time brings along the following advantages:

- The circuit breaker at position II does not switch off again with a remaining fault and is protected through this.
- With non-selective tripping by overreach at position III, no further disruption cycles may occur here because the short-circuit path via busbar B and the position II remains disrupted even with multiple reclosing.
- At position I, with multiple reclosing and even with a final tripping, an overlapping is allowed, because the line at position II remains open and thus, no actual overreaching can occur at position I.

The adaptive dead time also contains the reduced dead time (RDT), because the criteria are the same. A special setting of the reduced dead time (RDT) is unnecessary if the automatic reclosing function is used with adaptive dead time (ADT).

6.22.5.2 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:6601:1	General:Mode		• off • on • test	on
_:6601:101	General:79 operating mode		• with op., w/o act. time • with op., with act. time • w.pickup, w/o act. time • w.pickup, w. action time	with op., with act. time
_:6601:102	General:CB ready check bef. start		• no • yes	no
_:6601:103	General:Reclai. time aft.succ.cyc.		0.50 s to 300.00 s	3.00 s
_:6601:104	General:Block. time aft. man.close		0.00 s to 300.00 s	1.00 s
_:6601:105	General:Start signal supervis.time		0.01 s to 300.00 s	0.13 s
_:6601:106	General:CB ready superv. time		0.01 s to 300.00 s	3.00 s
_:6601:107	General:3-pole operate by 79		• no • yes	yes
_:6601:111	General:Max. dead-time extension		0.00 s to 300.00 s; ∞	1.20 s
_:6601:114	General:Voltage supervision time		0.10 s to 30.00 s	0.10 s
_:6601:115	General:Volt. thres.f. live line/bus		0.300 V to 340.000 V	48.000 V
ADT				
_:6631:101	ADT:1-pole trip allowed		• no • yes	no
_:6631:104	ADT:Action time		0.00 s to 300.00 s; ∞	0.20 s
_:6631:105	ADT:Maximum dead time		0.50 s to 3000.00 s	5.00 s
_:6631:102	ADT:CB ready check bef.close		• no • yes	no
_:6631:103	ADT:Synchroch. aft. 3-pole d.t.		• none • internal • external	none
_:6631:106	ADT:Intern. synchrocheck with		Setting options depend on configuration	

6.22.5.3 Information List

No.	Information	Data Class (Type)	Type
General			
_:6601:51	General:Mode (controllable)	ENC	C
_:6601:87	General:>Function off	SPS	I
_:6601:524	General:>Function on	SPS	I
_:6601:347	General:Function on	SPC	C
_:6601:82	General:>Block function	SPS	I
_:6601:501	General:>Release by ext.sync.	SPS	I
_:6601:502	General:>Blk. with 1-ph pickup	SPS	I
_:6601:503	General:>Blk. with 2-ph pickup	SPS	I
_:6601:504	General:>Blk. with 3-ph pickup	SPS	I
_:6601:505	General:>Blk. 1-pole AR	SPS	I
_:6601:506	General:>Blk. 3-pole AR	SPS	I
_:6601:507	General:>Pickup A for start	SPS	I
_:6601:508	General:>Pickup B for start	SPS	I
_:6601:509	General:>Pickup C for start	SPS	I
_:6601:510	General:>Pickup 1ph for start	SPS	I
_:6601:511	General:>Pickup 2ph for start	SPS	I
_:6601:512	General:>Pickup 3ph for start	SPS	I
_:6601:513	General:>Gen. pickup for start	SPS	I
_:6601:514	General:>General trip for start	SPS	I
_:6601:515	General:>Trip pole A for start	SPS	I
_:6601:516	General:>Trip pole B for start	SPS	I
_:6601:517	General:>Trip pole C for start	SPS	I
_:6601:518	General:>Trip 1-pole for start	SPS	I
_:6601:519	General:>Trip 3-pole for start	SPS	I
_:6601:522	General:>Delay close cmd.	SPS	I
_:6601:52	General:Behavior	ENS	O
_:6601:53	General:Health	ENS	O
_:6601:54	General:Inactive	SPS	O
_:6601:301	General:79 state	ENS	O
_:6601:302	General:Actual reclose cycle	INS	O
_:6601:303	General:Not ready	SPS	O
_:6601:304	General:79 successful	SPS	O
_:6601:305	General:CB ready superv.expir	SPS	O
_:6601:306	General:CB is not ready	SPS	O
_:6601:307	General:79 permits 1-pole trip	SPS	O
_:6601:308	General:AR only after 1p. trip	SPS	O
_:6601:309	General:In progress	SPS	O
_:6601:310	General:Reclaim time running	SPS	O
_:6601:311	General:Start sig. superv.exp.	SPS	O
_:6601:312	General:Max. dead time expired	SPS	O
_:6601:315	General:Dead t. aft.1pole trip	SPS	O
_:6601:316	General:Dead t. aft.3pole trip	SPS	O
_:6601:317	General:Dead t. aft.1ph pickup	SPS	O
_:6601:318	General:Dead t. aft.2ph pickup	SPS	O

No.	Information	Data Class (Type)	Type
_:6601:319	General:Dead t. aft.3ph pickup	SPS	O
_:6601:321	General:Close cmd. indication	ACT	O
_:6601:322	General:Cls.cmd after 1p.1.cyc	SPS	O
_:6601:323	General:Cls.cmd after 3p.1.cyc	SPS	O
_:6601:325	General:3-pole operate by 79	SPS	O
_:6601:327	General:Block. by binary input	SPS	O
_:6601:328	General:Blk.by CB ready sup.	SPS	O
_:6601:329	General:Blk.by strtsig.superv.	SPS	O
_:6601:330	General:Blk.by action time exp	SPS	O
_:6601:331	General:Blk.by max.d.t. expiry	SPS	O
_:6601:337	General:Block. by no cycle	SPS	O
_:6601:338	General:Block. by protection	SPS	O
_:6601:335	General:Blk.by loss of voltage	SPS	O
_:6601:336	General:Block. by max. cycles	SPS	O
_:6601:339	General:Cyc1 1p AR	INS	O
_:6601:340	General:Cyc1 3p AR	INS	O
ADT			
_:6631:51	ADT:Mode (controllable)	ENC	C
_:6631:501	ADT:>Remote close signal	SPS	I
_:6631:52	ADT:Behavior	ENS	O
_:6631:53	ADT:Health	ENS	O
_:6631:301	ADT:ADT is running	SPS	O
_:6631:302	ADT:Stage release prot.	SPS	O
_:6631:303	ADT:Synchrocheck request	SPS	O

6.22.6 Automatic Reclosing Function with Secondary Arc Detection

6.22.6.1 Description

The function **Automatic reclosing function with secondary arc detection** (**SAD**[50])

- Is an adaptive automatic reclosing function based on secondary arc detection.
- Recloses after a shortened dead time in the case of 1-phase, temporary faults.
  If the secondary arc extinguishes before the end of the dead time and no metallic fault occurs, the automatic reclosing function activates sooner.
- Processes different algorithms to detect secondary arcs in parallel and weights them.
  - After a 1-pole tripping, the close command can only be issued once the minimum dead time (see the following figure) has expired.
  - When the arc is extinguished, the close command is issued only after 100 ms to prevent reignition of the arc.
  - If the secondary arc is still burning after the expiry of the maximum dead time, a 3-pole tripping occurs. This is either finally or - if instantiated - another automatic reclosing cycle is started.

50 SAD = Secondary Arc Detection

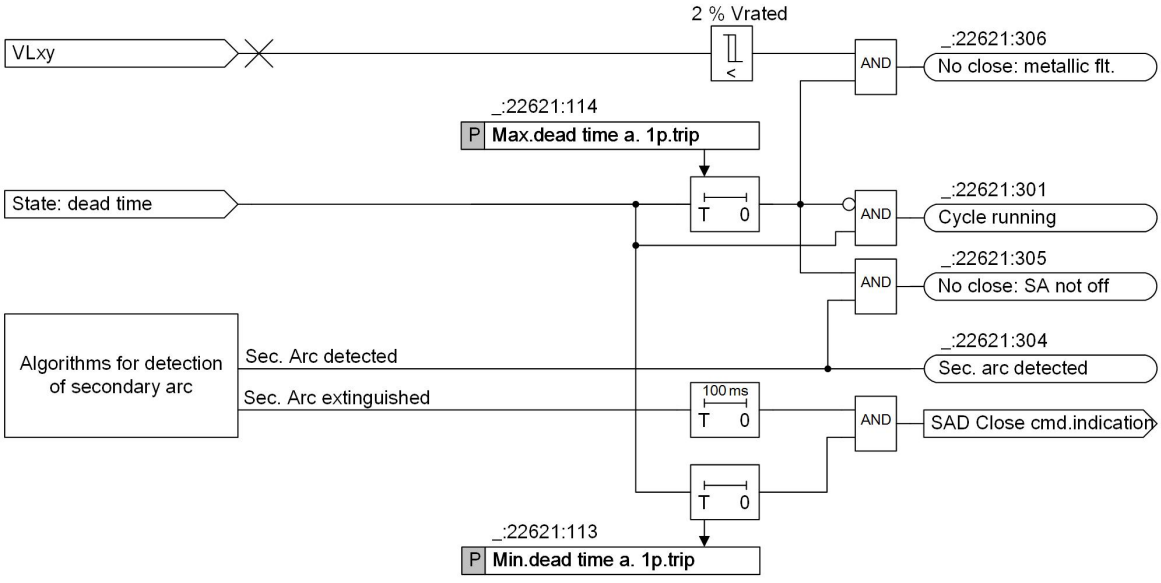
- Behaves as follows if no secondary arc is detected:
  - In case of a metallic fault, the function issues a final trip command.
  - In case of a non-metallic fault, the function issues a close command after the expiry of the minimum dead time.

This function replaces the cyclic automatic reclosing at the master end of the line. At the slave end of the line, Siemens still recommends using the automatic reclosing function with adaptive dead time (ADT).

6.22.2 Structure of the Function shows the structure of the function.

For the description of the general parameters, refer to *6.22.9 Application and Setting Notes for General Settings*.

Logic of the Stage



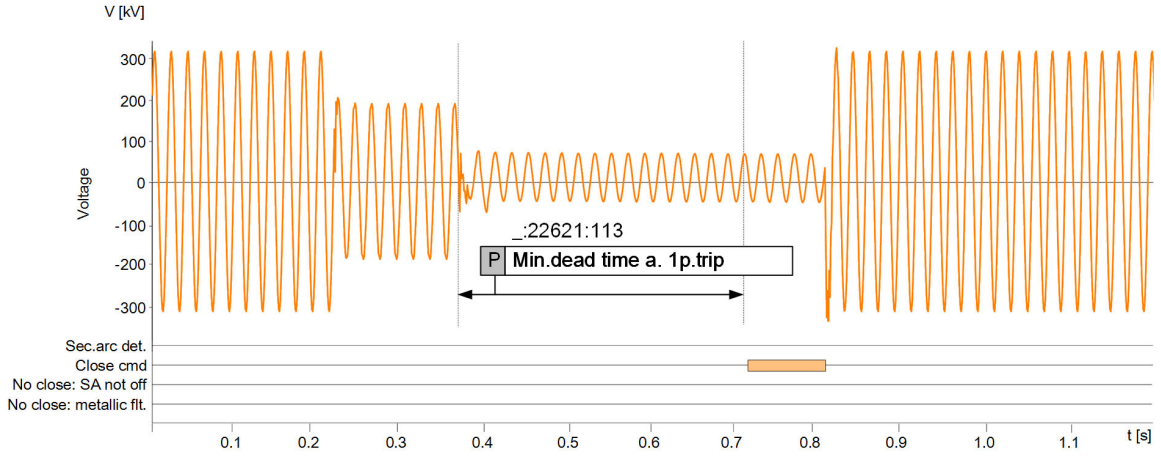
[lo_sad, 1, en_US]

Figure 6-409 Logic of the Stage SAD

VLxy Faulty-loop voltage

When the circuit breaker is open in a 1-pole way and the automatic reclosing function is ready, the dead times start (parameter: **`Min.dead time a. 1p.trip`** and **`Max.dead time a. 1p.trip`**) and the SAD cycle runs. If the maximum dead time has expired and the voltage of the faulty loop is less than 2 % V_{rated}, the indication *`(_:22621:306) No close: metallic flt.`* – no close command due to a metallic fault – is issued for a duration of 50 ms and the SAD cycle is ended. If a secondary arc is detected within the maximum dead time, the indication *`(_:22621:304) Sec. arc detected`* is issued. If the arc does not extinguish during the maximum dead time, the indication *`(_:22621:305) No close: SA not off`* is issued for 50 ms and the SAD cycle is ended.

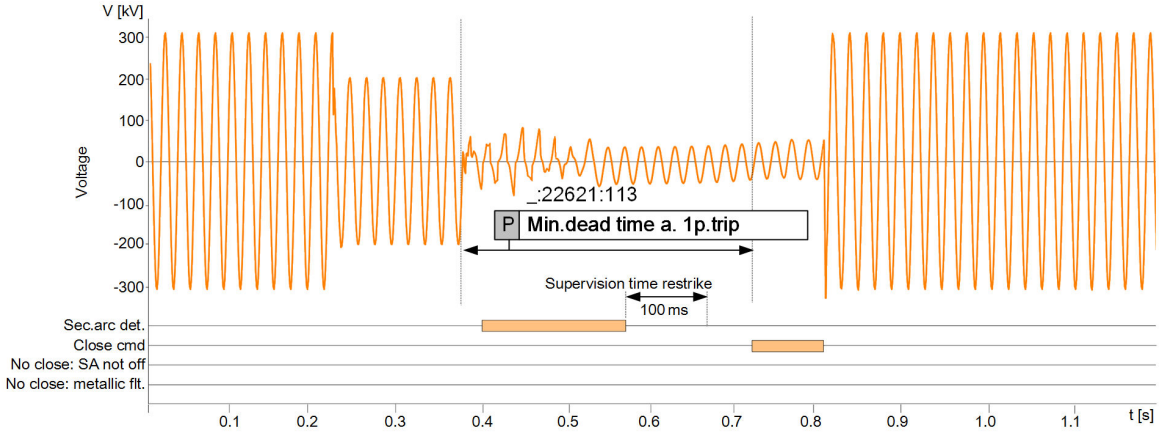
After a 1-pole tripping, a reclosing action can only be carried out once the minimum dead time (see the following figure) has elapsed.



[dw_SAD-times_1-legend, 2, en_US]

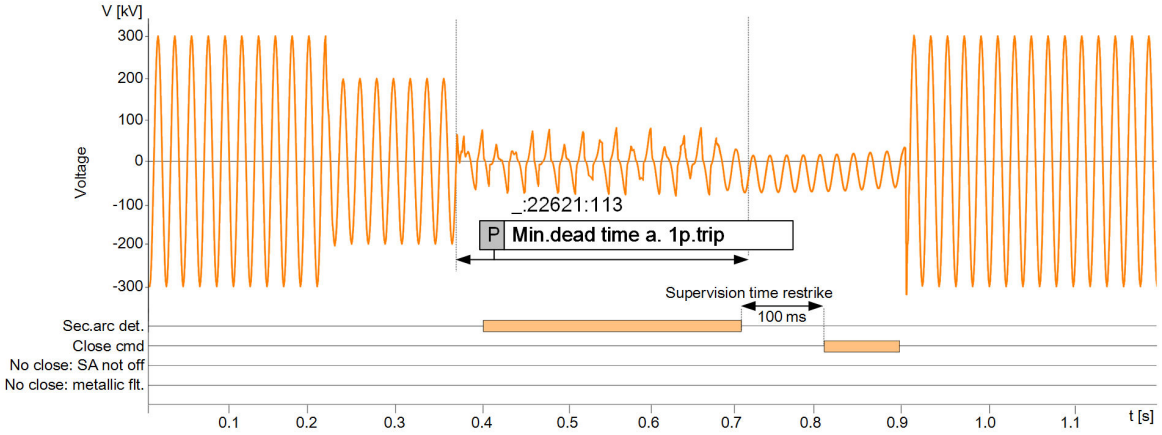
Figure 6-410 Example 1: No Secondary Arc; Close Command after Expiry of the Minimum Dead Time

If a secondary arc is detected, an additional supervision time of 100 ms takes effect after the arc is extinguished. The close command is issued only then. This prevents reclosing in case of a possible reignition of the arc. If no secondary arc is detected, this time is not relevant. If no metallic fault has been detected, the circuit breaker is reclosed after the minimum dead time has expired. The following figures show examples of when the close command is issued – depending on the burning duration of the arc.



[dw_SAD-times_2-legend, 2, en_US]

Figure 6-411 Example 2: Secondary Arc Burns Very Briefly (120 ms); Close Command after Expiry of the Minimum Dead Time



[dw_SAD-times_3-legend, 2, en_US]

Figure 6-412 Example 3: Secondary Arc Burns for 320 ms; Close Command after 420 ms (320 ms + 100 ms)

6.22.6.2 Application and Setting Notes for the Automatic Reclosing Function with Arc Detection

Parameter: Start from idle state allow.

- Default setting **(_:22621:102) Start from idle state allow.** = ***yes***

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode ***with action time***.

With the parameter **Start from idle state allow.**, you can determine whether the action time of this automatic reclosing cycle is started, if the automatic reclosing function is in idle state during with incoming general pickup. Set the parameter always to ***yes***, if the automatic reclosing function is configured for only 1 cycle. If several cycles are configured, you can control the effectiveness of the automatic reclosing cycles with this parameter and various action times.

For detailed information on the functionality, refer to the chapters *6.22.4.6 Cycle Control with Operating Mode 1: with Tripping/with Action Time* and *6.22.4.7 Cycle Control with Operating Mode 2: With Pickup/With Action Time*.

Parameter: Action time

- Default setting **(_:22621:103) Action time** = ***0.20 s***

With the parameter **Action time**, you can determine, within which time frame the trip command must appear, in order to start the automatic reclosing function. If the trip command occurs only after the action time has expired, automatic reclosing does not occur within the active automatic reclosing cycle.

For detailed information on the functionality, refer to the chapters *6.22.4.6 Cycle Control with Operating Mode 1: with Tripping/with Action Time* and *6.22.4.7 Cycle Control with Operating Mode 2: With Pickup/With Action Time*.

Parameter: Dead time aft. 3-pole trip

- Default setting **(_:22621:108) Dead time aft. 3-pole trip** = ***0.50 s***

With the parameter **Dead time aft. 3-pole trip**, you can determine after which dead time the automatic reclosing function will be executed.

After a 3-pole trip of the circuit breaker, the system stability is priority. Since the switched off line cannot develop synchronizing forces, only a short dead time is permitted in most cases. The usual duration is 0.3 s to 0.6 s. A longer period can be tolerated if a synchrocheck is carried out before reclosing. Longer 3-pole dead times are also possible in radial systems.

Parameter: Dead time aft. evolv. fault

These parameters are only significant if the parameter **(_:6601:109) Response to evolv. faults** is set to ***strt. evol.flt.dead time***.

- Default setting **(_:22621:109) Dead time aft. evolv. fault** = ***1.20 s***

With the parameter **Dead time aft. evolv. fault**, you can determine after which dead time the automatic reclosing function should be executed, if based on an evolving fault during the current dead time, a 3-pole trip has occurred. For this 3-pole dead time, stability concerns for the system are also important. Often, this dead time can be set to the same value as the parameter **(_:22621:108) Dead time aft. 3-pole trip**.

For detailed information on the function in the case of evolving faults during dead time, refer to chapter *6.22.4.13 Evolving-Fault Detection During the Dead Time*.

Parameter: CB ready check bef.close

- Default setting **(_:22621:111) CB ready check bef.close** = ***no***

With the parameter **CB ready check bef.close**, you can determine if, after the expiration of the dead time (that is, directly before assigning the close command), the readiness of the circuit breaker should be queried.

Parameter Value	Description
no	With the setting ***no***, the automatic reclosing function does not check again the readiness of the circuit breaker before assigning the close demand. Siemens recommends this setting, if it is sufficient to check the readiness of the circuit breaker for the entire switching cycle once before the start of a reclosing function, consisting of tripping-reclosing-tripping. The setting for checking the readiness of the circuit breaker before the start of the automatic reclosing function is done using the parameter **(_:6601:102) CB ready check bef. start**.
yes	With the setting ***yes***, the dead time can be extended if after the expiration of the dead time the circuit breaker is not ready for the next ON-OFF cycle. The maximum delay of the dead time can be set with the parameter **(_:6601:111) Max. dead-time extension**. Siemens recommends this setting, if it can be assumed that the circuit breaker becomes available to switch on the reclosing function only after an additional waiting period.

For detailed information on the function, refer to the chapters *6.22.4.16 Circuit-Breaker Readiness and Circuit-Breaker Condition* and *6.22.4.14 Closing Indication and Close Command* .

Parameter: Synchroch. aft. 3-pole d.t.

- Default setting **(_:22621:110) Synchroch. aft. 3-pole d.t.** = ***none***

With the parameter **Synchroch. aft. 3-pole d.t.**, you can determine if a synchrocheck must be carried out for the configured automatic reclosing cycle.

If during a 3-pole interruption in the system stability problems may be a concern, Siemens recommends carrying out a synchrocheck. If only 1-pole reclosure cycles are possible or stability problems are not to be expected during the 3-pole dead time, for example, due to a highly intermeshed system or radial system, select the parameter ***none***.

Parameter Value	Description
none	During the automatic reclosing cycle a synchrocheck is not executed.
internal	In the configured automatic reclosing cycle, a synchrocheck is executed after a 3-pole dead time before the close command of the circuit breaker. For the synchrocheck a synchrocheck stage of the internal synchronization function is used, which is contained in the same function group **Circuit breaker** as the automatic reclosing function. The selection of the synchrocheck stage that is used in the automatic reclosing cycle occurs through the following described parameter **Intern. synchrocheck with**.
external	In the configured automatic reclosing cycle, a synchrocheck is executed after a 3-pole dead time before the close command of the circuit breaker. An external synchrocheck device initiates the synchrocheck. The external synchrocheck device is connected with the binary signals *Synchrocheck request* and *>Release by ext.sync.*. For detailed information about the function, refer to chapter *6.22.4.14 Closing Indication and Close Command* in the section *Synchrocheck , Page 1150*.

Parameter: Min.dead time a. 1p.trip

- Default setting **(_:22621:113) Min.dead time a. 1p.trip** = ***0.35 s***

With the parameter **Min.dead time a. 1p.trip**, you define the minimum dead time after a 1-pole tripping. Automatic reclosing is possible after expiry of the minimum dead time at the earliest.

Parameter: Max.dead time a. 1p.trip

- Default setting **(_:22621:113) Max.dead time a. 1p.trip** = ***1.20 s***

With the parameter **Max.dead time a. 1p.trip**, you define the maximum dead time after a 1-pole tripping.
If the secondary arc is still burning after the expiry of the maximum dead time, a 3-pole tripping occurs. This is either finally or - if instantiated - another automatic reclosing cycle is started.

Parameter: Intern. synchrocheck with

With the parameter **(_:22621:112) Intern. synchrocheck with**, you determine which function block of the synchronization function for the Automatic reclosing function is used after a 3-pole dead time. This selection is possible only for function blocks of the synchronization function that are included in the same **Circuit breaker** function group as the Automatic reclosing function. The setting options of the parameter are generated dynamically, according to the actual parameterization.

6.22.6.3 Parameter

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:6601:1	General:Mode		• off • on • test	on
_:6601:101	General:79 operating mode		• with op., w/o act. time • with op., with act. time	with op., with act. time
_:6601:102	General:CB ready check bef. start		• no • yes	no
_:6601:103	General:Reclai. time aft.succ.cyc.		0.50 s to 300.00 s	3.00 s
_:6601:104	General:Block. time aft. man.close		0.00 s to 300.00 s	1.00 s

Addr.	Parameter	C	Setting Options	Default Setting
_:6601:105	General:Start signal supervis.time		0.01 s to 300.00 s	0.13 s
_:6601:106	General:CB ready superv. time		0.01 s to 300.00 s	3.00 s
_:6601:107	General:3-pole operate by 79		• no • yes	yes
_:6601:108	General:Evolving-fault detection		• with trip • with pickup	with trip
_:6601:109	General:Response to evolv. faults		• strt. evol.flt.dead time • blocks 79	blocks 79
_:6601:110	General:Max. dead-time delay		0.01 s to 300.00 s	0.50 s
_:6601:111	General:Max. dead-time extension		0.00 s to 300.00 s; ∞	1.20 s
_:6601:112	General:Send delay f. remot. close		0.00 s to 300.00 s; ∞	-1 s; ∞
79 SAD				
_:22621:102	SAD cycle:Start from idle state allow.		• no • yes	yes
_:22621:103	SAD cycle:Action time		0.00 s to 300.00 s; ∞	0.20 s
_:22621:108	SAD cycle:Dead time aft. 3-pole trip		0.00 s to 1800.00 s; ∞	0.50 s
_:22621:109	SAD cycle:Dead time aft. evolv. fault		0.01 s to 1800.00 s	1.20 s
_:22621:111	SAD cycle:CB ready check bef.close		• no • yes	no
_:22621:110	SAD cycle:Synchroch. aft. 3-pole d.t.		• none • internal • external	none
_:22621:113	SAD cycle:Min.dead time a. 1p.trip		0.10 s to 1800.00 s; ∞	0.35 s
_:22621:114	SAD cycle:Max.dead time a. 1p.trip		0.10 s to 1800.00 s; ∞	1.20 s
_:22621:112	SAD cycle:Intern. synchrocheck with		Setting options depend on configuration	

6.22.6.4 Information

No.	Information	Data Class (Type)	Type
General			
_:6601:87	General:>Function off	SPS	I
_:6601:524	General:>Function on	SPS	I
_:6601:347	General:Function on	SPC	C
_:6601:82	General:>Block function	SPS	I
_:6601:501	General:>Release by ext.sync.	SPS	I
_:6601:502	General:>Blk. with 1-ph pickup	SPS	I
_:6601:503	General:>Blk. with 2-ph pickup	SPS	I
_:6601:504	General:>Blk. with 3-ph pickup	SPS	I

No.	Information	Data Class (Type)	Type
_:6601:505	General:>Blk. 1-pole AR	SPS	I
_:6601:506	General:>Blk. 3-pole AR	SPS	I
_:6601:507	General:>Pickup A for start	SPS	I
_:6601:508	General:>Pickup B for start	SPS	I
_:6601:509	General:>Pickup C for start	SPS	I
_:6601:510	General:>Pickup 1ph for start	SPS	I
_:6601:511	General:>Pickup 2ph for start	SPS	I
_:6601:512	General:>Pickup 3ph for start	SPS	I
_:6601:513	General:>Gen. pickup for start	SPS	I
_:6601:514	General:>General trip for start	SPS	I
_:6601:515	General:>Trip pole A for start	SPS	I
_:6601:516	General:>Trip pole B for start	SPS	I
_:6601:517	General:>Trip pole C for start	SPS	I
_:6601:518	General:>Trip 1-pole for start	SPS	I
_:6601:519	General:>Trip 3-pole for start	SPS	I
_:6601:520	General:>Evolving fault start	SPS	I
_:6601:522	General:>Delay close cmd.	SPS	I
_:6601:51	General:Mode (controllable)	ENC	C
_:6601:52	General:Behavior	ENS	O
_:6601:53	General:Health	ENS	O
_:6601:54	General:Inactive	SPS	O
_:6601:301	General:79 state	ENS	O
_:6601:302	General:Actual reclose cycle	INS	O
_:6601:303	General:Not ready	SPS	O
_:6601:304	General:79 successful	SPS	O
_:6601:305	General:CB ready superv.expir	SPS	O
_:6601:306	General:CB is not ready	SPS	O
_:6601:307	General:79 permits 1-pole trip	SPS	O
_:6601:308	General:AR only after 1p. trip	SPS	O
_:6601:309	General:In progress	SPS	O
_:6601:310	General:Reclaim time running	SPS	O
_:6601:311	General:Start sig. superv.exp.	SPS	O
_:6601:313	General:Evolv.-fault detected	SPS	O
_:6601:315	General:Dead t. aft.1pole trip	SPS	O
_:6601:316	General:Dead t. aft.3pole trip	SPS	O
_:6601:317	General:Dead t. aft.1ph pickup	SPS	O
_:6601:318	General:Dead t. aft.2ph pickup	SPS	O
_:6601:319	General:Dead t. aft.3ph pickup	SPS	O
_:6601:320	General:Dead t. aft.evolv.flt.	SPS	O
_:6601:321	General:Close cmd. indication	ACT	O
_:6601:322	General:Cls.cmd after 1p.1.cyc	SPS	O
_:6601:323	General:Cls.cmd after 3p.1.cyc	SPS	O
_:6601:324	General:CloseCmd >=2nd.cyc	SPS	O
_:6601:325	General:3-pole operate by 79	SPS	O
_:6601:326	General:Remote close signal	SPS	O
_:6601:327	General:Block. by binary input	SPS	O

No.	Information	Data Class (Type)	Type
_:6601:328	General:Blk.by CB ready sup.	SPS	O
_:6601:329	General:Blk.by strtsig.superv.	SPS	O
_:6601:330	General:Blk.by action time exp	SPS	O
_:6601:331	General:Blk.by max.d.t. expiry	SPS	O
_:6601:332	General:Blk.by max. d.t. delay	SPS	O
_:6601:333	General:Blk. by evolving fault	SPS	O
_:6601:337	General:Block. by no cycle	SPS	O
_:6601:338	General:Block. by protection	SPS	O
_:6601:335	General:Blk.by loss of voltage	SPS	O
_:6601:336	General:Block. by max. cycles	SPS	O
_:6601:339	General:Cyc1 1p AR	INS	O
_:6601:340	General:Cyc1 3p AR	INS	O
_:6601:341	General:Cyc2+ 1p AR	INS	O
_:6601:342	General:Cyc2+ 3p AR	INS	O
_:6601:348	General:Blocked by fault loc.	SPS	O
79 SAD			
_:22621:500	SAD cycle:>Block 79 cycle	SPS	I
_:22621:52	SAD cycle:Behavior	ENS	O
_:22621:53	SAD cycle:Health	ENS	O
_:22621:301	SAD cycle:Cycle running	SPS	O
_:22621:302	SAD cycle:Stage release prot.	SPS	O
_:22621:303	SAD cycle:Synchrocheck request	SPS	O
_:22621:304	SAD cycle:Sec. arc detected	SPS	O
_:22621:305	SAD cycle:No close: SA not off	SPS	O
_:22621:306	SAD cycle:No close: metallic flt.	SPS	O

6.22.7 Operation with External Automatic Reclosing Function

6.22.7.1 Description

The operation of an external reclosing device with the SIPROTEC protection device occurs through the function mode **Operation with external automatic reclosing function**. In this function mode, the SIPROTEC protection functions create the trip command and the external reclosing device creates the close command.

The following figure shows the interaction of an external reclosing device with the functions of the SIPROTEC 5 device.

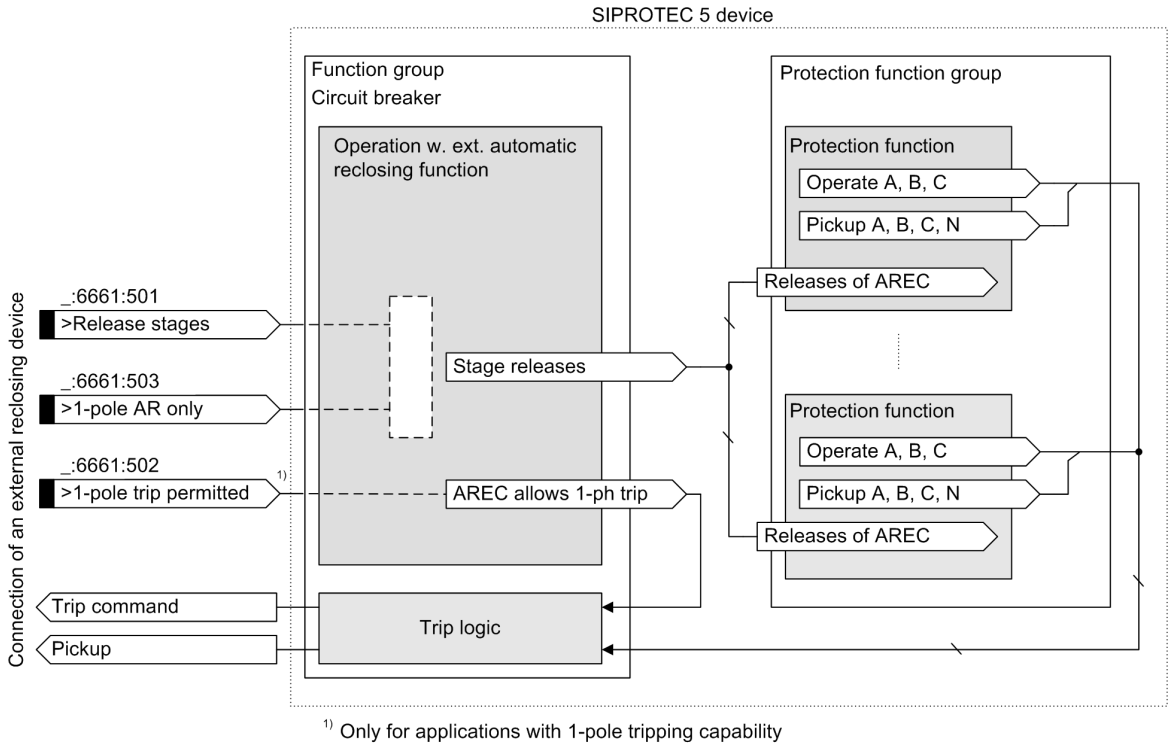


Figure 6-413 Connection of an External Automatic Reclosing Function

There are no setting parameters for operation with external automatic reclosing functions. The function provides exclusively the following described binary inputs. The external reclosing device can thus have an influence on the effects of the internal protection functions.

The following connection possibilities exist:

- From the external reclosing function, the signal *>Release stages* can be coupled so that the protection functions use special stages or zones for release. An example is the release of an overreaching zone with a distance protection or the non-delayed tripping of an overcurrent protection stage in the 1st reclosing cycle.
- For applications with 1-pole tripping, the external reclosing can provide the signal *>1-pole trip permitted*, based on which the protection functions can switch off the 1-pole circuit breaker.
- For applications with reclosing functions only with 1-pole faults and stage or zone releases through the reclosing function can the signal *>1-pole AR only* be connected. The protection functions use this information to allow the stage or zone release only affect 1-pole faults.

6.22.7.2 Information List

No.	Information	Data Class (Type)	Type
Ext			
_:6661:51	Ext:Mode (controllable)		C
_:6661:501	Ext:>Release stages		I
_:6661:502	Ext:>1-pole trip permitted		I
_:6661:503	Ext:>1-pole AR only		I
_:6661:52	Ext:Behavior		O
_:6661:53	Ext:Health		O
_:6661:54	Ext:Inactive		O

6.22.8 Control of the Internal Automatic Reclosing Function by an External Protection Device

The internal automatic reclosing function (AREC) can be started via the pickup indications of the phases A, B, C or via the trip command of an external protection device. The start depends on the operating mode set for the AREC, refer to *Parameter: 79 operating mode, Page 1181*.

For further information, refer to *6.22.3 Cooperation of the Automatic Reclosing Function and Protection Functions* .

Start of the Internal AREC via the Trip Command of an External Protection Device

If the internal AREC of the SIPROTEC 5 device is permitted to start via the trip command of an external protection device, Siemens recommends the following procedure for 1-pole cycles:

Route the following output signals of the external protection device to the binary inputs of the SIPROTEC 5 device:

Address	Binary Signal	Description
_:6601:513	>Gen. pickup for start	General pickup for the automatic reclosing function
_:6601:515	>Trip pole A for start	Trip command phase A for the automatic reclosing function
_:6601:516	>Trip pole B for start	Trip command phase B for the automatic reclosing function
_:6601:517	>Trip pole C for start	Trip command phase C for the automatic reclosing function

The general pickup is decisive for starting the action times. The general pickup is also necessary for the internal AREC to detect evolving faults via pickup. In other cases, the signal *>Gen. pickup for start* is not needed.

The trip commands decide whether the dead time is activated for 1-pole or 3-pole automatic reclosing cycles or whether reclosing is blocked in case of a 3-pole tripping. This depends on the parameterization of the dead times.

If 1-pole cycles are desired, *Figure 6-414* shows an example for the interconnection between the internal AREC of the SIPROTEC 5 device and an external protection device.

To achieve 3-pole coupling of the external protection and to release its accelerated stages before reclosing, you can route the following signals of the internal AREC to the binary outputs of the SIPROTEC 5 device:

Address	Binary Signal	Description
_:6601:307	79 permits 1-pole trip	The internal AREC is ready for the 1-pole automatic reclosing cycle. That is, the internal AREC permits 1-pole tripping (logic inversion of the 3-pole coupling).
_:6571:302	Stage release prot.	The cycle of the internal AREC is ready for the 1st automatic reclosing cycle and releases the stage of the external protection that is decisive for reclosing. For further cycles, corresponding output indications are available in the respective cycle. If required, route these output indications to a binary output. If the external protection does not require an overreach stage, it is not necessary to route the signal to a binary output. This is the case, for example, for the functions **Differential protection** or **Permissive overreach transfer trip with distance protection**.
_:6601:308	AR only after 1p. trip	The internal AREC function is programmed for 1-pole tripping. That is, the AREC function only recloses after 1-pole tripping. If the external protection does not require an overreach stage released by the AREC function, it is not necessary to route the signal to a binary output. This is the case, for example, for the functions **Differential protection** or **Permissive overreach transfer trip with distance protection**.

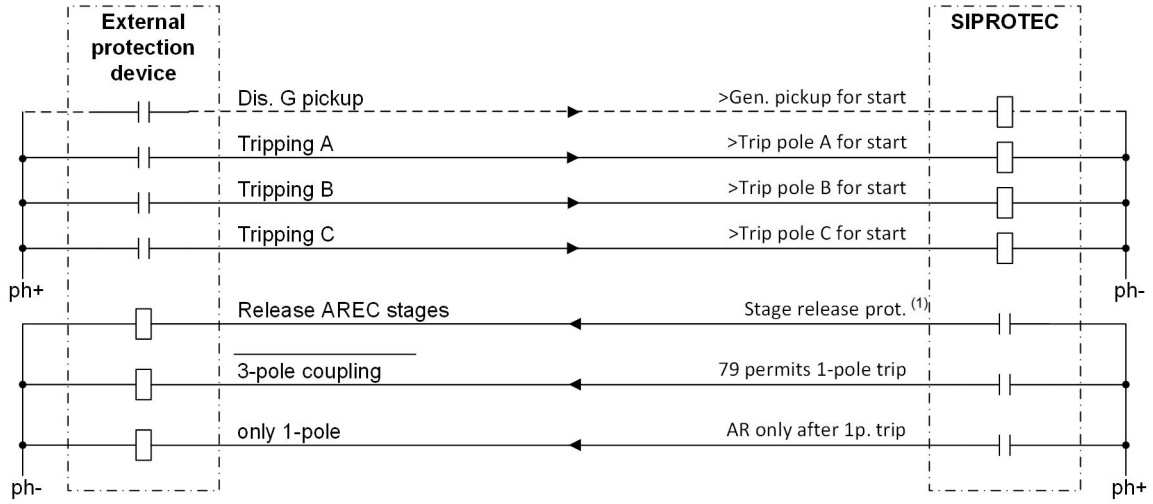
If the external protection device allows it, you can also report the 1-pole and 3-pole tripping to the internal AREC function instead of the 3 phase-selective trip commands. For this purpose, route the following signals to the binary inputs of the SIPROTEC 5 device:

Address	Binary Signal	Description
_:6601:513	>Gen. pickup for start	General pickup for the internal automatic reclosing function The general pickup is decisive for starting the action times.
_:6601:518	>Trip 1-pole for start	1-pole trip command for the internal automatic reclosing function
_:6601:519	>Trip 3-pole for start	3-pole trip command for the internal automatic reclosing function



NOTE

You must not route the phase selective signals, e.g. *>Trip pole A for start*, and the grouped signals, e.g. *>Trip 3-pole for start*, simultaneously. Decide on one variant.

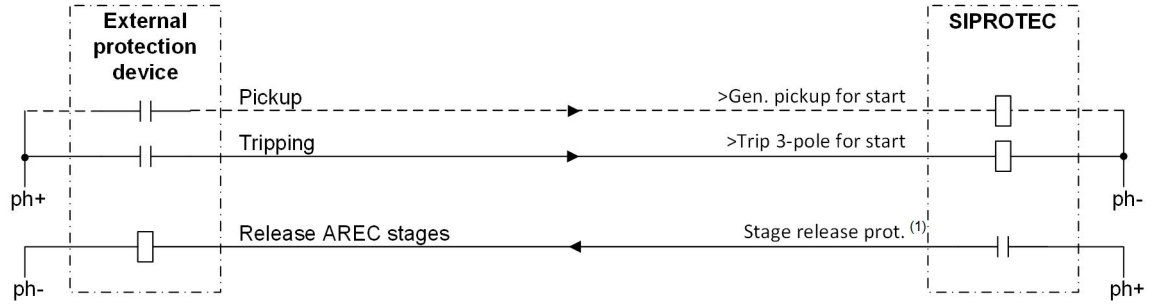


[lo_connect-example_with_ext-prot_1-3pole_reclose_AR, 1, en_US]

Figure 6-414 Connection Example, phase selective signals with External Protection Device for 1-/3-Pole AREC; Parameter **(_:6601:101) 79 operating mode** = ***with op., with act. time***

(1) Each AREC cycle has a dedicated release signal

For 3-pole automatic reclosing cycles, it is sufficient to route the trip command *(_:6601:519) >Trip 3-pole for start* to a binary input of the SIPROTEC 5 device. You can release overreach stages of the external protection via the signal *(_:6571:302) Stage release prot.*. Figure 6-415 shows an example.



[lo_connect-example_with_ext-prot_3pole_reclose_AR, 1, en_US]

Figure 6-415 Connection Example with External Protection Device for 3-Pole AREC; Parameter **(_:6601:101) 79 operating mode** = ***with op., with act. time***

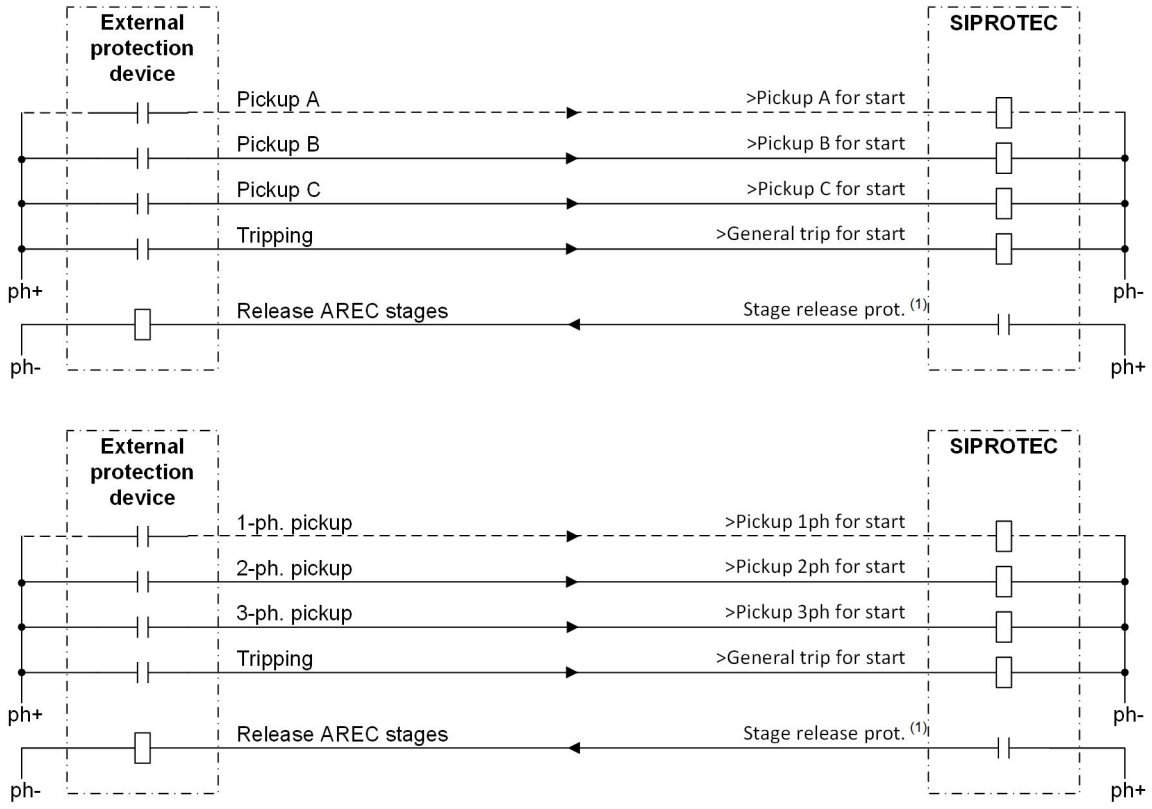
(1) Each AREC cycle has a dedicated release signal

Start of the Internal AREC via the Pickup Indications of an External Protection Device

Starting the internal AREC function via pickup indications is explicitly only possible with 3-pole tripping. In SIPROTEC 5 devices capable of 1-/3-pole tripping, the parameter **(_:2311:113) 1-pole operate allowed** must be set to ***no***, refer to *5.9.3 Application and Setting Notes*.

If the internal automatic reclosing function is started by the pickup and you want to distinguish the AREC response, you must route the phase-selective pickup signals from the external protection to the binary inputs of the SIPROTEC 5 device.

The general trip command via the signal *(_:6601:514) >General trip for start* is sufficient for tripping. Figure 6-416 shows connection examples.



[lo_connect-example_with_ext-prot_1pole-2pole-3pole_reclose_AR, 1, en_US]

Figure 6-416 Connection Example with External Protection Device for Fault-Type Dependent Dead Time – Dead-Time Control by Pickup Signals of the Protection Device; Parameter **79 operating mode** = ***w.pickup, w. action time***

(1) Each AREC cycle has a dedicated release signal

6.22.9 Application and Setting Notes for General Settings

For the automatic reclosing function, there are 3 functions available in the function library. In each function group **Circuit breaker**, a function from the automatic reclosing function can be used.

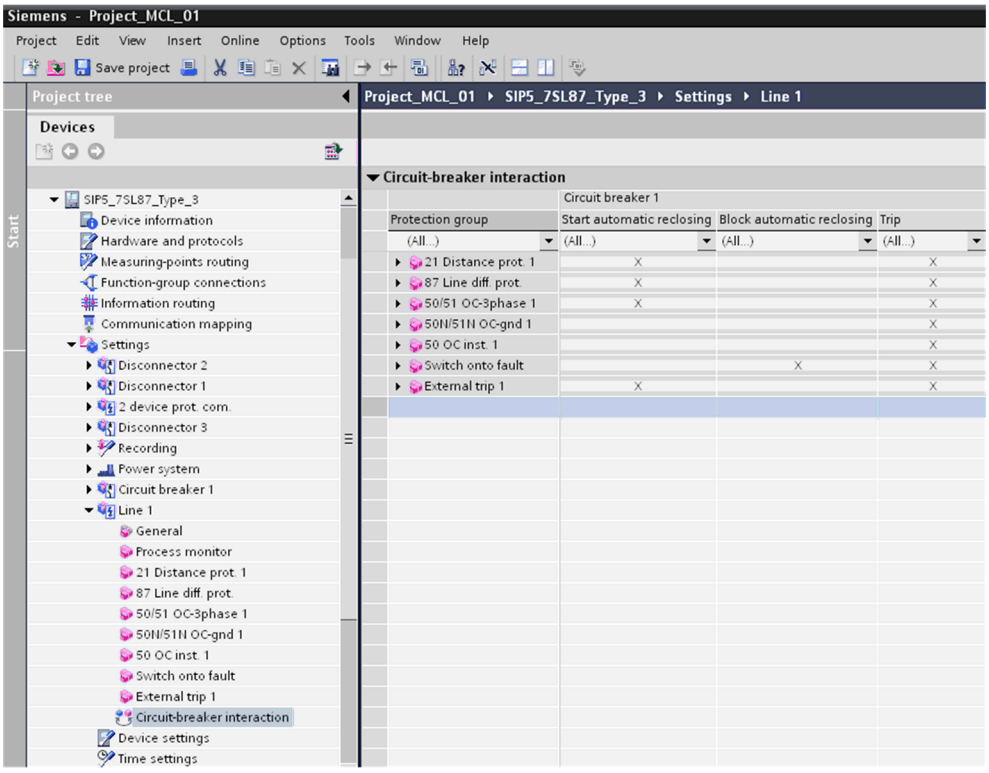
Configure one of the following function specifications:

- Cyclic Automatic reclosing function
- Automatic reclosing function with adaptive dead time (ADT)
- Automatic reclosing function with secondary arc detection (SAD)
- Operation with External automatic reclosing function

Starting the Automatic Reclosing Function

The configuration of the interaction between internal protection functions and the automatic reclosing function can be set separately for each protection function. The configuration occurs in a matrix view in DIGSI. The Automatic reclosing function also has the corresponding binary inputs and binary outputs through which the external protection devices can be connected to the internal Automatic reclosing function.

Configure the starting and blocking condition for the automatic reclosing function at the position shown in *Figure 6-417* in DIGSI or route the corresponding binary inputs.



[scdigsia-080311-01.tif, 1, en_US]

Figure 6-417 Configuration of the Protection Functions for Starting and Blocking the Automatic Reclosing Function in DIGSI

General Settings

If you use the **Cyclic automatic reclosing function**, the **Automatic reclosing function with adaptive dead time**, or the **Automatic reclosing function with secondary arc detection (SAD)**, set the following settings under **General**.

There are no settings for the function **Operation with external automatic reclosing function**. The control occurs exclusively through binary inputs and binary outputs.

Parameter: 79 operating mode

- Default setting **(_:6601:101) 79 operating mode** = ***with op., with act. time***

You can use the parameter **79 operating mode** to determine which start criteria the automatic reclosing function works with.

Parameter Value	Description
with op., with act. time	The automatic reclosing function cycles are dependent on the operate time of the protection function(s). The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. Siemens generally recommends this setting for applications with 1/3-pole tripping and for applications with 3-pole tripping if a single dead time, independent of the type of connection working, is required in the automatic reclosing function cycle. For detailed information, refer to chapter *6.22.4.1 Operating Modes for Cyclic Automatic Reclosing Function* , section **Operating mode 1**.
w.pickup, w. action time	The automatic reclosing function cycles are dependent on the operate time of the protection function(s) and the type of fault. The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. For applications with 3-pole tripping and dead time dependent on the circuit type, Siemens recommends this setting. For detailed information, refer to chapter *6.22.4.1 Operating Modes for Cyclic Automatic Reclosing Function* , section **Operating Mode 2**.
with op., w/o act. time	Each operate indication starts the automatic reclosing function. The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. The automatic reclosing function start must be configured so that it only occurs from the protection stages/zones for which an automatic reclosing should occur after tripping. For detailed information, refer to chapter *6.22.4.1 Operating Modes for Cyclic Automatic Reclosing Function* , section **Operating Mode 3**.
w.pickup, w/o act. time	Each operate indication starts the automatic reclosing function. The automatic reclosing function cycles are dependent on the type of fault. The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. The automatic reclosing function start must be configured so that it only occurs from the protection stages/zones for which an automatic reclosing should occur after tripping. For detailed information, refer to chapter *6.22.4.1 Operating Modes for Cyclic Automatic Reclosing Function* , section **Operating Mode 4**.

Parameter: CB ready check bef. start

- Default setting **(_:6601:102) CB ready check bef. start** = ***no***

With the parameter **CB ready check bef. start**, you can determine if the readiness of the circuit breaker should be tested **before starting** the automatic reclosing function.

Additionally or alternatively, it is possible to check the readiness of the circuit breaker after the expiration of the dead time, directly before the assignment of the close command. There is another parameter described in the chapter *6.22.10 Application and Setting Notes for 1 Cycle of the Cyclic Automatic Reclosing Function* for this function.

Parameter Value	Description
yes	The automatic reclosing function checks the readiness of the circuit breaker for a switching cycle, consisting of a tripping-reclosing-switching. If the circuit breaker is ready - signaled through a binary input - the startup of the automatic reclosing function can occur. If the circuit breaker is not ready, the automatic reclosing function reports the static blocking. Siemens recommends using this setting. **Note:** The presetting of this parameter does not correspond with the recommended setting for operation. The automatic reclosing function would otherwise be blocked with a non-available circuit breaker-ready-signal. Please set the parameter as recommended.
no	The readiness of the circuit breaker is not checked before starting the automatic reclosing function. The test also does not occur if the readiness signal from the circuit breaker is connected to a binary input on the device.

Parameter: Reclai. time aft.succ.cyc.

- Default setting **(_:6601:103) Reclai. time aft.succ.cyc.** = ***3.00 s***

With the parameter **Reclai. time aft.succ.cyc.**, you set the time used to decide if the currently running reclosing cycle was successful or not. Detailed information about the function of the reclaim time can be found in the chapter *6.22.4.15 Reclaim Time*.

The presetting for the reclaim time can be frequently maintained. In regions where thunderstorms and storms often occur, a shorter reclaim time makes sense in order to minimize the danger of the final disconnection due to sequential lightning strikes or cable spark over.

Select a long reclaim time if there is no possibility for circuit-breaker supervision with multiple automatic reclosing, for example, due to missing auxiliary contacts or lacking circuit-breaker-ready-information. In this case, the reclaim time must be longer than the recovery time of the circuit breaker.

Parameter: Block. time aft. man.close

- Default setting **(_:6601:104) Block. time aft. man.close** = ***1.00 s***

With the parameter **Block. time aft. man.close**, the time is determined for which the automatic reclosing should be blocked after a manual connection.

Set the time so that the circuit breaker can be safely switched on and off during connection to a short circuit without the automatic reclosing function being automatically closed.

Parameter: Start signal supervis.time

- Default setting **(_:6601:105) Start signal supervis.time** = ***0.25 s***

With the parameter **Start signal supervis.time**, you set the maximum time after which a circuit breaker must be opened after a trip command. If the time expires, a failure of the circuit breaker is assumed and the automatic reclosing function is dynamically blocked.

For detailed information about the function of the start supervision time, refer to chapter *6.22.4.5 Start*.

NOTE

With the use of an internal or external circuit-breaker failure protection at the same line branch, observe the following:

- The start supervision time should be the same as the circuit-breaker failure protection time delay. With this, you can make sure that in the case of a circuit-breaker failure followed by the tripping of the busbar, no automatic reclosing will be executed.
  (Note: An exception to this recommendation is described below.)
- During a 1-pole trip command repeat caused by the circuit-breaker failure protection, the start supervision time must be longer than the delay time for the 1-pole trip command repeat + the **Minimum operate time** set in the circuit-breaker protection function. With this, it can be ensured that the trip command is not connected before the 1-pole trip command repeat through the circuit-breaker failure protection from the coupling of the trip command of the 3-pole automatic reclosing function.
- The start supervision time must be longer than the time delay for the tripping of the busbars if a 1-pole trip command for the line branch should not be coupled by the automatic reclosing function or the circuit-breaker failure protection 3-pole before the circuit-breaker failure protection can trip the busbars. With this case, the automatic reclosing function must be blocked with the trip command for the busbars. This helps to avoid an automatic reclosing function being executed after the tripping of the busbars for the line branch. The blocking of the automatic reclosing function can occur with a CFC link to the binary input *>Block function*.

Parameter: CB ready superv. time

The setting of this parameter is only important if the cycle-specific parameter **CB ready check bef.close** is set to ***yes***. Otherwise, this parameter has no effect.

- Default setting **(_:6601:106) CB ready superv. time** = ***3.00 s***

With the parameter **CB ready check bef. start**, you can determine after which maximum time after the tripping the circuit breaker must be ready for the reclosing function.

Set the time somewhat longer than the regeneration time of the circuit breaker after an OFF-ON-OFF cycle.

For detailed information about the function, refer to the chapters *6.22.4.16 Circuit-Breaker Readiness and Circuit-Breaker Condition* and *6.22.4.14 Closing Indication and Close Command* .

Parameter: 3-pole operate by 79

This parameter is irrelevant and cannot be set if the circuit breaker is configured exclusively for 3-pole tripping.

- Recommended setting value **(_:6601:107) 3-pole operate by 79** = ***yes***

With the parameter **3-pole operate by 79**, you can determine if the automatic reclosing function creates a 3-pole operate indication to the 3-pole coupling of the circuit-breaker pole.

Parameter Value	Description
yes	The automatic reclosing function can create a 3-pole operate indication under the following conditions: • With the blocking of the automatic reclosing function in the 1-pole dead time, for example, through an evolving fault or external blocking • If an automatic reclosing function start is signalized with **2-pole tripping**, for example, through external binary inputs • For operating modes **with tripping**, if there is a 1-pole operate indication and the automatic reclosing function does not allow for 1-pole cycles in accordance with their parameterization. • If during a 1-pole the automatic reclosing function cycle the supervision of the circuit-breaker pole recognizes an implausible condition. Siemens recommends using this setting.
no	The automatic reclosing function does not create 3-pole tripping.

For detailed information about the functionality, refer to the chapters *6.22.4.11 Dead Time for Operating Modes with Tripping*, *6.22.4.16 Circuit-Breaker Readiness and Circuit-Breaker Condition* and *6.22.4.13 Evolving-Fault Detection During the Dead Time*.

Parameter: Evolving-fault detection

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting **(_:6601:108) Evolving-fault detection** = ***with trip***

With the parameter **Evolving-fault detection**, you can determine which criteria is used to recognize an evolving fault. The actual effect of the recognized evolving fault on the automatic reclosing function can be set with the parameter described below **Response to evolv. faults**.

Evolving faults are short circuits, which occur after switching off a short circuit during dead time.

For detailed information about evolving-fault detection, refer to chapter *6.22.4.13 Evolving-Fault Detection During the Dead Time*.

Parameter Value	Description
with trip	Evolving faults are recognized if an operate indication occurs during the dead time. Thus, it does not matter if the tripping-protection function is configured for the start of the automatic reclosing function or not. The pickup of a protection function without an operate indication does not lead to evolving-fault detection.
with pickup	Evolving faults are detected if during the dead time a protection function configured for the automatic reclosing function start is picked up or if an external pickup is detected through a binary input.

For applications with 1-/3-pole tripping, Siemens recommends the setting ***with trip*** if the system is adequately interconnected.

If multiple individual lines in a row form a total transmission path, the setting ***with pickup*** may be better suitable. With this setting, you can prevent 2 lines following each other from switching to 1-pole in different conductors during evolving faults. The consequence of this fault would be the remainder of a single conductor in the dead time for the overall transmission path. This is particularly important if power plants are coupled through the overall transmission path.

Parameter: Response to evolv. faults

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting **(_:6601:109) Response to evolv. faults** = ***blocks 79***

With the parameter **Response to evolv. faults**, you can determine how the automatic reclosing function reacts to recognized faults.

For detailed information about the automatic reclosing function for faults, refer to chapter *6.22.4.13 Evolving-Fault Detection During the Dead Time*.

Parameter Value	Description
blocks 79	The automatic reclosing function is immediately blocked until the disconnection of the fault. For blockings through faults during the 1-pole dead times, you can force a 3-pole coupling of the trip command through the automatic reclosing function if you set the parameter **3-pole operate by 79** to ***yes***.
strt. evol.flt.dead time	After the 3-pole trip command to clear up the fault, the automatic reclosing function starts a new 3-pole automatic reclosing function cycle with the set **Dead time aft. evolv. fault**.

Parameter: Max. dead-time delay

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting **(_:6601:110) Max. dead-time delay** = ***0.5 s***

With the parameter **Max. dead-time delay**, you determine at which time the starting of the dead time may be delayed before the automatic reclosing function is dynamically blocked.

The delay of the start of the dead time is possible with the binary input **>Dead time start delay**.

For detailed information about the functionality, refer to chapter *6.22.4.5 Start*.

Parameter: Max. dead-time extension

- Default setting **(_:6601:111) Max. dead-time extension** = ***1.2 s***

With the parameter **Max. dead-time extension**, you determine the time by which the dead time may be extended before the automatic reclosing function is dynamically blocked.

With the setting ***oo (invalid)***, the extension is unlimited.

An extension of the dead time can be required under the following conditions:

- Waiting for the readiness of the circuit breaker
- Inquiry of a synchronous test
- Delay through binary input in order, for example, to give the leading automatic reclosing function priority in a system with 1 1/2 circuit breaker layout.

Remember that longer dead times after 3-pole disconnection are only permissible if no stability problems occur or if a synchronous test occurs before the reclosing.

For detailed information about the functionality, refer to chapter *6.22.4.14 Closing Indication and Close Command* .

Parameter: Voltage supervision time

This parameter is only important if you use the subfunctions RDT, DLC, or the ADT function. If you do not use any of these functions, the setting of this parameter is free to select.

- Default setting **(_:6601:114) Voltage supervision time** = ***0.1 s***

With the parameter **Voltage supervision time**, you can determine the measuring time that is available as a criteria for the voltage decision. It should be longer than all transient oscillations through switching operations.

For the subfunctions **Reduced dead time** and **Reclosing function with adaptive dead time**, this measuring time applies for the determination of the surpassing of a voltage threshold. For the subfunction **Dead-line check**, the surpassing of a voltage threshold is checked.

Siemens recommends the setting 0.10 s.

For detailed information about the functionality, refer to the following parameters and to the chapters *6.22.4.19 Dead-Line Check (DLC) and Reduced Dead Time (RDT)* and *6.22.5.1 Description*.

Parameter: Volt. thres.f. live line/bus

This parameter is only important if you use the subfunction **RDT** or the function **ADT**. If you do not use any of these functions, the setting of this parameter is free to select.

- Default setting **(_:6601:115) Volt. thres.f. live line/bus** = ***48 V***

With the parameter **Volt. thres.f. live line/bus**, you can determine the limit voltage above which the line should be seen as fault-free. It must be lower than the smallest expected operating voltage. The phase-to-ground voltage applies as the reference value.

For detailed information about the functionality, refer to the following parameters and to the chapters *6.22.4.19 Dead-Line Check (DLC) and Reduced Dead Time (RDT)* and *6.22.5.1 Description*.

Parameter: Dead-line check/reduc.d.t

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting **(_:6601:113) Dead-line check/reduc.d.t** = ***without***

With the parameter **Dead-line check/reduc.d.t**, you can determine if the automatic reclosing function should work with one of the additional functions ***Dead-line check DLC*** or ***Reduced dead t. RDT***.

Parameter Value	Description
without	The automatic reclosing function occurs after the expiration of the parameterized dead times. DLC or RDT are not activated.
Reduced dead t. RDT	The automatic reclosing function works with a reduced dead time (RDT).
Dead-line check DLC	The automatic reclosing functions work with dead-line check. The closing indication is only assigned if the line was really de-energized during the dead time.

For detailed information about the functionality, refer to chapter *6.22.4.19 Dead-Line Check (DLC) and Reduced Dead Time (RDT)* .



NOTE

Use RDT or DLC only if the voltages of the line can be correctly measured with an open circuit breaker. This is only possible if the voltage transformer is aligned on the line-side - seen from the circuit breaker.

Parameter: Volt.thres. f. dead line/bus

This parameter is only important if you use the Dead-line check subfunction. If you do not use any of this subfunction, the setting of this parameter is free to select.

- Default setting **(_:6601:116) Volt.thres. f. dead line/bus** = ***30 V***

With the parameter **Volt.thres. f. dead line/bus**, you can determine the limit voltage below which the line should be seen with certainty as dead or turned off. The threshold value is used by the Dead-line check subfunction (dead-line check). The reference size is the phase-to-ground voltage.

For detailed information about the functionality, refer to chapter *6.22.4.19 Dead-Line Check (DLC) and Reduced Dead Time (RDT)* .

Parameter: Send delay f. remot. close

With the parameter **Send delay f. remot. close**, you can determine after which time after the automatic reclosing function the information is sent to the remote closing.

- Default setting **(_:6601:112) Send delay f. remot. close** = ***oo (invalid)***

The transmission delay prevents the device operating in the adaptive dead time mode on the opposite side from closing unnecessarily if the local reclosing function remains unsuccessful. On the other hand, it must be remembered that the line is not available for transporting energy as long as the opposite end is also closed. Thus, the **Send delay f. remot. close** must be added to the dead time in order to determine the system stability.

For detailed information about this functionality, refer to chapter *6.22.4.14 Closing Indication and Close Command* .

6.22.10 Application and Setting Notes for 1 Cycle of the Cyclic Automatic Reclosing Function

For the function of the cyclic automatic reclosing function, 1 cycle is preset. The preset cycle cannot be deleted. You can add and delete more cycles from the function library in **DIGSI 5**.

Parameter: Start from idle state allow.

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode ***with action time***.

- Default setting **(_:6571:102) Start from idle state allow.** = ***yes***

With the parameter **Start from idle state allow.** you can determine whether the action time of this automatic reclosing cycle is started, if the automatic reclosing function is in idle state during with incoming general pickup. Please set the parameter always to ***yes***, if the automatic reclosing function is configured for only 1 cycle. If several cycles are configured, you can control the effectiveness of the automatic reclosing cycles with this parameter and various action times.

Detailed information about the functionality can be found in Chapters *6.22.4.6 Cycle Control with Operating Mode 1: with Tripping/with Action Time* und *6.22.4.7 Cycle Control with Operating Mode 2: With Pickup/With Action Time*.

Parameter: Action time

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode ***with action time***.

- Default setting **(_:6571:103) Action time** = ***0.2 s***

With this parameter **Action time** you can determine, within which time frame the trip command must appear, in order to start the automatic reclosing function. If the trip command occurs only after the action time has expired, automatic reclosing does not occur within the active automatic reclosing cycle.

You can find detailed information about the functionality in

Chapters *6.22.4.6 Cycle Control with Operating Mode 1: with Tripping/with Action Time* and *6.22.4.7 Cycle Control with Operating Mode 2: With Pickup/With Action Time*.

Parameter: Dead time aft. 3-pole trip, Dead time aft. 1-pole trip

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode ***with tripping***.

- Default setting **(_:6571:108) Dead time aft. 3-pole trip** = ***0.5 s***
- Default setting **(_:6571:107) Dead time aft. 1-pole trip** = ***1.2 s***

With this parameter **Dead time aft. 3-pole trip** and **Dead time aft. 1-pole trip**, you can determine after which dead time the automatic reclosing function will be executed. You can set different dead times for 1-pole and 3-pole reclosing cycles. Whether a trip occurs for 1-pole or 3-pole depends on the type of the protection function, and if the tripping protection function for the start of the automatic reclosing function has been configured.

NOTE

If you would like to permit the automatic reclosing function only after a 1-pole tripping of the circuit breaker, set the dead time after the 3-pole trip (parameter dead time after 3-pole OFF) to ∞. If the automatic reclosing function should only occur after a 3-pole trip, set the dead time after the 1-pole trip (parameter **Dead time aft. 1-pole trip**) to ∞. Therefore, all protection functions will be tripped as 3-pole after each type of fault.

After a 3-pole trip of the circuit breaker, the system stability is priority. Since the switched off line cannot develop synchronizing forces, only a short dead time is permitted in most cases. The usual duration is 0.3 s to 0.6 s. A longer period can be tolerated if a synchrocheck is carried out prior to reclosing. Even in radial systems longer 3-pole dead times are possible. The dead time after a 1-pole trip of the circuit breaker must be long enough to ensure the short circuit arc has extinguished and the ambient air is deionized. It is only then that the automatic reclosing function can be successful. Due to the charge reversal of the conducted capacity, this time is longer, depending on the length of the line. Standard durations are between 0.9 s and 1.5 s.

Parameter: Dead time aft.1ph. pickup, Dead time aft.2ph. pickup, Dead time aft.3ph. pickup

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode ***with pickup***.

- Default setting **(_:6571:104) Dead time aft.1ph. pickup** = ***1.2 s***
- Default setting **(_:6571:105) Dead time aft.2ph. pickup** = ***1.2 s***
- Default setting **(_:6571:106) Dead time aft.3ph. pickup** = ***0.5 s***

With the 3 dead-time parameters, you can determine after which dead time the automatic reclosing function will be executed. Please set the times as desired for the respective type of short circuit.

- The parameter **Dead time aft.1ph. pickup** applies to dead times after 1-phase short circuits and the following protection tripping: A, B, C, or A-Gnd, B-Gnd, C-Gnd
- The parameter **Dead time aft.2ph. pickup** applies to dead times after 2-phase short circuits and the following protection tripping: A-B, B-C, C-A, or A-B-gnd, B-C-gnd, C-A-gnd
- The parameter **Dead time aft.3ph. pickup** applies to dead times after 3-phase short circuits and the following protection tripping: A-B-C or A-B-C-Gnd

NOTE

If you would like to avoid automatic reclosing during individual short-circuit types, please set the respective dead times to ***oo (invalid)***.

Example:

After 1-phase short-circuits, the automatic reclosing function should occur after 1.2 sec. The automatic reclosing function should not occur for 2-phase and 3-phase short circuits.
For this application, the parameters should be set as follows:

- **Dead time aft.1ph. pickup** = ***1.2 s***
- **Dead time aft.2ph. pickup** = ***oo (invalid)***
- **Dead time aft.3ph. pickup** = ***oo (invalid)***

Parameter: Dead time aft. evolv. fault

These parameters are only significant if the parameter **(_:6601:109) Response to evolv. faults** is set to ***strt. evol.flt.dead time***.

- Default setting **(_:6571:109) Dead time aft. evolv. fault** = ***1.2 s***

With the parameter **Dead time aft. evolv. fault**, you can determine after which dead time the automatic reclosing function should be executed, if based on an evolving fault during the current dead time, a 3-pole trip has occurred. For this 3-pole dead time, stability concerns for the system are also important. Often, this dead time as well as the parameter **(_:6571:108) Dead time aft. 3-pole trip** can be set.

Detailed information about the function during evolving faults during dead time are described in Chapter *6.22.4.13 Evolving-Fault Detection During the Dead Time*.

Parameter: CB ready check bef.close

- Default setting **(_:6571:111) CB ready check bef.close** = ***no***

With the parameter **CB ready check bef.close** you can determine if after the expiration of the dead time (meaning, directly prior to assigning the close command) readiness of the circuit breaker should be queried.

Parameter Value	Description
no	With the setting ***no***, the automatic reclosing function does not check again the readiness of the circuit breaker prior to assigning the close demand. Siemens recommends this setting, if it is sufficient to check the readiness of the circuit breaker for the entire switching cycle once before the start of a reclosing function, consisting of tripping-reclosing-tripping. The setting for checking the readiness of the circuit breaker prior to the start of the automatic reclosing function is done using the parameter **(_:6601:102) CB ready check bef. start**.
yes	With the setting ***yes***, the dead time can be extended if after the expiration of the dead time the circuit breaker is not ready for the next ON-OFF cycle. The maximum delay of the dead time can be set with the parameter **(_:6601:111) Max. dead-time extension**. Siemens recommends this setting, if it can be assumed that the circuit breaker becomes available to switch on the reclosing function only after an additional waiting period.

Detailed information about the function can be found in Chapters *6.22.4.16 Circuit-Breaker Readiness and Circuit-Breaker Condition* and *6.22.4.14 Closing Indication and Close Command* .

Parameter: Synchroch. aft. 3-pole d.t.

- Default setting **(_:6571:110) Synchroch. aft. 3-pole d.t.** = ***none***

With the parameter **Synchroch. aft. 3-pole d.t.** you can determine if a synchrocheck must be carried out for the configured automatic reclosing cycle.

If during a 3-pole interruption in the system stability problems may be a concern, the synchrocheck should be carried out. If only 1-pole reclosure cycles are possible or stability problems are not to be expected during the 3-pole dead time, for example, due to a highly intermeshed system or radial system, please select the parameter ***none***.

Parameter Value	Description
none	During the automatic reclosing cycle a synchrocheck is not executed.
internal	In the configured automatic reclosing cycle, a synchrocheck is executed after a 3-pole dead time prior to the close command of the circuit breaker. For the synchrocheck a synchrocheck stage of the internal synchronization function is used, which is contained in the same function group as the circuit breaker and the automatic reclosing function. The selection of the synchrocheck stage that is used in the automatic reclosing cycle occurs through the following described parameter **Internal synchrocheck**.
external	In the configured automatic reclosing cycle, a synchrocheck is executed after a 3-pole dead time prior to the close command of the circuit breaker. An external synchrocheck device initiates the synchrocheck. The external synchrocheck device is connected with the binary signals *Synchrocheck request* and *>Release by ext.sync.*. Detailed information about the function can be found in Chapter *6.22.4.14 Closing Indication and Close Command* under the section **Synchrocheck**.

Parameter: Internal synchrocheck

These parameters are only significant if the previously described parameter **(_:6571:110) Synchroch. aft. 3-pole d.t.** is set to ***internal***.

With the parameter **Internal Synchrocheck**, you can determine which function block of the synchronization function for the automatic reclosing function is used after a 3-pole dead time. This selection is only possible for function blocks of the synchronization function, and which are included in the same circuit-breaker function group as the automatic reclosing function. The setting options of the parameter will be generated dynamically, according to the actual parameterization.

6.23 Overcurrent Protection, Phases

6.23.1 Overview of Functions

The **Overcurrent protection, phases** function (ANSI 50/51):

- Detects short circuits in electrical equipment
- Can be used as backup overcurrent protection in addition to the main protection

6.23.2 Structure of the Function

The **Overcurrent protection, phases** function is used in protection function groups. 2 kinds of functions are available for the 3-phase overcurrent protection:

- **Overcurrent protection, phases – advanced** (50/51 OC-3ph-A)
- **Overcurrent protection, phases – basic** (50/51 OC-3ph-B)

The Basic function type is provided for standard applications. The Advanced function type offers more functionality and is provided for more complex applications.

Both function types are preconfigured by the manufacturer with 2 **Definite-time overcurrent protection** stages and with 1 **Inverse-time overcurrent protection** stage.

In the **Overcurrent protection, phase – advanced** function type, the following stages can be operated simultaneously:

- Maximum of 4 stages **Definite-time overcurrent protection – advanced**
- 1 stage **Inverse-time overcurrent protection – advanced**
- 1 stage **User-defined overcurrent protection characteristic curve**

In the **Overcurrent protection, phases – basic** function type, the following stages can be operated simultaneously:

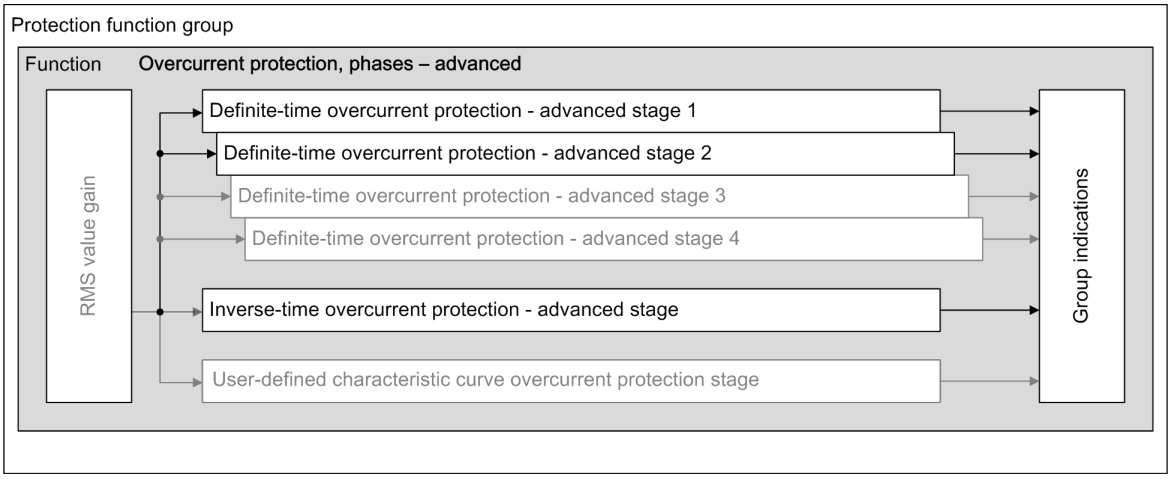
- Maximum of 4 stages **Definite-time overcurrent protection – basic**
- 1 stage **Inverse-time overcurrent protection – basic**

Stages that are not preconfigured are shown in gray in the following figures. Apart from the tripping delay characteristic, the stages are identical in structure.

The optional function block **Filter** offered in the advanced function allows to gain harmonics or to compensate the amplitude attenuation for the RMS value.

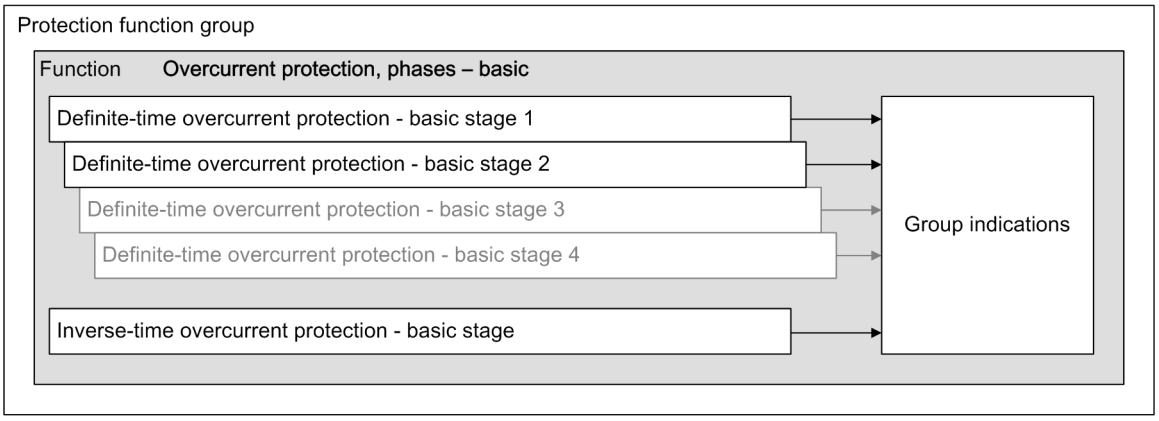
The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- **`Pickup`**
- **`Operate`**



[dw_ocp_ad with filter2, 1, en_US]

Figure 6-418 Structure/Embedding of the Function Overcurrent Protection, Phases – Advanced



[dw_ocp_bp_1, 3, en_US]

Figure 6-419 Structure/Embedding of the Function Overcurrent Protection, Phases – Basic

If the device-internal functions listed in the following are present in the device, these functions can influence the pickup values and time delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal. This functionality is only available in the Advanced function type.

- Cold-load pickup detection
- Binary input signal

If the device is equipped with the **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer-inrush currents.

6.23.3 Filter for RMS Value Gain

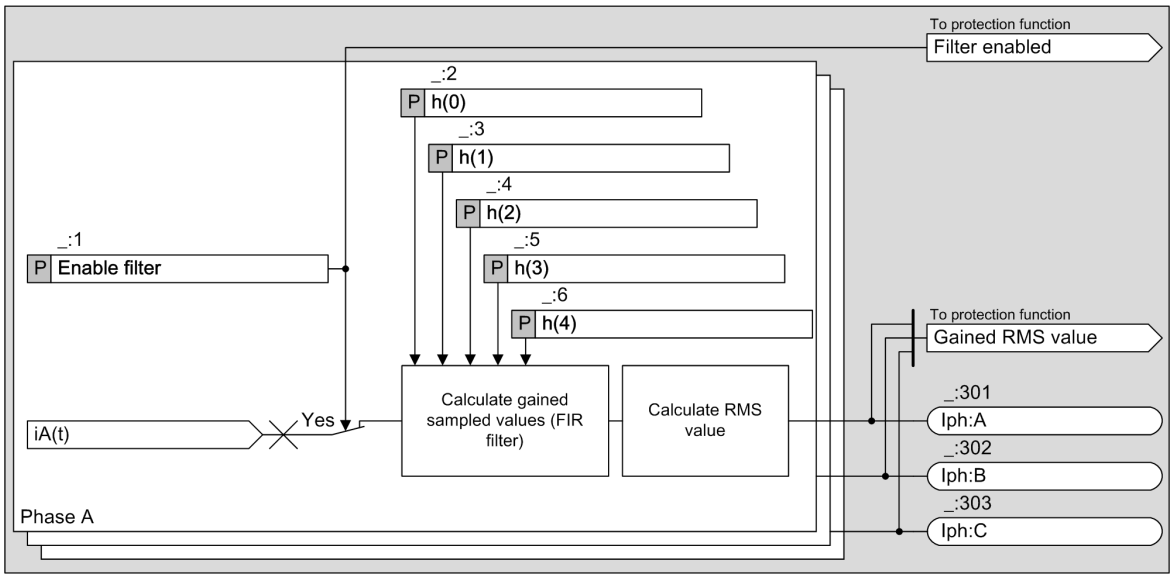
6.23.3.1 Description

The function block **Filter** can be used to adapt the RMS value for 2 means:

- To gain harmonics in a defined way. Higher harmonics can stress the protected object thermally more than lower harmonics. This is the case for reactors applied in AC filters. In addition, the amplitude attenuation of higher frequencies due to the anti-aliasing filter of the device is automatically compensated by the filter
- To only compensate the amplitude attenuation of higher frequencies due to the anti-aliasing filter

The filter gain (amplitude response) is realized by a 9-order FIR filter.

Logic



[lo_tolp_filter_stage, 1, en_US]

Figure 6-420 Logic Diagram of the Function Block Filter

The FIR filter gains the 8-kHz sampled values according to the set filter coefficients. Afterwards, the RMS value is calculated. The symmetrical 9-order filter coefficients are set via the values of the respective parameters **h(0)**, **h(1)**, **h(2)**, **h(3)**, and **h(4)**.

NOTE

A FIR-filter configuration tool is provided as an auxiliary PC tool. With this PC tool, the coefficients h(0), h(1), h(2), h(3), h(4) of the FIR filter are generated according to the required gain factors (amplitude response).

If you require the tool, contact the local Siemens representative to download it via the Intranet of Siemens Industry Online Support (SIOS). The tool is available on SIOS under **Protection** > **Engineering tools for protection** > **Further Tools**.

The gained RMS value is delivered to the protection stages only when the function block **Filter** is instantiated and the parameter **Enable filter** is set as ***yes***. Otherwise, the normal RMS value is used.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
Iph:A	Gained RMS measured value of current A	kA	A	Parameter **Rated current**
Iph:B	Gained RMS measured value of current B	kA	A	Parameter **Rated current**
Iph:C	Gained RMS measured value of current C	kA	A	Parameter **Rated current**

You can find the parameter **Rated current** in the **FB General** of function groups where the **Overcurrent protection, phases – advanced** function is used.

If the parameter **Enable filter** is set to ***no***, the functional measured values are shown as ---.

6.23.3.2 Application and Setting Notes

Parameter: `Enable filter`

- Default setting **`(_:1) Enable filter`** = ***`no`***.

With the parameter **`Enable filter`**, you set whether the **Filter** is enabled.

Parameter Value	Description
`yes`	If gained RMS values should be used in one of the protection stages, set parameter **`Enable filter`** = ***`yes`***.
`no`	If no gained RMS values are needed, set the parameter **`Enable filter`** = ***`no`***.

Parameter: `h(0),h(1),h(2),h(3),h(4)`

- Default setting **`(_:2) h(0)`** = ***`0.000`***
- Default setting **`(_:3) h(1)`** = ***`0.000`***
- Default setting **`(_:4) h(2)`** = ***`0.000`***
- Default setting **`(_:5) h(3)`** = ***`0.000`***
- Default setting **`(_:6) h(4)`** = ***`1.000`***

With the default value of the coefficients, the filter has no effect and no gain is applied.

If the filter shall be applied to adapt the RMS value calculation to a specific protection object such as a reactor, the reactor manufacturer has to provide the required amplitude response (gain factors) for the reactor. To determine the coefficients h(0) to h(4) for the FIR filter, you must enter the gain factors into the auxiliary PC tool which is available in the SIPROTEC download area. The 5 required coefficients are generated by the tool. They have to be entered manually as settings to configure the filter. The amplitude attenuation of higher frequencies due to the anti aliasing filter of the device is automatically taken into account and compensated by the filter.

To only compensate the attenuation of higher frequencies by the device, set the following coefficients in the filter.

Rated Frequency	Filter Coefficients for Only Compensating the Device Amplitude Attenuation
50 Hz	h(0) = -0.002 h(1) = -0.012 h(2) = 0.045 h(3) = -0.110 h(4) = 1.151
60 Hz	h(0) = -0.005 h(1) = -0.020 h(2) = 0.058 h(3) = -0.128 h(4) = 1.170

6.23.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Filter`				
_:1	Filter:Enable filter		• no • yes	no
_:2	Filter:h(0)		-100.000 to 100.000	0.000
_:3	Filter:h(1)		-100.000 to 100.000	0.000
_:4	Filter:h(2)		-100.000 to 100.000	0.000

Addr.	Parameter	C	Setting Options	Default Setting
_:5	Filter:h(3)		-100.000 to 100.000	0.000
_:6	Filter:h(4)		-100.000 to 100.000	1.000

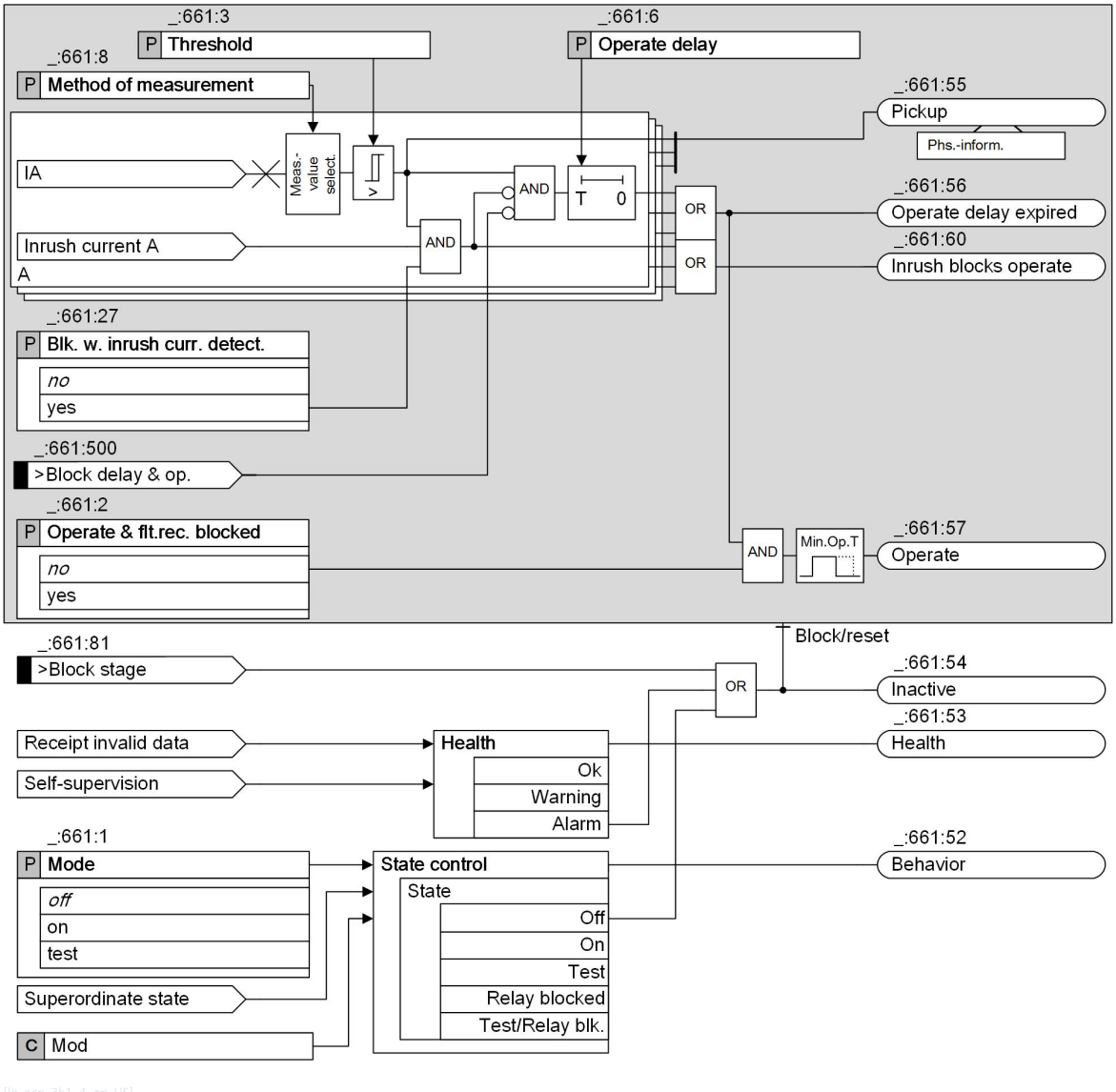
6.23.3.4 Information List

No.	Information	Data Class (Type)	Type
Filter			
_:301	Filter:Iph:A	MV	O
_:302	Filter:Iph:B	MV	O
_:303	Filter:Iph:C	MV	O
_:52	Filter:Behavior	ENS	O
_:53	Filter:Health	ENS	O

6.23.4 Stage with Definite-Time Characteristic Curve

6.23.4.1 Description

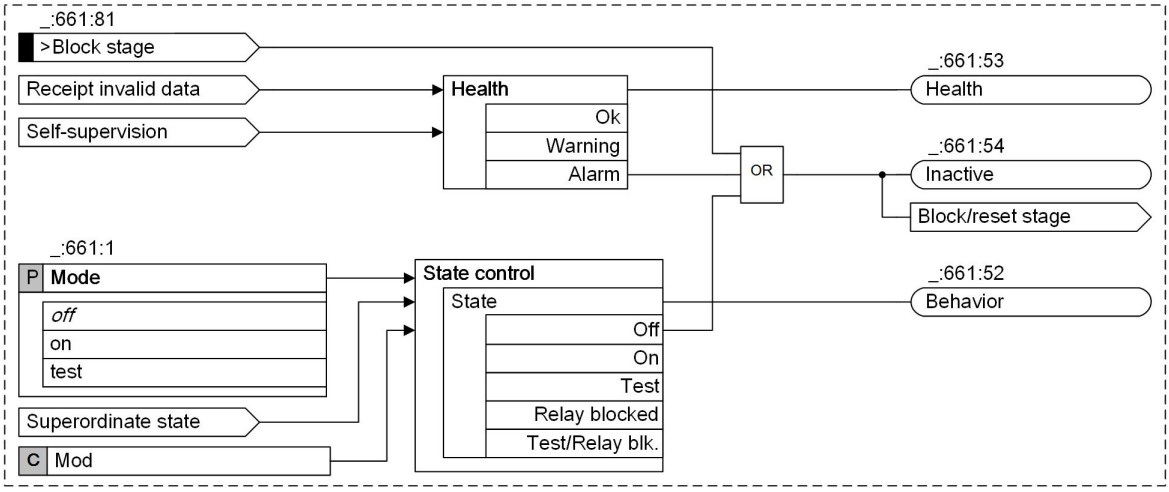
Logic of the Basic Stage



[lo_ocp_3b1, 4, en_US]

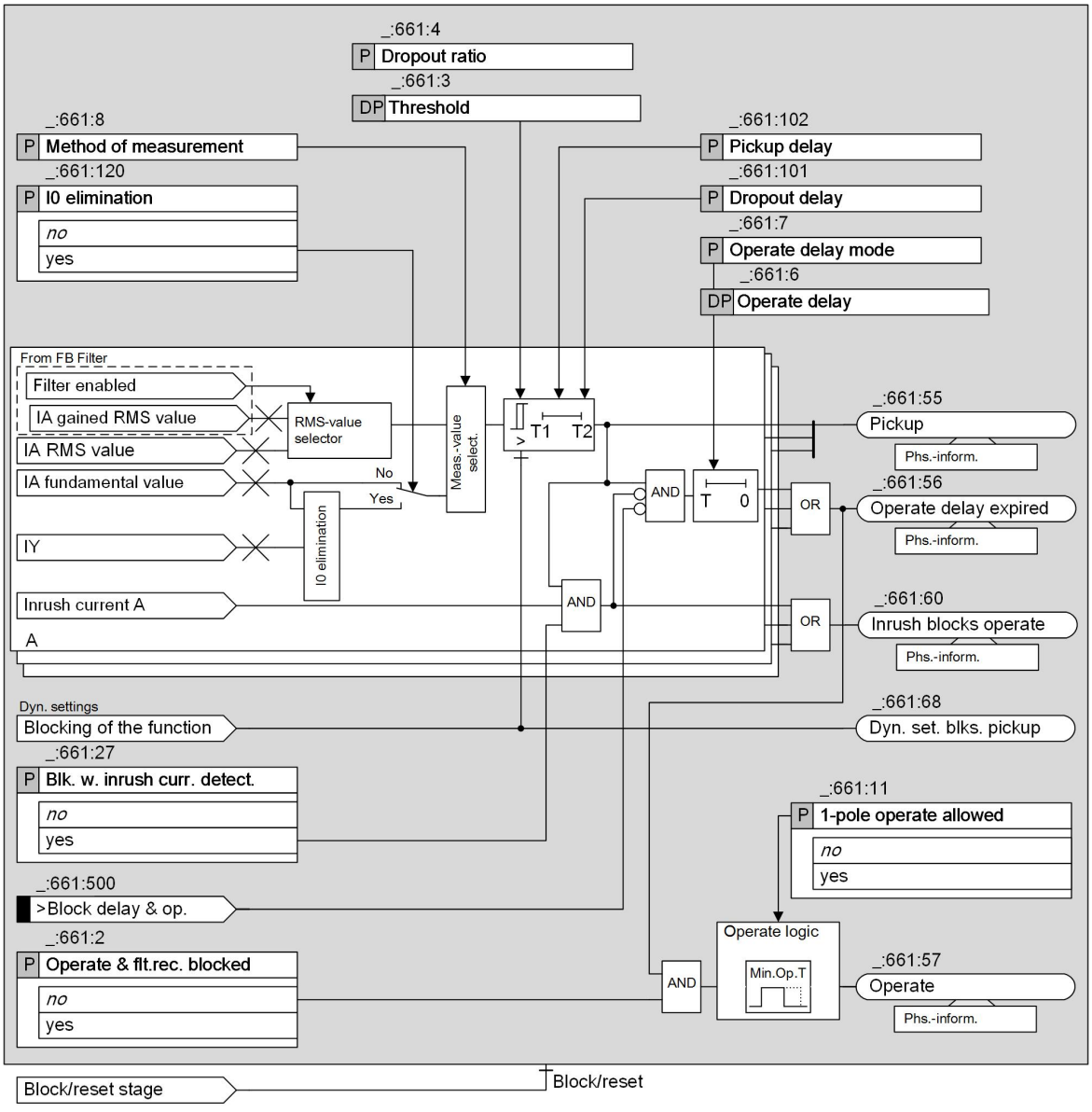
Figure 6-421 Logic Diagram of the Definite-Time Overcurrent Protection (Phases) – Basic

Logic of the Advanced Stage



[lo_ocp_advanced_umz_stage_control, 2, en_US]

Figure 6-422 Logic Diagram of the Stage Control



[lo_ocp_3p1, 5, en_US]

Figure 6-423 Logic Diagram of the Definite-Time Overcurrent Protection (Phases) – Advanced

Method of measurement (Basic and Advanced Stage)

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

RMS-Value Selection (Advanced Stage)

If ***RMS value*** is selected as the method of measurement, the protection function supports 2 kinds of RMS measurement.

- Normal RMS value
- Gained RMS value from the function block **Filter**

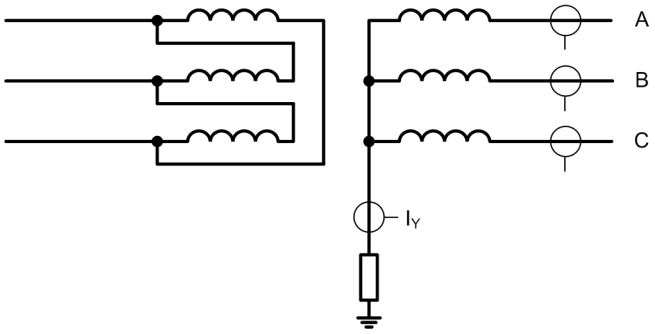
If the function block **Filter** is configured and if you have enabled the filter, the gained RMS value is automatically used.

NOTE

When the function block **Filter** is applied, only one 3-phase current measuring point is allowed to be connected to the 3-phase current interface of the function group.

I0 Elimination (Advanced Stage)

In order to increase the sensitivity for the 2-phase short circuit on the transformer low-voltage side, use the I0 elimination of the phase currents for the overcurrent-protection application on one transformer.
In order to determine the I0 elimination of the phase currents, the transformer neutral point current I_Y must be measured.



[dw_sgaocp, 1, en_US]

Figure 6-424 I0 Elimination Principle

The transformer neutral point current I_Y is measured via a 1-phase current measuring point that is connected to the **Transformer neutral point** function group. Connect the function group **Transformer neutral point** to the function group **Transformer side**. In the function **Overcurrent protection, phases** operates with in the **Transformer side** function group.

Connect protection-function group to protection-function group

	Transformer side 1	Transformer side 2	Transformer diff. 1
Protection group	neutral point	neutral point	side
(All)	(All)	(All)	(All)
Transformer side 1			X
Transformer side 2			X
Transform. neut.p 1		X	

[sc_cpfoiut, 1, en_US]

Figure 6-425 Connection of the Transformer Neutral Point Function Group with the Neutral Point Input of the Transformer Side Function Group.

In case of an I0 elimination, the following calculations result:

$\underline{I}_{A\text{-elim.}} = \underline{I}_A - 1/3\ \underline{I}_Y$

$\underline{I}_{B\text{-elim.}} = \underline{I}_B - 1/3\ \underline{I}_Y$

$\underline{I}_{C\text{-elim.}} = \underline{I}_C - 1/3\ \underline{I}_Y$

The phase current $\underline{I}_{phx\text{-elim.}}$ is necessary for the following protection process.

If the **Method of measurement** parameter is set to ***fundamental comp.***, the I0 elimination is applied.

The currents $\underline{I}_{phx\text{-elim.}}$ are available as functional values.

Pickup Delay (Advanced Stage)

If the current exceeds the threshold value, the pickup delay is generated. If the threshold remains exceeded during the pickup delay time, the pickup signal is generated.

Dropout Delay (Advanced Stage)

If the current falls below the dropout threshold, the dropout can be delayed for the time specified by the parameter **Dropout delay**. During the dropout delay, the pickup is maintained. Meanwhile, the operate delay continues to run (parameter **Operate delay mode** = ***Running dur. DO-delay***) or is frozen (parameter **Operate delay mode** = ***Frozen dur. DO-delay***). If the operate delay expires while the pickup is still maintained, the stage operates.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal **>Block stage** from an external or internal source
- Via the functionality of the **dynamic settings** (only available in the Advanced function type, see **Influence of other functions via dynamic settings** and *6.23.8.1 Description*).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in *6.23.7.1 Description* .

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in *6.23.8.1 Description* .

6.23.4.2 Application and Setting Notes

Parameter: Method of measurement

- Default setting **(_:661:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

Parameter: Operate delay mode

- Default setting **(_:661:7) Operate delay mode** = ***Running dur. DO-delay***

This parameter is not visible in the basic stage.

With the parameter **Operate delay mode**, you specify whether the operate delay continues to run or is frozen during the dropout delay.

This setting is only valid if the parameter **Dropout delay** is not ***0***.

Parameter Value	Description
Running dur. DO-delay	During the dropout delay, the operate delay continues to run.
Frozen dur. DO-delay	During the dropout delay, the operate delay is frozen. If the current exceeds the threshold value again, the operate delay continues to run.

Parameter: Threshold, Operate delay

- Default setting **(_:661:3) Threshold** = ***1.500 A*** (for the 1st stage)
- Default setting **(_:661:6) Operate delay** = ***0.30 s*** (for the 1st stage)

Set the **Threshold** and **Operate delay** parameters for the specific application.

The following details apply to a 2-stage characteristic curve (1st stage = definite-time overcurrent protection stage and 2nd stage = high-current stage).

1st stage (overcurrent stage):

The setting depends on the maximum occurring operating current. Pickup by overload must be excluded since overcurrent protection operates with short tripping times as short-circuit protection and not as overload protection. Therefore, set the **Threshold** parameter for lines to approx. 10 %, for transformers and motors to approx. 20 % above the maximum load that is expected.

EXAMPLE

Overcurrent-protection stage: 110-kV overhead line, 150 mm² cross-section

Maximum transmittable power	
P_{max}	= 120 MVA
Correspondingly	
I_{max}	= 630 A
Current transformer	= 600 A/5 A
Safety factor	= 1.1

Settings in primary and secondary measurands result in the setting values:

Threshold value 1st stage (primary) = $1.1 \cdot 630\ \text{A} = 693\ \text{A}$

Threshold value 1st stage (secondary) = $1.1 \cdot \frac{630\ \text{A}}{600\ \text{A}} \cdot 5\ \text{A} = 5.8\ \text{A}$

[fo_ocp_ph1, 2, en_US]

The **Operate delay** to be set is derived from the time-grading schedule that has been prepared for the system.

2nd Stage (High-Current Stage):

This tripping stage can also be used for current grading. This applies in the case of very long lines with low source impedance or ahead of high reactances (for example, transformers, shunt reactors). Set the **Threshold** parameter to ensure that the stage does not pick up in case of a short circuit at the end of the line.

Set the **Operate delay** parameter to ***0*** or to a low value.

Siemens recommends that the threshold values be determined with a system analysis. The following example illustrates the principle of grading with a current threshold on a long line.

EXAMPLE

High-current stage: 110-kV overhead line, 150 mm² cross-section

s (length) = 60 km

Z_L/s = 0.46 Ω/km

Ratio of zero-sequence impedance and positive-sequence impedance of the line: $Z_{L0}/Z_{L1} = 4$

Short-circuit power at the beginning of the line:

S_{sc}' = 2.5 GVA

Ratio of zero-sequence impedance and positive-sequence impedance of the source impedance at the beginning of the line: $Z_{P0}/Z_{P1} = 2$

Current transformer = 600 A/5 A

Resulting in the following values for the line impedance Z_L and the source impedance Z_P:

$$Z_L = 0.46\ \Omega/\text{km} \cdot 60\text{km} = 27.6\ \Omega$$

[fo_ocp_002, 1, en_US]

$$Z_P = \frac{110\ \text{kV}^2}{2500\ \text{MVA}} = 4.84\ \Omega$$

[fo_ocp_003, 1, en_US]

The 3-phase short-circuit current at the end of the line is $I_{sc\ end}$:

$$I_{sc\ end} = \frac{1.1 \cdot V_{rated}}{\sqrt{3} \cdot (Z_P + Z_L)} = \frac{1.1 \cdot 110\ \text{kV}}{\sqrt{3} \cdot (4.84\ \Omega + 27.6\ \Omega)} = 2150\ \text{A}$$

[fo_ocp_ph4, 1, en_US]

The settings in primary and secondary values result in the following setting values which include a safety margin of 10 %:

Threshold value 2nd stage (primary) = $1.1 \cdot 2150\ \text{A} = 2365\ \text{A}$

Threshold value 2nd stage (secondary) = $1.1 \cdot \frac{2150\ \text{A}}{600\ \text{A}} \cdot 5\ \text{A} = 19.7\ \text{A}$

[fo_ocp_004, 2, en_US]

If short-circuit currents exceed 2365 A (primary) or 19.7 A (secondary), there is a short circuit on the line to be protected. The overcurrent protection can cut off this short circuit immediately.

Note: The amounts in the calculation example are accurate enough for overhead lines. If the source impedance and line impedance have different angles, you have to use complex numbers to calculate the **Threshold** .

Parameter: I0 elimination

- Default setting **(_:661:120) I0 elimination** = ***no***

This parameter is not visible in the basic stage.

The I0 elimination in phase currents for overcurrent-protection applications can be used in a transformer. This increases the sensitivity for the 2-phase short circuit on the transformer low-voltage side. The following conditions must be fulfilled:

- The transformer neutral point current I_Y is measured and is available for the protection function group.
- The parameter **Method of measurement** is set to ***fundamental comp.***.

With the **I0 elimination** parameter, you can switch the I0 elimination function on or off.

Parameter: Pickup delay

- Default setting **(_:661:102) Pickup delay** = ***0.00 s***

This parameter is not visible in the basic stage.

For special applications, it is desirable that a short exceeding of the current threshold does not lead to the pickup of the stage and start fault logging and recording. If this stage is used as a thermal overload function, that is considered a special application.

When using the **Pickup delay** parameter, a time interval is defined during which a pickup is not triggered if the current threshold is exceeded.

For all short-circuit protection applications, this value is 0.00 s as a default.

Parameter: Dropout delay

- Default setting **(_:661:101) Dropout delay** = ***0.00 s***

This parameter is not visible in the basic stage.

Siemens recommends using the default setting ***0*** since the dropout of a protection stage must be done as fast as possible.

You can use the **Dropout delay** parameter ≠ ***0*** to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical Data) and set the result.

Parameter: Dropout ratio

- Default setting **(_:661:4) Dropout ratio** = ***0.95***

This parameter is not visible in the basic stage.

The recommended set value of ***0.95*** is appropriate for most applications.

To achieve high-precision measurements, the setting value of the parameter **Dropout ratio** can be reduced, for example, to ***0.98***. If you expect highly fluctuating measurands at the response threshold, you can increase the setting value of the parameter **Dropout ratio**. This avoids chattering of the tripping stage.

Parameter: 1-pole operate allowed

- Default setting **(_:661:11) 1-pole operate allowed** = ***no***

The parameter must be set for the specific application.

Parameter Value	Description
no	The stage always operates 3-pole.
yes	The stage operates phase-selectively. However, tripping by the device (generated in the trip logic of the **Circuit-breaker** function group) is always 3-pole because the device does not support phase-selective tripping.

6.23.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:661:1	Definite-T 1:Mode		• off • on • test	off
_:661:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:661:11	Definite-T 1:1-pole operate allowed		• no • yes	no
_:661:26	Definite-T 1:Dynamic settings		• no • yes	no
_:661:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:661:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:661:120	Definite-T 1:I0 elimination		• no • yes	no
_:661:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:661:102	Definite-T 1:Pickup delay		0.00 s to 60.00 s	0.00 s
_:661:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:661:6	Definite-T 1:Operate delay		0.00 s to 100.00 s	0.30 s
_:661:7	Definite-T 1:Operate delay mode		• Running dur. DO-delay • Frozen dur. DO-delay	Running dur. DO-delay
Dyn.s: AR off/n.rdy				
_:661:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:661:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:661:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:661:36	Definite-T 1:Stage blocked		• no • yes	no
_:661:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:20	Definite-T 1:Operate delay		0.00 s to 100.00 s	0.30 s
Dyn.set: AR cycle 2				
_:661:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:661:37	Definite-T 1:Stage blocked		• no • yes	no
_:661:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:21	Definite-T 1:Operate delay		0.00 s to 100.00 s	0.30 s
Dyn.set: AR cycle 3				
_:661:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no
_:661:38	Definite-T 1:Stage blocked		• no • yes	no
_:661:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:22	Definite-T 1:Operate delay		0.00 s to 100.00 s	0.30 s
Dyn.s: AR cycle>3				
_:661:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:661:39	Definite-T 1:Stage blocked		• no • yes	no
_:661:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A

Addr.	Parameter	C	Setting Options	Default Setting
_:661:23	Definite-T 1:Operate delay		0.00 s to 100.00 s	0.30 s
Dyn.s: Cold load PU				
_:661:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:661:40	Definite-T 1:Stage blocked		• no • yes	no
_:661:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:24	Definite-T 1:Operate delay		0.00 s to 100.00 s	0.30 s
Dyn.set: bin.input				
_:661:34	Definite-T 1:Effected by binary input		• no • yes	no
_:661:41	Definite-T 1:Stage blocked		• no • yes	no
_:661:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:25	Definite-T 1:Operate delay		0.00 s to 100.00 s	0.30 s

6.23.4.4 Information List

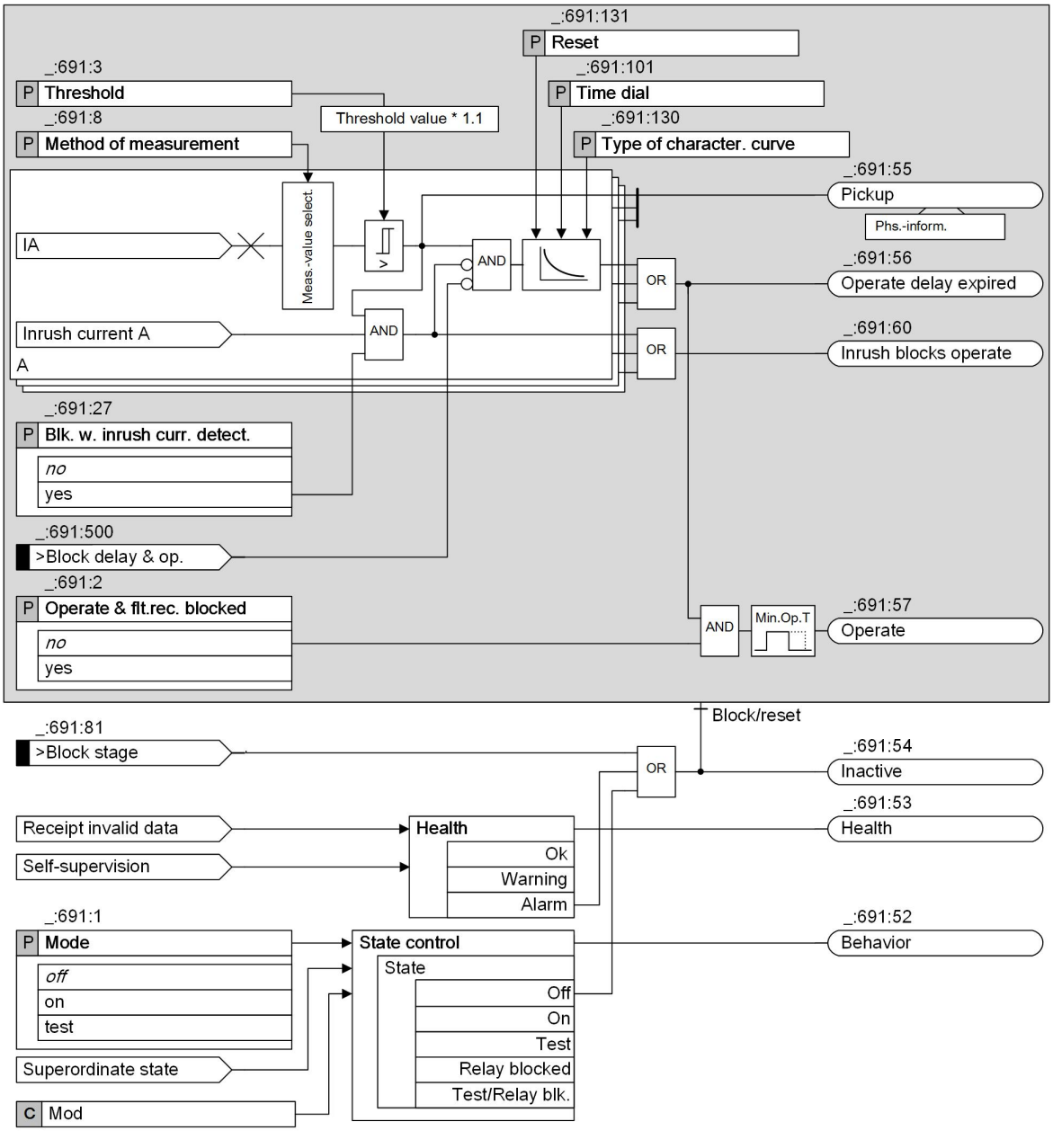
No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Definite-T 1			
_:661:81	Definite-T 1:>Block stage	SPS	I
_:661:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:661:500	Definite-T 1:>Block delay & op.	SPS	I
_:661:51	Definite-T 1:Mode (controllable)	ENC	C
_:661:54	Definite-T 1:Inactive	SPS	O
_:661:52	Definite-T 1:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:661:53	Definite-T 1:Health	ENS	O
_:661:60	Definite-T 1:Inrush blocks operate	ACT	O
_:661:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:661:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:661:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O
_:661:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:661:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:661:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:661:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O
_:661:55	Definite-T 1:Pickup	ACD	O
_:661:56	Definite-T 1:Operate delay expired	ACT	O
_:661:57	Definite-T 1:Operate	ACT	O
_:661:302	Definite-T 1:I0el.Iph	WYE	O
Definite-T 2			
_:662:81	Definite-T 2:>Block stage	SPS	I
_:662:84	Definite-T 2:>Activ. dyn. settings	SPS	I
_:662:500	Definite-T 2:>Block delay & op.	SPS	I
_:662:51	Definite-T 2:Mode (controllable)	ENC	C
_:662:54	Definite-T 2:Inactive	SPS	O
_:662:52	Definite-T 2:Behavior	ENS	O
_:662:53	Definite-T 2:Health	ENS	O
_:662:60	Definite-T 2:Inrush blocks operate	ACT	O
_:662:62	Definite-T 2:Dyn.set. AR cycle1act.	SPS	O
_:662:63	Definite-T 2:Dyn.set. AR cycle2act.	SPS	O
_:662:64	Definite-T 2:Dyn.set. AR cycle3act.	SPS	O
_:662:65	Definite-T 2:Dyn.set. ARcycl.>3act	SPS	O
_:662:66	Definite-T 2:Dyn.set. CLP active	SPS	O
_:662:67	Definite-T 2:Dyn.set. BI active	SPS	O
_:662:68	Definite-T 2:Dyn. set. blks. pickup	SPS	O
_:662:55	Definite-T 2:Pickup	ACD	O
_:662:56	Definite-T 2:Operate delay expired	ACT	O
_:662:57	Definite-T 2:Operate	ACT	O
_:662:302	Definite-T 2:I0el.Iph	WYE	O

6.23.5 Stage with Inverse-Time Characteristic Curve

6.23.5.1 Description

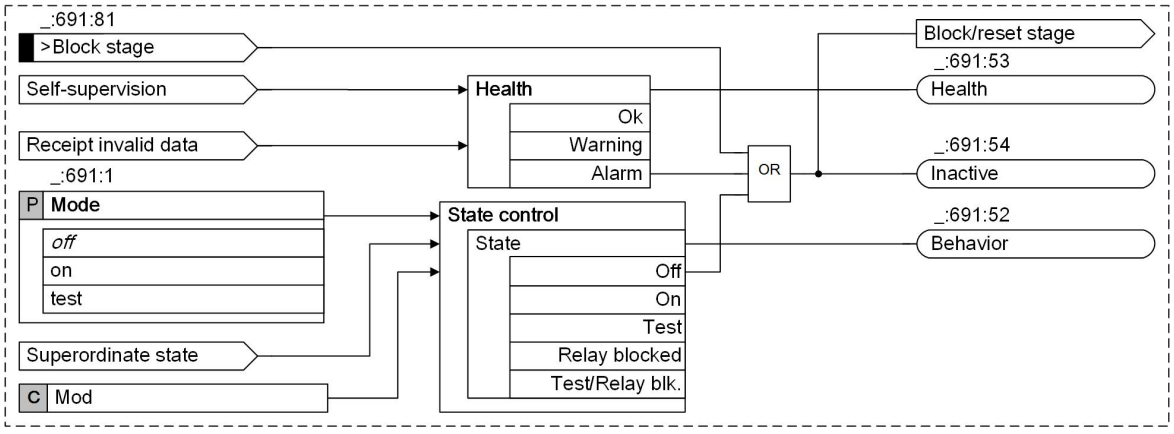
Logic of the Basic Stage



[lo_ocp3b2_3_en_US]

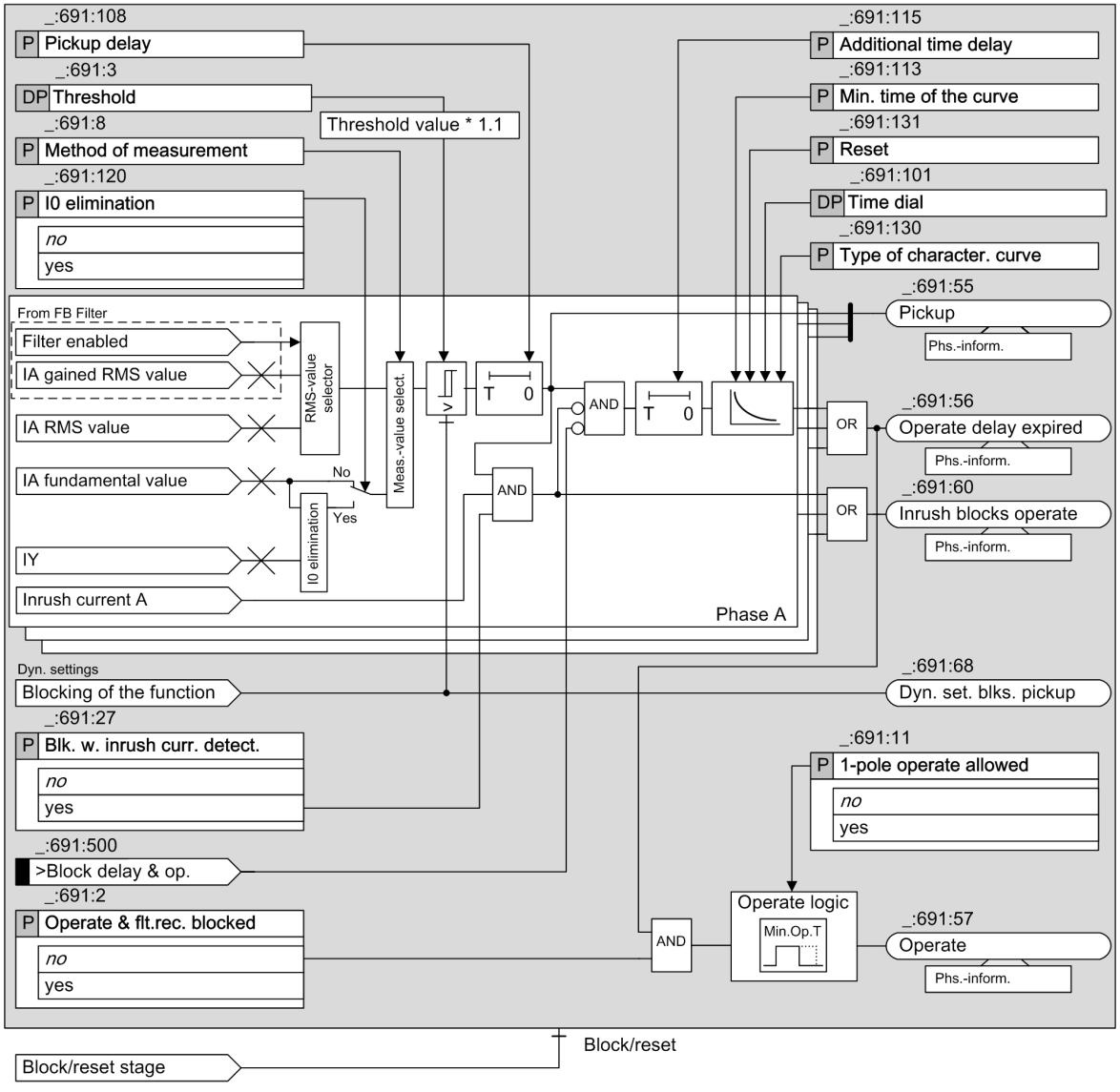
Figure 6-426 Logic Diagram Inverse-Time Overcurrent Protection (Phases) – Basic

Logic of the Advanced Stage



[lo_stage_control_OCP, 2, en_US]

Figure 6-427 Logic Diagram Stage Control



[lo_ocp_3p2, 4, en_US]

Figure 6-428 Logic Diagram Inverse-Time Overcurrent Protection (Phases) – Advanced

RMS-Value Selection (Advanced Stage)

If ***RMS value*** is selected as the method of measurement, the protection function supports 2 kinds of RMS measurement.

- Normal RMS value
- Gained RMS value from the function block **Filter**

If the function block **Filter** is configured and if you have enabled the filter, the gained RMS value is automatically used.

NOTE

When the function block **Filter** is applied, only one 3-phase current measuring point is allowed to be connected to the 3-phase current interface of the function group.

Pickup and Dropout Behaviors of the Inverse-Time Characteristic Curve according to IEC and ANSI (Basic and Advanced Stage)

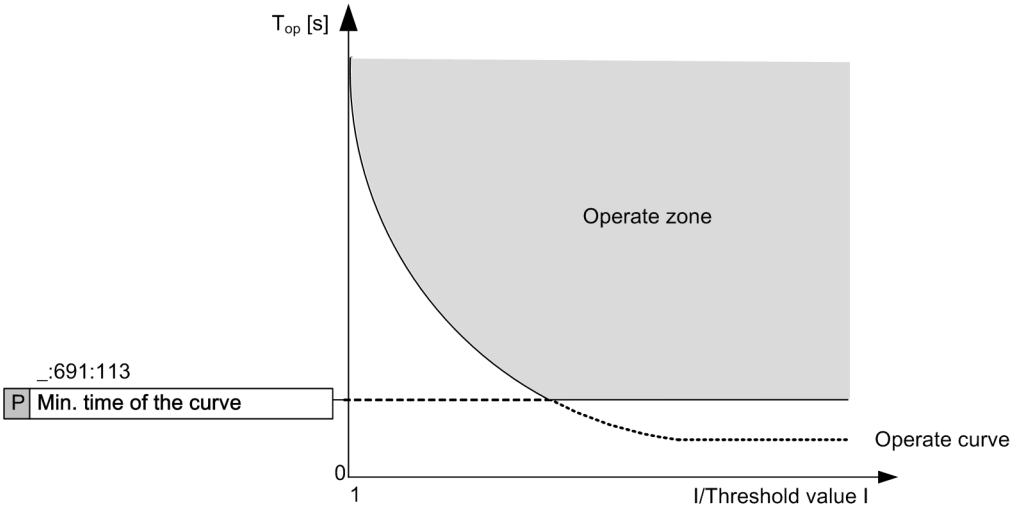
When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by a factor of 1.045 (0.95 · 1.1 · threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Minimum Time of the Curve (Advanced Stage)

With the parameter **`Min. time of the curve`**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.



[dw_ocp_3_mi, 1, en_US]

Figure 6-429 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter **Additional time delay**, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

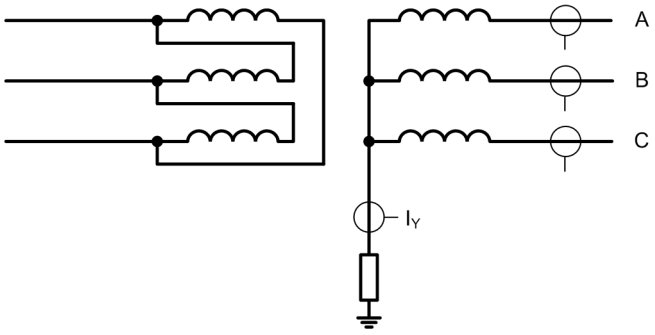
Method of Measurement (Basic and Advanced Stage)

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

I0 Elimination (Advanced Stage)

In order to increase the sensitivity for the 2-phase short circuit on the transformer low-voltage side, use the I0 elimination of the phase currents for the overcurrent-protection applications on one transformer.
In order to determine the I0 elimination of the phase currents, the transformer neutral point current I_Y must be measured.



[dw_sgaocp, 1, en_US]

Figure 6-430 I0 Elimination Principle

The transformer neutral point current I_Y is measured via a 1-phase current measuring point that is connected to the **Transformer neutral point** function group. Connect the function group **Transformer neutral point** to the function group **Transformer side**. In the function **Overcurrent protection, phases** operates with in the **Transformer side** function group.

Connect protection-function group to protection-function group

	Transformer side 1	Transformer side 2	Transformer diff. 1
Protection group	neutral point	neutral point	side
(All)	(All)	(All)	(All)
Transformer side 1			X
Transformer side 2			X
Transform. neut.p 1		X	

[sc_cpfoiut, 1, en_US]

Figure 6-431 Connection of the Transformer Neutral Point Function Group with the Neutral Point Input of the Transformer Side Function Group.

In case of an I0 elimination, the following calculations must be considered:

$\underline{I}_{A\text{-elim.}} = \underline{I}_A - 1/3\ \underline{I}_Y$

$\underline{I}_{B\text{-elim.}} = \underline{I}_B - 1/3\ \underline{I}_Y$

$\underline{I}_{C\text{-elim.}} = \underline{I}_C - 1/3\ \underline{I}_Y$

The phase current $\underline{I}_{phx\text{-elim.}}$ is necessary for the following protection process.

If the **Method of measurement** parameter is set to ***fundamental comp.***, the I0 elimination is operating.

The currents $\underline{I}_{phx\text{-elim.}}$ are available as functional values.

Pickup Delay (Advanced Stage)

If the current exceeds the threshold value, the pickup delay starts. If the threshold is exceeded during the pickup delay time, the pickup signal is generated.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal **>Block stage** from an external or internal source
- Via the functionality of the **dynamic settings** (only available in the Advanced function type, see **Influence of other functions via dynamic settings** and *6.23.8.1 Description*).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in *6.23.7.1 Description* .

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in *6.23.8.1 Description* .

6.23.5.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:691:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

Parameter: Type of character. curve

- Default setting **(_:691:130) Type of character. curve** = ***IEC normal inverse***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **Type of character. curve** required for your specific application. For more information about the parameter **Type of character. curve**, refer to chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*.

Parameter: Min. time of the curve

- Default setting **(_:691:113) Min. time of the curve** = ***0.00 s***

This parameter is only available in the advanced stage.

With the **Min. time of the curve** parameter, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.



NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: Additional time delay

- Default setting **(_:691:115) Additional time delay** = ***0.00 s***

With the **Additional time delay** parameter, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic time.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

Parameter: Threshold

- Default setting **(_:691:3) Threshold** = ***1.500 A***

Set the **Threshold** and **Type of character. curve** parameters for the specific application.

The setting depends on the maximum occurring operating current. Pickup by overload must be excluded since overcurrent protection operates with short tripping times as short-circuit protection and not as overload protection. Set the **Threshold** parameter for lines to approx. 10 %, for transformers and motors to approx. 20 % above the maximum expected load.

Note that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the **Threshold**.

EXAMPLE

Overcurrent-protection stage: 110-kV overhead line, 150 mm² cross-section

Maximum transmittable power
P_{max} = 120 MVA
Correspondingly
I_{max} = 630 A
Current transformer = 600 A/5 A

Settings in primary and secondary measurands result in the setting values:

Threshold value I> (primary) = 630 A

$$\text{Threshold value I> (secondary)} = \frac{630\ \text{A}}{600\ \text{A}} \cdot 5\ \text{A} = 5.25\ \text{A}$$

[fo_ocp_005, 2, en_US]

Parameter: I0 elimination

- Default setting **(_:661:120) I0 elimination** = ***no***

This parameter is not visible in the basic stage.

The I0 elimination in phase currents for overcurrent-protection applications can be used in a transformer. This increases the sensitivity for the 2-phase short circuit on the low-voltage side of the transformer. The following conditions must be fulfilled:

- The transformer neutral point current I_Y is measured and is available for the protection function group.
- The parameter **Method of measurement** is set to ***fundamental comp.***.

With the **I0 elimination** setting, you can switch the I0 elimination function on or off.

Parameter: Pickup delay

- Default setting **(_:661:102) Pickup delay** = ***0.00 s***

This parameter is not visible in the basic stage.

For special applications it is desirable if the current threshold is briefly exceeded, that this will not lead to the pickup of the stage and starts fault logging or recording. If this stage is used as a thermal overload function, that is considered a special application.

When using the **Pickup delay** parameter, a time interval is defined during which a pickup is not trigger if the current threshold is exceeded.

For all short-circuit protection applications, this value is 0.00 s and is considered as a default.

Parameter: Time dial

- Default setting **(_:691:101) Time dial** = ***1.00***

With the **Time dial** parameter, you displace the characteristic curve in the time direction.

The set value for the **Time dial** parameter is derived from the time-grading schedule that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter **Time dial** at ***1*** (default setting).

Parameter: `Reset`

- Default setting **`(_:691:131) Reset`** = ***`disk emulation`***

With the **`Reset`** parameter, you define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Select this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: `1-pole operate allowed`

- Default setting **`(_:691:11) 1-pole operate allowed`** = ***`no`***

The parameter must be set for the specific application.

Parameter Value	Description
`no`	The stage always operates 3-pole.
`yes`	The stage operates phase-selectively. However, tripping by the device (generated in the trip logic of the **Circuit-breaker** function group) is always 3-pole because the device does not support phase-selective tripping.

6.23.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:691:1	Inverse-T 1:Mode		• off • on • test	off
_:691:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:691:11	Inverse-T 1:1-pole operate allowed		• no • yes	no
_:691:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:691:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:691:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:691:120	Inverse-T 1:I0 elimination		• no • yes	no
_:691:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:108	Inverse-T 1:Pickup delay		0.00 s to 60.00 s	0.00 s
_:691:130	Inverse-T 1:Type of character. curve			

Addr.	Parameter	C	Setting Options	Default Setting
_:691:113	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:691:131	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:691:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:691:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:691:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:691:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:691:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:691:36	Inverse-T 1:Stage blocked		• no • yes	no
_:691:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 2				
_:691:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:691:37	Inverse-T 1:Stage blocked		• no • yes	no
_:691:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 3				
_:691:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no
_:691:38	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:691:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: AR cycle>3				
_:691:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:691:39	Inverse-T 1:Stage blocked		• no • yes	no
_:691:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:691:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:691:40	Inverse-T 1:Stage blocked		• no • yes	no
_:691:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: bin.input				
_:691:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:691:41	Inverse-T 1:Stage blocked		• no • yes	no
_:691:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

6.23.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Inverse-T 1			
_:691:81	Inverse-T 1:>Block stage	SPS	I
_:691:84	Inverse-T 1:>Activ. dyn. settings	SPS	I
_:691:500	Inverse-T 1:>Block delay & op.	SPS	I
_:691:51	Inverse-T 1:Mode (controllable)	ENC	C
_:691:54	Inverse-T 1:Inactive	SPS	O
_:691:52	Inverse-T 1:Behavior	ENS	O
_:691:53	Inverse-T 1:Health	ENS	O
_:691:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:691:62	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:691:63	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:691:64	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:691:65	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:691:66	Inverse-T 1:Dyn.set. CLP active	SPS	O
_:691:67	Inverse-T 1:Dyn.set. BI active	SPS	O
_:691:68	Inverse-T 1:Dyn. set. blks. pickup	SPS	O
_:691:59	Inverse-T 1:Disk emulation running	SPS	O
_:691:55	Inverse-T 1:Pickup	ACD	O
_:691:56	Inverse-T 1:Operate delay expired	ACT	O
_:691:57	Inverse-T 1:Operate	ACT	O
_:691:302	Inverse-T 1:I0el.Iph	WYE	O

6.23.6 Stage with User-Defined Characteristic Curve

6.23.6.1 Description

This stage is only available in the advanced function type.

This stage is structured the same way as the **Inverse-time overcurrent protection – advanced** stage (see chapter *6.23.5.1 Description*). The only differences are as follows:

- You can define the characteristic curve as desired.
- The pickup and dropout behaviors of this stage are determined by the standard parameter **Threshold** and, if necessary, by an additional parameter **Threshold (absolute)** .

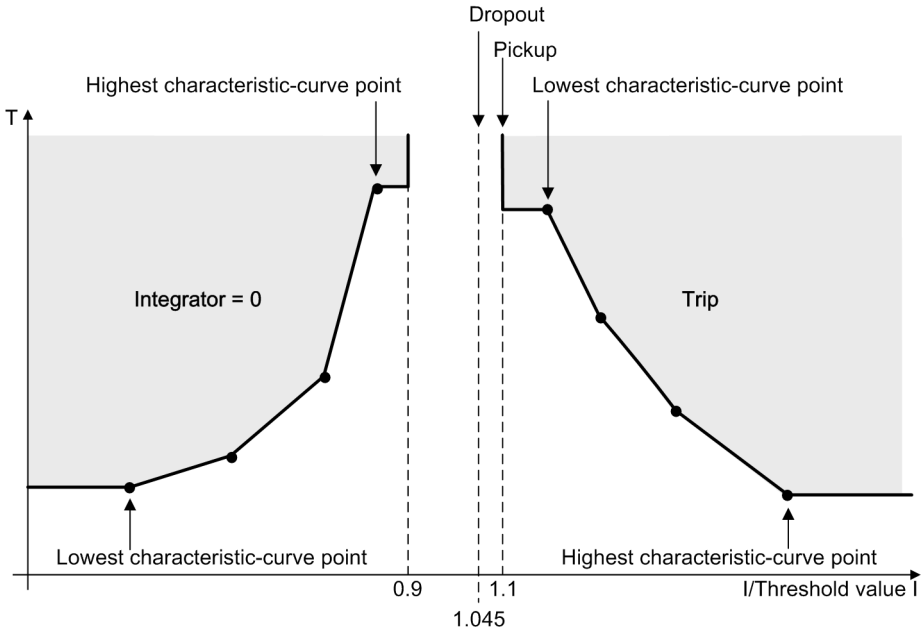
User-Defined Characteristic Curve

With the user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

Pickup and Dropout Behaviors with the User-Defined Characteristic Curve

When the input variable exceeds the **Threshold** value by 1.1 times, the characteristic curve is processed. An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x **Threshold** value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.



[dw_ocp_ken_02, 2, en_US]

Figure 6-432 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

The currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

If you want to change the pickup threshold of the stage without changing all points of the characteristic curve, you can use the additional **Threshold (absolute)** parameter.

You can set the **Threshold (absolute)** parameter to be greater than 1.1 times the **Threshold** value. Then the stage behaviors are as follows:

- The stage picks up when the measured current value exceeds the **Threshold (absolute)** value.
- The stage starts dropout when the measured current value falls short of the **Threshold (absolute)** value by 0.95 times.
- For measured current values lower than the **Threshold (absolute)** value, no pickup takes place and consequently the characteristic curve is not processed.

If you set the **Threshold (absolute)** parameter to be less than 1.1 times the **Threshold** value, the pickup and dropout behaviors are not affected by the **Threshold (absolute)** parameter.

6.23.6.2 Application and Setting Notes

This stage is structured the same way as the **Inverse-time overcurrent protection – advanced** stage. The only differences are described in chapter *6.23.6.1 Description* . This chapter provides only the application and setting notes for setting characteristic curves and for setting the **Threshold (absolute)** parameter. You can find more information on the other parameters of the stage in chapter *6.23.5.2 Application and Setting Notes* .

Parameter: Current/time value pairs (from the operate curve)

With these settings, you define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **Threshold** parameter to ***1.00*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to shift the characteristic curve.

Set the time value in seconds. The characteristic curve is shifted via the **Time dial** parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: Time dial

- Default setting **(_:101) Time dial** = ***1***

With the **Time dial** parameter, you displace the characteristic curve in the time direction.

The set value for the **Time dial** parameter is derived from the time-grading schedule that has been prepared for the electrical power system. Where no time grading and therefore no displacement of the characteristic curve is required, leave the **Time dial** parameter at ***1***.

Parameter: Reset

- Default setting **(_:110) Reset** = ***disk emulation***

With the **Reset** parameter, you define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Select this setting if the dropout is not to be performed after disk emulation but an instantaneous dropout is desired.

Parameter: Current/time value pairs (of the dropout characteristic curve)

With these settings, you define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **Threshold** parameter to ***1.00*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to shift the characteristic curve.

Set the time value in seconds. The characteristic curve is shifted via the **Time dial** parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: `1-pole operate allowed`

- Default setting **`(_:11) 1-pole operate allowed`** = ***`no`***

The parameter must be set for the specific application.

Parameter Value	Description
`no`	The stage always operates 3-pole.
`yes`	The stage operates phase-selectively. However, tripping by the device (generated in the trip logic of the **Circuit-breaker** function group) is always 3-pole because the device does not support phase-selective tripping.

Parameter: `Threshold (absolute)`

- Default setting **`(_:113) Threshold (absolute)`** = ***`0.000 A`***

With the **`Threshold (absolute)`** parameter, you define and change the absolute pickup threshold of the stage without changing all points of the characteristic curve.

The parameter is only used for special applications. With the default setting, this functionality is disabled.

You can find more information in *Pickup and Dropout Behaviors with the User-Defined Characteristic Curve , Page 1220*.

6.23.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:11	User curve #:1-pole operate allowed		• no • yes	no
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:120	User curve #:I0 elimination		• no • yes	no
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:113	User curve #:Threshold (absolute)	1 A @ 100 Irated	0.000 A to 40.000 A	0.000 A
		5 A @ 100 Irated	0.00 A to 200.00 A	0.00 A
		1 A @ 50 Irated	0.000 A to 40.000 A	0.000 A
		5 A @ 50 Irated	0.00 A to 200.00 A	0.00 A
		1 A @ 1.6 Irated	0.000 A to 1.600 A	0.000 A
		5 A @ 1.6 Irated	0.000 A to 8.000 A	0.000 A

Addr.	Parameter	C	Setting Options	Default Setting
_:111	User curve #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
_:115	User curve #:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no
_:38	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

6.23.6.4 Information List

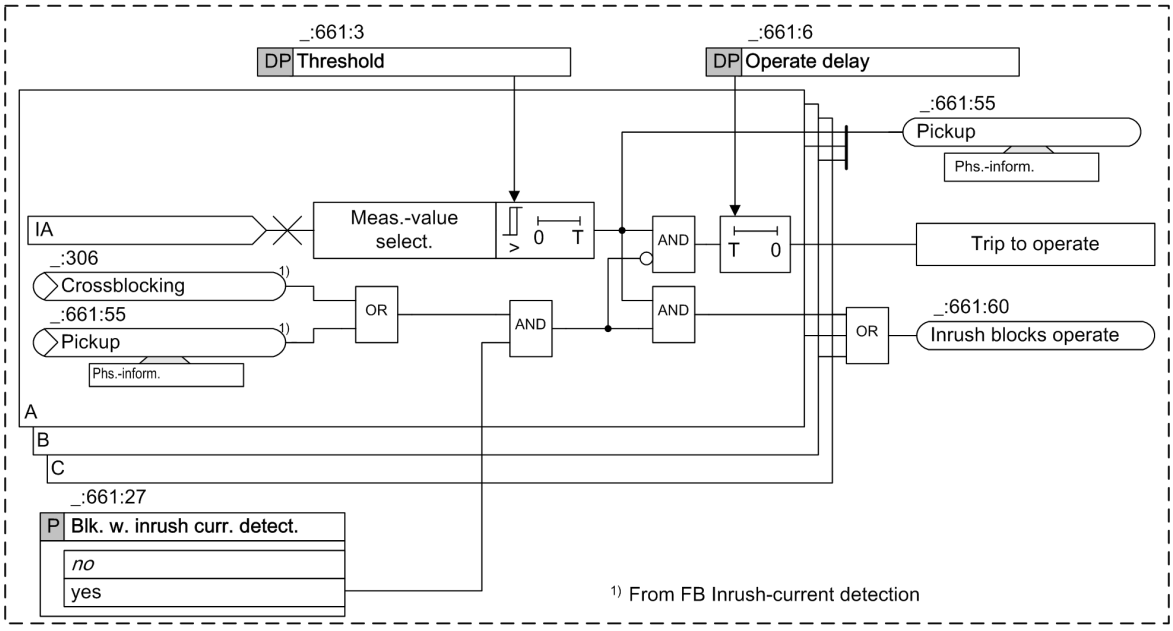
No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:84	User curve #:>Activ. dyn. settings	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:62	User curve #:Dyn.set. AR cycle1act.	SPS	O
_:63	User curve #:Dyn.set. AR cycle2act.	SPS	O
_:64	User curve #:Dyn.set. AR cycle3act.	SPS	O
_:65	User curve #:Dyn.set. ARcycl.>3act	SPS	O
_:66	User curve #:Dyn.set. CLP active	SPS	O
_:67	User curve #:Dyn.set. BI active	SPS	O
_:68	User curve #:Dyn. set. blks. pickup	SPS	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.23.7 Blocking of the Tripping by Device-Internal Inrush-Current Detection

6.23.7.1 Description

The **`Blk. w. inrush curr. detect.`** parameter allows you to define whether the operate indication of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started. After that time, the stage operates.

The following figure only shows the part of the stage (exemplified by definite-time overcurrent protection stage 1) that illustrates the influence of the blocking. Only if the central function **Inrush-current detection** (see chapter *12.62 Inrush-Current Detection*) is in effect can the blocking be set.



[lo_ocp3pha, 1, en_US]

Figure 6-433 Part-Logic Diagram on the Influence of Inrush-Current Detection Exemplified by the 1st Definite-Time Overcurrent Protection Stage

6.23.7.2 Application and Setting Notes

Parameter: **`Blk. w. inrush curr. detect.`**

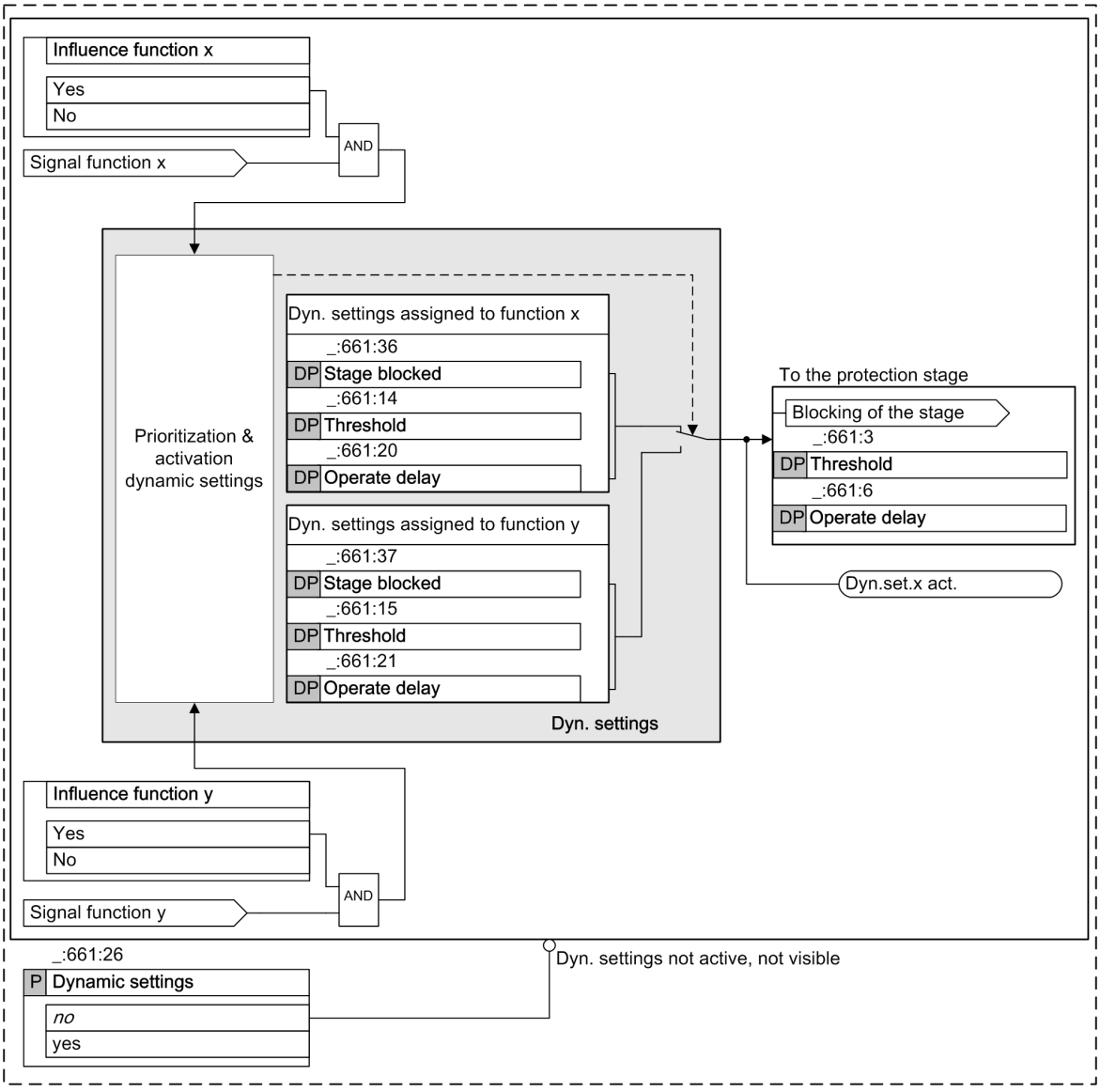
- Default setting **`(_:661:27) Blk. w. inrush curr. detect.`** = ***`no`***

Parameter Value	Description
`no`	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This, for example, applies to the high-current stage that is set such according to the short-circuit voltage V_{sc} of the transformer that it only picks up on faults from the high-voltage side. The transformer inrush current cannot become larger than the maximum transmittable short-circuit current.
`yes`	When the transformer inrush current detection detects an inrush current that would lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

6.23.8 Influence of Other Functions via Dynamic Settings

6.23.8.1 Description

The parameters **Threshold** and **Operate delay** used for tripping are so-called **dynamic settings**. Depending on other functions, the settings of these parameters can be changed dynamically (see *Figure 6-434*). Depending on other functions, the stage can also be blocked dynamically. This functionality is only available in function type Advanced.



[lo_ocp_3dpa, 2, en_US]

Figure 6-434 Principle of the Dynamic Settings Exemplified by 1st Definite-Time Overcurrent Protection Stage

If available in the device, the following functionalities can affect the overcurrent-protection stages:

Functionalities	Priority
Cold-load pickup detection	Priority 1
Binary input signal	Priority 2

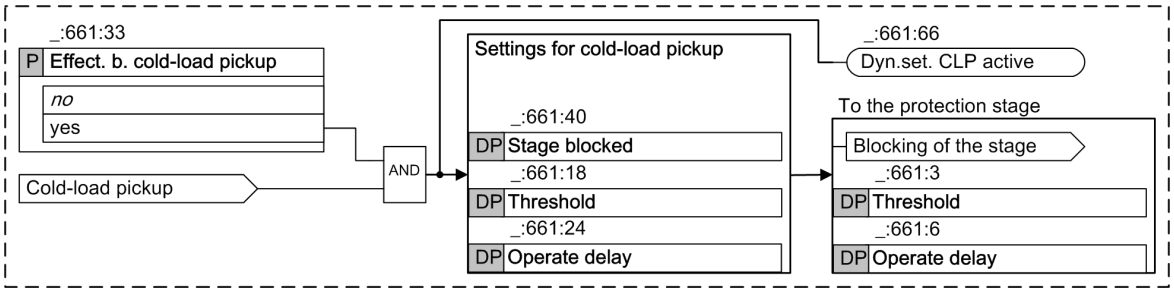
These functionalities generate signals that change the settings of the dynamic settings of the overcurrent-protection stage or block it, if required. In the latter case, the settings of the **Threshold** and **Operate**

delay parameters are of no relevance. Within the overcurrent-protection stage, each of these signals is provided with a configuration parameter **Influence of function ...** and its own dynamic settings (**Operate delay** and **Threshold**). The configuration settings are used to set whether the signal shall be active or not, this means whether the dynamic settings shall be activated or not. If one of these signals (for example, signal function x) becomes active and is to take effect, these settings become dynamic, that is, instantly active. This means that the setting assigned to the signal replaces the standard setting. If the signal becomes inactive, the standard settings apply again. The activation of the dynamic settings is reported.

Where several signals are active in parallel, the priority specified above shall apply. This means that a signal with priority 1 precedes that of priority 2. The settings assigned to signal 1 become active.

The functionality of the dynamic settings can be disabled. In this case, the settings assigned to the signals are not visible and are without effect.

Link to the Device-Internal Function *Cold-Load Pickup Detection (Advanced Stage)*



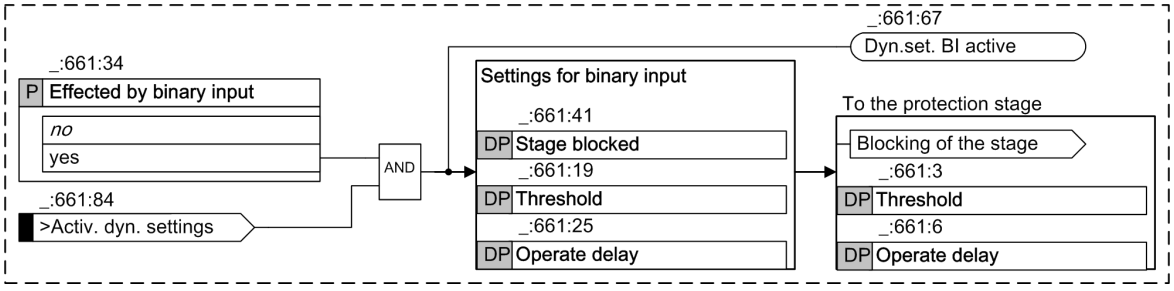
[lo_ocp3kal, 1, en_US]

Figure 6-435 Influence of the Cold-Load Pickup Detection on the Overcurrent-Protection Stage

In the case of cold-load pickup, you have the option to change the settings for the **Threshold** and **Operate delay** parameters of the protection stage. You can also block the stage. To do so, you must activate the influence of the cold-load pickup. You also have to set the **Threshold** and **Operate delay** or assign settings to **Stage blocked**, which take effect when the signal is active.

The way signals are generated **Cold-load pickup** is described in *5.5.4.1 Overview of Functions*.

Link to an External *Function via a Binary Input Signal (Advanced Stage)*



[lo_ocp3bin, 1, en_US]

Figure 6-436 Influence of the Binary Input on the Overcurrent-Protection Stage

You can use the binary input signal **>Activ. dyn. settings** to change the settings for the **Threshold** and the **Operate delay** parameters of the protection stage. You can also block the stage. To do so, you must activate the influence of the binary input. You also have to set the **Threshold** and **Operate delay** or assign settings to **Stage blocked**, which take effect when the signal is active.

6.23.8.2 Application and Setting Notes (Advanced Stage)

Parameter: Dynamic settings

- Default setting **(_:661:26) Dynamic settings** = *no*

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (cold-load pickup detection) or an external function should affect the overcurrent-protection stage (such as changing the setting of the threshold value or time delay, blocking of the stage), the setting must be changed to ***yes***. This makes the configuration parameters **Influence of function...** as well as the dynamic settings **Threshold**, **Operate delay** and **Stage blocked** of the stage visible and enables the settings to be set for the specific influence.

Influence of External Devices

The influence of an external device can also be configured.

To realize the application, the configuration setting **Effected by binary input** must be changed to ***yes*** (= influenced). This activates the **>Activ. dyn. settings** input signal within the stage. When the input signal becomes active, it switches to the assigned dynamic settings.

6.24 Overcurrent Protection, Ground

6.24.1 Overview of Functions

The **Overcurrent protection, ground** function (ANSI 50N/51N):

- Detects short circuits in electrical equipment
- Can be used as backup overcurrent protection in addition to the main protection

6.24.2 Structure of the Function

The **Overcurrent protection, ground** function is used in protection function groups. 2 kinds of functions are available for the 3-phase overcurrent protection:

- **Overcurrent protection, ground – advanced** (50N/51N OC-gnd-A)
- **Overcurrent protection, ground – basic** (50N/51N OC-gnd-B)

The function type Basic is provided for standard applications. The function type Advanced offers more functionality and is provided for more complex applications.

Both function types are pre-configured by the manufacturer with 2 **Definite-time overcurrent protection** stages and with 1 **Inverse-time overcurrent protection** stage.

In the function type **Overcurrent protection, ground – advanced** the following stages can be operated simultaneously:

- Maximum of 3 stages **Definite-time overcurrent protection – advanced**
- 1 stage **Inverse-time overcurrent protection – advanced**
- 1 stage **User-defined characteristic curve overcurrent protection**

In the function type **Overcurrent protection, ground – basic** the following stages can be operated simultaneously:

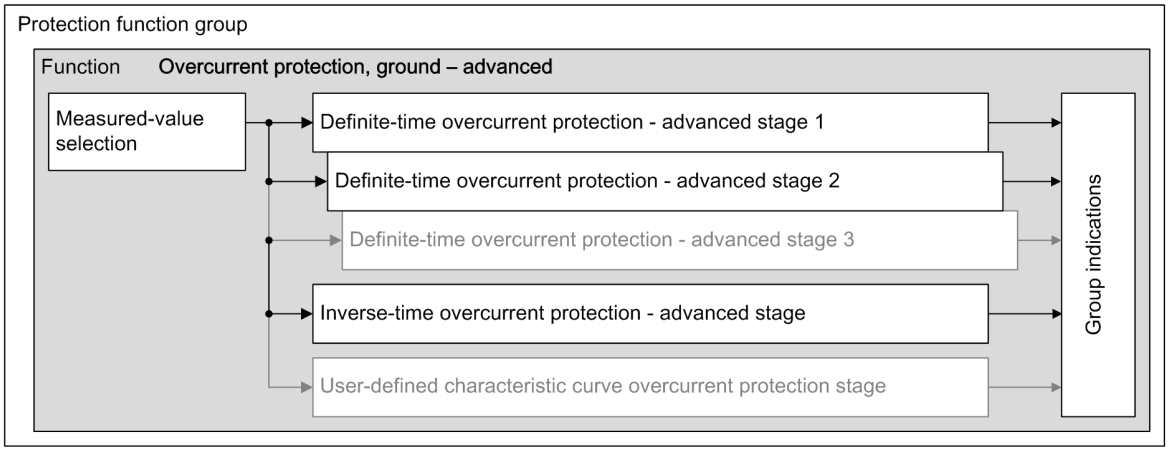
- Maximum of 3 stages **Definite-time overcurrent protection – basic**
- 1 stage **Inverse-time overcurrent protection – basic**

The non-preconfigured stages are shown in gray in the following figures. Apart from the tripping delay characteristic, the stages are identical in structure.

The measured-value selection (only advanced stage) is general functionality and has a uniform effect on the stages (see *Figure 6-437* and *6.24.3.1 Description*). This ensures that all stages of the function receive the same measured current value.

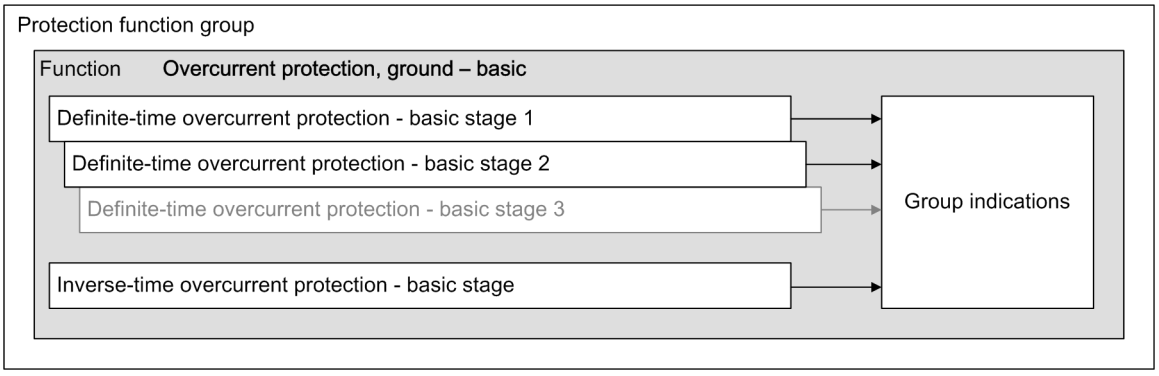
The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- **`Pickup`**
- **`Operate`**



[dw_ocp_ga2, 5, en_US]

Figure 6-437 Structure/Embedding of the Function Overcurrent Protection, Ground – Advanced



[dw_ocp_gb1, 4, en_US]

Figure 6-438 Structure/Embedding of the Function Overcurrent Protection, Ground – Basic

If the following listed, device-internal functions are present in the device, these functions can influence the pickup values and tripping delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Cold-load pickup detection
- Binary input signal

If the device is equipped with an **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer-inrush currents (available in both function types).

6.24.3 General Functionality

6.24.3.1 Description

Measured-Value Selection

The function provides the option to select between the values ***IN measured*** or ***3I0 calculated***.

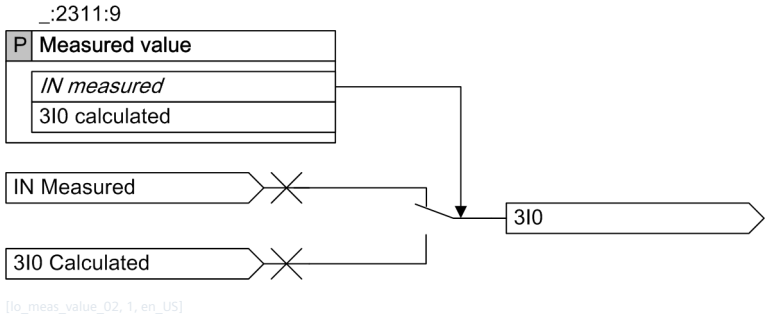


Figure 6-439 Logic Diagram of Measured-Value Selection

Both options are only available for the current-transformer connection types ***3-phase + IN*** and ***3-phase + IN-separate***. For other connection types respectively, only one option is possible. If you select an option that is not allowed, an inconsistency message is given.

Depending on the CT secondary rated current, the CT connection type, and the selected setting, the secondary threshold setting range varies according to the following table.

Table 6-10 Threshold Setting Range

Connection Type	Measured Value	CT Terminal Type	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 5 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 5 A)
3ph + IN	3I0 calculated	4 * Protection	0.010 A to 40.000 A	N/A	N/A	0.050 A to 200.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.002 A to 8.000 A
	IN measured	4 * Protection	0.010 A to 40.000 A	N/A	N/A	0.050 A to 200.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.002 A to 8.000 A
3ph + IN-separate	3I0 calculated	4 * Protection	0.010 A to 40.000 A	0.010 A to 40.000 A	0.050 A to 200.00 A	0.050 A to 200.00 A
		3 * Protection, 1 * sen.	0.010 A to 40.000 A	0.010 A to 40.000 A	0.050 A to 200.00 A	0.050 A to 200.00 A
		4 * Measurement	0.001 A to 1.600 A	0.001 A to 1.600 A	0.002 A to 8.000 A	0.002 A to 8.000 A
	IN measured	4 * Protection	0.010 A to 40.000 A	0.050 A to 200.00 A	0.010 A to 40.000 A	0.050 A to 200.00 A
		3 * Protection, 1 * sen.	0.001 A to 1.600 A	0.002 A to 8.000 A	0.001 A to 1.600 A	0.002 A to 8.000 A
		4 * Measurement	0.001 A to 1.600 A	0.002 A to 8.000 A	0.001 A to 1.600 A	0.002 A to 8.000 A

6.24.3.2 Application and Setting Notes

Parameter: `Measured value`

- Recommended setting value **`Measured value`** = ***`IN Measured`***

This parameter is not available in the basic function.

Parameter Value	Description
IN Measured	The function operates with the measured ground current IN. This is the recommended setting unless there is a specific reason to use the calculated zero-sequence current 3I0.
3I0 Calculated	The function operates with the calculated zero sequence current 3I0. This setting option can be used when applying a redundant 50N/51N function for safety reasons.

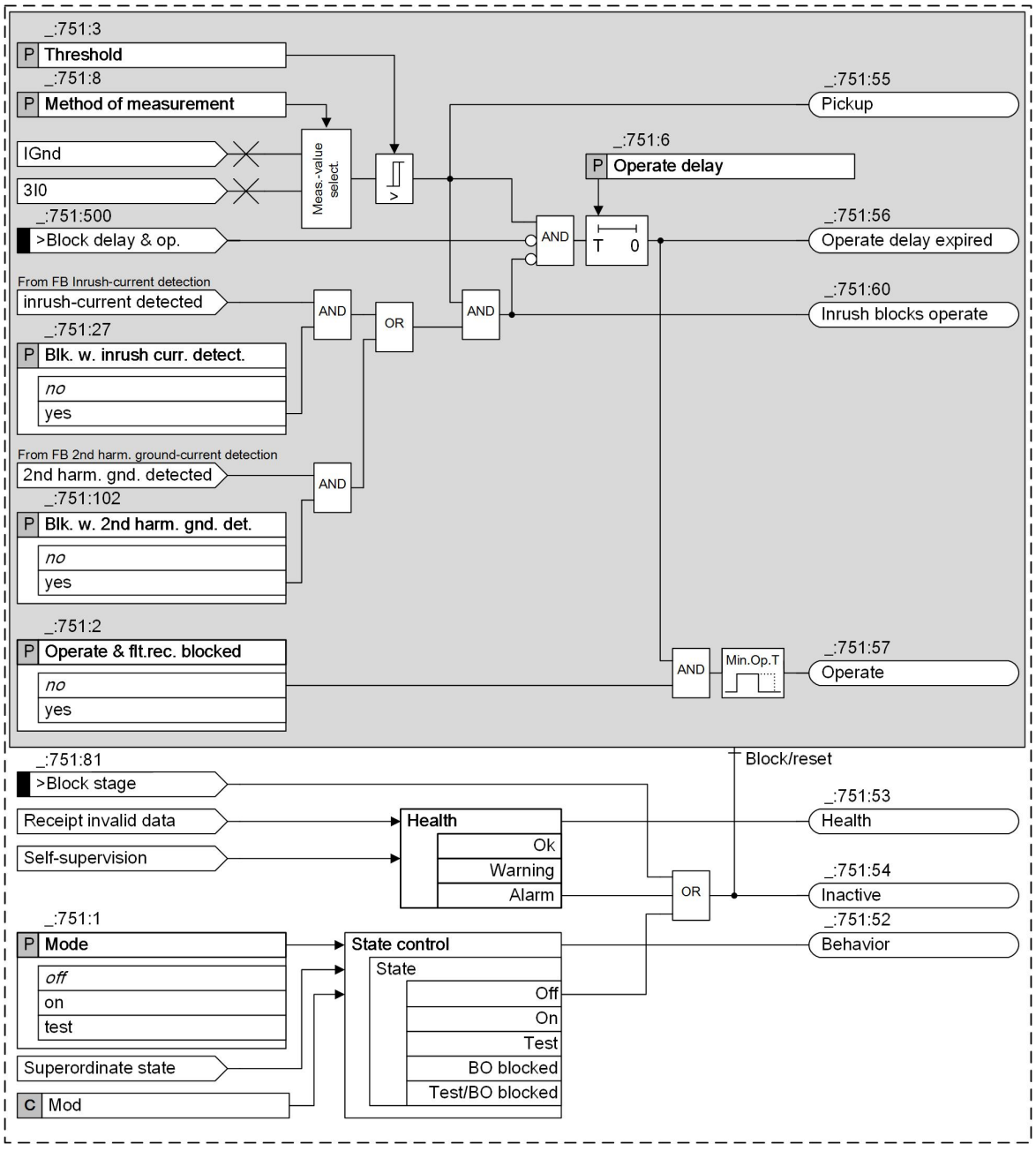
6.24.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:9	General:Measured value		• 3I0 calculated • IN measured	IN measured

6.24.4 Stage with Definite-Time Characteristic Curve

6.24.4.1 Description

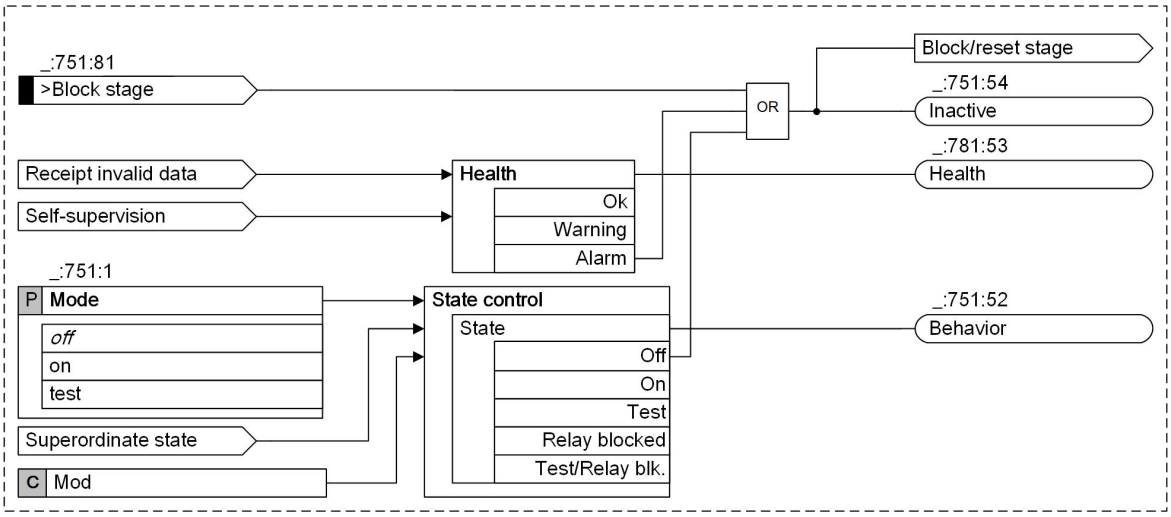
Logic of the Basic Stage



[lo_ocp_gb1, 4, en_US]

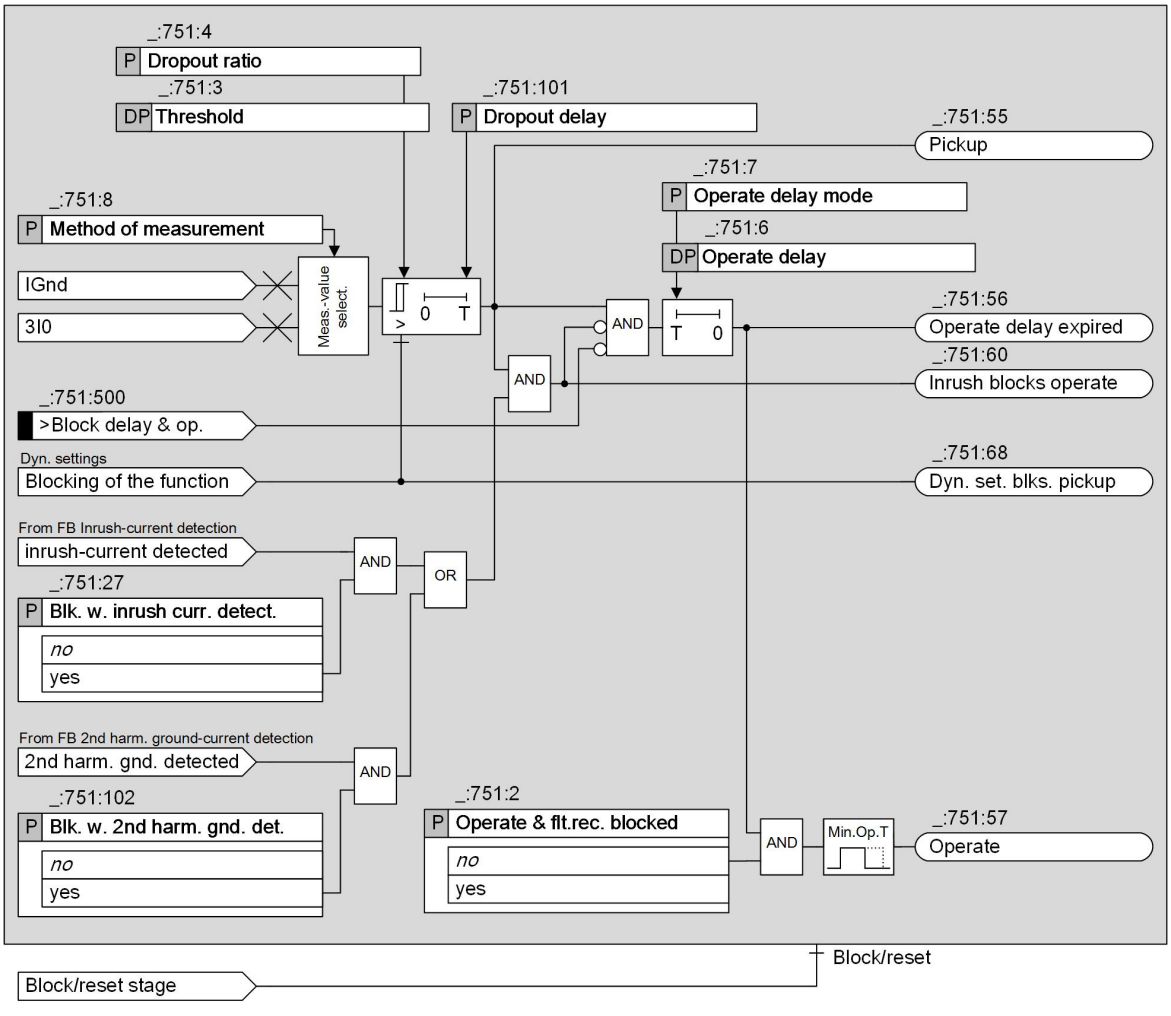
Figure 6-440 Logic Diagram Definite-Time Overcurrent Protection (Ground) – Basic

Logic of the Advanced Stage



[lo_ocp_gnd_umz_adv_stage_control, 2, en_US]

Figure 6-441 Logic Diagram Stage Control



[lo_ocp_gn1, 5, en_US]

Figure 6-442 Logic Diagram Definite-Time Overcurrent Protection (Ground) – Advanced

Method of Measurement (Basic and Advanced Stage)

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Dropout Delay (Advanced Stage)

If the current falls below the dropout threshold, the dropout can be delayed for the time specified by the parameter **Dropout delay**. During the dropout delay, the pickup is maintained. Meanwhile, the operate delay continues to run (parameter **Operate delay mode** = ***Running dur. DO-delay***) or is frozen (parameter **Operate delay mode** = ***Frozen dur. DO-delay***). If the operate delay expires while the pickup is still maintained, the stage operates.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal **>Block stage** from an external or internal source
- Via the functionality of the **dynamic settings** (see **Influence of other functions via dynamic settings** and *6.24.8.1 Description*).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in *6.24.7.1 Description*.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in *6.24.8.1 Description* .

6.24.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:751:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

Parameter: Operate delay mode

- Default setting **(_:661:7) Operate delay mode** = ***Running dur. DO-delay***

This parameter is not visible in the basic stage.

With the parameter **Operate delay mode**, you specify whether the operate delay continues to run or is frozen during the dropout delay.

This setting is only valid if the parameter **Dropout delay** is not ***0***.

Parameter Value	Description
Running dur. DO-delay	During the dropout delay, the operate delay continues to run.
Frozen dur. DO-delay	During the dropout delay, the operate delay is frozen. If the current exceeds the threshold value again, the operate delay continues to run.

Parameter: Threshold, Operate delay

- Default setting **(_:751:3) Threshold** = ***1.20 A*** (for the first stage)
- Default setting **(_:751:6) Operate delay** = ***0.300 s*** (for the first stage)

Set the **Threshold** and **Operate delay** parameters for the specific application.

The following details apply to a 2-stage characteristic curve (1st stage = definite-time overcurrent protection stage and 2nd stage = high-current stage).

1st stage (overcurrent stage):

The setting depends on the minimal occurring ground-fault current. This must be determined.

For very small ground-fault currents, Siemens recommends using the **Ground-fault protection against high-resistance ground faults in grounded systems** function.

The **Operate delay** to be set is derived from the time-grading schedule that has been prepared for the system. Where overcurrent protection is used in emergency mode, shorter time delays might be reasonable (one grading time above fast tripping), since the emergency mode only operates if the main protection function fails.

2nd stage (high-current stage):

This tripping stage can also be used for current grading. This applies in the case of very long lines with low source impedance or ahead of high reactances (for example, transformers, shunt reactors). Set the **Threshold** parameter to ensure that the stage does not pick up in case of a short-circuit at the end of the line.

Set the **Operate delay** parameter to ***0*** or to a low value.

Siemens recommends that the threshold values be determined with a system analysis. The following example illustrates the principle of grading with a current threshold on a long line.

EXAMPLE

High-current stage: 110-kV overhead line, 150 mm² cross-section

s (length) = 60 km

Z_L/s = 0.46 Ω/km

Ratio of zero-sequence impedance and positive-sequence impedance of the line: $Z_{L0}/Z_{L1} = 4$

Short-circuit power at the beginning of the line:

S_{sc}' = 2.5 GVA

Ratio of zero-sequence impedance and positive-sequence impedance of the source impedance at the beginning of the line: $Z_{P0}/Z_{P1} = 2$

Current transformer = 600 A/5 A

Resulting in the following values for the line impedance Z_L and the source impedance Z_P:

$$Z_L = 0.46\ \Omega/\mathrm{km} \cdot 60\mathrm{km} = 27.6\ \Omega$$

[fo_ocp_002, 1, en_US]

$$Z_P = \frac{110\ \mathrm{kV}^2}{2500\ \mathrm{MVA}} = 4.84\ \Omega$$

[fo_ocp_003, 1, en_US]

The 1-pole short-circuit current at the end of the line is $I_{scG\ end}$:

$$I_{sc\ gnd\ end} = \frac{1.1 \cdot V_N \cdot 3}{\sqrt{3} \cdot \left[Z_P \cdot \left(2 + \frac{Z_{P0}}{Z_{P1}}\right) + Z_L \cdot (2 + \frac{Z_{L0}}{Z_{L1}})\right]} = \frac{1.1 \cdot 110\mathrm{kV} \cdot 3}{\sqrt{3} \cdot [4.84\ \Omega \cdot (2+2) + 27.6\ \Omega \cdot (2+4)]} = 1133\ \mathrm{A}$$

[fo_ocp_005, 1, en_US]

The settings in primary and secondary values result in the following setting values which include a safety margin of 10 %:

Threshold value 2nd stage (primary) $= 1.1 \cdot 1133\ \mathrm{A} = 1246.3\ \mathrm{A}$

Threshold value 2nd stage (secondary) $= 1.1 \cdot \frac{1133\ \mathrm{A}}{600\ \mathrm{A}} \cdot 5\ \mathrm{A} = 10.39\ \mathrm{A}$

[fo_ocp_gr4, 3, en_US]

In case of short-circuit currents exceeding 1246 A (primary) or 10.39 A (secondary) there is a short-circuit on the line to be protected. The overcurrent protection can cut off this short circuit immediately.

Note: The amounts in the calculation example are accurate enough for overhead lines. If the source impedance, line impedance and zero-sequence impedance have very different angles, you have use complex numbers to calculate the **Threshold**.

Parameter: Dropout delay

- Recommended setting value **(_:751:101) Dropout delay** = ***0***

This parameter is not visible in the basic stage.

Siemens recommends using the default setting ***0*** since the dropout of a protection stage must be done as fast as possible.

You can use the **Dropout delay** parameter ≠ ***0*** to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical Data) and set the result.

Parameter: `Dropout ratio`

- Recommended setting value **`(_:751:4) Dropout ratio`** = ***`0.95`***

This parameter is not visible in the basic stage.

The recommended set value of ***`0.95`*** is appropriate for most applications.

To achieve high-precision measurements, the setting value of the parameter **`Dropout ratio`** can be reduced, for example, to ***`0.98`***. If you expect highly fluctuating measurands at the response threshold, you can increase the setting value of the parameter **`Dropout ratio`**. This avoids chattering of the stage.

6.24.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:101	General:Emergency mode		• no • caused by main prot. • caused by binary input	no
_:2311:9	General:Measured value		• 3I0 calculated • IN measured	IN measured
`General`				
_:751:1	Definite-T 1:Mode		• off • on • test	off
_:751:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:751:26	Definite-T 1:Dynamic settings		• no • yes	no
_:751:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:751:102	Definite-T 1:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:751:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:751:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:751:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:751:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:751:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
_:751:7	Definite-T 1:Operate delay mode		• Running dur. DO-delay • Frozen dur. DO-delay	Running dur. DO-delay
`Dyn.s: AR off/n.rdy`				
_:751:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:751:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:751:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:751:36	Definite-T 1:Stage blocked		• no • yes	no
_:751:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:751:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:751:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:751:37	Definite-T 1:Stage blocked		• no • yes	no
_:751:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:751:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:751:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no
_:751:38	Definite-T 1:Stage blocked		• no • yes	no
_:751:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:751:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:751:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:751:39	Definite-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:751:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:751:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: Cold load PU				
_:751:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:751:40	Definite-T 1:Stage blocked		• no • yes	no
_:751:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:751:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:751:34	Definite-T 1:Effected by binary input		• no • yes	no
_:751:41	Definite-T 1:Stage blocked		• no • yes	no
_:751:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:751:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
General				
_:752:1	Definite-T 2:Mode		• off • on • test	off
_:752:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:752:26	Definite-T 2:Dynamic settings		• no • yes	no
_:752:27	Definite-T 2:Blk. w. inrush curr. detect.		• no • yes	no
_:752:102	Definite-T 2:Blk. w. 2nd harm. gnd. det.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:752:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:752:3	Definite-T 2:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:752:4	Definite-T 2:Dropout ratio		0.90 to 0.99	0.95
_:752:101	Definite-T 2:Dropout delay		0.00 s to 60.00 s	0.00 s
_:752:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.30 s
_:752:7	Definite-T 2:Operate delay mode		• Running dur. DO-delay • Frozen dur. DO-delay	Running dur. DO-delay
Dyn.s: AR off/n.rdy				
_:752:28	Definite-T 2:Effect. by AR off/n.ready		• no • yes	no
_:752:35	Definite-T 2:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:752:29	Definite-T 2:Effected by AR cycle 1		• no • yes	no
_:752:36	Definite-T 2:Stage blocked		• no • yes	no
_:752:14	Definite-T 2:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:752:20	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:752:30	Definite-T 2:Effected by AR cycle 2		• no • yes	no
_:752:37	Definite-T 2:Stage blocked		• no • yes	no
_:752:15	Definite-T 2:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:752:21	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.30 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 3				
_:752:31	Definite-T 2:Effected by AR cycle 3		• no • yes	no
_:752:38	Definite-T 2:Stage blocked		• no • yes	no
_:752:16	Definite-T 2:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:752:22	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:752:32	Definite-T 2:Effected by AR cycle gr. 3		• no • yes	no
_:752:39	Definite-T 2:Stage blocked		• no • yes	no
_:752:17	Definite-T 2:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:752:23	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: Cold load PU				
_:752:33	Definite-T 2:Effect. b. cold-load pickup		• no • yes	no
_:752:40	Definite-T 2:Stage blocked		• no • yes	no
_:752:18	Definite-T 2:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:752:24	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:752:34	Definite-T 2:Effected by binary input		• no • yes	no
_:752:41	Definite-T 2:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:752:19	Definite-T 2:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:752:25	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.30 s

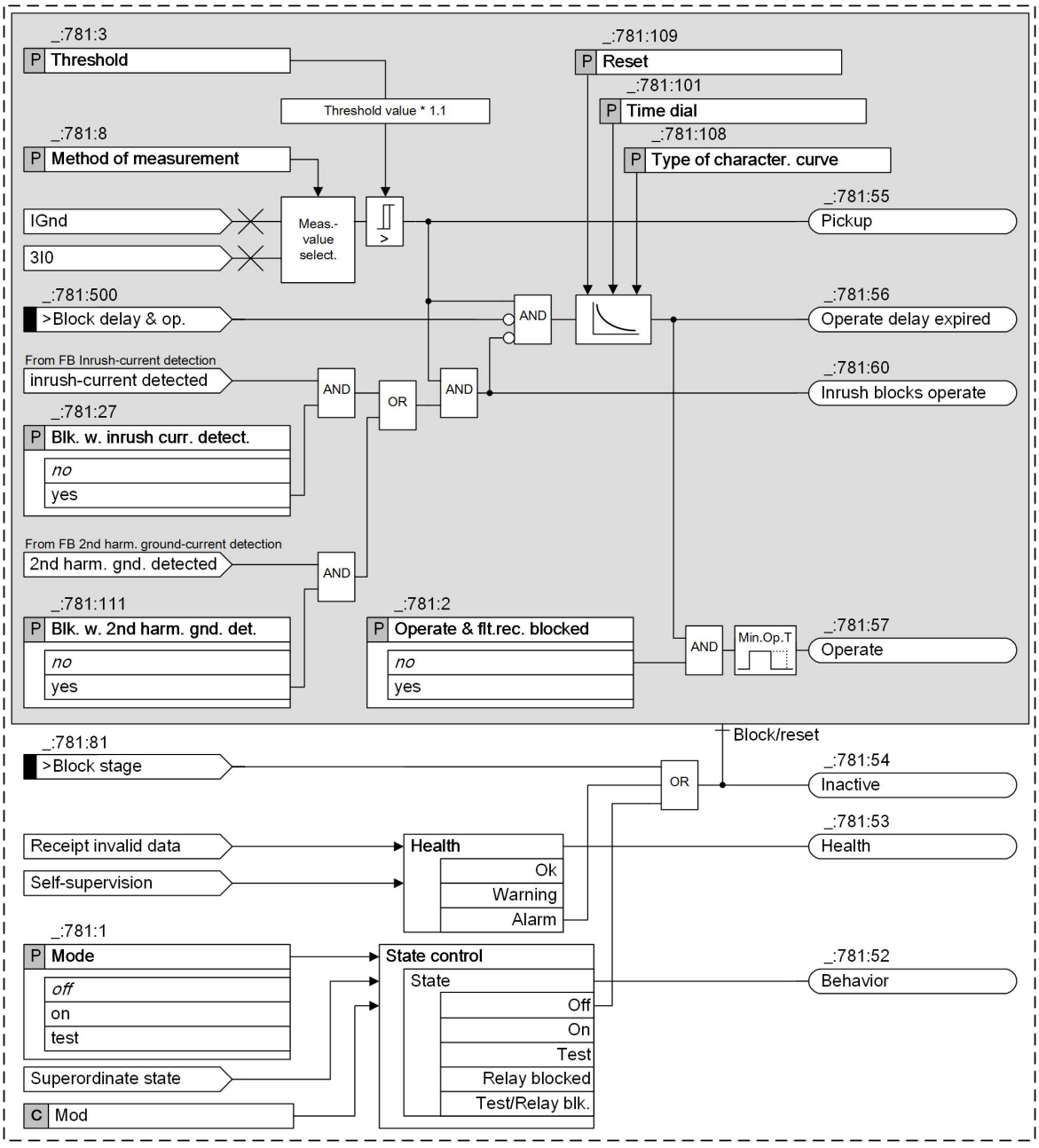
6.24.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Activation emg. mode	SPS	I
_:2311:300	General:Emergency mode act.	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Definite-T 1			
_:751:81	Definite-T 1:>Block stage	SPS	I
_:751:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:751:500	Definite-T 1:>Block delay & op.	SPS	I
_:751:51	Definite-T 1:Mode (controllable)	ENC	C
_:751:54	Definite-T 1:Inactive	SPS	O
_:751:52	Definite-T 1:Behavior	ENS	O
_:751:53	Definite-T 1:Health	ENS	O
_:751:60	Definite-T 1:Inrush blocks operate	ACT	O
_:751:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:751:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:751:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O
_:751:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:751:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:751:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:751:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O
_:751:55	Definite-T 1:Pickup	ACD	O
_:751:56	Definite-T 1:Operate delay expired	ACT	O
_:751:57	Definite-T 1:Operate	ACT	O

6.24.5 Stage with Inverse-Time Characteristic Curve

6.24.5.1 Description

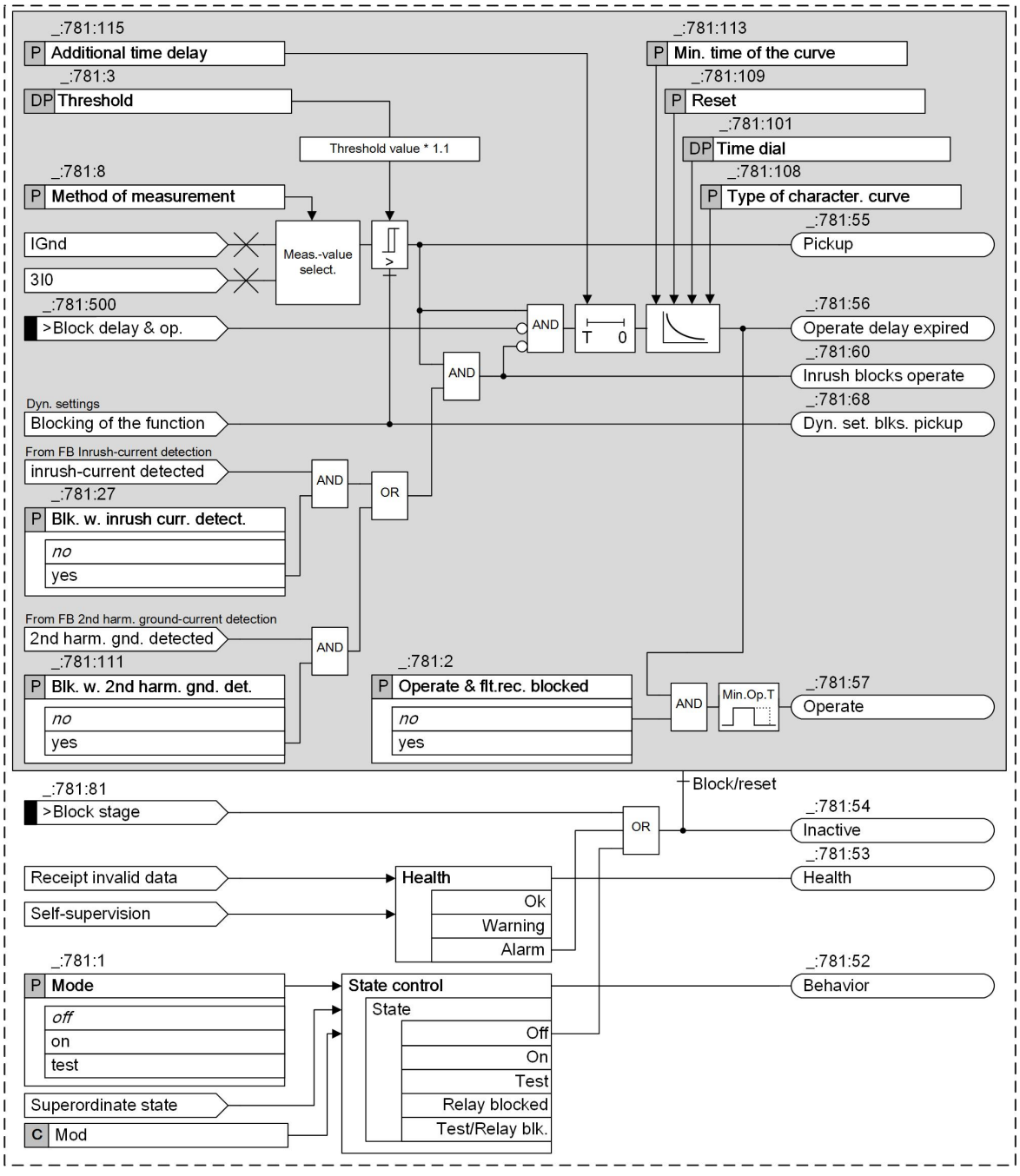
Logic of the Basic Stage



[lo_ocp_gr2, 6, en_US]

Figure 6-443 Logic Diagram Inverse-Time Overcurrent Protection (Ground) – Basic

Logic of the Advanced Stage



[lo_ocp_gn2, 5, en_US]

Figure 6-444 Logic Diagram Inverse-Time Overcurrent Protection (Ground) – Advanced

Pickup and Dropout Behaviors of the Inverse-Time Characteristic Curve According to IEC and ANSI (Basic and Advanced Stage)

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

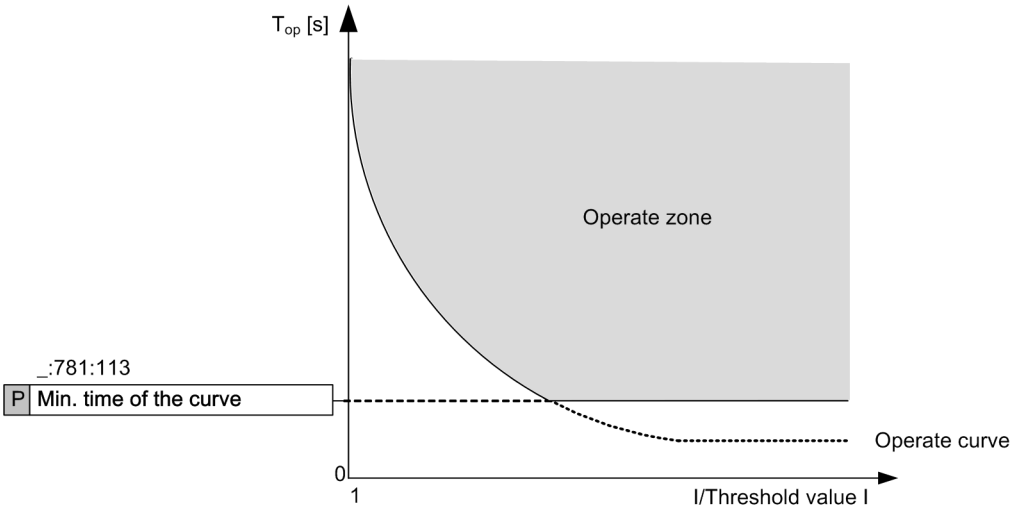
When the measured value falls below the pickup value by a factor of 1.045 (0.95 · 1.1 · threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting

parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Minimum Time of the Curve (Advanced Stage)

With the parameter **`Min. time of the curve`**, you define the minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.



[dw_ocp_gr3_mi, 1, en_US]

Figure 6-445 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter **`Additional time delay`**, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

Method of Measurement (Basic and Advanced Stage)

You use the **`Method of measurement`** parameter to define whether the stage uses the ***`fundamental comp.`*** or the calculated ***`RMS value`***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal **`>Block stage`** from an external or internal source
- Via the functionality of the **`dynamic settings`** (see **Influence of other functions via dynamic settings** and *6.24.8.1 Description*).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in *6.24.7.1 Description*.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in *6.24.8.1 Description* .

6.24.5.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:781:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

Parameter: Type of character. curve

- Default setting **(_:781:108) Type of character. curve** = ***IEC normal inverse***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **Type of character. curve** required for your specific application. For more information about the parameter **Type of character. curve**, refer to chapter*12.19.2 Stage with Inverse-Time Characteristic Curve*.

Parameter: Min. time of the curve

- Default setting **(_:781:113) Min. time of the curve** = ***0.00 s***

This parameter is only available in the advanced stage.
With the **Min. time of the curve** parameter, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: `Additional time delay`

- Recommended setting value **`(_:781:115) Additional time delay`** = ***`0.00 s`***

With the **`Additional time delay`** parameter, you define a definite-time delay in addition to the inverse-time delay.
If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.
This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommend keeping the default setting of 0 s.

Parameter: `Threshold`

- Default setting **`(_:781:3) Threshold`** = ***`1.20 A`***

The setting depends on the minimal occurring ground-fault current. This must be determined.

Parameter: `Time dial`

- Default setting **`(_:781:101) Time dial`** = ***`1`***

With the **`Time dial`** parameter, you displace the characteristic curve in the time direction.
The set value for the **`Time dial`** parameter is derived from the time-grading schedule that has been prepared for the electrical power system. Where overcurrent protection is used in emergency mode, shorter time delays might be reasonable (one grading time above fast tripping), since the emergency mode only operates if the main protection function fails.
Where no time grading and therefore no displacement of the characteristic curve is required, leave the **`Time dial`** parameter at ***`1`***.

Parameter: `Reset`

- Default setting **`(_:781:109) Reset`** = ***`disk emulation`***

With the **`Reset`** parameter, you define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Select this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

6.24.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:101	General:Emergency mode		• no • caused by main prot. • caused by binary input	no
_:2311:9	General:Measured value		• 3I0 calculated • IN measured	IN measured

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:781:1	Inverse-T 1:Mode		• off • on • test	off
_:781:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:781:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:781:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:781:111	Inverse-T 1:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:781:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:781:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:781:108	Inverse-T 1:Type of character. curve			
_:781:113	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:781:109	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:781:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:781:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:781:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:781:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:781:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:781:36	Inverse-T 1:Stage blocked		• no • yes	no
_:781:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:781:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 2				
_:781:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:781:37	Inverse-T 1:Stage blocked		• no • yes	no
_:781:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:781:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 3				
_:781:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no
_:781:38	Inverse-T 1:Stage blocked		• no • yes	no
_:781:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:781:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: AR cycle>3				
_:781:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:781:39	Inverse-T 1:Stage blocked		• no • yes	no
_:781:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:781:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:781:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:781:40	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:781:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:781:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: bin.input				
_:781:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:781:41	Inverse-T 1:Stage blocked		• no • yes	no
_:781:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:781:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

6.24.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Activation emg. mode	SPS	I
_:2311:300	General:Emergency mode act.	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Inverse-T 1			
_:781:81	Inverse-T 1:>Block stage	SPS	I
_:781:84	Inverse-T 1:>Activ. dyn. settings	SPS	I
_:781:500	Inverse-T 1:>Block delay & op.	SPS	I
_:781:51	Inverse-T 1:Mode (controllable)	ENC	C
_:781:54	Inverse-T 1:Inactive	SPS	O
_:781:52	Inverse-T 1:Behavior	ENS	O
_:781:53	Inverse-T 1:Health	ENS	O
_:781:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:781:62	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:781:63	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:781:64	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:781:65	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:781:66	Inverse-T 1:Dyn.set. CLP active	SPS	O

No.	Information	Data Class (Type)	Type
_:781:67	Inverse-T 1:Dyn.set. BI active	SPS	O
_:781:68	Inverse-T 1:Dyn. set. blks. pickup	SPS	O
_:781:59	Inverse-T 1:Disk emulation running	SPS	O
_:781:55	Inverse-T 1:Pickup	ACD	O
_:781:56	Inverse-T 1:Operate delay expired	ACT	O
_:781:57	Inverse-T 1:Operate	ACT	O

6.24.6 Stage with User-Defined Characteristic Curve

6.24.6.1 Description

This stage is only available in the advanced function type.

This stage is structured the same way as the **Inverse-time overcurrent protection – advanced** stage (see chapter *6.24.5.1 Description*). The only differences are as follows:

- You can define the characteristic curve as desired.
- The pickup and dropout behaviors of this stage are determined by the standard parameter **Threshold** and, if necessary, by an additional parameter **Threshold (absolute)**.

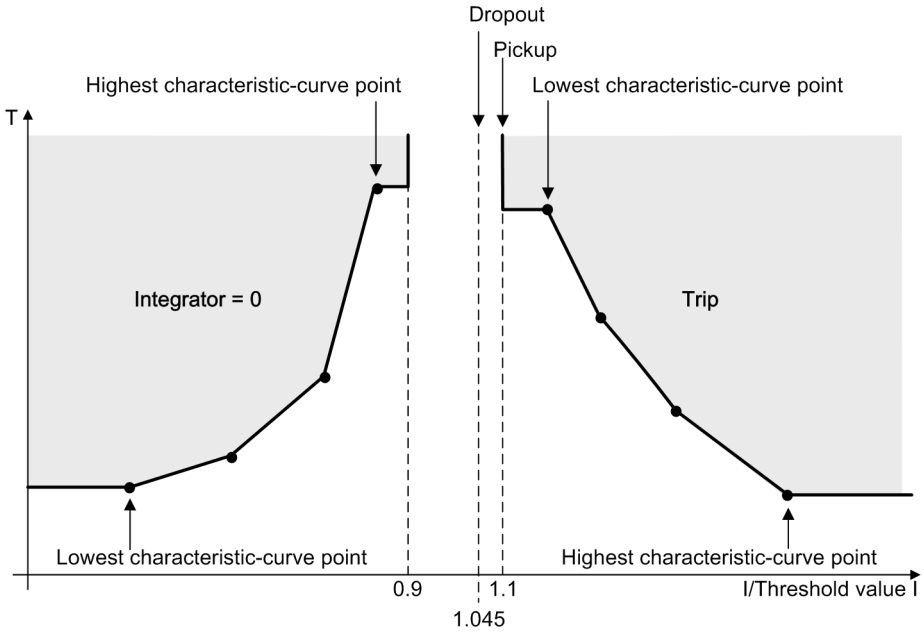
User-Defined Characteristic Curve

With the user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

Pickup and Dropout Behaviors with the User-Defined Characteristic Curve

When the input variable exceeds the **Threshold** value by 1.1 times, the characteristic curve is processed. An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x **Threshold** value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve).
The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.



[dw_ocp_ken_02, 2, en_US]

Figure 6-446 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

The currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

If you want to change the pickup threshold of the stage without changing all points of the characteristic curve, you can use the additional **`Threshold (absolute)`** parameter.

You can set the **`Threshold (absolute)`** parameter to be greater than 1.1 times the **`Threshold`** value. Then the stage behaviors are as follows:

- The stage picks up when the measured current value exceeds the **`Threshold (absolute)`** value.
- The stage starts dropout when the measured current value falls short of the **`Threshold (absolute)`** value by 0.95 times.
- For measured current values lower than the **`Threshold (absolute)`** value, no pickup takes place and consequently the characteristic curve is not processed.

If you set the **`Threshold (absolute)`** parameter to be less than 1.1 times the **`Threshold`** value, the pickup and dropout behaviors are not affected by the **`Threshold (absolute)`** parameter.

6.24.6.2 Application and Setting Notes

This stage is structured the same way as the **Inverse-time overcurrent protection – advanced** stage. The only differences are described in chapter *6.24.6.1 Description* . This chapter provides only the application and setting notes for setting characteristic curves and for setting the **`Threshold (absolute)`** parameter. You can find more information on the other parameters of the stage in chapter *6.24.5.2 Application and Setting Notes* .

Parameter: `Current/time value pairs` (from the operate curve)

With these settings, you define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **Threshold** parameter to ***1.00*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to shift the characteristic curve.

Set the time value in seconds. The characteristic curve is shifted via the **Time dial** parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: Time dial

- Default setting **(_:101) Time dial** = ***1***

With the **Time dial** parameter, you displace the characteristic curve in the time direction.

The set value for the **Time dial** parameter is derived from the time-grading schedule that has been prepared for the electrical power system. Where no time grading and therefore no displacement of the characteristic curve is required, leave the **Time dial** parameter at ***1***.

Parameter: Reset

- Default setting **(_:110) Reset** = ***disk emulation***

With the **Reset** parameter, you define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Select this setting if the dropout is not to be performed after disk emulation but an instantaneous dropout is desired.

Parameter: Current/time value pairs (of the dropout characteristic curve)

With these settings, you define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **Threshold** parameter to ***1.00*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to shift the characteristic curve.

Set the time value in seconds. The characteristic curve is shifted via the **Time dial** parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: Threshold (absolute)

- Default setting **(_:113) Threshold (absolute)** = ***0.000 A***

With the **Threshold (absolute)** parameter, you define and change the absolute pickup threshold of the stage without changing all points of the characteristic curve.

The parameter is only used for special applications. With the default setting, this functionality is disabled. You can find more information in *Pickup and Dropout Behaviors with the User-Defined Characteristic Curve , Page 1253*.

6.24.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:111	User curve #:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	User curve #:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:113	User curve #:Threshold (absolute)	1 A @ 100 Irated	0.000 A to 40.000 A	0.000 A
		5 A @ 100 Irated	0.00 A to 200.00 A	0.00 A
		1 A @ 50 Irated	0.000 A to 40.000 A	0.000 A
		5 A @ 50 Irated	0.00 A to 200.00 A	0.00 A
		1 A @ 1.6 Irated	0.000 A to 1.600 A	0.000 A
		5 A @ 1.6 Irated	0.000 A to 8.000 A	0.000 A
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
_:115	User curve #:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:14	User curve #:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no
_:15	User curve #:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no
_:17	User curve #:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no
_:19	User curve #:Threshold	1 A @ 100 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

6.24.6.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:84	User curve #:>Activ. dyn. settings	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:62	User curve #:Dyn.set. AR cycle1act.	SPS	O
_:63	User curve #:Dyn.set. AR cycle2act.	SPS	O
_:64	User curve #:Dyn.set. AR cycle3act.	SPS	O
_:65	User curve #:Dyn.set. ARcycl.>3act	SPS	O
_:66	User curve #:Dyn.set. CLP active	SPS	O
_:67	User curve #:Dyn.set. BI active	SPS	O
_:68	User curve #:Dyn. set. blks. pickup	SPS	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

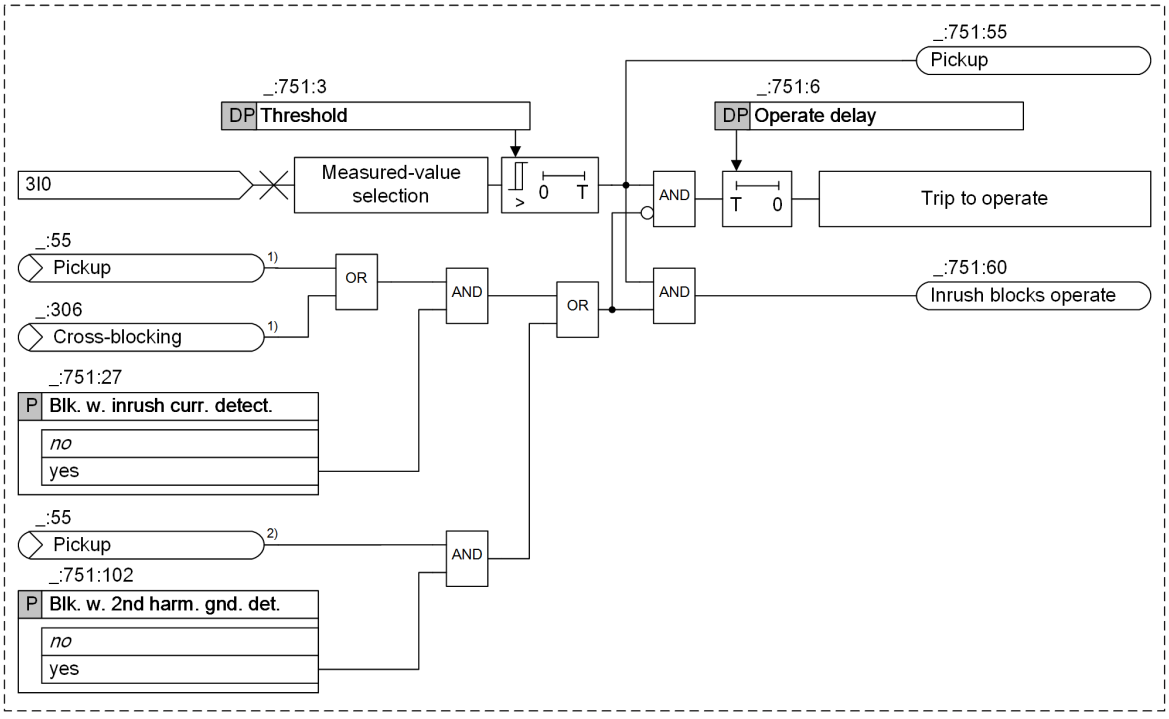
6.24.7 Blocking of the Tripping by Device-Internal Inrush-Current Detection

6.24.7.1 Description

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started. After that time, the stage operates.

The **Blk. w. 2nd harm. gnd. det.** parameter allows you to define whether the operate indication of the stage should be blocked when the detected 2nd harmonic component of the ground current exceeds a threshold value. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started. After that time, the stage operates.

The following figure only shows the part of the stage (exemplified by definite-time overcurrent protection stage 1) that illustrates the influence of the inrush-current detection. Only if the central function **Inrush-current detection** (see section *12.62 Inrush-Current Detection*) is in effect can the blocking be set.



[lo_ocp_grd, 2, en_US]

Figure 6-447 Part-Logic Diagram on the Influence of Inrush-Current Detection Exemplified by the 1st Definite-Time Overcurrent Protection Stage

(1) From FB **Inrush-current detection**

(2) From FB **2nd harmonic ground-current detection**

6.24.7.2 Application and Setting Notes

Parameter: Blk. w. inrush curr. detect.

- Default setting **(_:751:27) Blk. w. inrush curr. detect.** = ***no***

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This, for example, applies to the high-current stage that is set such according to the short-circuit voltage V_{sc} of the transformer that it only picks up on faults from the high-voltage side. The transformer inrush current cannot become larger than the maximum transmittable short-circuit current.
yes	When the transformer inrush-current detection detects an inrush current that would lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: **`Blk. w. 2nd harm. gnd. det.`**

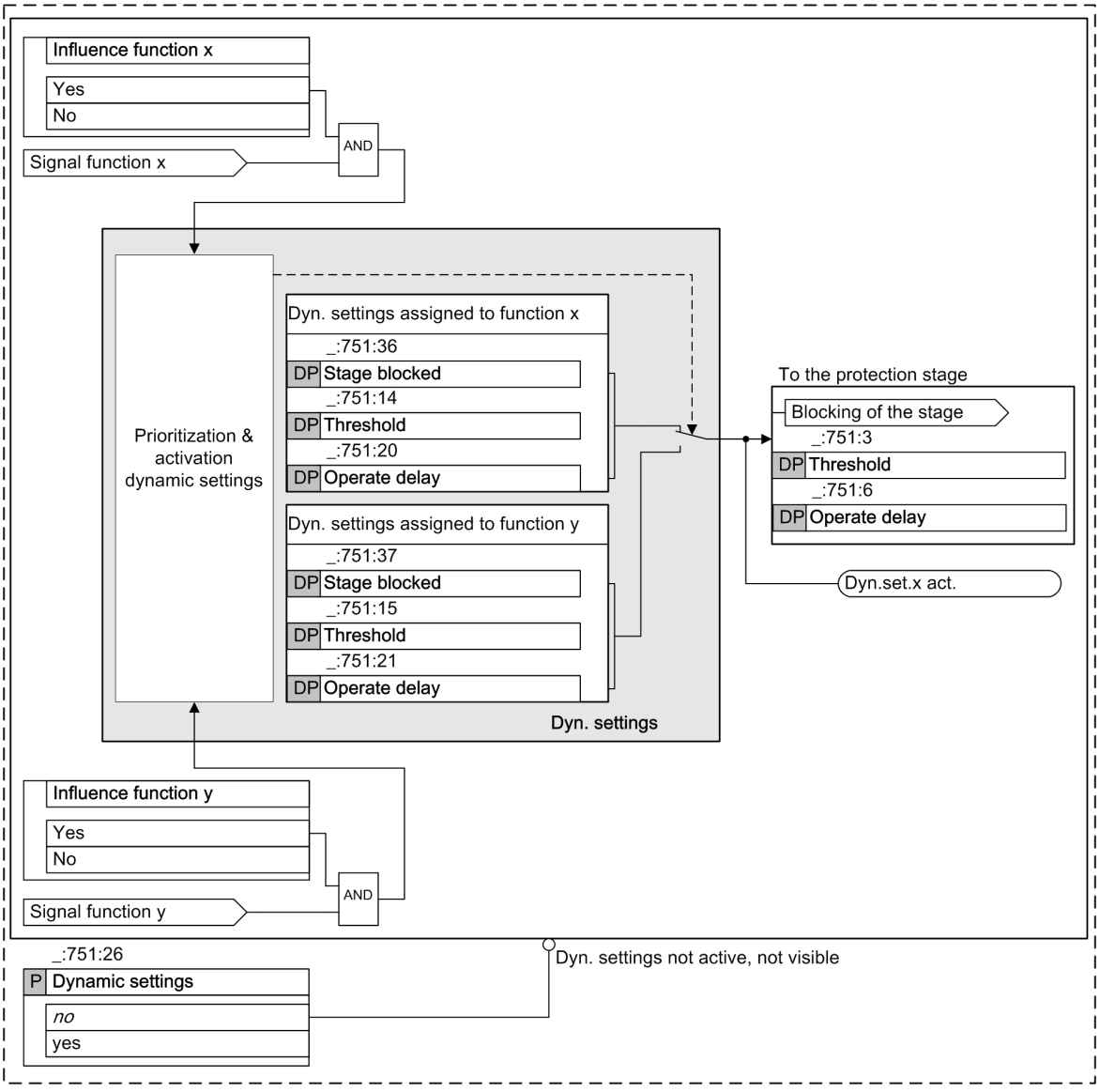
- Default setting **`(_:751:102) Blk. w. 2nd harm. gnd. det.`** = ***no***

Parameter Value	Description
no	If no 3I0/IN current flow due to CT saturation with a level above the pickup threshold is expected, select this setting.
yes	If 3I0/IN current flow due to CT saturation with a level above the pickup threshold is expected, the blocking must be activated. This provides stability for the following conditions: • CT saturation without inrush current since a saturated signal also contains 2nd-harmonic content • Phase inrush current that leads to CT saturation and therefore causes 2nd-harmonic inrush current being present also in the parasitic 3I0 current

6.24.8 Influence of Other Functions via Dynamic Settings

6.24.8.1 Description

The **`Threshold`** and **`Operate delay`** settings used for tripping are so-called **`dynamic settings`**. Depending on other functions, the settings of these parameters can be changed dynamically. Depending on other functions, the stage can also be blocked dynamically. This functionality is only available in function type Advanced.



[lo_ocp_gnd, 2, en_US]

Figure 6-448 Principle of the Dynamic Settings in the Example of 1st Definite-Time Overcurrent Protection Stage

If available in the device, the following functionalities can affect the overcurrent-protection stages:

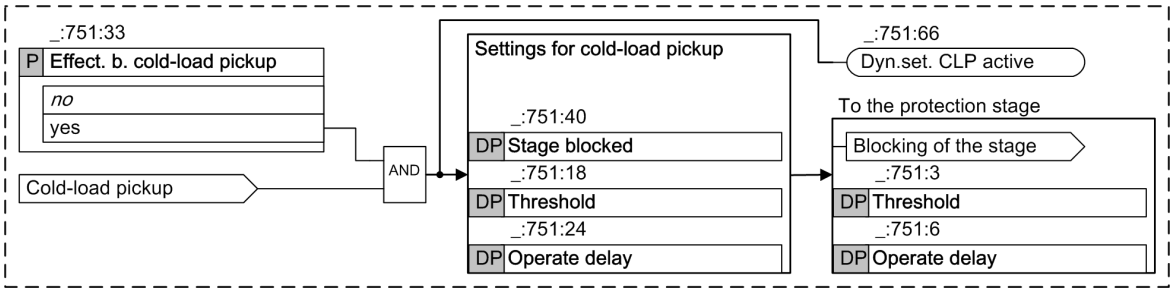
Functionalities	Priority
Cold-load pickup detection	Priority 1
Binary input signal	Priority 2

These functionalities generate signals that change the settings of the dynamic settings of the overcurrent-protection stage or block it, if required. In the latter case, the settings for the **Threshold** and the **Operate delay** are of no relevance. Within the overcurrent-protection stage, each of these signals is provided with a configuration parameter **Influence of function ...** and its own dynamic settings (**Operate delay** and **Threshold**). The configuration settings are used to set whether the signal shall be active or not, this means whether the dynamic settings shall be activated or not. If one of these signals (for example, signal function x) becomes active and is to take effect, these parameter settings become dynamic, that is, instantly active. This means that the setting assigned to the signal replaces the standard setting. If the signal becomes inactive, the standard settings apply again. The activation of the dynamic settings is reported.

Where several signals are active in parallel, the priority specified above shall apply. This means that a signal with priority 1 precedes that of priority 2. The settings assigned to signal 1 become active.

The functionality of the dynamic settings can be disabled. In this case, the settings assigned to the signals are not visible and are without effect.

Link to the Device-Internal Function *Cold-Load Pickup Detection (Advanced Stage)*



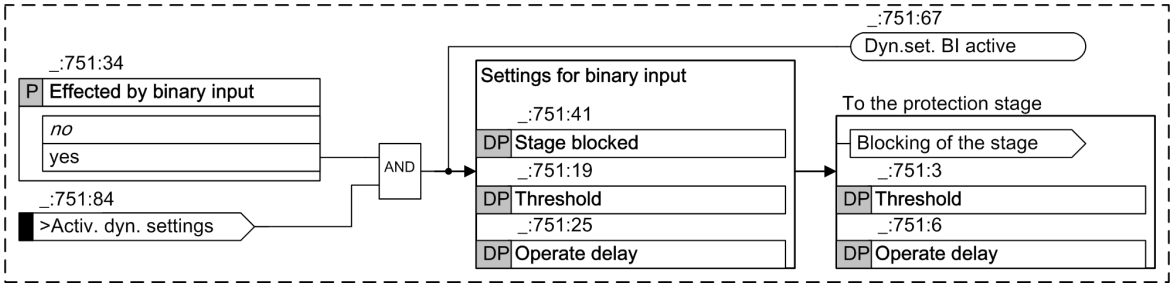
[lo_ocp_kal_gnd, 1, en_US]

Figure 6-449 Influence of the Cold-Load Pickup Detection on the Overcurrent-Protection Stage

You have the option of changing the settings for the **Threshold** and the **Operate delay** of the protection stage for a cold-load pickup. You can also block the stage. To do so, you must activate the influence of the cold-load pickup. You also have to set the **Threshold** and **Operate delay** or assign settings to **Stage blocked**, which take effect when the signal is active.

The way signals are generated **Cold-load pickup** is described in chapter *5.5.4.13 Cold-Load Pickup Detection (Optional)*.

Link to an External *Function via a Binary Input Signal (Advanced Stage)*



[lo_ocp_bin_gnd, 1, en_US]

Figure 6-450 Influence of the Binary Input on the Overcurrent-Protection Stage

You can use the binary input signal **>Activ. dyn. settings** to change the settings for the **Threshold** and the **Operate delay** of the protection stage. You can also block the stage. To do so, you must activate the influence of the binary input. You also have to set the **Threshold** and **Operate delay** or assign settings to **Stage blocked**, which take effect when the signal is active.

6.24.8.2 Application and Setting Notes (Advanced Stage)

Binary Input Signal: **Dynamic settings**

- Default setting **(_:751:26) Dynamic settings** = *no*

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (cold-load pickup detection) or an external function should affect the overcurrent-protection stage (such as changing the setting of the threshold value or time delay, blocking of the stage), the setting must be changed to ***yes***. This makes the configuration parameters **Influence of function...** as well as the dynamic settings **Threshold**, **Operate delay** and **Stage blocked** of the stage visible and enables the settings to be set for the specific influence.

Influence of External Devices

The influence of an external device can also be configured.

To realize the application, the configuration setting **Effected by binary input** must be changed to ***yes*** (= influenced). This activates the **>Activ. dyn. settings** input signal within the stage. When the input signal becomes active, it switches to the assigned dynamic settings.

6.25 Overcurrent Protection, 1-Phase

6.25.1 Function Overview

The **Overcurrent protection, 1-phase** function (ANSI 50N/51N):

- Detects and monitors the current measured in a transformer neutral point grounding
- Can operate as sensitive tank leakage protection
- Detects and monitors the circulating current between the neutral points of 2 capacitor banks
- Switches off high-current faults instantaneously

6.25.2 Structure of the Function

The **Overcurrent protection, 1-phase** function is used in protection function groups with 1-phase current measurement. 2 function types are available:

- **Overcurrent protection, 1-phase – advanced** (50N/51N OC-1ph-A)
- **Overcurrent protection, 1-phase – basic** (50N/51N OC-1ph-B)

The function type Basic is provided for standard applications. The function type Advanced offers more functionality and is provided for more complex applications.

Both function types are pre-configured by the manufacturer with 2 **Definite-time overcurrent protection** stages and with 1 **Inverse-time overcurrent protection** stage.

In the function type **Overcurrent protection, 1-phase – advanced** the following stages can be operated simultaneously:

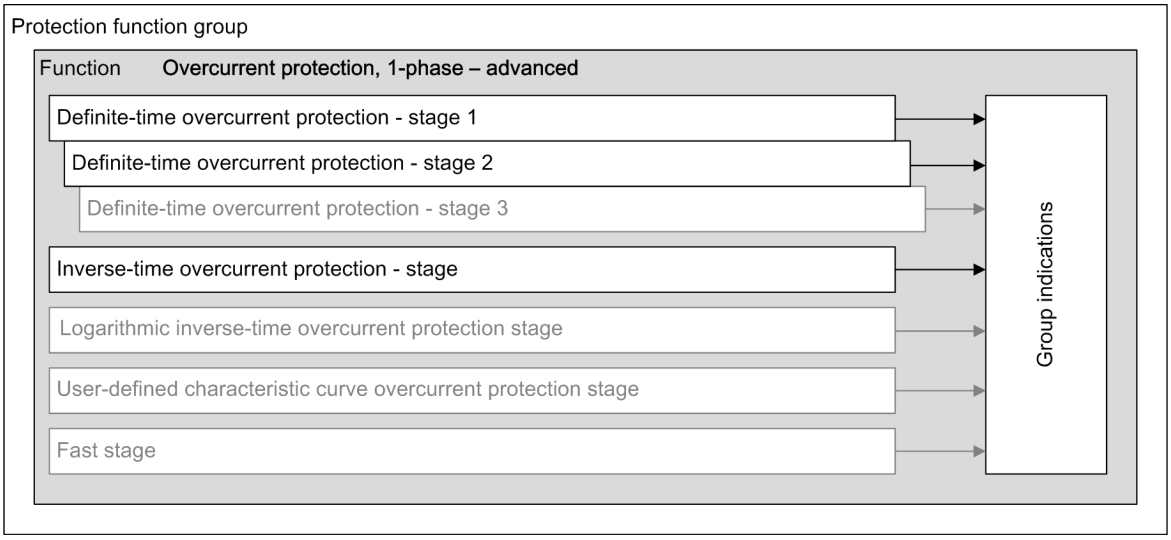
- Maximum of 3 stages **Definite-time overcurrent protection** (UMZ)
- 1 stage **Inverse-time overcurrent protection** (AMZ)
- 1 stage **Logarithmic inverse-time overcurrent protection**
- 1 stage **User-defined characteristic curve overcurrent protection**
- 1 **Fast stage**

In the function type **Overcurrent protection, 1-phase – basic**, the following stages can operate simultaneously:

- Maximum of 3 stages **Definite-time overcurrent protection**
- 1 stage **Inverse-time overcurrent protection**

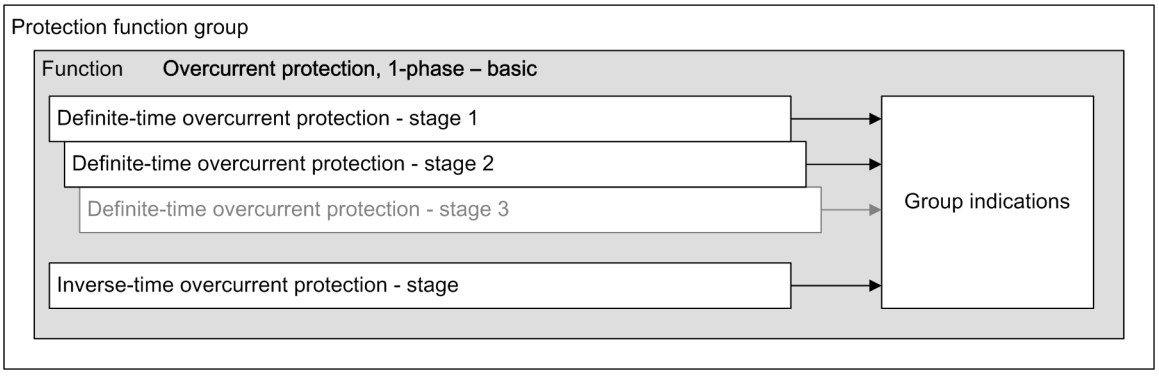
The non-preconfigured stages in *Figure 6-451* and *Figure 6-452* are shown in gray. Apart from the operate-delay characteristic curve, the **Definite-time overcurrent protection** stage, the **Inverse-time overcurrent protection** stage, the **Logarithmic inverse-time overcurrent protection** stage, and the **User-defined characteristic curve-time overcurrent protection** stage are structured identically.

The **Fast stage** uses a fast tripping algorithm. It is therefore suited in particular for sensitive ground-fault detection according to the high-impedance principle.



[dw_ocp_1pa, 4, en_US]

Figure 6-451 Structure/Embedding the Function Overcurrent Protection, 1-Phase – Advanced



[dw_ocp_1pb, 3, en_US]

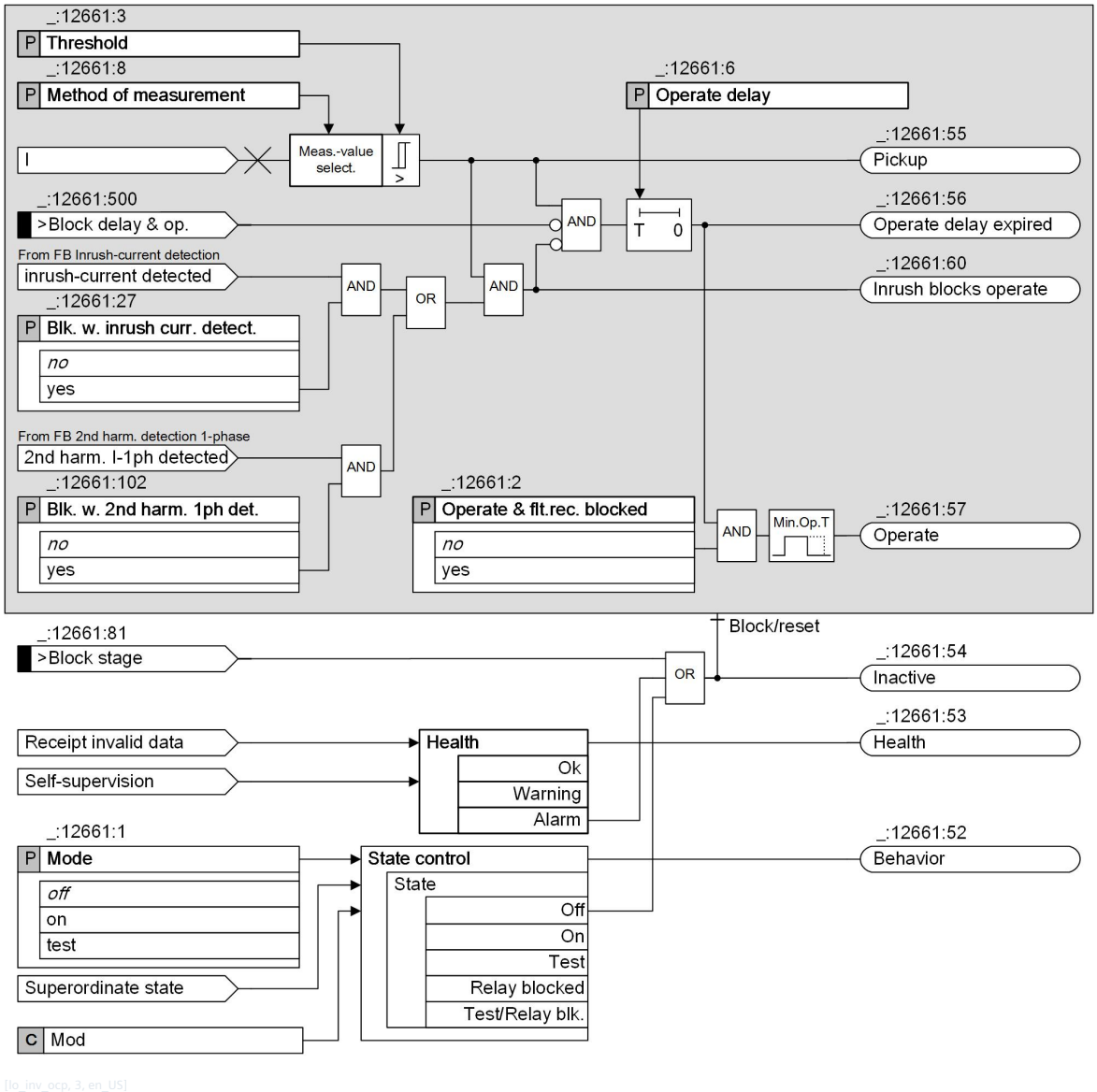
Figure 6-452 Structure/Embedding the Function Overcurrent Protection, 1-Phase – Basic

If the device is equipped with the **Inrush-current detection** function, you can stabilize the stages against issuing of the operate indication due to transformer inrush-currents.

6.25.3 Stage with Definite-Time Characteristic Curve

6.25.3.1 Description

Logic of a Stage



[lo_inv_ocp, 3, en_US]

Figure 6-453 Logic Diagram of the Definite-Time Overcurrent Protection, 1-Phase

Method of measurement

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Blocking of the Stage

The picked up stage can reset completely via the binary input signal *>Block stage*.

Blocking of the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also tripping. A running time delay is reset. The pickup is reported and a fault is opened.

Blocking of the Tripping by Device-Internal Inrush-Current Detection

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.9.11 Blocking of the Tripping by Device-Internal Inrush-Current Detection*.

6.25.3.2 Application and Setting Notes

Parameter: `Method of measurement`

- Recommended setting value **`(_:12661:8) Method of measurement`** = ***`fundamental comp.`***

With the **`Method of measurement`** parameter, you define whether the stage uses the ***`fundamental comp.`*** (standard method) or the calculated ***`RMS value`***.

Parameter Value	Description
`fundamental comp.`	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
`RMS value`	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **`threshold value`** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

Parameter: `Threshold`, `Operate delay`

- Default setting **`(_:12661:3) Threshold`** = ***`1.200 A`*** (for the first stage)
- Default setting **`(_:12661:6) Operate delay`** = ***`0.300 s`*** (for the first stage)

Set the **`Threshold`** and **`Operate delay`** parameters for the specific application.

6.25.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Definite-T 1`				
_:12661:1	Definite-T 1:Mode		• off • on • test	off
_:12661:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:12661:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:12661:102	Definite-T 1:Blk. w. 2nd harm. 1ph det.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:12661:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:12661:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:12661:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

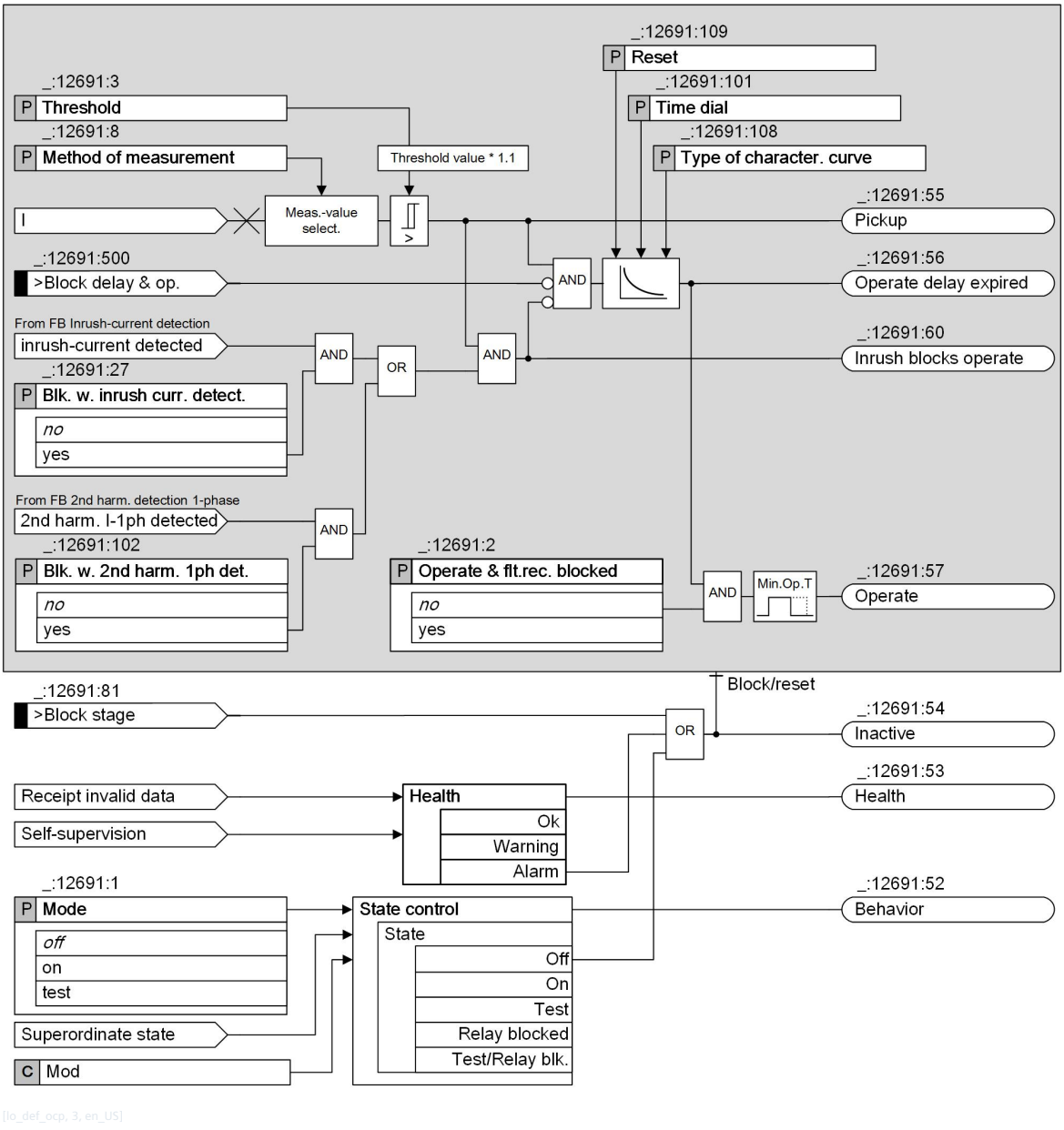
6.25.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Definite-T 1			
_:12661:81	Definite-T 1:>Block stage	SPS	I
_:12661:500	Definite-T 1:>Block delay & op.	SPS	I
_:12661:51	Definite-T 1:Mode (controllable)	ENC	C
_:12661:54	Definite-T 1:Inactive	SPS	O
_:12661:52	Definite-T 1:Behavior	ENS	O
_:12661:53	Definite-T 1:Health	ENS	O
_:12661:60	Definite-T 1:Inrush blocks operate	ACT	O
_:12661:55	Definite-T 1:Pickup	ACD	O
_:12661:56	Definite-T 1:Operate delay expired	ACT	O
_:12661:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:12662:81	Definite-T 2:>Block stage	SPS	I
_:12662:500	Definite-T 2:>Block delay & op.	SPS	I
_:12662:51	Definite-T 2:Mode (controllable)	ENC	C
_:12662:54	Definite-T 2:Inactive	SPS	O
_:12662:52	Definite-T 2:Behavior	ENS	O
_:12662:53	Definite-T 2:Health	ENS	O
_:12662:60	Definite-T 2:Inrush blocks operate	ACT	O
_:12662:55	Definite-T 2:Pickup	ACD	O
_:12662:56	Definite-T 2:Operate delay expired	ACT	O
_:12662:57	Definite-T 2:Operate	ACT	O

6.25.4 Stage with Inverse-Time Characteristic Curve

6.25.4.1 Description

Logic of the Stage



[lo_def_ocp, 3, en_US]

Figure 6-454 Logic Diagram of the Inverse-Time Overcurrent Protection (1-Phase)

Pickup and Dropout Behaviors of the Inverse-Time Characteristic Curve According to IEC and ANSI

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by a factor of 1.045 (0.95 · 1.1 · threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout

according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Method of Measurement

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Blocking of the Stage

The picked up stage can reset completely via the binary input signal *>Block stage*.

Blocking of the Time Delay

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also tripping. A running time delay is reset. The pickup is reported and a fault is opened.

Blocking of the Tripping by Device-Internal Inrush-Current Detection

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.9.11 Blocking of the Tripping by Device-Internal Inrush-Current Detection*.

6.25.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:12691:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

Parameter: Type of character. curve

- Default setting **(_:12691:108) Type of character. curve** = ***IEC normal inverse***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **Type of character. curve** required for your specific application.

Parameter: `Threshold`

- Default setting **`(_:12691:3) Threshold`** = ***`1.200 A`***

Set the **`Threshold`** and **`Type of character. curve`** parameters for the specific application.

Note that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the **`Threshold`**.

Parameter: `Time dial`

- Default setting **`(_:12691:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter **`Time dial`** at ***`1`*** (default setting).

Parameter: `Reset`

- Default setting **`(_:12691:109) Reset`** = ***`disk emulation`***

You use the **`Reset`** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

6.25.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Inverse-T 1`				
_:12691:1	Inverse-T 1:Mode		• off • on • test	off
_:12691:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:12691:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:12691:102	Inverse-T 1:Blk. w. 2nd harm. 1ph det.		• no • yes	no
_:12691:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:12691:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A

Addr.	Parameter	C	Setting Options	Default Setting
_:12691:108	Inverse-T 1:Type of character. curve		• ANSI long-time inv. • ANSI short-time inv. • ANSI extremely inv. • ANSI very inverse • ANSI normal inverse • ANSI moderately inv. • ANSI definite inverse • IEC normal inverse • IEC very inverse • IEC extremely inv. • IEC long-time inverse	IEC normal inverse
_:12691:109	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:12691:101	Inverse-T 1:Time dial		0.05 to 15.00	1.00

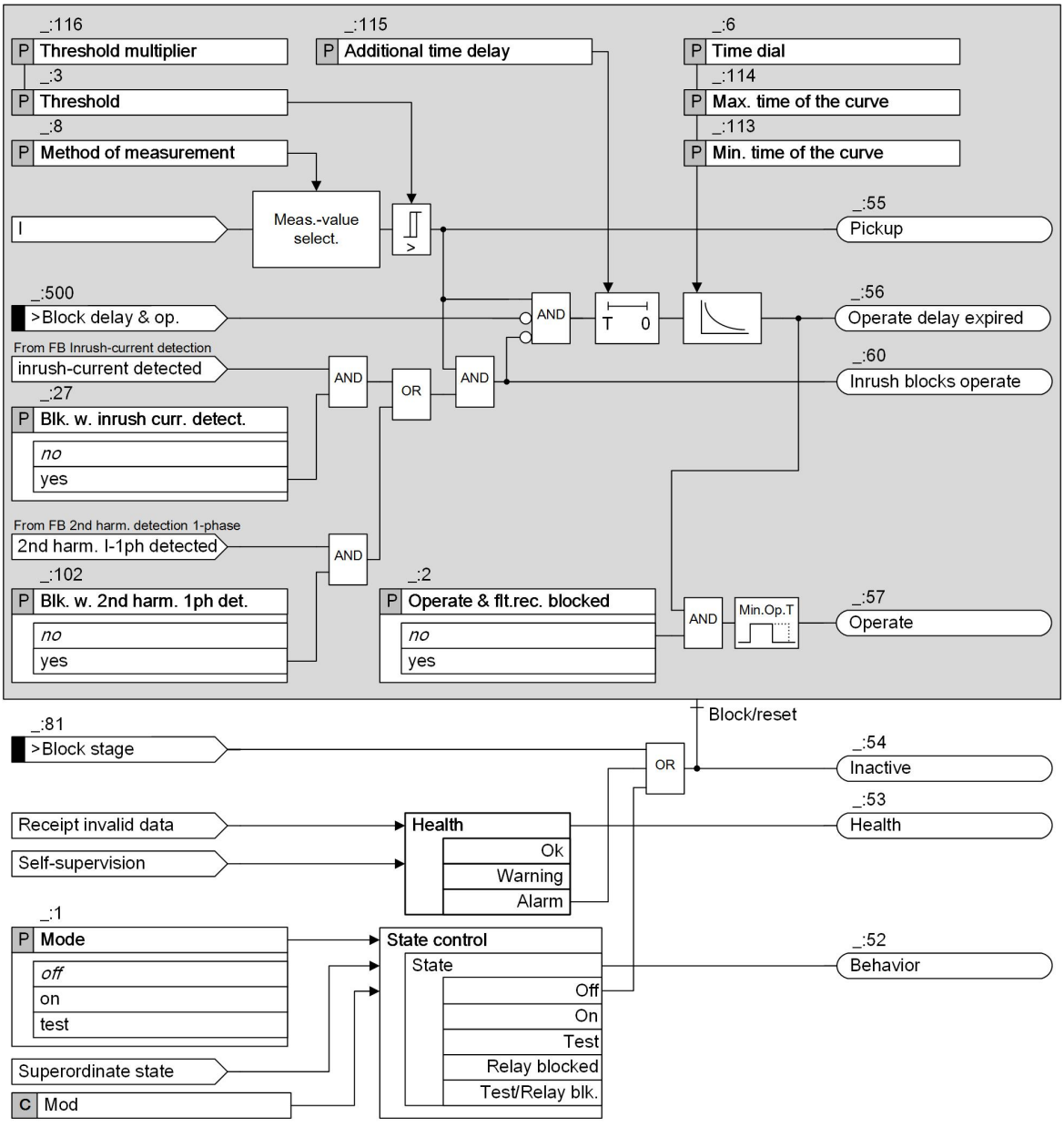
6.25.4.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Inverse-T 1			
_:12691:81	Inverse-T 1:>Block stage	SPS	I
_:12691:500	Inverse-T 1:>Block delay & op.	SPS	I
_:12691:51	Inverse-T 1:Mode (controllable)	ENC	C
_:12691:54	Inverse-T 1:Inactive	SPS	O
_:12691:52	Inverse-T 1:Behavior	ENS	O
_:12691:53	Inverse-T 1:Health	ENS	O
_:12691:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:12691:59	Inverse-T 1:Disk emulation running	SPS	O
_:12691:55	Inverse-T 1:Pickup	ACD	O
_:12691:56	Inverse-T 1:Operate delay expired	ACT	O
_:12691:57	Inverse-T 1:Operate	ACT	O

6.25.5 Stage with Inverse-Time Overcurrent Protection with Logarithmic-Inverse Characteristic Curve

6.25.5.1 Description

Logic of the Stage



[lo_ocp 1phase logarithmic, 3, en_US]

Figure 6-455 Logic Diagram of the Logarithmic Inverse-Time Overcurrent Protection (1-Phase)

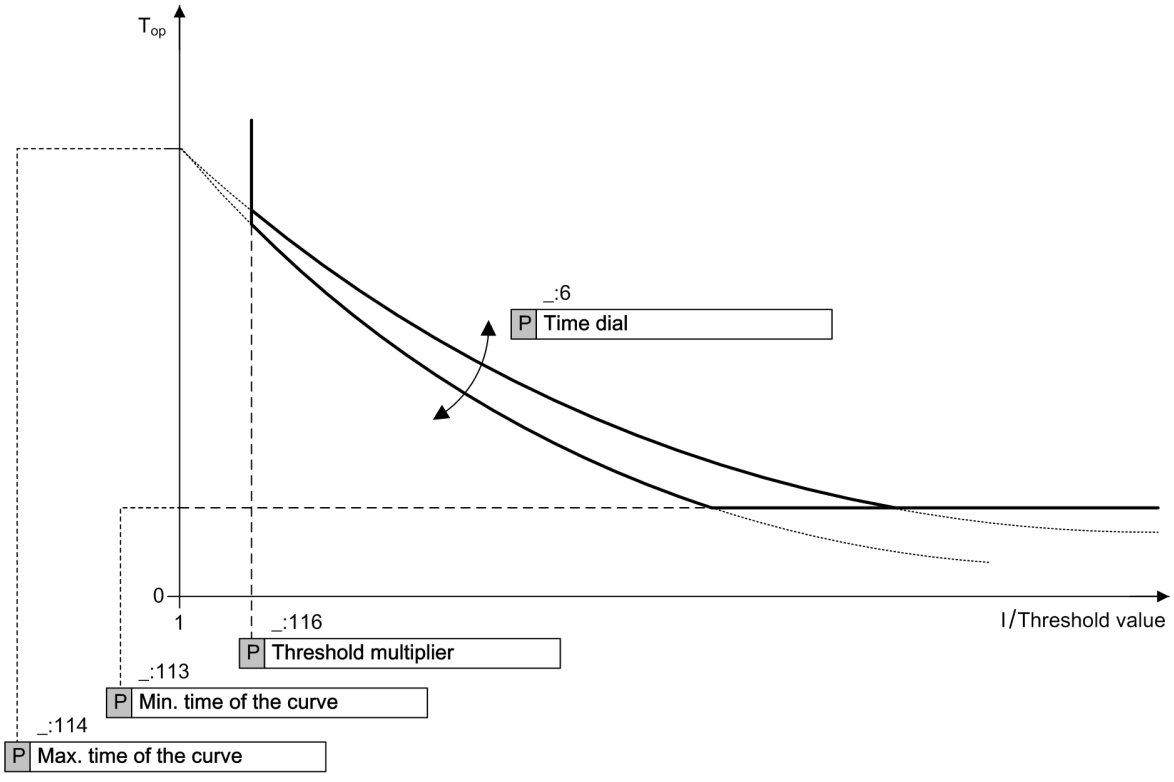
Apart from the operate curve, this type of stage is identical to the **Inverse-time overcurrent protection** stage (see chapter *6.25.4.1 Description*).

This section will only discuss the nature of the operate curve. For further functionality, refer to chapter *6.25.4.1 Description* .

Operate Curve

If the function picks up, the logarithmic inverse-time characteristic curve is processed. A time value T_{op} is calculated for every input value exceeding 95 % of the pickup value. An integrator accumulates the value $1/T_{op}$. If the accumulated integral reaches the fixed value 1, the stage operates.

The curve used to calculate the time value T_{op} is shown in the following figure. The **Threshold multiplier** parameter defines the beginning of the characteristic curve. The **Max. time of the curve** determines the initial value of the characteristic curve. The **Time dial** parameter changes the slope of the characteristic curve. At high currents, the **Min. time of the curve** parameter indicates the lower time limit.



[dw_ocp 1phase logarithmic, 1, en_US]

Figure 6-456 Operate Curve of Logarithmic Inverse-Time Characteristic

The time to operate is calculated with the following formula:

$$T_{op} = T_{max} - T_d \ In\left(\frac{I}{I_{thresh} \cdot I_{mul}}\right)$$

[fo_ocp 1phase logarithmic, 1, en_US]

Where

T_{max}	Maximum time of the curve (parameter **Max. time of the curve**)
T_d	Time dial (parameter **Time dial**)
T_{op}	Operate time
I	1-phase current
I_{thresh}	Threshold value (parameter **Threshold**)
I_{mul}	Threshold multiplier (parameter **Threshold multiplier**)

If the calculated time is less than T_{min} (parameter **Min. time of the curve**), T_{min} is used.

6.25.5.2 Application and Setting Notes

Apart from the operate curve, this type of stage is identical to the ground-fault protection type with inverse-time delay according to IEC and ANSI (see chapter *6.25.4.1 Description*).

This section only discusses the nature of the operate curve. For further functionality, refer to chapter *6.25.4.2 Application and Setting Notes* .

Stage Type Selection

If the operate delay is to be dependent on the current level according to a logarithmic characteristic curve, select this stage type.

Parameter: `Threshold`

- Default setting **`(_:3) Threshold`** = ***`1.20 A`***

With the parameter **`Threshold`**, you define the pickup value corresponding to the application. In doing so, for the time-graded stages, the setting for the superordinate and subordinate stages must be taken into account in the grading chart.

Parameter: `Threshold multiplier`

- Default setting **`(_:116) Threshold multiplier`** = ***`1.1`***

With the parameter **`Threshold multiplier`**, you define the beginning of the characteristic curve on the current axis (in relation to the threshold value).

General information cannot be provided. Define the value corresponding to the application.

EXAMPLE

`Threshold` (Secondary current)	I_{thresh} = 1.2 A
`Threshold multiplier`	I_{mul} = 1.1
Pickup value (Secondary current)	I_{PU} = 1.2 A ×1.1 = 1.32 A

Parameter: `Time dial`

- Default setting **`(_:6) Time dial`** = ***`1.250 s`***

With the parameter **`Time dial`**, you change the slope of the characteristic curve.

General information cannot be provided. Define the value corresponding to the application.

Parameter: `Max. time of the curve`

- Default setting **`(_:114) Max. time of the curve`** = ***`5.800 s`***

The parameter **`Max. time of the curve`** determines the initial value of the characteristic curve (for I = **`Threshold`**).

General information cannot be provided. Define the value corresponding to the application.

Parameter: `Min. time of the curve`

- Default setting **`(_:113) Min. time of the curve`** = ***`1.200 s`***

The parameter **`Min. time of the curve`** determines the lower time limit (at high currents).

General information cannot be provided. Define the value corresponding to the application.

Parameter: `Additional time delay`

- Default setting **`(_:115) Additional time delay`** = ***`0 s`***

With the parameter **Additional time delay**, you set an additional current-independent time delay. This additional delay is intended for special applications.
Siemens recommends setting this time to ***0 s*** so that it has no effect.

6.25.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Log.-inv.-T #				
_:1	Log.-inv.-T #:Mode		• off • on • test	off
_:2	Log.-inv.-T #:Operate & flt.rec. blocked		• no • yes	no
_:27	Log.-inv.-T #:Blk. w. inrush curr. detect.		• no • yes	no
_:102	Log.-inv.-T #:Blk. w. 2nd harm. 1ph det.		• no • yes	no
_:8	Log.-inv.-T #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:6	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
_:113	Log.-inv.-T #:Min. time of the curve		0.000 s to 60.000 s	1.200 s
_:114	Log.-inv.-T #:Max. time of the curve		0.000 s to 60.000 s	5.800 s
_:116	Log.-inv.-T #:Threshold multiplier		1.00 to 4.00	1.10
_:115	Log.-inv.-T #:Additional time delay		0.000 s to 60.000 s	0.000 s

6.25.5.4 Information List

No.	Information	Data Class (Type)	Type
Log.-inv.-T #			
_:81	Log.-inv.-T #:>Block stage	SPS	I
_:500	Log.-inv.-T #:>Block delay & op.	SPS	I
_:54	Log.-inv.-T #:Inactive	SPS	O
_:52	Log.-inv.-T #:Behavior	ENS	O
_:53	Log.-inv.-T #:Health	ENS	O
_:60	Log.-inv.-T #:Inrush blocks operate	ACT	O
_:55	Log.-inv.-T #:Pickup	ACD	O
_:56	Log.-inv.-T #:Operate delay expired	ACT	O
_:57	Log.-inv.-T #:Operate	ACT	O

6.25.6 Stage with User-Defined Characteristic Curve

6.25.6.1 Description

The **User-defined characteristic curve overcurrent protection** stage is only available in the advanced function type.

This stage is structured the same way as the stage with the inverse-time characteristic curve. The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

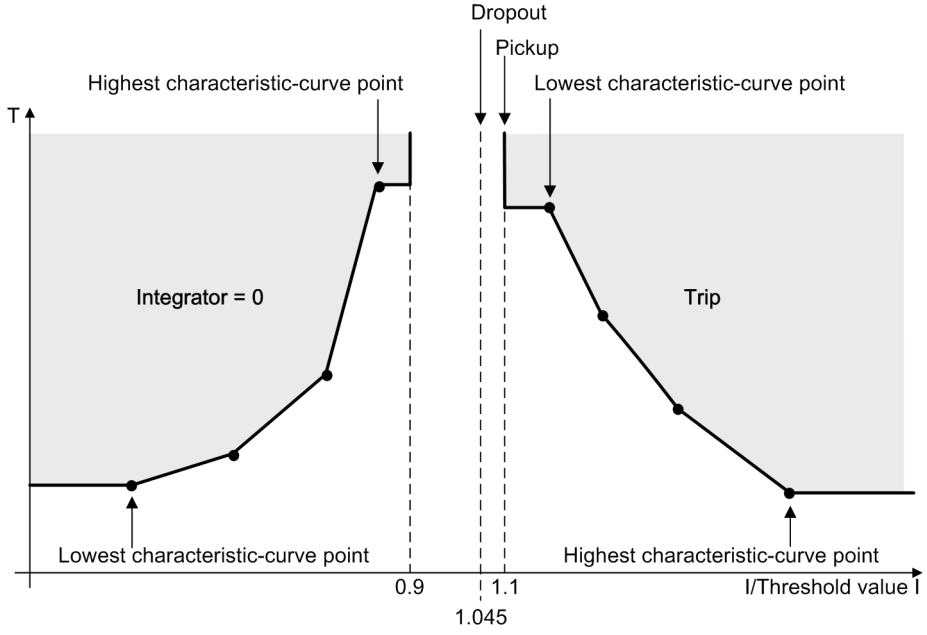
With the user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

Pickup and Dropout Behaviors with the User-Defined Characteristic Curve

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.



[dw_ocp_ken_02, 2, en_US]

Figure 6-457 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

Note that the currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

6.25.6.2 Application and Setting Notes

This stage is structured the same way as the stage with the inverse-time characteristic curve. The only difference is that you can define the characteristic curve as desired. This chapter only provides application and setting notes for setting characteristic curves.

Parameter: `Current/time value pairs` (from the operate curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: `Time dial`

- Default setting **`(_:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the **`Time dial`** parameter at ***`1`***.

Parameter: `Reset`

- Default setting **`Reset`** = ***`disk emulation`***

You use the **`Reset`** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: `Current/time value pairs` (of the dropout characteristic curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.

NOTE

The value pairs must be entered in continuous order.

6.25.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:102	User curve #:Blk. w. 2nd harm. 1ph det.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	User curve #:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.002 A to 8.000 A	6.000 A
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00

6.25.6.4 Information List

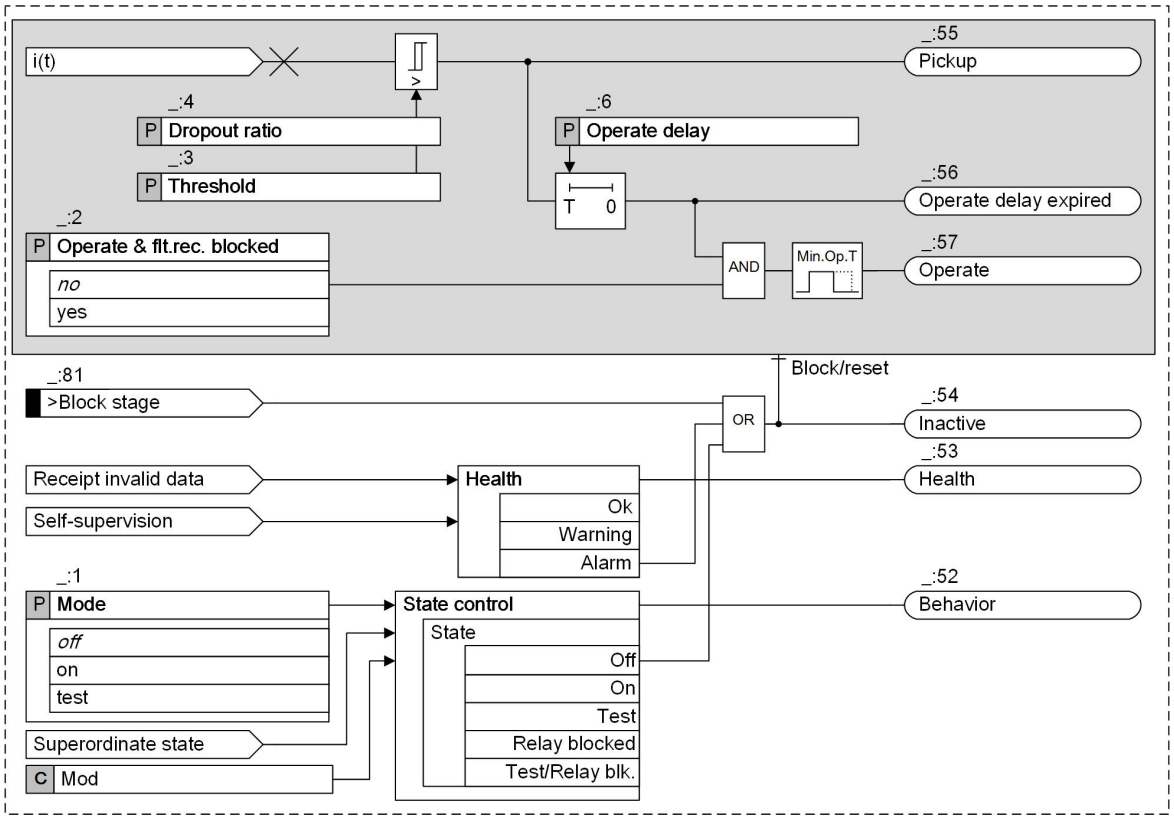
No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.25.7 Fast Stage

6.25.7.1 Description

Logic of a Stage

The fast stage is only available in function type Advanced.



[lo_ocp_1phs, 3, en_US]

Figure 6-458 Logic Diagram of the Fast Stage, 1-Phase

Method of Measurement, Pickup and Dropout Behaviors of the Fast Stage

This stage evaluates the unfiltered measurands. Thus, very short response times are possible. When the absolute values of 2 consecutive sampled values of the last half period exceed the **Threshold**, the stage picks up. When all sampled values of the previous period are less than the dropout threshold, the stage drops out.

Blocking of the Stage

The picked up stage can reset completely via the binary input signal *>Block stage*.

6.25.7.2 Application and Setting Notes

Parameter: Threshold, Operate delay

- Default setting **(_:3) Threshold** = ***10.00 A***
- Default setting **(_:6) Operate delay** = ***0.00 s***

Set the **Threshold** and **Operate delay** parameters for the specific application.

Ensure that the sampled values are compared directly without an additional factor with the set threshold value.

Parameter: `Dropout ratio`

- Recommended setting value **`(_:4) Dropout ratio`** = ***`0.90`***

The recommended setting value of ***`0.90`*** is sufficient for many applications. To obtain high-precision measurements, the **`Dropout ratio`** can be reduced. If you expect highly fluctuating measurands at the pickup threshold, you can increase the **`Dropout ratio`** setting. This avoids chattering of the tripping stage.

6.25.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Fast stage #`				
_:1	Fast stage #:Mode		• off • on • test	off
_:2	Fast stage #:Operate & flt.rec. blocked		• no • yes	no
_:3	Fast stage #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	10.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	50.000 A
_:4	Fast stage #:Dropout ratio		0.90 to 0.99	0.90
_:6	Fast stage #:Operate delay		0.00 s to 60.00 s	0.00 s

6.25.7.4 Information List

No.	Information	Data Class (Type)	Type
`Fast stage #`			
_:81	Fast stage #:>Block stage	SPS	I
_:54	Fast stage #:Inactive	SPS	O
_:52	Fast stage #:Behavior	ENS	O
_:53	Fast stage #:Health	ENS	O
_:55	Fast stage #:Pickup	ACD	O
_:56	Fast stage #:Operate delay expired	ACT	O
_:57	Fast stage #:Operate	ACT	O

6.25.8 Blocking of the Tripping by Device-Internal Inrush-Current Detection

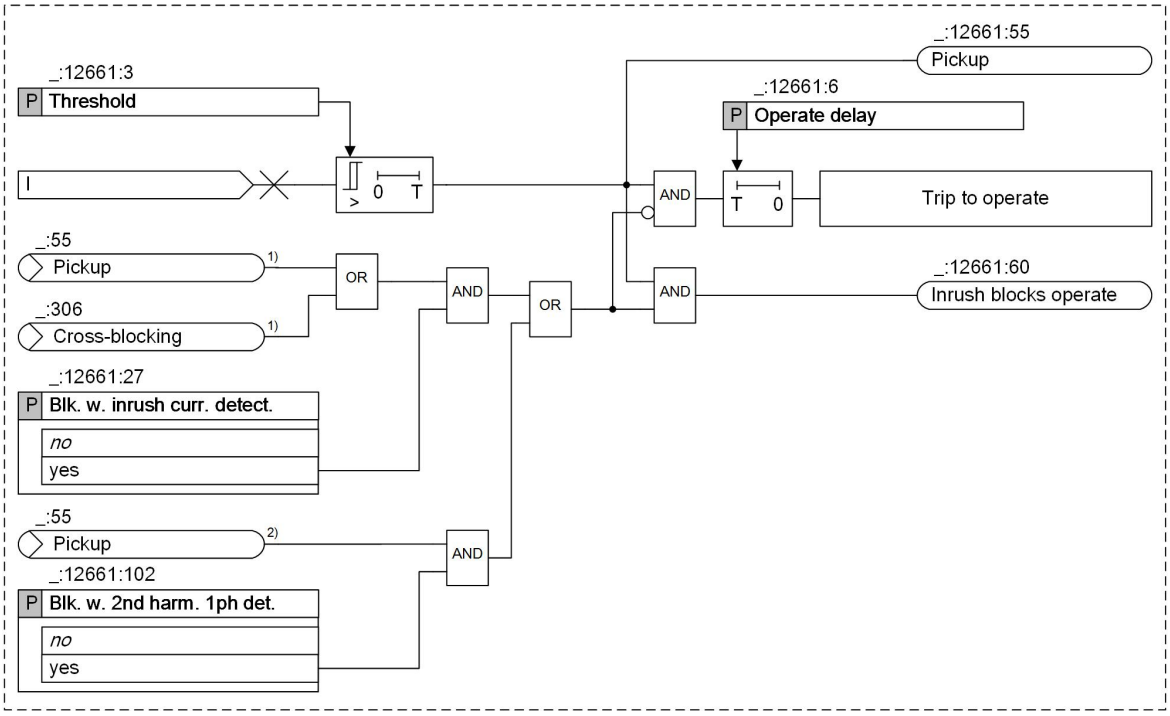
6.25.8.1 Description

The **`Blk. w. inrush curr. detect.`** parameter allows you to define whether the operate indication of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started. After that time, the stage operates.

The **`Blk. w. 2nd harm. 1ph det.`** parameter allows you to define whether the operate indication of the stage should be blocked when the detected 2nd harmonic component of the 1-phase current exceeds a threshold value. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time

delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started. After that time, the stage operates.

The following figure only shows the part of the stage (exemplified by definite-time overcurrent protection stage 1) that illustrates the influence of the inrush-current detection. Only if the central function **Inrush-current detection** (see section *12.62 Inrush-Current Detection*) is in effect can the blocking be set.



[lo_blk_by_inrush_ocp_1phase, 1, en_US]

Figure 6-459 Part-Logic Diagram on the Influence of Inrush-Current Detection Exemplified by the 1st Definite-Time Overcurrent Protection Stage

(1) From FB **Inrush-current detection**

(2) From FB **2nd harmonic detection 1-phase**

6.25.8.2 Application and Setting Notes

Parameter: **`Blk. w. inrush curr. detect.`**

- Default setting **`(_:12661:27) Blk. w. inrush curr. detect.`** = ***`no`***

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This, for example, applies to the high-current stage that is set such according to the short-circuit voltage V_{sc} of the transformer that it only picks up on faults from the high-voltage side. The transformer inrush current cannot become larger than the maximum transmittable short-circuit current.
yes	When the transformer inrush-current detection detects an inrush current that would lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: **`Blk. w. 2nd harm. 1ph det.`**

- Default setting **`(_:12661:102) Blk. w. 2nd harm. 1ph det.`** = ***no***

Parameter Value	Description
no	If no 1-phase current flow due to CT saturation with a level above the pickup threshold is expected, select this setting.
yes	If 1-phase current flow due to CT saturation with a level above the pickup threshold is expected, the blocking must be activated. This provides stability for the following conditions: • CT saturation without inrush current since a saturated signal also contains 2nd-harmonic content • Phase inrush current that leads to CT saturation and therefore causes 2nd-harmonic inrush current being present also in the parasitic 1-phase current

6.25.9 Application Example: High-Impedance Restricted Ground-Fault Protection

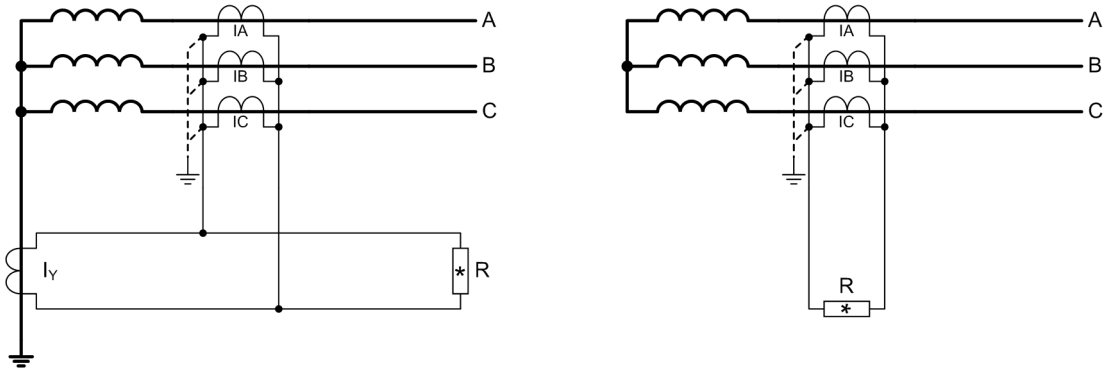
6.25.9.1 Description

With the high-impedance method, all current transformers operate in parallel at the limits of the protection range on a common, relatively high-impedance resistor R, the voltage of which is measured.

The current transformers must be of the same type of construction and have at least one core of their own for the High-impedance restricted ground-fault protection. Furthermore, they must have the same transfer ratio and approximately the same knee-point voltage.

The high-impedance principle is especially suited for ground-fault detection in grounded networks at transformers, generators, motors, and shunt reactors.

The left part of *Figure 6-460* shows an application example for a grounded transformer winding or a grounded motor/generator. The example at the right shows an ungrounded transformer winding or an ungrounded motor/generator. In this example, it is assumed that the network is grounded at a different point.



[dw_himpef, 2, en_US]

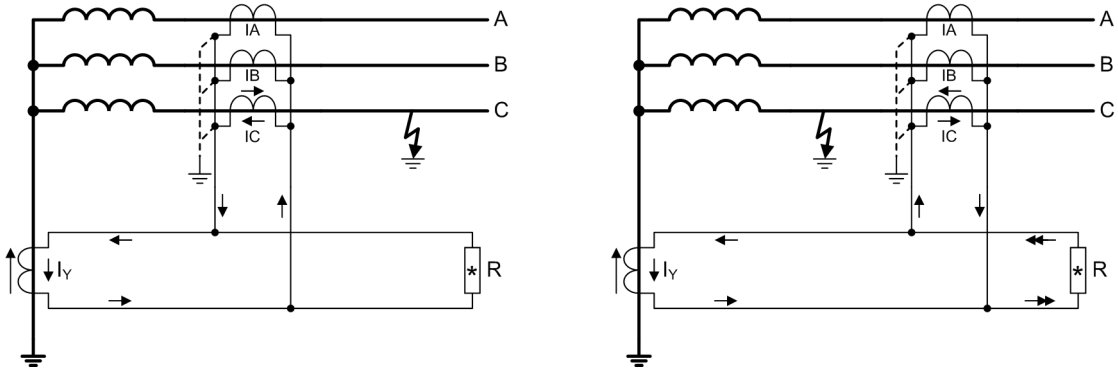
Figure 6-460 Restricted Ground-Fault Protection According to the High-Impedance Principle

Function of the High-Impedance Principle

The high-impedance principle is explained using the example of a grounded transformer winding.

In normal state, no residual currents flow, that is, in the transformer neutral point $I_Y = 0$ and in the phases $3I_0 = I_A + I_B + I_C = 0$.

With an external ground fault (on the left in *Figure 6-461*), the short-circuit current of which is fed via a grounded neutral point, the same current flows in the transformer neutral point and in the phases. The respective secondary currents (with the same transfer ratio of all current transformers) draw each other off. They are connected in series. At the resistor R, only a little voltage arises, which results from the internal resistances of the transformers and those of the transformer connection lines. Even if a current transformer is briefly saturated, it becomes a low-impedance during the time of the saturation and forms a low-impedance shunt to the high-impedance resistor R. The high resistance of the resistor thus has a stabilizing effect (so-called resistor stabilization).



[dw_prhimp, 2, en_US]

Figure 6-461 Principle of the Restricted Ground-Fault Protection According to the High-Impedance Principle

With a ground-fault in the protection range (on the right in *Figure 6-461*), a neutral-point current I_Y flows in any case. The magnitude of the residual current in the phase currents depends on the grounding conditions in the rest of the network. A secondary current corresponding to the entire short-circuit current attempts to flow via the resistor R. But since this resistor is high-impedance, a high voltage arises there which causes the saturation of the current transformers. The effective voltage at the resistor therefore corresponds approximately to the knee-point voltage of the current transformers.

The resistor R is thus dimensioned in such a way that even the smallest ground-fault current to be detected leads to a secondary voltage that corresponds to half of the knee-point voltage of the current transformers (see chapter 2.5.4).

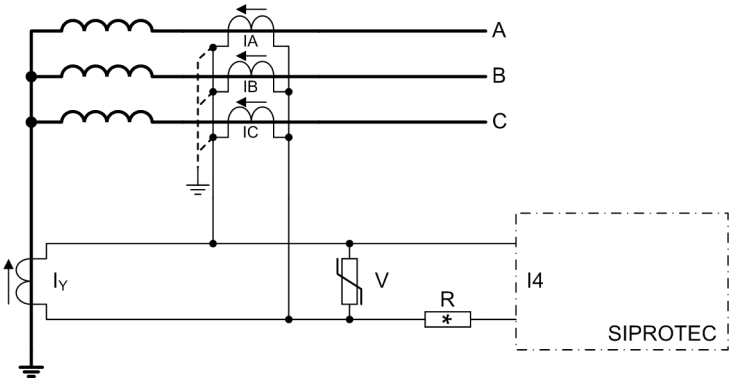
Further information can be found at *Sensitivity view for high-impedance ground-fault differential protection* in chapter *6.25.9.2 Application and Setting Notes* .

High-Impedance Restricted Ground-Fault Protection with a SIPROTEC 5 Device

Use the I4 measuring input of the SIPROTEC 5 device for the high-impedance restricted ground-fault protection. This input for this application is to be executed as a sensitive measuring input. Since this is a current input, the current is detected by this resistor instead of the voltage at the resistor R.

Figure 6-462 shows the connection diagram. The protection device is connected in series with the resistor R and thus measures its current.

The varistor V limits the voltage in case of an internal fault. The varistor cuts the high instantaneous voltage peaks in the case of transformer saturation. Simultaneously, a smoothing of the voltage arises without any relevant reduction of the average value.



[dw_anedif, 2, en_US]

Figure 6-462 Connection Diagram of the Restricted Ground-Fault Protection According to the High-Impedance Principle

As a protection against overvoltages, it is important that you connect the device directly at the grounded side of the current transformer. The high voltage at the resistor is thus kept away from the device.

In a similar manner, the high-impedance restricted ground-fault protection for generators, motors, and shunt reactors is used. With auto transformers, you must connect the upper-voltage side and low-voltage side current transformers and neutral-point transformer in parallel.

The method can be realized for each protected object. As busbar protection, the device, for example, is connected via the resistor to the parallel connection of the transformers of all feeders.

6.25.9.2 Application and Setting Notes

A prerequisite for the application of the high-impedance restricted ground-fault protection is that neutral-point current detection is possible on the station side (see example in (*Figure 6-462*). Furthermore, a sensitive input transformer must be available at device input I4. Set the pickup value for current at input I4 with the function **Overcurrent protection, 1-phase**.

Observe the interaction between current-transformer characteristic curve, external resistor R, and the voltage at R for the overall function of the high-impedance restricted ground-fault protection. Notes on this follow.

Current Transformer Data for High-Impedance Restricted Ground-Fault Protection

All affected current transformers must have the same ratio and approximately the same knee-point voltage. This is normally the case when the current transformers are of the same type and have the same rated data. You can calculate the knee-point voltage from the rated data as follows:

$$V_{KP} = \left(R_i + \frac{P_{rated}}{I_{rated}^2} \right) \cdot n \cdot I_{rated}$$

[fo_ukniep, 1, en_US]

V_{KP}	Knee-point voltage
Ri	Internal resistance of the current transformer
P_{rated}	Rated power of the current transformer

I_{rated}	Secondary rated current of the current transformer
n	Rated overcurrent factor

Rated current, rated power, and overcurrent factor are found on the name plate of the transformer.

EXAMPLE

Current transformer with the following data on the name plate: 800/5; 5P10; 30 VA
You can read the following transformer data with this data:

I_{rated}	= 5 A (out of 800/**5**)
n	= 10 (out of 5P**10**)
P_{rated}	= **30** VA

The internal resistance is frequently to be found in the test report of the transformer. If it is not known, it can be approximately determined by a direct current measurement at the secondary winding.

EXAMPLE

Calculation of the knee-point voltage
Current transformer 800/5; 5P10; 30 VA with $R_i = 0.3\ \Omega$

$$V_{KP} = \left(R_i + \frac{P_{rated}}{I_{rated}^2} \right) \cdot n \cdot I_{rated} = \left(0.3\ \Omega + \frac{30\ \text{VA}}{(5\ \text{A})^2} \right) \cdot 10 \cdot 5\ \text{A} = 75\ \text{V}$$

[fo_ukp5aw, 1, en_US]

Current transformer 800/1; 5P10; 30 VA with $R_i = 5\ \Omega$

$$V_{KP} = \left(R_i + \frac{P_{rated}}{I_{rated}^2} \right) \cdot n \cdot I_{rated} = \left(5\ \Omega + \frac{30\ \text{VA}}{(1\ \text{A})^2} \right) \cdot 10 \cdot 1\ \text{A} = 350\ \text{V}$$

[fo_ukp1aw, 1, en_US]

Besides the current-transformer data, the resistance of the longest connection line between transformer and device must be known.

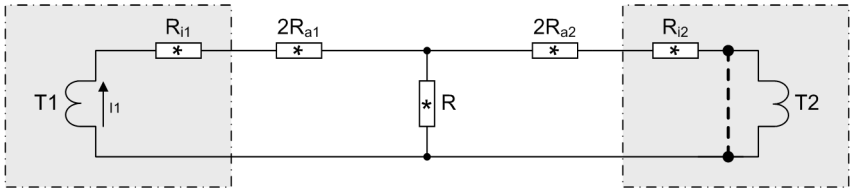
Stability Consideration for High-Impedance Restricted Ground-Fault Protection

The stability condition is based on the simplified assumption that one current transformer is completely saturated and the others transfer their partial currents proportionately in the case of an external fault. This is theoretically the worst case. A safety margin is automatically provided, since, in practice, even the saturated transformer still delivers some current.

Figure 6-463 shows an equivalent circuit of this simplification. CT1 and CT2 are assumed to be ideal transformers with their internal resistances R_{i1} and R_{i2}. R_a are the core resistances of the connection lines between transformer and resistance R; they are used doubled (forward line and return line). R_{a2} is the resistance of the longest connection line.

CT1 transmits the current I1. CT2 is assumed to be saturated. This is indicated by the dotted short-circuit line. The transformer thus represents a low-impedance shunt by its saturation.

A further prerequisite is $R >> (2R_{a2} + R_{i2})$.



[dw_vebhdi, 2, en_US]

Figure 6-463 Simplified Connection Diagram of a Layout for High-Impedance Restricted Ground-Fault Protection

The voltage at R is, then,

$V_R = I_1 \cdot (2R_{a2} + R_{i2})$

A further assumption is that the pickup value of the SIPROTEC 5 device corresponds to half of the knee-point voltage of the current transformers. In the edge case,

$V_R = V_{KP}/2$

The stability limit I_{SL} results, which means the through fault current up to which the arrangement remains stable:

$$I_{SL} = \frac{V_{KP}/2}{2 \cdot R_{a2} + R_{i2}}$$

[fo_istabl, 1, en_US]

EXAMPLE

For the 5 A transformer as above with V_{KP} = 75 V and R_i = 0.3 Ω

Longest connection line = 22 m with 4 mm² cross-section; that corresponds to R_a = 0.1 Ω

$$I_{SL} = \frac{V_{KP}/2}{2 \cdot R_{a2} + R_{i2}} = \frac{37.5\ V}{2 \cdot 0.1\,\Omega + 0.3\,\Omega} = 75\ A$$

[fo_isl5aw, 1, en_US]

In the example, the stability limit is 15 × rated current or 12 kA primary.

For the 1 A transformer as above with V_{KP} = 350 V and R_i = 5 Ω

Longest connection line = 107 m with 2.5 mm² cross-section; that corresponds to R_a = 0.75 Ω

$$I_{SL} = \frac{V_{KP}/2}{2 \cdot R_{a2} + R_{i2}} = \frac{175\ V}{2 \cdot 0.75\,\Omega + 5\,\Omega} = 27\ A$$

[fo_isl1aw, 1, en_US]

In the example, the stability limit is 27 × rated current or 21.6 kA primary.

Sensitivity Consideration for High-Impedance Restricted Ground-Fault Protection

The voltage present at the set of current transformers is supplied to the protection device via a series resistor R as proportional current for evaluation. For dimensioning of the resistor, the following must be taken into account:

The high-impedance restricted ground-fault protection should pick up at approximately half of the knee-point voltage of the current transformers. From this, you can calculate the resistor R.

Since the device measures the current through the resistor, the resistor and measuring input of the device must be connected in series. Since the resistor still should be high-impedance (aforementioned condition R >> $2R_{a2} + R_{i2}$), the inherent resistance of the measuring input can be neglected. The resistance results thus from the pickup current I_{pick} and half of the knee-point voltage:

$$R = \frac{V_{KP} / 2}{I_{pick.}}$$

[fo_berecr, 1, en_US]

EXAMPLE

For the 5 A transformer as above
Desired pickup value I_{pick} = 0.1 A (corresponds to 16 A primary)

$$R = \frac{V_{KP} / 2}{I_{pick.}} = \frac{75\ V / 2}{0.1\ A} = 375\ \Omega$$

[fo_ber5aw, 1, en_US]

For the 1 A transformer as above
Desired pickup value I_{pick} = 0.05 A (corresponds to 40 A primary)

$$R = \frac{V_{KP} / 2}{I_{pick.}} = \frac{350\ V / 2}{0.05\ A} = 3500\ \Omega$$

[fo_ber1aw, 1, en_US]

The series resistor R must be designed for a minimum continuous load $P_{continuous}$.

$$P_{continuous} \geq \frac{(V_{KP} / 2)^2}{R} = \frac{37.5^2}{375} = 3.75\ W \qquad \text{at the 5-A-transformer}$$

[fo_pdau5a, 1, en_US]

$$P_{continuous} \geq \frac{(V_{KP} / 2)^2}{R} = \frac{175^2}{3500} = 8.75\ W \qquad \text{at the 1-A-transformer}$$

[fo_pdau1a, 1, en_US]

Further, the series resistor R must be designed for a fault current lasting approximately 0.5 s. This time is usually sufficient for fault clearing through backup protection.
The thermal stress of the series resistor depends on the voltage $V_{RMS,stab}$ that is present during an internal fault.
It is calculated according to the following equations:

$$V_{RMS,rest} = 1.3 \cdot \sqrt[4]{V_{KP}^3 \cdot R \cdot I_{K,max,int}} = 1.3 \cdot \sqrt[4]{75^3 \cdot 375 \cdot 250} = 579.7\ V \qquad \text{at the 5-A-transformer}$$

[fo_usta5a, 1, en_US]

$$V_{RMS,rest} = 1.3 \cdot \sqrt[4]{V_{KP}^3 \cdot R \cdot I_{K,max,int}} = 1.3 \cdot \sqrt[4]{350^3 \cdot 3500 \cdot 50} = 2151.6\ V \qquad \text{at the 1-A-transformer}$$

[fo_usta1a, 1, en_US]

$I_{K,max,int}$ corresponds to the maximum fault current here in the case of an internal fault.
5-A current transformer 800/5 with 40 kA primary corresponds to $I_{K,max,int}$ = 250 A secondary.
1-A current transformer 800/1 with 40 kA primary corresponds to $I_{K,max,int}$ = 50 A secondary.
This results in a temporary load for the series resistor over 0.5 s of:

$$P_{0.5\,s} = \frac{V_{RMS,rest}^2}{R} = \frac{579.7^2}{375} = 896\ W \qquad \text{at the 5-A-transformer}$$

[fo_p05s5a, 1, en_US]

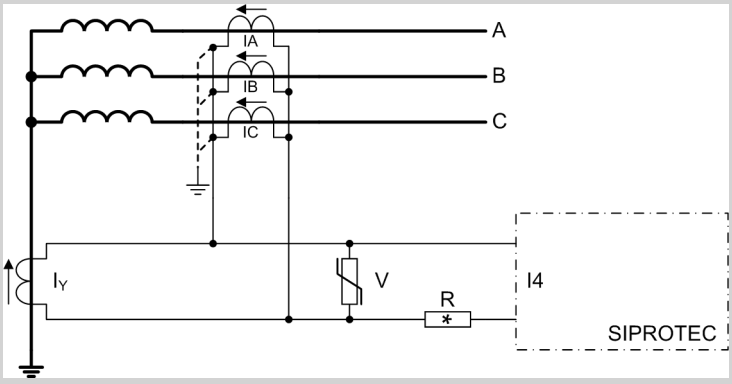
$$P_{0.5\,s} = \frac{V_{RMS,rest}^2}{R} = \frac{2151.6^2}{3500} = 1322.7\ W \qquad \text{at the 1-A-transformer}$$

[fo_p05s1a, 1, en_US]

Observe that with the selection of a higher pickup value I_{pick}, the resistor value must be lowered and therefore the dissipation rises sharply.

The varistor (see following figure) must be sized such that it remains high impedance up to the knee-point voltage, for example:

- Approx. 100 V with 5 A transformer
- Approx. 500 V with 1 A transformer



[dw_anedif, 2, en_US]

Figure 6-464 Connection Diagram of the Restricted Ground-Fault Protection According to the High-Impedance Principle

Even with unfavorable wiring, the maximum occurring voltage peaks do not exceed 2 kV for safety reasons.

When for performance reasons, several varistors must be connected in parallel, give preference to types with flat characteristic curves, in order to avoid an unbalanced load. Siemens therefore recommends the following types by METROSIL:

600A/S1/S256 (k = 450, β = 0.25)

600A/S1/S1088 (k = 900, β = 0.25)

In the example, set the pickup value of the first Definite-time overcurrent protection stage (setting **Threshold**) to 0.1 A for 5-A transformers or 0.05 A for 1-A transformers. No further protection stages are needed. Delete these or switch them off. Set the **Operate delay** setting to 0 s.

If several current transformers are connected in series, for example, with use as busbar protection with several feeders, the magnetization currents of the transformers switched in parallel can no longer be neglected. In this case, add up the magnetization currents at half of the knee-point voltage (corresponds to the set **Threshold**). These magnetization currents reduce the current through the resistor R. Thus, the actual pickup value is correspondingly higher.

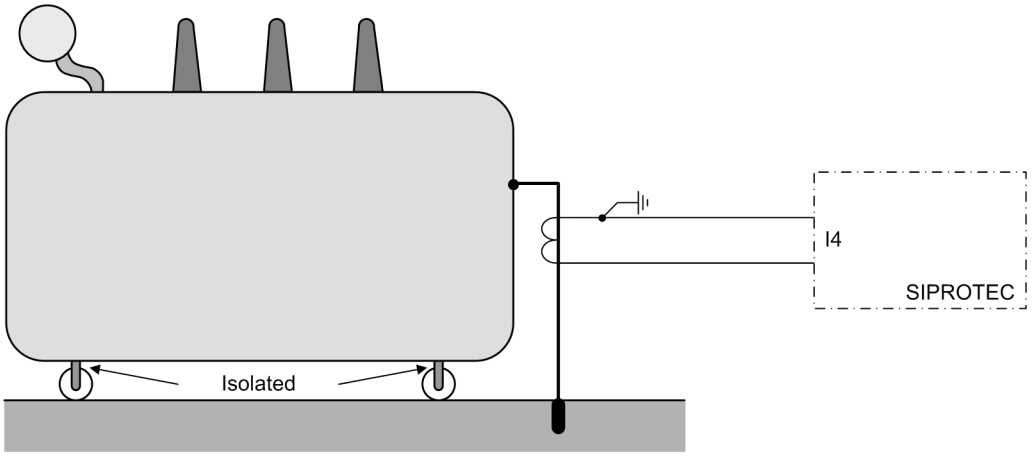
6.25.10 Application Example: Tank Leakage Protection

6.25.10.1 Description

Tank leakage protection records short-circuits to ground – including high-impedance ones – between a phase and the tank of a transformer. The tank is thus insulated, or at least grounded with high impedance. The tank must be connected with a line to ground. The current that flows through this line is fed to the protection device. If a short-circuit to ground occurs in a tank, a fault current (tank current) flows to substation ground via the ground connection.

The function **Overcurrent protection, 1-phase** detects the tank current. If the tank current exceeds the set **Threshold**, the function **Overcurrent protection, 1-phase** generates an operate indication. Depending on the set **Operate delay**, the transformer is tripped immediately or time-delayed on all sides.

For tank protection, a sensitive, 1-phase current measuring input is used.



[dw_prkess, 2, en_US]

Figure 6-465 Tank-Control Principle

6.25.10.2 Application and Setting Notes

A prerequisite for the application of tank protection is the availability of a sensitive input transformer at device input I4.

If you connect **Measuring point I 1-ph** with the function group **Voltage-current 1-phase**, the function **Overcurrent protection, 1-phase** works with the 1-phase current connected to input I4.

Use only the first definite-time overcurrent protection stage of function **Overcurrent protection, 1-phase**. The **`Threshold`** setting is used to set the pickup value. No further protection stages are needed. Delete these or switch them off. Set the **`Operate delay`** setting to 0 s.

6.26 Voltage-Dependent Overcurrent Protection, Phases

6.26.1 Overview of Functions

The **Voltage-dependent overcurrent protection** (ANSI 51V) function:

- Detects short circuits affecting electric equipment
- Can be used for special network conditions where the overcurrent pickup level should be decreased depending on the fault voltage
- Can be used for generators where the excitation voltage is derived from the machine terminals and the overcurrent pickup should be kept depending on the fault voltages

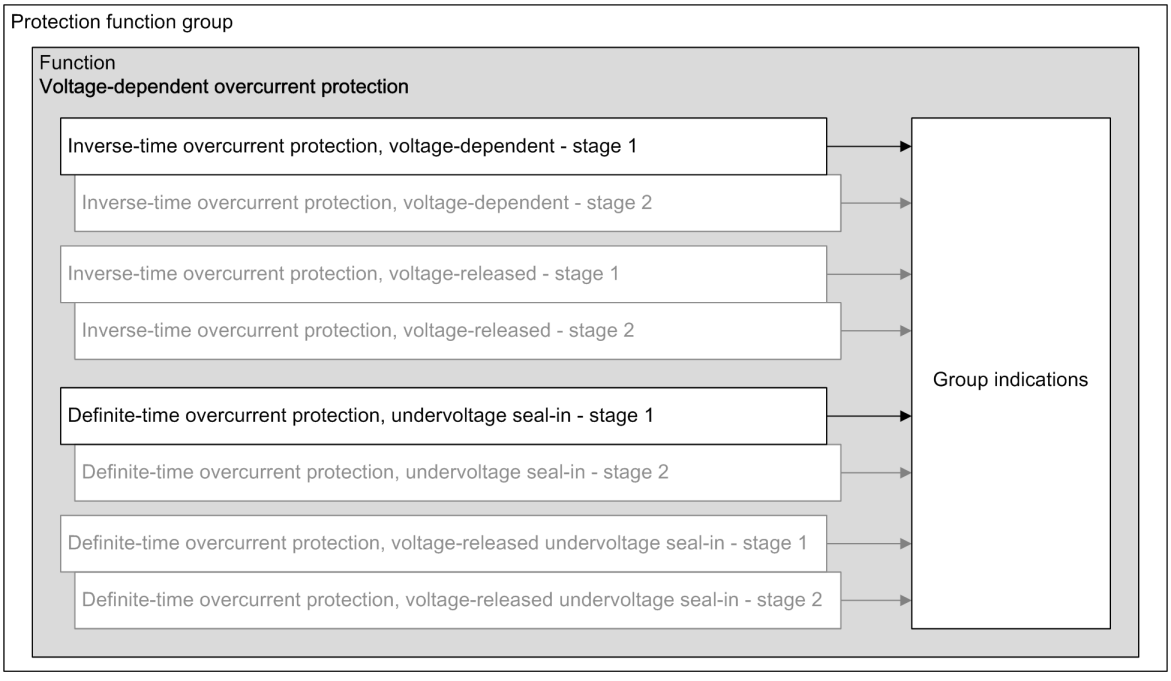
6.26.2 Structure of the Function

The **Voltage-dependent overcurrent protection** function is used in protection function groups with 3-phase current and voltage measurement.
The function **Voltage-dependent overcurrent protection** comes with the following factory-set stages:

- Inverse-time overcurrent protection, voltage-dependent stage
- Definite-time overcurrent protection, undervoltage seal-in stage

In this function, the following stages can operate simultaneously:

- A maximum of 2 inverse-time overcurrent protection, voltage-dependent stages
- A maximum of 2 inverse-time overcurrent protection, voltage-released stages
- A maximum of 2 definite-time overcurrent protection, undervoltage seal-in stages
- A maximum of 2 definite-time overcurrent protection, voltage-released undervoltage seal-in stages



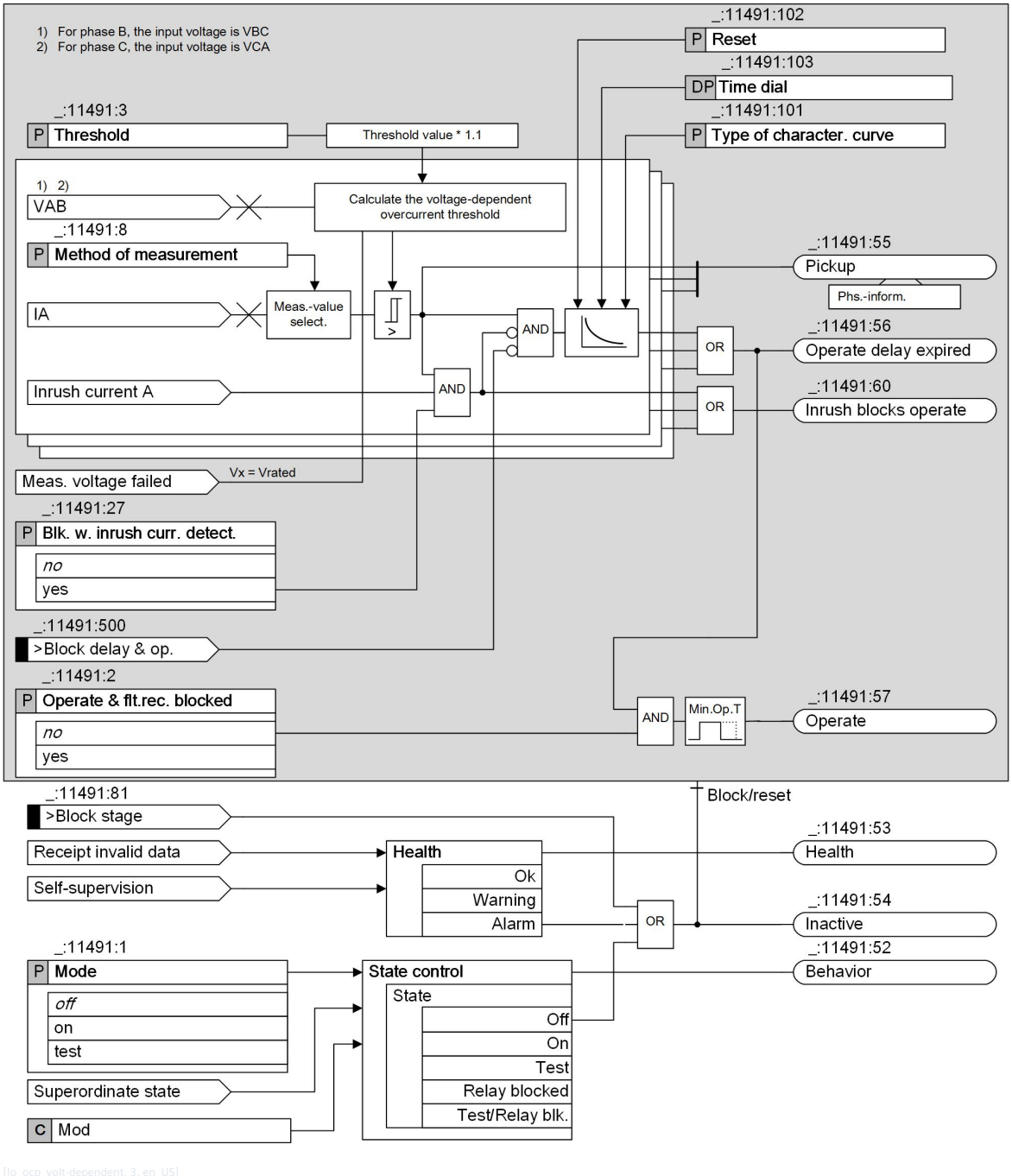
[dw_stuvol_release, 3, en_US]

Figure 6-466 Structure/Embedding of the Function

6.26.3 Stage with Inverse-Time Overcurrent Protection, Voltage-Dependent

6.26.3.1 Description

Logic of the Stage



[lo_ocp_volt-dependent, 3, en_US]

Figure 6-467 Logic Diagram of the Inverse-Time Overcurrent Protection, Voltage-Dependent

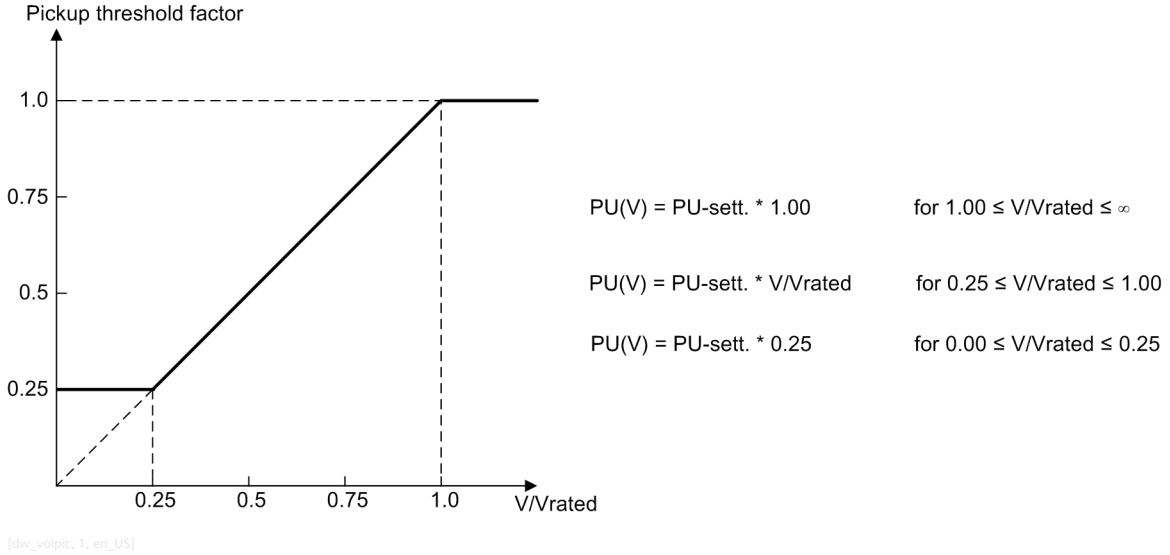
Method of Measurement

You use the **`Method of measurement`** parameter to define whether the stage uses the *`fundamental comp.`* (standard method) or the calculated *`RMS value`*.

- Measurement of the fundamental comp.:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Voltage-Dependent Pickup Threshold

The pickup threshold of the overcurrent stage depends on the voltage magnitude. A lower voltage decreases the current pickup value (see *Figure 6-468*). In the range between V/V_{rated} = 1.00 to 0.25 a linear, directly proportional dependence is realized.



[dw_volpic, 1, en_US]

Figure 6-468 Voltage Influence of the Pickup Threshold

With:

V	=	Measured phase-to-phase voltage
V_{rated}	=	Rated voltage (parameter Rated voltage in the function block General of the protection function group)
PU sett.	=	Pickup threshold setting (parameter address: _11491:3)
PU(V)	=	Applied pickup threshold according to the voltage influence

The minimum current pickup threshold value is 0.03 * Irated. This value cannot be decreased any further even not by voltage-dependent pickup threshold factor.

Decreasing the pickup threshold is carried out phase-selectively. The following table shows the assignment of voltages to current-carrying phases.

Table 6-11 Controlling Voltages in Relation to the Fault Current

Current	Controlling Voltage
I_A	V_{AB}
I_B	V_{BC}
I_C	V_{CA}

Pickup and Dropout Behaviors of the Inverse-Time Characteristic Curve According to IEC and ANSI

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement summarizes the weighted time. The weighted time results

from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by a factor of 1.045 (0.95 · 1.1 · threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Influence On the Operate Curve

The current pickup threshold is decreased proportional to the voltage decrease. Consequently, for a constant current I the I/Threshold-value ratio is increased and the operate time is reduced. Compared with the standard curves represented in the **Technical Data**, the operate curve shifts to the left side as the voltage decreases.

Measuring-Voltage Failure Detection

In case of a measuring-voltage failure detection the input voltage value is automatically set to V_{rated}, so that the pickup threshold factor will be 1.

Blocking of the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.23.7.1 Description* .

6.26.3.2 Application and Setting Notes

Parameter: **Blk. w. inrush curr. detect.**

- Default setting **(_:11491:27) Blk. w. inrush curr. detect.** = ***no***

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This applies, for example, to the high-current stage that is set according to the short-circuit voltage u_k of the transformer in such a way that the stage only picks up on faults from the high-voltage side. The transformer-inrush current cannot become larger than the maximum transmittable short-circuit current.
yes	When the transformer inrush-current detection detects an inrush current that would lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: Method of measurement

- Recommended setting value **(_:11491:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

Parameter: Threshold

- Default setting **(_:11491:3) Threshold** = ***1.500 A***

The recommended setting value of 1.500 A is suitable for most applications.

Set the **Threshold** and **Type of character. curve** parameters for the specific application.

The setting depends on the maximum occurring operating current. Pickup by overload must be excluded since overcurrent protection operates with short tripping times as short-circuit protection and not as overload protection.

Set the **Threshold** parameter for lines to approx.10 %, for transformers and motors to approx. 20 % above the maximum expected load.

Note that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the **Threshold**.

Parameter Type of character. curve

- Default setting **(_:11491:101) Type of character. curve** = ***IEC normal inverse***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **Type of character. curve** required for your specific application.

Parameter: Reset

- Default setting **(_:11491:102) Reset** = ***disk emulation***

The **Reset** parameter allows you to define whether the stage decreases according to the dropout characteristic curve (behavior of a disk emulation = rotor disc) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Select this setting if the dropout does not have to be performed after a disk emulation and an instantaneous dropout is desired instead.

Parameter: Time dial

- Default setting **(_:11491:103) Time dial** = ***1***

You can use the **Time dial** parameter to displace the characteristic curve in the time direction.

The setting value for the **Time dial** parameter is derived from the time-grading chart that has been prepared for the electrical power system.
Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter **Time dial** at 1 (default setting).

6.26.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-dependent 1				
_:11491:1	V-dependent 1:Mode		• off • on • test	off
_:11491:2	V-dependent 1:Operate & flt.rec. blocked		• no • yes	no
_:11491:27	V-dependent 1:Blk. w. inrush curr. detect.		• no • yes	no
_:11491:8	V-dependent 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:11491:3	V-dependent 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:11491:101	V-dependent 1:Type of character. curve			
_:11491:102	V-dependent 1:Reset		• instantaneous • disk emulation	disk emulation
_:11491:103	V-dependent 1:Time dial		0.05 to 15.00	1.00

6.26.3.4 Information List

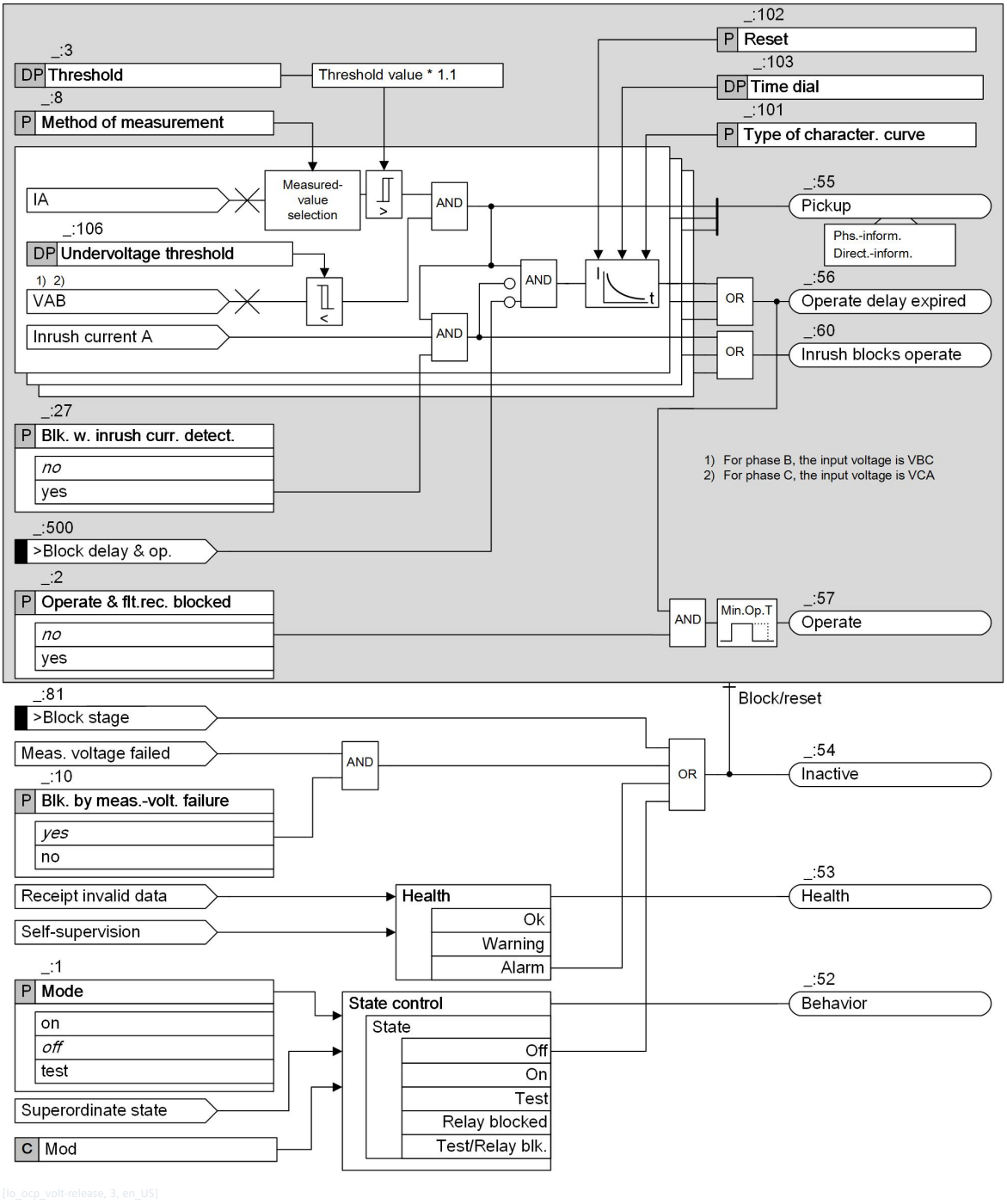
No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
V-dependent 1			
_:11491:81	V-dependent 1:>Block stage	SPS	I
_:11491:500	V-dependent 1:>Block delay & op.	SPS	I
_:11491:51	V-dependent 1:Mode (controllable)	ENC	C
_:11491:54	V-dependent 1:Inactive	SPS	O
_:11491:52	V-dependent 1:Behavior	ENS	O
_:11491:53	V-dependent 1:Health	ENS	O
_:11491:60	V-dependent 1:Inrush blocks operate	ACT	O
_:11491:59	V-dependent 1:Disk emulation running	SPS	O
_:11491:55	V-dependent 1:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:11491:56	V-dependent 1:Operate delay expired	ACT	O
_:11491:57	V-dependent 1:Operate	ACT	O

6.26.4 Stage with Inverse-Time Overcurrent Protection, Voltage-Released

6.26.4.1 Description

Logic of the Stage



[lo_ocp_volt-release, 3, en_US]

Figure 6-469 Logic Diagram of the Inverse-Time Overcurrent Protection, Voltage-Released

This stage is structured in the same way as the Inverse-time overcurrent, voltage-dependent stage (see *6.26.3.1 Description*). The only differences are the conditions for the pickup and the influence on the operate curve.

Measuring-Element Release

When the controlling voltage drops below the setting **Undervoltage threshold**, the respective measuring element is released.

The release of the measuring elements is carried out phase-selectively. The assignment of voltages to current-carrying phases is shown in *Figure 6-468*.

Blocking of the Stage with Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In case of a blocking, the picked up stage is reset. The following blocking options are available for the stage:

- From an internal source upon pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker

The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.26.4.2 Application and Setting Notes

This stage is structured in the same way as the **Inverse-time overcurrent, voltage-dependent** stage. The only differences are the conditions for the pickup and the influence on the operate curve. This chapter only provides the application and setting notes for the setting **Blk. by meas.-volt. failure** and **Undervoltage threshold**. For guidance on the other parameters of this stage, refer to *6.26.3.2 Application and Setting Notes*.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You can use the **Blk. by meas.-volt. failure** parameter to control the response of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal **Measuring-voltage failure detection** function is configured and switched on.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
no	The overcurrent-protection stage is not blocked when a measuring-voltage failure is detected.
yes	The overcurrent-protection stage is blocked when a measuring-voltage failure is detected. Siemens recommends using the default setting, as correct operation of the stage cannot be guaranteed if a measuring-voltage failure occurs.

Parameter: Undervoltage threshold

- Default setting **(_:104) Undervoltage threshold** = ***75.0 V***

When the controlling voltage is below the set value, the **Inverse-time overcurrent protection** stage is released.

The parameter is set to a value just below the lowest phase-to-phase voltage admissible during operation, for example, from 75 % to 80 % of V_{rated}.

6.26.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-release #				
_:1	V-release #:Mode		• off • on • test	off
_:2	V-release #:Operate & flt.rec. blocked		• no • yes	no
_:10	V-release #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	V-release #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	V-release #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	V-release #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:101	V-release #:Type of character. curve		• ANSI long-time inv. • ANSI short-time inv. • ANSI extremely inv. • ANSI very inverse • ANSI normal inverse • ANSI moderately inv. • ANSI definite inverse • IEC normal inverse • IEC very inverse • IEC extremely inv. • IEC long-time inverse	IEC normal inverse
_:102	V-release #:Reset		• instantaneous • disk emulation	disk emulation
_:103	V-release #:Time dial		0.05 to 15.00	1.00
_:104	V-release #:Under-voltage threshold		0.300 V to 175.000 V	75.000 V

6.26.4.4 Information List

No.	Information	Data Class (Type)	Type
V-release #			
_:81	V-release #:>Block stage	SPS	I
_:500	V-release #:>Block delay & op.	SPS	I
_:54	V-release #:Inactive	SPS	O
_:52	V-release #:Behavior	ENS	O
_:53	V-release #:Health	ENS	O

No.	Information	Data Class (Type)	Type
_:60	V-release #:Inrush blocks operate	ACT	O
_:59	V-release #:Disk emulation running	SPS	O
_:55	V-release #:Pickup	ACD	O
_:56	V-release #:Operate delay expired	ACT	O
_:57	V-release #:Operate	ACT	O

6.26.5 Stage with Definite-Time Overcurrent Protection, Undervoltage Seal-In

6.26.5.1 Description

Logic of the Stage

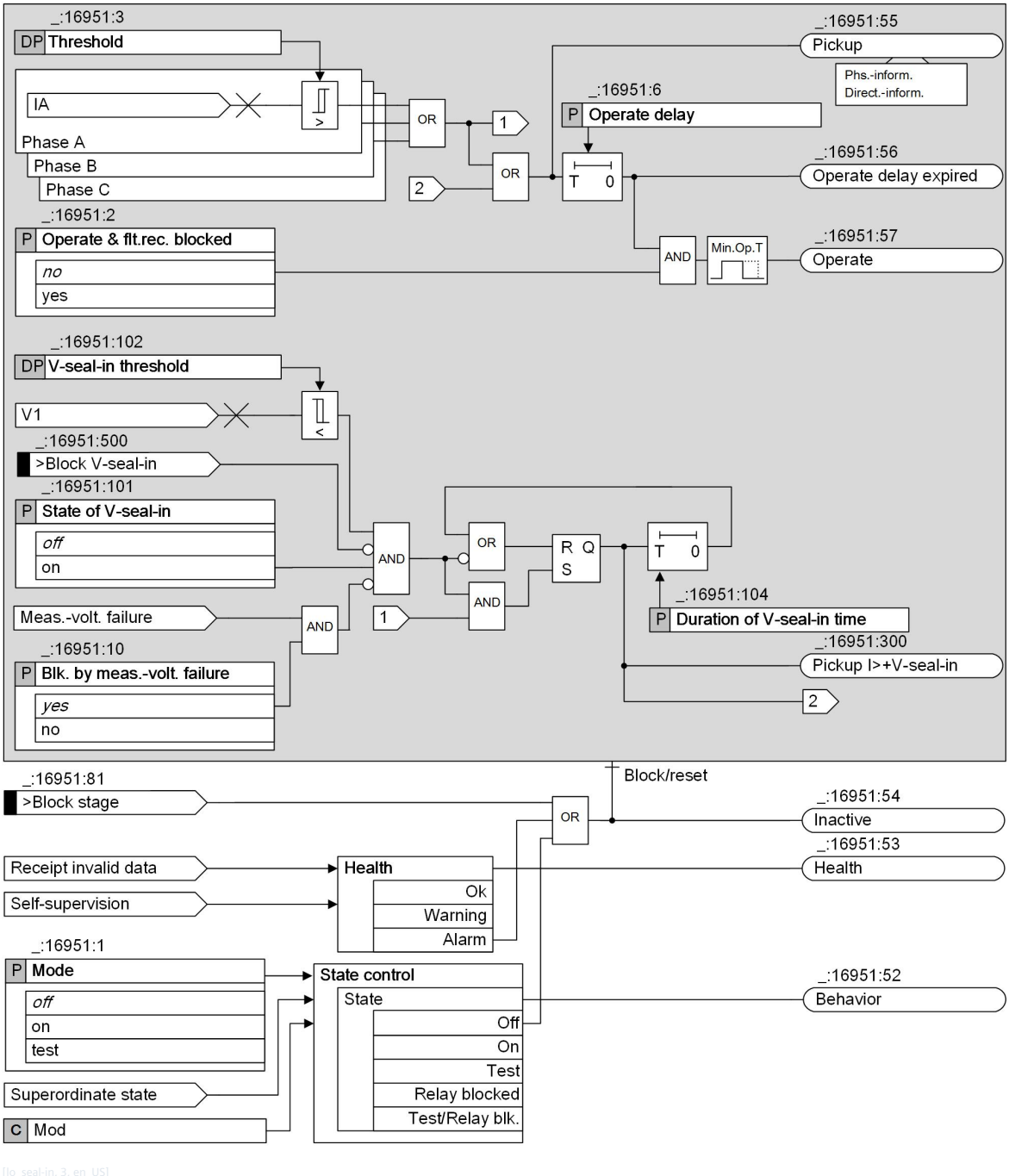


Figure 6-470 Logic Diagram of the Definite-Time Overcurrent Protection, Undervoltage Seal-in

Undervoltage Seal-In

In generators where the excitation voltage is derived from the machine terminals, the short-circuit current decreases quickly in the event of close-in faults (for example, in a generator or a generator-transformer range). The current decreases to a value below the current threshold within a few seconds because of the

absence of the excitation voltage. To avoid a dropout of the relay, the positive-sequence voltages are used as an additional criterion for detecting a short circuit.

The pickup signal is maintained for a settable seal-in time **Duration of V-seal-in time**, if the positive-sequence voltage falls below a settable threshold **V-seal-in threshold** after an overcurrent pickup, even if the current falls below the threshold again. If the voltage recovers before the seal-in time has elapsed, or if the undervoltage seal-in is blocked via a binary input *>Block V-seal-in*, the signal *Pickup I>+V-seal-in* drops out immediately.

You can switch off the undervoltage seal-in via the parameter **State of V-seal-in**.

Blocking of the Undervoltage Seal-in with Measuring-Voltage Failure

The **Undervoltage seal-in** can be blocked if a measuring-voltage failure occurs. In case of a blocking, the pickup signal *Pickup I>+V-seal-in* drops out immediately. The following blocking options are available for the **Undervoltage seal-in**:

- From an internal source upon pickup of the **Measuring-voltage failure detection** function.
- From an external source via the binary input signal *>Open* of the function block **VT miniature CB**, which links in the tripping of the voltage-transformer circuit breaker.

The parameter **Blk. by meas.-volt. failure** can be used to control the measuring-voltage failure detection. The **Undervoltage seal-in** remains unaffected if the parameter **Blk. by meas.-volt. failure** is switched off.

6.26.5.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting **(_:16951:2) Operate & flt.rec. blocked** = ***no***

With the parameter **Operate & flt.rec. blocked**, you can block the operate indication, the fault recording, and the fault log.

Parameter: Threshold

- Default setting **(_:16951:3) Threshold** = ***1.350 A***

The setting is mainly determined by the maximum operating current.

Pickup by overload must be excluded since the protection may trip if a short operate delay time is set. Set the **Threshold** parameter for generators to a value between 20 % and 30 %, for transformers and motors approx. 40 % above the expected peak load.

Parameter: Operate delay

- Default setting **(_:16951:6) Operate delay** = ***3.00 s***

The parameter **Operate delay** must be coordinated with the time grading of the network protection to guarantee the selectivity. Practical time delays are between 1 s to 2 s.

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:16951:10) Blk. by meas.-volt. failure** = ***yes***

With the parameter **Blk. by meas.-volt. failure**, you can activate (***yes***) or deactivate (***no***) the blocking by the **Measuring voltage failure detection** function. The recommended setting is the default setting.

Parameter: State of V-seal-in

- Default setting **(_:16951:101) State of V-seal-in** = ***off***

With the parameter **State of V-seal-in**, the seal-in functionality can be activated (switched ***on***). Siemens recommends this setting if the excitation transformer is connected to the main lead of the generator.

Parameter: `V-seal-in threshold`

- Default setting **`(_:16951:102) V-seal-in threshold`** = ***`46.2 V`***

The **`V-seal-in threshold`** (positive-sequence voltage) is set to a value below the lowest phase-to-phase voltage admissible during an operation, for example 80 % of the rated voltage of a generator. The positive-sequence voltage is evaluated. The practicable value for a voltage transformer with a rated secondary voltage of 100 V is 46.2 V.

The following table shows an example of a specification:

Threshold	1.4 * $I_{rated, Gen}$		
Operate delay	3.00 s		
Undervoltage seal-in	0.8 * $V_{rated, Gen}$		
Duration of V-seal-in time	4.00 s		
Dropout ratio	0.95		
Rated current $I_{rated, Gen}$	483 A	Rated voltage $V_{rated, Gen}$	6.3 kV
Rated current $I_{rated, VT, prim}$	500 A	Rated voltage $V_{rated, VT, prim}$	6.3 kV
Rated current $I_{rated, VT, sec}$	1 A	Rated voltage $V_{rated, VT, sec}$	100 V

The following secondary setting values result from this specification:

$$\text{Threshold} = \frac{1.4 \times I_{rated,Gen}}{I_{rated,CT,prim}} \times I_{rated,VT,sec} = \frac{1.4 \times 483\ A}{500\ A} \times 1\ A = 1.35\ A$$

[fo_ocp_uvsi_threshold, 1, en_US]

$$\text{Undervoltage seal} - \text{in} = \frac{0.8 \times V_{rated,Gen}}{V_{rated,VT,prim}} \times \frac{V_{reated,VT,sec}}{\sqrt{3}} = \frac{0.8 \times 6.3\ kV}{6.3\ kV} \times \frac{100\ V}{\sqrt{3}} = 46.200\ V$$

[fo_ocp_uvsi_seal-in, 1, en_US]

Parameter: `Duration of V-seal-in time`

- Default setting **`(_:16951:104) Duration of V-seal-in time`** = ***`4.00 s`***

The parameter **`Duration of V-seal-in time`** limits the pickup seal-in induced by an overcurrent or undervoltage. The value must be set higher than the value of the parameter **`Operate delay`**. The difference shall be greater than 0.5 s. In the default setting, a difference of 1 s is used.

6.26.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`V-seal-in 1`				
_:16951:1	V-seal-in 1:Mode		• off • on • test	off
_:16951:2	V-seal-in 1:Operate & flt.rec. blocked		• no • yes	no
_:16951:3	V-seal-in 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.75 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.75 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.350 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.750 A
_:16951:6	V-seal-in 1:Operate delay		0.00 s to 60.00 s	3.00 s

Addr.	Parameter	C	Setting Options	Default Setting
_:16951:10	V-seal-in 1:Blk. by meas.-volt. failure		• no • yes	yes
_:16951:101	V-seal-in 1:State of V-seal-in		• off • on	off
_:16951:102	V-seal-in 1:V-seal-in threshold		0.300 V to 175.000 V	46.200 V
_:16951:104	V-seal-in 1:Duration of V-seal-in time		0.10 s to 60.00 s	4.00 s

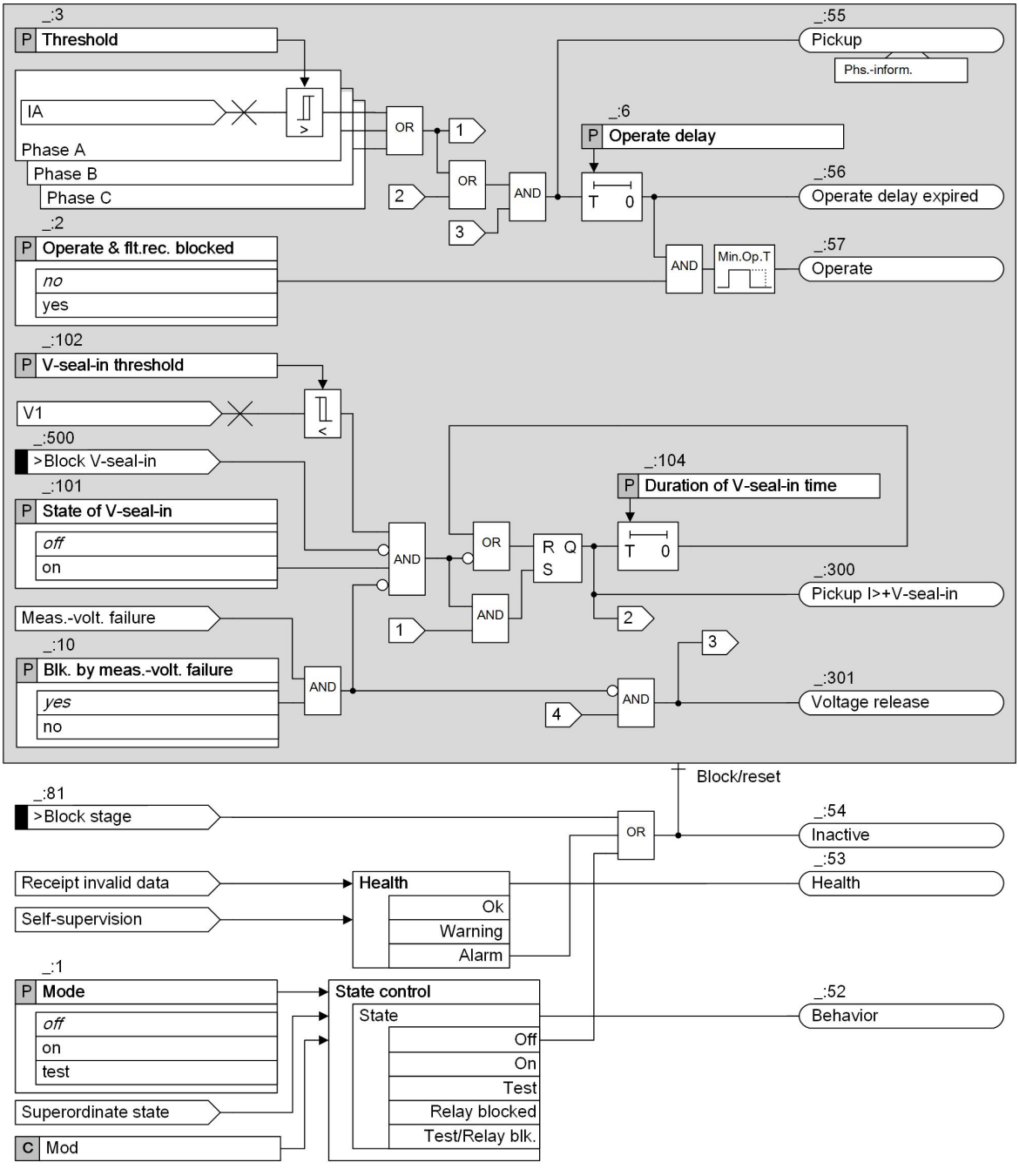
6.26.5.4 Information List

No.	Information	Data Class (Type)	Type
V-seal-in 1			
_:16951:81	V-seal-in 1:>Block stage	SPS	I
_:16951:500	V-seal-in 1:>Block V-seal-in	SPS	I
_:16951:52	V-seal-in 1:Behavior	ENS	O
_:16951:53	V-seal-in 1:Health	ENS	O
_:16951:54	V-seal-in 1:Inactive	SPS	O
_:16951:55	V-seal-in 1:Pickup	ACD	O
_:16951:300	V-seal-in 1:Pickup I>+V-seal-in	SPS	O
_:16951:56	V-seal-in 1:Operate delay expired	ACT	O
_:16951:57	V-seal-in 1:Operate	ACT	O

6.26.6 Stage with Definite-Time Overcurrent Protection, Voltage-Released Undervoltage Seal-In

6.26.6.1 Description

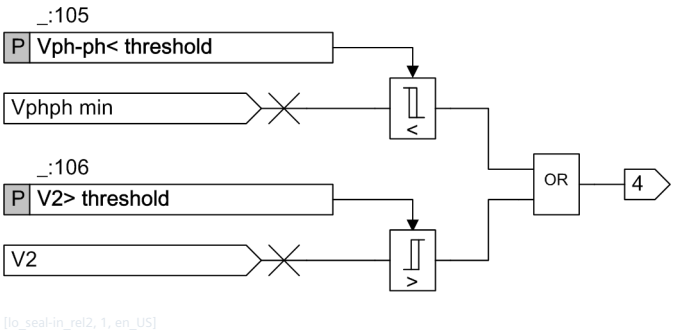
Logic of the Stage



[lo_seal-in_rel, 3, en_US]

Figure 6-471 Logic Diagram of the Definite-Time Overcurrent Protection, Voltage-Released Undervoltage Seal-in, Part 1

Signal 4 in the following figure refers to *Figure 6-471*.



[lo_seal-in_rel2, 1, en_US]

Figure 6-472 Logic Diagram of the Definite-Time Overcurrent Protection, Voltage-Released Undervoltage Seal-in, Part 2

Voltage Release

In addition to the current criterion with undervoltage seal-in, a voltage-released logic must be present to issue the indication *Pickup*. The voltage-released logic monitors the negative-sequence voltage and phase-to-phase voltages respectively for detecting unsymmetrical faults and symmetrical faults. With the voltage-released logic, the setting value of the parameter **Threshold** can be reduced in a certain range and the reliability and sensibility of this function can be improved correspondingly.

Undervoltage Seal-In

In generators where the excitation voltage is derived from the machine terminals, the short-circuit current decreases quickly in the event of close-in faults (for example, in a generator or a generator-transformer range). The current decreases to a value below the current threshold within a few seconds because of the absence of the excitation voltage. To avoid a dropout of the relay, the positive-sequence voltages are used as an additional criterion for detecting a short circuit.

The pickup signal is maintained for a settable seal-in time **Duration of V-seal-in time**, if the positive-sequence voltage falls below a settable threshold **V-seal-in threshold** after an overcurrent pickup, even if the current falls below the threshold again. If the voltage recovers before the seal-in time has elapsed, or if the undervoltage seal-in is blocked via a binary input *>Block V-seal-in*, the signal *Pickup I>+V-seal-in* drops out immediately.

You can switch off the undervoltage seal-in via the parameter **State of V-seal-in**.

Blocking of the Undervoltage Seal-in with Measuring-Voltage Failure

The **Undervoltage seal-in** can be blocked if a measuring-voltage failure occurs. In case of a blocking, the pickup signal *Pickup I>+V-seal-in* drops out immediately. The following blocking options are available for the **Undervoltage seal-in**:

- From an internal source upon pickup of the **Measuring-voltage failure detection** function.
- From an external source via the binary input signal *>Open* of the function block **VT miniature CB**, which links in the tripping of the voltage-transformer circuit breaker.

The parameter **Blk. by meas.-volt. failure** can be used to control the measuring-voltage failure detection. The **Undervoltage seal-in** remains unaffected if the parameter **Blk. by meas.-volt. failure** is switched off.

6.26.6.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting **(_:2) Operate & flt.rec. blocked** = *no*

With the parameter **Operate & flt.rec. blocked**, you can block the operate indication, the fault recording, and the fault log.

Parameter: `Threshold`

- Default setting **`(_:3) Threshold`** = ***`1.350 A`***

The setting is mainly determined by the maximum operating current.

Pickup by overload must be excluded since the protection may trip if a short operate delay time is set. Set the **`Threshold`** parameter for generators to a value between 20 % and 30 %, for transformers and motors approx. 40 % above the expected peak load.

Parameter: `Operate delay`

- Default setting **`(_:6) Operate delay`** = ***`3.00 s`***

The parameter **`Operate delay`** must be coordinated with the time grading of the network protection to guarantee the selectivity. Practical time delays are between 1 s to 2 s.

Parameter: `Blk. by meas.-volt. failure`

- Default setting **`(_:10) Blk. by meas.-volt. failure`** = ***`yes`***

With the parameter **`Blk. by meas.-volt. failure`**, you can activate (***`yes`***) or deactivate (***`no`***) the blocking by the **Measuring voltage failure detection** function. The recommended setting is the default setting.

Parameter: `State of V-seal-in`

- Default setting **`(_:101) State of V-seal-in`** = ***`off`***

With the parameter **`State of V-seal-in`**, the seal-in functionality can be activated (switched ***`on`***). Siemens recommends this setting if the excitation transformer is connected to the main lead of the generator.

Parameter: `V-seal-in threshold`

- Default setting **`(_:102) V-seal-in threshold`** = ***`46.2 V`***

The **`V-seal-in threshold`** (positive-sequence voltage) is set to a value below the lowest phase-to-phase voltage admissible during an operation, for example 80 % of the rated voltage of a generator. The positive-sequence voltage is evaluated. The practicable value for a voltage transformer with a rated secondary voltage of 100 V is 46.2 V.

The following table shows an example of a specification:

Threshold	1.4 * $I_{rated, Gen}$		
Operate delay	3.00 s		
Undervoltage seal-in	0.8 * $V_{rated, Gen}$		
Duration of V-seal-in time	4.00 s		
Dropout ratio	0.95		
Rated current $I_{rated, Gen}$	483 A	Rated voltage $V_{rated, Gen}$	6.3 kV
Rated current $I_{rated, VT, prim}$	500 A	Rated voltage $V_{rated, VT, prim}$	6.3 kV
Rated current $I_{rated, VT, sec}$	1 A	Rated voltage $V_{rated, VT, sec}$	100 V

The following secondary setting values result from this specification:

$$\text{Threshold} = \frac{1.4 \times I_{rated,Gen}}{I_{rated,CT,prim}} \times I_{rated,VT,sec} = \frac{1.4 \times 483\ A}{500\ A} \times 1\ A = 1.35\ A$$

[fo_ocp_uvsi_threshold, 1, en_US]

$$\text{Undervoltage seal} - \text{in} = \frac{0.8 \times V_{rated,Gen}}{V_{rated,VT,prim}} \times \frac{V_{reated,VT,sec}}{\sqrt{3}} = \frac{0.8 \times 6.3\ kV}{6.3\ kV} \times \frac{100\ V}{\sqrt{3}} = 46.200\ V$$

[fo_ocp_uvsi_seal-in, 1, en_US]

Parameter: `Duration of V-seal-in time`

- Default setting **`(_:104) Duration of V-seal-in time`** = ***`4.00 s`***

The parameter **`Duration of V-seal-in time`** limits the pickup seal-in induced by an overcurrent or undervoltage. The value must be set higher than the value of the parameter **`Operate delay`**. The difference shall be greater than 0.5 s. In the default setting, a difference of 1 s is used.

Parameter: `Vph-ph< threshold`

- Default setting **`(_:105) Vph-ph< threshold`** = ***`60.000 V`***

With the parameter **`Vph-ph< threshold`**, you can set the threshold at which the output signal *Voltage release* is activated when the minimum phase-to-phase voltage falls below this threshold.

Parameter: `V2> threshold`

- Default setting **`(_:106) V2> threshold`** = ***`4.600 V`***

With the parameter **`V2> threshold`**, you can set the threshold at which the output signal *Voltage release* is issued when V2 exceeds the threshold.

6.26.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Vseal-in+Vrel#`				
_:1	Vseal-in+Vrel#:Mode		• off • on • test	off
_:2	Vseal-in+Vrel#:Operate & flt.rec. blocked		• no • yes	no
_:3	Vseal-in+Vrel#:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 100 Irated	0.150 A to 175.000 A	6.750 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 50 Irated	0.150 A to 175.000 A	6.750 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.350 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.750 A
_:6	Vseal-in+Vrel#:Operate delay		0.00 s to 60.00 s	3.00 s
_:10	Vseal-in+Vrel#:Blk. by meas.-volt. failure		• no • yes	yes
_:101	Vseal-in+Vrel#:State of V-seal-in		• off • on	off
_:102	Vseal-in+Vrel#:V-seal-in threshold		0.300 V to 175.000 V	46.200 V
_:104	Vseal-in+Vrel#:Duration of V-seal-in time		0.10 s to 60.00 s	4.00 s
_:105	Vseal-in+Vrel#:Vph-ph< threshold		0.300 V to 175.000 V	60.000 V
_:106	Vseal-in+Vrel#:V2> threshold		0.300 V to 200.000 V	4.600 V

6.26.6.4 Information List

No.	Information	Data Class (Type)	Type
Vseal-in+Vrel#			
_:81	Vseal-in+Vrel#:>Block stage	SPS	I
_:500	Vseal-in+Vrel#:>Block V-seal-in	SPS	I
_:52	Vseal-in+Vrel#:Behavior	ENS	O
_:53	Vseal-in+Vrel#:Health	ENS	O
_:54	Vseal-in+Vrel#:Inactive	SPS	O
_:55	Vseal-in+Vrel#:Pickup	ACD	O
_:300	Vseal-in+Vrel#:Pickup I>+V-seal-in	SPS	O
_:301	Vseal-in+Vrel#:Voltage release	SPS	O
_:56	Vseal-in+Vrel#:Operate delay expired	ACT	O
_:57	Vseal-in+Vrel#:Operate	ACT	O

6.27 Directional Overcurrent Protection, Phases

6.27.1 Overview of Functions

The **Directional overcurrent protection, phases** function (ANSI 67):

- Detects short circuits at electrical equipment
- Can be used as backup overcurrent protection in addition to the main protection
- Ensures selective fault detection for parallel lines or transformers with infeed at one end
- Ensures selective fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies

6.27.2 Structure of the Function

The **Directional overcurrent protection, phases** function is used in protection function groups. 2 function types are offered:

- **Directional overcurrent protection, phases – advanced** (67 Dir.OC-3ph-A)
- **Directional overcurrent protection, phases – basic** (67 Dir.OC-3ph-B)

The Basic function type is provided for standard applications. The function type Advanced offers advanced functionality and is provided for more complex applications.

Both function types are preconfigured by the manufacturer with 2 **Directional, definite-time overcurrent protection** stages and with 1 **Directional inverse-time overcurrent protection** stage.

In the Advanced function type **Directional overcurrent protection, phases – advanced**, the following stages can be operated simultaneously:

- Maximum of 4 stages **Definite-time overcurrent protection – advanced**
- 1 stage **Inverse-time overcurrent protection – advanced**
- 1 stage **User-defined overcurrent protection characteristic curve**

In the Basic function type **Directional overcurrent protection, phases – basic** the following stages can be operated simultaneously:

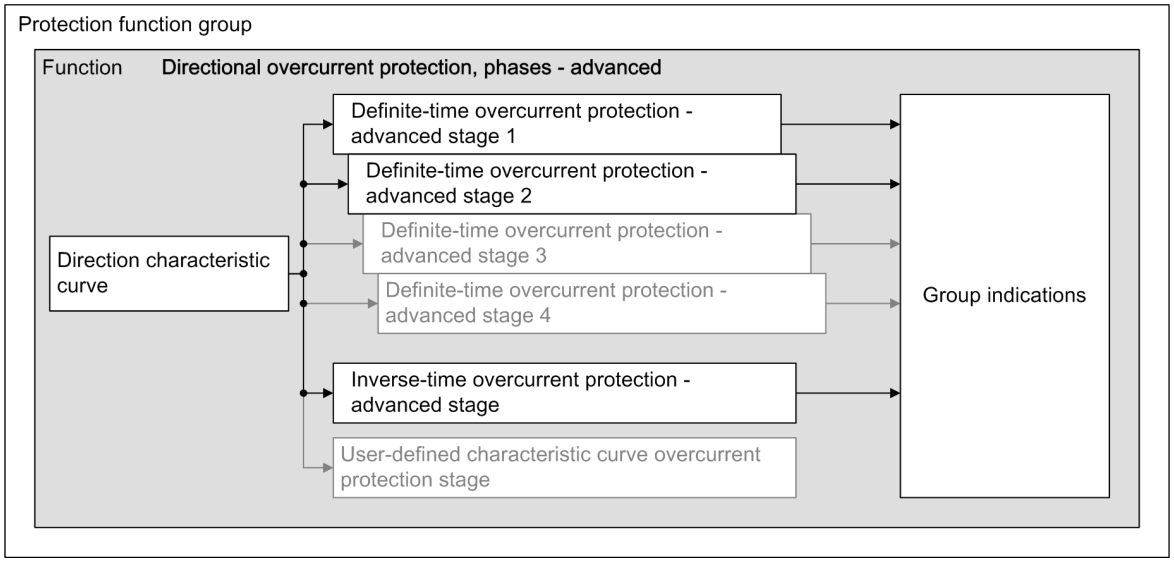
- Maximum of 4 stages **Definite-time overcurrent protection – basic**
- 1 stage **Inverse-time overcurrent protection – basic**

Stages that are not preconfigured are shown in gray in the following figures. Apart from the tripping delay characteristic, the stages are identical in structure.

The direction determination occurs on a functional level and has the same effects in all stages (see *Figure 6-473* and *6.27.7.1 Description*). In this way, it is ensured that all stages of a function receive the same direction result. Every stage can be set to the forward or reverse direction.

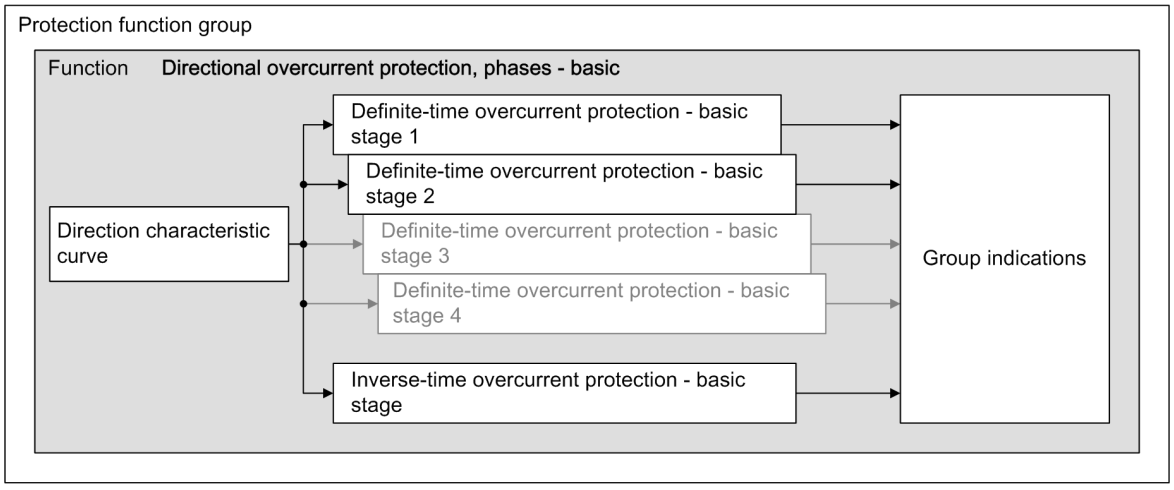
The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- **`Pickup`**
- **`Operate`**



[dw_diocan, 4, en_US]

Figure 6-473 Structure/Embedding the Function Directional Overcurrent Protection, Phases – Advanced



[dw_diocba, 5, en_US]

Figure 6-474 Structure/Embedding the Function Directional Overcurrent Protection, Phases – Basic

If the device-internal functions listed in the following are present in the device, these functions can influence the pickup values and tripping delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Automatic reclosing (AREC)
- Cold-load pickup detection
- Binary input signal

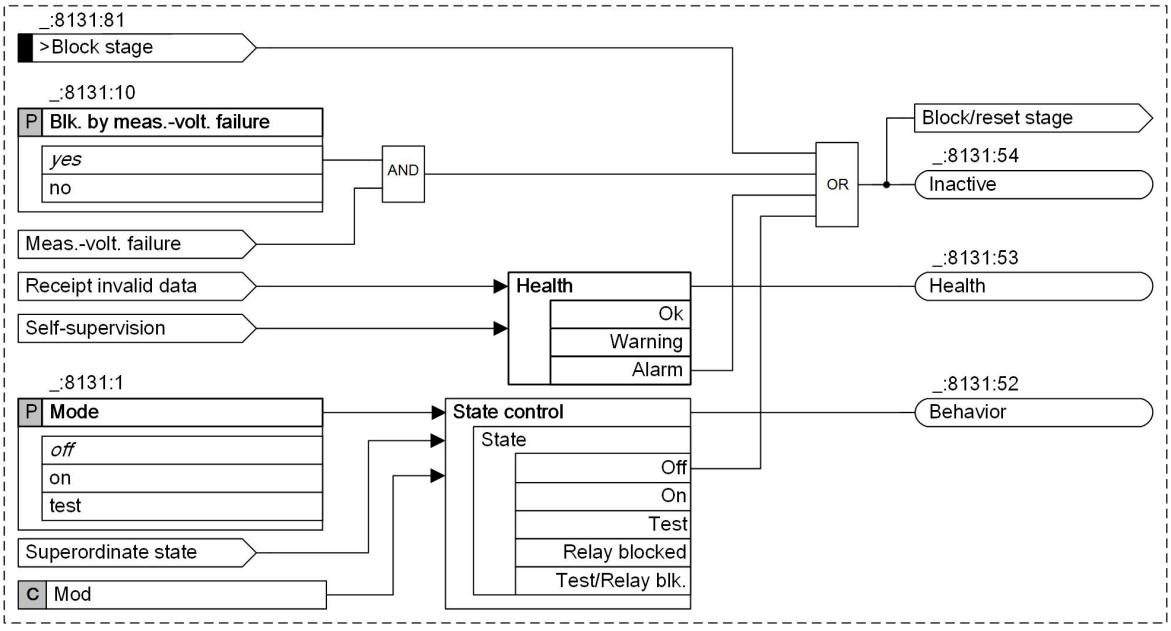
If the device is equipped with the **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer-inrush currents.

6.27.3 Stage Control

6.27.3.1 Description

Logic

The following figure represents the stage control. It applies to all types of stages.



[lo_docp_n2, 2, en_US]

Figure 6-475 Stage-Control Logic Diagram

Blocking of the Stage with Measuring-Voltage Failure (Basic and Advanced Stage)

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function (see chapter *8.3.2.1 Overview of Functions*)
- From an external source via the binary input signal **>Open** of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker

The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.27.3.2 Application and Setting Notes

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:8131:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following two conditions is met:

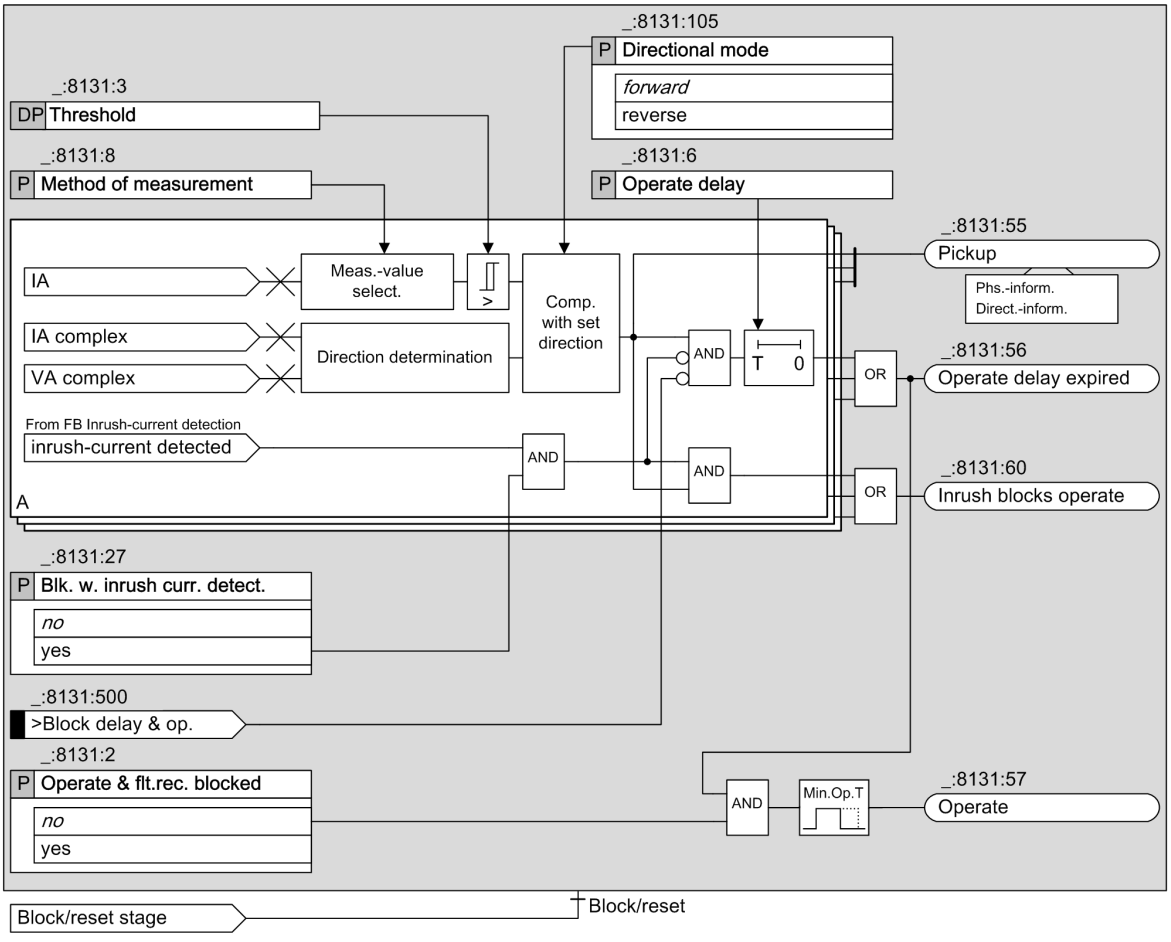
- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see chapter *8.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The directional overcurrent-protection stage is blocked. Siemens recommends that you retain the default setting, as correct direction determination cannot be guaranteed if a measuring-voltage failure occurs.
no	The directional overcurrent-protection stage is not blocked.

6.27.4 Stage with Definite-Time Characteristic Curve

6.27.4.1 Description

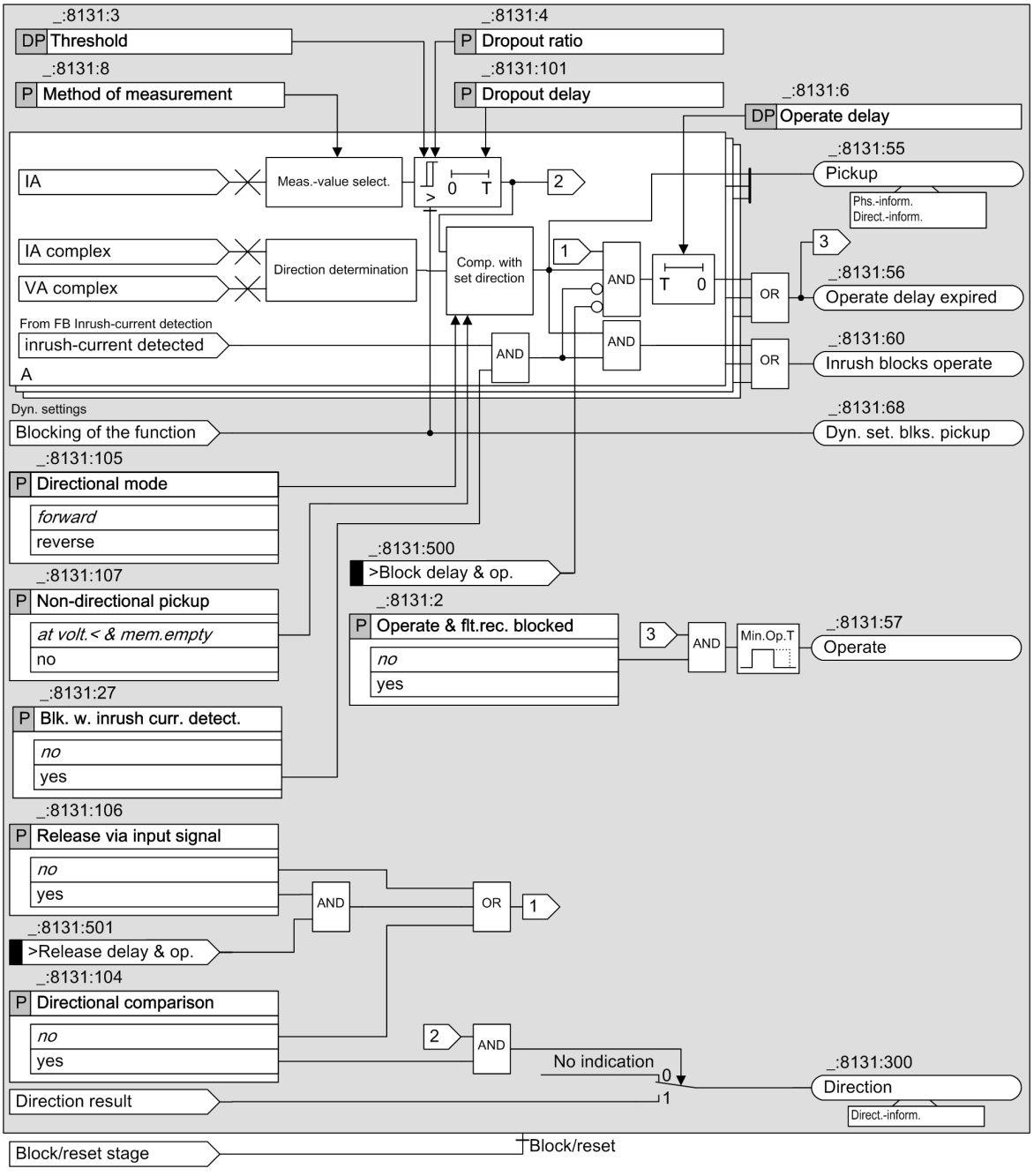
Logic of the Basic Stage



[lo_docg6b_2_en_US]

Figure 6-476 Logic Diagram of the Directional, Definite-Time Overcurrent Protection, Phases - Basic

Logic of the Advanced Stage



[lo_docp_31, 1, en_US]

Figure 6-477 Logic Diagram of the Directional, Definite-Time Overcurrent Protection, Phases - Advanced

Directional Mode (Basic and Advanced Stage)

You use the **`Directional mode`** parameter to define whether the stage works in a forward or reverse direction.

Direction determination itself works across stages (see section *6.27.7.1 Description*).

Non-Directional Pickup, Voltage Memory (Basic and Advanced Stage)

If a 3-phase close-up fault occurs, all 3 phase-to-ground voltages drop to almost 0. If this happens, direction determination can fall back on a voltage memory (see chapter *6.27.7.1 Description*). If no voltage

measurements which can be used to determine the direction are available in the voltage memory, the basic stage generally picks up without direction determination, that is non-directionally. For the advanced stage, the response can be defined via the **Non-directional pickup** parameter. With the ***at volt.< & mem.empty*** setting, the function picks up in such a situation without direction determination. With the ***no*** setting, the function does not pick up.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the **Directional comparison** parameter. With the ***yes*** setting, the function uses the threshold-value violation to determine the direction (forward or reverse) and reports the indication **Direction**. The direction indicated is independent of the directional mode set for the stage.

The **Release via input signal** setting and the **>Release delay & op.** input signal are available with directional comparison protection. If the **Release via input signal** parameter is set to ***yes***, the start of the time delay, and therefore the tripping of the stage, are only enabled if the **>Release delay & op.** input signal is active.

Method of Measurement (Basic and Advanced Stage)

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Dropout Delay (Advanced Stage)

If the value falls below the dropout threshold, the dropout can be delayed. The pickup is maintained for the specified time. The tripping delay continues to run. If the time delay expires while the pickup is still maintained, the stage operates.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal **>Block stage** (see chapter *6.27.3.1 Description*)
- Measuring-voltage failure (see chapter *6.27.3.1 Description*)
- Via the dynamic settings function (only provided in the Advanced function type, see chapter **Influence of other functions via dynamic settings** and chapter *6.23.8.1 Description*)

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.23.7.1 Description* .

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.23.8.1 Description* .

6.27.4.2 Application and Setting Notes

Parameter: `Directional mode`

- Default setting **`(_:8131:105) Directional mode`** = ***`forward`***

You use the **`Directional mode`** parameter to define the directional mode of the stage.

Parameter Value	Description
`forward`	Select this setting if the stage is to work in a forward direction (in the direction of the line).
`reverse`	Select this setting if the stage is to work in a reverse direction (in the direction of the busbar).

Parameter: `Method of measurement`

- Recommended setting value **`(_:8131:8) Method of measurement`** = ***`fundamental comp.`***

With the **`Method of measurement`** parameter, you define whether the stage uses the ***`fundamental comp.`*** (standard method) or the calculated ***`RMS value`***.

Parameter Value	Description
`fundamental comp.`	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
`RMS value`	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **`threshold value`** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

Parameter: `Directional comparison`, `Release via input signal`

- Default setting **`(_:8131:104) Directional comparison`** = ***`no`***
- Default setting **`(_:8131:106) Release via input signal`** = ***`no`***

These 2 parameters are not visible in the basic stage.

You use these parameters to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the **`Direction`** and **`>Release delay & op.`** signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.
yes	If the **Directional comparison** parameter is set to ***yes***, the **Release via input signal** parameter, the **Direction** output signal, and the **>Release delay & op.** input signal become available. If the **Release via input signal** parameter is set to ***yes***, the start of the time delay, and therefore also the operate signal of the stage, are only enabled if the **>Release delay & op.** input signal is active. The **>Release delay & op.** input signal must be connected to the release information from the opposite end (forward information from the **Direction** output signal); see also the application example in *6.27.10 Application Notes for Directional Comparison Protection* .

Parameter: **Non-directional pickup**

- Recommended setting value **(_:8131:107) Non-directional pickup** = ***at volt.< & mem.empty***

This parameter is not visible in the basic stage.

Parameter Value	Description
at volt.< & mem.empty	Select this setting if the stage is to pick up in a non-directional manner if the voltage memory is empty and determining of direction has to be performed at low voltages (3-phase close-up fault). An empty voltage memory may exist, for example, if there is a voltage transformer at the line end and the circuit breaker (CB) trips. Siemens recommends using the default setting.
no	Select this setting if determining of direction is required under all circumstances, that is, even in the event of pickup on a 3-phase close-up fault.

Parameter: **Threshold**

- Default setting **(_:8131:3) Threshold** = ***1.50 A*** (for the first stage)

The same considerations apply to setting the threshold value as for non-directional overcurrent protection. For further information, refer to section *6.23.4.2 Application and Setting Notes*.

Parameter: **Operate delay**

- Default setting **(_:8131:6) Operate delay** = ***0.300 s*** (for the 1st stage)

The Operate delay to be set is derived from the time-grading schedule that has been prepared for the system. Where overcurrent protection is used in emergency mode, shorter time delays might be reasonable (one grading time above fast tripping), since the emergency mode only operates if the main protection function fails.

Typical examples of grading times are provided in *6.27.9 Application Notes for Parallel Lines* and *6.27.10 Application Notes for Directional Comparison Protection* .

Parameter: **Dropout ratio**

- Recommended setting value **(_:8131:4) Dropout ratio** = ***0.95***

This parameter is not visible in the basic stage.

The recommended set value of 0.95 is appropriate for most applications.

For high-precision measurements, the setting value of the **Dropout ratio** parameter can be reduced, for example to 0.98. If you expect heavily fluctuating measurands at the response threshold, you can increase the setting value of the **Dropout ratio** parameter. This avoids chattering of the tripping stage.

Parameter: `Dropout delay`

- Recommended setting value **`(_:8131:101) Dropout delay`** = ***`0 s`***

This parameter is not visible in the basic stage.

Siemens recommends using this setting value, since the dropout of a protection stage must be performed as fast as possible.

You can use the **`Dropout delay`** parameter ≠ ***`0 s`*** to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical Data) and set the result.

6.27.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:102	General:Rotation angle of ref. volt.		-180 ° to 180 °	45 °
`General`				
_:8131:1	Definite-T 1:Mode		• off • on • test	off
_:8131:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:8131:105	Definite-T 1:Directional mode		• forward • reverse	forward
_:8131:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:8131:107	Definite-T 1:Non-directional pickup		• no • at volt.< & mem.empty	at volt.< & mem.empty
_:8131:104	Definite-T 1:Directional comparison		• no • yes	no
_:8131:106	Definite-T 1:Release via input signal		• no • yes	no
_:8131:10	Definite-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:8131:26	Definite-T 1:Dynamic settings		• no • yes	no
_:8131:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:8131:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:8131:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s

Addr.	Parameter	C	Setting Options	Default Setting
_:8131:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n.rdy				
_:8131:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:8131:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:8131:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:8131:36	Definite-T 1:Stage blocked		• no • yes	no
_:8131:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:8131:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:8131:37	Definite-T 1:Stage blocked		• no • yes	no
_:8131:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:8131:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no
_:8131:38	Definite-T 1:Stage blocked		• no • yes	no
_:8131:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.s: AR cycle>3				
_:8131:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:8131:39	Definite-T 1:Stage blocked		• no • yes	no
_:8131:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: Cold load PU				
_:8131:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:8131:40	Definite-T 1:Stage blocked		• no • yes	no
_:8131:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:8131:34	Definite-T 1:Effected by binary input		• no • yes	no
_:8131:41	Definite-T 1:Stage blocked		• no • yes	no
_:8131:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
General				
_:8132:1	Definite-T 2:Mode		• off • on • test	off
_:8132:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:8132:105	Definite-T 2:Directional mode		• forward • reverse	forward
_:8132:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:8132:107	Definite-T 2:Non-directional pickup		• no • at volt.< & mem.empty	at volt.< & mem.empty
_:8132:104	Definite-T 2:Directional comparison		• no • yes	no
_:8132:106	Definite-T 2:Release via input signal		• no • yes	no
_:8132:10	Definite-T 2:Blk. by meas.-volt. failure		• no • yes	yes
_:8132:26	Definite-T 2:Dynamic settings		• no • yes	no
_:8132:27	Definite-T 2:Blk. w. inrush curr. detect.		• no • yes	no
_:8132:3	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 200.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 200.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:8132:4	Definite-T 2:Dropout ratio		0.90 to 0.99	0.95
_:8132:101	Definite-T 2:Dropout delay		0.00 s to 60.00 s	0.00 s
_:8132:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.s: AR off/n.rdy				
_:8132:28	Definite-T 2:Effect. by AR off/n.ready		• no • yes	no
_:8132:35	Definite-T 2:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:8132:29	Definite-T 2:Effected by AR cycle 1		• no • yes	no
_:8132:36	Definite-T 2:Stage blocked		• no • yes	no
_:8132:14	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 200.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 200.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:8132:20	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 2				
_:8132:30	Definite-T 2:Effected by AR cycle 2		• no • yes	no
_:8132:37	Definite-T 2:Stage blocked		• no • yes	no
_:8132:15	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 200.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 200.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:8132:21	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.set: AR cycle 3				
_:8132:31	Definite-T 2:Effected by AR cycle 3		• no • yes	no
_:8132:38	Definite-T 2:Stage blocked		• no • yes	no
_:8132:16	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 200.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 200.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:8132:22	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.s: AR cycle>3				
_:8132:32	Definite-T 2:Effected by AR cycle gr. 3		• no • yes	no
_:8132:39	Definite-T 2:Stage blocked		• no • yes	no
_:8132:17	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 200.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 200.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:8132:23	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.s: Cold load PU				
_:8132:33	Definite-T 2:Effect. b. cold-load pickup		• no • yes	no
_:8132:40	Definite-T 2:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:8132:18	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 200.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 200.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:8132:24	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.set: bin.input				
_:8132:34	Definite-T 2:Effected by binary input		• no • yes	no
_:8132:41	Definite-T 2:Stage blocked		• no • yes	no
_:8132:19	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 200.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 200.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:8132:25	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s

6.27.4.4 Information List

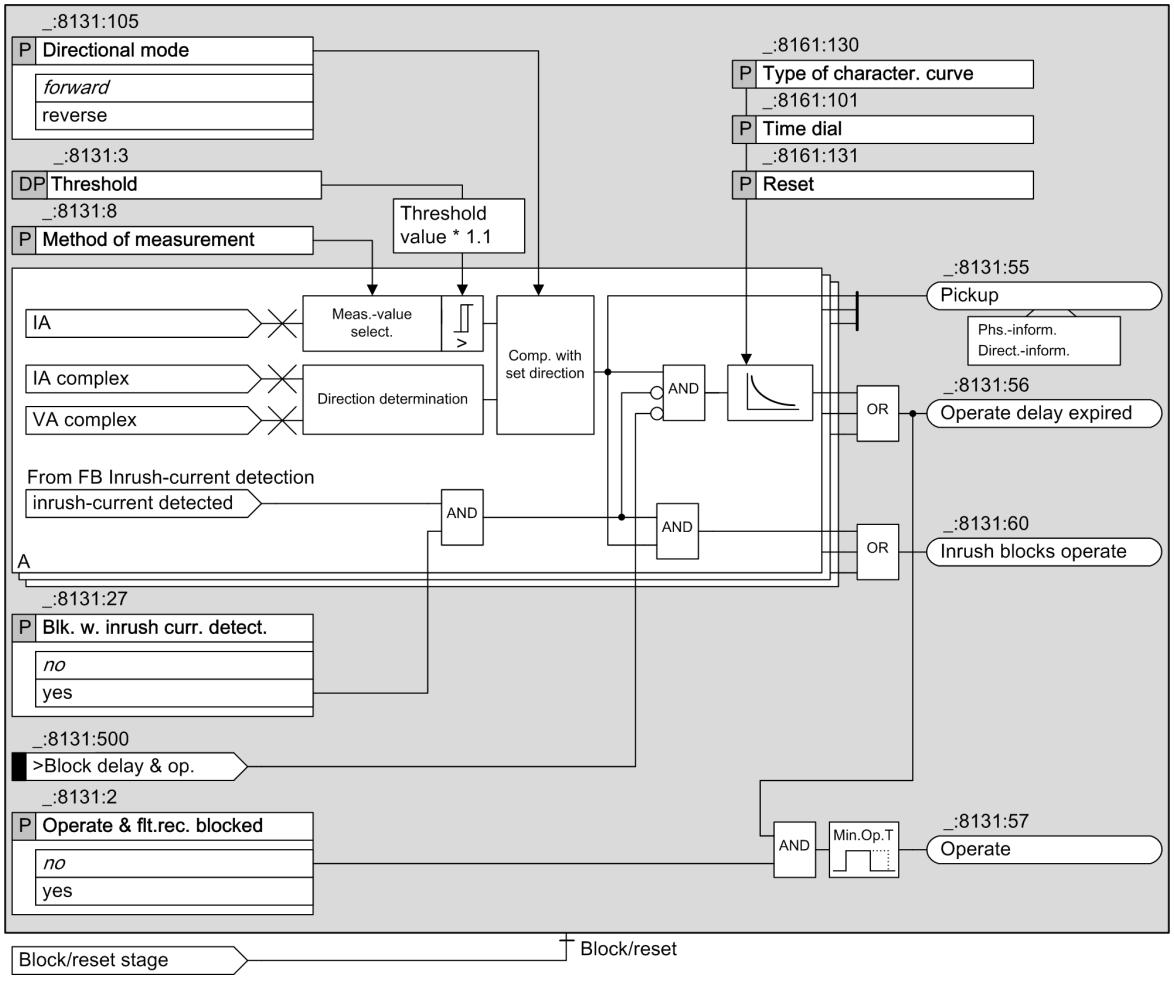
No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Activation emg. mode	SPS	I
_:2311:501	General:>Test of direction	SPS	I
_:2311:300	General:Emergency mode act.	SPS	O
_:2311:301	General:Test direction	ACD	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Definite-T 1			
_:8131:81	Definite-T 1:>Block stage	SPS	I
_:8131:501	Definite-T 1:>Release delay & op.	SPS	I
_:8131:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:8131:500	Definite-T 1:>Block delay & op.	SPS	I
_:8131:51	Definite-T 1:Mode (controllable)	ENC	C
_:8131:54	Definite-T 1:Inactive	SPS	O
_:8131:52	Definite-T 1:Behavior	ENS	O
_:8131:53	Definite-T 1:Health	ENS	O
_:8131:60	Definite-T 1:Inrush blocks operate	ACT	O

No.	Information	Data Class (Type)	Type
_:8131:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:8131:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:8131:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O
_:8131:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:8131:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:8131:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:8131:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O
_:8131:55	Definite-T 1:Pickup	ACD	O
_:8131:300	Definite-T 1:Direction	ACD	O
_:8131:56	Definite-T 1:Operate delay expired	ACT	O
_:8131:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:8132:81	Definite-T 2:>Block stage	SPS	I
_:8132:501	Definite-T 2:>Release delay & op.	SPS	I
_:8132:84	Definite-T 2:>Activ. dyn. settings	SPS	I
_:8132:500	Definite-T 2:>Block delay & op.	SPS	I
_:8132:54	Definite-T 2:Inactive	SPS	O
_:8132:52	Definite-T 2:Behavior	ENS	O
_:8132:53	Definite-T 2:Health	ENS	O
_:8132:60	Definite-T 2:Inrush blocks operate	ACT	O
_:8132:62	Definite-T 2:Dyn.set. AR cycle1act.	SPS	O
_:8132:63	Definite-T 2:Dyn.set. AR cycle2act.	SPS	O
_:8132:64	Definite-T 2:Dyn.set. AR cycle3act.	SPS	O
_:8132:65	Definite-T 2:Dyn.set. ARcycl.>3act	SPS	O
_:8132:66	Definite-T 2:Dyn.set. CLP active	SPS	O
_:8132:67	Definite-T 2:Dyn.set. BI active	SPS	O
_:8132:68	Definite-T 2:Dyn. set. blks. pickup	SPS	O
_:8132:55	Definite-T 2:Pickup	ACD	O
_:8132:300	Definite-T 2:Direction	ACD	O
_:8132:56	Definite-T 2:Operate delay expired	ACT	O
_:8132:57	Definite-T 2:Operate	ACT	O

6.27.5 Stage with Inverse-Time Characteristic Curve

6.27.5.1 Description

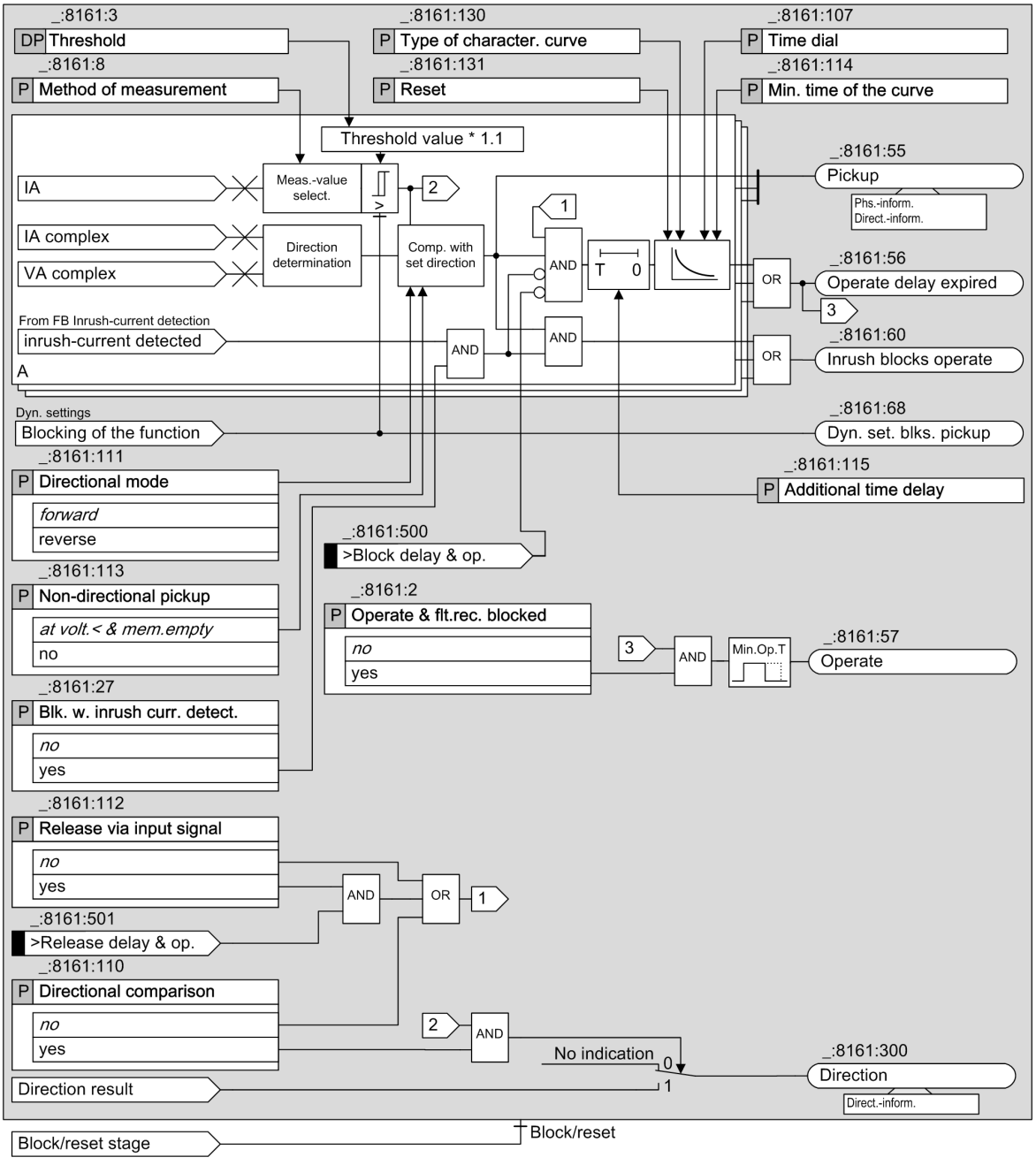
Logic of the Basic Stage



[lo_doci6b, 2, en_US]

Figure 6-478 Logic Diagram of the Directional, Inverse-Time Overcurrent Protection, Phases - Basic

Logic of the Advanced Stage



[lo_docp_33, 2, en_US]

Figure 6-479 Logic Diagram of the Directional, Inverse-Time Overcurrent Protection, Phases - Advanced

Directional Mode (Basic and Advanced Stage)

You use the **`Directional mode`** parameter to define whether the stage works in a forward or reverse direction.

The direction determination works across stages (see chapter *6.27.7.1 Description*).

Non-Directional Pickup, Voltage Memory (Basic and Advanced Stage)

If a 3-phase close-up fault occurs, all 3 phase-to-ground voltages drop to almost 0. If this happens, direction determination can fall back on a voltage memory (see chapter *6.27.7.1 Description*). If no voltage measurements which can be used to determine the direction are available in the voltage memory, the basic

stage generally picks up without direction determination, that is non-directionally. For the advanced stage, the response can be defined via the **Non-directional pickup** parameter. With the ***at volt.< & mem.empty*** setting, the function picks up in such a situation without direction determination. With the ***no*** setting, the function does not pick up.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the **Directional comparison** parameter. With the ***yes*** setting, the function uses the threshold-value violation to determine the direction (forward or reverse) and reports the indication **Direction**. The direction indicated is independent of the directional mode set for the stage.

The **Release via input signal** setting and the **>Release delay & op.** input signal are available with directional comparison protection. If the **Release via input signal** parameter is set to ***yes***, the start of the time delay, and therefore the tripping of the stage, are only enabled if the **>Release delay & op.** input signal is active.

Pickup and Dropout Behaviors of the Inverse-Time Characteristic Curve According to IEC and ANSI (Basic and Advanced Stage)

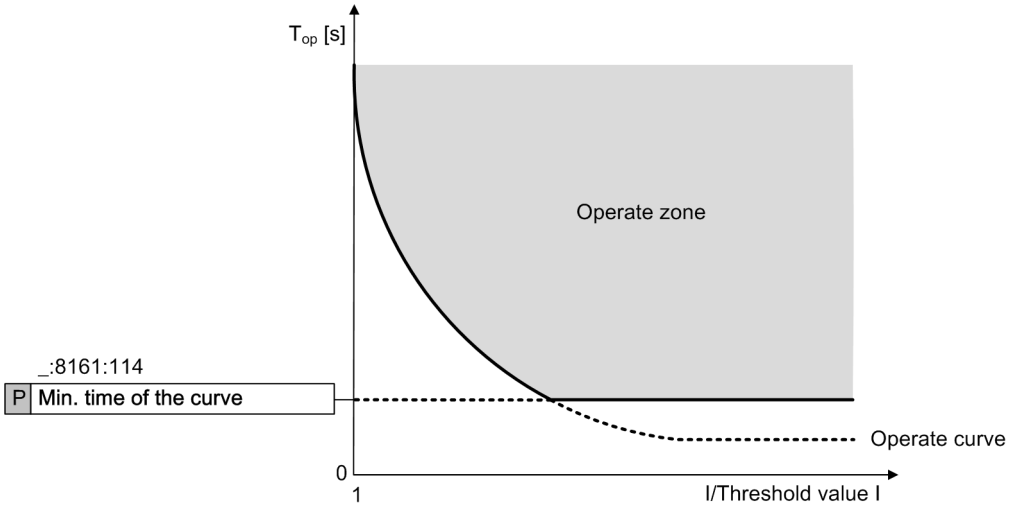
When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by a factor of 1.045 (0.95 · 1.1 · threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Minimum Time of the Curve (Advanced Stage)

With the parameter **Min. time of the curve**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.



[dw_docp_01, 1, en_US]

Figure 6-480 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter **Additional time delay**, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal **>Block stage** (see chapter *6.27.3.1 Description*)
- Measuring-voltage failure (see chapter *6.27.3.1 Description*)
- Via the functionality of the **dynamic settings** (only in the advanced function type, see subtitle **Influence of other functions via dynamic settings** and chapter *6.23.8.1 Description*).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.23.7.1 Description* .

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.23.8.1 Description* .

6.27.5.2 Application and Setting Notes

Parameter: Directional mode

- Default setting **(_:8161:111) Directional mode** = ***forward***

You use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in a forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in a reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value **(_:8161:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

Parameter: Directional comparison, Release via input signal

- Default setting **(_:8161:110) Directional comparison** = ***no***
- Default setting **(_:8161:112) Release via input signal** = ***no***

These 2 parameters are not visible in the basic stage.

You use these parameters to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the **Direction** and **>Release delay & op.** signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.
yes	If the **Directional comparison** parameter is set to ***yes***, the **Release via input signal** parameter, the **Direction** output signal, and the **>Release delay & op.** input signal become available. If the **Release via input signal** parameter is set to ***yes***, the start of the time delay, and therefore also the operate signal of the stage, are only enabled if the **>Release delay & op.** input signal is active. The **>Release delay & op.** input signal must be connected to the release information from the opposite end (forward information from the **Direction** output signal); see also the application example in *6.27.10 Application Notes for Directional Comparison Protection* .

Parameter: Non-directional pickup

- Recommended setting value **(_:8161:113) Non-directional pickup** = ***at volt.< & mem.empty***

This parameter is not visible in the basic stage.

Parameter Value	Description
at volt.< & mem.empty	Select this setting if the stage is to pick up in a non-directional manner if the voltage memory is empty and determining of direction has to be performed at low voltages (3-phase close-up fault). An empty voltage memory may exist, for example, if there is a voltage transformer at the line end and the CB trips. Siemens recommends using the default setting.
no	Select this setting if determining of direction is required under all circumstances, that is, even in the event of pickup on a 3-phase close-up fault.

Parameter: Type of character. curve

- Default setting **(_:8161:130) Type of character. curve** = ***IEC normal inverse***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **Type of character. curve** required for your specific application.

Parameter: Min. time of the curve

- Default setting **(_:8161:114) Min. time of the curve** = ***0.00 s***

This parameter is only available in the advanced stage.

With the parameter **Min. time of the curve**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.



NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: Additional time delay

- Default setting **(_:8161:115) Additional time delay** = ***0.00 s***

With the parameter **Additional time delay**, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

Parameter: Threshold

- Default setting **(_:8161:3) Threshold** = ***1.50 A***

The same considerations apply to setting the threshold value as for non-directional overcurrent protection. Therefore, refer to *6.23.5.2 Application and Setting Notes* for further information.

Parameter: Time dial

- Default setting **(_:8161:101) Time dial** = ***1***

Use the **Time dial** parameter to displace the characteristic curve in the time direction.

The set value for the **Time dial** parameter is derived from the time-grading chart that has been prepared for the electrical power system. Where overcurrent protection is used in emergency mode, shorter time delays might be reasonable (one grading time above fast tripping), since the emergency mode only operates if the main protection function fails.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the **Time dial** parameter at ***1*** (default setting).

Parameter: Reset

- Default setting **(_:8161:131) Reset** = ***disk emulation***

You use the **Reset** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

6.27.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:102	General:Rotation angle of ref. volt.		-180 ° to 180 °	45 °
General				
_:8161:1	Inverse-T 1:Mode		• off • on • test	off
_:8161:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:8161:111	Inverse-T 1:Directional mode		• forward • reverse	forward
_:8161:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:8161:113	Inverse-T 1:Non-directional pickup		• no • at volt.< & mem.empty	at volt.< & mem.empty
_:8161:110	Inverse-T 1:Directional comparison		• no • yes	no
_:8161:112	Inverse-T 1:Release via input signal		• no • yes	no
_:8161:10	Inverse-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:8161:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:8161:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:8161:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:130	Inverse-T 1:Type of character. curve			
_:8161:114	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:8161:131	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:8161:101	Inverse-T 1:Time dial		0.05 to 15.00	1.00
_:8161:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:8161:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:8161:35	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 1				
_:8161:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:8161:36	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:102	Inverse-T 1:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:8161:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:8161:37	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:103	Inverse-T 1:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:8161:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no
_:8161:38	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:104	Inverse-T 1:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:8161:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:8161:39	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:8161:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:105	Inverse-T 1:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:8161:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:8161:40	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:106	Inverse-T 1:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:8161:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:8161:41	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:107	Inverse-T 1:Time dial		0.05 to 15.00	1.00

6.27.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Activation emg. mode	SPS	I
_:2311:501	General:>Test of direction	SPS	I
_:2311:300	General:Emergency mode act.	SPS	O
_:2311:301	General:Test direction	ACD	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:4501:53	Group indicat.:Health	ENS	O
Inverse-T 1			
_:8161:81	Inverse-T 1:>Block stage	SPS	I
_:8161:501	Inverse-T 1:>Release delay & op.	SPS	I
_:8161:84	Inverse-T 1:>Activ. dyn. settings	SPS	I
_:8161:500	Inverse-T 1:>Block delay & op.	SPS	I
_:8161:51	Inverse-T 1:Mode (controllable)	ENC	C
_:8161:54	Inverse-T 1:Inactive	SPS	O
_:8161:52	Inverse-T 1:Behavior	ENS	O
_:8161:53	Inverse-T 1:Health	ENS	O
_:8161:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:8161:62	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:8161:63	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:8161:64	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:8161:65	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:8161:66	Inverse-T 1:Dyn.set. CLP active	SPS	O
_:8161:67	Inverse-T 1:Dyn.set. BI active	SPS	O
_:8161:68	Inverse-T 1:Dyn. set. blks. pickup	SPS	O
_:8161:59	Inverse-T 1:Disk emulation running	SPS	O
_:8161:55	Inverse-T 1:Pickup	ACD	O
_:8161:300	Inverse-T 1:Direction	ACD	O
_:8161:56	Inverse-T 1:Operate delay expired	ACT	O
_:8161:57	Inverse-T 1:Operate	ACT	O

6.27.6 Stage with User-Defined Characteristic Curve

6.27.6.1 Description

The structure of this stage is identical to that of the advanced stage with directional inverse-time characteristic curve (*6.27.4.1 Description*). The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

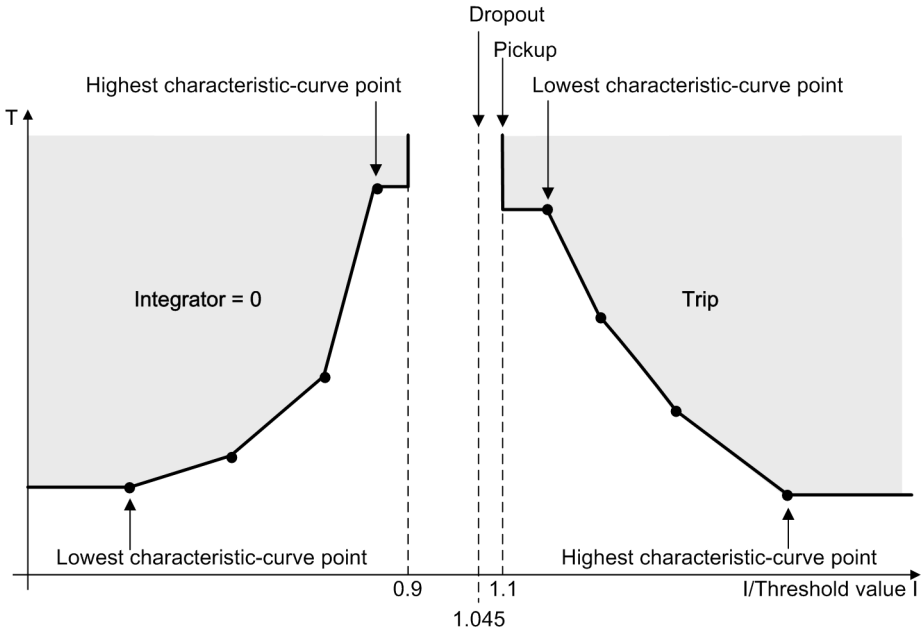
With the directional, user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

Pickup and Dropout Behaviors with User-Defined Characteristic Curve

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.



[dw_ocp_ken_02, 2, en_US]

Figure 6-481 Pickup and Dropout Behaviors when Using a Directional User-Defined Characteristic Curve

NOTE

Note that the currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

6.27.6.2 Application and Setting Notes

This stage is structured in the same way as the stage with a directional inverse-time characteristic curve. The only difference is that you can define the characteristic curve as desired. This chapter only provides application and setting notes for setting characteristic curves.

Parameter: `Current/time value pairs` (from the operate curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: `Time dial`

- Default setting **`(_:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The set value for the **Time dial** parameter is derived from the time-grading chart that has been prepared for the electrical power system. Where no time grading and therefore no displacement of the characteristic curve is required, leave the **Time dial** parameter set to ***1***.

Parameter: Reset

- Default setting **(_:115) Reset** = ***disk emulation***

You use the **Reset** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: Current/time value pairs (of the dropout characteristic curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **Threshold** parameter to ***1.00*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the **Time dial** parameter.



NOTE

The value pairs must be entered in continuous order.

6.27.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:110	User curve #:Directional mode		• forward • reverse	forward
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:112	User curve #:Non-directional pickup		• no • at volt.< & mem.empty	at volt.< & mem.empty
_:109	User curve #:Directional comparison		• no • yes	no
_:111	User curve #:Release via input signal		• no • yes	no
_:10	User curve #:Blk. by meas.-volt. failure		• no • yes	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:115	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

6.27.6.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:501	User curve #:>Release delay & op.	SPS	I
_:84	User curve #:>Activ. dyn. settings	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:62	User curve #:Dyn.set. AR cycle1act.	SPS	O
_:63	User curve #:Dyn.set. AR cycle2act.	SPS	O
_:64	User curve #:Dyn.set. AR cycle3act.	SPS	O
_:65	User curve #:Dyn.set. ARcycl.>3act	SPS	O
_:66	User curve #:Dyn.set. CLP active	SPS	O
_:67	User curve #:Dyn.set. BI active	SPS	O
_:68	User curve #:Dyn. set. blks. pickup	SPS	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:309	User curve #:Direction	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.27.7 Direction Determination

6.27.7.1 Description

General

Every phase has a separate direction-measuring element. If the threshold value in a phase is exceeded, the direction determination is started for this phase. If there are multiphase short circuits, all measuring elements involved perform direction determination independently. If one of the determined directions matches the set direction, the stage picks up (see descriptions of the stage logic).

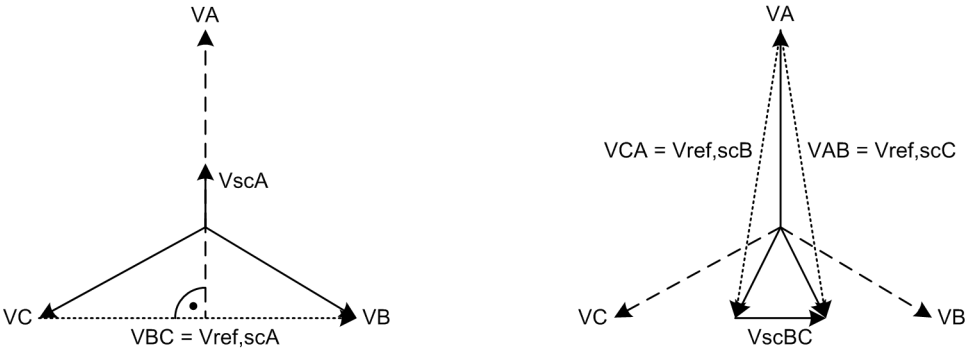
The direction is determined by calculating the phase angle between the short-circuit current and a reference voltage.

Measurands for Direction Determining

The directional measuring element uses the short-circuit current of the phase concerned and the cross-polarized phase-to-phase voltage (as the reference voltage) to determine the direction. This means that the direction can still be determined unambiguously and correctly, even if the short-circuit voltages collapse completely when a 1-phase or 2-phase fault occurs (close-up fault).

The phase-to-phase voltages are calculated when phase-to-ground voltages are connected.

The cross-polarized voltage (reference voltage) is vertical in relation to the short-circuit voltages for 1-phase-to-ground faults (*Figure 6-482*, left). For 2-phase short circuits, the position of the reference voltages changes up to 30°, depending on the extent to which the short-circuit voltages collapse (*Figure 6-482*, right).



[dw_docp_02, 1, en_US]

Figure 6-482 Cross-Polarized Voltages for Direction Determination

The following table shows how measurands are assigned for direction-determination purposes in the event of different types of fault.

Table 6-12 Measurands for Direction Determining

Threshold-Value Exceeding	Measuring Element							
	A		B		C		Ground	
	Current	Voltage	Current	Voltage	Current	Voltage	Current	Voltage
A	I_A	V_{BC}	–	–	–	–	–	–
B	–	–	I_B	V_{CA}	–	–	–	–
C	–	–	–	–	I_C	V_{AB}	–	–
Gnd	–	–	–	–	–	–	I_r	V_0
A, Gnd	–	V_{BC}	–	–	–	–	I_r	V_0
B, Gnd	–	–	I_B	V_{CA}	–	–	I_r	V_0
C, Gnd	–	–	–	–	I_C	V_{AB}	I_r	V_0
A, B	I_A	V_{BC}	I_B	V_{CA}	–	–	–	–
B, C	–	–	I_B	V_{CA}	I_C	V_{AB}	–	–
A, C	I_A	V_{BC}	–	–	I_C	V_{AB}	–	–
A, B, Gnd	I_A	V_{BC}	I_B	V_{CA}	–	–	I_r	V_0
B, C, Gnd	–	–	I_B	V_{CA}	I_C	V_{AB}	I_r	V_0
A, C, Gnd	I_A	V_{BC}	–	–	I_C	V_{AB}	I_r	V_0
A, B, C	I_A	V_{BC}	I_B	V_{CA}	I_C	V_{AB}	–	–
A, B, C, Gnd	I_A	V_{BC}	I_B	V_{CA}	I_C	V_{AB}	I_r	V_0

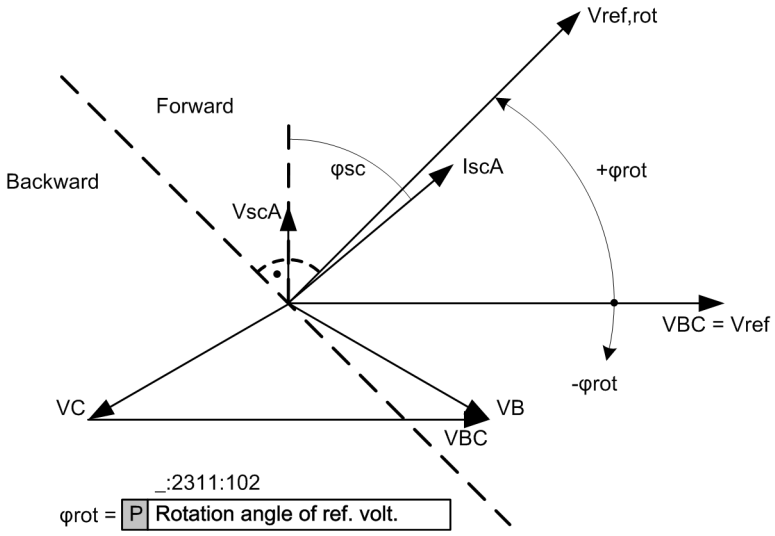
Voltage Memory

Saved voltages are used if, when a 3-pole close-up fault occurs, the measuring voltages are not sufficient for reliable direction determination. Insofar as and as long as no sufficient measuring voltage is available after the storage time (2 s) has elapsed, the detected direction is retained. If the memory does not contain any voltages (when closing onto a short circuit, for example), the behavior of the stage is defined using the **`Non-directional pickup`** parameter.

Direction Determination

As mentioned in the **General** section, the direction is determined by calculating the phase angle between short-circuit current and reference voltage. To take different system conditions and applications into account, the reference voltage can be rotated through an adjustable angle (**`Rotation angle of ref. volt.`** parameter). This moves the vector of the rotated reference voltage close to the vector of the short-circuit

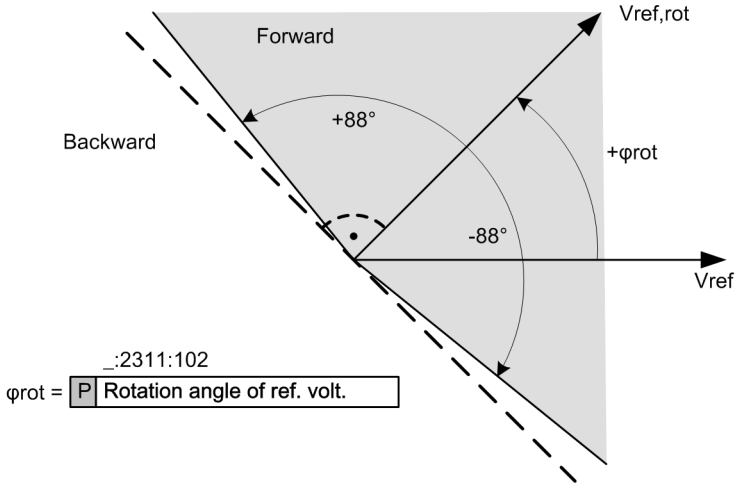
current. Consequently, the result of direction determination is as reliable as possible. *Figure 6-483* illustrates the relationship based on a 1-phase ground fault in phase A. The short-circuit current I_{scA} lags the short-circuit voltage by the short-circuit angle φ_{sc}. The reference voltage, in this case V_{BC} for measuring element A, is rotated positively (counterclockwise) by the setting value of the **`Rotation angle of ref. volt.`** parameter. In the scenario illustrated here, the rotation is +45°.



[dw_docp_33, 2, en_US]

Figure 6-483 Rotation of the Reference Voltage, Phase-Measuring Element

The rotated reference voltage defines the forward and reverse range, as shown in *Figure 6-484*. The forward range is calculated as ±88° around the rotated reference voltage $V_{ref,rot}$. If the short-circuit current vector is located in this range, the device decides on the forward direction. In the mirrored range, the device decides on the backward direction. In the intermediate range, the direction is undetermined.



[dw_docp_34, 2, en_US]

Figure 6-484 Forward Characteristic of the Directional Function, Phase-Measuring Element

Direction Determination for Test Purposes

If you activate the binary input signal **`>Test of direction`**, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. The direction can be determined as soon as current and voltage are greater than approx. 7 % of their secondary rated values.

6.27.7.2 Application and Setting Notes

Parameter: `Rotation angle of ref. volt.`

- Default setting **`(_:2311:102) Rotation angle of ref. volt.`** = ***45°***

The directional characteristic, that is, the position of the **forward** and **reverse** ranges, is set with the **`Rotation angle of ref. volt.`** parameter. The short-circuit angle is typically to be found in a range from 30° to 60° inductive. Therefore, in most cases, the default setting of +45° can be retained to position the reference voltage, as it ensures a reliable directional result.

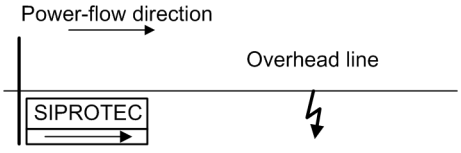
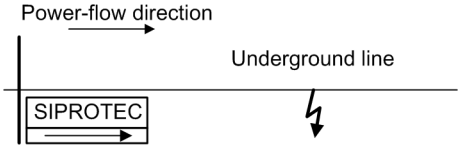
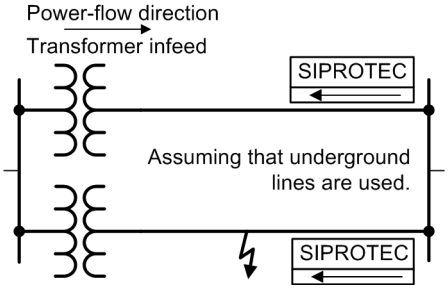
Some example settings for special applications appear in the following (*Table 6-13*). Please note that for phase-to-ground faults (PG faults), the reference voltage (fault-free voltage) is vertical in relation to the short-circuit voltage. This results in the following setting for the rotation angle:

`Rotation angle of ref. volt.` = 90 - φsh phase-measuring elements (PG faults)

Please also note that for phase-to-phase faults, the reference voltage is rotated between 0° (distant fault) and 30° (close-up fault) dependent upon the collapse of the faulted voltage (see *Figure 6-483*). You can take this into account with an average value of 15°.

`Rotation angle of ref. volt.` = 90 - φsh - 15° phase-measuring elements (PP faults)

Table 6-13 Example settings

Application	φsh typical	Setting `Rotation angle of ref. volt.`
	60°	Range 30° to 0° for PP faults Selected: 15°
	30°	Range 60° to 30° for PP faults Selected: 45°
	30°	Range 60° to 30° for PP faults Selected: 45°

Input signal: `>Test of direction`

If you activate the binary input signal **`>Test of direction`**, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. This provides an easy means of checking the direction during commissioning, without changing the threshold values of the stages.

6.27.8 Influence of Other Functions via Dynamic Settings

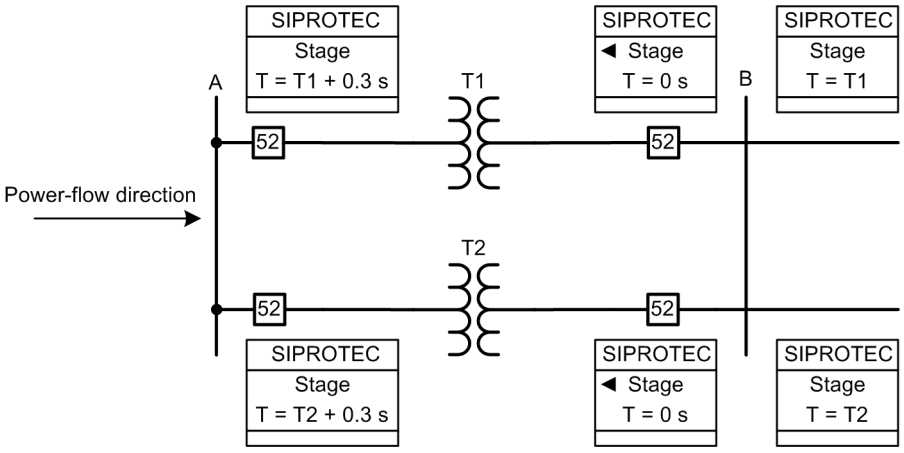
The influence of these functions via dynamic settings is described in chapter *6.23.8.1 Description* and chapter *6.23.8.2 Application and Setting Notes (Advanced Stage)* .

6.27.9 Application Notes for Parallel Lines

Parallel Lines or Transformers

In parallel lines or transformers with infeed at one end (see *Figure 6-485*), if there is no directional measuring element, a fault on feeder T1 will also trip the other feeder T2. In contrast, a directional measuring element in the devices on busbar B prevents the tripping of the circuit breaker in the parallel feeder. Therefore, in *Figure 6-485*, directional overcurrent protection is used in the places marked with direction arrows. Please note that the forward direction of the protection device represents the direction towards the object to be protected. This does not have to be the same as the power direction of normal power flow.

Set time grading in opposition to the power flow with increasing time. As load can only flow in one direction, you can set the directional devices without time delay.



[dw_docp_05, 1, en_US]

Figure 6-485 Parallel Line with Transformers

Legend for *Figure 6-485*

Stage ►:	Directional stage, **forward** direction set
Stage:	Non-directional stage
T:	Grading time

6.27.10 Application Notes for Directional Comparison Protection

The direction determination of directional overcurrent protection can be used to implement directional comparison protection for cable runs with infeed at both ends. Directional comparison protection is used for the selective isolation of a faulted line section (for example, subsections of closed rings). Sections are isolated in fast time, that is, they do not suffer the disadvantage of long grading times.

This technique requires that directional information can be exchanged between the individual protection stations. You can implement this information exchange using a communication channel (protection interface or IEC 61850 GOOSE) or with pilot wires for signal transmission via an auxiliary voltage loop.

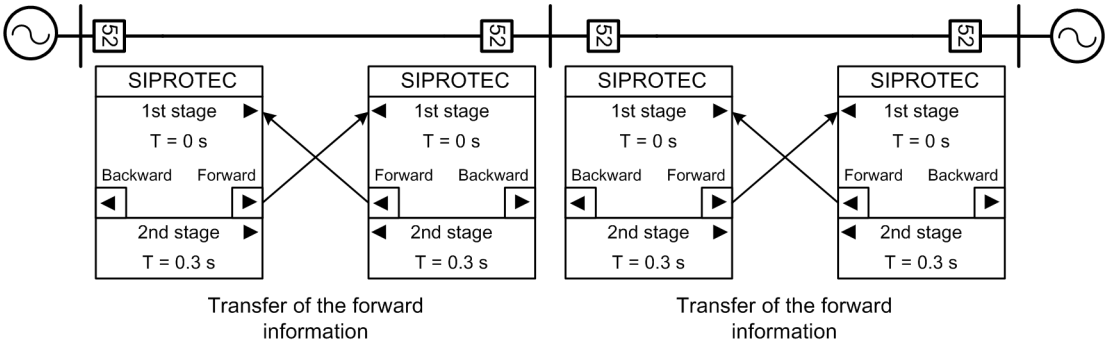
Protection Principle

The protection principle is shown in *Figure 6-486*. 2 devices (one at the start of the line and the other at the end of the line) work together in each line section. The information **fault in forward direction** is transferred between them. A directional definite-time overcurrent protection level is in operation in both devices in the forward direction (1st level). However, this level is not enabled in the idle state. The level is only released when the information **fault in forward direction** is received from the opposite end. If the enabled level also defines the fault in the forward direction, the fault must be on this line section and the level trips immediately. As this protection principle works with an enable procedure (and not with a blocking procedure), there is no need to delay the level.

A second directional definite-time overcurrent protection stage with standard time grading works in parallel with the first stage as a selective backup stage. This ensures full selectivity of protection in the following situations:

- Infeed at one end or weak infeed at one end: In this case, no release signal is generated.
- Failure of the communication route: In this case, the release signal is not transmitted.

To provide selective protection in fast time for busbars between the line sections also, you can combine this protection principle with the principle of reverse interlocking. This principle is not discussed in further detail in this document.



[dw_docp_07, 2, en_US]

Figure 6-486 Selectivity through Directional Comparison Protection

Legend for *Figure 6-486*

Stage ►:	Stage is set in the **forward** direction; stage 1 is instantaneous, stage 2 is graded
►, ◄:	If a threshold value is exceeded, the stage indicates the direction (forward or reverse)

If you are using a communication channel, the protocol-transmission methods detect if the channel is interrupted. If you are using pilot wires, Siemens recommends an operation based on a closed-circuit connection. The device uses a CFC chart to check and indicate if the binary input is dead for an unexpectedly long period. In contrast with the blocking procedure, overfunction is not possible if communication is lost. Therefore, a loss of communication is not critical where this procedure is concerned, although it must be detected and indicated.

Directional comparison protection can also be implemented as a blocking procedure. This procedure works under all system switching states, i.e. also with infeed at one end (or weak infeed). However, to use it you must delay the stage (typically by 100 ms) so that the blocking signal is received in time under all circumstances. It is also essential that you monitor the communication channel to avoid overfunction in the event of failure followed by a system incident.

Configuration of the Stage, CFC Chart

To configure the stage, proceed as follows:

- The **Directional mode** parameter of both stages must be set to ***forward***
- The **Directional comparison** and **Release via input signal** parameters of the first stage must be set to ***yes***. This is so that the first stage is only released if the **>Release delay & op.** input signal is active. Furthermore, the direction is indicated if a threshold value is exceeded.
- The first stage can be set without a time delay. The second stage has to be graded
- The information ***forward*** from the **Direction** signal in the first stage must be transmitted to the opposite end. The routing is determined by the type of transmission
- A CFC chart has to be implemented at the receive end to link the received (***forward*** information) and release signals, dependent upon the type of transmission.

6.28 Directional Overcurrent Protection, Ground

6.28.1 Overview of Functions

The **Directional overcurrent protection, ground** function (ANSI 67N):

- Detects short circuits to ground affecting electric equipment
- Ensures selective ground-fault detection for parallel lines or transformers with infeed at one end
- Ensures selective ground-fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies

6.28.2 Structure of the Function

The **Directional overcurrent protection, ground** function can be used in protection function groups which provide zero-sequence current and zero-sequence voltage measurements. 2 function types are offered:

- **Directional overcurrent protection, ground – advanced** (67N Dir.OC-gnd-A)
- **Directional overcurrent protection, ground – basic** (67N Dir.OC-gnd-B)

The basic function type shall be used for standard applications. The advanced function type provides more functionalities and is intended for more sophisticated applications.

Both function types are preconfigured by the manufacturer with 2 **Definite-time overcurrent protection** stages and 1 **Inverse-time overcurrent protection** stage.

In the advanced function type **Directional overcurrent protection, ground – advanced**, the following stages can operate simultaneously:

- A maximum of 4 **Definite-time overcurrent protection – advanced** stages
- 1 **Inverse-time overcurrent protection – advanced** stage
- 1 **Logarithmic inverse-time overcurrent protection** stage
- 1 **Logarithmic inverse time with knee-point overcurrent protection** stage
- 1 **User-defined characteristic curve overcurrent protection** stage

In the basic function type **Directional overcurrent protection, ground – basic**, the following stages can operate simultaneously:

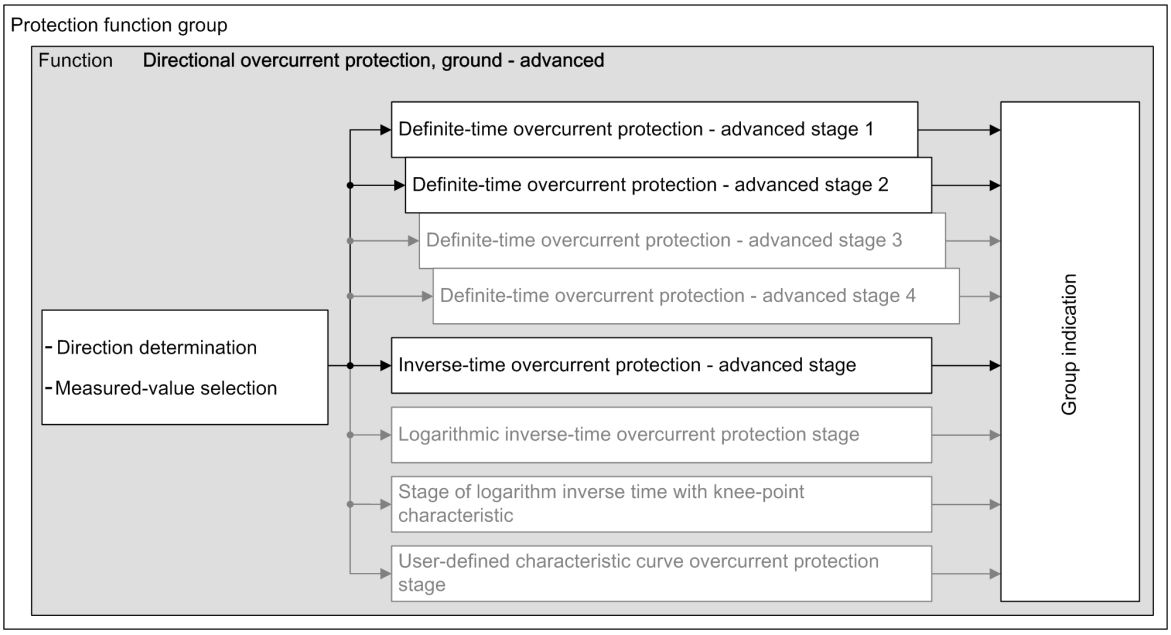
- A maximum of 4 **Definite-time overcurrent protection – basic** stages
- 1 **Inverse-time overcurrent protection – basic** stage

Referring to *Figure 6-487* and *Figure 6-488*, the stages not preconfigured are shown in gray. Apart from the operate-delay characteristic curve, the stages are similar in structure.

The general functionality includes the direction determination and the measured-value selection (only advanced function). They take place on the functional level and have a uniform effect on the stages (see *Figure 6-487* and chapter *6.13.3 General Functionality*). This ensures that all stages of the function receive the same measured current value and the same direction result. Each stage can be set to work in forward or reverse direction.

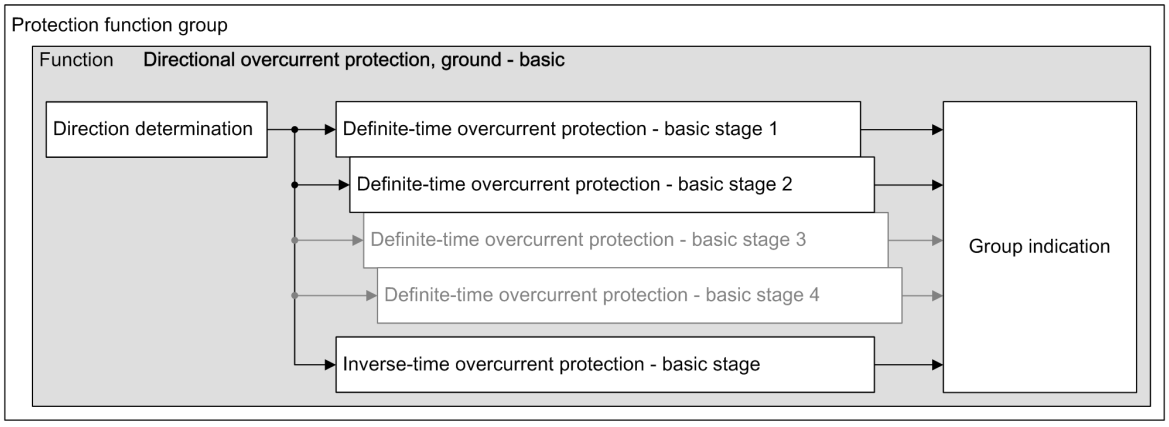
The group indication output logic generates the following group indications for the protection function by the logic OR from the stage-selective indications:

- Pickup
- Operate



[dw_rdirad, 3, en_US]

Figure 6-487 Structure/Embedding of the Function Directional Overcurrent Protection, Ground – Advanced



[dw_rdirba, 2, en_US]

Figure 6-488 Structure/Embedding of the Function Directional Overcurrent Protection, Ground – Basic

If the following listed device-internal functions are present in the device, these functions can influence the pickup values and operate delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Automatic reclosing (AREC)
- Cold-load pickup detection
- Binary input signal

If the device is equipped with the **Inrush-current detection** function, the stages can be stabilized against operate due to transformer-inrush currents.

6.28.3 General Functionality

6.28.3.1 Measured-Value Selection

Logic

The function provides the option to select between the values ***IN measured*** or ***3I0 calculated***.

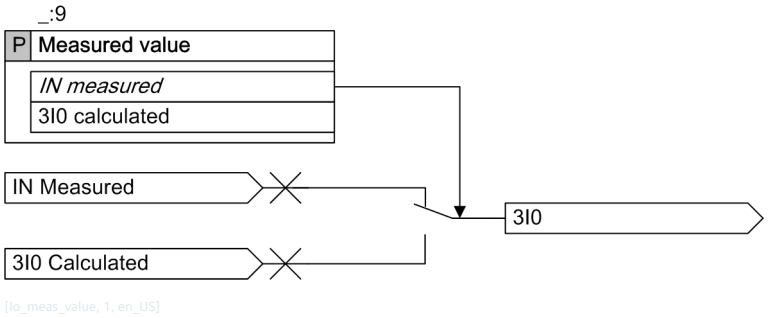


Figure 6-489 Logic Diagram of Measured-Value Selection

Both options are only available for the current-transformer connection types ***3-phase + IN*** and ***3-phase + IN-separate***. For other connection types respectively, only one option is possible. If you select an option that is not allowed, an inconsistency message is given.

Depending on the CT secondary rated current, the CT connection type, and the selected setting, the secondary threshold setting range varies according to the following table.

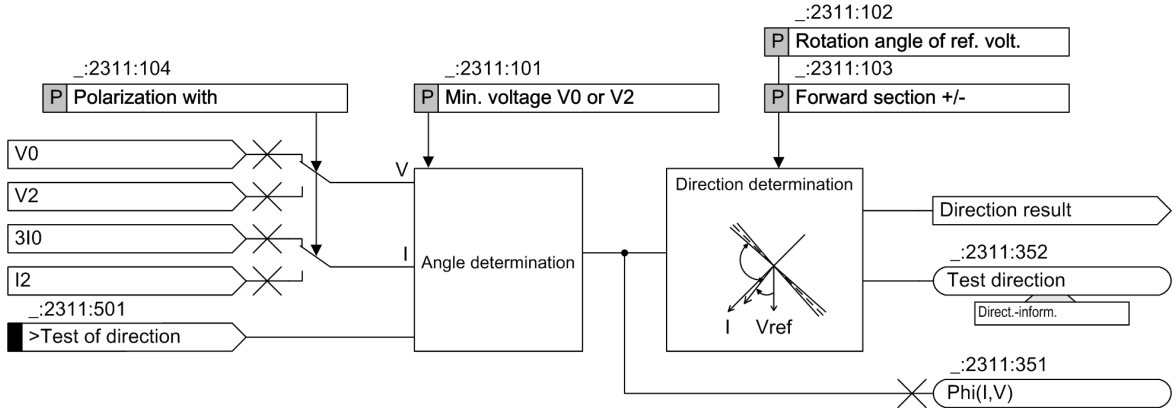
Table 6-14 Threshold Setting Range

Connection Type	Measured Value	CT Terminal Type	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 5 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 5 A)
3ph + IN	3I0 calculated	4 * Protection	0.030 A to 40.000 A	N/A	N/A	0.15 A to 200.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.030 A to 40.000 A	N/A	N/A	0.15 A to 200.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
3ph + IN-separate	3I0 calculated	4 * Protection	0.030 A to 40.000 A	0.030 A to 40.000 A	0.15 A to 200.00 A	0.15 A to 200.00 A
		3 * Protection, 1 * sen.	0.030 A to 40.000 A	0.030 A to 40.000 A	0.15 A to 200.00 A	0.15 A to 200.00 A
		4 * Measurement	0.001 A to 1.600 A	0.001 A to 1.600 A	0.005 A to 8.000 A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.030 A to 40.000 A	0.15 A to 200.00 A	0.030 A to 40.000 A	0.15 A to 200.00 A
		3 * Protection, 1 * sen.	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A
		4 * Measurement	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A

6.28.3.2 Direction Determination

Logic of Direction Determination

The following figure represents the logic of the direction determination. It applies to all types of stages.



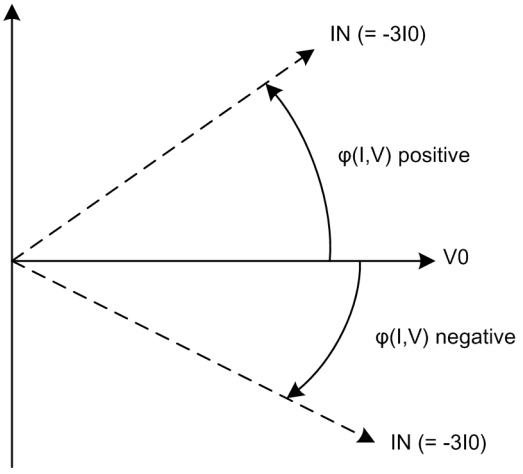
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Figure 6-490 Logic Diagram of Direction Determination

Measurand for the Direction Determination

With the parameter **`Direct. determination with`** you define whether the direction determination is calculated with the zero-sequence components 3I0 and V0 or with the negative-sequence components I2 and V2, which are present during faults in the network.

The angle between IN (=-3I0) and V0 (respectively -I2 and V2) in case of using the negative-sequence components is available as a functional measured value. This value is only present during faults in the network.



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Figure 6-491 Measured-Value Definition

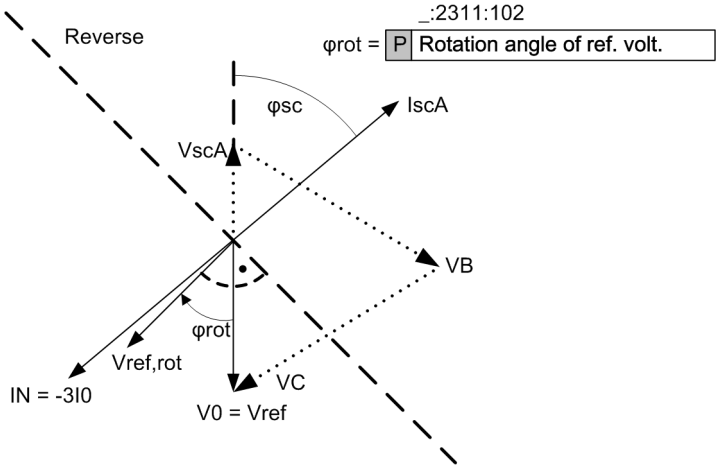
Start of the Direction Determination

If the zero-sequence current 3I0 exceeds the pickup threshold of a stage and the selected voltage (V0 or V2) exceeds the parameter **`Min. voltage V0 or V2`** as well, the direction determination is started.

Direction Determination with Zero-Sequence Values

The direction is determined by calculating the phase angle between the short-circuit current -3I0 and the rotated reference voltage $V_{ref, rot}$. Contrary to the **Directional overcurrent protection, phase** function, which works with the healthy voltage as reference voltage, the fault voltage V0 itself is the reference voltage for the **Directional overcurrent protection, ground** function. To take different system conditions and applications

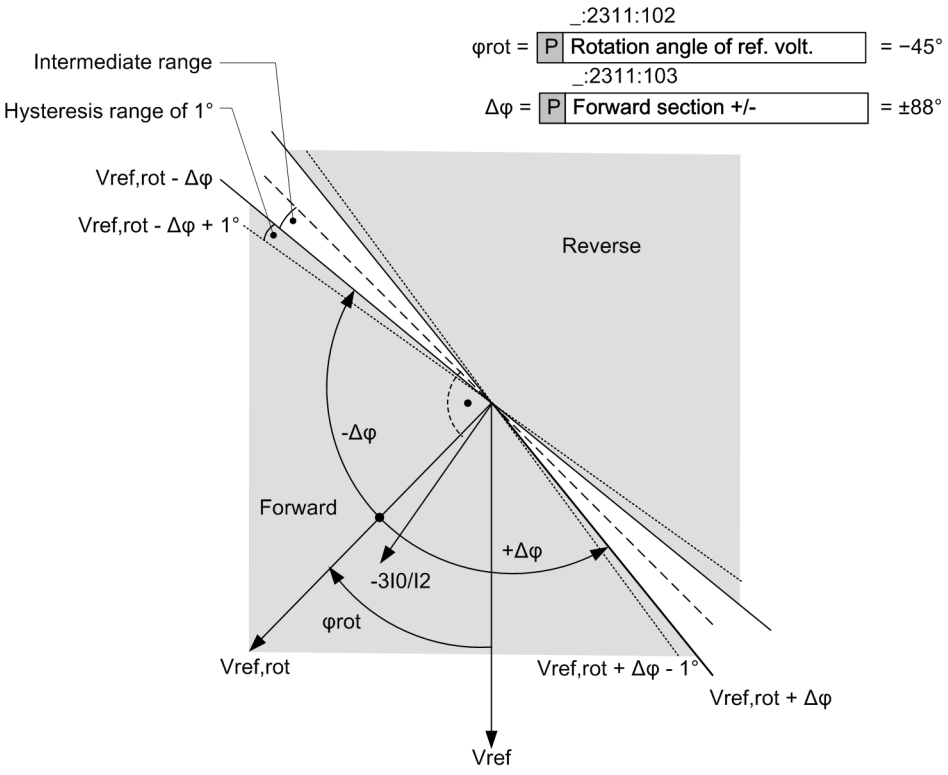
into account, the reference voltage V0 can be rotated through an adjustable angle (parameter **`Rotation angle of ref. volt.`**). This moves the vector of the rotated reference voltage close to the vector of the short-circuit current -3I0. Consequently, the result of direction determination is as reliable as possible. *Figure 6-492* illustrates the relationship based on a 1-phase-to-ground fault in phase A. The fault current has a phase displacement of 180° to the fault current IscA and lags the fault voltage by the fault angle φsc. The reference voltage V0 is rotated by φrot which is -45°.



[dw_roreze, 2, en_US]

Figure 6-492 Rotation of the Reference Voltage, Directional Overcurrent Protection, Ground Function with Zero-Sequence Values

The rotated reference voltage $V_{ref, rot}$ and the parameter **`Forward section +/-`** define the forward and reverse ranges, see *Figure 6-493*. The forward range is calculated as ± Δφ° around the rotated reference voltage $V_{ref, rot}$. Δφ is set with the parameter **`Forward section +/-`** . If the short-circuit current vector -3I0 is located in this range, the device decides on the forward direction. In the mirrored range, the device decides on the reverse direction. In the intermediate range, the direction is undetermined.



[dw_forrev, 2, en_US]

Figure 6-493 Forward/Reverse Characteristic of the Directional Overcurrent Protection, Ground Function

Direction Determination with Negative-Sequence Values

The method works in the same way as for zero-sequence values. Instead of 3I0 and V0, the negative-sequence values I2 and V2 are used for determining the direction.

Direction Determination for Test Purposes

If you activate the binary input signal *>Test of direction* , the direction is determined and indicated even without the current threshold being exceeded in one of the stages. The direction can be determined as soon as the zero-sequence current 3I0 and the zero-sequence voltage V0 exceeds approx. 7 % of the secondary rated values of phase current and voltage.

6.28.3.3 Application and Setting Notes

Parameter: `Measured value`

- Recommended setting value **`(_:9) Measured value`** = ***`IN Measured`***

This parameter is not available in the basic function.

Parameter Value	Description
`IN Measured`	The function operates with the measured ground current IN. This is the recommended setting unless there is a specific reason to use the calculated zero-sequence current 3I0.
`3I0 Calculated`	The function operates with the calculated zero-sequence current 3I0. This setting option can be used when applying a redundant 50N/51N function for safety reasons.

Parameter: `Min. voltage V0 or V2`

- Recommended setting value **`(_:2311:101) Min. voltage V0 or V2`** = ***`2 V`***

This parameter is not available in the basic function. The basic function uses a fixed value of 2 V.

You use the **Min. voltage V0 or V2** parameter to define the minimum zero-sequence voltage or negative-sequence voltage for the direction determination. The minimum voltage must be set greater than the maximum operational unbalance plus the voltage-transformer measuring errors.

As the measuring error of the individual voltage transformer is not added up, the critical measuring-error influence is the unbalance of the primary system.

Siemens recommends observing the operational zero-sequence voltage V0 of the protected object (for example, the line) via the operational measured values of the device and providing the maximum value with a certainty of 50 %.

EXAMPLE

Maximum operational measured value of zero-sequence voltage V0 = 0.5 Vsec

Min. voltage V0 or V2 = 1.5 · 0.5 V = 0.75 Vsec

If you have no information about maximum operational unbalance, Siemens recommends using the default setting.

Parameter: Rotation angle of ref. volt. / Forward section +/-

- Recommended setting value **(_:2311:102) Rotation angle of ref. volt.** = ***-45°***
- Recommended setting value **(_:2311:103) Forward section +/-** = ***88°***

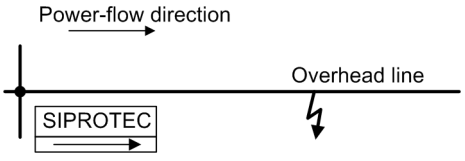
The parameter **Forward section +/-** is not available in the basic function. The basic function uses a fixed value of 88°.

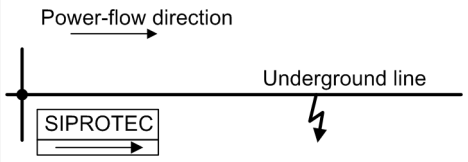
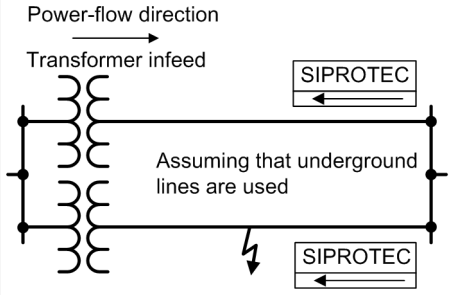
The direction characteristic, that is, the area of the forward and reverse ranges, is set with the **Rotation angle of ref. volt.** and the **Forward section +/-** parameters. The short-circuit angle is typically to be found in a range from -30° to -60° inductively. Therefore, in most cases, the default setting of -45° can be retained to position the reference voltage, as it ensures a reliable directional result.

Some example settings for special applications appear below *Table 6-15*. Note that for 1-phase-to-ground faults (PG faults), the reference voltage is the zero-sequence voltage V0. This results in the following setting for the rotation angle:

Rotation angle of ref. volt. = -φk ground-measuring elements (PG faults)

Table 6-15 Example Settings

Application	φk Typical	Setting **Rotation angle of ref. volt.**
	60°	-60°

	30°	-30°
	30°	-30°

Parameter: **`Direct. determination with`**

- Recommended setting value **`(_:2311:104) Direct. determination with`** = ***`zero sequence`***

This parameter is not available in the basic function. The basic function uses always zero-sequence components for the direction determination.

You use the parameter **`Direct. determination with`** to select the values for the direction determination.

Parameter Value	Description
`zero sequence`	Select ***`zero sequence`*** to determine the direction via the zero-sequence components V0 and 3I0. Siemens recommends using the zero-sequence components for the direction determination.
`negative sequence`	Select ***`negative sequence`*** to determine the direction via the negative-sequence components V2 and I2. The negative-sequence system can be used in case of danger that the zero-sequence voltage is too small due to unfavorable zero-sequence impedance conditions or that a parallel line influences the zero-sequence system.

Input Signal: ***`>Test of direction`***

If you activate the binary input signal ***`>Test of direction`***, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. This provides an easy means of checking the direction during commissioning, without changing the threshold values of the stages.

6.28.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:9	General:Measured value		• 3I0 calculated • IN measured	IN measured
_:2311:101	General:Min. voltage V0 or V2		0.150 V to 20.000 V	2.000 V
_:2311:102	General:Rotation angle of ref. volt.		-180 ° to 180 °	-45 °

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:103	General:Forward section +/-		0 ° to 90 °	88 °
_:2311:104	General:Direct. determination with		• zero sequence • negative sequence	zero sequence

6.28.3.5 Information List

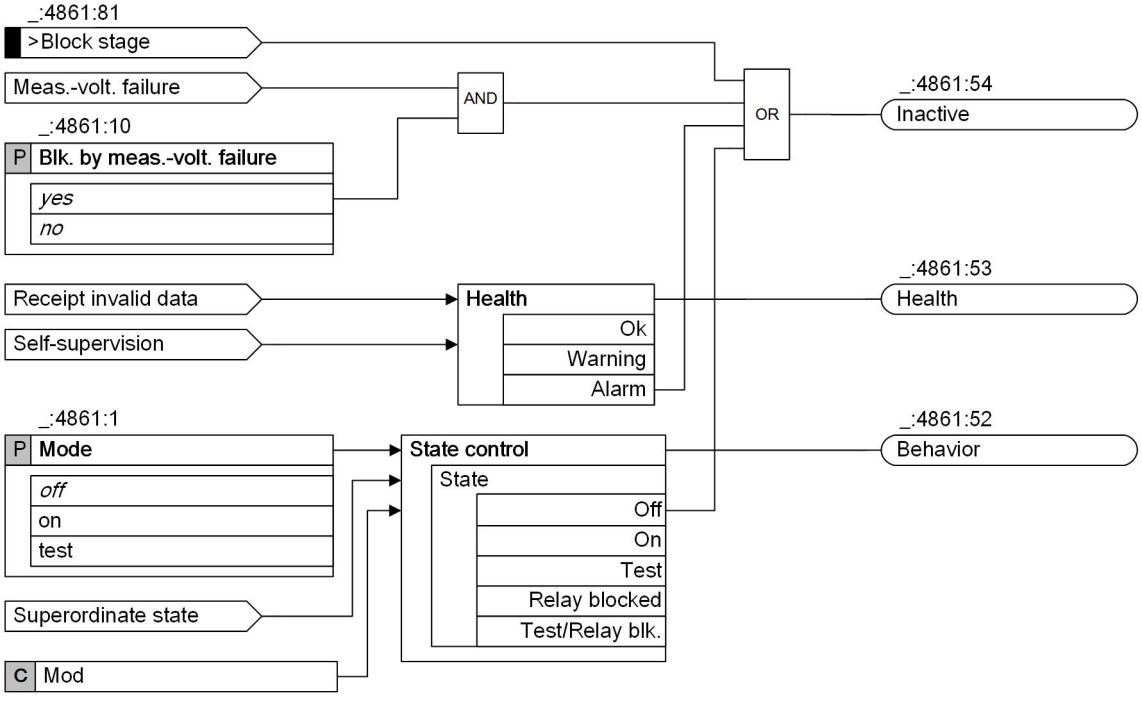
No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Test of direction	SPS	I
_:2311:352	General:Test direction	ACD	O
_:2311:351	General:Phi(I,V)	MV	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O

6.28.4 Stage Control

6.28.4.1 Description

Logic

The following figure represents the stage control. It applies to all types of stages.



[lo_sta_con, 2, en_US]

Figure 6-494 Logic Diagram of the Stage Control

Blocking of Stage in Case of Measuring-Voltage Failure

The stages can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From an internal source on the pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **Voltage-transformer circuit breaker**, which links to the trip of the voltage-transformer circuit breaker

The **Blk. by meas.-volt. failure** parameter can be set to either block or not block the stage when the **Measuring-voltage failure detection** function picks up.

6.28.4.2 Application and Setting Notes

Parameter: **Blk. by meas.-volt. failure**

- Recommended setting value **(_:4861:10) Blk. by meas.-volt. failure** = ***yes***

You can use the **Blk. by meas.-volt. failure** parameter to control the response of the stage when a measuring-voltage failure is detected.
A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

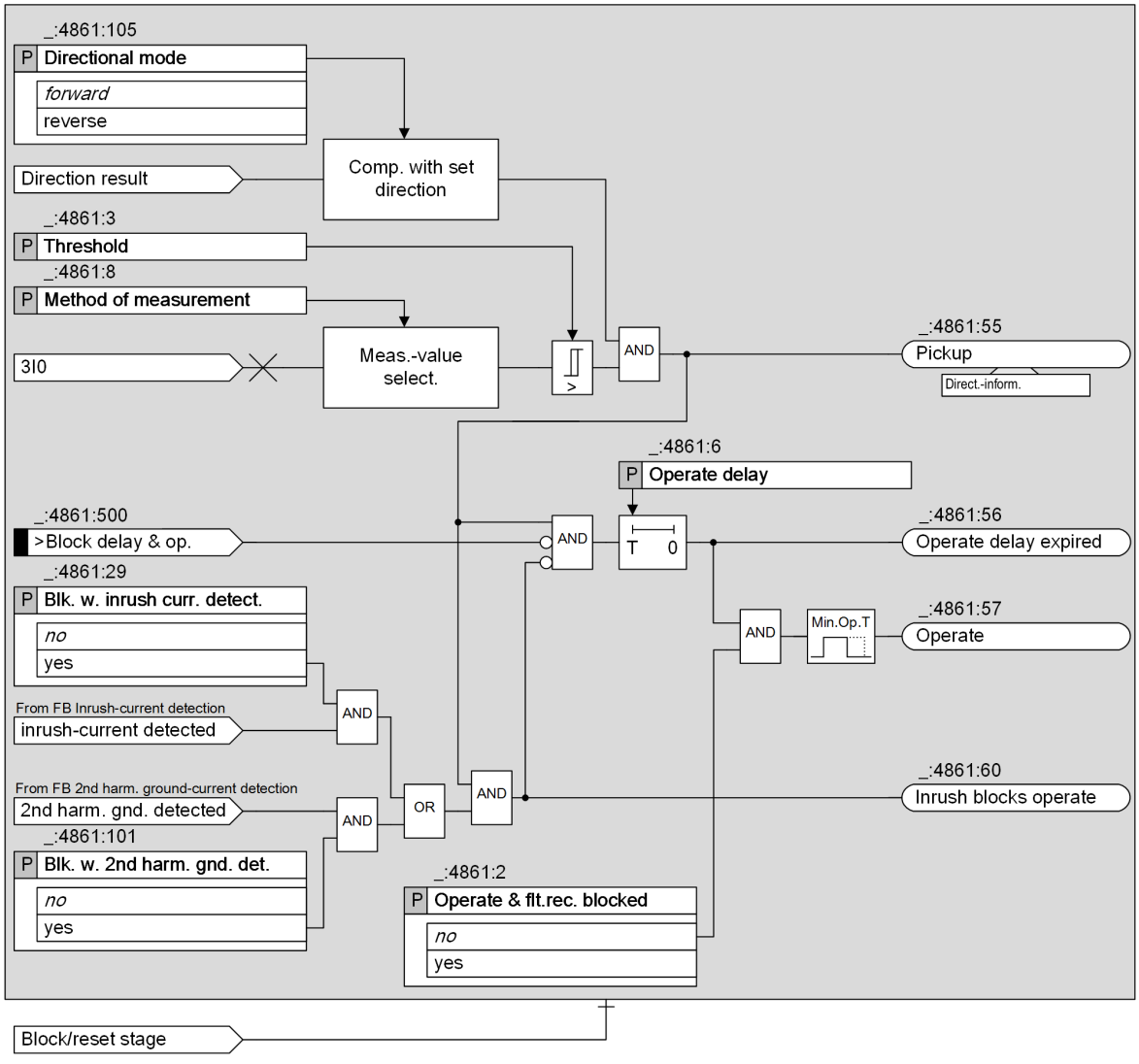
- The device-internal **Measuring-voltage failure detection** function is configured and switched on.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The directional overcurrent-protection stage is blocked when a measuring-voltage failure is detected. Siemens recommends using the default setting, as correct direction determination cannot be guaranteed if a measuring-voltage failure occurs.
no	The directional overcurrent-protection stage is not blocked when a measuring-voltage failure is detected.

6.28.5 Stage with Definite-Time Characteristic Curve

6.28.5.1 Description

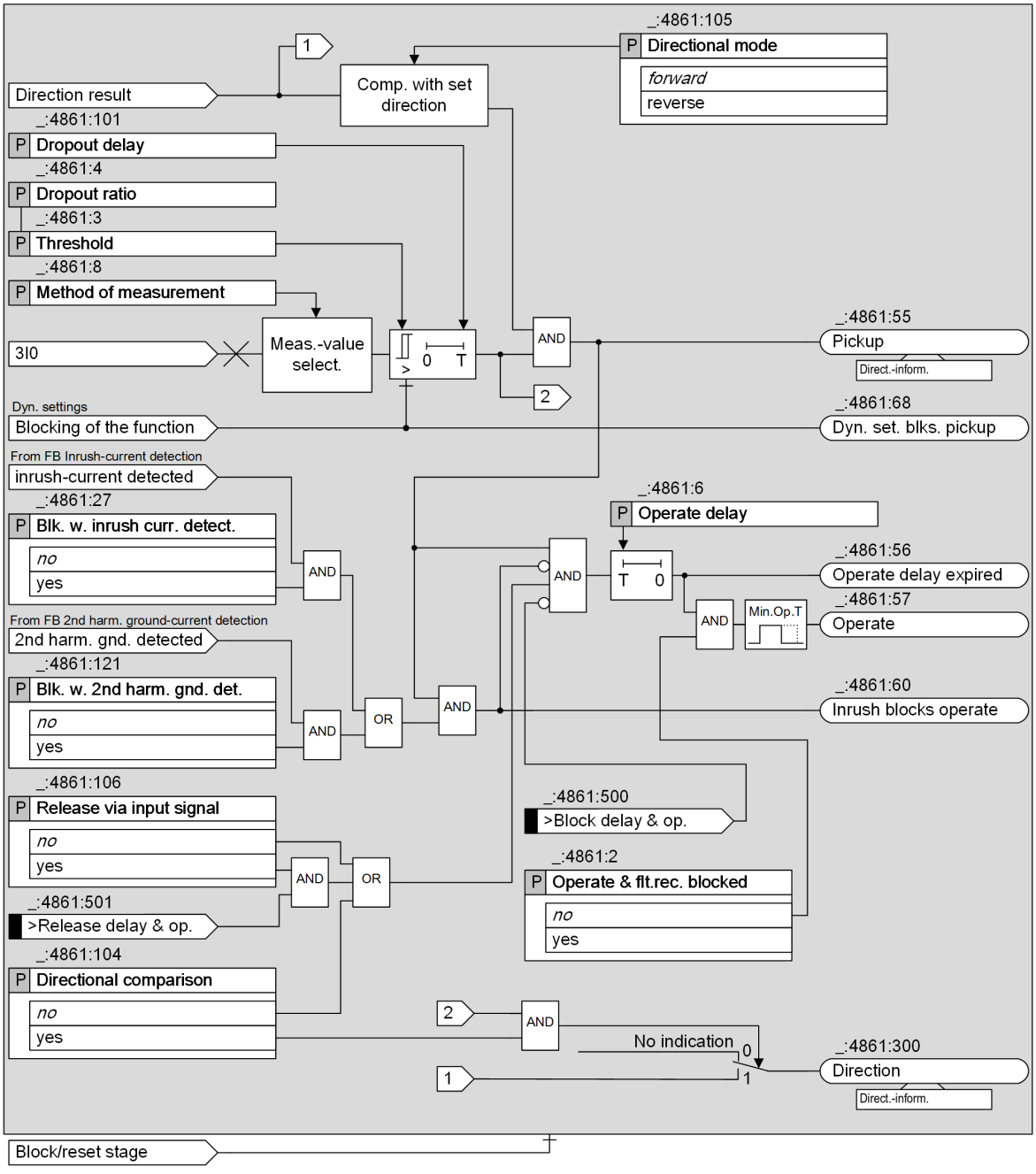
Logic of the Basic Stage



[lo_dirovb, 2, en_US]

Figure 6-495 Logic Diagram of the Directional Definite-Time Overcurrent Protection, Ground – Basic

Logic of the Advanced Stage



[lo_dirova, 1, en_US]

Figure 6-496 Logic Diagram of the Directional Definite-Time Overcurrent Protection, Ground – Advanced

Measurand (Basic and Advanced Stage)

The function uses the zero-sequence current (3I0) as a criterion for the ground fault.

Depending on the parameter setting connection type of the **Measuring point I-3ph**, the zero-sequence current is measured or calculated. Depending on the applied CT terminal type, the 3I0 **`Threshold`** range varies according to the following table.

Table 6-16 Threshold Setting Range

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary)
3-phase	Calculated	4 * Protection	0.030 A to 40.000 A
		3 * Protection, 1* sensitive	0.030 A to 40.000 A
		4 * Measurement	0.001 A to 1.600 A
x + IN x + IN-separate	Measured	4 * Protection	0.030 A to 40.000 A
		3 * Protection, 1* sensitive	0.001 A to 1.600 A
		4 * Measurement	0.001 A to 1.600 A

Method of Measurement (Basic and Advanced Stage)

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This measuring procedure processes the sampled current values and filters out the fundamental components numerically.
- Measurement of the RMS value:
  This measuring procedure determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Directional Mode (Basic and Advanced Stage)

You can use the **Directional mode** parameter to define whether the stage works in a forward or reverse direction.

The direction determination works across all stages (see chapter *6.28.3.2 Direction Determination*).

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal *>Block stage* (see chapter *6.28.4.1 Description*)
- Measuring-voltage failure (see chapter *6.28.4.1 Description*)
- Via the dynamic settings functionality (only available in the advanced function type, see **Influence of Other Functions via Dynamic Settings** and chapter *6.28.10 Influence of Other Functions via Dynamic Settings*)

Blocking of the Operate Delay (Basic and Advanced Stage)

You can use the binary input signal *>Block delay & op.* to prevent the start of the operate delay and thus also the generation of the operate signal. A running operate delay is reset. The pickup is indicated. Fault logging and fault recording take place.

Blocking of the Operate Delay and Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.24.7.1 Description*

Dropout Delay (Advanced Stage)

In case of undershooting of the dropout threshold, the dropout can be delayed. The pickup is maintained for the specified time. The operate delay continues to run. If the operate delay expires while the pickup is still maintained, the stage operates.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the **Directional comparison** parameter. With the ***yes*** setting, the direction indication *Direction* is released and the direction (forward or reverse) is determined, if the current exceeds the threshold of the stage. The direction indicated is independent of the directional mode set for the stage.

The **Release via input signal** parameter and the *>Release delay & op.* input signal are available with directional comparison protection. If the **Release via input signal** parameter is set to ***yes***, the start of the operate delay, and therefore the operate signal of the stage, are only enabled when the *>Release delay & op.* input signal is active.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can exert an influence on the overcurrent-protection stage:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.28.10 Influence of Other Functions via Dynamic Settings*.

6.28.5.2 Application and Setting Notes

Parameter: Directional mode

- Default setting **(_:4861:105) Directional mode** = ***forward***

You can use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value **(_:4861:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

Parameter: **Directional comparison**, **Release via input signal**

- Default setting **(_:4861:104) Directional comparison** = ***no***
- Default setting **(_:4861:106) Release via input signal** = ***no***

The parameters **Directional comparison** and **Release via input signal** are not visible for the basic stage.

You can use these settings to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the *Direction* and *>Release delay & op.* signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.
yes	If the **Directional comparison** parameter is set to ***yes***, the **Release via input signal** parameter, the *Direction* output signal, and the *>Release delay & op.* input signal become available. If the **Release via input signal** parameter is set to ***yes***, the starts of the operate delay and operate signal are only enabled when the *>Release delay & op.* input signal is active. The *>Release delay & op.* input signal must be connected to the enable information from the opposite end (forward information from the *Direction* output signal). See also the application example in *6.27.10 Application Notes for Directional Comparison Protection*

Parameter: **Dynamic settings**

- Default setting **(_:4861:26) Dynamic settings** = ***no***

This parameter is not visible for the basic stage.

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (**Automatic reclosing** or **Cold-load pickup detection**) or an external function should affect the overcurrent-protection stage (such as change the setting of the threshold value or operate delay, blocking of the stage), the setting must be changed to ***yes***. This makes the configuration parameters affected by **Auto reclosing**/**Cold-load PU**/**Binary input** as well as the dynamic settings **Threshold**, **Operate delay**, and **Stage blocked** of the stage visible and enables the settings to be set for the specific influence.

For further setting notes, refer to *6.24.8.2 Application and Setting Notes (Advanced Stage)* of the function **Overcurrent Protection, Ground**.

Parameter: **Blk. w. inrush curr. detect.**

- Default setting **(_:4861:27) Blk. w. inrush curr. detect.** = ***no***

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This applies, for example, to the high-current stage that is set according to the short-circuit voltage Vsc of the transformer in such a way that the stage only picks up on faults from the high-voltage side. The transformer inrush current cannot become larger than the maximum transmittable short-circuit current.
yes	When the transformer inrush-current detection detects an inrush current that would lead to an operate of the stage, the start of the operate delay and operate of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: `Threshold`

- Default setting **`(_:4861:3) Threshold`** = ***`1.20 A`***

For setting the threshold value, the same considerations apply as for the non-directional overcurrent protection function.

For further information, refer to *6.24.4.2 Application and Setting Notes* .

Parameter: `Dropout ratio`

- Recommended setting value **`(_:4861:4) Dropout ratio`** = ***`0.95`***

This parameter is not visible for the basic stage.

The recommended setting value of ***`0.95`*** is appropriate for most applications.

For high-precision measurements, the setting value of the **`Dropout ratio`** parameter can be reduced, for example to 0.98. If you expect highly fluctuating measurands at the pickup threshold, you can increase the setting value of the **`Dropout ratio`** parameter. This avoids chattering of the stage.

Parameter: Dropout delay

- Recommended setting value **`(_:4861:101) Dropout delay`** = ***`0 s`***

This parameter is not visible for the basic stage.

Siemens recommends using the dropout delay of 0 s, since the dropout of a protection stage must be performed as fast as possible.

You can use the **`Dropout delay`** parameter ≠ ***`0 s`*** to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical data) and set the result.

Parameter: `Operate delay`

- Default setting **`(_:4861:6) Operate delay`** = ***`0.300 s`*** (for the 1st stage)

The **`Operate delay`** to be set is derived from the time-grading chart that has been prepared for the system.

Typical examples of grading times are provided in sections *6.27.9 Application Notes for Parallel Lines* and *6.27.10 Application Notes for Directional Comparison Protection* .

6.28.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:4861:1	Definite-T 1:Mode		• off • on • test	off
_:4861:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:4861:105	Definite-T 1:Directional mode		• forward • reverse	forward
_:4861:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:4861:104	Definite-T 1:Directional comparison		• no • yes	no
_:4861:106	Definite-T 1:Release via input signal		• no • yes	no
_:4861:10	Definite-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:4861:26	Definite-T 1:Dynamic settings		• no • yes	no
_:4861:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:4861:121	Definite-T 1:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:4861:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:4861:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:4861:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n.rdy				
_:4861:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:4861:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:4861:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:4861:36	Definite-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4861:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:4861:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:4861:37	Definite-T 1:Stage blocked		• no • yes	no
_:4861:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:4861:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no
_:4861:38	Definite-T 1:Stage blocked		• no • yes	no
_:4861:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:4861:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:4861:39	Definite-T 1:Stage blocked		• no • yes	no
_:4861:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.s: Cold load PU				
_:4861:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:4861:40	Definite-T 1:Stage blocked		• no • yes	no
_:4861:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:4861:34	Definite-T 1:Effected by binary input		• no • yes	no
_:4861:41	Definite-T 1:Stage blocked		• no • yes	no
_:4861:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
General				
_:4862:1	Definite-T 2:Mode		• off • on • test	off
_:4862:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:4862:105	Definite-T 2:Directional mode		• forward • reverse	forward
_:4862:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:4862:104	Definite-T 2:Directional comparison		• no • yes	no
_:4862:106	Definite-T 2:Release via input signal		• no • yes	no
_:4862:10	Definite-T 2:Blk. by meas.-volt. failure		• no • yes	yes
_:4862:26	Definite-T 2:Dynamic settings		• no • yes	no
_:4862:27	Definite-T 2:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4862:121	Definite-T 2:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:4862:3	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4862:4	Definite-T 2:Dropout ratio		0.90 to 0.99	0.95
_:4862:101	Definite-T 2:Dropout delay		0.00 s to 60.00 s	0.00 s
_:4862:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.s: AR off/n.rdy				
_:4862:28	Definite-T 2:Effect. by AR off/n.ready		• no • yes	no
_:4862:35	Definite-T 2:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:4862:29	Definite-T 2:Effected by AR cycle 1		• no • yes	no
_:4862:36	Definite-T 2:Stage blocked		• no • yes	no
_:4862:14	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4862:20	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.set: AR cycle 2				
_:4862:30	Definite-T 2:Effected by AR cycle 2		• no • yes	no
_:4862:37	Definite-T 2:Stage blocked		• no • yes	no
_:4862:15	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4862:21	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 3				
_:4862:31	Definite-T 2:Effected by AR cycle 3		• no • yes	no
_:4862:38	Definite-T 2:Stage blocked		• no • yes	no
_:4862:16	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4862:22	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.s: AR cycle>3				
_:4862:32	Definite-T 2:Effected by AR cycle gr. 3		• no • yes	no
_:4862:39	Definite-T 2:Stage blocked		• no • yes	no
_:4862:17	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4862:23	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.s: Cold load PU				
_:4862:33	Definite-T 2:Effect. b. cold-load pickup		• no • yes	no
_:4862:40	Definite-T 2:Stage blocked		• no • yes	no
_:4862:18	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4862:24	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.set: bin.input				
_:4862:34	Definite-T 2:Effected by binary input		• no • yes	no
_:4862:41	Definite-T 2:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4862:19	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4862:25	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s

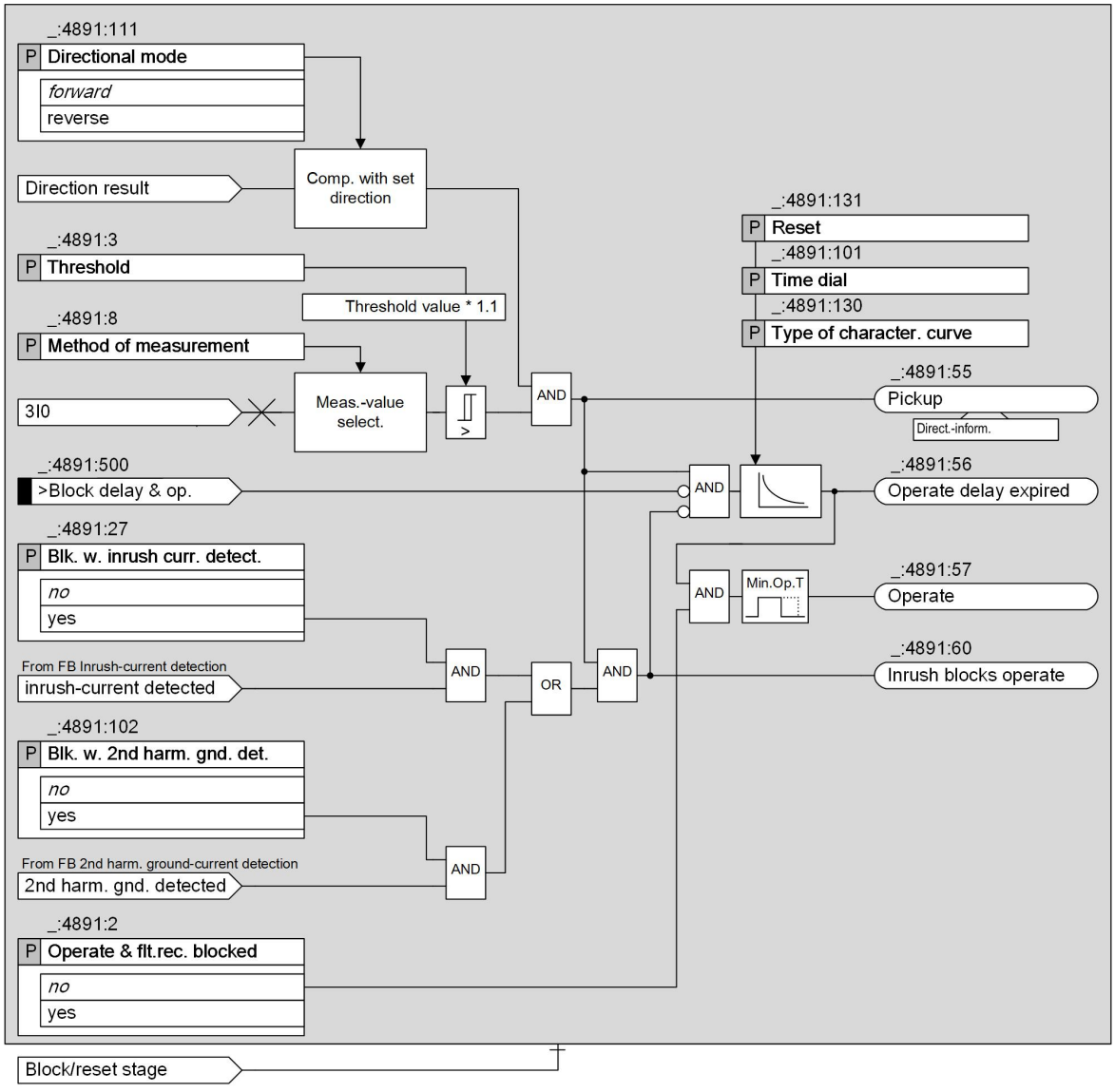
6.28.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Test of direction	SPS	I
_:2311:352	General:Test direction	ACD	O
_:2311:351	General:Phi(I,V)	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:4861:81	Definite-T 1:>Block stage	SPS	I
_:4861:501	Definite-T 1:>Release delay & op.	SPS	I
_:4861:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:4861:500	Definite-T 1:>Block delay & op.	SPS	I
_:4861:54	Definite-T 1:Inactive	SPS	O
_:4861:52	Definite-T 1:Behavior	ENS	O
_:4861:53	Definite-T 1:Health	ENS	O
_:4861:60	Definite-T 1:Inrush blocks operate	SPS	O
_:4861:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:4861:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:4861:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O
_:4861:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:4861:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:4861:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:4861:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O
_:4861:55	Definite-T 1:Pickup	ACD	O
_:4861:300	Definite-T 1:Direction	ACD	O
_:4861:56	Definite-T 1:Operate delay expired	ACT	O
_:4861:57	Definite-T 1:Operate	ACT	O

6.28.6 Stage with Inverse-Time Characteristic Curve

6.28.6.1 Description

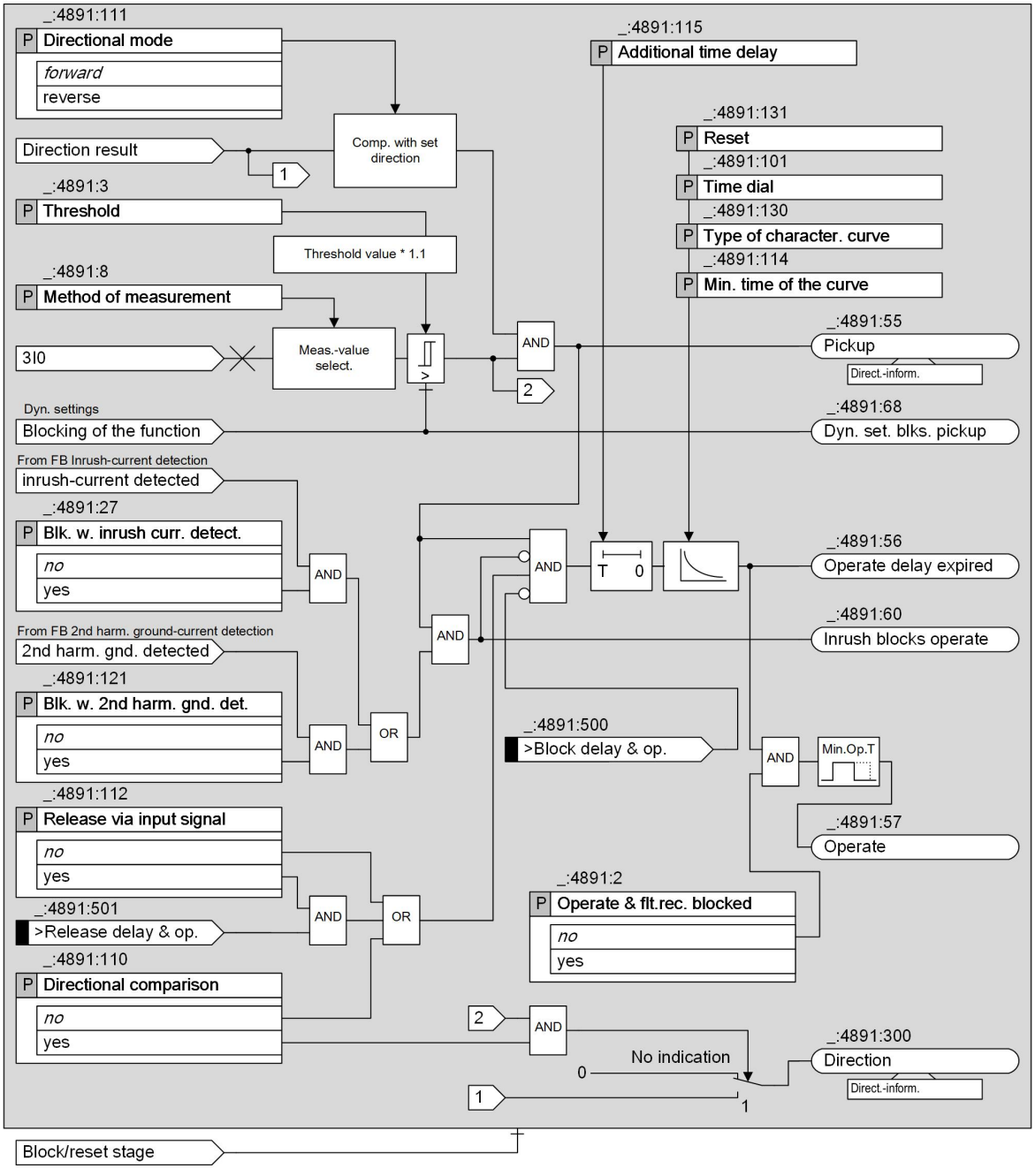
Logic of the Basic Stage



{Io_diinvb, 3, en_US}

Figure 6-497 Logic Diagram of the Directional Inverse-Time Overcurrent Protection, Ground – Basic

Logic of the Advanced Stage



[lo_diinva, 3, en_US]

Figure 6-498 Logic Diagram of the Directional Inverse-Time Overcurrent Protection, Ground – Advanced

Measurand (Basic and Advanced Stage)

The function uses the zero-sequence current (3I0) as a criterion for the ground fault.

Depending on the parameter setting connection type of the **Measuring point I-3ph**, the zero-sequence current is measured or calculated. Depending on the applied CT terminal type, the 3I0 **Threshold** range varies according to the following table.

Table 6-17 Threshold Setting Range

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary)
3-phase	Calculated	4 * Protection	0.030 A to 40.000 A
		3 * Protection, 1* sensitive	0.030 A to 40.000 A
		4 * Measurement	0.001 A to 1.600 A
x + IN x + IN-separate	Measured	4 * Protection	0.030 A to 40.000 A
		3 * Protection, 1* sensitive	0.001 A to 1.600 A
		4 * Measurement	0.001 A to 1.600 A

Method of Measurement (Basic and Advanced Stage)

You use the **Method of measurement** parameter to define whether the stage uses the standard method (***fundamental comp.***) or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This measuring procedure processes the sampled current values and filters out the fundamental components numerically.
- Measurement of the RMS value:
  This measuring procedure determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Directional Mode (Basic and Advanced Stage)

You can use the **Directional mode** parameter to define whether the stage works in a forward or reverse direction.

The direction determination works across all stages (see *6.28.3.2 Direction Determination*).

Pickup and Dropout Behaviors of the Inverse-Time Characteristic Curve According to IEC and ANSI (Basic and Advanced Stage)

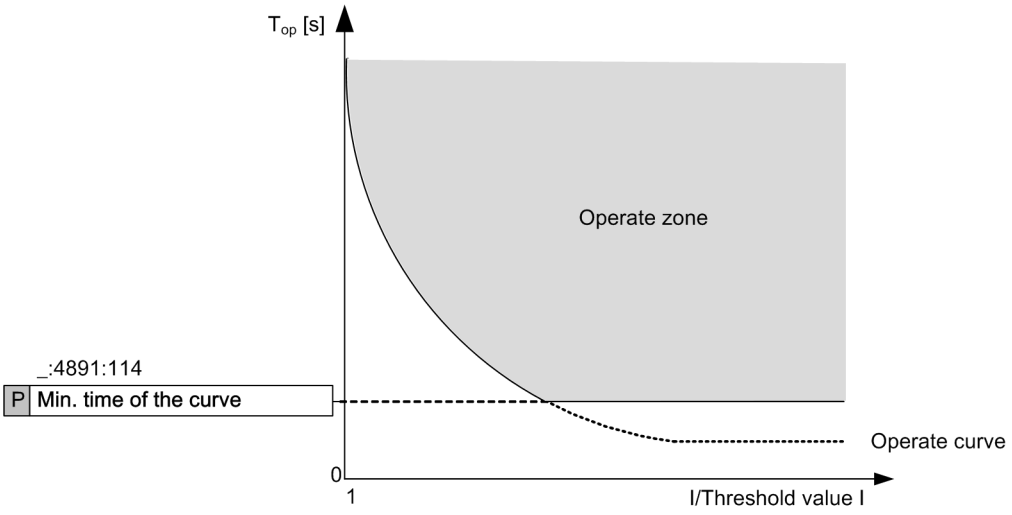
When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by a factor of 1.045 (0.95 · 1.1 · threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Minimum Time of the Curve (Advanced Stage)

With the parameter **Min. time of the curve**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.



[dw_min_time, 1, en_US]

Figure 6-499 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter **Additional time delay**, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal *>Block stage* (see *6.28.4.1 Description*)
- Measuring-voltage failure (see *6.28.4.1 Description*)
- Via the dynamic settings functionality (only available in the advanced function type, see **Influence of Other Functions via Dynamic Settings** and *6.28.10 Influence of Other Functions via Dynamic Settings*)

Blocking of the Operate Delay (Basic and Advanced Stage)

You can use the binary input signal *>Block delay & op.* to prevent the start of the operate delay and thus also the generation of the operate signal. A running operate delay is reset. The pickup is indicated. Fault logging and fault recording take place.

Blocking of the Operate Delay and Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in Blocking of the Tripping by Device-Internal Inrush-Current Detection

For more information, refer to *6.24.7.1 Description*.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the **Directional comparison** parameter. With the ***yes*** setting, the direction indication *Direction* is released and the direction (forward or reverse) is determined, if the current exceeds the threshold of the stage. The direction indicated is independent of the directional mode set for the stage.

The **Release via input signal** parameter and the *>Release delay & op.* input signal are available with directional comparison protection. If the **Release via input signal** parameter is set to ***yes***, the start of the operate delay, and therefore the operate signal of the stage, are only enabled when the *>Release delay & op.* input signal is active.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can exert an influence on the overcurrent-protection stage:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in *6.28.10 Influence of Other Functions via Dynamic Settings*.

6.28.6.2 Application and Setting Notes

Parameter: Directional mode

- Default setting **(_:4891:111) Directional mode** = ***forward***

You can use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value **(_:4891:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

Parameter: Directional comparison, Release via input signal

- Default setting **(_:4891:110) Directional comparison** = ***no***
- Default setting **(_:4891:112) Release via input signal** = ***no***

The parameters **Directional comparison** and **Release via input signal** are not visible for the basic stage.

You can use these settings to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the *Direction* and *>Release delay & op.* signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.
yes	If the **Directional comparison** parameter is set to ***yes***, the **Release via input signal** parameter, the *Direction* output signal, and the *>Release delay & op.* input signal become available. If the **Release via input signal** parameter is set to ***yes***, the starts of the operate delay and operate signal are only enabled when the *>Release delay & op.* input signal is active. The *>Release delay & op.* input signal must be connected to the release information from the opposite end (forward information from the *Direction* output signal). See also the application example in chapter *6.27.10 Application Notes for Directional Comparison Protection* .

Parameter: **Dynamic settings**

- Default setting **(_:4891:26) Dynamic settings** = ***no***

This parameter is not visible for the basic stage.

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (**Automatic reclosing** or **Cold-load pickup detection**) or an external function should affect the overcurrent-protection stage (such as change the setting of the threshold value or operate delay, blocking of the stage), the setting must be changed to ***yes***. This makes the configuration parameters affected by **Auto reclosing**/**Cold-load PU**/**Binary input** as well as the dynamic settings **Threshold**, **Time dial**, and **Stage blocked** of the stage visible and enables the settings to be set for the specific influence.

For further setting notes, refer to chapter *6.24.8.2 Application and Setting Notes (Advanced Stage)* of the function **Overcurrent Protection, Ground**.

Parameter: **Blk. w. inrush curr. detect.**

- Default setting **(_:4891:27) Blk. w. inrush curr. detect.** = ***no***

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This applies, for example, to the high-current stage that is set according to the short-circuit voltage V_{sc} of the transformer in such a way that the stage only picks up on faults from the high-voltage side. The transformer inrush current cannot become larger than the maximum transmittable shortcircuit current.
yes	When the transformer inrush-current detection detects an inrush current that would lead to an operate of the stage, the start of the operate delay and operate of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: **Min. time of the curve**

- Default setting **(_:4891:114) Min. time of the curve** = ***0.00 s***

This parameter is only available in the advanced stage.

With the parameter **Min. time of the curve**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.



NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: **Additional time delay**

- Default setting **(_:4891:115) Additional time delay** = ***0.00 s***

With the parameter **Additional time delay**, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommend keeping the default setting of 0 s.

Parameter: **Threshold**

- Default setting **(_:4891:3) Threshold** = ***1.20 A***

The setting depends on the minimal occurring ground-fault current. This must be detected.

Consider that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the **Threshold**.

Parameter: `Type of character. curve`

- Default setting **`(_:4891:130) Type of character. curve`** = ***`IEC normal inverse`***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **`Type of character. curve`** required for your specific application.

Parameter: `Time dial`

- Default setting **`(_:4891:101) Time dial`** = ***`1`***

You can use the **`Time dial`** parameter to displace the characteristic curve in the time direction.
The setting value for the **`Time dial`** parameter is derived from the time-grading chart that has been prepared for the electrical power system.
Where no time grading and therefore no displacement of the characteristic curve is required, leave the **`Time dial`** parameter at ***`1`*** (default setting).

Parameter: `Reset`

- Default setting **`(_:4891:131) Reset`** = ***`disk emulation`***

You can use the **`Reset`** parameter setting to define whether the stage decreases according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Select this setting if the dropout does not have to be performed after a disk emulation and an instantaneous dropout is desired instead.

6.28.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:4891:1	Inverse-T 1:Mode		• off • on • test	off
_:4891:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:4891:111	Inverse-T 1:Directional mode		• forward • reverse	forward
_:4891:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:4891:110	Inverse-T 1:Directional comparison		• no • yes	no
_:4891:112	Inverse-T 1:Release via input signal		• no • yes	no
_:4891:10	Inverse-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:4891:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:4891:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4891:121	Inverse-T 1:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:4891:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:130	Inverse-T 1:Type of character. curve			
_:4891:114	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:4891:131	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:4891:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:4891:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:4891:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:4891:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:4891:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:4891:36	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 2				
_:4891:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:4891:37	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 3				
_:4891:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no
_:4891:38	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: AR cycle>3				
_:4891:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:4891:39	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:4891:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:4891:40	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: bin.input				
_:4891:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:4891:41	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4891:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

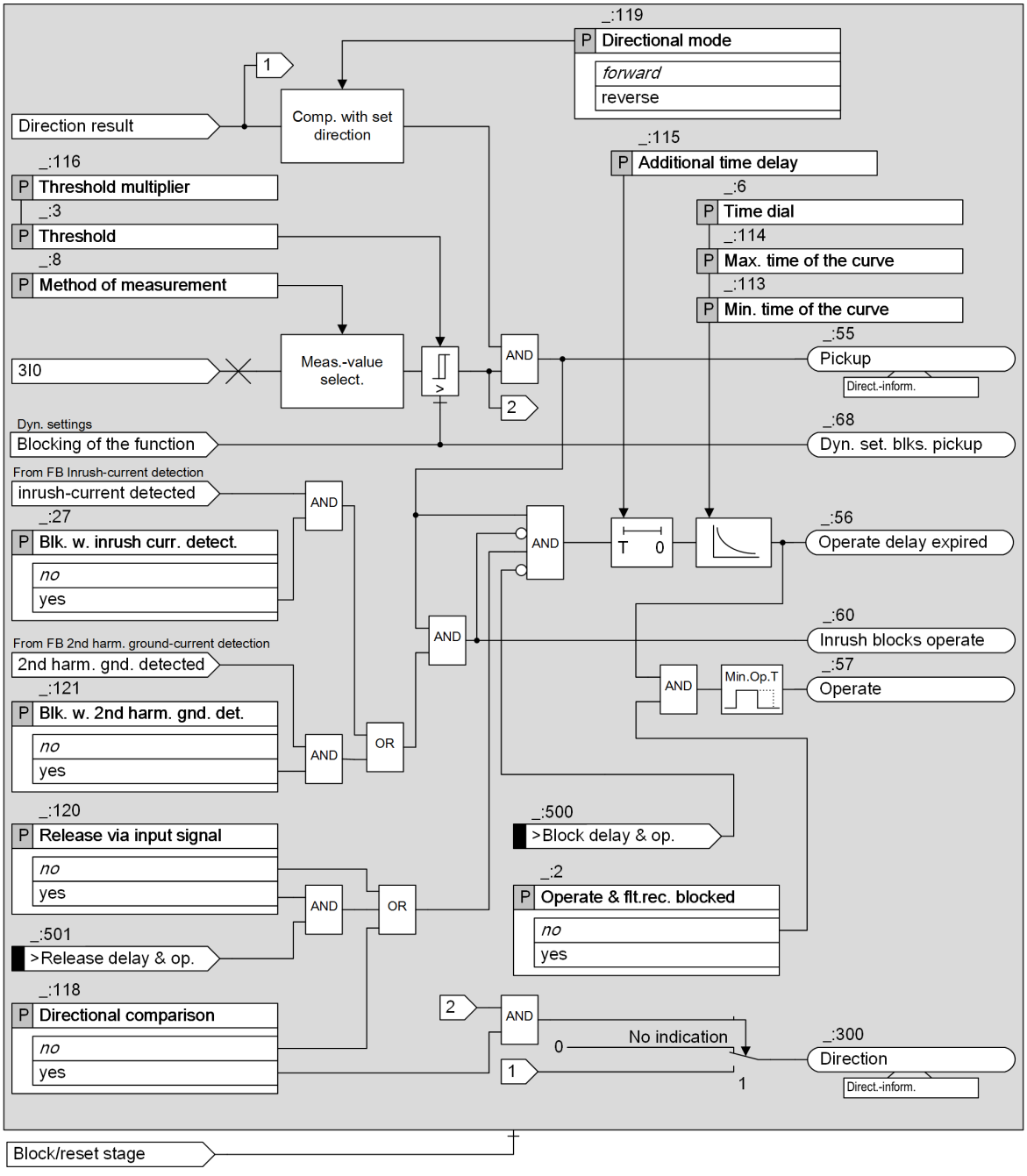
6.28.6.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T 1			
_:4891:81	Inverse-T 1:>Block stage	SPS	I
_:4891:501	Inverse-T 1:>Release delay & op.	SPS	I
_:4891:84	Inverse-T 1:>Activ. dyn. settings	SPS	I
_:4891:500	Inverse-T 1:>Block delay & op.	SPS	I
_:4891:54	Inverse-T 1:Inactive	SPS	O
_:4891:52	Inverse-T 1:Behavior	ENS	O
_:4891:53	Inverse-T 1:Health	ENS	O
_:4891:60	Inverse-T 1:Inrush blocks operate	SPS	O
_:4891:62	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:4891:63	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:4891:64	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:4891:65	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:4891:66	Inverse-T 1:Dyn.set. CLP active	SPS	O
_:4891:67	Inverse-T 1:Dyn.set. BI active	SPS	O
_:4891:68	Inverse-T 1:Dyn. set. blks. pickup	SPS	O
_:4891:59	Inverse-T 1:Disk emulation running	SPS	O
_:4891:55	Inverse-T 1:Pickup	ACD	O
_:4891:300	Inverse-T 1:Direction	ACD	O
_:4891:56	Inverse-T 1:Operate delay expired	ACT	O
_:4891:57	Inverse-T 1:Operate	ACT	O

6.28.7 Stage with Inverse-Time Overcurrent Protection with Logarithmic-Inverse Characteristic Curve

6.28.7.1 Description

Logic of the Stage



[lo_diloin, 4, en_US]

Figure 6-500 Logic Diagram of the Directional Logarithmic Inverse-Time Overcurrent Protection, Ground

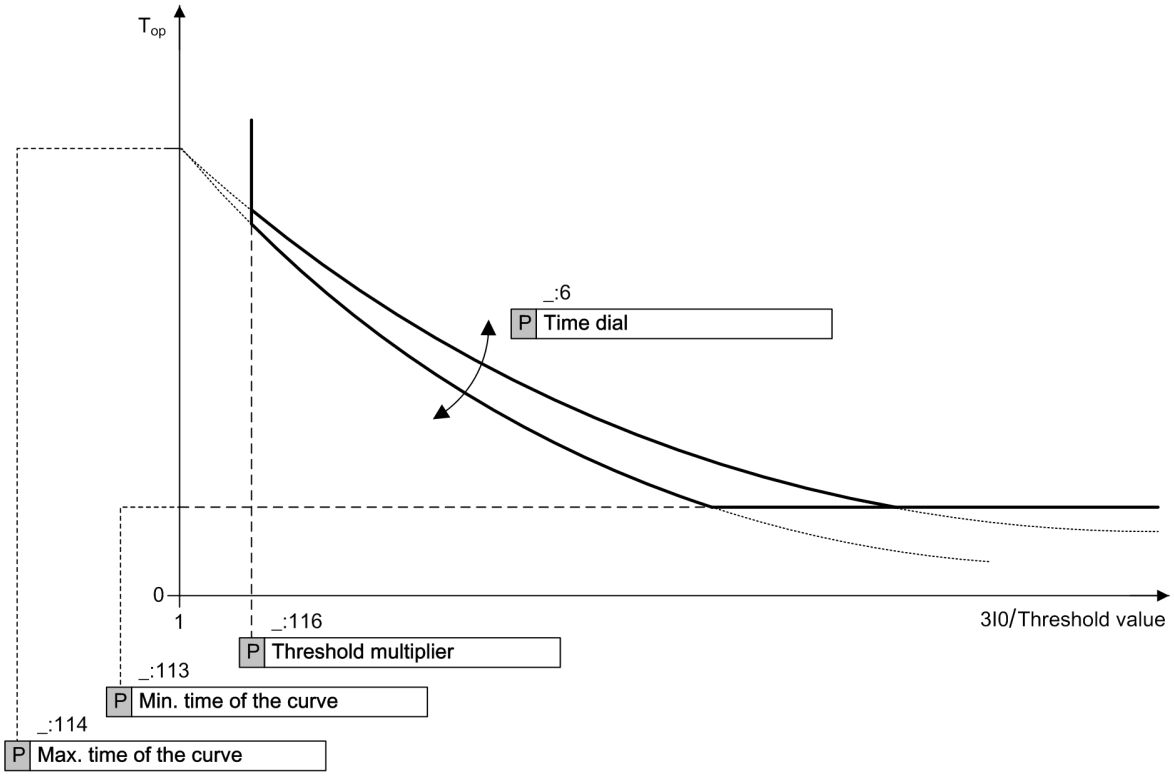
Apart from the operate curve, this type of stage is identical to the **Inverse-time overcurrent protection – advanced** stage (see chapter *6.28.6.1 Description*).

This section will only discuss the nature of the operate curve. For further functionality, refer to chapter *6.28.6.1 Description*.

Operate Curve

If the function picks up, the logarithmic inverse-time characteristic curve is processed. A time value T_{op} is calculated for every input value exceeding 95 % of the pickup value. An integrator accumulates the value $1/T_{op}$. If the accumulated integral reaches the fixed value 1, the stage operates.

The curve used to calculate the time value T_{op} is shown in the following figure. The **Threshold multiplier** parameter defines the beginning of the characteristic curve. The **Max. time of the curve** determines the initial value of the characteristic curve. The **Time dial** parameter changes the slope of the characteristic curve. At high currents, the **Min. time of the curve** parameter indicates the lower time limit.



[dw_loginv, 3, en_US]

Figure 6-501 Operate Curve of Logarithmic Inverse-Time Characteristic

The time to operate is calculated with the following formula:

$$T_{op} = T_{max} - T_d \ln\left(\frac{3I0}{I_{thresh} \times I_{mul}}\right)$$

[fo_mula_01, 1, en_US]

Where

T_{max}	Maximum time of the curve (parameter **Max. time of the curve**)
T_d	Time dial (parameter **Time dial**)
T_{op}	Operate time
3I0	Measured zero-sequence current

I_{thresh} Threshold value (parameter **Threshold**)

I_{mul} Threshold multiplier (parameter **Threshold multiplier**)

If the calculated time is less than T_{min} (parameter **Min. time of the curve**), T_{min} is used.

6.28.7.2 Application and Setting Notes

Apart from the operate curve, this type of stage is identical to the ground-fault protection type with inverse-time delay according to IEC and ANSI (advanced function type) (see *6.28.6.1 Description*).

This section only discusses the nature of the operate curve. For further functionality, refer to chapter *6.28.6.2 Application and Setting Notes*.

Stage Type Selection

If the operate delay is to be dependent on the current level according to a logarithmic characteristic curve, select this stage type.

Dynamic Settings: Threshold

- Default setting **(_:3) Threshold** = ***1.20 A***

Define the pickup value corresponding to the application. In doing so, for time-graded stages, the settings of the superordinate and of the subordinate stages in the time-grading chart must be taken into consideration.

Parameter: Threshold multiplier

- Default setting **(_:116) Threshold multiplier** = ***1.1***

You can use the **Threshold multiplier** parameter to define the beginning of the characteristic curve on the current axis (in relation to the threshold value).

General information cannot be provided. Define the value corresponding to the application.

EXAMPLE

Threshold (Secondary current)	I_{thresh} = 1.2 A
Threshold multiplier	I_{mul} = 1.1
Pickup value (Secondary current)	I_{PU} = 1.2 A ×1.1 = 1.32 A

Dynamic Settings: Time dial

- Default setting **(_:6) Time dial** = ***1.250 s***

You can use the **Time dial** parameter to change the slope of the characteristic curve.

General information cannot be provided. Define the value corresponding to the application.

Parameter: Max. time of the curve

- Default setting **(_:114) Max. time of the curve** = ***5.800 s***

The parameter **Max. time of the curve** determines the initial value of the characteristic curve (for 3I0 = **Threshold**).

General information cannot be provided. Define the value corresponding to the application.

Parameter: Min. time of the curve

- Default setting **(_:113) Min. time of the curve** = ***1.200 s***

The parameter **Min. time of the curve** determines the lower time limit (at high currents).

General information cannot be provided. Define the value corresponding to the application.

Parameter: `Additional time delay`

- Recommended setting value **`(_:115) Additional time delay`** = ***`0 s`***

You can set an additional current-independent time delay. This additional delay is intended for special applications.

Siemens recommends setting this time to ***`0 s`*** so that it has no effect.

6.28.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:1	Log.-inv.-T #:Mode		• off • on • test	off
_:2	Log.-inv.-T #:Operate & flt.rec. blocked		• no • yes	no
_:119	Log.-inv.-T #:Directional mode		• forward • reverse	forward
_:8	Log.-inv.-T #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:118	Log.-inv.-T #:Directional comparison		• no • yes	no
_:120	Log.-inv.-T #:Release via input signal		• no • yes	no
_:10	Log.-inv.-T #:Blk. by meas.-volt. failure		• no • yes	yes
_:26	Log.-inv.-T #:Dynamic settings		• no • yes	no
_:27	Log.-inv.-T #:Blk. w. inrush curr. detect.		• no • yes	no
_:121	Log.-inv.-T #:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:3	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:6	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
_:113	Log.-inv.-T #:Min. time of the curve		0.000 s to 60.000 s	1.200 s
_:114	Log.-inv.-T #:Max. time of the curve		0.000 s to 60.000 s	5.800 s
_:116	Log.-inv.-T #:Threshold multiplier		1.00 to 4.00	1.10
_:115	Log.-inv.-T #:Additional time delay		0.000 s to 60.000 s	0.000 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.s: AR off/n.rdy				
_:28	Log.-inv.-T #:Effect. by AR off/n.ready		• no • yes	no
_:35	Log.-inv.-T #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	Log.-inv.-T #:Effected by AR cycle 1		• no • yes	no
_:36	Log.-inv.-T #:Stage blocked		• no • yes	no
_:14	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:107	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.set: AR cycle 2				
_:30	Log.-inv.-T #:Effected by AR cycle 2		• no • yes	no
_:37	Log.-inv.-T #:Stage blocked		• no • yes	no
_:15	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:108	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.set: AR cycle 3				
_:31	Log.-inv.-T #:Effected by AR cycle 3		• no • yes	no
_:38	Log.-inv.-T #:Stage blocked		• no • yes	no
_:16	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:109	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.s: AR cycle>3				
_:32	Log.-inv.-T #:Effected by AR cycle gr. 3		• no • yes	no
_:39	Log.-inv.-T #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:17	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.s: Cold load PU				
_:33	Log.-inv.-T #:Effect. b. cold-load pickup		• no • yes	no
_:40	Log.-inv.-T #:Stage blocked		• no • yes	no
_:18	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:111	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.set: bin.input				
_:34	Log.-inv.-T #:Effected by binary input		• no • yes	no
_:41	Log.-inv.-T #:Stage blocked		• no • yes	no
_:19	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:112	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s

6.28.7.4 Information List

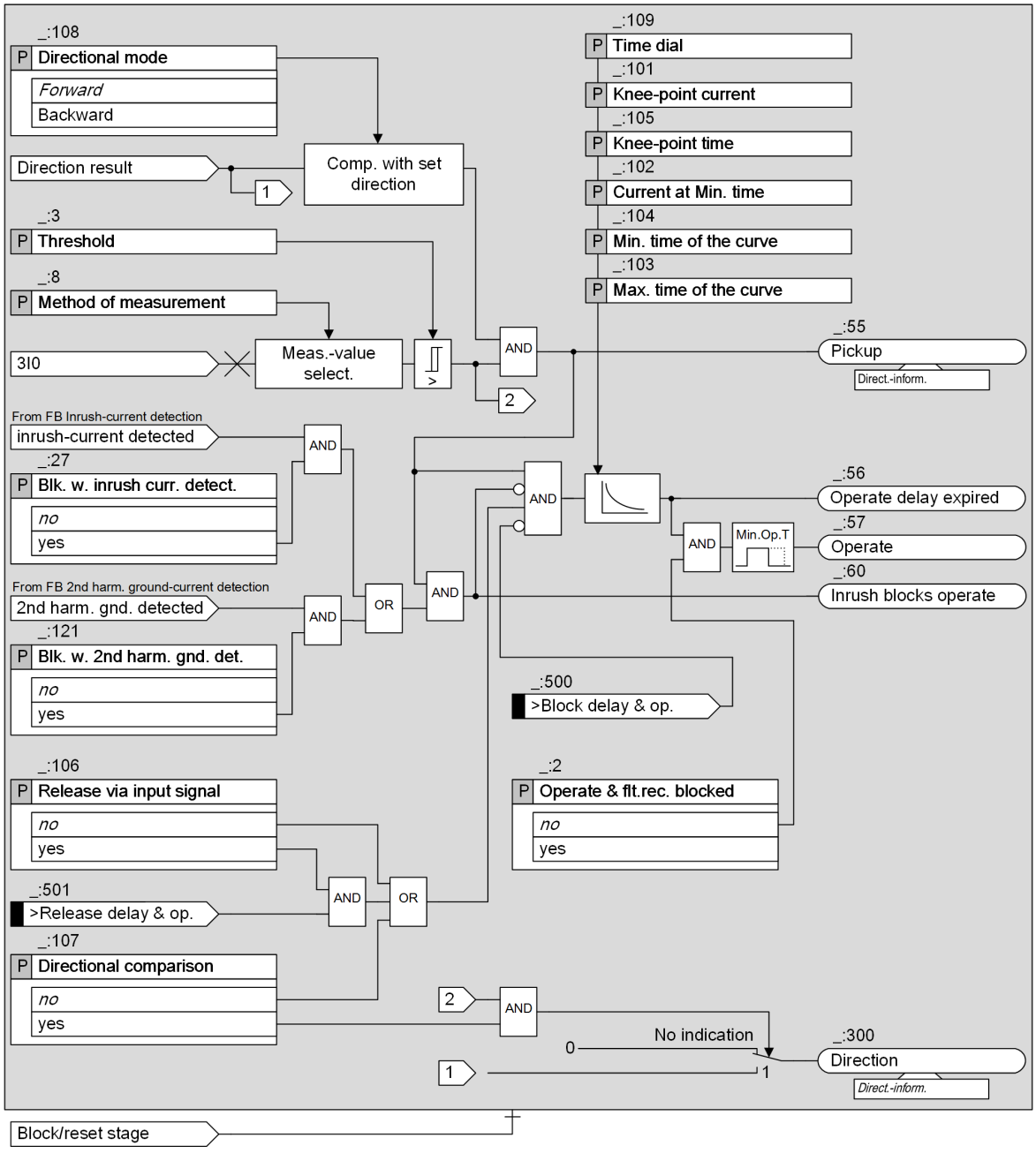
No.	Information	Data Class (Type)	Type
Log.-inv.-T #			
_:81	Log.-inv.-T #:>Block stage		I
_:501	Log.-inv.-T #:>Release delay & op.		I
_:84	Log.-inv.-T #:>Activ. dyn. settings		I
_:500	Log.-inv.-T #:>Block delay & op.		I
_:54	Log.-inv.-T #:Inactive		O
_:52	Log.-inv.-T #:Behavior		O
_:53	Log.-inv.-T #:Health		O
_:60	Log.-inv.-T #:Inrush blocks operate		O
_:62	Log.-inv.-T #:Dyn.set. AR cycle1act.		O
_:63	Log.-inv.-T #:Dyn.set. AR cycle2act.		O

No.	Information	Data Class (Type)	Type
_:64	Log.-inv.-T #:Dyn.set. AR cycle3act.		O
_:65	Log.-inv.-T #:Dyn.set. ARcycl.>3act		O
_:66	Log.-inv.-T #:Dyn.set. CLP active		O
_:67	Log.-inv.-T #:Dyn.set. BI active		O
_:68	Log.-inv.-T #:Dyn. set. blks. pickup		O
_:55	Log.-inv.-T #:Pickup		O
_:300	Log.-inv.-T #:Direction		O
_:56	Log.-inv.-T #:Operate delay expired		O
_:57	Log.-inv.-T #:Operate		O

6.28.8 Stage with Knee-Point Characteristic Curve

6.28.8.1 Description

Logic of the Stage



[lo_dilokn, 4, en_US]

Figure 6-502 Logic Diagram of the Directional Logarithmic Inverse Time with Knee-Point Overcurrent Protection, Ground

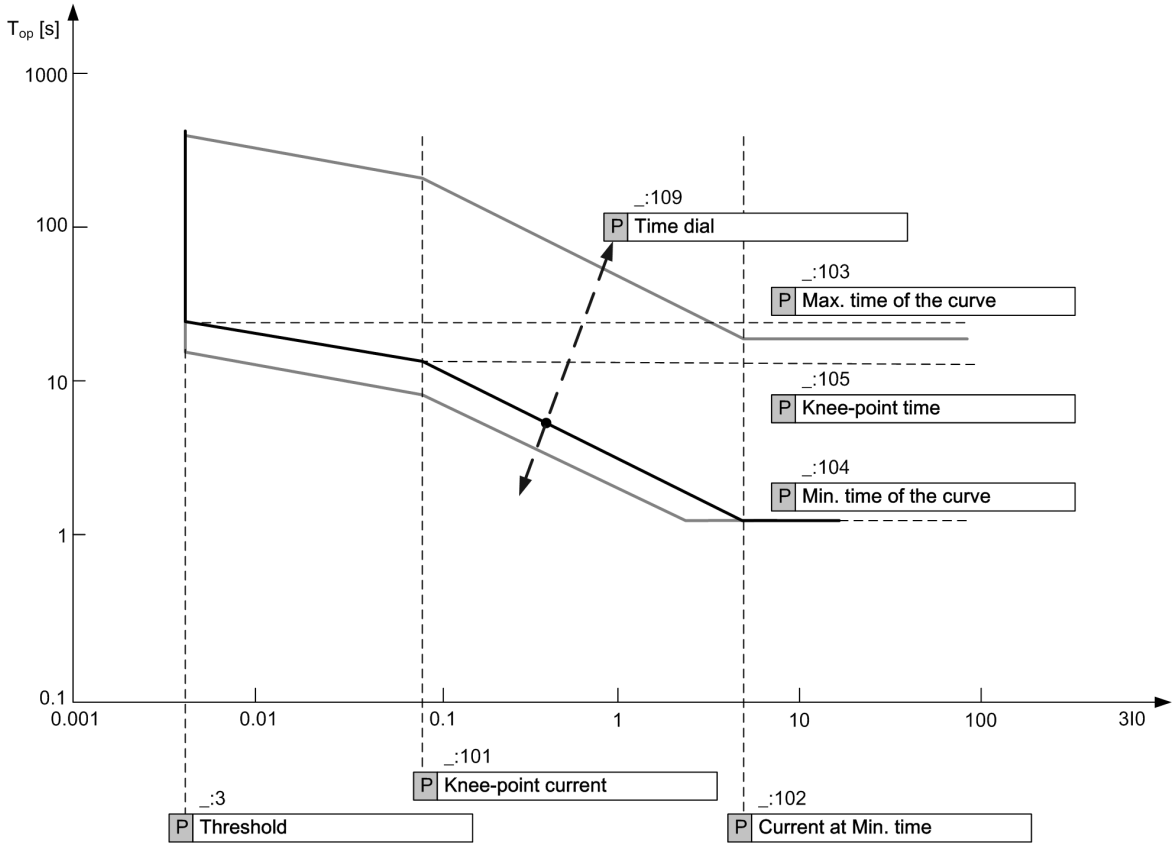
Apart from the operate curve, this type of stage is almost identical to the **Inverse-time overcurrent protection – advanced** stage (see chapter *6.28.6.1 Description*). The only difference is that the dynamic settings change functionality is not available.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter *6.28.6.1 Description*.

Operate Curve

If the function picks up, the logarithmic inverse-time characteristic curve is processed. A time value T_{op} is calculated for every input value exceeding 95 % of the threshold value. An integrator accumulates the value $1/T_{op}$. If the accumulated integral reaches the fixed value 1, the stage operates.

The curve used to calculate the time value T_{op} is shown in the following graphic. The curve is composed of 2 sections with different slops. 7 parameters are used to define the logarithmic inverse time with knee-point characteristic curve. The parameter **Max. time of the curve** determines the initial time value of the characteristic curve, and relates to the 3I0 **Threshold** value. The transition point is defined by parameter **Knee-point current** and parameter **Knee-point time**. The parameter **Min. time of the curve** indicates the lower time limit, and parameter **Current at Min. time** determines the current value at **Min. time of the curve**. The parameter **Time dial** servers as a time factor to the operate time.



[dw_loinkn, 3, en_US]

Figure 6-503 Operate Curve of the Logarithmic Inverse Time with Knee-Point Characteristic (In the Example of **Threshold** = ***0.004 A***)

6.28.8.2 Application and Setting Notes

Apart from the operate curve, this type of stage is almost identical to the **Inverse-time overcurrent protection – advanced** stage (see chapter *6.28.6.1 Description*). The only difference is that the dynamic settings change functionality is not available.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter *6.28.6.2 Application and Setting Notes*.

Parameter: Threshold

- Default setting **(_:3) Threshold** = ***1.20 A***

You can use the **Threshold** parameter to define the pickup value of the stage corresponding to the specific application.

Parameter: `Time dial`

- Default setting **`(_:6) Time dial`** = ***`0.2`***

You can use the **`Time dial`** parameter to displace the operate curve in the time direction.
General information cannot be provided. Define the value corresponding to the application.

Parameter: `Knee-point`

- Default setting **`(_:101) Knee-point current`** = ***`1.300 A`***
- Default setting **`(_:105) Knee-point time`** = ***`23.60 s`***

You use the **`Knee-point current`** parameter and the **`Knee-point time`** parameter to define the knee-point of the operate curve.
General information cannot be provided. Define the values corresponding to the application.

Parameter: Minimum Time of the Operate Curve

- Default setting **`(_:104) Min. time of the curve`** = ***`0.80 s`***
- Default setting **`(_:102) Current at Min. time`** = ***`1.500 A`***

Via the parameters **`Min. time of the curve`** and **`Current at Min. time`**, the point of the operate curve is defined where higher currents do no longer cause shorter operate times.
General information cannot be provided. Define the value corresponding to the application.

Parameter: Maximum Time of the Operate Curve

- Default setting **`(_:103) Max. time of the curve`** = ***`93.00 s`***

You can use the parameter **`Max. time of the curve`** to determine the initial value of the operate curve (for 3I0 = **`Threshold`**).
General information cannot be provided. Define the value corresponding to the application.

6.28.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:1	Log.inv.T KP #:Mode		• off • on • test	off
_:2	Log.inv.T KP #:Operate & flt.rec. blocked		• no • yes	no
_:108	Log.inv.T KP #:Direc-tional mode		• forward • reverse	forward
_:8	Log.inv.T KP #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:107	Log.inv.T KP #:Direc-tional comparison		• no • yes	no
_:106	Log.inv.T KP #:Release via input signal		• no • yes	no
_:10	Log.inv.T KP #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	Log.inv.T KP #:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:121	Log.inv.T KP #:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:3	Log.inv.T KP #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:109	Log.inv.T KP #:Time dial		0.05 to 1.50	0.20
_:101	Log.inv.T KP #:Knee-point current	1 A @ 100 Irated	0.030 A to 40.000 A	1.300 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.300 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.300 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.500 A
_:105	Log.inv.T KP #:Knee-point time		0.00 s to 100.00 s	23.60 s
_:102	Log.inv.T KP #:Current at Min. time	1 A @ 100 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 200.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:104	Log.inv.T KP #:Min. time of the curve		0.00 s to 30.00 s	0.80 s
_:103	Log.inv.T KP #:Max. time of the curve		0.00 s to 200.00 s	93.00 s

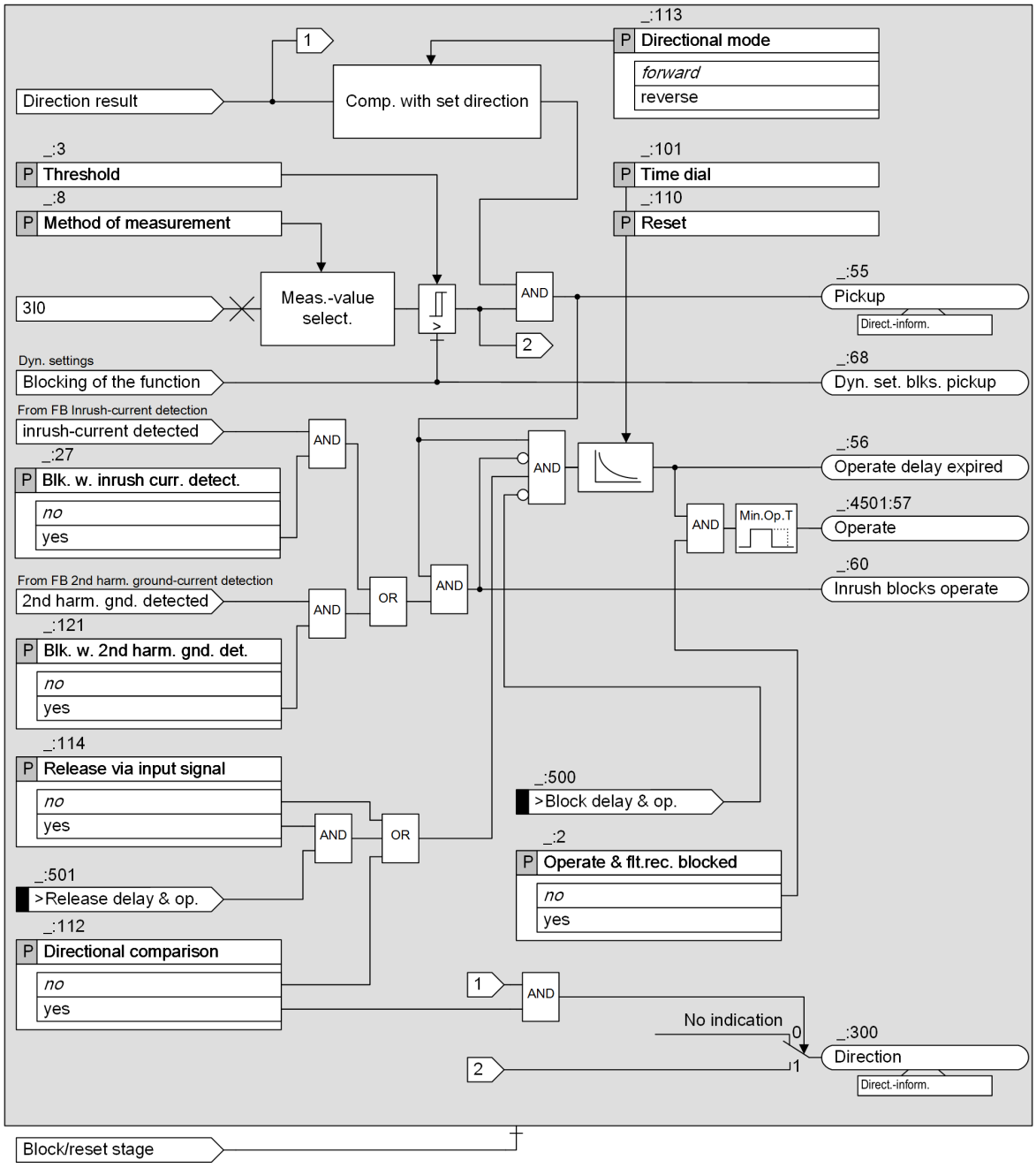
6.28.8.4 Information List

No.	Information	Data Class (Type)	Type
Stage #			
_:81	Log.inv.T KP #:>Block stage	SPS	I
_:501	Log.inv.T KP #:>Release delay & op.	SPS	I
_:500	Log.inv.T KP #:>Block delay & op.	SPS	I
_:54	Log.inv.T KP #:Inactive	SPS	O
_:52	Log.inv.T KP #:Behavior	ENS	O
_:53	Log.inv.T KP #:Health	ENS	O
_:60	Log.inv.T KP #:Inrush blocks operate	SPS	O
_:55	Log.inv.T KP #:Pickup	ACD	O
_:300	Log.inv.T KP #:Direction	ACD	O
_:56	Log.inv.T KP #:Operate delay expired	ACT	O
_:57	Log.inv.T KP #:Operate	ACT	O

6.28.9 Stage with User-Defined Characteristic Curve

6.28.9.1 Description

Logic of the Stage



[lo_dirusr, 2, en_US]

Figure 6-504 Logic Diagram of the Directional User-Defined Characteristic Curve Overcurrent Protection, Ground

This stage is structured in the same way as the **Inverse-time overcurrent protection – advanced** stage (see chapter *6.28.6.1 Description*). The only difference is that you can define the characteristic curve.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter *6.28.6.1 Description*.

User-Defined Characteristic Curve

With the directional, user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

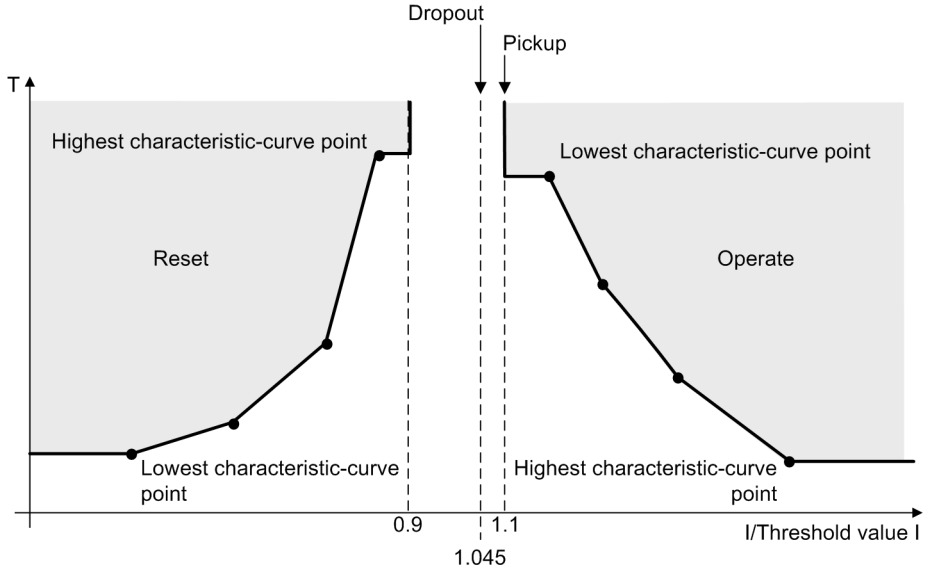
Pickup and Dropout Behaviors with User-Defined Characteristic Curves

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the threshold value by a factor of 1.045 (0.95 × 1.1× threshold value), the dropout is started. The pickup will be indicated as outgoing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is started from 0.9 of the set threshold value.

The following figure shows the pickup behavior and dropout behavior when a directional user-defined characteristic curve is used.



[dw_pidrbe, 1, en_US]

Figure 6-505 Pickup and Dropout Behaviors when Using a User-Defined Characteristic Curve

NOTE

Note that the currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

6.28.9.2 Application and Setting Notes

This stage is structured in the same way as the **Inverse-time overcurrent protection – advanced** stage. The only difference is that you can define the characteristic curve as required. This section only provides application and setting notes for setting the characteristic curves. For guidance on the other parameters of the stage, see chapter *6.28.6.2 Application and Setting Notes*.

Parameter: `Current/time value pairs` (of the Operate Curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting follows the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold setting afterwards if you want to displace the characteristic curve.

Specify the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.



NOTE

The value pairs must be entered in continuous order.

Parameter: `Time dial`

- Default setting **`(_:101) Time dial`** = ***`1`***

You can use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The setting value for the **`Time dial`** parameter is derived from the time-grading chart that has been prepared for the system. Where no grading and therefore no displacement of the characteristic curve is required, leave the **`Time dial`** set to ***`1`***.

Parameter: `Reset`

- Default setting **`(_:110) Reset`** = ***`disk emulation`***

The **`Reset`** parameter is used to define whether the stage drops out according to the dropout characteristic curve (behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	Both operate curve and a dropout characteristic curve have to be specified with this setting. Use this setting if the device is coordinated with electromechanical devices or other devices performing dropout after disk emulation.
`instantaneous`	Use this setting if the dropout is not to be performed after disk emulation, that is, if instantaneous dropout is required.

Parameter: `Current/time value pairs` (of the Dropout Curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting is determined by the characteristic curve you want to achieve.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold setting afterwards if you want to displace the characteristic curve.

Specify the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.



NOTE

The value pairs must be entered in continuous order.

6.28.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:1	User curve #:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:113	User curve #:Directional mode		• forward • reverse	forward
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:112	User curve #:Directional comparison		• no • yes	no
_:114	User curve #:Release via input signal		• no • yes	no
_:10	User curve #:Blk. by meas.-volt. failure		• no • yes	yes
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:121	User curve #:Blk. w. 2nd harm. gnd. det.		• no • yes	no
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 40.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 200.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

6.28.9.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:501	User curve #:>Release delay & op.	SPS	I
_:84	User curve #:>Activ. dyn. settings	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	SPS	O
_:62	User curve #:Dyn.set. AR cycle1act.	SPS	O
_:63	User curve #:Dyn.set. AR cycle2act.	SPS	O
_:64	User curve #:Dyn.set. AR cycle3act.	SPS	O
_:65	User curve #:Dyn.set. ARcycl.>3act	SPS	O
_:66	User curve #:Dyn.set. CLP active	SPS	O
_:67	User curve #:Dyn.set. BI active	SPS	O
_:68	User curve #:Dyn. set. blks. pickup	SPS	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:300	User curve #:Direction	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.28.10 Influence of Other Functions via Dynamic Settings

6.24.8.1 Description and *6.24.8.2 Application and Setting Notes (Advanced Stage)* describe the influence of other functions on dynamic settings.

6.29 Positive-Sequence Overcurrent Protection

6.29.1 Overview of Functions

The **Positive-sequence overcurrent protection** function (ANSI 50/51):

- Detects short circuits in electric equipment
- Can be applied when the zero-sequence current or negative-sequence current should not influence the tripping, for example, on the tertiary delta winding of an auto transformer

You can find a typical application scenario in the chapter *6.29.3.2 Application and Setting Notes*.

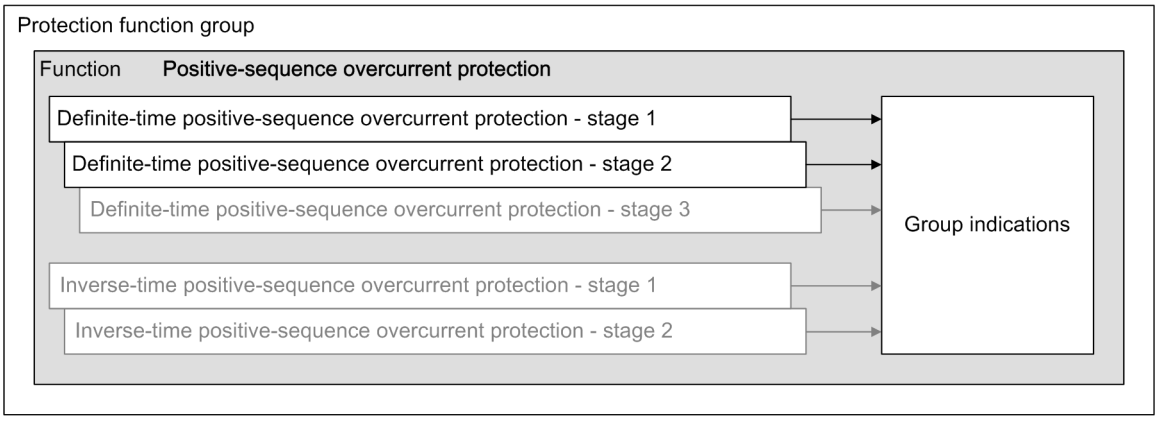
6.29.2 Structure of the Function

The **Positive-sequence overcurrent protection** function is used in protection function groups with 3-phase current measurement.
The function comes factory-set with 2 **Definite-time positive-sequence overcurrent protection** stages.
The following stages can be operated simultaneously within the function:

- 3 stages **Definite-time positive-sequence overcurrent protection**
- 2 stages **Inverse-time positive-sequence overcurrent protection**

Stages that are not preconfigured are shown in gray in the following figure. Apart from the tripping delay characteristic, the stages are identical in structure.
The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- **`Pickup`**
- **`Operate`**



[dw_PSP_structure, 1, en_US]

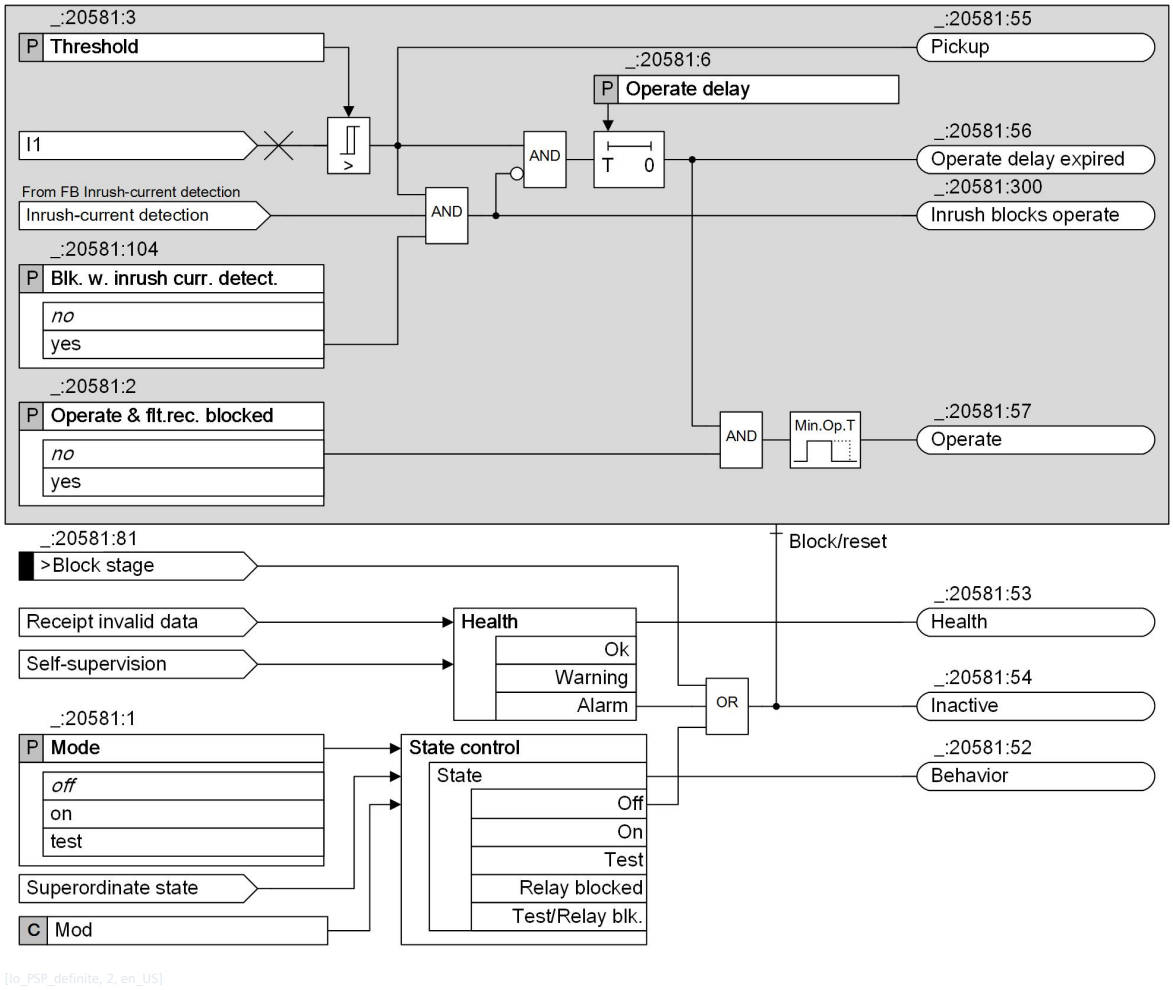
Figure 6-506 Structure/Embedding of the Function

If the device is equipped with an **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer-inrush currents.

6.29.3 Stage with Definite-Time Characteristic Curve

6.29.3.1 Description

Logic



[lo_PSP_definite, 2, en_US]

Figure 6-507 Logic Diagram of the Stage Definite-Time Positive-Sequence Overcurrent Protection

Method of Measurement

The fundamental phasors are calculated from the 3-phase phase currents. Based on this, the positive-sequence current is calculated.

Blocking of the Stage

You can block the stage externally or internally via the binary input signal **`>Block stage`**. In the event of blocking, the picked up stage is reset.

Blocking of Tripping via the Device-Internal Inrush-Current Detection Function

If the device is equipped with the additional **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer inrush currents.

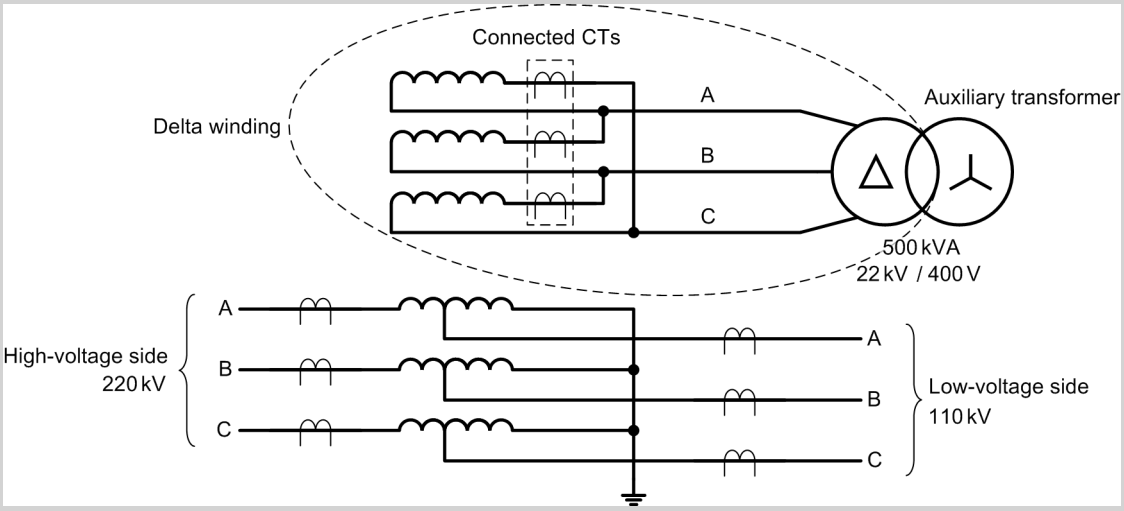
With the **`Blk. w. inrush curr. detect.`** parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and tripping are however blocked. The stage signals this by way of a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the tripping delay (time delay) is started. After that time, the stage operates.

6.29.3.2 Application and Setting Notes

Application Example

The **Positive-sequence overcurrent protection** function is applied to the tertiary delta winding of the auto transformer as shown in the following figure.

Short circuits on the delta winding must be detected. The stage should be as sensitive as possible but must not pick up in case of faults in the circuits connected to the low-voltage side of the auxiliary transformer. A single **Positive-sequence overcurrent protection** stage without time delay is applied and is connected with the CTs marked in the following figure. When the stage operates, both the high-voltage and low-voltage sides of the auto transformer will trip.



[dw_PSP_application_example, 1, en_US]

Figure 6-508 Auto Transformer with Tertiary Delta Winding

During ground faults on the high-voltage side (220 kV) or low-voltage side (110 kV) of the auto transformer, large currents circulate in the delta winding. This circulating current is a pure zero-sequence current. The protection function applied to the delta winding must not respond to this zero-sequence current. For this purpose, the **Positive-sequence overcurrent protection** function is applied.

In this application example, there is no circuit breaker on the delta winding, and the load on the delta winding is directly connected via the 500-kVA auxiliary transformer.

The application data in this application example is as follows:

Application Data	Value
Rated apparent power of the auto transformer	300 MVA
Rated apparent power of the auxiliary transformer ($S_{rated, aux}$)	500 kVA
Short-circuit voltage of the auxiliary transformer ($u_{k\text{-}aux}$)	12 %
Rated apparent power of the delta winding	30 MVA
Rated voltage of the delta winding ($V_{rated, delta}$)	22 kV
Connected load on the delta winding	500 kVA
Current transformer ratio in the delta winding ($Ratio_I$)	800 A/1 A

Generally, for the delta winding, the short-circuit current is substantially larger than the rated current, and the expected maximum load current is substantially smaller than the rated current. Therefore, you only need to consider the short-circuit current when determining the pickup threshold of the **Positive-sequence overcurrent protection** function.

As there is no circuit breaker between the delta winding and the connected auxiliary transformer, the pickup threshold of the **Positive-sequence overcurrent protection** function is graded against the maximum short-circuit current due to a short circuit on the low-voltage (400 V) side of the auxiliary transformer. The

maximum fault current for a fault on the low-voltage side of the auxiliary transformer must therefore be determined to establish the pickup threshold.

To determine the pickup threshold (setting of the **Threshold** parameter) of the stage, the following calculations must be carried out:

- Maximum short-circuit current ($I_{SC, max}$) on the high-voltage side of the auxiliary transformer due to a short circuit on the low-voltage (400 V) side

$$I_{SC, max} = \frac{S_{rated, aux} \cdot 100}{V_{rated, delta} \cdot \sqrt{3} \cdot u_{k\text{-}aux}} = \frac{500\ kVA \cdot 100}{22\ kV \cdot \sqrt{3} \cdot 12\ \%} = 109\ A$$

[fo_max_fault_current, 1, en_US]

- Primary-current pickup threshold ($I1_{stage1, prim}$)

  In this example, a safety margin (k_s) of 200 % is applied.

$$I1_{stage\ 1, prim} = \frac{I_{SC, max} \cdot k_s}{\sqrt{3}} = \frac{109\ A \cdot 2}{\sqrt{3}} = 126\ A$$

[fo_prim_threshold, 1, en_US]

- Secondary-current pickup threshold ($I1_{stage1, sec}$), which is the setting of the **Threshold** parameter

$$I1_{stage\ 1, sec} = I1_{stage\ 1, prim} \cdot \frac{1}{Ratio_I} = 126\ A \cdot \frac{1\ A}{800\ A} = 0.16\ A$$

[fo_sec_threshold, 1, en_US]

Parameter: Threshold, Operate delay

- Default setting **(_:20581:3) Threshold** = ***1.200 A*** (for the 1st stage)
- Default setting **(_:20581:6) Operate delay** = ***0.50 s*** (for the 1st stage)

Set the **Threshold** and **Operate delay** parameters for the specific application.

As time coordination with other protection functions is not required, you can set the **Operate delay** parameter to a rather small value of ***0.03 s***.

Parameter: Blk. w. inrush curr. detect.

- Default setting **(_:20581:104) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you stabilize the stage against tripping due to transformer-inrush currents. If transformers are parts of the protection zones, set this parameter to **yes**.

When the pickup threshold is set to 2 times the maximum short-circuit current, the threshold value should be above the current flowing during an inrush to the auxiliary transformer. Consequently, the setting of the **Blk. w. inrush curr. detect.** can remain ***no***. For more sensitive pickup thresholds, the **Blk. w. inrush curr. detect.** should be set to **yes**.

Parameter: Operate & flt.rec. blocked

- Default setting **(_:20581:2) Operate & flt.rec. blocked** = ***no***

With the **Operate & flt.rec. blocked** parameter, you block the operate indication, the fault recording, and the fault log.

6.29.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Definite-T 1				
_:20581:1	Definite-T 1:Mode		• off • on • test	off
_:20581:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:20581:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:20581:104	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:20581:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.50 s
Definite-T 2				
_:20582:1	Definite-T 2:Mode		• off • on • test	off
_:20582:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:20582:3	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:20582:104	Definite-T 2:Blk. w. inrush curr. detect.		• no • yes	no
_:20582:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.29.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Definite-T 1			
_:20581:81	Definite-T 1:>Block stage	SPS	I
_:20581:51	Definite-T 1:Mode (controllable)	ENC	C
_:20581:52	Definite-T 1:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:20581:53	Definite-T 1:Health	ENS	O
_:20581:54	Definite-T 1:Inactive	SPS	O
_:20581:56	Definite-T 1:Operate delay expired	ACT	O
_:20581:300	Definite-T 1:Inrush blocks operate	ACT	O
_:20581:55	Definite-T 1:Pickup	ACD	O
_:20581:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:20582:81	Definite-T 2:>Block stage	SPS	I
_:20582:51	Definite-T 2:Mode (controllable)	ENC	C
_:20582:52	Definite-T 2:Behavior	ENS	O
_:20582:53	Definite-T 2:Health	ENS	O
_:20582:54	Definite-T 2:Inactive	SPS	O
_:20582:56	Definite-T 2:Operate delay expired	ACT	O
_:20582:300	Definite-T 2:Inrush blocks operate	ACT	O
_:20582:55	Definite-T 2:Pickup	ACD	O
_:20582:57	Definite-T 2:Operate	ACT	O

6.29.4 Stage with Inverse-Time Characteristic Curve

6.29.4.1 Description

Logic

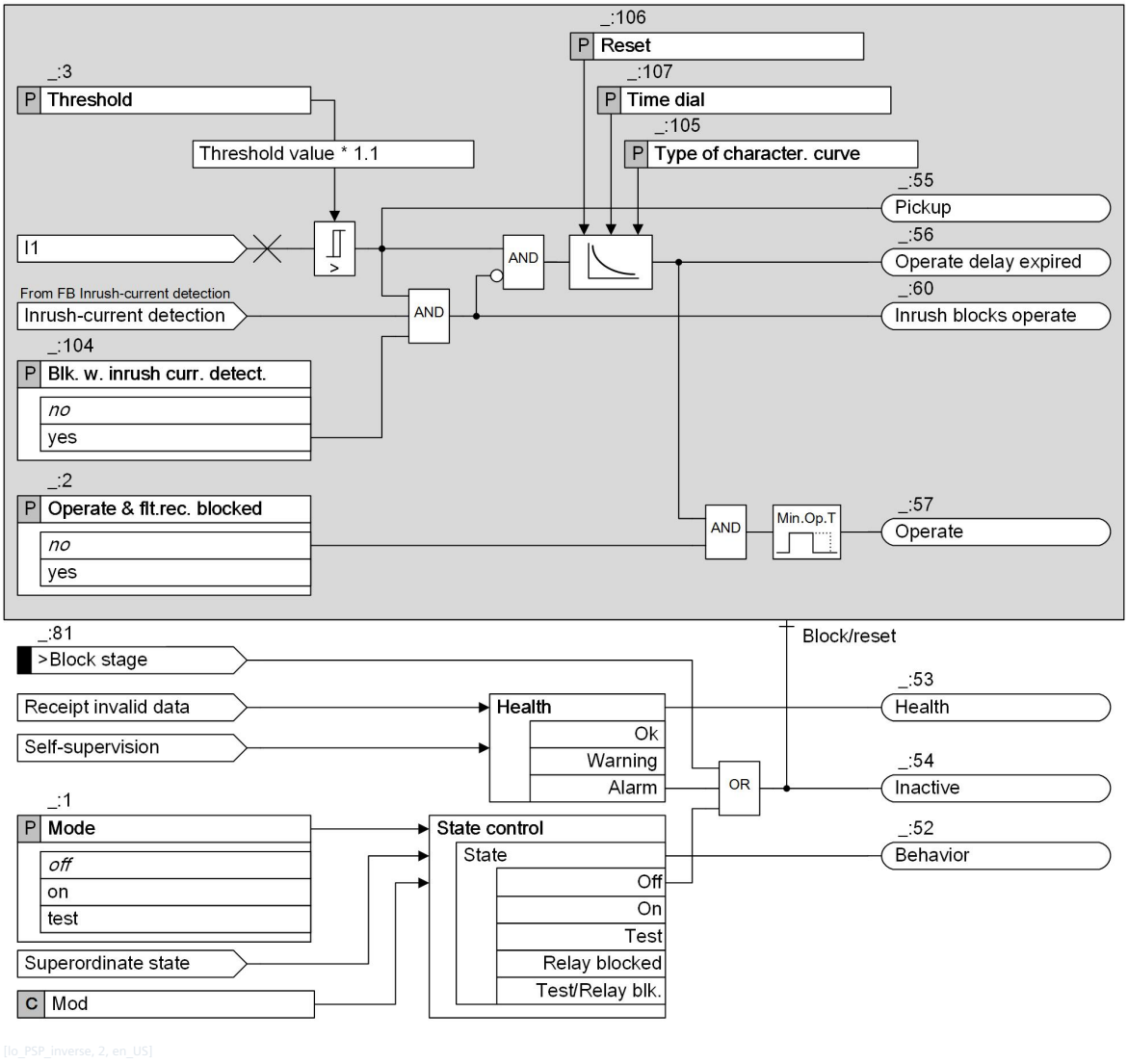


Figure 6-509 Logic Diagram of the Inverse-Time Positive-Sequence Overcurrent Protection

Method of Measurement

The fundamental phasors are calculated from the 3-phase phase currents. Based on this, the positive-sequence current is calculated.

Pickup and Dropout Behaviors of the Inverse-Time Characteristic Curve According to IEC and ANSI

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by a factor of 1.045 (0.95 · 1.1 · threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according

to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Blocking of the Stage

You can block the stage externally or internally via the binary input signal **>Block stage**. In the event of blocking, the picked up stage is reset.

Blocking of the Tripping by Device-Internal Inrush-Current Detection

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started. After that time, the stage operates.

6.29.4.2 Application and Setting Notes

Parameter: Type of character. curve

- Default setting **(_:105) Type of character. curve** = ***IEC normal inverse***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **Type of character. curve** required for your specific application. For more information about the parameter **Type of character. curve**, refer to chapter *12.25.2 Stage with Inverse-Time Characteristic Curve*.

Parameter: Threshold

- Default setting **(_:3) Threshold** = ***1.200 A***

Set the **Threshold** and **Type of character. curve** parameters for the specific application.

Note that a safety margin is set between the pickup value and the threshold value. The stage only picks up at approx. 10 % above the **Threshold**.

Parameter: Time dial

- Default setting **(_:107) Time dial** = ***1.00***

With the **Time dial** parameter, you displace the characteristic curve in the time direction.

The set value for the **Time dial** parameter is derived from the time-grading schedule that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter **Time dial** at ***1.00*** (default setting).

Parameter: Reset

- Default setting **(_:106) Reset** = ***disk emulation***

With the **Reset** parameter, you define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Select this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: Blk. w. inrush curr. detect.

- Default setting **(_:104) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you stabilize the stage against tripping due to transformer-inrush currents. If transformers are parts of the protection zones, set this parameter to **yes**.

6.29.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T #				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:3	Inverse-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:104	Inverse-T #:Blk. w. inrush curr. detect.		• no • yes	no
_:105	Inverse-T #:Type of character. curve		• ANSI long-time inv. • ANSI short-time inv. • ANSI extremely inv. • ANSI very inverse • ANSI normal inverse • ANSI moderately inv. • ANSI definite inverse • IEC normal inverse • IEC very inverse • IEC extremely inv. • IEC long-time inverse	IEC normal inverse
_:106	Inverse-T #:Reset		• instantaneous • disk emulation	disk emulation
_:107	Inverse-T #:Time dial		0.05 to 15.00	1.00

6.29.4.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	Inverse-T #:>Block stage	SPS	I
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:54	Inverse-T #:Inactive	SPS	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:60	Inverse-T #:Inrush blocks operate	ACT	O
_:59	Inverse-T #:Disk emulation running	SPS	O

No.	Information	Data Class (Type)	Type
_:55	Inverse-T #:Pickup	ACD	O
_:57	Inverse-T #:Operate	ACT	O

6.30 Group Indications of Overcurrent Protection Functions

6.30.1 Description

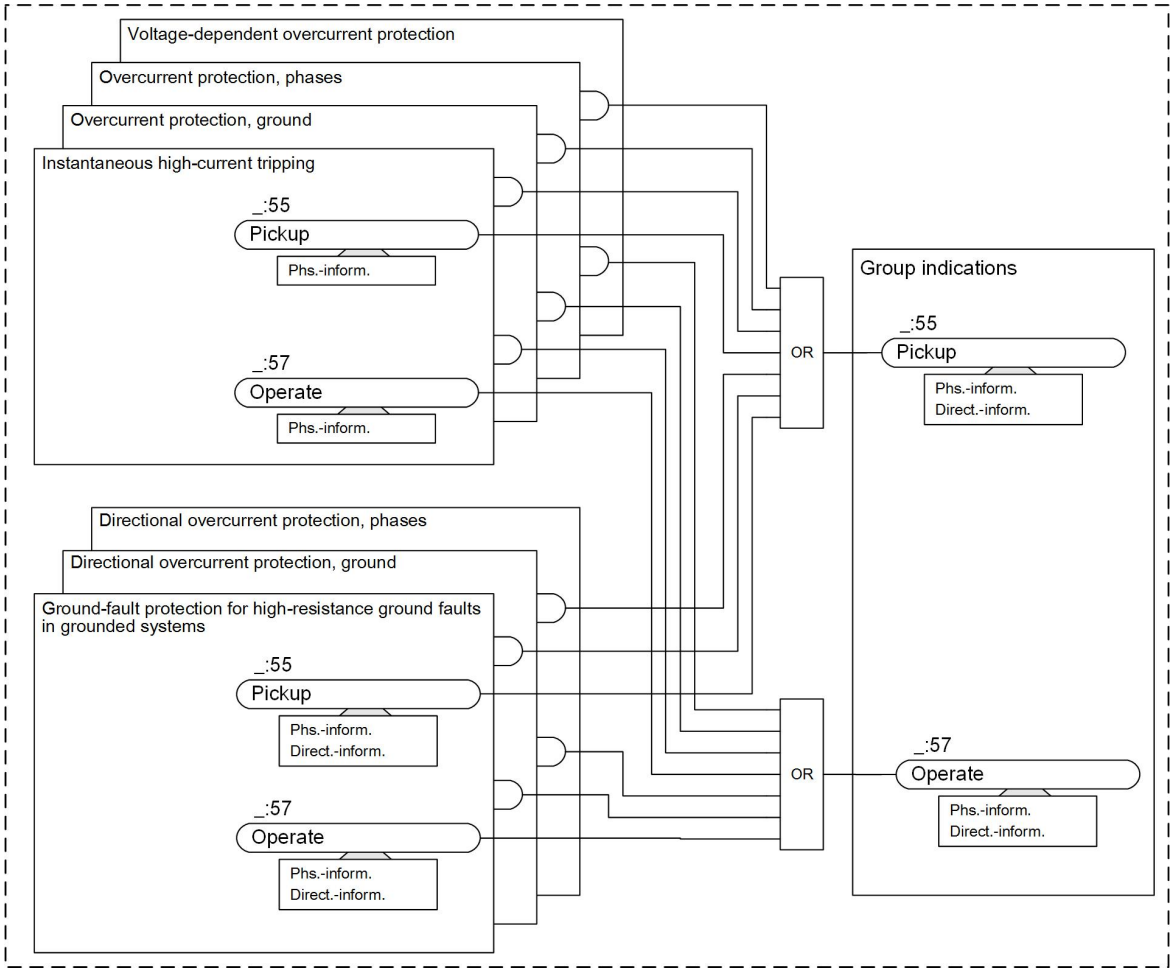
The function block **Group indications of the overcurrent protection functions** uses the pickup and operate indications of the following functions:

- Overcurrent protection, phases
- Overcurrent protection, ground
- Voltage-dependent overcurrent protection
- Directional overcurrent protection, phases
- Directional overcurrent protection, ground
- Ground-fault protection for high-impedance ground faults in grounded systems
- Instantaneous high-current tripping

The group indications of the overcurrent protection are generated by a logical OR of the stage-selective pickup and operate indications of the functions listed above (see also *Figure 6-510*):

- **`Pickup`**
- **`Operate`**

The pickup and operate indications are output, where present, with direction information.



[lo_oc_grin, 4, en_US]

Figure 6-510 Logic Diagram of the Overcurrent Protection Group Indications

6.31 Negative-Sequence Protection

6.31.1 Overview of Functions

The function **Negative-sequence protection** (ANSI 46):

- Detects 1-phase or 2-phase short circuits in the electrical power system with clearly increased sensitivity compared to the classical overcurrent protection
- Protects electric machines during excessive unbalanced load
- Reports unbalanced load conditions in the electricity supply system
- Detects phase interruptions in the primary system
- Locates short circuits or inversions in the connections to the current transformers

6.31.2 Structure of the Function

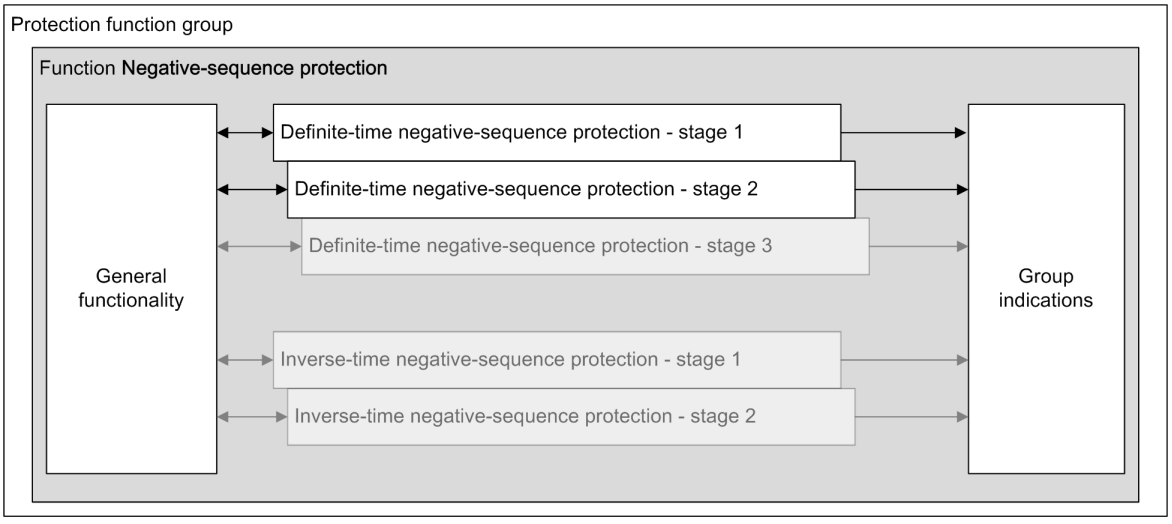
The **Negative-sequence protection** function is used in protection function groups with current measurement.

The function is preconfigured by the manufacturer with 2 **Definite-time negative-sequence protection** stages.

In the function **Negative-sequence protection**, the following stages can be operated simultaneously:

- 3 stages **Definite-time negative-sequence protection**
- 2 stages **Inverse-time negative-sequence protection**

The stages have an identical structure. Stages that are not preconfigured are shown in gray in the following figure.



[dw_nsp_str, 3, en_US]

Figure 6-511 Structure/Embedding of the Function

If the device is equipped with the **Inrush-current detection** function, the stages can be stabilized against operate due to transformer-inrush currents.

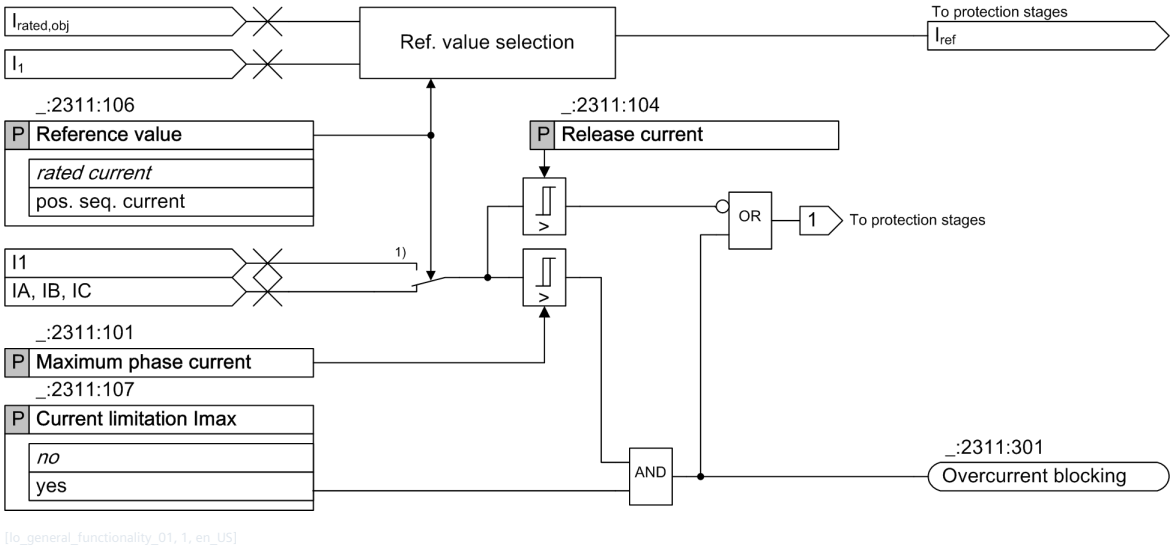
6.31.3 General Functionality

6.31.3.1 Description

Logic

The following figure represents the logic of the general functionality which applies across all configured stages. It contains:

- Selection of the reference value
- Current-release criterion



[lo_general_functionality_01, 1, en_US]

Figure 6-512 Logic Diagram of the General Functionality

(1) Switchover to I_1 with **(_:2311:106) Reference value** = ***pos. seq. current***

Reference Value

With the parameter **Reference value**, the negative-sequence current I_2 is normalized to the rated object current $I_{rated, obj}$ or to the positive-sequence current I_1. When I_2 is normalized to I_1, the sensitivity of the function for low short-circuit currents is increased.

Current Limitation and Maximum Phase Current

With the parameters **Current limitation Imax** and **Maximum phase current**, you restrict the operating range of the function. When the limiting is activated, pickup of the stages is blocked as soon as the maximum phase-current threshold value is exceeded. For more information, refer to the stage description.

Release Current

The threshold value of the **Release current** serves to release the negative-sequence protection.

6.31.3.2 Application and Setting Notes

Parameter: Reference value

- Default setting **(_:2311:106) Reference value** = ***rated current***

With the parameter **Reference value**, you define the normalization of the negative-sequence current I_2 to the rated object current $I_{rated, obj}$ ($I_2/I_{rated, obj}$) or to the positive-sequence current I_1 (I_2/I_1).

Parameter Value	Description
$I_2/I_{rated, obj}$	The negative-sequence current is referred to the rated current of the protected object. This is a preferred normalization for electrical machines, because the permissible limiting values are indicated exclusively referred to the machine rated current. You can also use this normalization for other applications.
I_2/I_1	The normalization of the negative-sequence system to the positive-sequence system yields a higher sensitivity. Use this normalization when detecting interruptions in the primary system.

Set the parameter depending on the application.

Parameter: **Current limitation Imax,Maximum phase current**

- Default setting **(_:2311:107) Current limitation Imax** = ***no***
- Recommended setting value **(_:2311:101) Maximum phase current** = ***10.0 A at 1 A***

If the protection function needs a maximum current limitation, set the value of the **Current limitation Imax** parameter from ***no*** to ***yes***. With the parameter **Maximum phase current**, you set the upper limit of the phase current. CT saturation will cause negative-sequence current in the secondary system. To avoid overfunction due to the CT saturation, a suitable phase-current limit value is 10 times of the rated protection-object current.

Parameter: **Release current**

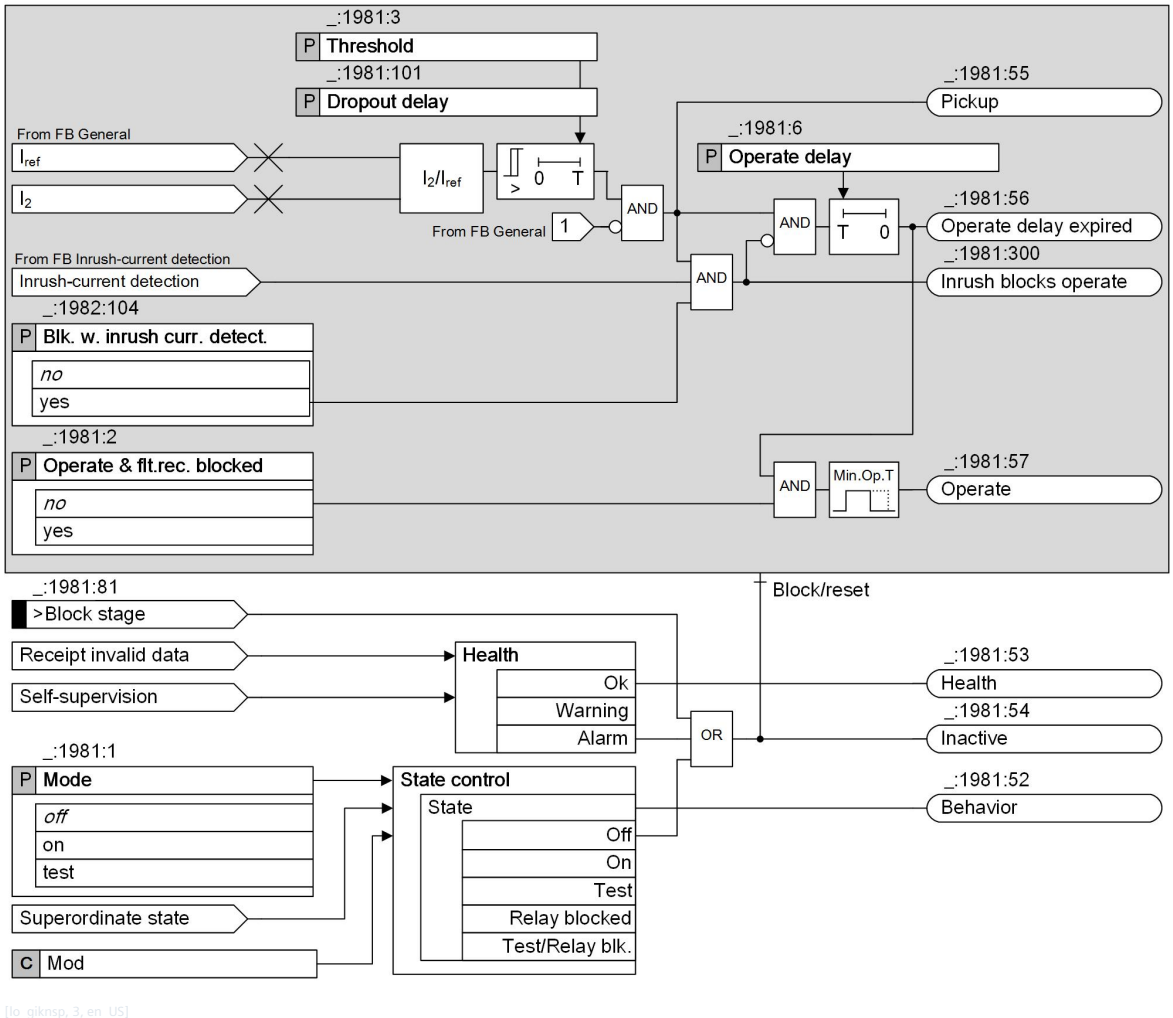
- Recommended setting value **(_:2311:104) Release current** = ***0.05 A at 1 A***

For the safe calculation of negative-sequence currents, the current in at least one phase must be greater than 5 % of the secondary rated device current. For a 1-A device, the value of **Release current** is 0.05 A (0.25 A for a 5-A device).

6.31.4 Stage with Definite-Time Characteristic Curve

6.31.4.1 Stage Description

Logic of a Stage



[lo_giknsp, 3, en_US]

Figure 6-513 Logic Diagram of the Stage Negative-Sequence Protection with Definite-Time Characteristic Curve

Method of Measurement

The fundamental phasors are calculated from the 3-phase phase currents. Based on this, the negative-sequence system and the positive-sequence system are calculated. Following this, the negative-sequence current is normalized to the reference current. The selection of the reference current is made in the **FB General**.

Blocking of the Stage

When blocked, the picked-up stage will drop out.

Blocking the stage is possible externally or internally via the binary input signal **`>Block stage`**.

Blocking of the Tripping by Device-Internal Inrush-Current Detection

The **`Blk. w. inrush curr. detect.`** parameter allows you to define whether the operate indication of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking

and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started. After that time, the stage operates.

6.31.4.2 Application and Setting Notes

Parameter: `Threshold`

- Recommended setting value **`(_:1981:3) Threshold`** = ***`10 %`***

The setting of the parameter **`Threshold`** depends on the respective application. A threshold value of 10 % is a practicable value for fault indications of electrical machines.

Parameter: `Operate delay`

- Recommended setting value **`(_:1981:6) Operate delay`** = ***`1500 ms`***

The setting of the **`Operate delay`** depends on the application. Observe the time grading in the power-system protection and do not set the time for monitoring too short. The default setting is practicable. For motors, the time depends on the permissible time period for the set unbalanced load.

Parameter: `Blk. w. inrush curr. detect.`

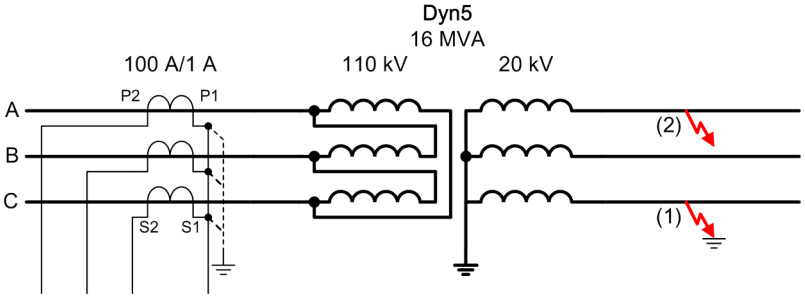
- Default setting **`(_:1981:104) Blk. w. inrush curr. detect.`** = ***`no`***

With the parameter **`Blk. w. inrush curr. detect.`**, the stage can be stabilized against tripping on transformer-inrush currents. If transformers are parts of the protection zones, set this parameter to **`yes`**.

Backup Protection with a Three-Winding Transformer

The function **Negative-sequence protection** can be used for a transformer as a responsive backup protection on the supply side. It aims to acquire weak current from the 1-phase and 2-phase short circuits. Also on the low-voltage side, 1-phase short circuits can be used, which do not create a zero-sequence system in the current on the upper-voltage side (for example in vector group Dyn).

The following example explains the achieved sensitivity. *Figure 6-514* shows the example with the relevant technical data.



[dw_1p2pku, 1, en_US]

Figure 6-514 1- Phase and 2-Phase Short Circuit on Transformer

(1) 1-phase ground fault
(2) 2-phase short circuit

The standardization is based on the transformer rated object current (**`Reference value`** = ***`rated current`***).

If the pickup value on the upper-voltage side is 12 % (**`Threshold`** = ***`12 %`***) of the transformer rated current, this corresponds to 0.1 A on the secondary side. With this the following currents and sensitivities are reached.

- 1-phase short circuit

$$I_{F;ph-gnd} = 3 \cdot \frac{V_{US}}{V_{LS}} \cdot \frac{I_{CT,prim}}{I_{CT,S}} \cdot I_2 = 3 \cdot \frac{110\,kV}{20\,kV} \cdot \frac{100\,A}{1\,A} \cdot 0.1\,A = 165\,A$$

[fo_einpk1, 3, en_US]

Sensitivity:

$$\frac{I_{F,ph-gnd}}{I_{rated,transf.-LS}}[\%] = \frac{I_{F,ph-gnd}}{\frac{S_{rated,transf.}}{\sqrt{3} \cdot V_{LS}}} \cdot 100\,\% = \frac{165\,A}{\frac{16\,MVA}{\sqrt{3} \cdot 20\,kV}} \cdot 100\,\% = 36\,\%$$

[fo_einpk2, 2, en_US]

- 2-phase short circuit

$$I_{F;ph-ph} = \sqrt{3} \cdot \frac{V_{HS}}{V_{LS}} \cdot \frac{I_{P,CT}}{I_{S,CT}} \cdot I_2 = \sqrt{3} \cdot \frac{110\,kV}{20\,kV} \cdot \frac{100\,A}{1\,A} \cdot 0.1A = 95\,A$$

[fo_zwpok3, 2, en_US]

Sensitivity:

$$\frac{I_{F,ph-ph}}{I_{rated,transf.-LS}}[\%] = \frac{I_{F,ph-ph}}{\frac{S_{rated,transf.}}{\sqrt{3} \cdot V_{LS}}} \cdot 100\,\% = \frac{95\,A}{\frac{16\,MVA}{\sqrt{3} \cdot 20\,kV}} \cdot 100\,\% = 21\%$$

[fo_zwepk4, 2, en_US]

Since this is the short circuit on the low-voltage side, the time delay must be coordinated with the times of subordinate protection devices.

Line or Cable Networks

In line or cable networks, the function **Negative-sequence protection** is used to detect weak current caused by unbalanced faults. In the unbalanced fault, the pickup values of the overcurrent protection are not reached.

The current is based on the rated object current (**`Reference value` = *`rated current`***).

Therefore:

The 2-phase short circuit with the current I leads to a negative-sequence current:

$$I_2 = \frac{1}{\sqrt{3}} \cdot I = 0.58 \cdot I$$

[fo_zwepk5, 2, en_US]

The 1-phase short circuit with the current I leads to a negative-sequence current:

$$I_2 = \frac{1}{3} \cdot I = 0.33 \cdot I$$

[fo_einpk6, 2, en_US]

If the protection works exclusively with short circuits, the protection must be set via the value for 2-phase operation. Then a 2-phase short circuit can be assumed with more than 60 % of the rated object current. Set the standardization on the rated object current. To avoid over-function with overload, Siemens recommends a pickup value of approx. 65 %. Coordinate the time delays with the network grading for phase short circuits.

Break in Primary System

To record breaks in the primary system, set standardization on I_2/I_1 (**`Reference value` = *`pos. seq. current`***) to achieve a higher sensitivity (independence of load current). For a 1-phase break, the ratio of the negative-sequence current and the positive-sequence current can be described according to the following equation with the negative-sequence and zero-sequence impedance (Z_2, Z_0).

$$\frac{I_2}{I_1} = \frac{1}{1 + \frac{\sum Z_2}{\sum Z_0}}$$

[fo_untpk7, 2, en_US]

In the isolated system or with one-sided ground, the zero-sequence impedance is infinity and thus the ratio is always 1. Observe a two-sided grounded network and set the zero-sequence impedance equal to the negative-sequence impedance, then the ratio is 0.5. If a wire break occurs in the secondary circuit, value of 1 or 0.5 is also possible.

For a 2-phase break, current can only flow with a two-sided grounded network. In this case, the ratio $I_2/I_1 = 1$. If a partial 1-phase load is expected, the ratio is also set. The setting value is dependent on the maximum 1-phase load. For a setting value of 10 %, the phase current can be 30 %.

If you want to prevent an indication with short circuits, activate the current limiting to, for example, 1.2 $I_{rated,obj}$ (**Current limitation Imax** = ***yes***; **Maximum phase current** = ***1.2 A at 1 A*** transformer and ideal adaptation to the protected object). Here calculate the current with the current transformer ratio to the secondary circuit.

The setting of the protection stage is aligned to the network type. A setting value of 25 % (**Threshold** = ***25 %***) offers a sufficiently high sensitivity. If errors occur in the current transformer circuit, there can be, however, also be a tripping. To prevent over-functions during the AREC cycles, the time delay for the tripping must be set long. A time of 60 s (**Operate delay** = ***60.00 s***) offers sufficient reliability.

6.31.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:106	General:Reference value		• pos. seq. current • rated current	rated current
_:2311:107	General:Current limitation Imax		• no • yes	no
_:2311:101	General:Maximum phase current	1 A @ 100 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	10.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	50.000 A
_:2311:104	General:Release current	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
Definite-T 1				
_:1981:1	Definite-T 1:Mode		• off • on • test	off
_:1981:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:1981:3	Definite-T 1:Threshold		5.0 % to 999.9 %	10.0 %
_:1981:4	Definite-T 1:Dropout ratio		0.40 to 0.99	0.95

Addr.	Parameter	C	Setting Options	Default Setting
_:1981:104	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:1981:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:1981:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	1.50 s
Definite-T 2				
_:1982:1	Definite-T 2:Mode		• off • on • test	off
_:1982:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:1982:3	Definite-T 2:Threshold		5.0 % to 999.9 %	65.0 %
_:1982:4	Definite-T 2:Dropout ratio		0.40 to 0.99	0.95
_:1982:104	Definite-T 2:Blk. w. inrush curr. detect.		• no • yes	no
_:1982:101	Definite-T 2:Dropout delay		0.00 s to 60.00 s	0.00 s
_:1982:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.31.4.4 Information List

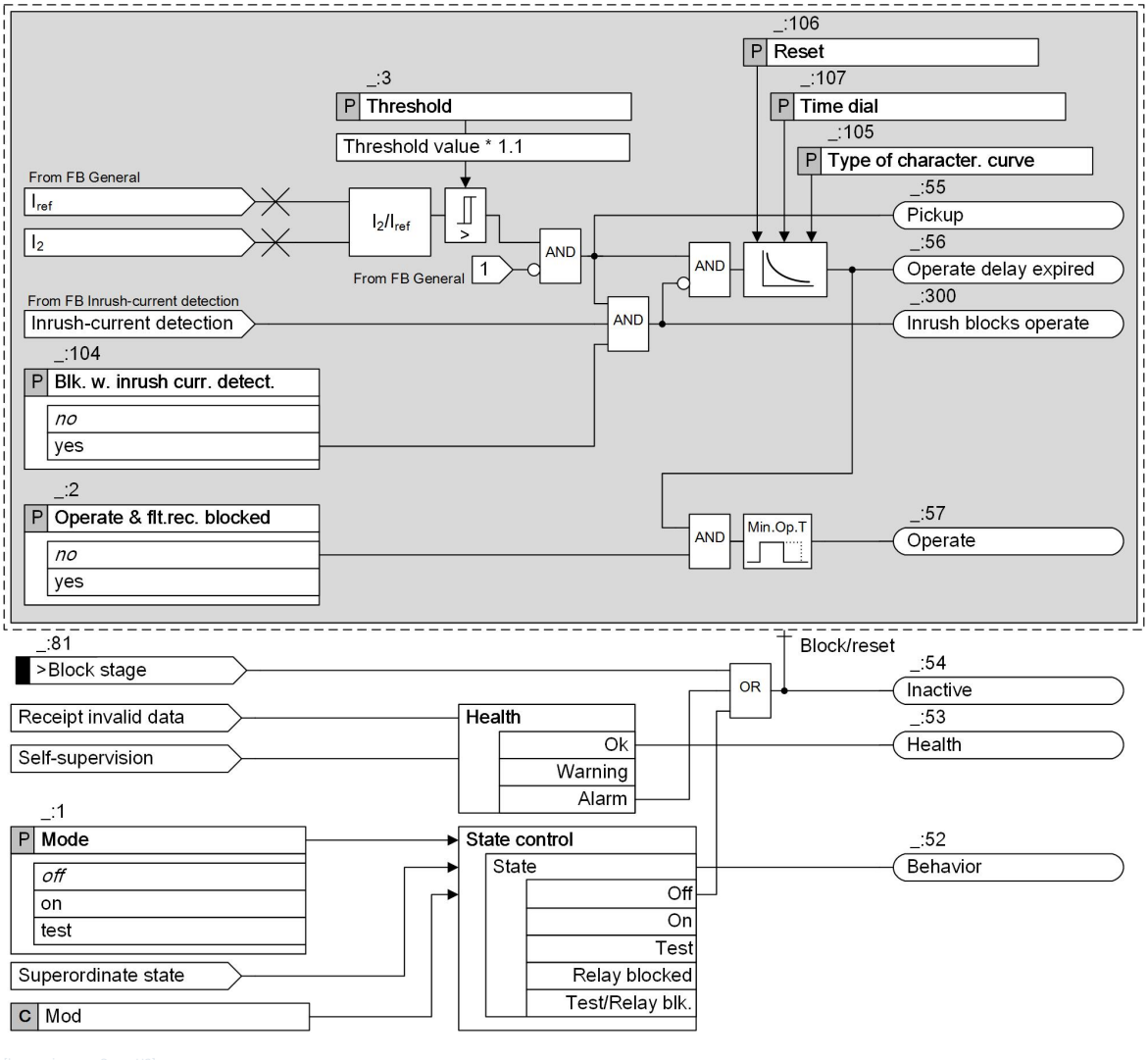
No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:Overcurrent blocking	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Definite-T 1			
_:1981:81	Definite-T 1:>Block stage	SPS	I
_:1981:51	Definite-T 1:Mode (controllable)	ENC	C
_:1981:52	Definite-T 1:Behavior	ENS	O
_:1981:53	Definite-T 1:Health	ENS	O
_:1981:54	Definite-T 1:Inactive	SPS	O
_:1981:56	Definite-T 1:Operate delay expired	ACT	O
_:1981:300	Definite-T 1:Inrush blocks operate	ACT	O
_:1981:55	Definite-T 1:Pickup	ACD	O
_:1981:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:1982:81	Definite-T 2:>Block stage	SPS	I
_:1982:51	Definite-T 2:Mode (controllable)	ENC	C

No.	Information	Data Class (Type)	Type
_:1982:52	Definite-T 2:Behavior	ENS	O
_:1982:53	Definite-T 2:Health	ENS	O
_:1982:54	Definite-T 2:Inactive	SPS	O
_:1982:56	Definite-T 2:Operate delay expired	ACT	O
_:1982:300	Definite-T 2:Inrush blocks operate	ACT	O
_:1982:55	Definite-T 2:Pickup	ACD	O
_:1982:57	Definite-T 2:Operate	ACT	O

6.31.5 Stage with Inverse-Time Characteristic Curve

6.31.5.1 Description

Logic of a Stage



[lo_nsp_inverse, 2, en_US]

Figure 6-515 Logic Diagram of the Negative-Sequence Protection with Inverse-Time Characteristic Curve

Method of Measurement

The fundamental phasors are calculated from the 3-phase phase currents. Based on this, the negative-sequence system and the positive-sequence system are calculated. Following this, the negative-sequence current is normalized to the reference current. The selection of the reference current is made in the **FB General**.

Pickup and Dropout Behaviors of the Inverse-Time Characteristic Curve According to IEC and ANSI

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by a factor of 1.045 (0.95 · 1.1 · threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Blocking of the Stage

When blocked, the picked-up protection stage will drop out.

Blocking the stage is possible externally or internally via the binary input signal **>Block stage**.

Blocking of the Tripping by Device-Internal Inrush-Current Detection

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started. After that time, the stage operates.

6.31.5.2 Application and Settings Notes

Parameter: Type of character. curve

- Default setting **(_:105) Type of character. curve** = ***IEC normal inverse***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **Type of character. curve** required for your specific application. For more information about the parameter **Type of character. curve**, refer to chapter *12.26.2 Stage with Inverse-Time Characteristic Curve*.

Parameter: Threshold

- Recommended setting value **(_:3) Threshold** = ***10.0 %***

The setting of the parameter **Threshold** depends on the respective application. A threshold value of 10 % is a practicable value for fault detection for different applications.

Parameter: Time dial

- Recommended setting value **(_:107) Time dial** = ***1.00***

With the parameter **Time dial**, you displace the characteristic curve in the time direction.

The set value for the parameter **Time dial** is derived from the time-grading schedule that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the **Time dial** parameter at 1.00 (default setting).

Parameter: `Reset`

- Default setting **`(_:106) Reset`** = ***`disk emulation`***

With the parameter **`Reset`**, you define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: `Blk. w. inrush curr. detect.`

- Default setting **`(_:104) Blk. w. inrush curr. detect.`** = ***`no`***

With the parameter **`Blk. w. inrush curr. detect.`**, the stage can be stabilized against tripping on transformer-inrush currents. If transformers are parts of the protection zones, set this parameter to ***`yes`***.

6.31.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Inverse-T #`				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:3	Inverse-T #:Threshold		5.0 % to 999.9 %	10.0 %
_:104	Inverse-T #:Blk. w. inrush curr. detect.		• no • yes	no
_:105	Inverse-T #:Type of character. curve			
_:106	Inverse-T #:Reset		• instantaneous • disk emulation	disk emulation
_:107	Inverse-T #:Time dial		0.05 to 15.00	1.00

6.31.5.4 Information List

No.	Information	Data Class (Type)	Type
`Inverse-T #`			
_:81	Inverse-T #:>Block stage	SPS	I
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:54	Inverse-T #:Inactive	SPS	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:300	Inverse-T #:Inrush blocks operate	ACT	O
_:59	Inverse-T #:Disk emulation running	SPS	O
_:55	Inverse-T #:Pickup	ACD	O
_:57	Inverse-T #:Operate	ACT	O

6.32 Directional Negative-Sequence Protection

6.32.1 Overview of Functions

The function **Directional negative-sequence protection with current-independent time delay** (ANSI 46) serves as the backup short-circuit protection for unbalanced faults.

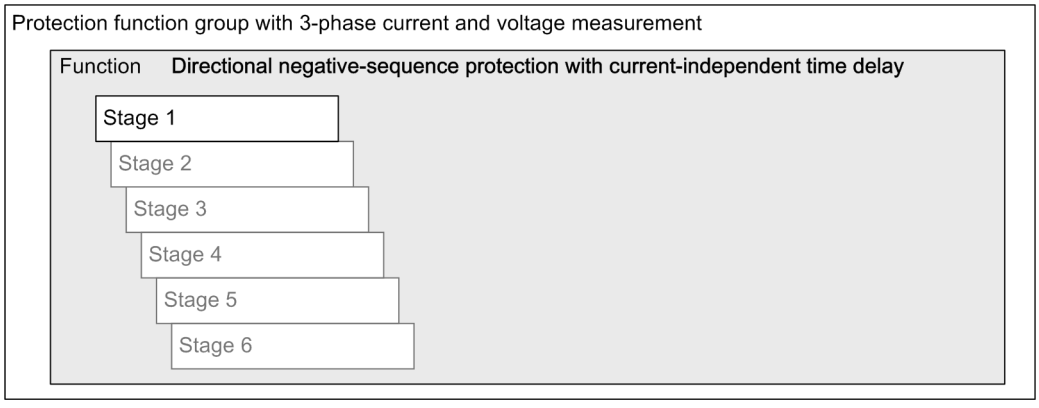
With the negative-sequence system, various supervision and protection tasks can be realized, for example:

- Recording of 1 or 2-phase short circuits in the system with a higher sensitivity than in classic overcurrent protection. The pickup value can be set under the rated object current.
- Recording of phase conductor interruptions in the primary system and in the current-transformer secondary circuits
- Location of short circuits or reversals in the connections to the current transformers
- Indication of unbalanced states in the energy system
- Protection of electrical machines following unbalanced loads that are caused by unbalanced voltages or conductor interruptions (for example, through a defective fuse)

6.32.2 Structure of the Function

The **Directional negative-sequence protection with definite time delay** function can be used in protection function groups with 3-phase current and voltage measurement.

The function comes factory-set with 1 stage. A maximum of 6 tripping stages can be operated simultaneously in the function.



[dw_nsp_dir, 1, en_US]

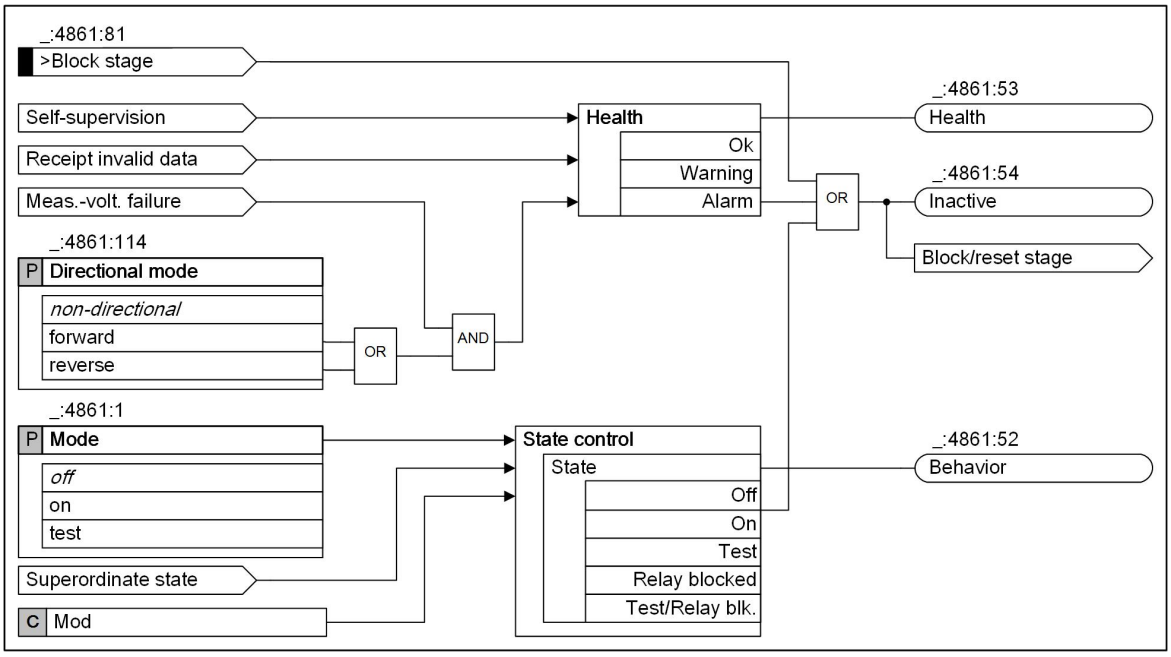
Figure 6-516 Structure/Embedding of the Function

If the device is equipped with the **Inrush-current detection** function, the tripping stages can be stabilized against tripping due to transformer-inrush currents.

6.32.3 Function Description

Stage Control

The following figure shows a stage control. It is available separately for each stage.



[lo_stensp, 2, en_US]

Figure 6-517 Stage Control of the Directional Negative-Sequence Protection

In addition to the generally valid stage control, the stage is blocked in the event of a measuring-voltage failure, provided the stage is working directionally.

Logic of the Stage

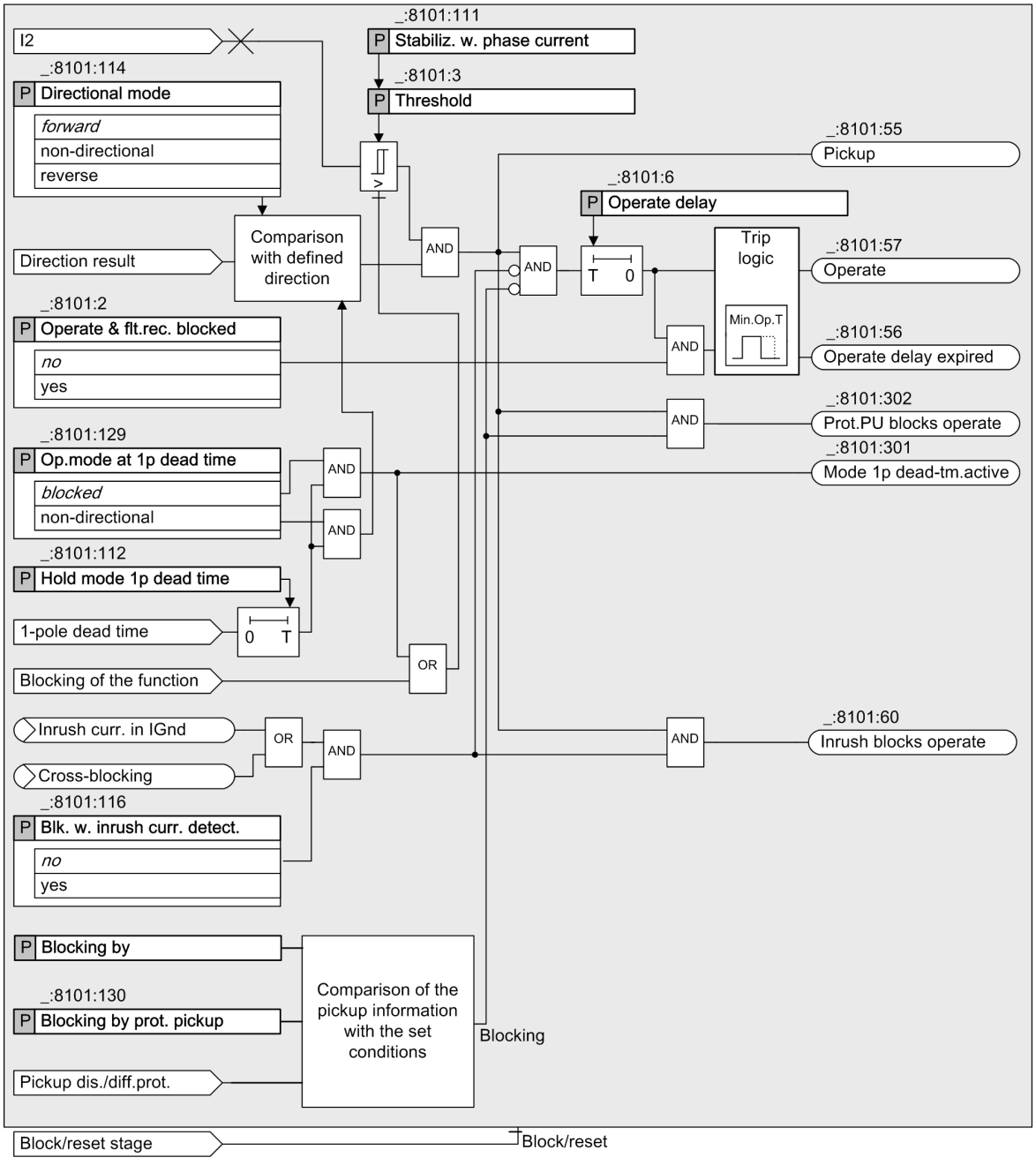


Figure 6-518 Logic Diagram of the Function Directional Negative-Sequence System Protection with Current-Independent Time Delay

Measurand

The negative-sequence current I2 is used as a measurand. From the 3-phase currents, the fundamental phasors are determined via a 1-cycle filter and, corresponding with the definition equation of the symmetrical components, the negative-sequence system is calculated from this.

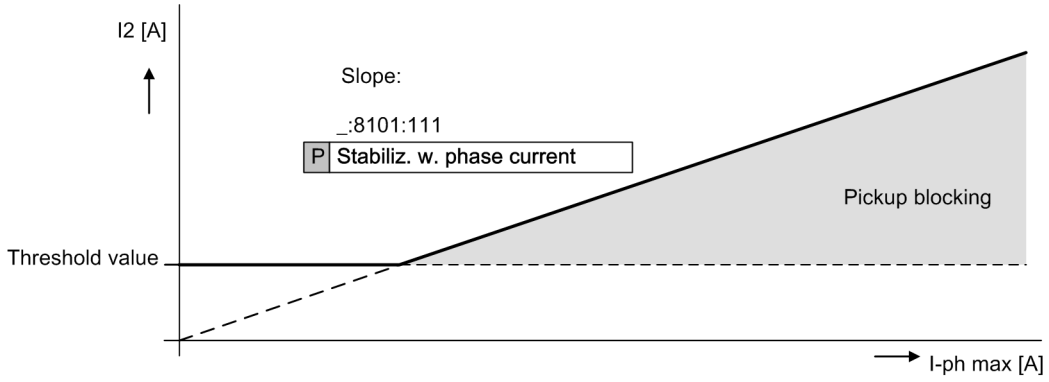
Functioning

The stage picks up if the negative-sequence system current exceeds the set threshold value and the parameterized direction agrees with the measured direction. The pickup drops out if the negative-sequence system current falls below 95 % of the set threshold.

Stabilization with Phase Current

Unbalance in operation and unbalanced transformer ratios can lead to spurious pickups and incorrect tripping. In order to avoid this, the directional negative-sequence system stage is stabilized with the phase currents. The threshold value increases with rising phase currents (see next image).

You can change the stabilization factor (= gradient) via the **Stabiliz. w. phase current** parameter.



[dw_stabil, 1, en_US]

Figure 6-519 Stabilization with Phase Currents

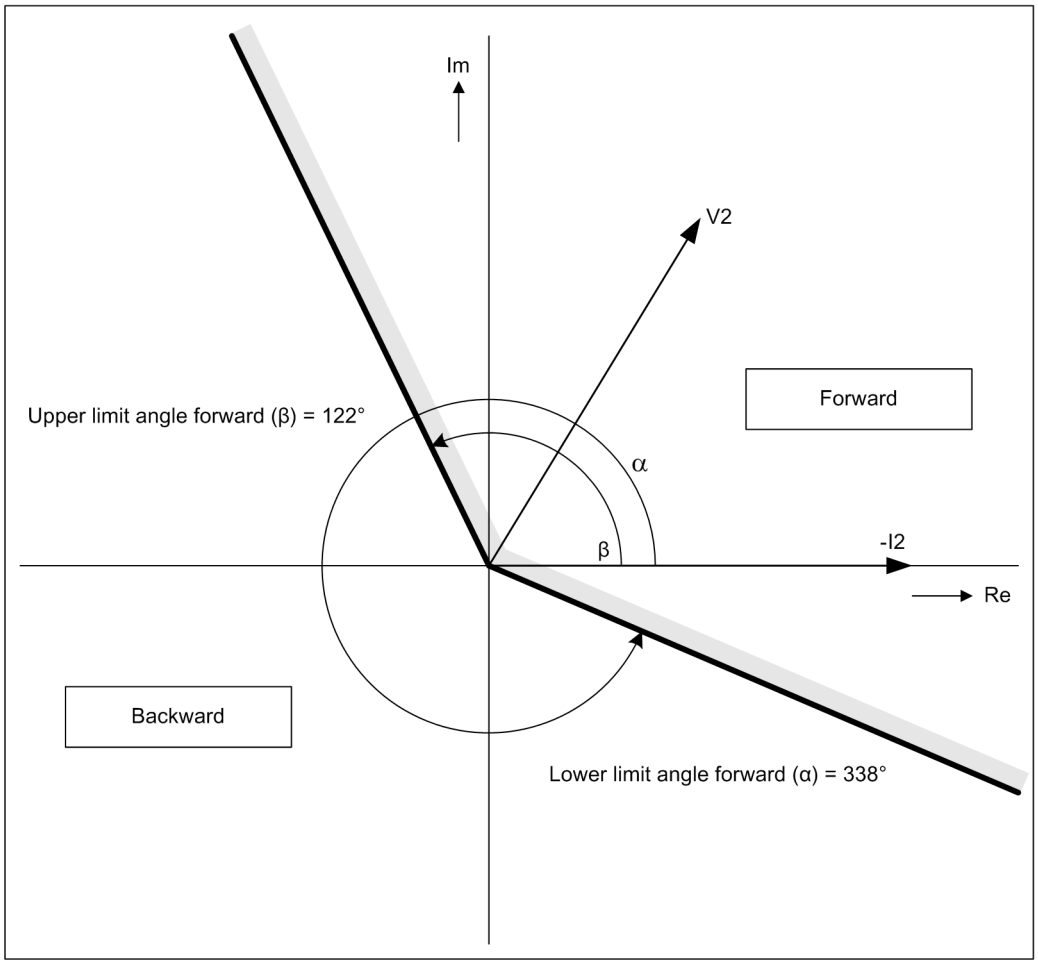
Direction Determination

The direction determination takes place with the negative-sequence system measurements I2 and V2.

The forward and reverse region is defined through the parameters **Angle forward α** and **Angle forward β** (see next figure). The reference for the 2 angles that must be set is the positive real axis. The angles are positively defined in a mathematical sense (counter-clockwise). The region between the limit angle α and the limit angle β - counted from the former in a positive direction - is the forward region. The remaining region is the reverse region.

For determining of the direction, the function places the measuring current I2 on the real axis. If the phasor of the negative-sequence system voltage V2 is located within the defined forward region, the function determines the direction as *forward*. In the other case, the function determines the direction as *reverse*.

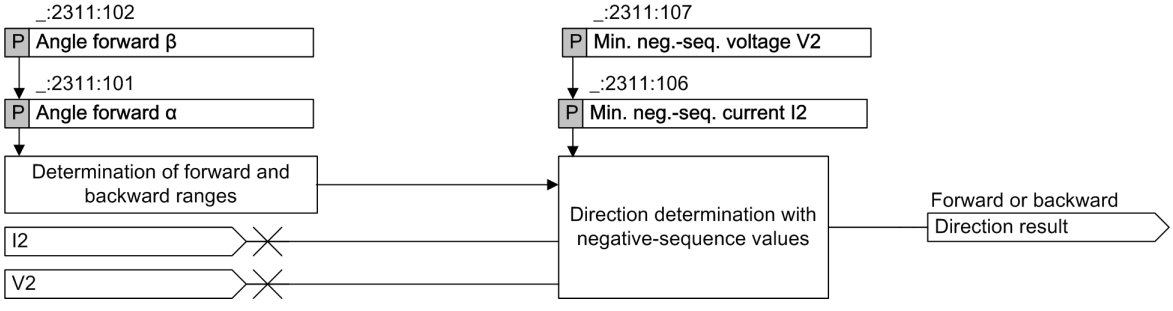
The requirement for determining the direction is that the adjustable minimum variables have been exceeded for the negative-sequence system current and negative-sequence system voltage (parameters **Min. neg.-seq. current I2** and **Min. neg.-seq. voltage V2**).



[dw_phasor, 1, en_US]

Figure 6-520 Phasor Diagram for Direction Determination with Negative-Sequence System Values

If the device determines a fault in the voltage-transformer secondary circuit (through the binary input *voltage transformer circuit-breaker dropout* or through **measuring-voltage failure detection**), direction determination will be disabled and every directionally set stage will be blocked. Non-directionally set stages become active again if there are faults in the voltage-transformer secondary circuit.



[lo_richtu, 1, en_US]

Figure 6-521 Logic of Direction Determination

Directional Mode

You use the **`Directional mode`** parameter to define whether the stage works in a forward or reverse direction. Non-directional operation is also possible.

Operating Mode upon 1-Pole Interruption

With the parameter **Op.mode at 1p dead time**, you determine if the stage is blocked during a 1-pole dead time, or if it works in a non-directional manner, even if it is set for directional operation. When the 1-pole dead time is complete, the corresponding device-internal signal is extended by the time of the parameter **Hold mode 1p dead time**.



NOTE

The **Op.mode at 1p dead time** parameter is only available in devices with 1-/3-pole tripping. In devices with 3-pole tripping, this setting does not apply.

Blocking the Tripping by Pickup of the Main Protection Functions

The pickup and type of pickup for the main protection functions can block the tripping of the stage. You can perform this setting via 2 parameters:

- **Blocking by**
  This setting is used to select the zone or stage at which blocking is to occur in the event of pickup.
- **Blocking by prot. pickup**
  The pickup type at which the blocking is to occur is defined with this parameter. The blocking can occur at any pickup or only at 1-pole or only at multipole pickups.
  This parameter is also used to set that no blocking should occur when the main protection has picked up.

Blocking of Tripping via the Device-Internal Inrush-Current Detection Function

If the device is equipped with the additional **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer inrush currents.
With the **Blk. w. inrush curr. detect.** parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and tripping are however blocked. The stage signals this by way of a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the tripping delay (time delay) is started. After that time, the stage operates.

6.32.4 Application and Setting Notes for Direction Determination

Parameter: Limit Angle Region Forward

- Recommended setting value **(_:2311:101) Angle forward α** = ***338°***
- Recommended setting value **(_:2311:102) Angle forward β** = ***122°***

With the parameters **Angle forward α** and **Angle forward β**, you can change the location of the directional characteristic curve.
Siemens recommends using the defaults, because the function with these settings reliably determines the direction.

Parameter: Minimum Negative-Sequence System Variables V2 and I2

- Default setting **(_:2311:107) Min. neg.-seq. voltage V2** = ***0.7 V***
- Default setting **(_:2311:106) Min. neg.-seq. current I2** = ***0.05 A***

With the parameters **Min. neg.-seq. voltage V2** and **Min. neg.-seq. current I2**, you can specify the minimum negative-sequence system values for direction determination with V2 and I2. The set limiting values must not be exceeded by operational unbalances.

6.32.5 Application and Setting Notes for Stages

Parameter: Directional mode

- Default setting **(_:8101:114) Directional mode** = ***forward***

You use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
non-directional	If the stage is to work in the forward and reverse direction (in the direction of the line and busbar), then select this setting. The stage will work with this setting even if no direction measurement is possible, for example due to insufficient polarization voltage (or none at all), or due to failure of the measuring voltage.
forward	Select these settings if the stage is only to work in a forward direction (in direction of the line).
reverse	Select this setting if the level is only to work in the reverse direction (in the direction of the busbar).

Parameter: Blk. w. inrush curr. detect.

If the device is equipped with the additional **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer inrush currents.

- Default setting **(_:8101:116) Blk. w. inrush curr. detect.** = ***no***

Parameter Value	Description
no	The transformer inrush current detection does not affect the stage. Select this setting in the following cases: 1) In cases where the device is not used on transformers. 2) In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer.
yes	When the transformer inrush current detection detects an inrush current that can lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer.

Parameter: Blocking by the main Protection

- Recommended setting value **(_:8101:140) Blocking by** =

If you wish to give selective fault clarification through the main protection function precedence over tripping through the directional negative-sequence protection, you can define this via the 2 parameters **Blocking by** and **Blocking by prot. pickup**. The **Blocking by** parameter is used to select the zones or tripping stages of the main protection function(s), upon whose pickup the negative-sequence protection is to be blocked.

Parameter: Blocking by prot. pickup

- Default setting **(_:8101:130) Blocking by prot. pickup** = ***every pickup***

The **Blocking by prot. pickup** parameter can be used to define the type of pickup, which leads to the blocking.

Parameter Value	Description
every pickup	Blocking at every pickup
1-phase pickup	Blocking only at 1-pole pickup

Parameter Value	Description
multi-phase pickup	Blocking only at multipole pickup
no pickup	If the pickup of the main protection function should not lead to blocking of the negative-sequence protection, select this setting.

Parameter: Op.mode at 1p dead time

- Default setting **(_:8101:129) Op.mode at 1p dead time** = ***blocked***

The **Op.mode at 1p dead time** parameter is used to define the behavior of the stage in the event of a 1-pole interruption.

Parameter Value	Description
blocked	The energy-transmission system is unbalanced in the 1-pole dead time. A mode-dependent negative-sequence system results from this, which can lead to an undesired pickup of the directional negative-sequence protection. That is why blocking with this setting makes sense if the pickup threshold of the stage is lower than/equal to the maximum mode-dependent negative-sequence current in the 1-pole dead time.
non-directional	If the directional negative-sequence protection is to continue to work in the 1-pole dead time, select this setting. The directional measurement works in a non-directional manner, because a reliable direction dead time measurement is not possible due to load current in the zero and negative-sequence system with the circuit breaker open on one pole. Set the pickup threshold of the stage higher than the maximum mode-dependent negative-sequence current in the 1-pole dead time.

NOTE

The **Op.mode at 1p dead time** parameter is only available in devices with 1-/3-pole tripping. In devices with 3-pole tripping, this setting does not apply.

Parameter: Hold mode 1-p dead time

- Default setting **(_:8101:112) Hold mode 1p dead time** = ***0.040 s***

The parameter **Hold mode 1p dead time** is used to define the time by which the device-internal signal for the 1-pole interruption is extended after the end of the 1-pole interruption.

At all line ends, there is no simultaneous switch-in after a 1-pole dead time. Thus, the parameterized operating mode for a 1-pole dead time must be retained for a certain time after the switch-in (end of the 1-pole dead time) until the other end or ends have securely switched in. The time to be set here corresponds to the maximum time between the switch-in of the 1st circuit breaker and the switch-in of the last circuit breaker at all ends of the feeder after a 1-pole dead time.

NOTE

The **Hold mode 1p dead time** parameter is only available in devices with 1-/3-pole tripping. In devices with 3-pole tripping, this setting does not apply.

Parameter: Stabiliz. w. phase current

- Recommended setting value **(_:8101:111) Stabiliz. w. phase current** = ***10 %***

In order to avoid unwanted pickups and tripping, the negative-sequence system current stage is stabilized with the phase currents.

More information can be found in chapter *6.32.3 Function Description*.

The threshold value increases as the phase currents increase.

You can change the stabilization factor (= gradient) via the **Stabiliz. w. phase current** parameter.

Siemens recommends a default setting of 10 % under normal operations.

Parameter: Threshold

- Default setting **(_:8101:3) Threshold** = ***1.5 A***

Define the pickup value corresponding to the application. In doing so, for the time-graded stages, the setting for the superordinate and subordinate stages must be taken into account in the grading chart.

With a very sensitive setting, you must make sure that the negative-sequence system current does not lead to undesired response of the stage due to unbalance (for example non-twisted line).

Parameter: Operate delay

- Default setting **(_:8101:6) Operate delay** = ***0.30 s***

The tripping delay (time delay) to be set is derived from the time-grading schedule that has been prepared for the system.

When selecting the current and time setting, pay attention to whether the stage must work dependent on the direction.

6.32.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Angle forward α		0 ° to 360 °	338 °
_:2311:102	General:Angle forward β		0 ° to 360 °	122 °
_:2311:107	General:Min. neg.-seq. voltage V2		0.150 V to 34.000 V	1.213 V
_:2311:106	General:Min. neg.-seq. current I2	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
Definite-T 1				
_:8101:1	Definite-T 1:Mode		• off • on • test	off
_:8101:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:8101:114	Definite-T 1:Directional mode		• non-directional • forward • reverse	forward
_:8101:111	Definite-T 1:Stabiliz. w. phase current		0 % to 30 %	10 %
_:8101:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A

Addr.	Parameter	C	Setting Options	Default Setting
_:8101:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
_:8101:116	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:8101:130	Definite-T 1:Blocking by prot. pickup		• every pickup • 1-phase pickup • multi-phase pickup • no pickup	every pickup
_:8101:129	Definite-T 1:Op.mode at 1p dead time		• blocked • non-directional	blocked
_:8101:112	Definite-T 1:Hold mode 1p dead time		0.000 s to 60.000 s	0.040 s
_:8101:140	Definite-T 1:Blocking by		Setting options depend on configuration	

6.32.7 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Test of direction	SPS	I
_:2311:300	General:Test direction	ACD	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Definite-T 1			
_:8101:81	Definite-T 1:>Block stage	SPS	I
_:8101:51	Definite-T 1:Mode (controllable)	ENC	C
_:8101:54	Definite-T 1:Inactive	SPS	O
_:8101:52	Definite-T 1:Behavior	ENS	O
_:8101:53	Definite-T 1:Health	ENS	O
_:8101:60	Definite-T 1:Inrush blocks operate	ACT	O
_:8101:302	Definite-T 1:Prot.PU blocks operate	SPS	O
_:8101:301	Definite-T 1:Mode1p dead-tm.active	SPS	O
_:8101:55	Definite-T 1:Pickup	ACD	O
_:8101:56	Definite-T 1:Operate delay expired	ACT	O
_:8101:57	Definite-T 1:Operate	ACT	O

6.33 Undercurrent Protection

6.33.1 Overview of Functions

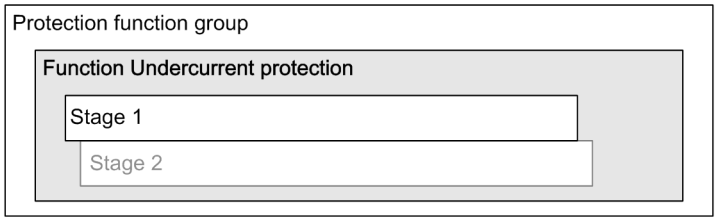
The **Undercurrent protection** function (ANSI 37):

- Detects the going current in a feeder after the opening of the infeed circuit breaker
- Detects the loss of loads
- Detects and protects pumps from running idle

6.33.2 Structure of the Function

The **Undercurrent protection** function is used in protection function groups with current measurement.

The **Undercurrent protection** function comes with 1 protection stage preconfigured at the factory. A maximum of 2 protection stages can be operated simultaneously in this function. The protection stages are structured identically.



[lo_stuundcu, 2, en_US]

Figure 6-522 Structure/Embedding of the Function

6.33.3 Stage Description

Logic of the Stage

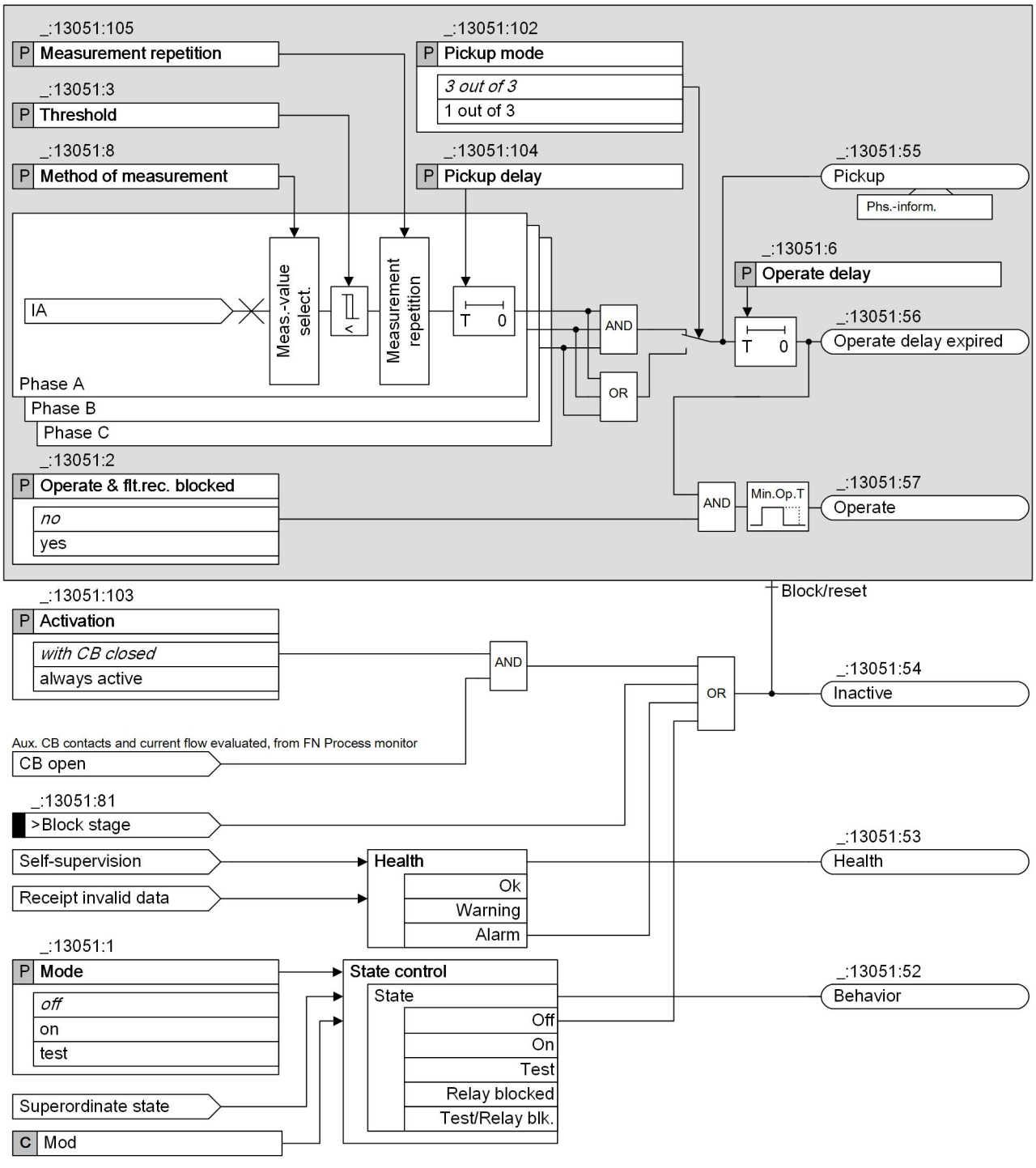


Figure 6-523 Logic Diagram of the Undercurrent Protection

Method of Measurement

You use the parameter **Method of measurement** to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

- Measurement of the fundamental comp.:
  This measurement method processes the sampled current values and numerically filters out the fundamental component.
- Measurement of the parameter value RMS value:
  This measurement method determines the current amplitude from the sampled values according to the definition equation of the RMS value. Harmonics are included in the analysis.

Measurement Repetition

To enable the pickup stabilization, you set the parameter **Measurement repetition** to a value other than 0. Then, if the input current keeps below the **Threshold** for a specified number (**Measurement repetition** value) of successive measuring cycles, the stage picks up. For 50 Hz, the measuring cycle time is 5 ms (**Method of measurement** = ***fundamental comp.***) or 10 ms (**Method of measurement** = ***RMS value***).

If you set this parameter to ***0*** (default value), the stabilization is not applied. The pickup signal is issued immediately after the input current falls below the parameter **Threshold**.

Pickup Mode

The parameter **Pickup mode** defines whether the protection stage picks up if all 3 measuring elements detect the undercurrent condition (***3 out of 3***) or if only 1 measuring element has to detect the undercurrent condition (***1 out of 3***).

Blocking the Stage

When blocked, the picked-up protection stage will drop out. Blocking the stage is possible externally or internally via the binary input signal *>Block stage*.

Activation and Blocking of the Stage Depending On the Circuit-Breaker Condition

With the parameter **Activation**, you define if the stage **Undercurrent protection** is always active or only active if the circuit breaker is indicating **closed**.

If the parameter **Activation** is set to ***with CB closed*** and the local circuit breaker is not **closed**, the function **Undercurrent protection** is blocked and no pickup is generated.

The circuit-breaker position is detected as **closed** if one of the following conditions is met:

- The binary inputs are connected to the auxiliary contacts of the circuit breaker. The circuit-breaker switch position is detected as **closed** via the related binary inputs of the indication *Position*. This is also true under the condition that no phase current is flowing.
- The current-flow criterion indicates that the circuit breaker is **closed**. This is also true under the condition that the auxiliary contacts indicate the circuit breaker as **open**.

Behavior on Leaving the Operating Range

The sampling frequency tracking makes a wide frequency operating range possible. If the stage has picked up before leaving the frequency operating range, the pickup is maintained. The signal **Pickup** is reset when a blocking condition becomes active.

6.33.4 Application and Setting Notes

Parameter: Activation

- Default setting **(_:13051:103) Activation** = ***with CB closed***

Parameter Value	Description
with CB closed	The **Undercurrent protection** is active only when the circuit-breaker position is detected as **closed**. A precondition is, that the **Position** indication is routed to binary inputs to obtain the CB position information via the CB auxiliary contacts. If this is not the case, the function will always be inactive.
always active	The **Undercurrent protection** stage is always active independent of the position of the circuit breaker.

Parameter: **Method of measurement**

- Recommended setting value **(_:13051:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Consider that aperiodic DC components present in the secondary circuit are measured and can cause an overfunction. For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$. If currents from more than one measuring point are added up in the current interface of a function group, the setting value should not be set lower than 0.1 $I_{rated,sec}$ multiplied by the number of added currents.

Parameter: **Pickup mode**

- Default setting **(_:13051:102) Pickup mode** = ***3 out of 3***

Use the **Pickup mode** parameter to define whether the protection stage picks up if all 3 measuring elements detect the undercurrent condition (***3 out of 3***) or if only 1 measuring element has to detect the undercurrent condition (***1 out of 3***).

Parameter: **Pickup delay**

- Default setting **(_:13051:104) Pickup delay** = ***0.00 s***

For special applications, it could be desirable that a short falling below the current threshold does not lead to the pickup of the stage and to the start of fault logging and recording.

With the **Pickup delay** parameter, you define a time interval during which a pickup is not triggered if the current falls below the threshold.

Parameter: **Threshold**

- Default setting **(_:13051:3) Threshold** = ***0.050 A***

Specify the **Threshold** (pickup threshold) for the specific application.

Parameter: **Measurement repetition**

- Default setting **(_:13051:105) Measurement repetition** = ***0***

For special applications, it could be desirable that a short falling of the input current below the pickup value does not lead to the pickup of the stage, which starts fault logging and recording. This is achieved by setting the parameter **Measurement repetition** to a value other than 0.

For example, if you set this parameter to ***2***, the pickup signal is issued when the current keeps being below the **Threshold** for 2 additional measuring cycles. For 50 Hz, the measuring cycle time is 5 ms (**Method of measurement** = ***fundamental comp.***) or 10 ms (**Method of measurement** = ***RMS value***).

Parameter: **Operate delay**

- Default setting **(_:13051:6) Operate delay** = ***0.05 s***

Operate delay must be set according to the specific application. No general application notes can be given.

6.33.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:13051:1	Stage 1:Mode		• off • on • test	off
_:13051:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:13051:103	Stage 1:Activation		• always active • with CB closed	with CB closed
_:13051:8	Stage 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:13051:105	Stage 1:Measurement repetition		0 to 10	0
_:13051:102	Stage 1:Pickup mode		• 1 out of 3 • 3 out of 3	3 out of 3
_:13051:3	Stage 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:13051:104	Stage 1:Pickup delay		0.00 s to 60.00 s	0.00 s
_:13051:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.50 s

6.33.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Stage 1			
_:13051:81	Stage 1:>Block stage	SPS	I
_:13051:51	Stage 1:Mode (controllable)	ENC	C
_:13051:54	Stage 1:Inactive	SPS	O

No.	Information	Data Class (Type)	Type
_:13051:52	Stage 1:Behavior	ENS	O
_:13051:53	Stage 1:Health	ENS	O
_:13051:55	Stage 1:Pickup	ACD	O
_:13051:56	Stage 1:Operate delay expired	ACT	O
_:13051:57	Stage 1:Operate	ACT	O

6.34 Overexcitation Protection

6.34.1 Overview of Functions

The **Overexcitation protection** (ANSI 24) is used for detecting high induction values in generators and transformers. It protects the equipment from excessive thermal loads.

The induction is recorded indirectly by analyzing the V/f ratio (also referred to as Volt per Hertz protection). Overvoltage leads to excessive magnetizing currents, while underfrequency leads to higher losses when resetting the magnetization.

If the power system is disconnected and the voltage and frequency control function in the remaining system does not react quickly or the power imbalance is excessive, there is a risk of overexcitation.

6.34.2 Structure of the Function

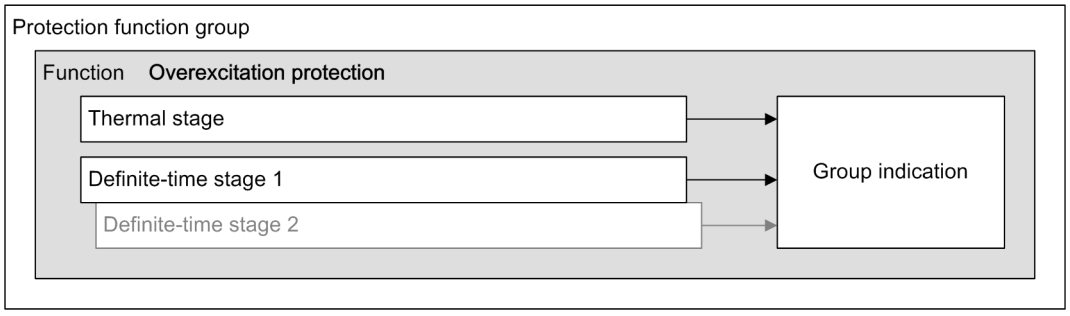
The **Overexcitation protection** function is used within protection function groups that have a 3-phase voltage input. The function comes with the following factory-set stages:

- Thermal stage adjustable with a user-defined characteristic curve
- Definite-time stage which can be delayed using a time component

Within this function, the following maximum number of stages can be operated simultaneously: one stage with a user-defined characteristic curve and 2 definite-time stages.

The group-indication output logic (see following figure) uses the logical OR function from the stage-selective indications to generate the following group indications of the entire **Overexcitation protection** function:

- Pickup
- Operate Indication



[dw_ovexuf, 3, en_US]

Figure 6-524 Structure/Embedding of the Function

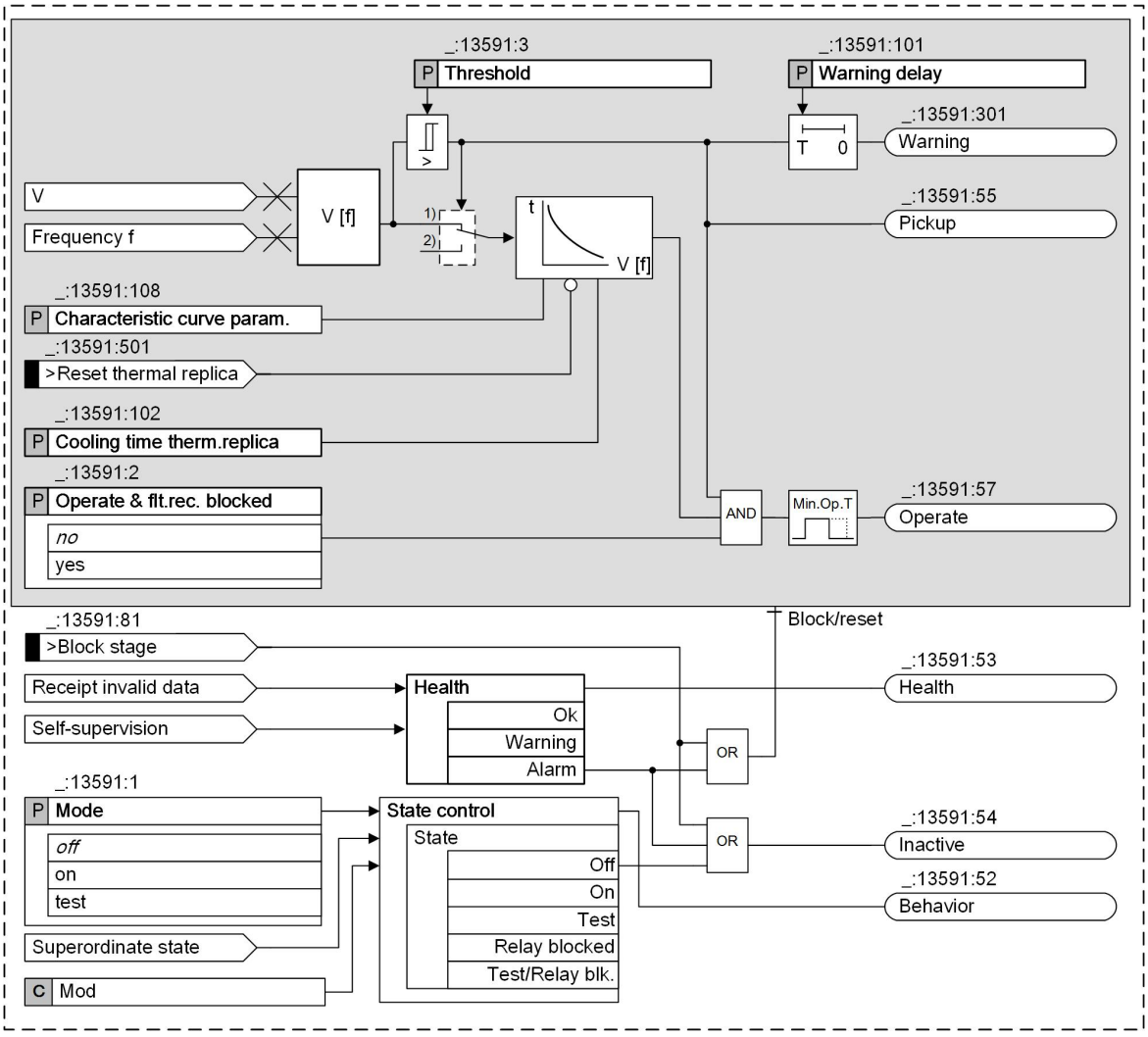
Function Measured Value

Measured Value	Description
(_:2311:322) V/f	Value calculated by the voltage and the frequency

6.34.3 Stage with Dependent Characteristic Curve (Thermal Stage)

6.34.3.1 Function Description

Logic



[lo_therm-char_V-f, 2, en_US]

Figure 6-525 Logic of the Overexcitation Protection with Thermal Characteristic Curve

(1) Heating
(2) Cooling

V/f Method of Measurement

The input values of the protection function are the continuously measured voltage and the frequency. The phase-to-phase voltage is used to process the voltage. The angle difference method (see *6.51 Overfrequency Protection*) is used to determine the frequency. Both values form the V/f ratio. In order to arrive at an absolute value, standardized data is applied.

Thus, the ratio is derived from:

$$\frac{V/V_{rated,obj.}}{f/f_{rated}}$$

[fo_verufn, 1, en_US]

with

V	Measured voltage (maximum phase-to-phase voltage)
$V_{rated, obj.}$	Adjusted rated voltage of the protected object
f	Measured frequency
f_{rated}	Adjusted rated frequency

Based on the definition above, the protection function refers exclusively to primary values of the protected object. A deviation between the primary rated voltage of the voltage transformer and the protected object is corrected automatically.

NOTE

This fact must be considered during a secondary test.

More information can be found in chapter *11.13 Functional Test for Overexcitation Protection* .

The function compares the calculated value of the measured V/f ratio with the threshold value and the user-defined thermal characteristic curve.

Depending on the characteristic curve, a **thermal** trip signal is triggered after a pre-determined duration.

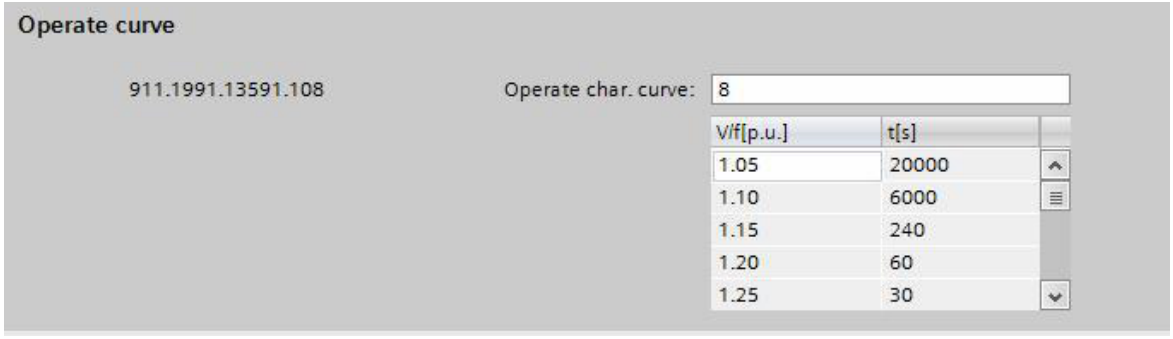
Characteristic Curve

You can freely configure the thermal characteristic curve with the user-defined values. This provides a flexible adjustment to the specified characteristics of the protected object. If the set threshold value (parameter **(_:13591:3) Threshold**) is exceeded, the evaluation of the characteristic curve is initiated. Exceeding the threshold value triggers an indication (*(_:13591:55) Pickup*). In addition, a definite-time stage may be used to generate a delayed indication output as (*(_:13591:301) warning*).

The pickup is used to start the integration process (weighted counting) of the thermal characteristic curve. If the time as a factor of V/f is reached, the pickup is triggered. Based on the replica of the thermal behavior, the trigger value is always 100 % (see *Thermal Behavior, Page 1439*).

If the value drops below the pickup threshold, the trip command is rescinded and the **internal counter** of the parameterized cooling time (parameter **(_:13591:102) Cooling time therm.replica**) is reduced. The dropout threshold of the pickup threshold is fixed to 0.98 * **Threshold**.

The thermal characteristic curve can be set through a maximum of 30 overexcitation value pairs V/f (referring to the rated values) and the operate time t can be set. The default characteristic curve refers to a standard transformer.

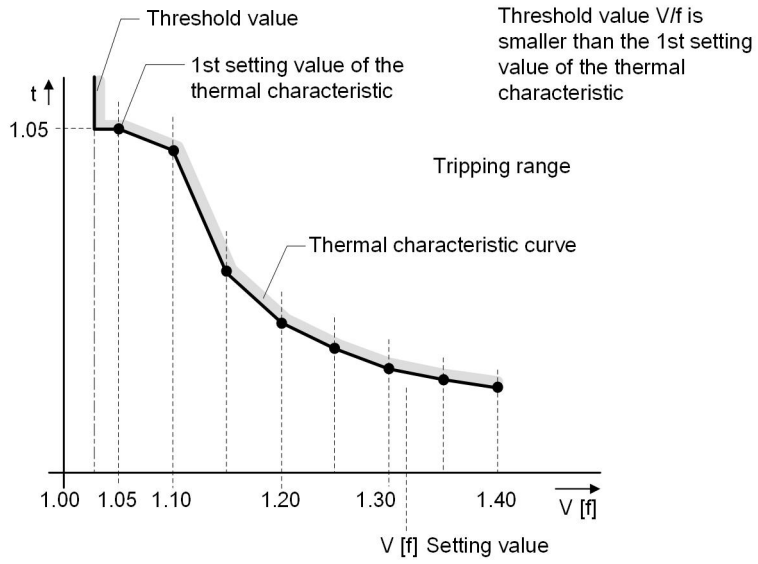


[sc_aulskn, 1, en_US]

Figure 6-526 Data Sheet for Adjustment of Thermal Characteristic Curve

The parameter **Threshold** (pickup threshold) affects the evaluation of the characteristic curve as follows:

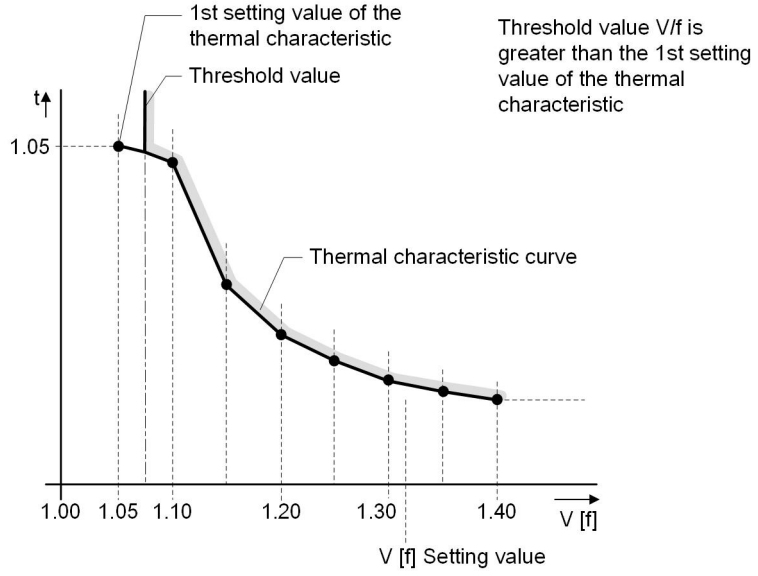
If the **Threshold** is smaller than the first characteristic pair, the set time will be extended (see *Figure 6-527*).



[dw_ovexak, 1, en_US]

Figure 6-527 Tripping Zone of the Thermal Characteristic Curve (I)

If the **Threshold** is greater, then a cutoff occurs (see *Figure 6-528*).



[dw_ovexab, 1, en_US]

Figure 6-528 Tripping Zone of the Thermal Characteristic Curve (II)

Warning Threshold

If the **Threshold** is exceeded, the time delay (parameter **(_:13591:101) Warning delay**) is started. If the time delay has elapsed, the indication (*(_:13591:301) Warning*) will be displayed.

Thermal Behavior

The time derived from the characteristic curve and associated with the V/f value is set to 100 %. With each function call, the time will be increased according to the respective weighted invocation interval. If the 100 % value is exceeded, tripping is initiated. If the V/f value is changed, the associated time from the characteristic curve is added as a new 100 % value.

In order to prevent excessive cooling times, the thermal storage has been limited internally to 150 %. The *fill level* of the thermal storage will be provided as functional measured value.

Measured Value	Description
(_:13591:321) V/f th.	Thermal tripping of the overexcitation protection. If the value reaches 100 %, the tripping occurs.

Cooling Time

If the value drops below the threshold value (**(_:13591:3) Threshold**), tripping of the thermal characteristic curve (dependent characteristic curve) is reverted. However, the parameterized cooling time (**Cooling time therm.replica**) reduces the thermal storage (counter content) to 0. This parameter is defined as time. It is required by the thermal replica in order to cool down from 100 % to 0 %.

Resetting the Thermal Map

The binary input indication *(_:13591:501) >Reset thermal replica* can be applied to reset the thermal replica. The thermal replica will then have a value of 0. A reparameterization will also lead to resetting the thermal replica.

Blocking the Stage

The function can be blocked externally or internally by the binary input signal *(_:13591:81) >Block stage*. Blocking will cause a picked up function to be reset.

6.34.3.2 Application and Setting Notes

Thermal overloads extended over a longer period will jeopardize electric equipment, for example, synchronous motors, generators, or transformers and may cause damage. When using the thermal, user-defined characteristic curve, the overexcitation protection is ideally suited for adjusting the specified limits of the protection equipment.

The following provides the recommended settings:

NOTE

One requirement for the correct mode of operation of the function is based on the proper setting of the power-system data.

You can find more detailed information on this in *6.1 Power-System Data*.

For additional setting recommendations, verity the following parameter in the power-system data:

- Adjusted rated frequency
- Adjusted rated voltage of the protected object
- Adjusted rated voltage of the voltage transformer of the applicable measuring point

Parameter: Threshold Value

- Default setting **(_:13591:3) Threshold** = *1.10*

  The **Threshold** parameter is used to describe the value for the permissible continuous overexcitation. The default value is a practical value used for transformers. The value may be less for generator applications. These values can be found in the manufacturer's information.

Parameter: Time Delayed Warning

- Default setting **(_:13591:101) Warning delay** = *10.00 s*

  When using the **Warning delay** parameter, the time can be determined by which the warning indication of the stage should be delayed after the pickup. This time delay depends on the specific application. This time must clearly exceed the reaction time of the regulators. 10 seconds is a feasible value.

Parameter: `Cooling Time Therm. Replica`

- Default setting **`(_:13591:102) Cooling time therm.replica`** = ***`3600 s`***

The **`Cooling time therm.replica`** parameter is used to define the cooling characteristics of the thermal replica. If concrete specifications are not given, the default value can be retained.

Parameter: `V/f/time value pairs` (operate curve)

With this parameter, the number of potting points along the thermal operate curve are defined. This is required for the calculation. The number of points defines the accuracy of the image of the specified characteristic curve. Adjust the value individually.

Set a V/f/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize. The default settings refer to a Siemens standard transformer.



NOTE

The value pairs must be entered in continuous order.



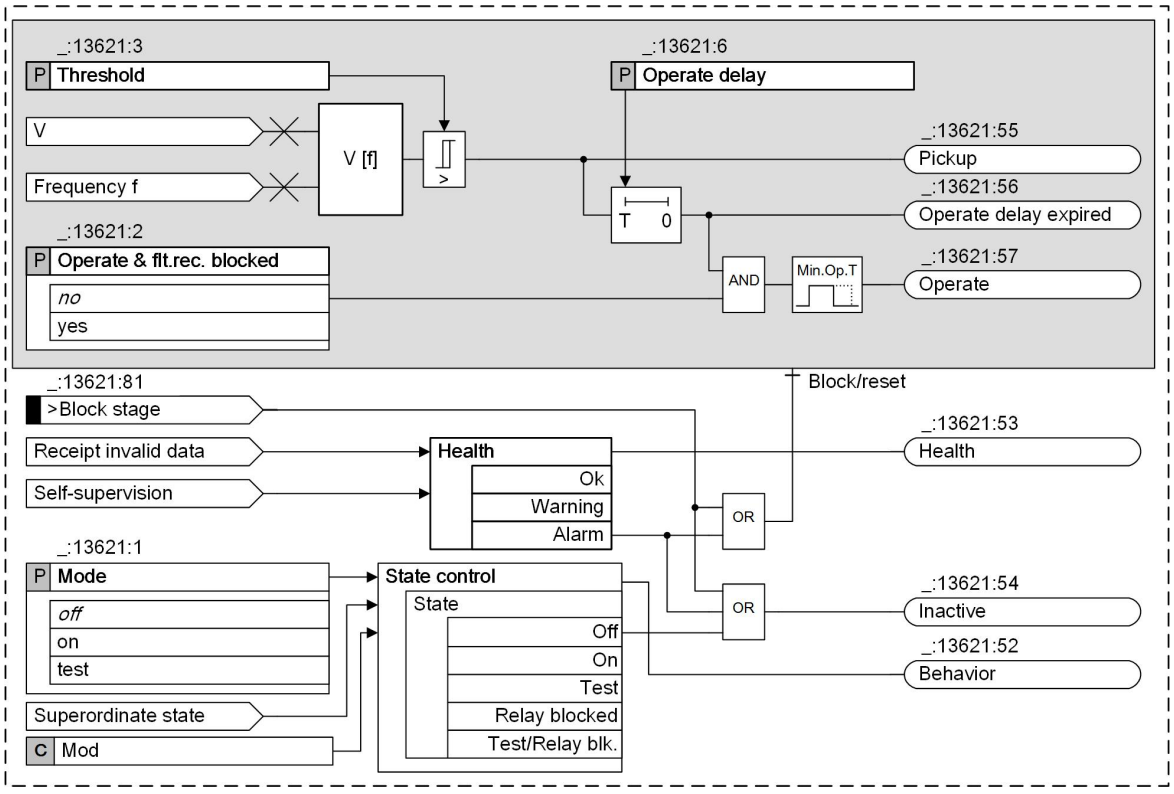
NOTE

Note that the V/f values that are lower than the V/f values of the smallest characteristic-curve point do not extend the operate time. Up to the smallest characteristic-curve point, the characteristic curves runs parallel to the V/f axis. V/f values that are larger than the V/f value of the largest characteristic-curve point do not reduce the operate time. From the largest characteristic-curve point, the pickup characteristic runs parallel to the V/f axis (see*Characteristic Curve, Page 1438*).

6.34.4 Stage with Definite-Time Characteristic Curve (Time Stage)

6.34.4.1 Function Description

Logic



{lo_dtchuf, 2, en_US}

Figure 6-529 Logic of the Overexcitation Protection with Independent Characteristic Curve (Definite-Time Stage)

Method of Measurement

This stage also evaluates the V/f value that is identical to the input value of the thermal stage.

For measurement-relevant details, see also *6.34.3 Stage with Dependent Characteristic Curve (Thermal Stage)*.

Operating Principle of the Definite-Time Stage

The stage comprises a threshold value and a time-delay stage. If the V/f value is greater than the set threshold value (**(_:13621:3) Threshold**), then the stage is tripped after an adjustable time delay has elapsed. You can set the time delay with the parameter **(_:13621:6) Operate delay**.

The dropout ratio for the **Threshold** is fixed to 98 %.

6.34.4.2 Application and Setting Notes

The definite-time stage can be applied when fast tripping is required in the presence of high V/f values. In this case, the stage acts superimposed on the thermal, dependent stage.

Parameter: Threshold Value

- Default setting **(_:13621:3) Threshold** = ***1.40***

  The **Threshold** parameter is used to describe the overexcitation value that causes the tripping function. The default value matches a feasible upper limit.

Parameter: `Tripping delay`

- Default setting **`(_:13621:6) Operate delay`** = ***`1.00 s`***

  The **`Operate delay`** parameter is used to determine the time by which the stage is delayed after the pickup. This time delay depends on the specific application. The default value is practical for the application described in the previous chapter.

6.34.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Definite-T 1`				
_:13621:1	Definite-T 1:Mode		• off • on • test	off
_:13621:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:13621:3	Definite-T 1:Threshold		1.00 to 1.40	1.40
_:13621:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	1.00 s
`Therm.charact.`				
_:13591:1	Therm.charact.:Mode		• off • on • test	off
_:13591:2	Therm.charact.:Operate & flt.rec. blocked		• no • yes	no
_:13591:3	Therm.charact.:Threshold		1.00 to 1.20	1.10
_:13591:101	Therm.charact.:Warning delay		0.00 s to 60.00 s	10.00 s
_:13591:102	Therm.charact.:Cooling time therm.replica		0 s to 100 000 s	3600 s

6.34.6 Information List

No.	Information	Data Class (Type)	Type
`General`			
_:2311:322	General:V/f	MV	O
`Group indicat.`			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
`Definite-T 1`			
_:13621:81	Definite-T 1:>Block stage	SPS	I
_:13621:51	Definite-T 1:Mode (controllable)	ENC	C
_:13621:54	Definite-T 1:Inactive	SPS	O
_:13621:52	Definite-T 1:Behavior	ENS	O
_:13621:53	Definite-T 1:Health	ENS	O

No.	Information	Data Class (Type)	Type
_:13621:55	Definite-T 1:Pickup	ACD	O
_:13621:56	Definite-T 1:Operate delay expired	ACT	O
_:13621:57	Definite-T 1:Operate	ACT	O
Therm.charact.			
_:13591:81	Therm.charact.:>Block stage	SPS	I
_:13591:501	Therm.charact.:>Reset thermal replica	SPS	I
_:13591:51	Therm.charact.:Mode (controllable)	ENC	C
_:13591:54	Therm.charact.:Inactive	SPS	O
_:13591:52	Therm.charact.:Behavior	ENS	O
_:13591:53	Therm.charact.:Health	ENS	O
_:13591:55	Therm.charact.:Pickup	ACD	O
_:13591:301	Therm.charact.:Warning	ACT	O
_:13591:57	Therm.charact.:Operate	ACT	O
_:13591:321	Therm.charact.:V/f th.	MV	O

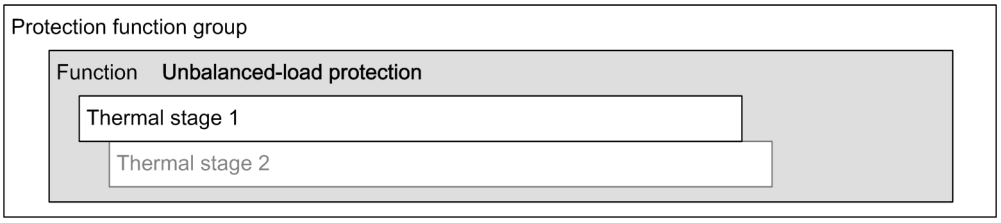
6.35 Unbalanced-Load Protection

6.35.1 Overview of Functions

The **Unbalanced-load protection** function detects unbalanced loads or line interruptions of electrical machines (generators and motors). Unbalanced loads create a counter-rotating magnetic field at double frequency in the rotor. The skin effect leads to local overheating on the surface of the rotor bars in the transition between the slot wedges and the winding bundles. Another effect of unbalanced loads is the overheating of the damper winding.

6.35.2 Structure of the Function

The **Unbalanced-load protection** function is used in the protection function group. The **Unbalanced-load protection** function is preconfigured with 1 stage. A maximum of 2 stages can operate simultaneously in the function.

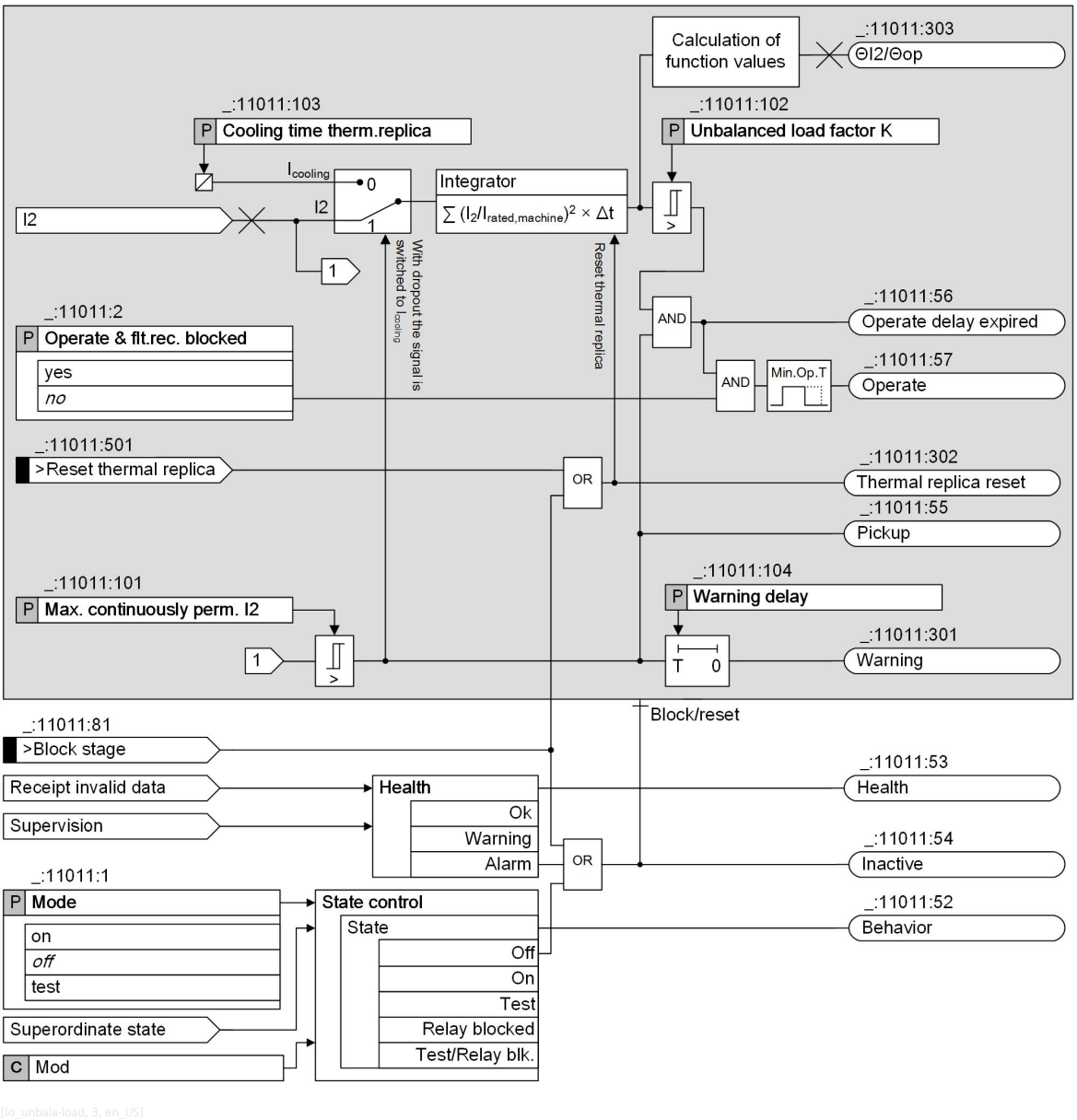


[dw_unbla, 1, en_US]

Figure 6-530 Structure/Embedding of the Function

6.35.3 Function Description

Logic of the Stage



[lo_unbala-load, 3, en_US]

Figure 6-531 Logic Diagram of the Unbalanced-Load Protection Function

Method of Measurement

The stage uses the negative-sequence current I_2 as a measurand. The negative-sequence current is calculated from the measured 3-phase currents according to the defining equation of symmetrical components.

Warning Stage

If the negative-sequence current I_2 continuously exceeds the parameter **`Max. continuously perm. I2`**, the ***`Warning`*** indication is given after expiry of a set time **`Warning delay`**.

Thermal Characteristic Stage

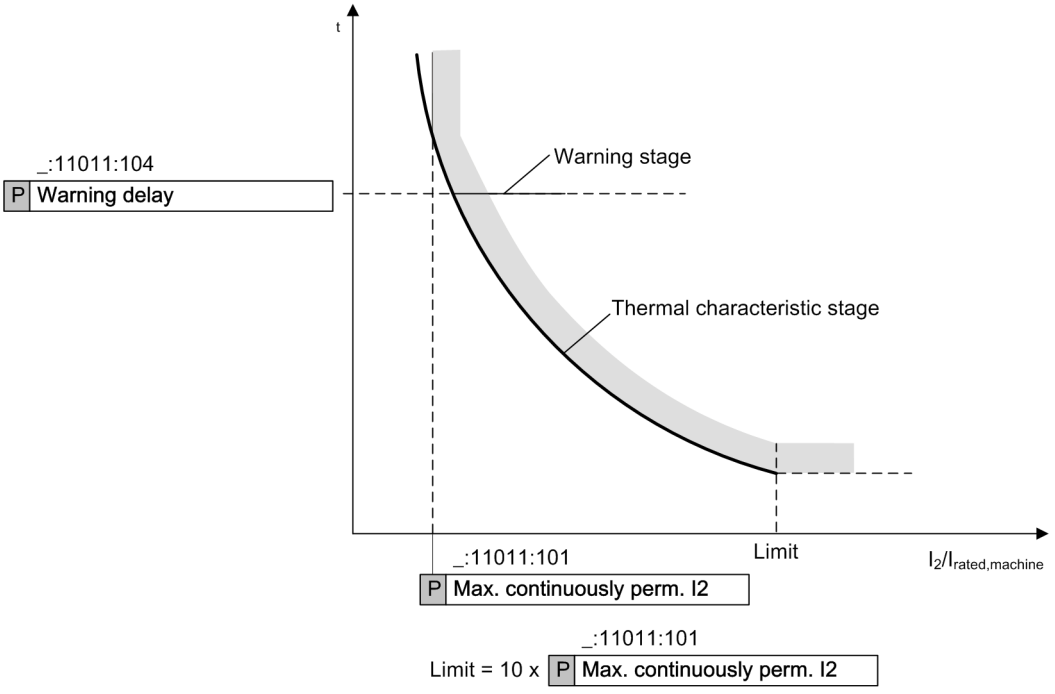
The machine manufacturers indicate the permissible unbalanced load using the following formula:

$$t_{I2\,Perm} = \frac{K}{\left(I_2 / I_{rated,machine}\right)^2}$$

[fo_rbanl, 1, en_US]

With:

t_{I2Perm}	Permissible time of the negative-sequence current
K	Unbalanced-load factor of the machine (parameter **Unbalanced load factor K**)
$I_2/I_{rated,machine}$	Actual unbalanced-load current as a per unit value(negative-sequence current/rated current of the machine)



[dw_unbalo, 2, en_US]

Figure 6-532 Operate Curve of the Unbalanced-Load Protection

The parameter **Unbalanced load factor K** depends on the machine. It also represents the time in seconds during which the machine can be loaded with a 100 % unbalanced load. This factor is typical in a range from 5 s to 40 s. The heating of the protected object starts to calculate as soon as the negative-sequence current I_2 exceeds the parameter **Max. continuously perm. I2**. The operate time is calculated from the flowing negative-sequence current I_2 with an integrating method of measurement depending on the thermal characteristic. As soon as the integrate result reaches the parameter **Unbalanced load factor K**, the thermal characteristic stage operates.

Limitation of Operate Curve

To avoid an overfunction of the thermal characteristic stage in the situation of unbalanced short circuits (for example, 2-phase short circuit), the input current I_2 is restricted to an upper limit. The limiting value is 10 times of **Max. continuously perm. I2**. If I_2 exceeds the limit, the operate time of the function is constant.

In addition, the thermal memory is limited to 200 % of **Unbalanced load factor K**. The limitation avoids a too long cooling after a delayed short-circuit tripping (for example, of external power-system faults).

Cooling Time Thermal Replica

The thermal replica starts to cool down as soon as the negative-sequence current I_2 is lower than **Max. continuously perm. I2**. The thermal replica decreases according to the parameter **Cooling time therm.replica**. The parameter **Cooling time therm.replica** is the time required by the thermal replica to cool down from 100 % to 0 %. If the parameter **Cooling time therm.replica** is set to 0, the thermal replica is reset immediately.

The parameter **Cooling time therm.replica** depends on the construction type of the machine, especially of the damper winding. Preloading is considered when unbalanced loading occurs again during the cooling time. The protection device thus operates in a shorter time.

Functional Measured Values

The following formula is used to calculate the functional measured value ΘI2/Θop:

$$\Theta I2/\Theta op = \frac{\sum_{0}^{t}\left(I_2/I_{rated,machine}\right)^2 \cdot \Delta t}{K} 100\ \%$$

[fo_runbl2, 1, en_US]

With

ΘI2/Θop	Functional measured value indicating the thermal replica of the unbalanced load
$\sum_{0}^{t}\left(I_2/I_{rated,\ machine}\right)^2 \cdot \Delta t$	Integrating method of measurement of the thermal replica of the negative-sequence system
K	Unbalanced-load factor of the machine (parameter **Unbalanced load factor K**)
$I_2/I_{rated,machine}$	Unbalanced-load as a per unit value (negative-sequence current/rated current of the machine)

If the functional measured value reaches 100 %, the operate of the function is initiated.

6.35.4 Application and Setting Notes

The function is used in the applications of machines. You can get the necessary settings from the technical data of the synchronous generators and motors. The setting example is applied for a generator application.

Parameter: Max. continuously perm. I2, Warning delay

- Default setting **(_:11011:101) Max. continuously perm. I2** = ***10.0 %***
- Default setting **(_:11011:104) Warning delay** = ***15 s***

If the negative-sequence current I_2 exceeds **Max. continuously perm. I2** , the stage picks up and a warning indication is given after the set time delay **Warning delay** .

The parameter **Max. continuously perm. I2** is given in percentage of the rated current of the protected object.

The setting value of the parameter **Max. continuously perm. I2** depends on following parts:

- Design of the machine (salient pole or non-salient pole rotor synchronous machine)
- Cooling system (directly or indirectly cooled)
- Size of the machine

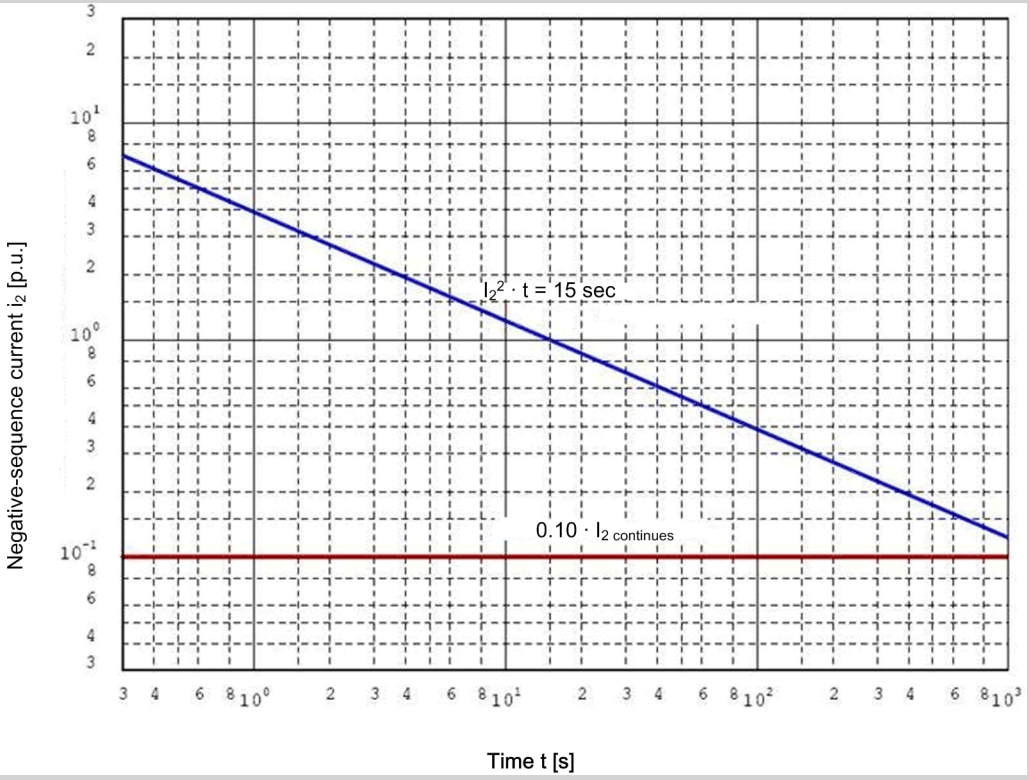
Depending on the standards IEEE C50.12 and IEC 60034-1, the parameter is given in the range between 5 % and 12 %. To set the parameter **Max. continuously perm. I2** , technical data of the machine

is required. The technical data of the machine is provided in the Technical Data Sheet of the machine manufacturer.

EXAMPLE

The following example shows the setting of the parameter **Max. continuously perm. I2** . The value 10 % is selected in the example.

To avoid issuing the *Warning* indication too fast, Siemens recommends a longer delay. Setting the parameter **Warning delay** in the range of 10 s to 20 s is practicable. 15 s is selected in the example.



[dw_unbloc, 1, en_US]

Figure 6-533 Example of an Unbalanced-Load Characteristic Specified by the Machine Manufacturer

Parameter: Unbalanced load factor K

- Default setting **(_:11011:102) Unbalanced load factor K** = ***15 s***

Unbalanced load factor K can be derived from the unbalanced-load characteristic according to *Figure 6-533*. You can read the time corresponding to **Unbalanced load factor K** at the point I_2 / $I_{rated,machine}$= 1. In the example, this is the p.u. value 10° which corresponds to a time of 15 s. As the example shows, the time is often written directly on the characteristic curve.

Parameter: Cooling time therm.replica

- Default setting **(_:11011:103) Cooling time therm.replica** = ***1500 s***

The parameter **Cooling time therm.replica** establishes the time required by the protected object to cool down the thermal replica to the initial value. If the machine manufacturer does not provide this information, the setting value of **Cooling time therm.replica** can be calculated from the setting values of **Unbalanced load factor K** and **Max. continuously perm. I2** by the formula in the following example.

EXAMPLE

$$\text{Cooling time therm. replica} = \frac{\text{Unbalanced load factor K}}{(\text{Max. continuously perm. I 2})^2}$$

[fo_rbala2_02, 1, en_US]

Max. continuously perm. I_2	= 10.0 % (corresponds to 0.1)
Unbalanced load factor K	= 15 s
Cooling time therm. replica	= 1500 s

6.35.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Therm. Stage 1				
_:11011:1	Therm. Stage 1:Mode		• off • on • test	off
_:11011:2	Therm. Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:11011:101	Therm. Stage 1:Max. continuously perm. I2		3.0 % to 30.0 %	10.0 %
_:11011:102	Therm. Stage 1:Unbalanced load factor K		1.0 s to 100.0 s	15.0 s
_:11011:103	Therm. Stage 1:Cooling time therm.replica		0 s to 50000 s	1500 s
_:11011:104	Therm. Stage 1:Warning delay		0.0 s to 60.0 s;∞	15.0 s

6.35.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Therm. Stage 1			
_:11011:81	Therm. Stage 1:>Block stage	SPS	I
_:11011:501	Therm. Stage 1:>Reset thermal replica	SPS	I
_:11011:51	Therm. Stage 1:Mode (controllable)	ENC	C
_:11011:53	Therm. Stage 1:Health	ENS	O
_:11011:54	Therm. Stage 1:Inactive	SPS	O
_:11011:52	Therm. Stage 1:Behavior	ENS	O
_:11011:302	Therm. Stage 1:Thermal replica reset	SPS	O
_:11011:301	Therm. Stage 1:Warning	ACD	O
_:11011:55	Therm. Stage 1:Pickup	ACD	O
_:11011:56	Therm. Stage 1:Operate delay expired	ACT	O

No.	Information	Data Class (Type)	Type
_:11011:57	Therm. Stage 1:Operate	ACT	O
_:11011:303	Therm. Stage 1:ΘI2/Θop	MV	O

6.36 Instantaneous High-Current Tripping

6.36.1 Overview of Functions

The function **Instantaneous high-current tripping** (ANSI 50) has the following tasks:

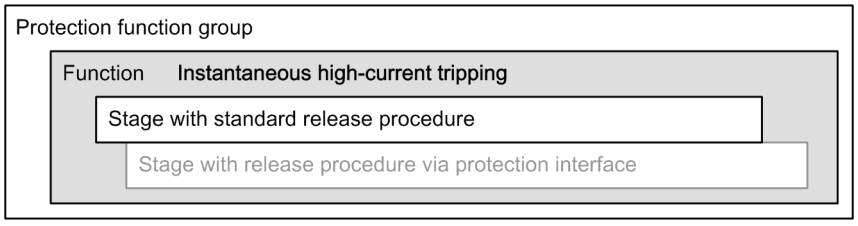
- Instantaneous tripping when switching onto an existing fault, for example, if a grounding switch is closed.
- Instantaneous disconnection of high currents above the highest overcurrent-protection stage.
- The function works independently of other functions.

6.36.2 Structure of the Function

The **Instantaneous high-current tripping** function offers 2 different increment types:

- Stage with standard release method
- Stage with release method via protection interface (only applicable if the device is equipped with a protection interface)

The function with the stage for the standard release procedure is factory-set.

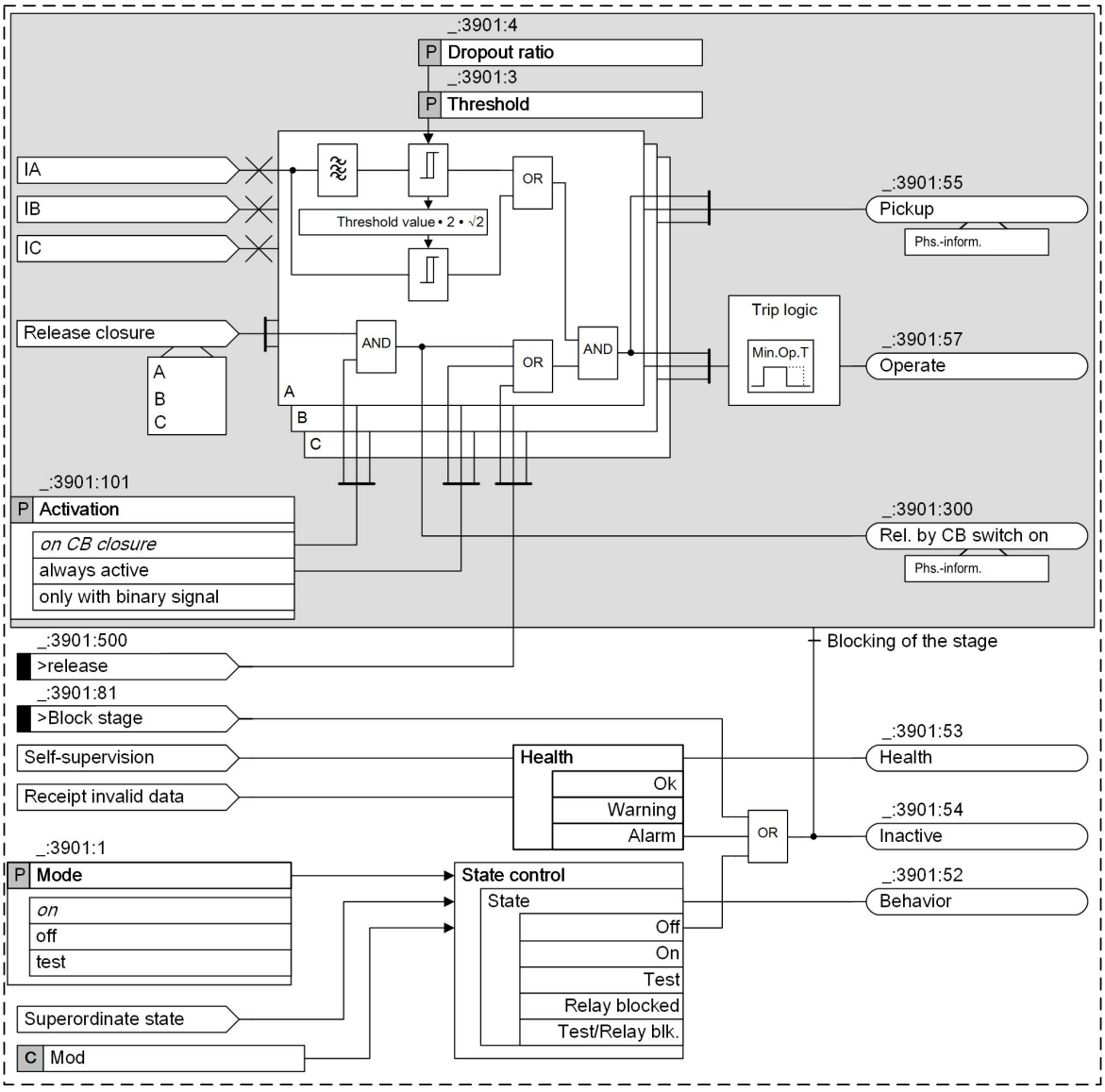


[dw_ihc_str, 1, en_US]

Figure 6-534 Structure/Embedding of the Function

6.36.3 Standard Release Procedure

Logic



[lo_hlore3_3_en_US]

Figure 6-535 Logic Diagram of Instantaneous High-Current Tripping with Standard Release Method

Activation

Using the **Activation** parameter, you set the conditions under which the stage is released.

- ***on CB closure***

  With this procedure, the stage is released only if the circuit breaker is about to be closed (the CB is open) or if the circuit breaker is being closed or the binary input signal *>release* is active. The way the *Rel. by CB switch on* signal is generated is described in chapter *5.9.8 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions*.

- ***always active***

  The stage is always released and is thus independent of the closing of the circuit breaker switch and of the binary input signal*>release*.

- ***only with binary signal***
  The stage is released only if the binary input signal *>release* is active.

Method of Measurement, Threshold Value

The stage works with 2 different methods of measurement:

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically. A DC component is thus eliminated. The RMS value of the fundamental component is compared with the set threshold value.
- Evaluation of the unfiltered measurand:
  The stage also works with unfiltered sampled values. Thus, very short operate times are possible. The current sampling values are compared with the threshold value of 2 · √2 of the preset threshold value.

6.36.4 Application and Setting Notes

Parameter: Activation

- Default setting **(_:3901:101) Activation** = ***on CB closure***

With the parameter **Activation**, you define the conditions under which the stage is released.

Parameter Value	Description
on CB closure	Select this setting to activate the stage only when the circuit breaker is closed.
always active	Select this setting to release the stage statically.
only with binary signal	Select this setting to release the stage via an external signal.

Parameter: Threshold

- Default setting **(_:3901:3) Threshold** = ***10.0 A*** for I_{rated} = 1 A or ***50.0 A*** for I_{rated} = 5 A

The stage works independently of the position of the remote circuit breakers. For this reason, set the **Threshold** so that the fault current flowing through does not trigger the stage. Thus, use this stage only if current grading over the protected object is possible, that is, for transformers, shunt reactors or long lines with low source impedance. In other cases, deactivate the stage.

EXAMPLE

Calculation example for current grading of a 110-kV overhead line measuring 150 mm²

s (length) = 100 km;

R_1/s = 0.21 Ω/km;

X_1/s = 0.43 Ω/km

Since the stage is non-directional, the calculation must consider the maximum short-circuit power at the start of the line or at the opposite end:

Ssc" = 3.5 GVA (subtransient, because the function can respond to the 1st peak value)

Current transformer: 600 A/5 A

The line impedance Z_L and the minimum source impedance Z_S are calculated on this basis:

Line impedance Z_L and Source impedance Z_S:

$$Z_1/s = \sqrt{0.21^2 + 0.43^2}\ \Omega/km = 0.479\ \Omega/km$$

$$Z_L = 0.479\ \Omega/km \cdot 100\ km = 47.9\ \Omega$$

$$Z_S = \frac{110\ kV^2}{3500\ MVA} = 3.46\ \Omega$$

[fo_glchzv, 1, en_US]

The maximum 3-phase short-circuit current I''_{sc} flowing through is (at a source voltage of 1.1 V_N):

$$I''_{sc} = \frac{1.1 \cdot V_{net}}{\sqrt{3} \cdot (Z_S + Z_L)} + \frac{1.1 \cdot 110\,kV}{\sqrt{3} \cdot (3.46\,\Omega + 47.9\,\Omega)} = 1360\,A$$

[fo_glchik, 1, en_US]

With a safety margin of 10 %, the following setting value results:

- **Threshold value** (primary) = 1.1 · 1360 A = 1496 A
- **Threshold value** (secondary) = $1.1 \cdot \frac{1360\,A}{600\,A} \cdot 5\,A = 12.5\,A$

[fo_glnste, 1, en_US]

If short-circuit currents exceed 1496 A (primary) or 12.5 A (secondary), there is a short circuit on the line to be protected. It can be disconnected immediately.

NOTE

The calculation was performed with absolute values, which is accurate enough for overhead lines. A complex calculation is required only if the source impedance and the line impedance have extremely different angles.

Parameter: `Dropout ratio`

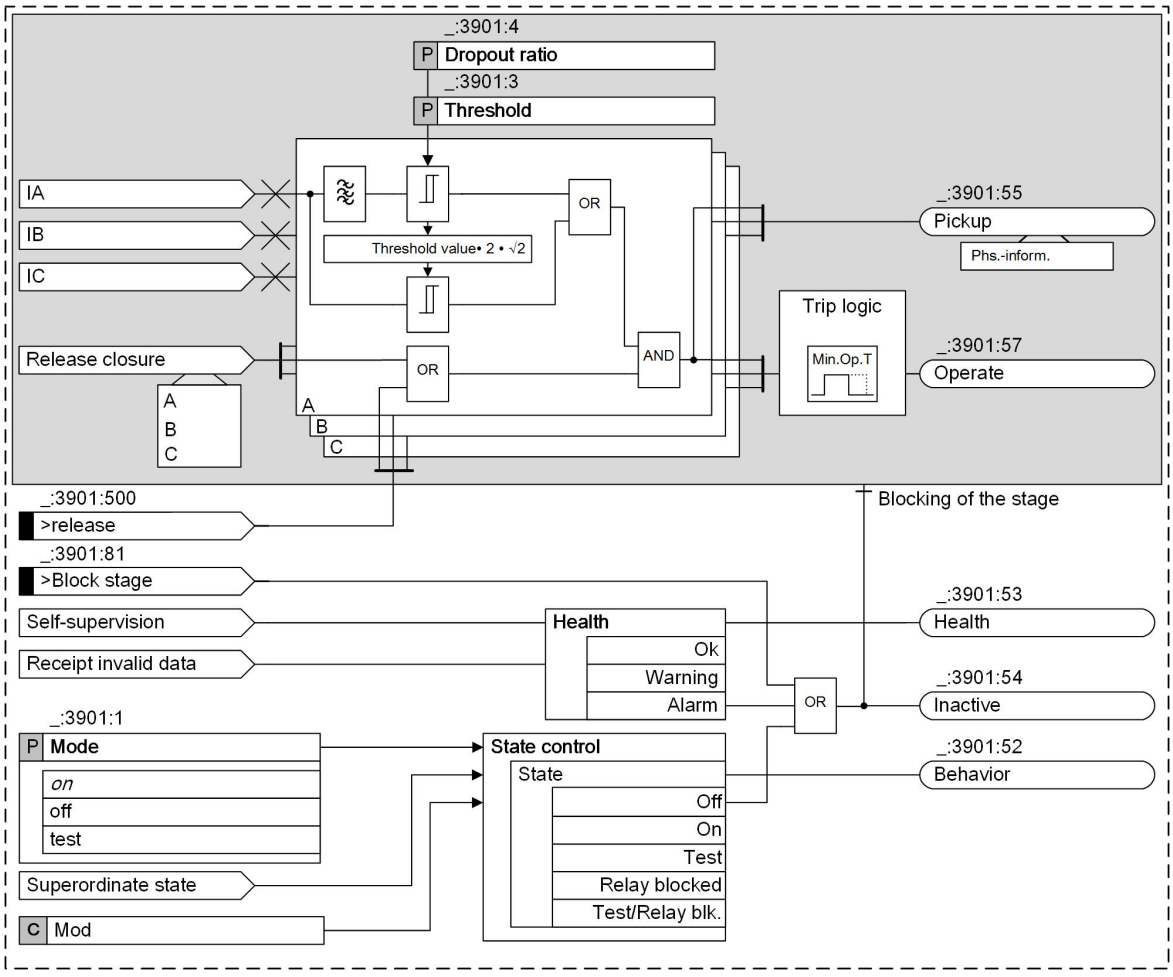
- Recommended setting value **`(_:3901:4) Dropout ratio`** = ***`0.90`***

The recommended setting value of ***`0.90`*** is sufficient for many applications. To obtain high-precision measurements, the **`Dropout ratio`** can be reduced. If you expect highly fluctuating measurands at the pickup threshold, you can increase the setting value of the parameter **`Dropout ratio`**. This avoids chattering of the tripping stage.

6.36.5 Release Procedure via Protection Interface

This stage can be applied only if the device is equipped with a protection interface.

Logic



[lo_hinre3, 2, en_US]

Figure 6-536 Logic Diagram of Instantaneous High-Current Tripping with Release Procedure via Protection Interface

Release

If one of the following conditions is fulfilled, the stage is released (the internal **Release** signal is present) (for further information, refer to *5.5.4 Process Monitor (FG Line)*):

- No voltage has yet been applied to the protected object, which means that the remote circuit breakers are open, or
- Switching to the local circuit breaker is imminent.

These conditions are recognized internally if a circuit breaker is open or just closed

Furthermore, the stage can be activated externally via the **`>release`** binary input signal.

NOTE

To enable internal release of the stage, the devices at all ends of the protected object must be informed of the circuit-breaker position (the circuit-breaker auxiliary contacts must be connected to the devices; the respective binary input signals must be routed).

Method of Measurement, Threshold Value

The stage works with 2 different methods of measurement:

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically. A DC component is thus eliminated. The RMS value of the fundamental component is compared with the set threshold value.
- Evaluation of the unfiltered measurand:
  If the current exceeds a preset threshold value by the
  current ≥ 2·√2·threshold value
  this stage will use unfiltered measurands in addition. Thus, very short operate times are possible.

6.36.6 Application and Setting Notes

Parameter: `Threshold`

- Default setting **`(_:3901:3) Threshold`** = ***`2.5 A`*** for I_{rated} = 1 A or ***`12.5 A`*** for I_{rated} = 5 A

Select the value high enough for the protection not to pick up on the RMS value of the inrush current that occurs when the local circuit breaker is closed. You do not have to consider short-circuit currents flowing through, because the stage is released only if the circuit breakers are opened at all remote ends of the protected object or the release was caused by the binary input *`>release`*.

Parameter: `Dropout ratio`

- Recommended setting value **`(_:3901:4) Dropout ratio`** = ***`0.90`***

The recommended setting value of ***`0.90`*** is sufficient for many applications. To obtain extremely accurate measurements, the dropout ratio can be reduced. If you expect highly fluctuating measurands at the pickup threshold, you can increase the dropout ratio. This avoids chattering of the tripping stage.

6.36.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Standard 1`				
_:3901:1	Standard 1:Mode		• off • on • test	on
_:3901:101	Standard 1:Activation		• on CB closure • only with binary signal • always active	on CB closure
_:3901:3	Standard 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	10.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	50.000 A
_:3901:4	Standard 1:Dropout ratio		0.50 to 0.90	0.90

6.36.8 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Standard 1			
_:3901:500	Standard 1:>release	SPS	I
_:3901:81	Standard 1:>Block stage	SPS	I
_:3901:51	Standard 1:Mode (controllable)	ENC	C
_:3901:54	Standard 1:Inactive	SPS	O
_:3901:52	Standard 1:Behavior	ENS	O
_:3901:53	Standard 1:Health	ENS	O
_:3901:300	Standard 1:Rel. by CB switch on	ACT	O
_:3901:55	Standard 1:Pickup	ACD	O
_:3901:57	Standard 1:Operate	ACT	O

6.37 Overvoltage Protection with 3-Phase Voltage

6.37.1 Overview of Functions

The function **Overvoltage protection with 3-phase voltage** (ANSI 59) is used to:

- Monitor the permissible voltage range
- Protect equipment (for example, plant components, machines, etc.) against damages caused by overvoltage
- Decouple systems (for example, wind power supply)

Abnormally high voltages in power systems are caused by voltage controller failure at the transformer or on long transmission lines under low-load conditions.

When using common-mode reactors in the protected power system, the device must shut down the line quickly if the reactors fail (for example, due to fault clearance). The insulation is endangered by the overvoltage condition.

Overvoltages at capacitor banks can be caused by resonances with line or transformer inductances.

In power plants increased voltage levels can be due to one of these factors:

- Incorrect operation when controlling the excitation system manually
- Failure of the automatic voltage controller
- After full load shedding of a generator
- Generators which are disconnected from the network or in island mode

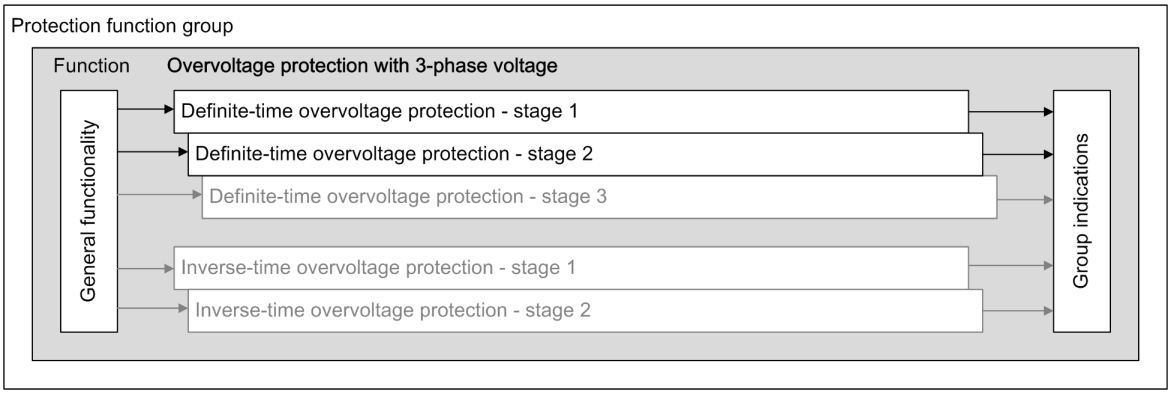
6.37.2 Structure of the Function

The **Overvoltage protection with 3-phase voltage** function is used in protection function groups with voltage measurement.

The **Overvoltage protection with 3-phase voltage** function comes factory-set with 2 **Definite-time overvoltage protection** stages. In this function, the following stages can operate simultaneously:

- 3 stages **Definite-time overvoltage protection**
- 2 stages **Inverse-time overvoltage protection**

Stages that are not preconfigured are shown in gray in the following figure.



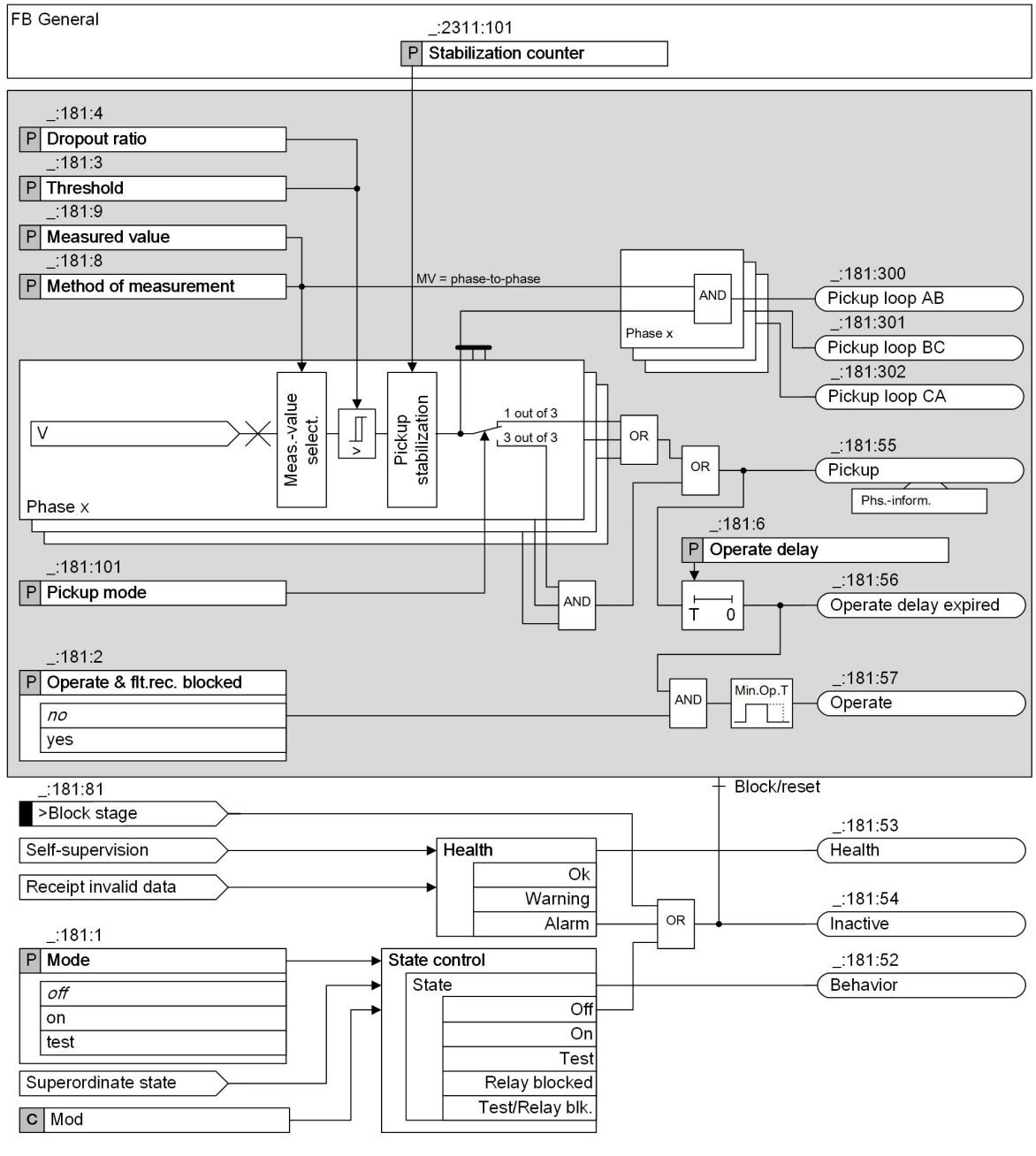
[dw_3-phase_ovp, 5, en_US]

Figure 6-537 Structure/Embedding of the Function

6.37.3 Stage with Definite-Time Characteristic Curve

6.37.3.1 Description

Logic of the Stage



[lo_3phas_i_5, en_US]

Figure 6-538 Logic Diagram of the Definite-Time Overvoltage Protection with 3-Phase Voltage

Method of Measurement

Use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the ***RMS value***.

- Measurement ***fundamental comp.***:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement ***RMS value***:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Pickup Stabilization

To enable the pickup stabilization, you set the **Stabilization counter** parameter to a value other than zero. Then, if the input voltage keeps exceeding the **Threshold** for a specified number (1 + **Stabilization counter** value) of successive measuring cycles, the stage picks up. For 50 Hz, the measuring cycle time is 10 ms.

If you set this parameter to ***0*** (default value), the stabilization is not applied. The pickup signal is issued immediately after the input voltage exceeds the **Threshold**.

Pickup Mode

The **Pickup mode** parameter defines whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (***3 out of 3***) or if only 1 measuring element detects the overvoltage condition (***1 out of 3***).

Measured Value

Use the **Measured value** parameter to define whether the tripping stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal *>Block stage*.

6.37.3.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:181:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends this method of measurement as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Do not set the **threshold value** of the stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting **(_:181:9) Measured value** = ***phase-to-phase***

With the **Measured value** parameter, you define whether the stage monitors the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA} or the phase-to-ground voltages V_A, V_B, and V_C.

Parameter Value	Description
phase-to-phase	If you want to monitor the voltage range, keep ***phase-to-phase*** as the default setting. In this case, the function will not pick up on ground faults. Siemens recommends the measured value ***phase-to-phase*** as the default setting.
phase-to-ground	Select the ***phase-to-ground*** setting if you want to detect voltage unbalances and overvoltage conditions caused by ground faults.

Parameter: Threshold

- Default setting **(_:181:3) Threshold** = ***110 V***

Depending on the **Measured value**, the **Threshold** is set either as phase-to-phase quantity or as phase-to-ground quantity. The default setting assumes that the voltage range is monitored on long-distance transmission lines under low-load conditions.

Specify the **Threshold** (pickup threshold) for the specific application.

Parameter: Stabilization counter

- Default setting **(_:2311:101) Stabilization counter** = ***0***

You can configure the **Stabilization counter** parameter in the function block **General**.

For special applications, it could be desirable that a short exceeding of the input voltage above the pickup value does not lead to the pickup of the stage, which starts fault logging and recording. This is achieved by setting the **Stabilization counter** parameter to a value other than zero.

For example, if you set this parameter to ***1***, the pickup signal is issued when the voltage keeps exceeding the **Threshold** for 2 successive measuring cycles. For 50 Hz, the measuring cycle time is 10 ms.

Parameter: Operate delay

- Default setting **(_:181:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:181:4) Dropout ratio** = ***0.95***

The recommended set value of ***0.95*** is appropriate for most applications. To achieve high measurement precision, the **Dropout ratio** can be reduced, to 0.98, for example.

Parameter: Pickup mode

- Recommended setting value **(_:181:101) Pickup mode** = ***1 out of 3***

With the **Pickup mode** parameter, you define whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (***3 out of 3***) or if only 1 measuring element detects the overvoltage condition (***1 out of 3***).

Parameter Value	Description
1 out of 3	Select the setting for protection applications or for monitoring the voltage range. Siemens recommends ***1 out of 3*** as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Operation as Supervision Function

If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

EXAMPLE

Example for 2-stage overvoltage protection

The example describes the possible settings for a 2-stage overvoltage protection function. We will look at the settings of the parameters **Threshold** and **Operate delay**.

- 1. Stage:
  To detect stationary overvoltages, set the threshold value of the first overvoltage-protection element at least 10 % above the max. stationary phase-to-phase voltage anticipated during normal operation. When setting the parameter **Measured value** to phase-to-phase voltage and a secondary rated voltage of 100 V, the secondary setting value of the first overvoltage-protection element is calculated as follows:

Threshold value: 10 % above V_{rated}

$V_{threshold, sec} = 1.1\ V_{rated, sec} = 1.1 \times 100\ V = 110\ V$

This requires that the primary rated voltages of protected object and voltage transformer are identical. If they are different, you have to adjust the pickup value.

For the **Operate delay** set a value of 3 s.

- 2. Stage:
  The second overvoltage-protection stage is intended for high overvoltages with short duration. A high pickup value is selected here, for example, 1.5 times the rated voltage. A time delay setting of 0.1 s to 0.2 s is sufficient then.

Stage	Setting Values	
	Threshold value	Time delay
1	1.1 V_{rated}	3 s
2	1.5 V_{rated}	0.1 s to 0.2 s

6.37.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Stabilization counter		0 to 10	0
Definite-T 1				
_:181:1	Definite-T 1:Mode		• off • on • test	off
_:181:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:181:9	Definite-T 1:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:181:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:181:101	Definite-T 1:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:181:3	Definite-T 1:Threshold		0.300 V to 340.000 V	110.000 V

Addr.	Parameter	C	Setting Options	Default Setting
_:181:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:181:6	Definite-T 1:Operate delay		0.00 s to 300.00 s	3.00 s
Definite-T 2				
_:182:1	Definite-T 2:Mode		• off • on • test	off
_:182:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:182:9	Definite-T 2:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:182:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:182:101	Definite-T 2:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:182:3	Definite-T 2:Threshold		0.300 V to 340.000 V	130.000 V
_:182:4	Definite-T 2:Dropout ratio		0.90 to 0.99	0.95
_:182:6	Definite-T 2:Operate delay		0.00 s to 300.00 s	0.50 s

6.37.3.4 Information List

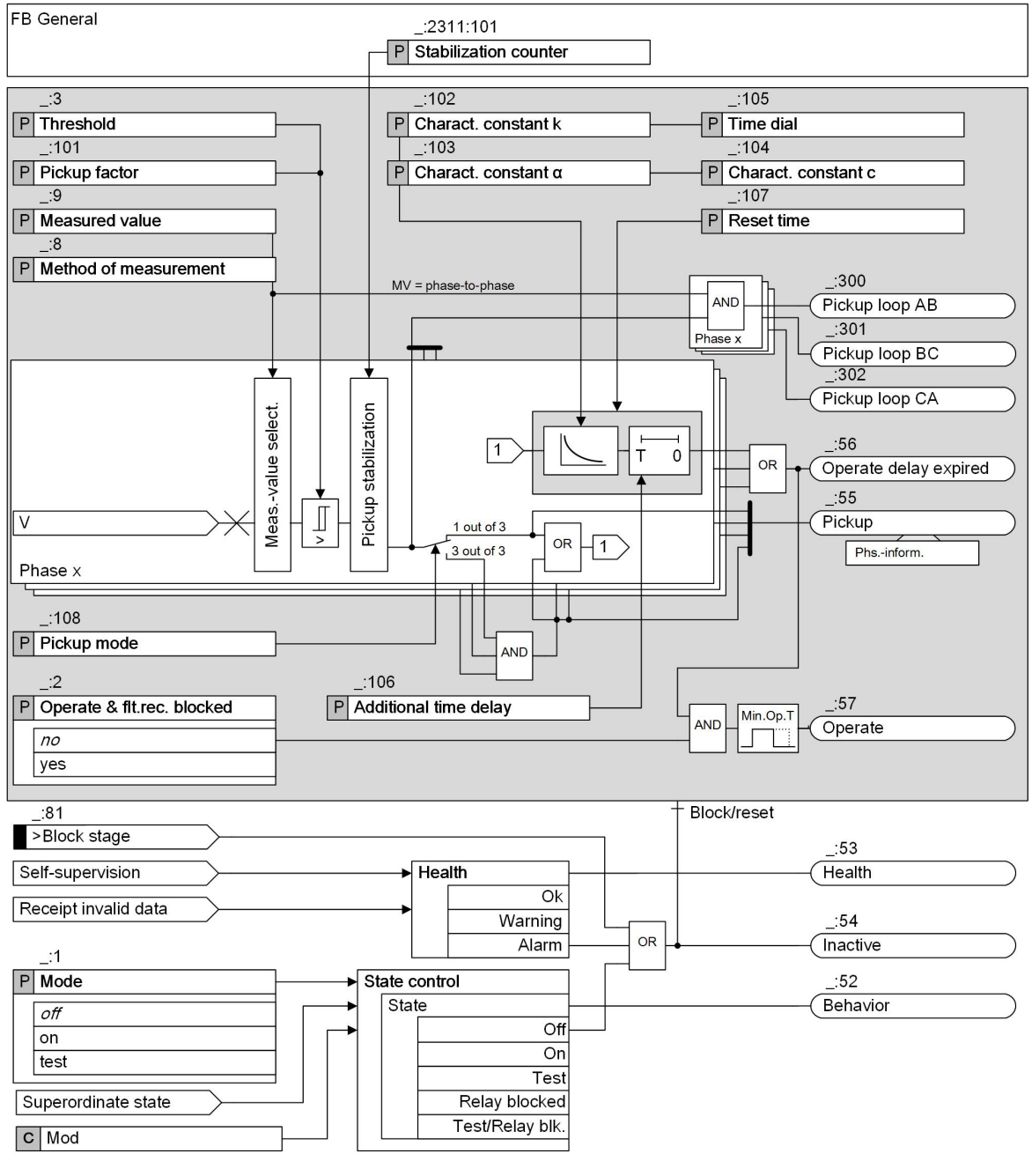
No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Definite-T 1			
_:181:81	Definite-T 1:>Block stage	SPS	I
_:181:51	Definite-T 1:Mode (controllable)	ENC	C
_:181:54	Definite-T 1:Inactive	SPS	O
_:181:52	Definite-T 1:Behavior	ENS	O
_:181:53	Definite-T 1:Health	ENS	O
_:181:55	Definite-T 1:Pickup	ACD	O
_:181:300	Definite-T 1:Pickup loop AB	SPS	O
_:181:301	Definite-T 1:Pickup loop BC	SPS	O
_:181:302	Definite-T 1:Pickup loop CA	SPS	O
_:181:56	Definite-T 1:Operate delay expired	ACT	O
_:181:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:182:81	Definite-T 2:>Block stage	SPS	I
_:182:51	Definite-T 2:Mode (controllable)	ENC	C
_:182:54	Definite-T 2:Inactive	SPS	O
_:182:52	Definite-T 2:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:182:53	Definite-T 2:Health	ENS	O
_:182:55	Definite-T 2:Pickup	ACD	O
_:182:300	Definite-T 2:Pickup loop AB	SPS	O
_:182:301	Definite-T 2:Pickup loop BC	SPS	O
_:182:302	Definite-T 2:Pickup loop CA	SPS	O
_:182:56	Definite-T 2:Operate delay expired	ACT	O
_:182:57	Definite-T 2:Operate	ACT	O

6.37.4 Stage with Inverse-Time Characteristic Curve

6.37.4.1 Description

Logic of the Stage



[lo_3ph_inv, 4, en_US]

Figure 6-539 Logic Diagram of the Inverse-Time Overvoltage Protection with 3-Phase Voltage

Method of Measurement

Use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the ***RMS value*** .

- Measurement ***fundamental comp.*** :
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement ***RMS value*** :
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Pickup Stabilization

To enable the pickup stabilization, you set the **Stabilization counter** parameter to a value other than zero. Then, if the input voltage keeps exceeding the pickup value for a specified number (1 + **Stabilization counter** value) of successive measuring cycles, the stage picks up. For 50 Hz, the measuring cycle time is 10 ms.

If you set this parameter to ***0*** (default value), the stabilization is not applied. The pickup signal is issued immediately after the input voltage exceeds the pickup value.

Pickup Mode

With the **Pickup mode** parameter, you define whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (***3 out of 3***) or if only 1 measuring element detects the overvoltage condition (***1 out of 3***).

Measured Value

Use the **Measured value** parameter to define whether the stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Pickup and Operate Curve

When the input voltage exceeds the threshold value by a settable value **Pickup factor** , the stage picks up and the inverse-time characteristic curve is processed. Operate delay starts. The operate delay is the sum of inverse-time delay and additional time delay.

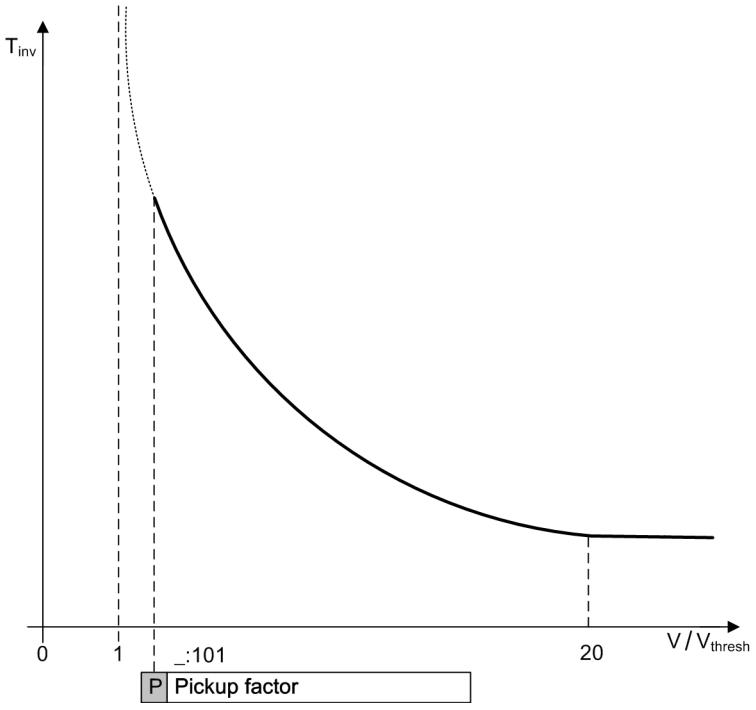
$$T_{op} = T_{inv} + T_{add}$$

Where

T_{op}	Operate delay
T_{inv}	Inverse-time delay
T_{add}	Additional time delay (parameter **Additional time delay**)

After pickup, the time value T_{inv} is calculated for every input voltage that exceeds the threshold. An integrator accumulates the value $1/T_{inv}$. Once the accumulated integral reaches the fixed value 1, the inverse-time delay expires. The additional time delay T_{add} starts. The stage operates after the additional time delay expires.

The inverse-time characteristic is shown in the following figure.



[dw_ovp_inv, 2, en_US]

Figure 6-540 Operate Curve of Inverse-Time Characteristic

The inverse-time delay is calculated with the following formula:

$$T_{inv} = T_p \left(\frac{k}{\left(\frac{V}{V_{thresh}} \right)^{\alpha} - 1} + c \right) [s]$$

Where

T_{inv}	Inverse-time delay
T_p	Time multiplier (parameter **Time dial**)
V	Measured voltage
V_{thresh}	Threshold value (parameter **Threshold**)
k	Curve constant k (parameter **Charact. constant k**)
α	Curve constant α (parameter **Charact. constant α**)
c	Curve constant c (parameter **Charact. constant c**)

When V/V_{thresh} is equal to or greater than 20, the inverse-time delay does not decrease any further.

Dropout Behavior

When the voltage falls below the dropout threshold (0.95 × pickup factor × threshold value), the pickup signal is going and the dropout is started. You can define the dropout behavior via parameter **Reset time** . Instantaneous reset takes place by setting **Reset time** to 0 s. A delayed reset takes place by setting the desired delay time.

During the **Reset time** (> 0 s), the elapsed operate delay is frozen. If the pickup value is exceeded again within this period, the stage operates when the rest of operate delay expires.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal *>Block stage* .

6.37.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the tripping stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends this method of measurement as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Do not set the **threshold value** of the tripping stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting **(_:9) Measured value** = ***phase-to-phase***

With the **Measured value** parameter, you define whether the tripping stage monitors the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA} or the phase-to-ground voltages V_A, V_B, and V_C.

Parameter Value	Description
phase-to-phase	If you want to monitor the voltage range, keep ***phase-to-phase*** as the default setting. In this case, the function will not pick up on ground faults. Siemens recommends the measured value ***phase-to-phase*** as the default setting.
phase-to-ground	Select the ***phase-to-ground*** setting if you want to detect voltage unbalances and overvoltage conditions caused by ground faults.

Parameter: Threshold, Pickup factor

- Default setting **(_:3) Threshold** = ***110.000 V***
- Default setting **(_:101) Pickup factor** = ***1.10***

The stage picks up when the measured voltage value exceeds the pickup value **Threshold** × **Pickup factor**.

Depending on the **Measured value**, the **Threshold** is set either as phase-to-phase quantity or as phase-to-ground quantity.

With the **Pickup factor** parameter, you modify the pickup value. To avoid a long-time operate delay after pickup when the measured value is slightly over the threshold, Siemens recommends using the default setting.

Specify the **Threshold** (pickup threshold) and **Pickup factor** for the specific application.

Parameter: Stabilization counter

- Default setting **(_:2311:101) Stabilization counter** = ***0***

You can configure the **Stabilization counter** parameter in the function block **General**.

For special applications, it could be desirable that a short exceeding of the input voltage above the pickup value does not lead to the pickup of the stage, which starts fault logging and recording. This is achieved by setting the **Stabilization counter** parameter to a value other than zero.

For example, if you set this parameter to ***1***, the pickup signal is issued when the voltage keeps exceeding the pickup value for 2 successive measuring cycles. For 50 Hz, the measuring cycle time is 10 ms.

Parameter: `Pickup mode`

- Recommended setting value **`(_:182:101) Pickup mode`** = ***`1 out of 3`***

With the **`Pickup mode`** parameter, you define whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (***`3 out of 3`***) or if only 1 measuring element detects the overvoltage condition (***`1 out of 3`***).

Parameter Value	Description
`1 out of 3`	Select the setting for protection applications or for monitoring the voltage range. Siemens recommends ***`1 out of 3`*** as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
`3 out of 3`	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Parameter: `Charact. constant k`, `Charact. constant α`, `Charact. constant c`

- Default setting **`(_:102) Charact. constant k`** = ***`1.00`***
- Default setting **`(_:103) Charact. constant α`** = ***`1.000`***
- Default setting **`(_:104) Charact. constant c`** = ***`0.000`***

With the parameters **`Charact. constant k`**, **`Charact. constant α`**, and **`Charact. constant c`**, you define the required inverse-time characteristic curve.

Parameter: `Time dial`

- Default setting **`(_:105) Time dial`** = ***`1.00`***

With the **`Time dial`** parameter, you displace the characteristic curve in the time direction.

As usually, there is no time grading for voltage protection and therefore no displacement of the characteristic curve, Siemens recommends leaving the **`Time dial`** parameter at ***`1.00`*** (default setting).

Parameter: `Additional time delay`

- Default setting **`(_:106) Additional time delay`** = ***`0.00 s`***

With the **`Additional time delay`** parameter, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, only the inverse-time delay is operative.

Parameter: `Reset time`

- Default setting **`(_:107) Reset time`** = ***`0.00 s`***

With the **`Reset time`** parameter, you define the reset time delay which is started when the voltage falls below the dropout threshold. Set the parameter **`Reset time`** to 0 s when instantaneous reset is desired.

Under network conditions of intermittent faults or faults which occur in rapid succession, Siemens recommends setting the **`Reset time`** to an appropriate value (> 0 s) to ensure the operation. Otherwise Siemens recommends keeping the default value to ensure a fast reset of the function.

6.37.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T #				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:9	Inverse-T #:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:8	Inverse-T #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:108	Inverse-T #:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:3	Inverse-T #:Threshold		0.300 V to 340.000 V	110.000 V
_:101	Inverse-T #:Pickup factor		1.00 to 1.20	1.10
_:102	Inverse-T #:Charact. constant k		0.00 to 300.00	1.00
_:103	Inverse-T #:Charact. constant α		0.010 to 5.000	1.000
_:104	Inverse-T #:Charact. constant c		0.000 to 5.000	0.000
_:105	Inverse-T #:Time dial		0.05 to 15.00	1.00
_:106	Inverse-T #:Additional time delay		0.00 s to 60.00 s	0.00 s
_:107	Inverse-T #:Reset time		0.00 s to 60.00 s	0.00 s

6.37.4.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	Inverse-T #:>Block stage	SPS	I
_:54	Inverse-T #:Inactive	SPS	O
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:55	Inverse-T #:Pickup	ACD	O
_:300	Inverse-T #:Pickup loop AB	SPS	O
_:301	Inverse-T #:Pickup loop BC	SPS	O
_:302	Inverse-T #:Pickup loop CA	SPS	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:57	Inverse-T #:Operate	ACT	O

6.38 Overvoltage Protection with Positive-Sequence Voltage

6.38.1 Overview of Functions

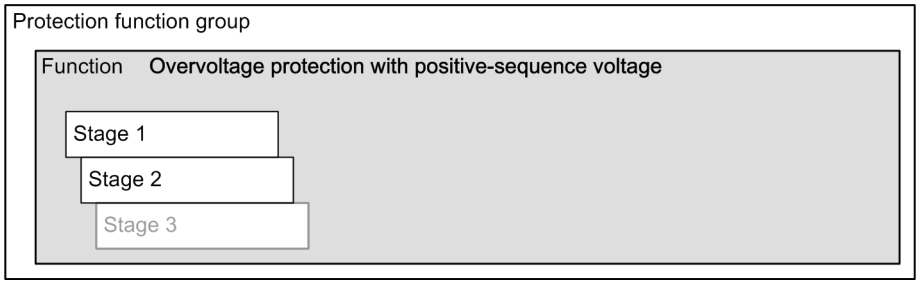
The function **Overvoltage protection with positive-sequence voltage** (ANSI 59) is used to:

- Detect symmetric stationary overvoltages
- Supervise the voltage range if the positive-sequence voltage is the decisive quantity

Unbalanced overvoltages, for example, caused by ground faults and unbalanced faults, are not detected due to the evaluation of the positive-sequence voltage.

6.38.2 Structure of the Function

The **Overvoltage protection with positive-sequence voltage** function is used in protection function groups, which are based on voltage measurement.
The function **Overvoltage protection with positive-sequence voltage** comes factory-set with 2 stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.



[dw_ovp_u1s, 1, en_US]
Figure 6-541 Structure/Embedding of the Function

6.38.3 Stage Description

Logic of a Stage

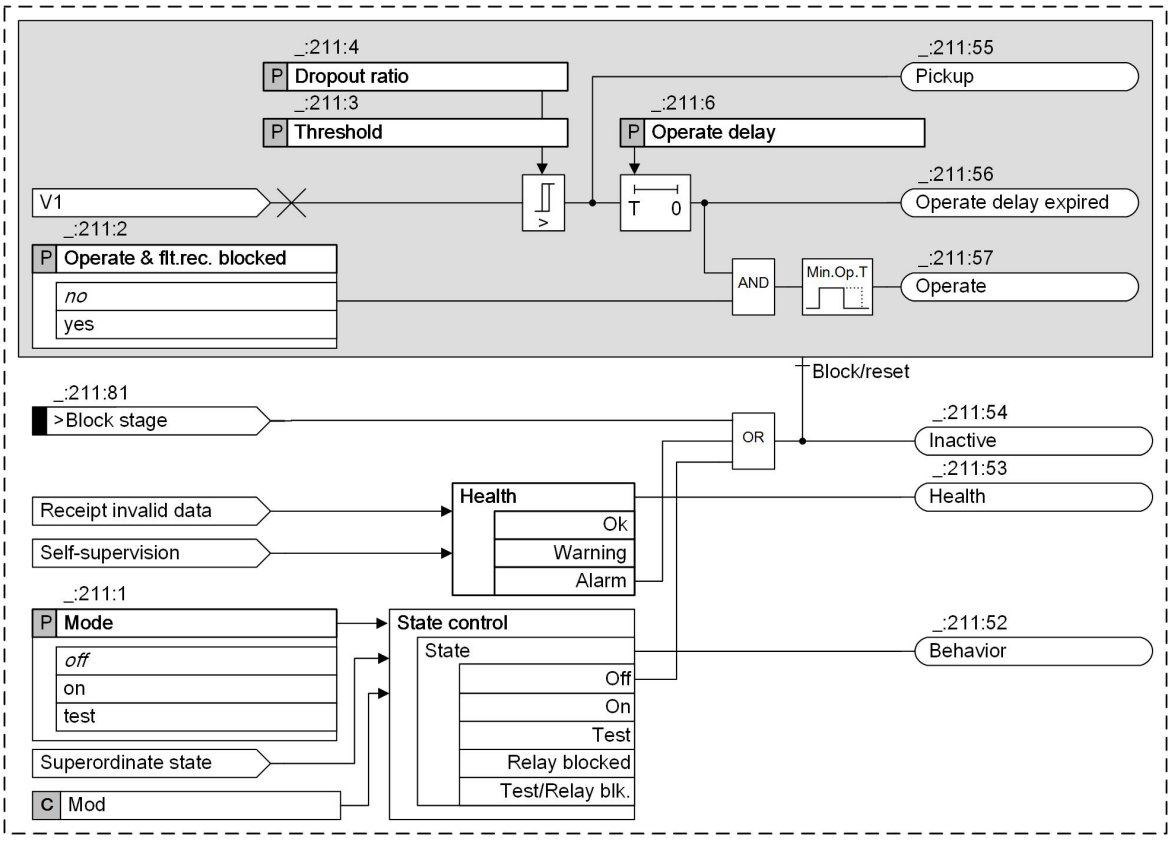


Figure 6-542 Logic Diagram of a Stage: Overvoltage Protection with Positive-Sequence Voltage

Method of Measurement

The stage uses the positive-sequence voltage. The positive-sequence voltage is calculated from the measured phase-to-ground voltages according to the defining equation.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal **>Block stage**.

6.38.4 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:211:3) Threshold** = ***65 V***

The Threshold is set according to the definition of the positive-sequence system.

Specify the Threshold (pickup threshold) for the specific application.

Parameter: Operate delay

- Default **(_:211:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:211:4) Dropout ratio** = ***0.95***

The default value of ***0.95*** is appropriate for most applications. To achieve high measurement precision, the **Dropout ratio** can be reduced, to 0.98, for example.

General Notes

If the overvoltage is high, the first stage can trip with a short time delay. If overvoltages are lower, the second stage can either only signal the threshold value violation (see *Operation as monitoring function*) or trip with a longer delay to allow the voltage controller to regulate the voltage back into the nominal range.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

6.38.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:211:1	Stage 1:Mode		• off • on • test	off
_:211:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:211:3	Stage 1:Threshold		0.300 V to 200.000 V	65.000 V
_:211:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:211:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:212:1	Stage 2:Mode		• off • on • test	off
_:212:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:212:3	Stage 2:Threshold		0.300 V to 200.000 V	75.000 V
_:212:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:212:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.38.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Stage 1			
_:211:81	Stage 1:>Block stage	SPS	I

No.	Information	Data Class (Type)	Type
_:211:51	Stage 1:Mode (controllable)	ENC	C
_:211:54	Stage 1:Inactive	SPS	O
_:211:52	Stage 1:Behavior	ENS	O
_:211:53	Stage 1:Health	ENS	O
_:211:55	Stage 1:Pickup	ACD	O
_:211:56	Stage 1:Operate delay expired	ACT	O
_:211:57	Stage 1:Operate	ACT	O
Stage 2			
_:212:81	Stage 2:>Block stage	SPS	I
_:212:51	Stage 2:Mode (controllable)	ENC	C
_:212:54	Stage 2:Inactive	SPS	O
_:212:52	Stage 2:Behavior	ENS	O
_:212:53	Stage 2:Health	ENS	O
_:212:55	Stage 2:Pickup	ACD	O
_:212:56	Stage 2:Operate delay expired	ACT	O
_:212:57	Stage 2:Operate	ACT	O

6.39 Overvoltage Protection with Negative-Sequence Voltage

6.39.1 Overview of Functions

The function **Overvoltage protection with negative-sequence voltage** (ANSI 47) is used to:

- Monitor the power system and electric machines for voltage unbalances
- Establish a release criterion of overcurrent protection for unbalanced faults

Voltage unbalances can be caused by various factors:

- The most common cause is unbalanced load, caused by different consumers in the individual phases, for example.
- Voltage unbalance can also be caused by phase failure, for example due to a tripped 1-phase fuse, a broken conductor, etc.
- Other causes can include faults in the primary system, for example, at the transformer or in installations for reactive-power compensation.

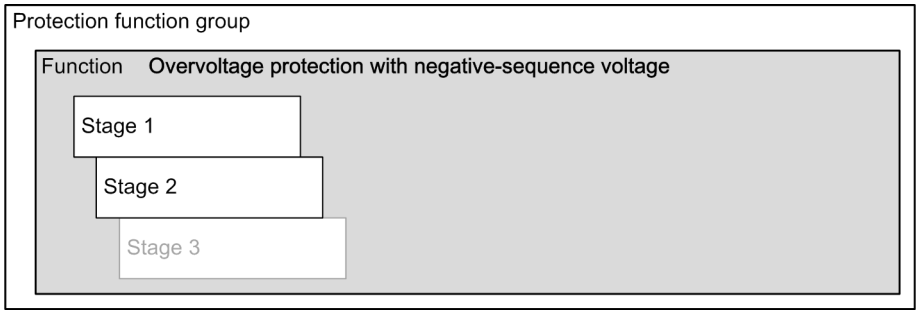
6.39.2 Structure of the Function

The **Overvoltage protection with negative-sequence voltage** function is used in protection function groups, which are based on voltage measurement.

The **Overvoltage protection with negative-sequence voltage** function comes factory-set with 2 stages.

A maximum of 3 stages can be operated simultaneously in the function.

The stages have an identical structure.



[dw_uZovps_ext, 2, en_US]

Figure 6-543 Structure/Embedding of the Function

6.39.3 General Functionality

6.39.3.1 Description

Logic

The following figure represents the logic of the average-value calculation of the negative-sequence voltage. The average value is forwarded to all subordinate stages.

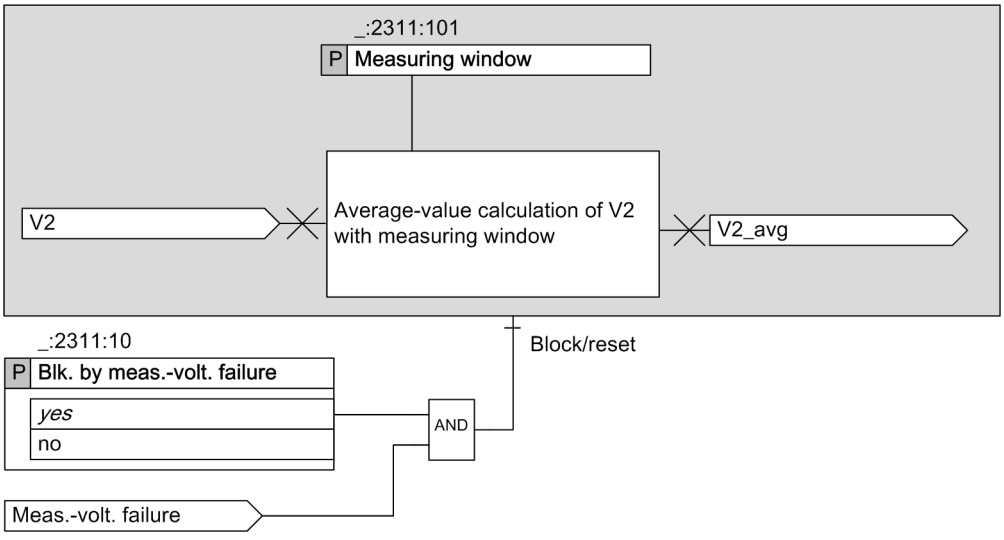


Figure 6-544 Logic Diagram of the General Functionality

Measurand

The average value of negative-sequence voltage is determined by a settable time interval (parameter: **Measuring window**). With the parameter **Measuring window**, you can adapt this function to all power-system conditions.

You can set the parameter **Measuring window** with a large value to get a more accurate calculated result, which leads to a longer pickup time however.

Blocking the Function with Measuring-Voltage Failure Detection

In case of blocking, the picked up function is reset. The following blocking options is available for the function:

- From inside on pick up of the **Measuring-voltage failure detection** function (see section *8.3.2.1 Overview of Functions*).
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker.

The parameter **Blk. by meas.-volt. failure** can be set so that the measuring-voltage failure detection blocks the function or does not block it.

6.39.3.2 Application and Setting Notes

Parameter: Measuring window

- Default setting **(_:2311:101) Measuring window** = ***1 cycle***

  With the parameter **Measuring window**, you can optimize the measuring accuracy or the pickup time of this function.

  For sensitive settings of the parameter **Threshold**, for example, lower than 10 % of the rated voltage, Siemens recommends using a higher number of cycles. Siemens recommends ***10 cycles***, and in this case, the pickup time is increased.

  For further information, refer to chapter *12.34 Overvoltage Protection with Negative-Sequence Voltage* .

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:2311:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the function when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see chapter *8.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection function is blocked (= default setting). Siemens recommends using the default setting.
no	The protection function is not blocked.

6.39.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:10	General:Blk. by meas.-volt. failure		• no • yes	yes
_:2311:101	General:Measuring window		1 cycles to 10 cycles	1 cycles

6.39.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:V2 average	MV	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O

6.39.4 Stage with Negative-Sequence Voltage

6.39.4.1 Description

Logic of a Stage

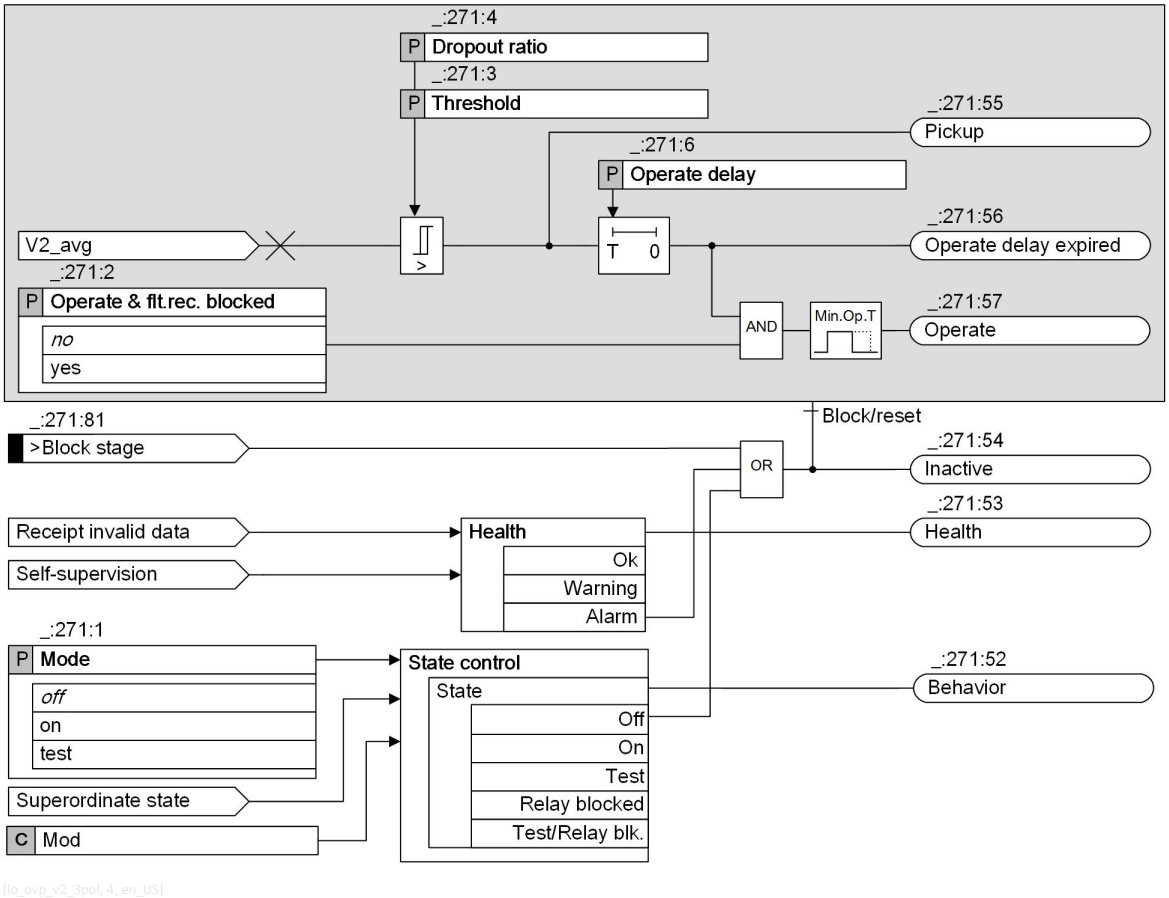


Figure 6-545 Logic Diagram of the Stage: Overvoltage Protection with Negative-Sequence Voltage

Method of Measurement

The stage uses the average value of the negative-sequence voltage, which is calculated from the function block **General Functionality**. For more information, refer to chapter *6.39.3.1 Description*.

Blocking the Stage

In case of blocking, the picked up function is reset. The following blocking option is available for the function:

- From an external or internal source via the binary input signal *>Block stage*

6.39.4.2 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:271:3) Threshold** = ***5.800 V***

The parameter **Threshold** is set according to the definition of the negative-sequence system.

Specify the **Threshold** (pickup threshold) for the specific application.

The secondary voltage of the voltage transformer can be used if the voltage transformer is adapted to the rated voltage. The value of the 10 % negative-sequence voltage at a 100 V rated secondary voltage is:

100 V / 1.73 * 0.1 = 5.77 V

Parameter: Dropout ratio

- Default setting **(_:271:4) Dropout ratio** = ***0.95***

The default setting of ***0.95*** is appropriate for most applications.

You can decrease the dropout ratio to avoid chattering of the stage if the threshold value is low. For example, for the stage with a 2 % setting, you can use a dropout ratio of 0.90.

Parameter: Operate delay

- Default setting **(_:271:6) Operate delay** = ***3.00 s***

Specify the **Operate delay** for the specific application. 3.00 s is a practicable value.

For a higher threshold value, a shorter tripping delay is required.

Operation as Supervision Function

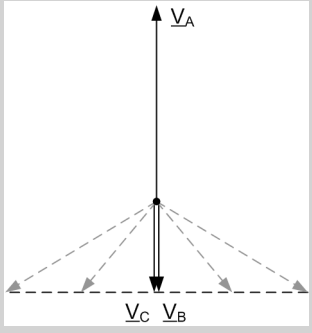
If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

Example 1:

Releasing an overcurrent protection stage for unbalanced faults

The following section describes how to set the function to release an **Overcurrent-protection** stage when unbalanced faults occur. Set the **Overcurrent-protection** stage only slightly higher than the load current, that is very sensitive. To prevent the **Overcurrent-protection** stage from picking up inadvertently, the **Overcurrent-protection** stage is released when the **Negative-sequence voltage** stage picks up. The **Overcurrent-protection** stage remains blocked as long as the **Negative-sequence voltage** stage has not picked up.

Figure 6-546 shows the voltage phasors during a 2-phase local fault between phases B and C. The phase-to-phase voltage V_{BC} is virtually 0.



[dw_ua_zeig, 1, en_US]

Figure 6-546 Voltage Phasors during a 2-Phase Local Fault

A 2-phase local fault generates a relatively large negative-sequence voltage of up to 50 % referred to the phase-to-ground voltage. The portion of the negative-sequence decreases in case of a remote fault. The lower setting limit results from the possible unbalance at full load. If you assume for example 5 % negative-sequence voltage, the pickup value must be higher. A setting value of 10 % warrants sufficient stability during unbalanced operating states and sufficient sensitivity to release the **Overcurrent-protection** stage when a fault occurs.

For a secondary rated voltage of 100 V, set the following secondary threshold value:

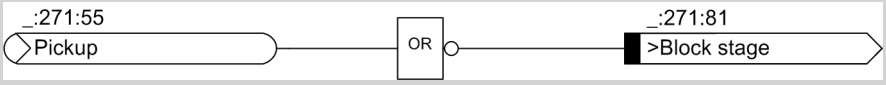
$$V2_{sec} = \frac{V_{rated}\ 100\ V}{\sqrt{3}} \times\ 10\ \% = \frac{100\ V}{\sqrt{3}} \times\ 0.1 \approx 5.8\ V$$

[fo_ovp_v2_secondary threshold, 1, en_US]

You can keep the default setting of 0.95 for the dropout ratio. This avoids chattering of the stage.

Set the **Negative-sequence voltage** stage so that it does not generate a fault when it picks up and does not initiate tripping. The **Overcurrent-protection** stage generates a fault indication. The pickup of the **Negative-sequence voltage** stage is used as the release criterion because the **Short-circuit** function must be released immediately when the **Negative-sequence voltage** stage has picked up. The time delay is thus not relevant and can be left at the default setting.

You implement the release of the **Overcurrent-protection** stage using a logic block chart. An inverter links the pickup of the **Negative-sequence voltage** stage with the **Overcurrent-protection** stage blocking.



[lo_invert, 1, en_US]

Figure 6-547 Linking the Pickup of the Negative-Sequence Voltage Stage

Stage	Setting Values		
	Secondary Threshold Value	Time Delay	Dropout Ratio
1	5.800 V	3.00 s	0.95

The second stage is not needed. It is deleted or remains off.

Example 2:

A negative-sequence voltage in the auxiliary system of the power plant causes negative-sequence currents on motors. This leads to a thermal overload of the rotors. The following estimation can be used as a basis: 1 % negative-sequence voltage can lead to approximately 5 % or 6 % negative-sequence current.

A negative-sequence voltage can be caused by a broken conductor on the high-voltage side. If a negative-sequence voltage occurs, this can, for example, initiate a switching of the infeed in order to prevent a protection trip of an unbalanced-load protection of the motors.

Siemens recommends using multiple stages for a better grading, whereby a sensitive setting of the threshold permits an increased tripping delay.

For a reference, only 2 stages are discussed.

The first stage has a pickup threshold of 10 % with a time delay of 1.5 s. The second stage has a pickup threshold of 3 % with a time delay of 8 s, see *Table 6-18*. Further, it is assumed that the voltage transformer is well adapted to the rated voltage.

$$V2_{sec} = \frac{100\ V}{1.73} \times \frac{V2\ [\%]}{100\%}$$

[fo_ovp_v2_secondary_threshold2, 1, en_US]

Table 6-18 Recommended Settings

Stage	Threshold	Operate Delay
Stage 1	5.800 V	1.50 s
Stage 2	1.730 V	8.00 s

6.39.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:271:1	Stage 1:Mode		• off • on • test	off
_:271:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:271:3	Stage 1:Threshold		0.300 V to 200.000 V	5.800 V
_:271:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:271:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:272:1	Stage 2:Mode		• off • on • test	off
_:272:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:272:3	Stage 2:Threshold		0.300 V to 200.000 V	9.000 V
_:272:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:272:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.39.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:V2 average	MV	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Stage 1			
_:271:81	Stage 1:>Block stage	SPS	I
_:271:51	Stage 1:Mode (controllable)	ENC	C
_:271:54	Stage 1:Inactive	SPS	O
_:271:52	Stage 1:Behavior	ENS	O
_:271:53	Stage 1:Health	ENS	O
_:271:55	Stage 1:Pickup	ACD	O
_:271:56	Stage 1:Operate delay expired	ACT	O
_:271:57	Stage 1:Operate	ACT	O
Stage 2			
_:272:81	Stage 2:>Block stage	SPS	I
_:272:51	Stage 2:Mode (controllable)	ENC	C
_:272:54	Stage 2:Inactive	SPS	O
_:272:52	Stage 2:Behavior	ENS	O
_:272:53	Stage 2:Health	ENS	O
_:272:55	Stage 2:Pickup	ACD	O
_:272:56	Stage 2:Operate delay expired	ACT	O
_:272:57	Stage 2:Operate	ACT	O

6.40 Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage

6.40.1 Overview of Functions

The function **Overvoltage protection with negative-sequence voltage/positive-sequence voltage** is used to:

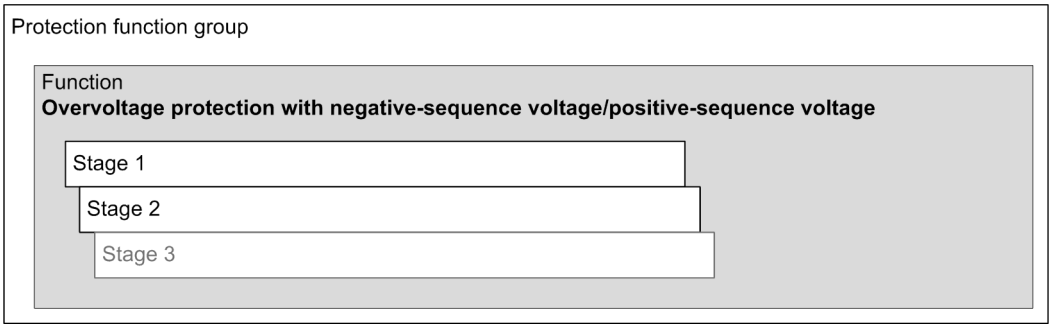
- Monitor the power system and electric machines for voltage unbalances
- Establish a release criterion of overcurrent protection for unbalanced faults

Voltage unbalances can be caused by various factors:

- The most common cause is unbalanced load, caused by different consumers in the individual phases, for example.
- Voltage unbalance can also be caused by phase failure, for example due to a tripped 1-phase fuse, a broken conductor, etc.
- Other causes can include faults in the primary system, for example, at the transformer or in installations for reactive-power compensation.

6.40.2 Structure of the Function

The **Overvoltage protection with negative-sequence voltage/positive-sequence voltage** function is used in protection function groups, which are based on voltage measurement.
The **Overvoltage protection with negative-sequence voltage/positive-sequence voltage** function comes factory-set with 2 stages. A maximum of 3 stages can be operated simultaneously in the function. The stages have an identical structure.



[lo_structure_V2_V1, 2, en_US]

Figure 6-548 Structure/Embedding of the Function

6.40.3 General Functionality

6.40.3.1 Description

Logic

The following figure represents the logic of the average-value calculation of the ratio of negative-sequence voltage to positive-sequence voltage. The average value is forwarded to all subordinate stages.

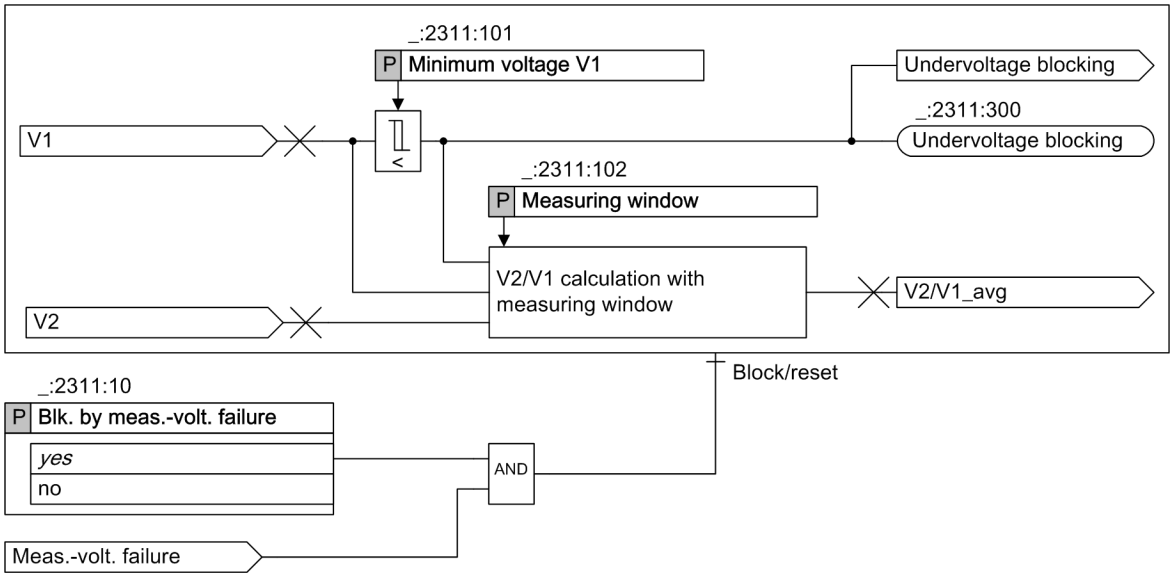


Figure 6-549 Logic Diagram of the General Functionality

Measurand

The average value of the ratio of negative-sequence voltage to positive-sequence voltage is determined by a settable time interval (parameter: **Measuring window**). With the parameter **Measuring window**, you can adapt this function to all power-system conditions.

You can set the parameter **Measuring window** with a large value to get a more accurate calculated result, which leads to a longer pickup time however.

Blocking the Function with Measuring-Voltage Failure Detection

In case of blocking, the picked up function is reset. The following blocking options is available for the function:

- From inside on pick up of the **Measuring-voltage failure detection** function (see section *8.3.2.1 Overview of Functions*).
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker.

The parameter **Blk. by meas.-volt. failure** can be set so that the measuring-voltage failure detection blocks the function or does not block it.

6.40.3.2 Application and Setting Notes

Parameter: Measuring window

- Default setting **(_:2311:102) Measuring window** = ***1 cycle***

  With the parameter **Measuring window**, you can optimize the measuring accuracy or the pickup time of this function.

  For sensitive settings of the parameter **Threshold**, for example, lower than 10 % of the rated voltage, Siemens recommends using a higher number of cycles. Siemens recommends ***10 cycles***, and in this case, the pickup time is increased.

  For further information, refer to chapter *12.35 Overvoltage Protection with Negative-Sequence Voltage/ Positive-Sequence Voltage* .

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:2311:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the function when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see chapter *8.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection function is blocked (= default setting). Siemens recommends using the default setting.
no	The protection function is not blocked.

6.40.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:10	General:Blk. by meas.-volt. failure		• no • yes	yes
_:2311:102	General:Measuring window		1 cycles to 10 cycles	1 cycles
_:2311:101	General:Minimum voltage V1		0.300 V to 60.000 V	5.000 V

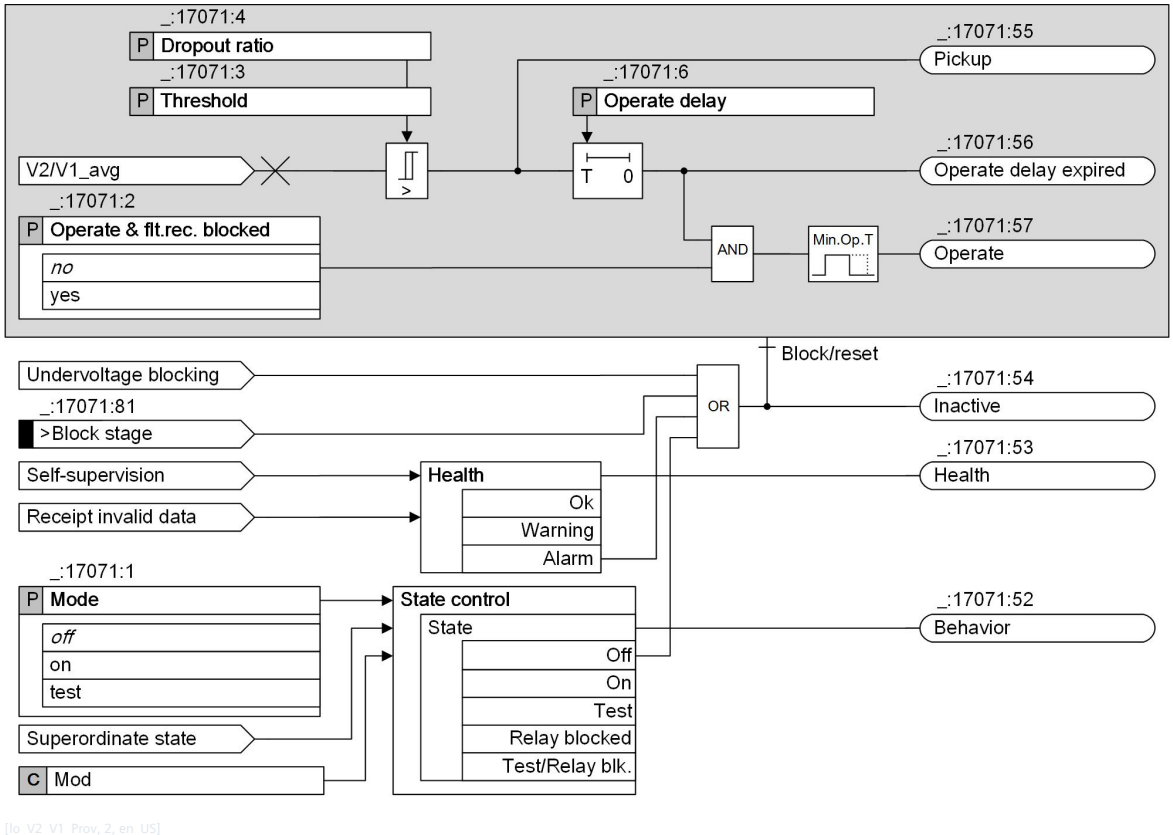
6.40.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
_:2311:301	General:V2/V1	MV	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O

6.40.4 Stage with Negative-Sequence Voltage/Positive-Sequence Voltage

6.40.4.1 Description

Logic of a Stage



[lo_V2_V1_Prov, 2, en_US]

Figure 6-550 Logic Diagram of the Stage: Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage

Method of Measurement

The stage uses the average value of the negative-sequence voltage/positive-sequence voltage, which is calculated from the function block **General Functionality**. For more information, refer to chapter *6.40.3.1 Description*.

Blocking the Stage

In case of blocking, the picked up function is reset. The following blocking option is available for the function:

- From an external or internal source via the binary input signal *>Block stage*

6.40.4.2 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:17071:3) Threshold** = *10.00 %*

The parameter **Threshold** is set in percentage according to the definition of the symmetrical compents. It is the ratio of the negative-sequence voltage to positive-sequence voltage.

Specify the **Threshold** (pickup threshold) for the specific application.

In the application with a lower threshold setting of about 2.00 %, there is a risk of an overfunction due to the measuring errors with small values as well as an influence via disturbances.

Parameter: Dropout ratio

- Default setting **(_:17071:4) Dropout ratio** = ***0.95***

The default setting of ***0.95*** is appropriate for most applications if a higher threshold is used.

You can decrease the dropout ratio to avoid chattering of the stage if the threshold value is low. For example, for the stage with a 2 % setting, you can use a dropout ratio of 0.90.

Parameter: Operate delay

- Default setting **(_:17071:6) Operate delay** = ***3.00 s***

Specify the **Operate delay** for the specific application. When using the sensitive setting of the threshold value that is described in this chapter, the function can be delayed by 3.00 s.

For a higher threshold value, a shorter tripping delay is required.

Operation as Supervision Function

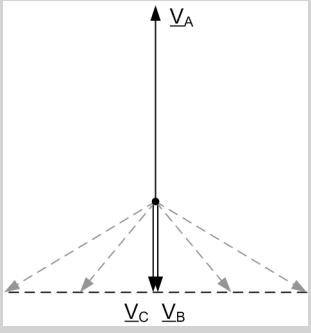
If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

Example 1:

Releasing an overcurrent protection stage for unbalanced faults

The following section describes how to set the function to release an **Overcurrent-protection** stage when unbalanced faults occur. Set the **Overcurrent-protection** stage only slightly higher than the load current, that is very sensitive. To prevent the **Overcurrent-protection** stage from picking up inadvertently, the **Overcurrent-protection** stage is released when the **Negative-sequence voltage** stage picks up. The **Overcurrent-Protection** stage remains blocked as long as the **Negative-sequence voltage** stage has not picked up.

Figure 6-551 shows the voltage phasors during a 2-phase local fault between phases B and C. The phase-to-phase voltage V_{BC} is virtually 0.



[dw_ua_zeig, 1, en_US]

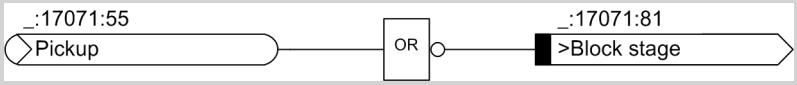
Figure 6-551 Voltage Phasors during a 2-Phase Local Fault

A 2-phase local fault generates a relatively large negative-sequence voltage of up to 100 % referred to the positive-sequence voltage. The portion of the negative-sequence decreases in case of a remote fault. The lower setting limit results from the possible unbalance at full load. If you assume for example 5 % of the negative-sequence voltage to positive-sequence voltage, the pickup value must be higher. A setting value of 10 % warrants sufficient stability during unbalanced operating states and sufficient sensitivity to release the **Overcurrent-protection** stage when a fault occurs.

You can keep the default setting of 0.95 for the dropout ratio. This avoids chattering of the stage.

Set the **Negative-sequence voltage** stage so that it does not generate a fault when it picks up and does not initiate tripping. The **Overcurrent-protection** stage generates a fault indication. The pickup of the **Negative-sequence voltage** stage is used as the release criterion because the **Short-circuit** function must be released immediately when the **Negative-sequence voltage** stage has picked up. The time delay is thus not relevant and can be left at the default setting.

You implement the release of the **Overcurrent-protection** stage using a logic block chart. An inverter links the pickup of the **Negative-sequence voltage** stage with the **Overcurrent-protection** stage blocking.



[lo_pickup V2, 1, en_US]

Figure 6-552 Linking the Pickup of the Negative-Sequence Voltage Stage

Stage	Setting Values		
	Percentage of the Negative-Sequence Voltage to Positive-Sequence Voltage	Time Delay	Dropout Ratio
1	10.00 %	3.00 s	0.95

The second stage is not needed. It is deleted or remains off.

Example 2:

A negative-sequence voltage in the auxiliary system of the power plant causes negative-sequence currents on motors. This leads to a thermal overload of the rotors. The following estimation can be used as a basis: 1 % negative-sequence voltage can lead to approximately 5 % or 6 % negative-sequence current.

A negative-sequence voltage can be caused by a broken conductor on the high-voltage side. If a negative-sequence voltage occurs, this can, for example, initiate a switching of the infeed in order to prevent a protection trip of an unbalanced-load protection of the motors.

Siemens recommends using multiple stages for a better grading, whereby a sensitive setting of the threshold permits an increased tripping delay.

For a reference, only 2 stages are discussed.

The first stage has a pickup threshold of 10 % with a time delay of 1.5 s. The second stage has a pickup threshold of 3 % with a time delay of 8 s, see*Table 6-19*.

Table 6-19 Recommended Settings

Stage	Threshold	Operate Delay
Stage 1	10.00 %	1.50 s
Stage 2	3.00 %	8.00 s

6.40.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:17071:1	Stage 1:Mode		• off • on • test	off
_:17071:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:17071:3	Stage 1:Threshold		0.50 % to 100.00 %	10.00 %
_:17071:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:17071:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:17072:1	Stage 2:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:17072:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:17072:3	Stage 2:Threshold		0.50 % to 100.00 %	15.00 %
_:17072:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:17072:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.40.4.4 Information List

No.	Information	Data Class (Type)	Type
Stage 1			
_:17071:81	Stage 1:>Block stage	SPS	I
_:17071:54	Stage 1:Inactive	SPS	O
_:17071:52	Stage 1:Behavior	ENS	O
_:17071:53	Stage 1:Health	ENS	O
_:17071:55	Stage 1:Pickup	ACD	O
_:17071:56	Stage 1:Operate delay expired	ACT	O
_:17071:57	Stage 1:Operate	ACT	O
Stage 2			
_:17072:81	Stage 2:>Block stage	SPS	I
_:17072:54	Stage 2:Inactive	SPS	O
_:17072:52	Stage 2:Behavior	ENS	O
_:17072:53	Stage 2:Health	ENS	O
_:17072:55	Stage 2:Pickup	ACD	O
_:17072:56	Stage 2:Operate delay expired	ACT	O
_:17072:57	Stage 2:Operate	ACT	O

6.41 Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage

6.41.1 Overview of Functions

The function **Overvoltage protection with zero-sequence voltage/residual voltage** (ANSI 59N):

- Detects ground faults in isolated or arc-suppression-coil-grounded systems
- Determines the phase affected by the ground fault
- Works with electrical machines to detect ground faults in the stator winding

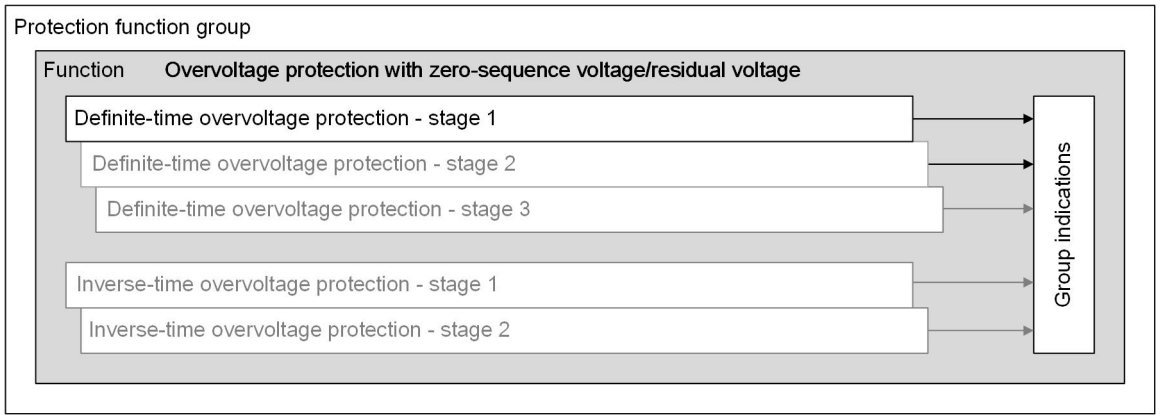
6.41.2 Structure of the Function

The function **Overvoltage protection with zero-sequence voltage/residual voltage** is used in protection function groups with voltage measurement.

The function **Overvoltage protection with zero-sequence voltage/residual voltage** comes factory-set with 1 stage **Definite-time overvoltage protection**. In this function, the following stages can operate simultaneously:

- 3 stages **Definite-time overvoltage protection**
- 2 stages **Inverse-time overvoltage protection**

Stages that are not preconfigured are shown in gray in the following figure.



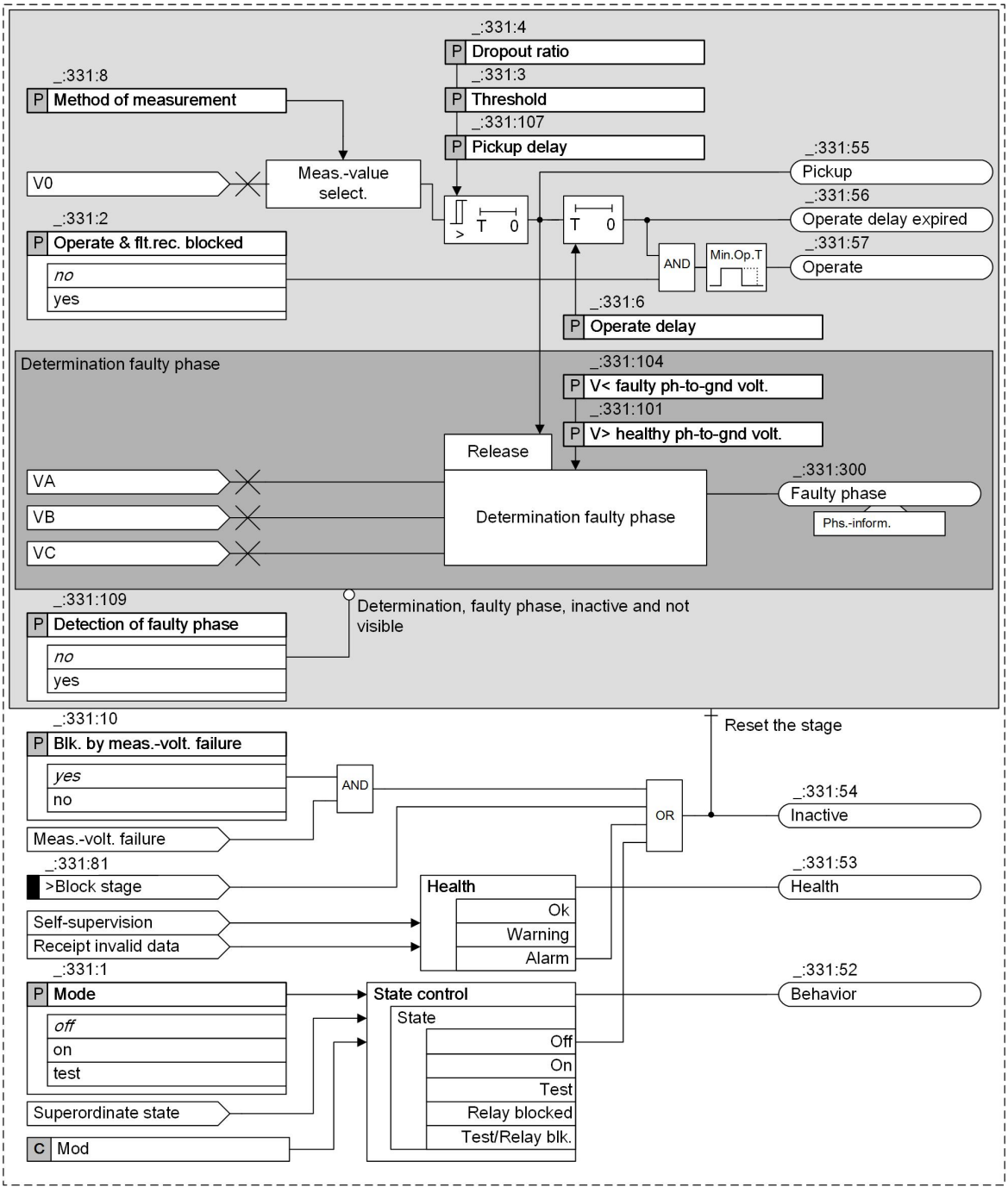
[dw_u0_ovps, 3, en_US]

Figure 6-553 Structure/Embedding of the Function

6.41.3 Stage with Definite-Time Characteristic Curve

6.41.3.1 Stage Description

Logic of the Stage



[lo_ovp_u_03, 3, en_US]

Figure 6-554 Logic Diagram of the Definite-Time Overvoltage Protection with Zero-Sequence Voltage/ Residual Voltage

Measured Value, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V_0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V_0 is calculated from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

With the parameter **Method of measurement**, you select the relevant method of measurement, depending on the application:

- ***fundamental comp.*** (standard filter):
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- ***RMS value*** (true RMS):
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value.
- ***fund. comp. long filter*** (fundamental component over 2 cycle filters with triangular window):
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically. The extended filter length compared to the standard filter and the use of the triangular window results in a particularly strong attenuation of harmonics and transient faults. The extended filter length causes the pickup time to increase slightly compared to the standard filter (refer to the technical data in *12.36 Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage*).

Pickup, Dropout

The stage compares the **Threshold** with the zero-sequence voltage V_0. The parameter **Pickup delay** allows you to delay the pickup of the stage depending on the residual voltage.

With the parameter **Dropout ratio**, you can define the ratio of the dropout value to the **Threshold**.

Determination of the Faulty Phase

You can use the parameter **Detection of faulty phase** to enable or disable the determination of the phase affected by the ground fault. Determining is released when the stage picks up. If 2 phases exceed the threshold value **V> healthy ph-to-gnd volt.** and 1 phase falls below the threshold value **V< faulty ph-to-gnd volt.**, the last phase is considered to be affected by the ground fault and is signaled as such.

Blocking the Stage

In the event of blocking, the picked up stage is reset. The following blocking options are available for the stage:

- Via the binary input signal **>Block stage** from an external or internal source
- From inside on pickup of the function **Measuring-voltage failure detection** (refer to *8.3.2.1 Overview of Functions*). The parameter **Blk. by meas.-volt. failure** can be set so that the measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal **>Open** of the function block **Voltage-transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker. The parameter **Blk. by meas.-volt. failure** can be set so that the measuring-voltage failure detection blocks the stage or does not block it.

6.41.3.2 Application and Setting Notes

Parameter: Method of measurement

- Default setting **(_:331:8) Method of measurement** = ***fundamental comp.***

With the parameter **Method of measurement**, you define whether the function works with the fundamental component or the calculated RMS value.

Parameter Value	Description
fundamental comp.	This method of measurement suppresses the harmonics or transient voltage peaks. Siemens recommends using this setting as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Do not set the **threshold value** of the tripping stage under 10 V for this method of measurement.
fund. comp. long filter	To implement a particularly strong attenuation of harmonics and transient faults, select this method of measurement. With this method, the length of the filter is longer than that of the standard filter. Note: In this case, the pickup time of the stage increases slightly (refer to the technical data in *12.36 Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage*).

Parameter: Pickup delay

- Recommended setting value **(_:331:107) Pickup delay** = ***0.00 ms***

The **Pickup delay** parameter allows you to delay the analysis of the measurand (to generate the pickup) depending on the occurrence of the residual voltage. A pickup delay can be necessary if high transients are anticipated after fault inception due to high line and ground capacitances.

Siemens recommends using the default setting **Pickup delay** = ***0.00 ms***.

Parameter: Threshold

- Default setting **(_:331:3) Threshold** = ***30.000 V***[51]

The threshold value of the function is set as the zero-sequence voltage V0. The device calculates the zero-sequence voltage V0 either from the residual voltage measured via the broken-delta winding or from the 3 phase-to-ground voltages.

The setting value depends on the system grounding:

- Since virtually the full residual voltage occurs during ground faults in isolated or arc-suppression-coil-grounded systems, the setting value is uncritical there. It should range between 20 V and 40 V. A higher sensitivity (= lower threshold value) can be necessary for high fault resistances.
- You should select a more sensitive (smaller) value in a grounded system. This value must be higher than the maximum residual voltage anticipated during operation caused by system unbalances.

EXAMPLE

For an isolated system

The residual voltage is measured via the broken-delta winding:

- If the ground fault is fully unbalanced, a residual voltage of 100 V is present at the device terminals.
- The threshold value should be set so that the stage picks up on 50 % of the full residual voltage.
- At full residual voltage, the zero-sequence voltage is 100 V/$\sqrt{3}$ = 57.7 V
  Setting value: 0.5 · 57.7 V = 28.9 V ≈ 30 V

Parameter: Dropout ratio

- Recommended setting value **(_:331:4) Dropout ratio** = ***0.95***

The recommended set value of ***0.95*** is appropriate for most applications. The dropout ratio can be reduced for example, to 0.98 to achieve a high measurement precision.

51 The specific setting limits depend on the transformer data and transformer connections set.

Parameter: Operate delay

- Default setting **(_:331:6) Operate delay** = ***3.00 s***

The **Operate delay** allows you to prevent transient residual voltages from initiating a trip. The setting depends on the specific application.

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:331:10) Blk. by meas.-volt. failure** = ***yes***

With the parameter **Blk. by meas.-volt. failure**, you control the behavior of the stage when a measuring-voltage failure is detected.
A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker (refer to *8.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: Detection of faulty phase

- Default setting **(_:331:109) Detection of faulty phase** = ***no***

With the parameter **Detection of faulty phase**, you control how the stage responds to determine which phase is affected by the ground fault.

Parameter Value	Description
no	The phase affected by the ground fault is not determined. Select the default setting if you do not want to use the stage to detect ground faults, for example, for applications in grounded systems.
yes	After a pickup by the residual voltage, the device tries to determine which phase is affected by the ground fault. Select this setting for applications in isolated or arc-suppression-coil-grounded systems.

Parameter: V< faulty ph-to-gnd volt.

- Default setting **(_:331:104) V< faulty ph-to-gnd volt.** = ***40.000 V***[52]

With the parameter **V< faulty ph-to-gnd volt.**, you set the threshold value for determining which phase is affected by the ground fault. The setting value is a phase-to-ground quantity.
The setting value must be smaller than the minimum phase-to-ground voltage occurring during operation. Siemens recommends using the default setting of ***40.000 V***.

Parameter: V> healthy ph-to-gnd volt.

- Default setting **(_:331:101) V> healthy ph-to-gnd volt.** = ***75.000 V***[52]

With the parameter **V> healthy ph-to-gnd volt.**, you set the threshold value for the 2 healthy phases. The setting value is a phase-to-ground quantity.
The setting value must be greater than the maximum phase-to-ground voltage occurring during operation, but smaller than the minimum phase-to-phase voltage occurring during operation. At V_{rated} = 100 V, set the value, for example, to ***75.000 V***. Siemens recommends using the default setting of ***75.000 V***.

52 The specific setting limits depend on the transformer data and transformer connections set.

Operation as Supervision Function

If you want the stage to have a reporting effect only, you can set the parameter **Operate & flt.rec. blocked** to disable the generation of the operate indication and fault logging.

6.41.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Definite-T 1				
_:331:1	Definite-T 1:Mode		• off • on • test	off
_:331:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:331:10	Definite-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:331:109	Definite-T 1:Detection of faulty phase		• no • yes	no
_:331:8	Definite-T 1:Method of measurement		• fundamental comp. • fund. comp. long filter • RMS value	fundamental comp.
_:331:3	Definite-T 1:Threshold		0.300 V to 200.000 V	30.000 V
_:331:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:331:107	Definite-T 1:Pickup delay		0.00 s to 320.00 s	0.00 s
_:331:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	3.00 s
_:331:101	Definite-T 1:V> healthy ph-to-gnd volt.		0.300 V to 200.000 V	75.000 V
_:331:104	Definite-T 1:V< faulty ph-to-gnd volt.		0.300 V to 200.000 V	40.000 V

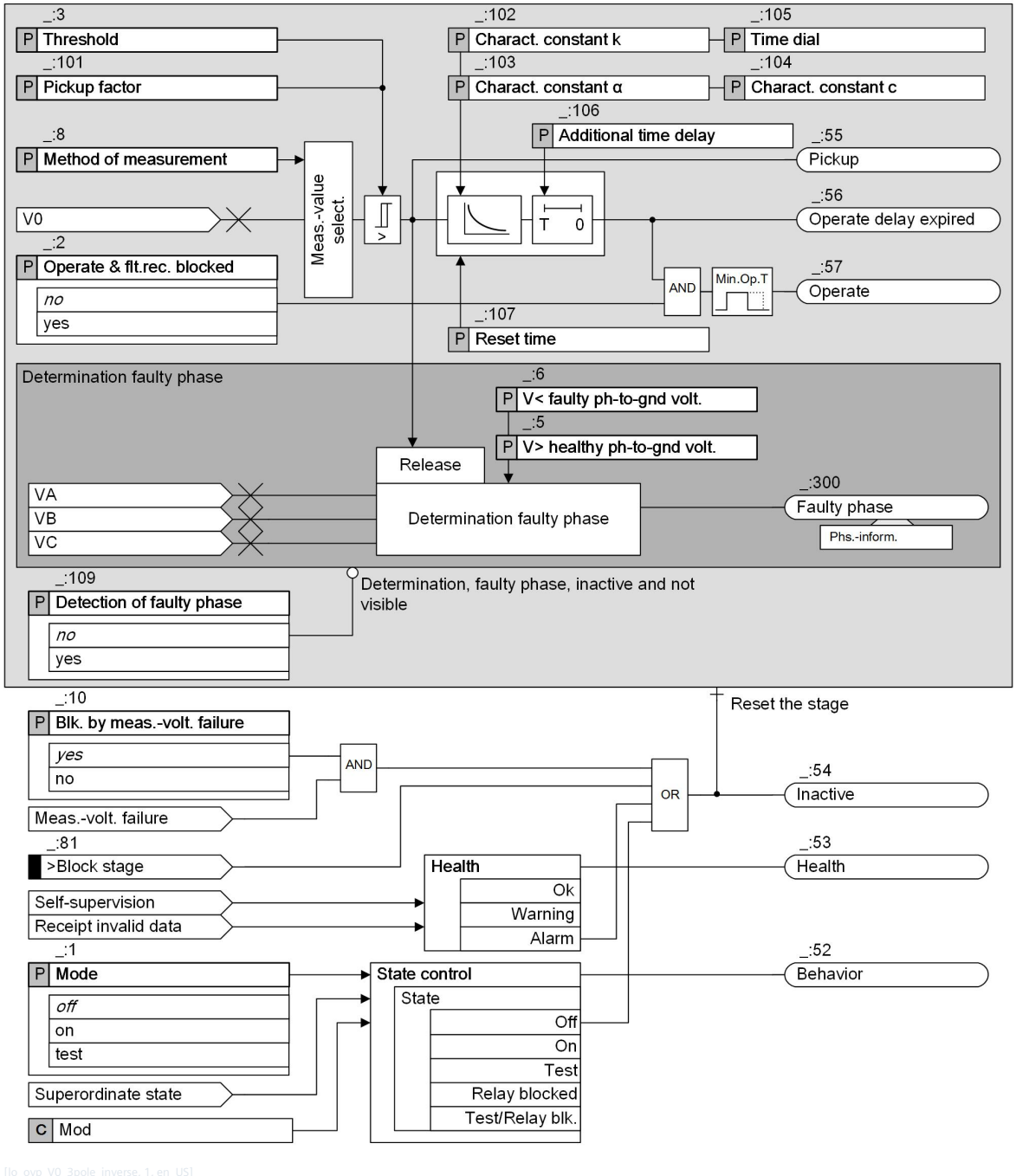
6.41.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Definite-T 1			
_:331:81	Definite-T 1:>Block stage	SPS	I
_:331:51	Definite-T 1:Mode (controllable)	ENC	C
_:331:54	Definite-T 1:Inactive	SPS	O
_:331:52	Definite-T 1:Behavior	ENS	O
_:331:53	Definite-T 1:Health	ENS	O
_:331:300	Definite-T 1:Faulty phase	ACT	O
_:331:55	Definite-T 1:Pickup	ACD	O
_:331:56	Definite-T 1:Operate delay expired	ACT	O
_:331:57	Definite-T 1:Operate	ACT	O

6.41.4 Stage with Inverse-Time Characteristic Curve

6.41.4.1 Description

Logic of the Stage



[lo_ovp_V0_3pole_inverse, 1, en_US]

Figure 6-555 Logic Diagram of the Inverse-Time Overvoltage Protection with Zero-Sequence Voltage/ Residual Voltage

Measured Value, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V_0. If the residual voltage is not available to the device as a measurand, the

zero-sequence voltage V_0 is calculated from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

With the parameter **Method of measurement**, you select the relevant method of measurement, depending on the application:

- ***fundamental comp.*** (standard filter):
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- ***RMS value*** (true RMS):
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value.
- ***fund. comp. long filter*** (fundamental component over 2 cycle filters with triangular window):
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically. The extended filter length compared to the standard filter and the use of the triangular window results in a particularly strong attenuation of harmonics and transient faults. The extended filter length causes the pickup time to increase slightly compared to the standard filter (refer to the technical data in *12.36 Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage*).

Pickup and Operate Curve

When the input voltage exceeds the threshold value by a settable value **Pickup factor**, the stage picks up and the inverse-time characteristic curve is processed. The operate delay starts. The operate delay is the sum of the inverse-time delay and the additional time delay.

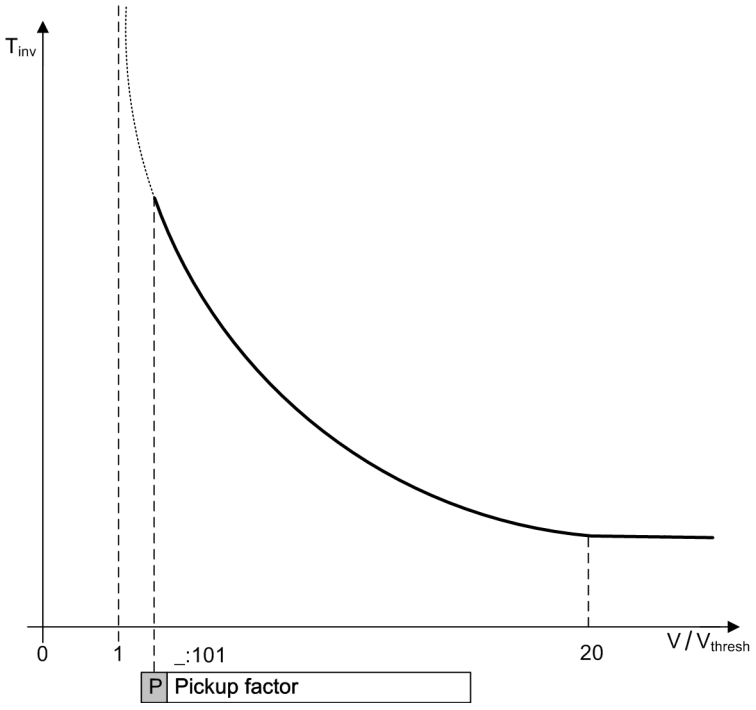
$$T_{op} = T_{inv} + T_{add}$$

Where

T_{op}	Operate delay
T_{inv}	Inverse-time delay
T_{add}	Additional time delay (parameter **Additional time delay**)

After pickup, the inverse-time delay T_{inv} is calculated for every input voltage that exceeds the threshold. An integrator accumulates the value $1/T_{inv}$. Once the accumulated integral reaches the fixed value 1, the inverse-time delay expires. The additional time delay T_{add} starts. The stage operates after the additional time delay expires.

The inverse-time characteristic curve is shown in the following figure.



[dw_ovp_inv, 2, en_US]

Figure 6-556 Operate Curve of Inverse-Time Characteristic Curve

The inverse-time delay is calculated with the following formula:

$$T_{inv} = T_p \left(\frac{k}{\left(\frac{V}{V_{thresh}} \right)^{\alpha} - 1} + c \right) [s]$$

Where

T_{inv}	Inverse-time delay
T_p	Time multiplier (parameter **Time dial**)
V	Zero-sequence voltage
V_{thresh}	Threshold value (parameter **Threshold**)
k	Curve constant k (parameter **Charact. constant k**)
α	Curve constant α (parameter **Charact. constant α**)
c	Curve constant c (parameter **Charact. constant c**)

When V/V_{thresh} is equal to or greater than 20, the inverse-time delay does not decrease any further.

Dropout Behavior

When the voltage falls below the dropout threshold (0.95 · pickup factor · threshold value), the dropout is initiated. You can define the dropout behavior via the parameter **Reset time**. An instantaneous reset takes place by setting **Reset time** to 0 s. A delayed reset takes place by setting the desired time delay.

During the **Reset time** (> 0 s), the elapsed operate delay is frozen. If the pickup value is exceeded again within this period, the stage operates when the rest of the operate delay expires.

Determination of the Faulty Phase

You can use the parameter **Detection of faulty phase** to enable or disable the determination of the phase affected by the ground fault. Determining is released when the stage picks up. If 2 phases exceed the

threshold value **V> healthy ph-to-gnd volt.** and 1 phase falls below the threshold value **V< faulty ph-to-gnd volt.**, the last phase is considered to be affected by the ground fault and is signaled as such.

Blocking the Stage

In the event of blocking, the picked up stage is reset. The following blocking options are available for the stage:

- Via the binary input signal **>Block stage** from an external or internal source
- From inside on pickup of the function **Measuring-voltage failure detection** (refer to *8.3.2.1 Overview of Functions*). The parameter **Blk. by meas.-volt. failure** can be set so that the measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal **>Open** of the function block **Voltage-transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker. The parameter **Blk. by meas.-volt. failure** can be set so that the measuring-voltage failure detection blocks the stage or does not block it.

6.41.4.2 Application and Setting Notes

Parameter: Method of measurement

- Default setting **(_:8) Method of measurement** = ***fundamental comp.***

With the parameter **Method of measurement**, you define whether the function works with the fundamental component or the calculated RMS value.

Parameter Value	Description
fundamental comp.	This method of measurement suppresses the harmonics or transient voltage peaks. Siemens recommends using this setting as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Do not set the **threshold value** of the tripping stage under 10 V for this method of measurement.
fund. comp. long filter	To implement a particularly strong attenuation of harmonics and transient faults, select this method of measurement. With this method, the length of the filter is longer than that of the standard filter. Note: In this case, the pickup time of the stage increases slightly (refer to the technical data in *12.36 Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage*).

Parameter: Threshold, Pickup factor

- Default setting **(_:3) Threshold** = ***30.000 V***
- Default setting **(_:101) Pickup factor** = ***1.10***

The stage picks up when the measured voltage value exceeds the pickup value **Threshold** · **Pickup factor**.

With the parameter **Pickup factor**, you modify the pickup value. To avoid a long-time operate delay after pickup when the measured value is slightly over the threshold, Siemens recommends using the default setting.

Specify the **Threshold** (pickup threshold) and **Pickup factor** for the specific application.

Parameter: Charact. constant k, Charact. constant α, Charact. constant c

- Default setting **(_:102) Charact. constant k** = ***1.00***
- Default setting **(_:103) Charact. constant α** = ***1.000***
- Default setting **(_:104) Charact. constant c** = ***0.000***

With the parameters **Charact. constant k**, **Charact. constant α**, and **Charact. constant c**, you define the required inverse-time characteristic curve.

Parameter: Time dial

- Default setting **(_:105) Time dial** = ***1.00***

With the parameter **Time dial**, you displace the characteristic curve in the time direction.

As usually, there is no time grading for voltage protection and therefore no displacement of the characteristic curve, Siemens recommends leaving the parameter **Time dial** at ***1.00*** (default setting).

Parameter: Additional time delay

- Default setting **(_:106) Additional time delay** = ***0.00 s***

With the parameter **Additional time delay**, you define a definite-time delay in addition to the inverse-time delay.

If you keep the default setting of ***0.00 s***, only the inverse-time delay is operative.

Parameter: Reset time

- Default setting **(_:107) Reset time** = ***0.00 s***

With the parameter **Reset time**, you define the reset time delay which is started when the voltage falls below the dropout threshold. Set the parameter **Reset time** to ***0.00 s*** when an instantaneous reset is desired.

Under network conditions of intermittent faults or faults which occur in fast succession, Siemens recommends setting the **Reset time** to an appropriate value (> ***0.00 s***) to ensure the operation. Otherwise, Siemens recommends keeping the default value to ensure a fast reset of the function.

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:10) Blk. by meas.-volt. failure** = ***yes***

With the parameter **Blk. by meas.-volt. failure**, you control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker (refer to *8.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: Detection of faulty phase

- Default setting **(_:109) Detection of faulty phase** = ***no***

With the parameter **Detection of faulty phase**, you control how the stage responds to determine which phase is affected by the ground fault.

Parameter Value	Description
no	The phase affected by the ground fault is not determined. Select the default setting if you do not want to use the stage to detect ground faults, for example, for applications in grounded systems.
yes	After a pickup by the residual voltage, the device tries to determine which phase is affected by the ground fault. Select this setting for applications in isolated or arc-suppression-coil-grounded systems.

Parameter: V< faulty ph-to-gnd volt.

- Default setting **(_:6) V< faulty ph-to-gnd volt.** = ***40.000 V***[53]

With the parameter **V< faulty ph-to-gnd volt.**, you set the threshold value for determining which phase is affected by the ground fault. The setting value is a phase-to-ground quantity.
The setting value must be smaller than the minimum phase-to-ground voltage occurring during operation. Siemens recommends using the default setting of ***40.000 V***.

Parameter: V> healthy ph-to-gnd volt.

- Default setting **(_:5) V> healthy ph-to-gnd volt.** = ***75.000 V***[53]

With the parameter **V> healthy ph-to-gnd volt.**, you set the threshold value for the 2 healthy phases. The setting value is a phase-to-ground quantity.
The setting value must be greater than the maximum phase-to-ground voltage occurring during operation, but smaller than the minimum phase-to-phase voltage occurring during operation. At V_{rated} = 100 V, set the value, for example, to ***75.000 V***. Siemens recommends using the default setting of ***75.000 V***.

Operation as Supervision Function

If you want the stage to have a reporting effect only, you can set the parameter **Operate & flt.rec. blocked** to disable the generation of the operate indication and fault logging.

6.41.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T #				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:10	Inverse-T #:Blk. by meas.-volt. failure		• no • yes	yes
_:109	Inverse-T #:Detection of faulty phase		• no • yes	no
_:8	Inverse-T #:Method of measurement		• fundamental comp. • fund. comp. long filter • RMS value	fundamental comp.
_:3	Inverse-T #:Threshold		0.300 V to 200.000 V	30.000 V
_:101	Inverse-T #:Pickup factor		1.00 to 1.20	1.10

53 The specific setting limits depend on the transformer data and transformer connections set.

Addr.	Parameter	C	Setting Options	Default Setting
_:102	Inverse-T #:Charact. constant k		0.00 to 300.00	1.00
_:103	Inverse-T #:Charact. constant α		0.010 to 5.000	1.000
_:104	Inverse-T #:Charact. constant c		0.000 to 5.000	0.000
_:105	Inverse-T #:Time dial		0.05 to 15.00	1.00
_:106	Inverse-T #:Additional time delay		0.00 s to 60.00 s	0.00 s
_:107	Inverse-T #:Reset time		0.00 s to 60.00 s	0.00 s
_:5	Inverse-T #:V> healthy ph-to-gnd volt.		0.300 V to 200.000 V	75.000 V
_:6	Inverse-T #:V< faulty ph-to-gnd volt.		0.300 V to 200.000 V	40.000 V

6.41.4.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	Inverse-T #:>Block stage	SPS	I
_:51	Inverse-T #:Mode (controllable)	ENC	C
_:54	Inverse-T #:Inactive	SPS	O
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:300	Inverse-T #:Faulty phase	ACT	O
_:55	Inverse-T #:Pickup	ACD	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:57	Inverse-T #:Operate	ACT	O

6.42 Overvoltage Protection with Any Voltage

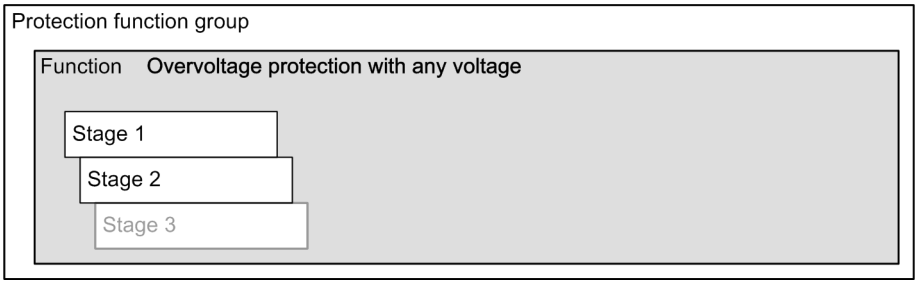
6.42.1 Overview of Functions

The function **Overvoltage protection with any voltage** (ANSI 59) detects any 1-phase overvoltages and is intended for special applications.

6.42.2 Structure of the Function

The **Overvoltage protection with any voltage** function is used in protection function groups, which are based on voltage measurement.

The function **Overvoltage protection with any voltage** comes factory-set with 2 stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

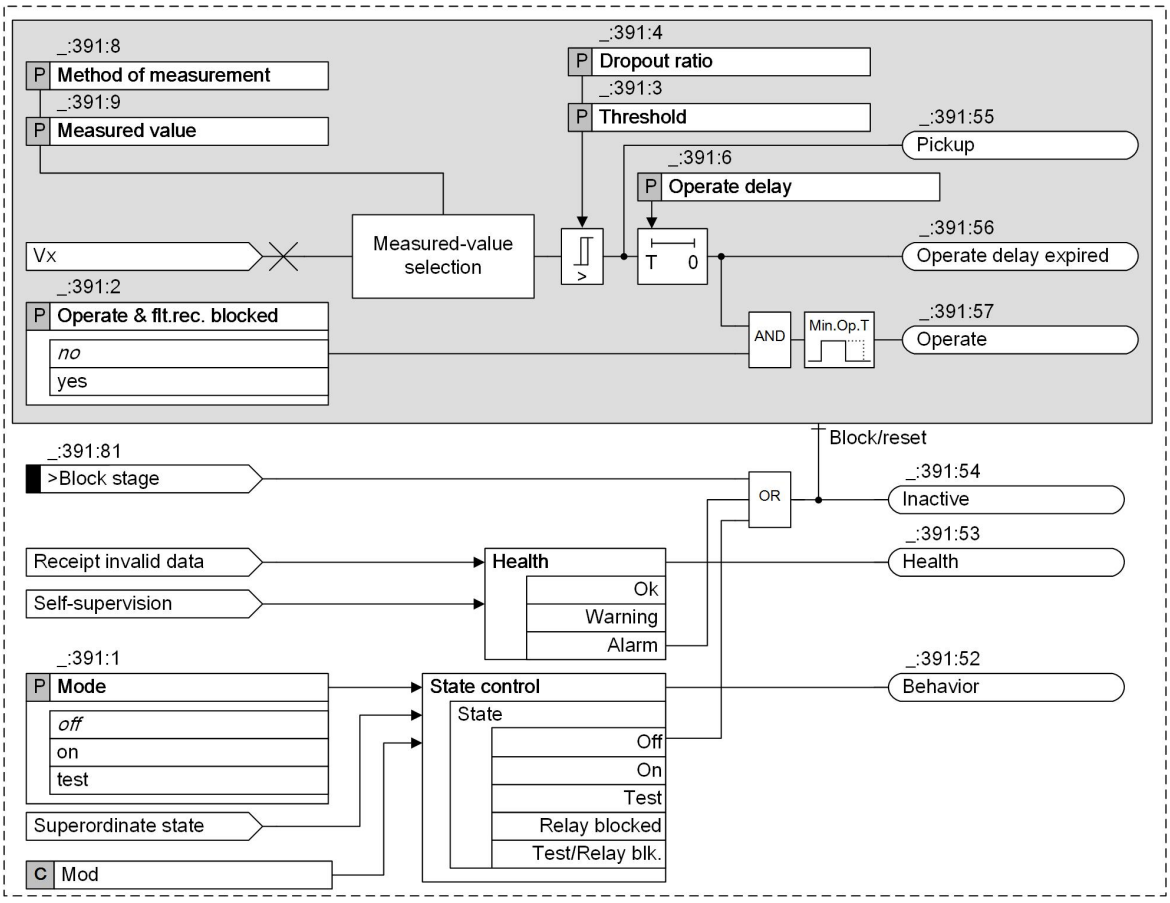


[dw_ovp_uxs, 1, en_US]

Figure 6-557 Structure/Embedding of the Function

6.42.3 Stage Description

Logic of a Stage



[lo_ovp_Vx_any-volt, 2, en_US]

Figure 6-558 Logic Diagram of a Stage: Overvoltage Protection with Any Voltage

NOTE

If the function **Overvoltage protection with any voltage** is used in a 1-phase function group, the parameter **`Measured value`** is not visible.

Method of Measurement

The **`Method of measurement`** parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

- Measurement of the ***`fundamental comp.`***:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement of the parameter value ***`RMS value`***:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

The parameter **`Measured value`** allows you to select whether the stage uses a measured (directly connected) voltage or a calculated phase-to-phase voltage.

If the function **Overvoltage protection with any voltage** is used in a 1-phase function group, the parameter **Measured value** is not visible.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal *>Block stage*.

6.42.4 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:391:8) Method of measurement** = ***fundamental comp.***

Use the **Method of measurement** parameter to define whether the tripping stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends this method of measurement as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks). Do not set the **threshold value** of the tripping stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting **(_:391:9) Measured value** = ***VA measured***

The **Measured value** parameter is used to specify which voltage is monitored by the stage.

The scope of setting options depends on the connection type for the voltage transformers and the routing of the measured values to the terminals of the voltage measuring point. You can find connection examples for voltage transformers in the *Appendix*.

The following setting options can be available:

- Measured phase-to-ground voltage V_A (***VA measured***)
- Measured phase-to-ground voltage V_B (***VB measured***)
- Measured phase-to-ground voltage V_C (***VC measured***)
- Measured phase-to-phase voltage V_{AB} (***VAB measured***)
- Measured phase-to-phase voltage V_{BC} (***VBC measured***)
- Measured phase-to-phase voltage V_{CA} (***VCA measured***)
- Calculated phase-to-phase voltage V_{AB} (***VAB calculated***)
- Calculated phase-to-phase voltage V_{BC} (***VBC calculated***)
- Calculated phase-to-phase voltage V_{CA} (***VCA calculated***)
- Calculated voltage V0 (***V0 calculated***)

The selection depends on the corresponding application.

NOTE

From V7.30 on, the value ***VN measured*** is no longer provided. If you have selected this value in earlier versions, you can use either the following methods instead after upgrading the configuration to V7.30 or a later version:

- Select the value ***V0 calculated*** for the **Measured value** parameter in the function **Overvoltage protection with any voltage**.
- Use the function **Overvoltage protection with zero-sequence voltage/residual voltage**.

If the function **Overvoltage protection with any voltage** is used in a 1-phase function group, the parameter **Measured value** is not visible.

Parameter: Threshold

- Default setting **(_:391:3) Threshold** = ***110 V***

Specify the **Threshold** (pickup threshold) for the specific application.

Depending on the measured value, the **Threshold** is set either as **Measured voltage** or as **Phase-to-phase** quantity.

NOTE

If the function is used in a **Voltage-current 1-phase** function group connected to the 1-phase voltage measuring point with the voltage type ***VN broken-delta***, you set the threshold value based on the equivalent zero-sequence voltage.

Calculate the equivalent zero-sequence voltage $V_{0\ equiv.\ sec}$ from the measured voltage $V_{N\ sec}$ with the following formula:

$$\frac{V_{0\ equi\ sec}}{V_{N\ sec}} = \frac{\text{Matching ratio Vph/VN}}{3}$$

For more information about the parameter **Matching ratio Vph / VN**, refer to *6.1.4 Application and Setting Notes for Measuring-Point Voltage 3-Phase (V-3ph)*.

Parameter: Operate delay

- Default setting **(_:391:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:391:4) Dropout ratio** = ***0.95***

The recommended set value of ***0.95*** is appropriate for most applications. To achieve high measurement precision, the **Dropout ratio** can be reduced, to 0.98, for example.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

6.42.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:391:1	Stage 1:Mode		• off • on • test	off
_:391:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:391:9	Stage 1:Measured value		• VA measured • VB measured • VC measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:391:8	Stage 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:391:3	Stage 1:Threshold		0.300 V to 340.000 V	110.000 V
_:391:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:391:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:392:1	Stage 2:Mode		• off • on • test	off
_:392:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:392:9	Stage 2:Measured value		• VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:392:8	Stage 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:392:3	Stage 2:Threshold		0.300 V to 340.000 V	130.000 V
_:392:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:392:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.42.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Stage 1			
_:391:81	Stage 1:>Block stage	SPS	I
_:391:51	Stage 1:Mode (controllable)	ENC	C
_:391:54	Stage 1:Inactive	SPS	O
_:391:52	Stage 1:Behavior	ENS	O
_:391:53	Stage 1:Health	ENS	O
_:391:55	Stage 1:Pickup	ACD	O
_:391:56	Stage 1:Operate delay expired	ACT	O
_:391:57	Stage 1:Operate	ACT	O
Stage 2			
_:392:81	Stage 2:>Block stage	SPS	I
_:392:51	Stage 2:Mode (controllable)	ENC	C
_:392:54	Stage 2:Inactive	SPS	O
_:392:52	Stage 2:Behavior	ENS	O
_:392:53	Stage 2:Health	ENS	O
_:392:55	Stage 2:Pickup	ACD	O
_:392:56	Stage 2:Operate delay expired	ACT	O
_:392:57	Stage 2:Operate	ACT	O

6.43 Undervoltage Protection with 3-Phase Voltage

6.43.1 Overview of Functions

The function **Undervoltage protection with 3-phase voltage** (ANSI 27):

- Monitors the permissible voltage range
- Protects equipment (for example, plant components and machines) against damages caused by undervoltage
- Handles disconnection or load shedding tasks in a system

6.43.2 Structure of the Function

The function **Undervoltage protection with 3-phase voltage** is used in protection function groups with voltage measurement.

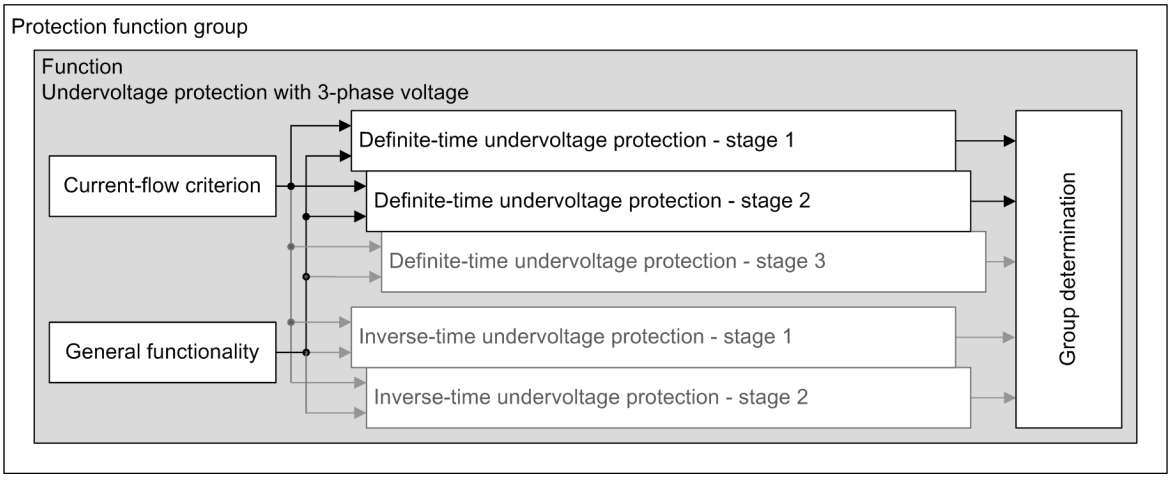
The function **Undervoltage protection with 3-phase voltage** comes factory-set with 2 **Definite-time undervoltage protection** stages.

In the function **Undervoltage protection with 3-phase voltage**, the following stages can be operated simultaneously:

- 3 stages **Definite-time undervoltage protection**
- 2 stages **Inverse-time undervoltage protection**

Stages that are not preconfigured are shown in gray in the following figure.

The protection function is structured such that one current-flow criterion can act on all undervoltage protection stages (see *Figure 6-559*). If the protection function group used has no current measurement, you can only set the current-flow criterion as **fulfilled** via the corresponding binary input signal.



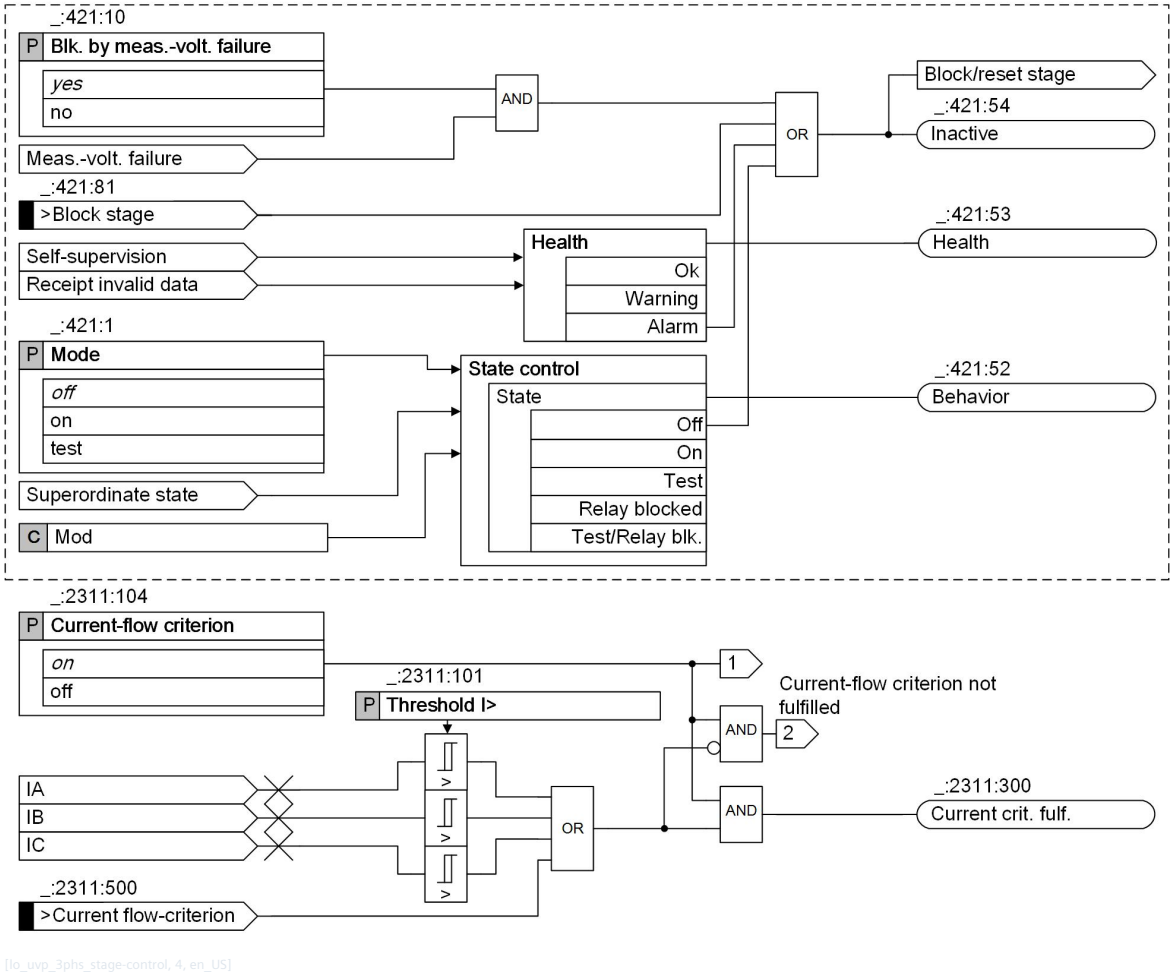
[dw_stru_3p, 5, en_US]

Figure 6-559 Structure/Embedding of the Function

6.43.3 Stage with Definite-Time Characteristic Curve

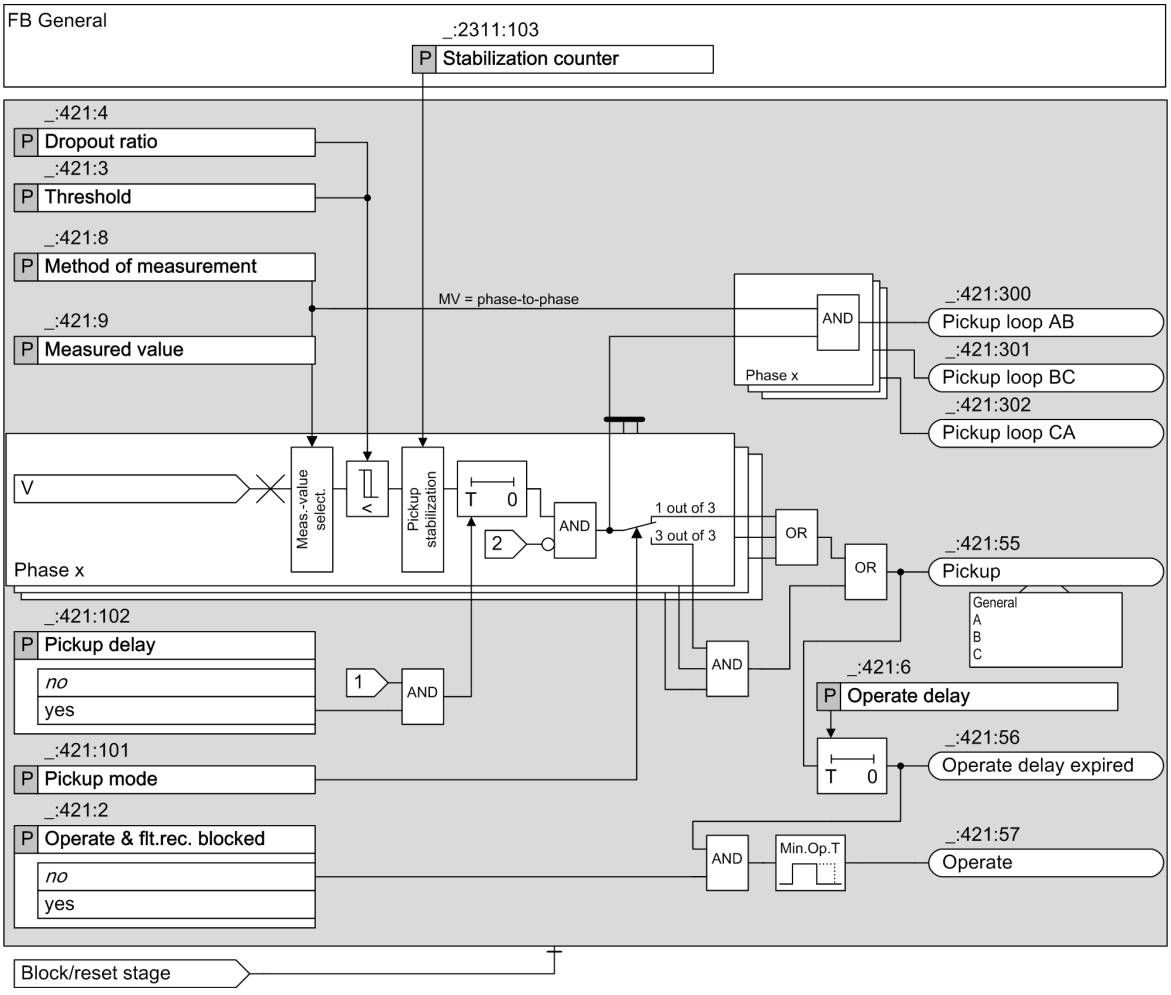
6.43.3.1 Description

Logic of the Stage



[lo_uvp_3phs_stage-control, 4, en_US]

Figure 6-560 Logic Diagram Stage Control



[lo_uvp_3ph, 3, en_US]

Figure 6-561 Logic Diagram of the Definite-Time Undervoltage Protection with 3-Phase Voltage

Method of Measurement

With the **Method of measurement** parameter, you select the relevant method of measurement, depending on the application.

- Measurement fundamental component:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement RMS value:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

With the **Measured value** parameter, you define whether the stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Pickup Stabilization

To enable the pickup stabilization, you set the **Stabilization counter** parameter to a value other than 0. Then, if the input voltage keeps being below the **Threshold** for a specified number (1 + **Stabilization**

counter value) of successive measuring cycles, the stage picks up. For 50 Hz, the measuring cycle time is 10 ms.

If you set this parameter to ***0*** (default value), the stabilization is not applied. The pickup signal is issued after the input voltage falls below the threshold value.

Pickup Mode

With the **Pickup mode** parameter, you define whether the stage picks up when there is a lower threshold-value violation in one measuring element (***1 out of 3***) or when there is a lower threshold-value violation in all 3 measuring elements (***3 out of 3***).

Pickup Delay

The **Pickup delay** parameter is only available and of relevance if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***).

If the circuit breaker opens when the current-flow criterion is being used, the undervoltage detection and current-flow dropout functions conflict with one another. Depending on the threshold value settings for undervoltage detection and current-flow criterion, it is possible that the undervoltage is detected before the current-flow criterion has dropped out. In this case, the stage picks up briefly. Use the **Pickup delay** parameter to prevent the stage from briefly picking up in this way when the circuit breaker opens. This is achieved by delaying the pickup by approximately 40 ms.

Current-Flow Criterion

The undervoltage protection stages work optionally with a current-flow criterion. The **Current-flow criterion** works across all tripping stages.

When the **Current-flow criterion** parameter is activated, the undervoltage protection stages only pick up if a settable minimum current (**Threshold I>**) is exceeded. A current below the minimum current blocks the stages.

The current-flow criterion can also be set to **fulfilled** with the binary input signal **>Current flow-criterion**. The function reports when the current-flow criterion is fulfilled.

Figure 6-561 illustrates the influence of the current-flow criterion.



NOTE

If the **(_:2311:104) Current-flow criterion** parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked-up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal *>Block stage* from an external or internal source
- From inside on pickup of the **Measuring-voltage failure detection** function (see *8.3.2.1 Overview of Functions*). The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.43.3.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:421:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends using this parameter value as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks). Do not set the **threshold value** of the stage under 10 V for this method of measurement.

Parameter: Measured value

- Recommended setting value **(_:421:9) Measured value** = ***phase-to-phase***

With the **Measured value** parameter, you define whether the stage monitors the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C. Parameter Value

Parameter Value	Description
phase-to-phase	If you want to detect voltage dips caused by multiphase short circuits, or generally monitor the voltage range, keep phase-to-phase as the default setting. The function will not pick up on ground faults. Siemens recommends the measured value ***phase-to-phase*** as the default setting.
phase-to-ground	Select the ***phase-to-ground*** setting if you want to detect voltage unbalances or overvoltage conditions caused by ground faults.

Parameter: Threshold

- Default setting **(_:421:3) Threshold** = ***80 V***

The **Threshold** is set in accordance with the **Measured value** as either a ***phase-to-phase*** or ***phase-to-ground*** variable.

Specify the **Threshold** (pickup threshold) for the specific application.

For the default setting, the lower limit of the voltage range to be monitored is assumed to be 80 % of the rated voltage of the protected object.

EXAMPLE:

Rated voltage of the protected object: $V_{rated,\ obj.} = 10\ kV$

Voltage transformer:

$$Ratio_V = \frac{10\ kV/\sqrt{3}}{100\ V/\sqrt{3}}$$

Threshold value: 80 % of $V_{rated,\ obj.}$

The secondary setting value is calculated as follows:

$$V_{Threshold\ value,\ sec} = \frac{0.8 \cdot V_{rated,obj.}}{Ratio_V} = \frac{0.8 \cdot 10\ kV \cdot 100\ V}{10\ kV} = 80\ V$$

[fo_schw_lw, 2, en_US]

Parameter: Stabilization counter

- Default setting **(_:2311:103) Stabilization counter** = ***0***

You can configure the **Stabilization counter** parameter in the function block **General**.

For special applications, it could be desirable that a short falling of the input voltage below the pickup value does not lead to the pickup of the stage, which starts fault logging and recording. This is achieved by setting the **Stabilization counter** parameter to a value other than zero.

For example, if you set this parameter to ***1***, the pickup signal is issued when the voltage keeps being below the **Threshold** for 2 successive measuring cycles. For 50 Hz, the measuring cycle time is 10 ms.

Parameter: Pickup mode

- Recommended setting value **(_:421:101) Pickup mode** = ***1 out of 3***

With the **Pickup mode** parameter, you specify whether the stage picks up when there is a lower threshold-value violation in one measuring element (***1 out of 3***) or when there is a lower threshold-value violation in all 3 measuring elements (***3 out of 3***).

Parameter Value	Description
1 out of 3	Use this setting for protection applications or for monitoring the voltage range. Siemens recommends ***1 out of 3*** as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Parameter: Pickup delay

- Default setting **(_:421:102) Pickup delay** = ***no***

The **Pickup delay** parameter is only available if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***). If the current-flow criterion is deactivated, no pickup delay is required.

With the **Pickup delay** parameter, you set whether pickup of the stage is to be delayed by approximately 40 ms or not. The delay avoids possible brief pickup of the stage when the circuit breaker opens.

When applied in parallel, the pickup delay and the delay through pickup stabilization add up.

Parameter Value	Description
no	Use this setting if you definitely do not want stage pickup to be subject to a time delay in the event of a fault. This setting results in pickup and, where applicable, tripping being performed as quickly as possible. Note that switching procedures (opening of the CB) can result in brief pickup of the stage, depending on the threshold-value settings for under-voltage pickup and the current-flow criterion. To prevent unwanted trip-ping, you must set a minimum tripping delay of 50 ms.
yes	Use this setting when switching procedures (opening of the CB) are not permitted to result in stage pickup. Note that pickup is delayed by approximately 40 ms. This delay is added to the operate time.

Parameter: Operate delay

- Default **(_:421:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:421:4) Dropout ratio** = ***1.05***

The recommended setting value of ***1.05*** is appropriate for most applications. To achieve high-precision measurements, the **Dropout ratio** can be reduced (to 1.02, for example).

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:421:10) Blk. by meas.-volt. failure** = ***yes***

With the **Blk. by meas.-volt. failure** parameter, you control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following two conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see *8.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

6.43.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:104	General:Current-flow criterion		• off • on	on
_:2311:101	General:Threshold I>	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:2311:103	General:Stabilization counter		0 to 10	0
Definite-T 1				
_:421:1	Definite-T 1:Mode		• off • on • test	off
_:421:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:421:10	Definite-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:421:9	Definite-T 1:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:421:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:421:101	Definite-T 1:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:421:102	Definite-T 1:Pickup delay		• no • yes	no
_:421:3	Definite-T 1:Threshold		0.300 V to 175.000 V	80.000 V
_:421:4	Definite-T 1:Dropout ratio		1.01 to 1.20	1.05
_:421:6	Definite-T 1:Operate delay		0.00 s to 300.00 s	3.00 s

Addr.	Parameter	C	Setting Options	Default Setting
Definite-T 2				
_:422:1	Definite-T 2:Mode		• off • on • test	off
_:422:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:422:10	Definite-T 2:Blk. by meas.-volt. failure		• no • yes	yes
_:422:9	Definite-T 2:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:422:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:422:101	Definite-T 2:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:422:102	Definite-T 2:Pickup delay		• no • yes	no
_:422:3	Definite-T 2:Threshold		0.300 V to 175.000 V	65.000 V
_:422:4	Definite-T 2:Dropout ratio		1.01 to 1.20	1.05
_:422:6	Definite-T 2:Operate delay		0.00 s to 300.00 s	0.50 s

6.43.3.4 Information List

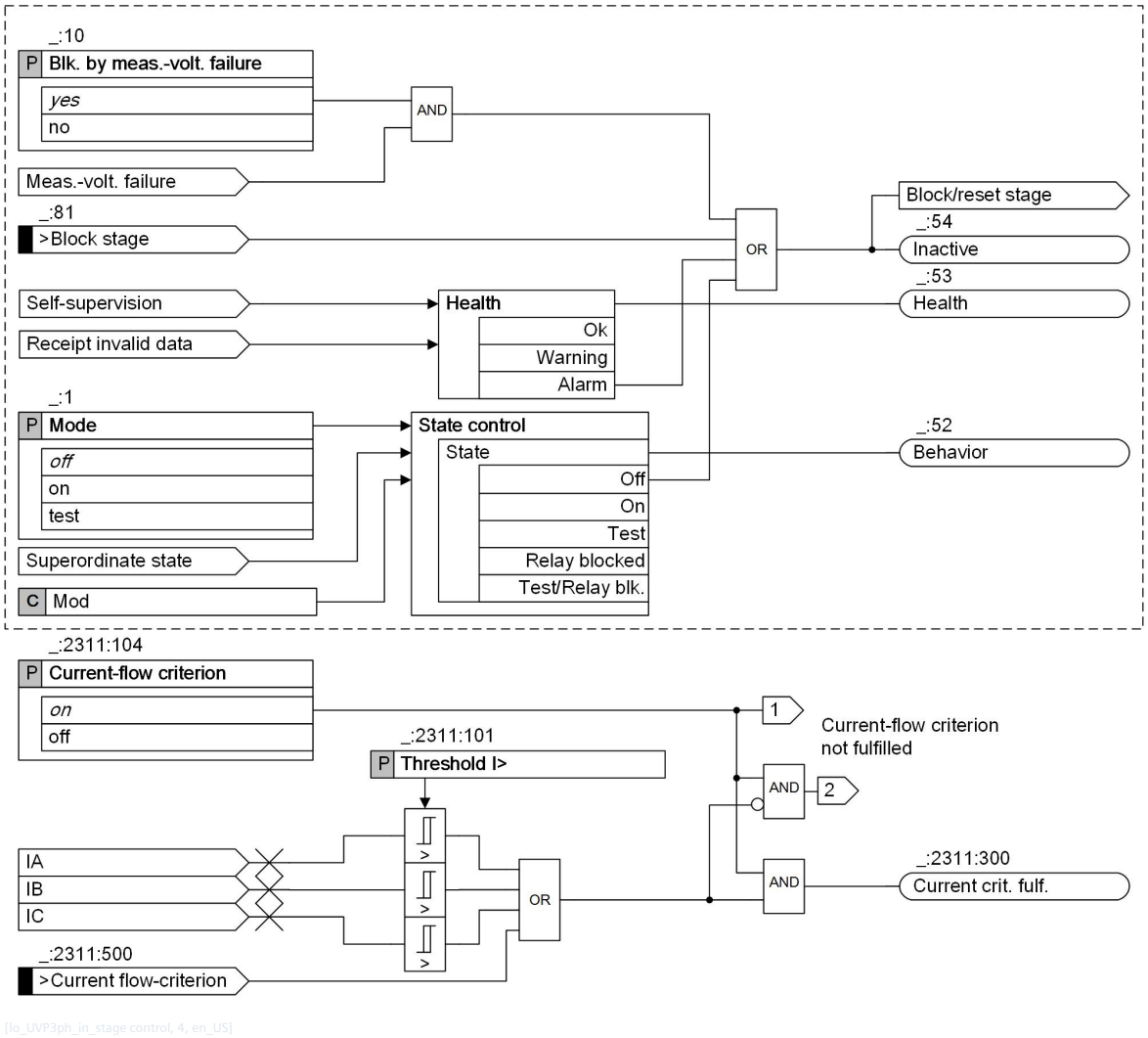
No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Current flow-criterion	SPS	I
_:2311:300	General:Current crit. fulf.	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Definite-T 1			
_:421:81	Definite-T 1:>Block stage	SPS	I
_:421:51	Definite-T 1:Mode (controllable)	ENC	C
_:421:54	Definite-T 1:Inactive	SPS	O
_:421:52	Definite-T 1:Behavior	ENS	O
_:421:53	Definite-T 1:Health	ENS	O
_:421:55	Definite-T 1:Pickup	ACD	O
_:421:300	Definite-T 1:Pickup loop AB	SPS	O
_:421:301	Definite-T 1:Pickup loop BC	SPS	O
_:421:302	Definite-T 1:Pickup loop CA	SPS	O
_:421:56	Definite-T 1:Operate delay expired	ACT	O

No.	Information	Data Class (Type)	Type
_:421:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:422:81	Definite-T 2:>Block stage	SPS	I
_:422:51	Definite-T 2:Mode (controllable)	ENC	C
_:422:54	Definite-T 2:Inactive	SPS	O
_:422:52	Definite-T 2:Behavior	ENS	O
_:422:53	Definite-T 2:Health	ENS	O
_:422:55	Definite-T 2:Pickup	ACD	O
_:422:300	Definite-T 2:Pickup loop AB	SPS	O
_:422:301	Definite-T 2:Pickup loop BC	SPS	O
_:422:302	Definite-T 2:Pickup loop CA	SPS	O
_:422:56	Definite-T 2:Operate delay expired	ACT	O
_:422:57	Definite-T 2:Operate	ACT	O

6.43.4 Stage with Inverse-Time Characteristic Curve

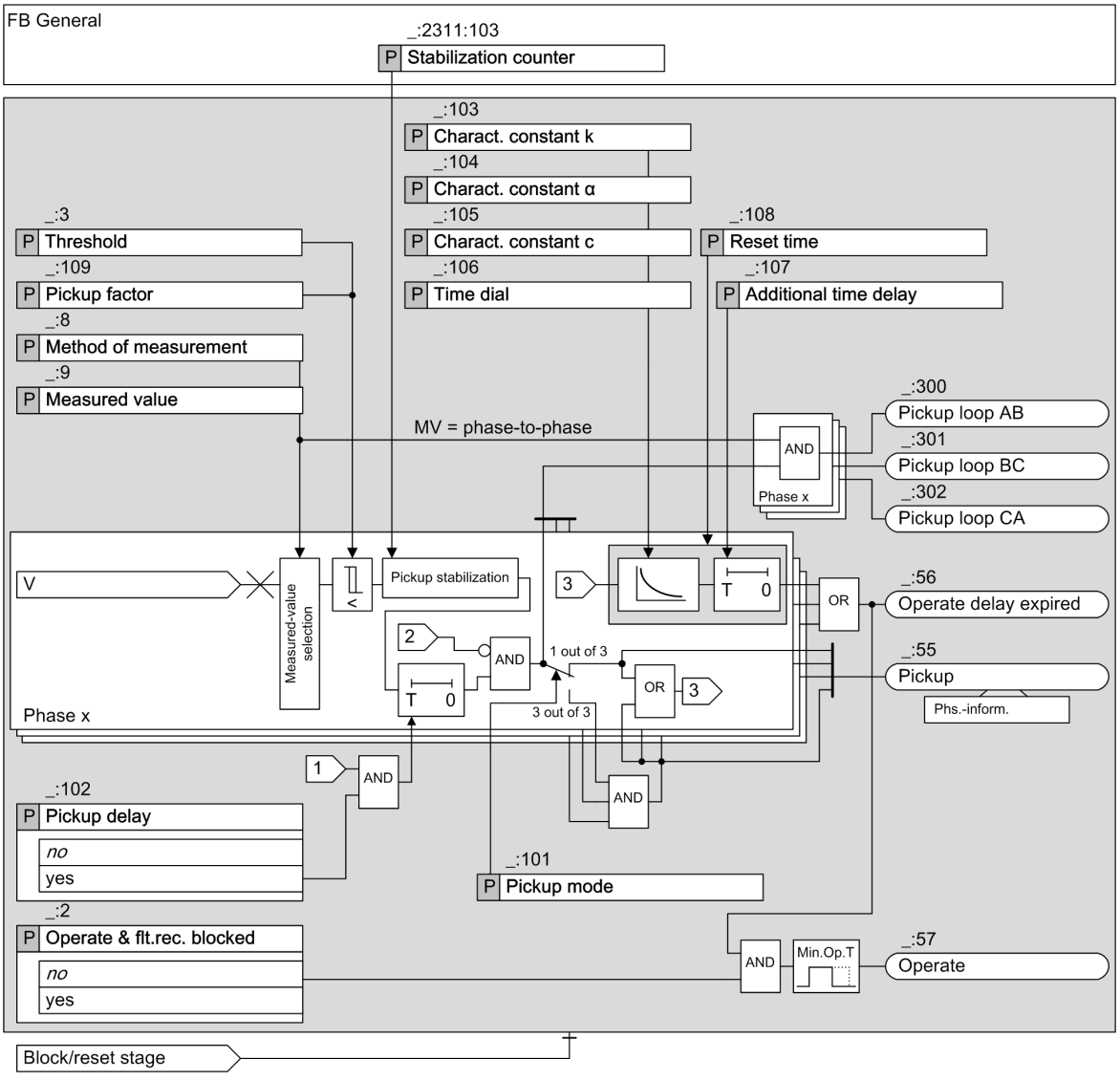
6.43.4.1 Description

Logic of the Stage



[lo_UVP3ph_in_stage control, 4, en_US]

Figure 6-562 Logic Diagram of the Stage Control



[lo_UVP3ph_In, 5, en_US]

Figure 6-563 Logic Diagram of the Inverse-Time Undervoltage Protection with 3-Phase Voltage

Method of Measurement

With the **Method of measurement** parameter, you define whether the stage uses the ***fundamental comp.*** or the ***RMS value***.

- Measurement ***fundamental comp.***:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement ***RMS value***:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

With the **Measured value** parameter, you define whether the stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Pickup Stabilization

To enable the pickup stabilization, you set the **Stabilization counter** parameter to a value other than zero. Then, if the input voltage keeps being below the pickup value for a specified number (1 + **Stabilization counter** value) of successive measuring cycles, the stage picks up. For 50 Hz, the measuring cycle time is 10 ms.

If you set this parameter to ***0*** (default value), the stabilization is not applied. The pickup signal is issued after the input voltage falls below the pickup value.

Pickup Mode

With the **Pickup mode** parameter, you define whether the stage picks up when there is a lower threshold-value violation in one measuring element (***1 out of 3***) or when there is a lower threshold-value violation in all 3 measuring elements (***3 out of 3***).

Pickup and Operate Curve

When the input voltage falls below the threshold value by a settable value **Pickup factor**, the stage picks up and the inverse-time characteristic curve is processed. The operate delay starts. The operate delay is the sum of inverse-time delay and additional time delay.

$T_{op}=T_{Inv}+T_{add}$

Where:

T_{op}	Operate delay
T_{Inv}	Inverse-time delay
T_{add}	Additional time delay (Parameter **Additional time delay**)

After pickup the time value T_{Inv} is calculated for every input voltage less than the dropout value. An integrator accumulates the value $1/T_{Inv}$. Once the accumulated integral reaches the fixed value 1, the inverse-time delay expires. The stage operates after the additional time delay.

The inverse-time delay is calculated with the following formula:

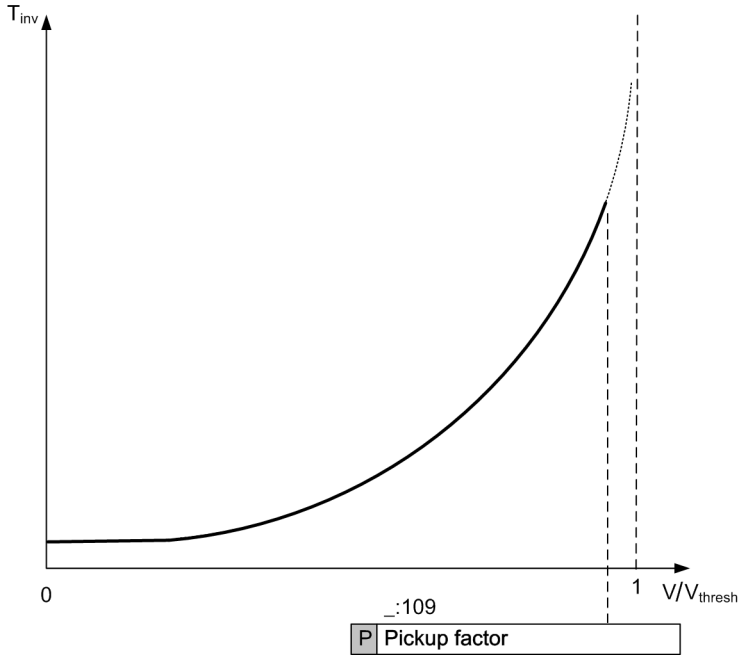
$$T_{Inv} = T_p \left(\frac{k}{1 - \left(\frac{V}{V_{Thresh}} \right)^{\alpha}} + c \right) [s]$$

[fo_uvp_3ph_inverse, 2, en_US]

Where

T_{Inv}	Inverse-time delay
T_p	Time multiplier (Parameter **Time dial**)
V	Measured undervoltage
V_{Thresh}	Threshold value (Parameter **Threshold**)
k	Curve constant k (Parameter **Charact. constant k**)
α	Curve constant α (Parameter **Charact. constant α**)
c	Curve constant c (Parameter **Charact. constant c**)

The inverse-time characteristic is shown in the following figure:



[dw_uvp_3ph_inverse, 1, en_US]

Figure 6-564 Inverse-Time Characteristics for Undervoltage Protection

Pickup Delay

The **Pickup delay** parameter is only available and of relevance if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***).

If the circuit breaker opens when the current-flow criterion is being used, the undervoltage detection and current-flow dropout functions conflict with one another. Depending on the threshold value settings for undervoltage detection and current-flow criterion, it is possible that the undervoltage is detected before the current-flow criterion has dropped out. In this case, the stage picks up briefly. Use the **Pickup delay** parameter to prevent the stage from briefly picking up in this way when the circuit breaker opens. This is achieved by delaying the pickup by approximately 40 ms.

Dropout Behavior

When the voltage exceeds the dropout value (1.05 x pickup factor x threshold value), the pickup signal is going and the dropout is started. You can define the dropout behavior via parameter **Reset time**. Instantaneous reset takes place by setting **Reset time** to 0 s. A delayed reset takes place by setting the desired delay time.

During the Reset time (> 0 s), the elapsed operate delay is frozen. If the stage picks up again within this period, the stage operates when the rest of operate delay expires.

Current-Flow Criterion

The undervoltage protection stages work optionally with a current-flow criterion. The **Current-flow criterion** works across all tripping stages.

When the **Current-flow criterion** parameter is activated, the undervoltage-protection stages only pick up if a settable minimum current (**Threshold I>**) is exceeded. A current below the minimum current blocks the stages.

The current-flow criterion can also be set to **fulfilled** with the binary input signal **>Current flow-criterion**. The function reports when the current-flow criterion is fulfilled.

Figure 6-563 illustrates the influence of the current-flow criterion.

NOTE

If the **(_:2311:104) Current-flow criterion** parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked-up stage is reset. The following blocking options are available for the stage:

- Via the binary input signal *>Block stage* from an external or internal source
- From inside on pickup of the **Measuring-voltage failure detection** function (see *8.3.2.1 Overview of Functions*) . The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.43.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends using this parameter value as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Do not set the **threshold value** of the stage under 10 V for this method of measurement.

Parameter: Measured value

- Recommended setting value **(_:9) Measured value** = ***phase-to-phase***

With the **Measured value** parameter, you define whether the stage monitors the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C.

Parameter Value	Description
phase-to-phase	If you want to detect voltage dips caused by multiphase short circuits, or generally monitor the voltage range, keep phase-to-phase as the default setting. The function will not pick up on ground faults. Siemens recommends the measured value ***phase-to-phase*** as the default setting.
phase-to-ground	Select the ***phase-to-ground*** setting if you want to detect voltage unbalances or overvoltage conditions caused by ground faults.

Parameter: Threshold, Pickup factor

- Default setting **(_:3) Threshold** = ***80.000 V***
- Default setting **(_:109) Pickup factor** = ***0.90***

The stage picks up when the measured voltage value falls below the pickup value **Threshold** × **Pickup factor**.

Depending on the **Measured value**, the **Threshold** is set either as ***phase-to-phase*** quantity or as ***phase-to-ground*** quantity.

With the **Pickup factor** parameter, you modify the pickup value. To avoid a long operate delay time after pickup, Siemens recommends using the default value of **Pickup factor**.

Specify the **Threshold** (pickup threshold) and **Pickup factor** for the specific application.

Parameter: Stabilization counter

- Default setting **(_:2311:103) Stabilization counter** = ***0***

You can configure the **Stabilization counter** parameter in the function block **General**.

For special applications, it could be desirable that a short falling of the input voltage below the pickup value does not lead to the pickup of the stage, which starts fault logging and recording. This is achieved by setting the **Stabilization counter** parameter to a value other than zero.

For example, if you set this parameter to ***1***, the pickup signal is issued when the voltage keeps being below the pickup value for 2 successive measuring cycles. For 50 Hz, the measuring cycle time is 10 ms.

Parameter: Pickup mode

- Recommended setting value **(_:101) Pickup mode** = ***1 out of 3***

With the **Pickup mode** parameter, you specify whether the stage picks up when there is a lower threshold-value violation in one measuring element (***1 out of 3***) or when there is a lower threshold-value violation in all 3 measuring elements (***3 out of 3***).

Parameter Value	Description
1 out of 3	Use this setting for protection applications or for monitoring the voltage range. Siemens recommends ***1 out of 3*** as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Parameter: Pickup delay

- Default setting **(_:102) Pickup delay** = ***no***

The **Pickup delay** parameter is only available if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***). If the current-flow criterion is deactivated, no pickup delay is required.

With the **Pickup delay** parameter, you set whether pickup of the stage is to be delayed by approximately 40 ms or not. The delay avoids possible brief pickup of the stage when the circuit breaker opens.

When applied in parallel, the pickup delay and the delay through pickup stabilization add up.

Parameter Value	Description
no	Use this setting if you definitely do not want stage pickup to be subject to a time delay in the event of a fault. This setting results in pickup and, where applicable, tripping being performed as quickly as possible. Note that switching procedures (opening of the CB) can result in brief pickup of the stage, depending on the threshold-value settings for under-voltage pickup and the current-flow criterion. To prevent unwanted tripping, you must set a minimum tripping delay of 50 ms.
yes	Use this setting when switching procedures (opening of the CB) are not permitted to result in stage pickup. Note that pickup is delayed by approximately 40 ms. This delay is added to the operate time.

Parameter: Charact. constant k, Charact. constant α, Charact. constant c

- Default setting **(_:103) Charact. constant k** = ***1.00***
- Default setting **(_:104) Charact. constant α** = ***1.000***
- Default setting **(_:105) Charact. constant c** = ***0.000***

With the **Charact. constant k**, **Charact. constant α**, and **Charact. constant c** parameters, you define the required inverse-time characteristic.

Parameter: Time dial

- Default setting **(_:106) Time dial** = ***1.00***

With the **Time dial** parameter, you displace the characteristic curve in the time direction.

As usually, there is no time grading for voltage protection and therefore no displacement of the characteristic curve, Siemens recommends leaving the **Time dial** parameter at ***1.00*** (default setting).

Parameter: Reset time

- Default setting **(_:108) Reset time** = ***0.00 s***

With the **Reset time** parameter, you define the reset time delay which is started when the voltage exceeds the dropout value. Set the parameter **Reset time** to 0 s when instantaneous reset is desired.

Under network conditions of intermittent faults or faults which occur in rapid succession, Siemens recommends setting the **Reset time** to an appropriate value > 0 s to ensure the operation. Otherwise, Siemens recommends keeping the default value to ensure a fast reset of the function.

Parameter: Additional time delay

- Default setting **(_:107) Additional time delay** = ***0.00 s***

With the **Additional time delay** parameter, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, only the inverse-time delay is operative.

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:10) Blk. by meas.-volt. failure** = ***yes***

With the **Blk. by meas.-volt. failure** parameter, you control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see *8.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

6.43.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T #				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:10	Inverse-T #:Blk. by meas.-volt. failure		• no • yes	yes
_:9	Inverse-T #:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:8	Inverse-T #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:101	Inverse-T #:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:102	Inverse-T #:Pickup delay		• no • yes	no
_:3	Inverse-T #:Threshold		0.300 V to 175.000 V	80.000 V
_:109	Inverse-T #:Pickup factor		0.80 to 1.00	0.90
_:103	Inverse-T #:Charact. constant k		0.00 to 300.00	1.00
_:104	Inverse-T #:Charact. constant α		0.010 to 5.000	1.000
_:105	Inverse-T #:Charact. constant c		0.000 to 5.000	0.000
_:106	Inverse-T #:Time dial		0.05 to 15.00	1.00
_:107	Inverse-T #:Additional time delay		0.00 s to 60.00 s	0.00 s
_:108	Inverse-T #:Reset time		0.00 s to 60.00 s	0.00 s

6.43.4.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	Inverse-T #:>Block stage	SPS	I
_:54	Inverse-T #:Inactive	SPS	O
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:55	Inverse-T #:Pickup	ACD	O
_:300	Inverse-T #:Pickup loop AB	SPS	O
_:301	Inverse-T #:Pickup loop BC	SPS	O
_:302	Inverse-T #:Pickup loop CA	SPS	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:57	Inverse-T #:Operate	ACT	O

6.44 Undervoltage Protection with Positive-Sequence Voltage

6.44.1 Overview of Functions

The **Undervoltage protection with positive-sequence voltage** function (ANSI 27):

- Monitors the permissible voltage range
- Protects equipment (for example, plant components and machines) from damages caused by undervoltage
- Protects motors and generators from inadmissible operating states and a possible loss of stability in the event of voltage dips

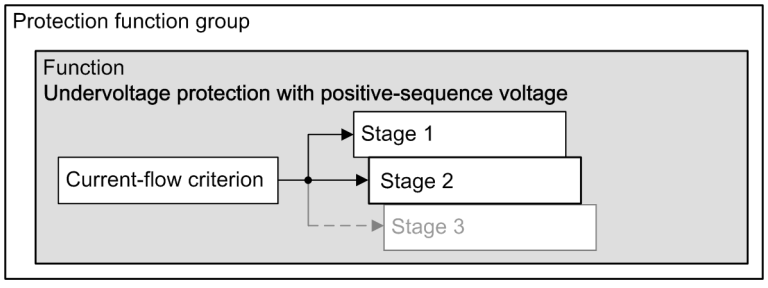
2-phase short circuits or ground faults lead to an unbalanced voltage collapse. In comparison to three 1-phase measuring systems, such events have no noticeable impact on the positive-sequence voltage. This makes this function particularly suitable for the assessment of stability problems.

6.44.2 Structure of the Function

The **Undervoltage protection with positive-sequence voltage** function is used in protection function groups, which are based on voltage measurement.

The **Undervoltage protection with positive-sequence voltage** function comes factory-set with 2 tripping stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The protection function is structured such that one current-flow criterion can act on all undervoltage protection stages (see *Figure 6-565*). If the protection function group used has no current measurement, you can only set the current-flow criterion as **fulfilled** via the corresponding binary input signal.

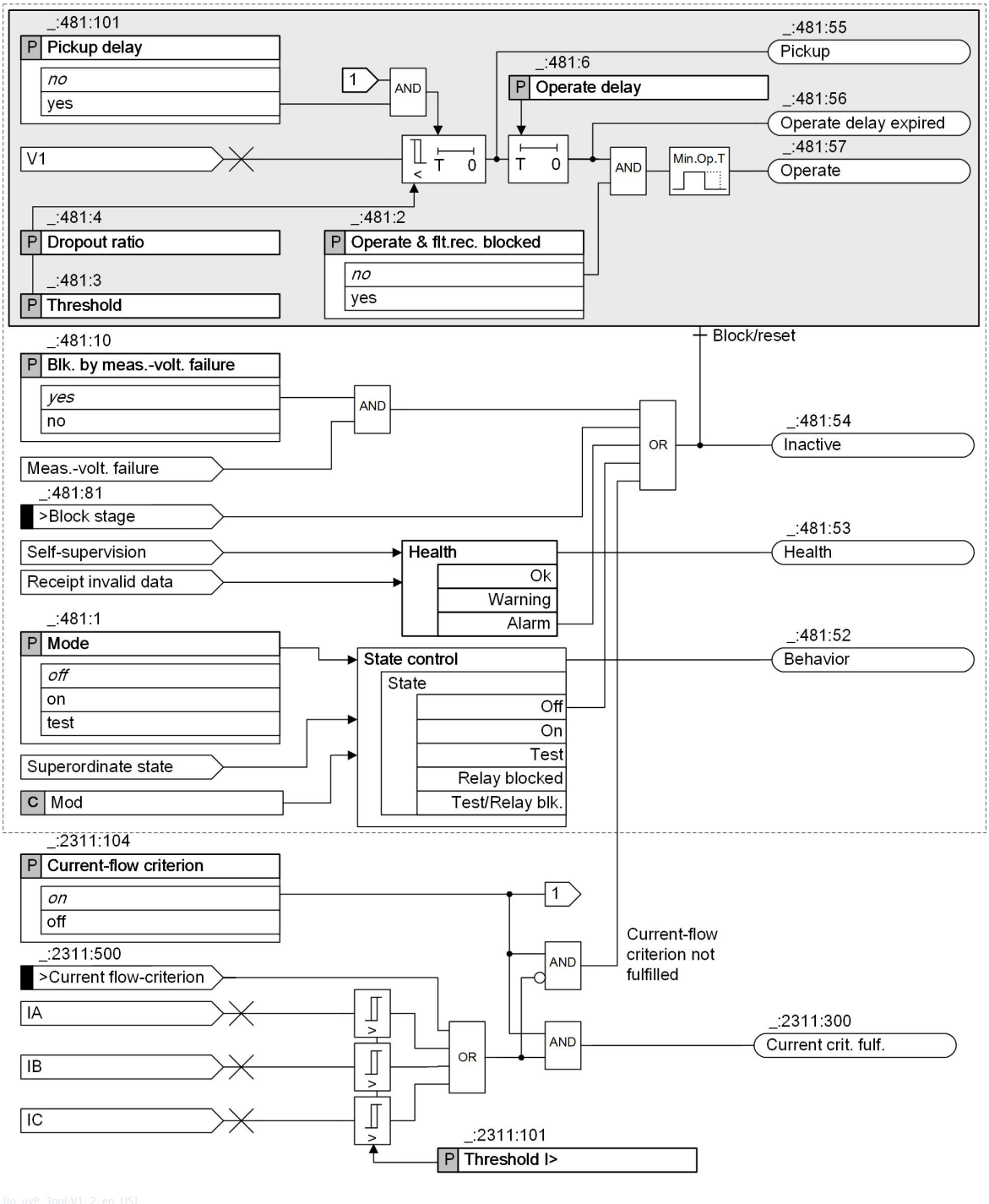


[dw_stuvu1, 3, en_US]

Figure 6-565 Structure/Embedding of the Function

6.44.3 Stage Description

Logic of the Stage



[lo_uvP_3pol-V1, 2, en_US]

Figure 6-566 Logic Diagram of the Stage Undervoltage Protection with Positive-Sequence Voltage

Method of Measurement

The stage uses the positive-sequence voltage. The positive-sequence voltage is calculated from the measured phase-to-ground voltages according to the defining equation.

Pickup Delay

The **Pickup delay** parameter is only available and of relevance if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***).

If the circuit breaker opens when the current-flow criterion is being used, the undervoltage detection and current-flow dropout functions conflict with one another. Depending on the threshold value settings for undervoltage detection and current-flow criterion, it is possible that the undervoltage is detected before the current-flow criterion has dropped out. In this case, the tripping stage picks up briefly. Use the **Pickup delay** parameter to prevent the tripping stage from briefly picking up in this way when the circuit breaker opens. This is achieved by delaying pickup by approximately 40 ms.

Current-Flow Criterion

The undervoltage-protection stages work optionally with a current-flow criterion. The current-flow criterion works across all stages.

When the **Current-flow criterion** parameter is switched on, the undervoltage protection stages only pick up if a settable minimum current (**Threshold I>**) is exceeded in at least one phase. A current below the minimum current blocks the tripping stages.

The current-flow criterion can also be set to **fulfilled** via the binary input signal **>Current flow-criterion**. The function reports when the current-flow criterion is fulfilled.

Figure 6-566 illustrates the influence of the current-flow criterion.



NOTE

If the **Current-flow criterion** parameter is switched off, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal *>Block stage* from an external or internal source
- From inside on pickup of the **Measuring-voltage failure detection** function (see chapter *8.3.2.1 Overview of Functions*). The **Blk. by meas.-volt. failure** parameter can be set to either block or not block the tripping stage when the measuring-voltage failure detection picks up.
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.44.4 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:481:3) Threshold** = ***46 V***

Specify the **Threshold** (pickup threshold) for the specific application. For the default setting, the lower limit of the voltage range to be monitored is assumed to be 80 % of the rated voltage of the protected object.

Parameter: Pickup delay

- Default setting **(_:481:101) Pickup delay** = ***no***

The **Pickup delay** parameter is only available if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***). If the current-flow criterion is deactivated, no pickup delay is required.

With the parameter **Pickup delay** you set whether pickup of the stage is to be delayed by approximately 40 ms or not. The delay avoids possible brief pickup of the stage when the circuit breaker opens.

Parameter Value	Description
no	Use this setting if you definitely do not want tripping-stage pickup to be subject to a time delay in the event of a fault. This setting results in pickup and, where applicable, tripping being performed as quickly as possible. Note that switching procedures (opening of the CB) can result in brief pickup of the tripping stage, depending on the threshold-value settings for undervoltage pickup and the current-flow criterion. To prevent unwanted tripping, you must set a minimum tripping delay of 50 ms.
yes	Use this setting when switching procedures (opening of the CB) are not permitted to result in tripping-stage pickup. Note that pickup is delayed by approximately 40 ms. This delay is added to the operate time.

Parameter: Operate delay

- Default setting **(_:481:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:481:4) Dropout ratio** = ***1.05***

The recommended setting value of 1.05 is sufficient for many applications. To obtain extremely accurate indications, the **Dropout ratio** can be reduced.

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:481:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.
A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see chapter *8.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: Current-flow criterion

- Recommended setting value **(_:2311:104) Current-flow criterion** = ***on***

Depending on the system, the voltage transformers can be located on the supply or the output side. These 2 possible voltage transformer locations induce a different behavior of the function after tripping and opening of the circuit breaker:

- If they are located on the supply side, the voltage still exists.
- If they are located on the output side, the voltage does not exist.

Parameter Value	Description
on	If the voltage transformers are located on the output side, you can use the current-flow criterion to make the pickup drops out when the current falls below a minimum value (parameter Threshold value I>).
off	In the case of undervoltage, the pickup of the undervoltage-protection stage persists when the current-flow criterion is not used.

Parameter: Threshold I>

- Recommended setting value **(_:2311:101) Threshold I>** = ***0.05 A***

The **Threshold I>** parameter makes it possible to detect when the circuit breaker is closed. Siemens recommends setting the **Threshold I>** parameter to 5% of the rated current. With a secondary rated transformer current of 1 A, the secondary setting value for **Threshold I>** would be 0.05 A.

If the sensitivity of the **Threshold I>** parameter is set too high, compensation processes in the secondary circuit of the current transformer extend the dropout time when breaking extremely high currents. To speed up dropout, increase the default setting.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

6.44.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:104	General:Current-flow criterion		• off • on	on
_:2311:101	General:Threshold I>	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
Stage 1				
_:481:1	Stage 1:Mode		• off • on • test	off
_:481:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:481:10	Stage 1:Blk. by meas.-volt. failure		• no • yes	yes
_:481:101	Stage 1:Pickup delay		• no • yes	no
_:481:3	Stage 1:Threshold		0.300 V to 200.000V	46.000V
_:481:4	Stage 1:Dropout ratio		1.01 to 1.20	1.05
_:481:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s

Addr.	Parameter	C	Setting Options	Default Setting
Stage 2				
_:482:1	Stage 2:Mode		• off • on • test	off
_:482:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:482:10	Stage 2:Blk. by meas.-volt. failure		• no • yes	yes
_:482:101	Stage 2:Pickup delay		• no • yes	no
_:482:3	Stage 2:Threshold		0.300 V to 200.000 V	40.000V
_:482:4	Stage 2:Dropout ratio		1.01 to 1.20	1.05
_:482:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.44.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Current flow-criterion	SPS	I
_:2311:300	General:Current crit. fulf.	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Stage 1			
_:481:81	Stage 1:>Block stage	SPS	I
_:481:51	Stage 1:Mode (controllable)	ENC	C
_:481:54	Stage 1:Inactive	SPS	O
_:481:52	Stage 1:Behavior	ENS	O
_:481:53	Stage 1:Health	ENS	O
_:481:55	Stage 1:Pickup	ACD	O
_:481:56	Stage 1:Operate delay expired	ACT	O
_:481:57	Stage 1:Operate	ACT	O
Stage 2			
_:482:81	Stage 2:>Block stage	SPS	I
_:482:51	Stage 2:Mode (controllable)	ENC	C
_:482:54	Stage 2:Inactive	SPS	O
_:482:52	Stage 2:Behavior	ENS	O
_:482:53	Stage 2:Health	ENS	O
_:482:55	Stage 2:Pickup	ACD	O
_:482:56	Stage 2:Operate delay expired	ACT	O
_:482:57	Stage 2:Operate	ACT	O

6.45 Undervoltage Protection with Any Voltage

6.45.1 Overview of Functions

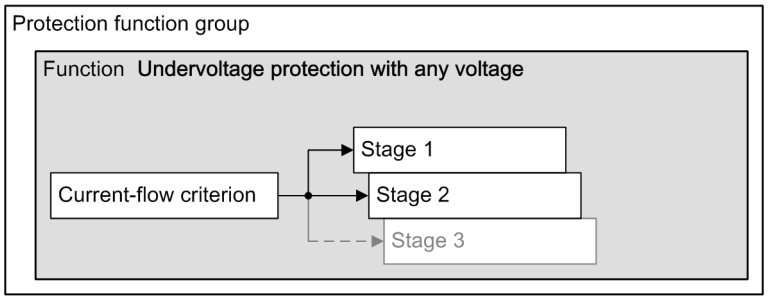
The function **Undervoltage protection with any voltage** (ANSI 27) detects any 1-phase undervoltage and is intended for special applications.

6.45.2 Structure of the Function

The **Undervoltage protection with any voltage** function is used in protection function groups, which are based on voltage measurement.

The function **Undervoltage protection with any voltage** comes factory-set with 2 stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The protection function is structured such that one current-flow criterion can act on all undervoltage protection stages (see *Figure 6-567*).



[dw_stuvux, 1, en_US]

Figure 6-567 Structure/Embedding of the Function

6.45.3 Stage Description

Logic of a Stage

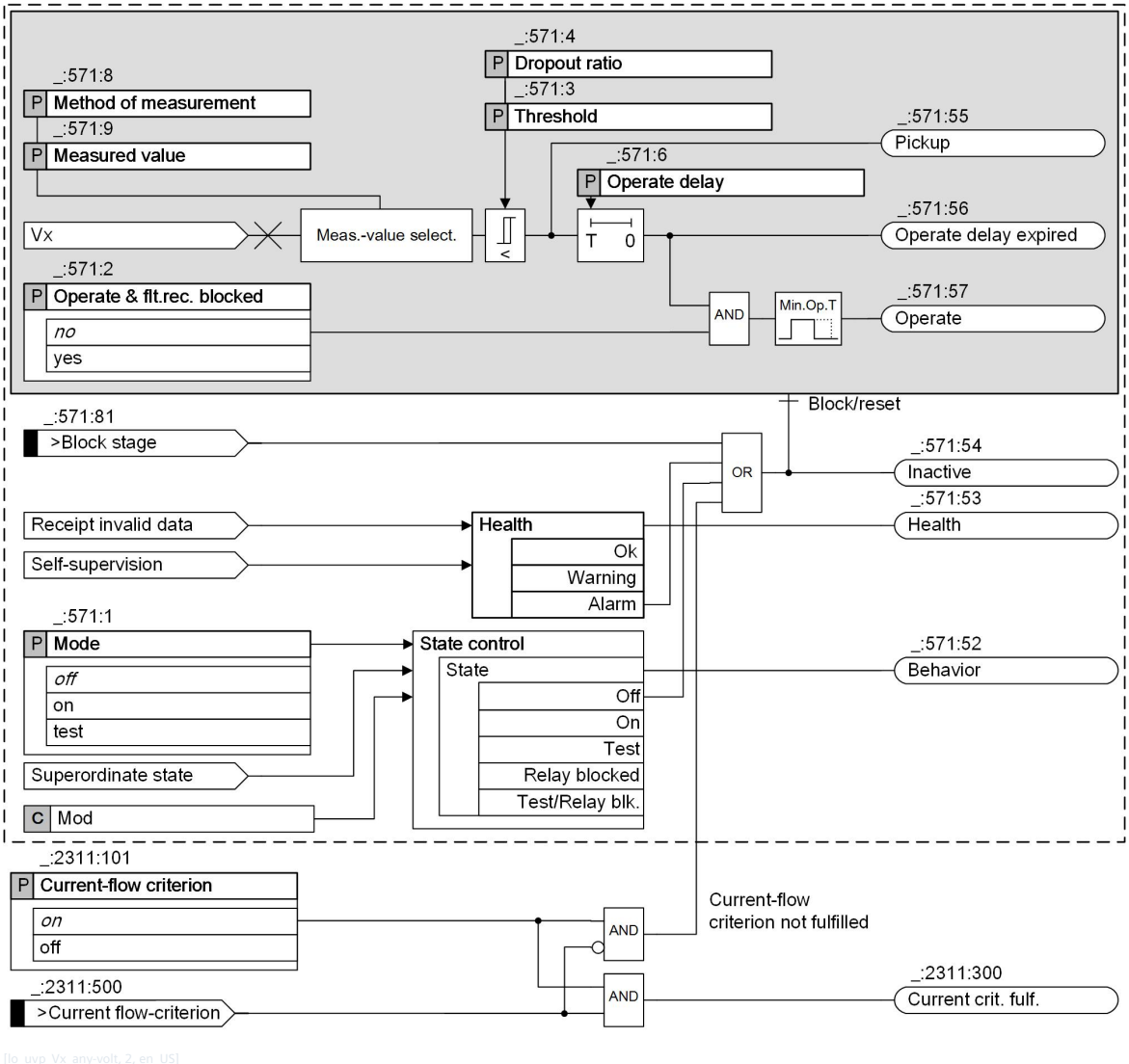


Figure 6-568 Logic Diagram of a Stage: Undervoltage Protection with Any Voltage

NOTE

If the function **Undervoltage protection with any voltage** is used in a 1-phase function group, the parameter **`Measured value`** is not visible.

Method of Measurement

The **`Method of measurement`** parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

- Measurement of the fundamental component:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

- Measurement of the RMS value:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

The parameter **Measured value** allows you to select whether the stage uses a measured (directly connected) voltage or a calculated phase-to-phase voltage.

If the function **Undervoltage protection with any voltage** is used in a 1-phase function group, the parameter **Measured value** is not visible.

Current-Flow Criterion

The undervoltage-protection stages work optionally with a current-flow criterion. The current-flow criterion works across all stages.

When the **Current-flow criterion** parameter is switched on, the undervoltage protection stages only pick up when the current-flow criterion has been set to **fulfilled** via the binary input signal **>Current flow-criterion**. The function reports when the current-flow criterion is fulfilled.

Figure 6-568 illustrates the influence of the current-flow criterion.



NOTE

If the **(_:2311:101) Current-flow criterion** parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking the stage is possible externally or internally via the binary input signal *>Block stage*.

6.45.4 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:571:8) Method of measurement** = ***fundamental comp.***

Use the **Method of measurement** parameter to define whether the tripping stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends using this parameter value as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks). Do not set the **threshold value** of the tripping stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting **(_:571:9) Measured value** = ***VA measured***

The **Measured value** parameter is used to specify which voltage is monitored by the stage.

The scope of setting options depends on the connection type for the voltage transformers and the routing of the measured values to the terminals of the voltage measuring point. You can find connection examples for voltage transformers in the *Appendix*.

The following setting options can be available:

- Measured phase-to-ground voltage V_A (***VA measured***)
- Measured phase-to-ground voltage V_B (***VB measured***)
- Measured phase-to-ground voltage V_C ***VC measured***)
- Measured phase-to-phase voltage V_{AB} (***VAB measured***)
- Measured phase-to-phase voltage V_{BC} (***VBC measured***)
- Measured phase-to-phase voltage V_{CA} (***VCA measured***)
- Calculated phase-to-phase voltage V_{AB} (***VAB calculated***)
- Calculated phase-to-phase voltage V_{BC} (***VBC calculated***)
- Calculated phase-to-phase voltage V_{CA} (***VCA calculated***)
- Calculated voltage V0 (***V0 calculated***)

The selection depends on the corresponding application.

NOTE

From V7.30 on, the value ***VN measured*** is no longer provided. If you have selected this value in earlier versions, you can select the value ***V0 calculated*** instead after upgrading the configuration to V7.30 or a later version.
If the function **Undervoltage protection with any voltage** is used in a 1-phase function group, the parameter **Measured value** is not visible.

Parameter: Threshold

- Default setting **(_:571:3) Threshold** = ***80 V***

Specify the **Threshold** (pickup threshold) for the specific application.
Depending on the **Measured value**, the **Threshold** is set either as **measured voltage** or as a **phase-to-phase** variable.

NOTE

If the function is used in a **Voltage-current 1-phase** function group connected to the 1-phase voltage measuring point with the voltage type ***VN broken-delta***, you set the threshold value based on the equivalent zero-sequence voltage.
Calculate the equivalent zero-sequence voltage $V_{0\ equiv.\ sec}$ from the measured voltage $V_{N\ sec}$ with the following formula:

$$\frac{V_{0\ equi\ \ sec}}{V_{N\ sec}} = \frac{\text{Matching ratio Vph/VN}}{3}$$

For more information about the parameter **Matching ratio Vph / VN**, refer to *6.1.4 Application and Setting Notes for Measuring-Point Voltage 3-Phase (V-3ph)*.

Parameter: Operate delay

- Default setting **(_:571:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:571:4) Dropout ratio** = ***1.05***

The recommended set value of ***1.05*** is appropriate for most applications. To achieve high measurement precision, the **Dropout ratio** can be reduced to 1.02, for example.

Parameter: Current-flow criterion

- Recommended setting value **(_:2311:101) Current-flow criterion** = ***on***

Parameter Value	Description
on	Because of the application, it makes sense that the stage is only active (that is, not blocked) when a certain current flow is present (see note).
off	Current flow monitoring does not make sense for the application.



NOTE

Because of the flexible setting options of the voltage measurand, the function itself does not determine the current associated with the voltage. A suitable current-flow monitoring function must be created by the user with the Continuous Function Chart (CFC), and connected to the binary input signal **>Current flow-criterion**.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

6.45.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Current-flow criterion		• off • on	on
Stage 1				
_:571:1	Stage 1:Mode		• off • on • test	off
_:571:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:571:9	Stage 1:Measured value		• VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:571:8	Stage 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:571:3	Stage 1:Threshold		0.300 V to 340.000 V	80.000 V
_:571:4	Stage 1:Dropout ratio		1.01 to 1.20	1.05

Addr.	Parameter	C	Setting Options	Default Setting
_:571:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:572:1	Stage 2:Mode		• off • on • test	off
_:572:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:572:9	Stage 2:Measured value		• VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:572:8	Stage 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:572:3	Stage 2:Threshold		0.300 V to 340.000 V	65.000 V
_:572:4	Stage 2:Dropout ratio		1.01 to 1.20	1.05
_:572:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.45.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Current flow-criterion	SPS	I
_:2311:300	General:Current crit. fulf.	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Stage 1			
_:571:81	Stage 1:>Block stage	SPS	I
_:571:51	Stage 1:Mode (controllable)	ENC	C
_:571:54	Stage 1:Inactive	SPS	O
_:571:52	Stage 1:Behavior	ENS	O
_:571:53	Stage 1:Health	ENS	O
_:571:55	Stage 1:Pickup	ACD	O
_:571:56	Stage 1:Operate delay expired	ACT	O

No.	Information	Data Class (Type)	Type
_:571:57	Stage 1:Operate	ACT	O
Stage 2			
_:572:81	Stage 2:>Block stage	SPS	I
_:572:51	Stage 2:Mode (controllable)	ENC	C
_:572:54	Stage 2:Inactive	SPS	O
_:572:52	Stage 2:Behavior	ENS	O
_:572:53	Stage 2:Health	ENS	O
_:572:55	Stage 2:Pickup	ACD	O
_:572:56	Stage 2:Operate delay expired	ACT	O
_:572:57	Stage 2:Operate	ACT	O

6.46 Rate-of-Voltage-Change Protection

6.46.1 Overview of Functions

In a power system, in addition to short circuits, there are other situations which also cause voltage changes. For example, too high loads can reduce the voltage level at the end of the line, or too high power production can cause a voltage-level increase.

The function **Rate-of-voltage-change protection** can be used to:

- Prevent the system from not secure states caused by unbalance between the generated and consumed active power
- Detect a network island state
- Advanced load-shedding applications
- Detect a rather fast voltage change related to a fault in the power system

6.46.2 Structure of the Function

The function **Rate-of-voltage-change protection** can be used in protection function groups with 3-phase voltage measurement.

2 stage types are available:

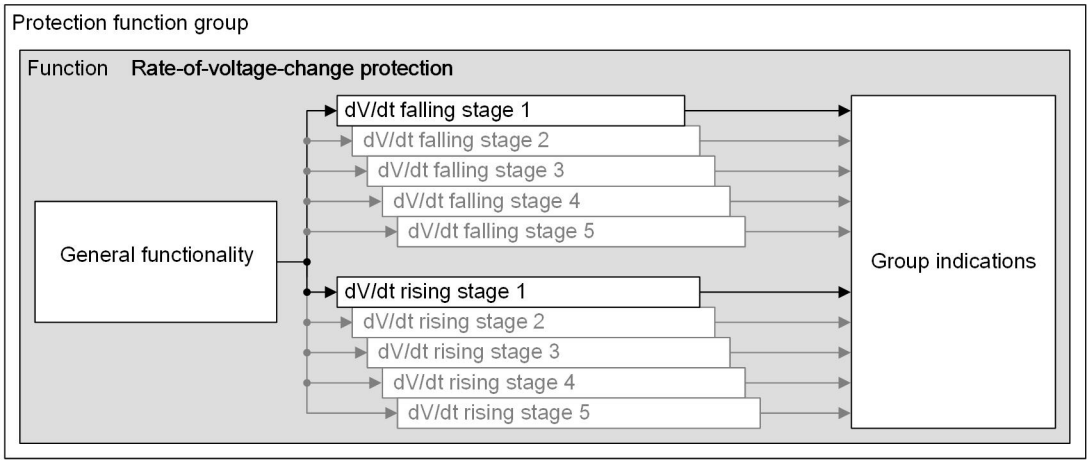
- **dV/dt rising**
- **dV/dt falling**

The function **Rate-of-voltage-change protection** comes factory-set with 1 **dV/dt rising** stage and 1 **dV/dt falling** stage. A maximum of 5 **dV/dt rising** stages and 5 **dV/dt falling** stages can be operated simultaneously within the function. Both stage types are similar in structure.

The general functionality works across stages on the function level.

The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- Pickup
- Operate



[dw_dVdt structure, 1, en_US]

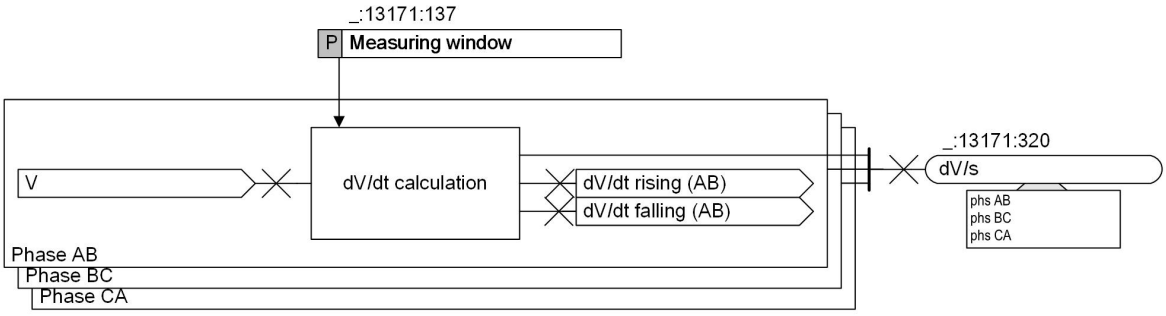
Figure 6-569 Structure/Embedding of the Function

6.46.3 General Functionality

6.46.3.1 Description

Logic

The following figure shows the dV/dt calculation logic. It applies to all configured stages.



[lo_dvdt_general, 1, en_US]

Figure 6-570 Logic Diagram of the General Functionality

dV/dt Calculation

The measured phase-to-phase voltages are used for calculating the rate of voltage change.

The measuring-window interval is used for calculating the dV/dt mean value for further processing. A larger measuring window increases the accuracy of the dV/dt mean value while simultaneously increasing the pickup time.

The ratio between the voltage difference and the time difference reflects the voltage change which can be positive or negative.

Functional Measured Value

Value	Description
dV/s	Calculated mean voltage change per second

6.46.3.2 Application and Setting Notes

Parameter: `Measuring window`

- Default setting **`(_:13171:137) Measuring window`** = ***`5 periods`***

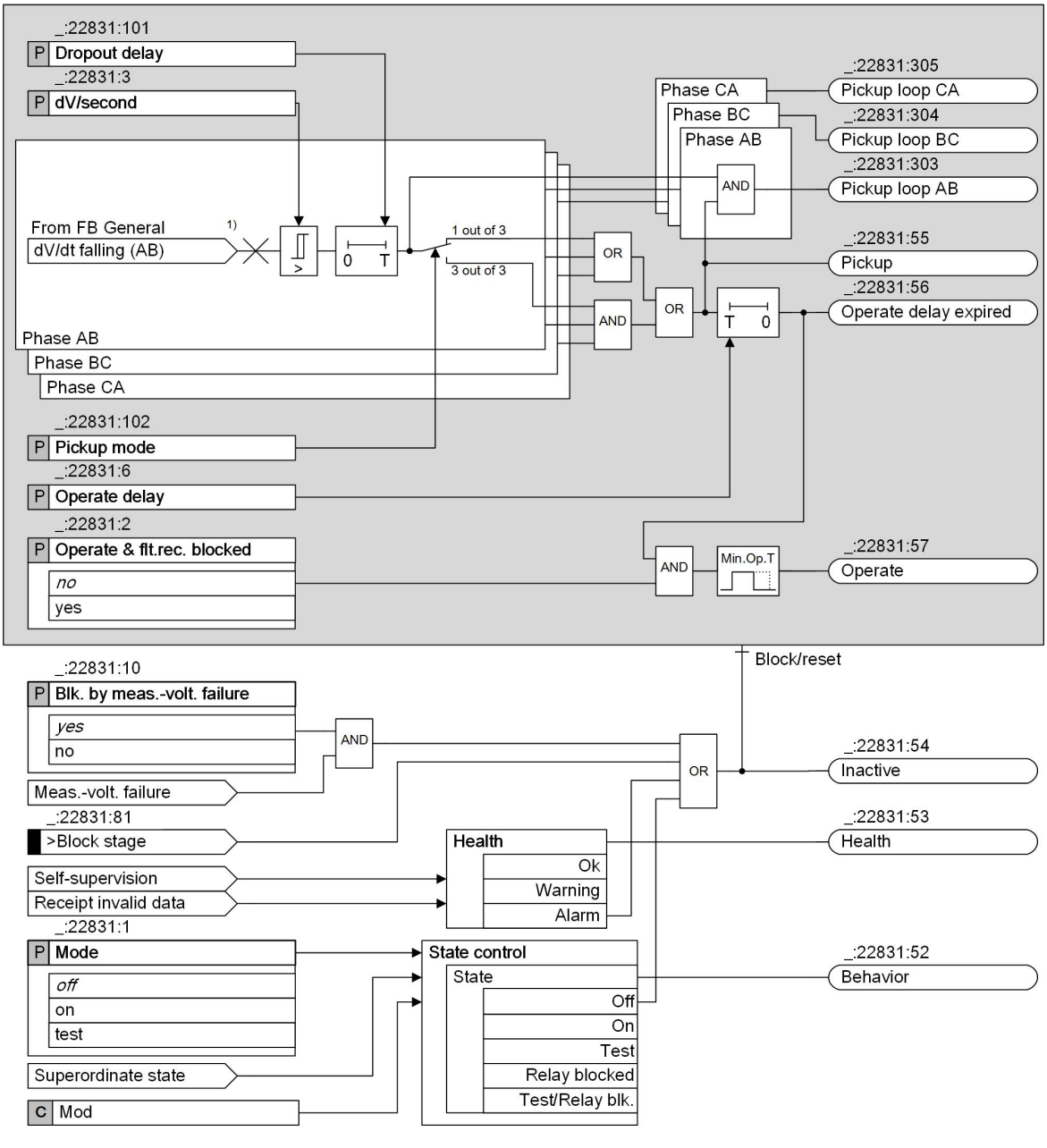
With the **`Measuring window`** parameter, you optimize the measuring accuracy or the pickup time of the function. If the measuring window increases, the measuring accuracy increases while the pickup time increases as well. You can find more information about the pickup time and measuring accuracy in the technical data in chapter *12.41 Rate-of-Voltage-Change Protection*.

If you do not have specific requirements for an especially short pickup time, Siemens recommends using the default setting. The default setting is a reasonable compromise between the measuring accuracy and the pickup time. If the measuring window is smaller than 5 periods, the accuracy of the calculated dV/dt value is affected.

6.46.4 Stage Description

6.46.4.1 Description

Logic of the Stage



[lo_dvdt_stage, 1, en_US]

Figure 6-571 Logic Diagram of the dV/dt Falling Stage

(1) For the stage type **dV/dt rising**, the value **dV/dt rising (AB)** is used.

Voltage Change

The stage **dV/dt falling** is used to detect a system-voltage decrease and the stage **dV/dt rising** is used to detect a system-voltage increase.

You set the threshold value **dV/second** as the absolute voltage change per second. You define the voltage-change direction via the stage type.

Pickup Mode

The **Pickup mode** parameter defines whether the stage picks up if all 3 measuring elements detect the voltage-change condition (***3 out of 3***) or if only 1 measuring element detects the voltage-change condition (***1 out of 3***).

Dropout Delay

If the dV/dt value falls below the dropout threshold, the dropout of the stage can be delayed. The pickup is maintained for the specified time. The operate delay continues to run. If the operate delay expires while the pickup is still maintained, the stage operates.

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **Voltage-transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker.

The **Blk. by meas.-volt. failure** parameter can be set so that **Measuring-voltage failure detection** blocks the stage or not.

6.46.4.2 Application and Setting Notes

Parameter: dV/second

- Default setting **(_:22831:3) dV/second** = ***20.000 V***

With the **dV/second** parameter, you determine the pickup value of the stage. The pickup value depends on the application.

For the load-shedding application, it is necessary to detect faster rates of voltage change in the range from 20 V to 30 V per second.

For an island-state detection of the network, the pickup value can be set much lower in the range of 1 V per second or less.

Parameter: Dropout delay

- Default setting **(_:22831:101) Dropout delay** = ***0.00 s***

The **Dropout delay** parameter maintains the pickup even if the measured value drops temporarily below the threshold value. A delay is required for very low pickup values to prevent a chattering of the function.

Parameter: Operate delay

- Default setting **(_:22831:6) Operate delay** = ***3.00 s***

You can use the **Operate delay** parameter to avoid overfunction due to disturbing influences (for example, switching operations). If the protection function is supposed to respond immediately, set the **Operate delay** to 0.00 s.

Parameter: Pickup mode

- Default setting **(_:22831:102) Pickup mode** = ***1 out of 3***

With the **Pickup mode** parameter, you define whether the protection stage picks up if all 3 measuring elements detect the voltage falling/rising condition (***3 out of 3***) or if only 1 measuring element detects the voltage falling/rising condition (***1 out of 3***).

Parameter Value	Description
1 out of 3	Select the setting for protection applications or for monitoring the voltage range. This setting reflects how the function operated in previous generations (SIPROTEC 4).
3 out of 3	Select this setting when using the stage to disconnect from the power system (for example in the case of wind farms).

Operation as Supervision Function

If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:22831:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

6.46.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:13171:137	General:Measuring window		2 periods to 50 periods	5 periods
dV/dt falling1				
_:22831:1	dV/dt falling1:Mode		• off • on • test	off
_:22831:2	dV/dt falling1:Operate & flt.rec. blocked		• no • yes	no
_:22831:10	dV/dt falling1:Blk. by meas.-volt. failure		• no • yes	yes
_:22831:102	dV/dt falling1:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:22831:3	dV/dt falling1:dV/second		0.500 V to 200.000 V	20.000 V
_:22831:6	dV/dt falling1:Operate delay		0.00 s to 60.00 s	3.00 s

Addr.	Parameter	C	Setting Options	Default Setting
_:22831:101	dV/dt falling1:Dropout delay		0.00 s to 60.00 s	0.00 s
dV/dt rising 1				
_:22801:1	dV/dt rising 1:Mode		• off • on • test	off
_:22801:2	dV/dt rising 1:Operate & flt.rec. blocked		• no • yes	no
_:22801:10	dV/dt rising 1:Blk. by meas.-volt. failure		• no • yes	yes
_:22801:102	dV/dt rising 1:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:22801:3	dV/dt rising 1:dV/second		0.500 V to 200.000 V	20.000 V
_:22801:6	dV/dt rising 1:Operate delay		0.00 s to 60.00 s	3.00 s
_:22801:101	dV/dt rising 1:Dropout delay		0.00 s to 60.00 s	0.00 s

6.46.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:13171:320	General:dV/s	DEL	O
_:13171:52	General:Behavior	ENS	O
_:13171:53	General:Operate	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
dV/dt falling1			
_:22831:81	dV/dt falling1:>Block stage	SPS	I
_:22831:51	dV/dt falling1:Mode (controllable)	ENC	C
_:22831:54	dV/dt falling1:Inactive	SPS	O
_:22831:52	dV/dt falling1:Behavior	ENS	O
_:22831:53	dV/dt falling1:Health	ENS	O
_:22831:55	dV/dt falling1:Pickup	ACD	O
_:22831:303	dV/dt falling1:Pickup loop AB	SPS	O
_:22831:304	dV/dt falling1:Pickup loop BC	SPS	O
_:22831:305	dV/dt falling1:Pickup loop CA	SPS	O
_:22831:56	dV/dt falling1:Operate delay expired	ACT	O
_:22831:57	dV/dt falling1:Operate	ACT	O
dV/dt rising 1			
_:22801:81	dV/dt rising 1:>Block stage	SPS	I
_:22801:51	dV/dt rising 1:Mode (controllable)	ENC	C
_:22801:54	dV/dt rising 1:Inactive	SPS	O

No.	Information	Data Class (Type)	Type
_:22801:52	dV/dt rising 1:Behavior	ENS	O
_:22801:53	dV/dt rising 1:Health	ENS	O
_:22801:55	dV/dt rising 1:Pickup	ACD	O
_:22801:303	dV/dt rising 1:Pickup loop AB	SPS	O
_:22801:304	dV/dt rising 1:Pickup loop BC	SPS	O
_:22801:305	dV/dt rising 1:Pickup loop CA	SPS	O
_:22801:56	dV/dt rising 1:Operate delay expired	ACT	O
_:22801:57	dV/dt rising 1:Operate	ACT	O

6.47 Undervoltage-Controlled Reactive-Power Protection

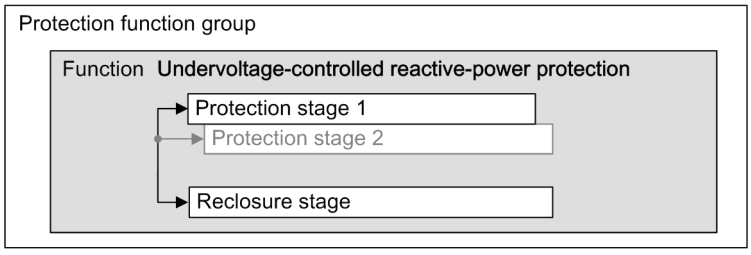
6.47.1 Overview of Functions

The **Undervoltage-controlled reactive-power protection** function (ANSI 27/Q):

- Detects critical power-system situations, mainly in case of regenerative generation
- Prevents a voltage collapse in power system by disconnecting the power-generation facility from the main power systems
- Ensures reconnection under stable power-system conditions

6.47.2 Structure of the Function

The **Undervoltage-controlled reactive-power protection** function can be used in protection function groups containing 3-phase voltage and current measurement. Depending on the device, it is preconfigured by the manufacturer with 1 **Protection stage** and 1 **Reclosure stage**. A maximum of 2 **Protection stages** and 1 **Reclosure stage** can operate simultaneously within the function.



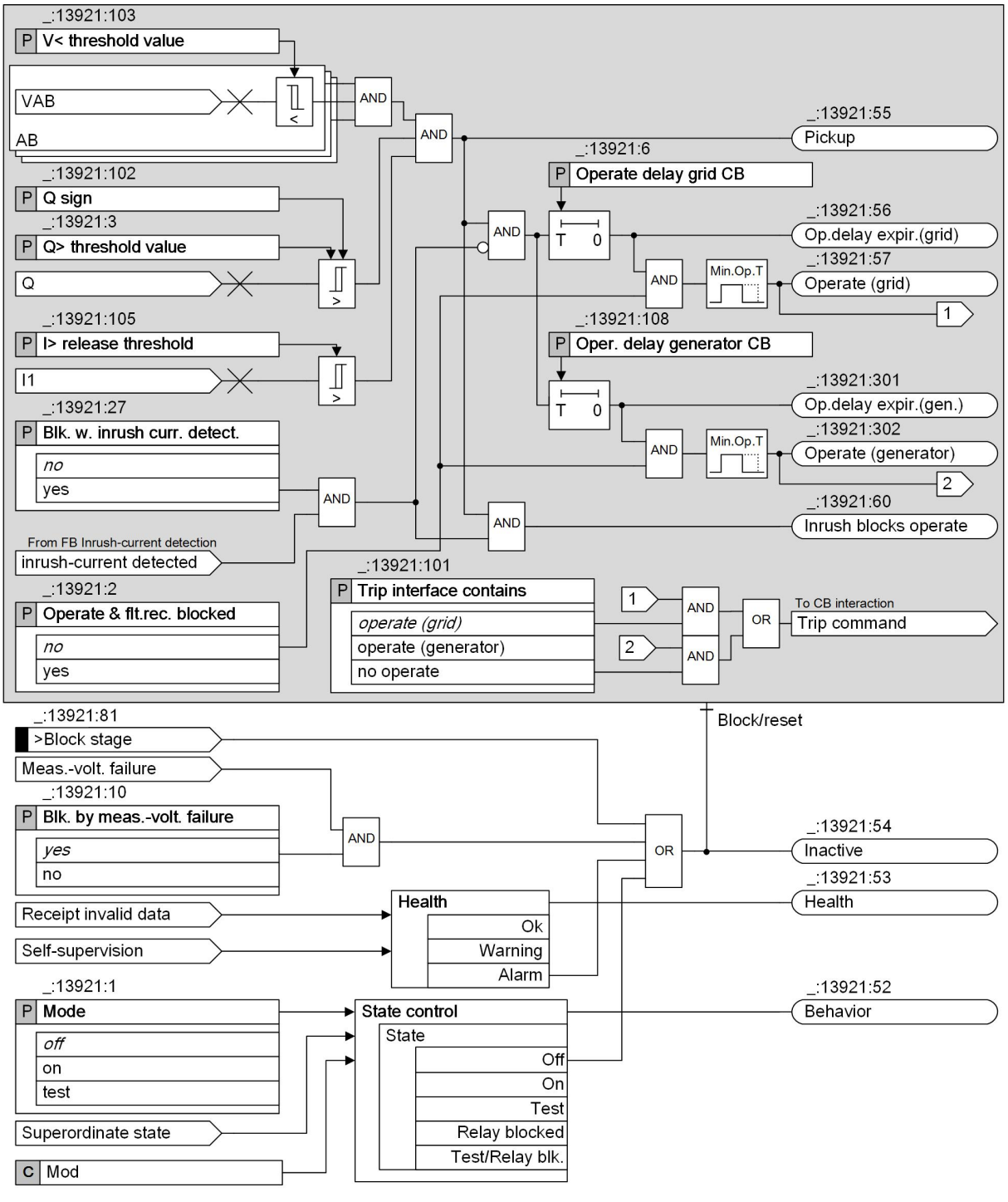
[dw_qvprot, 1, en_US]

Figure 6-572 Structure/Embedding of the Function

6.47.3 Protection Stage

6.47.3.1 Description

Logic of the Stage



[lo_qvprst, 2, en_US]

Figure 6-573 Logic Diagram of the Protection Stage of the Undervoltage-Controlled Reactive-Power Protection

Measurand

To detect critical power-system situations, the **Undervoltage-controlled reactive-power protection** function uses the fundamental values of the phase-to-phase voltages, the positive-sequence current, and the reactive power.

Q-Measurement Direction

The default directions of the positive reactive-power flow Q and the forward direction of the short-circuit protection are identical, in the direction of the protected object. Via parameter **`Q sign`**, the direction of the positive reactive-power flow Q can be changed by inverting the sign of the reactive power Q.

Pickup

The protection stage picks up under the following conditions:

- All 3 phase-to-phase voltages are below the parameterized threshold value.
- The positive-sequence current I_1 is above the parameterized threshold value.
- The power-generation facility requires more than the parameterized reactive power (Q is above the parameterized threshold value).

Trip Interface

The stage provides 2 operate signals, the *`Operate (generator)`* and the *`Operate (grid)`*. Depending on the parameter **`Trip interface contains`**, one or none of them will be forwarded to the trip interface of the circuit-breaker interaction.

Blocking of the Stage

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal *`>Block stage`*
- Measuring-voltage failure

Blocking of the Operate Delay and Operate Signal via the Device-Internal Inrush-Current Detection Function

The **`Blk. w. inrush curr. detect.`** parameter permits you to define whether the operate delay should be blocked by a threshold-value violation due to an inrush current.

For further information about device-internal **Inrush-current detection** function, refer to chapter *6.23.7.1 Description* .

6.47.3.2 Application and Setting Notes

Parameter: **`Blk. by meas.-volt. failure`**

- Recommended setting value **`(_:13921:10) Blk. by meas.-volt. failure`** = ***`yes`***

You use the **`Blk. by meas.-volt. failure`** parameter to control the response of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal **Measuring-voltage failure detection** function is configured and switched on.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The **Protection stage** is blocked when a measuring-voltage failure is detected. Siemens recommends using the default setting, as there is no assurance that the **Protection stage** will function correctly if the measuring voltage fails.
no	The **Protection stage** is not blocked when a measuring-voltage failure is detected.

Parameter: `Blk. w. inrush curr. detect.`

- Default setting **`(_:13921:27) Blk. w. inrush curr. detect.`** = ***no***

You use the **`Blk. w. inrush curr. detect.`** parameter to determine whether the operate delay and operate signal are blocked during the detection of an inrush current.

Parameter: `I> release threshold`

- Recommended setting value **`(_:13921:105) I> release threshold`** = ***0.100 A***

You use the **`I> release threshold`** parameter to define a precondition that the stage can pick up. The default setting is at 10 % of the rated current. Siemens recommends using the default setting.

Parameter: `V< threshold value`

- Recommended setting value **`(_:13921:103) V< threshold value`** = ***85.000 V***

You use the **`V< threshold value`** parameter to define one of the 2 pickup criteria. If all 3 phase-to-phase voltages drop below the parameterized undervoltage threshold value, the pickup criterion is fulfilled.

The setting should be set below the lower value of the permissible voltage range, according to the national transmission code. In Germany, the recommended undervoltage threshold is 85 % of the rated voltage. Therefore Siemens recommends using the default setting.

Parameter: `Q> threshold value`

- Default setting **`(_:13921:3) Q> threshold value`** = ***5 %***

You use the **`Q> threshold value`** parameter to define the second of the 2 pickup criteria. If the positive reactive power exceeds the parameterized **`Q> threshold value`**, the pickup criterion is fulfilled.

In the following example, the pickup takes place if Q exceeds 5 % of the power-supply system rated power.

EXAMPLE

The following example is given for settings in secondary values.

Rated voltage: $V_{rated,\ sec}$ = 100 V

Rated current: $I_{rated,\ sec}$ = 1 A

Threshold value: 5 % of the power-supply system rated power

You can calculate the setting value as follows:

$$Q >_{threshold} = 100\ V \cdot 1\ A \cdot \sqrt{3} \cdot 0.05 = 8.7\ VAr$$

[fo_qvprot, 1, en_US]

Parameter: Operate delay

- Default setting **`(_:13921:6) Operate delay grid CB`** = ***1.50 s***
- Default setting **`(_:13921:108) Oper. delay generator CB`** = ***0.50 s***

You can set the **`Operate delay grid CB`** for the circuit breaker at the power-supply system connection point, or set the **`Oper. delay generator CB`** for the circuit breaker of the facility, for example, the generator.

The time of the **Operate delay grid CB** should always be set longer than the time of the **Oper. delay generator CB**.

Parameter: Trip interface contains

- Default setting **(_:13921:101) Trip interface contains** = ***operate (grid)***

The stage provides 2 operate signals, the *Operate (generator)* and the *Operate (grid)*.
You use the **Trip interface contains** parameter to define whether one or none of them will be forwarded to the trip interface of the circuit-breaker interaction. The selected operate signal will trip the circuit breaker that has been connected to the protection function group.
The setting depends on the specific application.

Parameter: Q sign

- Default setting **(_:13921:102) Q sign** = ***not reversed***

The default directions of the positive reactive-power flow Q and the forward direction of the short-circuit protection are identical, in the direction of the main protected object (for example, a feeder). You use the **Q sign** parameter to reverse the sign and therefore the direction of the reactive-power flow Q. This reversal may be required for specific application, where the main protected object (for example, a line towards the main power systems) is in different direction to the power-generation facility.

Parameter Value	Description
not reversed	The protected object is in the same direction as the power-generation facility.
reversed	The protected object is not in the same direction as the power-generation facility.

6.47.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Prot. stage 1				
_:13921:1	Prot. stage 1:Mode		• off • on • test	off
_:13921:2	Prot. stage 1:Operate & flt.rec. blocked		• no • yes	no
_:13921:10	Prot. stage 1:Blk. by meas.-volt. failure		• no • yes	yes
_:13921:27	Prot. stage 1:Blk. w. inrush curr. detect.		• no • yes	no
_:13921:101	Prot. stage 1:Trip interface contains		• no operate • operate (generator) • operate (grid)	operate (grid)
_:13921:102	Prot. stage 1:Q sign		• not reversed • reversed	not reversed
_:13921:3	Prot. stage 1:Q> threshold value		1.00 % to 200.00 %	5.00 %
_:13921:103	Prot. stage 1:V< threshold value		3.000 V to 175.000 V	85.000 V

Addr.	Parameter	C	Setting Options	Default Setting
_:13921:105	Prot. stage 1:I> release threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:13921:108	Prot. stage 1:Oper. delay generator CB		0.00 s to 60.00 s	0.50 s
_:13921:6	Prot. stage 1:Operate delay grid CB		0.00 s to 60.00 s	1.50 s

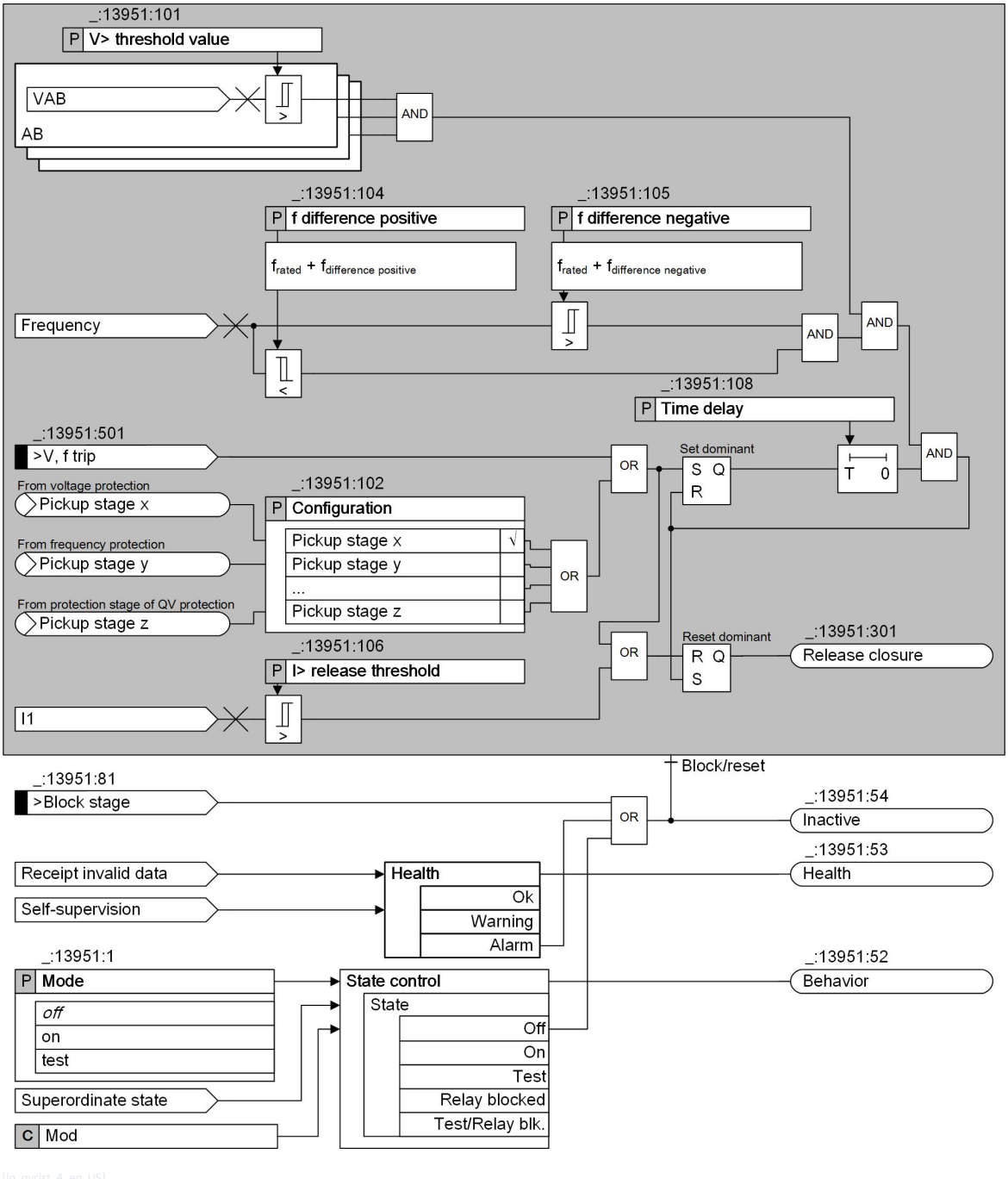
6.47.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Prot. stage 1			
_:13921:81	Prot. stage 1:>Block stage	SPS	I
_:13921:51	Prot. stage 1:Mode (controllable)	ENC	C
_:13921:54	Prot. stage 1:Inactive	SPS	O
_:13921:52	Prot. stage 1:Behavior	ENS	O
_:13921:53	Prot. stage 1:Health	ENS	O
_:13921:60	Prot. stage 1:Inrush blocks operate	ACT	O
_:13921:55	Prot. stage 1:Pickup	ACD	O
_:13921:301	Prot. stage 1:Op.delay expir.(gen.)	ACT	O
_:13921:302	Prot. stage 1:Operate (generator)	ACT	O
_:13921:56	Prot. stage 1:Op.delay expir.(grid)	ACT	O
_:13921:57	Prot. stage 1:Operate (grid)	ACT	O

6.47.4 Reclosure Stage

6.47.4.1 Description

Logic of the Stage



[lo_qvclst_4, en_US]

Figure 6-574 Logic Diagram of Reclosure Stage in Undervoltage-Controlled Reactive-Power Protection

Measurand

The stage works with fundamental values of voltage and current.

Release for Reconnecting

The release for reconnecting the power-generation facility is given under the following conditions:

- All 3 phase-to-phase voltages are above the threshold value.
- The power frequency is within a specified range.
- The reclosure time delay, started by the operate of specific protection functions, has elapsed. The time delay is started by the first operate signal of the protection stages configured via the **Configuration** parameter. All protection stages of the voltage protection, the frequency protection, and the QV protection are available for configuration.

External Start of Reclosure Time Delay

Reclosure time delay can be started via the binary input signal *>V, f trip*, which can be connected to external voltage and frequency protection trip signals.

Blocking of the Stage

The stage can be blocked via the binary input signal *>Block stage*.

6.47.4.2 Application and Setting Notes

Parameter: Configuration

- Default setting **(_:13951:102) Configuration** = ***no stage***

You use the **Configuration** parameter to define which operate signal of specific protection functions starts the release time delay of the **Reclosure stage**:

- Overfrequency protection
- Underfrequency protection
- Overvoltage protection
- Undervoltage protection
- Protection stage of undervoltage-controlled reactive-power protection

When the protection stage of undervoltage-controlled reactive-power protection is selected, only the signal *Operate (generator)* can start the release time delay of this stage. The signal *Operate (grid)* cannot start the release time delay.

The configuration depends on the specific application.

Parameter: I> release threshold

- Recommended setting value **(_:13951:106) I> release threshold** = ***0.100 A***

You use the **I> release threshold** parameter to define a precondition that the stage can work.

The default setting is at 10 % of the rated current. Siemens recommends using the default setting.

Parameter: V> threshold value

- Recommended setting value **(_:13951:101) V> threshold value** = ***95.000 V***

You use the **V> threshold value** parameter to set one of the 2 release criteria. The setting should be set above the lower value of the allowed voltage range, according to the national transmission code. In Germany, the recommended overvoltage threshold is 95 % of the rated voltage. Therefore Siemens recommends using the default setting.

Parameter: Frequency range

- Recommended setting value **(_:13951:104) f difference positive** = ***0.05 Hz***
- Recommended setting value **(_:13951:105) f difference negative** = ***-2.50 Hz***

You use these 2 parameters to define the admitted frequency deviation from the rated frequency. **f difference positive** defines the upper frequency range limit. **f difference negative** defines the lower frequency range limit.

Siemens recommends using the default settings, which reflect common practice in Germany. Other national transmission codes may require a slightly different range.

Parameter: Time delay

- Default setting **(_:13951:108) Time delay** = ***0.00 s***

You use the **Time delay** parameter to specify the minimum time delay for releasing the reconnection of the power-generation facility after tripping by protection.

The setting depends on the specific application.

6.47.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Reclos. stage				
_:13951:1	Reclos. stage:Mode		• off • on • test	off
_:13951:101	Reclos. stage:V> threshold value		3.000 V to 340.000 V	95.000 V
_:13951:104	Reclos. stage:f difference positive		0.01 Hz to 5.00 Hz	0.05 Hz
_:13951:105	Reclos. stage:f difference negative		-5.00 Hz to -0.01 Hz	-2.50 Hz
_:13951:106	Reclos. stage:I> release threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:13951:108	Reclos. stage:Time delay		0.00 s to 3600.00 s	0.00 s
_:13951:102	Reclos. stage:Configuration		Setting options depend on configuration	

6.47.4.4 Information List

No.	Information	Data Class (Type)	Type
Reclos. stage			
_:13951:81	Reclos. stage:>Block stage	SPS	I
_:13951:501	Reclos. stage:>V, f trip	SPS	I
_:13951:54	Reclos. stage:Inactive	SPS	O
_:13951:52	Reclos. stage:Behavior	ENS	O
_:13951:53	Reclos. stage:Health	ENS	O
_:13951:301	Reclos. stage:Release closure	ACT	O

6.48 Voltage-Comparison Supervision

6.48.1 Overview of Functions

The **Voltage-comparison supervision** function (ANSI 60):

- Monitors the voltage-transformer circuits by comparing the voltages from 2 voltage transformers
  If failures in the voltage circuits are detected, voltage-related protection functions can be blocked.
- Requires the connection of 2 voltage measuring points to the voltage interface of the function group
  You can take one of the voltages as the reference voltage and then the other becomes the main voltage. The reference voltage is used for comparison.

NOTE

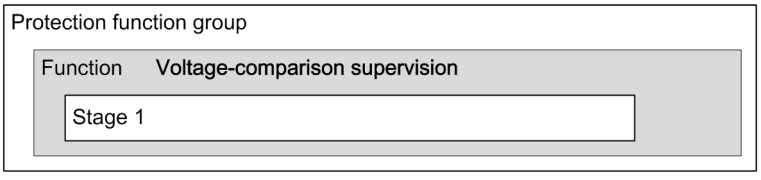
The voltage selection for the protection function in the FGs works independent of the status of the **Voltage-comparison supervision** function.

6.48.2 Structure of the Function

The **Voltage-comparison supervision** function can be used in the following function groups:

- Generator stator
- Generator side
- Voltage-current 3-phase (VI 3ph)
- Transformer side
- Auto transformer autoside (Auto trf. autoside)

The **Voltage-comparison supervision** function supports only 1 stage. The stage is preconfigured at the factory.



{dw_structure_VBP, 1, en_US}

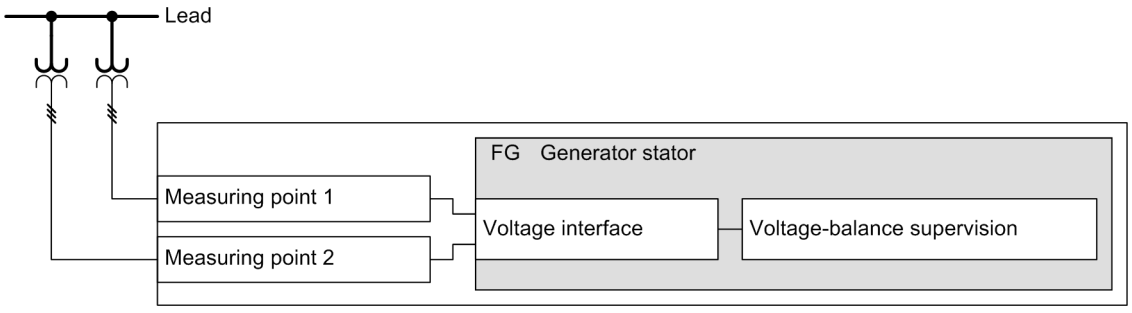
Figure 6-575 Structure/Embedding of the Function

6.48.3 Stage Description

6.48.3.1 Description

Function Application

The following figure shows an application example.

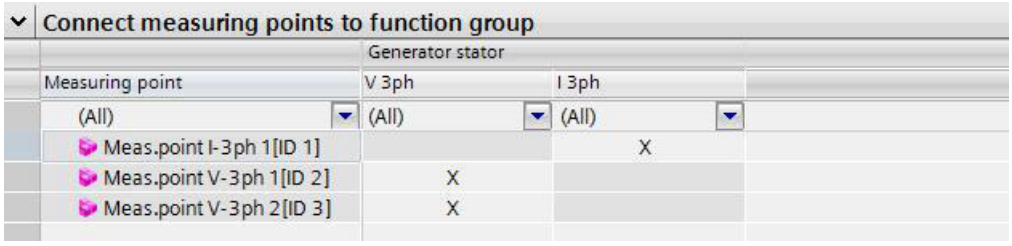


[dw_VBP application, 1, en_US]

Figure 6-576 Application Example

Connecting Measuring Points to a Function Group

The following figure shows the connection of the function group **Generator stator** with several measuring points in DIGSI. The ID of each measuring point appears in the brackets after the name.



[sc_VBStoFG, 1, en_US]

Figure 6-577 Connecting the Measuring Points to the Generator Stator Function Group

There are consistency checks that validate the connections of voltage measuring points to the function group:

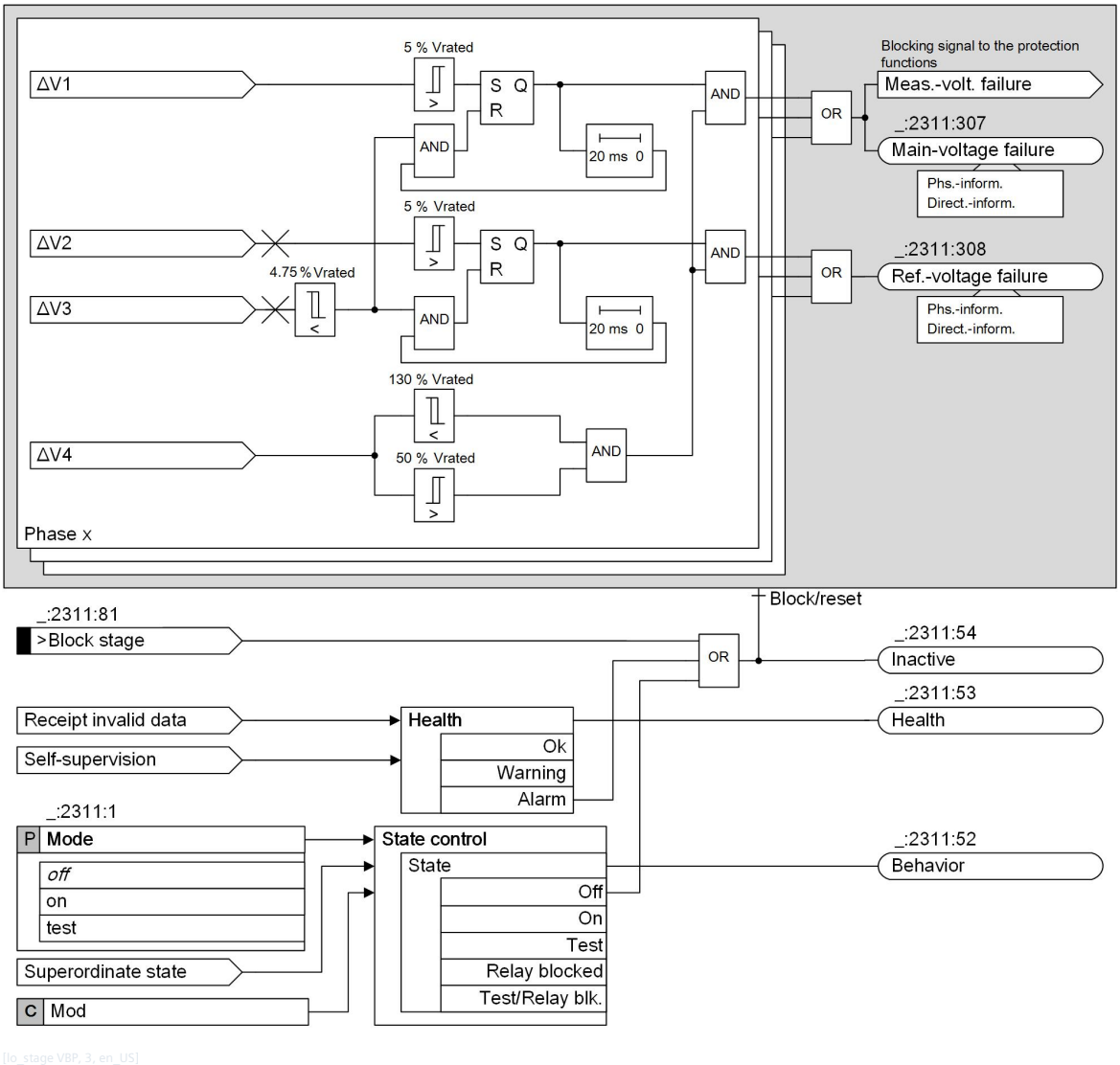
- The connection type must be identical for all measuring points connected to the same interface of the function group.
- The rated voltage (primary and secondary) must be identical for all measuring points connected to the same interface.
- 2 voltage measuring points must be connected to one voltage interface.
- Either the **Voltage-comparison supervision** function or the **Voltage measuring-point selection** function must be instantiated. They must not be instantiated at the same time.
  About the **Voltage measuring-point selection** function, you can find more information in chapter *6.71 Voltage Measuring-Point Selection*.

Voltage Selection

2 voltage measuring points are connected to a voltage interface of a function group. In the **Voltage-comparison supervision** function, you can set one of the voltages as the reference voltage via the parameter **`Reference voltage`**, and the other voltage becomes the main voltage.

- The reference voltage is used for voltage comparison.
- The main voltage is used for all voltage-related functions in the FGs that contain the **Voltage-comparison supervision** function.
  If the main voltage transformer is disconnected, the **Voltage-comparison supervision** function issues the blocking signal *`Meas.-volt failure`*. The signal is transmitted to all voltage-related protection functions which are used in the same FGs as the **Voltage-comparison supervision**.

Logic of the Stage



[lo_stage VBP, 3, en_US]

Figure 6-578 Logic Diagram of the Supervision Stage

The voltage inputs in the preceding figure are calculated with the following equations:

$\Delta V1 = |v(n)_{ref.}| - |v(n)_{main}|$

$\Delta V2 = |v(n)_{main}| - |v(n)_{ref.}|$

$\Delta V3 = |V_{ref.} - V_{main}|$

$\Delta V4 = \text{Max.}\ (V1_{ref.}, V1_{main})$

The following table shows the description of the voltages.

Table 6-20 Voltage Description

Voltages	Description
$v(n)_{ref.}$	Sampled value of the reference voltage
$v(n)_{main}$	Sampled value of the main voltage
$V_{ref.}$	Fundamental value of the reference voltage
V_{main}	Fundamental value of the main voltage
$V1_{ref.}$	Positive-sequence value of the reference voltage
$V1_{main}$	Positive-sequence value of the main voltage

Pickup

If the voltage difference between each 2 of 3 continuous sampling points is over 8 % Vrated of the plant, the supervision stage picks up.

Voltage Supervision

For the **Voltage-comparison supervision** function, the following 2 connection types are allowed:

- Phase-to-ground
  The phase-to-ground voltages are used for the voltage-difference comparison.
- Phase-to-phase
  The phase-to-phase voltages are used for the voltage-difference comparison.



NOTE

The **2 ph-to-ph volt. + VN** and **2 ph-to-ph voltages** connection types are not allowed.

Voltage-Failure Indication

For different connection types, the indications are different.

- Phase-to-ground
  You can get the voltage-failure information from the output signals *Main-voltage failure* and *Ref.-voltage failure*.
- Phase-to-phase
  - If one phase is influenced, the phase information is indicated.
  - If more than one phase is influenced, the phase-to-phase information is indicated.
    Take the main voltage transformer for example. You can determine the faulty phase with the following table.

Determination Criteria	Calculated Result		
(|vAB(n)ref.| - |vAB(n)main|) - 8 % Vrated	> 0	> 0	< 0
(|vBC(n)ref.| - |vBC(n)main|) - 8 % Vrated	< 0	> 0	> 0
(|vAC(n)ref.| - |vAC(n)main|) - 8 % Vrated	> 0	< 0	> 0
Failure Information	**Phase A is failed.**	**Phase B is failed.**	**Phase C is failed.**

Release Voltage

If the main positive-sequence voltage or the reference positive-sequence voltage is between 50 % Vrated and 130 % Vrated, the function is released.

Selection Invalid

An invalid measuring-point selection results in the following:

- The voltage measured values are displayed as ***Failure***.
- The validity of the voltage measured values is set to ***Invalid***.
- The indication *Health* is set to ***Alarm***.
- The indication *Selection invalid* becomes true.

Blocking of the Stage

In the event of blocking, the picked up function is reset. Blocking is possible externally or internally via the binary input signal *>Block stage*.

6.48.3.2 Application and Setting Notes

Parameter: Reference voltage

- Default setting **Reference voltage** = ***None***

With the parameter **Reference voltage**, you can set a measured voltage as the reference voltage.

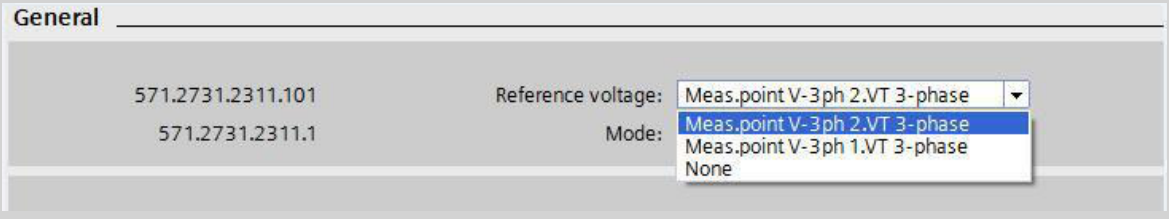


NOTE

You must assign a voltage measuring point to the parameter **Reference voltage**. The assignment influences the voltage-related protection functions which are used in the same FGs as the **Voltage-comparison supervision** function. These voltage-related protection functions use the unassigned voltage measuring point, which is defined as the main voltage in the **Voltage-comparison supervision** function. You can find more information in section *Voltage Selection, Page 1557*.

EXAMPLE

Meas.point V-3ph 1 and **Meas.point V-3ph 2** are connected to the **Voltage-comparison supervision** function. Then you have 2 more setting options, as shown in the following figure. You must select one of these setting options for the parameter **Reference voltage**.



[sc_VBS_ref_voltage, 1, en_US]

Parameter: Mode

- Default setting **(_:2311:1) Mode** = ***off***

With the parameter **Mode**, you can activate and deactivate the **Voltage-comparison supervision** function. If you switch to ***test*** mode, the **Voltage-comparison supervision** function is marked as invalid.

6.48.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
VolCmpSup 1				
_:2311:1	General:Mode		• off • on • test	off
_:2311:101	General:Reference voltage		Setting options depend on configuration	None

6.48.3.4 Information List

No.	Information	Data Class (Type)	Type
VolCmpSup 1			
_:2311:81	General:>Block stage	SPS	I
_:2311:501	General:>MP-ID selection	INS	I
_:2311:54	General:Inactive	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
_:2311:307	General:Main-voltage failure	ACD	O
_:2311:308	General:Ref.-voltage failure	ACD	O
_:2311:309	General:Selection invalid	SPS	O

6.49 Fault Locator

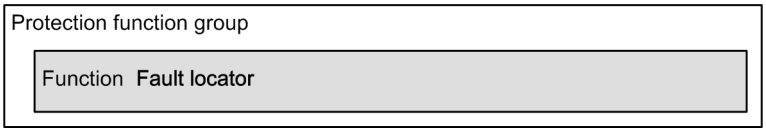
6.49.1 Overview of Functions

The **Fault locator** function is used to determine the distance to the fault location.

Quick determination of fault location and the associated rapid troubleshooting increase the availability of the line for the power transmission in the electrical power system. Fault-location determination is based on the determination of the reactance of the short-circuited measuring loops.

6.49.2 Structure of the Function

The function **Fault locator** can be used in protection function groups with 3-phase current and voltage measurement.



[dw_stbafo, 1, en_US]

Figure 6-579 Structure/Embedding of the Function

The fault location is calculated based on the line parameter. The fault-location determination is always carried out ***with going pickup*** of the short-circuit protection. There is an option to limit the fault-location determination to cases with tripping (setting value for parameter **Start** = ***with operate***).

The fault locator can be started as follows:

- Via the phase-segregated binary inputs *>Fault detected phs A*, *>Fault detected phs B*, *>Fault detected phs C*, and *>Fault detected gnd.*
- Via the differential protection
- Via the distance protection
- Via the directional overcurrent protection, phases or ground
- Via the overcurrent protection, phases or ground
- Via the non-phase segregated binary input *>Flt. det. w/o phs.&gnd.*

If multiple protection functions are operating in parallel, the fault locator is only started by the protection-function pickup with the highest priority. The functions are listed in decreasing priority.

The **Fault locator** function only works with the following current and voltage-transformer connection types (see parameter value).

Parameter	Parameter Value
CT connection	• ***3-phase + IN-separate*** • ***3-phase + IN*** • ***3-phase*** • ***2ph, 2p. CT + 2 IN-sep***
VT connection	• ***3 ph-to-gnd volt. + VN*** • ***3 ph-to-gnd voltages***

NOTE

The **Fault locator** function does not work with all possible current and voltage transformer connection types. An error message is displayed in DIGSI 5 if the **Fault locator** function cannot work with the set connection types. In this case check the current and voltage transformer connection type. You will find the **`CT connection`** or **`VT connection`** parameters in DIGSI 5 under **Power system** → **Meas.point I-3ph** or **Power system** → **Meas.point V-3ph**.

6.49.3 Function Description

Starting Conditions

Each protection function that can start the fault locator also provides the **fault locator** with information on the pickup and tripping times. If multiple protection functions pick up at the same time, the **fault locator** is started only by the function with the highest priority. The pickup pattern for the other protection functions is discarded.

The fault locator uses the pickup and tripping information for the protection function being started to form its own measurand memory for the following calculations. Depending on the pickup duration of the protection function, the measurand memory is positioned such that it contains prefault processes, short-circuit processes, and switch-off processes. If the pickup lasts for a longer time, only the short-circuit processes and switch-off processes are recorded by the measurand memory. The fault-location determination always starts only after the dropout of the pickup.

Fault-location determination is also possible via the starting condition ***`with going pickup`***, if the protection device only picks up and does not trigger. Fault-location determination is then performed via the starting condition ***`with operate`*** only if the protection device has reported the tripping and the pickup has dropped out.

Alternatively, the **fault locator** can be started via one or more binary inputs. If the phase-segregated indications *`>Fault detected phs A`*, *`>Fault detected phs B`*, *`>Fault detected phs C`*, and *`>Fault detected gnd.`* are routed in the DIGSI 5 information routing, the **fault locator** interprets the binary inputs as a phase-segregated external protection function and treats them with the highest priority.

NOTE

The phase-segregated start of the fault locator is only possible if you have routed all 4 indications in the DIGSI 5 information routing.

When routing the binary input *`>Flt. det. w/o phs.&gnd.`*, the binary input is interpreted as a non-segregated external protection function and is treated with the lowest priority. The fault locator starts when the binary input drops out.

When the parameter ***`with operate`*** is set and the **fault locator** is started via the binary input, the fault-location determination is started only when a device-internal protection function generates an operate indication, or when the binary input *`>Fault locator start`* is activated in addition to the above mentioned binary inputs.

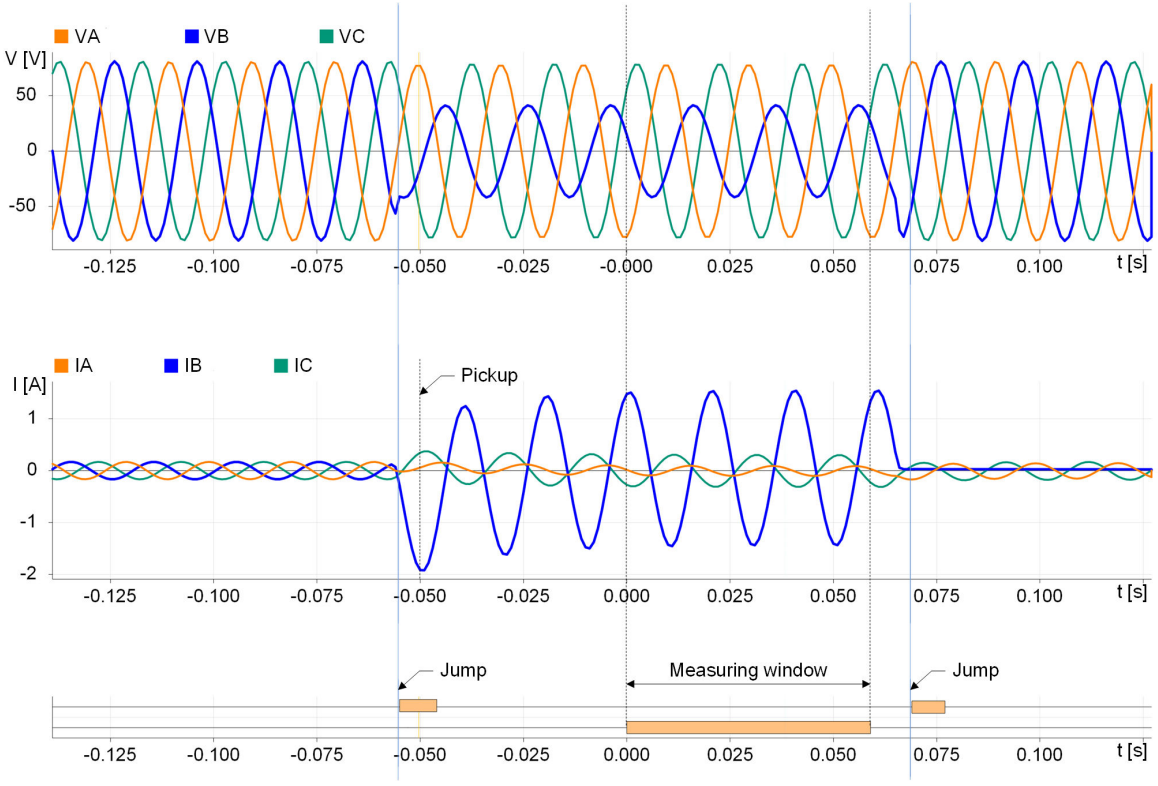
Fault locator	21.8671		*	*	*	*
>Fault detected phs A	21.8671.501	SPS	H			
>Fault detected phs B	21.8671.502	SPS		H		
>Fault detected phs C	21.8671.503	SPS			H	
>Fault detected gnd.	21.8671.504	SPS				H
>Flt. det. w/o phs.&gnd.	21.8671.505	SPS				
>Fault locator start	21.8671.506	SPS				

[sc_rout_BE, 1, en_US]

Figure 6-580 Routing Matrix for the Triggering of the Fault Locator via Binary Input

Determining Fault Location

The recorded sampled values of the short-circuit currents and voltages are transferred to an internal measurand memory. The pickup indications are used to determine the short-circuited loops. The measurand memory is searched for an optimal measurement window. The largest possible measurement window is selected. If possible, the measurement window is positioned at the end of the short-circuit process. This means that the transient response and the ring down have the least possible impact on the measuring result.



[dw_sigra_flo, 1, en_US]

Figure 6-581 Determining the Measurement Window

The impedances of the short-circuit loops are calculated of the measurement-window data. If there are multiple short-circuited loops, a selection process is used to select a loop and the results are then issued.

If it is not possible to determine a sufficient data window with usable measured values or a plausible short-circuited loop, the indication *FLO invalid* signals the invalid measuring result.

Output of the Fault Location

The following results for the fault location are output:

- The fault reactance X in Ω primary
- The fault resistance R in Ω primary
- The fault distance ***d*** of the line proportional to the reactance in kilometers or miles, converted on the basis of the parameterized reactance per unit length of the line
- The fault distance ***d*** as a percentage of the line length, calculated on the basis of the parameterized reactance per unit length and the parameterized line length
- The selected fault loop for calculation of the fault location

NOTE

The indication of distance in kilometers, miles, or percent is applicable only for homogeneous line sections. If the line comprises parts which exhibit different reactances per unit of length (for example, overhead-line-cable sections), you can then analyze the reactance determined from the fault location for separate calculation of the fault distance. Alternatively, you can use the **Fault locator plus** function, with which the non-homogeneous lines can be parameterized in line sections.

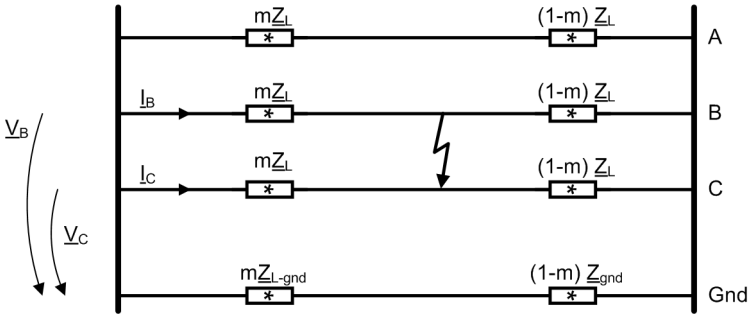
Impedance-Based Fault Location

The determination of the fault distance is based on the evaluation of the imaginary part of the calculated short-circuit impedance. The fault distance is determined by dividing the calculated reactance X with the parameterizable reactance per unit length (parameter **`X per length unit`**). Both the impedance up to the fault location and the fault distance are issued by the fault locator.

An impedance measuring element is available for each of the 6 possible short-circuit loops A-gnd, B-gnd, C-gnd, A-B, B-C, C-A. The loop to be measured is selected depending on the fault type.

For 2-phase short circuits with grounding, the phase-to-phase loop is preferred for fault location. For 3-phase short circuits, the average reactance, determined from the reactance of the 3 phase-to-phase loops is used.

A 2-phase short circuit B-C, for example, is used for the calculation of the phase-to-phase loop.



[dw_llschleife_flo, 1, en_US]

Figure 6-582 Short Circuit of a Phase-to-Phase Loop

The loop equation for the calculation of the short-circuit impedance of the phase-to-phase loop B-C is:

$$\underline{I}_A \cdot m \cdot \underline{Z}_L - \underline{I}_B \cdot m \cdot \underline{Z}_L = \underline{V}_A - \underline{V}_B$$

[fo_L2-L3_schl, 1, en_US]

With:

$\underline{V}_B$, $\underline{V}_C$	Short-circuit voltage phasor for phases B and C
$\underline{I}_B$, $\underline{I}_C$	Short-circuit current phasor phases B and C
m	Proportionate distance to the fault
$m\underline{Z}_L = m \cdot (R_L + jX_L)$	Line impedance up to fault location

The line impedance is calculated as follows:

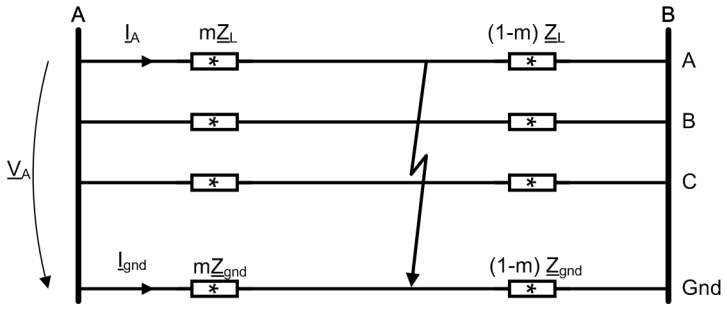
$$R = \frac{\mathrm{Rgnd}(\underline{V}_A - \underline{V}_B) \cdot \mathrm{Rgnd}(\underline{I}_A - \underline{I}_B) + \mathrm{Im}(\underline{V}_A - \underline{V}_B) \cdot \mathrm{Im}(\underline{I}_A - \underline{I}_B)}{\left[\mathrm{Rgnd}(\underline{I}_A - \underline{I}_B)\right]^2 + \left[\mathrm{Im}(\underline{I}_A - \underline{I}_B)\right]^2}$$

[fo_R_L2-L3_schl, 1, en_US]

$$X = \frac{\mathrm{Im}(\underline{V}_A - \underline{V}_B) \cdot \mathrm{Rgnd}(\underline{I}_A - \underline{I}_B) - \mathrm{Rgnd}(\underline{V}_A - \underline{V}_B) \cdot \mathrm{Im}(\underline{I}_A - \underline{I}_B)}{\left[\mathrm{Rgnd}(\underline{I}_A - \underline{I}_B)\right]^2 + \left[\mathrm{Im}(\underline{I}_A - \underline{I}_B)\right]^2}$$

[fo_X_L2-L3_schl, 1, en_US]

In case of a phase-to-ground short circuit, for example, A-gnd, for the calculation of a phase-to-ground loop, it must be considered that the impedance of the ground-return path does not match the impedance of the phases.



[dw_leschleife_flo, 1, en_US]

Figure 6-583 Short Circuit of a Phase-to-Ground Loop

In case of A-gnd short circuit, the phase-to-ground voltage $\underline{V}_A$, the phase current $\underline{I}_A$ and the ground current $\underline{I}_{gnd}$ are measured.

$$\underline{V}_A = \underline{I}_A \cdot m \cdot (R_L + jX_L) - \underline{I}_{gnd} \cdot m \cdot (k_r \cdot R_L + jk_xX_L)$$

[fo_L1-E_schl, 1, en_US]

The impedance at the fault location is calculated as:

$$R = \frac{\mathrm{Rgnd}(\underline{V}_A) \cdot \mathrm{Rgnd}(\underline{I}_x) + \mathrm{Im}(\underline{V}_A) \cdot \mathrm{Im}(\underline{I}_x)}{\mathrm{Rgnd}(\underline{I}_R) \cdot \mathrm{Rgnd}(\underline{I}_x) + \mathrm{Im}(\underline{I}_R) \cdot \mathrm{Im}(\underline{I}_x)}$$

[fo_R_L1-E_schl, 1, en_US]

and

$$X = \frac{\mathrm{Im}(\underline{V}_A) \cdot \mathrm{Rgnd}(\underline{I}_R) - \mathrm{Rgnd}(\underline{V}_A) \cdot \mathrm{Im}(\underline{I}_R)}{\mathrm{Rgnd}(\underline{I}_R) \cdot \mathrm{Rgnd}(\underline{I}_x) + \mathrm{Im}(\underline{I}_R) \cdot \mathrm{Im}(\underline{I}_x)}$$

[fo_X_L1-E_schl, 1, en_US]

With:

$\underline{V}_A$	Short-circuit voltage phasor
$\underline{I}_A$	Short-circuit current phasor phase A
$\underline{I}_{gnd}$	Ground-fault current phasor
$\underline{I}_R = \underline{I}_A - k_r \cdot \underline{I}_{gnd}$	Auxiliary quantity
$\underline{I}_x = \underline{I}_A - k_x \cdot \underline{I}_{gnd}$	Auxiliary quantity

The factors $k_r = R_{gnd}/R_{ph}$ and $k_x = X_{gnd}/X_{ph}$ depend only on the line constants and not on the distance to the fault.

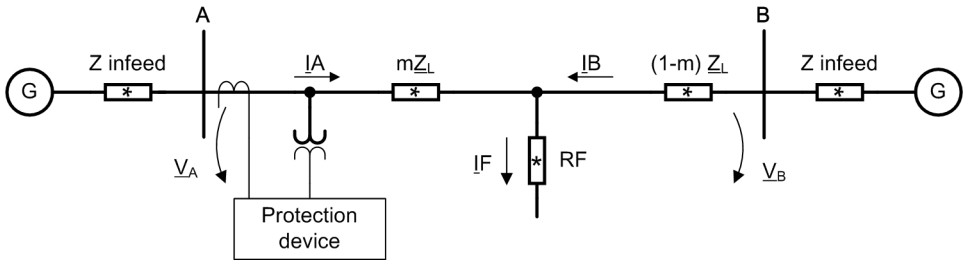
Measured-Value Correction at Load Current on Lines Fed on Both Sides

In the case of faults on lines fed on both sides and with load transport and contact resistance (see *Figure 6-584*), the fault voltage $\underline{V}_A$ is influenced not only by the voltage source on side A, but also by the voltage source on side B if both voltage sources feed to the fault location. Without special measures, this leads to measuring errors in the impedance, since the current portion $\underline{I}_B$ cannot be recorded at measuring point A. For long and highly loaded lines, this measuring error in the X portion of the fault impedance can be considerable. This X component is critical for the distance calculation.

The X component can be corrected when using load compensation. When using load compensation, the calculated R component comprises the combination of the fault resistance to be determined and the resistance of the line up to the fault location. This form of impedance calculation corresponds to the distance-protection

measurement protocol using the reactance method. The load compensation impacts both the 1-pole short circuit and the 2-pole short circuit. You can activate and deactivate the load compensation via the parameter **`Load compensation`**. If the distance protection operates with the reactance method, Siemens recommends switching on the load compensation for the fault locator too.

The following figure serves as an example of the description of the impedance calculation:



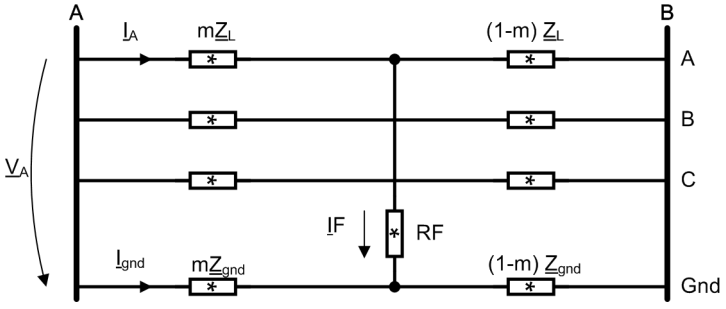
[dw_ueb_impedanzber, 2, en_US]

Figure 6-584 Fault Currents and Voltages of a Line Fed on Both Sides (1-Pole Display)

A	Measuring point
$\underline{V}_A$, $\underline{V}_B$	Voltage source
$\underline{I}_A$, $\underline{I}_B$	Partial fault currents
$\underline{I}_F$	Total fault current
$\underline{V}_A$	Fault voltage at measuring point A
RF	Common fault resistance
$\underline{Z}_L$, (1-m) $\underline{Z}_L$	Fault impedances
$\underline{Z}_A$, $\underline{Z}_B$	Source impedances
m	Proportionate distance to the fault

Impedance Calculation for Phase-to-Ground Loops

For calculation of a phase-to-ground loop, it must be considered that the impedance of the ground-return path generally does not match the impedance of the phases. This is the case, for example, for an A-gnd short circuit.



[dw_leschleife_rmd, 2, en_US]

Figure 6-585 Short Circuit of a Phase-to-Ground Loop

The loop equation for calculating the impedance is:

$$\underline{V}_A = m \cdot \underline{Z}_L \cdot (\underline{I}_A - \underline{k}_0 \cdot \underline{I}_{Gnd}) + RF \cdot \underline{I}F$$

[fo schl le ohne icomp, 3, en_US]

The loop equation is extended with the equivalent current $\underline{I}_{Subst.}$ on both sides and converted according to the impedance.

$$m \cdot |\underline{Z}_L| = \frac{\mathrm{Im}\{\underline{V}_A \cdot [\underline{I}_{Subst.} \cdot e^{j\delta_{comp}}]^*\}}{\mathrm{Im}\{\underline{Z}_L/|\underline{Z}_L| \cdot (\underline{I}_A - \underline{k}_0 \cdot \underline{I}_{gnd}) \cdot [\underline{I}_{Subst.} \cdot e^{j\delta_{comp}}]^*\}}$$

[fo schl le mit icomp, 4, en_US]

The following applies:

$$X = m \cdot |Z_L| \cdot \sin\varphi$$

[fo_x_impber, 1, en_US]

The reactance **X** of the phase-to-ground loop is calculated as follows:

$$X = \frac{\mathrm{Im}\{\underline{V}_A \cdot [\underline{I}_{Subst.} \cdot e^{j\delta_{comp}}]^*\}}{\mathrm{Im}\{\underline{Z}_L/|Z_L| \cdot (\underline{I}_A - \underline{k}_0 \cdot \underline{I}_{Gnd}) \cdot [\underline{I}_{Subst.} \cdot e^{j\delta_{comp}}]^*\}} \cdot \sin\varphi$$

[fo xf impber, 2, en_US]

With:

A	Measuring point
$\underline{V}_A$,	Fault voltage at measuring point A (phase-to-ground voltage)
$\underline{I}_A$, $\underline{I}_{Gnd}$	Partial fault currents
$\underline{I}_F$	Total fault current
RF	Common fault resistance
$\underline{Z}_L$, $\underline{Z}_B$	Line impedance
m	Proportionate distance to the fault
$\underline{I}_{Subst.}$	Equivalent current
$\underline{k}_0$	Ground-fault factor
δ_{Comp}	Compensation angle

You can select the equivalent current $\underline{I}_{Subst.}$ such that the impact of the fault current $\underline{I}_B$ is compensated at the fault resistance R_F. This prevents the measuring error in the reactance.

The resulting measuring error in RF can be compensated only partially.
RF is calculated as follows:

$$R = \frac{\mathrm{Im}\{\underline{V}_A \cdot [\underline{Z}_L \cdot (\underline{I}_A - \underline{k}_0 \cdot \underline{I}_{gnd})]^*\}}{\mathrm{Im}\{\underline{I}_F \cdot [\underline{Z}_L \cdot (\underline{I}_A - \underline{k}_0 \cdot \underline{I}_{gnd})]^*\}} + X \cdot \mathrm{ctg}(\varphi)$$

[fo_rf_impber, 4, en_US]

The protection device cannot measure the fault current $\underline{I}_F$ directly. Therefore, either $3\underline{I}_0$ or $3\underline{I}_2$ is used as an equivalent for $\underline{I}_F$. In order to achieve the best result, the procedure uses the larger one of the 2 equivalent currents. If the angles of the source impedances and the line impedance are not equal, you can compensate the inhomogeneity using the compensation angles.

The compensation angles δ_{comp} depend on the network conditions and can be calculated for the zero and negative-sequence system using the following formulas:

$$\delta_{comp,0} = \arg\left(\frac{\underline{Z}_{A,0} + \underline{Z}_{B,0} + \underline{Z}_{L,0}}{(1-m)\underline{Z}_{L,0} + \underline{Z}_{B,0}}\right)$$

[fo_kompwi_nullsys_impber, 1, en_US]

$$\delta_{comp,2} = \arg\left(\frac{\underline{Z}_{A,2} + \underline{Z}_{B,2} + \underline{Z}_{L,2}}{(1-m)\underline{Z}_{L,2} + \underline{Z}_{B,2}}\right)$$

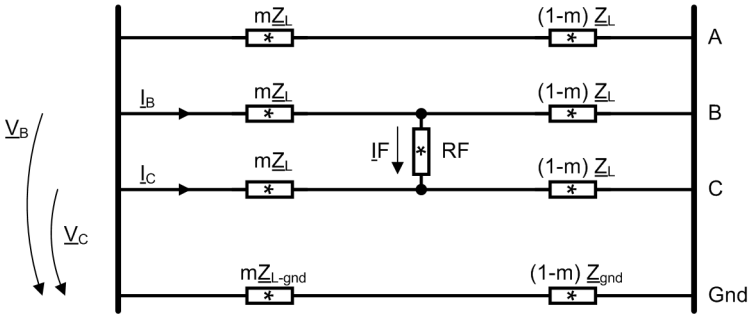
[fo_kompwi_gegensys_impber, 1, en_US]

With:

$\underline{Z}_{A,0}$, $\underline{Z}_{B,0}$	Source impedances in zero-sequence system
$\underline{Z}_{L,0}$	Line impedance in zero-sequence system
m	Proportionate distance to the fault
$\delta_{comp,0}$	Compensation angle in zero-sequence system
$\underline{Z}_{A,2}$, $\underline{Z}_{B,2}$	Source impedances in negative-sequence system
$\underline{Z}_{L,2}$	Line impedance in negative-sequence system
$\delta_{comp,2}$	Compensation angle in negative-sequence system

Impedance Calculation for Phase-to-Phase Loops

A 2-phase short circuit B-C is assumed as an example for the calculation:



[dw_llschleife_rmd, 3, en_US]

Figure 6-586 Short Circuit of a Phase-to-Phase Loop

The loop equation for the calculation of the phase-to-phase loop is:

$$\underline{V}_{BC} = m \cdot \underline{Z}_L \cdot (\underline{I}_B - \underline{I}_C) + RF \cdot \underline{I}F$$

[fo schl II ohne icomp, 2, en_US]

Thus, **X** is calculated as follows:

$$X = \frac{\mathrm{Im}\left\{\underline{V}_{BC} \cdot \left[\underline{I}_{subst} \cdot e^{j\delta_{comp}}\right]^*\right\}}{\mathrm{Im}\left\{\underline{Z}_L / |\underline{Z}_L| \cdot (\underline{I}_B - \underline{I}_C) \cdot \left[\underline{I}_{subst} \cdot e^{j\delta_{comp}}\right]^*\right\}} \cdot \sin\varphi$$

[fo xf impber LLschl, 2, en_US]

Whereby the following applies for the B-C loop: $\underline{I}_{subst} = (\underline{a} - \underline{a}^2) \cdot \underline{I}_2$ and $\underline{a} = e^{j120°}$.

The rotation of the negative-sequence system, which is dependent on the fault loop, performs the fault-locator algorithm internally.

RF is calculated as follows:

$$R = \frac{\mathrm{Im}\left\{\underline{V}_{BC} \cdot \left[\underline{Z}_L \cdot (\underline{I}_B - \underline{I}_C)\right]^*\right\}}{\mathrm{Im}\left\{2 \cdot \underline{I}_{subst} \cdot \left[\underline{Z}_L \cdot (\underline{I}_B - \underline{I}_C)\right]^*\right\}} + X \cdot \mathrm{ctg}(\varphi)$$

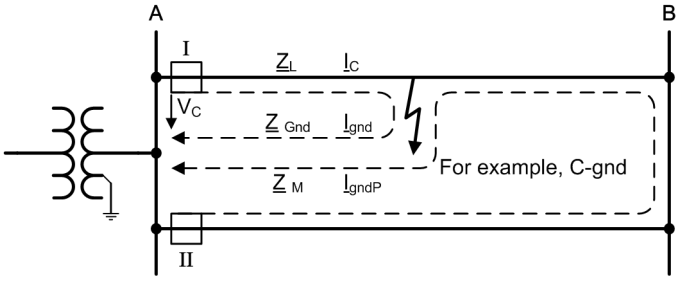
[fo rf impber LLschl, 4, en_US]

Measured-Value Correction for Parallel Lines

For ground faults on double lines, the values determined for the impedance calculation are influenced by the coupling of the ground impedances of both line systems. Without special measures, this leads to measuring errors in the impedance-calculation result. The device is therefore equipped with parallel-line compensation. This parallel-line compensation considers the ground current of the parallel line in the line equation and thereby compensates the coupling influence, similar to the determination of the distance in distance protection. To this end, you must connect the ground current of the parallel line to the device and configure it. The parallel-line compensation only provides correct values for 1-phase short circuits on the line to be protected.

Compensation is not possible for faults located externally, including those on the parallel line, and does not improve the measured values.

You can activate and deactivate the parallel-line compensation with the parameter **`Parallel-line compensat.`**. Furthermore, the parallel-line compensation is only released, if the ratio between the calculated ground current $\underline{I}_{gnd}$ of the particular line and the ground current of the parallel line $\underline{I}_{gndP}$ is above the parameterized threshold **`Gnd.curr.ratio(MutComp)`**.



[dw_parkomp_L3-E, 1, en_US]

Figure 6-587 Ground Fault on a Double Line

The impact of the parallel-line compensation is calculated as follows:

Calculation without load-current compensation:

$$\underline{V}_C = \underline{I}_C \cdot m \cdot \underline{Z}_L - \underline{I}_{gnd} \cdot m \cdot \underline{Z}_{gnd} - \underline{I}_{gndP} \cdot m \cdot \underline{Z}_{0M}/3$$

[fo_parkomp1, 1, en_US]

$$\underline{V}_C = \underline{I}_C \cdot m \cdot (R_L + jX_L) - \underline{I}_{gnd} \cdot m \cdot (k_r \cdot R_L + jk_x \cdot X_L) - I_{gndP} \cdot m \cdot (k_{mR} \cdot R_L + jk_{mX} \cdot X_L)$$

[fo_parkomp2, 1, en_US]

I_{gndP} is the ground current of the parallel line. The ratios $k_{mR} = R_{0M}/3R_{ph}$ and $k_{mx} = X_{0M}/3X_{ph}$ are line constants that result from the geometry of the double line and the suitability of the grounding.

Calculation with load-current compensation:

$$\underline{V}_C = \underline{I}_C \cdot m \cdot \underline{Z}_L - \underline{I}_{gnd} \cdot m \cdot \underline{Z}_{gnd} - \underline{I}_{gndP} \cdot m \cdot \underline{Z}_{0M}/3 + R_F \cdot \underline{I}_F$$

[fo_parkomp1_rmd, 1, en_US]

$$\underline{V}_C = m \cdot \underline{Z}_L\left(\underline{I}_C - \underline{I}_{gnd} \cdot \underline{k}_0 - \underline{I}_{gndP} \cdot \underline{k}_{0M}\right) + R_F \cdot \underline{I}_F$$

[fo_parkomp2_rmd, 1, en_US]

The factor $\underline{k}_{0M} = \underline{Z}_{0M}/(3\underline{Z}_{ph})$ is a line constant that results from the geometry of the double line and the suitability of the grounding.

With:

$\underline{Z}_{0M}$	Coupling impedance in zero-sequence system
R_{0M}	Coupling resistance in zero-sequence system
X_{0M}	Coupling reactance in zero-sequence system
$\underline{k}_{0M}$	Coupling factor in zero-sequence system

6.49.4 Application and Setting Notes

The function requires the following key line data to calculate fault distance:

- Reactance per unit length of the line per kilometer or per mile
- Line length for the correct output of the fault distance as a percentage of the line length
- Residual-compensation factors in the setting format **Kr** and **Kx** or **K0** and **Angle (K0)**.

Parameter: Start

- Recommended setting value **(_:101) Start** = ***with going pickup***

The **Start** parameter is used to define the criterion for starting the fault location.

Parameter Value	Description
with going pickup	If a pickup signal of the protection functions designated for the start has dropped out, the fault-location determination starts.
with operate	If one of the protection functions designated for start has reported the tripping and the pickup has dropped out, the fault-location determination starts.

As an alternative, the fault locator can be started using external binary input.

Parameter: Parallel-Line Compensation

- Default setting **(_:102) Parallel-line compensat.** = ***no***

The parameter **Parallel-line compensat.** is only visible if the ground current of the parallel line is connected to the **Line** function group.

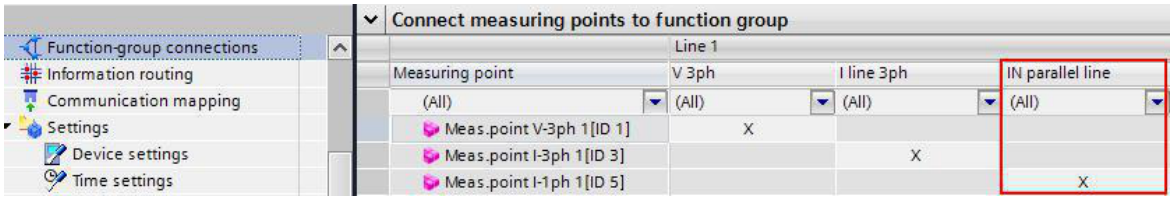


Figure 6-588 Routing in DIGSI

If you wish to apply the parallel-line compensation for double lines, set the **Parallel-line compensat.** parameter to ***yes***.

Parameter Value	Description
no	The parallel-line compensation does not become effective with this setting.
yes	The parallel-line compensation becomes effective with this setting.

The following conditions have to be fulfilled so that the parallel-line compensation functions:

- Connect the ground current of the parallel line in the correct polarity to an additional current input.
- Set the input used for the parallel current in the correct ratio to the phase currents for the power-system data.

  The parallel-line compensation is carried out only if the ground current of the line to be protected (I_{gnd}) is greater than the ground current of the parallel line (I_{gndP}) evaluated with the parameter **Gnd.curr.ratio(MutComp)**.

  Siemens recommends keeping the default setting **Gnd.curr.ratio(MutComp)** = ***85*** **%** . In highly unbalanced system conditions and if the coupling factor is very small (XM/XL less than 0.4), a smaller value may be advisable.
- Set the coupling impedances to the parallel system for the line data.

Parameter: Load Compensation

- Default setting **(_:103) Load compensation** = ***no***

With the **Load compensation** parameter, you can correct measuring errors for 1-phase and 2-phase short circuits on lines fed on both sides.

Parameter Value	Description
no	The load compensation does not become effective with this setting.
yes	The load compensation becomes effective with this setting. If you use the load compensation, the following parameters are relevant and are shown automatically: • **(_:104) Substitute for IF** • **(_:106) Comp. angle zero seq.** • **(_:107) Comp. angle neg. seq.** If the distance protection operates with the reactance method, Siemens recommends switching on the load compensation.

Parameter: Substitute for IF

- Default setting **(_:104) Substitute for IF** = ***3I0***

The parameter **Substitute for IF** is only visible and relevant if you use the load compensation.

With the **Substitute for IF** parameter, for ground-impedance loops, you define which substitute value to use at the fault location for the fault current IF that cannot be measured due to the fault resistance.

First, calculate the compensation angles for the zero-sequence system and the negative-sequence system. Set the parameter **Substitute for IF** according to the smaller compensation angle. The smaller compensation angle indicates that the associated system (zero-sequence or negative-sequence system) is more homogeneous and that the fault current can be approximated in a better way through the fault resistance at the fault location.

Parameter: Compensation Angle for Zero-Sequence System/Negative-Sequence System

- Default setting **(_:106) Comp. angle zero seq.** = ***0.00°***
- Default setting **(_:107) Comp. angle neg. seq.** = ***0.00°***

The parameters **Comp. angle zero seq.** and **Comp. angle neg. seq.** are only visible and relevant if you use the load compensation.

If you have determined an angle difference between the measured $3I_0$ or $3I_2$ and I_F based on network model tests or calculations, you can compensate this with the parameters **Comp. angle zero seq.** or parameter **Comp. angle neg. seq.**.

A setting of the compensation angle deviating from 0 is only relevant for non-homogeneous systems.

With the **Comp. angle zero seq.** parameter, you compensate the angle difference between the $3I_0$ calculated by the device and the fault current I_F.

With the **Comp. angle neg. seq.** parameter, you compensate the angle difference between the $3I_2$ calculated by the device and the fault current I_F.



NOTE

If you use the **Fault locator** function in the **Line** function group, the function operates with the line parameters of the function group.

If you use the **Fault locator** function in the **Voltage/current 3-phase** function group, you must enter the following line parameters in the **Voltage/current 3-phase** function group.

Parameter: X per length unit

- Default setting **(_:113) X per length unit** = *0.0525 Ω/km*

With the **X per length unit** parameter, you set the reactance per unit length for the line to be protected. You set the **X per length unit** parameter as a relative value in Ω/km or Ω/miles.

Parameter: Line length

- Default setting **(_:114) Line length** = *60 km*

With the **Line length** parameter, you can set the length of the line to be protected as a unit of length in km or miles.

Parameter: Line angle

- Default setting **(_:108) Line angle** = *85.00°*

Calculate the setting value for the parameter **Line angle** from the line constants for the line to be protected as follows:

$$\tan\varphi = \frac{X_L}{R_L} \qquad \text{or} \qquad \varphi = \arctan\left(\frac{X_L}{R_L}\right)$$

[fo_lwinkl, 1, en_US]

where:

R_L	Resistance of the line to be protected
X_L	Reactance of the line to be protected

EXAMPLE

110-kV overhead line, 150 mm² with the data

$R'_1 = 0.19\ \Omega/\text{km}$

$X'_1 = 0.42\ \Omega/\text{km}$

You calculate the setting value for the line angle as follows:

$$\tan\varphi = \frac{X_L}{R_L} = \frac{X'_1}{R'_1} = \frac{0.42\ \Omega/\text{km}}{0.19\ \Omega/\text{km}} = 2.21$$

[fo_tan_phi, 1, en_US]

$$\arctan(2.21) = 65.7°$$

[fo_arctan_phi, 1, en_US]

Parameter: Kr and Kx

- Default setting **(_:104) Kr** = *1.00*
- Default setting **(_:105) Kx** = *1.00*

The **Kr** and **Kx** parameters are used to set the residual compensation factors as scalar values. The **Kr** and **Kx** parameters are relevant for the **Fault locator** function.

Calculate the setting values for the parameters **Kr** and **Kx** from the line data as follows:

Resistance ratio	Reactance ratio
$Kr = \frac{R_{gnd}}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1\right)$	$Kx = \frac{X_{gnd}}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1\right)$

where:

R_0	Zero-sequence system resistance of the line
X_0	Zero-sequence system reactance of the line
R_1	Positive-sequence system resistance of the line
X_1	Positive-sequence system reactance of the line

This data can either be used for the entire line or as length-related values, since the quotients are length-independent. You can calculate the data both from the primary values and from the secondary values.

EXAMPLE

110-kV overhead line, 150 mm² with the data:

R_1/s	0.19 Ω/km positive-sequence system resistance
X_1/s	0.42 Ω/km positive-sequence system reactance
R_0/s	0.53 Ω/km zero-sequence system resistance
X_0/s	1.19 Ω/km zero-sequence system reactance
s	Line length

You receive the following setting values for the parameters **Kr** and **Kx**:

$$k_r = \frac{R_{Gnd}}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1\right) = \frac{1}{3} \cdot \left(\frac{0.53\ \Omega/km}{0.19\ \Omega/km} - 1\right) = 0.60$$

[fo_kr, 1, en_US]

$$k_x = \frac{X_{Gnd}}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1\right) = \frac{1}{3} \cdot \left(\frac{1.19\ \Omega/km}{0.42\ \Omega/km} - 1\right) = 0.61$$

[fo_kx, 1, en_US]

Parameter: K0 and Angle (K0)

- Default setting **K0** = ***1.000***
- Default setting **Angle (K0)** = ***0.00°***

NOTE

The visibility of the **K0** and **Angle (K0)** parameters depends on the selected setting format of the residual compensation factors. The parameters **K0** and **Angle (K0)** are only visible if you have set the parameter **Set. format residu. comp.** = ***K0*** for the device. The **Set. format residu. comp.** parameter can be found in the DIGSI 5 project tree under **Name of the device** → **Parameter** → **Device settings**.

The **K0** and **Angle (K0)** parameters are used to set the complex grounding-resistance factor.

Make sure that the line angle is set correctly because the device needs the line angle for calculation of the compensation components from the K0 factor. The complex grounding-resistance factor is defined by the value and the angle. You can calculate the complex grounding-resistance factor from the line data as follows:

$$K_0 = \left|\frac{\underline{Z}_{Gnd}}{\underline{Z}_L}\right| = \left|\frac{1}{3} \cdot \left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1\right)\right|$$

[fo_K01, 1, en_US]

where:

$\underline{Z}_0$	(Complex) zero-sequence impedance
$\underline{Z}_1$	(Complex) positive-sequence impedance

This data can either be used for the entire line or as length-related values, since the quotients are length-independent. You can calculate the data both from the primary values and from the secondary values.

For overhead lines, you can use the values for the calculation because the angles of the zero-sequence system and the positive-sequence system differ only slightly. For cables, however, significant angular differences can occur, as the following example illustrates.

EXAMPLE

110-kV single-conductor liquid-filled cable 3 · 185 mm² Cu with the data:

$\underline{Z}_1/s$	$0.408 \cdot e^{j73^\circ}$ Ω/km positive-sequence impedance
$\underline{Z}_0/s$	$0.632 \cdot e^{j18.4^\circ}$ Ω/km zero-sequence impedance
s	Line length

The values for calculation of the grounding-resistance factor **K0** are:

$$\frac{\underline{Z}_0}{\underline{Z}_1} = \frac{0.632}{0.408} \cdot e^{j(18.4^\circ - 73^\circ)} = 1.55 \cdot e^{-j\,54.6^\circ} = 1.55 \cdot (0.579 - j\,0.815) = 0.898 - j\,1.263$$

[fo_1_k0, 1, en_US]

$$k_0 = \left|\frac{1}{3} \cdot \left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1\right)\right| = \left|\frac{1}{3} \cdot (0.898 - j\,1.263 - 1)\right| = \left|\frac{1}{3} \cdot (-0.102 - j\,1.263)\right|$$

[fo_2_k0, 1, en_US]

The setting value of the parameter **K0** is calculated from:

$$k_0 = \left|\frac{1}{3} \cdot \sqrt{(-0.102^2) + (-1.263^2)}\right| = 0.42$$

[fo_3_k0, 1, en_US]

When determining the angle, take note of the quadrant of the result. The following table lists the quadrants and the angle range obtained from the operational signs of the real and imaginary parts of **K0**.

Real Part	Imaginary Part	tan Phi (K0)	Quadrant/Range		Calculation Method
+	+	+	I	0° to 90°	arc tan (|Im| / |Re|)
+	-	-	IV	-90° to 0°	–arc tan (|Im| / |Re|)
-	-	+	III	-90° to -180°	arc tan (|Im| / |Re|) –180°
-	+	-	II	+90° to +180°	–arc tan (|Im| / |Re|) +180°

In this example, the following setting value for the **Angle (K0)** parameter is obtained:

$$\varphi(K_0) = \arctan\left(\frac{1.263}{0.102}\right) - 180^\circ = -94.6^\circ$$

[fo_phi_K0, 1, en_US]

6.49.5 Settings

Settings for the Instantiation of the Fault Locator in the Line Function Group

Addr.	Parameter	C	Setting Options	Default Setting
Fault locator				
_:1	Fault locator:Mode		• off • on • test	off
_:101	Fault locator:Start		• with operate • with going pickup	with going pickup
_:102	Fault locator:Parallel-line compensat.		• no • yes	yes
_:103	Fault locator:Load compensation		• no • yes	no
_:104	Fault locator:Substitute for IF		• 3I2 • 3I0	3I0
_:106	Fault locator:Comp. angle zero seq.		-40.00 ° to 40.00 °	0.00 °
_:107	Fault locator:Comp. angle neg. seq.		-40.00 ° to 40.00 °	0.00 °

Settings for the Instantiation of the Fault Locator in the VI 3-Ph Function Group

Addr.	Parameter	C	Setting Options	Default Setting
Fault locator				
_:1	Fault locator:Mode		• off • on • test	off
_:101	Fault locator:Start		• with operate • with going pickup	with going pickup
_:103	Fault locator:Load compensation		• no • yes	no
_:122	Fault locator:Substitute for IF		• 3I2 • 3I0	3I0
_:124	Fault locator:Comp. angle zero seq.		-40.00 ° to 40.00 °	0.00 °
_:125	Fault locator:Comp. angle neg. seq.		-40.00 ° to 40.00 °	0.00 °
_:113	Fault locator:X per length unit	1 A	0.0005 Ω/km to 9.5000 Ω/km	0.0525 Ω/km
		5 A	0.0001 Ω/km to 1.9000 Ω/km	0.0105 Ω/km
_:114	Fault locator:Line length		0.10 km to 1000.00 km	60.00 km
_:108	Fault locator:Line angle		10.00 ° to 89.00 °	85.00 °
_:104	Fault locator:Kr		-0.33 to 11.00	1.00
_:105	Fault locator:Kx		-0.33 to 11.00	1.00
_:118	Fault locator:K0		0.000 to 11.000	1.000
_:150	Fault locator:Angle (K0)		-180.00 ° to 180.00 °	0.00 °

6.49.6 Information List

No.	Information	Data Class (Type)	Type
Fault locator			
_:501	Fault locator:>Fault detected phs A	SPS	I
_:502	Fault locator:>Fault detected phs B	SPS	I
_:503	Fault locator:>Fault detected phs C	SPS	I
_:504	Fault locator:>Fault detected gnd.	SPS	I
_:505	Fault locator:>Flt. det. w/o phs.&gnd.	SPS	I
_:506	Fault locator:>Fault locator start	SPS	I
_:54	Fault locator:Inactive	SPS	O
_:52	Fault locator:Behavior	ENS	O
_:53	Fault locator:Health	ENS	O
_:302	Fault locator:Fault resistance prim.	MV	O
_:303	Fault locator:Fault reactance prim.	MV	O
_:308	Fault locator:Fault resistance sec.	MV	O
_:309	Fault locator:Fault reactance sec.	MV	O
_:304	Fault locator:Fault distance	MV	O
_:305	Fault locator:Fault distance in %	MV	O
_:306	Fault locator:Fault loop	ENS	O
_:307	Fault locator:FLO invalid	ENS	O

6.50 Fault Locator Plus

6.50.1 Overview of Functions

The **Fault locator plus** function

- Is used for 2-sided measurement of the distance to the fault location
- Also reliably detects the fault location with 2-sided infeed, faults with ground involvement and with fault resistances
- Can be used for fault-location determination with non-homogeneous lines

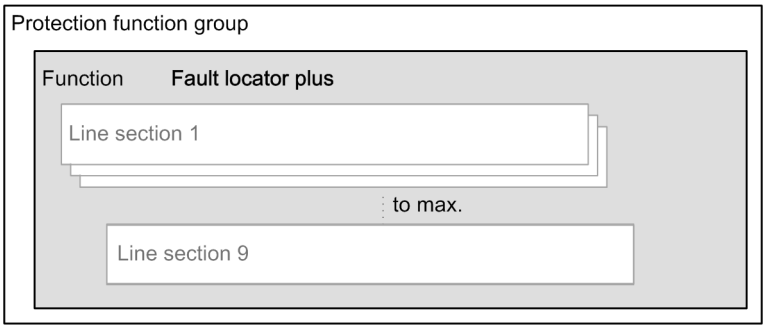
The **Fault locator plus** function calculates the fault location with the measured values of both line ends. For the transmission of the measured values between the line ends, a communication connection must be present via the protection interface.

If 2-sided fault-location determination is not possible, alternatively, the 1-sided method is used with a calculation of the reactance of the short-circuited measurement loops.

Fast fault-location determination and the associated fast fault clearance increase the availability of the line for power transmission in the electrical power system.

6.50.2 Structure of the Function

The **Fault locator plus** function can be used in protection function groups with 3-phase current and voltage measurement.



[dwst fo_double, 1, en_US]

Figure 6-589 Structure/Embedding of the Function

The fault location is calculated based on the line parameters. Fault-location determination is always carried out ***with going pickup*** of the short-circuit protection. There is an option to limit fault-location determination to cases with tripping (setting the value for the parameter **Start** = ***with operate***).

For inhomogeneous lines, such as overhead line/cable sections, you can set parameters for separate line sections with dedicated line data. You can instantiate a maximum of 9 line sections.

For 2-sided fault-location determination, the measured values of both line ends must to be available at each line end. For this purpose, a SIPROTEC 5 device must be installed with a protection interface at each end of the area to be protected. The devices exchange their measurands via protection interface. The measurands are encrypted in digital telegrams and transmitted via protection communication. The current and voltage transformers selectively delimit the protection range.

2-sided fault-location determination is not possible with the function **Fault locator plus** under the following conditions, for example:

- The fault is not located on the line.
- The devices at the line ends do not have a protection interface.

- Protection communication is disrupted.
- With a 1-sided infeed, a metallic fault occurs.

NOTE

If 2-sided fault-location determination is not possible, the function **Fault locator plus** alternatively works with the 1-sided method for fault-location determination.

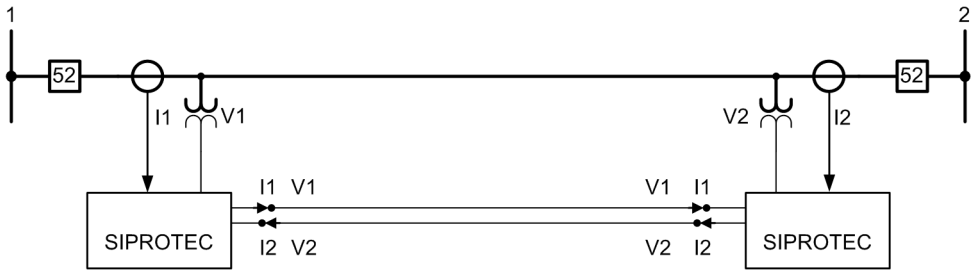


Figure 6-590 Data Exchange for 2 Devices, Each With Protection Communication

Fault locator plus can be started as follows:

- Via the phase-segregated binary inputs *>Fault detected phs A*, *>Fault detected phs B*, *>Fault detected phs C*, and *>Fault detected gnd.*
- Via differential protection
- Via distance protection
- Via directional overcurrent protection, phases or ground
- Via overcurrent protection, phases or ground
- Via the non-phase-segregated binary input *>Flt. det. w/o phs.&gnd.*

If multiple protection functions are operating in parallel, the fault locator is only started by the function pickup with the highest priority. The functions are listed in decreasing priority.

Connection Types of the Current and Voltage Transformers

NOTE

The function **Fault locator plus** does not work with all possible current and voltage transformer connection types.

An error message is displayed in DIGSI 5 if the function cannot work with the set connection type. In this case, check the current and voltage transformer connection type.

You can find the **CT connection** or **VT connection** settings in DIGSI 5 under **Power system** → **Meas.point I-3ph** or **System data** → **Meas.point V-3ph**.

The **Fault locator plus** function only works with the following current and voltage transformer connection types (see parameter value).

Parameter	Parameter Value
CT connection	• ***3-phase + IN-separate*** • ***3-phase + IN*** • ***3-phase***
VT connection	• ***3 ph-to-gnd volt. + VN*** • ***3 ph-to-gnd voltages***

6.50.3 Function Description

Starting Conditions

Each protection function that can start the fault locator also provides **Fault locator plus** with information on the pickup and tripping times. If multiple protection functions pick up at the same time, **Fault locator plus** is started only by the function with the highest priority.

The fault locator uses the pickup and tripping information for the protection function being started to form its own measurand memory for the following calculations. Depending on the pickup duration of the protection function, the measurand memory is positioned such that it contains prefault processes, short-circuit processes, and switch-off processes. If the pickup lasts for a longer time, only the short-circuit processes and switch-off processes are recorded by the measurand memory. The fault-location determination always starts only after the dropout of the pickup.

Fault-location determination is also possible via the starting condition ***with going pickup***, if the protection device only picks up and does not trigger. Fault-location determination is then performed via the starting condition ***with operate*** only if the protection device has reported the tripping and the pickup has dropped out.

Alternatively, the **Fault locator** can be started via one or more binary inputs. If the phase-segregated indications *>Fault detected phs A*, *>Fault detected phs B*, *>Fault detected phs C*, and *>Fault detected gnd.* are routed in the DIGSI 5 information routing, the **Fault locator** interprets the binary inputs as a phase-segregated external protection function and treats them with the highest priority.

NOTE

The phase-segregated start of the fault locator will only be possible if you have routed all 4 indications in the DIGSI 5 information routing.

When routing the binary input *>Flt. det. w/o phs.&gnd.*, the binary input is interpreted as a non-segregated external protection function and is treated with the lowest priority. The fault locator starts when the binary input drops out.

When the parameter ***with operate*** is set and the **Fault locator** is started via the binary input, the fault-location determination is started only when a device-internal protection function generates an operate indication, or when the binary *>Fault locator start* input is activated in addition to the above mentioned binary inputs.

Fault locator plus	21.1611		*	*	*	*
General	21.1611.2311		*	*	*	*
>Block function	21.1611.2311.81	SPS				
>Fault detected phs A	21.1611.2311.501	SPS	H			
>Fault detected phs B	21.1611.2311.502	SPS		H		
>Fault detected phs C	21.1611.2311.503	SPS			H	
>Fault detected gnd.	21.1611.2311.504	SPS				H
>Flt. det. w/o phs.&gnd.	21.1611.2311.505	SPS				
>Fault locator start	21.1611.2311.506	SPS				

[scRang_FOplus, 1, en_US]

Figure 6-591 Routing Matrix for the Triggering of the Fault Locator via Binary Input

Definition of the Line Sections

For inhomogeneous lines, for example, cable/overhead line setions, you can define several line sections and set the line parameters separately for each line section.

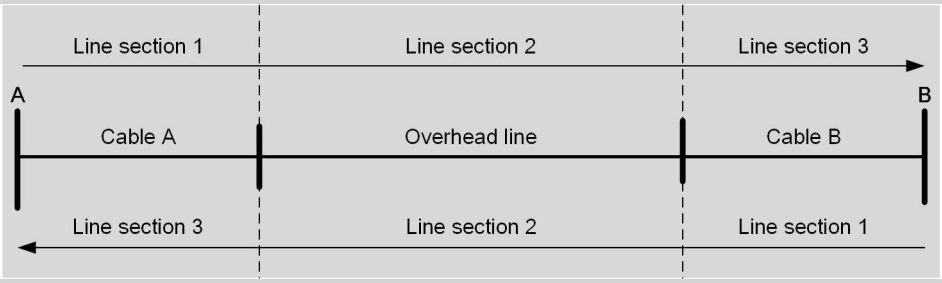
NOTE

If you have an inhomogeneous line with several line sections, you must enter the line sections in the device at the opposite end back-to-front. The function checks the correct parameter configuration and issues the inconsistency indication *(_:2311:310) Line sect. setting err.* in the case of a fault.

EXAMPLE:

The line between line ends **A** and **B** consists of the line sections Cable **A** – overhead line – Cable **B**. Consider the following with the parameter configuration of the function:

- Instantiate each of 3 line ends in the device at line end **A** and at line end **B** and enter the line data for each section.
- Ensure that you enter the data for the line sections in device **B** back-to-front to device **A**.



[dw def line sections, 1, en_US]

Figure 6-592 Line with 3 Line Sections

Installation Site	Definition of Line Sections
Device **A**	Define the line sections on device **A** as follows: • Line section **1**: Line data from cable **A** • Line section **2**: Line data from the overhead line • Line section **3**: Line data from cable **B**
Device **B**	Define the line sections on device **B** as follows: • Line section **1**: Line data from cable **B** • Line section **2**: Line data from the overhead line • Line section **3**: Line data from cable **A**

You can rename the instantiated line sections.

Algorithm for 2-Sided Fault-Location Determination

For an unbranched line with known current and known voltage on the line ends, the voltage can be calculated at any position x of the line. The algorithm calculates the voltage of both sides of the line. At the fault location itself, the voltage calculated from both line ends must correspond. If both voltage curves are displayed graphically, their intersection is the position of the fault location $\mathbf{d_{FL}}$. *Figure 6-593* illustrates the basic principle of 2-sided fault-location determination. The algorithm calculates the voltage curves with the measured data of the protection devices of both line ends **A** and **B**. The voltage curve is not linear and is calculated as follows with the telegraph equation:

$$\underline{V}_d(d) = \cosh\left(\underline{\gamma} \cdot d\right) \cdot \underline{V} - \underline{Z} \cdot \sinh(\underline{\gamma} \cdot d) \cdot I$$

[fo telegraph equation line, 1, en_US]

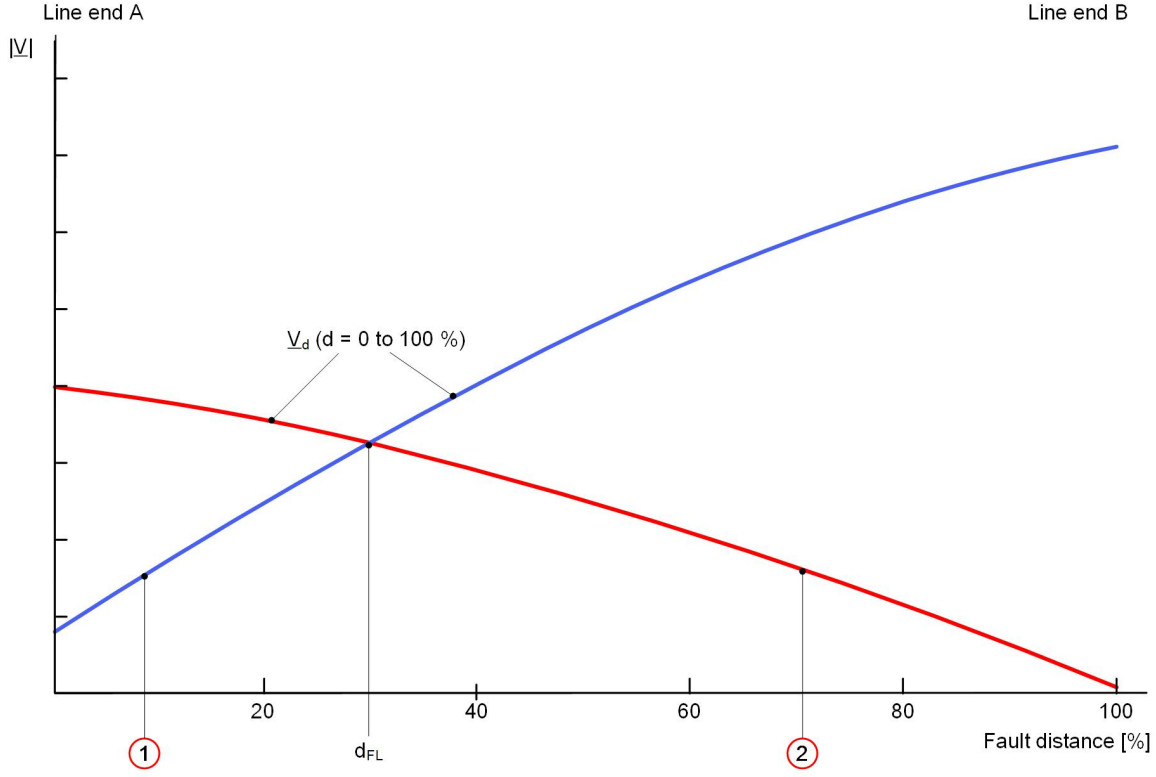
with

$\underline{\gamma} = j\omega \cdot \sqrt{L' \cdot C'}$ Wave propagation constant

$\underline{Z} = j\omega \sqrt{\frac{L'}{C'}}$ Wave impedance

d Distance

$\underline{V}$, $\underline{I}$ Measured values on the line ends



[dw fault locator voltage char, 1, en_US]

Figure 6-593 Voltage Curve, Calculated from Both Sides of the Line

with:

1 Voltage curve calculated with the measured values at line end **A**

2 Voltage curve calculated with the measured values at line end **B**

d_{FL} Fault location

The algorithm of the 2-sided fault-location determination offers the following advantages compared to the 1-sided method:

- Correct fault-location determination is also possible with power flow, 2-sided infeed and high fault resistances.
- The algorithm is independent from the zero-sequence system and therefore also from its influencing variables, such as inductive couplings of parallel lines.
- An imprecise setting of the residual impedance compensation factors has no influence on the precision of the fault location.

Output of the Fault Location

The following results for the fault location are issued:

- The fault resistance in Ω primary and secondary
- The fault transfer resistance in Ω primary and secondary
  This value is only issued, if 2-sided fault-location determination is possible.
- The fault reactance up to the fault location in Ω primary and secondary
- The fault distance ***d*** in km or miles
- The fault distance ***d*** in percentage of the line length
- The number of the line section, in which the fault was localized
- The selected fault loop for calculation of the fault location

The indication of distance in kilometers, miles, or percent is also applicable only for inhomogeneous line sections (for example, overhead line cable routes). If you have defined several line sections for an inhomogeneous line, the **Fault locator plus** function issues the number of the faulty line section.

NOTE

If 2-sided fault-location determination is not possible by the **Fault locator plus** function, the function works automatically with the algorithm for the 1-sided fault-location determination.
You can find the description for the 1-sided fault locator in *6.49.1 Overview of Functions*.

6.50.4 Application and Setting Notes

The following line data are relevant for the 2-sided fault-location determination:

- Reactance per unit length of the line per kilometer or per mile
- Line length for the correct output of the fault distance as a percentage of the line length

The following parameters are only relevant for the 1-sided fault-location determination:

- **`Parallel-line compensat.`**
- **`Gnd.curr.ratio(MutComp)`**
- **`Load compensation`**
- The residual compensation factors in the setting format **`Kr`** and **`Kx`** or **`K0`** and **`Angle (K0)`**.

NOTE

Parallel-line compensation and load compensation are only possible with homogeneous lines.
If you define more than one line section and set the parameter **`Parallel-line compensat.`** or **`Load compensation`** = ***`yes`***, DIGSI reports an inconsistency.

Parameter: Start

- Recommended setting value **`(_:2311:101) Start`** = ***`with going pickup`***

With the parameter **`Start`**, you define the criterion for starting the fault location.

Parameter Value	Description
`with going pickup`	If a pickup signal of the protection functions designated for the startup has dropped out, fault-location determination starts.
`with operate`	If one of the protection functions designated for startup has reported the tripping and the pickup has dropped out, fault-location determination starts.

As an alternative, the fault locator can be started using an external binary input.

Parameter: Parallel-line compensat.

- Default setting **(_:2311:102) Parallel-line compensat.** = ***no***

The parameter **Parallel-line compensat.** is only visible when the ground current of the parallel line is connected to the **Line** function group.

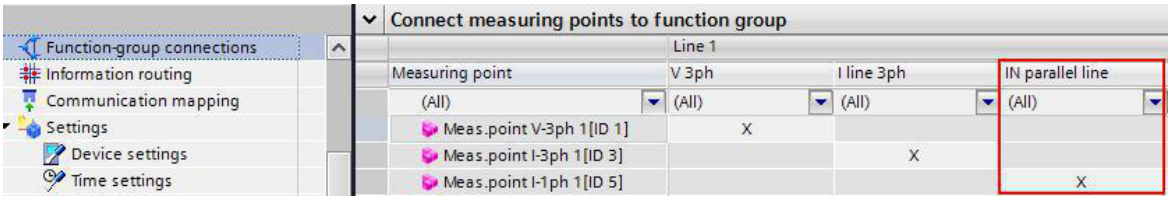


Figure 6-594 Routing in DIGSI

This parameter is only relevant for 1-sided fault-location determination.
If you wish to apply the parallel-line compensation for double lines, set the **Parallel-line compensat.** parameter to ***yes***.

Parameter Value	Description
no	The parallel-line compensation is not effective with this setting.
yes	The parallel-line compensation is effective with this setting.

The following conditions have to be fulfilled so that the parallel-line compensation functions:

- Connect the ground current of the parallel line in the correct polarity to an additional current input.
- Set the input used for the parallel current in the correct ratio to the phase currents for the power-system data.

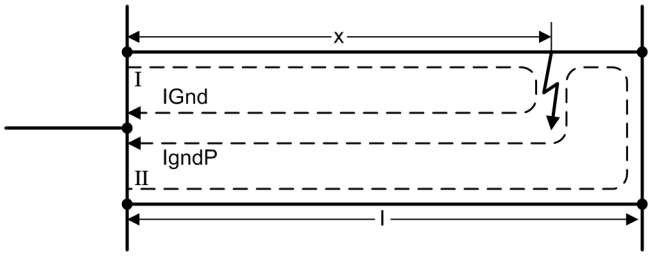
  Parallel-line compensation is only carried out if the ground current of the line to be protected (I_{gnd}) is greater than the ground current of the parallel line (I_{gndP}) evaluated with the parameter **Gnd.curr.ratio(MutComp)**.

  Siemens recommends keeping the default setting **Gnd.curr.ratio(MutComp)** = ***85*** **%**. In highly unbalanced system conditions and if the coupling factor is very small (XM/XL less than 0.4), a smaller value may be advisable.
- Set the coupling impedances to the parallel system correctly for the line data.

Parameter: Gnd.curr.ratio(MutComp)

- Recommended setting value **(_:2311:109) Gnd.curr.ratio(MutComp)** = ***85*** **%**

This parameter is only relevant for the 1-sided fault-location determination.
With the **Gnd.curr.ratio(MutComp)** parameter, you define the ground-current balance for parallel-line compensation. This parameter is important for parallel-line compensation in the event of ground faults outside of the line to be protected.
For the ground-current balance of the distance protection, the setting value indicates the current ratio I_{gnd}/I_{gndP} for the protection device at installation site II (see *Figure 5-48*).



[dwparkomrw-161013, 1, en_US]

Figure 6-595 Radius of Parallel-Line Compensation at II

Parallel-line compensation is only carried out if the ground current of the line to be protected (I_{gnd}) is greater than the ground current of the parallel line (I_{gndP}) evaluated with the parameter **Gnd.curr.ratio(MutComp)**.

Siemens recommends keeping the default setting **Gnd.curr.ratio(MutComp)** = ***85 %*** . In highly unbalanced system conditions and if the coupling factor is very small (XM/XL less than 0.4), a smaller value may be advisable.

Parameter: Load compensation

- Default setting **(_:2311:103) Load compensation** = ***no***

This parameter is only relevant for 1-sided fault-location determination.

With the parameter **Load compensation**, you correct measuring errors for 1-phase short circuits on lines fed on both sides. This is the case for overhead lines without grounding cable or with unfavorable grounding conditions of the towers, if high contact resistances can occur in the event of 1-phase short circuits.

Parameter Value	Description
no	The load compensation is not effective with this setting.
yes	The load compensation is effective with this setting. If you operate using load compensation, the following parameters are relevant and are shown automatically: • **Substitute for IF** • **Comp. angle zero seq.** • **Comp. angle neg. seq.** If distance protection operates with the reactance method, Siemens recommends switching on load compensation.

Parameter: Substitute for IF

- Default setting **(_:2311:104) Substitute for IF** = ***3I0***

The parameter **Substitute for IF** is only visible and relevant if you operate using load compensation.

With the parameter **Substitute for IF**, you define which substitute value can be used in ground-impedance loops for the unmeasurable fault current IF and replace it with the fault resistance at the fault location.

First, calculate the compensation angle for the zero-sequence system and the negative-sequence system. Set the parameter **Substitute for IF** for the relatively smaller compensation angle. The relatively smaller compensation angle indicates that the associated system (zero-sequence and negative-sequence system) is more homogeneous and the fault current can be approximated better through the fault resistance at the fault location.

Parameter: Compensation Angle for Zero-Sequence System/Negative-Sequence System

- Default setting **(_:2311:106) Comp. angle zero seq.** = ***0.00°***
- Default setting **(_:2311:107) Comp. angle neg. seq.** = ***0.00°***

The parameters **Comp. angle zero seq.** and **Comp. angle neg. seq.** are only visible and relevant if you operate using load compensation.
If, based on network model tests or calculations, an angle difference between the measured $3I_0$ or $3I_2$ and I_F was determined, this can be compensated for with the parameter **Comp. angle zero seq.** or the parameter **Comp. angle neg. seq.**.
A setting of the compensation angle deviating from 0 is only relevant for non-homogeneous systems.
When using the **Comp. angle zero seq.** parameter, the angle difference between the $3I_0$ calculated by the device and the fault current I_F is being compensated.
When using the **Comp. angle neg. seq.** parameter, the angle difference between the $3I_2$ calculated by the device and the fault current I_F is being compensated.

NOTE

For non-homogeneous lines, for example, cable/overhead line routes, you can define several line sections and set the line parameters separately for each line section.
You can find further information on the line parameters in *6.49.4 Application and Setting Notes*.

Parameter: C1 per length unit

- Default setting **(_:16921:112) C1 per length unit** = ***0.010 µF/km***

With the **C1 per length unit** parameter, you specify the capacitance per unit length in the positive-sequence system for the line to be protected. You set the **C1 per length unit** parameter as a relative value in µF/km or µF/miles. The capacitance per unit length in the positive-sequence system is identical to the operating capacitance c_b'.

Parameter: C0 per length unit

- Default setting **(_:16921:148) C0 per length unit** = ***0.010 µF/km***

With the **C0 per length unit** parameter, you specify the capacitance per unit length in the zero-sequence system for the line to be protected. You set the **C0 per length unit** parameter as a relative value in µF/km or µF/miles. The capacitance per unit length in the zero-sequence system is identical to the ground capacitance c_{gnd}'.

Parameter: X per length unit

- Default setting **(_:16921:113) X per length unit** = ***0.0525 Ω/km***

With the **X per length unit** parameter, you set the reactance per unit length for the line to be protected. You set the **X per length unit** parameter as a relative value in Ω/km or Ω/miles.

Parameter: Line length

- Default setting **(_:16921:114) Line length** = ***60 km***

With the **Line length** parameter, you can set the length of the line to be protected as a unit of length in km or miles.

Parameter: Line angle

- Default setting **(_:16921:108) Line angle** = ***85.00°***

Calculate the setting value for the parameter **Line angle** from the line constants for the line to be protected as follows:

$$\tan\varphi = \frac{X_L}{R_L} \qquad \text{or} \qquad \varphi = \arctan\left(\frac{X_L}{R_L}\right)$$

[fo_lwinkl, 1, en_US]

where:

R_L	Resistance of the line to be protected
X_L	Reactance of the line to be protected

EXAMPLE

110 kV overhead line 150 mm² with the data

$R'_1 = 0.19\ \Omega/km$

$X'_1 = 0.42\ \Omega/km$

You calculate the setting value for the line angle as follows:

$$\tan\varphi = \frac{X_L}{R_L} = \frac{X'_1}{R'_1} = \frac{0.42\ \Omega/km}{0.19\ \Omega/km} = 2.21$$

[fo_tan_phi, 1, en_US]

$$\arctan(2.21) = 65.7°$$

[fo_arctan_phi, 1, en_US]

Parameter: Kr and Kx

- Default setting **(_:16921:104) Kr** = ***1.00***
- Default setting **(_:16921:105) Kx** = ***1.00***

The **Kr** and **Kx** parameters are used to set the residual compensation factors as scalar values. The **Kr** and **Kx** parameters are relevant for the **Fault locator** function.

Calculate the setting values for the parameters **Kr** and **Kx** from the line data as follows:

Resistance ratio	Reactance ratio
$Kr = \frac{R_{gnd}}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1 \right)$	$Kx = \frac{X_{gnd}}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1 \right)$

where:

R_0	Zero-sequence system resistance of the line
X_0	Zero-sequence system reactance of the line
R_1	Positive-sequence system resistance of the line
X_1	Positive-sequence system reactance of the line

This data can either be used for the entire line or as length-related values, since the quotients are length-independent. You can calculate the data both from the primary values and from the secondary values.

EXAMPLE

110-kV overhead line 150 mm² with the data:

R_1/s	0.19 Ω/km positive-sequence system resistance
X_1/s	0.42 Ω/km positive-sequence system reactance
R_0/s	0.53 Ω/km zero-sequence system resistance
X_0/s	1.19 Ω/km zero-sequence system reactance
s	Line length

You receive the following setting values for the parameters **Kr** and **Kx**:

$$k_r = \frac{R_{Gnd}}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1\right) = \frac{1}{3} \cdot \left(\frac{0.53\ \Omega/km}{0.19\ \Omega/km} - 1\right) = 0.60$$

[fo_kr, 1, en_US]

$$k_x = \frac{X_{Gnd}}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1\right) = \frac{1}{3} \cdot \left(\frac{1.19\ \Omega/km}{0.42\ \Omega/km} - 1\right) = 0.61$$

[fo_kx, 1, en_US]

Parameter: K0 and Angle (K0)

- Default setting **(_:16921:118) K0** = ***1.000***
- Default setting **(_:16921:150) Angle (K0)** = ***0.00°***

NOTE

The visibility of the **K0** and **Angle (K0)** parameters depends on the selected setting format of the residual compensation factors. The parameters **K0** and **Angle (K0)** are only visible if you have set the parameter **Set. format residu. comp.** = ***K0*** for the device. You can find the parameter **Set. format residu. comp.** in the DIGSI 5 project tree under **Name of the device** → **Settings** → **Device settings**.

The **K0** and **Angle (K0)** parameters are used to set the complex grounding-resistance factor.

Make sure that the line angle is set correctly because the device needs the line angle for calculation of the compensation components from the K0 factor. The complex grounding-resistance factor is defined by the absolute value and the angle. You can calculate the complex grounding-resistance factor from the line data as follows:

$$K_0 = \left|\frac{\underline{Z}_{Gnd}}{\underline{Z}_L}\right| = \left|\frac{1}{3} \cdot \left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1\right)\right|$$

[fo_K01, 1, en_US]

where:

$\underline{Z}_0$	(Complex) zero-sequence impedance
$\underline{Z}_1$	(Complex) positive-sequence impedance

This data can either be used for the entire line or as length-related values, since the quotients are length-independent. You can calculate the data both from the primary values and from the secondary values.

For overhead lines, you can use the values for the calculation because the angles of the zero-sequence system and the positive-sequence system differ only slightly. For cables, however, significant angular differences can occur, as the following example illustrates.

EXAMPLE

110-kV single-conductor liquid-filled cable 3 · 185 mm² Cu with the data:

$\underline{Z}_1/s$	$0.408 \cdot e^{j73^\circ}$ Ω/km positive-sequence impedance
$\underline{Z}_0/s$	$0.632 \cdot e^{j18.4^\circ}$ Ω/km zero-sequence impedance
s	Line length

The values for calculation of the grounding-resistance factor **K0** are:

$$\frac{\underline{Z}_0}{\underline{Z}_1} = \frac{0.632}{0.408} \cdot e^{j(18.4^\circ - 73^\circ)} = 1.55 \cdot e^{-j\,54.6^\circ} = 1.55 \cdot (0.579 - j\,0.815) = 0.898 - j\,1.263$$

[fo_1_k0, 1, en_US]

$$k_0 = \left|\frac{1}{3} \cdot \left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1\right)\right| = \left|\frac{1}{3} \cdot (0.898 - j\,1.263 - 1)\right| = \left|\frac{1}{3} \cdot (-0.102 - j\,1.263)\right|$$

[fo_2_k0, 1, en_US]

The setting value of the parameter **K0** is calculated from:

$$k_0 = \left|\frac{1}{3} \cdot \sqrt{(-0.102^2) + (-1.263^2)}\right| = 0.42$$

[fo_3_k0, 1, en_US]

When determining the angle, take note of the quadrant of the result. The following table lists the quadrants and the angle range obtained from the operational signs of the real and imaginary parts of **K0**.

Real Part	Imaginary Part	tan Phi (K0)	Quadrant/Range		Calculation Method
+	+	+	I	0° to 90°	arc tan (|Im| / |Re|)
+	-	-	IV	-90° to 0°	–arc tan (|Im| / |Re|)
-	-	+	III	-90° to -180°	arc tan (|Im| / |Re|) –180°
-	+	-	II	+90° to +180°	–arc tan (|Im| / |Re|) +180°

In this example, the following setting value for the **Angle (K0)** parameter is obtained:

$$\varphi(K_0) = \arctan\left(\frac{1.263}{0.102}\right) - 180° = -94.6°$$

[fo_phi_K0, 1, en_US]

Parameter: Blocking of the auto. recl.

- Default setting **(_:16921:120) Blocking of the auto. recl.** = ***no***

With the parameter **Blocking of the auto. recl.**, with inhomogeneous lines, you can block the **Automatic reclosing** function for faults on individual line sections, for example, on cable sections.

NOTE

The parameter **Blocking of the auto. recl.** is only visible, if you have instantiated the function block **Blk by FtLc. #** in the **Automatic reclosing** function.

You can find the function block **Blk by FtLc. #** in the DIGSI 5 library in the FG **Circuit breaker** → **Automatic reclosing function** → **Bocking by fault locator**.

Parameter Value	Description
no	The **Fault locator plus** function has no impact on the **Automatic reclosing** function.
yes	The **Fault locator plus** function blocks the **Automatic reclosing** function. The blocking only functions if the function block (FB) **Blk by FtLc. #** is instantiated in the **Automatic reclosing** function. The parameter **(_:102) Min. dead time of blocking** is in the FB. Set the parameter **Min. dead time of blocking** to the smallest dead time of all instantiated AREC cycles.

6.50.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Control				
_:2311:1	General:Mode		• off • on • test	off
_:2311:101	General:Start		• with operate • with going pickup	with going pickup
Compensation				
_:2311:102	General:Parallel-line compensat.		• no • yes	no
_:2311:109	General:Gnd.curr.ratio(MutComp)		50 % to 95 %	85 %
_:2311:103	General:Load compensa-tion		• no • yes	no
_:2311:104	General:Substitute for IF		• 3I2 • 3I0	3I0
_:2311:106	General:Comp. angle zero seq.		-40.00 ° to 40.00 °	0.00 °
_:2311:107	General:Comp. angle neg. seq.		-40.00 ° to 40.00 °	0.00 °
Line data 1				
_:16921:112	Line section 1:C1 per length unit	1 A	0.000 µF/km to 100000.000 µF/km	0.010 µF/km
		5 A	0.000 µF/km to 500000.000 µF/km	0.050 µF/km
_:16921:148	Line section 1:C0 per length unit	1 A	0.000 µF/km to 100000.000 µF/km	0.010 µF/km
		5 A	0.000 µF/km to 500000.000 µF/km	0.050 µF/km
_:16921:113	Line section 1:X per length unit	1 A	0.0005 Ω/km to 9.5000 Ω/km	0.0525 Ω/km
		5 A	0.0001 Ω/km to 1.9000 Ω/km	0.0105 Ω/km
_:16921:114	Line section 1:Line length		0.10 km to 1000.00 km	60.00 km
_:16921:108	Line section 1:Line angle		10.00 ° to 89.00 °	85.00 °
_:16921:104	Line section 1:Kr		-0.33 to 11.00	1.00
_:16921:105	Line section 1:Kx		-0.33 to 11.00	1.00
_:16921:118	Line section 1:K0		0.000 to 11.000	1.000
_:16921:150	Line section 1:Angle (K0)		-180.00 ° to 180.00 °	1.00 °
_:16921:106	Line section 1:KmR		0.00 to 8.00	1.00
_:16921:107	Line section 1:KmX		0.00 to 8.00	1.00
_:16921:124	Line section 1:Km0		0.000 to 8.000	1.000
_:16921:125	Line section 1:Angle (Km0)		-180.00 ° to 180.00 °	0.00 °
_:16921:120	Line section 1:Blocking of the auto. recl.		• no • yes	no

Settings in the AWE

Addr.	Parameter	C	Setting Options	Default Setting
Blk by FtLc. #				
_:102	Blk by FtLc. #:Min. dead time of blocking		0.00 s to 1800.00 s	0.50 s

6.50.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:81	General:>Block function	SPS	I
_:2311:501	General:>Fault detected phs A	SPS	I
_:2311:502	General:>Fault detected phs B	SPS	I
_:2311:503	General:>Fault detected phs C	SPS	I
_:2311:504	General:>Fault detected gnd.	SPS	I
_:2311:505	General:>Flt. det. w/o phs.&gnd.	SPS	I
_:2311:506	General:>Fault locator start	SPS	I
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
_:2311:54	General:Inactive	SPS	O
_:2311:302	General:Fault resistance prim.	MV	O
_:2311:321	General:Fault trans. resis. prim.	MV	O
_:2311:303	General:Fault reactance prim.	MV	O
_:2311:308	General:Fault resistance sec.	MV	O
_:2311:322	General:Fault trans. resis. sec.	MV	O
_:2311:309	General:Fault reactance sec.	MV	O
_:2311:304	General:Fault distance	MV	O
_:2311:305	General:Fault distance in %	MV	O
_:2311:306	General:Fault loop	ENS	O
_:2311:307	General:State	ENS	O
_:2311:310	General:Line sect. setting err.	SPS	O
Line section 1			
_:16921:52	Line section 1:Behavior	ENS	O
_:16921:53	Line section 1:Health	ENS	O
_:16921:301	Line section 1:Fault on section	SPS	O

6.51 Overfrequency Protection

6.51.1 Overview of Functions

The **Overfrequency protection** function (ANSI 81O):

- Detect overfrequencies in electrical power systems or machines
- Monitor the frequency band and output failure indications
- Disconnect generating units when the power frequency is critical
- Provide additional turbine protection if the speed limiter fails

Frequency deviations are caused by an unbalance between the active power generated and consumed. Overfrequency is caused by load shedding (island network), power system disconnection or disturbances of the frequency controller. Overfrequency implies a risk of self excitation of machines which are connected to long lines without load.

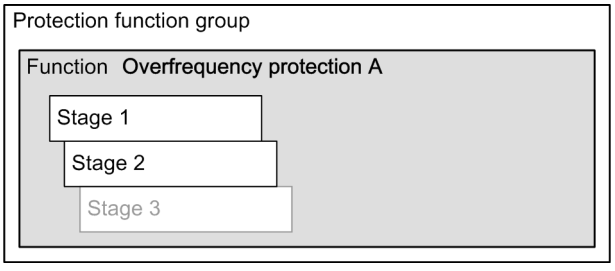
Overfrequency protection is available in two functional configurations (selectable from the DIGSI functions library). The functional configurations differ in the frequency measurement method they use.

6.51.2 Structure of the Function

The **Overfrequency protection** function is used in protection function groups, which are based on voltage measurement.

The overfrequency protection function comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The parameters **`Dropout differential`** and **`Minimum voltage`** are set for all stages.

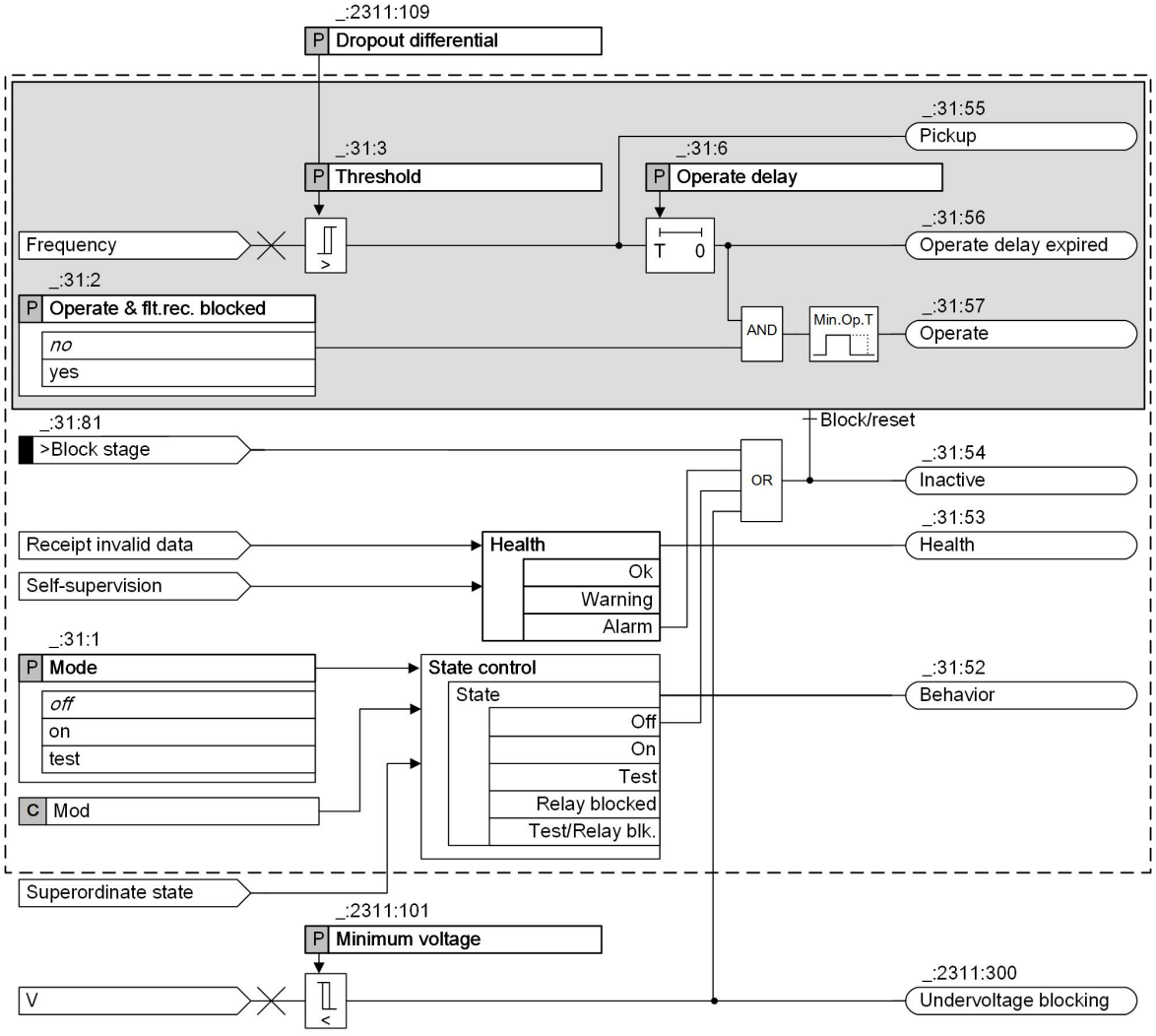


[dw_stofqp, 1, en_US]

Figure 6-596 Structure/Embedding of the Function

6.51.3 Overfrequency-Protection Stage

Logic of a Stage



[lo_stofqp, 2, en_US]

Figure 6-597 Logic Diagram of the Overfrequency-Protection Stage

Frequency-Measurement Method

Underfrequency protection is available in 2 functional configurations. These work with different frequency-measurement methods. You select the frequency-measurement method in dependence of the application.

- Angle-difference method (method A):

  The angle-difference method determines the phasor of the positive-sequence voltage in multiphase systems. In the case of 1-phase connection, it always processes the phasor of the connected voltage. Since the change of angle of the voltage phasor over a given time interval is proportional to the frequency change, the current frequency can be derived from it.

- Filtering method (method B):

  The filtering method processes the instantaneous voltage values and determines the current frequency using a suitable combination of filters. The frequency-protection function selects automatically the largest voltage as the measurand. In a multiphase connection, the phase-to-phase voltage is always the largest. If in a multiphase connection the selected voltage is no longer available, the function changes over automatically to the next maximum voltage. The function can even operate with just one voltage.

Both methods of measurement are characterized by a high measuring accuracy combined with a short response time. Disturbance values such as harmonics, high frequency disturbances, phase-angle jumps during switching operations and compensation processes due to power swings are effectively suppressed.



NOTE

The angle difference method (method A) requires the sampling-frequency tracking.

If you use the angle difference method as method of measurement, ensure that sampling-frequency tracking is active (see *3.3.2 Sampling-Frequency Tracking*).

Functional Measured Value

The angle-difference method provides the following measured value:

Measured Value	Description
f	Frequency calculated with the angle-difference method

Behavior on Leaving the Operating Range

The sampling-frequency tracking makes a wide frequency operating range possible. If the stage has picked up before leaving the frequency operating range and the measuring voltage is higher than the set minimum voltage, the pickup is maintained. A dropout of the pickup is only possible by means of a blocking.

Blocking the Stage

In the event of blocking, a picked-up stage will be reset. The following blocking options are available for the stage:

- Externally or internally via the logical binary input *>Block stage*
- Internally when the voltage drops below the **Minimum voltage**

6.51.4 Application and Setting Notes

Frequency-Measurement Method

The frequency measurement method is selected with the functional configuration from the DIGSI functions library. The letter at the end of the function name describes the method of measurement.

Redundant solutions can be implemented by combining 2 different methods of frequency measurement. You can implement a **2-out-of-2 decision** by connecting the operate indications of both functions in a CFC with a logical AND gate. This increases the reliability of protection.

Frequency-Measurement Method	Description
Angle difference method (method A)	Select this method of measurement if the frequency protection stage is used for the protection of machines.
Filtering method (method B)	Select this method of measurement if the frequency protection stage is used in an electrical power system.

Parameter: Threshold

- Recommended setting value **(_:31:3) Threshold** = ***51.50 Hz*** for f_{rated} = 50 Hz

With the parameter **Threshold**, you define the pickup threshold of the overfrequency protection stage in dependence of the application. 51.50 Hz is a typical warning threshold in 50-Hz systems.

Parameter: Operate delay

- Recommended setting value **(_:31:6) Operate delay** = ***10 s***

With the parameter **Operate delay**, you set the stage so that overfunctions due to disturbing influences (for example, switching operations) are avoided. Fairly high time delays are sufficient for warning indications.

Parameter: Minimum voltage

- Recommended setting value **(_:2311:101) Minimum voltage** = **37.500 V**

For the **Undervoltage blocking**, Siemens recommends 65 % of the rated voltage of the protected object as the setting value.
Calculate the secondary or primary setting value with the phase-to-ground voltage, that is, $V_{rated}/\sqrt{3}$.
For V_{rated} = 100 V secondary, the setting value of the **Minimum voltage** is calculated as follows:

$$\text{Minimum voltage} = 0.65 \cdot V_{rated} = 0.65 \cdot \frac{100\ \text{V}}{\sqrt{3}} = 37.500\ \text{V}$$

[fo_minimal voltage A, 1, en_US]

In the angle-difference method, the setting value relates to the positive-sequence system.

NOTE

If in DIGSI you switch over the settings view of the parameters to ***Percent***, the phase-to-phase value of the rated voltage is the reference value for the **Minimum voltage** in both methods of measurement.

Parameter: Dropout differential

- Recommended setting value **(_:2311:109) Dropout differential** = ***20 mHz***

Due to the high-precision frequency measurement, the recommended setting value for the **Dropout differential** can remain at 20 mHz. For a later dropout of the stage, increase the setting value of the dropout differential. For example, if the pickup value (parameter **Threshold**) of the stage is set to 51.5 Hz and the **Dropout differential** to 100 mHz, the stage will drop out at 51.4 Hz.

Setting example for the overfrequency protection for generators

If the overspeed limiter does not function properly, the overfrequency protection issues an additional alarm indication. Overspeeding can be caused by load shedding or by a disturbance of the speed limiter (for example, in an island network).
One possible frequency limit could be 1.03 f_{rated}. If the machine does not recover, it can be shut down with a 2nd stage of, for example, 1.08 f_{rated}. To avoid overfunctions, you can set a sufficient time delay for the warning indication or tripping.
For this application, 2 stages of the overfrequency protection are used. The following table shows a setting suggestion.

Stage	Caused by	Setting Values		
		At f_{rated} = 50 Hz	At f_{rated} = 60 Hz	Delay
f1>	Warning or disconnection	51.50 Hz	61.80 Hz	20.00 s
f2>	Shutdown	54.00 Hz	64.80 Hz	5.00 s

NOTE

This table shows one example of a possible frequency protection setting. The setting values can differ depending on the application.

6.51.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Minimum voltage		3.000 V to 175.000 V	37.500 V
_:2311:109	General:Dropout differential		20 mHz to 2000 mHz	20 mHz
Stage 1				
_:31:1	Stage 1:Mode		• off • on • test	off
_:31:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:31:3	Stage 1:Threshold	Overfrequency A	40.00 Hz to 90.00 Hz	51.50 Hz
		Overfrequency B	40.00 Hz to 70.00 Hz	
_:31:6	Stage 1:Operate delay		0.00 s to 600.00 s	10.00 s
Stage 2				
_:32:1	Stage 2:Mode		• off • on • test	off
_:32:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:32:3	Stage 2:Threshold	Overfrequency A	40.00 Hz to 90.00 Hz	54.00 Hz
		Overfrequency B	40.00 Hz to 70.00 Hz	
_:32:6	Stage 2:Operate delay		0.00 s to 600.00 s	5.00 s

6.51.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
_:2311:301	General:f	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:31:81	Stage 1:>Block stage	SPS	I
_:31:54	Stage 1:Inactive	SPS	O
_:31:52	Stage 1:Behavior	ENS	O
_:31:53	Stage 1:Health	ENS	O
_:31:55	Stage 1:Pickup	ACD	O
_:31:56	Stage 1:Operate delay expired	ACT	O
_:31:57	Stage 1:Operate	ACT	O
Stage 2			
_:32:81	Stage 2:>Block stage	SPS	I

No.	Information	Data Class (Type)	Type
_:32:54	Stage 2:Inactive	SPS	O
_:32:52	Stage 2:Behavior	ENS	O
_:32:53	Stage 2:Health	ENS	O
_:32:55	Stage 2:Pickup	ACD	O
_:32:56	Stage 2:Operate delay expired	ACT	O
_:32:57	Stage 2:Operate	ACT	O

6.52 Underfrequency Protection

6.52.1 Overview of Functions

The **Underfrequency protection** function (ANSI 81U) is used to:

- Detect underfrequencies in electrical power systems or machines
- Monitor the frequency band and output failure indications
- Decouple power systems
- Load shedding to ensure power system stability and protect motors
- Disconnect generating units when the power system frequency is critical (for example, $f < 0.95\ f_{rated}$)

Frequency deviations are caused by an unbalance between the active power generated and consumed. Underfrequency is caused by an increase of the consumers' active power demand or by a decrease of the power generated. These conditions occur in the case of power system disconnection, generator failure, or disturbances of the power and frequency controller.

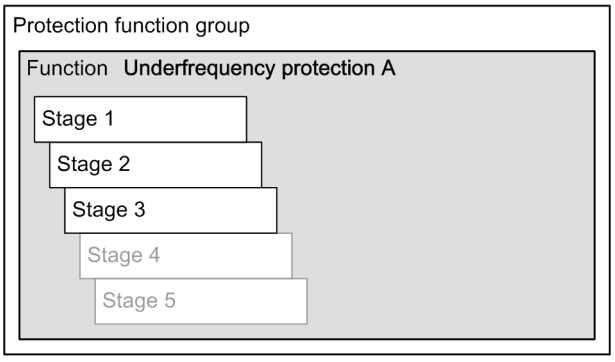
Underfrequency protection is available in 2 functional configurations (selectable from the DIGSI functions library). The functional configurations differ in the frequency measurement method they use.

6.52.2 Structure of the Function

The **Underfrequency protection** function is used in protection function groups, which are based on voltage measurement.

The **Underfrequency protection** function comes with 3 factory-set stages. A maximum of 5 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The parameters **`Dropout differential`** and **`Minimum voltage`** are set for all stages.

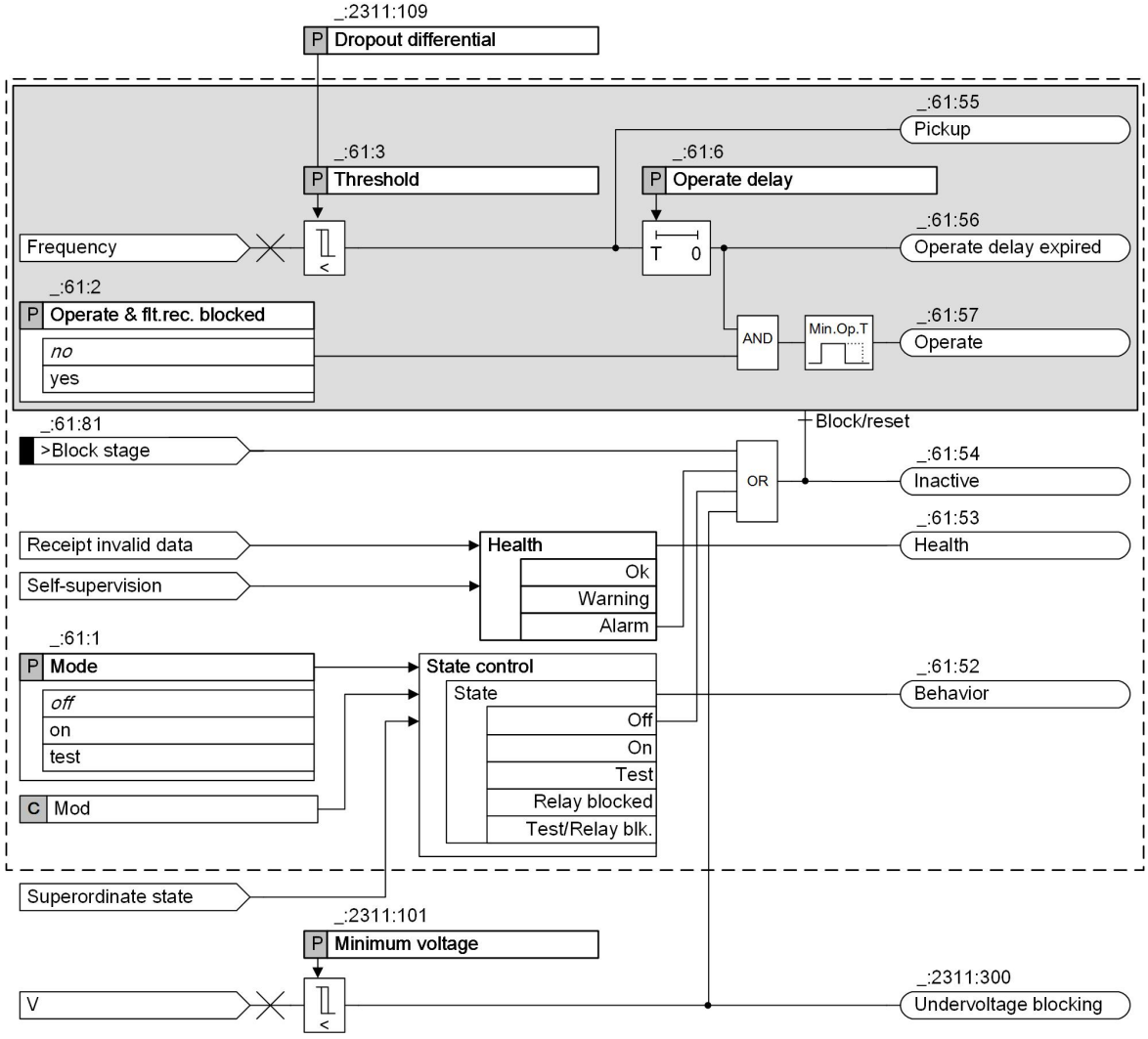


[dw_stufgp, 1, en_US]

Figure 6-598 Structure/Embedding of the Function

6.52.3 Underfrequency-Protection Stage

Logic of a Stage



[lo_stuf_qp, 3, en_US]

Figure 6-599 Logic Diagram of the Underfrequency-Protection Stage

Frequency-Measurement Method

Underfrequency protection is available in 2 functional configurations. These work with different frequency-measurement methods. You select the frequency-measurement method in dependence of the application.

- Angle-difference method (method A):
  The angle-difference method determines the phasor of the positive-sequence voltage in multiphase systems. In the case of 1-phase connection, it always processes the phasor of the connected voltage. Since the change of angle of the voltage phasor over a given time interval is proportional to the frequency change, the current frequency can be derived from it.
- Filtering method (method B):
  The filtering method processes the instantaneous voltage values and determines the current frequency using a suitable combination of filters. The frequency-protection function selects automatically the largest voltage as the measurand. In a multiphase connection, the phase-to-phase voltage is always the largest. If in a multiphase connection the selected voltage is no longer available, the function changes over automatically to the next maximum voltage. The function can even operate with just one voltage.

Both methods of measurement are characterized by a high measuring accuracy combined with a short response time. Disturbance values such as harmonics, high frequency disturbances, phase-angle jumps during switching operations and compensation processes due to power swings are effectively suppressed.



NOTE

The angle difference method (method A) requires the sampling-frequency tracking.

If you use the angle difference method as method of measurement, ensure that sampling-frequency tracking is active (see *3.3.2 Sampling-Frequency Tracking*).

Behavior on Leaving the Operating Range

Sampling-frequency tracking makes an additional frequency operating range possible. If the stage has picked up before leaving the frequency operating range and the measuring voltage is higher than the set minimum voltage, the pickup is maintained. A dropout of the pickup is only possible by means of a blocking.

Blocking the Stage

In the event of blocking, a picked-up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal *>Block stage* from an external or internal source
- Internally when the voltage drops below the **Minimum voltage**

6.52.4 Application and Setting Notes

Frequency-Measurement Method

The frequency measurement method is selected with the functional configuration from the DIGSI functions library. The letter at the end of the function name describes the method of measurement.

Redundant solutions can be implemented by combining 2 different methods of frequency measurement. You can implement a **2-out-of-2 decision** by connecting the operate indications of both functions in a CFC with a logical AND gate. This increases the security of protection.

Method of Measurement	Description
Angle-difference method (method A)	Select this method of measurement if the frequency protection stage is used for the protection of machines.
Filtering method (method B)	Select this method of measurement if the frequency protection stage is used in an electrical power system.

Parameter: Threshold

- Recommended setting value **(_:61:3) Threshold** = ***49.80 Hz*** for f_{rated} = 50 Hz

With the parameter **Threshold**, you define the pickup threshold of the underfrequency protection stage in dependence of the application. 49.8 Hz is a typical warning threshold in 50-Hz systems.

Parameter: Operate delay

- Recommended setting value **(_:61:6) Operate delay** = ***10.00 s***

With the parameter **Operate delay**, you set the stage so that overfunctions due to disturbing influences (for example switching operations) are avoided. Fairly high time delays are sufficient for warning indications.

Parameter: Minimum voltage

- Recommended setting value **(_:2311:101) Minimum voltage** = **37.500 V**

For the **Undervoltage blocking**, Siemens recommends 65 % of the rated voltage of the protected object as the setting value.

Calculate the secondary or primary setting value with the phase-to-ground voltage, that is, $V_{rated}/\sqrt{3}$.

For V_{rated} = 100 V secondary, the setting value of the **Minimum voltage** is calculated as follows:

$$\text{Minimum voltage} = 0.65 \cdot V_{rated} = 0.65 \cdot \frac{100\ \text{V}}{\sqrt{3}} = 37.500\ \text{V}$$

[fo_minimal voltage A, 1, en_US]

In the angle-difference method, the setting value relates to the positive-sequence system.

NOTE

If in DIGSI you switch over the settings view of the parameters to ***Percent***, the phase-to-phase value of the rated voltage is the reference value for the **Minimum voltage** in both methods of measurement.

Parameter: Dropout differential

- Recommended setting value **(_:2311:109) Dropout differential** = ***20 mHz***

Due to the high-precision frequency measurement, the recommended setting value for the **Dropout differential** can remain at 20 mHz. If in your application you wish a subsequent dropout of the tripping stage, then increase the setting value of the dropout differential. For example, if the pickup value (parameter **Threshold**) of the tripping stage is set to 49.8 Hz and the **Dropout differential** to 100 mHz, the stage will drop out at 49.9 Hz.

Setting Example of Underfrequency Protection for Generators

Underfrequency protection provides an additional protection for the turbine. It has the task of ensuring the demand of a power plant by a timely decoupling from the electrical power system. After the decoupling from the electrical power system, the turbo set controller sets the generator unit to the rated speed, so that the demand can continue to be supplied with rated frequency.

Turbo-generators can operate permanently at as little as 95 % of the rated frequency. This requires the apparent power to be reduced by the same factor. A decrease of the frequency leads not only to a higher current consumption by the inductive loads but is also a hazard to stable operation.

The decoupling from the electrical power system is initiated without delay at 0.95 f_{rated}. After the decoupling, the power-plant unit has to recover. If it does not, the turbine is stopped for its own protection. In the turbine, underfrequency can lead to resonances and inadmissible strains of the turbine blades. You can delay the tripping in order to give the speed controllers sufficient time for a response.

The frequency value to be set depends on the specifications of the power plant operator or the turbine manufacturer (speed monitoring). It is approx. 0.94 f_{rated}.

For this application, 3 stages of the underfrequency protection are used. The following table shows a setting suggestion.

Stage	Caused by	Setting Values		
		At f_{rated} = 50 Hz	At f_{rated} = 60 Hz	Delay
f1<	Warning	49.80 Hz	59.80 Hz	10.00 s
f2<	Decoupling from power system	47.50 Hz	57.00 Hz	0.00 s
f3<	Shutdown	47.00 Hz	56.40 Hz	10.00 s

NOTE

This table shows one example of a possible frequency protection setting. The setting values can differ depending on the application and the turbine.

6.52.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Minimum voltage		3.000 V to 175.000 V	37.500 V
_:2311:109	General:Dropout differential		20 mHz to 2000 mHz	20 mHz
Stage 1				
_:61:1	Stage 1:Mode		• off • on • test	off
_:61:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:61:3	Stage 1:Threshold		30.00 Hz to 70.00 Hz	49.80 Hz
_:61:6	Stage 1:Operate delay		0.00 s to 600.00 s	10.00 s
Stage 2				
_:62:1	Stage 2:Mode		• off • on • test	off
_:62:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:62:3	Stage 2:Threshold		30.00 Hz to 70.00 Hz	47.50 Hz
_:62:6	Stage 2:Operate delay		0.00 s to 600.00 s	10.00 s
Stage 3				
_:63:1	Stage 3:Mode		• off • on • test	off
_:63:2	Stage 3:Operate & flt.rec. blocked		• no • yes	no
_:63:3	Stage 3:Threshold		30.00 Hz to 70.00 Hz	47.00 Hz
_:63:6	Stage 3:Operate delay		0.00 s to 600.00 s	10.00 s

6.52.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Operate	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O

No.	Information	Data Class (Type)	Type
Stage 1			
_:61:81	Stage 1:>Block stage	SPS	I
_:61:51	Stage 1:Mode (controllable)	ENC	C
_:61:54	Stage 1:Inactive	SPS	O
_:61:52	Stage 1:Behavior	ENS	O
_:61:53	Stage 1:Health	ENS	O
_:61:55	Stage 1:Pickup	ACD	O
_:61:56	Stage 1:Operate delay expired	ACT	O
_:61:57	Stage 1:Operate	ACT	O
Stage 2			
_:62:81	Stage 2:>Block stage	SPS	I
_:62:51	Stage 2:Mode (controllable)	ENC	C
_:62:54	Stage 2:Inactive	SPS	O
_:62:52	Stage 2:Behavior	ENS	O
_:62:53	Stage 2:Health	ENS	O
_:62:55	Stage 2:Pickup	ACD	O
_:62:56	Stage 2:Operate delay expired	ACT	O
_:62:57	Stage 2:Operate	ACT	O
Stage 3			
_:63:81	Stage 3:>Block stage	SPS	I
_:63:51	Stage 3:Mode (controllable)	ENC	C
_:63:54	Stage 3:Inactive	SPS	O
_:63:52	Stage 3:Behavior	ENS	O
_:63:53	Stage 3:Health	ENS	O
_:63:55	Stage 3:Pickup	ACD	O
_:63:56	Stage 3:Operate delay expired	ACT	O
_:63:57	Stage 3:Operate	ACT	O

6.53 Underfrequency Load Shedding

6.53.1 Overview of Functions

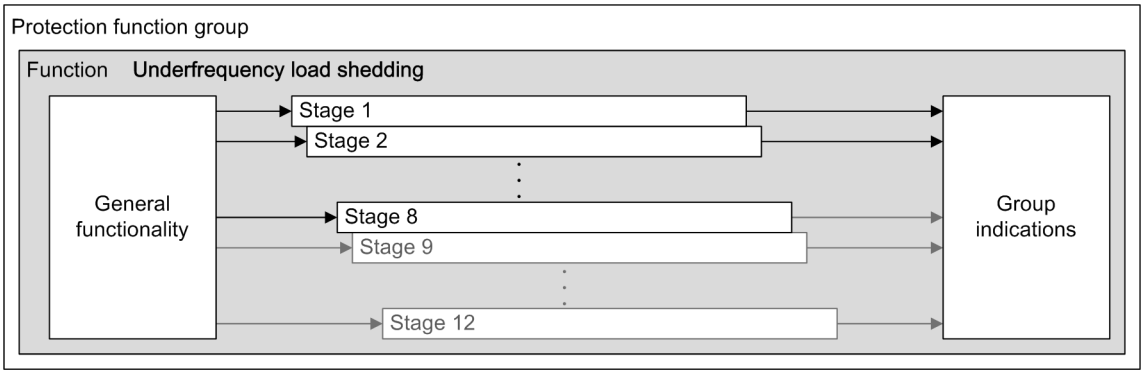
The **Underfrequency load shedding** function:

- Detects underfrequencies in the electrical power systems
- Switches off the medium-voltage busbar or feeders that consume active power to stabilize the frequency
- Maintains operations for the medium-voltage busbar or feeders that generate active power

6.53.2 Structure of the Function

The **Underfrequency load shedding** function can be used in the **Voltage/Current 3-phase** function group and in the **Line** function group.

The **Underfrequency load shedding** function comes factory-set with 8 stages. A maximum of 12 stages can be operated simultaneously within the function. These stages are identical in structure.



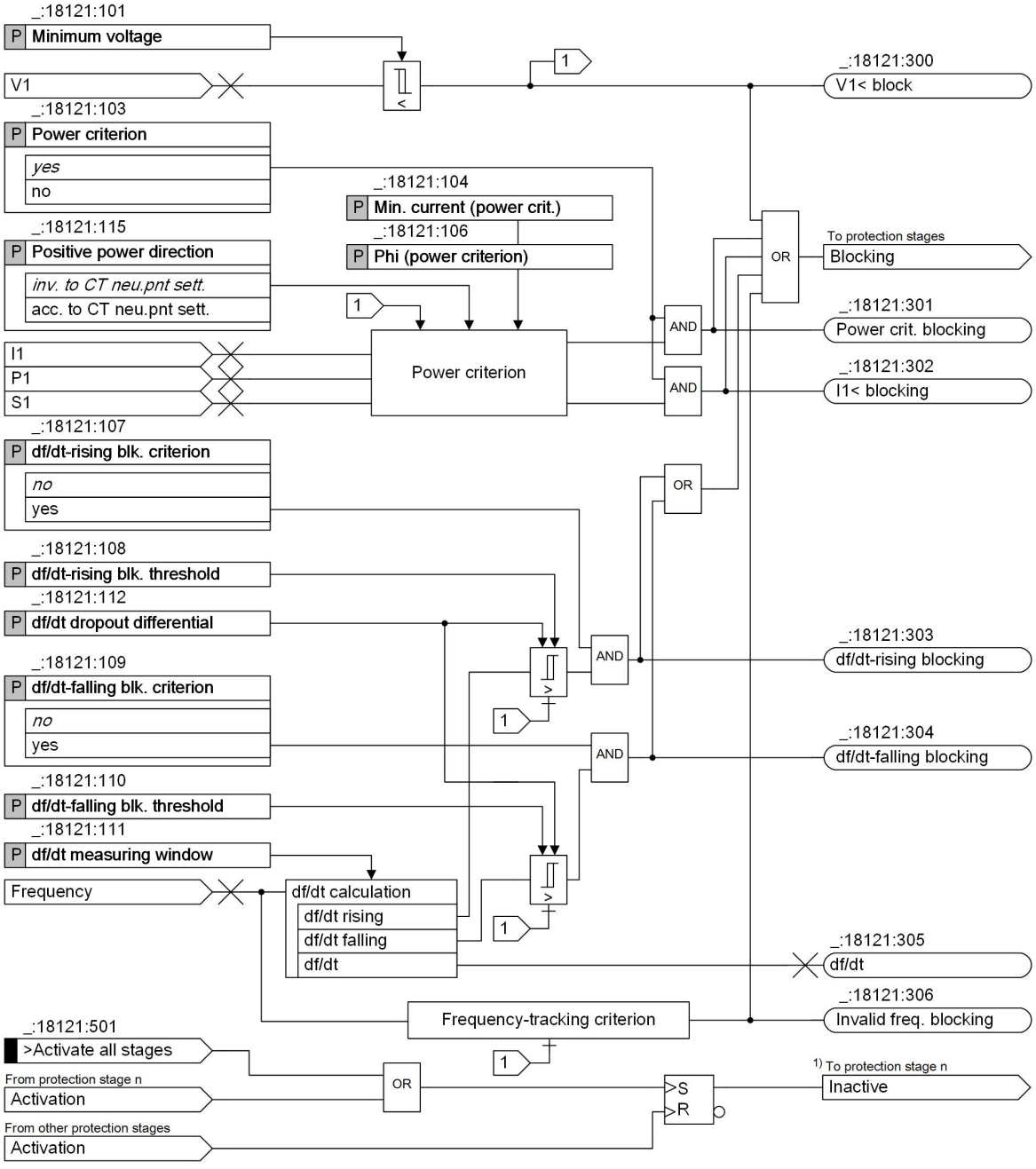
[dw_load shedding_structure, 1, en_US]

Figure 6-600 Structure/Embedding of the Function

6.53.3 General Functionality

6.53.3.1 Description

Logic



[lo_UFLS_general functionality, 2, en_US]

Figure 6-601 Logic Diagram of the General Functionality

(1) n means the number of the protection stage.

Measurands

The general functionality requires the following input measurands:

- Positive-sequence voltage V1
- Positive-sequence current I1
- Positive-sequence system apparent power S1
- Positive-sequence system active power P1
- Frequency

S1 and P1 are both calculated from V1 and I1. The frequency is calculated from V1.

The frequency and the frequency change rate df/dt are calculated via the angle difference algorithm. For more information, see *6.51.3 Overfrequency-Protection Stage*.

Undervoltage Blocking

The frequency of the **Underfrequency load shedding** function is calculated from the positive-sequence voltage V1. In order to obtain a reliable and accurate frequency calculation result, the magnitude of V1 is monitored. If the magnitude of V1 is smaller than the **`Minimum voltage`**, all the protection stages are blocked and the *V1< block* indication is issued.

Power Criterion

If a feeder delivers active power towards the busbar, or if the medium-voltage busbar delivers active power to the high-voltage busbar, it is meaningless to switch off this feeder or the medium-voltage busbar during the load-shedding process. The power criterion determines the power-flow direction and includes this information as a blocking criterion into the load-shedding decision of all protection stages.

The parameter **`Positive power direction`** defines the positive active-power flow direction of the function in relation to the standard forward direction of the protection functionality. For more information, see *6.53.3.2 Application and Setting Notes*.

In the following figures, if the power flow is located in the release area which is marked in gray, the protection stages are released. In the remaining area, the protection stages are blocked.

The release area is configured via the following parameters:

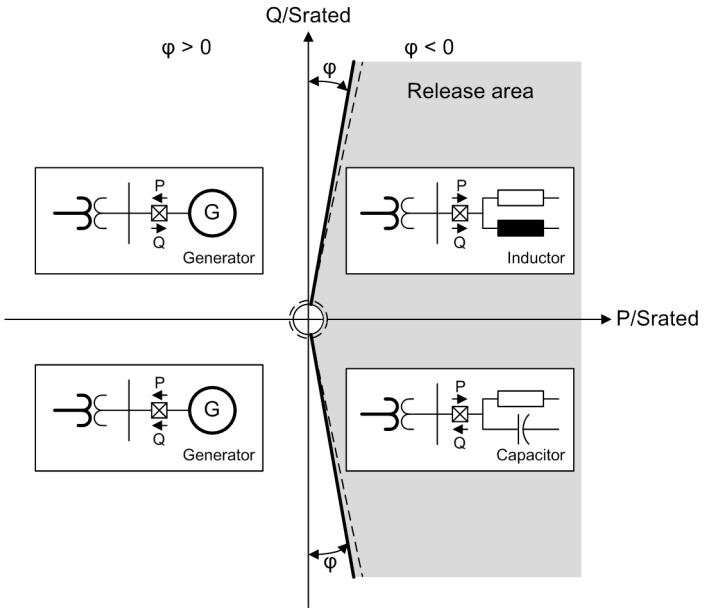
- The parameter **`Phi (power criterion)`** defines the area which limits the range of the power angle.
- The parameter **`Min. current (power crit.)`** defines the minimum positive-sequence current that must be present to calculate the active power in a reliable way. In the following figures, the minimum current is indicated as the circle whose center is the origin of the coordinates.

The power criterion is checked only when the following 2 conditions are fulfilled:

- The positive-sequence current I1 exceeds the threshold **`Min. current (power crit.)`**, that is, I1 is out of the circle in the following figures.
- The undervoltage blocking is not fulfilled, that is, the magnitude of V1 is not smaller than the **`Minimum voltage`**.

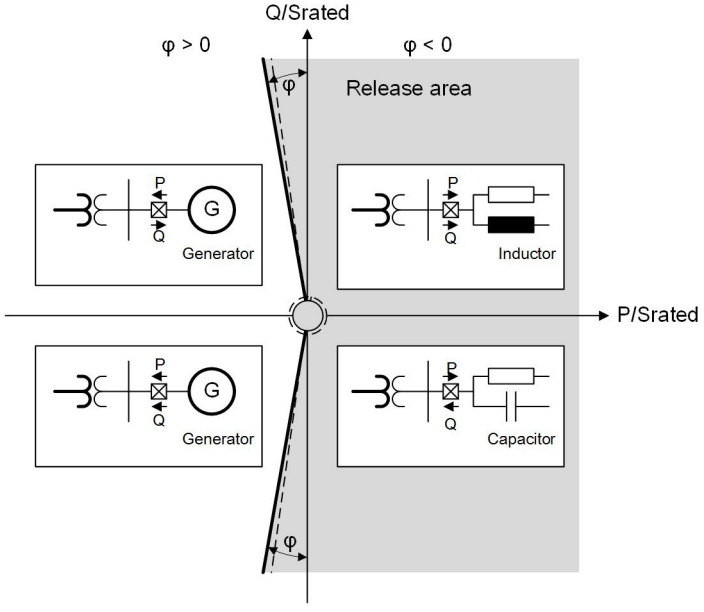
The dashed lines in the figures show the dropout characteristics. The dropout differential of the power angle is 1°.

The symbol φ in the following figures represents the setting value of the parameter **`Phi (power criterion)`**.



[dw_load_shedding_power_crit<0, 1, en_US]

Figure 6-602 Power-Criterion Checking at **Phi (power criterion)** ≤ 0



[dw_load shedding_power_crit>0, 2, en_US]

Figure 6-603 Power-Criterion Checking at **Phi (power criterion)** > 0 (according to VDE-AR-N 4142:2020-04)

The power criterion contains the check of the current criterion and of the power-angle criterion.

You can determine whether to check the power criterion or not by setting the **Power criterion** parameter. The power criterion is carried out only when the **Power criterion** parameter is set to ***yes***.

The working method of the current criterion and of the power-angle criterion differ at **Phi (power criterion)** ≤ 0 and **Phi (power criterion)** > 0.

For **Phi (power criterion)** ≤ 0, the power criterion is checked as follows:

- When the positive-sequence current I1 falls below the **Min. current (power crit.)**, the current criterion is not fulfilled and the *I1< blocking* indication is issued. Therefore, all the protection stages are blocked and the power-angle criterion is not considered.
- When I1 exceeds the **Min. current (power crit.)** and the power angle is out of the release area, the *Power crit. blocking* indication is issued and all the protection stages are blocked.

For **Phi (power criterion)** > 0, the power criterion is checked as follows:

- When I1 falls below the **Min. current (power crit.)**, all the protection stages are released and the power-angle criterion is not considered.
- When I1 exceeds the **Min. current (power crit.)** and the power angle is out of the release area, the *Power crit. blocking* indication is issued and all the protection stages are blocked.

df/dt Blocking

If the change rate of df/dt is too high, the **Underfrequency load shedding** function may not be applicable anymore.

The df/dt blocking comprises the df/dt-rising blocking and the df/dt-falling blocking.

The df/dt-rising criterion and the df/dt-falling criterion can be individually switched on or off. These 2 df/dt criteria are operative only when the magnitude of the positive-sequence voltage V1 is greater than the **Minimum voltage**:

- The df/dt-rising blocking takes place when the df/dt-rising value exceeds the setting value of the parameter **df/dt-rising blk. threshold**. It is signaled via the indication *df/dt-rising blocking*.
- The df/dt-falling blocking takes place when the df/dt-falling value exceeds the setting value of the parameter **df/dt-falling blk. threshold**. It is signaled via the indication *df/dt-falling blocking*.

Frequency-Tracking Criterion

The frequency-tracking criterion is only checked when no undervoltage blocking is given.

The frequency of the **Underfrequency load shedding** function is calculated via the angle difference algorithm, which requires the sampling-frequency tracking to be active (see *3.3.2 Sampling-Frequency Tracking*). If the sampling-frequency tracking is inactive, all the protection stages are blocked and the signal *Invalid freq. blocking* is issued.

Activating/Deactivating Protection Stages

The mechanism of exclusive stage activation is described in *Exclusive Stage Activation, Page 1611*.

Functional Measured Value

Value	Description
df/dt	Calculated rate of frequency change

6.53.3.2 Application and Setting Notes

Parameter: Minimum voltage

- Default setting **(_:18121:101) Minimum voltage** = *0.700 p.u.*

If the magnitude of V1 is smaller than the **Minimum voltage**, all protection stages are blocked.

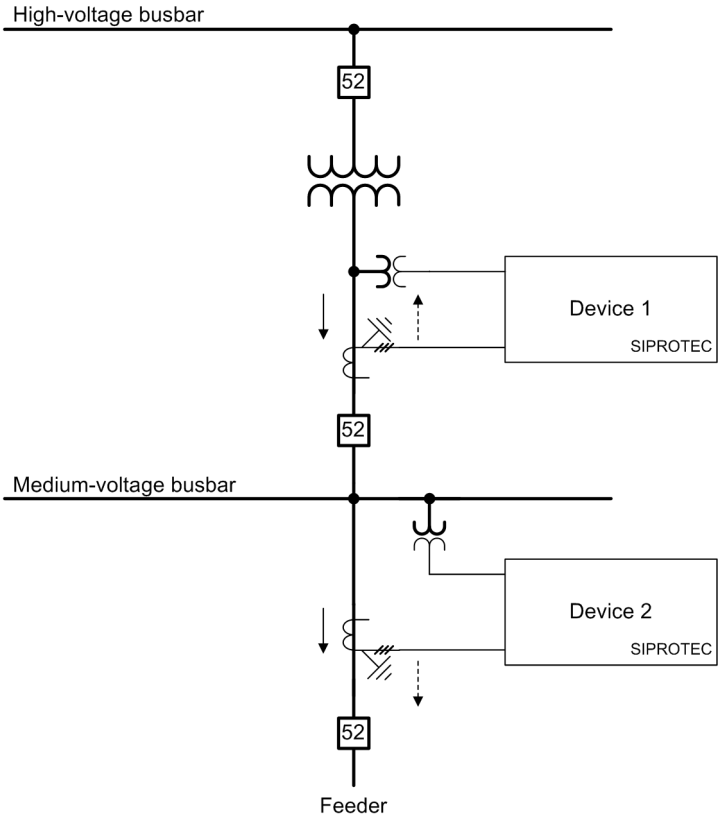
The **Minimum voltage** parameter is set as a per-unit value related to the rated voltage of the connected voltage measuring point. Siemens recommends using the default setting.

Parameter: Positive power direction

- Default setting **(_:18121:115) Positive power direction** = *inv. to CT neu.pnt sett.*

With the **Positive power direction** parameter, you define the positive active-power flow direction of the function in relation to the standard forward direction of the protection functionality.

The following figure shows 2 application scenarios of protection devices with the **Underfrequency load shedding** function.



[dw_UFLS_positive power direction, 1, en_US]

Figure 6-604 Application Scenarios

Dotted arrow: Standard forward direction of the protection functionality
Solid arrow: Positive active-power flow direction

The standard forward direction of the protection functionality is from the busbar to the protected object which is the transformer for device 1 or the feeder for device 2. The standard forward direction of the protection functionality is configured via the **(_:8881:116) Neutr.point in dir.of ref.obj** parameter of the measuring point I-3ph (see chapter *6.1.5 Application and Setting Notes for Measuring-Point Current 3-Phase (I-3ph)*). For the load-shedding function, the positive active-power flow direction can differ from the standard forward direction of the protection functionality, such as for device 1. To adapt the function to this condition, the **Positive power direction** parameter is used. With the **Positive power direction** parameter, you can set the positive active-power flow direction either to the same as or to the inverse of the standard forward direction.

- For device 1, set the **Positive power direction** parameter to ***inv. to CT neu.pnt sett.***. Then, the positive active-power flow direction of the power criterion is opposite to the standard forward direction of the protection functionality. Consequently, the **Underfrequency load shedding** function sheds the medium-voltage busbar when the positive power-flow direction is from the high-voltage busbar to the medium-voltage busbar.
- For device 2, set the **Positive power direction** parameter to ***acc. to CT neu.pnt sett.***. Then, the positive active-power flow direction of the power criterion is the same as the standard forward direction of the protection functionality. Consequently, the **Underfrequency load shedding** function sheds the feeder when the positive power-flow direction is from the medium-voltage busbar to the feeder.

Parameter: Power criterion, Phi (power criterion), Min. current (power crit.)

- Default setting **(_:18121:103) Power criterion** = ***yes***
- Default setting **(_:18121:106) Phi (power criterion)** = ***-5°***
- Default setting **(_:18121:104) Min. current (power crit.)** = ***0.050 p.u.***

The power criterion evaluates the power-flow direction as a blocking criterion for the protection stages.

- With the **Power criterion** parameter, you configure whether to apply the power criterion or not.

  If a feeder can deliver active power towards the busbar, or if the medium-voltage busbar can deliver active power to the high-voltage busbar, Siemens recommends using the power criterion to exclude the feeder or the medium-voltage busbar from being shed under this condition. If a feeder or the medium-voltage busbar is always consuming active power, the power criterion is not required.
- With the **Phi (power criterion)** parameter, you decide whether the protection stage is blocked or released in the case of low active-power flow. If the active-power flow is low, the determined active power-flow direction is not always reliable.

  For **Phi (power criterion)** ≤ 0, the protection stage is released for a clear forward active power-flow direction. If the active power-flow direction is not reliable, the protection stages are blocked. For **Phi (power criterion)** > 0, the behavior is the contrary.

  The **Phi (power criterion)** parameter can be set depending on your philosophy.
- With the **Min. current (power crit.)** parameter, you set the minimum positive-sequence current threshold to achieve a reliable active-power criterion result. The **Min. current (power crit.)** parameter is set as a per-unit value related to the rated current of the connected current measuring point. Siemens recommends using the default setting.

Parameter: df/dt-rising blk. criterion, df/dt-rising blk. threshold, df/dt-falling blk. criterion, df/dt-falling blk. threshold

- Default setting **(_:18121:107) df/dt-rising blk. criterion** = ***no***
- Default setting **(_:18121:108) df/dt-rising blk. threshold** = ***1.0 Hz/s***
- Default setting **(_:18121:109) df/dt-falling blk. criterion** = ***no***
- Default setting **(_:18121:110) df/dt-falling blk. threshold** = ***3.0 Hz/s***

If the change rate of df/dt is too high, the **Underfrequency load shedding** function may not be applicable anymore.

With the parameters **df/dt-rising blk. criterion** and **df/dt-falling blk. criterion**, you determine whether to check the df/dt-rising blocking and the df/dt-falling blocking.

With the parameters **df/dt-rising blk. threshold** and **df/dt-falling blk. threshold**, you set the threshold rates of df/dt-rising and df/dt-falling.

Parameter: df/dt measuring window

- Default setting **(_:18121:111) df/dt measuring window** = ***5 periods***

With the **df/dt measuring window** parameter, you optimize the measuring accuracy or the pickup time of the function.

The default setting provides the maximum measuring accuracy. If you do not have specific requirements for a decreased pickup time, Siemens recommends using the default setting.

For a non-sensitive setting (high threshold value), you can set the **df/dt measuring window** parameter to a value which is smaller than ***5 periods***.

Parameter: df/dt dropout differential

- Default setting **(_:18121:112) df/dt dropout differential** = ***0.1 Hz/s***

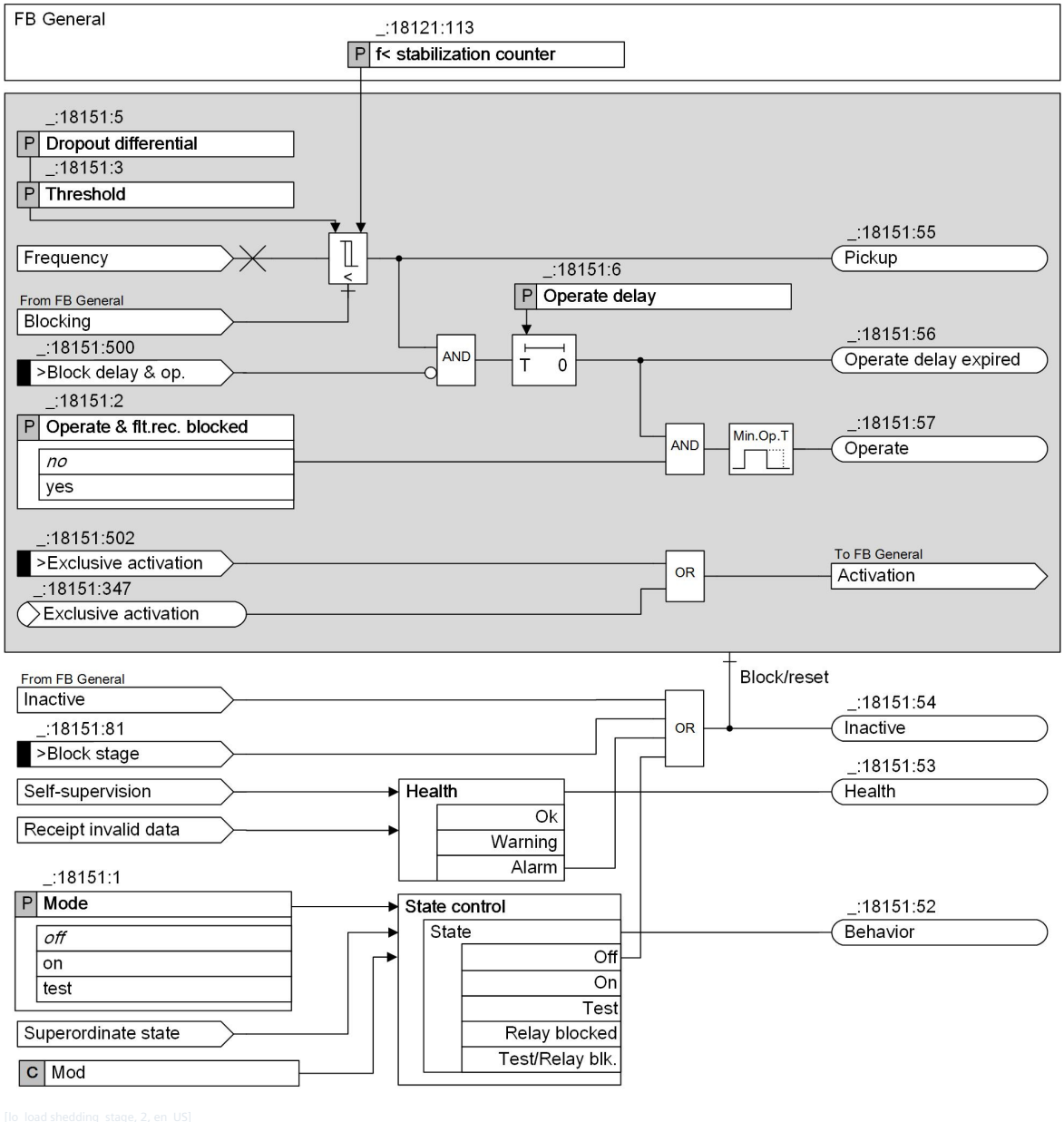
With the **df/dt dropout differential** parameter, you define the dropout threshold of the parameters **df/dt-rising blk. threshold** and **df/dt-falling blk. threshold**.

The default setting is a reasonable value. Siemens recommends using the default setting.

6.53.4 Stage Description

6.53.4.1 Description

Logic of the Stage



[lo_load shedding_stage, 2, en_US]

Figure 6-605 Logic Diagram of the Underfrequency Load Shedding Stage

Pickup and Operate

If the following 3 conditions are all fulfilled, a **Pickup** indication is issued:

- The frequency value drops below the **Threshold**.
- The **Blocking** input from the function block **General** is inactive.
- The preceding 2 conditions are fulfilled during the configured number of frequency measurement cycles (cycle time = 10 ms). You can set the number with the parameter **f< stabilization counter**.

If the **Pickup** signal is maintained during the **Operate delay** time, an **Operate** indication is issued.

Exclusive Stage Activation

A load-shedding schema defines in which order feeders (power consumers) are disconnected. To not discriminate power consumers, this order is changed regularly. The mechanism of exclusive stage activation supports this order change efficiently.

Even though multiple protection stages are instantiated and their **Mode** parameters are set to *on*, you can only activate one stage at a time via the exclusive stage activation in an **Underfrequency load shedding** function.

The exclusive stage activation comprises the following input signals:

- The SPS signal *>Exclusive activation* which is offered in the protection stage.
- The SPC signal *Exclusive activation* which is offered in the protection stage.
  This SPC signal allows the exclusive stage activation from a station controller.
- The SPS signal *>Activate all stages* which is offered in the function block **General**.

The protection stage which receives the newest SPS signal *>Exclusive activation* or SPC signal *Exclusive activation* remains active and all other stages are deactivated. If 2 or more protection stages simultaneously receive the SPS signals *>Exclusive activation* and/or the SPC signals *Exclusive activation*, only the protection stage with the largest stage number is activated.

If the SPS signal *>Activate all stages* is activated, the exclusive stage activation is reset, that is, all protection stages whose **Mode** parameters are set to *on* become active again.

After a normal device restart (reset), the statuses of the protection stages which were influenced by the SPS signal *>Exclusive activation* or the SPC signal *Exclusive activation* are still maintained.

After an initial startup, the exclusive stage activation is reset.

EXAMPLE

Configured protection stages:	Protection stages 1 to 8
Protection stages whose **Mode** parameters are set to *on*:	Protection stages 1 to 8

The following cases occur in sequence:

- **Case 1:**
  Scenario: In the protection stage 1, the SPS signal *>Exclusive activation* or the SPC signal *Exclusive activation* is activated.
  Result: The protection stage 1 remains active and stages 2 to 8 are deactivated.
- **Case 2:**
  Scenario: In the protection stage 2, the SPS signal *>Exclusive activation* or the SPC signal *Exclusive activation* is activated.
  Result: The protection stage 2 is activated, the stage 1 is deactivated, and stages 3 to 8 remain deactivated.
- **Case 3:**
  Scenario: The SPS signal *>Activate all stages* is activated.
  Result: The protection stages 1 to 8 are activated.

- **Case 4:**
  Scenario: In the protection stages 2 to 4, the SPS signal *>Exclusive activation* or the SPC signal *Exclusive activation* is activated simultaneously.
  Result: The protection stage 4 is activated and the other stages are deactivated.
- **Case 5:**
  Scenario: A normal device restart (reset) occurs.
  Result: After the device restart, the protection stage 4 remains activated and the other stages remain deactivated.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal *>Block stage* from an external or internal source
- Via the *Inactive* input from the function block **General**

Behavior on Leaving the Operating Range

The sampling frequency tracking makes a wide frequency-operating range possible. If the stage has picked up before leaving the frequency-operating range, the pickup is maintained. The **Pickup** signal is reset when a blocking condition becomes active.

6.53.4.2 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:18151:3) Threshold** = ***49.00 Hz*** for f_{rated} = 50 Hz

With the **Threshold** parameter, you define the underfrequency pickup value of the stage. The specific value depends on the application and the total number of the stages applied in parallel.

Parameter: Operate delay

- Default setting **(_:18151:6) Operate delay** = ***0.10 s***

Set the **Operate delay** parameter for the specific application.

Parameter: Dropout differential

- Default setting **(_:18151:5) Dropout differential** = ***20 mHz***

With the **Dropout differential** parameter, you define the dropout threshold. For example, if you set the **Threshold** to 49.00 Hz and the dropout differential to 20 mHz, the stage drops out at 49.02 Hz.

Due to the high-precision frequency measurement, the setting value can remain at the default value of 20 mHz.

Parameter: Operate & flt.rec. blocked

- Default setting **(_:18151:2) Operate & flt.rec. blocked** = ***no***

With the **Operate & flt.rec. blocked** parameter, you can block the operate indication, the fault recording, and the fault log.

Parameter: f< stabilization counter

- Default setting **(_:18121:113) f< stabilization counter** = ***6***

You can configure the **f< stabilization counter** parameter in the function block **General**.

With the **f< stabilization counter** parameter, you set the number of measurement cycles in which the measured frequency value must be lower than the frequency threshold to meet the pickup condition. With this setting, you can optimize the pickup-condition reliability versus the pickup time.

The measuring cycle time is 10 ms. With the default setting of ***6***, the pickup time is the sum of the inherent frequency measuring time (approx. 10 ms to 30 ms) plus the 6 times measuring repetition of 60 ms, which is 70 ms to 90 ms in total.

In order to avoid a wrong pickup in case of a phase jump, Siemens recommends setting the value of the **f< stabilization counter** parameter not below 5.

6.53.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:18121:101	General:Minimum voltage		0.300 p.u. to 0.900 p.u.	0.700 p.u.
_:18121:103	General:Power criterion		• no • yes	yes
_:18121:104	General:Min. current (power crit.)		0.020 p.u. to 0.200 p.u.	0.050 p.u.
_:18121:115	General:Positive power direction		• inv. to CT neu.pnt sett. • acc. to CT neu.pnt sett.	inv. to CT neu.pnt sett.
_:18121:106	General:Phi (power crite-rion)		-30° to 30°	-5°
_:18121:107	General:df/dt-rising blk. criterion		• no • yes	no
_:18121:108	General:df/dt-rising blk. threshold		0.1 Hz/s to 20.0 Hz/s	1.0 Hz/s
_:18121:109	General:df/dt-falling blk. criterion		• no • yes	no
_:18121:110	General:df/dt-falling blk. threshold		0.1 Hz/s to 20.0 Hz/s	3.0 Hz/s
_:18121:111	General:df/dt measuring window		2 periods to 5 periods	5 periods
_:18121:112	General:df/dt dropout differential		0.02 Hz/s to 0.99 Hz/s	0.10 Hz/s
_:18121:113	General:f< stabilization counter		1 to 20	6
Stage 1				
_:18151:1	Stage 1:Mode		• off • on • test	off
_:18151:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:18151:3	Stage 1:Threshold		40.00 Hz to 70.00 Hz	49.00 Hz
_:18151:5	Stage 1:Dropout differ-ential		20 mHz to 2000 mHz	20 mHz
_:18151:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.10 s

6.53.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:18121:501	General:>Activate all stages	SPS	I
_:18121:300	General:V1< block	SPS	O
_:18121:306	General:Invalid freq. blocking	SPS	O
_:18121:301	General:Power crit. blocking	SPS	O
_:18121:302	General:I1< blocking	SPS	O
_:18121:303	General:df/dt-rising blocking	SPS	O
_:18121:304	General:df/dt-falling blocking	SPS	O
_:18121:305	General:df/dt	MV	O
_:18121:52	General:Behavior	ENS	O
_:18121:53	General:Operate	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Stage 1			
_:18151:81	Stage 1:>Block stage	SPS	I
_:18151:500	Stage 1:>Block delay & op.	SPS	I
_:18151:502	Stage 1:>Exclusive activation	SPS	I
_:18151:347	Stage 1:Exclusive activation	SPC	C
_:18151:51	Stage 1:Mode (controllable)	ENC	C
_:18151:54	Stage 1:Inactive	SPS	O
_:18151:52	Stage 1:Behavior	ENS	O
_:18151:53	Stage 1:Health	ENS	O
_:18151:55	Stage 1:Pickup	ACD	O
_:18151:56	Stage 1:Operate delay expired	ACT	O
_:18151:57	Stage 1:Operate	ACT	O

6.54 Rate of Frequency Change Protection

6.54.1 Overview of Functions

The function **Rate of frequency change protection** is used to:

- Detect a frequency change quickly
- Prevent the system from not secure states caused by unbalance between the generated and consumed active power
- Network decoupling
- Load shedding

6.54.2 Structure of the Function

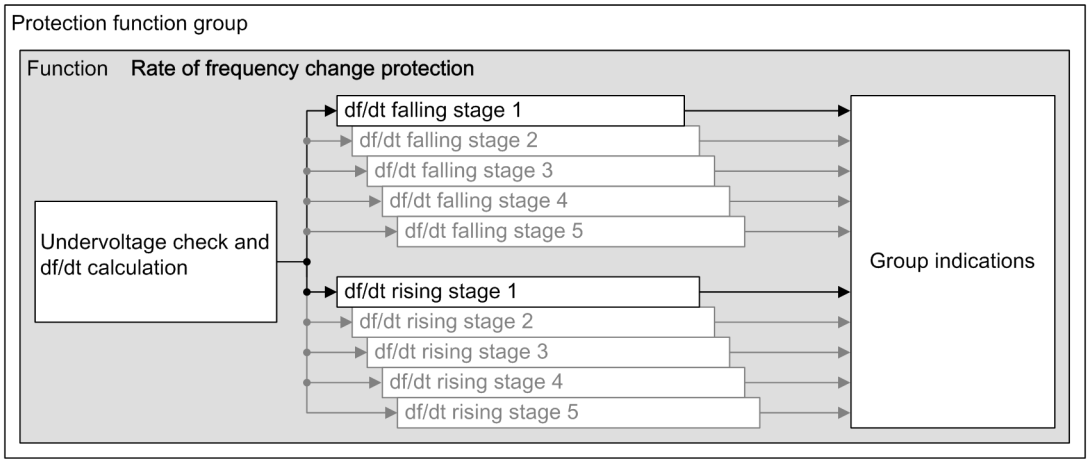
The function **Rate of frequency change protection** can be used in protection function groups containing a 3-phase voltage measurement.

2 function block types are available:

- **df/dt rising**
- **df/dt falling**

The function **Rate of frequency change protection** is preconfigured by the manufacturer with 1 df/dt rising stage and 1 df/dt falling stage. A maximum of 5 df/dt rising stages and 5 df/dt falling stages can operate simultaneously within the function. Both of the function block types are similar in structure.

Undervoltage check and df/dt calculation are general functionalities and take place on the function level. All stages use these general functionalities.



[dw_dfdt 01, 1, en_US]

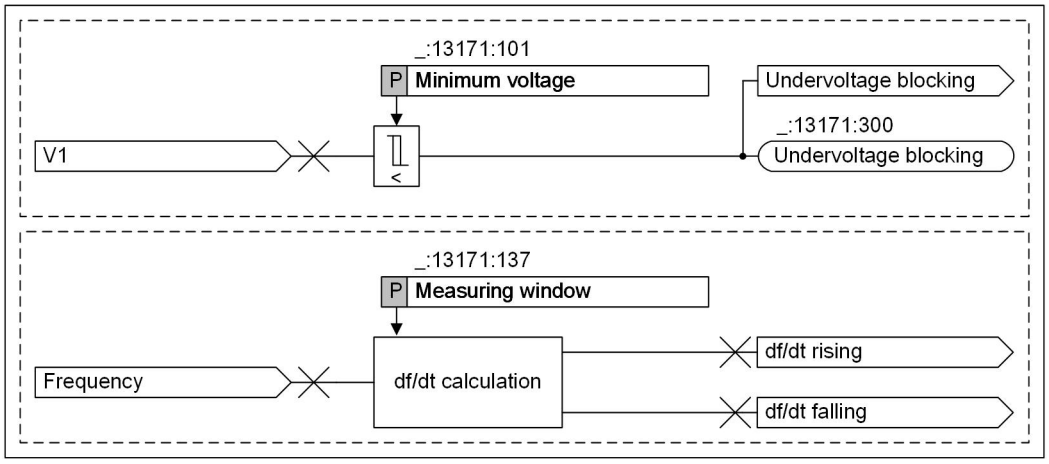
Figure 6-606 Structure/Embedding of the Function

6.54.3 General Functions (Undervoltage Test, df/dt Calculation)

6.54.3.1 Description

Logic

The following figure represents the logic of undervoltage check and df/dt calculation. It applies to all types of stages.



[lo_dfdtgf, 2, en_US]

Figure 6-607 Logic Diagram of General Functionality

Measurand

This function uses the frequency calculated via the angle difference algorithm.

For more information, refer to chapter *6.51.3 Overfrequency-Protection Stage*.

The frequency difference is calculated over a settable time interval (default setting: 5 periods).

The ratio between the frequency difference and the time difference reflects the frequency change which can be positive or negative.

A stabilization counter works to avoid overfunction. This counter is increased if the set threshold value is exceeded. If the value drops below the threshold value, the counter is reset immediately. The counter is set to 8 internally and is activated at each half system cycle.

Undervoltage Blocking

If the measuring voltage drops below the **`Minimum voltage`**, the **Rate of frequency change protection** is blocked because precise frequency values cannot be calculated anymore.

Functional Measured Value

Value	Description
df/dt	Calculated rate of frequency change

6.54.3.2 Application and Setting Notes

Parameter: `Minimum voltage`

- Recommended setting value **`(_:13171:101) Minimum voltage`** = ***`37.500 V`***

For the **Undervoltage blocking**, 65 % of the rated voltage of the protected object is recommended.

The method of measurement uses the phasor of the positive-sequence voltage. When determining the setting value, keep in mind that the absolute value of the sound positive-sequence voltage is equal to the absolute value of the phase-to-ground voltage. The default setting is referred to this value.

Parameter: `Measuring window`

- Default setting **`(_:13171:137) Measuring window`** = ***`5 periods`***

You can use the **`Measuring window`** parameter to optimize the measuring accuracy or the pickup time of the function. For information regarding pickup time and measuring accuracy, refer to the technical data.

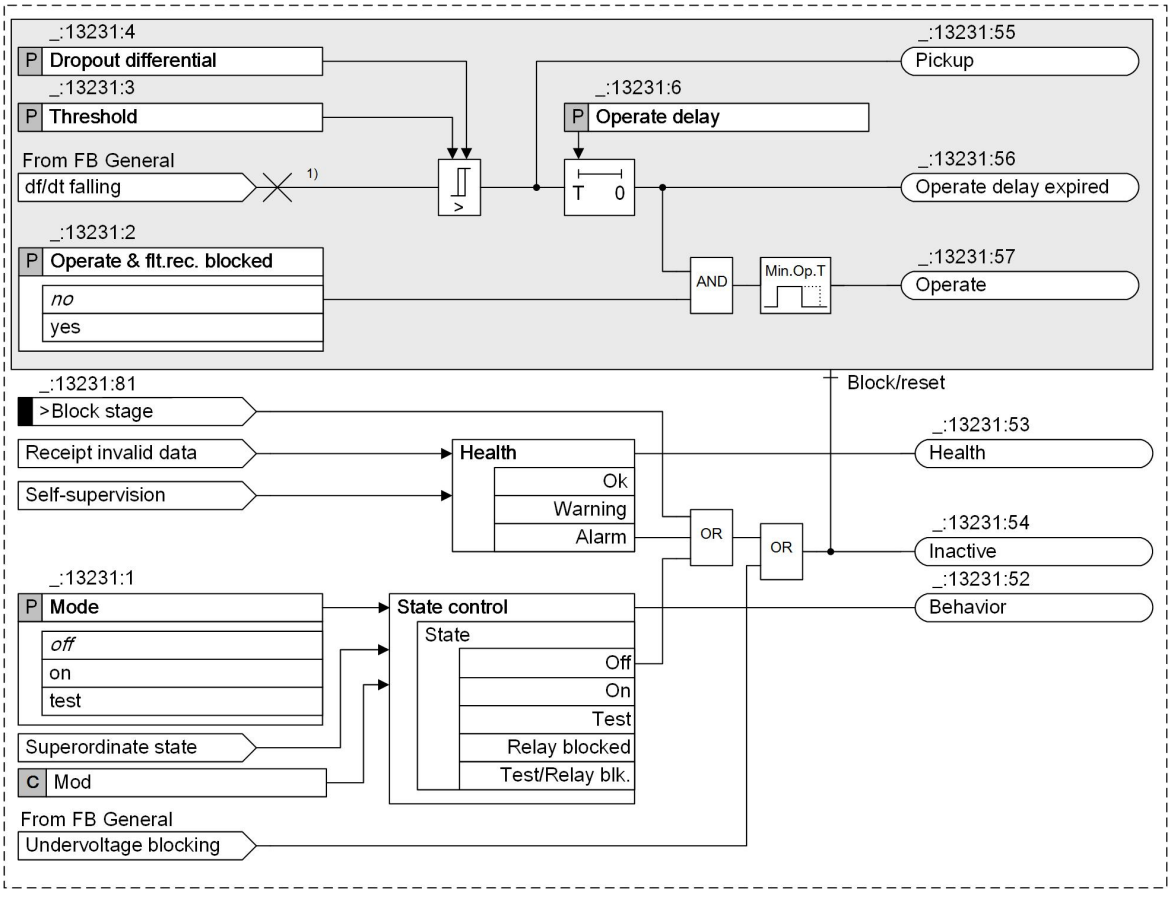
The default setting provides maximum measuring accuracy. If you do not have specific requirements for a decreased pickup time, Siemens recommends using the default setting.

The default setting is a reasonable compromise between measuring accuracy and pickup time. For a non-sensitive setting (high threshold value), you can set the parameter **Measuring window** to a smaller value.

6.54.4 Stage Description

6.54.4.1 Description

Logic of the Stage



[lo_dfdt_st_2, en_US]

Figure 6-608 Logic Diagram of Rate of Frequency Change Protection

(1) For the stage type **df/dt rising**, the value **df/dt rising** is used.

Frequency Rising/Falling

The stage **df/dt falling** is used to detect frequency falling and the stage **df/dt rising** is used to detect frequency rising.

You set the threshold value as an absolute value. You define the frequency-change direction via the selected stage type.

Blocking of the Stage

The following blockings reset the picked up stage completely:

- Via the binary input signal *>Block stage*
- Via the undervoltage blocking when the voltage drops below the **Minimum voltage**

6.54.4.2 Application and Setting Notes

Parameter: `Threshold`

- Default setting **`(_:13231:3) Threshold`** = ***`3.000 Hz/s`***

The pickup value depends on the application and is determined by power-system conditions. In most cases, a network analysis will be necessary. A sudden disconnection of loads leads to a surplus of active power. The frequency rises and causes a positive frequency change. On the other hand, a failure of generators leads to a deficit of active power. The frequency drops and results in a negative frequency change.

The following relations can be used as an example for estimation. They apply for the change rate at the beginning of a frequency change (approximate 1 s).

$$\frac{df}{dt} = -\frac{f_{rated}}{2H} \cdot \frac{\Delta P}{S_{rated}}$$

Where:

f_{rated}	Rated frequency
ΔP	Active power change $\Delta P = P_{Consumption} - P_{Generation}$
S_{rated}	Rated apparent power of the machines
H	Inertia constant

Typical data for H:

For hydro generators (salient-pole machines)	H = 1.5 s to 6 s
For turbine-driven generators (non-salient pole rotors)	H = 2 s to 10 s
For industrial turbine-driven generators	H = 3 s to 4 s

EXAMPLE

f_{rated} = 50 Hz
H = 3 s
Case 1: $\Delta P/S_{rated}$ = 0.12
Case 2: $\Delta P/S_{rated}$ = 0.48
Case 1: df/dt = -1 Hz/s
Case 2: df/dt = -4 Hz/s

Parameter: `Operate delay`

- Default setting **`(_:13231:6) Operate delay`** = ***`1.00 s`***

You can use the **`Operate delay`** parameter to avoid overfunction due to disturbing influences (for example, switching operations). If the protection function is supposed to respond quickly, set the **`Operate delay`** parameter to 0 s.

For monitoring small changes (< 1 Hz/s), a small time delay is useful to avoid overfunctioning.

Parameter: `Dropout differential`

- Recommended setting value **`(_:13231:4) Dropout differential`** = ***`0.10 Hz/s`***

You can use the **`Dropout differential`** parameter to define the dropout value. The recommended value is ***`0.10 Hz/s`***.

NOTE

In case of power-system incidents, especially in case of transmission incidents and influence of voltage-stabilizing measures via power-electronic components (reactive-power compensation through SVC), the magnitude and the phase angle of the voltage can change. Sensitive settings can lead to overfunction. Therefore, it is reasonable to block the **Rate of Frequency Change Protection** if other protection functions, for example, residual voltage or negative-sequence voltage, pick up. To do this, use the blocking input *>Block stage* and connect it via CFC.

6.54.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:13171:101	General:Minimum voltage		3.000 V to 175.000 V	37.500 V
_:13171:137	General:Measuring window		2 periods to 5 periods	5 periods
df/dt falling1				
_:13231:1	df/dt falling1:Mode		• off • on • test	off
_:13231:2	df/dt falling1:Operate & flt.rec. blocked		• no • yes	no
_:13231:3	df/dt falling1:Threshold		0.100 Hz/s to 20.000 Hz/s	3.000 Hz/s
_:13231:4	df/dt falling1:Dropout differential		0.02 Hz/s to 0.99 Hz/s	0.10 Hz/s
_:13231:6	df/dt falling1:Operate delay		0.00 s to 60.00 s	1.00 s
df/dt rising1				
_:13201:1	df/dt rising1:Mode		• off • on • test	off
_:13201:2	df/dt rising1:Operate & flt.rec. blocked		• no • yes	no
_:13201:3	df/dt rising1:Threshold		0.100 Hz/s to 20.000 Hz/s	3.000 Hz/s
_:13201:4	df/dt rising1:Dropout differential		0.02 Hz/s to 0.99 Hz/s	0.10 Hz/s
_:13201:6	df/dt rising1:Operate delay		0.00 s to 60.00 s	1.00 s

6.54.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:13171:300	General:Undervoltage blocking	SPS	O
_:13171:301	General:df/dt	MV	O
_:13171:52	General:Behavior	ENS	O
_:13171:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
df/dt falling1			
_:13231:81	df/dt falling1:>Block stage	SPS	I
_:13231:54	df/dt falling1:Inactive	SPS	O
_:13231:52	df/dt falling1:Behavior	ENS	O
_:13231:53	df/dt falling1:Health	ENS	O
_:13231:55	df/dt falling1:Pickup	ACD	O
_:13231:56	df/dt falling1:Operate delay expired	ACT	O
_:13231:57	df/dt falling1:Operate	ACT	O
df/dt rising1			
_:13201:81	df/dt rising1:>Block stage	SPS	I
_:13201:54	df/dt rising1:Inactive	SPS	O
_:13201:52	df/dt rising1:Behavior	ENS	O
_:13201:53	df/dt rising1:Health	ENS	O
_:13201:55	df/dt rising1:Pickup	ACD	O
_:13201:56	df/dt rising1:Operate delay expired	ACT	O
_:13201:57	df/dt rising1:Operate	ACT	O

6.55 Phase-Sequence Switchover

6.55.1 Overview of Functions

The **Phase-sequence reversal** function enables correct execution of the protection of the device and supervision functions, independently of the phase sequence of the phases in a system or system section.

The phase sequence is set via parameters. You can select between the phase sequences ***ABC*** or ***ACB***.

Binary inputs also provide the option of switching over the phase sequence with respect to the parameter setting. For example, in pumped-storage hydropower plants with motor or motor/generator operation you temporarily change the direction of rotation by changing over the phase sequence.

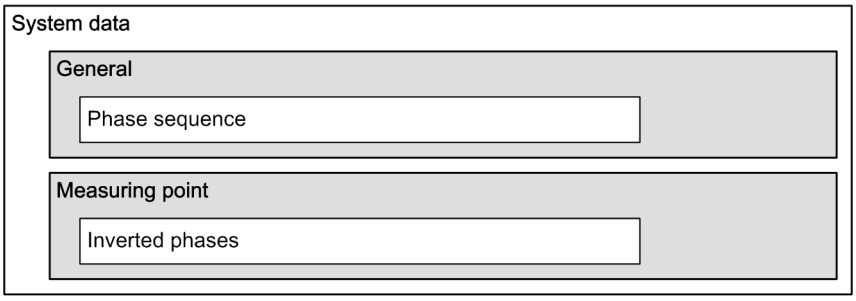
The phase sequence has an effect on calculation of the positive-sequence system and negative-sequence system values and on calculation of phase-to-phase values. A phase-rotation reversal therefore has an effect on all protection and supervision functions that use these values.

You can change the phase sequence in 2 ways via binary inputs.

- Change over the phase sequence for the entire device.
  In doing so, all 3-phase measuring points are switched over. All analog inputs are therefore affected (for example current and voltage inputs simultaneously).
- Change over the phase sequence per measuring point.
  In doing so, only the activated measuring points are switched over. The other measuring points remain unaffected.

6.55.2 Structure of the Function

The **Phase-sequence switchover** function is integrated in the **Power-system data**. You will find the signals in the DIGSI 5 project tree under **Name of the device** → **Settings**. There you will find the parameter for setting the phase sequence and the binary inputs via which you can influence a change in the phase sequence.



[dw_ph_rein, 1, en_US]

Figure 6-609 Structure/Embedding of the Function

6.55.3 Function Description

General

The phase sequence of the system is set in the device via the **`Phase sequence`** parameter. You will find the signals in the DIGSI 5 project tree under **Name of the device** → **Settings** → **Power-system data** → **General**. There are 3 methods to change the phase sequence for different operational requirements.

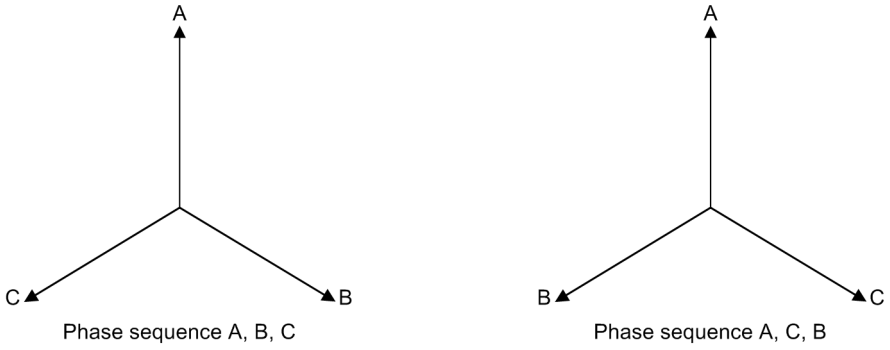
- Changing the phase sequence via the setting parameter.
  - **Note**: With version V7.50 and higher, this setting parameter is a reset parameter. If the parameter is changed and transmitted to the device, the device performs a startup. The parameter change affects all 3-phase measuring points. If the device is in operation and if measurands are present at the measuring points, perform a parameter change carefully since this affects all measuring points.

- With the binary signal *>Phs-rotation reversal*, you change over the phase sequence of all measuring points.
- With the binary signal *>Invert Phases*, you change over the phase sequence per measuring point.
  The **Inverted phases** parameter available for each measuring point is used to set which phases at the measuring point must be swapped. The parameter can be found at each 3-phase measuring point.

The 2 binary-signal mechanisms are explained separately below.

Switchover of the Phase Sequence of All Measuring Points

The direction of rotation of the currents and voltages depends on the phase sequence. The following drawing shows the vector definitions for the 2 phase sequences.



[dw_ph_rdrf, 1, en_US]

Figure 6-610 Vector with Different Phase Sequences

The phase sequence of a system or a system section is defined when parameterizing via the **Phase sequence** parameter. The setting parameter acts on all measuring points.

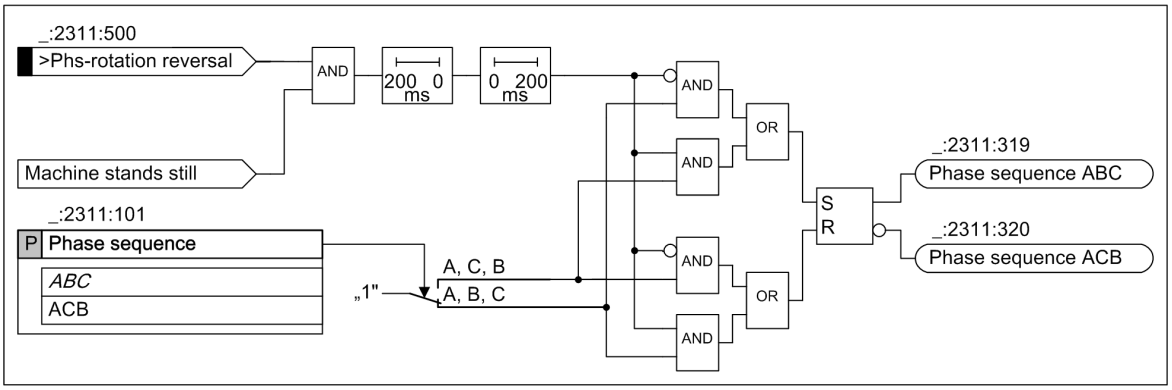
The operationally induced switchover between the phase sequence ***ABC*** and the phase sequence ***ACB*** is initiated via the binary input *>Phs-rotation reversal*. This switches over the phase sequence simultaneously at all 3-phase measuring points.

The following image shows a logic diagram for determining the current phase assignment and switchover. The indications shown on the right show the present phase sequence. If the phase sequence is set via the **Phase sequence** parameter to ***ABC***, activation of the binary input will result in a switchover to the phase sequence ***ACB***.

NOTE

The switchover of the phase sequence is only authorized for a time at which no measured values are pending. The switchover command must be present for at least 200 ms. The change of phase sequence is only permissible when the machine is at standstill. If the current and voltage values of all 3-phase measuring points are below 5 % of the rated variables, this is recognized as machine standstill.

A renewed machine standstill must be detected for a resetting of the phase sequence to the set preferred position.



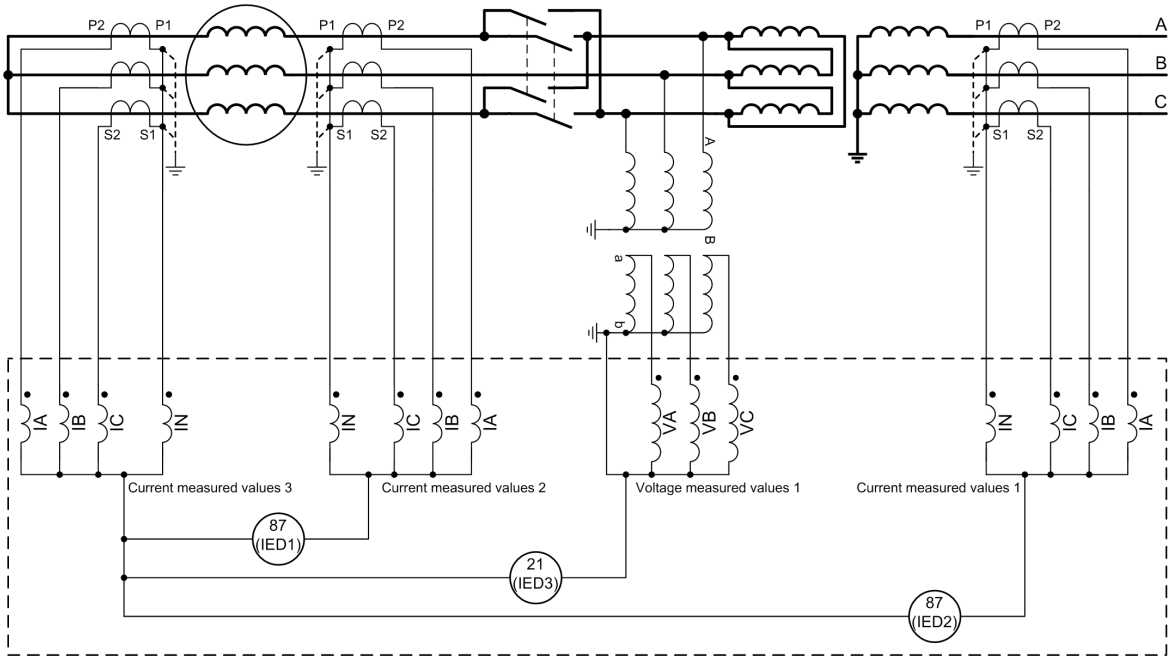
[dw_phrpsys1, 2, en_US]

Figure 6-611 Phase Sequence Switchover

Changing Over the Phase Sequence per Measuring Point

A switchover of the phase sequence per measuring point can also be necessary for operational reasons. This switchover enables proper behavior of the protection equipment, for example at the transition from generator operation to motor operation (pump operation).

The following example shows an application in a pumped storage plant. The switchover of the phase sequence (change in rotational direction) realizes the transition there from generator operation to motor operation. Which phases and measuring points are changed over depends on the conditions in the system.



[dw_phrapp, 2, en_US]

Figure 6-612 Application Example for Phase-Rotation Reversal in a Pump Station

The example shows 2 differential protection devices (IED1 and IED2) and an impedance protection (IED3) with the connected measuring points.

The phase sequence is insignificant for the differential protection of IED1, as the protected object is not affected by the switchover option of the phase sequence.

The phase sequence is also relevant to the differential protection of IED2, as the protected object extends beyond the switchover option.

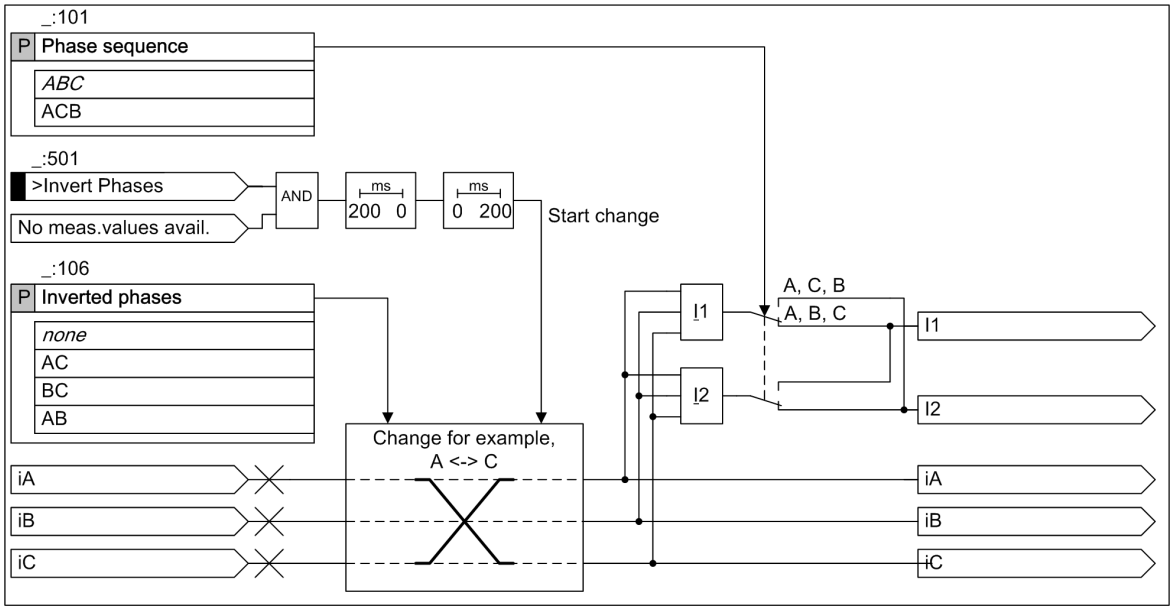
The phase sequence is also relevant to the impedance protection (IED3). Depending on the switch position, the voltage measured values 1 and the current measured values 3 have a different phase sequence.

The phase sequence of the system is set in the device via the **Phase sequence** parameter for generator operation. The **Inverted phases** parameter is used to set which phase is swapped for the relevant measuring point. The swap is communicated to the measuring point via the binary input signal *>Invert Phases*. The changed phase sequence is then included for calculation of the measurands at the measuring point.

In accordance with *Figure 6-612* the phase sequence is set to ***ABC***. A is swapped with C in motor operation. The **Inverted phases** parameter must be set to ***AC*** for the measuring points of current measured values 2 and current measured values 3. As a result, the phase assignment for the differential protection IED2 and the impedance protection IED3 is correct. The positive-sequence and negative-sequence current is calculated correctly.

The following logic diagram shows the principle for determining the present phase assignment and measured variables with the example of currents.

The switchover of the phase sequence is only authorized for a time at which no measured values are pending at the selected measuring points. The switchover command must be present for at least 200 ms. The change in the phase sequence is only implemented if the measurands at the measuring points that are to be switched are under 5 % of the rated variables. If the currents of the measuring points of current measured values 2 and current measured values 3 of the example fall below 5 % of their rated variables, the switchover is released and the set phases are switched with active binary input.



[lo_phrgph, 1, en_US]

Figure 6-613 Measured Values for Changed-Over Phases

6.55.4 Application and Setting Notes

Parameter: Phase sequence

- Default setting **(_:101) Phase sequence** = ***ABC***

ABC	Phase sequence A, B, C
ACB	Phase sequence A, B, C

Parameter: Inverted phases

- Default setting **(_:106) Inverted phases** = ***none***

none	No phase exchange
AC	Phase A changed over with phase C

BC	Phase B changed over with phase C
AB	Phase C changed over with phase B



NOTE

If you change the setting value of the parameter **Inverted phases**, consider the following:
The device can take the new setting value only if the binary input signal *>Invert Phases* is not active.

Input signal: *>Phs-rotation reversal*

The *>Phs-rotation reversal* binary input is used to switch between the ***ABC*** phase sequence and the ***ACB*** phase sequence. The switchover direction depends on the setting of the **Phase sequence** parameter. In doing so, the phase sequence of all 3-phase measuring points is changed. Changing of the phase-rotation reversal via the binary input is only possible if no measurands (< 5 % of the rated variables) are present at all 3-phase measuring points.

Input signal: *>Invert Phases*

The binary input *>Invert Phases* is used to activate the setting of the parameter **Inverted phases**. In doing so, the phase sequence of the selected measuring point is changed. Changing of the phase sequence via the binary input is only possible if no measurand (< 5 % of the rated variables) is present at the respective 3-phase measuring point.

6.55.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:101	General:Phase sequence		• ABC • ACB	ABC
General				
_:101	VT 3-phase:Rated primary voltage		0.10 kV to 1200.00 kV	400.00 kV
_:102	VT 3-phase:Rated secondary voltage		80 V to 230 V	100 V
_:103	VT 3-phase:Matching ratio Vph / VN		0.10 to 9.99	1.73
_:104	VT 3-phase:VT connection		• 3 ph-to-gnd volt. + VN • 3 ph-to-gnd voltages • 3 ph-to-ph volt. + VN • 3 ph-to-ph voltages	3 ph-to-gnd volt. + VN
_:106	VT 3-phase:Inverted phases		• none • AC • BC • AB	none
_:111	VT 3-phase:Tracking		• inactive • active	active
_:107	VT 3-phase:Measuring-point ID		0 to 100	0

6.55.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:500	General:>Phs-rotation reversal	SPS	I
_:501	General:>Invert Phases	SPS	I
General			
_:319	General:Phase sequence ABC	SPS	O
_:320	General:Phase sequence ACB	SPS	O
_:321	General:Freq.out of oper.range	SPS	O
_:322	General:f sys	MV	O
_:323	General:f track	MV	O
General			
_:315	VT 3-phase:Phases AB inverted	SPS	O
_:316	VT 3-phase:Phases BC inverted	SPS	O
_:317	VT 3-phase:Phases AC inverted	SPS	O

6.56 Instantaneous Tripping at Switch onto Fault

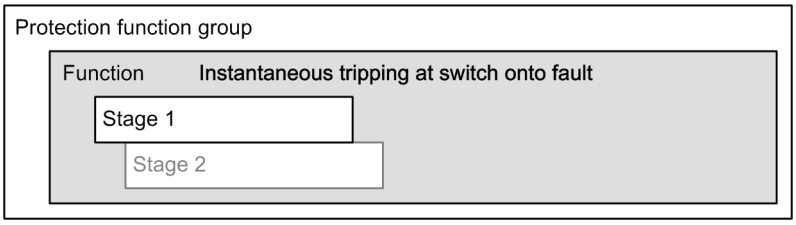
6.56.1 Overview of Functions

The **Instantaneous tripping at switch onto fault** function serves for immediate tripping when switching onto a fault.

The function does not have its own measurement and must be linked to another protection function with the pickup (measurement).

6.56.2 Structure of the Function

The function **Instantaneous tripping at switch onto fault** can be used in all protection function groups. The function is preconfigured with 1 stage. A maximum of 2 tripping stages can be operated simultaneously within the function. The tripping stages have an identical structure.



[dw_strsto, 1, en_US]

Figure 6-614 Structure/Embedding of the Function

6.56.3 Stage Description

Logic of the Stage

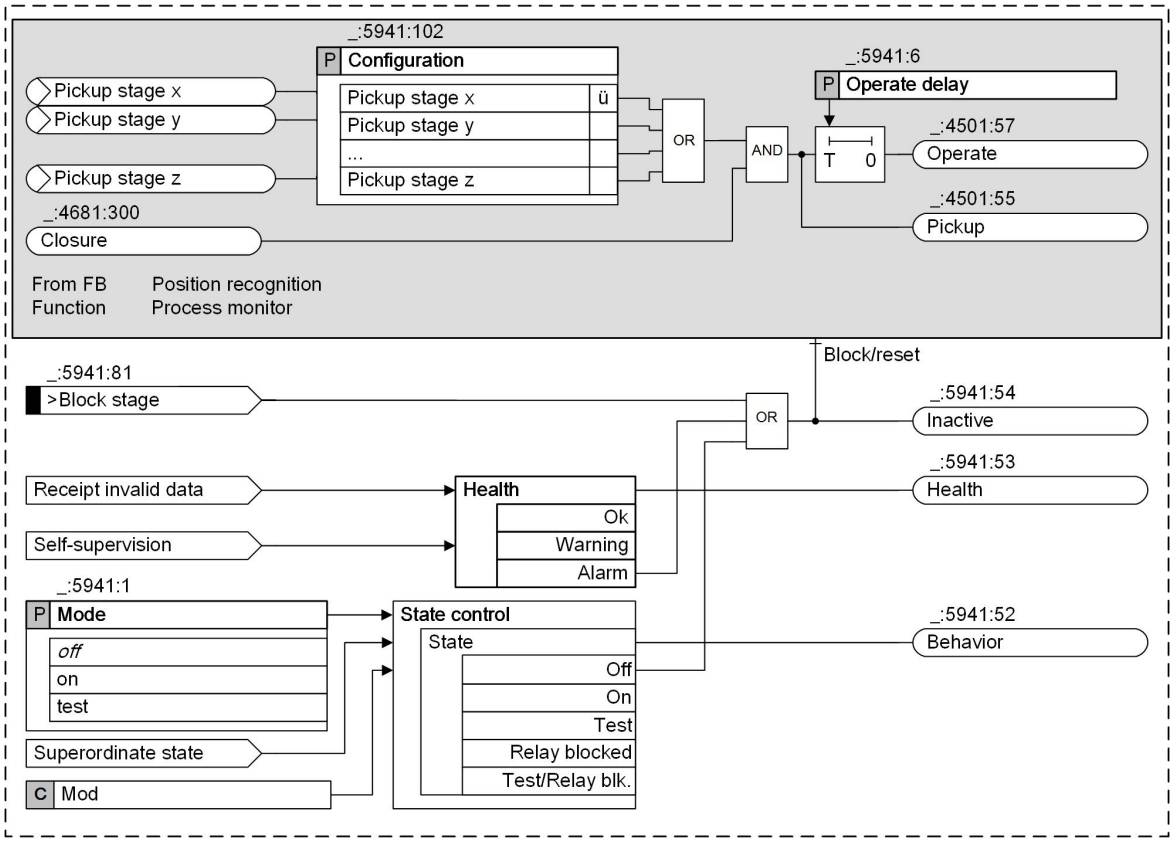


Figure 6-615 Logic Diagram of the Stage Instantaneous Tripping at Switch onto Fault

Connection of the Stage

The stage is intended to initiate instantaneous tripping when switching onto a fault. To do this, the stage must be connected to one or more pickups from protection functions or protection stages, for example, to pickup of an overcurrent-protection stage. That is, the stage of the **Instantaneous tripping at switch onto fault** function does not have its own measuring function but requires the pickup of another protection function or protection stage to pick up.

The stage is active only if switching is pending or executed (refer to *6.23 Overcurrent Protection, Phases*).

NOTE

If a protection stage picks up and tripping is blocked by the **Inrush-current detection** function, the **Instantaneous tripping at switch onto fault** function does not pick up. In this case there is no fault recording either.

Despite this, if a fault recording is necessary, you can activate it with the parameter **`(_:114) Start flt.rec`** of the **Inrush-current detection** function (refer to *6.68.1 Inrush-Current Detection*).

6.56.4 Application and Setting Notes

Parameter: Configuration

- Default setting **`(_:5941:102) Configuration`** = ***`no stage`***

The **Configuration** parameter is used to define the pickup of a protection function or protection stage that the **Instantaneous tripping at switch onto fault** function uses to respond.
Normally, the pickups of protection functions and stages with high fault current are selected:

- Overcurrent protection (phase and ground)
- Directional overcurrent protection (phase and ground)
- Ground-fault protection for grounded systems

A specific protection stage is generally used. This can be one of the protection stages provided for the protection application, which itself trips with a delay. An additional protection stage with settings optimized for this use case, for example, increased threshold value and blocking of self-tripping, can also be used.

Parameter: Operate delay

- Recommended setting value **(_:5941:6) Operate delay** = ***0.00 s***

When switching onto a fault, the tripping should usually be instantaneous. The tripping delay is therefore set to 0.

6.56.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:5941:1	Stage 1:Mode		• off • on • test	off
_:5941:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:5941:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.00 s
_:5941:102	Stage 1:Configuration		Setting options depend on configuration	

6.56.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Stage 1			
_:5941:81	Stage 1:>Block stage	SPS	I
_:5941:51	Stage 1:Mode (controllable)	ENC	C
_:5941:54	Stage 1:Inactive	SPS	O
_:5941:52	Stage 1:Behavior	ENS	O
_:5941:53	Stage 1:Health	ENS	O
_:5941:55	Stage 1:Pickup	ACD	O
_:5941:57	Stage 1:Operate	ACT	O

6.57 Thermal Overload Protection, 3-Phase - Advanced

6.57.1 Overview of Functions

The **Thermal overload protection, 3-phase – advanced** function (ANSI 49) is used to:

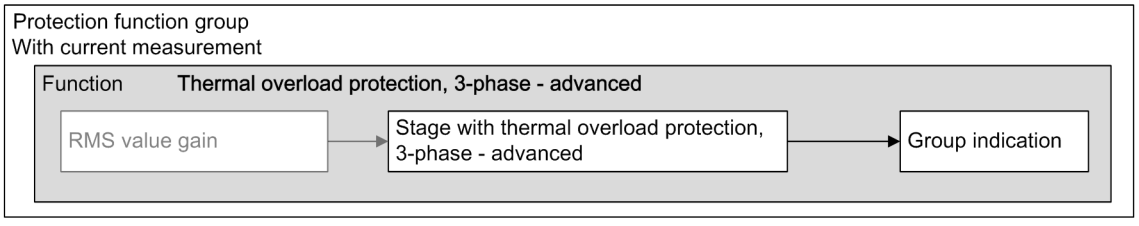
- Protect the equipment (motors, generators, transformers, capacitors, overhead lines, and cables) against thermal overloads
- Monitor the thermal state of motors, generators, transformers, capacitors, overhead lines, and cables

6.57.2 Structure of the Function

The **Thermal overload protection, 3-phase – advanced** function is used in protection function groups with current measurement.

The function is preconfigured by the manufacturer with 1 **Thermal overload protection, 3-phase – advanced** stage.

The non-preconfigured function block **Filter** can optionally be applied to gain the RMS value used by the **Thermal overload protection, 3-phase – advanced** stage.



[dw_TOLP_with_filter_stage, 2, en_US]

Figure 6-616 Structure/Embedding of the Function

6.57.3 Filter for RMS Value Gain

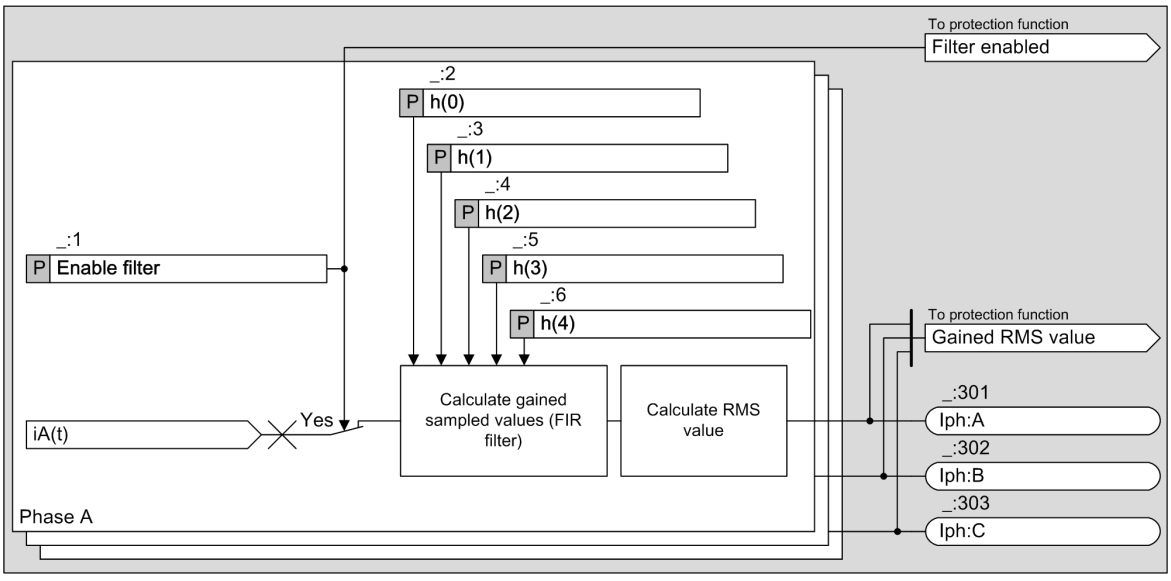
6.57.3.1 Description

The function block **Filter** can be used to adapt the RMS value for 2 means:

- To gain harmonics in a defined way. Higher harmonics can stress the protected object thermally more than lower harmonics. This is the case for reactors applied in AC filters. In addition, the amplitude attenuation of higher frequencies due to the anti-aliasing filter of the device is automatically compensated by the filter
- To only compensate the amplitude attenuation of higher frequencies by the device (due to the anti-aliasing filter)

The filter gain (amplitude response) is realized by a 9-order FIR filter.

Logic



[lo_tolp_filter_stage, 1, en_US]

Figure 6-617 Logic Diagram of the Function Block Filter

The FIR filter gains the 8-kHz sampled values according to the set filter coefficients. Afterwards the RMS value is calculated. The symmetrical 9-order filter coefficients are set via the respective parameters **h(0)**, **h(1)**, **h(2)**, **h(3)** and **h(4)**.

NOTE

A FIR-filter configuration tool is provided as an auxiliary PC tool. With this PC tool, the coefficients h(0), h(1), h(2), h(3), h(4) of the FIR filter are generated according to the required gain factors (amplitude response). The tool can be obtained from the SIPROTEC download area. For more information about the tool, refer to the tool help function.

The gained RMS value is delivered to the protection stages only when the function block **Filter** is instantiated and the parameter **Enable filter** is set as ***yes*** . Otherwise, the normal RMS value is used.

Functional Measured Values

Values	Description	Primary	Secon-dary	% Referenced to
Iph:A	Filtered RMS measured value of current A	kA	A	Parameter **Rated current**
Iph:B	Filtered RMS measured value of current B	kA	A	Parameter **Rated current**
Iph:C	Filtered RMS measured value of current C	kA	A	Parameter **Rated current**

You can find the parameter **Rated current** in the **FB General** of function groups where the **Thermal overload protection, 3-phase - advanced** function is used.

If the parameter **Enable filter** is set to ***no***, the function values are shown as ---.

6.57.3.2 Application and Setting Notes

Parameter: Enable filter

- Default setting **(_:1) Enable filter** = ***no***.

With the parameter **Enable filter**, you set whether the **Filter** is enabled.

Parameter Value	Description
yes	If gained RMS values should be used in one of the protection stages, set parameter **Enable filter** = ***yes***.
no	If no gained RMS values are needed, set the parameter **Enable filter** = ***no***.

Parameter: `h(0),h(1),h(2),h(3),h(4)`

- Default setting **(_:2) h(0)** = ***0.000***
- Default setting **(_:3) h(1)** = ***0.000***
- Default setting **(_:4) h(2)** = ***0.000***
- Default setting **(_:5) h(3)** = ***0.000***
- Default setting **(_:6) h(4)** = ***1.000***

With the default value of the coefficients, the filter has no effect and no gain is applied.

If the filter shall be applied to adapt the RMS value calculation to a specific protection object such as a reactor, the reactor manufacturer has to provide the required amplitude response (gain factors) for the reactor. To determine the coefficients h(0) to h(4) for the FIR filter, you must enter the gain factors into the auxiliary PC tool which is available in the SIPROTEC download area. The 5 required coefficients are generated by the tool. They have to be entered manually as settings to configure the filter. The amplitude attenuation of higher frequencies due to the anti aliasing filter of the device is automatically taken into account and compensated by the filter.

To only compensate the attenuation of higher frequencies by the device, set the following coefficients in the filter.

Rated Frequency	Filter Coefficients for Only Compensating the Device Amplitude Attenuation
50 Hz	h(0) = -0.002 h(1) = -0.012 h(2) = 0.045 h(3) = -0.110 h(4) = 1.151
60 Hz	h(0) = -0.005 h(1) = -0.020 h(2) = 0.058 h(3) = -0.128 h(4) = 1.170

6.57.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Filter				
_:1	Filter:Enable filter		• no • yes	no
_:2	Filter:h(0)		-100.000 to 100.000	0.000
_:3	Filter:h(1)		-100.000 to 100.000	0.000
_:4	Filter:h(2)		-100.000 to 100.000	0.000
_:5	Filter:h(3)		-100.000 to 100.000	0.000
_:6	Filter:h(4)		-100.000 to 100.000	1.000

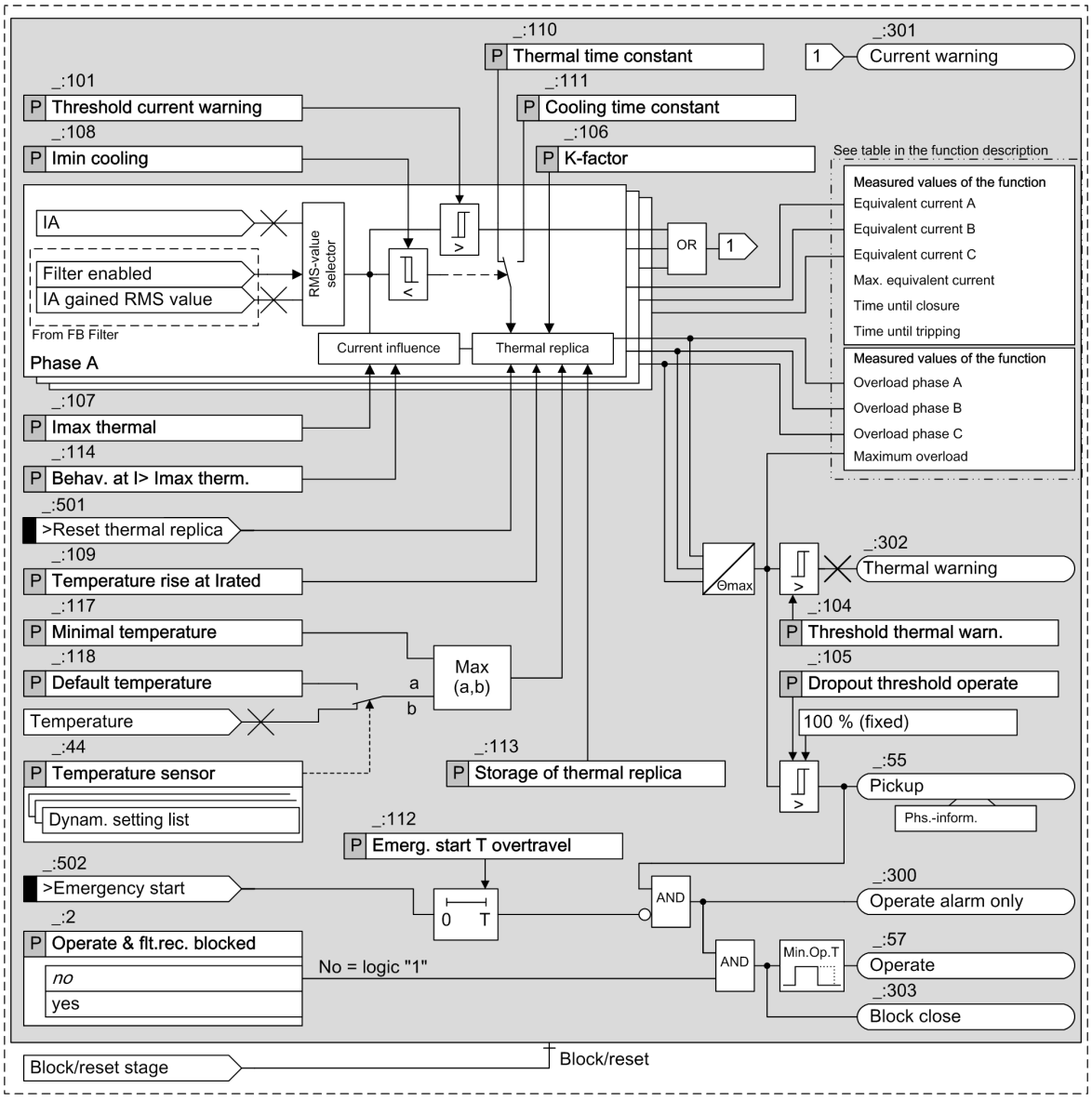
6.57.3.4 Information List

No.	Information	Data Class (Type)	Type
Filter			
_:301	Filter:Iph:A	MV	O
_:302	Filter:Iph:B	MV	O
_:303	Filter:Iph:C	MV	O
_:52	Filter:Behavior	ENS	O
_:53	Filter:Health	ENS	O

6.57.4 Stage with Thermal Overload Protection, 3-Phase - Advanced

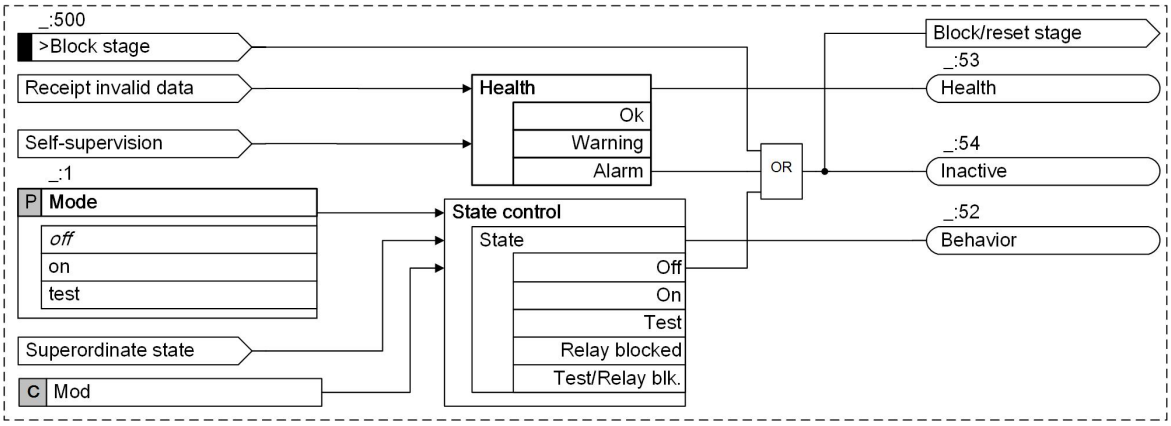
6.57.4.1 Description

Logic



[lo_tolp_with_filter_stage, 2, en_US]

Figure 6-618 Logic Diagram of the Thermal Overload Protection, 3-Phase - Advanced Stage



[lo_stage_control_TOLP, 2, en_US]

Figure 6-619 Logic Diagram of the Stage Control

RMS-Value Selection

The protection function supports 2 kinds of RMS measurement:

- Normal RMS value
- Gained RMS value from the function block **Filter**

The gained RMS value is automatically used if the function block **Filter** is configured and the filter has been enabled.

NOTE

When the function block **Filter** is applied, only one current measuring point I-3ph is allowed to be connected to the 3-phase current interface of the function group.

Thermal Replica

The protection function calculates the overtemperature from the phase currents based on a thermal single-body model according to the thermal differential equation with

$$I_{p.u.}^2 = \tau_{th} \frac{d\theta}{dt} + \theta - \theta_{Amb}$$

[fo_diffgl-170914, 2, en_US]

With the following standardization:

$$I_{p.u.} = \frac{I}{I_{max}} = \frac{I}{K \cdot I_{rated\ ,obj.}} \qquad \theta = \frac{\vartheta}{\vartheta_{max}} = \frac{\vartheta}{K^2 \cdot \Delta\vartheta_{rated\ ,obj.}}$$

$$\tau_{th} = R_{th} \cdot C_{th} \qquad \theta_{Amb} = \frac{\vartheta_{Amb} - 40\ °C}{\vartheta_{max}} = \frac{\vartheta_{Amb} - 40\ °C}{K^2 \cdot \Delta\vartheta_{rated\ ,obj.}}$$

[fo_normie_01, 3, en_US]

Θ	Current overtemperature, in relation to the final temperature at a maximum permissible phase current k $I_{rated, obj}$
Θ_{Amb}	Standardized ambient temperature, where ϑ_{Amb} describes the coupled ambient temperature. The coupled ambient temperature ϑ_{Amb} can be the measured ambient temperature or the ambient temperature preset using the **`Default temperature`** parameter.
$\Delta\vartheta_{rated\ obj}$	Overtemperature of the protected object set at rated current

τ_{th}	Thermal time constant (temperature rise/cooling) of the protected object
k	This factor indicates the maximum continuous permissible phase current. The factor refers to the rated current of the protected object ($k = I_{max}/I_{rated, obj}$)
$I_{rated, obj}$	Rated current of the protected object

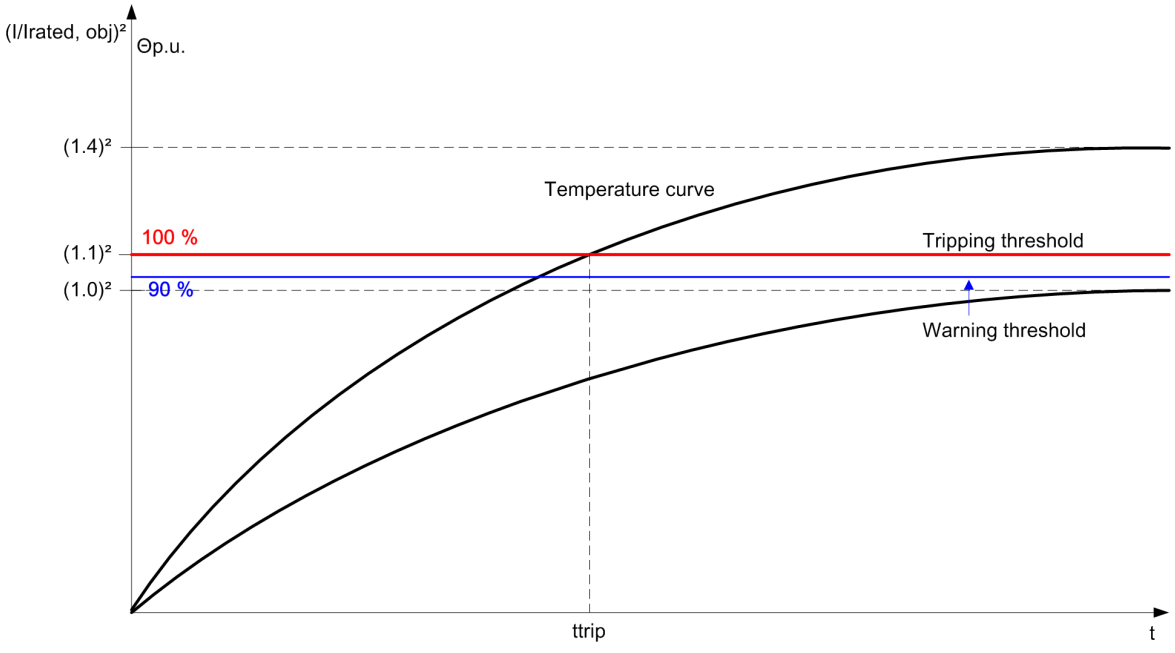
At the same time, $I_{rated, obj}$ is the rated current of the assigned protected object side:

- In the case of transformers, the rated current of the winding to be protected, which the device calculates from the set rated apparent power and rated voltage, is decisive.
- The uncontrolled winding forms the basis in the case of transformers with voltage control
- In the case of generators, motors and reactors, the rated current, which the device calculates from the set rated apparent power and rated voltage, is decisive.
- In the case of lines, nodes and busbars, the rated current of the protected object is set directly

In a steady state, the solution to the thermal differential equation is an e-function whose asymptote represents the final overtemperature Θ_{end}. The time constant τ_{th} determines the rise. After reaching an initial adjustable overtemperature threshold Θ_{warn} (**`Threshold thermal warn.`**), a warning indication is given.

If the overtemperature limit Θ_{Off} (tripping overtemperature) is exceeded, an operate indication is immediately issued and the equipment disconnected from the power supply. This threshold is specified at 100 % and corresponds to the final temperature set at a flowing permissible continuous current (I_{max}).

Figure 6-620 shows the temperature rise at different overload currents and the supervision thresholds.



[dw_temp_ve, 1, en_US]

Figure 6-620 Temperature History for Different Overload Currents (**`K-factor`** = ***`1.1`***)

The overtemperature is calculated separately for each phase. The current overtemperature can be obtained from the operational measured values. It is shown in percent. An indication of 100 % means that the thermal threshold has been reached. The maximum overtemperature of the phases is regarded as the tripping temperature. This means that the highest of the 3 phase currents is always assumed.

The analysis of the RMS values of the currents over a broad frequency band also includes the harmonic components. These harmonic components contribute to the temperature rise of the equipment.

If the flowing current falls below an adjustable minimum current **`Imin cooling`** , the **`Cooling time constant`** is activated.

Operate Curve

If the ambient temperature is not measured and set to 40°C, you can get the operate curve as following:

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj.}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - 1}$$

[fo_auslos, 1, en_US]

t	Operate time
τ_{th}	Time constant
I	Measured load current
$I_{preload}$	Preload current
k	Setting factor according to VDE 0435 part 3011 or IEC 60255-149 (K factor)
$I_{rated, obj}$	Rated current of the protected object

Ambient Temperature

This function takes the ambient temperature into consideration. The reference temperature of the thermal model is 40 °C.

Compared to the reference temperature, a different ambient temperature leads to different results.

- The ambient temperature is smaller than the reference temperature.

  If the ambient temperature is smaller than the reference temperature, the thermal limit increases. This means that the persistent maximum permissible current increases and results in a higher actual K factor.
- The ambient temperature is larger than the reference temperature.

  If the ambient temperature is larger than the reference temperature, the thermal limit decreases. This means that the persistent maximum permissible current decreases and results in a lower actual K factor.

The ambient temperature can be measured with an RTD (Resistance Temperature Detector) element and can influence the thermal limit dynamically. Alternatively, a higher or lower ambient temperature can be considered statically with the parameter **`Default temperature`**, which results in a lower or higher actual K factor compared to the parameter that corresponds to an ambient temperature of 40 °C.

So, the parameter **`Default temperature`** is a fixed value to describe the ambient temperature if no sensor is connected or it is the value to be considered if the temperature sensor is defective. The parameter **`Minimal temperature`** parameter limits the coupled ambient temperature. If the measured ambient temperature is lower than the minimum temperature, the minimum temperature is processed in the thermal model.

To calculate the actual K factor depending on the ambient temperature, the value of the parameter **`Temperature rise at Irated`** is required.

The ambient temperature is measured by an external RTD unit or by an IO111 module and provided by the functions **RTD unit Ether.**, **RTD unit serial**, or **Temperature module IO111** of the function group **Analog unit**. When using the parameter **`Temperature sensor`** , the respective temperature sensor can be selected.

If the temperature measurement is faulty, for example, due to an open circuit between the device and the RTD unit, the health state of the function **Thermal overload protection, 3-phase – advanced** changes to *Warning*. In this case, the process continues with either the temperature measured last or the value set under the parameter **`Default temperature`**, depending on which value is higher.

Current Influence

The thermal replica based on the single-body model applies with limitations to high overcurrent situations (short circuits, motor startup currents). To avoid an overfunction of the overload protection, the thermal replica must be influenced for overcurrents (exceeding $\mathbf{I}_{threshold}$). You can select between 2 strategies for this:

- Freezing of the thermal memory
- Limitation of the input current for the thermal replica to the set current. The temperature rise is thereby **retarded** at high currents.

Warning Thresholds

The thermal warning threshold issues a warning indication before the tripping threshold (tripping temperature) is reached. In this way, for example, a load can be reduced in sufficient time and a disconnection avoided. At a normal **K-factor** of ***1.1***, a thermal memory value of 83 % sets in at continuously flowing rated current.

Apart from the thermal warning threshold, the overload protection also has a current-warning threshold. This current-warning threshold can signal an overload current in sufficient time before the overtemperature value has reached the warning or tripping threshold.

Dropout of Tripping

Once the thermal memory has fallen below the setting value of the **Dropout threshold operate** , the trip command is canceled upon tripping. In contrast, the current-warning threshold and the thermal warning threshold are reduced at a fixed dropout threshold (see Technical Data).

Behavior in the Event of Auxiliary-Voltage Failure

The behavior of the thermal replica can be controlled upon auxiliary-voltage failure via the setting parameter **Storage of thermal replica** . You can save the thermal state for a time of 500 min. Once the supply voltage returns, the thermal replica continues to function with the saved thermal state.

If the thermal replica is not saved, it will be reset to 0 upon failure of the auxiliary voltage.

Resetting the Thermal Map

You can reset the thermal memory via the binary input indication **>Reset thermal replica** . The thermal memory will then have a 0 value. A reparameterization will also lead to resetting the thermal memory.

Emergency Start

Depending on the operating conditions, tripping can be blocked or closure enabled despite the permissible thermal limits being exceeded. Upon activation of the binary input signal **>Emergency start** , tripping is blocked and closure enabled. This does not affect the state of the thermal memory. After the input **>Emergency start** disappears, the blocking remains in effect for the set **Emerg. start T overtravel** .

Blocking the Function

Blocking will cause a picked up function to be reset. The tripping function can be blocked externally or internally by the binary input signal **>Block stage** .

All indications then drop out and the thermal memory is set to the value 0.

Blocking Closure

The signal **Block close** can be used to prevent closure of the protected object at a high thermal load. The signal is set if the tripping overtemperature is exceeded, and canceled if the temperature falls below the dropout threshold.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:601:305) Time until trip	Expected time until tripping	s	s	s
(_:601:304) Time until close	Time until close release	s	s	s
(_:601:306) Overload phase A	Thermal measured values of the phases	%	%	Tripping temperature
(_:601:307) Overload phase B				
(_:601:308) Overload phase C				

Values	Description	Primary	Secondary	% Referenced to
(_:601:309) Overload maximum	Thermal measured value of the overload protection	%	%	Tripping temperature
(_:601:310) Equival. current phs A	Current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values
(_:601:311) Equival. current phs B				
(_:601:312) Equival. current phs C				
(_:601:313) Equival. current max.	Maximum current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values

6.57.4.2 Application and Setting Notes

Motors and generators as well as transformers are at risk from longer-lasting overloads. The overload protection has a thermal operate curve, which can be adapted to the overload capacity of the equipment that is to be protected.

Parameter: Threshold current warning

- Default setting **(_:101) Threshold current warning** = ***1.000 A*** at I_{rated} = 1 A

Set the threshold to the maximum permissible continuous current ($I_{max, perm}$). This results in the same setting value as for the **K-factor**.

Parameter: Threshold thermal warn.

- Default setting **(_:104) Threshold thermal warn.** = ***90 %***

The default setting can be left at a **K-factor**, of ***1.1***, as the thermal memory results for 83 % at continuously flowing rated current. The calculation uses the rule of three: 100 % corresponds to (**K-factor**)^2 and x % corresponds to 1^2.

$$\frac{\Theta}{\Theta_{off}} = \frac{100\ \%}{k^2} = 83\ \%$$

[fo_warnsc_2, en_US]

At a **K-factor** of 1.05, the thermal memory for rated current is already 91 % filled. Increase the **Threshold thermal warn.** to 95 %.

Parameter: Dropout threshold operate

- Default setting **(_:105) Dropout threshold operate** = ***90 %***

The **Dropout threshold operate** parameter is used to drop out pickup and tripping when the value drops below this threshold. A setting on the order of magnitude of the warning threshold is recommended. You can select a lower setting value for special applications, desired additional cooling or longer blocking of closing.

Note that the calculation of the operational measured value **Time until close** refers to this value.

Parameter: Emerg. start T overtravel

- Default setting **(_:112) Emerg. start T overtravel** = ***300 s***

The **Emerg. start T overtravel** parameter is used to set the time for which blocking of the tripping has to remain active after an outgoing binary input signal **>Emergency start**. With an outgoing input signal, the load on the protection object is removed. The emergency start T-overtravel must be set long enough to allow the thermal memory to fall below the dropout threshold after cooling. Select a time on the order of magnitude of the **Cooling time constant**. In the example, 105 min (6300 s) have been assumed.

Parameter: K-factor

- Default setting **(_:106) K-factor** = ***1.10***

The **K-factor** parameter is used to describe the limiting value for the maximum permissible continuous load. The rated current $I_{rated, obj}$ of the protected object (motors, generators, transformers) is the basic current for the overload detection. If motors are designed according to temperature class F and operated according to temperature class B, selection of the 1.1 times rated current (**K-factor** = ***1.1***) is always permissible. In the case of transformers, **K factors** of **1.15** to maximum **2.1** can also occur.

You can determine the **K-factor** on the basis of the thermally permissible continuous current $I_{max, perm.}$:

$$K-factor = \frac{I_{max,perm.}}{I_{rated,obj.}}$$

[fo_tolp_kf, 2, en_US]

NOTE

The thermally permissible continuous current for the protected object is known from relevant tables, from the thermal limit curves or from the specifications of the manufacturer!

EXAMPLE

Motor and transformer with the following data

Continuous permissible current: $I_{max\ perm.} = 1.1\ I_{rated\ motor}$

Rated current of the motor: $I_{rated\ motor} = 1100$ A

Selected **K factor** of 1.1

Parameter: Thermal time constant

- Default setting **(_:110) Thermal time constant** = ***900 s***

The **Thermal time constant** parameter is used to define the tripping characteristics of the stage.

NOTE

The **Thermal time constant** is specified by the machine manufacturer.

For motors, for instance, it is on the order of magnitude of 10 to 30 min. Deviations are possible. A **Thermal time constant** of ***15.12 min*** is a customary value in practice.

If, on the other hand, the **Thermal time constant** is not known, but only an operate curve is available, the time constant can also be concluded from this. Define the **K-factor** for this by calculating the maximum permissible overcurrent or assuming the **K-factor** (**K-factor** = ***1.1***). The operate time for a current value (for example, 1.5 $I_{rated, obj.}$) is read off from the operate curve. The current value must be close to the overload current value.

The operate curves are indicated for both the cold and warm state. The operate curve for the **cold** state is recommended for calculating the time constant.

Use the formula for the operate time to calculate the **Thermal time constant** parameter. It must be converted according to the time constant τ_{th}. For the cold-operation case, set the previous current to 0 ($I_{previous\ load} = 0$).

$$t = \tau_{th} \cdot \ln\left[\frac{\frac{1}{k^2}\left(\frac{I}{I_{rated\ ,obj.}}\right)^2 - \frac{1}{k^2}\left(\frac{I_{preload}}{I_{rated\ ,obj.}}\right)^2}{\frac{1}{k^2}\left(\frac{I}{I_{rated\ ,obj.}}\right)^2 - 1}\right]$$

[fo_konsmt, 2, en_US]

EXAMPLE

For the asynchronous motor

K factor = 1.1

Characteristic curve class 10 according to ANSI: At 1.5 $I/I_{rated, obj}$, a required operate time of 700 s is derived from the characteristic curve.

The **Thermal time constant** can therefore be calculated:

$$700\ s = \tau_{th} \cdot \ln \frac{\frac{1}{1.1^2}\left(\frac{1.5\, I_{rated,obj.}}{I_{rated,obj.}}\right)^2}{\frac{1}{1.1^2}\left(\frac{1.5\, I_{rated,obj.}}{I_{rated,obj.}}\right)^2 - 1} = \tau_{th} \cdot 0.772$$

[fo_konsta_01, 2, en_US]

This results in a setting value of 907 s for the **Thermal time constant**.

Parameter: Cooling time constant

- Default setting **(_:111) Cooling time constant** = ***3600 s***

The **Cooling time constant** parameter is used to define the cooling characteristics of the thermal stage. If the machines come to a standstill and hence self-cooling (for instance, via the fan impeller) is absent, the cooling will take considerably longer. Standstill sensing is performed via the current. For the **Cooling time constant**, 7 times the time of the thermal time constant 6350 s (105 min) is selected. This is a customary value in practice.

NOTE

The **Cooling time constant** is a multiple of the thermal time constant and can be taken from the motor data.

Parameter: Imax thermal

- Default setting **(_:107) Imax thermal** = ***2.5 A*** at I_{rated} = 1 A

The **Imax thermal** parameter allows you to set the threshold current for the **Behav. at I> Imax therm.** parameter. If you calculate with relatively long start times for motors (longer than 25 s), the current limiting must be reduced to 2 $I/I_{rated, obj}$.

Parameter: Imin cooling

- Default setting **(_:108) Imin cooling** = ***0.500 A***

When defining the minimum current **Imin cooling**, you can use the no-load current for orientation. If no data is available, set 0.05 $I/I_{rated, obj}$. If the current falls below this value, there is an automatic switchover to the **Cooling time constant**.

Parameter: Temperature rise at Irated

- Default setting **(_:109) Temperature rise at Irated** = ***70 K***

Consider this parameter only if the ambient temperature is not 40 °C or if you use a sensor for the measurement of the ambient temperature.

At an ambient temperature of 40 °C, if the equipment operates continuously with the rated current, the temperature rise is 70 K. Here, the rated current refers to the protected object. You can find the temperature value in the technical data of the equipment or measure it. If you use a temperature sensor when measuring

at the rated current, deduct the actual ambient temperature or the coolant temperature from the measured value.

When selecting the setting value, you can also use the specified temperature class for orientation. Usually, you will find the overtemperature expressed in Kelvin (K), which can be accepted as is. If the absolute temperature is given, the ambient temperature must be deducted. As a rule, this is 40 °C.

The overtemperature at maximum permissible current (***ϑmax***) and the **`Temperature rise at Irated`** (***ϑrated,obj.***) can be converted by using the following formula:

$$k^2 = \left(\frac{\Delta\vartheta_{max}}{\Delta\vartheta_{rated\ ,obj.}} \right)$$

[fo_ueb_for_Irated, 3, en_US]

EXAMPLE:

Temperature class **B** for continuous operation: permissible overtemperature = 80 K

From this, a temperature for I_{rated} of 120 °C (80 K + 40 °C) can be derived when using a temperature sensor for the measurement.

Temperature class **F** as thermal limiting value: permissible overtemperature = 105 K.

From this, a maximum temperature of 145 °C (105 K + 40 °C) derives.

From these values, the K factor can be derived:

$$k^2 = \frac{\Delta\vartheta_{max\ ,Obj.}}{\Delta\vartheta_{rated\ ,Obj.}} = \frac{105\ K}{80\ K} = 1.31 \qquad \rightarrow\ k = 1.146$$

[fo_bsp_kfaktor, 3, en_US]

If you select a setting value of 1.1 for the **`K-factor`**, your selection can be considered as conservative.

NOTE

For electrical machines, the limits can vary depending on the type of coolant.

Consult the machine manufacturer to agree on a setting value for the overtemperature.

Parameter: **`Storage of thermal replica`**

- Default setting **`(_:113) Storage of thermal replica`** = ***`no`***

If a continuous auxiliary voltage for the bay units is ensured, the bay default setting can be retained.

Parameter: **`Behav. at I> Imax therm.`**

- Default setting **`(_:114) Behav. at I> Imax therm.`** = ***`current limiting`***

The **`Behav. at I> Imax therm.`** parameter is used to select the process by which the function reacts to short-circuit currents. To prevent premature tripping of the overload protection at low time constants, high preloading and high short-circuit currents, the thermal replica can be modified. As overcurrent due to a starting of the motor also leads to a certain heating of the stator winding, limiting the input current is recommended for machines.

Parameter Value	Description
`current limiting`	The input currents are limited to the value set in the **`Imax thermal`** parameter. If the measured current exceeds the set current value, the limited current value is supplied to the thermal replica. An advisable current threshold is approx. 2 to 2.5 $I_{rated, obj}$.
`freeze therm. rep.`	If input currents exceed the **`Imax thermal`** parameter, the thermal replica will be frozen for the time the parameter is exceeded. This parameter value is provided to enable compatibility with **older products**!

Parameter: `Temperature sensor`

- Default setting **`(_:44) Temperature sensor`** = ***none***

With the **`Temperature sensor`** parameter, you determine which temperature sensor to use to detect the ambient temperature.

A temperature sensor is used to measure the ambient temperature of the protected object and to feed it to the device via an RTD unit (RTD = Resistance Temperature Detector) or via an IO111 module. The function **Thermal overload protection, 3-phase – Advanced** receives the measured temperature value via the functions **RTD unit Ether.** or **RTD unit Serial** or **Temperature module IO111** from the function group **Analog units**.

Parameter: `Default temperature`

- Default setting **`(_:118) Default temperature`** = ***40 °C***

The **`Default temperature`** defines the ambient temperature under the following conditions:

- No temperature sensor for measuring the ambient temperature is connected.
- The temperature measurement is faulty and the last measured temperature value is less than the **`Default temperature`**.

The actual K factor which defines the thermal limit of the function **Thermal overload protection, 3-phase – Advanced** is influenced by the parameter **`Default temperature`**. For the default value ***40 °C***, the persistent maximum permissible current equals to K times the $I_{rated,\ motor}$. A lower or higher **`Default temperature`** results in a higher or lower actual K factor. Siemens recommends using the default setting.

Parameter: `Minimal temperature`

- Default setting **`(_:117) Minimal temperature`** = ***-20 °C***

If the measured ambient temperature drops below the set value, the set value is assumed as the ambient temperature. If the overload protection works with a prespecified outside temperature, and this temperature drops below the value set in the **`Minimal temperature`** parameter, the **`Minimal temperature`** is also used.

6.57.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
49 Th.overl. #				
_:1	49 Th.overl. #:Mode		• off • on • test	off
_:2	49 Th.overl. #:Operate & flt.rec. blocked		• no • yes	no
_:101	49 Th.overl. #:Threshold current warning	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:104	49 Th.overl. #:Threshold thermal warn.		50 % to 100 %	90 %
_:105	49 Th.overl. #:Dropout threshold operate		50 % to 99 %	90 %
_:112	49 Th.overl. #:Emerg. start T overtravel		0 s to 15000 s	300 s

Addr.	Parameter	C	Setting Options	Default Setting
_:106	49 Th.overl. #:K-factor		0.10 to 4.00	1.10
_:110	49 Th.overl. #:Thermal time constant		10 s to 60000 s	900 s
_:111	49 Th.overl. #:Cooling time constant		10 s to 60000 s	3600 s
_:107	49 Th.overl. #:Imax thermal	1 A @ 100 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 100 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 50 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	12.500 A
_:108	49 Th.overl. #:Imin cooling	1 A @ 100 Irated	0.000 A to 10.000 A	0.500 A
		5 A @ 100 Irated	0.00 A to 50.00 A	2.50 A
		1 A @ 50 Irated	0.000 A to 10.000 A	0.500 A
		5 A @ 50 Irated	0.00 A to 50.00 A	2.50 A
		1 A @ 1.6 Irated	0.000 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.000 A to 8.000 A	2.500 A
_:109	49 Th.overl. #:Temperature rise at Irated		40 K to 200 K	70 K
_:113	49 Th.overl. #:Storage of thermal replica		• no • yes	no
_:114	49 Th.overl. #:Behav. at I> Imax therm.		• current limiting • freeze therm. rep.	current limiting

6.57.4.4 Information List

No.	Information	Data Class (Type)	Type
49 Th.overl. #			
_:500	49 Th.overl. #:>Block stage	SPS	I
_:501	49 Th.overl. #:>Reset thermal replica	SPS	I
_:51	49 Th.overl. #:Mode (controllable)	ENC	C
_:54	49 Th.overl. #:Inactive	SPS	O
_:52	49 Th.overl. #:Behavior	ENS	O
_:53	49 Th.overl. #:Health	ENS	O
_:301	49 Th.overl. #:Current warning	SPS	O
_:302	49 Th.overl. #:Thermal warning	SPS	O
_:303	49 Th.overl. #:Block close	SPS	O
_:55	49 Th.overl. #:Pickup	ACD	O
_:300	49 Th.overl. #:Operate alarm only	ACT	O
_:57	49 Th.overl. #:Operate	ACT	O
_:304	49 Th.overl. #:Time until close	MV	O
_:305	49 Th.overl. #:Time until trip	MV	O
_:306	49 Th.overl. #:Overload	MV	O
_:310	49 Th.overl. #:Equival. current	MV	O

6.58 Thermal Overload Protection, User-Defined Characteristic Curve

6.58.1 Overview of Functions

The **Thermal overload protection, user-defined characteristic curve** function (ANSI 49) is used to:

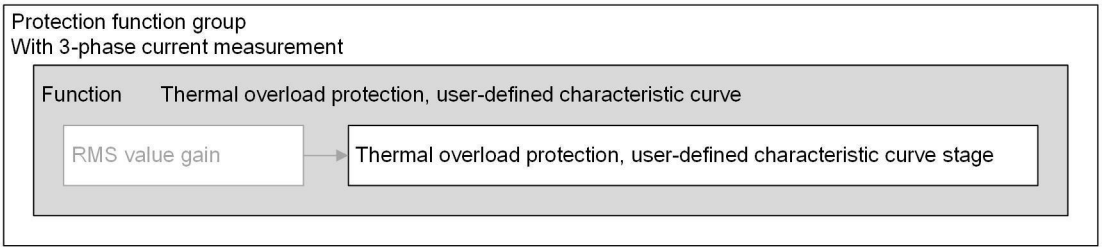
- Protect the equipment (motors, generators, and transformers) against thermal overloads
- Realize a manufacturer specific overload characteristic curve for specific equipment, for example, shunt reactors
- Monitor the thermal state of motors, generators, and transformers

6.58.2 Structure of the Function

The **Thermal overload protection, user-defined characteristic curve** function is used in protection function groups with 3-phase current measurement.

The function comes factory-set with 1 **Thermal overload protection, user-defined characteristic curve** stage.

The non-preconfigured function block **Filter** can optionally be applied to gain the RMS value used by the **Thermal overload protection, user-defined characteristic curve** stage.



[dw_TOLP_user_curve_str, 2, en_US]

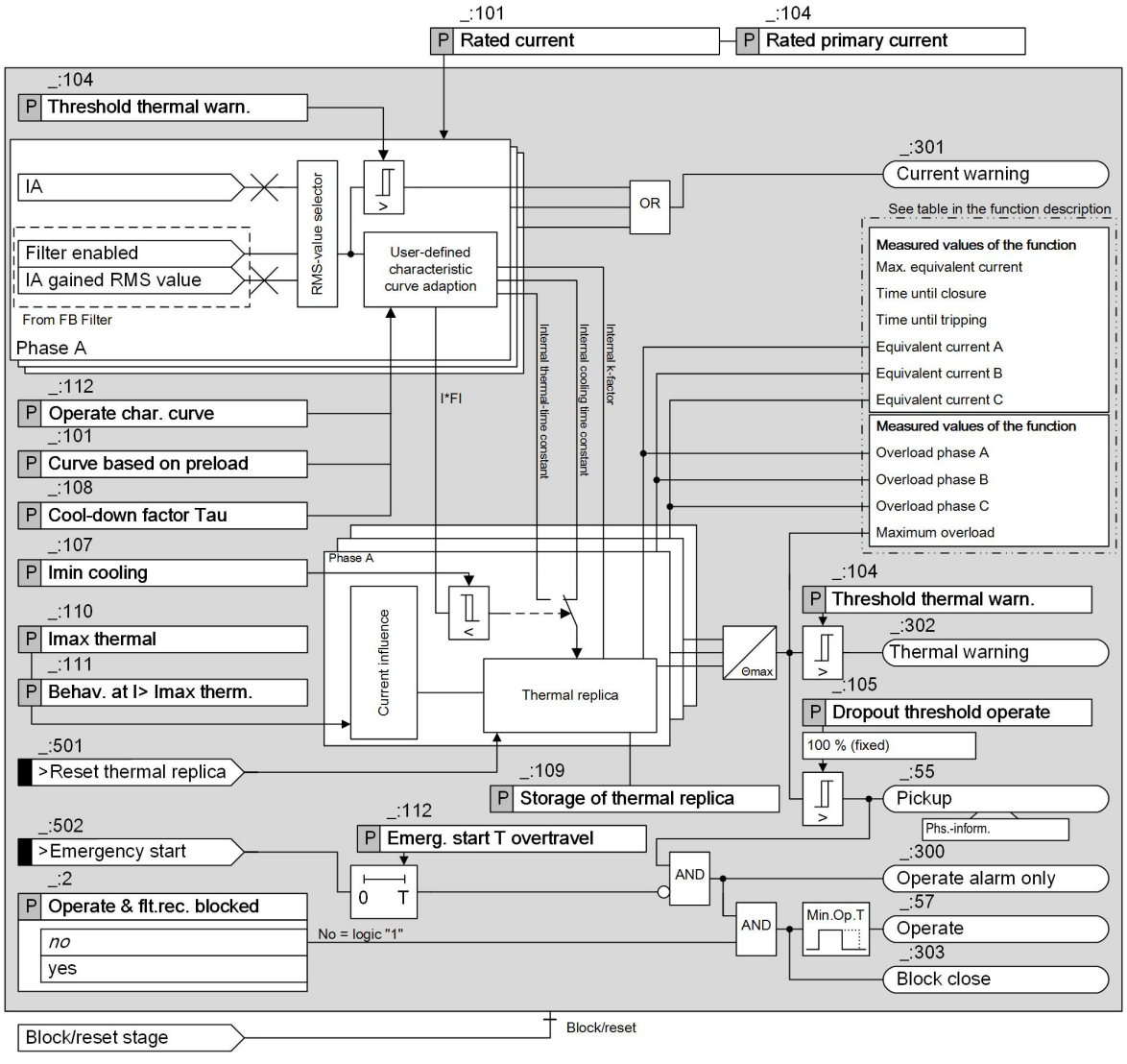
Figure 6-621 Structure/Embedding of the Function

6.58.3 Function Description

Filter for RMS Value Gain

You can find more information about the function block **Filter** in chapter *6.23.3 Filter for RMS Value Gain*.

Logic

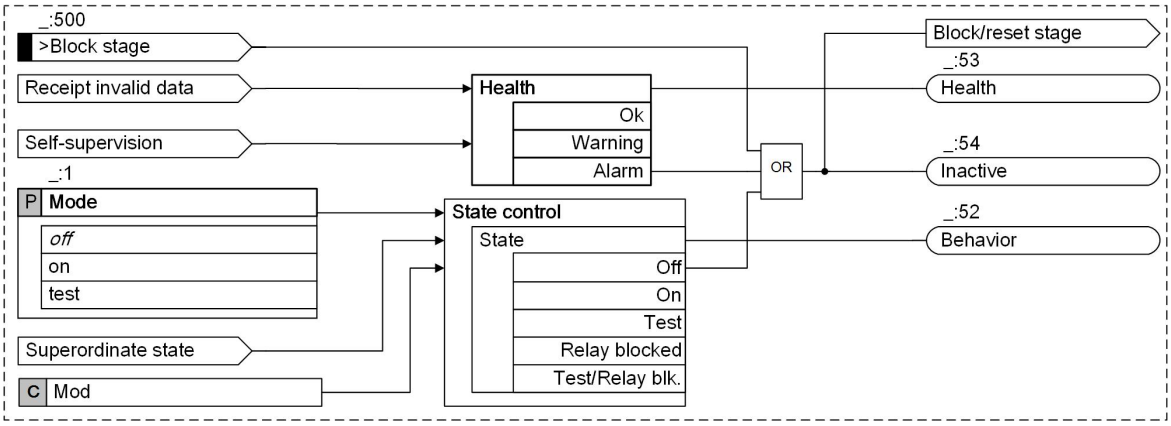


[lo_tolp_user_curve_stage, 2, en_US]

Figure 6-622 Logic Diagram of the Thermal Overload Protection, User-Defined Characteristic Curve Function

(1) The **(_:101) Rated current** parameter is from the protected object.

(2) The **(_:104) Rated primary current** parameter is from the used current transformer.



[lo_stage_control_TOLP, 2, en_US]

Figure 6-623 Logic Diagram of the Stage Control

RMS-Value Selection

The protection function supports 2 kinds of RMS measurement:

- Normal RMS value
- Gained RMS value from the function block **Filter**

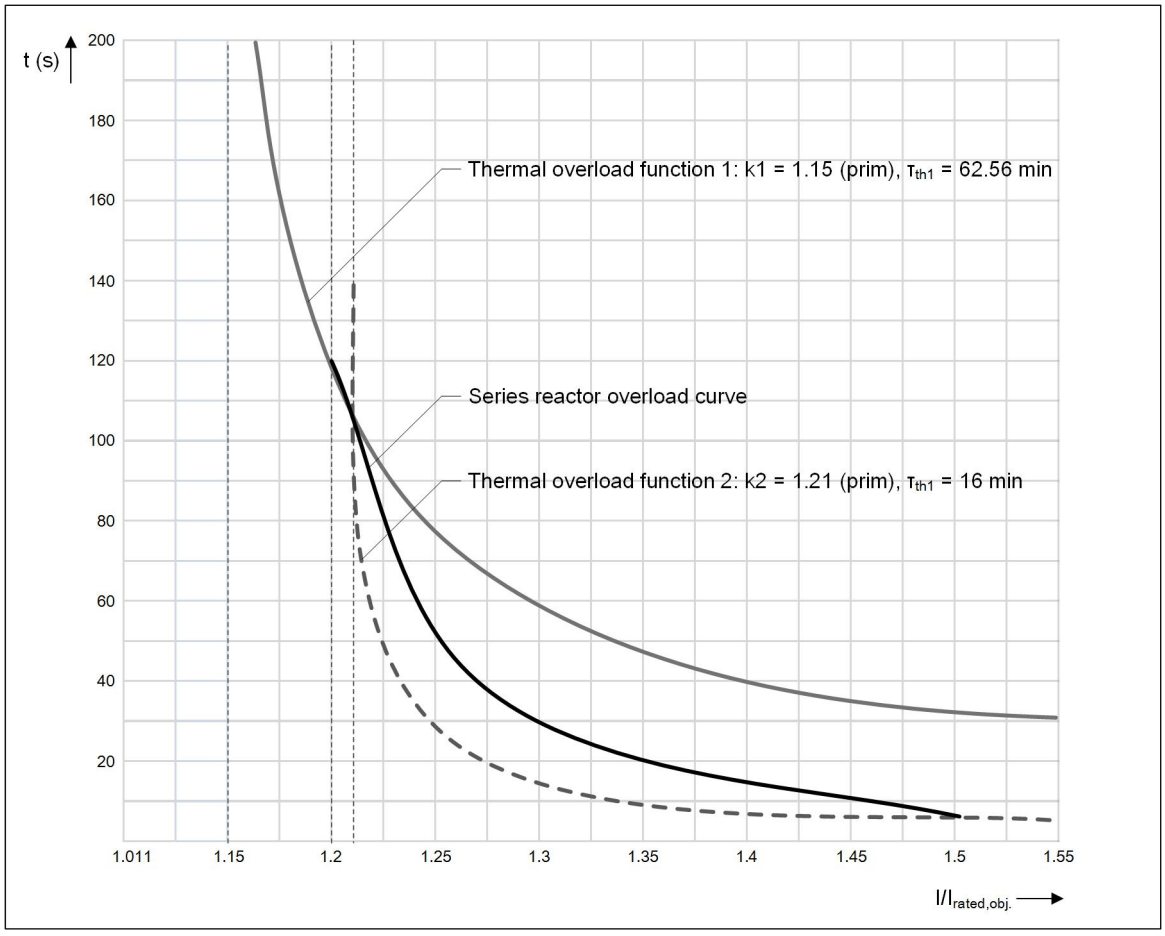
The gained RMS value is automatically used if the function block **Filter** is configured and the filter has been enabled.

NOTE

When the function block **Filter** is applied, only one current measuring point I-3ph is allowed to be connected to the 3-phase current interface of the function group.

User-Defined Characteristic Curve

For specific equipment (for example, shunt reactors and transformers) or for special applications, the manufacturer specifies an overload characteristic curve. This curve cannot be described accurately with a single-body model so that deviations can occur. The following figure shows an example of a predefined overload characteristic curve and 2 standard characteristic curves based on the single-body model.



[dw_TOLP_user_curve_characteristic, 2, en_US]

Figure 6-624 User-Defined Characteristic Curve with Replica of Standard Characteristics

The calculation is identical to the realization of the standard **Thermal overload protection, 3-phase - advanced** function. You can find more information in the function description **Thermal overload protection, 3-phase - advanced** starting from chapter *6.57.1 Overview of Functions*.

The main deviations are as follows:

- The thermal characteristic is set with a flexible characteristic ($t_{trip} = f(I/I_{rated,obj})$).
  - The first point of the characteristic curve is important and is used to calculate the internal k-Factor. To meet the applications with a minimum internal k-Factor value of 1.001, the minimum $I/I_{rated,obj}$ value of 1.011 can be set as the first point of the characteristic curve.
  - The point at $I/I_{rated,obj} = 1.5$ is used to calculate the internal thermal time constant. If there is no point at $I/I_{rated,obj} = 1.5$, the point which is the closest to $I/I_{rated,obj} = 1.5$ from $I/I_{rated,obj} = 1.1$ is used to calculate the internal thermal time.
  - The points are set according to the maximum permissible load current.
- The **`Curve based on preload`** parameter describes for which thermal preload the user-defined characteristic curve is valid. Normally, such a curve is given for protected objects under rated load.
- The **`Cool-down factor Tau`** parameter is used for the determination of the cooling time constant. The set factor is multiplied with the internal calculated time constant.
- The thermal model is based on a constant ambient temperature of 40 °C. It cannot be corrected via the external measurement.

Thermal Replica

The protection function calculates the overtemperature from the phase currents on the basis of a thermal single-body model according to the thermal differential equation with

$$I_{p.u.}^2 = \tau_{th} \frac{d\theta}{dt} + \theta$$

[fo_tolp_diffgl, 1, en_US]

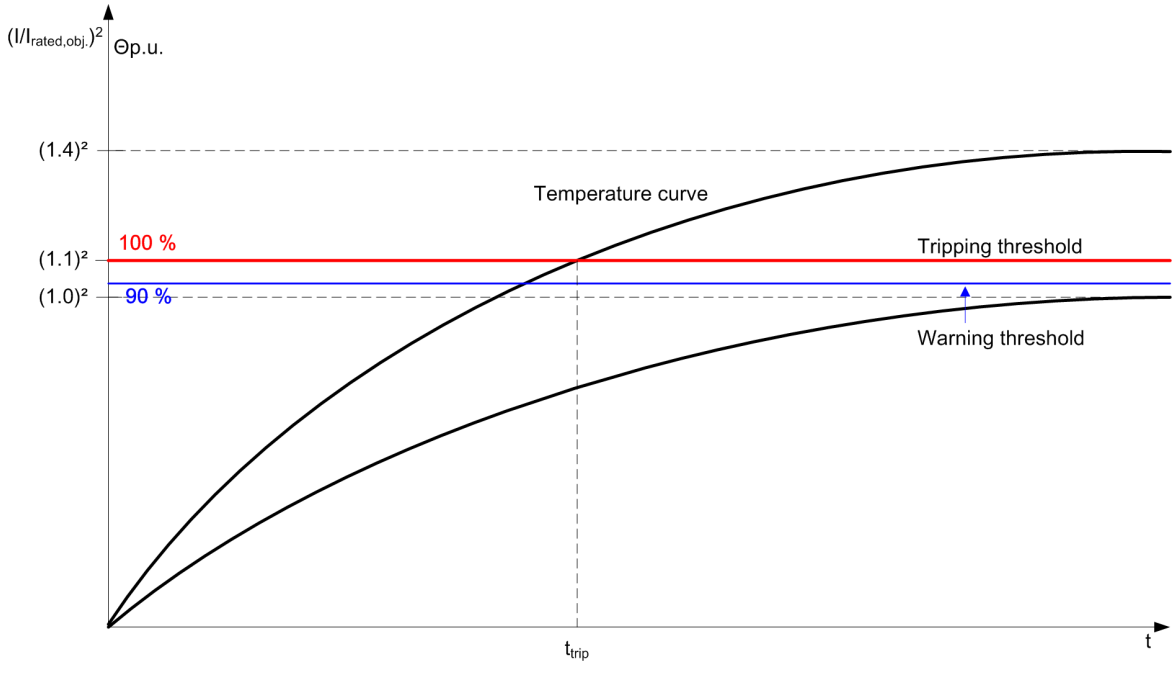
With the following standardization:

$$I_{p.u.} = \frac{I}{I_{max}} = \frac{I}{K \cdot I_{rated\ ,obj.}} \quad \theta = \frac{\vartheta}{\vartheta_{max}} = \frac{\vartheta}{K^2 \cdot \Delta\vartheta_{rated\ ,obj.}}$$

$$\tau_{th} = R_{th} \cdot C_{th}$$

[fo_tolp_normie, 1, en_US]

Θ	Current overtemperature, in relation to the final temperature at a maximum permissible phase current k $I_{rated, obj}$
$\Delta\vartheta_{rated\ obj}$	Overtemperature of the protected object set at rated current
τ_{th}	Thermal time constant (temperature rise/cooling) of the protected object. The value is calculated internally.
K	This factor indicates the maximum continuous permissible phase current. The factor refers to the rated current of the protected object ($K = I_{max}/I_{rated, obj}$) and is calculated internally.
$I_{rated, obj}$	Rated current of the protected object



[dw_TOLP_temperature, 1, en_US]

Figure 6-625 Temperature History for Different Overload Currents (**K-factor** = ***1.1***)

The overtemperature is calculated separately for each phase. The current overtemperature can be obtained from the operational measured values. It is shown in percent. An indication of 100 % means that the thermal threshold has been reached. The maximum overtemperature of the phases is regarded as the tripping temperature. This means that the highest of the 3 phase currents is always assumed.

The analysis of the RMS values of the currents over a broad frequency band also includes the harmonic components. These harmonic components contribute to the temperature rise of the equipment.

Current Influence

The thermal replica based on the single-body model applies only with limitations to high overcurrent situations (short circuits, motor startup currents). To avoid an overfunction of the overload protection, the thermal replica must be influenced in case of overcurrents (exceeding $I_{threshold}$). You can select between 2 strategies for this:

- Freezing of the thermal memory
- Limitation of the input current for the thermal replica to the set current. The temperature rise is thereby **retarded** at high currents.

Warning Thresholds

The thermal warning threshold issues a warning indication before the tripping threshold (tripping temperature) is reached. In this way, for example, a load can be reduced in sufficient time and a disconnection can be avoided. If the first setting value of the user-defined characteristic curve is set to 1.1 of the rated current, a thermal memory value of 83 % is set to the continuously flowing rated current.

Apart from the thermal warning threshold, the overload protection also has a current-warning threshold. This current-warning threshold can signal an overload current in sufficient time before the overtemperature value has reached the warning or tripping threshold.

Dropout of Tripping

Once the thermal memory has fallen below the setting value of the **Dropout threshold operate**, the trip command is cancelled upon tripping. In contrast, the current-warning threshold and the thermal warning threshold are reduced at a fixed dropout threshold (see Technical Data).

Behavior in the Event of Auxiliary-Voltage Failure

The behavior of the thermal replica can be controlled upon auxiliary-voltage failure via the setting parameter **Storage of thermal replica**. You can save the thermal state for a time of 500 min. Once the supply voltage returns, the thermal replica continues to function with the saved thermal state.

If the thermal replica is not saved, it will be reset to 0 upon failure of the auxiliary voltage.

Resetting the Thermal Memory

You can reset the thermal memory via the binary input indication **>Reset thermal replica**. The thermal memory will then have a 0 value.

Emergency Start

Depending on the operating conditions, tripping can be blocked or closure enabled despite the permissible thermal limits being exceeded. Upon activation of the binary input signal **>Emergency start**, tripping is blocked and closure enabled. This does not affect the state of the thermal memory. After the input **>Emergency start** disappears, the blocking remains in effect for the set **Emerg. start T overtravel**.

Blocking the Function

Blocking will cause a picked up function to be reset. The tripping function can be blocked externally or internally by the binary input signal **>Block stage**.

All indications then drop out and the thermal memory is not calculated.

Blocking Closure

The signal **Block close** can be used to prevent closure of the protected object at a high thermal load. The signal is set if the tripping overtemperature is exceeded, and cancelled if the temperature falls below the dropout threshold.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:601:305) Time until trip	Expected time until tripping	s	s	s
(_:601:304) Time until close	Time until close release	s	s	s
(_:601:306) Overload phase A	Thermal measured values of the phases	%	%	Tripping temperature
(_:601:307) Overload phase B				
(_:601:308) Overload phase C				
(_:601:309) Overload maximum	Thermal measured value of the overload protection	%	%	Tripping temperature
(_:601:310) Equival. current phs A	Current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values
(_:601:311) Equival. current phs B				
(_:601:312) Equival. current phs C				
(_:601:313) Equival. current max.	Maximum current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values

6.58.4 Application and Setting Notes

Motors and generators as well as transformers are at risk from long-lasting overloads. You can adapt the given overload characteristic curve to the user-defined characteristic curve with the **Thermal overload protection, user-defined characteristic curve** function. You can find the predefined characteristic curve in the chapter *12.52 Thermal Overload Protection, User-Defined Characteristic Curve*.

When setting the parameters, consider the following:

- The settings for the used current transformer (primary values and secondary values) must be set correctly in the power system.
- The rated values for the protected object must be correct in the used function group.

Parameter: `Threshold current warning`

- Recommended setting value **`(_:101) Threshold current warning`** = ***`1.1 A`*** at I_{rated} = 1 A

Set the threshold to the maximum permissible continuous current ($I_{max, perm}$). This results in the same setting value as for the first value of the user-defined characteristic curve.

Parameter: `Threshold thermal warn.`

- Recommended setting value **`(_:104) Threshold thermal warn.`** = ***`90 %`***

If the first value of the user-defined characteristic curve is 1.1 of the rated current, the default setting can be left. The thermal memory results for 83 % at continuously flowing rated object current.

If the first value of the user-defined characteristic curve is 1.05 of the rated object current, the thermal memory for rated current is already 91 % filled. Increase the **`Threshold thermal warn.`** to 95 %.

Parameter: `Dropout threshold operate`

- Recommended setting value **`(_:105) Dropout threshold operate`** = ***`90 %`***

The **`Dropout threshold operate`** parameter is used to drop out pickup and tripping when the value drops below this threshold. A setting on the order of magnitude of the warning threshold is recommended. You can select a lower setting value for special applications, desired additional cooling or longer blocking of closing.

Note that the calculation of the operational measured value **`Time until close`** refers to this value.

Parameter: Emerg. start T overtravel

- Default setting **(_:112) Emerg. start T overtravel** = ***300 s***

The **Emerg. start T overtravel** parameter is used to set the time for which blocking of the tripping has to remain active after an outgoing binary input signal **>Emergency start**. With an outgoing input signal, the load on the protected object is removed. The emergency start T-overtravel must be set long enough to allow the thermal memory to fall below the dropout threshold after cooling. Select a time on the order of magnitude of the **Cooling time constant**. In the example, 5 min (300 s) have been assumed.

Parameter: Imax thermal

- Recommended setting value **(_:107) Imax thermal** = ***2.5 A*** at I_{rated} = 1 A

The **Imax thermal** parameter allows you to set the threshold current for the **Behav. at I> Imax therm.** parameter. If you calculate with relatively long start times for motors (longer than 25 s), the current limiting must be reduced to 2 $I/I_{rated, obj}$.

Parameter: Imin cooling

- Recommended setting value **(_:108) Imin cooling** = ***0.5 A*** at I_{rated} = 1 A

When defining the minimum current **Imin cooling**, you can use the no-load current for orientation. If no data is available, set 0.5 $I/I_{rated, obj}$. If the current falls below this value, the internal thermal time constant τ automatically switches to the internal cooling time constant with the **Cool-down factor Tau** parameter.

Parameter: Storage of thermal replica

- Recommended setting value **(_:113) Storage of thermal replica** = ***no***

If a continuous auxiliary voltage for the bay units is ensured, the default setting can be retained.

Parameter: Behav. at I> Imax therm.

- Recommended setting value **(_:114) Behav. at I> Imax therm.** = ***current limiting***

The **Behav. at I> Imax therm.** parameter is used to select the process by which the function reacts to short-circuit currents. To prevent premature tripping of the overload protection at low time constants, high preloading and high short-circuit currents, the thermal replica can be modified. As overcurrent due to a starting of the motor also leads to a certain heating of the stator winding, limiting the input current is recommended for machines.

Parameter Value	Description
current limiting	The input currents are limited to the value set in the **Imax thermal** parameter. If the measured current exceeds the set current value, the limited current value is supplied to the thermal replica. An advisable current threshold is approx. 2 to 2.5 $I_{rated, obj}$.
freeze therm. rep.	If input currents exceed the **Imax thermal** parameter, the thermal replica will be frozen for the time the parameter is exceeded.

Parameter: Curve based on preload

- Default value **(_:101) Curve based on preload** = ***100 %***

The **Curve based on preload** parameter is used for a certain load case. In most cases, it applies for an operation under rated conditions. For that, it is assumed that rated current is flowing permanently. This is referred to as warm condition. In this case, the default setting 100 % is applied.

Thus, the thermal behavior is also correct for different preloads.

For cases without preload or cold condition, set the parameter to 0 %.

Parameter: **Cool-down factor Tau**

- Default value **(_:108) Cool-down factor Tau** = *7.0*

If the current becomes lower than the setting value of the **Imin cooling** parameter, you can set the **Cool-down factor Tau** parameter to calculate the internal cooling time constant.

Parameter: **Operate char. curve**

- Default value **Operate char. curve** = *1.1 p.u., 600.00 s*

With the **Operate char. curve** parameter, you define the characteristic curve in a tabular form with ordered normalized current values and associated normalized time values.

When setting the parameter, consider the following:

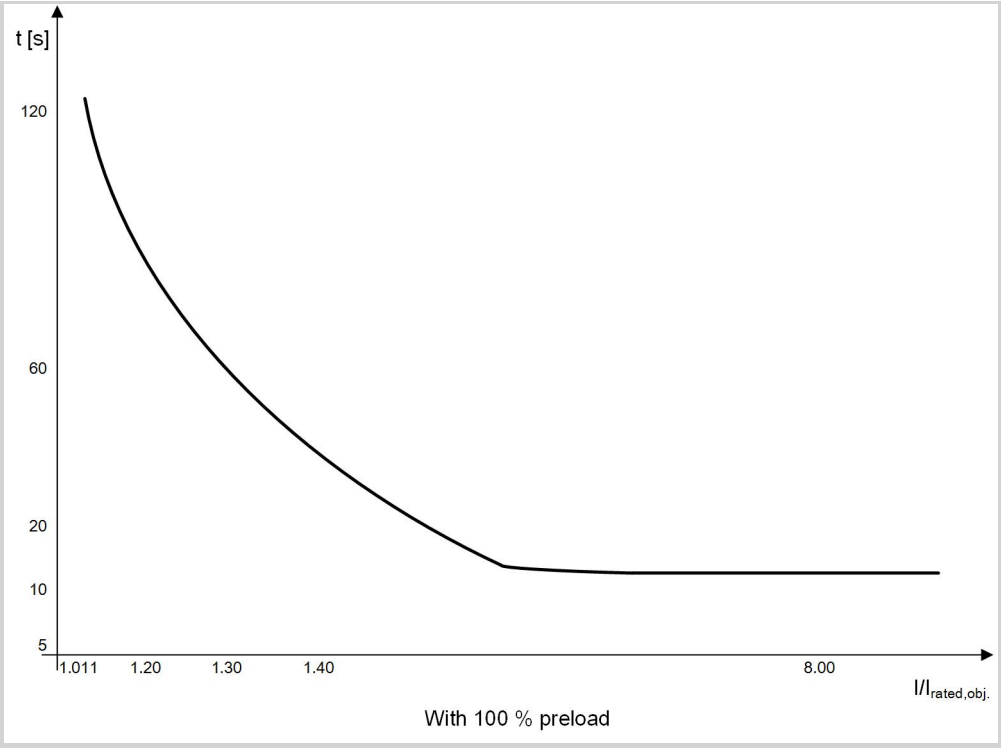
- Set the current value as per-unit value with the rated current of the protected object as reference.
- Set the time value in seconds.
- Enter the values in continuous order.

EXAMPLE

With the following 12 points, you can get a user-defined characteristic curve as shown in the following figure.

Table 6-21 User-Defined Points

I / I_{obj}	t (s)
1.16	120.00
1.21	96.00
1.25	76.00
1.28	62.00
1.35	48.00
1.42	37.50
1.48	33.50
1.58	27.50
1.84	20.50
2.09	14.00
2.25	9.85
8.00	9.85



[dw_TOLP_predefined curve, 2, en_US]

Figure 6-626 Example of the User-Defined Characteristic Curve

6.58.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User charact.#:Mode		• off • on • test	off
_:2	User charact.#:Operate & flt.rec. blocked		• no • yes	no
_:102	User charact.#:Threshold current warning	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:104	User charact.#:Threshold thermal warn.		50 % to 100 %	90 %
_:105	User charact.#:Dropout threshold operate		50 % to 99 %	90 %
_:106	User charact.#:Emerg. start T overtravel		0 s to 15000 s	300 s

Addr.	Parameter	C	Setting Options	Default Setting
_:107	User charact.#:Imin cooling	1 A @ 100 Irated	0.000 A to 10.000 A	0.500 A
		5 A @ 100 Irated	0.00 A to 50.00 A	2.50 A
		1 A @ 50 Irated	0.000 A to 10.000 A	0.500 A
		5 A @ 50 Irated	0.00 A to 50.00 A	2.50 A
		1 A @ 1.6 Irated	0.000 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.000 A to 8.000 A	2.500 A
_:108	User charact.#:Cool-down factor Tau		0.5 to 20.0	7.0
_:109	User charact.#:Storage of thermal replica		• no • yes	no
_:110	User charact.#:Imax thermal	1 A @ 100 Irated	0.030 A to 35.000 A	2.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	12.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	12.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	12.500 A
_:111	User charact.#:Behav. at I> Imax therm.		• current limiting • freeze therm. rep.	current limiting
_:112	User charact.#:Operate char. curve		Setting options depend on configuration	1.1 p.u., 600 s
_:101	User charact.#:Curve based on preload		0 % to 100 %	100 %

6.58.6 Information List

No.	Information	Data Class (Type)	Type
User charact.#			
_:81	User charact.#:>Block stage	SPS	I
_:500	User charact.#:>Reset thermal replica	SPS	I
_:501	User charact.#:>Emergency start	SPS	I
_:51	User charact.#:Mode (controllable)	ENC	C
_:54	User charact.#:Inactive	SPS	O
_:52	User charact.#:Behavior	ENS	O
_:53	User charact.#:Health	ENS	O
_:300	User charact.#:Current warning	SPS	O
_:301	User charact.#:Thermal warning	SPS	O
_:302	User charact.#:Block close	SPS	O
_:55	User charact.#:Pickup	ACD	O
_:303	User charact.#:Operate alarm only	ACT	O
_:57	User charact.#:Operate	ACT	O
_:304	User charact.#:Time until close	MV	O
_:305	User charact.#:Time until trip	MV	O
_:306	User charact.#:Overload phase A	MV	O
_:307	User charact.#:Overload phase B	MV	O
_:308	User charact.#:Overload phase C	MV	O
_:309	User charact.#:Overload maximum	MV	O

No.	Information	Data Class (Type)	Type
_:310	User charact.#:Equival. current phs A	MV	O
_:311	User charact.#:Equival. current phs B	MV	O
_:312	User charact.#:Equival. current phs C	MV	O
_:313	User charact.#:Equival. current max.	MV	O

6.59 Thermal Overload Protection, 1-Phase

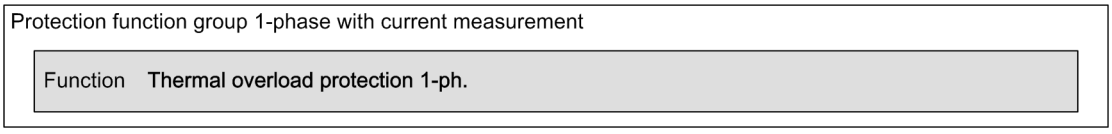
6.59.1 Overview of Functions

The **Thermal overload protection 1-phase** function (ANSI 49) is used to:

- Protect the equipment (reactors or resistors in the neutral point of a transformer) from thermal overload

6.59.2 Structure of the Function

The **Thermal overload protection 1-phase** function is used in 1-phase protection function groups with current measurement.
The **Thermal overload protection, 1-phase** function is steplessly preconfigured.

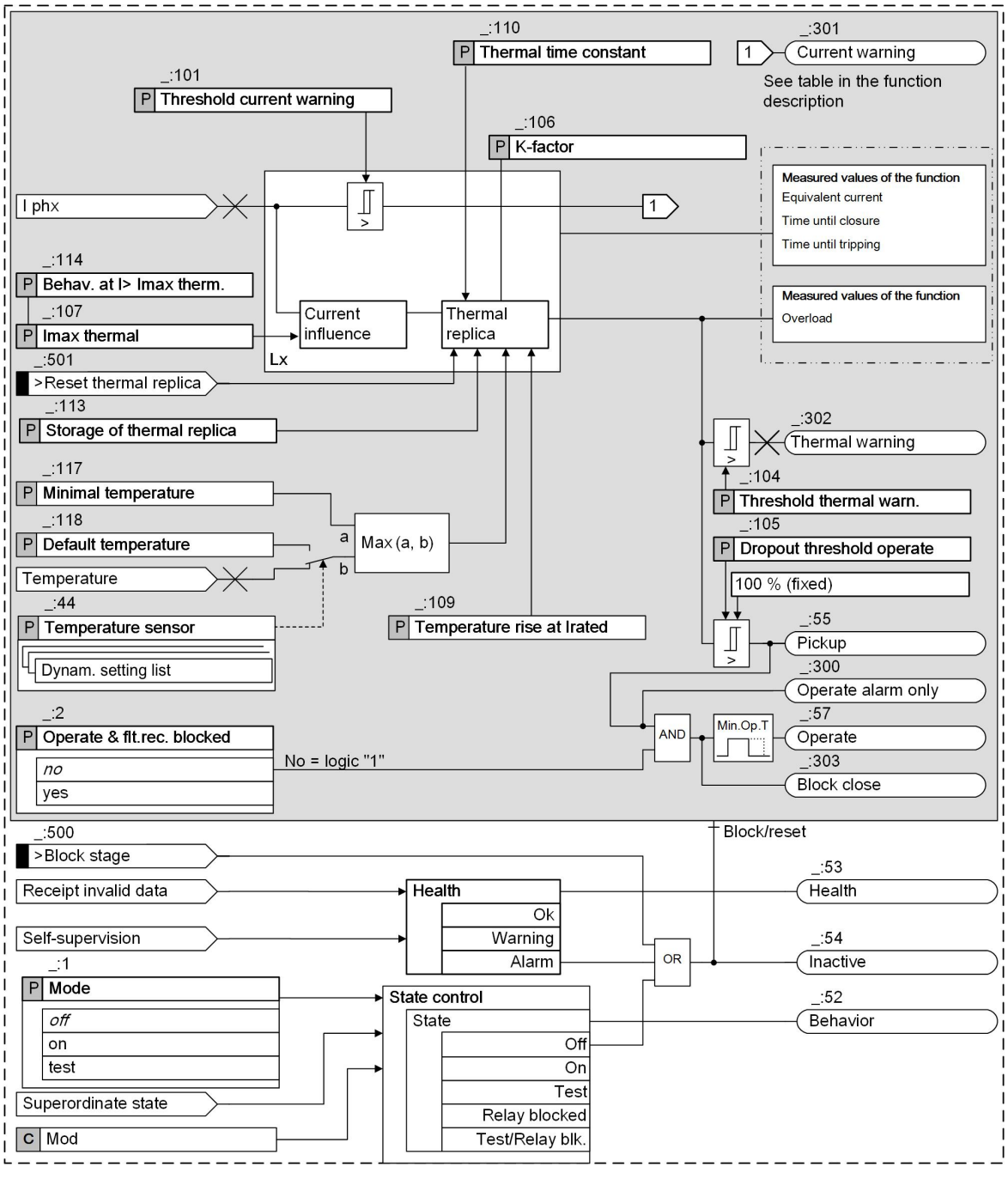


{dw_tolp1p, 2, en_US}

Figure 6-627 Structure/Embedding of the Function

6.59.3 Function Description

Logic



[lo_tolp_1p, 3, en_US]

Figure 6-628 Logic Diagram of the Thermal Overload Protection Function

Thermal Replica

The protection function calculates the overtemperature from the current flowing in the protected object (for example, reactor or resistance in the transformer neutral point) on the basis of a thermal single-body model according to the thermal differential equation with

$$I_{p.u.}^2 = \tau_{th} \frac{d\Theta}{dt} + \Theta - \Theta_V$$

[fo_diffgl, 2, en_US]

With the following standardization:

$$I_{p.u.} = \frac{I}{I_{max}} = \frac{I}{k \cdot I_{rated,obj.}} \qquad \Theta = \frac{\vartheta}{\vartheta_{max}} = \frac{\vartheta}{k^2 \cdot \Delta\vartheta_{rated,obj.}}$$

$$\tau_{th} = R_{th} \cdot C_{th} \qquad \Theta_V = \frac{\vartheta_{Amb} - 40\,°C}{\vartheta_{max}} = \frac{\vartheta_{Amb} - 40\,°C}{k^2 \cdot \Delta\vartheta_{rated,obj.}}$$

[fo_normie, 2, en_US]

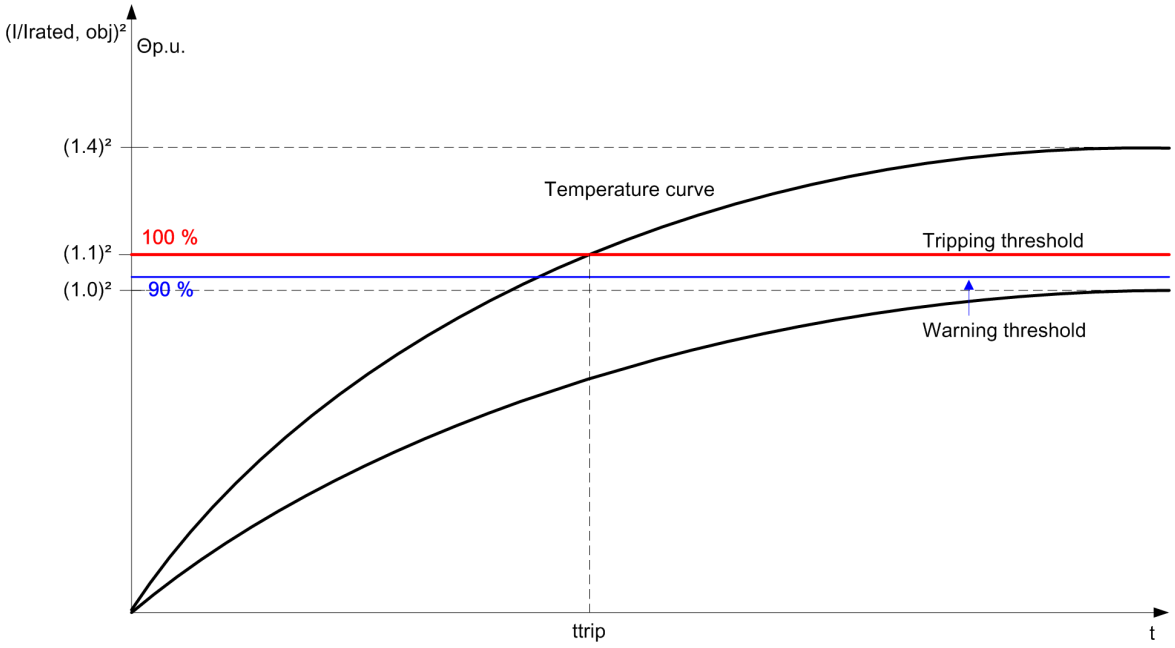
Θ	Current overtemperature, in relation to the final temperature at a maximum permissible current k $I_{rated,obj}$
Θ_V	Standardized ambient temperature, where ϑ_{Amb} describes the coupled ambient temperature. The coupled ambient temperature ϑ_{Amb} can be the measured ambient temperature or the ambient temperature preset using the **`Default temperature`** parameter.
$\Delta\vartheta_{rated,obj}$	Overtemperature of the protected object set at rated current
τ_{th}	Thermal time constant (temperature rise/cooling) of the protected object
k	This factor indicates the maximum continuous permissible phase current. The factor refers to the rated current of the protected object ($k = I_{max}/I_{rated,obj}$)
$I_{rated,obj}$	Rated current of the protected object

At the same time, $I_{rated,obj}$ is the rated current of the protected object.

In a steady state, the solution to the thermal differential equation is an e-function whose asymptote represents the final overtemperature Θ_{end}. The time constant τ_{th} determines the rise. After reaching an initial adjustable overtemperature threshold Θ_{warn} (**`Threshold thermal warn.`**), a warning indication is given.

If the overtemperature limit Θ_{Off} (tripping overtemperature) is exceeded, an operate indication is immediately issued and the equipment disconnected from the power supply. This threshold is specified at 100 % and corresponds to the final temperature set at a flowing permissible continuous current (I_{max}).

Figure 6-629 shows the temperature rise at different overload currents and the supervision thresholds.



[dw_temp_ve, 1, en_US]

Figure 6-629 Temperature History for Different Overload Currents (**K-factor** = ***1.1***)

The current overtemperature can be obtained from the operational measured values. It is shown in percent. An indication of 100 % means that the thermal tripping threshold has been reached.

The analysis of the RMS value of the current over a broad frequency band also includes the harmonic components. These harmonic components contribute to the temperature rise of the equipment.

Operate Curve

If the ambient temperature is not measured and set to 40°C, you get the following operate curve:

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj.}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - 1}$$

[fo_auslos, 1, en_US]

t	Operate time
τ_{th}	Time constant
I	Measured load current
$I_{preload}$	Preload current
k	Setting factor according to VDE 0435 part 3011 or IEC 60255-149 (K factor)
$I_{rated,obj}$	Rated current of the protected object

Ambient Temperature

This function can take the ambient temperature into consideration The reference temperature of the thermal model is 40 °C. If the ambient temperature drops below the reference temperature, the thermal limit increases. The equipment can be stressed more. If the ambient temperature is higher, the conditions change.

The **Default temperature** parameter can be used to fix or measure the ambient temperature. The **Minimal temperature** parameter limits the coupled ambient temperature. If the measured ambient temperature is lower than the minimum temperature, the minimum temperature is processed in the thermal model.

The ambient temperature refers to the overtemperature of the protected object, which sets itself at the rated current (parameter **Temperature rise at Irated**).

The measured ambient temperature is measured by an external RTD unit (RTD = Resistance Temperature Detector) or by an IO111 module and provided by the functions **RTD unit Ether.**, **RTD unit serial**, or **Temperature module IO111** of the function group **Analog unit**. When using the **Temperature sensor** parameter, the respective temperature sensor can be selected.

If the temperature measurement is disrupted, for example, due to an open circuit between the device and the RTD unit, the health state of the **Thermal overload protection, 1-phase** function changes to *warning*. In this case, the process continues with either the temperature measured last or the value set under the **Default temperature** parameter, whichever value is the highest.

Current Influence

The thermal replica based on the single-body model applies with limitations to high overcurrent situations (short circuits). To avoid an overfunction of the overload protection, the thermal replica must be influenced for overcurrents (exceeding $\mathbf{I}_{\text{limit}}$). You can select between 2 strategies for this:

- Freezing of the thermal memory
- Limitation of the input current for the thermal replica to the set current. The temperature rise is thereby **retarded** at high currents.

Warning Thresholds

The thermal warning threshold issues a warning indication before the tripping threshold (tripping temperature) is reached. In this way, for example, a load can be reduced in sufficient time and a disconnection avoided. At a normal **K-factor** of ***1.1***, a thermal memory value of 83 % sets in at continuously flowing rated current.

Apart from the thermal warning threshold, the overload protection also has a current-warning threshold. This current-warning threshold can signal an overload current in sufficient time before the overtemperature value has reached the warning or tripping threshold.

Dropout of Tripping

Once the thermal memory has fallen below the setting value of the **Dropout threshold operate**, the trip command is cancelled upon tripping. In contrast, the current-warning threshold and the thermal warning threshold are reduced at a fixed dropout threshold (see technical data).

Behavior in the Event of Auxiliary-Voltage Failure

The behavior of the thermal replica can be controlled upon auxiliary-voltage failure via the **Storage of thermal replica** parameter. You can save the thermal state for a down time of 500 min. If the supply voltage returns, the thermal replica continues to function with the saved thermal state.

If the thermal replica is not saved, it will be reset to 0 upon failure of the auxiliary voltage.

Resetting the Thermal Map

You can reset the thermal memory via the binary input indication **>Reset thermal replica**. The thermal memory will then have a 0 value. A reparameterization will also lead to resetting the thermal memory.

Blocking the Function

Blocking will cause a picked up function to be reset. The function can be blocked externally or internally by the binary input signal **>Block stage**.

All indications then drop out and the thermal memory is set to the value 0.

Blocking Closure

The signal **Block close** can be used to prevent closure of the protected object at a high thermal load. The signal is set if the tripping overtemperature is exceeded, and cancelled if the temperature falls below the dropout threshold.

Functional Measured Values

Measured Value	Description
(_:310) Equival. current	Besides the thermal measured values in percent, the equivalent current is also issued as a thermal current-measured value (A or kA). The current equivalent is the primary current, which corresponds to the thermal measured value in percent, assuming steady-state conditions.
(_:304) Time until close	The **Time until close** is the expected time until it is possible for the protected object for reclosure. The calculation of this value is based on the assumption of constant currents. The thermal replica has then fallen below the setting value of the dropout threshold.
(_:305) Time until trip	The **Time until trip** is the expected time until tripping (100 % value exceeded) occurs. The calculation of this value is based on the assumption of constant currents.
(_:306) Overload	The value **Overload** indicates the current temperature of the protected object in percent. Tripping occurs if 100 % is exceeded.

6.59.4 Application and Setting Notes

Parameter: Threshold current warning

- Recommended setting value **(_:101) Threshold current warning** = ***1.1 A*** for I_{rated} = 1 A

Set the threshold to the maximum permissible continuous current ($I_{max, perm}$). This results in the same setting value as for **K-factor**.

Parameter: Threshold thermal warn.

- Recommended setting value **(_:104) Threshold thermal warn.** = ***90 %***

The default setting can be left at a **K-factor** of 1.1, because the thermal memory sets itself to 83 % at continuously flowing rated current. The calculation uses the rule of three: 100 % corresponds to (**K-factor**)^2 and x % corresponds to 1^2.

$$\frac{\Theta}{\Theta_{off}} = \frac{100\ \%}{k^2} = 83\ \%$$

[fo_warmsc, 2, en_US]

At a **K-factor** of 1.05, the thermal memory for rated current is 91 % filled. Increase the **Threshold thermal warn.** to 95 %.

Parameter: Dropout threshold operate

- Recommended setting value **(_:105) Dropout threshold operate** = ***90 %***

The **Dropout threshold operate** parameter is used to cancel pickup and tripping when the value drops below this threshold. A setting on the order of magnitude of the warning threshold is recommended. You can select a lower setting value for special applications, desired additional cooling, or longer blocking of switching on.
The calculation of the operational measured value **Time until close** refers to this value.

Parameter: K-factor

- Recommended setting value **(_:106) K-factor** = ***1.1***

The **K-factor** parameter is used to describe the limiting value for the maximum permissible continuous load. The rated current $I_{rated, obj}$ of the protected object (for example, resistance) is the basic current for overload sensing.
You can determine **K-factor** on the basis of the thermally permissible continuous current $I_{max, perm.}$:

$$K\text{-factor} = \frac{I_{max,perm.}}{I_{rated,obj.}}$$

[fo_tolp_kf, 2, en_US]

NOTE

The thermally permissible continuous current for the protected object is known from relevant tables or from the specifications of the manufacturer!

Siemens recommends using the default value as it is a typical value for many applications.

Parameter: Thermal time constant

- Default value **(_:110) Thermal time constant** = ***900 s (15 min)***

The **Thermal time constant** parameter is used to define the operate curve of the stage. If no time constant is given, you can derive it from other values.

EXAMPLE

Protection of a current-limiting resistance

Rated current of the resistance: I_{rated} = 100 A

Values for the overload capability:

- 1.1 I_{rated} permanent (k-Factor = 1.1; k = 1.1)
- 1.5 I_{rated} for 20 s for charge by cold

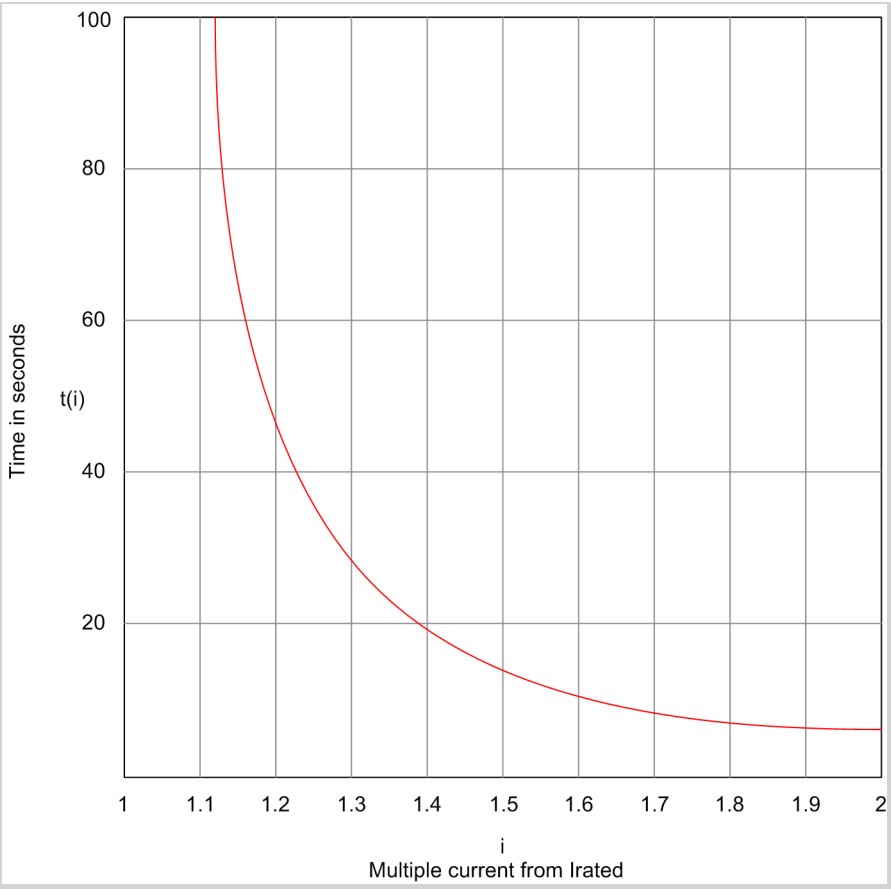
The following time constant results from these assumed values:

$$\tau_{th} = t \times \left[\ln \frac{\left(\frac{I}{k \times I_{rated,obj}}\right)^2}{\left(\frac{I}{k \times I_{rated,obj}}\right)^2 - 1} \right]^{-1} = 20\ s \times \left[\ln \frac{\left(\frac{1.5}{1.1}\right)^2}{\left(\frac{1.5}{1.1}\right)^2 - 1} \right]^{-1} = 20\ s \times \left[\ln \frac{1.86}{0.86} \right]^{-1} \approx 26\ s$$

[fo_time_constance, 1, en_US]

For **Thermal time constant**, set 26 s.

The following time-dependent characteristic results from the data. In case of a current increase to 1.5 I_{rated}, the tripping occurs in 20 s.



Parameter: Imax thermal

- Recommended setting value **(_:107) Imax thermal** = ***2.5 A*** for I_{rated} = 1 A

The **Imax thermal** parameter allows you to set the threshold current for the **Behav. at I> Imax therm.** parameter. The selected current threshold of 2.5 $I_{rated, obj}$ is a practicable value.

Parameter: Temperature rise at Irated

- Default setting **(_:109) Temperature rise at Irated** = ***70 K***

NOTE

For an application as a 1-phase overload protection, the ambient temperature measured via the temperature sensor is not taken into account. Therefore, the setting has no influence. You can keep the default setting. If you take into account the temperature, note the following descriptions.

Set the overtemperature as the value that is the result if the equipment is continuously operated with the rated current and at an ambient temperature of 40 °C. Here, the rated current refers to the protected object. You can find the temperature value in the Technical data of the equipment or you can measure the value. If you use a temperature sensor when measuring at the rated current, deduct the actual ambient temperature or the coolant temperature from the measured value.

When selecting the setting value, you can also use the specified temperature class for orientation. Usually, you will find the overtemperature expressed in Kelvin (K), which can be accepted as is. If the absolute temperature is given, the ambient temperature must be deducted. As a rule, this is 40 °C.

The overtemperature (***ϑmax***) at maximum permissible current and the **Temperature rise at Irated** (***ϑrated,obj.***) can be converted by using the following formula:

$$k^2 = \left(\frac{\Delta\vartheta_{max}}{\Delta\vartheta_{rated\ ,obj.}} \right)$$

[fo_ueb_for_Irated, 3, en_US]

EXAMPLE:

Temperature class **B** for continuous operation: permissible overtemperature = 80 K
From this, a temperature for I_{rated} of 120 °C (80 K + 40 °C) can be derived when using a measuring element for the measurement.
Temperature class **F** as thermal limiting value: permissible overtemperature = 105 K.
From this, a maximum temperature of 145 °C (105 K + 40 °C) derives.
From these values, the magnitude of the K factor can also be derived.

$$k^2 = \frac{\Delta\vartheta_{max\ ,Obj.}}{\Delta\vartheta_{rated\ ,Obj.}} = \frac{105\ K}{80\ K} = 1.31 \qquad \rightarrow\ k = 1.146$$

[fo_bsp_kfaktor, 3, en_US]

If selecting a setting value of 1.1 for the **K-factor**, your selection can be considered as conservative.

Parameter: Storage of thermal replica

- Recommended setting value **(_:113) Storage of thermal replica** = ***no***

If a continuous auxiliary voltage of the bay units is ensured, the default setting can be retained.

Parameter: Behav. at I> Imax therm.

- Recommended setting value **(_:114) Behav. at I> Imax therm.** = ***current limiting***

The **Behav. at I> Imax therm.** parameter is used to select the process by which the function reacts to short-circuit currents. To prevent premature tripping of the overload protection at low time constants, high preloading and high short-circuit currents, the thermal replica can be modified.
The default setting has been selected compatible with SIPROTEC 4 devices. If you wish to take further temperature rise into consideration, the **current limiting** procedure is recommended.

Parameter Value	Description
current limiting	The input current is limited to the value set in the **Imax thermal** parameter. If the measured current exceeds the set current value, the limited current value is supplied to the thermal replica. An advisable current threshold is approx. 2 to 2.5 $I_{rated, obj}$.
freeze therm. rep.	If the input current exceeds the **Imax thermal** parameter, the thermal replica will be frozen for the time the parameter is exceeded. This parameter value is provided to enable compatibility with older products!

Parameter: Temperature sensor

- Default setting **(_:44) Temperature sensor** = ***none***

Use the **Temperature sensor** parameter to determine which temperature sensor to use to detect the ambient temperature.
A temperature sensor is used to measure the ambient temperature of the protected object and to feed it to the device via an RTD unit (RTD = Resistance Temperature Detector) or via an IO111 module. The function **Thermal overload protection** receives the measured temperature value via the functions **RTD unit Ether.**, **RTD unit Serial**, or **Temperature module IO111** from the function group **Analog units**.

Parameter: Default temperature

- Recommended setting value **(_:118) Default temperature** = ***40 °C***

Under the following conditions, the **Default temperature** will be set as ambient temperature:

- A temperature sensor for measuring the ambient temperature is not connected.
- The temperature measurement is interrupted and the measured temperature value is less than the **Default temperature**.

Siemens recommends using the default setting.

Parameter: Minimal temperature

- Default setting **(_:117) Minimal temperature** = ***-20 °C***

If the measured ambient temperature drops below the preset value, the set value will be assumed as the ambient temperature. If the overload protection works with a prespecified outside temperature, and this temperature drops below the value set in the **Minimal temperature** parameter, the **Minimal temperature** can also be used.

6.59.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
49 Th.overl. #				
_:1	49 Th.overl. #:Mode		• off • on • test	off
_:2	49 Th.overl. #:Operate & flt.rec. blocked		• no • yes	no
_:101	49 Th.overl. #:Threshold current warning	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:104	49 Th.overl. #:Threshold thermal warn.		50 % to 100 %	90 %
_:105	49 Th.overl. #:Dropout threshold operate		50 % to 99 %	90 %
_:106	49 Th.overl. #:K-factor		0.10 to 4.00	1.10
_:110	49 Th.overl. #:Thermal time constant		10 s to 60000 s	900 s
_:107	49 Th.overl. #:Imax thermal	1 A @ 100 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 100 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 50 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	12.500 A
_:109	49 Th.overl. #:Temperature rise at Irated		40 K to 200 K	70 K
_:113	49 Th.overl. #:Storage of thermal replica		• no • yes	no
_:114	49 Th.overl. #:Behav. at I> Imax therm.		• current limiting • freeze therm. rep.	current limiting

6.59.6 Information List

No.	Information	Data Class (Type)	Type
49 Th.overl. #			
_:500	49 Th.overl. #:>Block stage	SPS	I
_:501	49 Th.overl. #:>Reset thermal replica	SPS	I
_:51	49 Th.overl. #:Mode (controllable)	ENC	C
_:54	49 Th.overl. #:Inactive	SPS	O
_:52	49 Th.overl. #:Behavior	ENS	O
_:53	49 Th.overl. #:Health	ENS	O
_:301	49 Th.overl. #:Current warning	SPS	O
_:302	49 Th.overl. #:Thermal warning	SPS	O
_:303	49 Th.overl. #:Block close	SPS	O
_:55	49 Th.overl. #:Pickup	ACD	O
_:300	49 Th.overl. #:Operate alarm only	ACT	O
_:57	49 Th.overl. #:Operate	ACT	O
_:304	49 Th.overl. #:Time until close	MV	O
_:305	49 Th.overl. #:Time until trip	MV	O
_:306	49 Th.overl. #:Overload	MV	O
_:310	49 Th.overl. #:Equival. current	MV	O

6.60 Temperature Supervision

6.60.1 Overview of Functions

The **Temperature supervision** function checks the thermal state of:

- Motors
- Generators
- Transformers

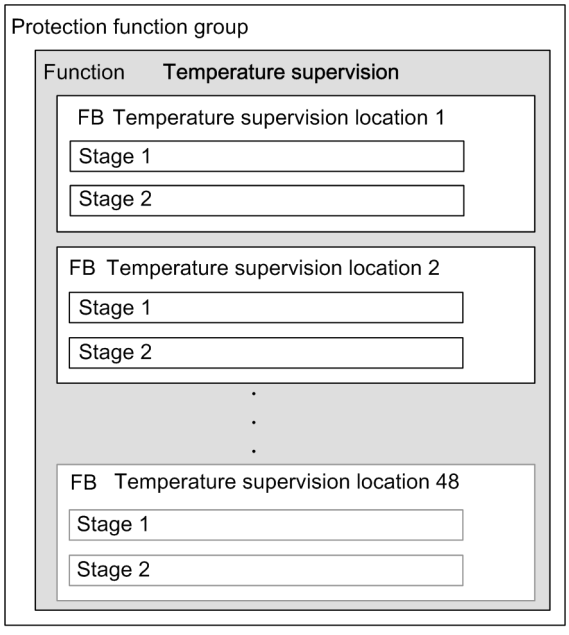
In rotating machines, it also checks bearing temperatures for a limit violation.

The temperatures are measured at various locations of the protected object using temperature sensors (RTD = Resistance Temperature Detector) and are sent to the device via one or more RTD units.

The **Temperature supervision** function receives its measured temperature values via the **RTD unit Ether.** or **RTD unit serial** functions from the **Analog units** function group.

6.60.2 Structure of the Function

The Temperature supervision function can work in all protection function groups. A maximum of 48 temperature supervision locations can operate simultaneously in the **Temperature supervision function** function. Each temperature supervision location has 2 threshold stages.

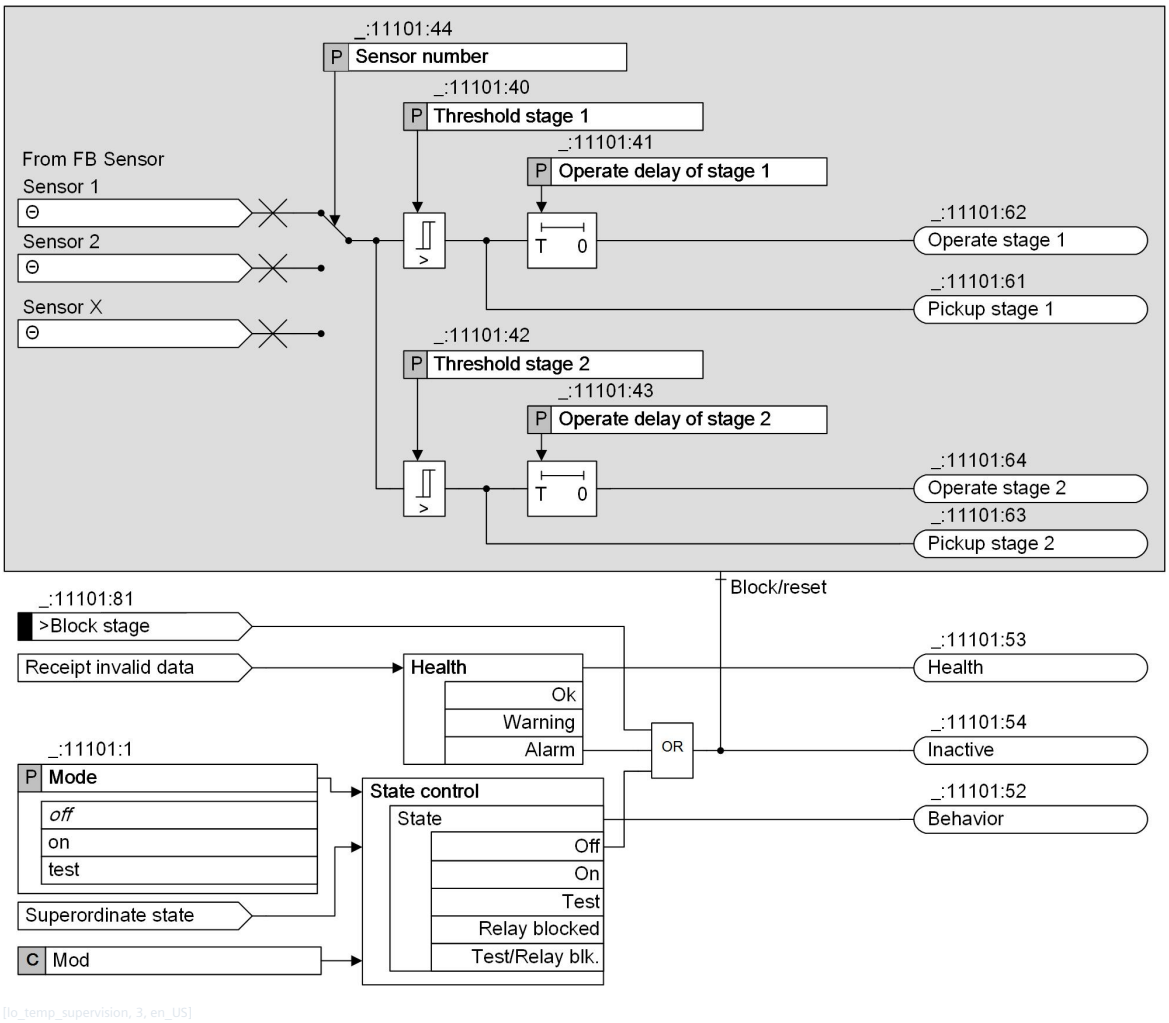


[dw_str_tmp, 1, en_US]

Figure 6-630 Structure/Embedding of the Function

6.60.3 Function Description

Logic



[lo_temp_supervision, 3, en_US]

Figure 6-631 Logic Diagram for a Temperature Supervision Location

The **Temperature supervision location** function block (**Location** FB) receives a measured temperature value in °C or °F as an input variable delivered from the temperature sensor function blocks of the **Analog units** function group. The **Sensor number** parameter is used to select the temperature sensor.

2 threshold value decisions can be performed for each measuring point. If the measured temperature value is greater than or equal to the set threshold values, the stages generate a pickup indication independent of one another and, after a set tripping time delay, an operate indication.

The indications from the supervision locations remain available for further processing.

NOTE

The pickup of the stages does not result in fault logging. The operate indications of the stages do not go into the trip logic of the device.

6.60.4 Application and Setting Notes

If you use an external RTD unit, connect the RTD unit via an interface (Ethernet or serial) to the SIPROTEC 5 device. Observe the setting notes for configuration of the interfaces in chapter *Analog Transformer Function Group Type* under *5.11.7.3 Communication with an RTD Unit*.

Parameter: `Sensor location`

- Default setting **`(_:11101:46) Sensor location`** = ***`Other`***

You inform the device of the sensor installation location using the **`Sensor location`** parameter. ***`Oil`***, ***`Ambient`***, ***`Turn`***, ***`Bearing`*** and ***`Other`*** are available for selection. The selection is not evaluated in the device, it only serves an informational purpose in the medium in which the temperature measurement takes place.

Parameter: `Sensor number`

- Default setting **`(_:11101:44) sensor number`** = ***`no function block selected`***

With the **`sensor number`** parameter, you assign a specific sensor whose temperature is to be monitored to the **Location** function block. You perform the assignment in DIGSI using a list box that contains all connected RTD units and their sensors.

Parameter: `Threshold stage 1`

- Default setting **`(_:11101:40) Threshold stage 1`** = ***`100 °C`***

With the **`Threshold stage 1`** parameter you establish the temperature value whose exceedance causes a pickup of the 1st tripping stage.

Parameter: `Operate delay of stage 1`

- Default setting **`(_:11101:41) Operate delay of stage 1`** = ***`5 s`***

With the **`Operate delay of stage 1`** parameter you establish the time the operate indication of the 1st tripping stage should be delayed after the pickup. This time delay depends on the specific application. If you set the time delay to ∞ the operate indication is blocked.

Parameter: `Threshold stage 2`

- Default setting **`(_:11101:42) Threshold stage 2`** = ***`120 °C`***

With the **`Threshold stage 2`** parameter you establish the temperature value whose exceedance causes a pickup of the 2nd tripping stage.

Parameter: `Operate delay of stage 2`

- Default setting **`(_:11101:43) Operate delay of stage 2`** = ***`0 s`***

With the **`Operate delay of stage 2`** parameter you establish the time the operate indication of the 2nd tripping stage should be delayed after the pickup. This time delay depends on the specific application. If you set the time delay to ∞ the operate indication is blocked.

Temperature Unit

Temperature Unit To change the display and evaluation of measured temperature values from °C to °F, adapt the DIGSI user default settings accordingly (see *5.11.7.5 Temperature Sensor*).

6.60.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Point 1				
_:11101:46	Point 1:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11101:1	Point 1:Mode		• off • on • test	off
_:11101:40	Point 1:Threshold stage 1		-50°C to 250°C	100°C
_:11101:41	Point 1:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11101:42	Point 1:Threshold stage 2		-50°C to 250°C	120°C
_:11101:43	Point 1:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11101:44	Point 1:Sensor		Setting options depend on configuration	
Point 2				
_:11102:46	Point 2:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11102:1	Point 2:Mode		• off • on • test	off
_:11102:40	Point 2:Threshold stage 1		-50°C to 250°C	100°C
_:11102:41	Point 2:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11102:42	Point 2:Threshold stage 2		-50°C to 250°C	120°C
_:11102:43	Point 2:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11102:44	Point 2:Sensor		Setting options depend on configuration	
Point 3				
_:11103:46	Point 3:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11103:1	Point 3:Mode		• off • on • test	off
_:11103:40	Point 3:Threshold stage 1		-50°C to 250°C	100°C

Addr.	Parameter	C	Setting Options	Default Setting
_:11103:41	Point 3:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11103:42	Point 3:Threshold stage 2		-50°C to 250°C	120°C
_:11103:43	Point 3:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11103:44	Point 3:Sensor		Setting options depend on configuration	
Point 4				
_:11104:46	Point 4:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11104:1	Point 4:Mode		• off • on • test	off
_:11104:40	Point 4:Threshold stage 1		-50°C to 250°C	100°C
_:11104:41	Point 4:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11104:42	Point 4:Threshold stage 2		-50°C to 250°C	120°C
_:11104:43	Point 4:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11104:44	Point 4:Sensor		Setting options depend on configuration	
Point 5				
_:11105:46	Point 5:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11105:1	Point 5:Mode		• off • on • test	off
_:11105:40	Point 5:Threshold stage 1		-50°C to 250°C	100°C
_:11105:41	Point 5:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11105:42	Point 5:Threshold stage 2		-50°C to 250°C	120°C
_:11105:43	Point 5:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11105:44	Point 5:Sensor		Setting options depend on configuration	
Point 6				
_:11106:46	Point 6:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11106:1	Point 6:Mode		• off • on • test	off
_:11106:40	Point 6:Threshold stage 1		-50°C to 250°C	100°C
_:11106:41	Point 6:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11106:42	Point 6:Threshold stage 2		-50°C to 250°C	120°C
_:11106:43	Point 6:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11106:44	Point 6:Sensor		Setting options depend on configuration	
Point 7				
_:11107:46	Point 7:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11107:1	Point 7:Mode		• off • on • test	off
_:11107:40	Point 7:Threshold stage 1		-50°C to 250°C	100°C
_:11107:41	Point 7:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11107:42	Point 7:Threshold stage 2		-50°C to 250°C	120°C
_:11107:43	Point 7:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11107:44	Point 7:Sensor		Setting options depend on configuration	
Point 8				
_:11108:46	Point 8:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11108:1	Point 8:Mode		• off • on • test	off
_:11108:40	Point 8:Threshold stage 1		-50°C to 250°C	100°C
_:11108:41	Point 8:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11108:42	Point 8:Threshold stage 2		-50°C to 250°C	120°C
_:11108:43	Point 8:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11108:44	Point 8:Sensor		Setting options depend on configuration	

Addr.	Parameter	C	Setting Options	Default Setting
Point 9				
_:11109:46	Point 9:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11109:1	Point 9:Mode		• off • on • test	off
_:11109:40	Point 9:Threshold stage 1		-50°C to 250°C	100°C
_:11109:41	Point 9:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11109:42	Point 9:Threshold stage 2		-50°C to 250°C	120°C
_:11109:43	Point 9:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11109:44	Point 9:Sensor		Setting options depend on configuration	
Point 10				
_:11110:46	Point 10:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11110:1	Point 10:Mode		• off • on • test	off
_:11110:40	Point 10:Threshold stage 1		-50°C to 250°C	100°C
_:11110:41	Point 10:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11110:42	Point 10:Threshold stage 2		-50°C to 250°C	120°C
_:11110:43	Point 10:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11110:44	Point 10:Sensor		Setting options depend on configuration	
Point 11				
_:11111:46	Point 11:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11111:1	Point 11:Mode		• off • on • test	off
_:11111:40	Point 11:Threshold stage 1		-50°C to 250°C	100°C
_:11111:41	Point 11:Operate delay of stage 1		0 s to 60 s; ∞	5 s

Addr.	Parameter	C	Setting Options	Default Setting
_:11111:42	Point 11:Threshold stage 2		-50°C to 250°C	120°C
_:11111:43	Point 11:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11111:44	Point 11:Sensor		Setting options depend on configuration	
Point 12				
_:11112:46	Point 12:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11112:1	Point 12:Mode		• off • on • test	off
_:11112:40	Point 12:Threshold stage 1		-50°C to 250°C	100°C
_:11112:41	Point 12:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11112:42	Point 12:Threshold stage 2		-50°C to 250°C	120°C
_:11112:43	Point 12:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11112:44	Point 12:Sensor		Setting options depend on configuration	

6.60.6 Information List

No.	Information	Data Class (Type)	Type
Point 1			
_:11101:81	Point 1:>Block stage	SPS	I
_:11101:54	Point 1:Inactive	SPS	O
_:11101:52	Point 1:Behavior	ENS	O
_:11101:53	Point 1:Health	ENS	O
_:11101:61	Point 1:Pickup stage 1	SPS	O
_:11101:62	Point 1:Operate stage 1	SPS	O
_:11101:63	Point 1:Pickup stage 2	SPS	O
_:11101:64	Point 1:Operate stage 2	SPS	O
Point 2			
_:11102:81	Point 2:>Block stage	SPS	I
_:11102:54	Point 2:Inactive	SPS	O
_:11102:52	Point 2:Behavior	ENS	O
_:11102:53	Point 2:Health	ENS	O
_:11102:61	Point 2:Pickup stage 1	SPS	O
_:11102:62	Point 2:Operate stage 1	SPS	O
_:11102:63	Point 2:Pickup stage 2	SPS	O
_:11102:64	Point 2:Operate stage 2	SPS	O
Point 3			
_:11103:81	Point 3:>Block stage	SPS	I

No.	Information	Data Class (Type)	Type
_:11103:54	Point 3:Inactive	SPS	O
_:11103:52	Point 3:Behavior	ENS	O
_:11103:53	Point 3:Health	ENS	O
_:11103:61	Point 3:Pickup stage 1	SPS	O
_:11103:62	Point 3:Operate stage 1	SPS	O
_:11103:63	Point 3:Pickup stage 2	SPS	O
_:11103:64	Point 3:Operate stage 2	SPS	O
Point 4			
_:11104:81	Point 4:>Block stage	SPS	I
_:11104:54	Point 4:Inactive	SPS	O
_:11104:52	Point 4:Behavior	ENS	O
_:11104:53	Point 4:Health	ENS	O
_:11104:61	Point 4:Pickup stage 1	SPS	O
_:11104:62	Point 4:Operate stage 1	SPS	O
_:11104:63	Point 4:Pickup stage 2	SPS	O
_:11104:64	Point 4:Operate stage 2	SPS	O
Point 5			
_:11105:81	Point 5:>Block stage	SPS	I
_:11105:54	Point 5:Inactive	SPS	O
_:11105:52	Point 5:Behavior	ENS	O
_:11105:53	Point 5:Health	ENS	O
_:11105:61	Point 5:Pickup stage 1	SPS	O
_:11105:62	Point 5:Operate stage 1	SPS	O
_:11105:63	Point 5:Pickup stage 2	SPS	O
_:11105:64	Point 5:Operate stage 2	SPS	O
Point 6			
_:11106:81	Point 6:>Block stage	SPS	I
_:11106:54	Point 6:Inactive	SPS	O
_:11106:52	Point 6:Behavior	ENS	O
_:11106:53	Point 6:Health	ENS	O
_:11106:61	Point 6:Pickup stage 1	SPS	O
_:11106:62	Point 6:Operate stage 1	SPS	O
_:11106:63	Point 6:Pickup stage 2	SPS	O
_:11106:64	Point 6:Operate stage 2	SPS	O
Point 7			
_:11107:81	Point 7:>Block stage	SPS	I
_:11107:54	Point 7:Inactive	SPS	O
_:11107:52	Point 7:Behavior	ENS	O
_:11107:53	Point 7:Health	ENS	O
_:11107:61	Point 7:Pickup stage 1	SPS	O
_:11107:62	Point 7:Operate stage 1	SPS	O
_:11107:63	Point 7:Pickup stage 2	SPS	O
_:11107:64	Point 7:Operate stage 2	SPS	O
Point 8			
_:11108:81	Point 8:>Block stage	SPS	I
_:11108:54	Point 8:Inactive	SPS	O

No.	Information	Data Class (Type)	Type
_:11108:52	Point 8:Behavior	ENS	O
_:11108:53	Point 8:Health	ENS	O
_:11108:61	Point 8:Pickup stage 1	SPS	O
_:11108:62	Point 8:Operate stage 1	SPS	O
_:11108:63	Point 8:Pickup stage 2	SPS	O
_:11108:64	Point 8:Operate stage 2	SPS	O
Point 9			
_:11109:81	Point 9:>Block stage	SPS	I
_:11109:54	Point 9:Inactive	SPS	O
_:11109:52	Point 9:Behavior	ENS	O
_:11109:53	Point 9:Health	ENS	O
_:11109:61	Point 9:Pickup stage 1	SPS	O
_:11109:62	Point 9:Operate stage 1	SPS	O
_:11109:63	Point 9:Pickup stage 2	SPS	O
_:11109:64	Point 9:Operate stage 2	SPS	O
Point 10			
_:11110:81	Point 10:>Block stage	SPS	I
_:11110:54	Point 10:Inactive	SPS	O
_:11110:52	Point 10:Behavior	ENS	O
_:11110:53	Point 10:Health	ENS	O
_:11110:61	Point 10:Pickup stage 1	SPS	O
_:11110:62	Point 10:Operate stage 1	SPS	O
_:11110:63	Point 10:Pickup stage 2	SPS	O
_:11110:64	Point 10:Operate stage 2	SPS	O
Point 11			
_:11111:81	Point 11:>Block stage	SPS	I
_:11111:54	Point 11:Inactive	SPS	O
_:11111:52	Point 11:Behavior	ENS	O
_:11111:53	Point 11:Health	ENS	O
_:11111:61	Point 11:Pickup stage 1	SPS	O
_:11111:62	Point 11:Operate stage 1	SPS	O
_:11111:63	Point 11:Pickup stage 2	SPS	O
_:11111:64	Point 11:Operate stage 2	SPS	O
Point 12			
_:11112:81	Point 12:>Block stage	SPS	I
_:11112:54	Point 12:Inactive	SPS	O
_:11112:52	Point 12:Behavior	ENS	O
_:11112:53	Point 12:Health	ENS	O
_:11112:61	Point 12:Pickup stage 1	SPS	O
_:11112:62	Point 12:Operate stage 1	SPS	O
_:11112:63	Point 12:Pickup stage 2	SPS	O
_:11112:64	Point 12:Operate stage 2	SPS	O

6.61 Hotspot Calculation

6.61.1 Overview of Functions

The **Hot-spot calculation** function (ANSI 49H) protects the transformer against thermal destruction at increased operating currents and monitors the thermal state of the turns.

The main use of this function is monitoring the temperature of the turns in the transformer. Continuously monitoring the temperature at special points, the **hot spots**, is very important. An increased turn temperature can have serious effects on the transformer.

The most frequent consequential damage of this is:

- Reduction of the service life
- Formation of gas bubbles that can result in insulation breakdown
- Destruction of the winding insulation

The hot-spot calculation considers the IEC 60076-7 and IEEE C57.91 2011 standards and calculates 3 relevant variables for the protection function:

- Hot-spot temperature
- Relative aging
- Load margin until warning and alarm indication

The following information about the protected object is necessary to calculate the hot-spot temperature:

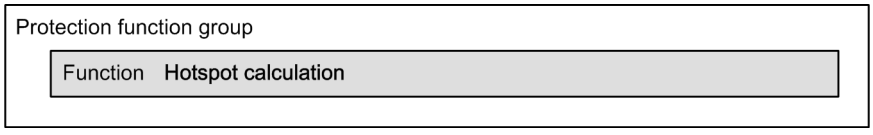
- Cooling methods
- Power factor
- Coolant temperature (top-oil temperature in the protected object)
- Transformer size
- Oil and turn time constants
- Factors as per IEC 60076-7 or IEEE C57.91 2011

The top-oil temperature is measured using temperature measuring points. In this case, up to 12 temperature measuring points can be transmitted to the protection device via one temperature coupling. One of these measuring points can be selected for calculating of the hot-spot temperature in the oil.

6.61.2 Structure of the Function

The **Hot-spot calculation** function can be used in every protection function group that has a 3-phase current input. During the engineering phase, you can incorporate the function into the project using drag & drop from the DISGI 5 function library.

The **Hot-spot calculation** function is continuous.

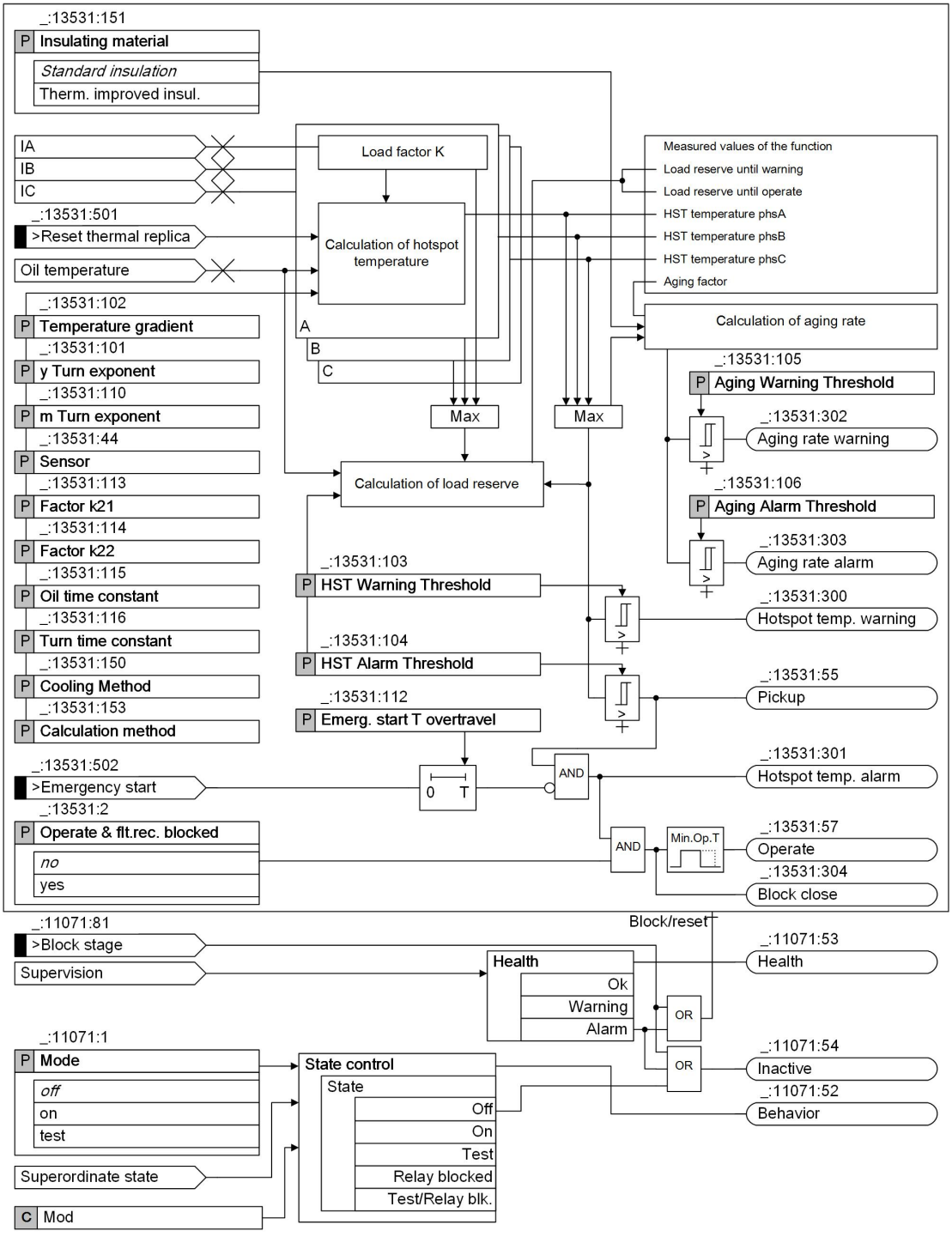


[dwhotspt-260213-01.tif, 1, en_US]

Figure 6-632 Structure/Embedding of the Function

6.61.3 Function Description

Logic of the Function



[lo_hotspt, 3, en_US]

Figure 6-633 Logic Diagram of the Hotspot Calculation Function

The hotspot temperature of a transformer winding can be calculated according to IEC 60076-7 or IEEE C57.91 2011. The following 3 variables, relevant for the protection function, are calculated:

- Temperature at the hotspot in the protected object
- Relative aging
- Load margin until warning and alarm indication

Measurement of the top-oil temperature on the transformer is required for this function. Specify a measuring point for the temperature measuring equipment that is relevant for calculating the hotspot temperature.

Cooling Versions

Calculating the hotspot is dependent on the cooling method. Air cooling is always available and is differentiated into 2 convection types:

- **AN** (**A**ir **N**atural): Artificial convection
- **AF** (**A**ir **F**orced): Forced-air convection (ventilation)

If a liquid coolant is also available, there are the following cooling versions:

- **ON** (**O**il **N**atural = convective oil flow): The coolant (oil) moves in the tank due to the temperature differences that occur. The cooling effect coming from natural convection is not very pronounced.
- **OF** (**O**il **F**orced = forced oil flow): The coolant (oil) moves in the tank because of an oil pump. The cooling effect is, for this reason, greater than for **ON**.
- **OD** (**O**il **D**irected = directed oil flow): The coolant (oil) follows a directional route in the tank because of an oil pump. As a result, the oil flow can be increased at points that are particularly temperature critical. The cooling effect is particularly good for this reason, the temperature gradient is smallest.

Calculating the Hotspot Temperature According to IEC 60076-7

The hotspot of the protected object is an important state value. The hottest point of the transformer occurs on the insulation of the topmost inner turn and it is relevant for the service life. The coolant temperature in the transformer increases from the bottom to the top. The cooling method influences the magnitude of the temperature gradient.

The hotspot temperature is composed of 3 components:

- Temperature at the hottest point in the coolant (coupled in by way of temperature measurement)
- Component coming from the temperature increase of the turn caused by the transformer load. It specifies the temperature gradient from the hotspot of the winding to the top-oil temperature.
- Component of the temperature rise of the turn due to a sudden change in the transformer load

To calculate the temperature at the hotspot, the protection device needs the following information:

- Data from the appropriate measuring point
- Data on the current in the winding
- Settings of the characteristic properties of the cooling system

An indication and/or tripping is generated if an adjustable threshold (temperature alarm) is exceeded.

To calculate the hotspot inside the transformer, the sum is formed from the top-oil temperature and the temperature difference between the hotspot and the top-oil:

$\Theta_h(t) = \Theta_o(t) + \Delta\Theta_h(t)$

with

$\Theta_h(t)$	Temperature of the hotspot in °C
$\Theta_o(t)$	Top-coolant temperature (oil temperature) in °C
$\Delta\Theta_h(t)$	Temperature difference between the hotspot of the winding and the oil in °C

The following 2 factors determine the temperature ratio between the hotspot and the oil temperature:

- Change in the oil viscosity (flow behavior of the oil)
- Change in the ohmic turn resistance (load-dependent)

$\Delta\Theta_h\,(t) = \Delta\Theta_{h1}\,(t) - \Delta\Theta_{h2}\,(t)$

$\Delta\Theta_{h1}\,(t) = \Delta\Theta_{h1}(t\text{-}1) + d\Delta\Theta_{h1}(t)$

$\Delta\Theta_{h2}\,(t) = \Delta\Theta_{h2}(t\text{-}1) + d\Delta\Theta_{h2}(t)$

with

$\Delta\Theta_{h1}\,(t)$	Temperature difference due to the turn resistance
$\Delta\Theta_{h2}\,(t)$	Temperature difference due to the oil viscosity

The following 2 equations are used for the calculation:

$$d\Delta\Theta_{h1}(t) = \frac{dt}{k_{22}\tau_w} \cdot (k_{21} \cdot K^Y \cdot H_{gr} - \Delta\Theta_{h1}(t - \Delta t))$$

[fohsalt8-300513-01.tif, 1, en_US]

$$d\Delta\Theta_{h2}(t) = \frac{dt}{(1/k_{22})\tau_o} \cdot \left[(k_{21} - 1) \cdot K^Y \cdot H_{gr} - \Delta\Theta_{h2}(t - \Delta t)\right]$$

[fohsalt9-300513-01.tif, 1, en_US]

with

H_{gr}	Insulation temperature gradient
K	Load ratio I/I_N (measured)
y	Turn exponent
k_{21}, k_{22}	Constant of the thermal model
τ_o	Oil time constant
τ_w	Turn time constant
t	Current calculation time point
Δt	Calculation Interval

During this, the load ratio K is determined from the measured current of the side and the rated object current. The rated current of the appropriate function group is used as the rated object current.

Calculating the Hotspot Temperature According to IEEE C57.91 2011

To calculate the hotspot inside the transformer, the sum is formed from the top-oil temperature and the temperature difference between the hotspot and the top-oil. The equation corresponds to the IEC standard:

$\Theta_h\,(t) = \Theta_o\,(t) + \Delta\Theta_h\,(t)$

with

$\Theta_h\,(t)$	Temperature of the hotspot in °C
$\Theta_o\,(t)$	Top-coolant temperature (oil temperature) in °C
$\Delta\Theta_h\,(t)$	Temperature difference between the hotspot of the winding and the oil in °C

$$\Delta\Theta_h(t) = (\Delta\Theta_h(t - \Delta t)) + \frac{\Delta t}{\tau_w}(\Delta\Theta_{H,U}(t) - \Delta\Theta_h(t - \Delta t))$$

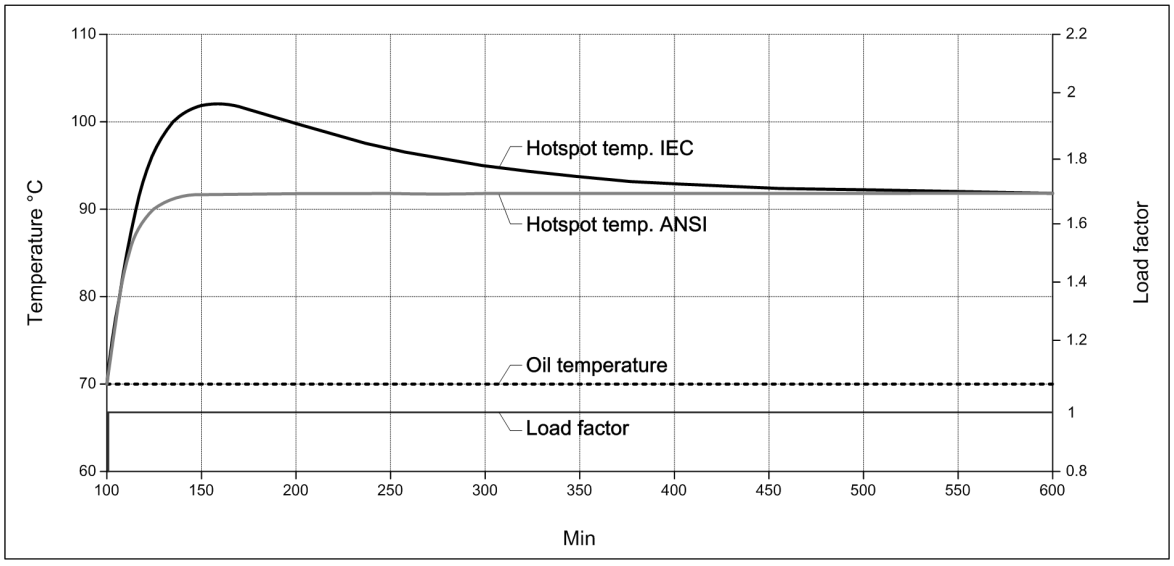
[fohsalt7-060313-01.tif, 1, en_US]

$\Delta\Theta_{H,V}(t) = K^{2m} \cdot H_{gr}$

with

$\Delta\Theta_{H,V}(t)$	Load-dependent hotspot temperature increase via the top-oil temperature
K	Load ratio I/I_N (measured)
m	Turn exponent
H_{gr}	Temperature gradient from the turn hotspot to the oil temperature at rated load
τ_w	Turn time constant
t	Current calculation time point
Δt	Calculation Interval

The following graphic shows an example for the behavior of the hotspot temperature during a load jam of $0 \cdot I/I_N$ to $1 \cdot I/I_N$ and a steady oil temperature of 70 °C. All required settings correspond to the default values. The results of the calculation methods according to IEC 60076-7 and IEEE C57.91 2011 are compared.



[dwhslsfk-170613-01.tif, 1, en_US]

Figure 6-634 Example of a Hotspot Calculation

Calculation of the Relative Aging

The service life of cellulose insulation refers to a temperature of 98 °C in the immediate environment of the insulation. Experience has shown that an increase of 6 K cuts the service life in half. This yields the following equation for a relative aging V at a temperature different from 98 °C:

$$V = \frac{\text{Aging at } \Theta_h}{\text{Aging at } 98\,^\circ\text{C}} = 2^{(\Theta_h - 98\,^\circ\text{C})/6}$$

[fohsalt1-260213-01.tif, 1, en_US]

with

V	Relative aging
Θ_h	Temperature of the hotspot in °C

The mean relative aging rate L results from forming the average over an observed time lapse from T1 to T2. The time period between T1 and T2 is 1 min.

$$L = \frac{1}{T_2 - T_1} \cdot \int_{T_1}^{T_2} V dt$$

[fohsalt2-260213-01.tif, 1, en_US]

with

L	Mean relative aging
T2 - T1	60 s

At a steady rated load, L = 1 corresponds to a hotspot temperature of 98 °C; at values over 1, accelerated aging occurs, for example, at L = 2 only half the service life is reached with respect to normal load conditions.

The relative aging is defined according to IEC only in the range from 80 °C to 140 °C. This is the defined operating range of the aging calculation. Temperatures below 80 °C do not extend calculated aging. Values exceeding 140 °C do not result in a reduction in the calculated aging.

The calculation of relative aging described refers only to the winding insulation and is, for this reason, not applicable for other failure causes.

Results

The hotspot temperature is calculated for the associated function group of the protected object. The currents of this function group and the measured coolant temperature at a selected temperature measuring point are used for this. The rated object current of the appropriate function group is used as the rated current.

Hotspot Thresholds

There are 2 indication thresholds for the hotspot temperature: A warning threshold **HST Warning Threshold** and an alarm threshold **HST Alarm Threshold**. There is also one adjustable threshold each for warning **Aging Warning Threshold** and alarm **Aging Alarm Threshold** for the mean aging rate.

Emergency Start

If the transformer must be operated beyond the maximum permissible hotspot temperature for operational reasons, the trip command can be blocked or a closure made possible by way of a binary input (*>Emergency start*).

After the binary input signal *>Emergency start* drops out, it may be necessary for the blocking to stay in effect because the hotspot temperature determined is still above the trip threshold. For this reason, the protection function is equipped with an adjustable seal-in time (**Emerg. start T overtravel**) that starts when the binary input signal drops and continues to suppress the trip command. Tripping by the hotspot calculation is only possible again after this time has elapsed.

This binary input acts only on the alarm indication and the trip command, has no effect on fault logging and does not reset the thermal image.

Blocking the Function

In the event of blocking, the picked up function will be reset. The function can be blocked externally or internally by the binary input signal *>Block stage*. All indications drop out with this.

Blocking Closure

The signal *Block close* can be used to prevent closure of the protected object at a high thermal load. The signal is set if the tripping temperature is exceeded, and cancelled if the temperature falls below the dropout threshold.

Functional Measured Values

Measured Value	Description
(_:13531:307) Tmp.A	Hotspot temperature for phase A in °C or °F (depending on the setting)
(_:13531:308) Tmp.B	Hotspot temperature for phase B in °C or °F (depending on the setting)
(_:13531:309) Tmp.C	Hotspot temperature for phase C in °C or °F (depending on the setting)
(_:13531:310) TmpMa	Hotspot temperature for the 3 phases in °C or °F (depending on the setting)
(_:13531:311) AgRate	Relative aging rate
(_:13531:305) RsWarn	Load margin until warning indication in percent
(_:13531:306) RsAlm	Load margin until alarm indication in percent

You can read the current status at any time on the device under the functional measured value.

You can find the functional measured values for the **Hotspot calculation** under the following menu item of the device:

- Main menu → Measurements → Function → Functional Measured Values → Hotspot calculation

6.61.4 Application and Setting Notes

Parameter: Sensor

- Default setting **(_:13531:44) sensor** = ***No function block selected***

With the **Sensor** parameter, you specify which connected temperature measuring point is used for hotspot calculation. The sensor for measuring the top-oil temperature must be connected to this temperature measuring point. If no temperature measuring equipment is connected, the **Consistency failure** parameter is displayed.

Parameter: Cooling Method

- Default setting **(_:13531:150) Cooling Method** = ***ONAN Oil nat.&Air nat.***

With the **Cooling Method** parameter, you specify the cooling method. You will find the definitions under the margin title **Cooling versions** in the function description of the hotspot calculation.

Parameter: Emerg. start T overtravel

- Default setting **(_:13531:112) Emerg. start T overtravel** = ***300 s***

With the **Emerg. start T overtravel** parameter, you set the time for which blocking of the tripping has to remain active after the outgoing input signal **>Emergency start**. With an outgoing input signal, the load on the protected object is removed. The **Emerg. start T overtravel** is set so that the hotspot temperature can drop below the dropout threshold in this time.

Parameter: HST Warning Threshold

- Default setting **(_:13531:103) HST Warning Threshold** = ***98 °C***

With the **HST Warning Threshold** parameter, you set a temperature at which a warning is output when this temperature is exceeded.

Parameter: HST Alarm Threshold

- Default setting **(_:13531:104) HST Alarm Threshold** = ***108 °C***

With the **HST Alarm Threshold** parameter, you set a temperature at which an alarm is output when this temperature is exceeded.

Parameter: Insulating material

- Default setting **Insulating material** = ***Standard insulation***

With the parameter **Insulating material**, you set the available insulating material for the transformer windings. Potential setting options are ***Standard insulation*** or thermally improved insulation (***Therm. improved insul.***). The max. hotspot temperature required for continuous load depends on the thermal resistance of the insulating materials used. The thermal resistance is 98° for thermally non-stabilized paper and 110° for thermally stabilized paper. Relative aging depends on the hotspot temperature of the transformer windings. This is how the type of insulating material is incorporated into the aging rate calculation.

Parameter: Aging Warning Threshold

- Default setting **(_:13531:105) Aging Warning Threshold** = ***1.000***

With the **Aging Warning Threshold** parameter, you set the threshold value at which a warning indication of the calculated relative aging is output.

Parameter: Aging Alarm Threshold

- Default setting **(_:13531:106) Aging Alarm Threshold** = ***2.000***

With the **Aging Alarm Threshold** parameter, you set the threshold value at which an alarm indication of the calculated relative aging is output.

Parameter: Turn time constant

- Default setting **(_:13531:116) Turn time constant** = ***10 min***

With the **Turn time constant** parameter, you account for the heat transfer from an electrical conductor (turn) to the outside of the insulation. This takes a few minutes. If no appropriate specifications are available, those found in IEC 60076-7 or IEEE C57.91 2011 may be used. You can find an excerpt from the tables of these standards with the relevant data in this case in *Table 6-22*.

Parameter: Calculation method

- Default setting **(_:13531:153) Calculation method** = ***IEC 60076-7***

With the **Calculation method** parameter, you specify the standard used for calculating the hotspot temperature. Depending on the selection, the required setting values are either displayed or hidden.

IEC 60076-7

The following settings apply only for the calculation method according to the IEC 60076-7 standard.

Parameter: y Turn exponent

- Default setting **(_:13531:101) y Turn exponent** = ***1.6***

To calculate the hotspot temperature, the device requires the **y Turn exponent**. If no specifications are available, those found in IEC 60076-7 may be used. You can find an excerpt from the tables of these standards with the relevant data in this case in *Table 6-22*.

Parameter: Temperature gradient

- Default setting **(_:13531:102) Temperature gradient** = ***22***

To calculate the hotspot temperature, the device requires the **Temperature gradient** (H_{gr}). This temperature gradient specifies the temperature difference between the hot spot of the winding and the top-oil temperature at rated load.

The setting is unitless. The temperature gradient is specified in °C (SI unit). If the value is only known for °F, convert it according to the following equation:

°C = K · 5/9

°C	Value in °C
K	Temperature gradient in °F

If no specifications are available, those found in IEC 60076-7 may be used. You can find an excerpt from the tables of this standard with the relevant data in this case in *Table 6-22*.

Parameter: Factor k21

- Default setting **(_:13531:113) Factor k21** = ***2.0***

Parameter: Factor k22

- Default setting **(_:13531:114) Factor k22** = ***2.0***

The parameters **Factor k21** and **Factor k22** are model constants that account for the turn configuration of the transformer with regard to oil flow. If no specifications for the transformer in question are available, those found in IEC 60076-7 may be used. You can find an excerpt from the tables of this standard with the relevant data in this case in *Table 6-22*.

Parameter: Oil time constant

- Default setting **(_:13531:115) Oil time constant** = ***210 min***

The **Oil time constant** parameters account for oil flow and flow rate. The time constant depends on the winding type and the cooling method. If no specifications are available, those found in IEC 60076-7 may be used. You can find an excerpt from the tables of this standard with the relevant data in this case in *Table 6-22*.

IEEE C57.91 2011

The following settings apply only for the calculation method according to the IEEE C57.91 2011 standard.

Parameter: m Turn exponent

- Default setting **(_:13531:110) m Turn exponent** = ***0.8***

To calculate the hotspot temperature, the device requires the **m Turn exponent**. If no specifications are available, those found in IEEE C57.91 2011 may be used. You can find an excerpt from the tables of this standard with the relevant data in this case in *Table 6-22*.

Parameter: Temperature gradient

- Default setting **(_:13531:130) Temperature gradient** = ***22***

To calculate the hotspot temperature, the device requires the **Temperature gradient** (H_{gr}). This temperature gradient specifies the temperature difference between the hot spot of the winding and the top-oil temperature at rated load.

The setting is unitless. The temperature gradient is specified in °C (SI unit). If the value is only known for °F, convert it according to the following equation:

°C = K · 5/9

°C	Value in °C
K	Temperature gradient in °F

If no specifications are available, those found in IEEE C57.91 2011 may be used. You can find an excerpt from the tables of this standard with the relevant data in this case in *Table 6-22*.

Thermal Data of Transformers

If no specifications for the transformer in question are available, those found in the IEC 60076-7 or IEEE C57.91 2011 standards may be used. You can find an excerpt from the tables of these standards with the data relevant here in the table below.

Table 6-22 Thermal Data of Transformers

		Distribution Transformers	Medium-Size and Large Power Transformers						
Cooling methods		ONAN	ONAN[1)]	ONAN	ONAF[1)]	ONAF	OF[1)]	OF	OD
Turn exponent (IEC)	y	1.6	1.3	1.3	1.3	1.3	1.3	1.3	2.0
Turn exponent (ANSI)	m	0.8	0.65	0.65	0.65	0.65	0.65	0.65	1.0
Constant	k_{21}	1.0	3.0	2.0	3.0	2.0	1.45	1.3	1.0
Constant	k_{22}	2.0	2.0	2.0	2.0	2.0	1.0	1.0	1.0
Oil time constant	τ_o [min]	180	210	210	150	150	90	90	90

		Distribution Transformers	Medium-Size and Large Power Transformers						
Turn time constant	τ_w [min]	4	10	10	7	7	7	7	7
Insulation temperature gradient	H_{gr} [°C]	23	–	26	–	26	–	22	29
[1] If the turns of an ON-cooled or OF-cooled transformer are cooled in a zigzag connection									

6.61.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:13531:1	Hotspot calc.:Mode		• off • on • test	off
_:13531:2	Hotspot calc.:Operate & flt.rec. blocked		• no • yes	no
_:13531:100	Hotspot calc.:Consis-tency failure		• no MP configured • no Sensor configured	no Sensor configured
_:13531:150	Hotspot calc.:Cooling Method		• ONAN Oil nat.&Air nat. • ONAF Oil nat.&Air for. • OF Oil forced • OD Oil directed	ONAN Oil nat.&Air nat.
_:13531:112	Hotspot calc.:Emerg. start T overtravel		0 s to 15 000 s	300 s
_:13531:103	Hotspot calc.:HST Warning Threshold		80°C to 140°C	98°C
_:13531:104	Hotspot calc.:HST Alarm Threshold		80°C to 140°C	108°C
_:13531:151	Hotspot calc.:Insulating material		• Standard insulation • Therm. improved insul.	Standard insula-tion
_:13531:105	Hotspot calc.:Aging Warning Threshold		0.125 to 128.000	1.000
_:13531:106	Hotspot calc.:Aging Alarm Threshold		0.125 to 128.000	2.000
_:13531:116	Hotspot calc.:Turn time constant		0 min to 30 min	10 min
_:13531:153	Hotspot calc.:Calculation method		• IEC 60076-7 • IEEE C57.91 2011	IEC 60076-7
IEC 60076-7				
_:13531:101	Hotspot calc.:y Turn exponent		1.6 to 2.0	1.6
_:13531:102	Hotspot calc.:Tempera-ture gradient		20 to 50	22
_:13531:113	Hotspot calc.:Factor k21		1.0 to 5.0	2.0
_:13531:114	Hotspot calc.:Factor k22		1.0 to 5.0	2.0
_:13531:115	Hotspot calc.:Oil time constant		50 min to 500 min	210 min

Addr.	Parameter	C	Setting Options	Default Setting
IEEE C57.91 2011				
_:13531:110	Hotspot calc.:m Turn exponent		0.8 to 1.0	0.8
_:13531:130	Hotspot calc.:Tempera-ture gradient		20 to 50	22
_:13531:44	Hotspot calc.:Sensor		Setting options depend on configuration	

6.61.6 Information List

No.	Information	Data Class (Type)	Type
Hotspot calc.			
_:13531:81	Hotspot calc.:>Block stage	SPS	I
_:13531:502	Hotspot calc.:>Emergency start	SPS	I
_:13531:501	Hotspot calc.:>Reset thermal replica	SPS	I
_:13531:51	Hotspot calc.:Mode (controllable)	ENC	C
_:13531:54	Hotspot calc.:Inactive	SPS	O
_:13531:52	Hotspot calc.:Behavior	ENS	O
_:13531:53	Hotspot calc.:Health	ENS	O
_:13531:300	Hotspot calc.:Hotspot temp. warning	SPS	O
_:13531:301	Hotspot calc.:Hotspot temp. alarm	SPS	O
_:13531:302	Hotspot calc.:Aging rate warning	SPS	O
_:13531:303	Hotspot calc.:Aging rate alarm	SPS	O
_:13531:55	Hotspot calc.:Pickup	ACD	O
_:13531:57	Hotspot calc.:Operate	ACT	O
_:13531:304	Hotspot calc.:Block close	SPS	O
_:13531:307	Hotspot calc.:Tmp.A	MV	O
_:13531:308	Hotspot calc.:Tmp.B	MV	O
_:13531:309	Hotspot calc.:Tmp.C	MV	O
_:13531:310	Hotspot calc.:TmpMa	MV	O
_:13531:311	Hotspot calc.:AgRate	MV	O
_:13531:305	Hotspot calc.:RsWarn	MV	O
_:13531:306	Hotspot calc.:RsAlm	MV	O

6.62 Circuit-Breaker Failure Protection

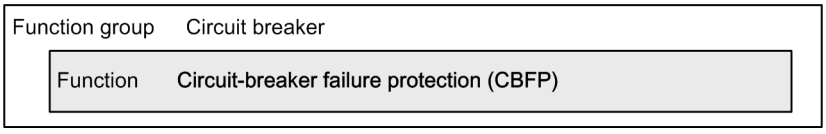
6.62.1 Overview of Functions

The **Circuit-breaker failure protection** function (ANSI 50BF) monitors the tripping of the associated circuit-breaker (CB) and generates a backup trip signal if the circuit-breaker fails.

Starting with version V7.50, the previous function **CB failure** has been replaced with the new Circuit-breaker failure protection with an adaptive algorithm **Adaptive CB failure protection**. In this way, you achieve a faster, more reliable detection of the opening of the circuit breaker in the event of complex signal histories. The 2 functions are identical, with the exception of a slightly increased processor load, in terms of setting options, logic and indications. Siemens recommends using the adaptive circuit-breaker failure protection and avoiding mixing the protection types in one device. You can find additional information on the processor load in DIGSI for each device under **Device information** in the **Resource consumption** tab.

6.62.2 Structure of the Function

The function **Circuit-breaker failure protection** (CBFP) can be used in the **Circuit-breaker** function group.



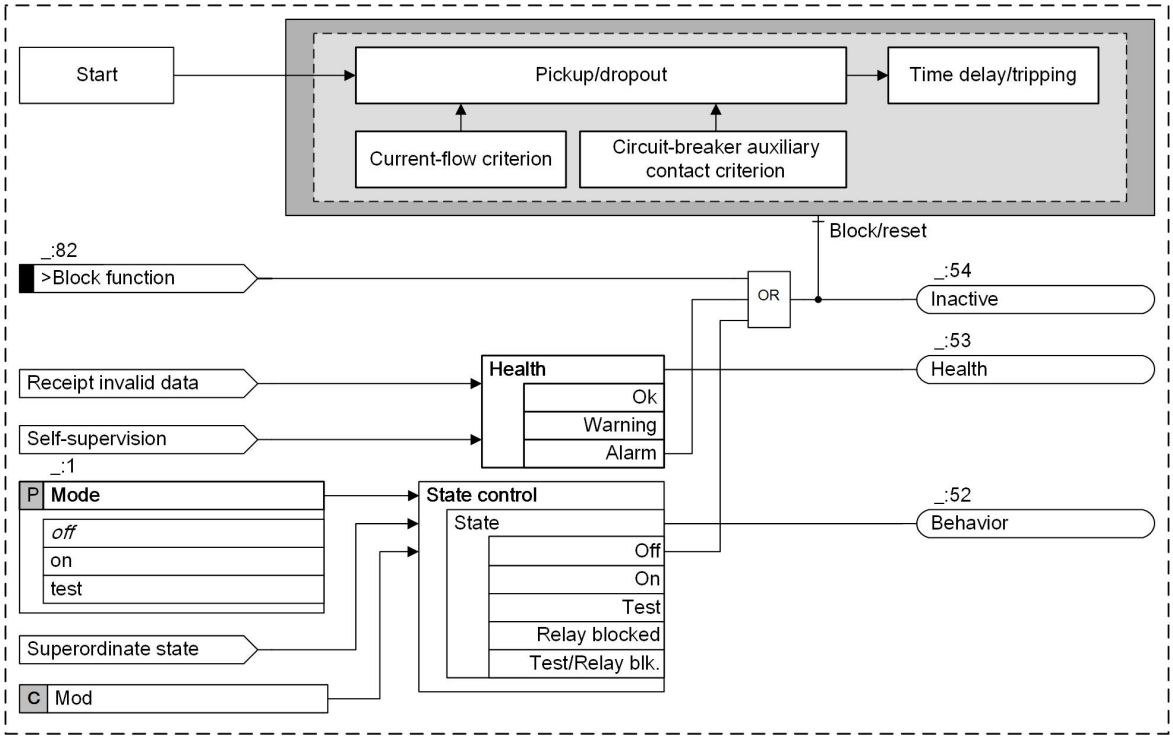
[dw_strbfp, 1, en_US]

Figure 6-635 Structure/Embedding of the Function

Figure 6-636 shows the functionalities and the function control of the function.

The start is initiated by the device-internal protection function or by an external protection. Along with the start, the current-flow criterion or the circuit-breaker auxiliary contact criterion is used to check whether the circuit breaker is closed. If the circuit breaker is closed, the function picks up and starts the time delay. During the time delay, the system continuously checks whether the circuit breaker has opened. If this is the case, the function drops out. If the circuit breaker is not opened, the function trips upon expiration of the time delay.

The following description elaborates on the detailed functionality of the individual function blocks.



[lo_svs_bfp, 3, en_US]

Figure 6-636 Function Logic Overview

6.62.3 Function Description

The circuit-breaker failure protection function is started by device-internal protection functions and/or externally (via a binary input or an interface, such as GOOSE). *Figure 6-637* and *Figure 6-638* show the functionality.

Internal Start

By default, each device-internal protection stage that must control the local circuit breaker starts the circuit-breaker failure protection. The function is started by the tripping of the protection stage. In the default setting, the starting signal **`Internal start`** (see *Figure 6-637*) is held when the pickup signal has a falling edge or the protection function has tripped. The Circuit-breaker failure protection function can in this case only drop out if the circuit breaker is detected to be open. This is detected using the current flow or circuit-breaker auxiliary contact criterion. If necessary, the Circuit-breaker failure protection function can also drop out when the pickup signal has a falling edge or the protection function trips (internal starting signal is not held).

You can use routing to determine whether individual protection stages or protection functions are used as a starting source or whether the start is only supposed to be external.

The internal starting sources are routed in the protection function groups via the entry **Circuit-breaker interaction** (for this, see*2.1 Embedding of Functions in the Device*. *Figure 2-6*.

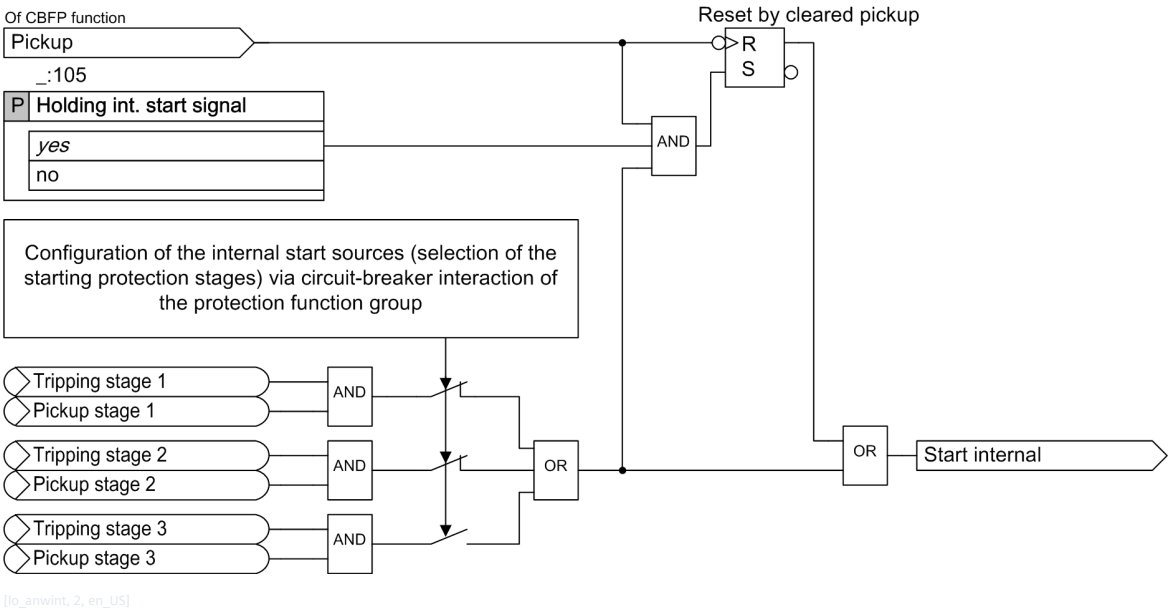


Figure 6-637 Internal Start of the Circuit-Breaker Failure Protection Function

External Start

The parameter **Start via binary input** is used to set whether the external start is initiated by a 1-channel or 2-channel signal. The required routing of the input signals is compared with the setting. If a routing is missing, an error message is generated. The Health signal changes to the state *warning*.

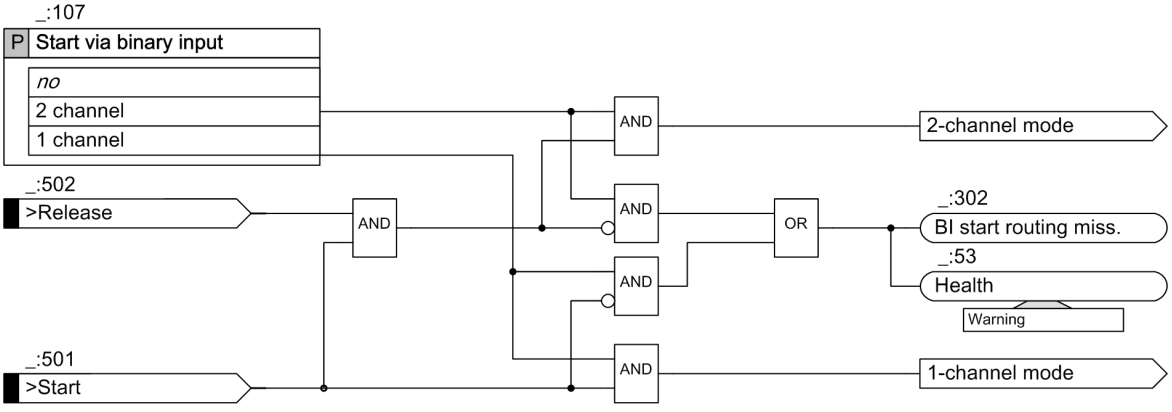


Figure 6-638 Configuration of the External Start of the Circuit-Breaker Failure Protection Function

In 1-channel operation, the start is initiated with the binary input signal **>Start** only.

In 2-channel operation, the binary input signal **>Release** must also be activated to initiate the start. In the default setting, the starting signal **External start** drops out immediately when the input signals have a falling edge (see *Figure 6-639*). If necessary, the starting signal can be held. In this case the start remains active when the binary input signals have a falling edge.

The input signals are monitored to avoid an unwanted pickup of the function.

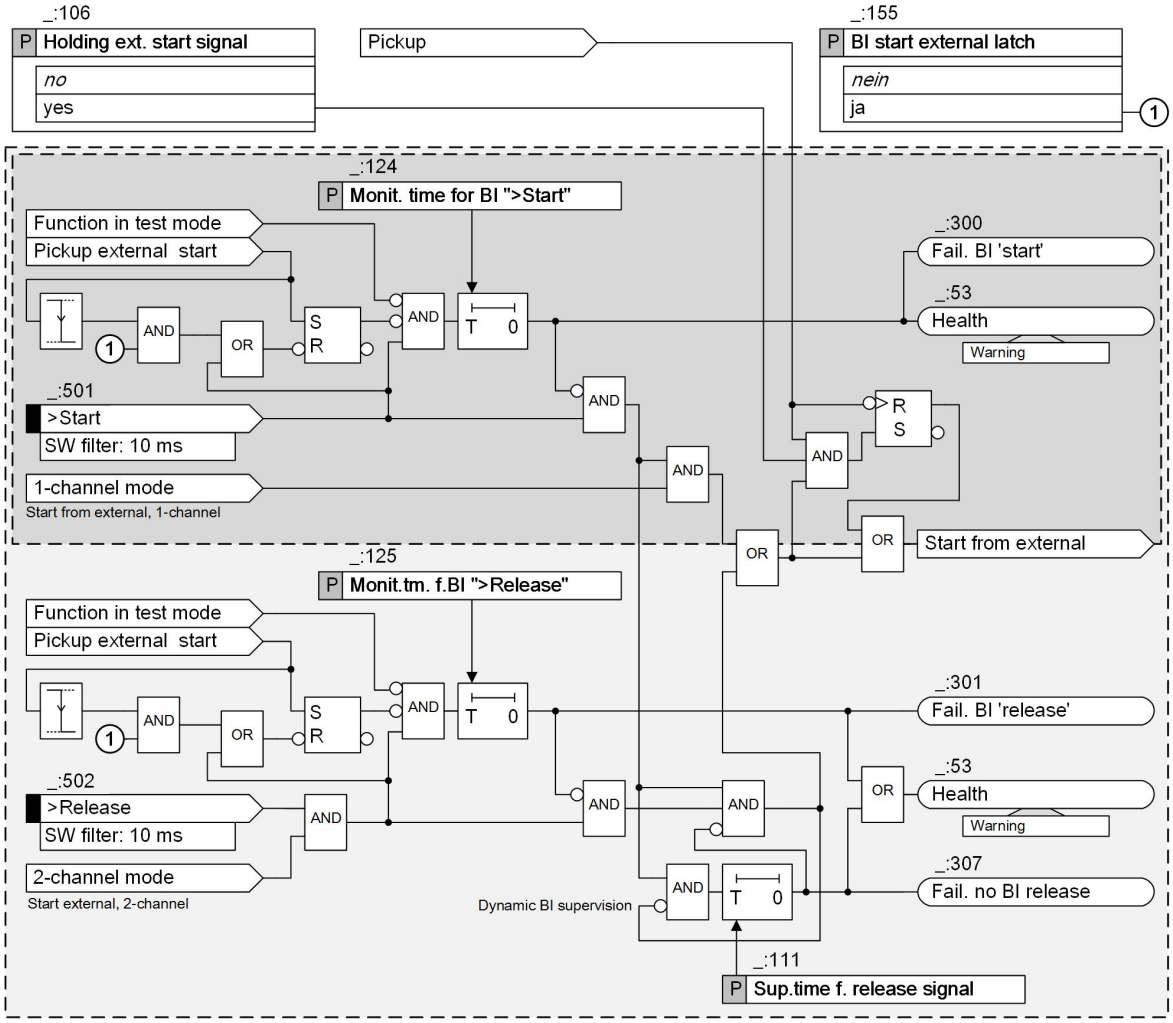
If either of the signals **>Start** or **>Release** is active for more than the set supervision time of the corresponding signal without the function being picked up, an error in the binary input circuit is assumed. The corresponding signal is blocked to exclude an external pickup of the function. An indication to this effect is output, and the Health signal changes to the state *warning*. The blocking is reset as soon as the binary input signal drops out.

Supervision is disabled in the following cases:

- On pickup of the Circuit-breaker failure protection function (only in the case of an external start). This prevents an unwanted pickup of the supervision if the external protection that starts the Circuit-breaker failure protection function uses a lockout functionality. When the starting signal drops out, supervision is enabled again.
- As long as the function or the device is in **test mode**. This allows to check the function without the supervision blocking the function.

If the signal **>Start** is active and no release signal is present after elapse of a settable supervision time for the starting signal, the pickup is blocked and an indication to this effect is output. The Health signal changes to the state Warning. The blocking is reset with the dropout of the starting signal.

The binary input signals only take effect if the binary inputs are activated for at least 10 ms (SW filter, see *Figure 6-639*).



[lo_ext, 3, en_US]

Figure 6-639 External Start of the Circuit-Breaker Failure Protection Function, Logic

Current-Flow Criterion

The current-flow criterion is the primary criterion for determining the circuit-breaker switch position. A circuit-breaker pole is supposed to be closed, and the current-flow criterion fulfilled, as soon as one of the phase currents exceeds the phase-current threshold value, and at the same time a plausibility current exceeds the associated threshold value. The plausibility current can be either a 2nd phase current (to compare with the threshold value for phase currents) or the zero-sequence or negative-sequence current (to compare with

the sensitive threshold value). The additional evaluation of the plausibility current increases the safety of a criterion.

If you are using the transformer connection type **3-phase, 2prim.trans.**, the ground current is neither measured nor calculated. The plausibility check via the ground current is therefore not possible. The setting ***Direct release*** via the ground current does not lead to a pickup of the circuit-breaker failure protection.

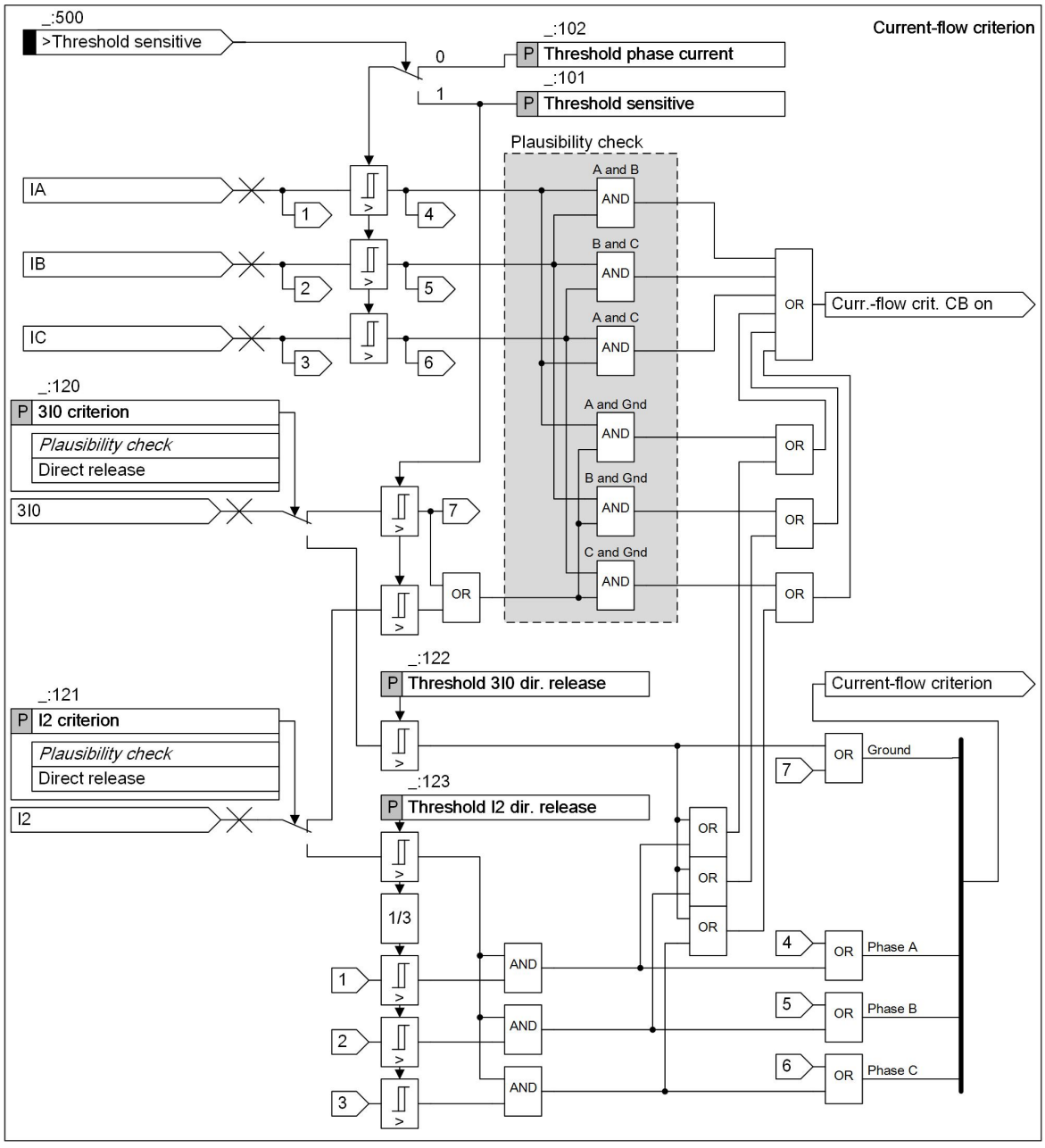
In the case of ground faults, the sensitive threshold value can be dynamically applied to the phase currents as well. The current-flow criterion is in this case fulfilled when the currents exceed the sensitive threshold value. The phase-current threshold value is then ineffective. The binary signal **>Threshold sensitive** is used for the switchover.

If you set the parameter **3I0 criterion** to ***Direct release***, you block the plausibility check of the zero-sequence current. In this way a pickup can only be achieved by way of this current. The **Threshold 3I0 dir. release** parameter is used to set the threshold value to be exceeded.

If you set the parameter **I2 criterion** to ***Direct release***, you also switch off the plausibility check of the negative-sequence current. The **Threshold I2 dir. release** parameter is used to set the threshold value to be exceeded.

If you set the parameter **I2 criterion** to ***Direct release***, a plausibility check is performed via the phase currents with 1/3 * **Threshold I2 dir. release**.

The measuring algorithm is optimized for fast dropout when the value drops below the threshold value.



[lo_current1, 4, en_US]

Figure 6-640 Current-Flow Criterion

Circuit-Breaker Auxiliary Contact Criterion

Settings allow you to specify whether the circuit-breaker auxiliary contacts are permitted for determining the circuit-breaker switch position.

The double-point indication **`3-pole position`** (from the function block **Circuit-breaker**) is used to determine whether all 3 poles of the circuit breaker are closed. If the double-point indication is not routed, the output is an error message. Furthermore, the Health signal changes to the state *`warning`*.

The detection of a static disturbed position (not an intermediate position) has the effect that the circuit-breaker auxiliary contact criterion is not used (the internal signal **`Aux.co.crit.: CB Clsd`** is disabled).

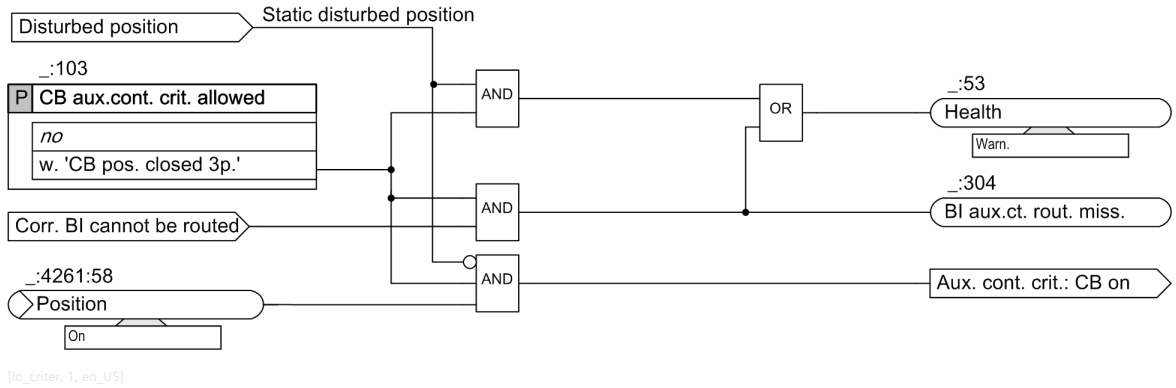


Figure 6-641 Circuit-Breaker Auxiliary Contact Criterion

Pickup/Dropout

After the start, a check is performed whether the circuit breaker is closed. The current-flow criterion and the circuit-breaker auxiliary contact criterion are available for this purpose.

Even if the circuit-breaker auxiliary contact criterion is permitted, preference is given to the fulfilled current-flow criterion because the current-flow criterion is the most reliable criterion for detecting whether the circuit breaker is closed. This means that the circuit breaker is deemed to be closed if it is closed according to the current-flow criterion but at the same time open according to the circuit-breaker auxiliary contact criterion.

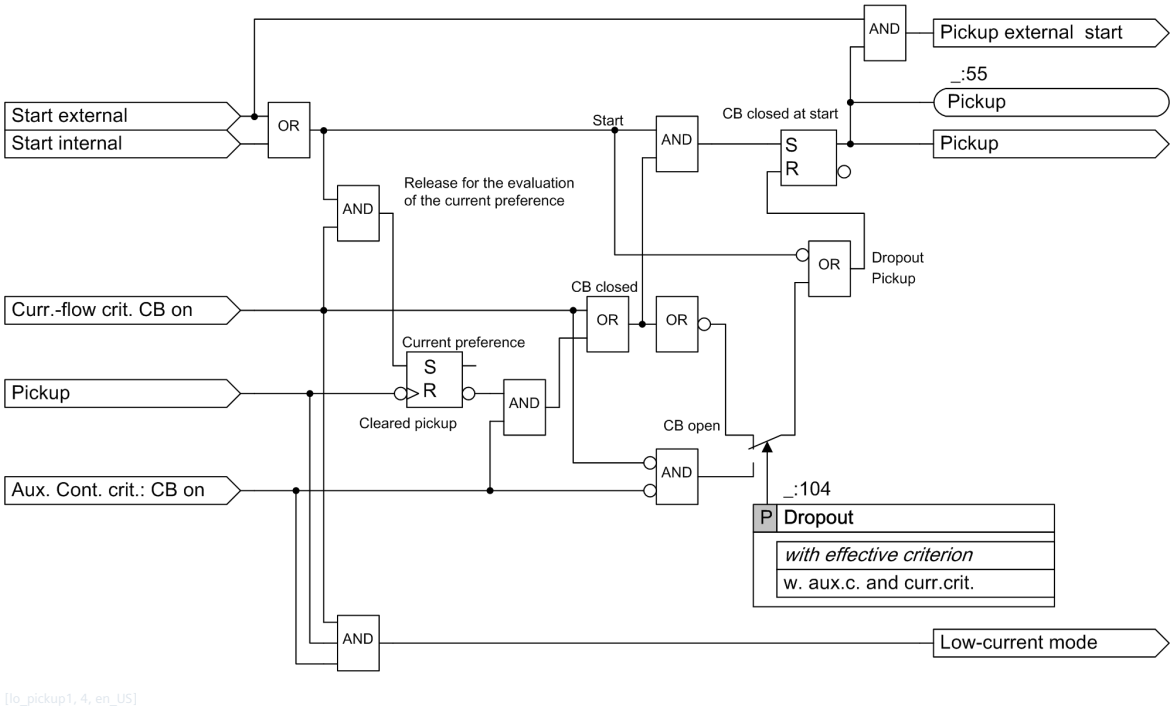
If no current is flowing at the start time, the function can only pick up on the basis of the circuit-breaker auxiliary contact criterion. For this purpose, the circuit-breaker auxiliary contacts must be permitted as criterion. When the current begins to flow after the start, the function switches over to the current-flow criterion.

If the circuit breaker is detected as closed and the starting condition is present, the function picks up.

The pickup starts a time delay (see Delay/Tripping). While the delay is running, the system checks continuously whether the circuit breaker has opened. In the default setting, the opening of the circuit breaker is checked on the basis of the currently valid criterion, which is normally the current-flow criterion because it is preferred. If until expiration of the time delay, no current flow above the set threshold values has been detected, the circuit-breaker auxiliary contact criterion becomes effective.

The function has also a setting in which dropout is only possible if both criteria in parallel detect the circuit breaker to be open (dropout with auxiliary contact and current-flow criterion).

In the default setting, the internal starting signal is held (see *Figure 6-637* and *Figure 6-639*). This means that dropout is controlled solely by the current or the circuit-breaker auxiliary contact criterion. If dropout is also to occur on the falling edge of the starting signal (that is, when the pickup signal has a falling edge or the protection function trips), holding of the start signal must be disabled.



[lo_pickup1, 4, en_US]

Figure 6-642 Pickup/Dropout of the Circuit-Breaker Failure Protection Function

Delay/Tripping

In a first step, tripping at the local circuit breaker can be repeated. Tripping is repeated after expiration of the settable delay T1. If the local CB was not yet tripped, for example, in the event of an external start of the circuit-breaker failure protection, the trip logic of the circuit breaker itself is activated when the time delay T1 elapses.

Time delay T2 (backup tripping) can commence in parallel either with the start of time T1 or after expiration of time T1.

If time delay T2 expires without a dropout of the function, a circuit-breaker failure is assumed and the backup tripping signal **`Tripping T2`** is output. If there is a protection interface in the device, if needed a transfer-trip signal can be sent to the opposite end.

For detailed information, see *3.6 Protection Communication*.

If the **`>CB defect`** input signal is valid, any repetition of the trip signal is suppressed, and the backup tripping signal T2 is generated immediately (without delay). The binary input of the **`>CB defect`** input signal must be activated for at least 20 ms before the signal becomes valid.

With help of the *`CB failure pole`* indication, you can determine the phase currents that are above the threshold value at the tripping time T2.

The **`Minimum operate time`** parameter defines the minimum duration for tripping the function. In contrast to other protection functions, the parameter is set within its own function. As a result, the setting is independent of the identically named global parameter that is set in the **Device settings**.

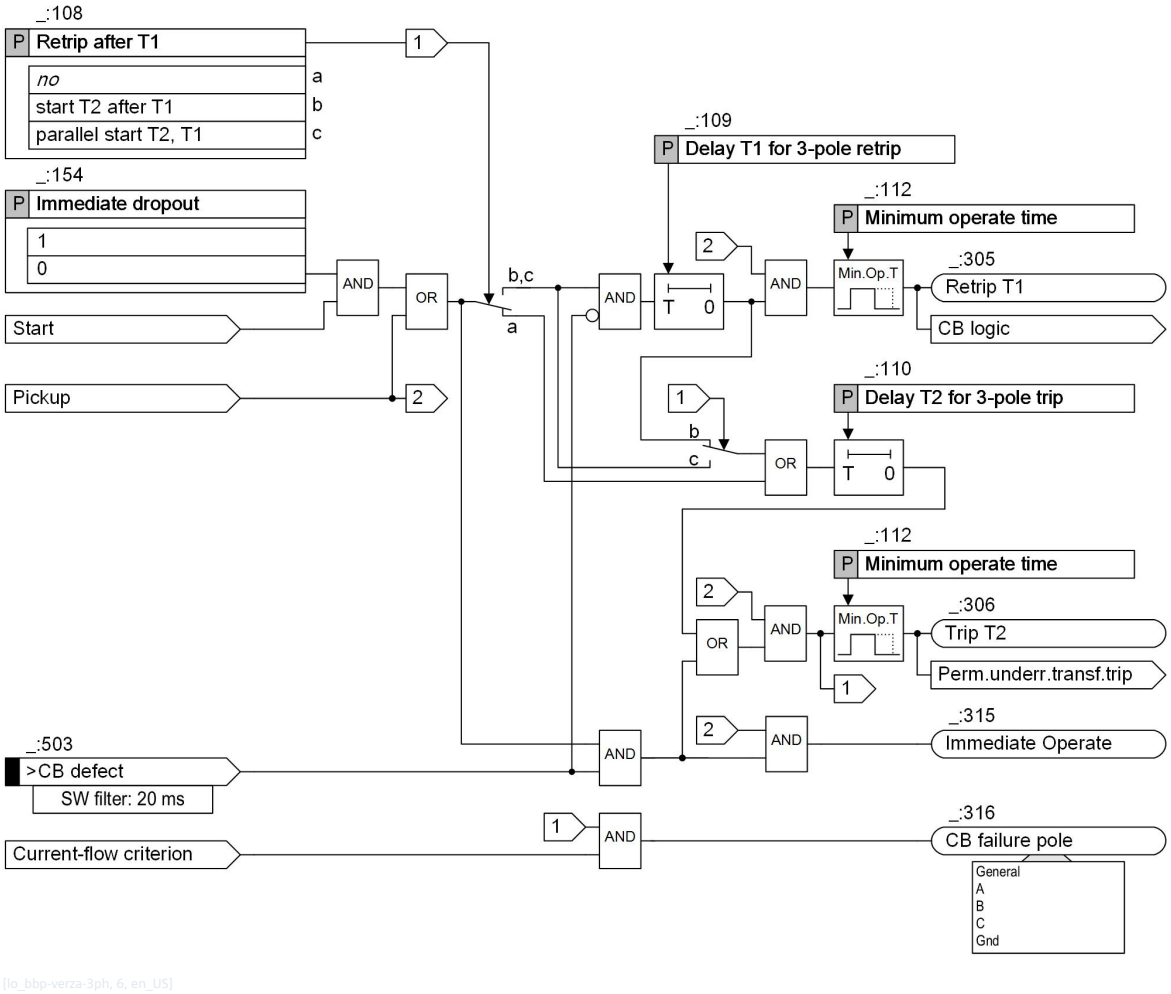
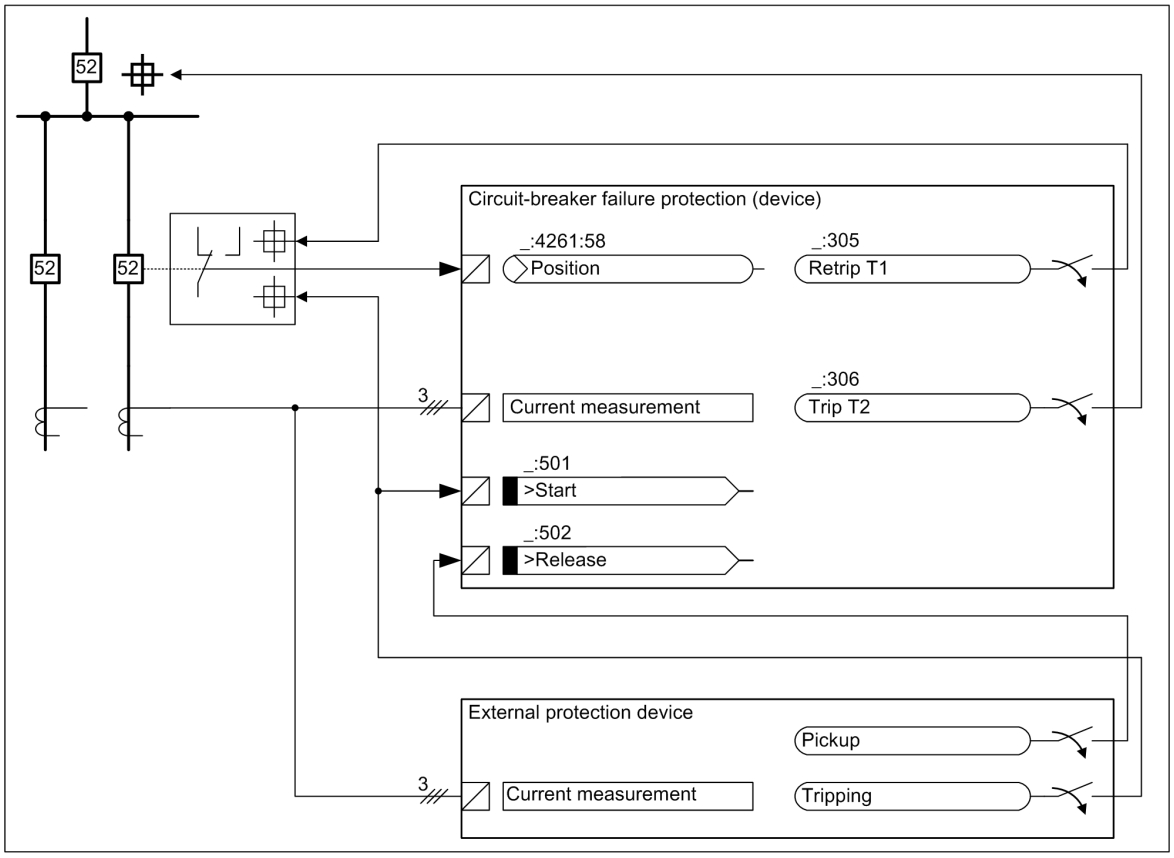


Figure 6-643 Delay/Tripping of the Circuit-Breaker Failure Protection Function

With the parameter **`Immediate dropout`**, you determine whether the circuit-breaker switch position is checked continuously or on expiration of the T1 and T2 time delays. If the circuit-breaker switch position is checked once the time delays have expired, the function picks up using Start.

6.62.4 Application and Setting Notes

Figure 6-644 gives an overview of the functions involved in an external start of the CBFP function. In the case of an internal start, there is no external protection device and the protection functionality is located in the CBFP device.



[lo_extpol, 2, en_US]

Figure 6-644 Circuit-Breaker Failure Protection with External Start, Tripping Repetition, and 3-Pole Tripping (T2)

Routing: Configuration of Internal Starting Sources (Internal Protection Function)

Configuration of the internal starting sources takes place in the protection function groups via the **Circuit-breaker interaction** entry (*2.1 Embedding of Functions in the Device*, *Figure 2-6*).

By default, the function can be started by any tripping of the internal protection functions that control the local circuit breaker. Depending on the specific application, it can be necessary to exclude certain device-internal protection functions from starting the CBFP. For instance, busbar disconnection following a local circuit-breaker failure may be undesirable in the case of load-shedding applications or ground faults in isolated/resonant-grounded systems.

Where a start exclusively from external sources is required, all internal protection functions must be routed so that they are excluded as a starting source.

Parameter: Start via binary input

- Default setting **(_:107) Start via binary input** = ***no***

Parameter Value	Description
no	If no external start is intended, the parameter is set to ***no***.
2 channel	2-channel start is used if there is a danger that the circuit-breaker failure protection causes a tripping due to a faulty activation of the start binary input. This is the case in the following situations: a) The CBFP pickup value (threshold value) is set to less than the load current. b) There can be operating conditions under which the current flow is higher than the pickup value. To avoid a possible overfunction, Siemens recommends using the 2-channel start.
1 channel	The 1-channel start must be used where only one control circuit of a binary input is available for starting the CBFP.

Input Signals: >Start, >Release

The start and release input signals have a filtering time of ***10 ms*** as default setting. If a transient control signal to the binary inputs is to be expected due to the design of the external binary-input control circuits and due to environmental conditions, the filtering time can be extended. This delays the start of the CBFP function.

Input Signals	Description
>Start	The start input signal is linked with the tripping of the external protection device (*Figure 6-644*).
>Release	The release input signal is normally linked with the pickup of the external protection device (*Figure 6-644*). Another common configuration is the parallel wiring of the external trip initiation to both binary inputs (start and release).

Parameter: Supervision time f. release signal

- Default setting **(_:111) Sup.time f. release signal** = ***0.06 s***

The setting depends on the external function which generates the release signal. If the pickup or tripping of the external protection is used as release signal, the default setting can be kept. If it is ensured that the release signal is always present before the start signal, the time can be set to 0.

Parameter: Holding internal start signal

- Recommended setting value **(_:105) Holding int. start signal** = ***yes***

Parameter Value	Description
yes	In the case of an internal start, the start signal is hold. The dropout of the CBFP depends exclusively on the determination of the circuit-breaker position. This setting must be selected if it is not ensured that all 3 poles of the CB have opened when the pickup signal of the protection function has a falling edge. Siemens recommends using this method as the standard method.
no	Holding of the start signal can be disabled if it is ensured by the application that the CB has reliably opened when the start signal has a falling edge, or if the CBFP is explicitly required to drop out when the start signal has a falling edge.

EXAMPLE

Holding Internal Start Signal (Setting Value: yes)

In the event of a 2-pole fault, only one contact of the CB opens. The fault current is thus reduced, and the starting phase short-circuit protection drops out.

Parameter: Holding external start signal

- Recommended setting value **(_:106) Holding ext. start signal** = ***no***

Parameter Value	Description
no	The CBFP drops out when the external start signal has a falling edge. This setting prevents the CBFP from generating a tripping signal when an unwanted pulse is received at the binary input and the current flow is high enough. Siemens recommends using this method as the standard method.
yes	You can hold the start signal if it is not ensured that the circuit breaker is open when the external start signal has a falling edge.

EXAMPLE

Holding External Start Signal (Setting Value: Yes)

The function is started from the opposite end via an auxiliary device for command transmission. This device generates only a signal pulse.

NOTE

Siemens would like to point out that, with a hold signal, the CBFP generates a trip signal each time a starting pulse is received and the current flow is high enough. Remember this particularly in the case of an external start.

Parameters: Threshold phase current/Threshold sensitive

- Recommended setting value **(_:102) Threshold phase current** = ***approx. 0.50*** $I_{sc, min}$
- Recommended setting value **(_:101) Threshold sensitive** = ***approx. 0.50*** $I_{sc,min}$

In order to ensure that the disconnection of the fault is promptly detected and the function can drop out quickly, Siemens recommends setting both thresholds to half the minimum short-circuit current ($I_{sc, min}$).

If – depending on the neutral-point treatment and/or load conditions – ground faults lead to relatively low fault currents, a sensitive setting of the parameter **Threshold sensitive** must be selected according to the rule (0.5 $I_{sc, min}$). There can also be values which are noticeably below the rated or load current.

Input Signal: >Threshold sensitive

In order to ensure that the function picks up reliably in all switch positions of the power system (examples: opposite end of line open, switching onto a ground fault), the setting of the parameter **Threshold sensitive** can be applied dynamically to all currents - including phase currents – in the presence of ground faults. For this purpose, the binary signal **>Threshold sensitive** must be activated. This can be done via a device-internal function for ground-fault detection (if provided in the device), for example, using **Overvoltage protection with zero-sequence voltage**. In this case, the pickup of the V0> function must be linked with the binary signal. Alternatively, the signal can be coupled from a separate device for sensitive ground-fault detection via a binary input.

Parameter: Circuit-breaker auxiliary-contact criterion allowed for protection

- Recommended setting value **(_:103) CB aux.cont. crit. allowed** = ***no***

Parameter Value	Description
no	If sufficient current flow is ensured under all conditions with the CB closed, Siemens recommends not to permit the auxiliary contacts as a further criterion for determining the CB position, because measurement based on the current flow is the most reliable criterion.
w. 'CB pos. closed 3p.'	The auxiliary contacts are permitted as a further criterion in applications (see the following examples) where the current is no reliable criterion for determining the circuit-breaker position.

Parameter: 3I0 criterion

- Recommended setting value (_:120) **3I0 criterion** = ***Plausibility check***

Parameter Value	Description
Plausibility check	The ground current is only used to check the plausibility of the phase currents. The value set under the parameter **Threshold sensitive** is used as the threshold for the ground current.
Direct release	The current-flow criterion can be fulfilled only by the ground current without the phase currents exceeding their set threshold value. The value set under the parameter **Threshold 3I0 dir. release** is used in this case as the threshold for the ground current.

If you have set the **Threshold phase current** to be larger than the maximum load current, overfunction because of a false start is impossible. To ensure **Circuit-breaker failure protection** for smaller ground faults even with this setting, you can select **3I0 criterion** to be ***Direct release*** and **Threshold 3I0 dir. release** to be appropriately smaller than **Threshold phase current**.

Parameter: I2 criterion

- Recommended setting value (_:121) **I2 criterion** = ***Plausibility check***

Parameter Value	Description
Plausibility check	The negative-sequence current is only used to check the plausibility of the phase currents. The value set under the parameter **Threshold sensitive** is used as the threshold for the negative-sequence current.
Direct release	If a phase current exceeds 1/3 of the **Threshold I2 dir. release**, the current-flow criterion can be fulfilled only by the negative-sequence current without the phase currents exceeding their set threshold value. The threshold for the negative-sequence current uses the value set in the **Threshold I2 dir. release** parameter in this case.

If you have set the **Threshold phase current** to be larger than the maximum load current, overfunction because of a false start is impossible. To have Circuit-breaker failure protection function for smaller unbalanced faults even with this setting, you can select **I2 criterion** to be ***Direct release*** and **Threshold 3I0 dir. release** to be appropriately smaller than **Threshold phase current**.

Parameter: Threshold 3I0 dir. release

Recommended setting value **(_:122) Threshold 3I0 dir. release** = ***approx. 0.5 Isc***$_{min}$

This parameter is effective only if the **3I0 criterion**parameter is set to ***Direct release***. Siemens recommends setting the threshold to half the minimum short-circuit current (Isc_{min}) to ensure that the disconnection of the fault is promptly detected and the function can drop out quickly.

Parameter: Threshold I2 dir. release

Recommended setting value **(_:123) Threshold I2 dir. release** = ***approx. 0.5 $I2_{min}$***

This parameter is effective only if the **I2 criterion**parameter is set to ***Direct release***. Siemens recommends setting the parameter to half the permissible negative-sequence current ($I2_{min}$) to achieve a fast fault clearing in the event of an undesired negative-sequence system component.

Parameters: Monit. time for BI ">Start"/Monit.tm. f.BI ">Release"

- Default setting **(_:124) Monit. time for BI ">Start"** = ***15 s***
- Default setting **(_:125) Monit.tm. f.BI ">Release"** = ***15 s***

With these parameters, you set the monitoring time of the binary inputs **>Start**/**>Release**. If the **Circuit-breaker failure protection** does not pick up during this monitoring time, a failure in the binary-input circuit is assumed. Siemens recommends retaining the default setting of 15 s.

EXAMPLES

Applications which Require you to Permit the Circuit-Breaker Auxiliary-Contact Criterion:

- Tripping of the high and low-voltage side CB on the transformer. If only one of the 2 CBs trips, there is no more current flow.
- Tripping of protection functions whose tripping decision is not based on a current measurement in combination with voltage or frequency protection functions
- Injection of the tripping signal from Buchholz protection

Parameter: Dropout

- Recommended setting value **(_:104) Dropout** = ***with effective criterion***

The parameter **Dropout** is available if the circuit-breaker auxiliary contact criterion is permitted (see parameter **CB aux.cont. crit. allowed**).

Parameter Value	Description
with effective criterion	Siemens recommends keeping the default setting, because it prefers the current as a reliable criterion for detection of an open CB and thus for dropout of the CBFP function.
w. aux.c. and curr.crit.	Select this setting for applications on transformers or generators (see the preceding examples) in which the current flow is such that the current is no longer a reliable criterion for detecting the opening of the CB.

Parameter: Retrip

- Default setting **(_:108) Retrip after T1** = ***no***

Parameter Value	Description
no	Where no redundant CB control is provided, a repetition of the trip signal to the local CB is not required.
start T2 after T1	Where a redundant CB control (2nd trip coil with 2 trip circuits) is provided, a repetition of the trip signal to the local CB makes sense. Siemens recommends the setting ***start T2 after T1*** because it provides a clear chronological separation of the processes for trip repeat and backup tripping. Remember here that the overall fault-clearance time in case of a failure of the local CB is the sum of T1 and T2.
parallel start T2, T1	As an alternative to the setting ***start T2 after T1***, the user can start T2 and T1 in parallel.

Parameter: Delay T1 for 3-pole retrip

- Default setting **(_:109) Delay T1 for 3-pole retrip** = ***0.05 s***

The parameter is visible only when retripping is set.

The setting depends on the user's philosophy.

The following settings make sense:

- If the minimum fault-clearing time has top priority, Siemens recommends setting the time to 0. This setting causes initiation of the retrip immediately upon the start. The drawback is that a defect of the 1st trip circuit is not detected.
- With a small time delay of, for instance, 50 ms, the defect of the 1st trip circuit can be detected based on the evaluation of the fault record.
- With a long time delay, which reliably ensures the dropout of the CBFP with the CB open, the rising edge indication of the trip repeat **Retrip T1** is a sure signal for a fault in the 1st trip circuit. The following example shows how this time is determined.

EXAMPLE

Determining the T1 Time that Reliably Ensures the Dropout of the CBFP with the CB Open:

Time of binary device output (when tripping is caused by device-internal protection)	5 ms
CB inherent time up to current interruption	2 periods (assumed rated frequency = 50 Hz)
Dropout time of CBFP function	1 period
Subtotal	65 ms
Security	Factor 2
Total (time T1)	130 ms

Parameter: Delay T2 for 3-pole trip

- Default setting **(_:110) Delay T2 for 3-pole trip** = ***0.13 s***

This setting has to ensure that after opening of the local CB the function drops out reliably and that backup tripping is avoided under all circumstances. The setting depends on the parameter **Retrip after T1**.

If T2 is started after T1, there is no need to consider the time T1 for the setting of T2.

EXAMPLE

Determining the T2 Time that Reliably Ensures the Dropout of the CBFP with the CB Open:

Time of binary device output (when tripping is caused by device-internal protection)	5 ms
CB inherent time up to current interruption	2 periods (assumed rated frequency = 50 Hz)
Dropout time of CBFP function	1 period
Subtotal	65 ms
Security	Factor 2
Total (time T2)	130 ms

If T1 and T2 are started in parallel, take into account the time T1 for the setting of T2.

EXAMPLE

Simultaneous Start of T2 and T1

Time for a reliable dropout after the local CB has opened	130 ms
Setting of T1	50 ms
Total (= T2)	180 ms

Parameter: Minimum operate time

- Default setting **(_:112) Minimum operate time** = **-**

The **Minimum operate time** parameter is used to set the minimum duration for tripping the function.



CAUTION

Too short setting times for the minimum tripping duration

If you set a time that is too short for tripping, there is a risk (dropout of the function without the current-flow criterion) that the device contacts will interrupt the control loop. If this happens, the device contacts will burn out.

✧ Set a minimum time period that is long enough to ensure that the circuit breaker reliably reaches the end position **Open** after a control operation.

Input Signal: >CB defect

The input signal **>CB defect** has a default filtering time of 20 ms. This filtering time prevents the input signal from becoming effective in the case of a transient activation of the physical binary input, which can be caused by the pressure change when the CB opens.

This time can be set to 0 if such a transient pickup of the physical binary input can be excluded due to the CB design.

Output Signal: Retrip T1

If only 1 control circuit is available for the local circuit breaker, the output signal does not necessarily have to be routed because the signal also controls the circuit-breaker trip logic.

If a 2nd control circuit is present, the **Retrip T1** output signal must be routed to the associated binary output.

Output Signal: Trip T2

For operational handling of the adjacent circuit breakers, the backup tripping (indication **Trip T2**) must be routed to a binary output; and if necessary, to an interface (intertripping to opposite end).

Parameter: CBFP interact. with dBBP

- Default setting (_:153) **CBFP interact. with dBBP** = ***No***

  If you use a merging unit as the bay unit of the distributed busbar protection, the **CBFP interact. with dBBP** parameter becomes visible after the successful central-unit update in the merging unit.

Parameter Value	Description
no	With this parameter, you specify that this function operates independently from the distributed busbar protection.
yes	With this parameter, the function will work with the distributed busbar protection.

Parameter: `Immediate dropout`

- Recommended setting (_:154) **`Immediate dropout`** = ☑

Parameter Value	Description
☑	The criteria are checked continuously and the circuit-breaker failure protection drops out immediately once the criteria have no longer been met. Siemens recommends keeping this setting.
☐	This setting is used to take alternating load cases into account in the event of a fault, for example when using a breaker-and-a-half layout. The time delays and function pickup are actuated separately using a starter. The criteria for determining a closed circuit breaker are only checked once the time delays have expired. Select the monitoring times for the binary inputs *>Start* and *>Release* in such a way that supervision for these inputs does not respond prior to achieving the current or circuit-breaker auxiliary-contact criterion.

Parameter: `BI start external latch`

- Default setting (_:155) **`BI start external latch`** = ☑

Parameter Value	Description
☑	In the case of buffered sources (for example lock-out mechanism after tripping) the start binary signal is latched externally after the protection trip. This means that the binary-input supervision remains inactive until the binary-input source has been reset. Supervision is only activated after this has taken place.
☐	In the case of sources that are not buffered for an external start, the expectation is that they will drop out once the circuit-breaker failure protection has picked up. If this is not the case, the binary input may fail. This is why this setting results in binary-input supervision being reactivated once the Circuit-breaker failure protection function drops out.

6.62.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
50BF Ad.CBF #				
_:1	50BF Ad.CBF #:Mode		• off • on • test	on
_:105	50BF Ad.CBF #:Holding int. start signal		• no • yes	yes
_:107	50BF Ad.CBF #:Start via binary input		• no • 2 channel • 1 channel	no
_:106	50BF Ad.CBF #:Holding ext. start signal		• no • yes	no
_:111	50BF Ad.CBF #:Sup.time f. release signal		0.00 s to 1.00 s	0.06 s
_:103	50BF Ad.CBF #:CB aux.cont. crit. allowed		• no • w. 'CB pos. closed 3p.'	no

Addr.	Parameter	C	Setting Options	Default Setting
_:104	50BF Ad.CBF #:Dropout		• with effective criterion • w. aux.c. and curr.crit.	with effective criterion
_:108	50BF Ad.CBF #:Retrip after T1		• no • start T2 after T1 • parallel start T2, T1	no
_:102	50BF Ad.CBF #:Threshold phase current	1 A @ 100 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	2.500 A
_:101	50BF Ad.CBF #:Threshold sensitive	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A
_:109	50BF Ad.CBF #:Delay T1 for 3-pole retrip		0.000 s to 60.000 s	0.050 s
_:110	50BF Ad.CBF #:Delay T2 for 3-pole trip		0.050 s to 60.000 s	0.130 s
_:112	50BF Ad.CBF #:Minimum operate time		0.00 s to 60.00 s	0.10 s
_:120	50BF Ad.CBF #:3I0 criterion		• Direct release • Plausibility check	Plausibility check
_:121	50BF Ad.CBF #:I2 criterion		• Direct release • Plausibility check	Plausibility check
_:122	50BF Ad.CBF #:Threshold 3I0 dir. release	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A
_:123	50BF Ad.CBF #:Threshold I2 dir. release	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A
_:124	50BF Ad.CBF #:Monit. time for BI ">Start"		0.05 s to 60.00 s	15.00 s
_:125	50BF Ad.CBF #:Monit.tm. f.BI ">Release"		0.05 s to 60.00 s	15.00 s
_:154	50BF Ad.CBF #:Immediate dropout		• 0 • 1	true
_:155	50BF Ad.CBF #:BI start external latch		• 0 • 1	true

Table 6-23 Starting with V8.40, the Merging Units Have the Following Enhancement that is Especially Intended for Use with the Distributed Busbar Protection and Evaluated there:

Addr.	Parameter	C	Setting Options	Default Setting
50BF Ad.CBF #				
_:153	50BF Ad.CBF #:CBFP interact. with dBBP		• no • yes	no

6.62.6 Information List

No.	Information	Data Class (Type)	Type
50BF Ad.CBF #			
_:501	50BF Ad.CBF #:>Start	SPS	I
_:502	50BF Ad.CBF #:>Release	SPS	I
_:82	50BF Ad.CBF #:>Block function	SPS	I
_:503	50BF Ad.CBF #:>CB defect	SPS	I
_:500	50BF Ad.CBF #:>Threshold sensitive	SPS	I
_:54	50BF Ad.CBF #:Inactive	SPS	O
_:52	50BF Ad.CBF #:Behavior	ENS	O
_:53	50BF Ad.CBF #:Health	ENS	O
_:55	50BF Ad.CBF #:Pickup	ACD	O
_:305	50BF Ad.CBF #:Retrip T1	ACT	O
_:306	50BF Ad.CBF #:Trip T2	ACT	O
_:302	50BF Ad.CBF #:BI start routing miss.	SPS	O
_:304	50BF Ad.CBF #:BI aux.ct. rout. miss.	SPS	O
_:300	50BF Ad.CBF #:Fail. BI 'start'	SPS	O
_:307	50BF Ad.CBF #:Fail. no BI release	SPS	O
_:301	50BF Ad.CBF #:Fail. BI 'release'	SPS	O
_:315	50BF Ad.CBF #:Immediate Operate	SPS	O
_:316	50BF Ad.CBF #:CB failure pole	ACD	O

6.63 Circuit-Breaker Restrike Protection

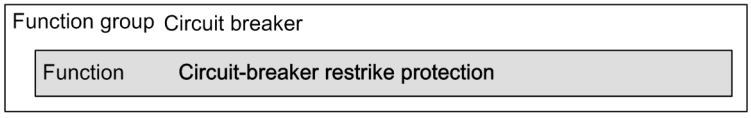
6.63.1 Overview of Function

The **Circuit-breaker restrike protection** function:

- Monitors the circuit breaker against restriking, for example, caused by an overvoltage over the circuit-breaker poles after switching off a capacitor bank
- Generates a backup operate signal in case of a circuit-breaker restriking

6.63.2 Structure of the Function

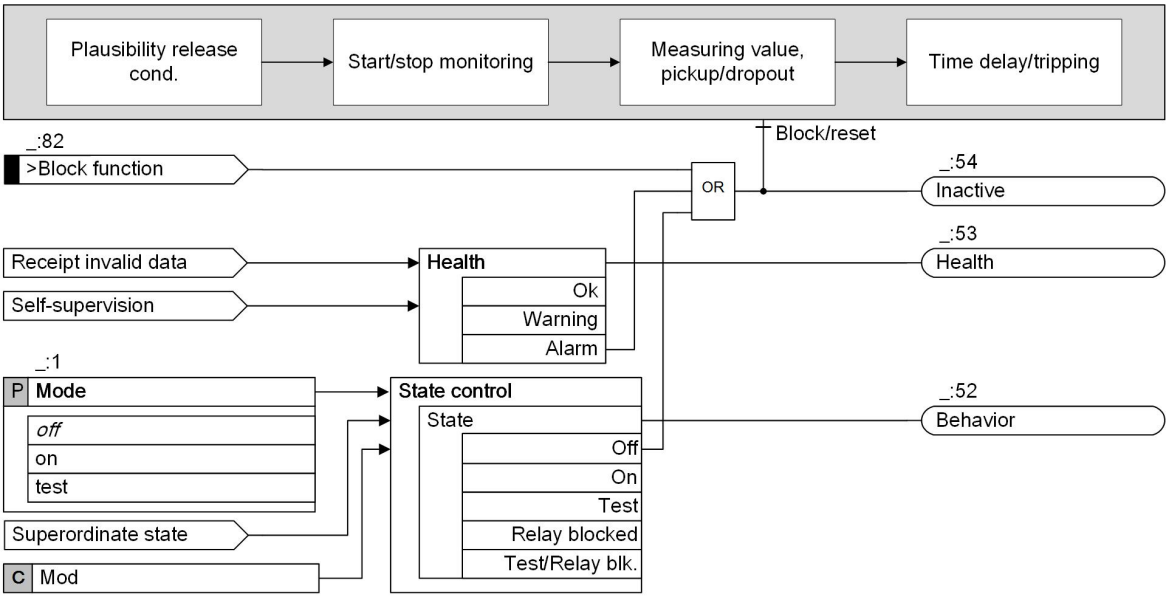
The **Circuit-breaker restrike protection** function is used in the **Circuit-breaker** function group. A maximum of 2 functions can operate simultaneously within the function group.



[lo_strrestrike, 2, en_US]

Figure 6-645 Structure/Embedding of the Function

The function logic is grouped into the parts shown in *Figure 6-646*. In the following chapter, these logic parts are described in detail.



[lo_respro, 2, en_US]

Figure 6-646 Logic Overview of the Function

6.63.3 Function Description

Plausibility Release

The function **Circuit-breaker restrike protection** issues a trip command to a superordinated circuit breaker, usually the infeed circuit breaker of a busbar. Overfunction of this protection can cause extreme problems for the whole application.

The logic of plausibility release strongly reduces the risk of a false start of the function by adding an extra release criteria for a function start.

Each criterion can be switched on or off individually.

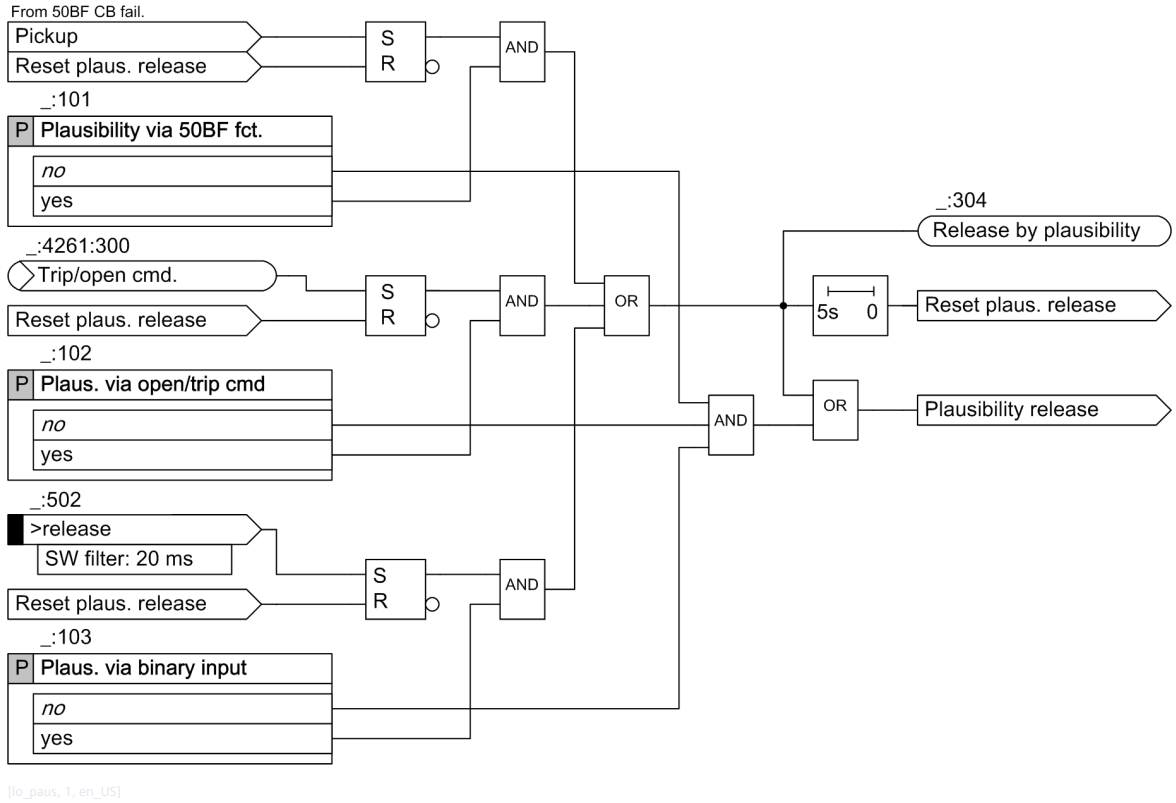


Figure 6-647 Logic Diagram for the Plausibility Release of the Circuit-Breaker Restrike Protection

The plausibility-release logic checks the following conditions:

- When the parameter **`Plausibility via 50BF fct.`** is set to ***yes***, the pickup signal of the **Circuit-breaker failure protection** is monitored. The plausibility release is given if the **Circuit-breaker failure protection** has picked up.
- When the parameter **`Plaus. via open/trip cmd`** is set to ***yes***, the trip/open command is monitored. The plausibility release is given if the trip/open command has been generated.
- When the parameter **`Plaus. via binary input`** is set to ***yes***, the *>release* signal is monitored. The plausibility release is given if the *>release* signal has been received.

If one of the conditions is fulfilled, the plausibility release is given for 5 s. The 5-s timer ensures that the release criterion and start condition relate to the same circuit-breaker opening/tripping process.

If all the 3 plausibility settings are set to ***no***, the start/stop-monitoring logic considers the release as fulfilled.

For safety reasons, the input signal *>release* has a preset software filtering time of 20 ms.

Start/Stop Monitoring

Via the start/stop monitoring logic, the monitoring duration of the current signal regarding restriking is determined.

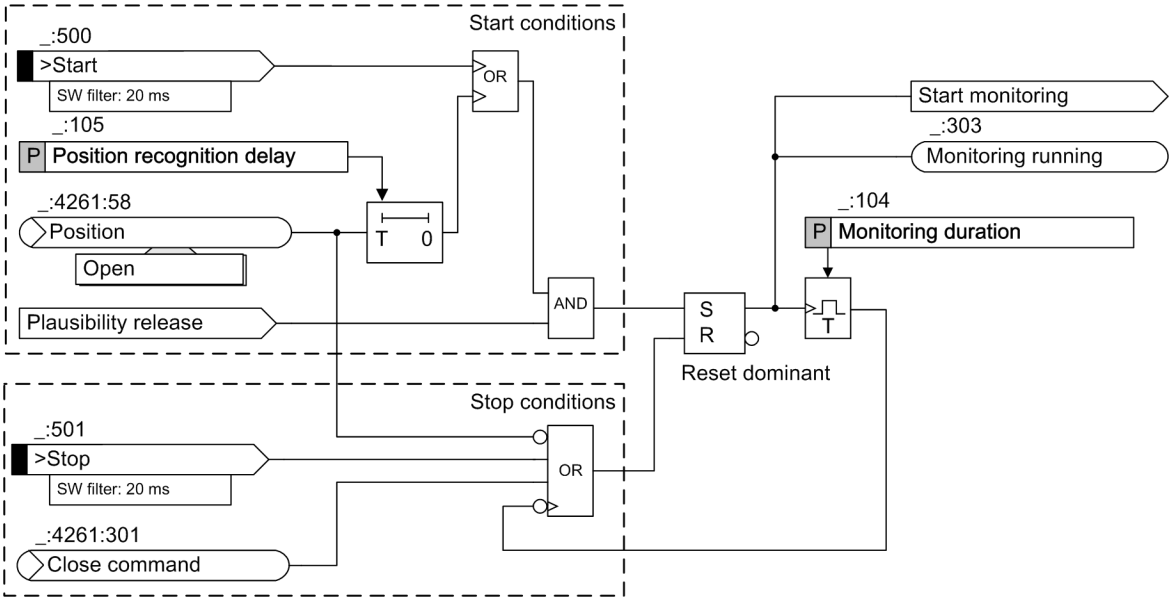


Figure 6-648 Logic Diagram for Start/Stop Monitoring of the Circuit-Breaker Restrike Protection

The monitoring is started if one of the following conditions is met:

- The circuit-breaker position is detected as **open** via the circuit-breaker auxiliary contacts during the time set with the parameter **`Position recognition delay`**.

  The **`Position recognition delay`** time is used for safety means to ensure that the circuit breaker is definitely open when the monitoring starts. This parameter allows to adapt this start criterion to all kinds of auxiliary-contact configurations.

- The binary input signal *`>Start`* is activated.

For safety reasons, the input signal has a preset software filtering time of 20 ms.

In addition to the active start criterion, the plausibility release (refer to the *Plausibility Release, Page 1708*) must be present to start the monitoring duration.

With the fulfilled start condition, the **`Monitoring duration`** timer is started. This timer defines how long the current signal is monitored regarding restriking. If the time expires, the monitoring is terminated.

The monitoring is also terminated immediately if one of the following conditions is met:

- The circuit-breaker position is detected no longer as **open**.
- A close command is given by the device.
- The binary input signal *`>Stop`* is activated.

  For safety reasons, the input signal has a preset software filtering time of 20 ms.

Measuring Value, Pickup/Dropout

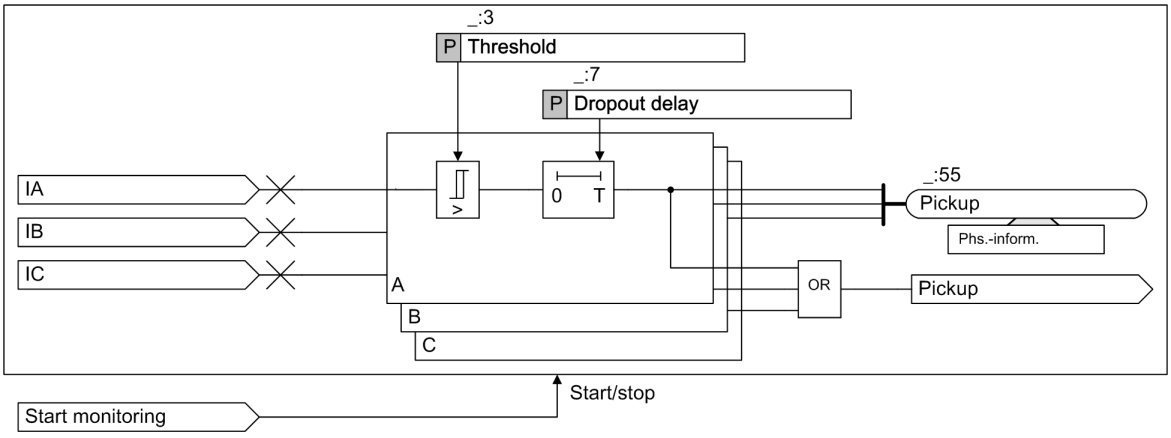
During the **`Monitoring duration`**, the current signal is monitored phase-selectively regarding restriking.

As a measuring value, the fundamental component of the current is used.

- On one hand, current peaks are damped but still detected reliably by the fundamental-component value.
- On the other hand, a DC (Direct Current) component is suppressed. A DC component can occur after switching off the circuit breaker.

Thus, the fundamental-component value is a good choice for a reliable restrike detection.

If any phase current exceeds the set current threshold value, the function picks up. The coming pickup indicates the first restrike current pulse. With the pickup, the operate delay timers are started, see also the following description *Delay/Tripping, Page 1711*.



[lo_pickdrop, 1, en_US]

Figure 6-649 Logic Diagram for Measuring Value, Pickup/Dropout of the Circuit-Breaker Restrike Protection

If restriking occurs, the current signal drops below the current threshold if the time between restrike pulses is long enough. In this case, the operate delay must not be reset. During the dropout delay, the pickup is extended to ensure that the operate delay timers are not reset. However, if the dropout delay time expires (no new current peak occurred), the function drops out and the operate delay timers are reset.

Delay/Tripping

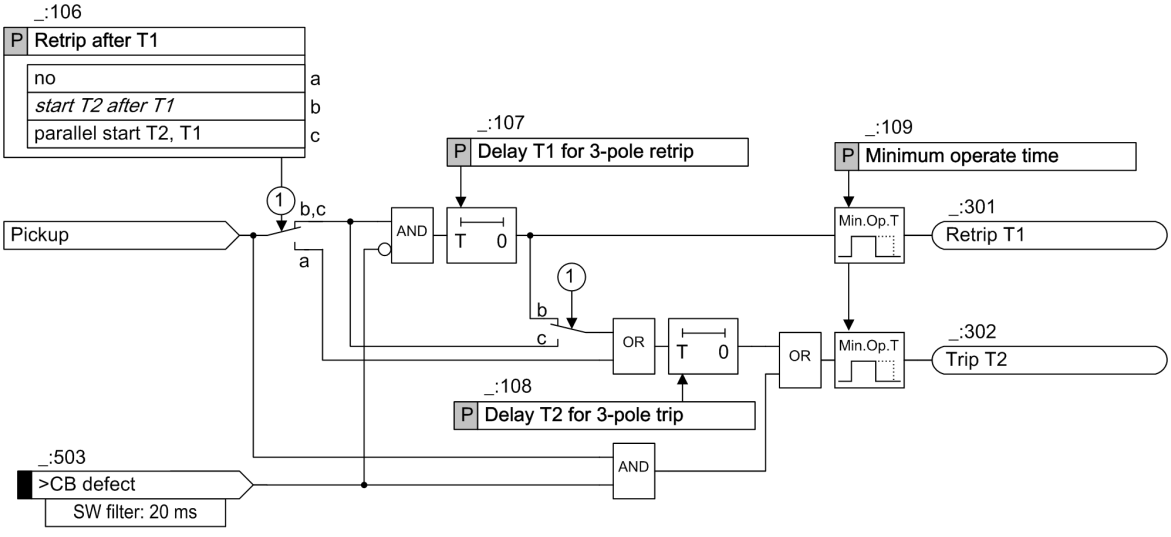
In the first step, tripping of the local circuit breaker can be repeated. Tripping is repeated after expiration of the settable delay T1. The retrip on the local circuit breaker is as a safety mechanism as well. In the event of a wrong start and pickup, only the local circuit breaker is opened instead of the superordinated circuit breaker.

Time delay T2 (backup tripping) can start in parallel either with the start of time T1 or after expiration of time T1.

If time delay T2 expires, circuit-breaker restriking takes place and the backup-tripping signal *Trip T2* is generated.

If the *>CB defect* input signal is valid, any repetition of the trip signal is suppressed and the backup-tripping signal *Trip T2* is generated immediately (without delay). For safety reasons, a default software filter time of 20 ms is preset (configurable in DIGSI) for the binary input signal *>CB defect*.

The **Minimum operate time** parameter defines the minimum duration for the trip command of the function. In contrast to other protection functions, the parameter is set within its own function. As a result, the setting is independent of the identically named comprehensive parameter that is set in the **Device settings**.



[lo_del_trip, 2, en_US]

Figure 6-650 Logic Diagram for Delay/Tripping of the Circuit-Breaker Restrike Protection

6.63.4 Application and Setting Notes

Parameter: Switch On or Off Additional Plausibility Release Criteria

- Default setting **(_:101) Plausibility via 50BF fct.** = ***no***
- Default setting **(_:102) Plaus. via open/trip cmd** = ***no***
- Default setting **(_:103) Plaus. via binary input** = ***no***

When using the plausibility release, the start condition and the release condition instead of only the start condition must be present to start the current monitoring regarding restriking. Since the current threshold value is set below the operating current, a false start would directly cause tripping. Thus, the plausibility release strongly reduces the risk that a falsely given start criterion leads to a wrong tripping of the superordinated circuit breaker.

3 different release criteria are available. You can use one or more than one or none of them. The selection depends on the application.

NOTE

When using release criteria, it must be ensured that the criteria are given under all the conditions where the **Circuit-breaker restrike protection** shall be started. If you choose no release criteria, the release is permanently given.

- **Open/trip command by the device**

Use this criterion in case that all control or trip commands are given by the protection device.

NOTE

Opening the circuit breaker manually without using the device will not release the start of the **Circuit-breaker restrike protection**.

- **Pickup of the Circuit-breaker failure protection**

Use this criterion if the **Circuit-breaker restrike protection** should only be started in case that the **Circuit-breaker failure protection** was started (picked up) before.

NOTE

Opening the circuit breaker by control or manually will not trigger the **Circuit-breaker failure protection**. Consequently the **Circuit-breaker restrike protection** cannot be released either.

- **Binary input signal**

Use this option if neither of the above 2 release criteria fit the application and you want to define your own release criterion.

Input signals: *>Start, >release, >Stop*

Input Signals	Description
>Start	This input signal allows to start the monitoring, for example, via protocol commands from a master (by use of a CFC chart) or by other specific conditions.
>release	This input signal allows to define specific release conditions by use of a CFC chart. Also refer to *Parameter: Switch On or Off Additional Plausibility Release Criteria , Page 1712*.
>Stop	This input signal allows to stop the monitoring, for example, via protocol commands from a master (by use of a CFC chart) or by other specific conditions.

The input signals *>Start* , *>release* , and *>Stop* have a filtering time of *20 ms* as default setting. If a transient spurious signal to the binary inputs is expected due to the design of the external binary-input control circuits and environmental conditions, the filtering time can be extended.

Parameter: Position recognition delay

- Default setting **(_:105) Position recognition delay** = *0.02 s*

With the parameter **Position recognition delay**, you define how long the circuit breaker must be detected as **open** (via the circuit-breaker auxiliary contacts) before the monitoring time is started. This definition is a safety feature to ensure that the monitoring is not started too early. For example, in case that due to a non-standard auxiliary-contacts configuration, the circuit-breaker is already detected as **open** while current flow is still present.

The setting depends on the circuit-breaker auxiliary-contacts configuration. If it can be ensured that the auxiliary contacts announce the circuit breaker as **open** after the current flow is interrupted, the time can be set to zero.

Parameter: Monitoring duration

- Default setting **(_:104) Monitoring duration** = *200.00 s*

With the parameter **Monitoring duration** , you define how long the current signal is monitored regarding restriking after the circuit breaker has been opened.

With ongoing discharging of the capacitor bank, the probability of restriking is decreasing. There is no need to set the monitoring time longer than the discharging time. Siemens recommends setting the monitoring time in the range of 0.5 * discharging time to 1 * discharging time.

Parameter: Threshold

- Default setting **(_:3) Threshold** = *0.250 A*

After opening of the circuit breaker, the phase currents are compared with the threshold value. If no restriking takes place, the current is zero. Consequently the threshold for detecting restriking can be set much smaller than the operating current. A typical value is 25 % of the operating current.

With a threshold below the operating current, a falsely-given start directly cause tripping. For minimizing this risk, Siemens recommends applying a release criterion additionally. Refer to *Parameter: Switch On or Off Additional Plausibility Release Criteria , Page 1712*.

Parameter: Dropout delay

- Default setting **(_:7) Dropout delay** = *0.05 s*

The parameter **Dropout delay** ensures that a short dropping below the current threshold does not cause the operate delay timers to be reset.

Since restriking is normally a periodical effect, the dropout delay can be set to a rather small time. Siemens recommends applying the default value of 50 ms.

Input signal: *>CB defect*

The input signal *>CB defect* has a preset filtering time of 20 ms. This filtering time prevents the input signal from becoming effective in the case of a transient activation of the physical binary input, which can be caused by the pressure change when the circuit breaker opens.

This time can be set to 0 if such a transient response of the physical binary input can be excluded due to the circuit-breaker design.

Parameter: Retrip after T1

- Default setting **(_:106) Retrip after T1** = *start T2 after T1*

Parameter Value	Description
start T2 after T1	The retrip on the local circuit breaker is a safety mechanism to avoid false tripping of the superordinated circuit breaker. With generating a retrip, only the local circuit breaker is tripped in the event of a false start. Afterwards the **Circuit-breaker restrike protection** function drops out during the T2 delay time. Siemens recommends applying a retrip on the local circuit breaker. Siemens also recommends applying the parameter value ***start T2 after T1***. The parameter value provides a clear chronological separation of the processes for trip repeat and backup tripping. Remember that the overall fault-clearance time in case of circuit-breaker restriking is the sum of T1 and T2.
no	No retrip is given
parallel start T2, T1	As an alternative to the setting ***parallel start T2, T1*** the customer can start T2 and T1 in parallel.

Parameter: **Delay T1 for 3-pole retrip**

- Default setting (_:109) **Delay T1 for 3-pole retrip** = ***0.00 s***

The parameter is visible only when the parameter **Retrip after T1** is set to ***start T2 after T1*** or ***parallel start T2, T1*** .

The retrip on the local circuit breaker is as a safety mechanism to avoid false tripping of the superordinated circuit breaker. In the event of a false start, only the local circuit breaker is tripped by the retrip. Afterwards the **Circuit-breaker restrike protection** function will drop out during the T2 delay time.

Siemens recommends applying a retrip on the local circuit breaker. Since the retrip is a safety mechanism, it can be given without a delay time. Siemens recommends setting the delay time to 0 s.

Parameter: **Delay T2 for 3-pole trip**

- Default setting (_:110) **Delay T2 for 3-pole trip** = ***0.15 s***

This parameter defines the duration of restriking after the backup tripping is sent. The following should be considered:

- When using the retrip functionality, this delay time must ensure a safe function dropout after giving the retrip on the local circuit breaker.

Siemens recommends applying a delay time of 150 ms which is the default setting.

Parameter: **Minimum operate time**

- Default setting **(_:109) Minimum operate time** = ***0.15 s***

The **Minimum operate time** parameter is used to set the minimum duration for the trip command of the function.



CAUTION

Do not set a time that is too short.

If you set a time that is too short, there is a danger (dropout of the function without the current-flow criterion) that the device contacts interrupt the control circuit. If this happens, the device contacts burn out.

✧ Set a duration that is long enough to ensure that the circuit breaker reliably reaches its final position (**open**) after a control operation.

Output signal: *Retrip T1*

The output signal *Retrip T1* must be routed to a binary output.

If only one control circuit is available for the local circuit breaker, the output signal must be routed to the binary output to which the general circuit breaker trip command (command *Position*) is routed.

If a second control circuit is present, the *Retrip T1* output signal can be routed to the associated binary output.

Output signal: *Trip T2*

In order to trip the adjacent circuit breakers, the backup tripping (indication *Trip T2*) must be routed to a binary output and if necessary, to an interface (intertripping to the opposite end). Thus, the circuit breaker on the opposite end can be tripped without delay.

6.63.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Restrike prt.#				
_:1	Restrike prt.#:Mode		• off • on • test	off
_:101	Restrike prt.#:Plausibility via 50BF fct.		• no • yes	no
_:102	Restrike prt.#:Plaus. via open/trip cmd		• no • yes	no
_:103	Restrike prt.#:Plaus. via binary input		• no • yes	no
_:106	Restrike prt.#:Retrip after T1		• no • start T2 after T1 • parallel start T2, T1	start T2 after T1
_:104	Restrike prt.#:Monitoring duration		1.00 s to 600.00 s	200.00 s
_:105	Restrike prt.#:Position recognition delay		0.00 s to 60.00 s	0.02 s
_:3	Restrike prt.#:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A
_:7	Restrike prt.#:Dropout delay		0.00 s to 60.00 s	0.05 s
_:107	Restrike prt.#:Delay T1 for 3-pole retrip		0.00 s to 60.00 s	0.00 s
_:108	Restrike prt.#:Delay T2 for 3-pole trip		0.05 s to 60.00 s	0.15 s
_:109	Restrike prt.#:Minimum operate time		0.00 s to 60.00 s	0.15 s

6.63.6 Information List

No.	Information	Data Class (Type)	Type
Restrike prt.#			
_:500	Restrike prt.#:>Start	SPS	I
_:501	Restrike prt.#:>Stop	SPS	I
_:502	Restrike prt.#:>release	SPS	I
_:82	Restrike prt.#:>Block function	SPS	I
_:503	Restrike prt.#:>CB defect	SPS	I
_:54	Restrike prt.#:Inactive	SPS	O
_:52	Restrike prt.#:Behavior	ENS	O
_:53	Restrike prt.#:Health	ENS	O
_:304	Restrike prt.#:Release by plausibility	SPS	O
_:303	Restrike prt.#:Monitoring running	SPS	O
_:55	Restrike prt.#:Pickup	ACD	O
_:301	Restrike prt.#:Retrip T1	ACT	O
_:302	Restrike prt.#:Trip T2	ACT	O

6.64 Pole Discrepancy Protection

6.64.1 Overview of Functions

Due to the high probability of 1-phase short circuits in power systems, 1-pole tripping and automatic reclosing is used mainly in transmission to ensure the reliable and stable operation of the system. However, this brings about new problems, that is, open-phase operation adds certain risks to the power system.

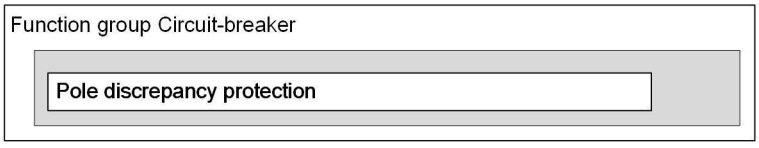
Therefore, a function that can reflect open-phase operation conditions of CBs must be installed to open those CBs in abnormal status. Siemens develops the function block **Pole discrepancy protection** for this purpose.

The function block **Pole discrepancy protection** has the task to detect discrepancies in the position of the 3 circuit-breaker poles. Under steady-state operating conditions, either all 3 poles of the circuit breaker must be closed, or all 3 poles must be open. Discrepancy is permitted only for a short time interval during a 1-pole automatic reclose cycle.

6.64.2 Structure of the Function

In DIGSI 5, you can find the function block **Pole discrepancy protection** under the directory **Global DIGSI 5 libraries** > **FG Circuit breaker**.

You can instantiate 1 function block **Pole discrepancy protection** in the function group .



[dw_structure_PD, 1, en_US]

Figure 6-651 Structure/Embedding of the Function Block

6.64.3 Description

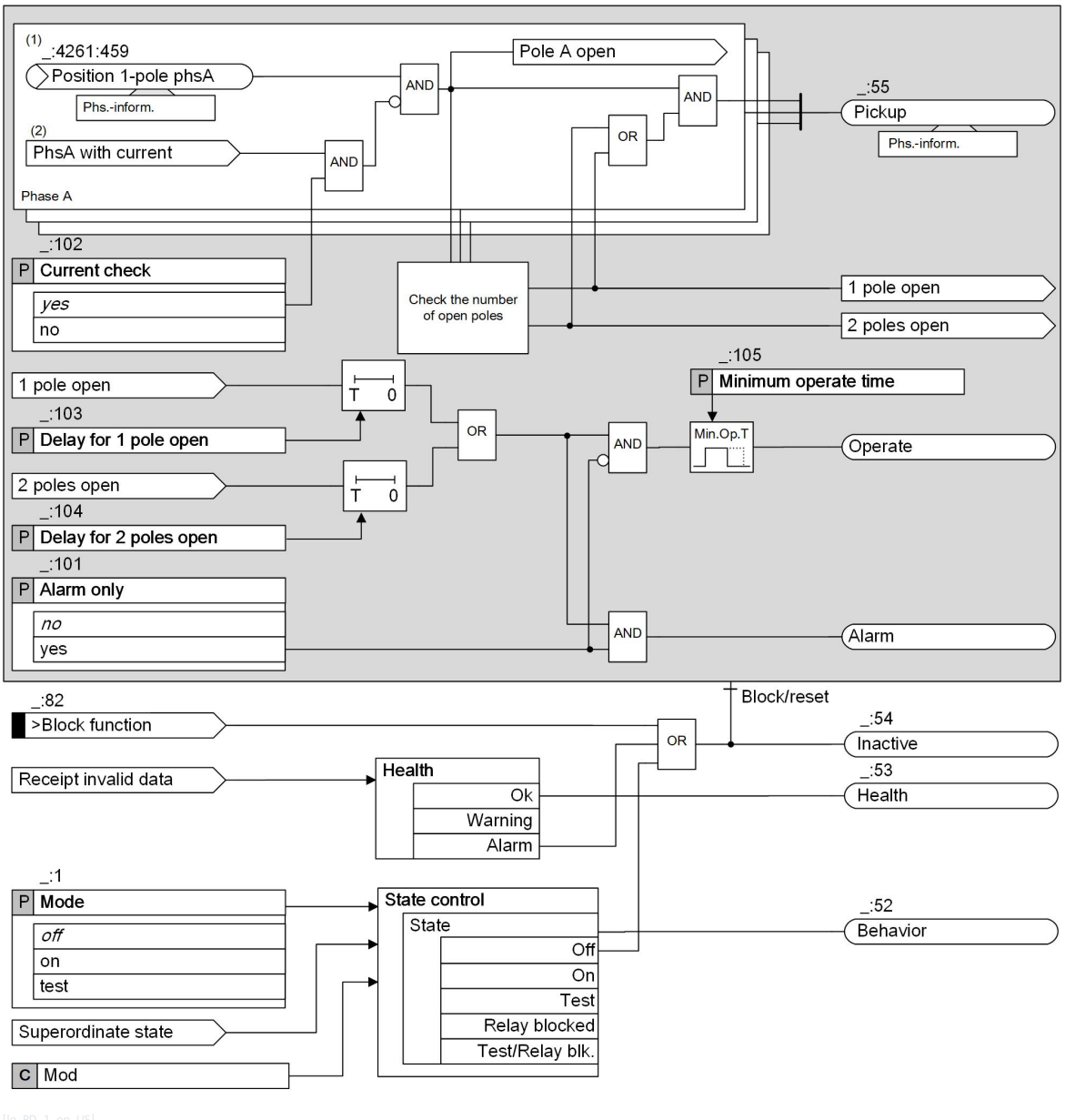
Routing 1-Pole Positions

With the following CB signals routed, the function block **Pole discrepancy protection** can obtain positions of the phase-selective CB auxiliary contacts:

- Position 1-pole phsA
- Position 1-pole phsB
- Position 1-pole phsC

If any of the signals is not routed, *Health* of the function block **Pole discrepancy protection** is set to ***Alarm***.

Logic



[lo_PD, 1, en_US]

Figure 6-652 Logic Diagram of the Function Block Pole Discrepancy Protection

(1) From FB Circuit breaker

(2) From FB CB position recognition

Positions of the CB Poles

There a 2 ways to get the positions of the poles:

- With current check
  The function block **Circuit-breaker position recognition** calculates the positions of the CB poles from the evaluation of the CB auxiliary contacts and the current flow.
  If you want to take the current flow into consideration in the function block **Pole discrepancy protection**, you can set the parameter **Current check** to ***yes***. Then, the function block **Pole discrepancy protection** reuses the results of the function block **Circuit-breaker position recognition**.
  For more information, refer to *5.9.8 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions*.
- Without current check
  If you set the parameter **Current check** to ***no***, then, the current flow is not considered and the function block **Pole discrepancy protection** gets the positions of the CB poles from the function block **Circuit breaker**.

Current-Flow Criterion

For each phase, the internal signal **PhaseX with current** comes from the function block **Circuit-breaker position recognition**. When the phase current exceeds the parameter **Current thresh. CB open**, the value of the corresponding signal **PhaseX with current** is ***true***.

Pickup

Whenever a pole discrepancy is detected, the function block **Pole discrepancy protection** issues the signal *Pickup*.

Tripping

If you want the function block **Pole discrepancy protection** to trip the circuit breaker, set the parameter **Alarm only** to ***no***. Then, when a 1-pole-open discrepancy or a 2-pole-open discrepancy is detected, the function block **Pole discrepancy protection** issues the signal *Operate*.
The signal *Operate* can block the function **Automatic reclosing**.

Fault Recording and Fault Logging

If you enable the function block **Pole discrepancy protection**, once the signal *Operate* is issued, the fault recording and fault logging are triggered.

Blocking of the Function Block

In the event of blocking, the function is reset. Blocking is possible externally or internally via the binary input signal *>Block function*.

6.64.4 Application and Setting Notes

Parameter: Alarm only

- Default setting **(_:101) Alarm only** = ***no***

With the parameter **Alarm only**, you can decide to trip the circuit breaker or not.
With the default value ***no***, after pickup, once the time delay expires, the signal *Operate* is issued.

Parameter: Current check

- Default setting **(_:102) Current check** = ***yes***

With the parameter **Current check**, you can decide to take the current flow into consideration or not. For more information, refer to *Positions of the CB Poles, Page 1719*.

Siemens recommends keeping the default setting to ensure precise positions.

Parameters: `Delay for 1 pole open`, `Delay for 2 poles open`

- Default setting **`(_:103) Delay for 1 pole open`** = ***`2.00 s`***
- Default setting **`(_:104) Delay for 2 poles open`** = ***`2.00 s`***

With these parameters, you can determine the minimum time delay for operating the function block **Pole discrepancy protection**.
If you enable the function **Automatic reclosing**, set these parameters larger than the parameter **`Dead time aft. 1-pole trip`**.

Parameter: `Minimum operate time`

- Default setting **`(_:105) Minimum operate time`** = ***`0.12 s`***

With the parameter **`Minimum operate time`**, you set the minimum duration for the trip command of the function block **Pole discrepancy protection**.

6.64.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Pole discrep.`				
_:1	Pole discrep.:Mode		• off • on • test	off
_:101	Pole discrep.:Alarm only		• no • yes	no
_:102	Pole discrep.:Current check		• no • yes	yes
_:103	Pole discrep.:Delay for 1 pole open		0.00 s to 60.00 s	2.00 s
_:104	Pole discrep.:Delay for 2 poles open		0.00 s to 60.00 s	2.00 s
_:105	Pole discrep.:Minimum operate time		0.00 s to 60.00 s	0.12 s

6.64.6 Information List

No.	Information	Data Class (Type)	Type
`Pole discrep.`			
_:82	Pole discrep.:>Block function	SPS	I
_:51	Pole discrep.:Mode (controllable)	ENC	C
_:54	Pole discrep.:Inactive	SPS	O
_:52	Pole discrep.:Behavior	ENS	O
_:53	Pole discrep.:Health	ENS	O
_:55	Pole discrep.:Pickup	ACD	O
_:300	Pole discrep.:Alarm	SPS	O
_:57	Pole discrep.:Operate	ACT	O

6.65 Out-of-Step Protection

6.65.1 Overview of Functions

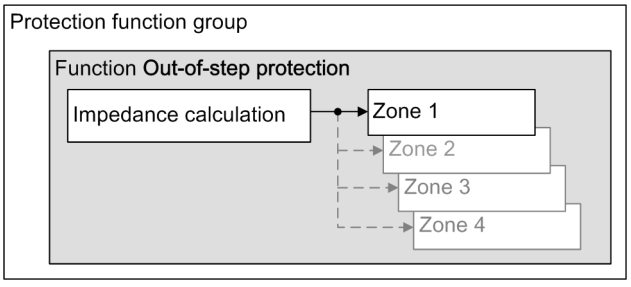
The **Out-of-step protection** function (ANSI 78)

- Detects an out-of-step condition (asynchronous operation) between machines connected and the power system and between power systems
- Protects generators from unacceptable electromechanical stresses
- Prevents damage and unacceptable aging of equipment
- Ensures the stability of the entire power system by disconnection
- Suitable for integration into more complex automatic operations for power system monitoring and disconnection
- Serves as a basic function for the protection of larger power plant units
- Used in the protection of power systems for selective disconnection in case of power swings

6.65.2 Structure of the Function

The **Out-of-step protection** function is preconfigured with one zone by the manufacturer. A maximum of 4 zones can be operated simultaneously in the function (see *Figure 6-653*). All zones are configured identically.

The **Out-of-step protection** function is contained in a function group with at least 3 voltage inputs and current inputs. The process monitor provides the function with status information regarding the protected object (open poles on the line in particular). The protected object can be a line or a power plant unit (generator with generator transformer).



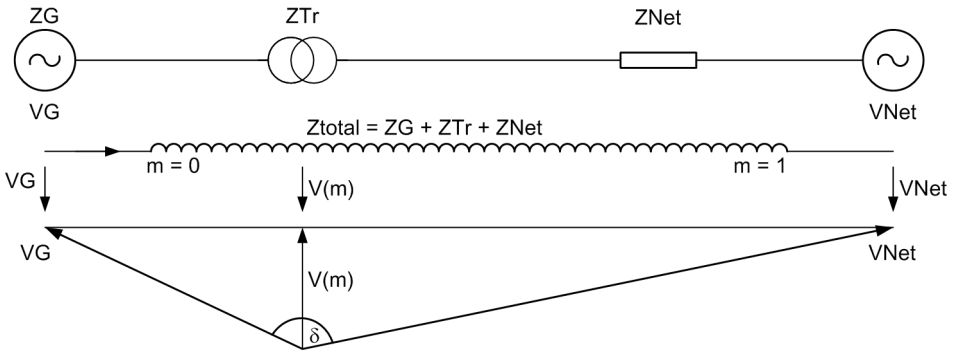
[dwoosstr-190912-01.tif, 1, en_US]

Figure 6-653 Structure of the Function

6.65.3 Description of a Zone

Measuring Principle of the Out-Of-Step Protection

Out-of-step protection is based on measuring the impedance and analyzing the history of the impedance phasor. The simplified 2-machines model shown in the following figure is used for that purpose. The left side of the figure shows the generator with a driving voltage V_G. The impedances - generator impedance Z_G, transformer impedance Z_{Tr}, and system impedance Z_N – are located between the 2 sources. The power system with a voltage V_{Net} can be found as a backup machine on the right side.



[dwmodlpe-230211-01.tif, 1, en_US]

Figure 6-654 The 2-Machines Model to Explain a Power Swing

Measuring point m divides the total impedance into 2 impedances m· Z_{total} and (1-m)· Z_{total}. The following details apply to the impedance at a measuring point m:

$$\underline{Z}(m) = \frac{\underline{V}(m)}{\underline{I}(m)}$$

[foimpdnz-170309-01.tif, 1, en_US]

Current I does not depend on the measuring point m:

$$\underline{I}(m) = \underline{I} = \frac{\underline{V}_G - \underline{V}_{Net}}{\underline{Z}_{total}}$$

[fostroms-170309-01.tif, 1, en_US]

Voltage V at the measuring point m is calculated for:

$$\underline{V}(m) = \underline{V}_G - (m \cdot \underline{Z}_{total} \cdot \underline{I})$$

[fospanng-170309-01.tif, 1, en_US]

In combination with

$$\underline{V}_G = V_G \cdot e^{j\delta_G} \qquad \underline{V}_{Net} = V_{Net} \cdot e^{j\delta_N} \qquad \delta = \delta_G - \delta_{Net}$$

[foumesor-170309-01.tif, 1, en_US]

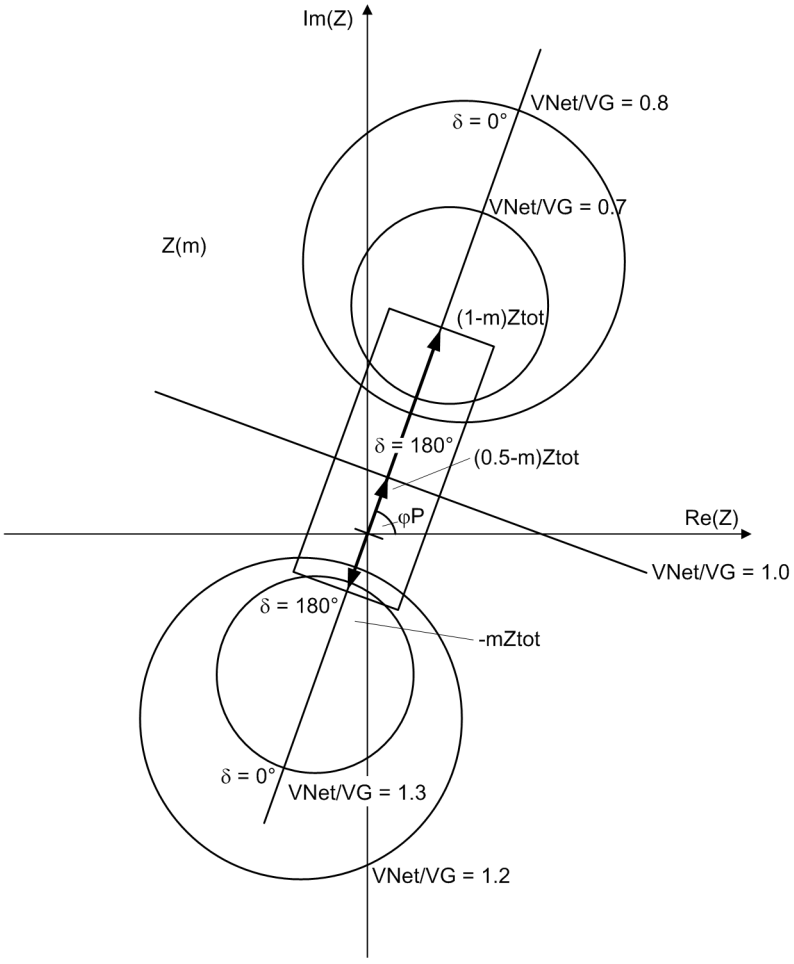
the data results in the formula:

$$\underline{Z}(m) = \left[\frac{1}{1 - \frac{V_{Net}}{V_G} \cdot e^{-j\delta}} - m \right] \cdot \underline{Z}_{total}$$

[fozmesrt-170309-01.tif, 1, en_US]

Angle δ is the angle between the generator voltage and the power system voltage. In normal operation, this angle depends on the load profile and is relatively constant. In contrast, in the event of an out-of-step condition, the angle changes continuously and passes through all values between 0° and 360°. *Figure 6-655* shows the impedance process at the measuring point m according to the equation mentioned above. The point of origin corresponds to the point where the protection device is built in (measuring point of the voltage-transformer substitute). Assuming a constant ratio between V_{Net}/V_G and a variable angle δ, the locus diagram is a set of circles. The center and the radius are specified through the ratio V_{Net}/V_G. All centers of the circles are located on one axis specified by the direction of Z_{total}. The maximum and minimum impedance values are the result for the 2 extreme values δ = 0° and δ = 180°. If the measuring point coincides directly

with the electrical center of the system, the measured voltage and thus the operating impedance result in 0 at an angle δ = 180°.



[dwzverla-230211-01.tif, 1, en_US]

Figure 6-655 Impedance Trajectories for Different Voltage Conditions

Impedance Method of Measurement

The fundamental components are determined from the phase-to-ground voltages and the phase currents and are the basis for calculating the phasors of the positive sequence system. The phasors of the positive-sequence system are the basis for calculating the impedance.

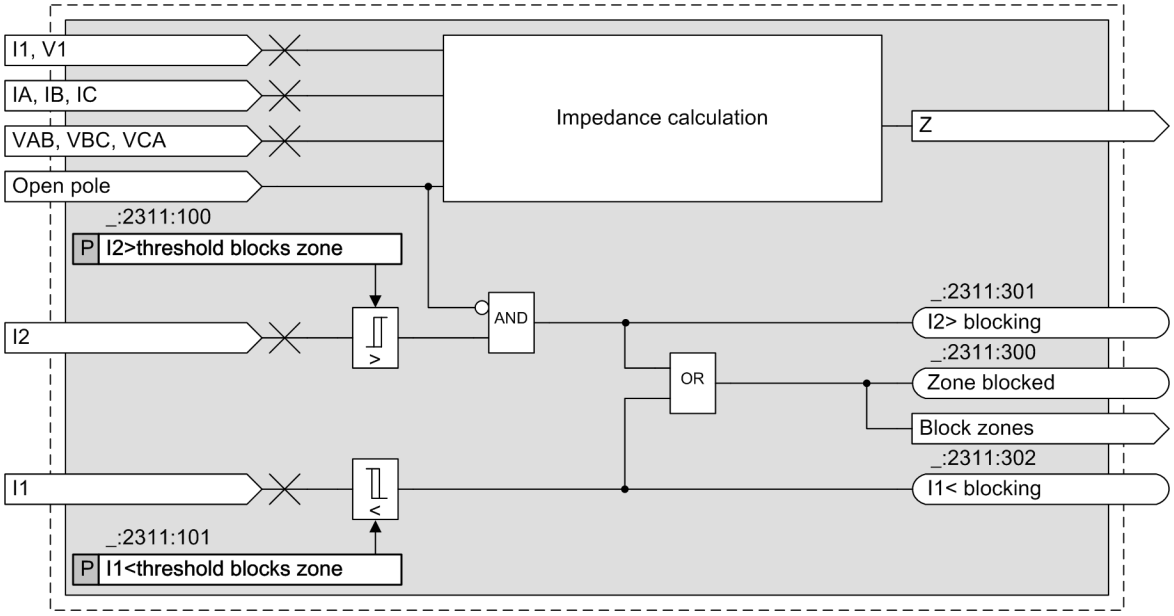
Special cases:

- If an unbalanced fault occurs during swinging, the zone (zones) is/are frozen.
- If an open circuit-breaker pole is detected, the loop resistance of a healthy loop is calculated temporarily.

Out-of-step detection works when the positive-sequence current flow is high enough. If the flow falls below the adjustable positive-sequence current threshold **`I1<threshold blocks zone`**, the zone (zones) is/are frozen.

Behavior in the Event of Unbalanced Faults

To avoid overfunctioning of the Out-of-step protection in the event of unbalanced faults (for example, short-circuits), the negative-sequence current is evaluated. If the negative-sequence current exceeds the pickup threshold **`I2>threshold blocks zone`**, the zones for the detection of an out-of-step condition are blocked. *Figure 6-656* shows the partial logic and the input variables for the impedance calculation.



[lo0imped-100611-01.tif, 2, en_US]

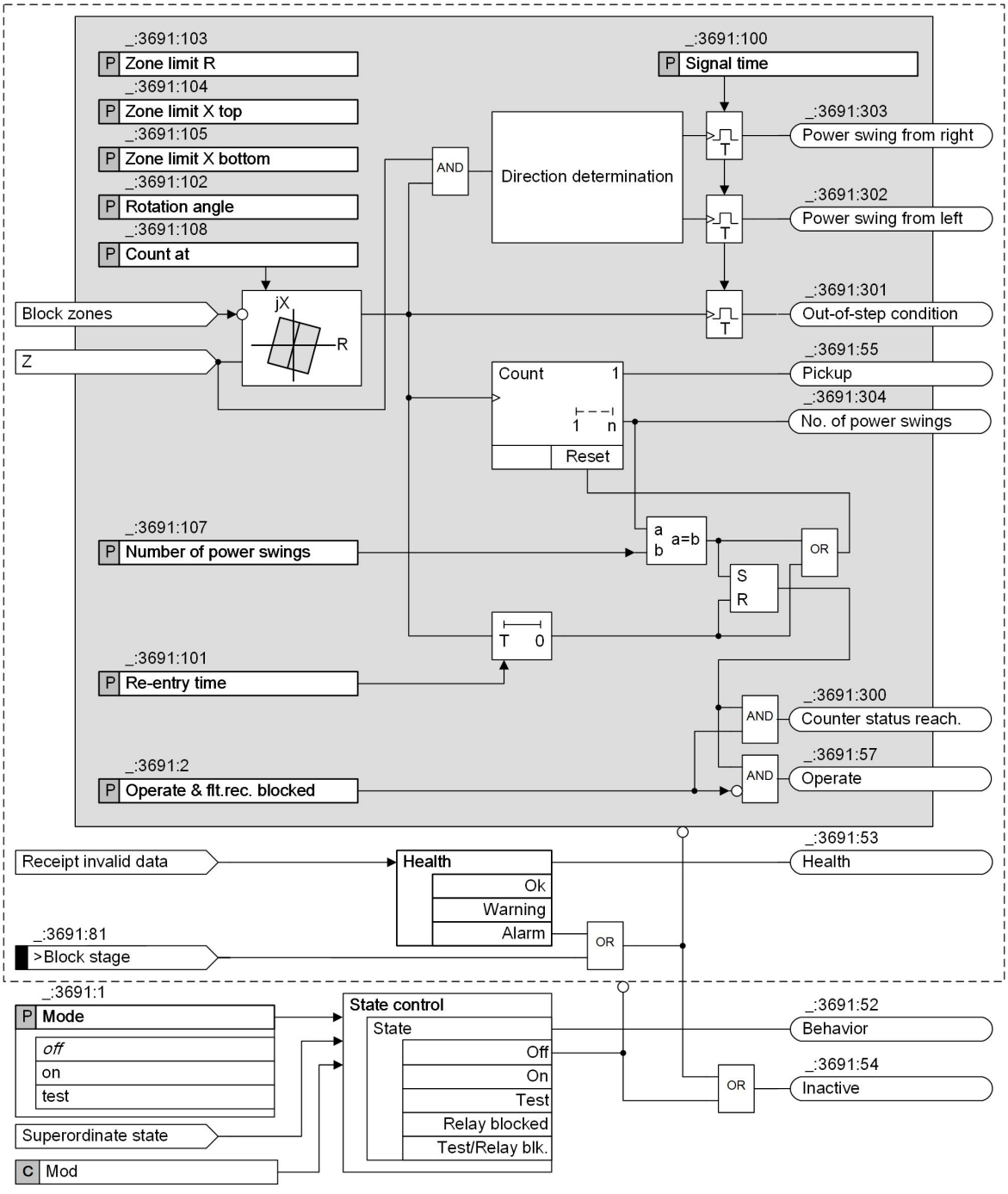
Figure 6-656 Impedance Measurement and Monitoring of the Positive and Negative Sequenced of the Currents

Identifying the Out-of-Step Condition/Central Logic

Figure 6-657 shows the central logic. Cycling of the positive-sequence impedance phasor through the set impedance zone is monitored and counted. The power swing counter is incremented depending on the setting of the parameter **(_:3691:108) Count at**. Each counter increment is signaled. The signal duration can be set via the **(_:3691:100) Signal time** parameter. The trip command is issued when the counter status (parameter **(_:3691:107) Number of power swings**) is reached after incrementing. Between each counter increment, the function checks whether another power swing occurs within a specified time (parameter **(_:3691:101) Re-entry time**). If this is not the case, the counter is reset. The central logic detects the direction of the power swing and issues an indication. In generator mode, for example, the impedance swings into the zone from the right.

NOTE

If the impedance phasor enters through the straight lines, which can be set using the parameters **Zone limit X top** or **Zone limit X bottom**, the power swing direction is not determined. Since the direction determination is coordinated with the setting parameter **Count at**, the above limitation applies only to the setting ***entry***, ***entry left*** and ***entry right***.

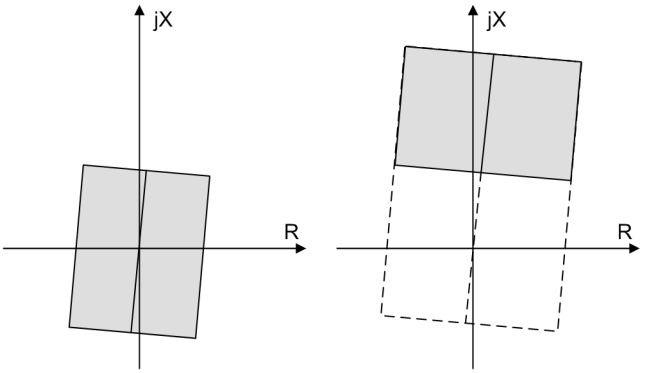


[lo_ost_zon, 2, en_US]

Figure 6-657 Logic Diagram of a Zone

Impedance Zone (Characteristic Curve)

An impedance phasor within the impedance zone is the essential criterion for the out-of-step condition. In order to implement different applications, resistance and reactance are freely settable. The resistance setting parameter **`Zone limit R`** works inversely to the imaginary axis. A lower and an upper setting value (**`Zone limit X bottom`** and **`Zone limit X top`**) can be selected for reactance. The zone can be shifted in any X direction. *Figure 6-658* shows 2 possible setting examples. To map the power system impedance (R, jX), the zone can also be rotated through an angle **`Rotation angle`**. If several zones are used in power system protection applications, they are typically interleaved.



[dwzonein-230211-01.tif, 1, en_US]

Figure 6-658 Zone Setting

Power-Swing Counter

Passing though the impedance zone is the criterion for incrementing the power swing counter. Use the setting parameter (**Count at**) to define when the counter is incremented. Depending on the application, there are different selection options available for this parameter. For machine protection applications, you only see 3 selection options without direction dependency.

entry	The counter is incremented upon entry into the zone.
entry left	The counter is incremented upon entry into the zone from the left.
entry right	The counter is incremented upon entry into the zone from the right.
axis	The counter is incremented upon crossing the middle ordinate of the zone.
axis from left	The counter is incremented upon crossing the middle ordinate of the zone from the left.
axis from right	The counter is incremented upon crossing the middle ordinate of the zone from the right.
exit	The counter is incremented upon exit of the zone.
exit left	The counter is incremented upon exiting the zone from the left.
exit right	The counter is incremented upon exiting the zone from the right.
	In all cases, the impedance phasor must first have crossed the entry line and the middle ordinate.

Figure 6-659 shows how counting is done for the different trajectories of the impedance phasor. 2 zones are shown as an example. Each zone has a counter of its own.

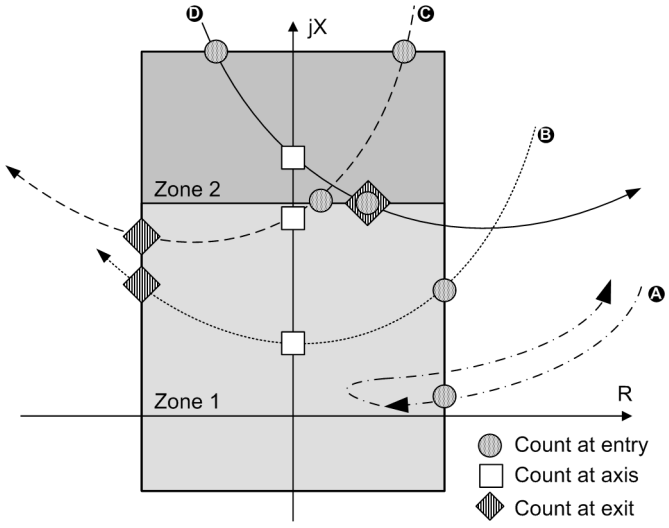
4 cases are shown:

Case A: The counter for zone 1 is incremented only if ***entry*** or ***entry right*** is set for zone 1.

Case B: The counter for zone 1 is incremented. The time at which the increment takes place depends on the settings (***entry***, ***entry right***, ***axis***, ***axis from right***, ***exit***, ***exit left***).

Case C: The counter for zone 2 is incremented only if ***entry*** or ***entry right*** is set for zone 2. The counter for zone 1 is incremented. The time at which the increment takes place depends on the settings (***entry***, ***entry right***, ***axis***, ***axis from right***, ***exit***, ***exit left***).

Case D: The counter for zone 1 is incremented only if ***entry*** or ***entry right*** is set for zone 1. The counter for zone 2 is incremented. The time at which the increment takes place depends on the settings (***entry***, ***entry left***, ***axis***, ***axis from left***, ***exit***, ***exit right***).

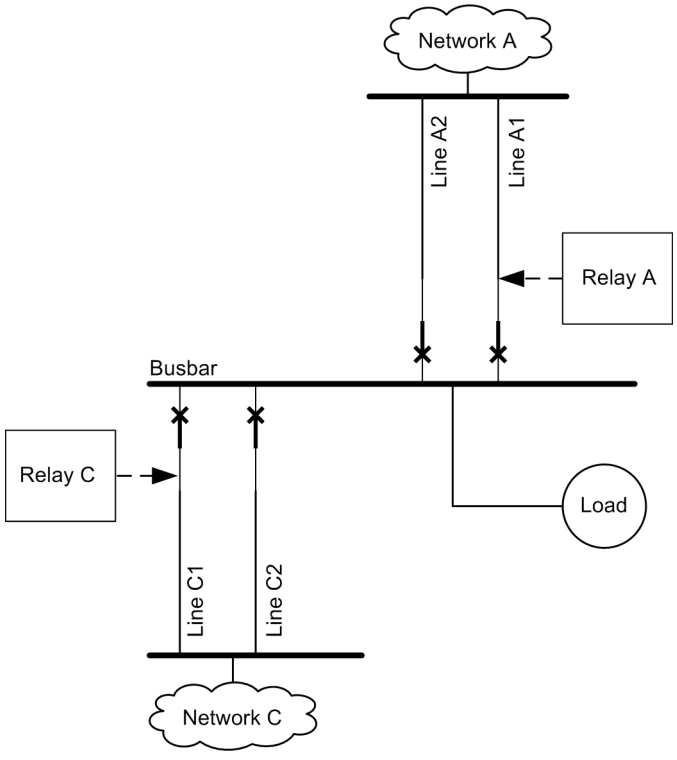


[dwerhzae-100611-01.tif, 1, en_US]

Figure 6-659 Incrementing the Power Swing Counter for Different Impedance Phasor Trajectories

6.65.4 Application and Setting Notes (System Protection)

The protection setting is exemplified by a power-system configuration. If a power swing occurs in the power system, the out-of-step protection must separate the power system into islands. Each system island must be able to establish a stable operating state. Although a certain amount of load shedding must be taken into account, the aim is to minimize power loss. *Figure 6-660* shows the power-system configuration used in the example.



[dwbspnet-210211-01.tif, 1, en_US]

Figure 6-660 Power-System Configuration

If an asynchronous swing condition occurs, the out-of-step protection function separates the 2 systems A and C from each other. To allow the subnetwork with power reserve to remain connected to the busbar (and the local load), either the lines A1 and A2 or the lines C1 and C2 must be disconnected from the busbar, depending on the direction of the impedance curve. This ensures that the infeeding side remains connected with the busbar and the local load.

Focus of the Example

In the example (*Figure 6-660*), the setting values for relay A are determined. All information and calculations in this section are therefore based on relay A. Out-of-step tripping by this relay is also passed to the circuit breakers for lines A1 and A2, since both lines must be disconnected if an out-of-step condition occurs. Similarly, relay C affects the circuit breakers for lines C1 and C2. Since the out-of-step impedance measurement in relay A is also affected by the power flows in line A2, 2 separate setting values are determined for relay A. The appropriate setting characteristic is enabled depending on the switch position of the line A2 circuit breaker (**ON** or **OFF**).

The parameters for the 2 zones (zone 1 and 2) are shown below with reference to the operating state of line A2 (active or open). In practice, the corresponding zone must be blocked or enabled using the binary input (GOOSE). Settings that are the same for both zones are not described separately.

Blocking the Zone

- Recommended setting value **(_:2311:100) I2>threshold blocks zone** = ***20*** **%**

Out-of-step tripping must be prevented in case of unbalanced faults and single open-pole conditions. To do so, the negative-sequence current threshold (parameter **I2>threshold blocks zone**) is set to ***20*** **%** (default setting).

If power-swing frequencies > 7 Hz are expected to occur, Siemens recommends increasing the setting value to 40 % to 45 %.

The setting value should not be set to be too sensitive in the case of a 1-pole AREC. Check the possible negative-sequence current on the line to be protected if a pole on the adjacent line is open following a 1-pole AREC. As a result, a negative-sequence current flows on the healthy line (parallel line).

Zone Impedance Calculation

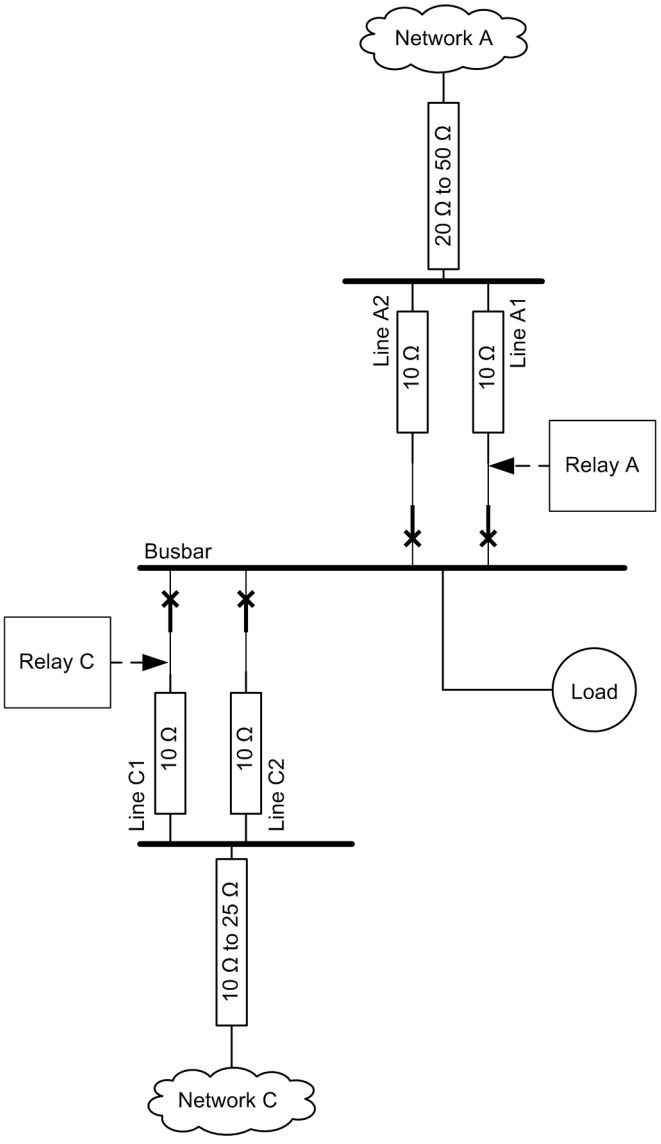
To set the zones, the **electrical center** of the power system, as seen from the relay, must be determined.



NOTE

Note that the infeed conditions are not fixed to the sources and that the parallel line is not always available. Therefore, the electrical center of the power system is not located at a fixed point.

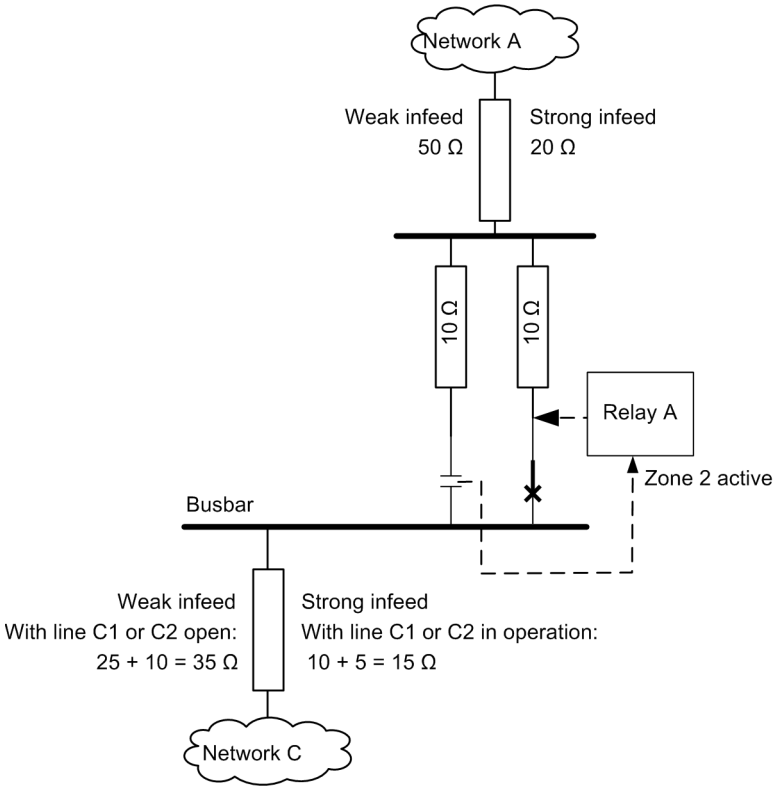
For setting the zone limit, you have to calculate the electrical center **active** and **open** using the maximum and minimum infeed and with parallel line. The source impedances of the infeeds and lines in *Figure 6-661* are specified for the purposes of the example. All impedance values are secondary values and are related to a secondary rated current of 1 A. Power system simulation tests are recommended in practice to determine the zone limits.



[dwvorimp-020211-01.tif, 1, en_US]

Figure 6-661 Source Impedances of Infeeds and Feeders

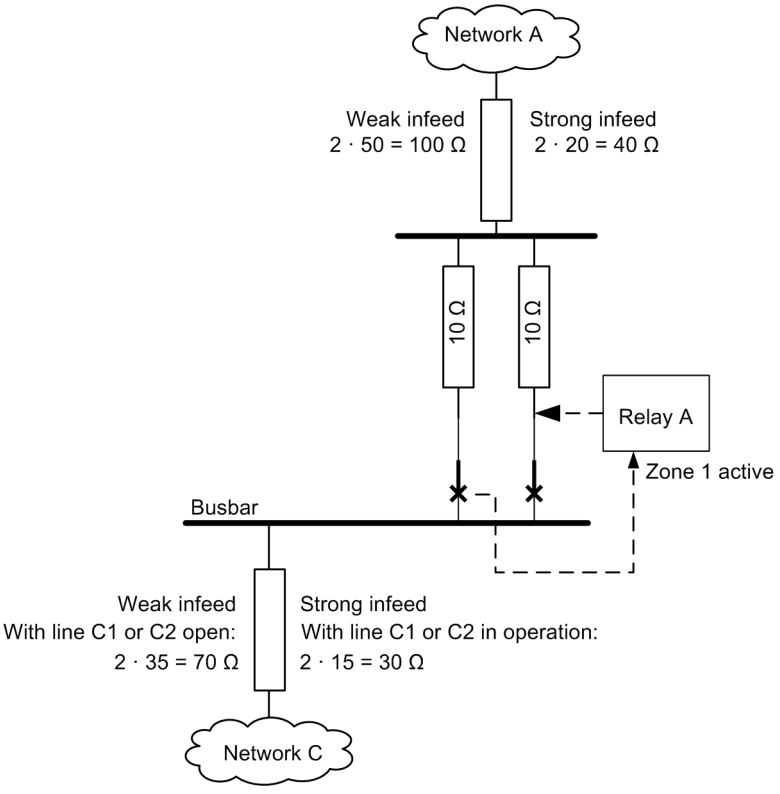
To determine the source impedances as seen from relay A, *Figure 6-661* is simplified as follows for the state = line A2 open (zone 2 active):



[dwvrimp2-020211-01.tif, 1, en_US]

Figure 6-662 Calculation of Source Impedances with Open Line A2 (Zone 2 Active)

The impedances of lines C1 and C2 and of infeed C are combined in *Figure 6-662*. Only one of the 2 lines is used for calculation in the case of a weak infeed (10 Ω); both are used in parallel for a strong infeed (5 Ω). Since the values for zone 2 are calculated with line A2 open here, simply add the impedance in the direction of power system A for strong infeed to the line impedance of 10 Ω and 25 Ω for weak infeed. The results for zone 2 are entered in *Table 6-24*.



[dwvorim1-020211-01.tif, 1, en_US]

Figure 6-663 Calculation of Source Impedances with Closed Line A2 (Zone 1 Active)

When line A2 is in operation, the current is split between lines A1 and A2. The impedance seen from Relay A is therefore doubled at the infeeds. *Figure 6-663* shows the relevant values for strong and weak infeed. The impedances for zone 1 are entered in *Table 6-24*. Zone 1 is effective when line A2 is active.

Table 6-24 Extreme Conditions: Extreme Conditions: Impedance, Seen from Relay A

Condition	Activated Zone in Relay A	Line A2	Impedance / $\Omega_{secondary}$ In the direction of source A	Impedance / $\Omega_{secondary}$ In the direction of source C
Strong source power system A Weak source power system C	Zone 1	Active	50 Ω	70 Ω
	Zone 2	Open	30 Ω	35 Ω
Weak source power system A Strong source power system C	Zone 1	Active	110 Ω	30 Ω
	Zone 2	Open	60 Ω	15 Ω

The condition in which both sides provide a weak or strong source is not relevant for the determination of the outermost ends of the electrical center.

If one end shows a maximum source impedance and the other a minimum one, you obtain the outermost end of the electrical center. Use the following equation for calculation (shown for relay A):

$$Z_{Center_A} = Z_{Source_A} - \frac{Z_{Source_A} + Z_{Source_B}}{2}$$

[foeztrum-170309-01.tif, 1, en_US]

The results must be calculated separately for zone 2 and zone 1 according to the open or closed switch positions of infeed B. *Table 6-25* shows the electrical center, as seen from relay A.

Table 6-25 Calculation Results for the Electrical Center

Source Side A / $\Omega_{secondary}$	Source Side C / $\Omega_{secondary}$	Activated Zone in Relay A	Line A2	Electrical Center (Impedance, Seen from Relay A) / $\Omega_{secondary}$
50 Ω	70 Ω	Zone 1	Active	-10 Ω
30 Ω	35 Ω	Zone 2	Open	-2.5 Ω
110 Ω	30 Ω	Zone 1	Active	40 Ω
60 Ω	15 Ω	Zone 2	Open	22.5 Ω

If the 2 sources have different voltage levels, the power-swing impedance differs from the electrical center. This fact must be considered when determining the outermost ends of the electrical center:

$$Z_{deviation} = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} \cdot Z_{total}$$

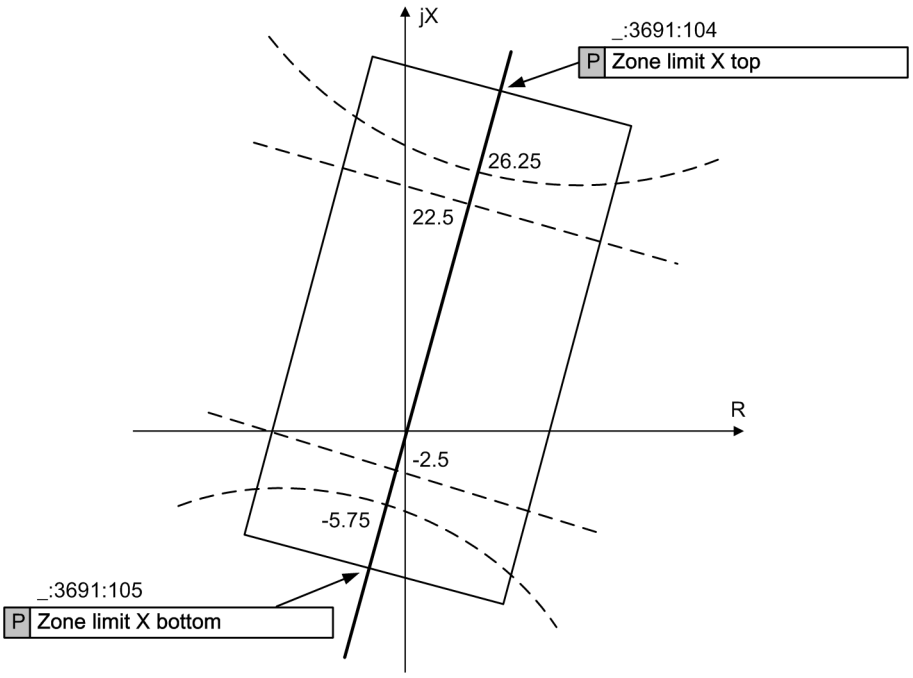
[fodvitio-170309-01.tif, 1, en_US]

Table 6-26 shows the results obtained for relay A.

Table 6-26 Impedance Deviation from Electrical Center

Z_{total} / $\Omega_{secondary}$	Activated Zone in Relay A	Line A2	Electrical Center (Seen from Relay A) / $\Omega_{secondary}$	Deviation with a Voltage Level Difference of 10 % / $\Omega_{secondary}$	Outer End of the Electrical Center / $\Omega_{secondary}$
50 + 70 Ω	Zone 1	Active	-10 Ω	-6 Ω	-16 Ω
30 + 35 Ω	Zone 2	Open	-2.5 Ω	-3.25 Ω	-5.75 Ω
110 + 30 Ω	Zone 1	Active	40 Ω	7 Ω	47 Ω
60 + 15 Ω	Zone 2	Open	22.5 Ω	3.75 Ω	26.25 Ω

Figure 6-664 shows the outer ends of the electrical center for relay A, zone 2 (line A2 is open), including the possible power-swing impedance locations.



[dwimpelo-070611-01.tif, 1, en_US]

Figure 6-664 Swing Impedance Locations and Outer Ends of the Electrical Center for Relay A (Line A2 is Open)

To ensure that the power swing zone in *Figure 6-664* covers the power swing trajectories, the upper and lower zone limits X are calculated as shown in the following formula. The calculated values reliably cover the determined outermost electrical centers in *Table 6-26*. The safety clearance is half the distance between the determined centers. Depending on the application, another formula can be used to satisfy the requirements placed on the geometry of the zone:

$$\text{Upper Zone Limit} = 26.25\ \Omega + \frac{26.25\ \Omega + 5.75\ \Omega}{2} = 42.25\ \Omega$$

$$\text{Lower Zone Limit} = -5.75\ \Omega - \frac{26.25\ \Omega + 5.75\ \Omega}{2} = -21.75\ \Omega$$

[foznengr-310111-01.tif, 1, en_US]

Table 6-27 shows the **zone limit X** setting for relay A based on this formula.

Table 6-27 jX Setting for the Zones

Activated Zone in Relay A	Line A2	Most Extreme Electrical Center, 1st Quadrant	Most Extreme Electrical Center, 3rd Quadrant	`Upper Zone Limit X`	`Lower Zone Limit X`
Zone 1	Active	47 Ω	-16 Ω	78.5 Ω	-47.5 Ω
Zone 2	Open	26.25 Ω	-5.75 Ω	42.25 Ω	-21.75 Ω

To determine the **`Zone limit R`**, the out-of-step tripping mode must be considered:

- If an out-of-step tripping on entry occurs, the R setting must equal the smallest value which occurs when the power swing reaches the transient stability limit angle.
- The R setting is less critical if the out-of-step condition trips when the axis of symmetry is exceeded. It can be set to the 0.9-fold minimum stable load impedance or to the 0.25-fold distance between the values of **Zone limit X**. Note that the circuit breaker is exposed to a very strong recovery voltage after switching.
- If an out-of-step tripping on exit occurs, the R setting depends on how long the trip command is to be present after the axis of symmetry has been exceeded (180°-condition). The calculation of the R setting can be based on the currently set swing locus angle.

In the example, tripping is to occur when the zone is entered. Therefore, you have to calculate the R setting using the transient stability limit angle δ. Based on the maximum transmission angle under stable operating conditions, the transient stability limit angle is calculated as follows:

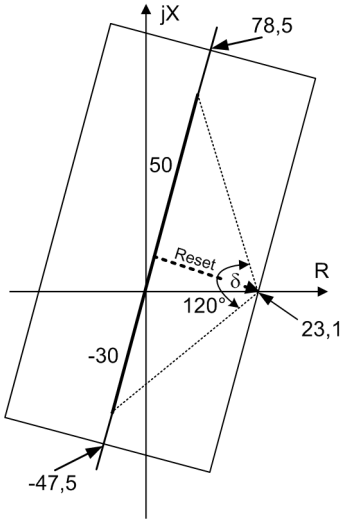
Transient stability angle = 180 - maximum transmission angle.

A maximum transmission angle of 60° can be assumed in most cases. The result is a transient stability limit δ of 120°.

To ensure that the R setting is not too high, it must be determined on the basis of the minimum source impedances. The minimum source impedances (with closed/open line A2) or relay A are shown in *Table 6-28*.

Table 6-28 Calculated R Setting Values

Condition	Activated Zone in Relay A	Line A2	Impedance in the Direction of Source A	Impedance in the Direction of Source C	Zone Limit R Setting
Strong source A	Zone 1	Active	50 Ω	30 Ω	23.1 Ω
Strong source C	Zone 2	Open	30 Ω	15 Ω	13.0 Ω



[dwreinst-210211-01.tif, 1, en_US]

Figure 6-665 Calculation of the R Setting with Minimum Source Impedances (Line A2 Active, Zone 1)

$$R_{set.} = \frac{Z_{Source_A} + Z_{Source_C}}{2 \cdot \tan\left(\frac{\delta}{2}\right)}$$

$$R_{set.} = \frac{50\,\Omega + 30\,\Omega}{2 \cdot \tan 60} = 23.1\,\Omega$$

[forfmel1-310111-01.tif, 1, en_US]

Determination of the Rotation Angle of the Characteristic

Not all impedances in the power system have the same angle. Set the rotation angle to the same value as the impedance angle of the total impedance between the 2 sources (sum of the impedances of power system A and C). This example uses the typical angle of 85° for transmission lines.

(_:3691:102) Rotation angle = ***85°***

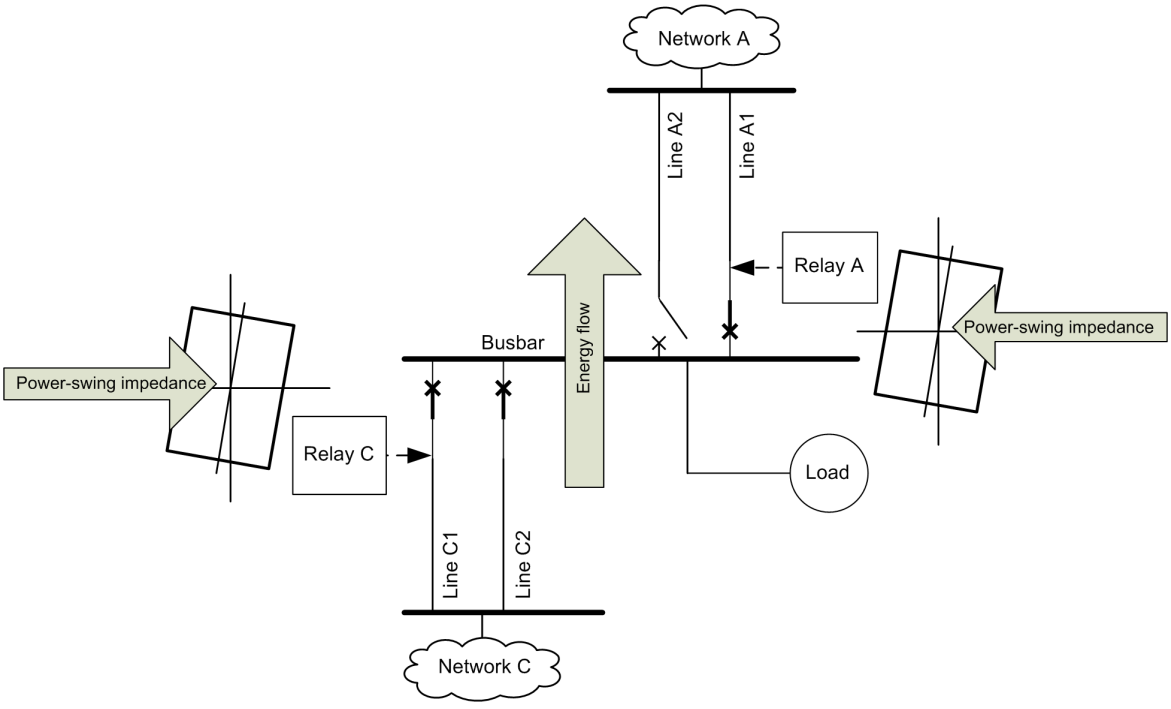
Counting of Power Swings

In this application, power swing tripping is to take place immediately on entry. Therefore the number of power swings is set to 1:

(_:3691:107) Number of power swings = ***1***

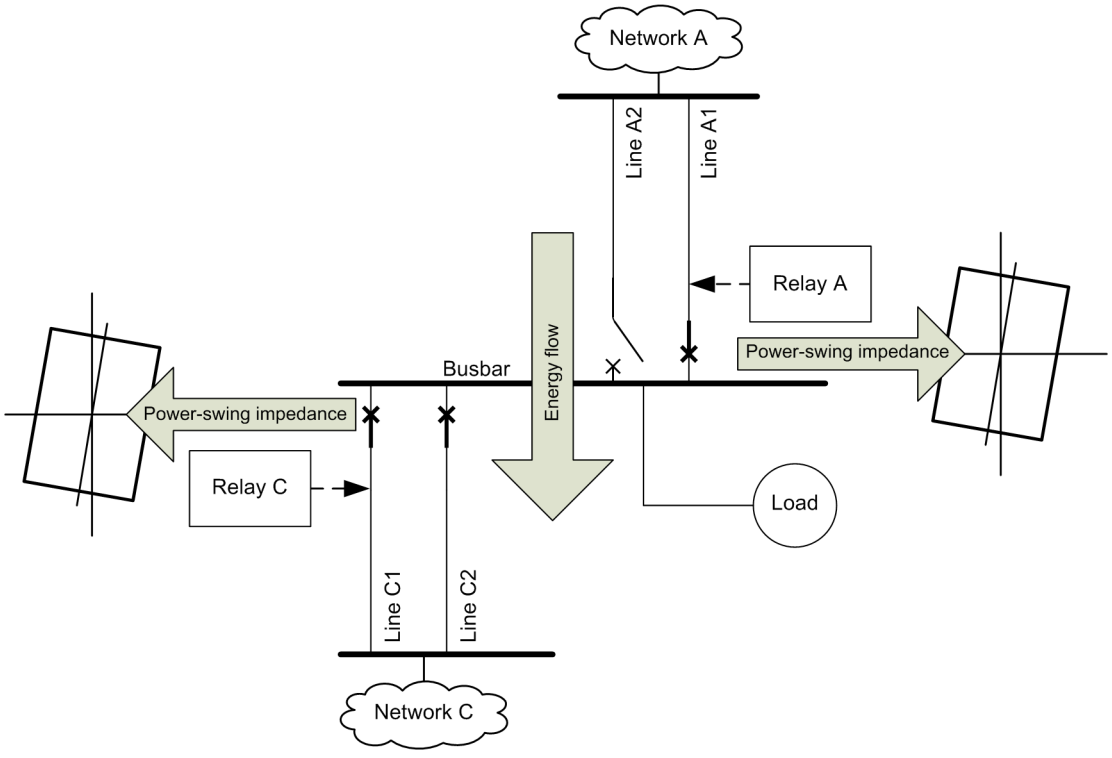
Power swing tripping is to cause selective disconnection to keep the busbar connected to the infeeding power system. *Figure 6-666* and *Figure 6-667* show the swing impedance trajectory for relay C and A depending on the energy flow. Power swing tripping is to cause a selective disconnection of the power system that draws energy from the busbar. Therefore, power swing tripping takes places at entry from the right. In *Figure 6-666*, line A1 is disconnected from the busbar by relay A with swing tripping. Power system C remains connected to the busbar via lines C1 and C2 and feeds the load connected there.

(_:3691:108) Count at = ***entry right***



[dwenergc-020211-01.tif, 1, en_US]

Figure 6-666 Direction of the Swing Impedance Locus with Energy Transfer from Power System C to Power System A



[dwenerga-020211-01.tif, 1, en_US]

Figure 6-667 Direction of the Swing Impedance Locus with Energy Transfer from Power System A to Power System C

In *Figure 6-667*, the energy flows in the opposite direction. Out-of-step tripping must take place at lines C1 and C2. In this case, power system A remains connected to the local load of the busbar.

Setting the Time Function Elements

- Recommended setting value **(_:3691:101) Re-entry time** = ***20 s***

Use the **Re-entry time** parameter to define the resetting condition for the counter. If the counter was incremented and if there is no new swing cycle during the re-entry time, the swing counter is set back to 0. Assuming slow power swings of approx. 0.2 Hz (corresponds to a duration of 5 s), the setting value of 20 s offers sufficient safety.

- Recommended setting value **(_:3691:100) Signal time** = ***0.05 s***

Use the **Signal time** parameter to define how long a binary indication (incrementing or swing direction), is present, for instance at a contact. The time depends on the speed of subsequent evaluation units. A value between 50 ms and 100 ms is sufficient for fast further processing.

6.65.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:I1<threshold blocks zone		10 % to 400 %	20 %
_:2311:100	General:I2>threshold blocks zone		5 % to 500 %	20 %

Addr.	Parameter	C	Setting Options	Default Setting
Zone 1				
_:3691:1	Zone 1:Mode		• off • on • test	off
_:3691:2	Zone 1:Operate & flt.rec. blocked		• no • yes	no
_:3691:103	Zone 1:Zone limit R	1 A	0.100 Ω to 600.000 Ω	10.000 Ω
		5 A	0.020 Ω to 120.000 Ω	2.000Ω
_:3691:104	Zone 1:Zone limit X top	1 A	0.100 Ω to 600.000 Ω	10.000 Ω
		5 A	0.020 Ω to 120.000 Ω	2.000 Ω
_:3691:105	Zone 1:Zone limit X bottom	1 A	-600.000 Ω to 600.000 Ω	-10 000 Ω
		5 A	-120.000 Ω to 120.000 Ω	-2000 Ω
_:3691:102	Zone 1:Rotation angle		60.0 ° to 90.0 °	90.0 °
_:3691:108	Zone 1:Count at		• exit • axis • entry • exit left • exit right • axis from left • axis from right • entry left • entry right	exit
_:3691:107	Zone 1:Number of power swings		1 to 20	1
_:3691:101	Zone 1:Re-entry time		0.00 s to 60.00 s	20.00 s
_:3691:100	Zone 1:Signal time		0.00 s to 60.00 s	0.05 s

6.65.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Zone blocked	SPS	O
_:2311:302	General:I1< blocking	SPS	O
_:2311:301	General:I2> blocking	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Zone 1			
_:3691:81	Zone 1:>Block stage	SPS	I
_:3691:54	Zone 1:Inactive	SPS	O
_:3691:52	Zone 1:Behavior	ENS	O
_:3691:53	Zone 1:Health	ENS	O
_:3691:55	Zone 1:Pickup	ACD	O
_:3691:56	Zone 1:Operate delay expired	ACT	O
_:3691:57	Zone 1:Operate	ACT	O
_:3691:300	Zone 1:Counter status reach.	SPS	O

No.	Information	Data Class (Type)	Type
_:3691:301	Zone 1:Out-of-step condition	SPS	O
_:3691:302	Zone 1:Power swing from left	SPS	O
_:3691:303	Zone 1:Power swing from right	SPS	O
_:3691:304	Zone 1:No. of power swings	INS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O

6.66 Arc Protection

6.66.1 Overview of Function

The function **Arc protection**:

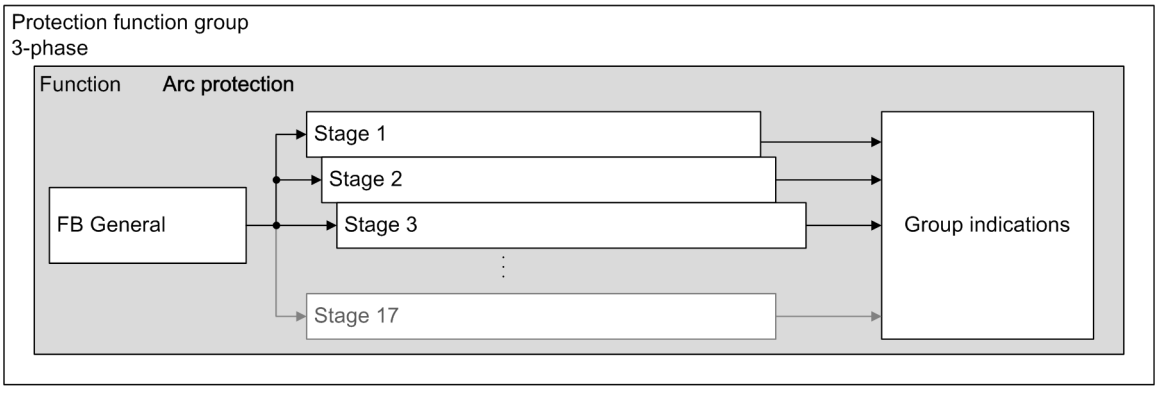
- Detects arcs in air-insulated switchgear parts without delay and in a fail-safe way
- Limits system damage through instantaneous high-speed tripping
- Protect systems from thermal overload
- Increases safety of personnel
- Trips in a 3-pole way
- Is suitable for use in all voltage levels

6.66.2 Structure of the Function

The **Arc protection** function can be added to function groups that provide current measured values.
The **Arc protection** function consists of the following blocks.

- General
- 3 stages
- Output logic 3-phase

The **Arc protection** function is preconfigured with 3 stages. A maximum of 17 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.
The following figure shows the basic structure of the **Arc protection** function.

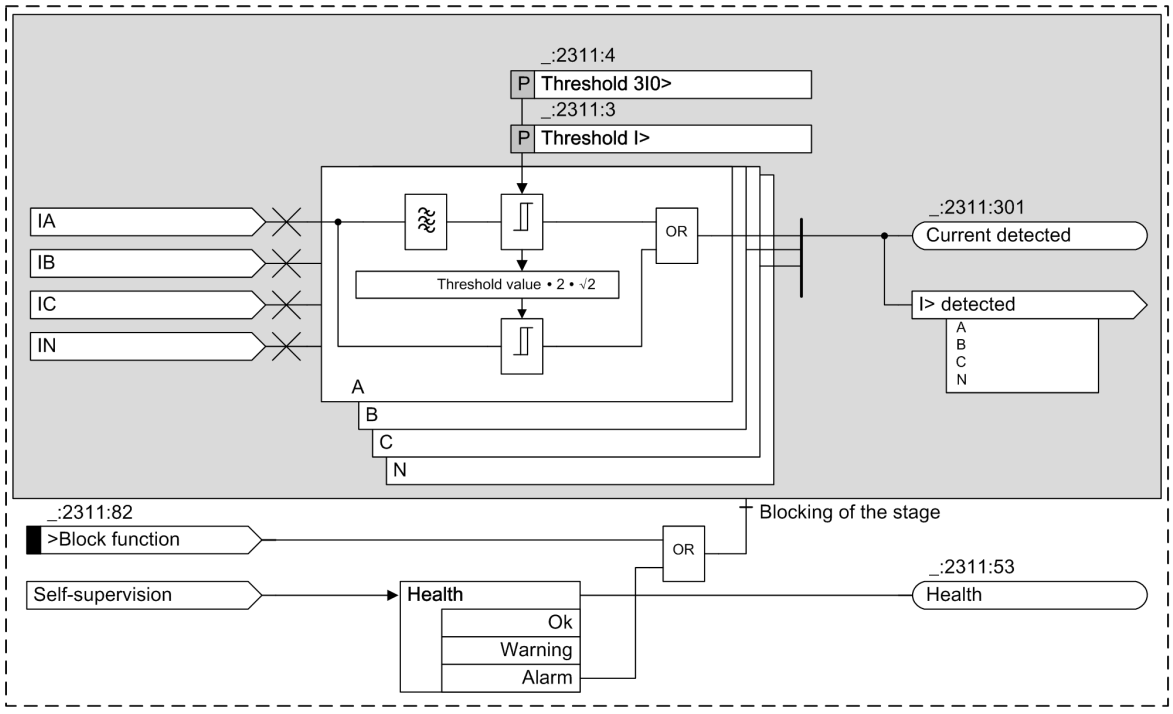


{dw_structure_arcprot, 2, en_US}

Figure 6-668 Structure/Embedding of the Arc Protection Function

6.66.3 Function Description

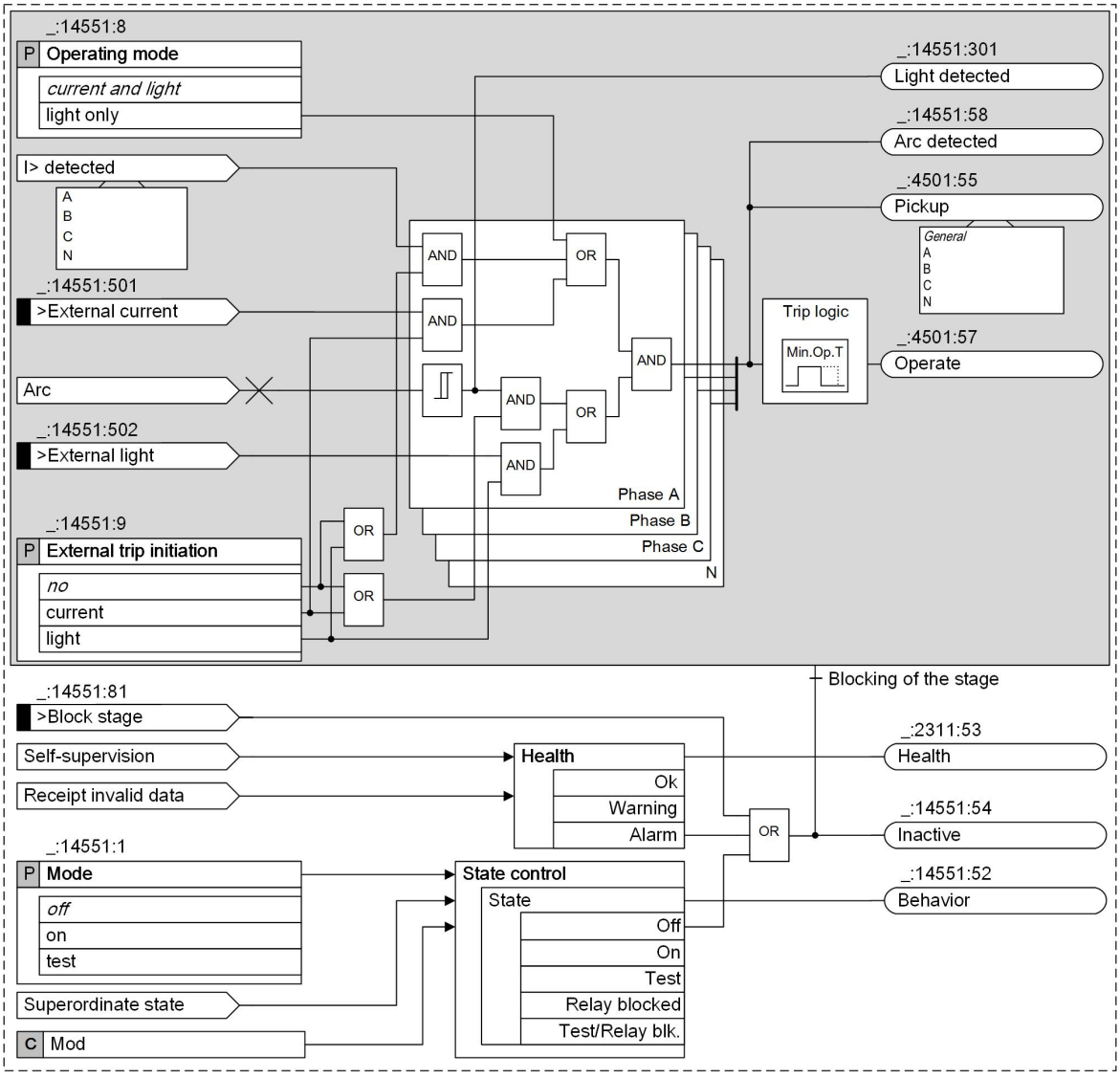
General Logic of the Function Block



[lo_fb0_arcprot, 3, en_US]

Figure 6-669 General Logic Diagram of the Function Block

Logic of the Stage



[lo_stage_arcprotection, 2, en_US]

Figure 6-670 Logic Diagram of the Stage

The **Arc protection** function uses a locally connected optical arc sensor or an external trip initiation by other devices in order to detect arcs.

NOTE

Install the arc sensors inside the switchgear in such a way that they are not hidden behind other system components!

Shadowing of the arc sensors must be avoided!

NOTE

Once an optical sensor has detected an arc, you must replace the affected optical sensor!

Within the **Arc protection** function, you can use a fast current-flow criterion as an additional release criterion. The parameters for the current-flow criterion can be found in the **General** block. For each stage, you can select individually whether the current-flow criterion must be evaluated as well.

Method of Measurement, Current-Flow Criterion

The current-flow criterion works with 2 different methods of measurement:

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically. A direct-current component is thus eliminated. The RMS value of the fundamental component is compared with the set threshold value.
- Evaluation of the unfiltered measurand:
  If the current exceeds the threshold value set by the current ≥ 2 ·√2 · threshold value, the stage uses additional unfiltered measurands. Thus, very short operate times are possible.



NOTE

If using the current-flow criterion in addition to the light, prevent a potential overfunction caused by the suddenly occurring light signal.

If you use the current-flow criterion, arcs are typically detected in 4 ms!

Self Monitoring

The **Arc protection** function uses a self-monitoring circuit. This circuit monitors the optical arc sensors and the fiber-optic cables. The arc-protection module uses the fiber-optic cable to send a cyclic test signal (light) to the arc sensors. If the channel is operating properly, the test signal is sent back to the arc protection module. If the test signal is not returned to the arc protection module, the indication *channel # Sensor failure* is generated.

If the self-monitoring function detects a fault, the indication *Health* is set to *Alarm* and the stage/function is blocked.

6.66.4 Application and Setting Notes – General Settings

Go to **General** under the function **Arc protection** and set the following parameters. The setting values apply to all stages.

Parameter: Sensor supervision

- Default setting **(_:2311:2) Sensor supervision** = ***yes***

With the parameter **Sensor supervision**, you set whether you want to monitor the arc sensors or not.

Parameter: Threshold I>

- Default setting **(_:2311:3) Threshold I>** = ***2.000 A***

With the parameter **Threshold I>**, you define the trigger threshold of the phase currents. The **Threshold I>** is relevant for the current-flow criterion of the function **Arc protection**.

Set the **Threshold I>** of the function **Arc protection** in such a manner that the RMS value of the inrush current does not exceed the **Threshold I>** when activating the local circuit breaker.

For more information about how to calculate the setting value, refer to *6.23.4.2 Application and Setting Notes*.

Parameter: Threshold 3I0>

- Default setting **(_:2311:4) Threshold 3I0>** = ***1.000 A***

With the parameter **Threshold 3I0>**, you determine the tripping threshold for the zero-sequence current. The **Threshold 3I0>** is relevant for the current-flow criterion of the function **Arc protection**.

Set the **Threshold 3I0>** of the function **Arc protection** in such a manner that the RMS value of the inrush current does not exceed the **Threshold 3I0>** when activating the local circuit breaker.

For more information about how to calculate the setting value, refer to *6.24.4.2 Application and Setting Notes*

NOTE

If you set the parameter **CT connection** = ***3-phase, 2 primary CT*** for the **3-phase current measuring point**, the parameter **Threshold 3I0>** has no effect.

If you set the parameter **CT connection** = ***3-phase + IN*** for the **3-phase current measuring point**, the function works with the measured current IN.

If you set the parameter **CT connection** = ***3-phase + IN-separate*** for the **3-phase current measuring point**, the function works with the calculated current 3I0.

6.66.5 Application and Setting Notes for the Stage

Parameter: External trip initiation

- Default setting **(_:14551:9) External trip initiation** = ***no***

With the **External trip initiation** parameter, you set whether an external input signal is used to trigger the stage.

Parameter Value	Description
no	The stage does not operate with an external input signal.
current	The stage operates with an external input signal. If the stage operates with an external input signal, the binary input signal *>External current* must be routed in the DIGSI 5 information routing. In this setting option, the binary input signal *>External current* is only visible in the DIGSI 5 information routing
light	The stage operates with an external input signal. If the stage operates with an external input signal, the binary input signal *>External light* must be routed in the DIGSI 5 information routing. In this setting option, the binary input signal *>External light* is only visible in the DIGSI 5 information routing **Note**: When working with the ***light*** external trip initiation, do not select a channel. If an additional channel is selected with this setting value, the DIGSI 5 will signal an inconsistency.

Parameter: Operating mode

- Default setting **(_:14551:8) Operating mode** = ***current and light***

With the **Operating mode** parameter, you define the basic functionality of the stage.

Parameter Value	Description
current and light	The stage operates with the input variables current and light. The current-flow criterion ensures that the light signal originates from an arc. Siemens recommends using this setting value.
light only	This stage operates only with the input signal 'light' and is triggered even if current is not measured. This operating mode can cause a overfunction if light is detected suddenly. Use this setting value only if the effect caused by external light signals is impossible.

Parameter: Sensor

- Default setting **(_:14551:11) Sensor** = ***point sensor***

With the **Sensor** parameter, you set which sensor type is connected to the device.

Parameter Value	Description
point sensor	A point sensor is connected to the device.
line sensor	A line sensor is connected to the device.
custom	If you select this setting option, the parameter **Threshold light** is visible. Siemens recommends the default setting values ***point sensor*** or ***line sensor***. This allows arcs to be detected reliably regardless of diffused light.

Parameter: Threshold light

- Default setting **(_:14551:7) Threshold light** = ***-20.00 dB***

With the **Threshold light** parameter, you set the light sensitivity. If you set **Threshold light** to a smaller value, the sensitivity increases. If you set **Threshold light** to a higher value, the sensitivity decreases. If the sensors even pick up in case of a switching arc of the circuit breaker, set the **Threshold light** parameter to a higher value.

Siemens recommends the default settings for point or line sensors.

Set the parameter **Threshold light** manually only if you have special default settings for light sensitivity.

Parameter: Channel

- Default setting **(_:14551:10) Channel** = ***No channel is selected***

With the **Channel**parameter, you select which sensor channel the stage uses.

If the **Arc protection** function has several stages, a different channel must be selected for each stage.

For parameter **Channel**, the selection texts are identical to the name of the arc-protection module and its channels.

6.66.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:1	General:Mode		• off • on • test	on
_:2311:2	General:Sensor supervision		• no • yes	yes
_:2311:3	General:Threshold I>	1 A @ 100 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:2311:4	General:Threshold 3I0>	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:14551:1	Stage 1:Mode		• off • on • test	off
_:14551:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:14551:9	Stage 1:External trip initiation		• no • light • current	no
_:14551:8	Stage 1:Operating mode		• light only • current and light	current and light
_:14551:11	Stage 1:Sensor		• point sensor • line sensor • custom	point sensor
_:14551:7	Stage 1:Threshold light		-34.00 dB to -10.00 dB	-20.00 dB
_:14551:10	Stage 1:Channel		Setting options depend on configuration	
Stage 2				
_:14552:1	Stage 2:Mode		• off • on • test	off
_:14552:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:14552:9	Stage 2:External trip initiation		• no • light • current	no
_:14552:8	Stage 2:Operating mode		• light only • current and light	current and light
_:14552:11	Stage 2:Sensor		• point sensor • line sensor • custom	point sensor
_:14552:7	Stage 2:Threshold light		-34.00 dB to -10.00 dB	-20.00 dB
_:14552:10	Stage 2:Channel		Setting options depend on configuration	
Stage 3				
_:14553:1	Stage 3:Mode		• off • on • test	off
_:14553:2	Stage 3:Operate & flt.rec. blocked		• no • yes	no
_:14553:9	Stage 3:External trip initiation		• no • light • current	no
_:14553:8	Stage 3:Operating mode		• light only • current and light	current and light

Addr.	Parameter	C	Setting Options	Default Setting
_:14553:11	Stage 3:Sensor		• point sensor • line sensor • custom	point sensor
_:14553:7	Stage 3:Threshold light		-34.00 dB to -10.00 dB	-20.00 dB
_:14553:10	Stage 3:Channel		Setting options depend on configuration	

6.66.7 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:82	General:>Block function	SPS	I
_:2311:51	General:Mode (controllable)	ENC	C
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
_:2311:301	General:Current detected	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Stage 1			
_:14551:81	Stage 1:>Block stage	SPS	I
_:14551:82	Stage 1:>External light	SPS	I
_:14551:501	Stage 1:>External current	SPS	I
_:14551:51	Stage 1:Mode (controllable)	ENC	C
_:14551:54	Stage 1:Inactive	SPS	O
_:14551:52	Stage 1:Behavior	ENS	O
_:14551:53	Stage 1:Health	ENS	O
_:14551:318	Stage 1:Fault arc counter	INC	C
_:14551:58	Stage 1:Arc detected	SPS	O
_:14551:301	Stage 1:Light detected	SPS	O
_:14551:55	Stage 1:Pickup	ACD	O
_:14551:57	Stage 1:Operate	ACT	O
Stage 2			
_:14552:81	Stage 2:>Block stage	SPS	I
_:14552:82	Stage 2:>External light	SPS	I
_:14552:501	Stage 2:>External current	SPS	I
_:14552:51	Stage 2:Mode (controllable)	ENC	C
_:14552:54	Stage 2:Inactive	SPS	O
_:14552:52	Stage 2:Behavior	ENS	O
_:14552:53	Stage 2:Health	ENS	O
_:14552:318	Stage 2:Fault arc counter	INC	C
_:14552:58	Stage 2:Arc detected	SPS	O
_:14552:301	Stage 2:Light detected	SPS	O
_:14552:55	Stage 2:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:14552:57	Stage 2:Operate	ACT	O
Stage 3			
_:14553:81	Stage 3:>Block stage	SPS	I
_:14553:82	Stage 3:>External light	SPS	I
_:14553:501	Stage 3:>External current	SPS	I
_:14553:51	Stage 3:Mode (controllable)	ENC	C
_:14553:54	Stage 3:Inactive	SPS	O
_:14553:52	Stage 3:Behavior	ENS	O
_:14553:53	Stage 3:Health	ENS	O
_:14553:318	Stage 3:Fault arc counter	INC	C
_:14553:58	Stage 3:Arc detected	SPS	O
_:14553:301	Stage 3:Light detected	SPS	O
_:14553:55	Stage 3:Pickup	ACD	O
_:14553:57	Stage 3:Operate	ACT	O

Information about the Self-Monitoring Function of the Arc Protection Module

No.	Information	Data Class (Type)	Type
channel #			
_:307	channel #:Sensor failure	SPS	O

6.66.8 Application Example for Arc Protection with Point Sensors in Operating Mode: Light Only

6.66.8.1 Description

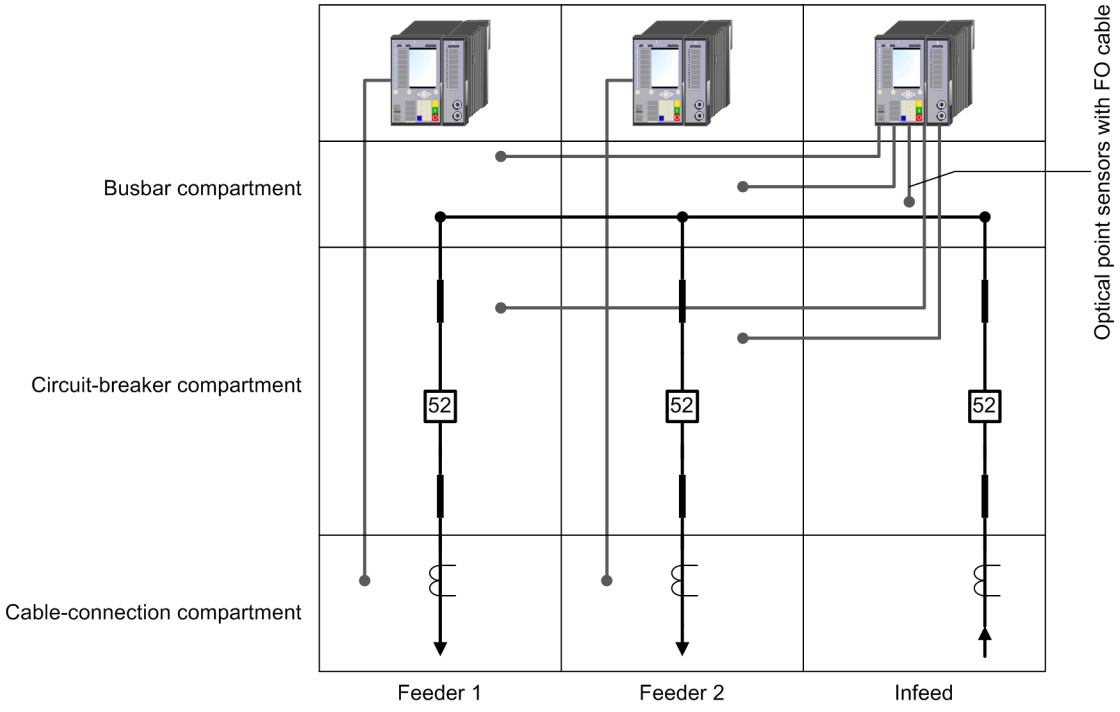
Overview

The example describes the **Arc protection** function in a medium-voltage switchgear with one infeed and 2 feeders. The **Arc protection** function operates with the **Operating mode** = ***light only***.

The following items are considered in the example below:

- Positioning the optical point sensors in the switchgear
- Connecting the optical point sensors to the protection devices in the feeders and the infeed
- Number of necessary stages of the functions in the protection devices of the feeders and the infeed
- Setting notes about the selected parameters in the stages of the function

The following figure shows the arrangement and the connection of the optical point sensors:



[dw_arcprot-light-only, 2, en_US]

Figure 6-671 Layout and Connection of the Optical Point Sensors (Operating Mode = Light only)

For this example, the following is assumed:

- The circuit breaker of the infeed must be switched off. This ensures that the arcs in the busbar compartments of the infeed and the feeders or in the circuit-breaker compartment of the feeders are off.

  Install the optical point sensors in the busbar compartments (BB compartment) of the infeed and feeders. Install additional optical point sensors in the circuit-breaker compartment (CB compartment) of the feeders. Connect all optical point sensors to the protection device of the infeed.
- The optical point sensors in the cable-connection compartment of the feeders detect arcs in this compartment. Install one optical point sensor in the cable-connection compartment of the feeders and connect it to the protection device of the feeder. This allows for the selective clearing of arcs inside the cable-connection compartment.

  Due to the pressure waves that occur during the formation of an arc, partitions can deform and cause undesirable light influences in adjacent compartments. This can result in a non-selective tripping.
- If there is an arc in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device must switch off.

NOTE

If the **Arc protection** function operates in **`Operating mode`** = ***`light only`***, the effects of external light can result in non-selective tripping.

NOTE

It must be considered that the number of arc protection modules connected to the device depends on the hardware configuration of the device.

When using modular devices, a maximum of 15 sensors can be connected. If using non-modular devices, a maximum of 6 sensors (3 sensors per module) can be connected.

6.66.8.2 Application and Setting Notes

General Notes

- Connect one optical point sensor from the cable-connection compartment in feeder 1 to the protection device in feeder 1. Arcs in the cable-connection compartment are cleared selectively by the circuit breaker in feeder 1.
- Connect one optical point sensor from the cable-connection compartment in feeder 2 to the protection device in feeder 2. Arcs in the cable-connection are cleared selectively by the circuit breaker in feeder 2.
- Connect optical point sensors from all busbar compartments and all circuit-breaker compartments of feeders 1 and 2 to the protection device in the infeed. Arcs in these compartments are detected and cleared by the device in the infeed.

Setting Notes for the Protection Device in Feeder 1

The **Arc protection** function operates with **one** stage.
Set the parameters of the stage as follows:

- Parameter: **Operating mode** = ***light only***
- Parameter: **Sensor** = ***point sensor***
- Parameter: **External trip initiation** = ***no***
- Parameter: **Channel** = ***Arc mod. 1 channel 1***

The parameters in block **General** are not relevant since the **Operating mode** = ***light only***.

Setting Notes for the Protection Device in Feeder 2

The **Arc protection** function operates with **one** stage.
Set the parameters of the stage as follows:

- Parameter: **Operating mode** = ***light only***
- Parameter: **Sensor** = ***point sensor***
- Parameter: **External trip initiation** = ***no***
- Parameter: **Channel** = ***Arc mod. 1 channel 1***

The parameters in block **General** are not relevant since the **Operating mode** = ***light only***.

Setting Notes for the Protection Device in the Infeed

The **Arc protection** function operates with **5** stages.
Set the parameters of the stages as follows:

- Parameter: **Operating mode** = ***light only*** (applies to all stages)
- Parameter: **Sensor** = ***point sensor*** (applies to all stages)
- Parameter: **External trip initiation** = ***no*** (applies to all stages)
- Parameter: **Channel** = ***Arc mod. 1 channel 1*** (Stage 1) → Busbar compartment supervision in feeder 1
  Parameter: **Channel** = ***Arc mod. 1 channel 2*** (Stage 2) → Circuit-breaker compartment supervision in feeder 1
  Parameter: **Channel** = ***Arc mod. 1 channel 3*** (Stage 3) → Busbar compartment supervision in feeder 2
  Parameter: **Channel** = ***Arc mod. 2 channel 1*** (Stage 4) → Circuit-breaker compartment supervision in feeder 2
  Parameter: **Channel** = ***Arc mod. 2 channel 2*** (Stage 5) → Busbar compartment supervision in the infeed

The parameters in block **General** are not relevant since the **Operating mode** = ***light only***.

6.66.9 Application Example for Arc Protection with Point Sensors in Operating Mode: Light and Current

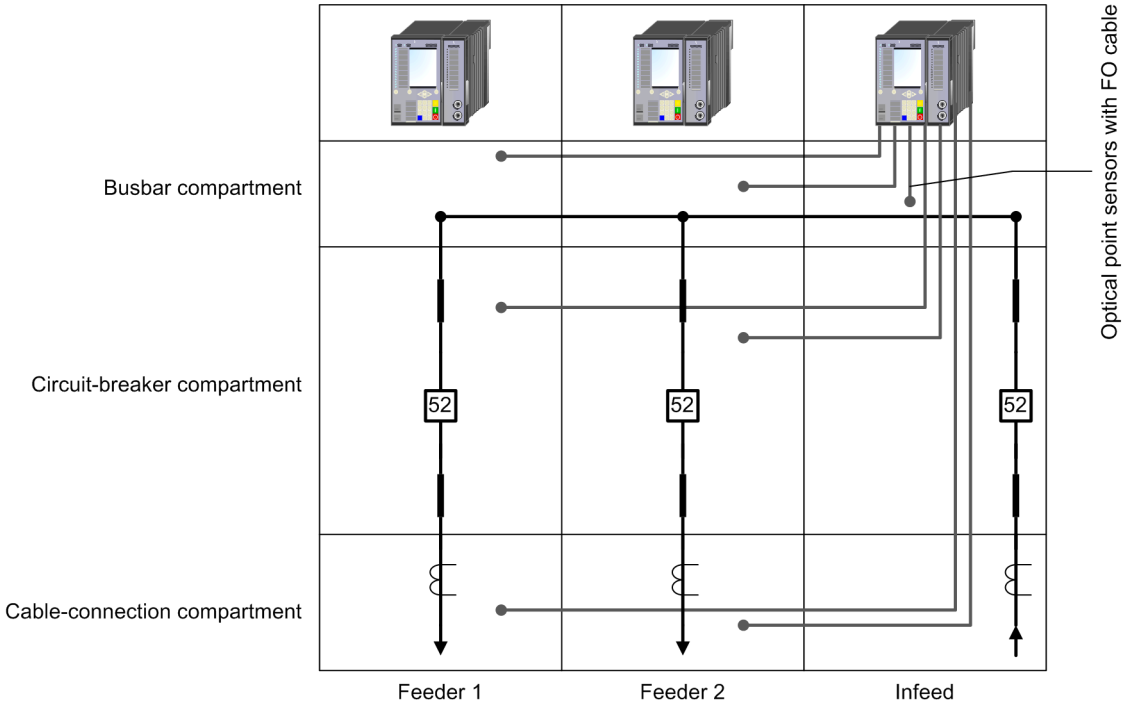
6.66.9.1 Description

Overview

The example describes the **Arc protection** function in a medium-voltage switchgear with one infeed and 2 feeders. The **Arc protection** function operates with the **Operating mode** = ***current and light***. In the example, all arcs are detected by the protection device in the infeed.

The following items are considered in the example:

- Positioning the optical point sensors in the switchgear
- Connecting the optical point sensors to the protection devices in the feeders and the infeed
- Number of necessary stages of the functions in the protection devices of the feeders and the infeed
- Setting notes about selected parameters in the stages of the function



[dw_light-and-current, 2, en_US]

Figure 6-672 Layout and Connection of the Optical Point Sensors (Operating Mode = Current and Light)

For this example, the following is assumed:

- The current-flow criterion offers additional security to prevent unwanted tripping caused by sudden light influences.

  Depending on the arc location in the cable-connection compartment of the feeder, it is not always possible to measure the current. If an arc is detected in the cable-connection compartment of the feeder, the current will therefore be evaluated in the infeed.
- Install the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders as well as the busbar compartment of the infeed. Connect the optical point sensors to the protection device in the infeed.

- The protection device in the infeed clears all arcs in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of feeder 1 and 2. Furthermore, the protection device clears arcs in the busbar compartment of the infeed.
- If the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders, or in the busbar compartment of the infeed detect an arc, the protection device in the infeed evaluates the current as well.
- If an arc occurs in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device must trip.

NOTE

If the **Arc protection** function operates with the **`Operating mode`** = ***`current and light`***, the additional current-flow criterion prevents unwanted tripping caused by external light influences.

NOTE

This application example requires the connection of several optical point sensors to a single protection device. It must be considered that the number of arc-protection modules that are connected to the device depends on the hardware configuration of the device.

When using modular devices, a maximum of 15 sensors can be connected. If you use non-modular devices, a maximum of 6 sensors (3 sensors per module) can be connected.

6.66.9.2 Application and Setting Notes

General Notes

- Connect the optical point sensors from the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of feeders 1 and 2 to the protection device in the infeed. Arcs in the busbar compartment, the circuit-breaker compartment and the cable-connection compartment of feeders 1 and 2 are detected and cleared by the device in the infeed.
- Connect an optical point sensor from the busbar compartment in the infeed to the protection device in the infeed. Arcs in the busbar compartment of the infeed are cleared selectively by the circuit breaker in the infeed.

Setting Notes for the Protection Device in the Infeed

The **Arc protection** function operates with **7** stages.

Set the parameters of the stages as follows:

- Parameter: **`Operating mode`** = ***`current and light`*** (applies to all stages)
- Parameter: **`Sensor`** = ***`point sensor`*** (applies to all stages)
- Parameter: **`External trip initiation`** = ***`no`*** (applies to all stages)

- Parameter: **Channel** = ***Arc mod. 1 channel 1*** (Stage 1) → Busbar compartment supervision in feeder 1
  Parameter: **Channel** = ***Arc mod. 1 channel 2*** (Stage 2) → Circuit-breaker compartment supervision in feeder 1
  Parameter: **Channel** = ***Arc mod. 1 channel 3*** (Stage 3) → Cable-connection compartment supervision in feeder 1
  Parameter: **Channel** = ***Arc mod. 2 channel 1*** (Stage 4) → Busbar compartment supervision in feeder 2
  Parameter: **Channel** = ***Arc mod. 2 channel 2*** (Stage 5) → Circuit-breaker compartment supervision in feeder 2
  Parameter: **Channel** = ***Arc mod. 2 channel 3*** (Stage 6) → Cable-connection compartment supervision in feeder 2
  Parameter: **Channel** = ***Arc mod. 3 channel 1*** (Stage 7) → Busbar compartment supervision in the infeed

You can find more information about the settings of the parameters **Threshold I>** and **Threshold 3I0>** in chapter *6.66.4 Application and Setting Notes – General Settings*.

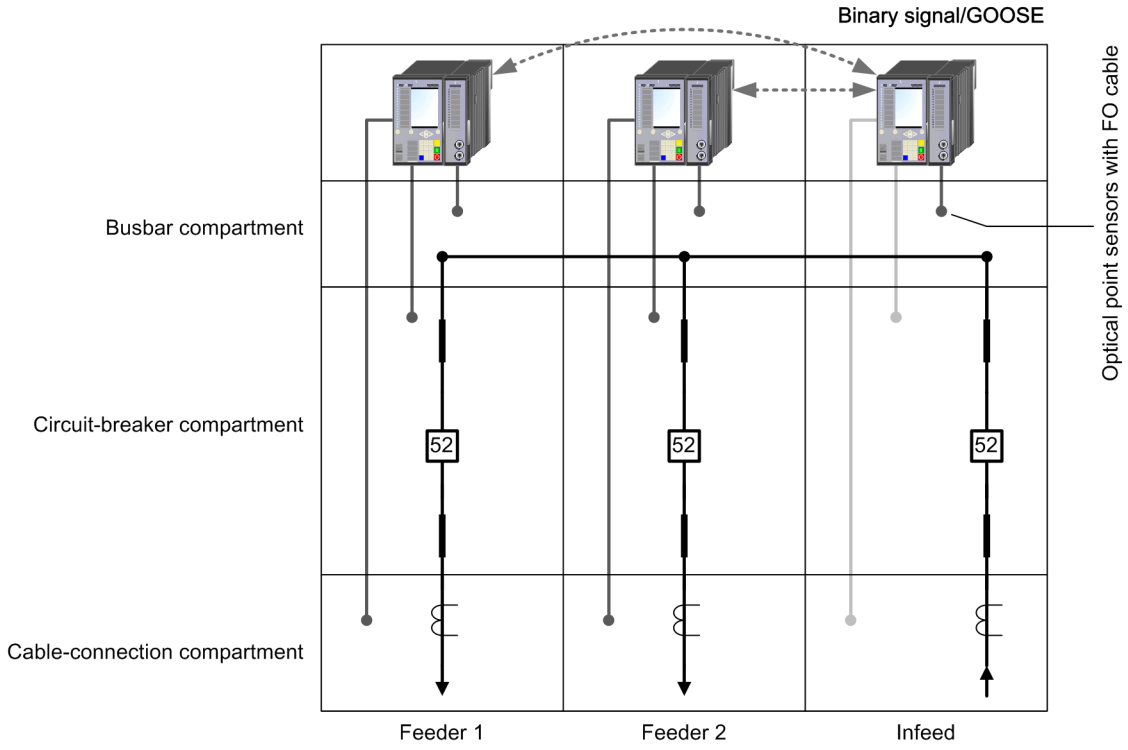
6.66.10 Application Example for Arc Protection with Point Sensors via External Trip Initiation

6.66.10.1 Description

Overview

The example describes the **Arc protection** function in a medium-voltage switchgear with one infeed and 2 feeders. The stages of the **Arc protection** function are triggered by **External trip initiation**.
The following items are considered in the example below:

- Positioning the optical point sensors in the switchgear
- Connecting the optical point sensors to the protection devices in the feeders and the infeed
- Number of necessary stages of the functions in the protection devices of the feeders and the infeed
- Setting notes about the selected parameters in the stages of the function



[dw_arcprot-extern-input, 3, en_US]

Figure 6-673 Arc Protection with External Trip Initiation

For this example, the following is assumed:

- Install the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeder and the infeed. Connect the optical point sensors to the respective protection device in the feeder and infeed.
- If the optical point sensors detect an arc in the busbar compartment or the circuit-breaker compartment of the feeders, the *Light detected* indication is sent via binary inputs/outputs, a protection interface, or IEC 61850 GOOSE to the protection device in the infeed. Then, the protection device in the infeed evaluates the current as well. If the measured current exceeds the thresholds **Threshold I>** and/or **Threshold 3I0>**, the protection device in the infeed switches off the malfunction.

  You can find detailed information in chapter *6.66.10.2 Application and Setting Notes*
- Arcs in the cable-connection compartment of the feeders can also be switched off selectively by the protection device of the affected feeder. To do this, the *Current detected* pickup indication from the infeed unit must be sent to the appropriate protection device in the feeder.
- If an arc occurs in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device trips.

NOTE

If the **Arc protection** function operates via the **External trip initiation**, only 3 optical point sensors are required per feeder protection device in order to detect the arcs (only one arc-protection module).

The number of GOOSE messages is not limited. Therefore, the number of feeders is not limited, and the protection of complex systems is feasible.

6.66.10.2 Application and Setting Notes

General Notes:

- Install the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders and the infeed to the respective protection devices.
- Arcs in the busbar compartment and the circuit-breaker compartment of the feeders must be switched off by the protection device in the infeed. To do this, the protection devices in the feeder device must send the indication *Light detected* to the infeed device. Use the binary inputs/outputs, a protection interface, or IEC 61850 GOOSE.
  The protection device in the infeed evaluates the current. If the measured current exceeds the **Threshold I>** and/or **Threshold 3I0>** threshold values, the protection device in the infeed switches off faults on the busbar and the circuit-breaker compartment of the feeders.
  Connect the signals over 4 stages, using the external trip initiation or a CFC chart.
- Arcs in the cable-connection compartment of the feeders are switched off locally. The protection device in the infeed evaluates the current. If the measured current exceeds the threshold values **Threshold I>** and/or **Threshold 3I0>**, the *Current detected* indication is sent to the protection devices in the feeders. If, at the same time, an optical sensor in a cable-connection compartment detects light, the protection device trips in the corresponding feeder.

Setting Notes for the Protection Device in Feeder 1

The **Arc protection** function operates with **3** stages.

Stage 1 and 2 (supervision of busbar compartment and circuit-breaker compartment):

Set the parameters of the stages as follows:

- Parameter: **Operating mode** = ***light only***
- Parameter: **Sensor** = ***point sensor***
- Parameter: **External trip initiation** = ***no***
- Parameter: **Operate & flt.rec. blocked** = ***yes***
- Parameter: **Channel** = ***Arc mod. 1 channel 1*** (stage 1) → busbar-compartment supervision in feeder 1
  Parameter: **Channel** = ***Arc mod. 1 channel 2*** (stage 2) → circuit-breaker compartment supervision in feeder 1

Stage 3 (supervision of cable-connection compartment):

Set the parameters of the stage as follows:

- Parameter: **Operating mode** = ***current and light***
- Parameter: **Sensor** = ***point sensor***
- Parameter: **External trip initiation** = ***current***
  The protection device in the infeed evaluates the current. If the measured current exceeds the threshold values **Threshold I>** and/or **Threshold 3I0>**, the protection device in the infeed returns the indication *Current detected* to the protection device in the feeder.
  Only if the indication in the feeder device *Current detected* is connected with the signal *>Externa l current* an external trip initiation for this stage is effective.
- Parameter: **Operate & flt.rec. blocked** = ***no***
- Parameter: **Channel** = ***Arc mod. 1 channel 3***

Setting Notes for the Protection Device in Feeder 2

The **Arc protection** function operates with **3** stages.

Stage 1 and 2 (supervision of busbar compartment and circuit-breaker compartment):

Set the parameters of the stages as follows:

- Parameter: **Operating mode** = ***light only***
- Parameter: **Sensor** = ***point sensor***
- Parameter: **External trip initiation** = ***no***
- Parameter: **Operate & flt.rec. blocked** = ***yes***
- Parameter: **Channel** = ***Arc mod. 1 channel 1*** (stage 1) → busbar-compartment supervision in feeder 2
  Parameter: **Channel** = ***Arc mod. 1 channel 2*** (stage 2) → circuit-breaker compartment supervision in feeder 2

Stage 3 (supervision of cable-connection compartment):
Set the parameters of the stage as follows:

- Parameter: **Operating mode** = ***current and light***
- Parameter: **Sensor** = ***point sensor***
- Parameter: **External trip initiation** = ***current***
  The protection device in the infeed evaluates the current. If the measured current exceeds the threshold values **Threshold I>** and/or **Threshold 3I0>**, the protection device in the infeed returns the indication *Current detected* to the protection device in the feeder.
  Only if the indication in the feeder device *Current detected* is connected with the signal *>External current* an external trip initiation for this stage is effective.
- Parameter: **Operate & flt.rec. blocked** = ***no***
- Parameter: **Channel** = ***Arc mod. 1 channel 3***

Setting Notes for the Protection Device in the Infeed

The **Arc protection** function operates with **7** stages.
Stage 1 (busbar-compartment supervision):

- Parameter: **Operate & flt.rec. blocked** = ***no***
  If an arc is detected in the busbar compartment of the infeed and the thresholds **Threshold I>** and/or **Threshold 3I0>** are exceeded, an operate indication is generated immediately.
- Parameter: **Channel** = ***Arc mod. 1 channel 1***
- Parameter: **Operating mode** = ***current and light***
- Parameter: **Sensor** = ***point sensor***
- Parameter: **External trip initiation** = ***no***

Stage 2 (circuit-breaker compartment supervision):

- Parameter: **Operate & flt.rec. blocked** = ***yes***
  If an arc is detected in the circuit-breaker compartment of the infeed (light-gray point sensors in *Figure 6-673*), a pickup indication is generated immediately. The arc is switched off by a superordinate protection device.
- Parameter: **Channel** = ***Arc mod. 1 channel 2***
- Parameter: **Operating mode** = ***current and light***
- Parameter: **Sensor** = ***point sensor***
- Parameter: **External trip initiation** = ***no***

Stage 3 (cable-connection compartment supervision):

- Parameter: **Operate & flt.rec. blocked** = ***yes***

  If an arc is detected in the cable-connection compartment of the infeed (light-gray point sensors in *Figure 6-673*), a pickup indication is generated immediately. The arc is switched off by a superordinate protection device.

  Depending where the arc is generated in the cable-connection compartment of the infeed, it is not always possible to measure the current. If an arc is detected in the cable-connection compartment of the infeed, the current must be evaluated by the superordinate protection device.

- Parameter: **Channel** = ***Arc mod. 1 channel 3***
- Parameter: **Operating mode** = ***light only***
- Parameter: **Sensor** = ***point sensor***
- Parameter: **External trip initiation** = ***no***

Stage 4 to 7 (External trip initiation):

- Parameter: **Operate & flt.rec. blocked** = ***no***
- Parameter: **Operating mode** = ***current and light***
- Parameter: **External trip initiation** = ***light***

  If an arc is detected in the busbar compartment or the circuit-breaker compartment of the feeder, the feeder device sends the *Light detected* indication to the infeed device. Only if the indication in the infeed device *Light detected* is connected with the signal *>External light*, an external trip initiation via these stages is effective.

  The protection device in the infeed evaluates the current. If the measured current exceeds the **Threshold I>** and/or **Threshold 3I0>** threshold values, the protection device in the infeed switches off the arc.

6.66.10.3 Application and Setting Notes for Variant 2 (with Feedback to Feeder Protection Devices)

General Notes:

- Connect the optical sensors in the busbar compartment, the CB compartment, and the cable-connection compartment of the feeder 1 and 2 and the infeed to the respective protection devices.
- Arcs in the busbar compartment and in the CB compartment of the feeders must be cleared by the protection device in the infeed. To do this, the protection devices in the feeder must send the indication *Arc detected* to the infeed device. Use the binary inputs/outputs, a protection interface, or IEC 61850 GOOSE.
- Arcs in the cable-connection compartment of the feeder are cleared selectively. Here, the message *Arc detected* is sent as well via binary inputs/outputs, a protection interface, or IEC 61850 GOOSE to the protection device in the infeed.

  The protection device in the infeed evaluates the current. If the measured current exceeds the threshold values **Threshold I>** and/or **Threshold 3I0>**, the protection device in the infeed sends the pickup indication of the stage back to the protection device in the affected feeder. The protection device in the affected feeder clears the arc selectively.

  Due to the pressure wave that occurs during an arc, partitions may deform and cause undesirable light influences in adjacent compartments. This may result in a non-selective trip.



NOTE

The **External trip initiation** function must be instantiated in the protection devices of the feeders.

Setting Information for the Protection Device in Feeder 1

The **Arc protection** function operates with **4** stages.

Stage 1 to 3:

- Parameter: **Operating mode** = ***light only***
- Parameter: **External trip initiation** = ***no***
- Parameter: **Operate & flt.rec. blocked** = ***yes***
- Parameter: **Channel** = ***Arc mod. 1 channel 1*** (Stage 1) → Monitoring busbar compartment in feeder 1

  Parameter: **Channel** = ***Arc mod. 1 channel 2*** (Stage 2) → Monitoring CB compartment in feeder 1

  Parameter: **Channel** = ***Arc mod. 1 channel 3*** (Stage 3) → Monitoring cable-connection compartment in feeder 1

Stage 4 (External trip initiation):

- Parameter: **Operate & flt.rec. blocked** = ***no***
- Parameter: **Operating mode** = ***light only***
- Parameter: **External trip initiation** = ***yes***

  If an arc is detected in the cable-connection compartment of the feeder, the indication *Arc detected* is sent to the protection device in the infeed.

  The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds **Threshold I>** and/or **Threshold 3I0>**, the protection device in the infeed picks up. The pickup indication from the protection device in the infeed is injected via this stage into the feeder protection device. This makes a selective tripping in the feeder possible.

Setting Information for the Protection Device in Feeder 2

The **Arc protection** function operates with **4** stages.

Stage 1 to 3:

- Parameter: **Operating mode** = ***light only***
- Parameter: **External trip initiation** = ***no***
- Parameter: **Operate & flt.rec. blocked** = ***yes***
- Parameter: **Channel** = ***Arc mod. 1 channel 1*** (Stage 1) → Monitoring busbar compartment in feeder 2

  Parameter: **Channel** = ***Arc mod. 1 channel 2*** (Stage 2) → Monitoring CB compartment in feeder 2

  Parameter: **Channel** = ***Arc mod. 1 channel 3*** (Stage 3) → Monitoring cable-connection compartment in feeder 2

Stage 4 (External trip initiation):

- Parameter: **Operate & flt.rec. blocked** = ***no***
- Parameter: **Operating mode** = ***light only***
- Parameter: **External trip initiation** = ***yes***

  If an arc is detected in the cable-connection compartment of the feeder, the indication *Arc detected* is sent to the protection device in the infeed.

  The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds **Threshold I>** and/or **Threshold 3I0>**, the protection device in the infeed picks up. The pickup indication from the protection device in the infeed is injected via this stage into the feeder protection device. This makes a selective tripping in the feeder possible.

Setting Information for the Protection Device in the Infeed

If arcs in the cable-connection compartments of the feeder shall be switched off selectively by the protection device in the feeder, the following setting notes for the protection device in the infeed apply.

The **Arc protection** function operates with **9** stages.

Stage 1 (busbar-compartment monitoring):

- Parameter: **Operate & flt.rec. blocked** = ***no***

  If an arc is detected in the busbar compartment of the infeed, an operate indication is generated immediately.
- Parameter: **Channel** = ***Arc mod.. 1 channel 1***
- Parameter: **Operating mode** = ***current and light***
- Parameter: **External trip initiation** = ***no***

Stage 2 (CB compartment monitoring):

- Parameter **Operate & flt.rec. blocked** = ***yes***

  If an arc is detected in the CB compartment of the infeed (light-gray sensors in *Figure 6-673*), a pickup indication is generated immediately. The arc is cleared by a superordinate protection device.
- Parameter: **Channel** = ***Arc mod.. 1 channel 2***
- Parameter: **Operating mode** = ***current and light***
- Parameter: **External trip initiation** = ***no***

Stage 3 (cable-connection compartment monitoring):

- Parameter: **Operate & flt.rec. blocked** = ***yes***

  If an arc is detected in the cable-connection compartment of the infeed (light-gray sensors in *Figure 6-673*), a pickup indication is generated immediately. The arc is cleared by a superordinate protection device.

  Depending on the arc location in the cable-connection compartment of the infeed, it is not always possible to measure the current. If an arc is detected in the cable-connection compartment of the infeed, the current must be evaluated by the superordinate protection device.
- Parameter: **Channel** = ***Arc mod.. 1 channel 3***
- Parameter: **Operating mode** = ***light only***
- Parameter: **External trip initiation** = ***no***

Stage 4 to 7 (External trip initiation):

- Parameter: **Operate & flt.rec. blocked** = ***no***
- Parameter: **Operating mode** = ***current and light***
- Parameter: **External trip initiation** = ***yes***

If an arc is detected in the busbar compartment or the CB compartment of the feeders, the feeder device sends the indication *Arc detected* to the infeed device. An external trip initiation via these stages is effective only if the indication *Arc detected* is connected with the signal *>External Arc* in the infeed device.

The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds **Threshold I>** and/or **Threshold 3I0>**, the protection device in the infeed clears the arc.

Stage 8 and 9 (External trip initiation):

- Parameter: **Operate & flt.rec. blocked** = ***yes***
- Parameter: **Operating mode** = ***current and light***
- Parameter: **External trip initiation** = ***yes***

If an arc is detected in the cable-connection compartment of the feeder, the feeder device sends the indication *Arc detected* to the infeed device. An external trip initiation via these stages is effective only if the indication *Arc detected* is connected with the signal *>External Arc* in the infeed device.

The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds **Threshold I>** and/or **Threshold 3I0>**, the protection device in the infeed picks up. The pickup indication

Arc detected will be sent back to the feeder protection device. This makes a selective tripping in the feeder possible.

6.67 Power-Plant Disconnection Protection

6.67.1 Overview of Functions

The **Power-plant disconnection protection** function (ANSI 37 (-dP)):

- Detects external short circuits in the vicinity of the power plant (line, busbar) and opens the high-voltage circuit breaker if the fault duration is long.
- Prevents an impermissible stress on the shaft assembly due to high mechanical stress as a result of an abrupt active-power unloading.
- Prevents power swings of the power-plant unit with the electrical power system as a result of excessively long fault-clearing times.
- Protects the stator winding from excessively long short-circuit current stress.

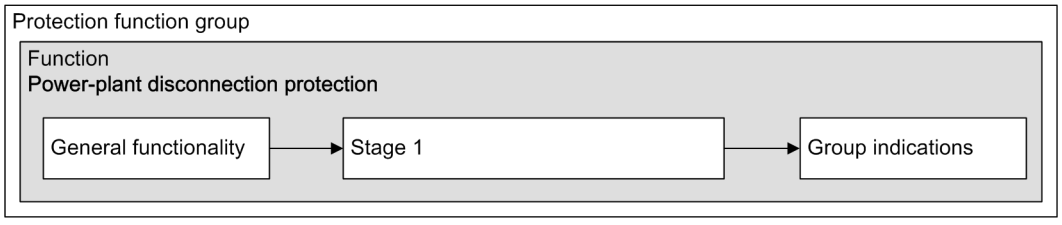
6.67.2 Structure of the Function

The **Power-plant disconnection protection** function is used in the **Generator stator** protection function group. It can also run in the **3-phase voltage-current** function group.

You can copy the function during engineering into the appropriate function group.

The **Power-plant disconnection protection** function consists of 1 stage, which contains the necessary function blocks.

The function processes the 3-phase voltage of the main generator lead and the current of the **Generator stator** function group. The following figure shows the basic structure of the function.



[dw_PPD_structure, 2, en_US]

Figure 6-674 Structure/Embedding of the Function

6.67.3 Function Description

Basic Principle of Power-Plant Disconnection Protection

In the event of system incidents, the sudden change of the electric torque of the generator leads to torsional vibrations in the shaft assemblies of power-plant units. These lead to increased mechanical stress and, in the extreme case, to the destruction of the shaft assembly.

In the event of an external, 3-phase short circuit, there is an abrupt active-power unloading in the power-plant unit, which causes a change of the electric torque. Due to the relief of torque, the angular velocity of the rotor increases and the rotor angle increases. The rotor angle describes the torsional state of the shaft. The rotor angle is the angle difference between the angle of the synchronous generated voltage of the generator and the power-system voltage (reference point in the power system).

NOTE

The rotor angle, which is shown among the functional measured values in the **Generator stator** function group, relates to the terminal voltage of the generator and is somewhat smaller.

The equations presented below show, in simplified form, basic relationships of the resulting stress.

$$\omega_L = \frac{1}{\Theta} \cdot \Delta T t_F + \omega_0;\ \Delta T = T_{mech} - T_{el}$$

[fo_powerplant_stress_01, 2, en_US]

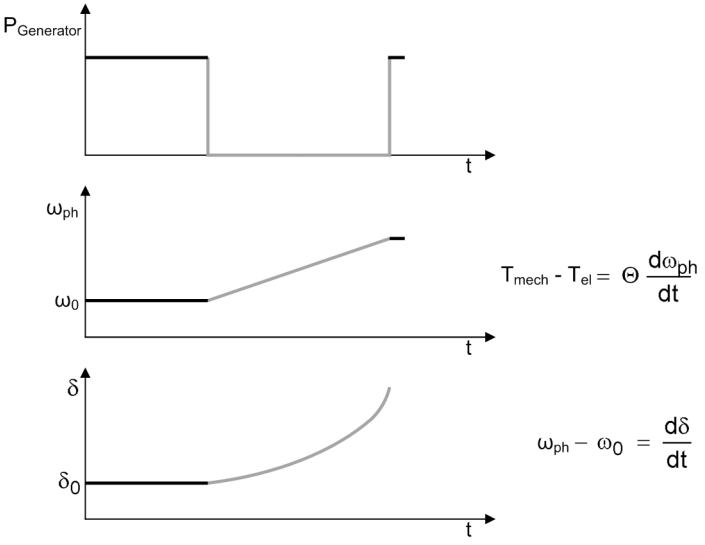
$$\delta = \frac{1}{\Theta} \cdot \Delta T (t_F)^2 + \delta_0$$

[fo_powerplant_stress_02, 2, en_US]

with

T_{mech}	Mechanical torque (turbine torque)
T_{el}	Electric torque (air gap torque)
Θ	Mass moment of inertia of the shaft
ω_L	Angular velocity of the rotor
ω_0	Synchronous angular velocity (constant: $\omega_0 = 2\pi f$)
t_F	Fault-clearing time
δ	Rotor angle of the generator
δ_0	Rotor angle before fault inception

The following figure schematically shows the effect of the sudden active-power jump.



[dw_PPD_rotor-angle, 2, en_US]

Figure 6-675 History of the Rotor Angle for Short Circuit near the Power Plant

As the electric torque changes, the angular velocity of the rotor changes linearly with the fault duration. The rotor angle increases quadratically with the fault duration. The rotor angle at the time when the fault is cleared has a considerable influence on the mechanical stress on the shaft assembly.

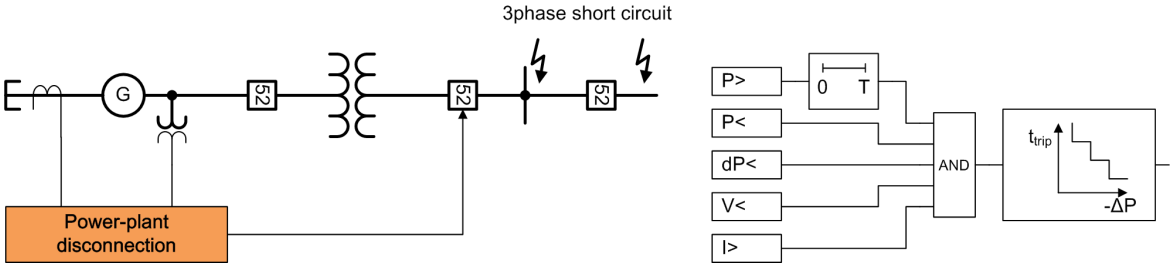
If the voltage does not collapse at the interconnection point, active power can still be output into the power system during the fault. Thereby the change of electric torque is smaller and the stress on the shaft assembly is lower. This means that a longer fault duration is permissible.

Power-plant disconnection avoids an impermissible stress on the shaft assembly. The evaluation of multiple criteria ensures safe functionality:

- Overcurrent — Criterion for detecting short circuits
- Undervoltage — Criterion for detecting undervoltage
- Active power P< — Criterion for detecting active-power decrease

- Active-power release P> — Criterion that the generator has output sufficient active power to the electrical power system before fault inception
- Active-power change dP< — Decisive criterion for determining the stress on the shaft assembly. A multi-stage characteristic curve is possible→ $t_{out} = f(\Delta P)$.

The following figure shows the basic structure. You can find detailed information regarding the implementation under *Logic of the Function, Page 1762* and in chapter *6.67.4 Application and Setting Notes*.



[dw_PPD_power-plant-coupler, 2, en_US]

Figure 6-676 Basic Structure of Power-Plant Disconnection

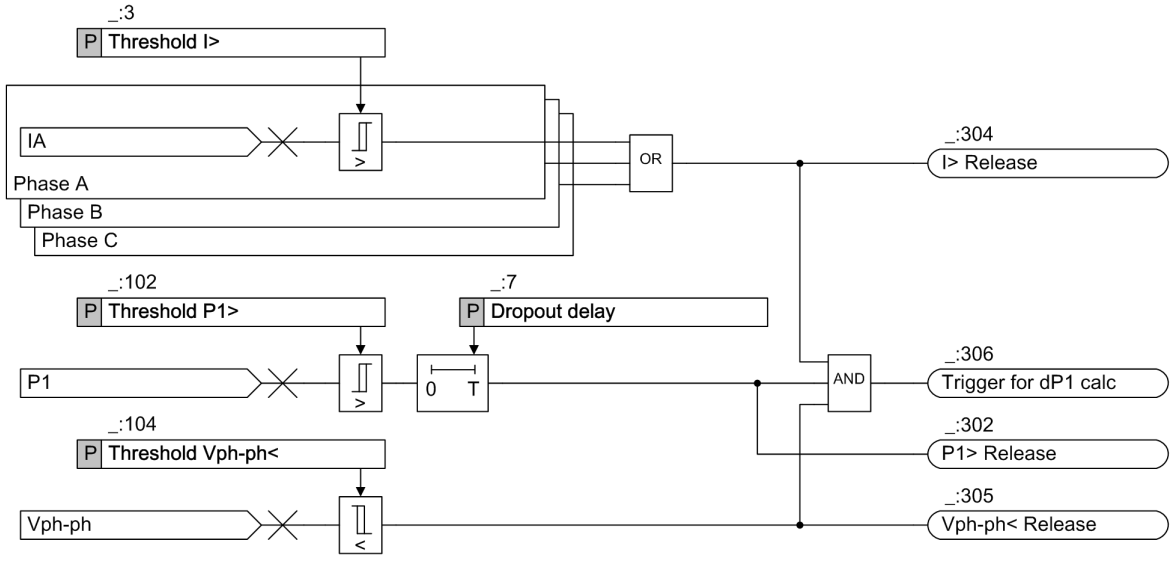
Logic of the Function

The **Power-plant disconnection protection** function includes multiple different criteria. *Figure 6-677* shows the logic for enabling active-power change measurement (dP measurement).

If the following criteria are satisfied, the indication *Trigger for dP1 calc.* is output and the calculation of the active-power difference begins:

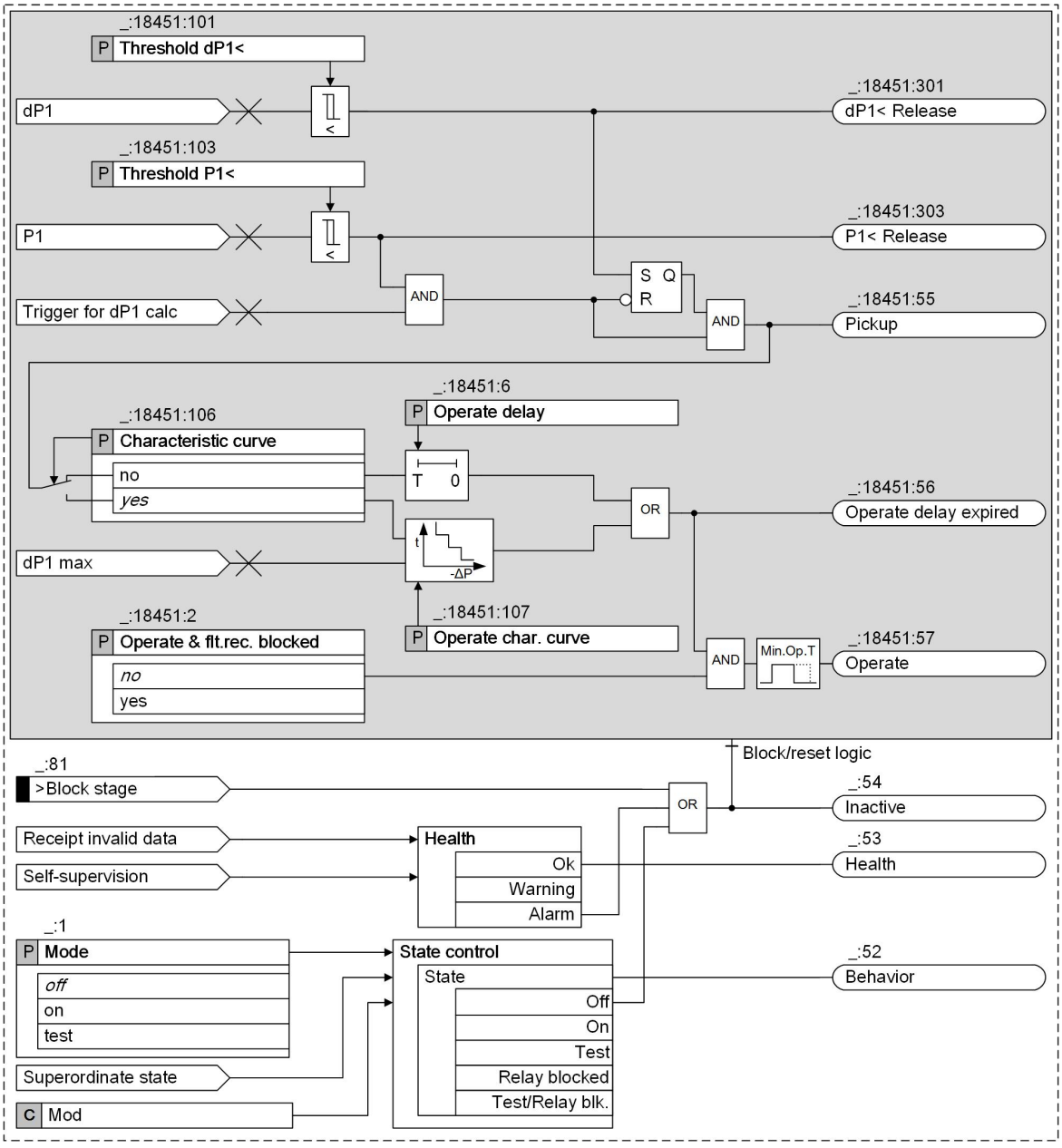
- Overcurrent pickup
- Undervoltage pickup
- Infeed of an appropriate active power from the power-plant unit into the power system

The indication *Trigger for dP1 calc.* describes the calculation time, starting from which the active power before fault inception, P1(t_{prior}) is stored internally. In order to avoid an incorrect measurement during transition processes, the active power is not measured at the time of the trigger; instead the value of approx. 2 cycles before the trigger time is used.



[lo_PPD_db_measurement, 2, en_US]

Figure 6-677 Logic Diagram for Release of dP Measurement



[lo_PPD_function, 3, en_US]

Figure 6-678 Logic Diagram of the Function

Figure 6-678 gives an overview of the implementation and the effect of the individual criteria. The measurands are evaluated every 1/4 cycle so that the function can respond quickly to changes in the power and can – if necessary – quickly fall back. The evaluation of the tracked voltage and current signals at the sampling frequency ensures the high level of measuring accuracy over a wide frequency range.

The measured active power is evaluated solely in percent related to the generator apparent power. It is therefore always less than 100 % and the maximum value is determined under rated conditions by cos φ (power factor). The percentage value for the phase currents is related to the generator rated current; the percentage value for the phase-to-phase voltage is related to the generator rated voltage.

Table 6-29 Implementation and Effect of the Individual Criteria

Criterion	Method of Measurement/Description
I>	Phase-segregated calculation of the fundamental component RMS value • The overcurrent criterion detects the short circuit. The currents are detected on a phase-segregated basis. The vector group of the generator transformer leads only to 2-phase or 3-phase fault currents on the generator side (also see the **Impedance protection** function).
V_{PP}<	Phase-to-phase voltage of the fundamental phasor • The undervoltage criterion detects an external short circuit. In case of a fault, the voltage must be below the threshold value. The undervoltage criterion also makes it possible for the function to drop out if the fault is cleared by the line protection.
P1>	Positive-sequence system active power P1 • If a power plant is operated in the partial-load range, a relatively low load on the shaft assembly can be expected. For this reason, it is checked whether the power-plant unit is feeding in a minimum demand. The criterion is dropout-delayed (parameter: **Dropout delay**), since the threshold value will be undershot in case of a fault.
P1<	Positive-sequence system active power P1 • Falling below an active-power threshold is an additional criterion for fault detection. In the event of a fault, the measured active power must be less than the threshold value.
dP1	$dP1(t) = P1(t_{prior}) - P1(t)$ • This calculates the change of active power starting from fault inception. When a short circuit is detected, the calculation of the power difference begins. The criterion calculates the power difference from the active power before fault inception and the actual active power at the calculation time. For fault detection, the 1st active-power jump is detected and stored in the RS flip-flop. If the preceding conditions are fulfilled and the dP threshold value (query of a negative jump) has been fallen below, the function picks up and the timer is started. If only a fixed time stage (**Characteristic curve** = ***no***) is active, there is tripping after expiration of the time, presuming that all the above conditions are still fulfilled.
dP1max	$dP1(t)max = Max (P1(t_{prior}) - P1(t))$ • If the characteristic curve for protection tripping is to be used, the active-power difference is measured continuously from the trigger time. In contrast to the dP measurement, the maximum active-power difference detected during the pickup is used as a variable in the characteristic curve. This characteristic curve offers the benefit that you can respond according to the level of the active-power change.

By using a multi-stage characteristic curve, you can assign a permissible tripping time to the maximum active-power difference. You can define the number of stages from 2 to 5 and thus optimally adapt the function to the system conditions. Longer tripping times are permitted for small active-power differences.

You can also select only 1 stage. Select between the stagewise operate curve or the defined time.

Functional Measured Values

Functional measured values are available to you so that you can better evaluate the behavior of the function. You can collect these functional measured values in a fault record for example.

Measured Value	Description
P1(t)	Positive-sequence system active power, which is evaluated by the function. The measured value is calculated every 1/4 cycle.
dP1(t)	Continuous representation of the active-power change, starting from the trigger time. With this, you can evaluate the change of the active-power difference at the prefault instant (t_{prior}).
dP1(t)max	This measured value flows into the characteristic curve. It represents the maximum active power during the duration of the fault.

Blocking the Function

You can completely reset the function by using the binary input signal **> Blocking stage**.

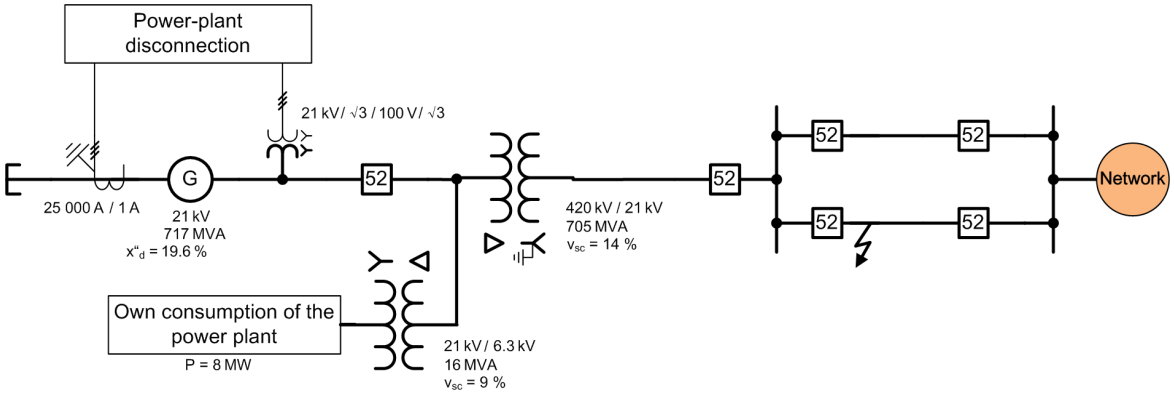
If internal supervision picks up, for example, by interrupting the voltage measuring circuit, the function is blocked.

6.67.4 Application and Setting Notes

For a typical application for a power-plant unit, Siemens recommends the following basic settings. A setting tailored to the power-plant unit, particularly regarding active-power difference and the permissible time delay, is possible only with a power-system study with the specific plant parameter settings. *Figure 6-679* and *Figure 6-680* show typical system configurations and also contain relevant technical data. Preferably load the function into the **Generator stator** or **Voltage-current, 3-phase** function group.

Generator-Stator Function Group

If the function is loaded into the **Generator-stator** function group (see the connection example in *Figure 6-679*), the function must be blocked with the generator circuit breaker open. In the event of a fault in the generator, a fault current still flows for a short time after fault clearing, that is, with an open generator circuit breaker, and therefore there is a risk of an overfunction. Power-plant disconnection remains picked up and opens the high-voltage circuit breaker. This means that you lose the generator transformer and the infeed for internal demand.



[dw_PPD_connection-examples, 2, en_US]

Figure 6-679 Connection Example for the Generator-Stator Function Group

Make the following settings in the **Generator-stator** function group. If calculating with per-unit values, these settings are necessary for scaling the quantities.

NOTE

Make sure that you set the correct generator data in the power-system data.

Parameters: `Rated apparent power`

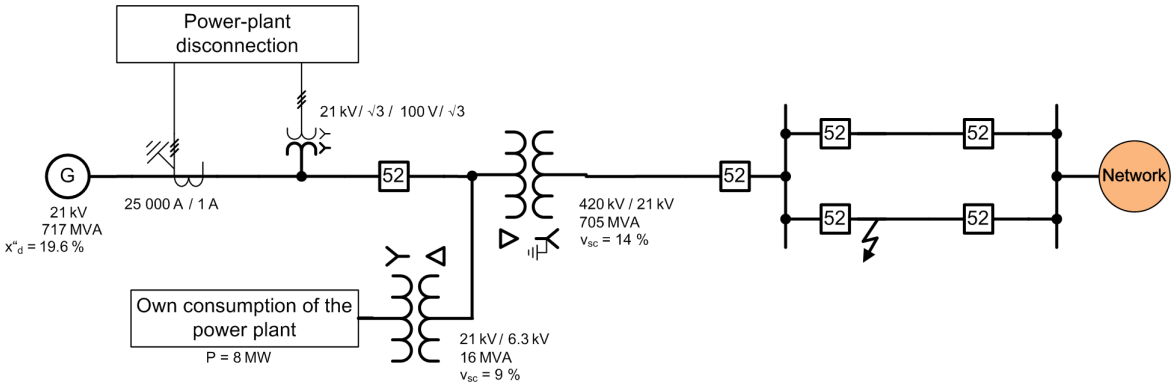
With the parameter **`(_:14671:103) Rated apparent power`**, you set the rated apparent power for the generator to be protected. In the connection example (*Figure 6-679*), that is 717 MVA.

Parameters: `Rated voltage`

With the parameter **`(_:14671:102) Rated voltage`**, you set the rated voltage for the generator to be protected. In the connection example (*Figure 6-679*), that is 21 kV.

The settings for **`Rated apparent power`** and **`Rated voltage`** yield a **`Rated current`** of 717 MVA / (√3 · 21 kV) = 19 712 A.

Load into the Voltage-Current 3-Phase Function Group



[dw_PPD_connection-example 2, 1, en_US]

Figure 6-680 Connection Example for the Voltage-Current 3-Phase Function Group

Make the following settings in the **Voltage-current 3-phase** function group. If calculating with per-unit values, these settings are necessary for scaling the quantities.

NOTE

Make sure that you set the correct generator data in the power-system data.

NOTE

If the current transformer is grounded towards the generator (see *Figure 6-680*), set the parameter **`Neutr.point in dir.of ref.obj`** to ***no***. The parameter can be found in the DIGSI 5 project tree under **Name of the device** → **Settings** → **Power system** → **Measuring point I 3-phase**.

Parameters: `Rated current`

With the parameter **`(_:9451:101) Rated current`**, you set the rated current for the generator to be protected. In the connection example (*Figure 6-680*), that is 19 712 A.

Parameters: `Rated voltage`

With the parameter **`(_:9451:102) Rated voltage`**, you set the rated voltage for the generator to be protected. In the connection example (*Figure 6-680*), that is 21 kV.

The settings for **`Rated current`** and **`Rated voltage`** yield a **`Rated apparent power`** of $\sqrt{3} \cdot 21\ \text{kV} \cdot 19\,712\ \text{A} = 717\ \text{MVA}$.

NOTE

The default settings of the following threshold values are given in percent. In DIGSI 5, you can show the **Percent** mode in the path **Project** → **Device** → **Settings** → **Device settings** → **Edit mode**. You can find more information about the mode in *3.10 General Notes for Setting the Threshold Value of Protection Functions*.

Parameter: `Threshold P1>`

- Default setting **`(_:18451:102) Threshold P1>`** = ***60 %***

With the **`Threshold P1>`** parameter, you can set the active power that a generator must feed into the power system before a short circuit occurs. If the active power fed in is lower than the set value, power-plant disconnection does not pick up.

A typical cos φ value of 0.8 to 0.9 yields a percentage of 80 % to 90 % active power (reference power is the apparent power). Therefore the setting value is more than half the maximum active power. Siemens recommends a value of > 50 % ($P1/S_{rated,Gen}$).

Parameter: Dropout delay

- Default setting **(_:18451:7) Dropout delay** = ***0.5 s***

You must set the parameter **Dropout delay** to be longer than the maximum tripping delay. Also take into account the setting values of the characteristic curve (see *Table 6-30*). After expiration of this time, the storage of the active power before fault inception $P1(t_{prior})$ will be canceled. The determined active-power change relates to $P1(t_{prior})$. The **Dropout delay** is an additional safety criterion for avoiding faulty calculation of the active-power difference.

The default setting is a practicable value. If necessary, you must increase the time somewhat.

Parameter: Threshold P1<

- Default setting **(_:18451:103) Threshold P1<** = ***30 %***

With this parameter, you can set the active power that must be undershot in the case of a short circuit. If the active power is less than the set power, a release signal will be issued. The setting value must be smaller than the **Threshold P1>** setting value. To enable a pickup at residual voltage, you must not set the parameter **Threshold P1<** too low.

The default setting is a practicable value.

Parameter: Threshold Vph-ph<

- Default setting **(_:18451:104) Threshold Vph-ph<** = ***70 %***

To guarantee a reliable pickup, the terminal voltage of the generator during the short circuit close to the power plant must certainly be below the parameter **Threshold Vph-ph<**. This means that you must not set the parameter **Threshold Vph-ph<** too low. On the other hand, you must take the defined voltage range into consideration (typically: +/- 5 % or 7.5 %). It must also be ensured that the voltage safely drops out after fault clearing.

If there are unbalanced short circuits in the power system, unbalanced phase-to-phase voltages will also be measured on the generator side. If there is a 1-phase short circuit on the high-voltage side, only 1 phase-to-phase voltage will dip on the generator side. The voltage threshold is also a criterion for determining the time for the active power before fault inception.

A typical setting range is between 50 % and 75 %. The default setting is a practicable value.



NOTE

When determining the **Threshold Vph-ph<** parameter, note that the fault current leads to a voltage drop across the generator transformer. You must additionally take into account the short-circuit impedance of the transformer (in simplified form, the short-circuit voltage v_{sc}) in this case.

The possible generator-side terminal voltage can be estimated as follows:

$$V\,[\%] \approx v_{sc}\,[\%] \cdot \frac{I''_{3-phase}}{I_{rated,Gen}}$$

[fo_generator terminal voltage, 2, en_US]

Example

v_{sc} = 14 %

$I''_{3\text{-phase}} = 3I_{rated,Gen}$

$$V\,[\%] \approx v_{sc}\,[\%] \cdot \frac{I''_{3-phase}}{I_{rated,Gen}} = 14\,\% \cdot \frac{3I_{rated,Gen}}{I_{rated,Gen}} = 42\,\%$$

[fo_generator terminal voltage, example, 2, en_US]

Parameter: Threshold I>

- Default setting **(_:18451:3) Threshold I>** = *130 %*

In order to detect an external short circuit, define the current pickup value with the **Threshold I>** parameter. The default setting is a practicable value.

You can estimate the initial short-circuit alternating current with the subtransient reactance of the generator x''_d and the short-circuit voltage v_{sc} of the transformer:

$$I''_{3-phase} = \frac{I_{rated\ ,Gen}}{x''_d + v_{sc}}$$

[fo_shortcircit AC current, 2, en_US]

For the numerical example:

$$I''_{3-phase} \approx \frac{I_{rated,Gen} \cdot 100\,\%}{19.6\,\% + 14\,\%} \approx 3I_{rated,Gen}$$

[fo_shortcircit AC current, example, 2, en_US]

The default setting is a practicable value.

Parameter: Threshold dP1<

- Default setting **(_:18451:101) Threshold dP1<** = *-70 %*

With the **Threshold dP1<** parameter, you set the value that leads to pickup of the **Power-plant disconnection** function. The prerequisite is that the above-mentioned conditions have been satisfied. The level of the threshold value is determined, among other things, by the following settings. If you want only 1 fixed stage with a defined tripping time (parameter **Characteristic curve** = *no*), you must set a larger negative threshold value for the active-power change. Assume a 3-phase close-up short circuit without residual voltage. If cos φ = 0.8 and full-load operation is assumed, then the *ideal* active-power change is approx. -80 % (at full load, the active power is 80 % $P/S_{rated,Gen}$ and in the fault case 0 %); this *ideal* state cannot be achieved.

The default setting is a practicable value. The turbo-generator set manufacturer must supply the final value or you determine the value from the dynamic calculations.

If you want to use the characteristic curve (parameter **Characteristic curve** = *yes*), set the parameter **Threshold dP1<** to the lowest threshold value of the characteristic curve (see *Table 6-30*).

Parameter: Operate delay

- Default setting **(_:18451:6) Operate delay** = *0.15 s*

You must set the **Operate delay** parameter on the basis of the application. The turbo-generator set manufacturer will specify the time. Take account of the *Fault Ride Through* capability (FRT capability) from the requirements of the *Grid Code* (grid and system rules of the power-system operator). The FRT capability means that the power-plant unit must remain stable on the power system in the event of a 3-phase short circuit and must not lose synchronism after a fault clearing (asynchronous active-power swing with the power system). A typical FRT time is 0.15 s, which is also the default time delay. Assume an additional pickup delay of approx. 25 ms. The dropout delay is on the same order of the magnitude. 20 ms is used for the estimation.

The **Operate delay** can be estimated as follows:

$$t_{pickup\ -ind.} \geq t_{fault} - t_{pickup} + t_{dropout}$$

[fo_pickupInd.Time, 1, en_US]

$$\text{Operate delay} > t_{\text{pickup -ind.}} + \text{Safety time}$$

[fo_op.DelayTime, 1, en_US]

With:

$t_{\text{pickup-ind.}}$	Pickup indication time
t_{fault}	Maximum permissible fault-clearing time
t_{pickup}	Pickup delay
t_{dropout}	Dropout delay

EXAMPLE

$t_{\text{fault}} = 140$ ms

$t_{\text{pickup}} = 25$ ms

$t_{\text{dropout}} = 20$ ms

$$t_{\text{pickup -ind.}} \geq t_{\text{fault}} - t_{\text{pickup}} + t_{\text{dropout}} = 140\ \text{ms} - 25\ \text{ms} + 20\ \text{ms} = 135\ \text{ms}$$

[fo_pickupInd.Time with data, 1, en_US]

$$\text{Operate delay} > t_{\text{pickup -ind.}} + \text{Safety time} = 135\ \text{ms} + 10\ \text{ms} = 145\ \text{ms}$$

[fo_op.DelayTime with data, 1, en_US]

The parameter **Operate delay** is set to 150 ms (0.15 s).

Parameter: Characteristic curve

- Default setting **(_:18451:106) Characteristic curve** = ***yes***

With the **Characteristic curve** parameter, you specify whether you want to use the characteristic curve or a fixed tripping delay (**Characteristic curve** = ***no***). Siemens recommends the default setting, because you can act with different delays on different active-power changes with the characteristic curve. In that way, you increase the security of supply and avoid an excessively fast power-system disconnection if there are small active-power changes.

Parameters: Operate char. curve

If you use the characteristic curve, you can set the number of desired stages. The number of table values is visible, depending on the setting. 3 stages is a pragmatic approach.

Small active-power changes lead to a smaller stress. For this reason, longer tripping times are permissible. You must request the final values from the turbo-generator set manufacturer or determine them with a dynamic system calculation program that takes account of the system parameter settings.

NOTE

In DIGSI, set the active-power jump of the operate curve in the descending order.

The following table shows an example of a rough estimation of the operate curve setting.

Table 6-30 Operate-Curve Settings of the 3 Stages

Negative Active-Power Jump	Permissible Time Delay
-40 %	0.30 s
-50 %	0.20 s
-65 %	0.15 s

NOTE

Set the **Threshold dP1<** parameter to the smallest value of the characteristic curve.

6.67.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:18451:1	Stage 1:Mode		• off • on • test	off
_:18451:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:18451:101	Stage 1:Threshold dP1<		-100.00 % to -30.00 %	-70.00 %
_:18451:102	Stage 1:Threshold P1>		50.00 % to 100.00 %	60.00 %
_:18451:7	Stage 1:Dropout delay		0.00 s to 60.00 s	0.50 s
_:18451:103	Stage 1:Threshold P1<		0.00 % to 60.00 %	30.00 %
_:18451:3	Stage 1:Threshold I>	1 A @ 100 Irated	0.030 A to 35.000 A	1.300 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.300 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.300 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.500 A
_:18451:104	Stage 1:Threshold Vph-ph<		0.300 V to 175.000 V	70.000 V
_:18451:106	Stage 1:Characteristic curve		• no • yes	yes
_:18451:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.15 s

6.67.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:15781:301	General:P1	MV	O
_:15781:302	General:dP1	MV	O
_:15781:303	General:dP1max	MV	O
_:15781:52	General:Behavior	ENS	O
_:15781:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:52	Group indicat.:Behavior	ENS	O
_:4501:53	Group indicat.:Health	ENS	O
Stage 1			
_:18451:81	Stage 1:>Block stage	SPS	I
_:18451:51	Stage 1:Mode (controllable)	ENC	C

No.	Information	Data Class (Type)	Type
_:18451:54	Stage 1:Inactive	SPS	O
_:18451:52	Stage 1:Behavior	ENS	O
_:18451:53	Stage 1:Health	ENS	O
_:18451:301	Stage 1:dP1< Release	SPS	O
_:18451:302	Stage 1:P1> Release	SPS	O
_:18451:303	Stage 1:P1< Release	SPS	O
_:18451:304	Stage 1:I> Release	SPS	O
_:18451:305	Stage 1:Vph-ph< Release	SPS	O
_:18451:306	Stage 1:Trigger for dP1 calc	SPS	O
_:18451:55	Stage 1:Pickup	ACD	O
_:18451:56	Stage 1:Operate delay expired	ACT	O
_:18451:57	Stage 1:Operate	ACT	O

6.68 Inrush-Current and 2nd Harmonic Detection

6.68.1 Inrush-Current Detection

6.68.1.1 Overview of Functions

The function **Inrush-current detection**

- Recognizes an inrush process on transformers
- Generates a blocking signal for protection functions that protect the transformer (protected object) or for protection functions that are affected in undesirable ways when transformers are switched on
- Allows a sensitive setting of the protection functions

The following protection functions evaluate the blocking signal

- Overcurrent protection with a pickup value below the maximum inrush current
- Negative-sequence protection as sensitive backup protection for transformers
- Distance protection for impedance stages graded through the transformer

NOTE

The Transformer differential protection has its own inrush-current detection.

You can find more information in chapter *6.2.3.6 Differential Protection Function (I-DIFF)* under the section *Inrush-Current Detection*.

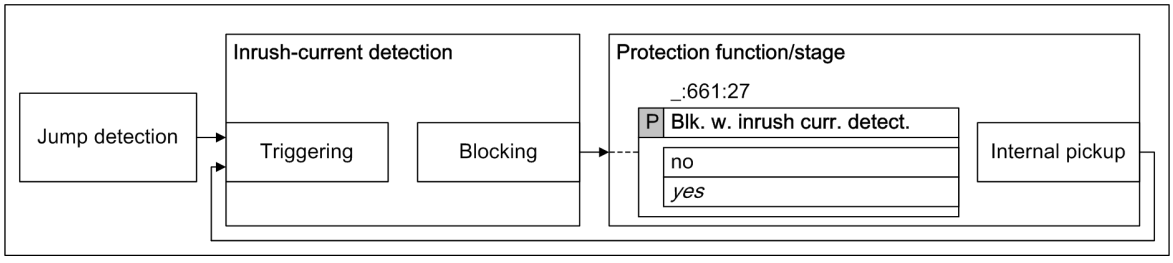
6.68.1.2 Structure of the Function

The function **Inrush-current detection** is not an individual protection function. In the connection process of a transformer, it transmits a blocking signal to other protection functions. For this reason, the inrush-current detection must be in the same function group as the functions that are to be blocked.

The following figure shows the embedding of the function. The setting parameter **`Blk. w. inrush curr. detect.`** establishes the connection between inrush-current detection and the functions that are to be blocked. If the parameter is set to ***`yes`***, the connection is effective.

A jump detection or the threshold value exceeding of the functions to be blocked is used as trigger signal for synchronization of the internal measurement methods.

The jump detection reacts to changes in the current. The threshold value exceeding is recognized due to an internal pickup of the protection function that is to be blocked.



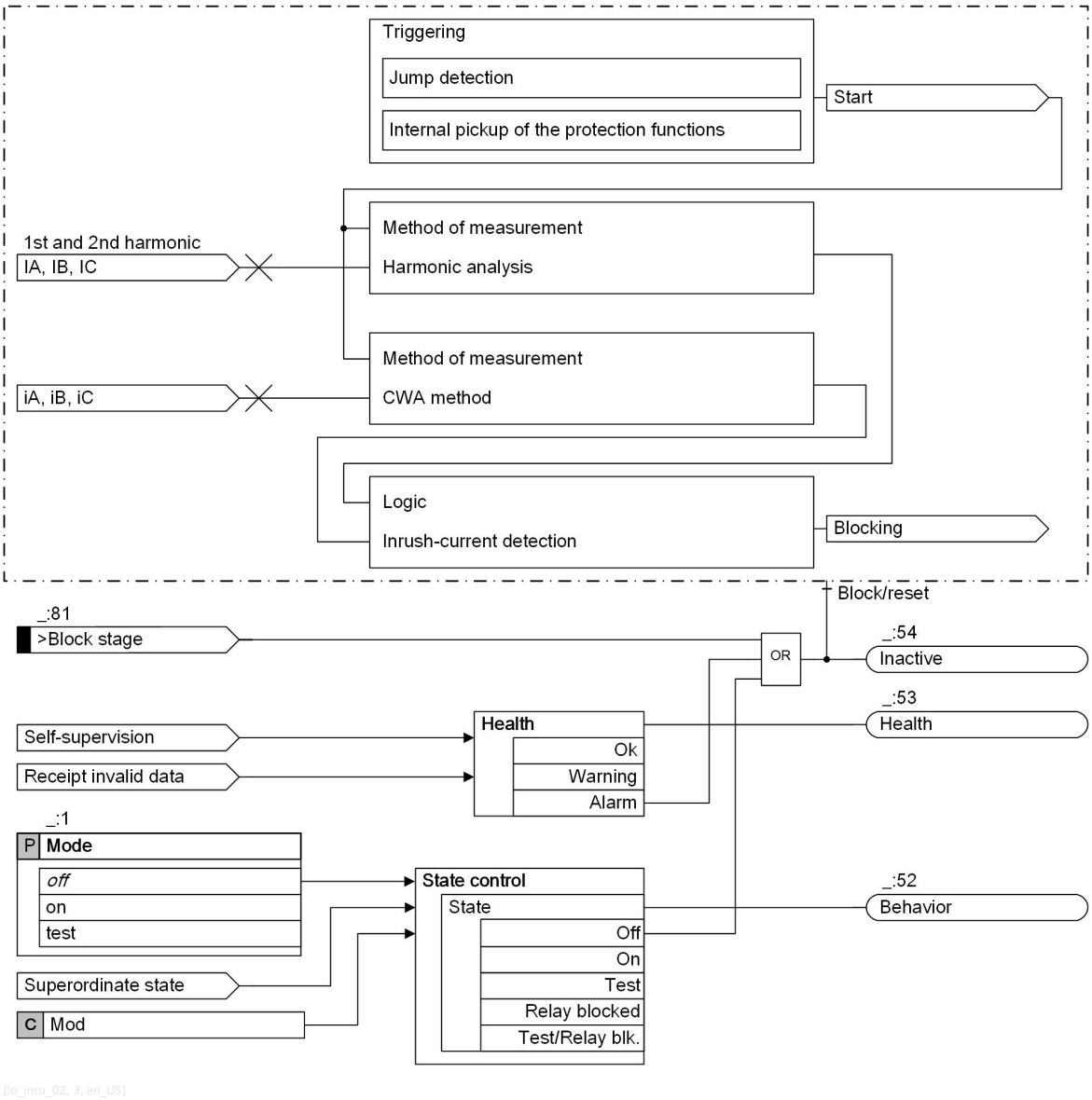
[dw_irsh01, 1, en_US]

Figure 6-681 Structure/Embedding of the Function

6.68.1.3 Function Description

The function **Inrush-current detection** analyzes the trigger signal of the jump detection or the threshold-value violation of the function to be blocked in a start logic and synchronizes the method of measurement. In order to securely record the inrush processes, the function uses the methods of measurement **Harmonic Analysis** and the **CWA method** (current wave shape analysis). Both methods work in parallel and link the results with a logical OR.

If you wish to work with only one process, deactivate the other method by way of the parameters **`Blocking with 2. harmonic`** or **`Blocking with CWA`** .

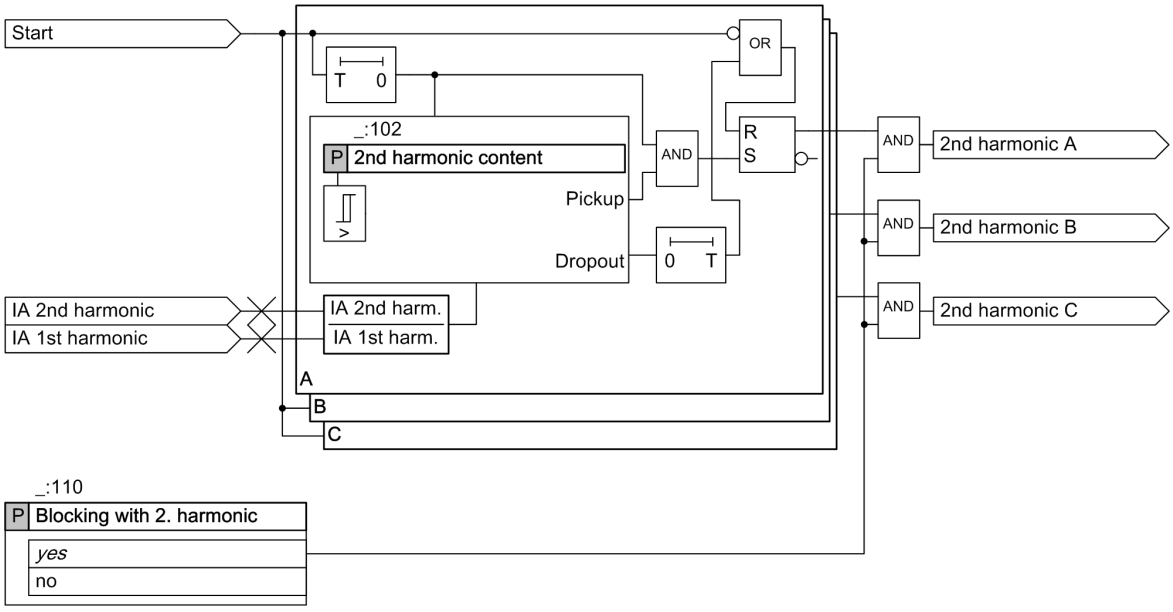


[lo_inru_02, 3, en_US]

Figure 6-682 Basic Structure of the Inrush-Current Detection

Harmonic Analysis

For this method of measurement, the content of the 2nd harmonic and the fundamental component (1st harmonic) are determined for each of the phase currents I_A, I_B, and I_C and the quotient $I_{2nd\ harm}$ / $I_{1st\ harm}$ is formed from this. If this quotient exceeds the set threshold value, a phase-selective signal is issued.
If 75 % of the set threshold value is exceeded, this leads to a pickup reset (dropout ratio = 0.75).

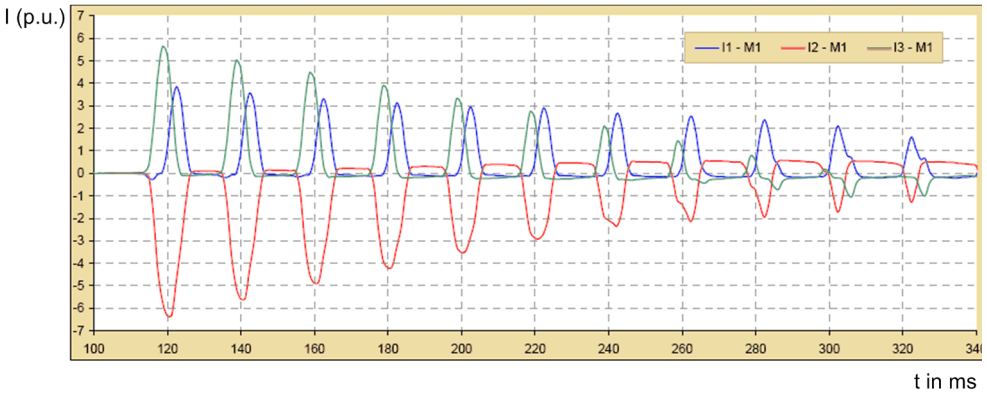


[lo_inrush_10, 1, en_US]

Figure 6-683 Logic of the Harmonic Analysis Function (T = 1 Period)

CWA Method (Current Wave Shape Analysis)

The CWA method executes a wave shape analysis of the phase currents IA, IB, and IC. If all 3 phase currents show flat areas at the same point in time, the inrush-current detection signal will be issued. This signal applies for all 3 phases simultaneously. The following figure shows a typical inrush-current characteristic, with the simultaneously occurring flat areas clearly recognizable.

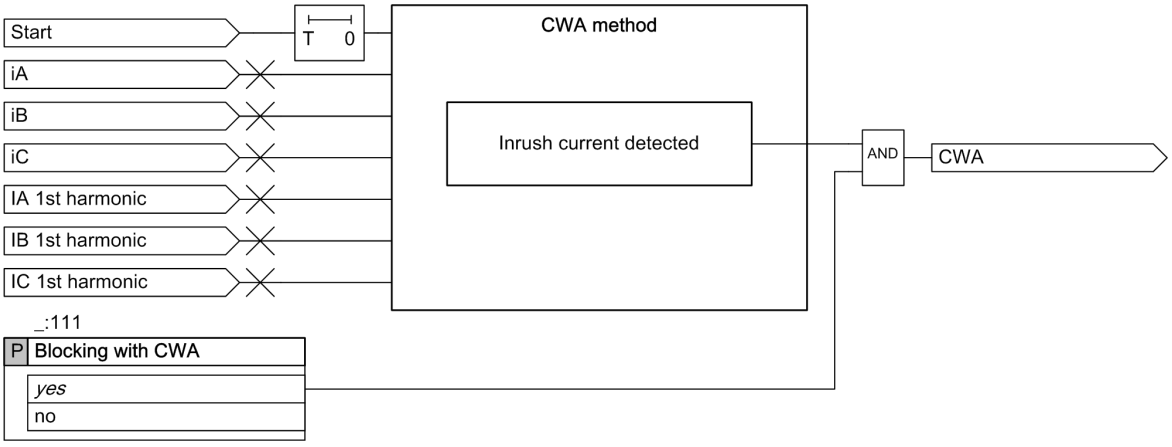


[dw_inrush_03, 1, en_US]

Figure 6-684 Inrush-Current Characteristic

The following figure shows the logic diagram of the CWA method.

From the present fundamental-component current (1st harmonic), the threshold value for identification of the flat areas is derived via an internal factor.



[lo_inrush_05, 1, en_US]

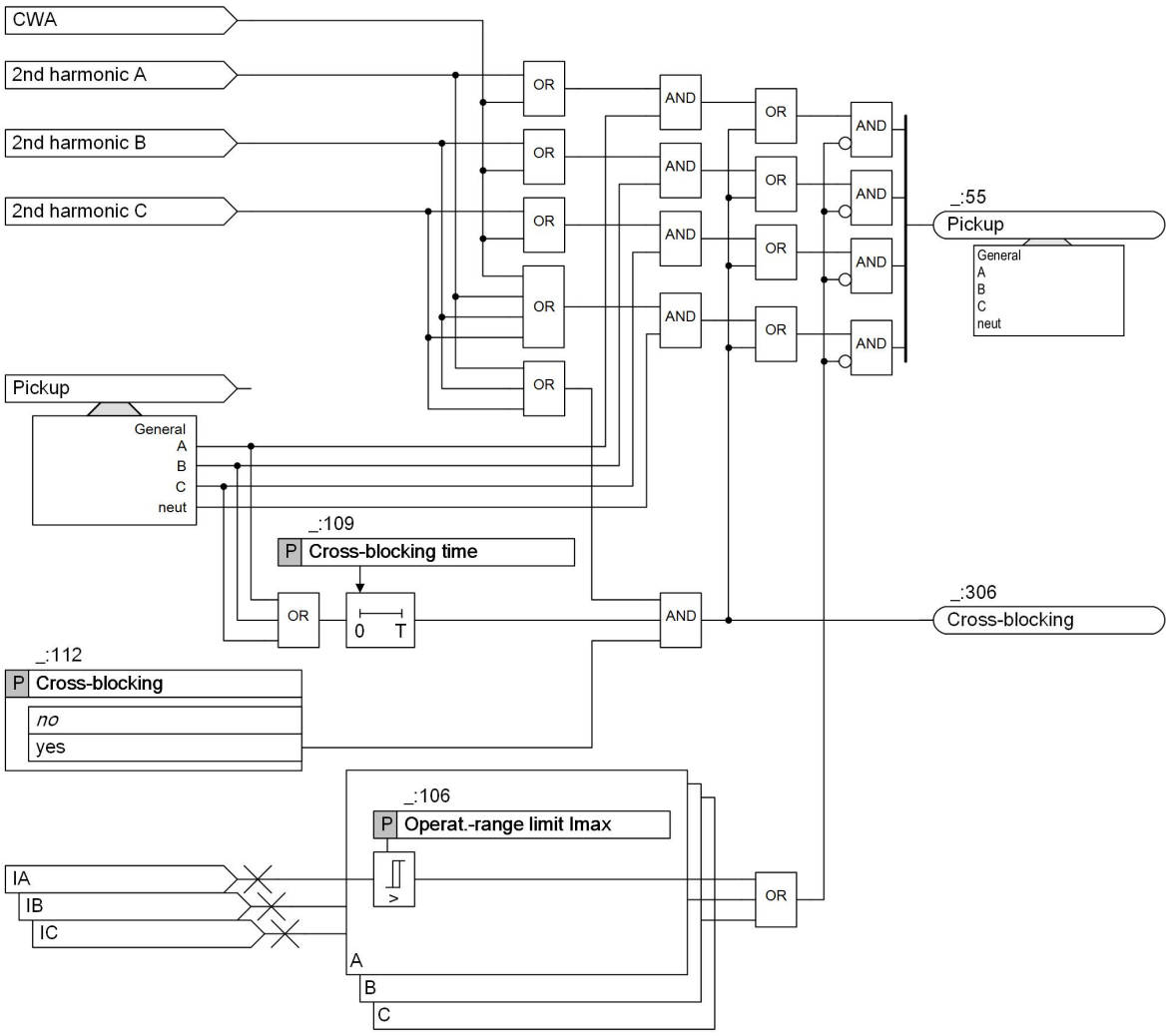
Figure 6-685 Logic of the CWA-Method Function (T = 1 Period)

Logic of the Inrush-Current Detection

The following logic diagram shows the link of the 2 methods of measurement **Harmonic Analysis** and **CWA method**.

The crossblock function influences the **Harmonic Analysis** process. If you have set the parameter **`Cross-blocking`** to ***`yes`***, you will receive a blocking indication in the event of threshold-value violation for all 3 phase currents and the measured or calculated zero-sequence current ($I_{2nd\ harm}$ / $I_{1st\ harm}$). The crossblock function works via a timer. Set parameters for time depending on the expected duration factor via the parameter **`Cross-blocking time`**.

If the phase current exceeds the maximum permissible current **`Operat.-range limit Imax`**, the inrush-current detection will be blocked.



[lo_inrush_12_2_en_US]

Figure 6-686 Logic Diagram of the Inrush-Current Detection

6.68.1.4 Application and Setting Notes

Parameter: Operat.-range limit Imax

- Recommended setting value **(_:106) Operat.-range limit Imax** = ***7.5 A***

  With the parameter **Operat.-range limit Imax**, you can specify at which current the inrush-current detection is blocked internally. Set the value to be greater than the RMS value of the maximum inrush current of the transformer. A practicable value is 7.5 times the transformer rated current.

Parameter: Blocking with CWA

- Recommended setting value = **(_:111) Blocking with CWA** = ***yes***

Parameter Value	Description
yes	**CWA process** activated.
no	**CWA process** deactivated.

Parameter: Blocking with 2. harmonic

- Recommended setting value **(_:110) Blocking with 2. harmonic** = ***yes***

Parameter Value	Description
yes	**Harmonic analysis** process activated.
no	**Harmonic analysis** process deactivated.



NOTE

Make sure that at least one process is activated. Siemens recommends retaining the advised setting values.

Parameter: 2nd harmonic content

- Recommended setting value **(_:102) 2nd harmonic content** = ***15 %***
  With the parameter **2nd harmonic content**, you can specify the pickup value of the harmonic analysis function. The setting value of 15 % is practicable for most transformers.

Parameter: Cross-blocking

- Recommended setting value **(_:112) Cross-blocking** = ***no***

Parameter Value	Description
no	Through the CWA process working in parallel in the inrush-current detection, the function is not activated as standard.
yes	If a subfunction of the inrush-current detection is identified in the course of the closure trials during commissioning, set the parameter **Cross-blocking** to ***yes***.

Parameter: Cross-blocking time

- Default setting **(_:109) Cross-blocking time** = ***0.06 s***
  You define the duration of this blocking with the **Cross-blocking time** parameter. The default setting of ***0.06 s*** (about 3 periods) has proven practicable. Set the time as short as possible and check the value during the closure trials. The parameter **Cross-blocking time** is inactive at **Cross-blocking** = ***no***.

Parameter: Start flt.rec

- Default setting **(_:114) Start flt.rec** = ***yes***
  With the **Start flt.rec** parameter, you determine whether a fault record should be started upon pickup of the inrush-current detection. The following settings are possible:

Parameter Value	Description
no	No fault recording starts with pickup.
yes	The fault recording starts with pickup. When the protection function is blocked by the inrush-current detection, a fault recording is started nevertheless.

6.68.1.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inrush detect.				
_:1	Inrush detect.:Mode		• off • on • test	on

Addr.	Parameter	C	Setting Options	Default Setting
_:106	Inrush detect.:Operat.-range limit Imax	1 A @ 100 Irated	0.030 A to 35.000 A	7.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	37.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	7.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	37.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	7.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	37.500 A
_:111	Inrush detect.:Blocking with CWA		• no • yes	yes
_:110	Inrush detect.:Blocking with 2. harmonic		• no • yes	yes
_:102	Inrush detect.:2nd harmonic content		10 % to 45 %	15 %
_:112	Inrush detect.:Cross-blocking		• no • yes	no
_:109	Inrush detect.:Cross-blocking time		0.03 s to 200.00 s	0.06 s
_:114	Inrush detect.:Start flt.rec		• no • yes	yes

6.68.1.6 Information List

No.	Information	Data Class (Type)	Type
Inrush detect.			
_:81	Inrush detect.:>Block stage	SPS	I
_:54	Inrush detect.:Inactive	SPS	O
_:52	Inrush detect.:Behavior	ENS	O
_:53	Inrush detect.:Health	ENS	O
_:300	Inrush detect.:2.harmonic phase A	SPS	O
_:301	Inrush detect.:2.harmonic phase B	SPS	O
_:302	Inrush detect.:2.harmonic phase C	SPS	O
_:305	Inrush detect.:CWA	SPS	O
_:306	Inrush detect.:Cross-blocking	SPS	O
_:55	Inrush detect.:Pickup	ACD	O

6.68.2 2nd Harmonic Ground Detection

6.68.2.1 Overview of Functions

The **2nd harmonic to ground detection** function:

- Detects the content of 2nd harmonics in the neutral-point phase current **IN** or in the calculated zero-sequence current **3I0**.
- Generates a blocking signal for protection functions that use the neutral-point phase current **IN** or the calculated zero-sequence current **3I0** as a measured value
- Allows a sensitive setting of the protection functions

The following protection functions analyze the blocking signal:

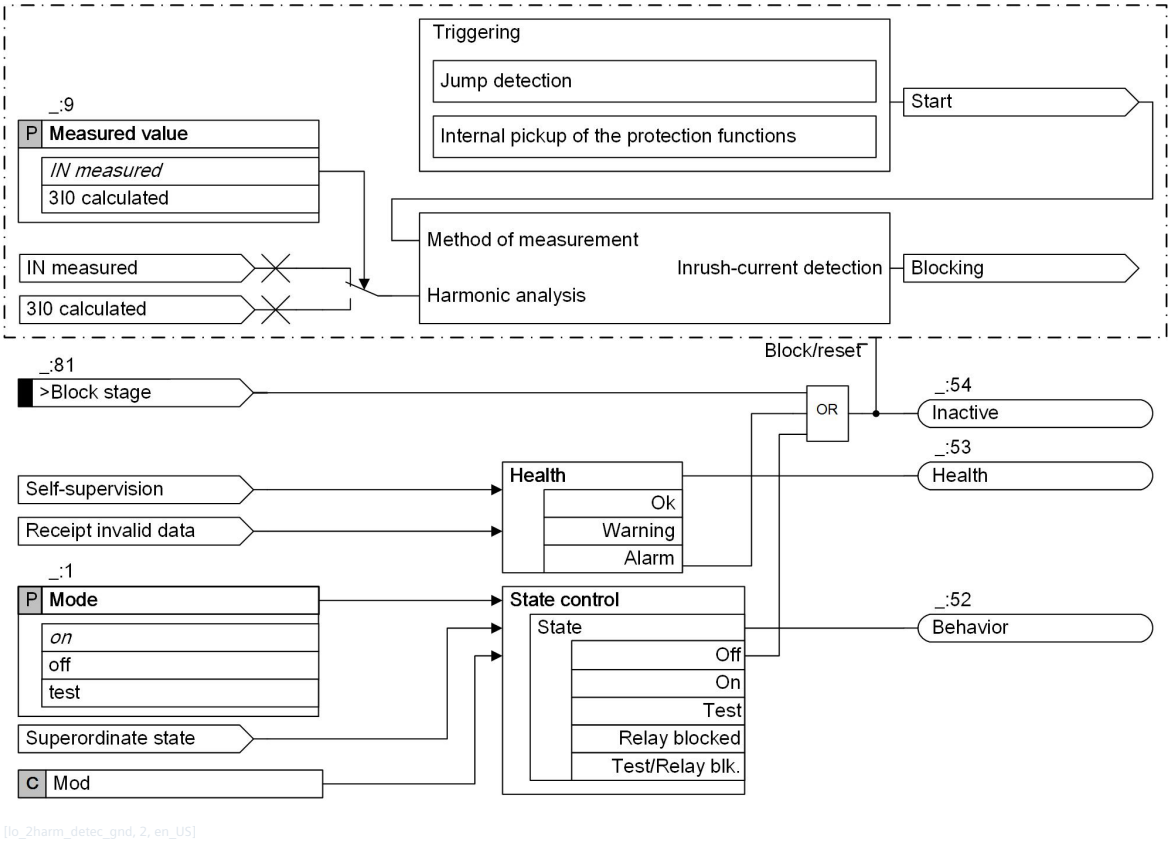
- Overcurrent protection, ground
- Directional sensitive ground-fault detection
- Non-directional sensitive ground-fault detection

6.68.2.2 Structure of the Function

The **2nd harmonic ground detection** function is not an autonomous protection function. In the connection process of a transformer, it sends a blocking signal to other protection functions. For this reason, the **2nd harmonic ground detection** function must be in the same function group as the functions that are to be blocked.

6.68.2.3 Function Description

Logic



[lo_2harm_detec_gnd, 2, en_US]

Figure 6-687 Logic of 2nd Harmonic Detection Ground

Harmonic Analysis

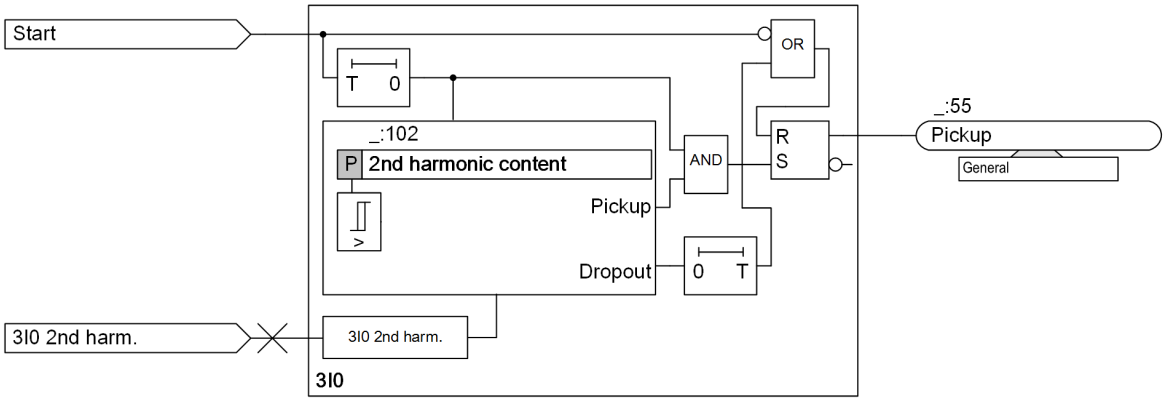
For this method of measurement, the content of the 2nd harmonic and the fundamental component (1st harmonic) is determined for the neutral-point phase current **IN** or the calculated zero-sequence current **3I0** and the quotient $I_{2nd\ harm}/I_{1st\ harm}$ is formed from this. If this quotient exceeds the set threshold value, a blocking signal is issued.

NOTE

During a transformer saturation, the high content of the 2nd harmonic in the ground current must not lead to a pickup of the function.

NOTE

If the ground current is measured in case of a sensitive transformer and the measured value exceeds the saturation threshold of 1.6 · IN, the function switches to the calculated 3I0 value.



[lo_harmon-analyse, 1, en_US]

Figure 6-688 Logic of the Harmonic Analysis Function

6.68.2.4 Application and Setting Notes

Parameter: Measured value

- Default setting = **(_:9) Measured value** = ***IN measured***

Parameter Value	Description
IN measured	The function evaluates the measured neutral-point phase current **IN**.
3I0 calculated	The function evaluates the calculated zero-sequence current **3I0**.

Parameter: 2nd harmonic content

- Default setting **(_:102) 2nd harmonic content** = ***15 %***

With the parameter **2nd harmonic content**, you can specify the percentage content of the 2nd harmonic in ***IN measured*** or in ***3I0 calculated*** at which the inrush-current detection is blocked internally.

6.68.2.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
2.hrm.det. gnd				
_:1	2.hrm.det. gnd:Mode		• off • on • test	on
_:9	2.hrm.det. gnd:Measured value		• 3I0 calculated • IN measured	IN measured
_:102	2.hrm.det. gnd:2nd harmonic content		10 % to 45 %	15 %

6.68.2.6 Information List

No.	Information	Data Class (Type)	Type
2.hrm.det. gnd			
_:81	2.hrm.det. gnd:>Block stage	SPS	I

No.	Information	Data Class (Type)	Type
_:51	2.hrm.det. gnd:Mode (controllable)	ENC	C
_:54	2.hrm.det. gnd:Inactive	SPS	O
_:52	2.hrm.det. gnd:Behavior	ENS	O
_:53	2.hrm.det. gnd:Health	ENS	O
_:55	2.hrm.det. gnd:Pickup	ACD	O

6.68.3 2nd Harmonic Detection 1-Phase

6.68.3.1 Overview of Functions

The **2nd harmonic detection 1-phase** function:

- Detects the content of 2nd harmonics of a 1-phase current
- Generates a blocking signal for protection functions that use this 1-phase current as a measured value
- Allows a sensitive setting of the protection functions

The following protection functions analyze the blocking signal:

- Overcurrent protection, 1-phase

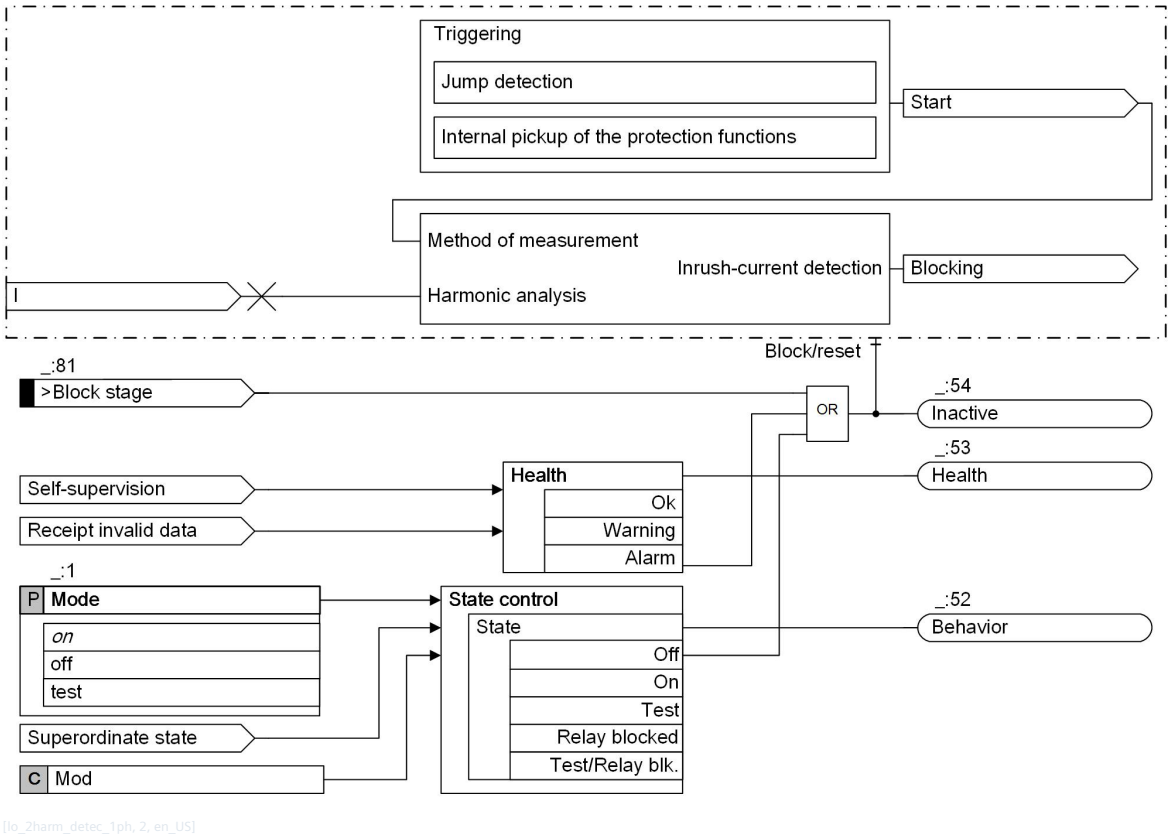
6.68.3.2 Structure of the Function

The function **2nd harmonic detection 1-phase** is not an autonomous protection function. In the connection process of a transformer, it sends a blocking signal to other protection functions. For this reason, the function **2nd harmonic detection 1-phase** must be instantiated in the same function group as the function **Inrush-current detection** and the functions that are to be blocked.

If the function **2nd harmonic detection 1-phase** and the functions to be blocked are not instantiated in the same function group, you must interconnect the protection function groups. Interconnect the protection function groups in the DIGSI 5 **Project tree > Function-group connections > Protection-FG <-> Protection-FG**.

6.68.3.3 Function Description

Logic



[lo_2harm_detec_1ph, 2, en_US]

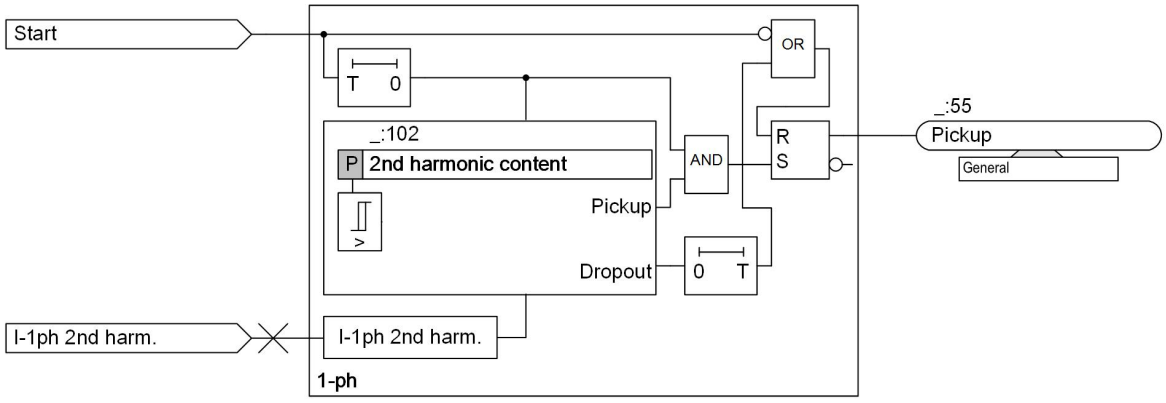
Figure 6-689 Logic of 2nd Harmonic Detection 1-Phase

Harmonic Analysis

For this method of measurement, the content of the 2nd harmonic and the fundamental component (1st harmonic) is determined for the 1-phase current and the quotient $I_{2nd\ harm}/I_{1st\ harm}$ is formed from this. If this quotient exceeds the set threshold value, a blocking signal is issued.

NOTE

During a transformer saturation, the high content of the 2nd harmonic in the 1-phase current must not lead to a pickup of the function.



[lo_harmon-analyse_1ph, 1, en_US]

Figure 6-690 Logic of the Harmonic Analysis Function

6.68.3.4 Application and Setting Notes

Parameter: `2nd harmonic content`

- Default setting **`(_:102) 2nd harmonic content`** = ***`15 %`***

With the parameter **`2nd harmonic content`**, you can specify the percentage content of the 2nd harmonic at which the inrush-current detection is blocked internally.

6.68.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`2.hrm.det. 1ph`				
_:1	2.hrm.det. 1ph:Mode		• off • on • test	on
_:102	2.hrm.det. 1ph:2nd harmonic content		10 % to 45 %	15 %

6.68.3.6 Information List

No.	Information	Data Class (Type)	Type
`2.hrm.det. 1ph`			
_:81	2.hrm.det. 1ph:>Block stage	SPS	I
_:51	2.hrm.det. 1ph:Mode (controllable)	ENC	C
_:54	2.hrm.det. 1ph:Inactive	SPS	O
_:52	2.hrm.det. 1ph:Behavior	ENS	O
_:53	2.hrm.det. 1ph:Health	ENS	O
_:55	2.hrm.det. 1ph:Pickup	ACD	O

6.69 Power Protection (P,Q), 3-Phase

6.69.1 Overview of Functions

The **3-phase power protection (P, Q)** function (ANSI 32) is used to:

- Detect whether the active or reactive power rises above or drops below a set threshold
- Monitor agreed power limits and output warning indications
- Detect both active and reactive power feedback in the power systems or on electric machines
- Detect machines (motors, generators) running without load and output an indication to shut them down.
- Be integrated into any automation solution, for example, to monitor very specific power limits (further logical processing in CFC)

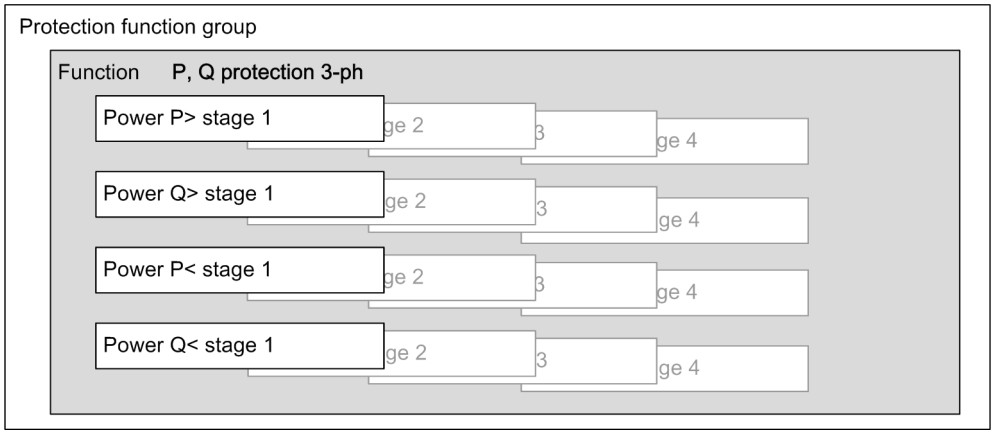
6.69.2 Structure of the Function

The **3-phase power protection (P, Q)** function can be integrated in function groups, which provide measured voltages and currents of the 3-phases for calculation of the power.

The **3-phase power protection (P,Q)** function comes with one factory-set stage each for the active and the reactive power. The following stages are preconfigured:

- Power P>
- Power Q>
- Power P<
- Power Q<

A maximum of 4 active power stages and 4 reactive power stages can be operated simultaneously in the function. The tripping stages have an identical structure.



[dw_GPP 3-phase structure, 2, en_US]

Figure 6-691 Structure/Embedding of the Function

Logical Combination of Output Signals

The operate indications of the active and reactive power stage(s) can be logically combined in CFC. When an operate indication is present in both the active and the reactive power stage, an alarm indication is generated.

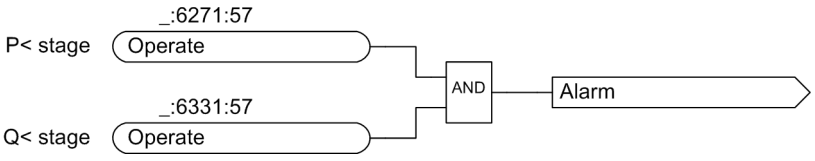


Figure 6-692 Logical Combination of Operate Indications in CFC

6.69.3 Active Power Stage

Logic of a Stage

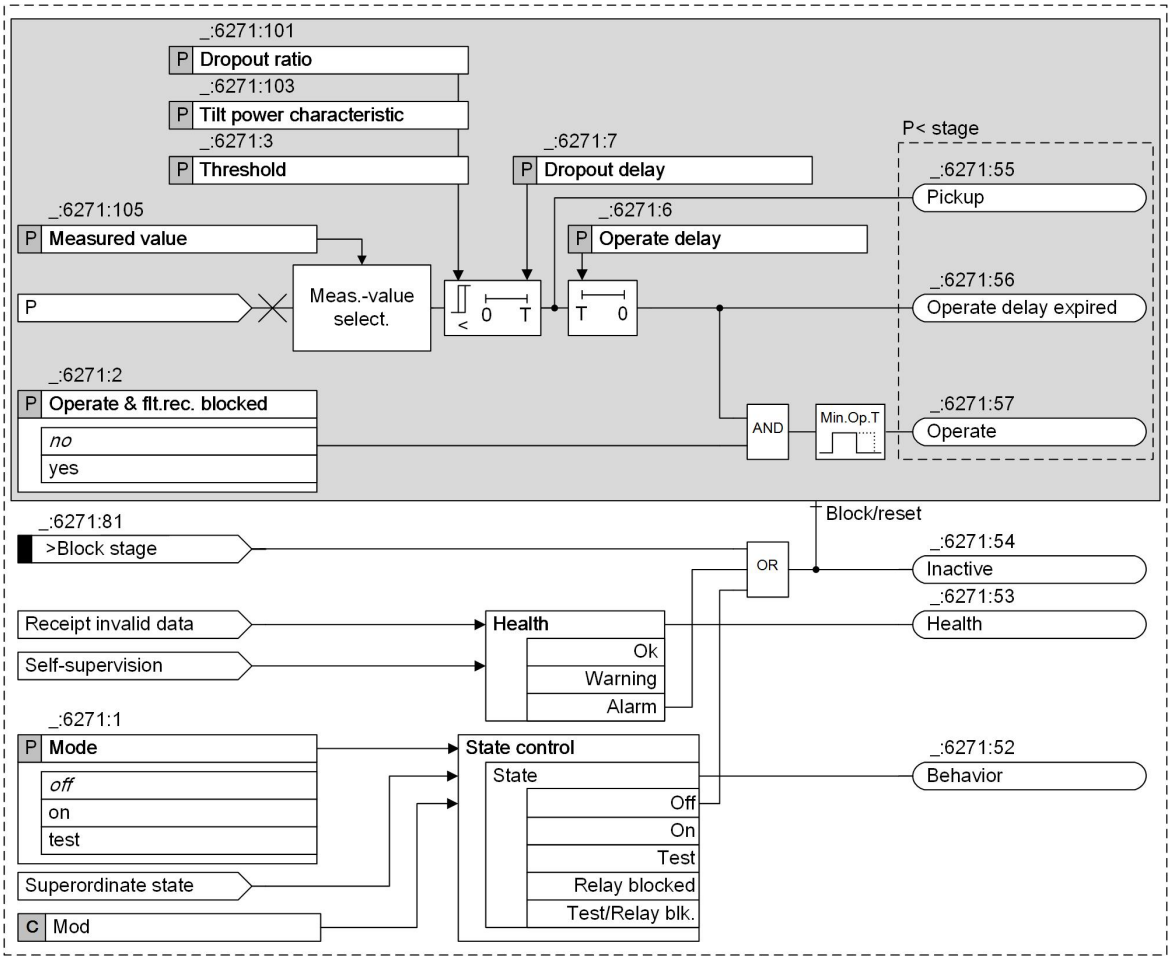


Figure 6-693 Logic Diagram of the Active Power Stage (Stage Type: Power P<)

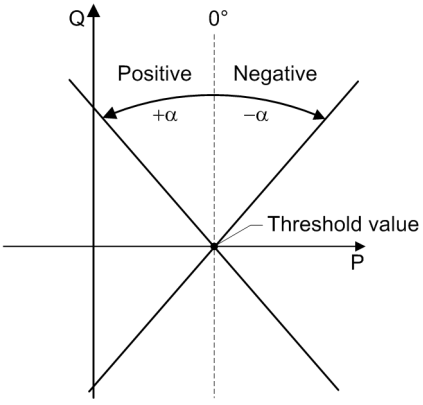
Measured Value

The **Measured value** parameter is used to specify which measured power value is analyzed by the tripping stage. Possible settings are ***positive seq. power*** and the phase-selective powers ***power of phase A***, ***power of phase B*** or ***power of phase C***.

Pickup Characteristic

With the stage type you specify if the stage work as a **greater stage** (stage type: **Power P>**) or as a **smaller stage** (stage type: **Power P<**).

The **Threshold** parameter is used to define the pickup threshold of the stage. The **Tilt power characteristic** parameter is used to define the tilt of the pickup characteristic. The figure below shows the definition of the signs.



[dw_tilt-power active power, 2, en_US]

Figure 6-694 Tilt-Power Characteristic

Pickup

The stage compares the selected power value with the set **Threshold**. Depending on the stage type (**Power P>** or **Power P<**) being above or falling below the threshold value will lead to a pickup.

Dropout Delay

A delay can be set for the dropout when the measured value falls below the dropout threshold. The pickup is maintained for the specified time. The time delay of the tripping (parameter **Operate delay**) continues to run. Once the **Operate delay** has elapsed, the stage trips.

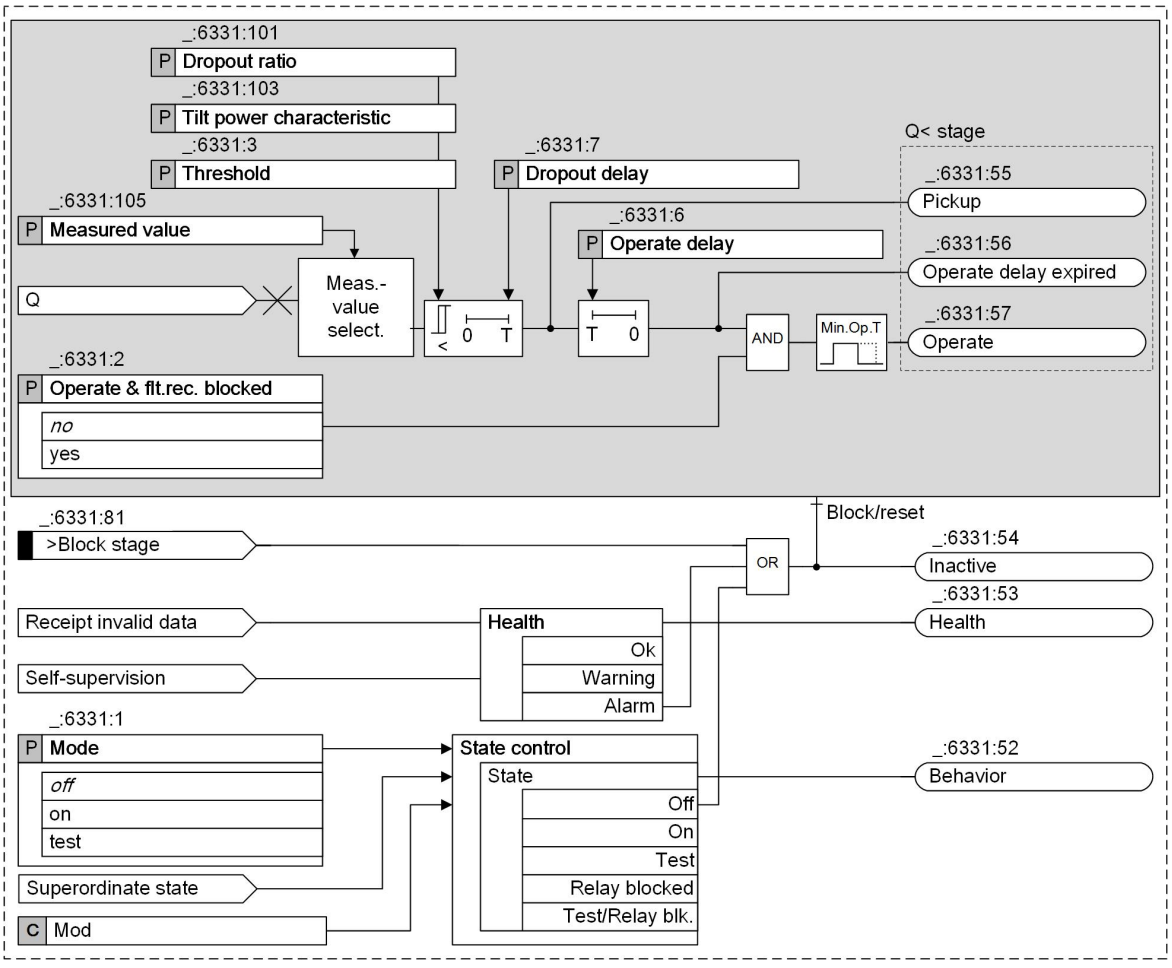
Blocking the Stage

In the event of blocking, a picked-up stage is reset. The following blocking options are available for the stage:

- Internally or externally via the binary input signal *>Block stage*
- The frequency is less than or equal to 10 Hz.

6.69.4 Reactive Power Stage

Logic of a Stage



[lo_3phase reactive power, 3, en_US]

Figure 6-695 Logic Diagram of the Reactive Power Stage (Stage Type: Power Q<)

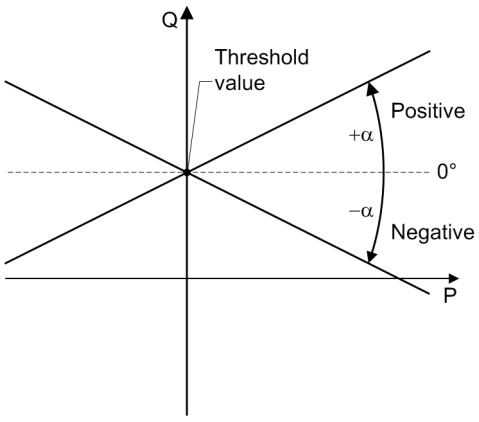
Measured Value

The **Measured value** parameter is used to specify which measured power value is processed by the tripping stage. Possible settings are ***positive seq. power*** and the phase-selective powers ***power of phase A***, ***power of phase B*** or ***power of phase C***.

Pickup Characteristic

With the stage type you specify if the stage work as a **greater stage** (stage type: **Power Q>**) or as a **smaller stage** (stage type: **Power Q<**).

The **Threshold** parameter is used to define the pickup threshold of the stage. The **Tilt power characteristic** parameter is used to define the tilt of the pickup characteristic. The figure below shows the definition of the signs.



[dw_tilt-power reactive power, 2, en_US]

Figure 6-696 Tilt-Power Characteristic

Pickup

The stage compares the selected power value with the set **Threshold**. Depending on the stage type (**Power Q>** or **Power Q<**) being above or falling below the threshold value will lead to a pickup.

Dropout Delay

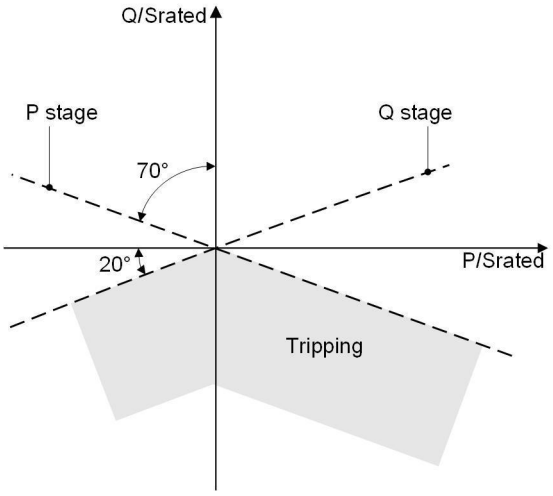
A delay can be set for the dropout when the measured value falls below the dropout threshold. The pickup is maintained for the specified time. The time delay of the tripping (parameter **Operate delay**) continues to run. Once the **Operate delay** has elapsed, the stage trips.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking the stage is possible externally or internally via the binary input signal *>Block stage*.

6.69.5 Application Example

The setting of the function will be explained using an active/reactive power range as an example. If the apparent power phasor is within the power range (in *Figure 6-697* tripping zone defined by characteristics), an alarm indication is generated. For this purpose, you have to make an AND operation of the stage indications of the active and reactive power stage in CFC. The function used is 3-phase power measurement. *Figure 6-697* shows the threshold values and the location of the characteristics in the PQ diagram.



[dw_GPP PQ diagram, 2, en_US]

Figure 6-697 Pickup Values and Characteristic Curves

6.69.6 Setting Notes for the Active Power Stage

Stage Type

In the following example, a drop of the active power below a threshold is to be monitored. In the **3-phase circuit breaker (P, Q)** function, work with the stage type **Power P<**.

Parameter: Measured value

- Recommended setting value **(_:6271:105) Measured value** = ***positive seq. power***

The **Measured value** parameter is used to specify which measured power value is evaluated. For 3-phase measurement, Siemens recommends to evaluate the positive-sequence system power.

Parameter: Threshold

- Recommended setting value **(_:6271:3) Threshold** = ***0 %***

The **Threshold** parameter is used to define the pickup threshold of the active power stage. In the example, the pickup characteristic runs across the point of origin of the coordinates. Set the parameter **Threshold** to ***0 %***.

NOTE

If you use several settings groups, consider the following:

- The threshold of a stage must have the same sign in all settings groups.
- Switching from a positive threshold to a negative threshold or vice versa is not allowed. As a result, DIGSI reports an inconsistency.
- If you want to change the sign of the threshold of a stage in an additional settings group, instantiate a new stage and enable it. If the new stage should not be effective in another settings group, disable the stage there.

Parameter: Dropout ratio

- Recommended setting value **(_:6271:101) Dropout ratio** = ***1.05***

A hysteresis of 5 % is sufficient for most applications. The setting value for the **lower stage** is therefore 1.05.

Parameter: Tilt power characteristic

- Recommended setting value **(_:6271:103) Tilt power characteristic** = ***+70°***

The **Tilt power characteristic** parameter is used to incline the pickup characteristic. In the above example, an inclination is required. The setting value is ***+70°*** (for a definition of the sign, see *Figure 6-694*).

Parameter: Dropout delay

- Recommended setting value **(_:6271:7) Dropout delay** = ***20 ms***

The **Dropout delay** parameter maintains the pickup even if the measured value drops momentarily below the threshold value. A delay is required for very low pickup values to prevent a so-called chattering of the function. In the example, the setting value is 20 ms.

Parameter: Operate delay

- Recommended setting value **(_:6271:6) Operate delay** = ***100 ms***

The **Operate delay** must be set for the specific application. In the example, a setting value of 100 ms has been selected.

6.69.7 Setting Notes for the Reactive Power Stage

Stage Type

In the example, the reactive power is to be monitored if it falls below the threshold. In the **3-phase circuit breaker (P, Q)** function, work with the stage type **Power Q<**.

Parameter: Measured value

- Recommended setting value **(_:6331:105) Measured value** = ***positive seq. power***

The **Measured value** parameter is used to specify which measured power value is evaluated. For 3-phase measurement, Siemens recommends to evaluate the positive-sequence system power.

Parameter: Threshold

- Recommended setting value **(_:6331:3) Threshold** = ***0 %***

The **Threshold** parameter is used to define the pickup threshold of the reactive power stage. In the example, the pickup characteristic runs across the point of origin of the coordinates. Set the parameter **Threshold** to ***0 %***.

NOTE

If you use several settings groups, consider the following:

- The threshold value of a stage must have the same sign in all settings groups.
- Switching from a positive threshold value to a negative threshold value or vice versa is not allowed. As a result, DIGSI reports an inconsistency.
- If you want to change the sign of the threshold value of a stage in an additional settings group, instantiate a new stage and enable it. If the new stage should not be effective in another settings group, disable the stage there.

Parameter: Dropout ratio

- Recommended setting value **(_:6331:101) Dropout ratio** = ***0.95***

A hysteresis of 5 % is sufficient for most applications. The setting value for the **lower stage** is therefore 0.95.

Parameter: Tilt power characteristic

- Recommended setting value **(_:6331:103) Tilt power characteristic** = ***+20°***

The **Tilt power characteristic** parameter is used to incline the pickup characteristic. In the example (see *Figure 6-697*), the power characteristic has a tilt of 20°. Set the **Tilt power characteristic** parameter to ***+20°*** (for a definition of the sign, see *Figure 6-696*).

Parameter: Dropout delay

- Recommended setting value **(_:6331:7) Dropout delay** = ***20 ms***

The **Dropout delay** parameter maintains the pickup even if the measured value drops momentarily below the threshold value. A delay is required for very low pickup values to prevent a so-called chattering of the function. In the example, the setting value is 20 ms.

Parameter: Operate delay

- Recommended setting value **(_:6331:6) Operate delay** = ***100 ms***

The **Operate delay** must be set for the specific application. In the example, a setting value of 100 ms has been selected.

6.69.8 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Power P> 1				
_:6241:1	Power P> 1:Mode		• off • on • test	off
_:6241:2	Power P> 1:Operate & flt.rec. blocked		• no • yes	no
_:6241:104	Power P> 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6241:3	Power P> 1:Threshold		-200.0 % to -1.0 % 1.0 % to 200.0 %	80.0 %
_:6241:101	Power P> 1:Dropout ratio		0.90 to 0.99	0.95
_:6241:103	Power P> 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °
_:6241:7	Power P> 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6241:6	Power P> 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power P< 1				
_:6271:1	Power P< 1:Mode		• off • on • test	off
_:6271:2	Power P< 1:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:6271:105	Power P< 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6271:3	Power P< 1:Threshold		-200.0 % to -1.0 % 1.0 % to 200.0 %	5.0 %
_:6271:101	Power P< 1:Dropout ratio		1.01 to 1.10	1.05
_:6271:103	Power P< 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °
_:6271:7	Power P< 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6271:6	Power P< 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power Q> 1				
_:6301:1	Power Q> 1:Mode		• off • on • test	off
_:6301:2	Power Q> 1:Operate & flt.rec. blocked		• no • yes	no
_:6301:105	Power Q> 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6301:3	Power Q> 1:Threshold		-200.0 % to -1.0 % 1.0 % to 200.0 %	70.0 %
_:6301:101	Power Q> 1:Dropout ratio		0.90 to 0.99	0.95
_:6301:103	Power Q> 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °
_:6301:7	Power Q> 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6301:6	Power Q> 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power Q< 1				
_:6331:1	Power Q< 1:Mode		• off • on • test	off
_:6331:2	Power Q< 1:Operate & flt.rec. blocked		• no • yes	no
_:6331:105	Power Q< 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6331:3	Power Q< 1:Threshold		-200.0 % to -1.0 % 1.0 % to 200.0 %	-30.0 %
_:6331:101	Power Q< 1:Dropout ratio		0.90 to 0.99	0.95
_:6331:103	Power Q< 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °
_:6331:7	Power Q< 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6331:6	Power Q< 1:Operate delay		0.00 s to 60.00 s	1.00 s

6.69.9 Information List

No.	Information	Data Class (Type)	Type
Power P> 1			
_:6241:81	Power P> 1:>Block stage	SPS	I
_:6241:54	Power P> 1:Inactive	SPS	O
_:6241:52	Power P> 1:Behavior	ENS	O
_:6241:53	Power P> 1:Health	ENS	O
_:6241:55	Power P> 1:Pickup	ACD	O
_:6241:56	Power P> 1:Operate delay expired	ACT	O
_:6241:57	Power P> 1:Operate	ACT	O
Power P< 1			
_:6271:81	Power P< 1:>Block stage	SPS	I
_:6271:54	Power P< 1:Inactive	SPS	O
_:6271:52	Power P< 1:Behavior	ENS	O
_:6271:53	Power P< 1:Health	ENS	O
_:6271:55	Power P< 1:Pickup	ACD	O
_:6271:56	Power P< 1:Operate delay expired	ACT	O
_:6271:57	Power P< 1:Operate	ACT	O
Power Q> 1			
_:6301:81	Power Q> 1:>Block stage	SPS	I
_:6301:54	Power Q> 1:Inactive	SPS	O
_:6301:52	Power Q> 1:Behavior	ENS	O
_:6301:53	Power Q> 1:Health	ENS	O
_:6301:55	Power Q> 1:Pickup	ACD	O
_:6301:56	Power Q> 1:Operate delay expired	ACT	O
_:6301:57	Power Q> 1:Operate	ACT	O
Power Q< 1			
_:6331:81	Power Q< 1:>Block stage	SPS	I
_:6331:54	Power Q< 1:Inactive	SPS	O
_:6331:52	Power Q< 1:Behavior	ENS	O
_:6331:53	Power Q< 1:Health	ENS	O
_:6331:55	Power Q< 1:Pickup	ACD	O
_:6331:56	Power Q< 1:Operate delay expired	ACT	O
_:6331:57	Power Q< 1:Operate	ACT	O

6.70 Reverse-Power Protection

6.70.1 Overview of Functions

The **Reverse-power protection** function (ANSI 32R):

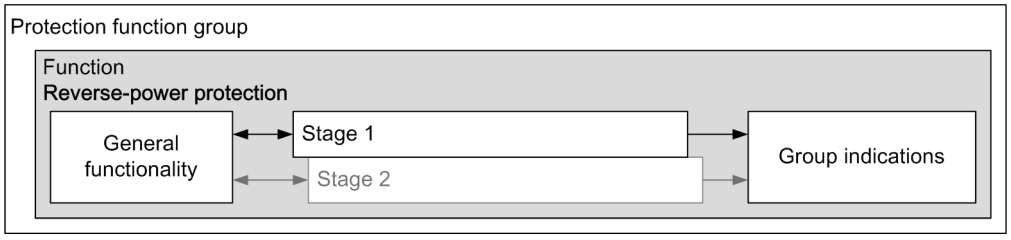
- Monitors the motor operation of generators and thus detects driving-power failure
- Prevents endangering the turbine (e.g. the turbine-blade damage due to overheating) by opening the circuit breaker of the system
- Protects a turbo-generator set

For the generator, there is a danger that the turbo-generator set accelerates and reaches overspeed in case of an incorrect residual-steam passage (quick-stop valves defective) after the circuit breaker has opened. Consequently, disconnecting the system (opening the circuit breaker of the system) shall only occur after reverse power (active-power consumption) has been detected.

6.70.2 Structure of the Function

The **Reverse-power protection** function comes factory-set with 1 stage. A maximum of 2 stages can be operated simultaneously within the function.

In all function groups, the function works with a 3-phase voltage and current interface. Depending on the current transformer used, this is the **Voltage/current 3-phase** function group or the **Generator stator** function group.



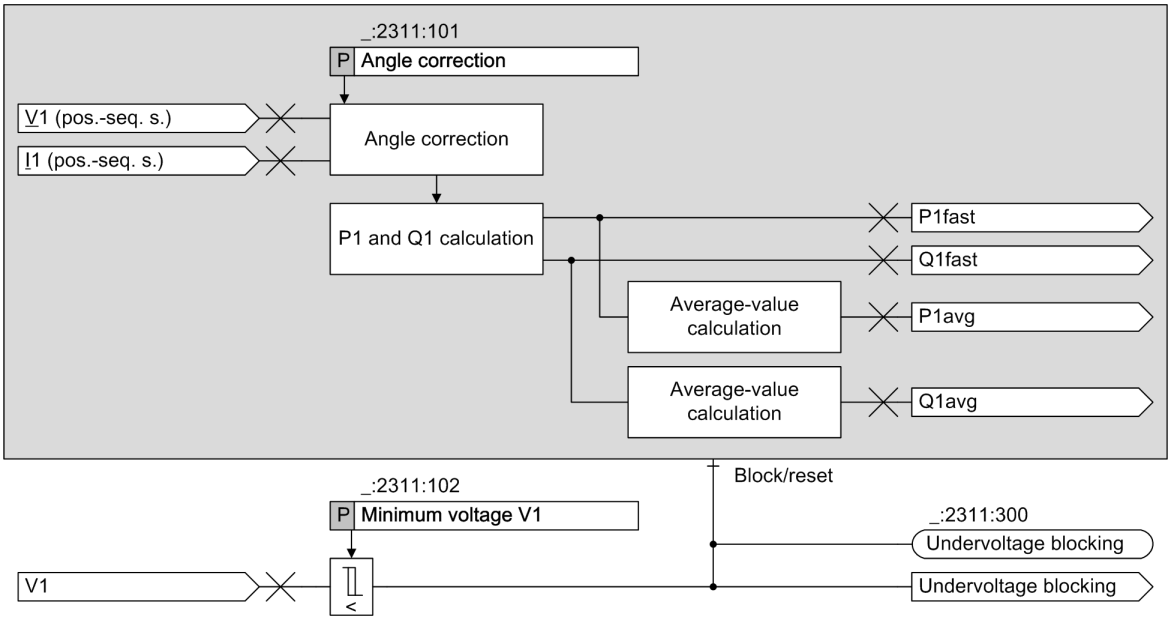
[dw_rpp_structure, 3, en_US]

Figure 6-698 Structure/Embedding of the Function

6.70.3 General Functionality

6.70.3.1 Description

Logic of the Function



[lo_RPP general functionality, 2, en_US]

Figure 6-699 Logic Diagram of the Cross-Stage Functionality

Calculating the Reverse Power

The reverse-power protection calculates the active power from the symmetrical components of the fundamental components of the voltages and currents. It generates the average value of the active power over a fixed number of cycles. Since positive-sequence variables are used for evaluation, the reverse power is determined independently of unbalance in currents or voltages. The frequency-tracking sampled values are used for calculation. The determined reverse power corresponds to the load on the driving-power side. The calculated active-power value corresponds to the total active power.

Taking the phase-displacement angle of the voltage and current transformers into account, the function calculates the exact active power even with a high apparent power and a small cos φ. A constant correction angle φ_{corr} makes correction possible. The influence of the current-transformer angle error is predominant here. Determine this constant correction angle when you commission the protection device in the plant and adjust it as specified in the table (see *Table 11-6*).

Power Calculation and Angle Correction

To satisfy the high measuring-accuracy requirements, the power measured value is additionally averaged over 16 cycles before it is supplied to the protection function. The active power is calculated from the symmetrical-component vectors of voltage V1 and current I1. The total power is evaluated as power. The complex apparent power results from the following relationship. The real component is the active power:

$\underline{S} = 3\underline{V}_1 \cdot \underline{I}_1^{\,*} = 3V_1\, e^{j\phi V} \cdot I_1\, e^{-j\phi I} = 3V_1\, I_1\, e^{j(\phi V - \phi I)}$

$P = 3V_1\, I_1 \cos(\varphi_V - \varphi_I)$

The angle error between voltage transformer and current transformer has a strong influence on the measuring accuracy. With the parameter **(_:2311:101) Angle correction** , you can correct the angle error. The following 2 methods are possible here:

- Determine the angle error from the transformer test report data. Ask the transformer manufacturer for these values when you order the transformer.
- While the generator is connected to the power system, measure to determine the angle error (see chapter *11.16.2 Primary Test*).

The influence on the power-system voltage makes it very difficult to test high-power generators with a measurement while the generator is connected to the power system. In this case, you must determine the angle error from the transformer test report data (see chapter *6.70.3.2 Application and Setting Notes*). Alternatively, you can use instrument transformers with small angle errors. This is ensured with class 0.2 instrument transformers (voltage and current). The following equation describes the influence of the angle error:

$P = 3V_1\, I_1 \cos(\varphi_V + \varphi_{V,F} - (\varphi_I + \varphi_{I,F})) = 3V_1\, I_1 \cos(\varphi_U - \varphi_I + (\varphi_{V,F} - \varphi_{I,F}))$

The angle error to be corrected results as:

$\phi_{Corr} = \varphi_{V,F} - \varphi_{I,F}$

To rotate in the correct direction, the correction angle is considered with inverted sign inside the unit.

Functional Measured Values

You can use the following functional measured values to check the behavior of the protection function and to support commissioning. The total power is represented as the measured value.

Measured Value	Description	
P1fast	Positive-sequence system active power calculated per cycle	Angle correction influences the measured value
Q1fast	Positive-sequence system reactive power calculated per cycle	Angle correction influences the measured value
P1avg	Positive-sequence system active power calculated from **P1fast** over 16 cycles	Input value for Reverse-power protection
Q1avg	Positive-sequence system reactive power calculated from **Q1fast** over 16 cycles	–

6.70.3.2 Application and Setting Notes

In the general functionality, you can adjust the parameter **(_:2311:101) Angle correction**. The parameter results from the angle error of the primary transformer. In SIPROTEC 5, the input transformers are calibrated so that the angle error is negligible. You can assume an error of < 0.1°. There is no difference between a protection input and an instrument-transformer input.



NOTE

If you use class 0.2 instrument transformers on the primary side to avoid the influence of the angle, you can connect a protection device with a protection current transformer without any problems.

Class 0.2 voltage transformers have a maximum admissible angle error of 10 min (0.17°). The angle error of a class 0.2 measuring current transformer at rated current is approximately 10 min, at 0.2 I_{rated} = 15 min, and at 0.05 I_{rated} = 30 min.

Parameter: Angle correction

- Default setting **(_:2311:101) Angle correction** = 0°

To determine the correction angle via measurement with the primary system, follow the instructions in chapter *11.16.2 Primary Test*.

You can use the method that is explained in the following section to derive the necessary correction angle from the transformer measuring reports.

Example

This example uses a class 0.2 voltage transformer with a rated burden of 45 VA. The following data was taken from the measuring report.

Table 6-31 For Phase A

V/Vn	$S_b = S_{br}$		$S_b = S_{br}/4$	
	ϵ_v [%]	δ_v [min]	ϵ_v [%]	δ_v [min]
0.8	-0.14	0.31	0.16	-0.34
1	-0.15	0.43	0.15	-0.24
1.2	-0.16	0.68	0.14	-0.06

The values resulting for the phases B and C are almost identical.

Furthermore, a termination with a rated burden (other measuring devices are still connected) is assumed so that an angle error of +0.43 min (rated-voltage value) is used as the calculation variable.

A current transformer of type 5PR is used here. This current transformer features a gap that limits the remanence to 10 %. However, this gap results in larger angle errors. The following tables show excerpts from the test reports.

Table 6-32 Phase A

I/I_n [%]	$Sb = S_{br}$ (cos β = 0.8)	
	ϵ_i [%]	δ_i [min]
100	0.314	46.40

Table 6-33 Phase B

I/I_n [%]	$Sb = S_{br}$ (cos β = 0.8)	
	ϵ_i [%]	δ_i [min]
100	0.247	35.10

Table 6-34 Phase C

I/I_n [%]	$Sb = S_{br}$ (cos β = 0.8)	
	ϵ_i [%]	δ_i [min]
100	0.702	41.10

Since the positive-sequence system power is evaluated in the device, take the sign into account when you add the angle errors per phase, and divide the result by 3.

The following value results in this example:

$$\delta_i[\text{min}] = \frac{1}{3}\left(\delta_{i,A} + \delta_{i,B} + \delta_{i,C}\right) = \frac{1}{3}(46.40 + 35.10 + 41.10) = 40.87\ \text{min}$$

The resulting correction angle is:

$$\varphi_{corr}\,[\text{min}] = \varphi_{V,F} - \varphi_{I,F} = 0.43\ \text{min} - 40.87\ \text{min} = -40.44\ \text{min}$$

$$\varphi_{corr}[^\circ] = \frac{\varphi_{corr[\text{min}]}}{60} \cdot 1^\circ = \frac{-40.44}{60} \cdot 1^\circ = -0.674^\circ$$

Set the parameter **(_:2311:101) Angle correction** = ***-0.67***°.

Parameter: **`Minimum voltage V1`**

- Default setting **`(_:2311:102) Minimum voltage V1`** = 5.000 V

With the parameter **`Minimum voltage V1`**, you can limit the operating range of the reverse-power protection. If the positive-sequence voltage falls below the set value, the reverse-power protection is deactivated. If no other restrictions are known, Siemens recommends using the default setting.

6.70.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Angle correction		-10.00 ° to 10.00 °	0.00 °
_:2311:102	General:Minimum voltage V1		0.300 V to 60.000 V	5.000 V

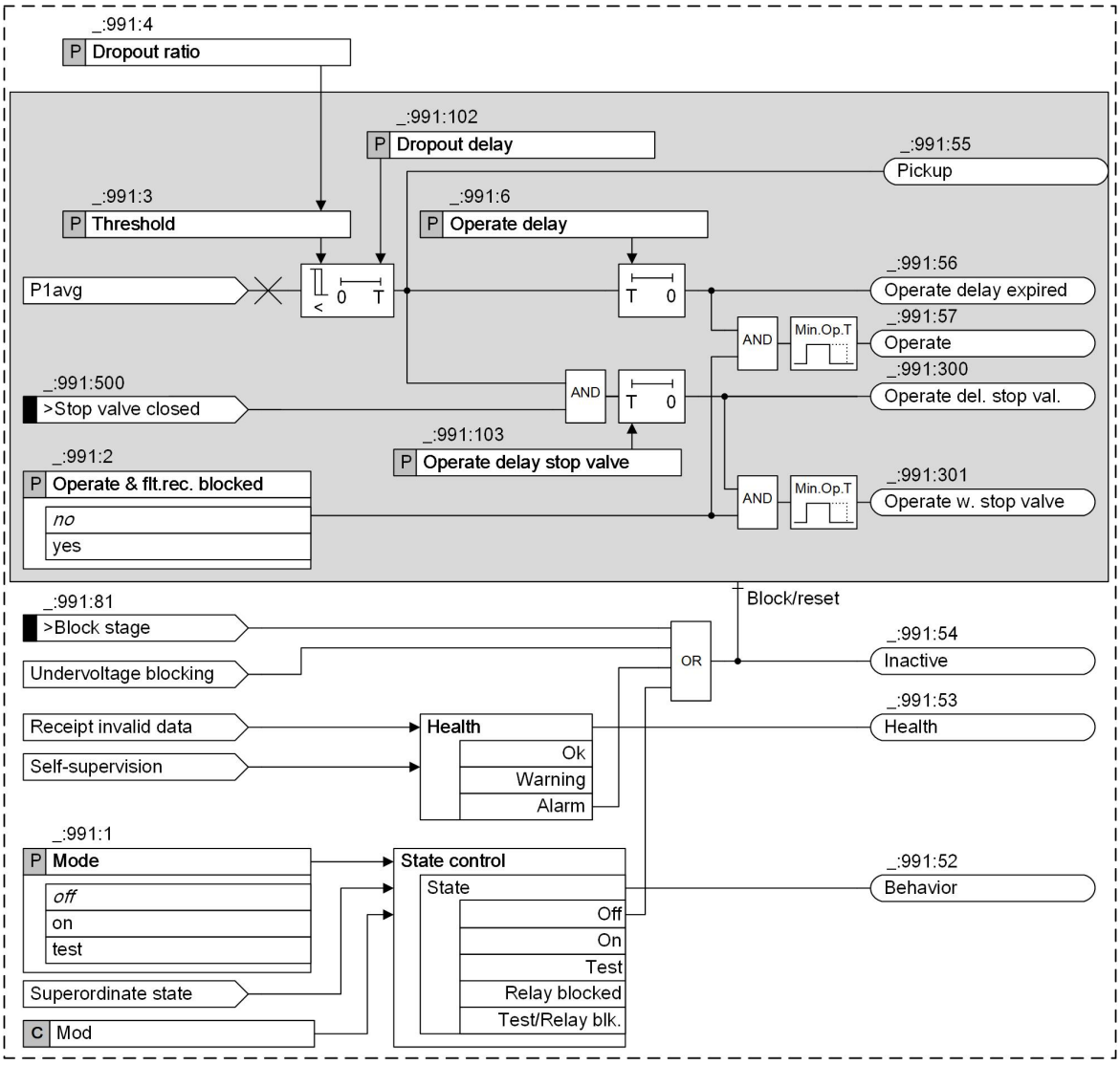
6.70.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
_:2311:301	General:P1avg	MV	O
_:2311:302	General:Q1avg	MV	O
_:2311:303	General:P1fast	MV	O
_:2311:304	General:Q1fast	MV	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O

6.70.4 Stage Description

6.70.4.1 Description

Logic of the Stage



[lo_RPP stage, 4, en_US]

Figure 6-700 Logic Diagram of the Reverse-Power Protection Stage

Trip Command

To bridge brief power consumption during synchronization or during power swings caused by system incidents, tripping (shutdown of the generator via reverse power) is delayed by a settable time (for example, 10 s).

A brief delay is enough when the quick-stop valve is closed. Couple the position of the quick-stop valve via the binary input signal **>Stop valve closed** . When quick stop is tripped, the short Operate delay thus becomes effective.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking of the stage is possible externally or internally via the binary input signal **>Block stage** .

6.70.4.2 Application and Setting Notes

If reverse power occurs in a power plant, the turbo-generator set must be disconnected from the electrical power system. Operating the turbine without the minimum steam flow (cooling effect) is dangerous. For a gas turbine cogeneration unit, the motor load can also be too great for the electrical power system.

Parameter: `Threshold`

- Recommended setting value **`(_:991:3) Threshold`** = ***`-1.00 %`***

The friction losses that have to be overcome mainly determine the active power consumed by a turbo-generator set. Depending on the plant, the consumed active power is of the following ranges:

Steam turbines	$P_{reverse}/S_{rated}$ = 1.00 % to 3.00 %
Diesel drives	$P_{reverse}/S_{rated}$ > 5.00 %
Gas turbines	$P_{reverse}/S_{rated}$ = up to 30.00 %

You can measure the reverse power of the turbo-generator set yourself in a primary test by using the protection function. Set the setting value **`P`** $_{reverse}$, for example, to 0.5 times the value of the measured reverse power. This power is shown additionally in the functional measured values in the **Reverse-power protection** function (**`P1avg`**). For large machines with very small reverse power, you must use the angle-error correction option of the current and voltage transformers.



NOTE

In the current-input selection, you can select protection current transformers or instrument transformers on the device side. Since the transformers are calibrated at the factory, there are hardly any differences between the transformers for the **Reverse-power protection** function. You can thus always select device inputs with a protection current transformer.

In contrast, a primary current transformer significantly influences the measuring accuracy via its angle error. The angle error of a class 0.2 instrument transformer is significantly smaller than the angle error of a class 5P protection current transformer. A separate function group is necessary for the connection to an instrument transformer. Use a **Voltage/current 3-phase** function group and load the **Reverse-power protection** function from the library.

Do not connect the **Reverse-power protection** function to a linear core-type transformer (for example, a TPZ type), as these transformers have a large angle error (for example, approx. 180 min).

Parameter: Dropout delay

- Recommended setting value **`(_:991:102) Dropout delay`** = ***`0.00 s`***

With the **`Dropout delay`** parameter, the pickup can be latched. It is necessary to latch the pickup, for example, if leaking steam valves prevent a constant consumed active power, and pickup starts **chattering**.

Parameter: Dropout ratio

- Recommended setting value **`(_:991:4) Dropout ratio`** = ***`0.60`***

The default value is valid for small reverse power values. It can be increased if the active-power consumption is greater. For an active-power setting of -5 %, for example, a **`Dropout ratio`** of about 0.85 is admissible.

Parameter: Operate delay

- Recommended setting value **`(_:991:6) Operate delay`** = ***`10.00 s`***

With reverse power without quick-stop valve, there can be a brief reverse-power consumption after synchronization and during power swings after a system incident (after a 3-phase short circuit, for example). With the parameter **`Operate delay`**, you can bridge the short reverse-power consumption with an operate delay of approximately 10 s.

Parameter: Operate Delay with Quick-Stop Tripping

- Recommended setting value **(_:991:103) Operate delay stop valve** = ***1.00 s***

If a fault leads to quick-stop tripping, the reverse-power protection switches off after quick-stop tripping with a short delay. This is accomplished with an oil-pressure switch or a limit switch at the quick-stop valve. For the tripping, make sure that the reverse power only results from the missing driving power on the turbine side. A tripping delay is necessary to bridge the active-power transient associated with a sudden valve closing operation until a steady-state active-power value is achieved. To do this, set the parameter **Operate delay stop valve** to approximately ***1.00 s*** to ***3.00 s***. For a gas turbine cogeneration unit, set the value to approximately ***0.50 s***.

The set times are additional time delays. These additional time delays do not include the operating times (measurement, relay) of the protection function.

6.70.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:991:1	Stage 1:Mode		• off • on • test	off
_:991:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:991:3	Stage 1:Threshold		-30.00 % to -0.30 %	-1.00 %
_:991:4	Stage 1:Dropout ratio		0.40 to 0.99	0.60
_:991:102	Stage 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:991:6	Stage 1:Operate delay		0.00 s to 60.00 s	10.00 s
_:991:103	Stage 1:Operate delay stop valve		0.00 s to 60.00 s	1.00 s

6.70.4.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:991:81	Stage 1:>Block stage	SPS	I
_:991:500	Stage 1:>Stop valve closed	SPS	I
_:991:54	Stage 1:Inactive	SPS	O
_:991:52	Stage 1:Behavior	ENS	O
_:991:53	Stage 1:Health	ENS	O
_:991:55	Stage 1:Pickup	ACD	O
_:991:56	Stage 1:Operate delay expired	ACT	O
_:991:57	Stage 1:Operate	ACT	O
_:991:300	Stage 1:Operate del. stop val.	ACT	O
_:991:301	Stage 1:Operate w. stop valve	ACT	O

6.71 Voltage Measuring-Point Selection

6.71.1 Overview of Functions

The function block **Voltage measuring-point selection** can:

- Provide the ability to switchover the voltage measuring points to be applied, if various voltage measuring points are connected to the voltage interface of the function group
- Select the correct voltage based on the switch position of the plant

If more than one voltage measuring points are connected to the same voltage interface of the function group, use the **Voltage measuring-point selection** function block in the function group to select the correct voltage based on the switch position of the plant.

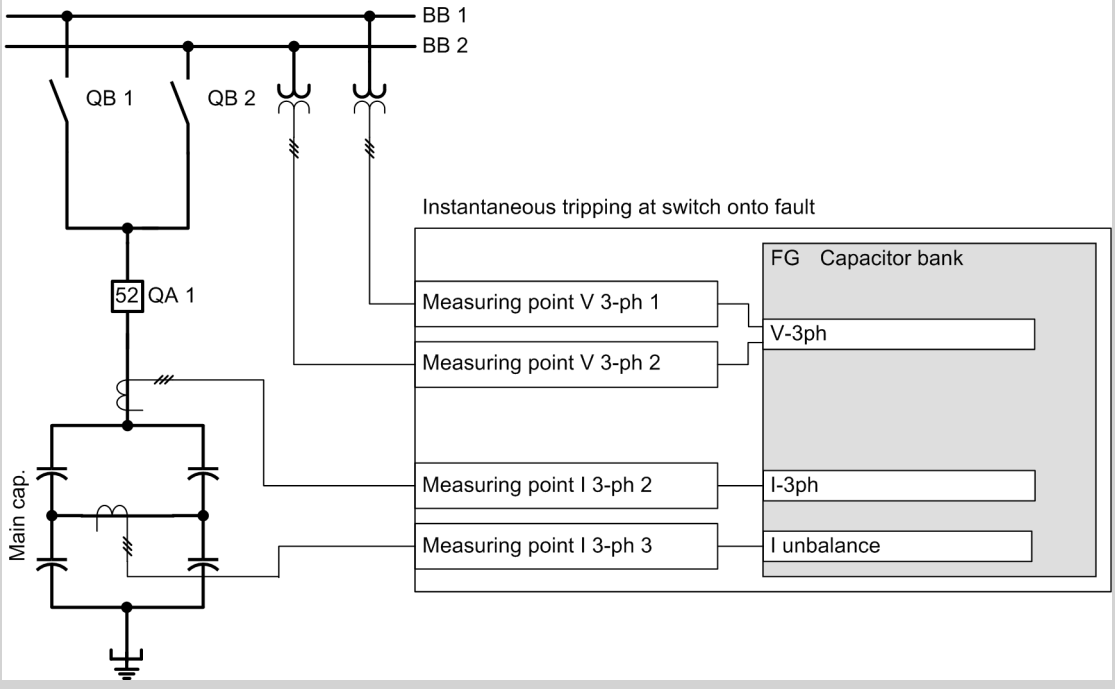
The **Voltage measuring-point selection** is a common functionality for the function groups of the protected objects.

6.71.2 Function Description

The **Voltage measuring-point selection** function block realizes the selection of 1-phase voltage measuring points or of 3-phase voltage measuring points by a logic block chart. The logic block chart controls the input *>MP-ID selection* depending on the switch positions of disconnectors.

Example

Figure 6-701 shows an example of voltage measuring points selection for the function group **Capacitor bank** in a double busbar application.

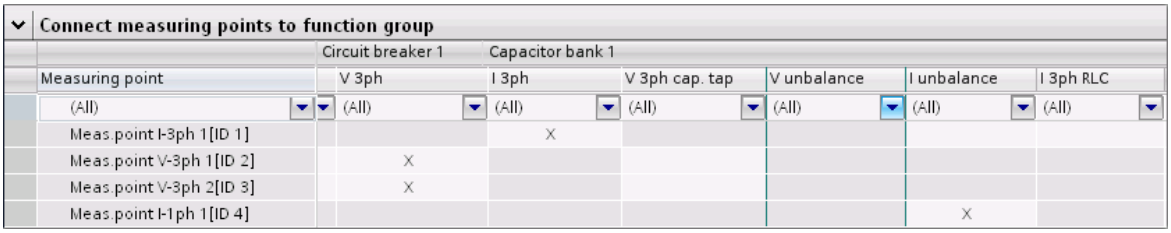


[dw_busbar_double_2, en_US]

Figure 6-701 Double Busbar with Capacitor Bank

Connecting Measuring Points to Capacitor Bank Function Group

Figure 6-702 shows the connection of the function group **Capacitor bank** with several measuring points in DIGSI. The ID of each measuring point appears in the bracket after the name.



Connect measuring points to function group

	Circuit breaker 1	Capacitor bank 1				
Measuring point	V 3ph	I 3ph	V 3ph cap. tap	V unbalance	I unbalance	I 3ph RLC
(All)	(All)	(All)	(All)	(All)	(All)	(All)
Meas.point I-3ph 1 [ID 1]		X				
Meas.point V-3ph 1 [ID 2]	X					
Meas.point V-3ph 2 [ID 3]	X					
Meas.point I-1ph 1 [ID 4]					X	

[sc_connection, 1, en_US]

Figure 6-702 Connecting the Measuring Points with the Capacitor Bank Function Group

There are consistency checks that validate the connections of voltage measuring points to the function group:

- The connection type must be identical for all measuring points connected to the same interface of the function group.
- The rated voltage (primary and secondary) must be identical for all measuring points connected to the same interface.
- If more than 1 measuring point is connected to one voltage interface, a function block must be added to enable the selection of the voltage measuring points.

6.71.3 Application and Setting Notes

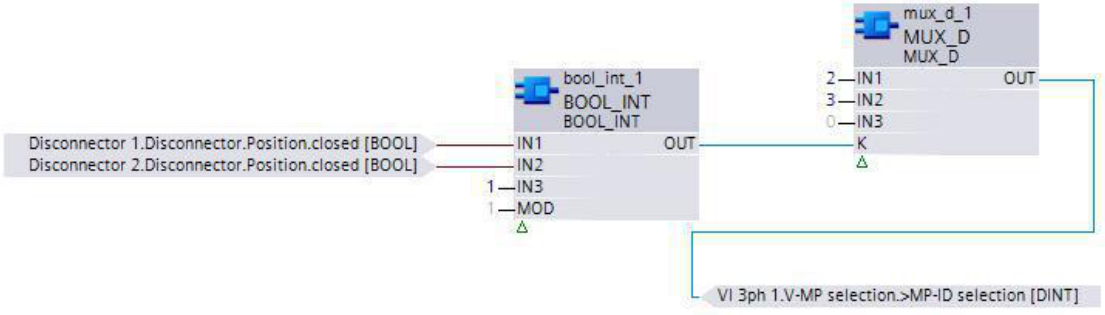
CFC Control

The voltage measuring point is selected by logic block chart on basis of the measuring point IDs. If more than one measuring point is connected to the interface of the function group, instantiate the function block **Voltage measuring-point selection** from the library in the corresponding function group.

In order to ensure the correct measuring-point connection for the function group, a logic block chart has to define the actual valid IDs for the input *>MP-ID selection* of the function block.

The following logic block chart implementation is based on the example given in *Figure 6-701*.

If the Disconnector 1 (QB1) is closed and no matter what the position the Disconnector 2 (QB2) is, the value 2 is the output of CFC block **mux_d_1** and transferred to the input *>MP-ID selection*. Then, the **Meas.point V-3ph** with ID 2 is selected as the reference voltage. Similarly, the **Meas.point V-3ph** with ID 3 is selected as the reference voltage if the Disconnector 1 (QB1) is not closed (open or in intermediate position) while Disconnector 2 (QB2) is closed.



[sc_lo-cfcVP, 1, en_US]

Figure 6-703 Logic Block Chart: Voltage Selection Using Measuring Point ID

However, the disconnectors might be both open or in a transient state. In this case, the input IN3 of the block **bool_int_1** becomes true, the value 0 is used as the ID for voltage selection input (*>MP-ID selection*). If ID 0 is selected, then all voltage values of the respective function-group interface are set to 0 V immediately. An alarm indication *Selection invalid* is issued and the indication *Health* is issued as *OK*. In case you want to supply the function group with voltage values under the condition that both disconnectors are open or in transient state from one or the other busbar, you can alter the CFC chart respectively.

NOTE

An invalid measuring-point selection (ID < 0 or an ID of a unconnected measuring point) for input *>MP-ID selection* results in the following:

- The voltage measured values are displayed as **failure**.
- The validity of the voltage measured values is set to **invalid**.
- The indication *Health* is set to ***Alarm***.
- The indication *Selection invalid* becomes true.

6.71.4 Information List

No.	Information	Data Class (Type)	Type
V-MP selection			
_:501	V-MP selection:>MP-ID selection	INS	I
_:53	V-MP selection:Health	ENS	O
_:301	V-MP selection:Selection invalid	SPS	O

6.72 Current-Jump Detection

6.72.1 Overview of Functions

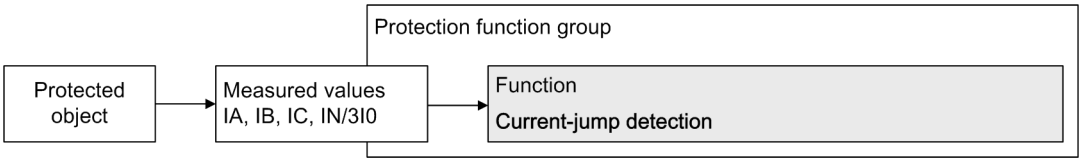
The **Current jump detection** function has the following tasks:

- Detection of jumps in the phase or zero-sequence current (ΔI)
- Generation of an indication when the measurands change by more than a configured threshold value from one system period to the next.

The function for detecting jumps in the phase or zero-sequence current is an additional function used for indication purposes or for further processing in user-specific CFC logics. Pick up of the function therefore neither opens a separate fault in the fault log nor generates an operate indication.

6.72.2 Structure of the Function

The **Current-jump detection** function is used in protection function groups based on current measurement. It can be instantiated multiple times.



[dw_struki, 1, en_US]

Figure 6-704 Structure/Embedding of the Function

6.72.3 Function Description

Current-jump detection operates directly with the sampled values without numeric filtering. This provides very short response times to sudden changes in the current. The method used is not sensitive to slow changes of amplitude or frequency.

Using a configurable selection of measured values, you can select from 3 line currents or the residual current. Current-jump detection is phase-selective for the line current A, B and C.

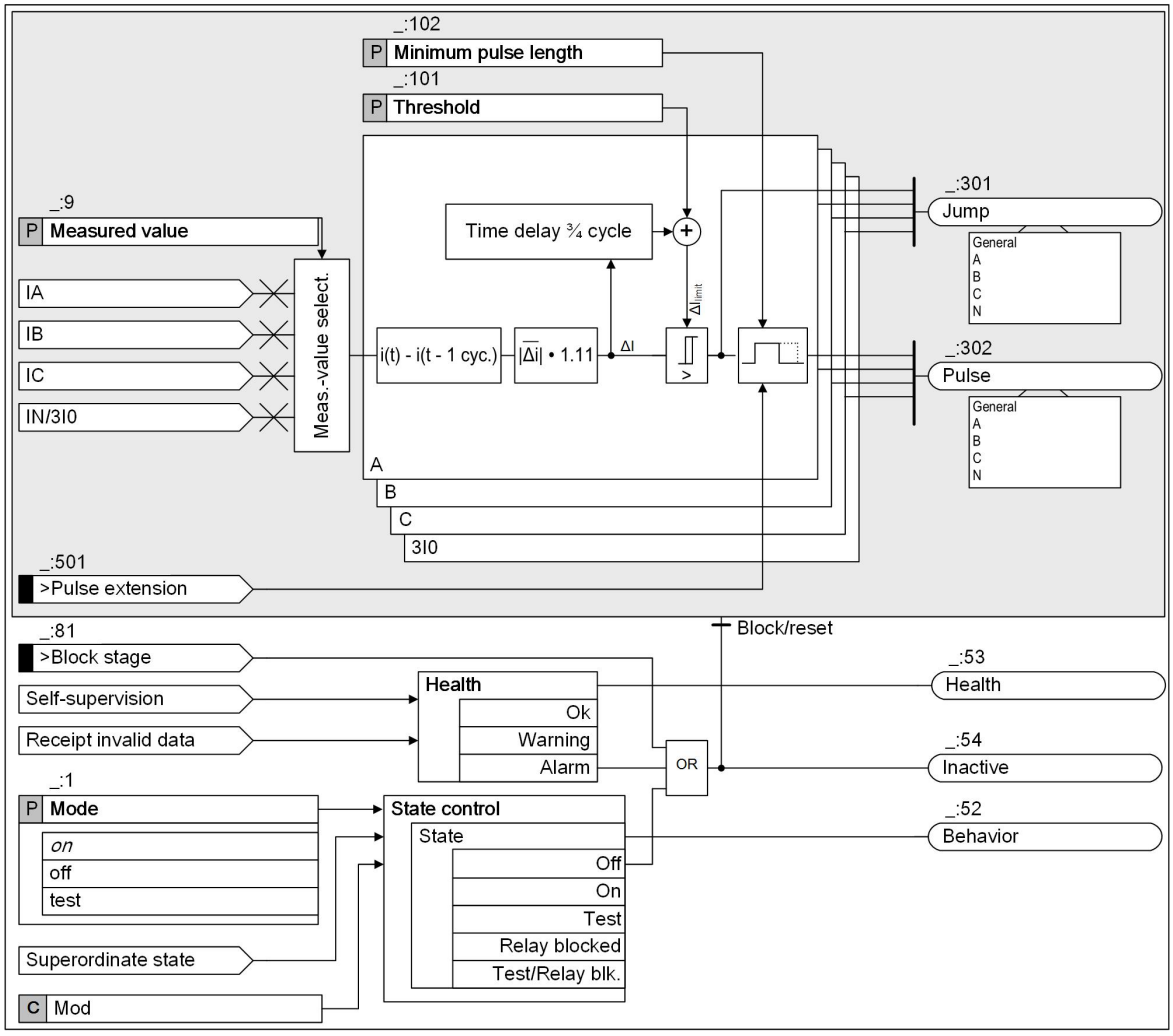
The difference from the previous sampled value of the first system cycle is calculated for each sampled value. The rectified average is then determined for a ½ system cycle from this differential signal Δi(t). The rectified average for sinusoidal measurands is then converted to a RMS value ΔI by subsequent multiplication by 1.11. The resultant measurand ΔI is then compared with the threshold value.

If the parameter **(_:101) Threshold** is exceeded, the output indication *Jump* is generated. If you have selected the phase currents for measurement, the output indication data type used includes the separate phase information. If you have selected the residual current for measurement, the output indication data type used includes the NI information. If the current-jump detection responds (ΔI_{Limit}), the general information is generated in the output indication in all cases.

Dropout occurs with a dynamically increased threshold value (ΔI_{Limit}) in accordance with the logic in *Figure 6-705*. Dynamic increase of the dropout threshold value achieves optimally short dropout times.

The output indication *Pulse* is formed with the configurable timer **(_:102) Minimum pulse length**. As a consequence, this output indication has a consistent minimum size. If you activate the binary input *>Pulse extension*, you can prolong the pulse duration even further. If the binary input *>Pulse extension* has been activated, the indication *Pulse* drops off when the configured time has elapsed and the falling edge of the binary input is detected.

Logic



[lo_jump_ii, 2, en_US]

Figure 6-705 Current-Jump Detection Logic

6.72.4 Application and Setting Notes

Parameter: `Measured value`

- Default setting **`(_:9) Measured value`** = ***`phase currents`***

With the parameter **`Measured value`**, you set whether the line current(s) or the residual current is to be used for jump detection.

Parameter Value	Description
`phase currents`	The tripping stage evaluates the line currents IA, IB, and IC phase-selectively to detect a jump.
`zero-sequence current`	The tripping stage evaluates the residual current IN/3I0 to detect a jump.

Parameter: `Threshold`

- Default setting **`(_:101) Threshold`** = ***`0.10 A`*** for I_{rated} = 1A or ***`0.50 A`*** for I_{rated} = 5 A

With the parameter **Threshold**, you set the threshold value for the measurand which, when exceeded, generates the output indication *Jump*.

Parameter: Minimum pulse length

- Default setting **(_:102) Minimum pulse length** = *0.10 s*

With the parameter **Minimum pulse length**, you specify a consistent minimum size for the output indication *Pulse*.

6.72.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
I-jump det. #				
_:1	I-jump det. #:Mode		• off • on • test	off
_:9	I-jump det. #:Measured value		• phase currents • zero-sequence current	phase currents
_:101	I-jump det. #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:102	I-jump det. #:Minimum pulse length		0.01 s to 60.00 s	0.10 s

6.72.6 Information List

No.	Information	Data Class (Type)	Type
I-jump det. #			
_:81	I-jump det. #:>Block stage	SPS	I
_:501	I-jump det. #:>Pulse extension	SPS	I
_:54	I-jump det. #:Inactive	SPS	O
_:52	I-jump det. #:Behavior	ENS	O
_:53	I-jump det. #:Health	ENS	O
_:301	I-jump det. #:Jump	ACT	O
_:302	I-jump det. #:Pulse	ACT	O

6.73 Voltage-Jump Detection

6.73.1 Overview of Functions

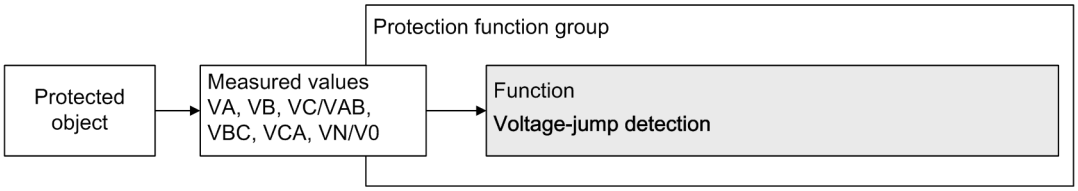
The **Voltage-jump detection** function has the following tasks:

- Recognition of jumps in the phase or zero-sequence voltage (ΔV)
- Generation of an indication when the measurands change by more than a configured threshold value from one system cycle to the next.

The function for detecting jumps in the phase or zero-sequence voltage is an additional function used for indication purposes or for further processing in user-specific CFC logics. Pick up of the function therefore neither opens a separate fault in the fault log nor generates an operate indication.

6.73.2 Structure of the Function

The **Voltage-jump detection** function is used in protection function groups based on voltage measurement. It can be instantiated multiple times.



[dw_struku, 1, en_US]

Figure 6-706 Structure/Embedding of the Function

6.73.3 Function Description

Voltage-jump detection operates directly with the sampled values without numeric filtering. This provides very short response times to sudden changes in the voltage. The method used is not sensitive to slow changes of amplitude or frequency.

By using a configurable selection of measured values, you can select from phase-to-ground voltages, phase-to-phase voltages or the zero-sequence voltage. Voltage-jump detection is phase-selective.

The difference from the previous sampled value of a system cycle is calculated for each sampled value. The rectified average is then determined for a ½ system cycle from this differential signal Δv(t). The rectified average for sinusoidal measurands is then converted to a RMS value ΔV by subsequent multiplication by 1.11. The resultant measurand ΔV is then compared with the threshold value.

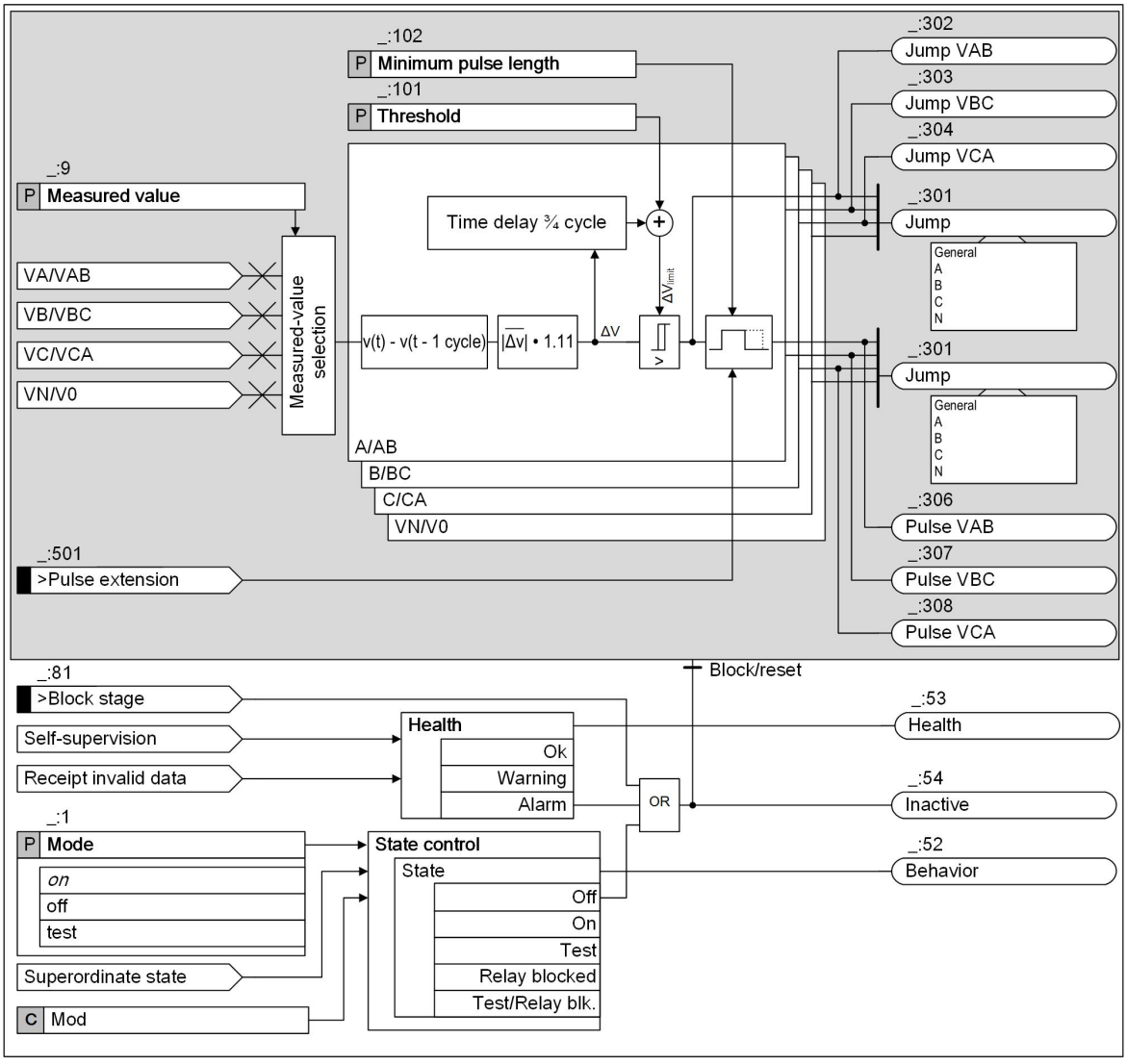
If the parameter **(_:101) Threshold** is exceeded, the output indication *Jump* is generated. If the measured value is set to phase-to-phase, the sudden change in voltage is signaled selectively for the individual measuring elements that have picked up (*Jump VAB*, *Jump VBC* or *Jump VCA*). If you have selected the phase-to-phase or phase-to-ground voltages for measurement, the output indication data type used includes the separate phase information. If you have selected the zero-sequence voltage for measurement, the output indication data type used includes the N information. If the voltage-jump detection responds (ΔV_{Limit}), the general information is generated in the output indication in all cases.

Dropout occurs with a dynamically increased threshold value ΔU_{Limit} in accordance with the information in *Figure 6-707*. Dynamic increase of the dropout threshold value achieves optimally short dropout times.

A timing element is added to the indication *Jump*. The element generates a pulse from this. The length of this pulse can be set using the parameter **(_:102) Minimum pulse length**. This gives the output indication *Pulse* a reliable minimum size. If you activate the binary input *>Pulse extension*, you can prolong the pulse duration even further. If the binary input *>Pulse extension* has been activated, the indication *Pulse* drops off when the configured time has elapsed and the falling edge of the binary input

is detected. If the measured value is set to phase-to-phase, the pulse duration is signaled selectively for the individual measuring elements that have picked up (*Pulse VAB*, *Pulse VBC* or *Pulse VCA*).

Logic



[lo_jump_uu, 3, en_US]

Figure 6-707 Voltage-Jump Detection Logic

6.73.4 Application and Setting Notes

Parameter: `Measured value`

- Default setting **`(_:9) Measured value`** = ***`phase-to-ground`***

With the parameter **`Measured value`** , you specify which measured values of voltage are to be used for determining the voltage jumps.

Parameter Value	Description
phase-to-ground	The tripping stage evaluates the phase-to-ground voltages VA, VB and VC.
phase-to-phase	The tripping stage evaluates the phase-to-phase voltages VAB, VBC and VCA.
zero-sequence voltage	The tripping stage evaluates the zero-sequence voltage VN/V0.

Parameter: **Threshold**

- Default setting **(_:101) Threshold** = ***5.000 V***

With the parameter **Threshold** , you set the threshold value for the measurand which, when exceeded, generates the output indication *Jump* .

Parameter: **Minimum pulse length**

- Default setting **(_:102) Minimum pulse length** = ***0.10 s***

With the parameter **Minimum pulse length** , you specify a consistent minimum size for the output indication *Pulse* .

6.73.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-jump det. #				
_:1	V-jump det. #:Mode		• off • on • test	off
_:9	V-jump det. #:Measured value		• phase-to-ground • phase-to-phase • zero-sequence voltage	phase-to-ground
_:101	V-jump det. #:Threshold		0.300 V to 340.000 V	5.000 V
_:101	V-jump det. #:Threshold		0.300 V to 340.000 V	5.000 V
_:102	V-jump det. #:Minimum pulse length		0.01 s to 60.00 s	0.10 s

6.73.6 Information List

No.	Information	Data Class (Type)	Type
V-jump det. #			
_:81	V-jump det. #:>Block stage	SPS	I
_:501	V-jump det. #:>Pulse extension	SPS	I
_:54	V-jump det. #:Inactive	SPS	O
_:52	V-jump det. #:Behavior	ENS	O
_:53	V-jump det. #:Health	ENS	O
_:301	V-jump det. #:Jump	ACT	O
_:302	V-jump det. #:Jump VAB	SPS	O
_:303	V-jump det. #:Jump VBC	SPS	O
_:304	V-jump det. #:Jump VCA	SPS	O

No.	Information	Data Class (Type)	Type
_:305	V-jump det. #:Pulse	ACT	O
_:306	V-jump det. #:Pulse VAB	SPS	O
_:307	V-jump det. #:Pulse VBC	SPS	O
_:308	V-jump det. #:Pulse VCA	SPS	O

6.74 Vector-Jump Protection

6.74.1 Overview of Functions

The **Vector-jump protection** function:

- Is used for network decoupling of the power generating unit in case of a load loss
- Evaluates the phase-angle jump of the voltage phasors

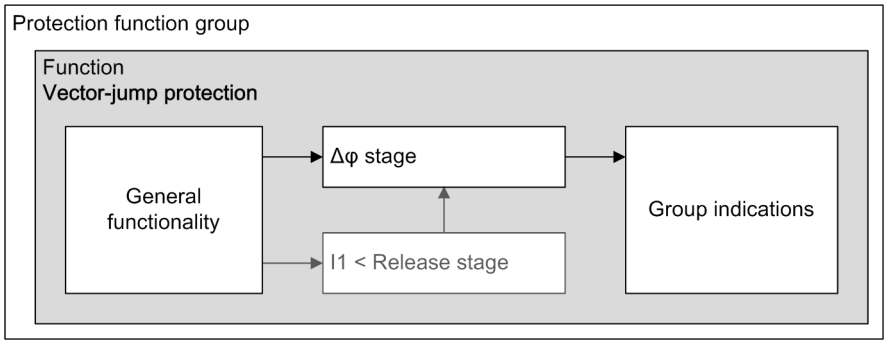
6.74.2 Structure of the Function

The **Vector-jump protection** function can be used in the following function groups:

- Voltage-current 3-phase
- Voltage 3-phase
- Transformer side

The **Vector-jump protection** function comes factory-set with a **Δφ** stage.
The following stages can operate simultaneously within the function:

- 1 **Δφ** stage
- 1 **I1 < Release** stage



[dw_VJP_structure, 1, en_US]

Figure 6-708 Structure/Embedding of the Function

6.74.3 General Functionality

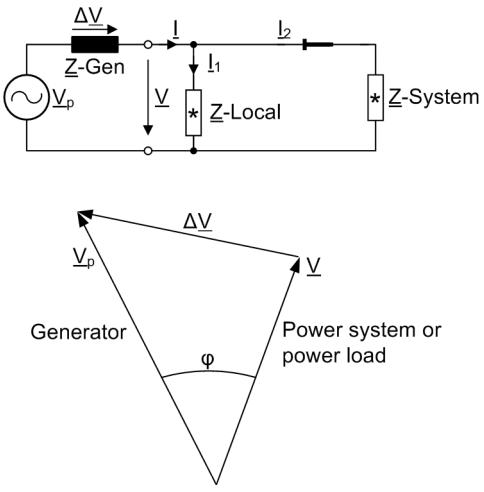
6.74.3.1 Description

Basic Principle of Vector-Jump Protection

The following 2 figures show the basic principle of the function **Vector-jump protection**.
The following figure shows the voltage vector of the steady state condition. The load current causes a voltage drop between the internal voltage V_p and the generator terminal voltage V.

If the load is switched off, the following situations occur:

- The current is reduced.
- A smaller voltage drop is caused.



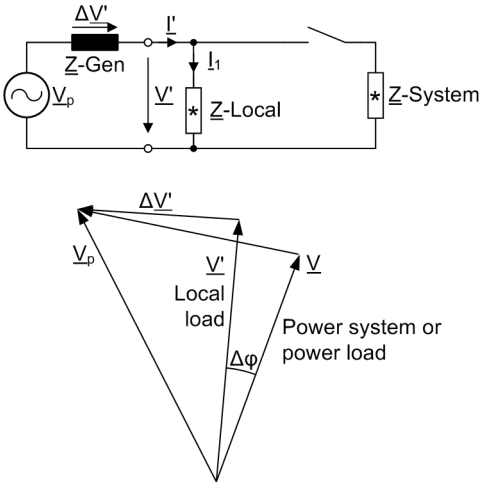
[dw_load loss, 1, en_US]

Figure 6-709 Voltage Vector of the Steady State

The following figure shows the situations after the load is switched off:

- The terminal voltage V changes to V'.
- An additional phase-angle jump occurs.

A phase-angle jump occurs with load loss and is the evaluation criterion for the function **Vector-jump protection**. If the phase-angle differential exceeds a set threshold, the generator circuit breaker or the circuit breaker of the system switch opens. Therefore, the generator unit can be protected against unacceptable stress.



[dw_vector change, 1, en_US]

Figure 6-710 Vector Change after the Load Shedding

Table 6-35 Vector Description

Vector	Description
$\underline{V}_p$	Vector of the generator internal voltage (rotor voltage)
$\underline{V}$	Vector of the generator terminal voltage
$\Delta\underline{V}$	Vector of the voltage differential
$\underline{V}'$	Vector of the terminal voltage after the load shedding
$\Delta\underline{V}'$	Vector of the voltage differential after the load shedding

The following measures are applied to avoid unwanted tripping:

- Correction of steady-state deviations from rated frequency
- Frequency operating range limited to f_{rated} ± 3 Hz
- High measuring accuracy by using frequency-tracked measured values and evaluation of the positive-sequence phasor
- Enabling the minimum voltage for the function **Vector-jump protection**
- Blocking the function when the primary voltage is switched on or off as switching can lead to a phase-angle jump

Logic

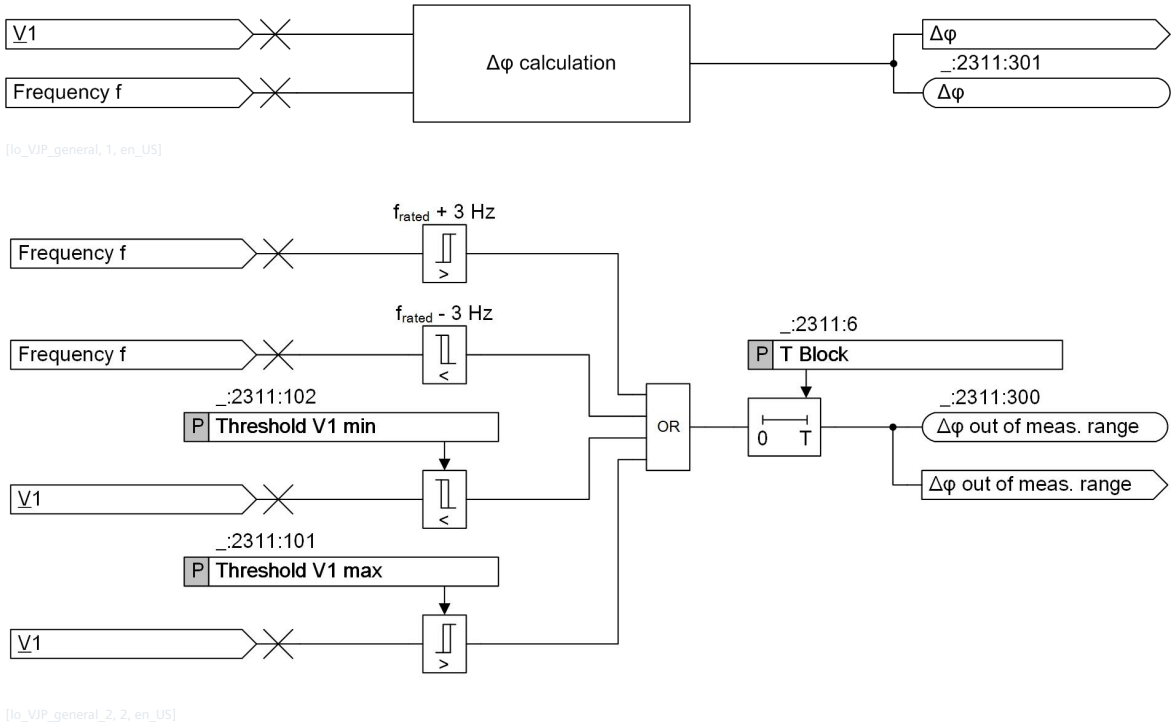


Figure 6-711 Logic Diagram of the General Functionality

Phase-Angle Calculation

The phase-angle differential is calculated at different time intervals (t-T, t-2T, t-3T[54]) from the vector of the positive-sequence voltage via a delta-interval measurement. With the current measured power frequency, the measuring errors of the angle measurement caused by frequency deviations are compensated.

Range

If the measured frequency or voltage is below the set threshold, the function **Vector-jump protection** is blocked.

The voltage and frequency bands have the following limits:

- The threshold of the voltage band is configurable.
- The frequency band ranges is fixed from f_{rated} - 3 Hz to f_{rated} + 3 Hz.

54 T = period or cycle time of the power system

Measurand

The general functionality calculates the phase-angle displacement Δφ and sends it to the **Δφ** stage. Δφ is used for comparison with the parameter **Threshold Δφ**. Δφ is displayed in the functional measured value and can be routed in a fault record and displayed in the fault log.

The functional measured values of Δφ in HMI are displayed differently in the following situations:

- If the function **Vector-jump protection** is inactive, the function value of Δφ is displayed as "---"
- If the function **Vector-jump protection** is active and has not picked up, the functional measured value of Δφ is displayed as 0.0°
- If the function **Vector-jump protection** is active and has picked up, the functional measured value of Δφ is displayed as a calculated value (for example, 12.0°) and remains unchanged until the next pickup of the function **Vector-jump protection**.

6.74.3.2 Application and Setting Notes

Parameter: Threshold V1 min

- Default setting **(_:2311:102) Threshold V1 min** = ***46.189 V***

With the parameter **Threshold V1 min**, you can define the minimum threshold of the voltage band.

The setting value is closed to the allowed lower limit of the voltage band. The default setting is 80 % of the rated positive-sequence voltage. The value of the rated positive-sequence voltage is 100 V/√3.

Parameter: Threshold V1 max

- Default setting **(_:2311:101) Threshold V1 max** = ***75.058 V***

With the parameter **Threshold V1 max**, you can define the maximum threshold of the voltage band.

The setting value is closed to the allowed higher limit of the voltage band. The default setting is 130 % of the rated positive-sequence voltage. The value of the rated positive-sequence voltage is 100 V/√3.

Parameter: T Block

- Default setting **(_:2311:6) T Block** = ***0.10 s***

With the parameter **T Block**, you set the dropout delay of the **Δφ** stage.

When voltages are connected or disconnected, the overfunction can be avoided with the timer **T Block**.

Siemens recommends to use the default setting of the parameter **T Block**. Keep in mind that the parameter **T Block** has always to be set to 2 cycles more than the measuring window for vector-jump measurement.

6.74.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:102	General:Threshold V1 min		0.300 V to 175.000 V	46.189 V
_:2311:101	General:Threshold V1 max		0.300 V to 175.000 V	75.058 V
_:2311:6	General:T Block		0.00 s to 60.00 s	0.10 s

6.74.3.4 Information List

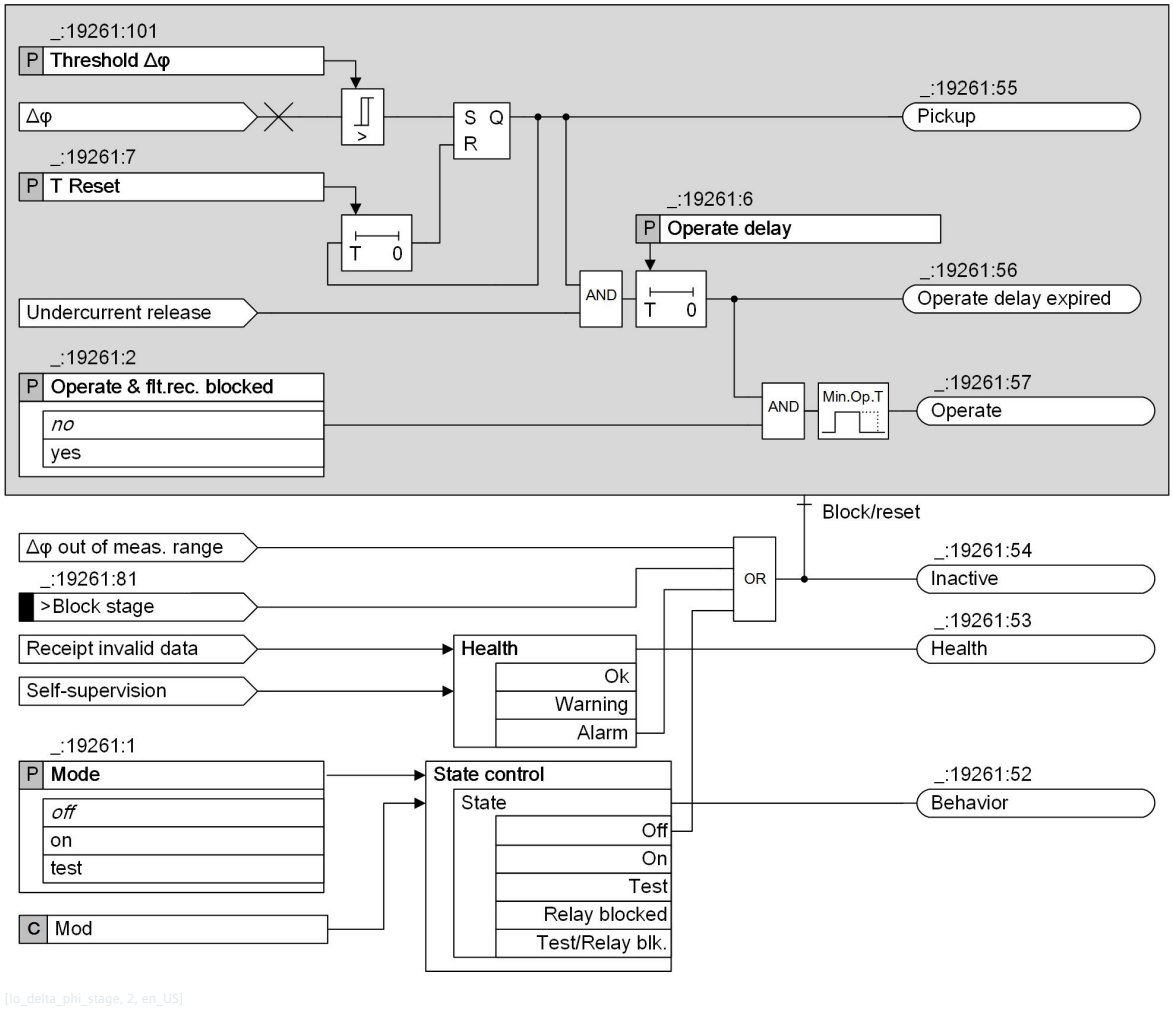
No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:Δφ	MV	O
_:2311:300	General:Δφ out of meas. range	SPS	O

No.	Information	Data Class (Type)	Type
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O

6.74.4 Δφ Stage

6.74.4.1 Description

Logic



[lo_delta_phi_stage, 2, en_US]

Figure 6-712 Logic Diagram of the Δφ Stage

In the logic diagram, the **I1 < Release** stage is instantiated. You can find more information in chapter *6.74.5.1 Description*.

If the **I1 < Release** stage is not instantiated, the AND operation has no influence. The *Operate* indication is issued under the following conditions:

- The parameter **Operate & flt.rec. blocked** is set to ***no***.
- The operate delay expires.
- The phase-angle differential exceeds the parameter **Threshold Δφ**.

Measurand

The **Δφ** stage gets the measured value $\Delta\phi$ from the general functionality.

Pickup

The **Δφ** stage compares the value of the vector jump $\Delta\phi$ with the **Threshold Δφ**.

If the value of the **Threshold Δφ** is exceeded, the pickup delay starts.

The vector jump $\Delta\phi$ is stored in an RS flip-flop. Trippings can be delayed by the associated time delay.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- The parameter **Mode** is in the state *off*.
- The binary input signal *>Block stage* is active.
- The signal *Δφ out of meas. range* is active.

6.74.4.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting **(_:19261:2) Operate & flt.rec. blocked** = *no*

With the parameter **Operate & flt.rec. blocked**, you can block the operate indication, the fault recording, and the fault log. If you want the stage to have a warning indication only, set the parameter **Operate & flt.rec. blocked** to *yes*.

Parameter: Threshold Δφ

- Default setting **(_:19261:101) Threshold Δφ** = *10°*

With the parameter **Threshold Δφ**, you can set the pickup value of the **Δφ** stage.

The parameter value to be set for the vector jump depends on the supply and load conditions. Load changes cause a jump of the voltage vector. The value to be set must be established in accordance with the particular power system. An estimation can be done based on the system equivalent circuit in *Figure 6-710*. A network calculation considering the relevant source and load situations will be more precise.

If the setting for the parameter **Threshold Δφ** is too sensitive, every time loads are connected or disconnected, the protection function performs a network decoupling. Therefore, If no other calculated value is applicable to the setting of this parameter, Siemens recommends using the default setting.

Parameter: Operate delay

- Default setting **(_:19261:6) Operate delay** = *0.00 s*

With the parameter **Operate delay**, you can set the operate delay of the **Δφ** stage. For the tripping stage, set the operate delay between *0.00 s* and *60.00 s*.

Siemens recommends the default setting.

The following requirements can necessitate a change of the parameter **Operate delay** with respect to the default setting:

- The operate indication should be transmitted with delay to a programmable logic.
- There shall be enough time for an external blocking to take effect.

Parameter: T Reset

- Default setting **T Reset** = *5.00 s*

With the parameter **T Reset**, you can set the reset time for the *Pickup* indication stored in the RS flip-flop. When the timer **T Reset** expires, the protection function is reset automatically.

The reset time meets the following conditions:

- The reset time depends on the decoupling requirements
- The reset time must expire before the circuit breaker is reclosed

6.74.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage Δφ 1				
_:19261:1	Stage Δφ 1:Mode		• off • on • test	off
_:19261:2	Stage Δφ 1:Operate & flt.rec. blocked		• no • yes	no
_:19261:101	Stage Δφ 1:Threshold Δφ		2.0° to 30.0°	10.0°
_:19261:6	Stage Δφ 1:Operate delay		0.00 s to 60.00 s	0.00 s
_:19261:7	Stage Δφ 1:T Reset		0.00 s to 60.00 s	5.00 s

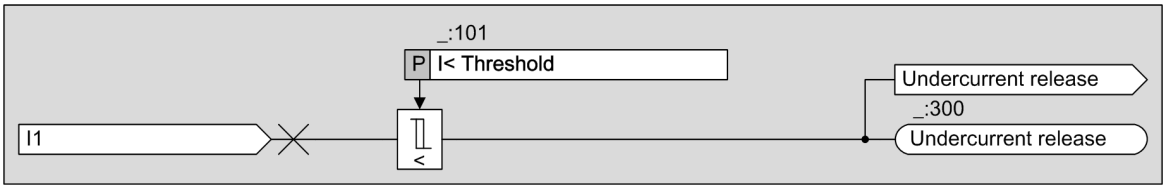
6.74.4.4 Information List

No.	Information	Data Class (Type)	Type
Stage Δφ 1			
_:19261:81	Stage Δφ 1:>Block stage	SPS	I
_:19261:54	Stage Δφ 1:Inactive	SPS	O
_:19261:52	Stage Δφ 1:Behavior	ENS	O
_:19261:53	Stage Δφ 1:Health	ENS	O
_:19261:55	Stage Δφ 1:Pickup	ACD	O
_:19261:56	Stage Δφ 1:Operate delay expired	ACT	O
_:19261:57	Stage Δφ 1:Operate	ACT	O

6.74.5 I1 < Release Stage

6.74.5.1 Description

Logic



[lo_undercurrent_release_stage, 1, en_US]

Figure 6-713 Logic Diagram of the I1 < Release Stage

The **I1 < Release** stage is an optional stage and is used to reduce the risk of overfunction.
The indication *Undercurrent release* is an additional safety criterion to avoid an unexpected trip. It indicates a load loss of the connected line to the system and the phase-angle criterion is released. If any load in the network is switched on or off, an unexpected trip can occur.

If the **I1 < Release** stage is not instantiated, the **Δφ** stage works without current-flow criterion. You can find more information in chapter *6.74.4.1 Description*.

If the positive-sequence current falls below the parameter **I< Threshold**, the message *Undercurrent release* is issued and is forwarded to the **Δφ** stage.

6.74.5.2 Application and Setting Notes

Parameter: I< Threshold

- Default setting **(_:101) I< Threshold** = ***0.100 A***

With the parameter **I< Threshold**, you can set the pickup value of the **I < Release** stage corresponding to the specific application. Consider that the current measuring point must be on the line side. The parameter **I< Threshold** depends on the load situation.

6.74.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
I1 < Release #				
_:101	I1 < Release #:I< Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A

6.74.5.4 Information List

No.	Information	Data Class (Type)	Type
I1 < Release #			
_:300	I1 < Release #:Undercurrent release	SPS	O

7 Control Functions

7.1	Introduction	1822
7.2	Switching Devices	1825
7.3	Switching Sequences	1855
7.4	Control Functionality	1862
7.5	Synchronization Function	1890
7.6	User-Defined Function Block [Control]	1938
7.7	CFC-Chart Settings	1943
7.8	Tap Changers	1945
7.9	Voltage Controller	1959
7.10	Point-on-Wave Switching	2038

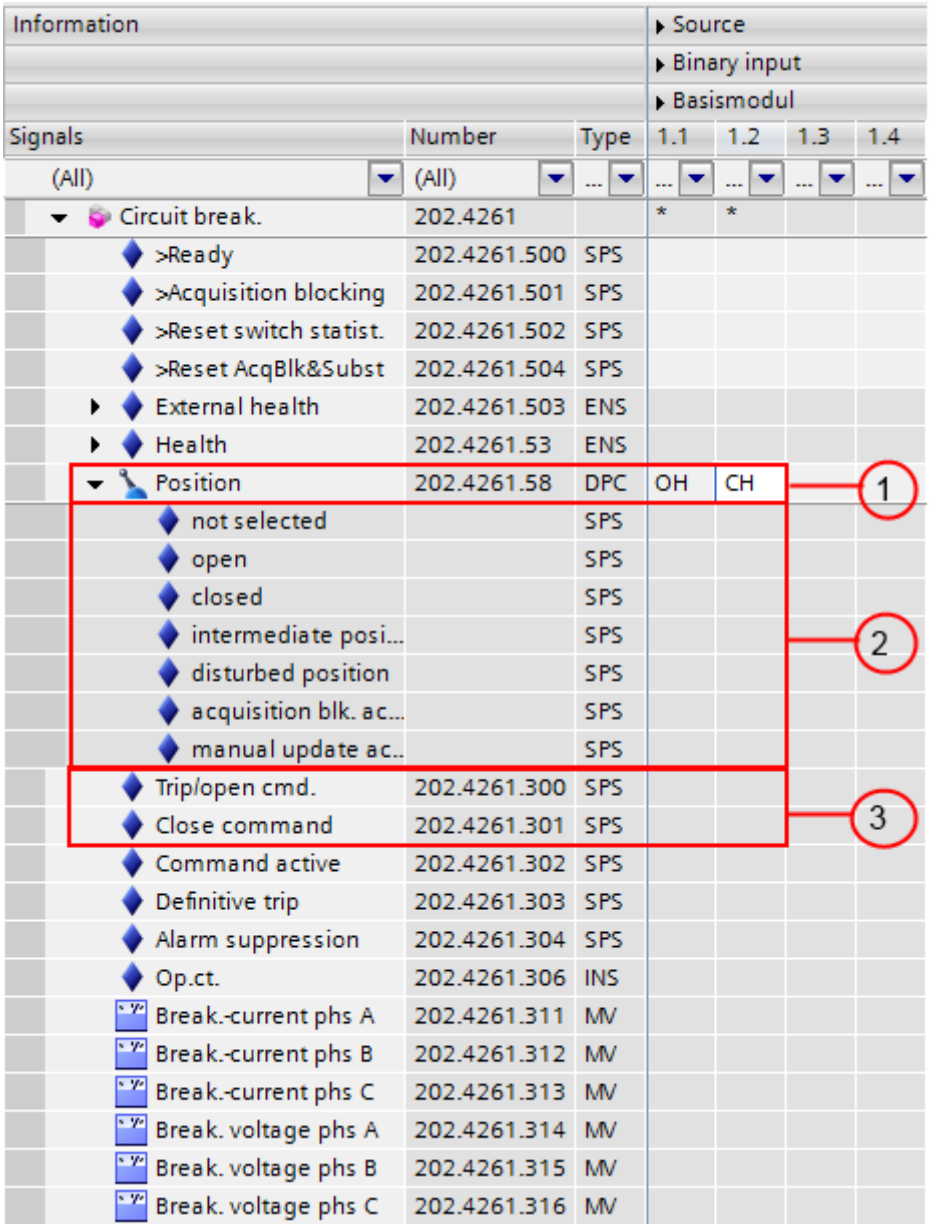
7.1 Introduction

7.1.1 Overview

The SIPROTEC 5 series of devices offers powerful command processing capability as well as additional functions that are needed when serving as bay controllers for the substation automation technology or when providing combi-protection. The object model for the devices is based on the IEC 61850 standard, making the SIPROTEC 5 series of devices ideally suited for use in systems employing the IEC 61850 communication protocol. In view of the function blocks necessary for the control functions, other logs are also used.

7.1.2 Concept of Controllables

The concept of so-called controllables is based on the data model described in IEC 61850. Controllables are objects that can be controlled, such as a switch with feedback. The model of a transformer tap changer, for example, contains controllables. The controllables are identifiable by their last letter **C** of the data type (for example, DPC = Double Point Controllable/Double Command with feedback or BSC = Binary-Controlled Step Position Indication / transformer tap command with feedback).



[sc_control, 1, en_US]

(1) Position (connect with binary inputs)
(2) Signalization of the current condition
(3) Command output (connect with relay)

The trip, opening, and the close commands are connected to the relays. For the trip command, a choice between saved and unsaved output is possible. The position is connected with 2 binary inputs (double-point indication). In addition, signals are available that display the current state of the switch (**not selected**, **off**, **on**, **intermediate position**, **disturbed position**). These signals can be queried in CFC, for example, in order to build interlocking conditions.

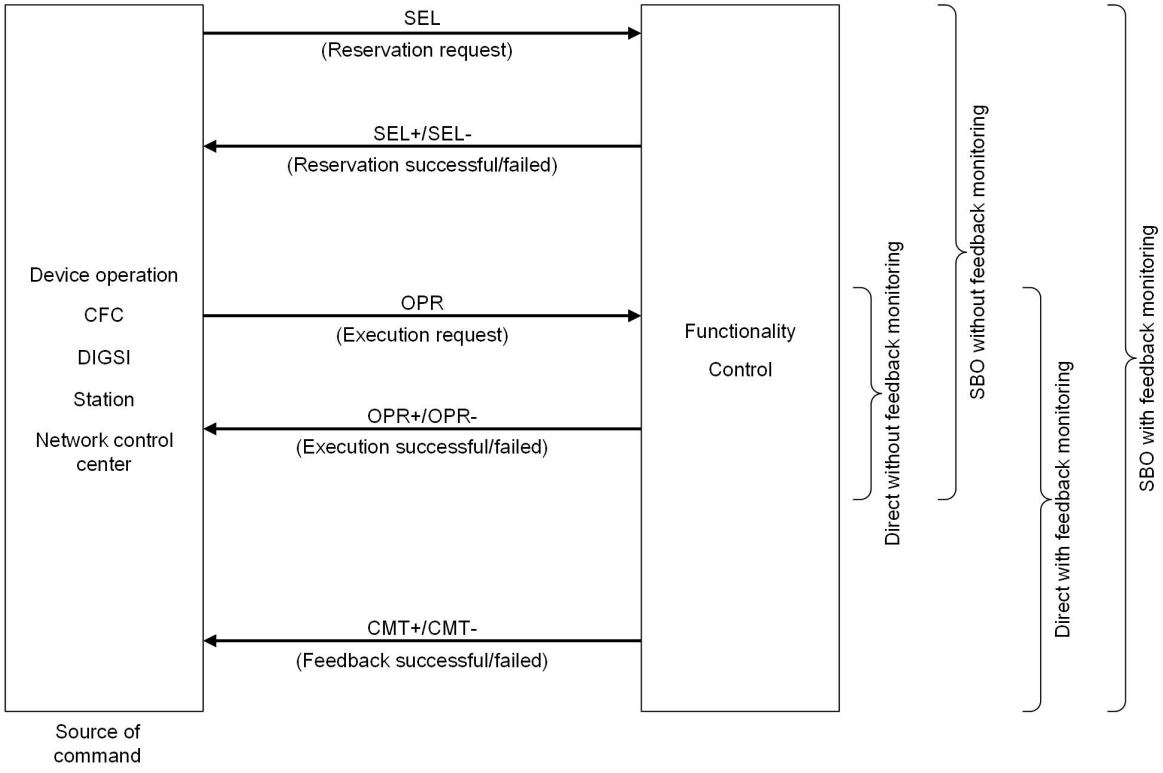
Control Models

You can set the operating mode of the controllables by selecting the control model.

4 different control models are available:

- Direct without feedback monitoring (**`direct w. normal secur.`**)
- With reservation (SBO)[55] without feedback monitoring (**`SBO w. normal secur.`**)
- Direct with feedback monitoring (**`direct w. enh. security`**)
- With SBO with feedback monitoring (**`SBO w. enh. security`**)

The next figure shows the command sources, command types, and control models.



[dw_steuer, 2, en_US]

Figure 7-1 Command Sources, Command Types, and Control Models

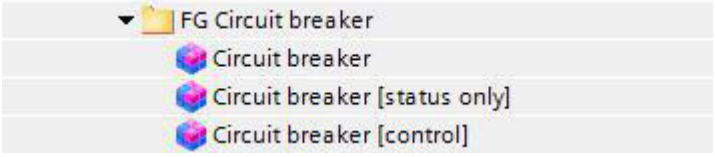
The figure shows the control models (right) with the respective control mechanisms (center). The standard control model for a switching command in an IEC 61850 compliant system is **SBO with feedback monitoring** (**`SBO w. enh. security`**). This control model is the default setting for newly created switching devices.

55 SBO: Select Before Operate

7.2 Switching Devices

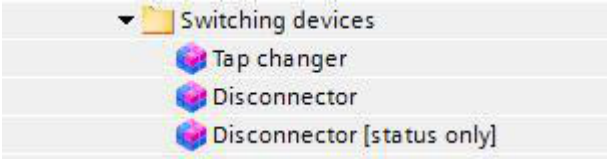
7.2.1 General Overview

You can find the following switching devices in the DIGSI 5 library in the function groups **Circuit breaker** and **Switching devices** (see following figures).



[sc_cb_ausw, 1, en_US]

Figure 7-2 Selecting the Circuit-Breaker Switching Device Using the DIGSI Circuit-Breaker Function Group Menu



[scswausw, 1, en_US]

Figure 7-3 Selecting the Remaining Switching Devices Using the DIGSI Switching-Devices Menu

7.2.2 Switching Device Circuit Breaker

7.2.2.1 Structure of the Circuit-Breaker Switching Device

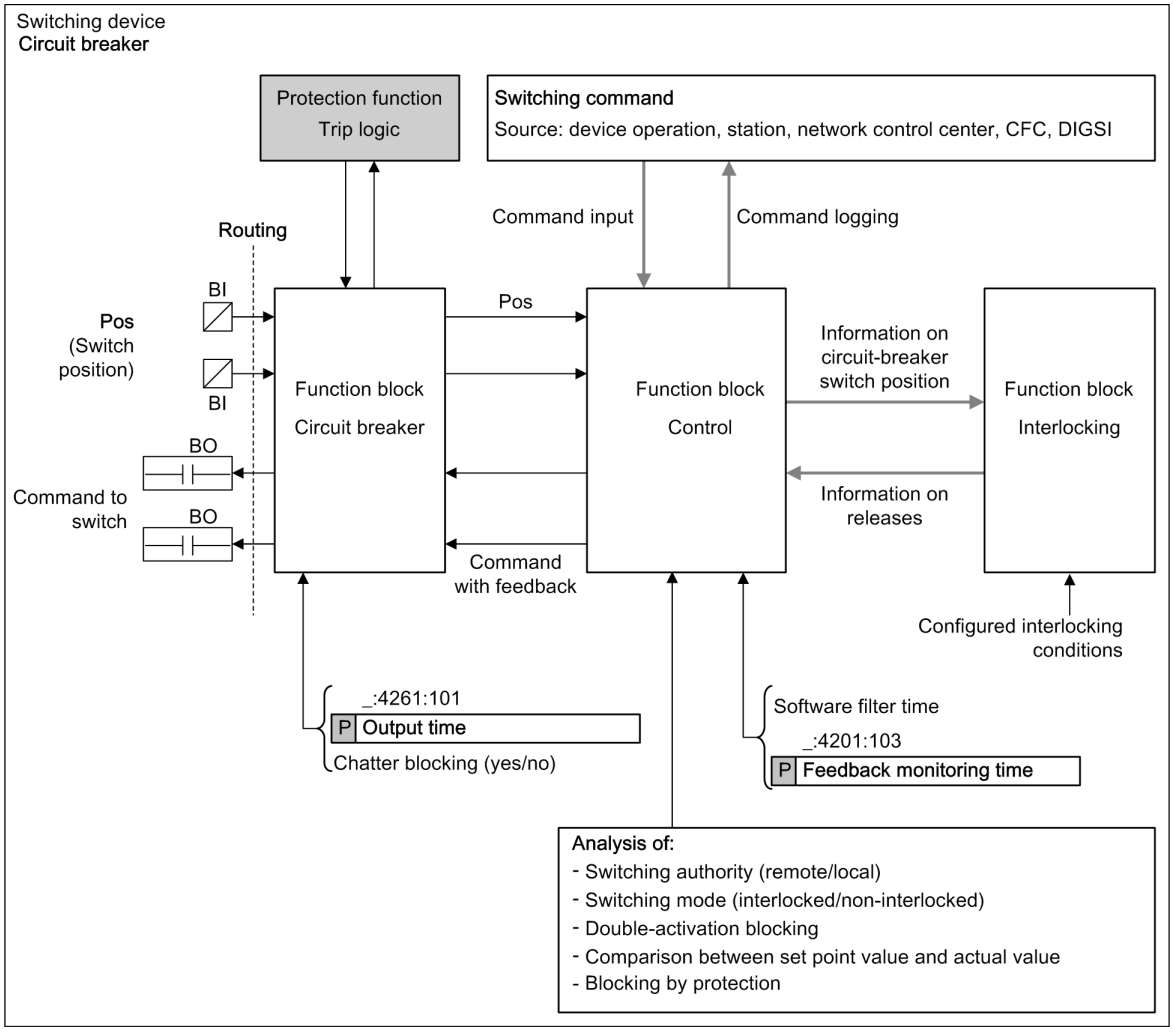
This chapter describes the control properties of the **Circuit-breaker** switching device.

The **Circuit-breaker** switching device contains the following function blocks that are needed for control:

- Function block **Circuit breaker**
- Function block **Control**
- Function block **Interlocking**

This corresponds to the logical nodes XCBR, CSWI, and CILO in IEC 61850.

In the case of protection devices or combined protection and control devices, additional functions can be contained in the **Circuit-breaker** switching device, for example, **Synchrocheck**, the **Automatic reclosing (AREC)**, the **Trip logic**, or **Manual On function**. However, these are not relevant for the control function. You can find the description of these functions in the chapter *Protection and Automatic Functions*. In addition, other functions can be initialized. You can find the description of these functions in the chapter *Protection Functions*.



[dw_breake, 1, en_US]

Figure 7-4 Control Function Blocks of the Circuit-Breaker Switching Device

The circuit breaker in DIGSI 5 is linked with the binary inputs that acquire the switch position via information routing. The circuit breaker in DIGSI 5 is also linked with the binary outputs that issue the switching commands.

The **Circuit-breaker** switching device is available in the following types:

- **3-pole circuit breaker [control only]**
  This switching device contains the function blocks **Control**, **Interlocking**, and **Circuit breaker** needed for control. The standard situation for the control function is that the SIPROTEC 5 device switches all 3 poles of the circuit breaker ***On*** or ***Off*** together. The **Synchronization function** can also be added.
- **3-pole circuit breaker**, **Circuit breaker [without current]**
  This switching device contains additional base function blocks for protection functions (for example, **Trip logic**, **Manual closure**, **Circuit-breaker test**).
- **1-pole circuit breaker**
  This switching device is intended for 1-pole tripping via the protection functions and contains the same base function blocks for protection as the **3-pole circuit breaker** switching device.
- **Circuit breaker [status only]**
  This switching device contains only the function block **Circuit breaker**. It is used to acquire the position of a switch, for example, from a neighboring bay. This object type can be used to model switches that can only be read but not controlled by the SIPROTEC 5 device.

NOTE

When setting the parameters of a device, you will find 2 circuit-breaker types in the DIGSI 5 library:

- **3-pole circuit breaker** or **1-pole circuit breaker**, depending on the device type selected (3-pole or 1-pole tripping)
- **Circuit breaker [status only]**

Function Blocks of the Circuit Breaker

Table 7-1 Function Blocks of the Circuit-Breaker Function Group

Function Block	Description	Parameter	Function
Circuit breaker	The Circuit-breaker function block in the SIPROTEC 5 device represents the physical switch.	**Output time**	The circuit breaker forms the switch position from the positions of the binary inputs and also outputs the command via the binary outputs.
Control	Command processing	**Control model** **SBO time-out** **Feedback monitoring time** **Check switching authority** **Check if pos. is reached** **Check double activat. blk.** **Check blk. by protection**	Command check, communication with the command source and with the function block **Circuit breaker**
Interlocking	Switchgear interlocking protection	Interlocking condition (deposited in CFC)	The functionality **Interlocking** generates the releases for switchgear interlocking protection.

For the setting values of the parameter, refer to *7.2.2.2 Application and Setting Notes*.

Additional Setting Options of the Circuit-Breaker Switching Element

The setting options of the circuit breaker are assigned to the function blocks on the basis of their relevance. Additional setting options of the circuit breakers that cannot be directly assigned to one of the 3 function blocks are nevertheless available:

Table 7-2 Setting Options of the Controllable **Cmd. with feedback** in the Function Block **Control** of the Circuit Breaker.

Properties	Function	To Be Found in
Software filtering time	Software filtering time for position detection	Position of the function block **Control** [56]
Retrigger filter (yes/no)	Switching retriggering of the filtering time on/off by changing the position	Position of the function block **Control** [56]
Message time before filtering (yes/no)	Consideration of the hardware filtering time for position-detection time stamp	Position of the function block **Control**[56]

56 First click **Position** and then click the **Details** key in the **Properties** window (below).

Properties	Function	To Be Found in
Suppress intermediate position (yes/no)	When activated, only the intermediate position is suppressed by the duration of the software filtering time.	Position of the function block **Control** 56
Treatment of spontaneous position changes (Gen. Software Filt./Spont. Software Filt.)	If you select the ***General software filter*** setting, the general settings for software filtering of spontaneous position changes and for position changes caused by a switching command apply. By selecting ***Spontaneous software filter***, a separate filtering is activated for spontaneous position changes.	Position of the function block **Control** 56
Spontaneous software filtering time	Software filtering time for spontaneous position changes	Position of the function block **Control** 56
Spontaneous retrigger filter (yes/no)	Switching on/off retriggering of the filtering time by spontaneous position change	Position of the function block **Control** 56
Spontaneous indication timestamp before filtering (yes/no)	Consideration of the hardware filtering time for position-detection time stamp in case of a spontaneous change	Position of the function block **Control** 56
Inhibit intermediate position for a spontaneous chng. (yes/no)	When activated, only the spontaneous change to the intermediate position is suppressed by the duration of the software filtering time.	Position of the function block **Control** 56

Table 7-3 Setting Options of the Controllable **Position** in the Circuit-Breaker Function Block (Chatter Blocking)

Properties	Function	To Be Found in
Chatter blocking (yes/no)	Switching chatter blocking on/off	Position of the function block **Circuit breaker**56

Table 7-4 Additional Settings in the Device Settings Having Effects on the Circuit Breaker

Properties	Function	To Be Found in
Number of permissible status changes	Chatter-blocking setting value: Once for the entire device	Device settings (to be found under Settings)
Chatter test time		
Number of chatter tests		
Chatter idle time		
Chatter check time		

The inputs and outputs as well as the setting options of the function blocks **Circuit breaker** and **Control** are described in the next section (refer to *7.2.2.3 Connection Variants of the Circuit Breaker*).

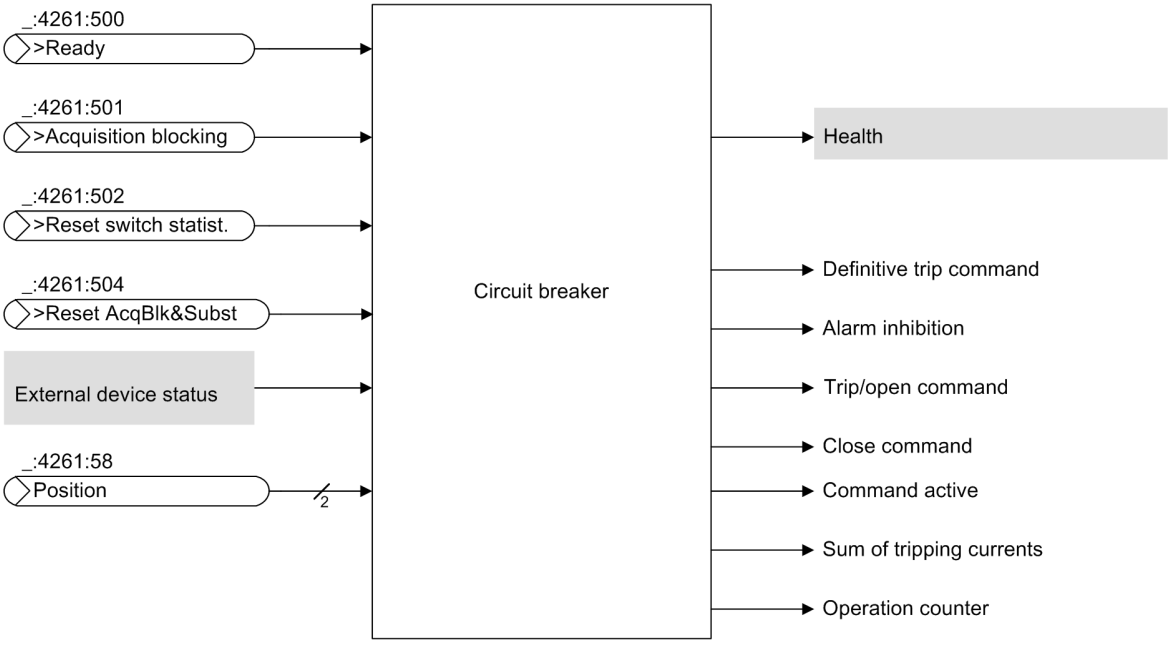
Interlocking

The function block **Interlocking** generates the releases for switchgear interlocking protection. The actual interlocking conditions are deposited in CFC. For more information on this, refer to the general chapter *7.4.1 Command Checks and Switchgear Interlocking Protection*.

7.2.2.2 Application and Setting Notes

Circuit Breaker

The Circuit-breaker function block in the SIPROTEC 5 device represents the physical switch device. The task of the circuit breaker is to replicate the switch position from the status of the binary inputs.
The following figure shows the logical inputs and outputs of the **Circuit-breaker** function block.



[dw_func_ls, 2, en_US]

Figure 7-5 Logical Inputs and Outputs of the Circuit-Breaker Function Blocks

Table 7-5 and *Table 7-6* list the inputs and outputs with a description of their function and type. For inputs, the effect of **Quality = invalid** on the value of the signal is described.

EXAMPLE

If the signal **>Ready** has the **Quality = invalid**, then the value is set to **cleared**. In problematic operating states, the circuit breaker should signal that it is not ready for an **Off-On-Off cycle**.

Table 7-5 Inputs of the Circuit-Breaker Function Block

Signal Name	Description	Type	Default Value if Signal Quality = invalid
>Ready	The signal **>Ready** indicates that the OFF-ON-OFF cycle is possible with the circuit breaker. This signal is used for the AREC standby status.	SPS	Going
>Acquisition blocking	The binary input activates acquisition blocking. You can also set this binary input with an external toggle switch.	SPS	Unchanged
>Reset AcqBlk&Subst	Acquisition blocking and the substitution of the circuit breaker are reset with this input. If the input is activated, setting the acquisition blocking and the substitution is blocked.	SPS	Unchanged
>Reset switch statist.	Among other things, the binary input sets the operation counter for the switch to the value 0.	SPS	Unchanged

Signal Name	Description	Type	Default Value if Signal Quality = invalid
External health	The binary input **External health** reflects the circuit-breaker status (EHealth). This input will be set by the CFC using the BUILD_ENS block. In turn, BUILD_ENS can query binary inputs that represent the conditions ***OK***, ***Warning***, or ***Alarm*** (as a result of the function **Trip-circuit supervision**).	ENS	Unchanged
Position	The signal **Position** can be used to read the circuit-breaker position with double-point indication.	DPC	Unchanged

If the quality of the input signal assumes the status **Quality = invalid**, then the standby status (EHealth) of the **Circuit-breaker** function block is set to ***Warning***.

Table 7-6 Outputs of the Circuit-Breaker Function Block

Signal Name	Description	Type
Definitive trip	Protection has finally been tripped.	SPS
Alarm suppression	The signaling contact for external alarm inhibition is suppressed during the runtime of automatic reclosing (optional) as well as during the command output of switching commands.	SPS
Op.ct.	The information counts the number of switching cycles of the circuit breaker.	INS
Trip/open cmd.	This logic output is responsible for the command output **Off**.	SPS
Close command	This logic output is responsible for the command output **On**.	SPS
Command active	The binary output **Command active** is responsible for signaling a running command (relay active or selected switching device (SEL)).	SPS
CB open hours	The statistical value counts the hours the circuit breaker is open.	INS
Operating hours	The statistical value counts the hours where at least one phase current is greater than the **Current thresh. CB open** parameter.	INS

Control

It is the task of the controls to execute command checks and establish communication between the command source and the circuit breaker. Using the control settings, you specify how the commands are to be processed (see also chapter *7.4.1 Command Checks and Switchgear Interlocking Protection*).

Through the function SBO (Select Before Operate, reservation[57]), the switching device is reserved prior to the actual switching operation, thus it remains locked for additional commands. Feedback monitoring provides information about the initiator of the command while the command is in process, that means, informing whether or not the command was implemented successfully. These 2 options can be selected individually in the selection of the control model, so that 4 combinations in total are available (see the following table).

The control makes the following settings available (see next table).

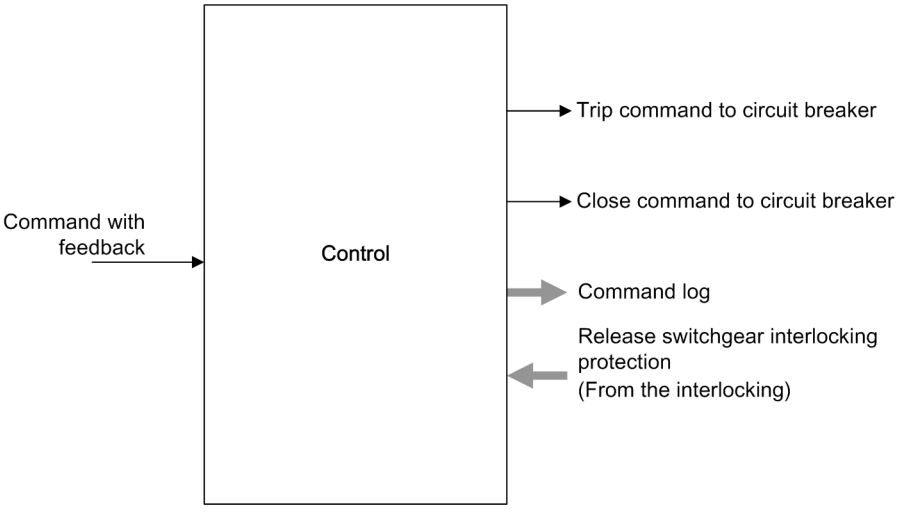
Parameters	Default Setting	Possible Parameter Values
(_:4201:101) Control model	***SBO w. enh. security***[58]	***direct w. normal secur.*** ***SBO w. normal secur.*** ***direct w. enh. security*** ***SBO w. enh. security***
(_:4201:102) SBO time-out	***30.00 s***	0.01 s to 1800 s (Increment: 0.01 s)

57 In the IEC 61850 standard, reservation is described as **Select before Operate (SBO)**.

58 This default setting is the standard control model for a switching command in an IEC 61850-compliant system.

Parameters	Default Setting	Possible Parameter Values
(_:4201:103) Feedback monitoring time	1.00 s	0.01 s to 1800 s (Increment: 0.01 s)
(_:4201:104) Check switching authority	yes	no yes advanced
(_:4201:105) Check if pos. is reached	yes	no yes
(_:4201:106) Check double activat. blk.	yes	no yes
(_:4201:107) Check blk. by protection	yes	no yes

The following figure shows the logical inputs and outputs of the **Control** function block.



[dw_steue1, 1, en_US]

Figure 7-6 Logical Inputs and Outputs of the Control Function Block

Table 7-7 Control Function Block Input and Output

Signal Name	Description	Type	Value if Signal Quality=Invalid
Cmd. with feedback	With the **Cmd. with feedback** signal, the circuit-breaker position is accepted via the double-point indication of the **Circuit-breaker** function block and the command is issued.	Controllable (DPC) Unchanged	Unchanged

In the information routing of DIGSI 5, you may select a function key as a possible command source. In addition, it is displayed here if the command is activated by CFC. The logging is routed here.

7.2.2.3 Connection Variants of the Circuit Breaker

For each switching device, you can establish the number of poles (for example, 1-pole, 1.5-pole or 2-pole) that are switched with or without feedback. This results in the necessary amount of information to be processed, thus establishing the command type.

Whether the circuit breaker is triggered 1-, 1.5-, or 2-pole, depends on the design of the auxiliary and control-voltage system. In most cases, the activation of the opening coil of the circuit breaker is 1-pole.

Table 7-8 Meaning of the Abbreviations of the Connection Variants

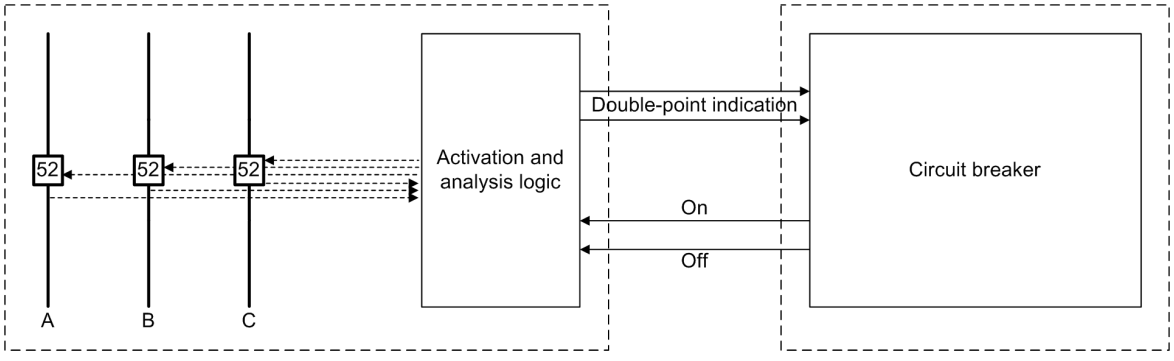
Abbreviation	Meaning of the Abbreviation of the Connection Variants
BO	Binary output
L+; L-	Control voltage
A	Trip command
Gnd	Close command

Table 7-9 Meaning of the Abbreviations in DIGSI

Abbreviation	Description of the Input in DIGSI
V	Unsaved trip command Click the right mouse button and enter **V**.
X	Close Command Click the right mouse button and enter **X** for the respective binary output.
OH	The switching-device feedback is in the position **OFF**, if there is voltage present at the routed binary input (H). Click the right mouse button and enter **OH**.
OL	The switching-device feedback is in the position **OFF**, if there is no voltage present at the routed binary input (L). Click the right mouse button and enter **OL**.
CH	The switching-device feedback is in the position **ON**, if there is voltage present at the routed binary input (H). Click the right mouse button and enter **CH**.
CL	The switching-device feedback is in the position **ON**, if there is no voltage present at the routed binary input (H). Click the right mouse button and enter **CL**.
TL	Trip command stored Click the right mouse button and enter **TL**.

Connection Variant: 3-Pole Circuit Breaker

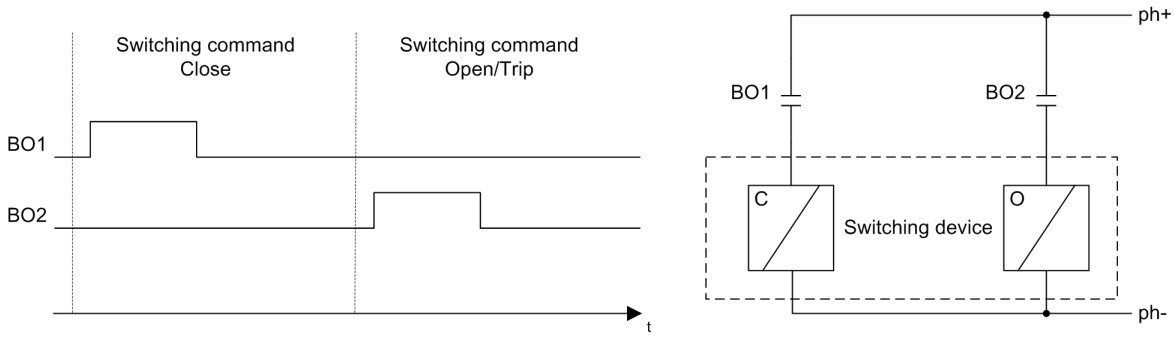
This is the standard type for the control function. All 3 individual poles of the circuit breaker are triggered together by a double command.



[dw_3-pole_ls, 1, en_US]

Figure 7-7 3-Pole Circuit Breaker

1-Pole Triggering



[dw_1-pole, 1, en_US]

Figure 7-8 1-Pole Triggering

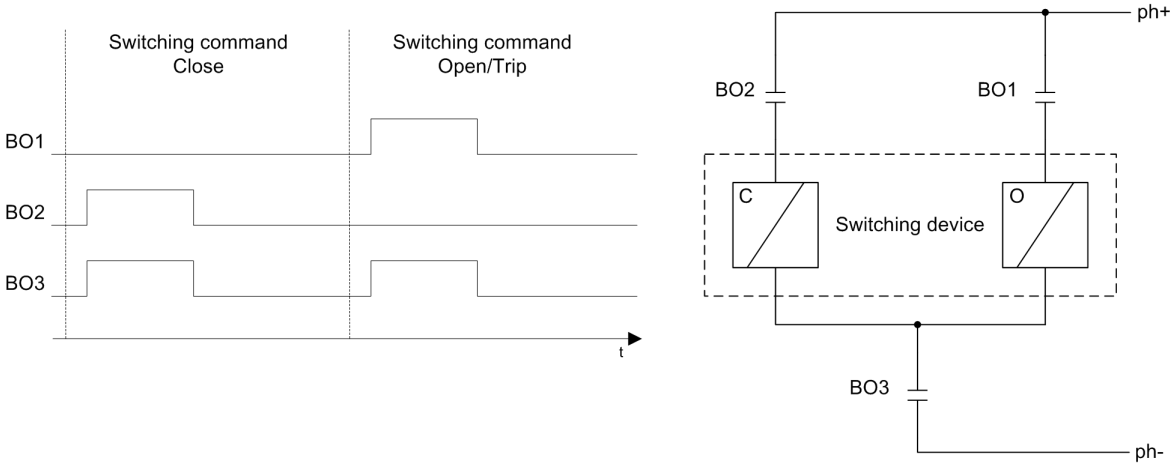
Information			S	Destination				
				Binary output				
				Base module				
Signals	Number	Type		1.1	1.2	1.3	1.4	1.5
(All)	(All)	...		...	...	...	...	...
Trip logic	301.5341							
Circuit break.	301.4261			*	*			
>Ready	301.4261.500	SPS						
>Acquisition blocking	301.4261.501	SPS						
>Reset switch statist.	301.4261.502	SPS						
>Reset AcqBlk&Subst	301.4261.504	SPS						
External health	301.4261.503	ENS						
Health	301.4261.53	ENS						
Position 3-pole	301.4261.58	DPC						
Position 1-pole phsA	301.4261.459	DPC						
Position 1-pole phsB	301.4261.460	DPC						
Position 1-pole phsC	301.4261.461	DPC						
Trip/open cmd. 3-pole	301.4261.300	SPS			U			
Trip only pole A	301.4261.401	SPS						
Trip only pole B	301.4261.402	SPS						
Trip only pole C	301.4261.403	SPS						
Close command	301.4261.301	SPS		X				

[sc_rang1p_cb1p, 1, en_US]

Figure 7-9 1-Pole Triggering, Routing in DIGSI

You can select the contacts for ***On*** and ***Off*** as desired. They need not necessarily be next to one another. The letter **U** represents an unlatched command. Alternatively, **TL** (latched tripping) can be selected.

1.5-Pole Triggering



[dw_5-pole, 1, en_US]

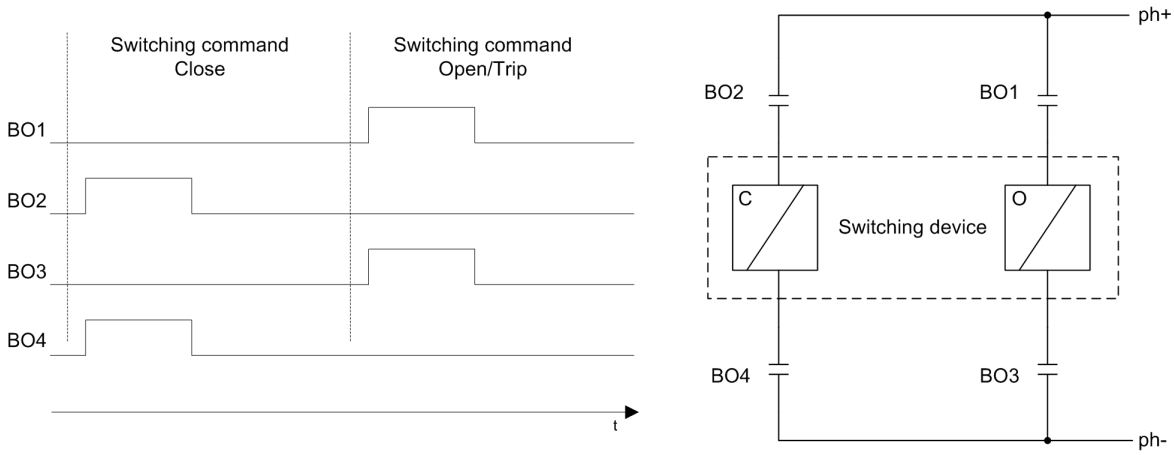
Figure 7-10 1.5-Pole Triggering

Information			S	Destination				
				Binary output				
				Base module				
Signals	Number	Type		1.1	1.2	1.3	1.4	1.5
(All)	(All)	...		...	...	...	...	...
Trip logic	301.5341							
Circuit break.	301.4261			*	*	*		
>Ready	301.4261.500	SPS						
>Acquisition blocking	301.4261.501	SPS						
>Reset switch statist.	301.4261.502	SPS						
>Reset AcqBlk&Subst	301.4261.504	SPS						
External health	301.4261.503	ENS						
Health	301.4261.53	ENS						
Position 3-pole	301.4261.58	DPC						
Position 1-pole phsA	301.4261.459	DPC						
Position 1-pole phsB	301.4261.460	DPC						
Position 1-pole phsC	301.4261.461	DPC						
Trip/open cmd. 3-pole	301.4261.300	SPS		U		U		
Trip only pole A	301.4261.401	SPS						
Trip only pole B	301.4261.402	SPS						
Trip only pole C	301.4261.403	SPS						
Close command	301.4261.301	SPS			X	X		

[sc_rang_1p_cb15p, 1, en_US]

Figure 7-11 1.5-Pole Triggering, Routing in DIGSI

2-Pole Triggering



[dw_2-pole-open, 1, en_US]

Figure 7-12 2-Pole Triggering

Information			Source								Destination			
			Binary input							CFC	Binary output			
			Base module							Em	Base module			
Signals	Number	Type	1.1	1.2	1.3	1.4	2.1	2.2	2.3		1.1	1.2	1.3	1.4
(All)	(All)	...	...	...	...	...	...	...	...	...	...	...	...	...
Line 1	21													
Circuit breaker 1	301		*	*	*	*	*				*	*	*	*
Trip logic	301.5341													
Circuit break.	301.4261		*	*	*	*	*				*	*	*	*
>Ready	301.4261.500	SPS					H							
>Acquisition blocking	301.4261.501	SPS												
>Reset switch statist.	301.4261.502	SPS												
>Reset AcqBlk&Subst	301.4261.504	SPS												
External health	301.4261.503	ENS												
Health	301.4261.53	ENS												
Position 3-pole	301.4261.58	DPC	OH											
Position 1-pole phsA	301.4261.459	DPC		CH										
Position 1-pole phsB	301.4261.460	DPC			CH									
Position 1-pole phsC	301.4261.461	DPC				CH								
Trip/open cmd. 3-pole	301.4261.300	SPS									U	U	U	
Trip only pole A	301.4261.401	SPS									X			
Trip only pole B	301.4261.402	SPS										X		
Trip only pole C	301.4261.403	SPS											X	
Close command	301.4261.301	SPS												X
Command active	301.4261.302	SPS												

[sc_rang_1p_cb13p, 1, en_US]

Figure 7-13 2-Pole Triggering, Routing in DIGSI

Connection Variant: 1-Pole Circuit Breaker

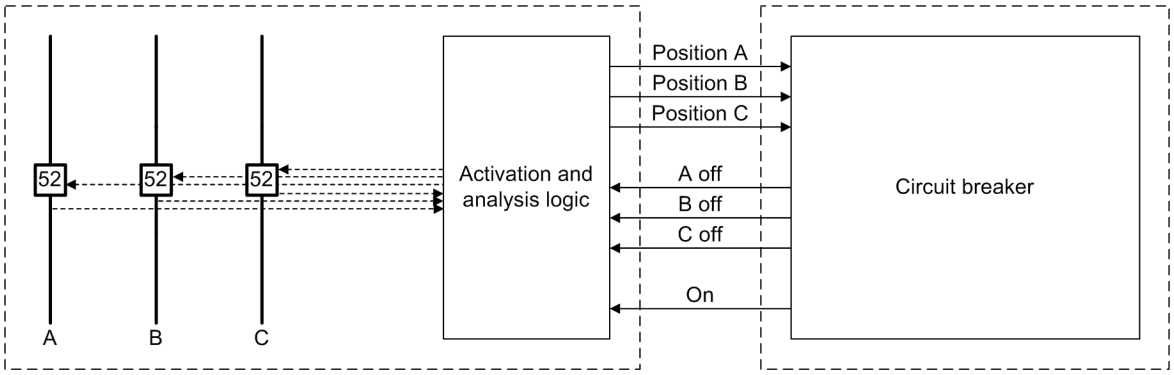
The 1-pole circuit breaker is used for separate activation and acquisition of the individual poles of a circuit breaker. It is intended for joint use by 1-pole protection and control functions.

NOTE

The wiring of the **Circuit-breaker** function group with binary inputs and binary outputs occurs 1 time per device.

The control function in this type switches all 3 poles on or off simultaneously.

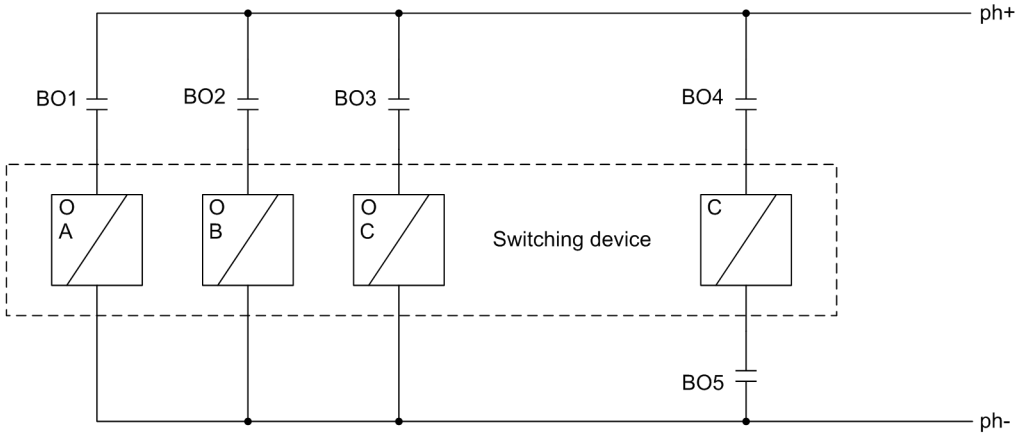
The protection functions can switch off 1-pole. The close command is always 3-pole. Optionally only the open poles are closed.



[dw_1polls, 1, en_US]

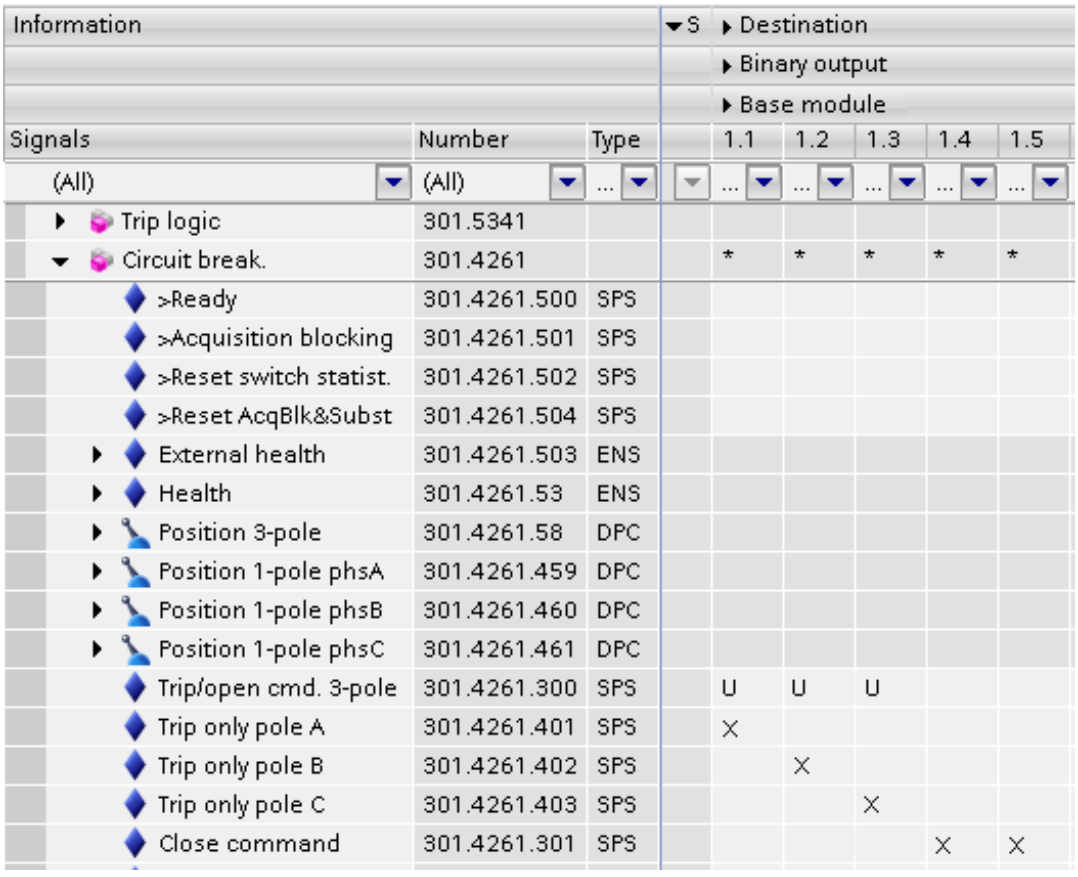
Figure 7-14 Circuit Breaker with 1-Pole Triggering

For the circuit breaker with 1-pole triggering, triggering takes place via one relay per phase for the trip command and via a 4th relay for the close command (see next figure).



[dw_1panls, 1, en_US]

Figure 7-15 1-Pole Connection of a Circuit Breaker



Information			S	Destination				
				Binary output				
				Base module				
Signals	Number	Type		1.1	1.2	1.3	1.4	1.5
(All)	(All)	...		...	...	...	...	...
Trip logic	301.5341							
Circuit break.	301.4261			*	*	*	*	*
>Ready	301.4261.500	SPS						
>Acquisition blocking	301.4261.501	SPS						
>Reset switch statist.	301.4261.502	SPS						
>Reset AcqBlk&Subst	301.4261.504	SPS						
External health	301.4261.503	ENS						
Health	301.4261.53	ENS						
Position 3-pole	301.4261.58	DPC						
Position 1-pole phsA	301.4261.459	DPC						
Position 1-pole phsB	301.4261.460	DPC						
Position 1-pole phsC	301.4261.461	DPC						
Trip/open cmd. 3-pole	301.4261.300	SPS		U	U	U		
Trip only pole A	301.4261.401	SPS		X				
Trip only pole B	301.4261.402	SPS			X			
Trip only pole C	301.4261.403	SPS				X		
Close command	301.4261.301	SPS					X	X

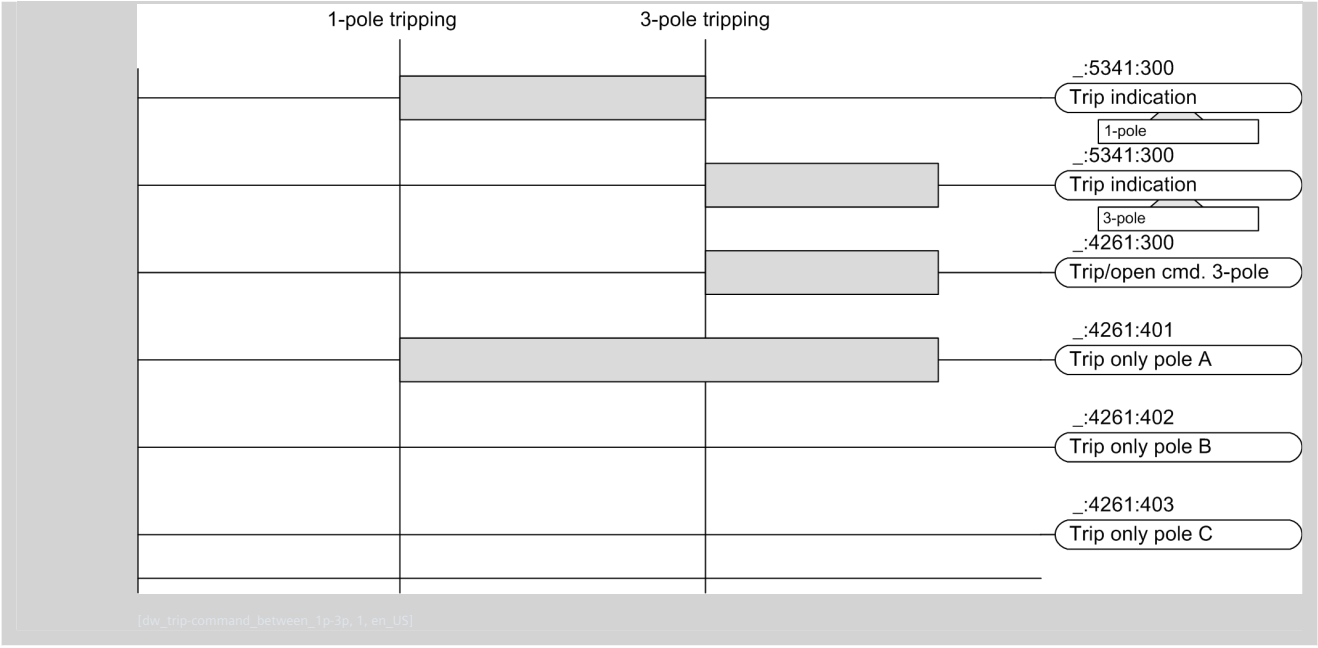
[sc_rang_1p_cb13pz, 1, en_US]

Figure 7-16 Routing in DIGSI

In the previous figure, the switch is connected 1-pole. The protection trip command is routed individually for the 3 phases (**`Trip only pole A`** to **`Trip only pole C`**). The protection trip command is routed for the 3 phases (**`Trip/open cmd. 3-pole`**). The control always switches off the 3 poles of the switch. In addition, the 3 **U** (Unlatched) routings of the trip command and open command are set to 3-pole. This routing is also used by protection functions that trip 3 poles. The close command is issued simultaneously for all 3 phases.

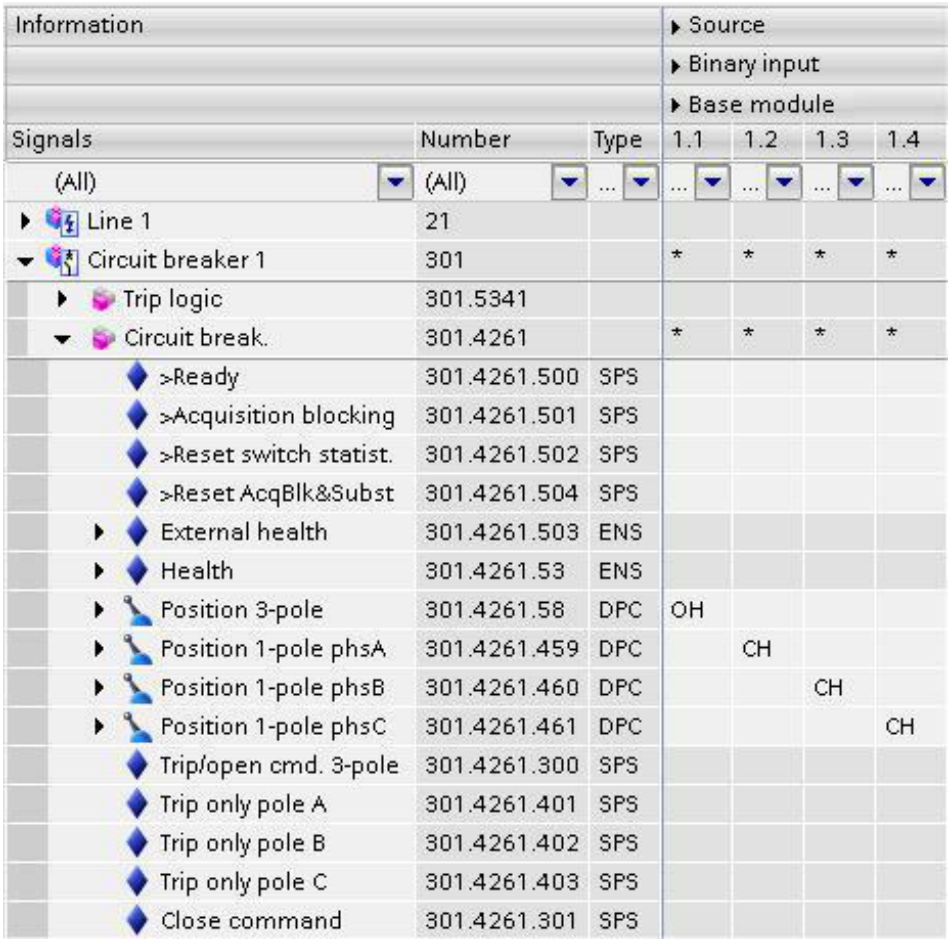
Example: Trip Command during Transition from 1-Pole to 3-Pole

During a transition from 1-pole to 3-pole tripping **`Trip only pole A`** remains active. When, for example informing an external AREC whether it is a 1-pole or 3-pole tripping, you can use the indication *`Trip logic:Trip indication:1-pole`* and *`Trip logic:Trip indication:3-pole`*.



Acquisition of the Circuit-Breaker Position

The binary inputs for feedback of the switch position are routed as shown in the previous figure (see also see *5.9.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information*).



Information			Source			
			Binary input			
			Base module			
Signals	Number	Type	1.1	1.2	1.3	1.4
(All)	(All)	...	...	...	...	...
Line 1	21					
Circuit breaker 1	301		*	*	*	*
Trip logic	301.5341					
Circuit break.	301.4261		*	*	*	*
>Ready	301.4261.500	SPS				
>Acquisition blocking	301.4261.501	SPS				
>Reset switch statist.	301.4261.502	SPS				
>Reset AcqBlk&Subst	301.4261.504	SPS				
External health	301.4261.503	ENS				
Health	301.4261.53	ENS				
Position 3-pole	301.4261.58	DPC	OH			
Position 1-pole phsA	301.4261.459	DPC		CH		
Position 1-pole phsB	301.4261.460	DPC			CH	
Position 1-pole phsC	301.4261.461	DPC				CH
Trip/open cmd. 3-pole	301.4261.300	SPS				
Trip only pole A	301.4261.401	SPS				
Trip only pole B	301.4261.402	SPS				
Trip only pole C	301.4261.403	SPS				
Close command	301.4261.301	SPS				

[sc_rang_1p_cb_Hk, 1, en_US]

Figure 7-17 Routing of the 1-Pole in DIGSI

You can find the meaning of abbreviations in *Table 7-8* and *Table 7-9*.

The indication **Command active** can also be routed to a binary output. This binary output is always active if either a close or trip command is pending, or the switching device was selected by the command control.

7.2.2.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Ref. for %-values				
_:2311:101	General:Rated normal current		0.20 A to 100000.00 A	1000.00 A
_:2311:102	General:Rated voltage		0.10 kV to 1200.00 kV	400.00 kV
Breaker settings				
_:2311:112	General:Current thresh. CB open	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2311:136	General:Op. mode BFP		• unbalancing • I> query	unbalancing

Addr.	Parameter	C	Setting Options	Default Setting
Trip logic				
_:5341:103	Trip logic:Reset of trip command		• with I< • with I< & aux.contact • with dropout	with I<
Circuit break.				
_:4261:101	Circuit break.:Output time		0.02 s to 1800.00 s	0.10 s
_:4261:105	Circuit break.:Indicat. of breaking values		• with trip • always	always
Manual close				
_:6541:101	Manual close:Action time		0.01 s to 60.00 s	0.30 s
_:6541:102	Manual close:CB open dropout delay		0.00 s to 60.00 s	0.00 s
Control				
_:4201:101	Control:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:4201:102	Control:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:4201:103	Control:Feedback monitoring time		0.01 s to 1800.00 s	1.00 s
_:4201:104	Control:Check switching authority		• no • yes • advanced	yes
_:4201:105	Control:Check if pos. is reached		• no • yes	yes
_:4201:106	Control:Check double activat. blk.		• no • yes	yes
_:4201:107	Control:Check blk. by protection		• no • yes	yes
Switching authority				
_:4201:151	Control:Swi.dev. related sw.auth.		• 0 • 1	false
_:4201:152	Control:Specific sw. authorities		• 0 • 1	true
_:4201:115	Control:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:4201:153	Control:Num. of specific sw.auth.		2 to 5	2
_:4201:155	Control:Ident. sw.auth. 1		Freely editable text	

Addr.	Parameter	C	Setting Options	Default Setting
_:4201:156	Control:Ident. sw.auth. 2		Freely editable text	
_:4201:157	Control:Ident. sw.auth. 3		Freely editable text	
_:4201:158	Control:Ident. sw.auth. 4		Freely editable text	
_:4201:159	Control:Ident. sw.auth. 5		Freely editable text	
_:4201:154	Control:Multiple specific sw.auth.		• 0 • 1	false
CB test				
_:6151:101	CB test:Dead time		0.00 s to 60.00 s	0.10 s
_:6151:102	CB test:Trip only		• 0 • 1	false
_:6151:103	CB test:Consider current criterion		• 0 • 1	false
_:6151:104	CB test:Current threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A

7.2.2.5 Information List

No.	Information	Data Class (Type)	Type
Trip logic			
_:5341:300	Trip logic:Trip indication	ACT	O
_:5341:58	Trip logic:Trip ind.:Busbar diff.prt.	ACT	O
_:5341:59	Trip logic:Trip ind.:Busbar BFP	ACT	O
_:5341:60	Trip logic:Trip ind.:Busbar ext.trip	ACT	O
_:5341:52	Trip logic:Behavior	ENS	O
_:5341:53	Trip logic:Health	ENS	O
Circuit break.			
_:4261:500	Circuit break.:>Ready	SPS	I
_:4261:501	Circuit break.:>Acquisition blocking	SPS	I
_:4261:502	Circuit break.:>Reset switch statist.	SPS	I
_:4261:504	Circuit break.:>Reset AcqBlk&Subst	SPS	I
_:4261:505	Circuit break.:>Trip release BBP	SPS	I
_:4261:503	Circuit break.:External health	ENS	I
_:4261:52	Circuit break.:Behavior	ENS	O
_:4261:53	Circuit break.:Health	ENS	O
_:4261:58	Circuit break.:Position 3-pole	DPC	C
_:4261:300	Circuit break.:Trip/open cmd. 3-pole	SPS	O
_:4261:301	Circuit break.:Close command	SPS	O
_:4261:410	Circuit break.:Open cmd. 1-pole phsA	SPS	O
_:4261:411	Circuit break.:Open cmd. 1-pole phsB	SPS	O

No.	Information	Data Class (Type)	Type
_:4261:412	Circuit break.:Open cmd. 1-pole phsC	SPS	O
_:4261:413	Circuit break.:Close cmd. 1-pole phsA	SPS	O
_:4261:414	Circuit break.:Close cmd. 1-pole phsB	SPS	O
_:4261:415	Circuit break.:Close cmd. 1-pole phsC	SPS	O
_:4261:302	Circuit break.:Command active	SPS	O
_:4261:303	Circuit break.:Definitive trip	SPS	O
_:4261:304	Circuit break.:Alarm suppression	SPS	O
_:4261:416	Circuit break.:PoW capability	ENS	O
_:4261:326	Circuit break.:BBP trip relays blocked	SPS	O
_:4261:327	Circuit break.:no release of trip cmd	SPS	O
_:4261:306	Circuit break.:Op.ct.	INS	O
_:4261:307	Circuit break.:ΣI Brk.	BCR	O
_:4261:308	Circuit break.:ΣIA Brk.	BCR	O
_:4261:309	Circuit break.:ΣIB Brk.	BCR	O
_:4261:310	Circuit break.:ΣIC Brk.	BCR	O
_:4261:311	Circuit break.:Break.-current phs A	MV	O
_:4261:312	Circuit break.:Break.-current phs B	MV	O
_:4261:313	Circuit break.:Break.-current phs C	MV	O
_:4261:317	Circuit break.:Break. current 3I0/IN	MV	O
_:4261:314	Circuit break.:Break. voltage phs A	MV	O
_:4261:315	Circuit break.:Break. voltage phs B	MV	O
_:4261:316	Circuit break.:Break. voltage phs C	MV	O
_:4261:322	Circuit break.:CB open hours	INS	O
_:4261:323	Circuit break.:Operating hours	INS	O
Manual close			
_:6541:501	Manual close:>Block manual close	SPS	I
_:6541:500	Manual close:>Input	SPS	I
_:6541:300	Manual close:Detected	SPS	O
_:6541:52	Manual close:Behavior	ENS	O
_:6541:53	Manual close:Health	ENS	O
Reset LED Group			
_:13381:500	Reset LED Group:>LED reset	SPS	I
_:13381:320	Reset LED Group:LED have been reset	SPS	O
_:13381:52	Reset LED Group:Behavior	ENS	O
_:13381:53	Reset LED Group:Health	ENS	O
Control			
_:4201:503	Control:>Sw. authority local	SPS	I
_:4201:504	Control:>Sw. authority remote	SPS	I
_:4201:505	Control:>Sw. mode interlocked	SPS	I
_:4201:506	Control:>Sw. mode non-interl.	SPS	I
_:4201:52	Control:Behavior	ENS	O
_:4201:53	Control:Health	ENS	O
_:4201:58	Control:Cmd. with feedback	DPC	C
_:4201:302	Control:Switching auth. station	SPC	C
_:4201:308	Control:Enable sw. auth. 1	SPC	C
_:4201:309	Control:Enable sw. auth. 2	SPC	C

No.	Information	Data Class (Type)	Type
_:4201:310	Control:Enable sw. auth. 3	SPC	C
_:4201:311	Control:Enable sw. auth. 4	SPC	C
_:4201:312	Control:Enable sw. auth. 5	SPC	C
_:4201:313	Control:Switching authority	ENS	O
_:4201:314	Control:Switching mode	ENS	O
Interlocking			
_:4231:500	Interlocking:>Enable opening	SPS	I
_:4231:501	Interlocking:>Enable closing	SPS	I
_:4231:502	Interlocking:>Enable opening(fixed)	SPS	I
_:4231:503	Interlocking:>Enable closing (fixed)	SPS	I
_:4231:52	Interlocking:Behavior	ENS	O
_:4231:53	Interlocking:Health	ENS	O
CB test			
_:6151:52	CB test:Behavior	ENS	O
_:6151:53	CB test:Health	ENS	O
_:6151:301	CB test:Test execution	ENS	O
_:6151:302	CB test:Trip command issued	ENS	O
_:6151:303	CB test:Close command issued	ENS	O
_:6151:304	CB test:Test canceled	ENS	O
_:6151:311	CB test:3-pole open-close	SPC	C

7.2.3 Disconnector Switching Device

7.2.3.1 Structure of the Disconnector Switching Device

Like the circuit breaker, the **Disconnector** switching device contains the following 3 function blocks:

- Function block **Disconnector**
- Function block **Control**
- Function block **Interlocking**

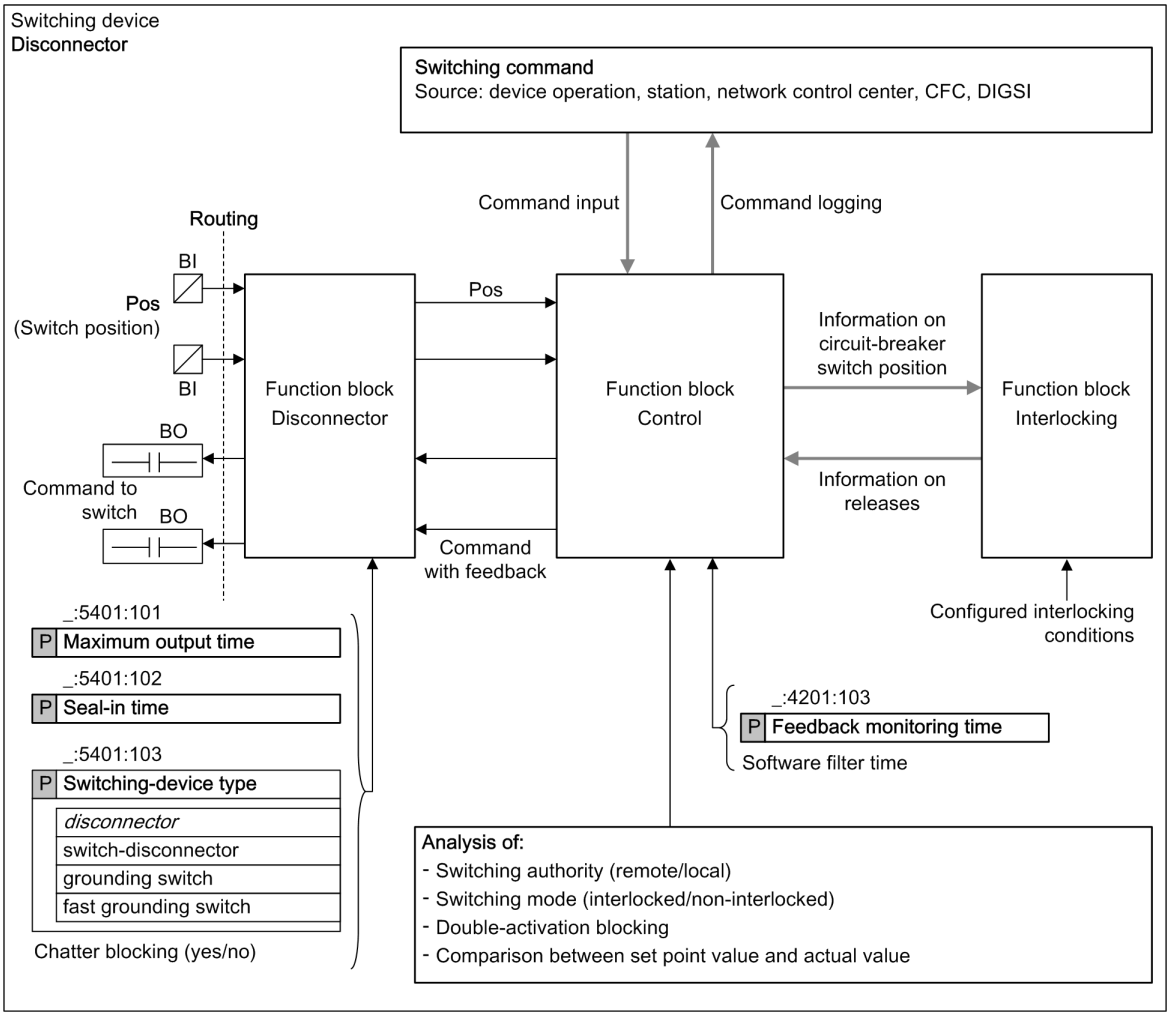
This corresponds to the logical nodes XSWI, CSWI, and CILO in IEC 61850.



NOTE

In contrast to the **Circuit-breaker** switching device, the **Disconnector** switching device cannot contain any additional functions because protection functions or synchronization can have no effect on the disconnector.

The following figure shows the structure of the **Disconnector** switching element:



[dw_discon, 2, en_US]

Figure 7-18 Control-Relevant Function Blocks of the Disconnector Switching Device

The **Disconnector** switching device behaves like the **Circuit-breaker** switching device. The only difference is the designation of the function block that the physical switch provides (disconnector instead of circuit breaker). Blocking by protection is not provided in the analysis of the **Control** function block.

The **Disconnector** switching device is available in the DIGSI 5 library in 2 different variants:

- **Disconnector with 3-pole connection**
  The device switches all 3 poles of the disconnector on or off simultaneously.
- **Disconnector without triggering (only status detection, no control)**
  This variant is rarely encountered. It is encountered with grounding switches that frequently cannot be controlled, but only provide their current position. In addition, the position of a disconnector in a neighboring bay can be acquired.

Function Blocks of the Disconnector

Table 7-10 Function Blocks of the Disconnector Function Group

Function Block	Description	Parameter	Function
Discon-nector	The disconnector represents the physical switch in the SIPROTEC 5 device.	**`Maximum output time`** **`Seal-in time`** **`Switching-device type`**	The disconnector replicates the switch position from the status of the binary inputs and also transmits the command via the binary outputs.
Control	Command processing	**`Control model`** **`SBO time-out`** **`Feedback monitoring time`** **`Check switching authority`** **`Check if pos. is reached`** **`Check double activat. blk.`**	Command checks, communication with the command source and with the function block **Disconnector**
Inter-locking	Switchgear interlocking protection	Interlocking condition (deposited in CFC)	The **Interlocking** functionality generates the releases for switchgear interlocking protection.

You can find the setting values of the parameter in *7.2.3.2 Application and Setting Notes*.

Additional Settings of Disconnector Switching Element

The settings of the disconnector are assigned to the function blocks on the basis of their relevance. Additional disconnector settings that cannot be directly assigned to one of the 3 function blocks and are identical to the circuit-breaker settings are available:

Table 7-11 Setting Options of the Controllable **`Command with Feedback`** in the **`Control`** Function Block of the Circuit Breaker

Characteristics	Function	To Be Found in
`Software filtering time`	Software filtering time for position detection	Position of the **Control**(1) function block
`Retrigger filter` (yes/no)	Switching retriggering of the filtering time on/off by changing the position	Position of the **Control**(1) function block
`Message time before filtering` (yes/no)	Consideration of the hardware filtering time for position-detection time stamp	Position of the **Control**(1) function block
`Suppress intermediate position` (yes/no)	When activated, only the intermediate position is suppressed by the duration of the software filtering time.	Position of the **Control**(1) function block

Characteristics	Function	To Be Found in
Spontaneous position changes filtered by (Gen. Software Filt./Spont. Software Filt.)	If the ***General software filter*** setting is selected, the general settings for software filtering of spontaneous position changes and for position changes caused by a switching command apply. By selecting ***Spontaneous software filter***, a separate filtering is activated for spontaneous position changes.	Position of the **Control**(1) function block
Spontaneous software filter time	Software filtering time for spontaneous position changes	Position of the **Control**(1) function block
Spontaneous retrigger filter (yes/no)	Switching on/off retriggering of the filtering time by spontaneous position change	Position of the **Control**(1) function block
Spontaneous indication timestamp before filtering (yes/no)	Consideration of the hardware filtering time for position-detection time stamp in case of a spontaneous change	Position of the **Control**(1) function block
Spontaneous suppress intermediate position (yes/no)	When activated, only the spontaneous change to the intermediate position is suppressed by the duration of the software filtering time.	Position of the **Control**(1) function block

(1) First click **Position** and then click the **Details** button in the **Properties** window (below).

Table 7-12 Setting Options of the Controllable **Position** in the Disconnector Function Block (Chatter Blocking)

Characteristics	Function	To Be Found in
Chatter blocking (yes/no)	Switching chatter blocking on/off	Position of the **Disconnector** (1) function block

(1) First click **Position** and then click the **Details** button in the **Properties** window (below).

Table 7-13 Additional Settings in the Device Settings with Effects on the Disconnector

Characteristics	Function	To Be Found in
Number of permissible state changes	Chatter-blocking setting value: Once for the entire device	Device settings (to be found under Settings)
Chatter test time		
Number of chatter tests		
Chatter dead time		
Chatter test time		

The inputs and outputs as well as the setting options of the **Disconnector switch** function block are described in *7.2.3.3 Trigger Variants of the Disconnector*. The **Control** function block is described identically as the **Circuit-breaker** function block, with the exception that the command check blocking is available through protection only with the circuit breaker.

You can find more information on this in *7.2.2.2 Application and Setting Notes*.

Interlocking

The **Interlocking** function block generates the releases for switchgear interlocking protection. The actual interlocking conditions are deposited in CFC. For more information on this, see the general chapter *7.4.1 Command Checks and Switchgear Interlocking Protection*.

7.2.3.2 Application and Setting Notes

Disconnector

The disconnector represents the physical switch in the SIPROTEC 5 device. The task of the disconnector is to replicate the switch position from the status of the binary inputs.

The **Disconnector** function block is linked automatically via the information matrix with the binary inputs that register the switch position and with the binary outputs that issue the switching commands.

The **Disconnector** function block makes the following settings available (see next table).

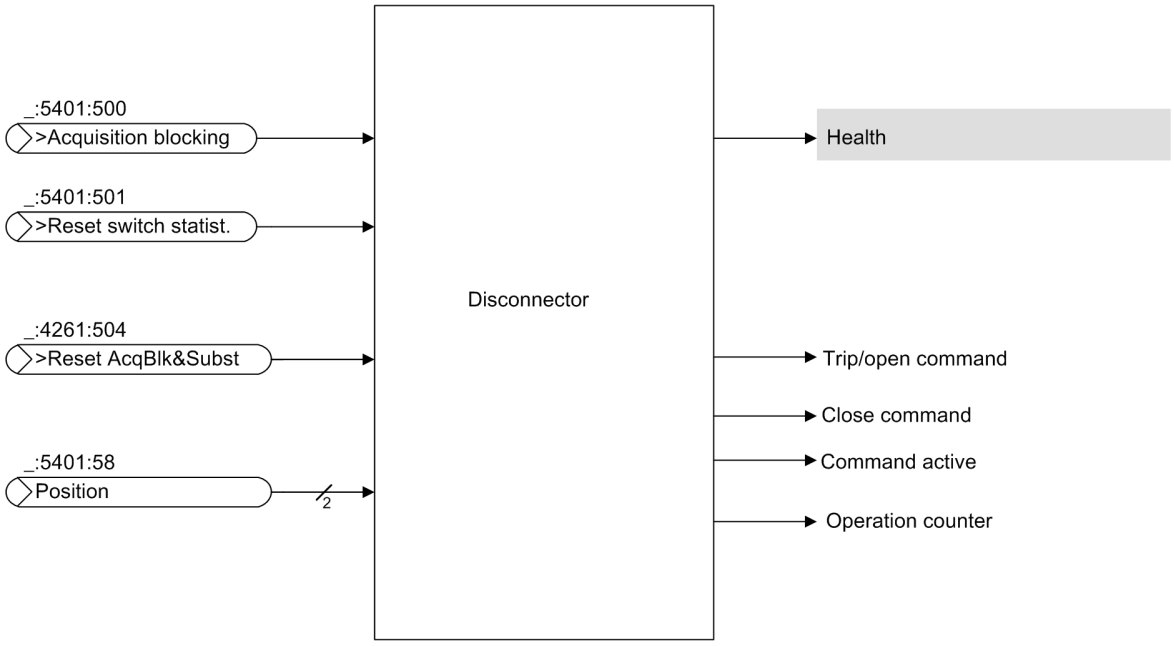
Parameters	Default Setting	Possible Parameter Values
(_:5401:101) Maximum output time The **Maximum output time** specifies the duration of the output pulse created by the switching command.	***10.00 s***	0.02 s to 1800 s (Increment: 0.01 s)
(_:5401:102) Seal-in time If the target actuating position is not yet attained although feedback has already been received, the output time is extended by the **Seal-in time**. The Seal-in time is relevant for equipment that sends feedback before the switching operation is completely performed. The Seal-in time is only considered for control models with feedback monitoring.	***0.00 s***	0 s to 60 s
(_:5401:103) Switching-device type The **Switching-device type** specifies the type of the switching device.	***disconnector***	***switch-disconnector*** ***disconnector*** ***grounding switch*** ***fast grounding switch***



NOTE

The parameter **Switching-device type** is effective only on the IEC 61850 interface. This parameter is used to set the disconnector switching device type for communication via IEC 61850. It is a mandatory data object in the IEC 61850 standard.

The following figure shows the logical inputs and outputs of the **Disconnector** function block.



[dw_out_inp, 2, en_US]

Figure 7-19 Logical Inputs and Outputs of the Disconnector Function Block

Table 7-14 and *Table 7-15* list the inputs and outputs with a description of their function and type. For inputs, the effect of **Quality = invalid** on the value of the signal is described.

Table 7-14 Inputs of the Disconnector Function Block

Signal Name	Description	Type	Value if Signal Quality=Invalid
>Acquisition blocking	The binary input activates acquisition blocking. You can also set this binary input with an external toggle switch.	SPS	Unchanged
>Reset AcqBlk&Subst	Acquisition blocking and the substitution of the circuit breaker are reset with this input. If the input is activated, setting of the acquisition blocking and of the substitution is blocked.	SPS	Unchanged
>Reset switch statist.	The binary input sets the operation counter for the switch to the value 0.	SPS	Unchanged
Position	The binary input **Position** can be used to read the disconnector position with double-point indication.	DPC	Unchanged

If the quality of the input signal assumes the status **Quality = invalid**, then the standby status (Health) of the **Disconnector** function block is set to *warning*.

Table 7-15 Outputs of the Disconnector Function Block

Signal Name	Description	Type
Open command	This binary output is responsible for the command output **Off**.	SPS
Close command	This binary output is responsible for the command output **On**.	SPS

Signal Name	Description	Type
Command active	The binary output **Command active** is a running command for the signalization (command active or selected switching device). During Command active either an On or Off command is active.	SPS
Op.ct.	The information counts the number of disconnector switching cycles.	INS

Control

It is the task of the controls to execute command checks and establish communication between the command source and the disconnector. Using the control settings, you specify how the commands are to be processed (see also chapter *7.4.1 Command Checks and Switchgear Interlocking Protection*).

Through the function SBO (Select Before Operate, reservation[59]), the switching device is reserved prior to the actual switching operation, thus it remains locked for additional commands. Feedback monitoring provides information about the initiator of the command while the command is in process, that means, informing whether or not the command was implemented successfully. These two options can be selected individually in the selection of the control model, so that 4 combinations in total are available (see the following table).

The control makes the following settings available (see next table).

Parameters	Default Setting	Possible Parameter Values
(_:4201:101) Control model	***SBO w. enh. security***[60]	***direct w. normal secur.*** ***SBO w. normal secur.*** ***direct w. enh. security*** ***SBO w. enh. security***
(_:4201:102) SBO time-out	***30.00 s***	-
(_:4201:103) Feedback monitoring time	***10.00 s***	-
(_:4201:104) Check switching authority	***yes***	***no*** ***yes*** ***advanced***
(_:4201:105) Check if pos. is reached	***yes***	***no*** ***yes***
(_:4201:106) Check double activat. blk.	***yes***	***no*** ***yes***

7.2.3.3 Trigger Variants of the Disconnector

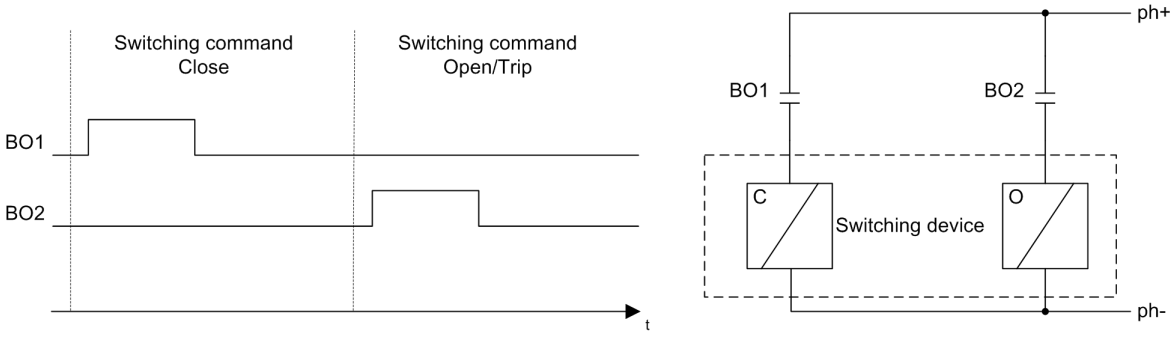
The activation types are identical to those for the circuit breaker. The meaning of abbreviations can be found in *7.2.2.3 Connection Variants of the Circuit Breaker* and *7.2.2.3 Connection Variants of the Circuit Breaker*.

Whether the disconnector is triggered for 1-, 1.5-, or 2-phases depends on the design of the auxiliary and control voltage system.

59 In the IEC 61850 standard, Reservation is described as **Select before Operate (SBO)**.

60 This default setting is the standard control model for a switching command in an IEC 61850-compliant system.

1-Pole Triggering



[dw_1ptren, 1, en_US]

Figure 7-20 1-Pole Triggering

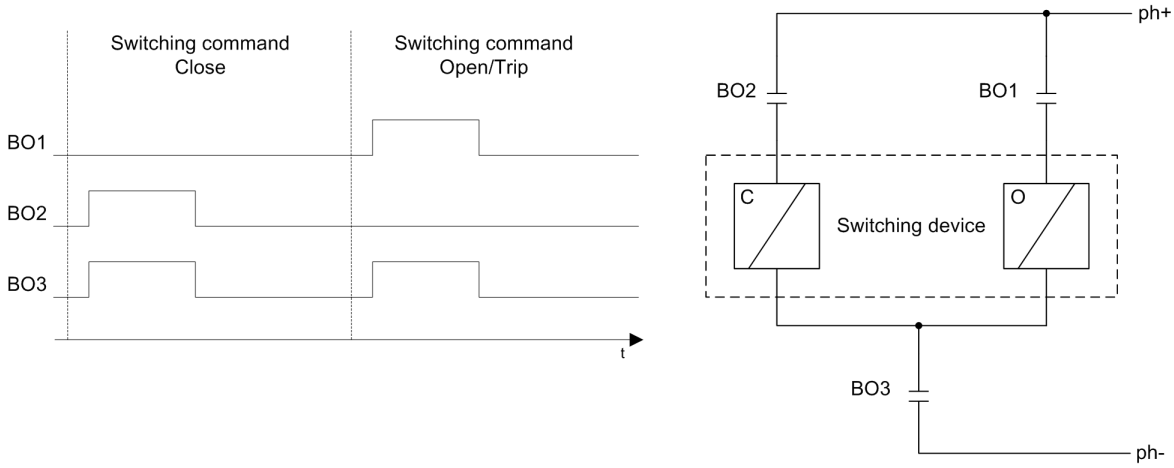
Information			S	Destination			
				Binary output			
				Basismodul			
Signals	Number	Type		1.1	1.2	1.3	1.4
	(All)	...		...	...	...	...
Disconnector 1	601			*	*		
Disconnector	601.5401			*	*		
>Acquisition blocking	601.5401.500	SPS					
>Reset switch statist.	601.5401.501	SPS					
>Reset AcqBlk&Subst	601.5401.504	SPS					
Health	601.5401.53	ENS					
Position	601.5401.58	DPC					
Open command	601.5401.300	SPS			X		
Close command	601.5401.301	SPS		X			

[scrangtrenn1p, 1, en_US]

Figure 7-21 1-Pole Triggering, Routing in DIGSI

You can select the contacts for ***On*** and ***Off*** as desired. They need not necessarily be next to one another.

1.5-Pole Triggering



[dw_5-pole, 1, en_US]

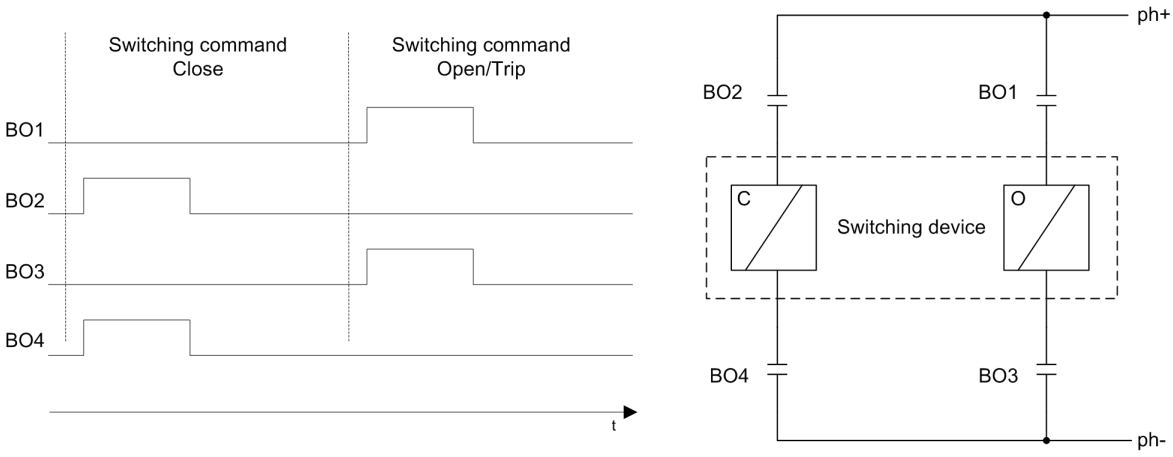
Figure 7-22 1.5-Pole Triggering

Information			S	Destination			
				Binary output			
				Basismodul			
Signals	Number	Type		1.1	1.2	1.3	1.4
	(All)	...		...	...	...	...
Disconnector 1	601			*	*	*	
Disconnector	601.5401			*	*	*	
>Acquisition blocking	601.5401.500	SPS					
>Reset switch statist.	601.5401.501	SPS					
>Reset AcqBlk&Subst	601.5401.504	SPS					
Health	601.5401.53	ENS					
Position	601.5401.58	DPC					
Open command	601.5401.300	SPS		X		X	
Close command	601.5401.301	SPS			X	X	

[scrangtrenn15p, 1, en_US]

Figure 7-23 1.5-Pole Triggering, Routing in DIGSI

2-Pole Triggering



[dw_2-pole-open, 1, en_US]

Figure 7-24 2-Pole Triggering

Information			S	Destination			
				Binary output			
				Basismodul			
Signals	Number	Type		1.1	1.2	1.3	1.4
	(All)	...		...	...	...	...
Disconnector 1	601			*	*	*	*
Disconnector	601.5401			*	*	*	*
>Acquisition blocking	601.5401.500	SPS					
>Reset switch statist.	601.5401.501	SPS					
>Reset AcqBlk&Subst	601.5401.504	SPS					
Health	601.5401.53	ENS					
Position	601.5401.58	DPC					
Open command	601.5401.300	SPS		X		X	
Close command	601.5401.301	SPS			X		X

[scrangtrenn2p, 1, en_US]

Figure 7-25 2-Pole Triggering, Routing in DIGSI

The feedback is routed via the position with the disconnector.

7.2.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Control				
_:4201:101	Control:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:4201:102	Control:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:4201:103	Control:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s

Addr.	Parameter	C	Setting Options	Default Setting
_:4201:104	Control:Check switching authority		• no • yes	yes
_:4201:105	Control:Check if pos. is reached		• no • yes	yes
_:4201:106	Control:Check double activat. blk.		• no • yes	yes
Disconnector				
_:5401:101	Disconnector:Maximum output time		0.01 s to 1800.00 s	10.00 s
_:5401:102	Disconnector:Seal-in time		0.00 s to 60.00 s	0.00 s
_:5401:103	Disconnector:Switching-device type		• switch-disconnector • disconnector • grounding switch • fast grounding switch	disconnector

7.2.3.5 Information List

No.	Information	Data Class (Type)	Type
Control			
_:4201:503	Control:>Sw. authority local	SPS	I
_:4201:504	Control:>Sw. authority remote	SPS	I
_:4201:505	Control:>Sw. mode interlocked	SPS	I
_:4201:506	Control:>Sw. mode non-interl.	SPS	I
_:4201:52	Control:Behavior	ENS	O
_:4201:53	Control:Health	ENS	O
_:4201:58	Control:Cmd. with feedback	DPC	C
_:4201:302	Control:Switching auth. station	SPC	C
_:4201:308	Control:Enable sw. auth. 1	SPC	C
_:4201:309	Control:Enable sw. auth. 2	SPC	C
_:4201:310	Control:Enable sw. auth. 3	SPC	C
_:4201:311	Control:Enable sw. auth. 4	SPC	C
_:4201:312	Control:Enable sw. auth. 5	SPC	C
_:4201:313	Control:Switching authority	ENS	O
_:4201:314	Control:Switching mode	ENS	O
Interlocking			
_:4231:500	Interlocking:>Enable opening	SPS	I
_:4231:501	Interlocking:>Enable closing	SPS	I
_:4231:502	Interlocking:>Enable opening(fixed)	SPS	I
_:4231:503	Interlocking:>Enable closing (fixed)	SPS	I
_:4231:52	Interlocking:Behavior	ENS	O
_:4231:53	Interlocking:Health	ENS	O
Disconnector			
_:5401:500	Disconnector:>Acquisition blocking	SPS	I
_:5401:501	Disconnector:>Reset switch statist.	SPS	I
_:5401:504	Disconnector:>Reset AcqBlk&Subst	SPS	I
_:5401:52	Disconnector:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:5401:53	Disconnector:Health	ENS	O
_:5401:58	Disconnector:Position	DPC	C
_:5401:300	Disconnector:Open command	SPS	O
_:5401:301	Disconnector:Close command	SPS	O
_:5401:302	Disconnector:Command active	SPS	O
_:5401:305	Disconnector:Op.ct.	INS	O

7.3 Switching Sequences

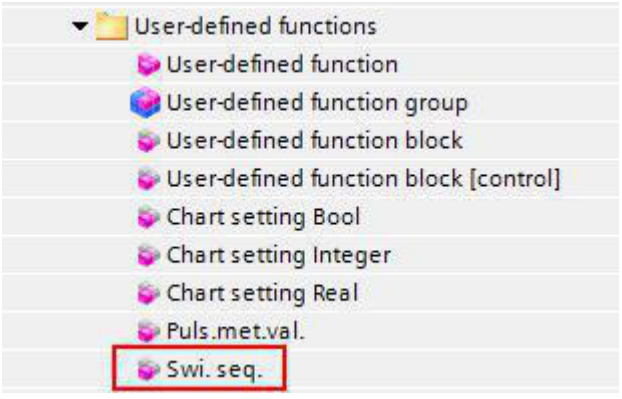
7.3.1 Overview of Functions

Switching sequences may be running inside the device that switch the switchgear automatically in a prespecified sequence.

A switching sequence consists of a special function block **Switching sequence** (Swi. seq.) from the DIGSI 5 Library and the project-specific list of the switching commands that are generated in the CFC.

7.3.2 Function Description

The function block **Switching sequence** is located in folder **User-defined functions** in the DIGSI 5 Library.



[sc_udeffb, 1, en_US]

Figure 7-26 Function Block **Switching Sequence** in the Library

These function blocks can be used in the information matrix on the highest level (level of the function groups) or in a user-defined function group.

One **Switching sequence** function block is used per switching sequence. The function block is the interface for controlling and monitoring the condition of the CFC switching sequence. The task of the function block is to verify the relative conditions for control commands, for example, switching authority, interlocking conditions, etc. You can connect the signals of the function block with the CFC chart. They start and stop the switching sequence and provide data about the status of the switching sequence (see *Figure 7-27*). The CFC chart is used to activate the switching device that must be switched. The CFC blocks define, among other things, the switching devices that must be switched.

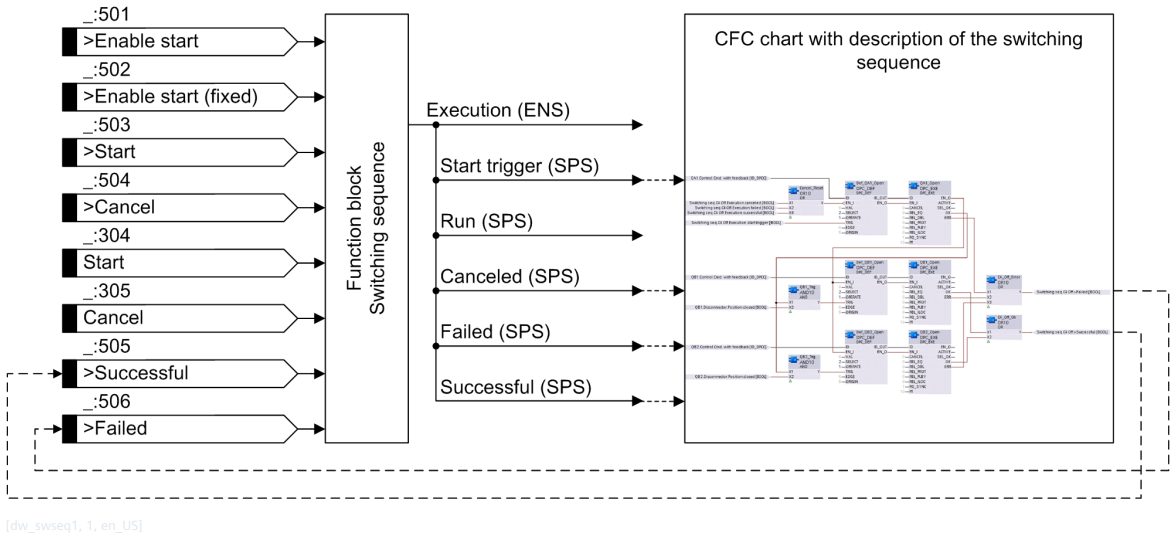


Figure 7-27 **Switching Sequence** Function Block

Starting and Canceling a Switching Sequence

One of the following methods can be used to start a switching sequence:

- On-site operation: menu or display page
- Input *>Start* during rising edge, for example, via binary input
- Controllable *Start* for the start via a communication protocol, for example, IEC 61850, T103, or DNP
- Input *>Start* via a function key
- Controllable *Start* via a function key

One of the following methods can be used to cancel a switching sequence:

- On-site operation: menu or display page
- Input *>Cancel* during rising edge, for example, via binary input
- Controllable *Cancel* for the cancelation via a communication protocol, for example, IEC 61850, T103, or DNP
- Input *>Cancel* via a function key
- Controllable *Cancel* via a function key

On-Site Operation

If at least one **Switching sequence** function block is used in the device, a new **Switching sequences** entry is shown in the first line of the **Control** menu. If this menu item is selected, an overview of all switching sequences and the current status will be displayed (see *Figure 7-28*, example with 2 switching sequences). You can start or cancel the switching sequences from this menu.

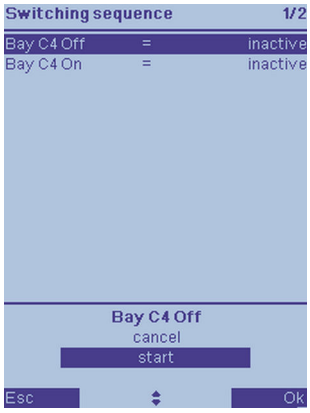
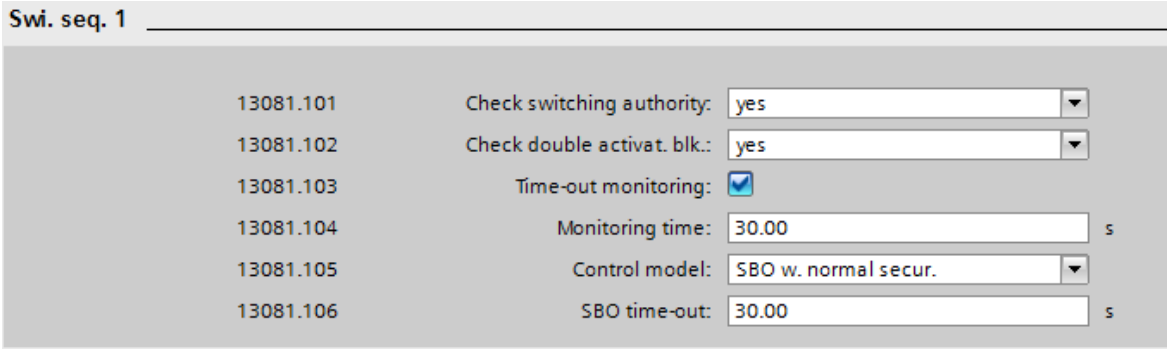


Figure 7-28
Overview of the Switching Sequences on the Device Display

7.3.3 Application and Setting Notes

The function block offers similar settings to the **Control** function block of a circuit breaker or disconnector (see chapter *7.2.1 General Overview*).



[sc_ccs4pa, 1, en_US]

Figure 7-29 Settings of the **Switching Sequence** Function Block

Parameter: **`Check switching authority`**

- Default setting **`(_:101) Check switching authority`** = ***`yes`***

With the **`Check switching authority`** parameter, you can determine whether the switching authority should be checked before the execution of the switching sequence.

Parameter: **`Check double activat. blk.`**

- Default setting **`(_:102) Check double activat. blk.`** = ***`yes`***

With the **`Check double activat. blk.`** parameter, you can determine whether the double activation of switching devices should be checked. The setting value ***`yes`*** indicates that a switching sequence will be started only if no switching commands for a circuit breaker and disconnector are active, provided that double-activation blocking was activated for those switching devices.

Parameter: **`Time-out monitoring`**

With the **`Time-out monitoring`** parameter, you can determine whether the feedback from the process should be evaluated. The feedback is gathered via the inputs *`>Successful`* and *`>Failed`*.

Parameter: **`Monitoring time`**

- Default setting **`(_:104) Monitoring time`** = ***`30.00 s`***

With the **`Monitoring time`** parameter, you can determine the duration of the monitoring time.

Parameter: **`Control model`**

- Default setting **`(_:105) Control model`** = ***`SBO w. normal secur.`***

With the **`Control model`** parameter, you select between ***`direct w. normal secur.`*** or ***`SBO w. normal secur.`*** to start the switching sequence.

It is not possible to set a control model for cancelation of the switching sequence. The control model ***`direct w. normal secur.`*** is always used to cancel the function.

Information

The **Switching sequence** function block provides the following data:

Swi. seq. 1	13081	
>Enable start	13081.501	SPS
>Enable start (fixed)	13081.502	SPS
>Start	13081.503	SPS
>Cancel	13081.504	SPS
>Successful	13081.505	SPS
>Failed	13081.506	SPS
Health	13081.53	ENS
Execution	13081.302	ENS
start trigger		SPS
running		SPS
canceled		SPS
failed		SPS
successful		SPS
Start	13081.304	SPC
Cancel	13081.305	SPC
Switching auth. station	13081.303	SPC

[sc_infof1, 1, en_US]

Figure 7-30 Data Provided by the **Switching Sequence** Function Block

In the **Switching sequence** function block, the interlocking is analog to the **Interlocking** function block and it is possible to use it in the switching sequence:

- *`>Enable start`*: Connection to interlocking conditions (CFC) for the start of the entire switching sequence. Not in effect in the **non-interlocked** switching mode.
- *`>Enable start (fixed)`*: Non-revocable interlocking conditions for the start of the entire switching sequence. In effect regardless of the switching mode.

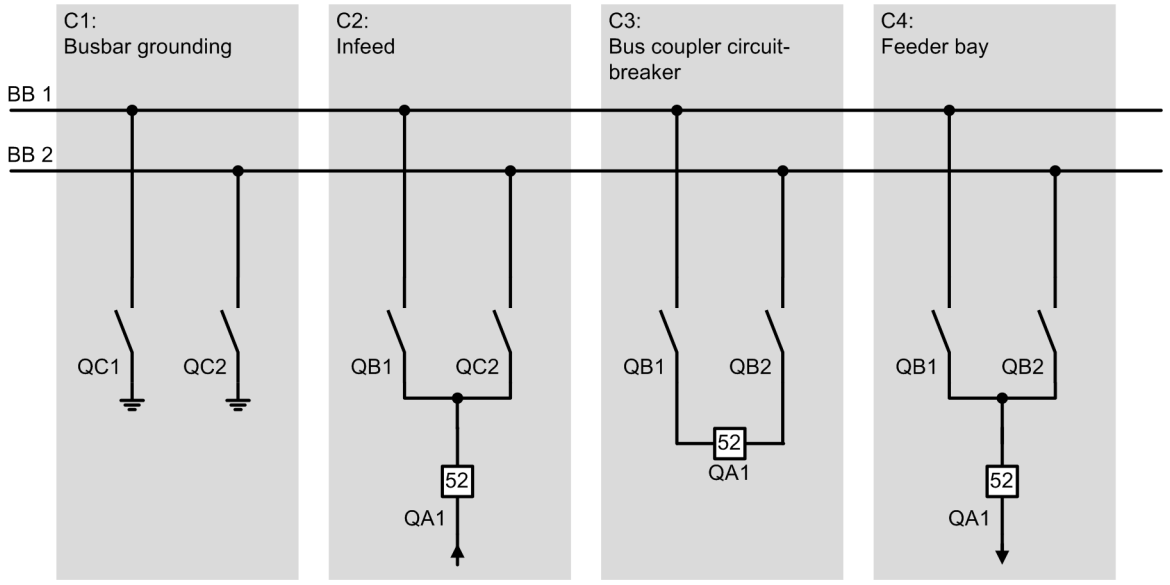
If the time-out monitoring is activated (parameter **`Time-out monitoring`**), the process feedback must take place via the inputs *`>Successful`* and *`>Failed`*. If the last switching command of the switching sequence was executed successfully, the input *`>Successful`* usually is set. To do this, connect the feedback of the last switching command from the CFC with this input of the function block during the device parameterization.

If a switching command fails, this feedback can be captured by the input *`>Failed`*. The active switching sequence will be ended immediately and does not have to wait for a time-out.

The indication *`Execution`* signals the current state of the switching sequence. The events *`running`*, *`canceled`*, *`failed`*, and *`successful`* are generated only while the time-out monitoring is activated. The event *`Start Trigger`* is used to start the switching sequence in the CFC chart.

Example for a Switching Sequence with CFC

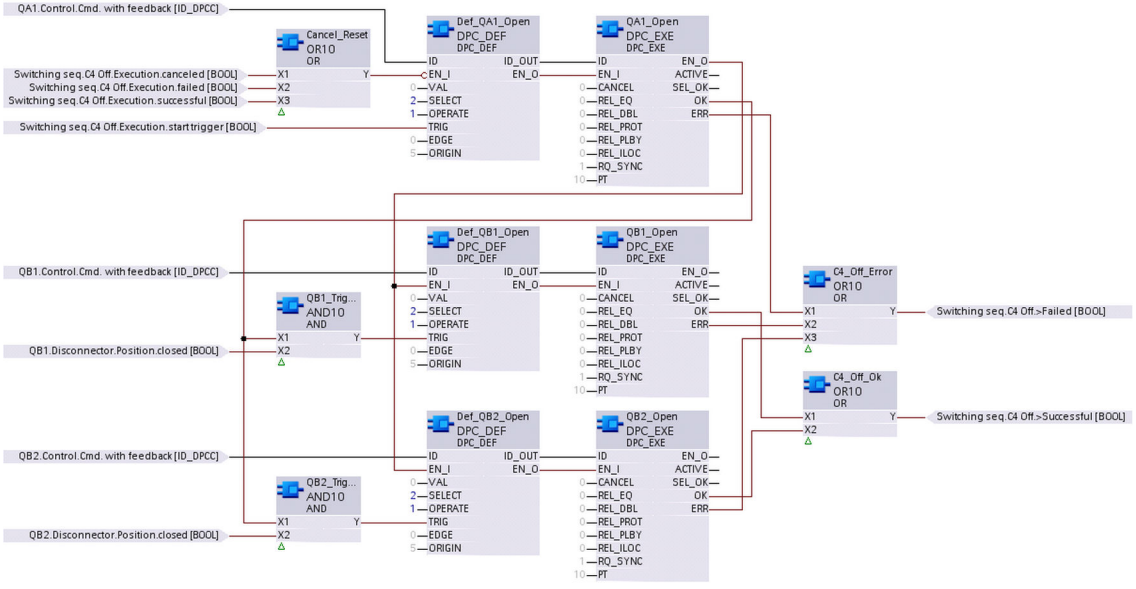
The following figure shows a single-line diagram for a substation with 4 bays: Busbar grounding, infeed, bus-coupler circuit-breaker, and feeder bay.



[dw_bspunt, 1, en_US]

Figure 7-31 Example of a Substation

The switching sequence **C4 Off** (*Figure 7-32*) should switch off feeder bay C4. The circuit breaker is opened; followed by opening of one of the 2 busbar disconnectors.



[sc_ssc4as, 1, en_US]

Figure 7-32 CFC Switching Sequence **C4 Off**

Command Execution

As described in section *Starting and Canceling a Switching Sequence, Page 1856*, the display page or the **Control** menu can be used to start the switching sequence. The *Start Trigger* signal for indication *Execution* is used to recognize the start and initiates the switching sequence by pickup of **TRIG** in the DPC-DEF building block of circuit breaker QA1. Building blocks DPC-DEF and DPC-EXE are always used in pairs. The DEF building block controls the type and nature of the command

- **VAL** = Switching direction (0 = Off, 1 = On)
- **SELECT** = Select switching device (2 = Select with a value suitable for the preset control model ***SBO w. enh. security***)
- **OPERATE** = Switch switching device (1 = Switching device is switched on or off)

Using the connected DPC-EXE building block, the command checks can be deactivated (**REL_**...). In the application example, all inputs are set to 0 and therefore, all checks are activated.

After the open command of circuit breaker QA1 is acknowledged via the auxiliary contacts, the **OK** output of the CFC block DPC_EXE becomes active and triggers the next switching object. With the input **PT** the signal for the **OK** output is time-delayed (in the example by 10 ms) and creates a dead time between individual switching commands and the switching sequence. This dead time is important for the updating of the interlocking conditions.

If QB1 is closed, QB1 will be opened. If QB2 is closed, QB2 will be opened. In order to implement this logic, the **OK** output signal of QA1 is linked with the respective positions of circuit breakers QB1 and QB2 via the logical AND function. This signal serves as a trigger for the trip command of QB1 or QB2.

Because in this example the time-out monitoring is activated, the feedback about the successful or unsuccessful execution of the switching sequence must be parameterized. The **Switching sequence** function block provides the inputs *>Successful* and *>Failed*. In order to acknowledge the entire switching sequence positively, the OR operation of the **OK** outputs for the disconnectors QB1 and QB2 is sufficient. The feedback of all failed executions takes place via the OR operation of all **ERR** outputs of the switching devices. The benefit of such assessment is the fact that, in case of a failure, waiting for the time-out is not necessary, but the active switching sequence can be ended immediately.

In this example, the use of the **EN_I** input of building block DPC-DEF fulfills 2 tasks:

- Cancelation of the entire switching sequence
- Resetting of the outputs **OK** and **ERR** on building block DPC-EXE

By linking all **EN_I** inputs and **EN_O** outputs of building blocks DPC-DEF and DPC-EXE, the execution of the switching sequence can be controlled centrally since the value is transmitted between the building blocks. Only if input **EN_I** on the DPC-EXE is set to 1, a switching command is issued. If the input drops back to 0 while a command is being processed, this command will be canceled. With this behavior, cancelation of an entire switching sequence can be achieved. As recognition of a cancelation, the *canceled* signal of the indication *Execution* is used in the CFC chart and connected with the input **EN_I** of the first switching device, in this example, with the DPC-DEF building block of circuit breaker QA1.

Since the **OK** and **ERR** outputs of the DPC-EXE building block maintain their value until execution of the next command, it is necessary to reset the continuous output after each execution of the switching sequence for correct execution of the entire CFC switching sequence multiple times. In this case, the use of the **EN_I** input is also helpful. In the input drops back to 0, the **OK** and **ERR** outputs are also reset to 0. The triggers for ending the switching sequence are the events *failed* and *successful*. For this reason, in the above example, the signals *failed* and *successful* of the indication *Execution* were connected with **EN_I** of the DPC-DEF building block.

7.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Swi. seq. #				
_:101	Swi. seq. #:Check switching authority		• no • yes • advanced	yes
_:102	Swi. seq. #:Check double activat. blk.		• no • yes	yes
_:103	Swi. seq. #:Time-out monitoring		• 0 • 1	true
_:104	Swi. seq. #:Monitoring time		0.02 s to 3600.00 s	30.00 s
_:105	Swi. seq. #:Control model		• direct w. normal secur. • SBO w. normal secur.	SBO w. normal secur.
_:106	Swi. seq. #:SBO time-out		0.01 s to 1800.00 s	30.00 s
Switching authority				
_:151	Swi. seq. #:Swi.dev. related sw.auth.		• 0 • 1	false
_:152	Swi. seq. #:Specific sw. authorities		• 0 • 1	true
_:115	Swi. seq. #:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:153	Swi. seq. #:Num. of specific sw.auth.		2 to 5	2
_:154	Swi. seq. #:Multiple specific sw.auth.		• 0 • 1	false

7.3.5 Information List

No.	Information	Data Class (Type)	Type
Swi. seq. #			
_:501	Swi. seq. #:>Enable start	SPS	I
_:502	Swi. seq. #:>Enable start (fixed)	SPS	I
_:503	Swi. seq. #:>Start	SPS	I
_:504	Swi. seq. #:>Cancel	SPS	I
_:505	Swi. seq. #:>Successful	SPS	I
_:506	Swi. seq. #:>Failed	SPS	I
_:53	Swi. seq. #:Health	ENS	O
_:302	Swi. seq. #:Execution	ENS	O
_:304	Swi. seq. #:Start	SPC	C
_:305	Swi. seq. #:Cancel	SPC	C

7.4 Control Functionality

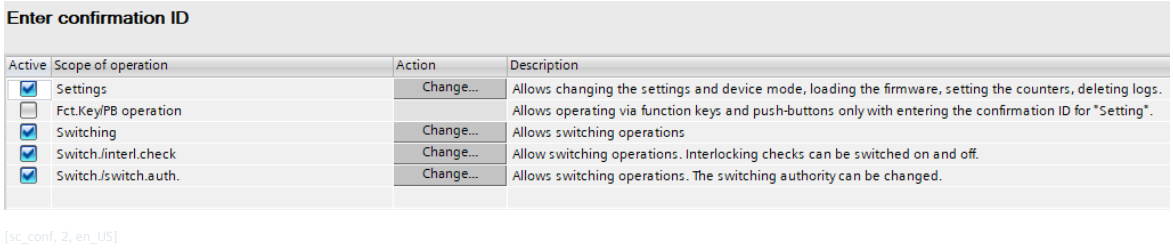
7.4.1 Command Checks and Switchgear Interlocking Protection

Before switching commands can be issued by the SIPROTEC 5 device, several steps are used to check the command:

- Switching mode (interlocked/non-interlocked)
- Switching authority (local/DIGSI/station/remote)
- Switching direction (set=actual)
- Bay interlocking and substation interlocking
- 1-out-of-n check (double-activation blocking)
- Blocking by protection function

Confirmation IDs (with Inactive RBAC)

SIPROTEC 5 devices can operate using role-based access control (RBAC). If RBAC is active in the device, the authorizations to execute various actions are linked directly to the role concept.
If RBAC is inactive in the device, various actions are secured using the **confirmation IDs**. The following **confirmation IDs** from the **Safety** menu apply to the control functions:



[sc_conf, 2, en_US]

Figure 7-33 Confirmation IDs in DIGSI 5: Settings Menu

The following table identifies the meanings of the confirmation IDs:

Table 7-16 Relevant Confirmation IDs for Controls

Confirmation ID	Meaning	Description
Setting	Changing settings	The confirmation ID is requested before the device parameters can be changed.
Operation (function keys)	Process data access via function buttons	Access to process data is possible with the help of push-buttons and function buttons. The confirmation ID of **Set/operation** is requested.
Switching	General release for control of switching devices	The confirmation ID is usually not needed for bay controllers. In the case of protection devices, this confirmation ID can be used to safeguard control of switching devices.

Confirmation ID	Meaning	Description
Switch./interl.check	Switching non-interlocked	Switching mode: Release for switching without querying the interlocking conditions (***S1 operation***). The fixed interlocking conditions (for example, **>Enable opening(fixed)** and **>Enable closing (fixed)**) are still queried if this is set in the parameters. The confirmation ID is queried only for devices without a key switch; otherwise it is replaced with the key switch position.
Switch./switch.auth.	Release for switching authority **Local**	The confirmation ID is queried only for devices without a key switch; otherwise it is replaced with the key switch position.

The confirmation IDs are preset with the following values:

- Setting 222222
- Switching 333333
- Switch./interl.check 444444
- Switch./switch.auth. 666666

If you have configured a device with key switches, the confirmation IDs for non-interlocked switching and switching authority are not displayed or editable in DIGSI; the function is handled by the position of the key switch.

To increase security, change these codes with DIGSI.

Switching Mode (Interlocked/Non-Interlocked)

The switching mode determines whether or not the switchgear interlocking that has been configured in the CFC is checked before the command is output.

You can change the switching mode with the key switch **S1** (interlocking off/normal). For devices without a key switch, you can change the switching mode with a corresponding menu item on the display (after input of a confirmation ID). You can also set the switching mode for switching commands from the sources DIGSI, station or remote.



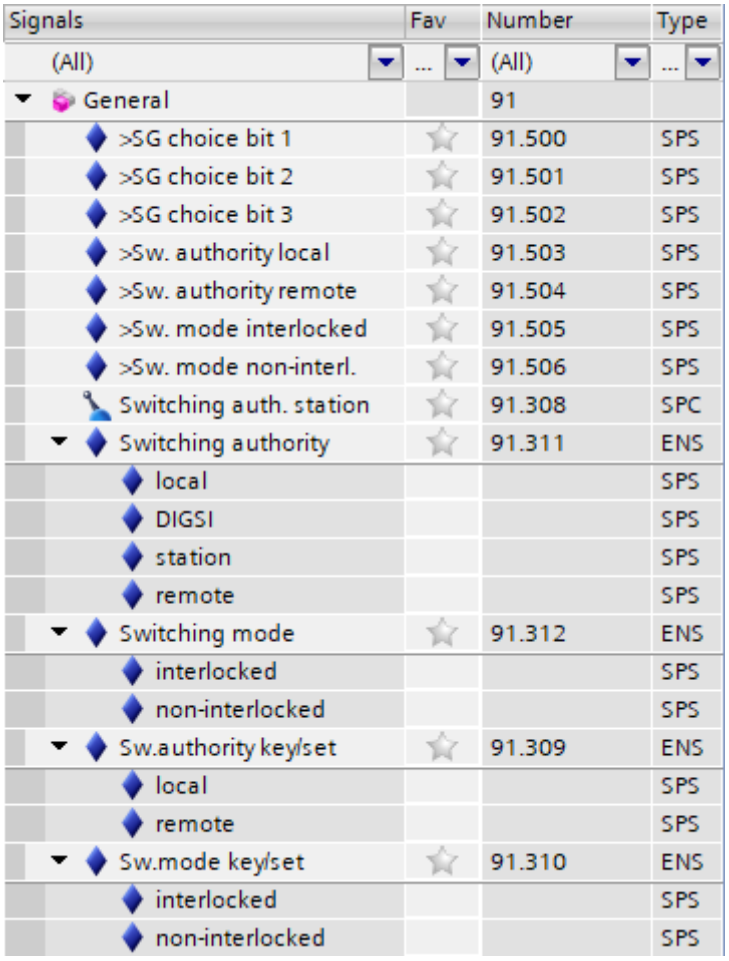
DANGER

If the switching mode = non-interlocked, the switchgear interlocking protection is shut off.

Erroneous switching operations can lead to severe or fatal injuries.

✧ Ensure manually that all checks have been implemented.

In addition, you can set the switching mode directly with a binary input or CFC. Use the **General** function block (see next figure).



Signals	Fav	Number	Type
(All)	...	(All)	...
General		91	
>SG choice bit 1		91.500	SPS
>SG choice bit 2		91.501	SPS
>SG choice bit 3		91.502	SPS
>Sw. authority local		91.503	SPS
>Sw. authority remote		91.504	SPS
>Sw. mode interlocked		91.505	SPS
>Sw. mode non-interl.		91.506	SPS
Switching auth. station		91.308	SPC
Switching authority		91.311	ENS
local			SPS
DIGSI			SPS
station			SPS
remote			SPS
Switching mode		91.312	ENS
interlocked			SPS
non-interlocked			SPS
Sw.authority key/set		91.309	ENS
local			SPS
remote			SPS
Sw.mode key/set		91.310	ENS
interlocked			SPS
non-interlocked			SPS

[sc_moscha, 1, en_US]

Figure 7-34 Switching Mode in Function Block General

The following table shows the effects of changing the switching mode to use command checks.

Table 7-17 Relationship Between Switching Mode and Command Checks

Command Check	Switching Mode	
	Interlocked	Non-Interlocked
Switching authority	Checked	Checked
Switching direction (set=actual)	Checked	Checked
Fixed interlocking conditions	Checked	Checked
Interlocking conditions	Checked	Not checked
1-out-of-n check (double-activation blocking)	Checked	Not checked
Blocking by protection function	Checked	Not checked

Switching Authority

The switching authority determines which command source is allowed. The following command sources are possible:

- **Local**:

  A switching command from the local control (cause-of-error source **Local**) is possible only if the switching authority is set to **Local** and the device is capable of on-site operation. Setting the switching authority to **Local** is typically accomplished with key switch **S5** (Local/Remote). In this case, commands from all other sources are rejected. If the switching authority is set to **Local**, the setting cannot be changed **remotely**.

- **DIGSI**:

  A switching command from DIGSI (connected via USB or Ethernet, cause-of-error source **Maintenance**) is accepted only if the switching authority in the device is set to **Remote**. Once DIGSI has signed on the device for command output, no commands from other command sources or a different DIGSI PC will be executed.

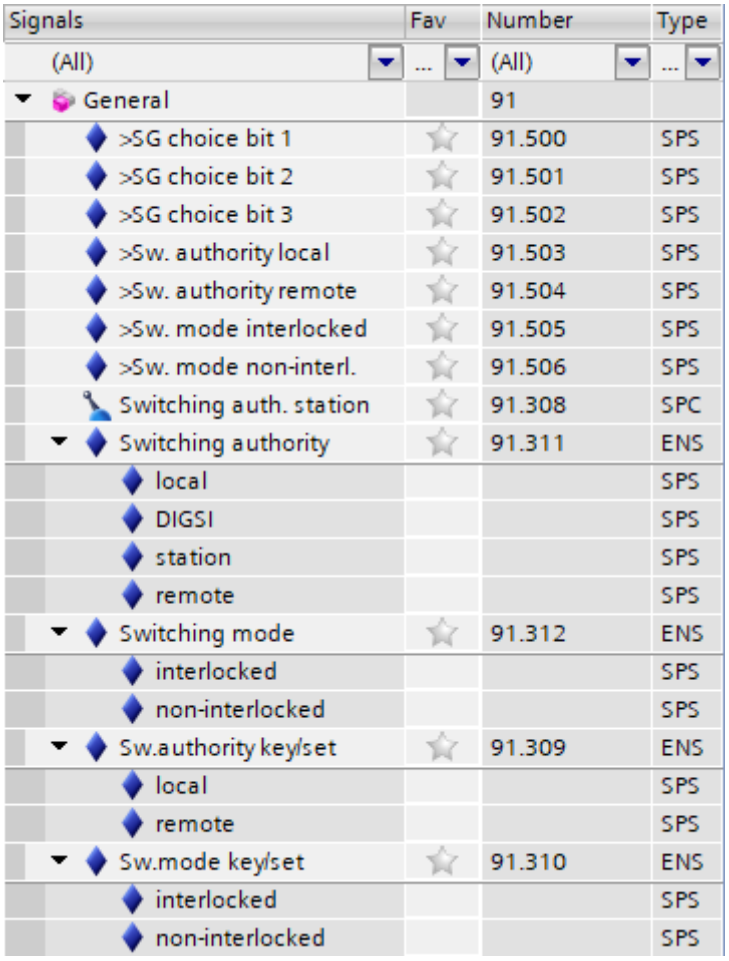
- **Station**:

  This switching authority level can be activated via a parameter in the **General** function block. A switching command from the station level (cause-of-error source **Station** or **Automatic station**) is accepted if the switching authority is set to **Remote** and the controllable **Station switching authority** is set. This is accomplished by a command from the substation automation technology. Switching commands from the device or from outside the station (cause-of-error source **Local**, **Remote** or **Automatic remote**) are rejected.

  Full support of the switching-authority level is assured only when using the IEC 61850 protocol.

- **Remote**:

  This switching authority level stands from remote control directly from the network control center or (if the switching authority level **Station** is not activated) generally for **Remote** control. The cause-of-error source is **Automatic remote**. Commands from this level are accepted if the switching authority is set to **Remote** and the controllable **Station switching authority** is not set. Switching commands from the device or from the station (cause-of-error source **Local**, **Station** or **Automatic station**) are rejected.



[sc_moscha, 1, en_US]

Figure 7-35 Display of Switching Authority and Switching Mode in Information Routing (in Function Block General)

Sw. authority key/set and **Sw.mode key/set** indicate the current state of the key switch or parameter for switching authority or switching mode and provide this information for further processing in the CFC. In the CFC, for example, it is possible to set up an automatic routine to ensure that the switching authority is automatically set to ***Local*** when the key switch is set to ***non-interlocked***.

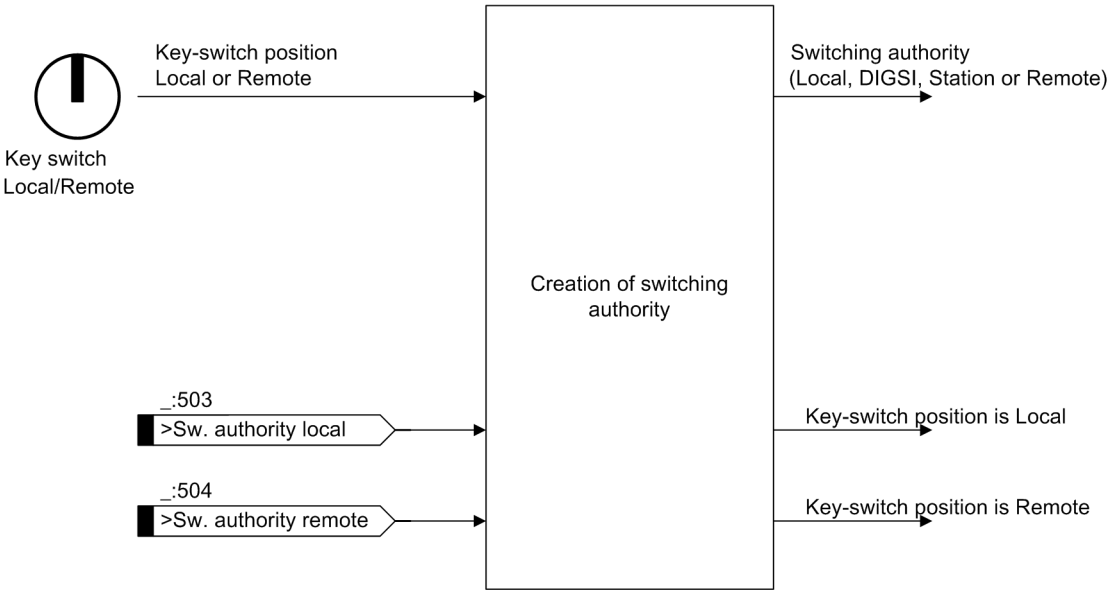
The following table shows the dependency of the switching mode on the key-switch position and the switching authority. In the case of switching commands from **Remote**, the information on whether switching is to be made to locked or unlocked is also sent. For this reason, the position of the key switch is irrelevant for the switching mode in these cases. The information in the table assumes that, in the case of **remote** switching commands or those from the **station**, the switching mode is *interlocked* in each case.

Table 7-18 Dependency of the Switching Mode on the Key-Switch Position and Switching Authority

	Switching Authority		
Key Switch for Switching Mode	**Local**	**Remote**	**Station**
Interlocked	Interlocked	Interlocked	Interlocked
Not interlocked	Non-interlocked	Interlocked	Interlocked

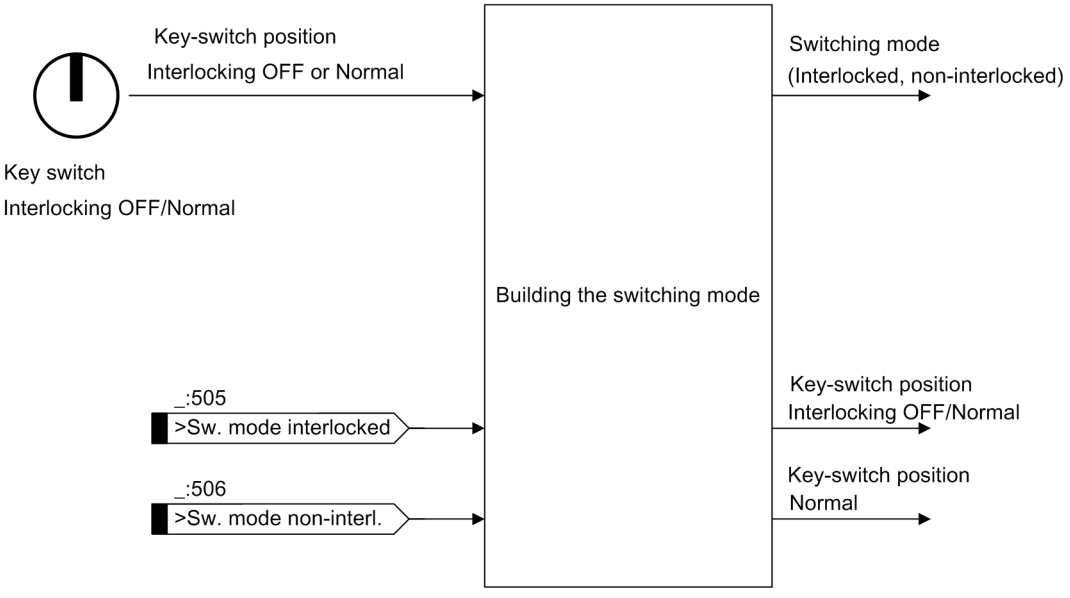
The signals shown in *Figure 7-35* in DIGSI 5 information routing have the following relationship:

- In terms of switching authority and switching mode, the respective key switch position serves as the input signal and the input signals in the matrix.
- The state of the switching authority and switching mode is indicated by corresponding output signals.
- The **Switching authority** and **Switching mode** functions link the input signals and in this way establish the output signals (see *Figure 7-36* and *Figure 7-37*).



[dw_authority, 1, en_US]

Figure 7-36 Establishing Switching Authority



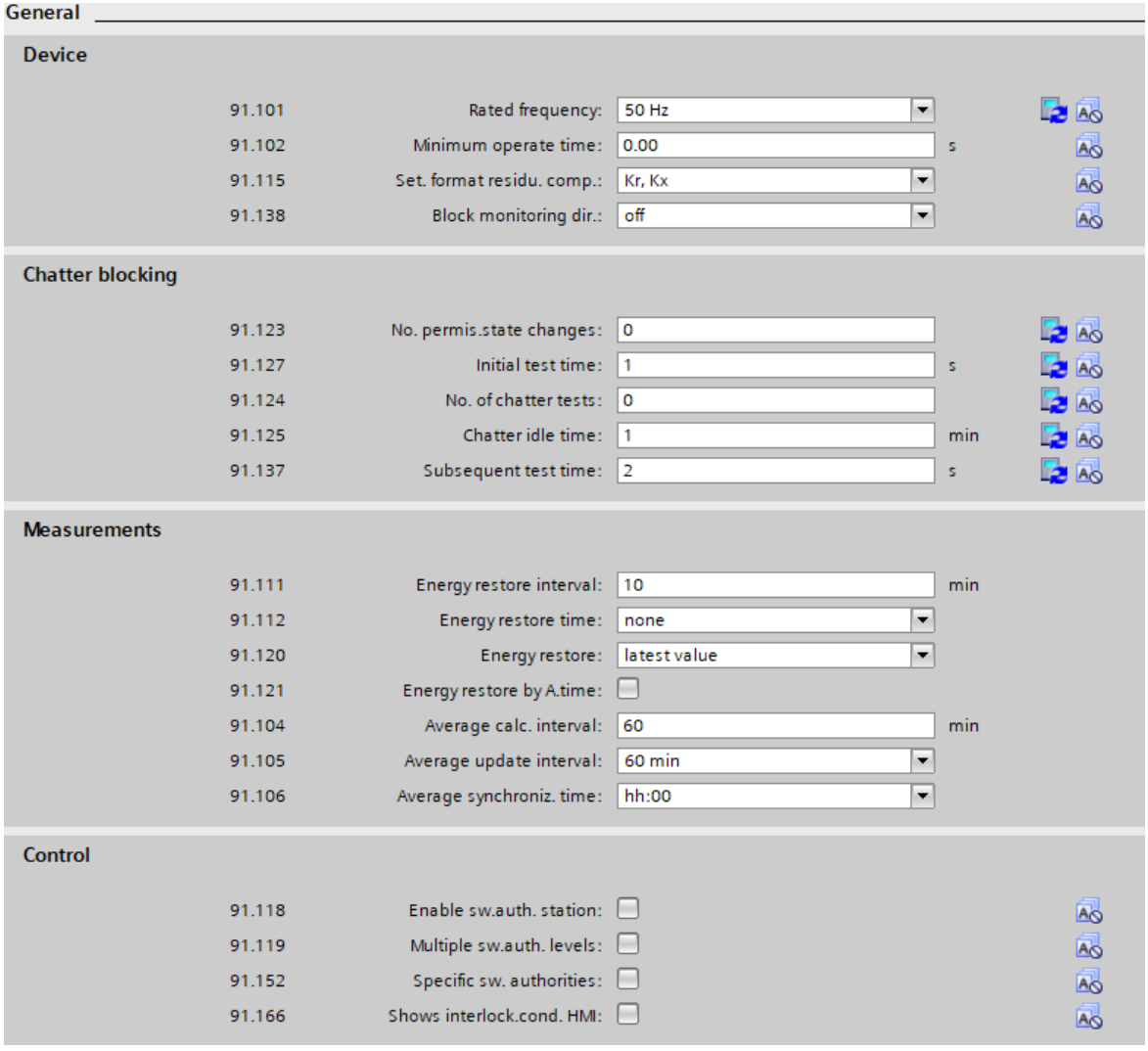
[dw_modsch, 1, en_US]

Figure 7-37 Establishing Switching Mode

In the case of both functions, the input signals overwrite the state of the key switch. This allows external inputs to also set the switching authority or switching mode, if desired (for instance, by querying an external key switch).

The following additional settings are available for the switching authority:

- **`Enable sw.auth. station`** (defined in IEC 61850 Edition 2):
  If you would like to use this switching authority, set the check mark **General/Control**.
- **`Multiple sw.auth. levels`**:
  This option permits switching commands from several command sources in the device if the switching authority **Remote** is selected. Subsequently, a distinction between these command sources can also be made. You can find more details in the following table. Activate this option by setting the check mark **General/Control**.
- **`Specific sw. authorities`**:
  You can enable additional options for the switching authority check. You can find more information about these options in *Specific Switching Authority, Page 1869*. By default, these are not used.
- **`Show int.lck.cond. on HMI`**:
  You can activate the parameter to show the status of interlocking conditions in the device. For additional information refer to *Specific Switching Authority, Page 1869*. By default, this parameter is inactive.



[sc_akt_hoh, 2, en_US]

Figure 7-38 How to Activate the Station Switching Authority and to Enable Several Switching-Authority Levels

Table 7-19 Effect on Switching Authority when Several Switching-Authority Levels Are Enabled with/ without Activation of the Station Switching Authority

Release Several Switching Authority Levels	Switching Authority in the Device	Status of DIGSI in the Device	Station Switching Authority Activated	State of the Station Switching Authority	Resulting Switching Authority
No	Local	–	–	–	Local
	Remote	Signed on	–	–	DIGSI
		Not signed on	No	–	Station and remote
			Yes	Set	Station
				Not set	Remote
Yes	Local	–	–	–	Local
	Remote	Signed on	–	–	DIGSI
		Not signed on	No	–	Local and station and remote
			Yes	Set	Local and station
				Not set	Local and station and remote

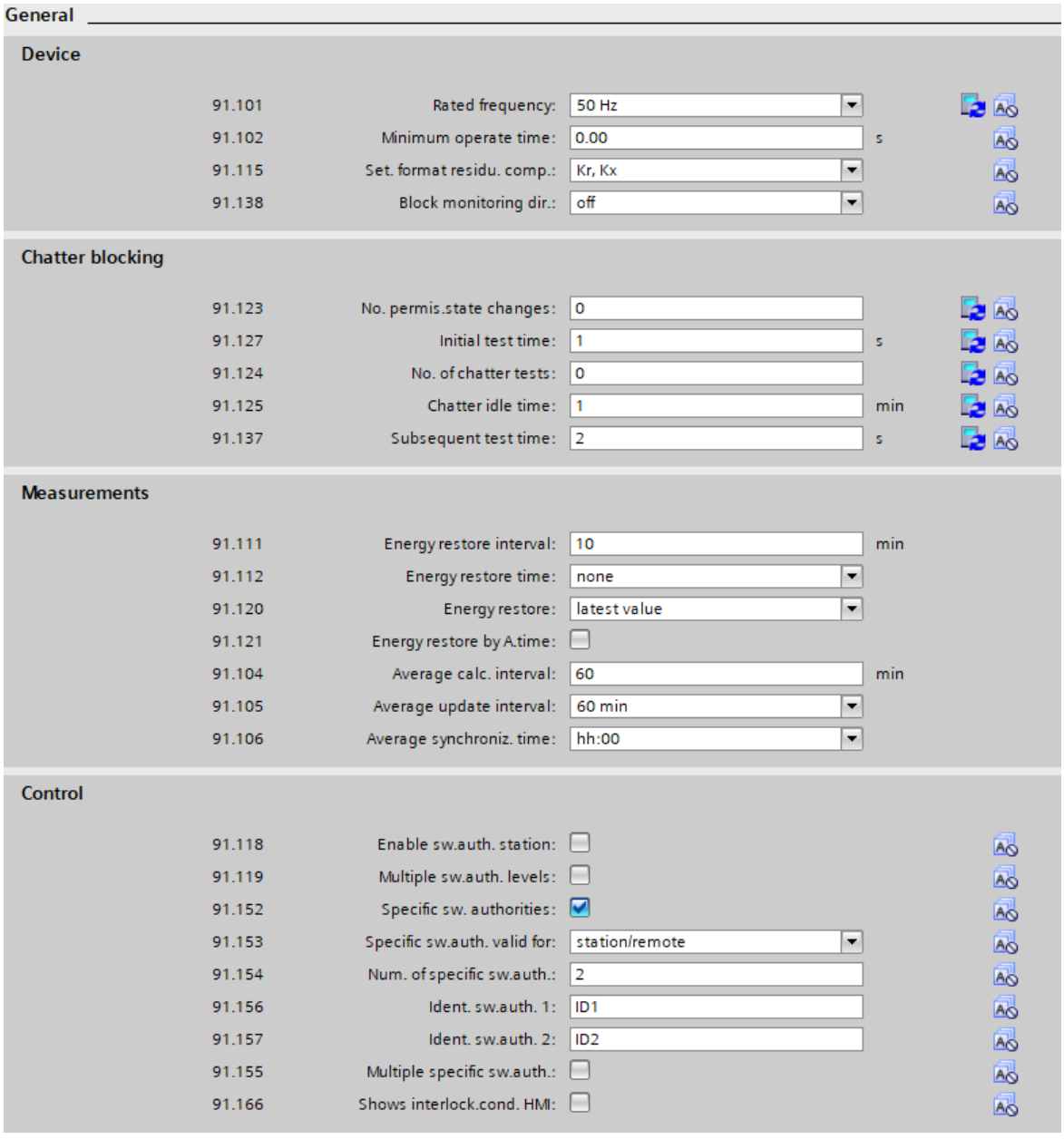
The following table shows the result of the switching-authority check, based on the set switching authority and the cause of the command. This overview represents a simplified normal case (no multiple command sources when using Station and Remote).

Table 7-20 Result of a Switching-Authority Check

Cause Source	Switching Authority			
	Local	DIGSI	Station	Remote
Local	Release	Blocked	Blocked	Blocked
Station	Blocked	Blocked	Release	Blocked
Remote	Blocked	Blocked	Blocked	Release
Local automatic operation	Release	Release	Release	Release
Station automatic operation	Blocked	Blocked	Release	Blocked
Remote automatic operation	Blocked	Blocked	Blocked	Release
DIGSI	Blocked	Release	Blocked	Blocked

Specific Switching Authority

Special switching authorities can be configured as extension of the switching-authority check. This makes it possible to differentiate the **Remote** command sources at the bay level. Switching authority can be routed to or revoked from different control centers that can, for example, belong to different companies. Thus, precisely one of these command sources can switch at a certain time. This function is based on extending the switching-authority check by verifying the identifier of the command source (field **Originator/orIdent** of switching command). In order to turn on the function, go to **General/Control** and set the check mark for the parameter **`Specific sw. authorities`**. More settings for the configuration of the identifiers and the behavior of the function as well as additional signals appear (see *Figure 7-40*). In order to permit an additional command source to switch, you must activate this specific switching authority. In order to do this, set the controllable **`Enable sw. auth. 1`** to **`Enable sw. auth. 5`**.



[sc_act additional options sw authority, 4, en_US]

Figure 7-39 Activating Additional Options of the Switching Authority

The additional parameters allow you to set the following options:

- **`Specific sw.auth. valid for`** (for ***`station/remote`***, only ***`remote`*** or only ***`station`***):
  With this parameter, you determine for which command source the extended switching-authority check is used.

Table 7-21 Result Derived from the Combination of the Parameter Value **`Specific sw.auth. valid for`** and the Level of the Command Source (Field **`Originator/orCat`** of the Switching Command)

Command Source	`Specific sw.auth. valid for`		
	`station`	***`station/remote`***	***`remote`***
Local, local automatic	No check	No check	No check
Station, station automatic	Check	Check	No check

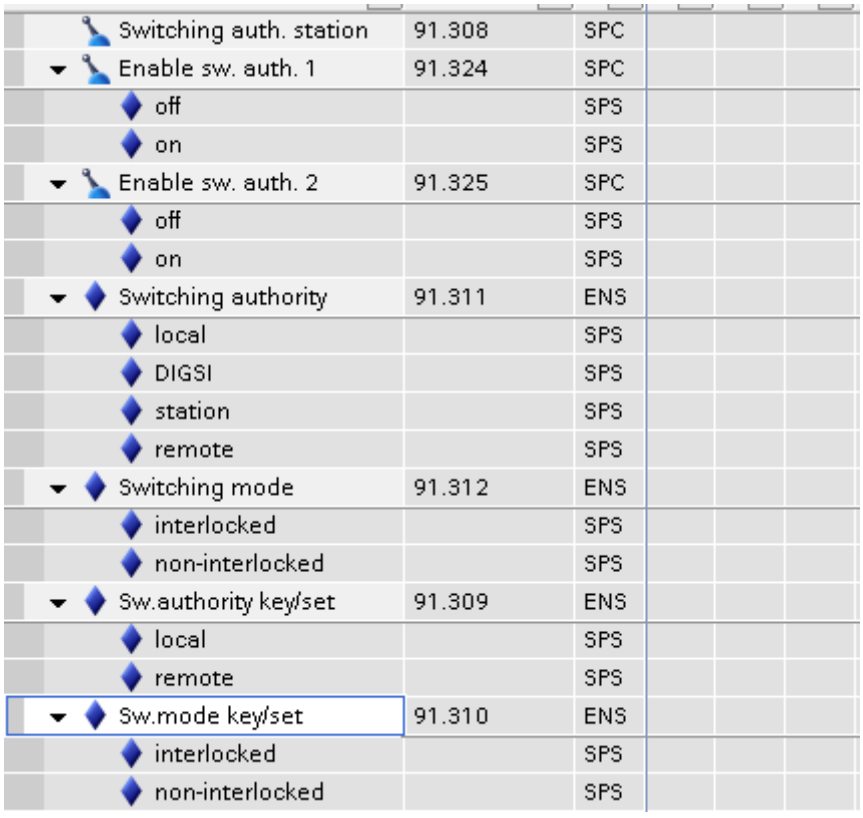
Command Source	Specific sw.auth. valid for		
	station	*station/remote*	*remote*
Remote, remote automatic	No check	Check	Check
DIGSI	No check	No check	No check

- **Num. of specific sw.auth.**:
  With this parameter, you determine how many specific switching authorities are available. This determines the number of parameters **Identifier switching authority** as well as the controllable **Active. Sw. auth.**.
- **Identifier switching authority 1** to **Identifier switching authority 5**:
  The number of names that appear corresponds to the number set in the previous parameter. You can select the names as you wish, 1 to 64 characters are allowed. The command check verifies whether these titles correspond with those sent by the command source. This applies to the switching commands as well as to the activation of a specific switching authority. The requirement for this is the system interface IEC 61850. The field **Originator/orIdent** is used.
- **Multiple specific sw.auth.** ensures the simultaneous validity of the various command sources. The following table shows how to determine the resulting specific switching authority when activating the command sources of Remote or Station. If this parameter is activated, all parameterized command sources get permissible automatically (see last row in the table) and they cannot be deactivated via the controllable **Enable sw. auth. 1** to **Enable sw. auth. 5**. Otherwise, the enabled command source with the lowest number has always the highest priority and prevails against the other numbers.

Table 7-22 Determining Switching Authority if Multiple Command Sources Are Available

Multiple specific sw.auth.	Enable sw. auth. 1	Enable sw. auth. 2	Enable sw. auth. 3	Enable sw. auth. 4	Enable sw. auth. 5	Resulting Specific Switching Authority
No	On	*	*	*	*	Switch. auth. 1
No	Off	On	*	*	*	Switch. auth. 2
No	Off	Off	On	*	*	Switch. auth. 3
No	Off	Off	Off	On	*	Switch. auth. 4
No	Off	Off	Off	Off	On	Switch. auth. 5
No	Off	Off	Off	Off	Off	None
Yes	On	On	On	On	On	All

The * symbol in the previous table refers to any value.



[sc_sw authority and mode in info routing, 1, en_US]

Figure 7-40 Display of Switching Authority and Switching Mode in the Information Routing (in Function Block General), Example of 2 Activated Remote Switching Authorities

Individual Switching Authority and Switching Mode for the Switching Devices

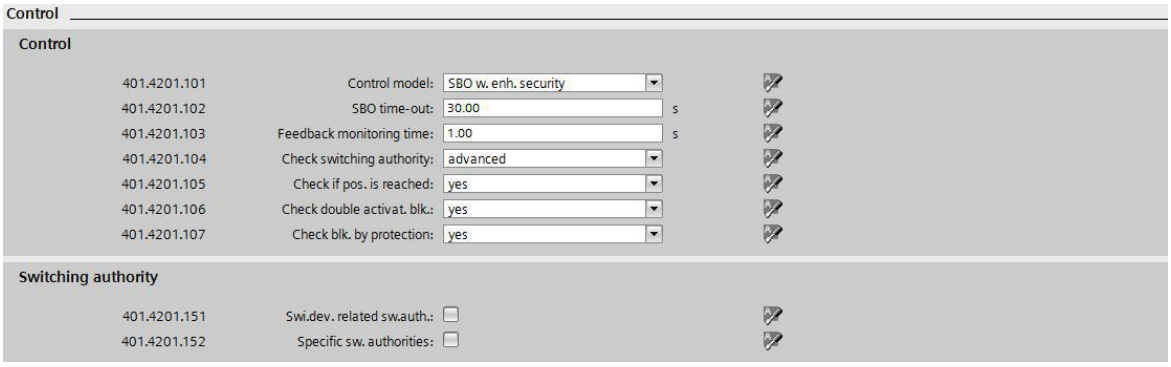
In a standard case, the functionalities switching authority, switching mode, and specific switching authority as described in the previous sections, are applicable to the entire bay unit and, therefore, are valid for all switching devices that are controlled by this bay unit. In addition, you can configure an individual switching authority and specific switching authority as well as individual switching modes for single switching devices. Therefore, individual switching devices can accept various switching authorities and switching modes simultaneously.

This is offered for the following function groups and function blocks:

- **Circuit-breaker** function group
- **Disconnector** function group
- **Transformer tap changer** function group
- **Switching sequence** function block

This allows to select individual settings for each switching device. This is useful if, for example, switching devices of different utilities are managed within a single bay.

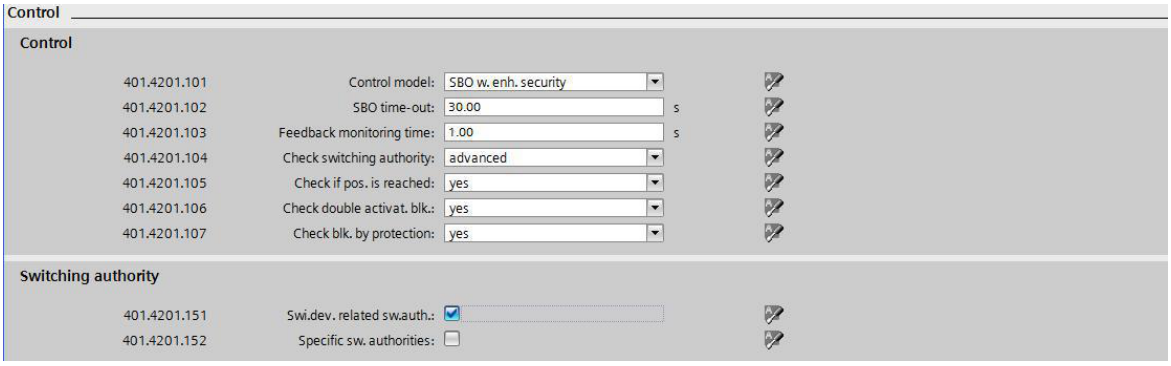
In order to activate this option, go to the function block **Control** of a switching device and set the parameter **`Check switching authority`** to ***`advanced`***. An additional table containing initially 2 parameters is displayed.



[sc_add parameters sw authority sw device, 1, en_US]

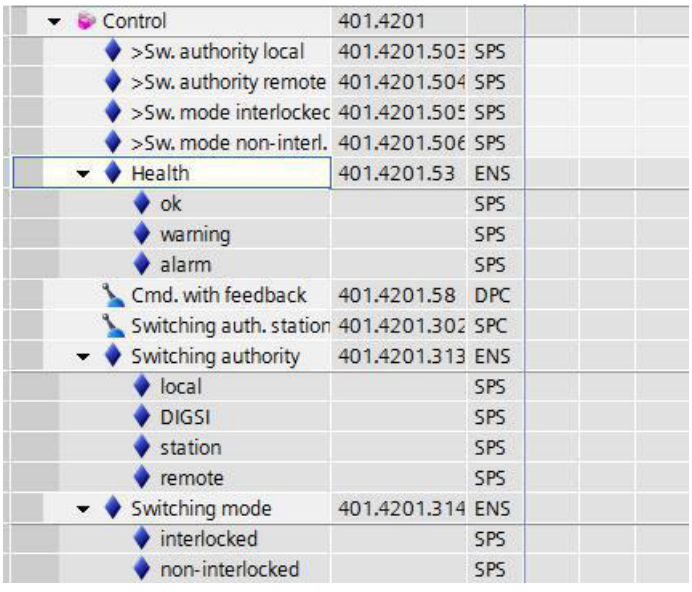
Figure 7-41 Additional Parameters for Switching Authorities in the Parameters of a Switching Device

When activating the parameter **Swi.dev. related sw.auth.**, an individual switching authority as well as an individual switching mode for this switching device are configured. Additional signals are displayed in the **Control** function block of the corresponding switching device.



[sc_extended parameters sw authority sw device, 1, en_US]

Figure 7-42 Expanded Parameters for the Switching Authority in the Switching Device



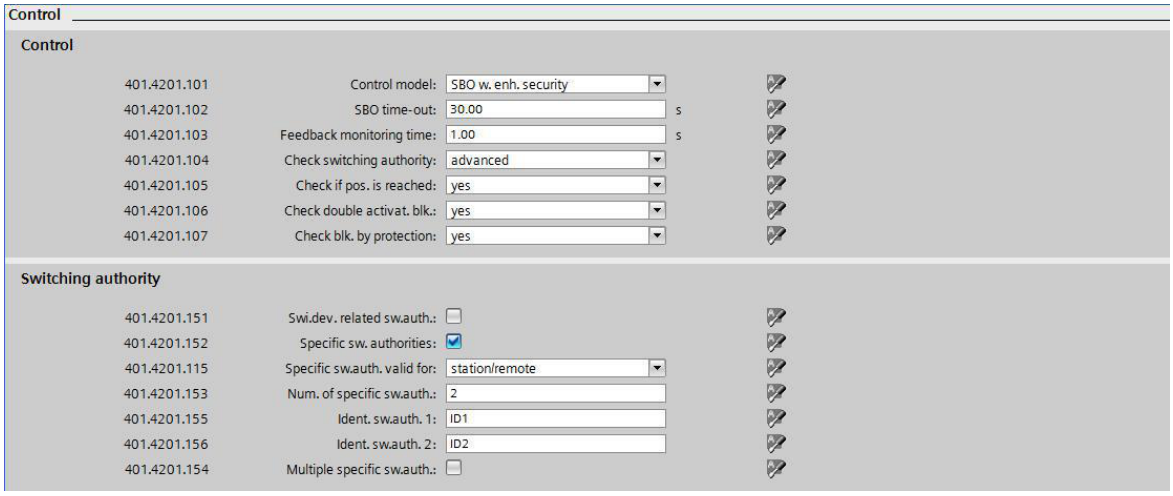
[sc_switching auth sw mode changeable, 1, en_US]

Figure 7-43 Individually Modifiable Switching Authority and Switching Mode for Switching Devices

The new input signals that are displayed allow you to set the individual switching authority and switching mode for the switching devices. For this switching device, these inputs overwrite the central switching

authority and the switching mode. The outputs *Switching authority* and *Switching mode* indicate the states only for this switching device.

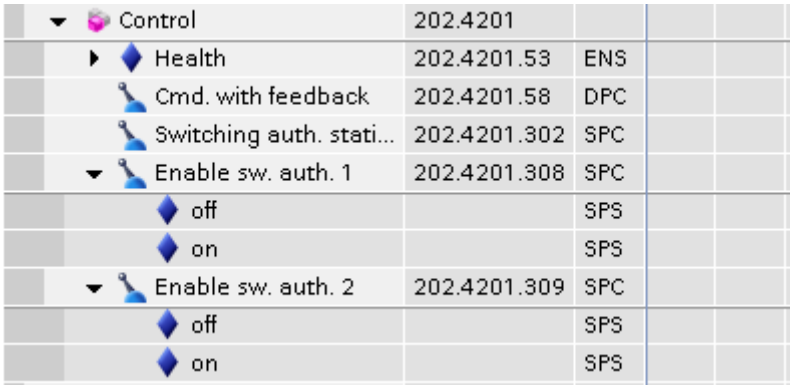
When activating **Specific sw. authorities**, an individual specific switching authority for this switching device is configured. Additional parameters are displayed.



[sc_parameters FB control all additional options, 1, en_US]

Figure 7-44 Parameters of the FB Control with All Additional Options

The functionality of the specific switching authority for the individual switching device and the significance of the additional parameters is identical to the operating mode of the central specific switching authority. Additional signals are displayed in the **Control** function block.



[sc_specific sw authority changeable per sw device, 1, en_US]

Figure 7-45 Specific Switching Authority, Modifiable for Each Switching Device

Switching Direction (Set = Actual)

With this check, you avoid switching a switching device into a state that has already been achieved. For instance, before a trip command is issued to a circuit breaker, its current position is determined. If this circuit breaker is already in the ***Off*** position, no command is issued. This is logged accordingly.

Switchgear Interlocking Protection

Switchgear interlocking protection means avoiding maloperation by checking the bay and substation interlocking and thus preventing equipment damage and personal injury. The interlocking conditions are always system-specific and for this reason are stored as CFC charts in the devices.

SIPROTEC 5 devices recognize 2 different types of interlocking conditions:

- Normal interlocking conditions:
  These can be revoked by changing the switching mode to **non-interlocked**.

- Non-revocable (fixed) interlocking conditions:
  These are still checked even if the switching mode is set to **non-interlocked**.
  Application: Replacing mechanical interlocking, for example, that prevent actuation of a medium-voltage switch.

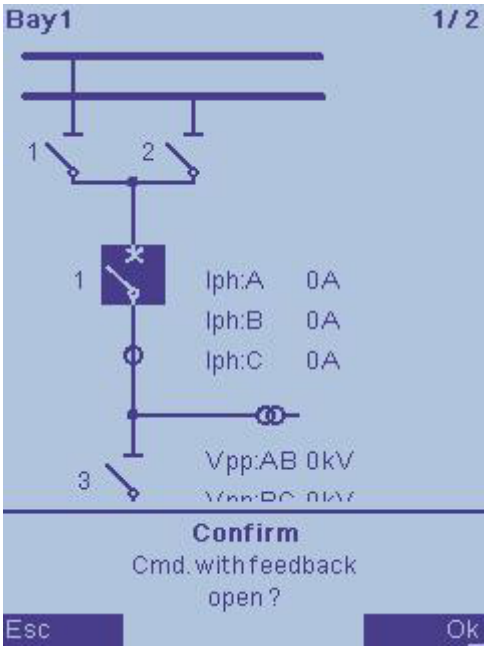
Each of the 2 categories has 2 release signals (for the ***On*** and ***Off*** switching directions) that represent the result of the interlocking plan, so that interlocking is in effect during the command check (see the figure below). The default setting for all release signals is ***TRUE***, so that no switchgear interlocking checks take place if no CFC charts have been prepared.

Information			Source							
			Binary input							
			Base module							
Signals	Number	Type	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
(All)	(All)	...	...	...	...	...	...	...	...	...
Circuit breaker 1	201									
Trip logic	201.5341									
Circuit break.	201.4261									
Manual close	201.6541									
Control	201.4201									
Interlocking	201.4231									
>Enable opening	201.4231.500	SPS								
>Enable closing	201.4231.501	SPS								
>Enable opening (fixed)	201.4231.502	SPS								
>Enable closing (fixed)	201.4231.503	SPS								
Health	201.4231.53	ENS								

[sc_verrie, 1, en_US]

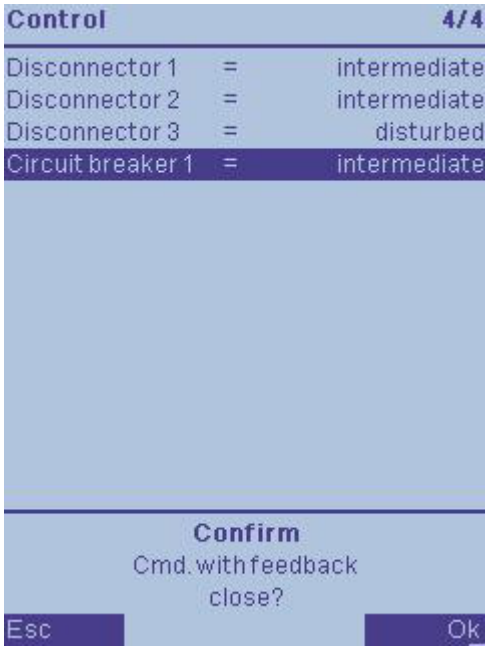
Figure 7-46 Interlocking Signals in Function Block Interlocking

By default, the status of interlocking conditions is not visible in the device, see the following figure.



[sc_HMI_WO_Position, 1, en_US]

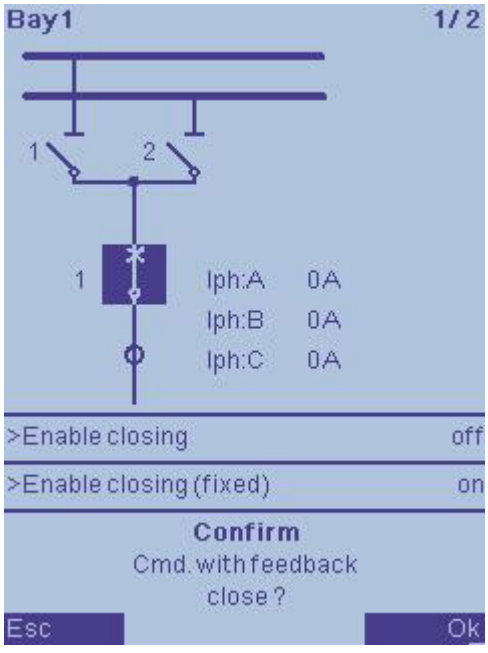
Figure 7-47 The Status of Interlocking Conditions is not Visible in the Control Display



[sc_HMI_WO_Position2, 1, en_US]

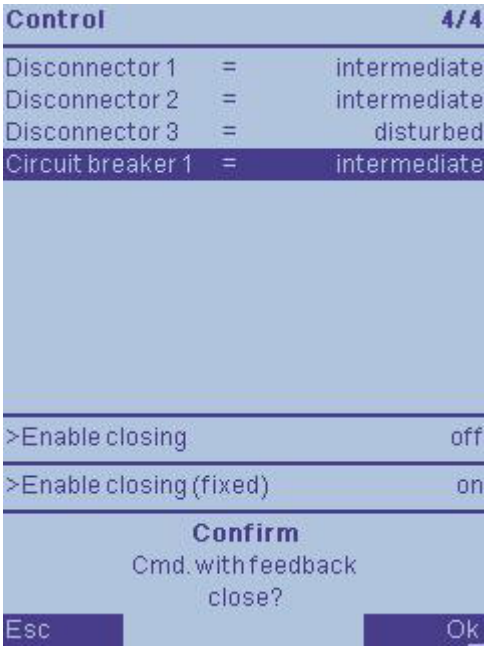
Figure 7-48 The Status of Interlocking Conditions is not Visible in the Control Menu

But, if you activate the parameter **`Show int.lck.cond. on HMI`** by navigating to **Settings** > **Device settings** > **General** > **Control** in DIGSI 5, you can get the status of interlocking conditions in the device.



[sc_HMI_W_Position, 1, en_US]

Figure 7-49 The Status of Interlocking Conditions is Visible in the Control Display



[sc_HMI_W_Position2, 1, en_US]

Figure 7-50 The Status of Interlocking Conditions is Visible in the Control Menu

EXAMPLE

For Interlocking

For the making direction of the circuit breaker QA in bay E01 (see the figure below), it is necessary to check whether the disconnectors QB1, QB2, and QB9 are in the defined position, that is, either **`On`** or ***`Off`***. Opening the circuit breaker QA should be possible at any time.

The interlocking equations are: QA_On = ((QB1 = On) or (QB1 = Off)) and ((QB2 = On) or (QB2 = Off)) and ((QB9 = On) or (QB9 = Off)). There is no condition for opening.

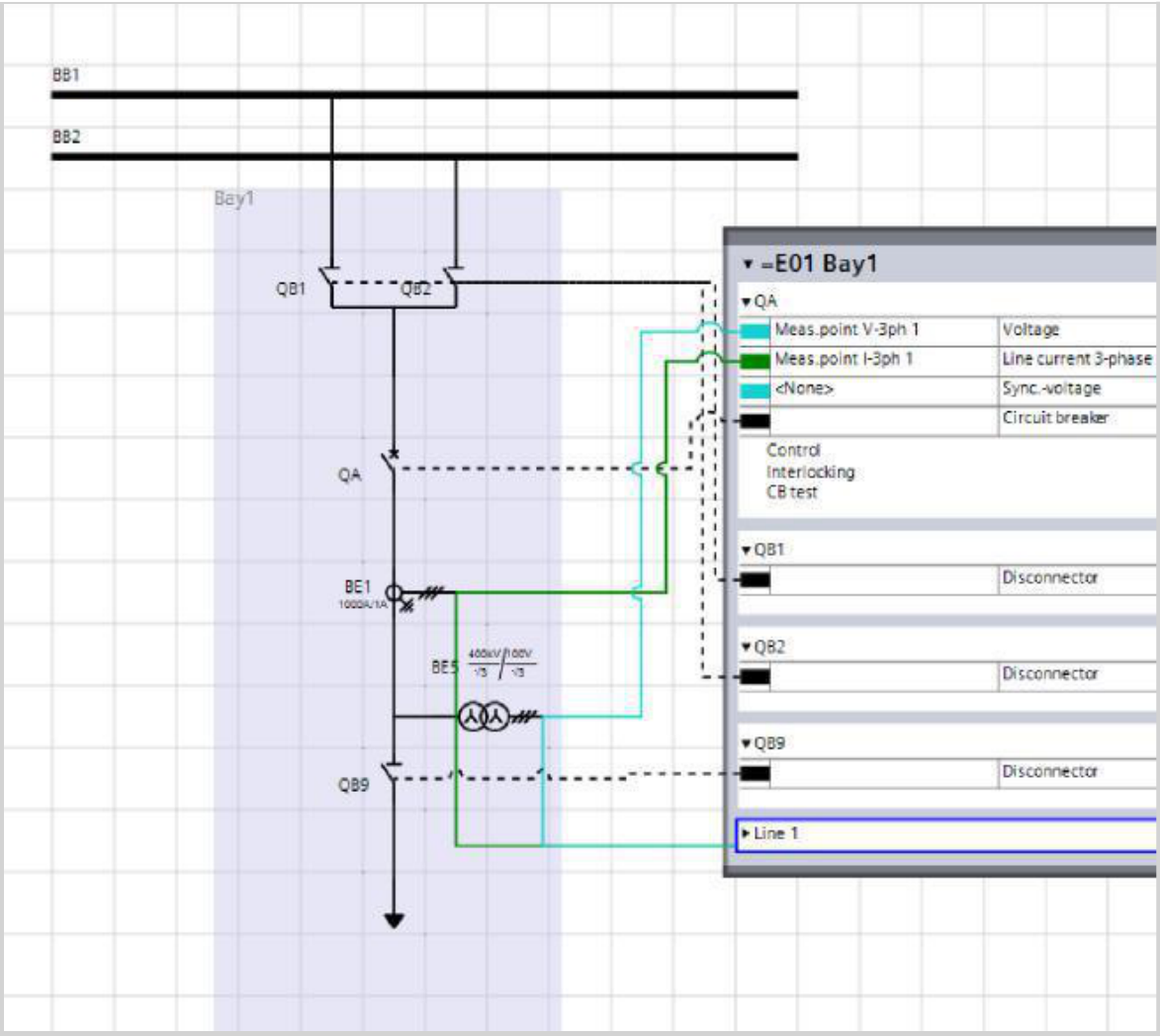


Figure 7-51 Feeder Bay for a Double Busbar System

The CFC chart that is required to implement the interlocking equation is shown in the next figure.

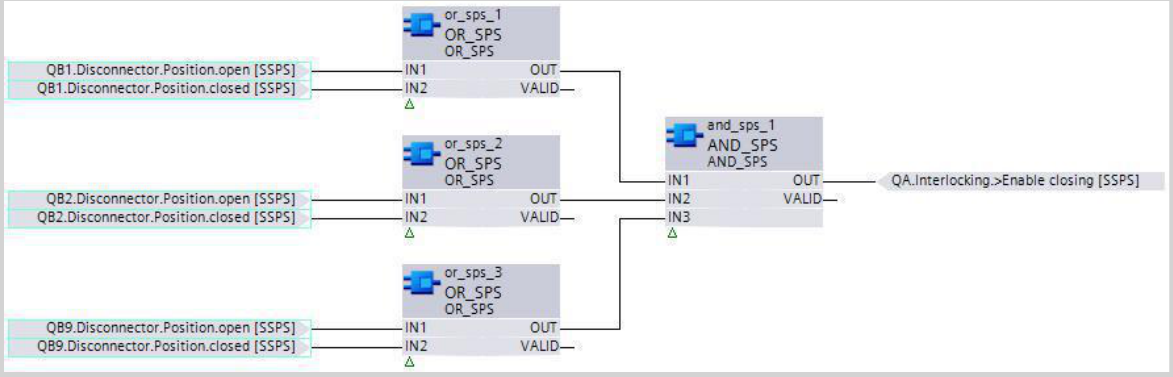


Figure 7-52 Interlocking Chart for Bay Interlocking

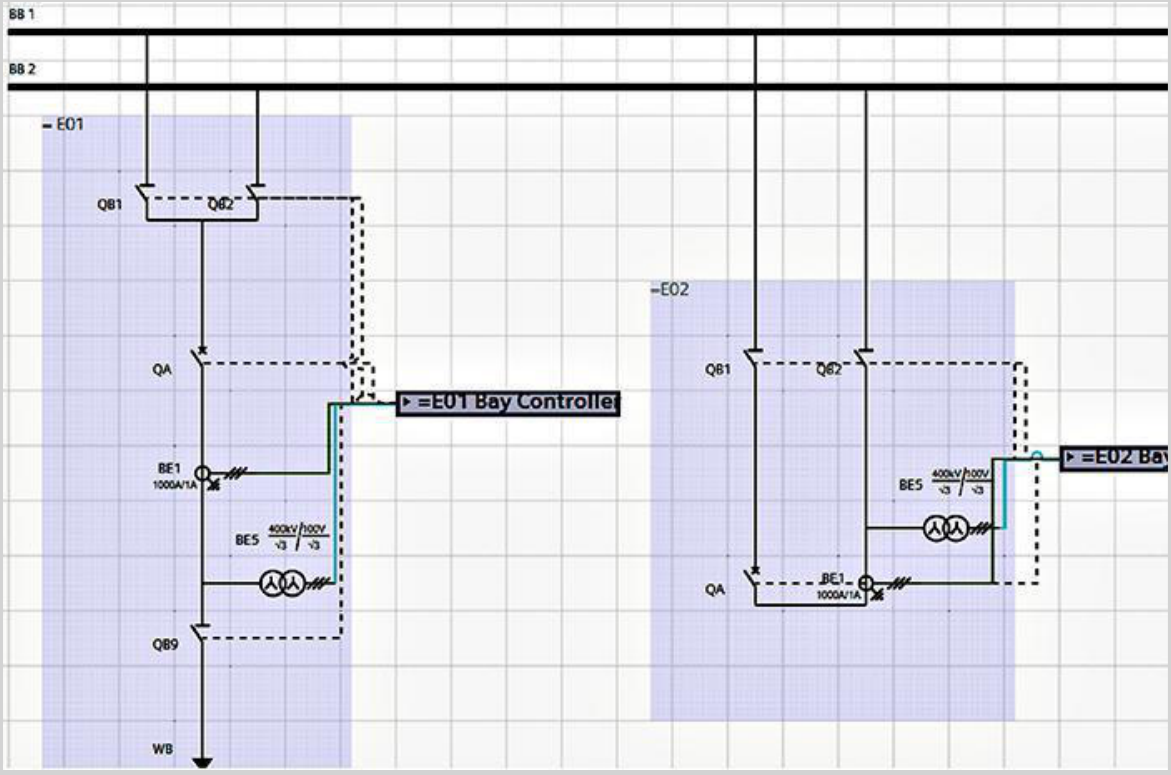
Since the **Disconnector** function block provides the defined position ***On*** or ***Off***, the exclusive OR gate XOR is not necessary for the linkage. A simple OR suffices.

As can be seen in the CFC chart, the result of the check is connected to the **>Release on signal** in the **Interlocking** function block in the **Circuit breaker QA** function group (see *Figure 7-52*).

EXAMPLE

For System Interlocking

This example considers the feeder = E01 from the previous example (bay interlocking) and additionally the coupler bay = E02 (see the figure below).



[sc_system, 1, en_US]

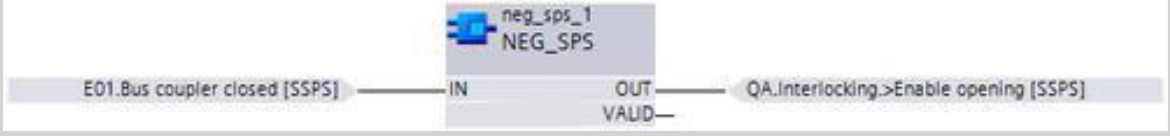
Figure 7-53 System with Feeder and Coupler Bays

The circuit breaker QA in coupler bay = E02 will be considered next. As the multibay interlocking condition, you must provide the bus-coupler circuit-breaker command block at the end:

If the 2 busbars in bay = E01 are connected, that is, if the 2 disconnectors QB1 and QB2 in bay =E01 are closed, the circuit breaker QA in bay = E02 is not allowed to be switched off. Accordingly, bay = E01 in the CFC of the device generates the indication *Bus coupler closed* from the positions of the switches QB1 and QB2 and, using IEC 61850-GOOSE, transmits it to bay = E02 in the device. You must then store the following interlocking condition in bay = E02:

QA_Off = NOT (= E01/Bus coupler closed)

In the CFC chart for the bus coupler device = E02, you must create the following CFC chart (see the figure below).



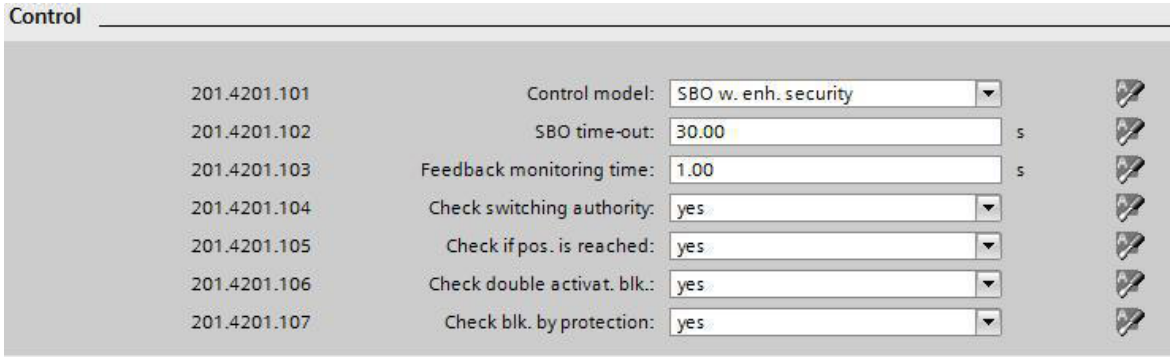
[sc_planve, 1, en_US]

Figure 7-54 Interlocking Chart for System Interlocking

1-Out-of-n Check (Double-Activation Blocking)

The double-activation blocking prevents 2 commands from being executed in the device simultaneously. You can set the device-internal check for each switching device as a parameter in the **Control** function block.

The default setting is ***Yes***, that is, double-activation blocking is active (see the figure below).

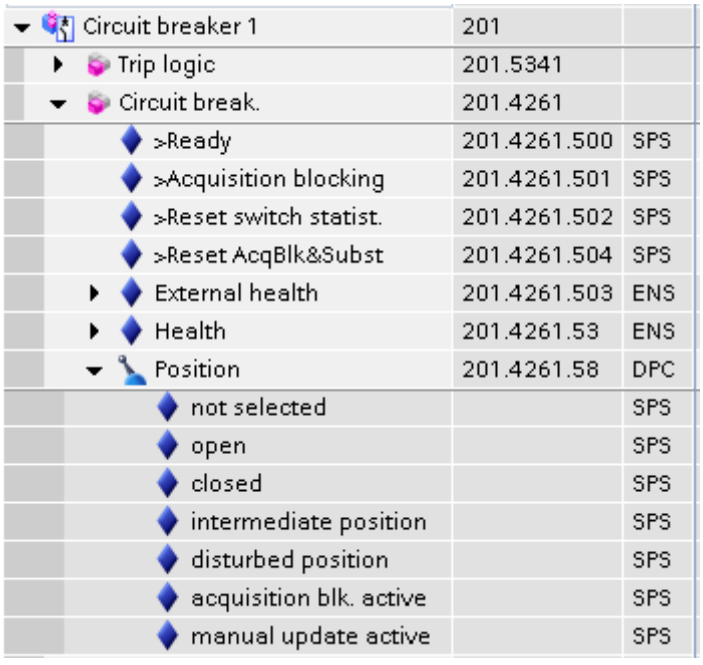


[sc_double, 1, en_US]

Figure 7-55 Activating the Double-Activation Blocking

With SIPROTEC 5, it is also possible to achieve multibay double-activation blocking.

In this case, send the signal **`not selected`** to other devices for analysis using IEC 61850-GOOSE. This signal is available under **Position** in every **Circuit breaker** or **Disconnector** function block in the switching device function groups (see figure below).



[sc_notselected, 1, en_US]

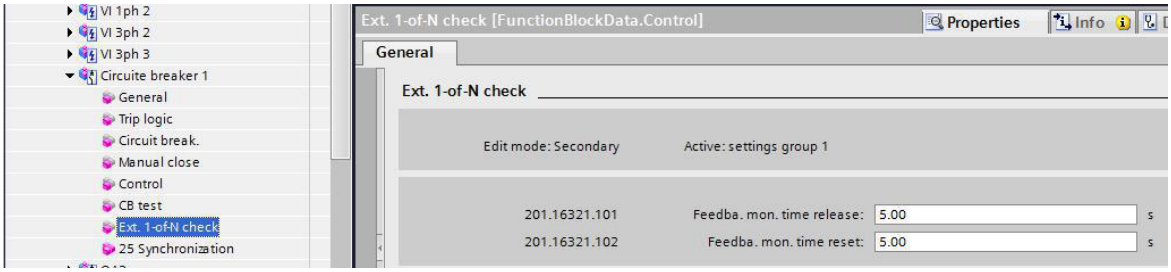
Figure 7-56 Signal *`not selected`* in the Circuit-Breaker Function Block

The signal is then queried in the CFC interlocking conditions for the associated switching devices and is used to generate the release signal (for example, **`>Release on`**).

External 1-of-N Check (Cross-Bay Double-Activation Blocking)

The function block **Ext. 1-of-N check** offers another option to implement a cross-bay 1-out-of-n check. You can select this function block in the FG **Circuit breaker** – **Control** in the DIGSI library. This function makes it possible to interlock other switching devices across all bays before the allocation of the switching device takes place in its own assigned bay or before the switching operation can be executed.

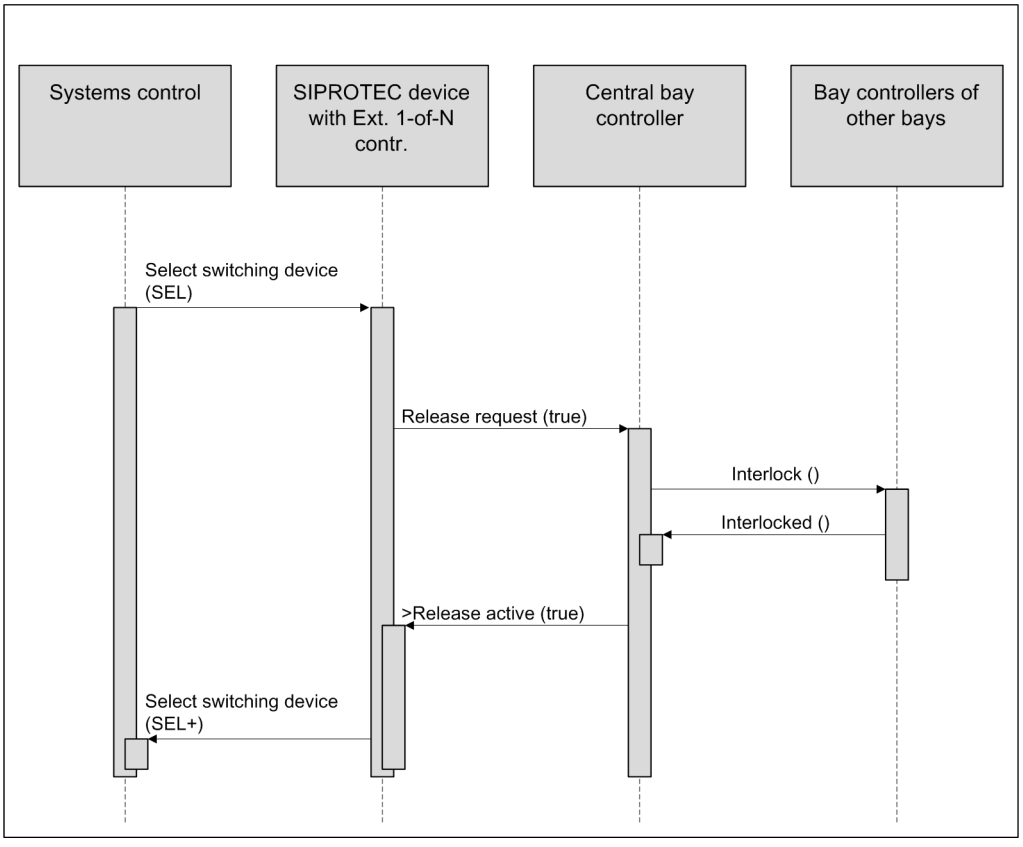
You can use the function block **Ext. 1-of-N check** in the **Circuit breaker** and **Disconnector** function groups. In order to use the function, a control model **with feedback monitoring** must be configured in the circuit-breaker control.



[sc_library properties info routing ext 1-out-of-n control, 1, en_US]

Figure 7-57 Command Execution

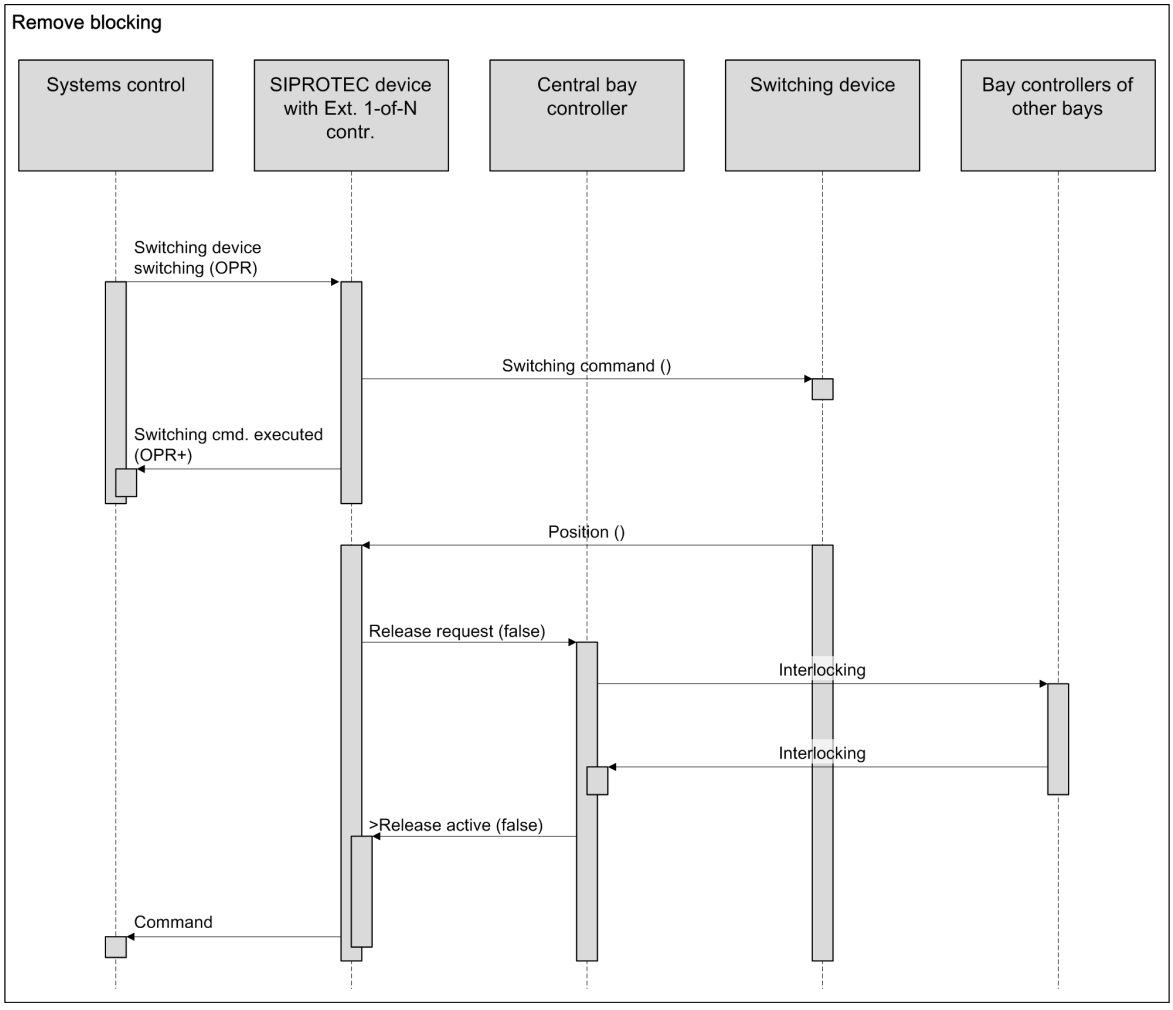
If the external 1-of-N check is instantiated, the output ***Release request*** prompts a central bay controller before executing a switching command. This bay controller must permit the switching operation (see the following figure). If the allocated switching devices were locked in another bay, the release is issued. Only when the release was issued via the input ***>Release active*** is the allocation (**`Control model`**: ***`SBO w. enh. security`***) or the switching command (**`Control model`**: ***`direct w. enh. security`***) executed and confirmed. The central bay controller is parameterized to reject a 2nd switching request.



[dw_set blocking, 1, en_US]

Figure 7-58 Setting the Blocking

Once the switch position has been reached, interlocking of the switching devices is canceled via the output ***Release request***. The switching command is completed and acknowledged with CMT (see the following figure) only when interlocking termination has been acknowledged positively via the input ***>Release active***.



[dw_remove blocking, 2, en_US]

Figure 7-59 Terminating the Blocking

User I/O Objects of the External 1-of-N Check Function Block

Name	I/O	Description	Range
Release request	O	This output remains active from the time of the switching prompt until the new position is reached.	true/false
>Release active	I	If this input is set, the switching device is released for switching operation. As long as this input is set, this switching device is blocked for additional switching operations.	true/false

Blocking by Protection Function

- Default setting **(_:107) Check blk. by protection** = ***yes***

In devices with protection and control functions, Siemens recommends that no switching commands can be issued while protection functions have picked up.

The default setting for blocking by the protection function is therefore ***yes***. If necessary, you can disable this blocking. You can find the settings on the same page as the double-activation blocking (see *Figure 7-55*).

NOTE

Remember, for instance, that pickup of the thermal overload protection can create a fault as well and thus prevent switching commands.

NOTE

The command check **Blocking by protection function** is only available for controlling circuit breakers, because in this case a unique relationship with protection functions has been configured. In disconnectors, this relationship is not always unique, precisely with regard to the 1 1/2 circuit-breaker layout, and it must be mapped for each system using CFC charts.

To carry out the command check **Blocking by protection function** for disconnectors, use the following indications (if present) in your interlocking conditions:

- Group indication: **`Pickup`** (Function group **Transformer**)
- Circuit-breaker failure protection: **`Pickup`** (**Circuit-breaker failure protection**)

7.4.2 Command Logging

All commands in the sequence are logged. The command log contains:

- Date and time
- Name of the switching device (or function group)
- Reason for the transmission (SEL = Selected, OPR = Operate, CMT = Command execution end, SPN = Spontaneous)
- Status or switching direction

EXAMPLE

The following example illustrates control of a circuit breaker QA1 for various cases.

- Successful command output
- Interrupted command
- Command interrupted by switchgear interlocking
- Command ended due to missing feedback
- Spontaneous change of switch position without command output

The following figures indicate command logging for various scenarios of the standard control model SBO with feedback monitoring.



[sc_bbcon_1, 1, en_US]

Figure 7-60 Positive Case (Display 1)



[sc_bbcon_2, 1, en_US]

Figure 7-61 Positive Case (Display 2)



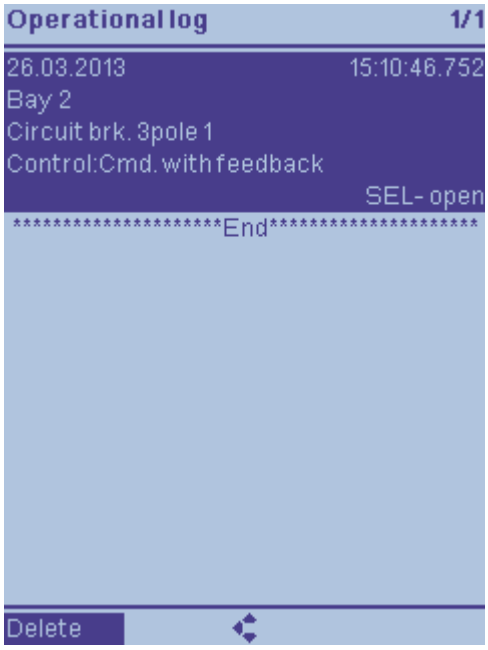
[sc_bbcon_3, 1, en_US]

Figure 7-62 Positive Case (Display 3)



[sc_bbcon_4, 1, en_US]

Figure 7-63 Positive Case with Command Cancellation



[sc_bbcon_5, 1, en_US]

Figure 7-64 Negative Case (Blocked by Switchgear Interlocking)



[sc_bbcon_7, 1, en_US]

Figure 7-65 Negative Case (Expiration of Feedback Supervision Time) (Display 1)



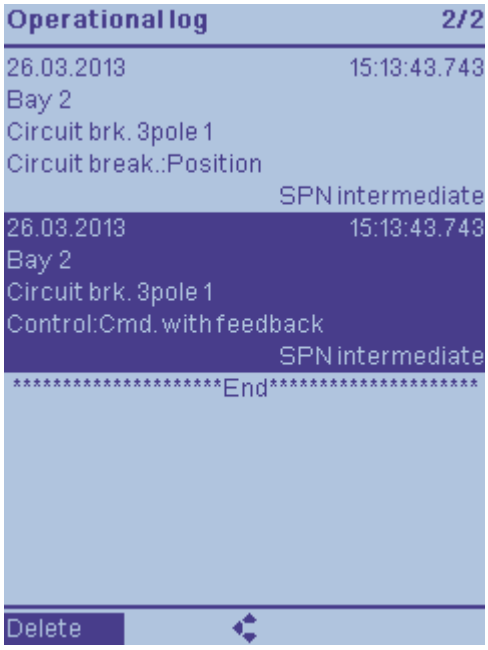
[sc_bbcon_8, 1, en_US]

Figure 7-66 Negative Case (Expiration of Feedback Supervision Time) (Display 2)



[sc_bbcon_9, 1, en_US]

Figure 7-67 Negative Case (Expiration of Feedback Supervision Time) (Display 3)



[sc_bbcon_6, 1, en_US]

Figure 7-68 Spontaneous Status Change

Depending on the transmission reason, the desired control value or the actual state value of the controllable and the switching device can be contained in the log.
The following table shows the relationship.

Table 7-23 Relationship between the Reason for Transmission and the Value Logged

Reason for Transmission	Value
Selected (SEL)	Desired value
Operate (OPR)	Desired value
Command cancellation (CNC)	Desired value
Command execution and termination (CMT)	Actual value
Spontaneous change (SPN)	Actual value

7.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Control				
_:101	Control:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:102	Control:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:103	Control:Feedback monitoring time		0.01 s to 1800.00 s	1.00 s
_:104	Control:Check switching authority		• no • yes	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:105	Control:Check if pos. is reached		• no • yes	yes
_:106	Control:Check double activat. blk.		• no • yes	yes
_:107	Control:Check blk. by protection		• no • yes	yes

7.4.4 Information List

No.	Information	Data Class (Type)	Type
Control			
_:53	Control:Health	ENS	O
_:58	Control:Cmd. with feedback	DPC	C

7.5 Synchronization Function

7.5.1 Overview of Functions

The 1-channel **Synchronization function** (ANSI 25) checks whether the activation is permissible without a risk to the stability of the system when interconnecting 2 parts of an electrical power system.
Typical applications are as follows:

- Synchronization of a line and a busbar
- Synchronization of 2 busbars via a cross-coupling
- Synchronization of a generator and a busbar

A power transformer between the 2 measuring points can also be taken into consideration.
The following operating modes are covered:

- Synchrocheck
- Switching synchronous power systems
- Switching asynchronous power systems
- Switching to dead line/busbar

7.5.2 Structure of the Function

The function **Synchronization** is used in the function group **Circuit-breaker**.
The following stage types can be used within the function:

- Synchrocheck stage
- Synchronous/asynchronous stage



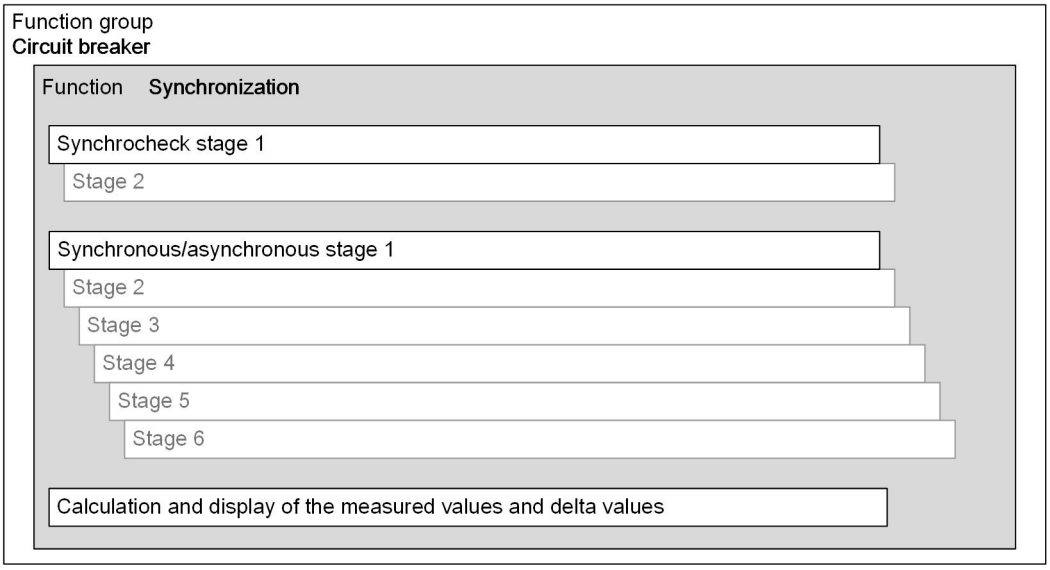
NOTE

Siemens recommends using the synchronization functions for the following powers of the plant:

- 1-channel synchronization function for a plant with a power of < 10 MVA
- 1.5-channel paralleling function for a plant with a power of < 100 MVA
- 2-channel paralleling function for a plant with a power of ≥ 100 MVA

For a 1-channel synchronization function, the probability for a correct switching or for erroneous switching is identical. With the 1.5-channel paralleling function, you can achieve much greater reliability. In this function, a 2-out-of-2 decision has already been made, but only one channel switches. You can achieve the best reliability with the 2-channel paralleling function. In this function, there is also a 2-out-of-2 decision, but both channels are part of the close-command creation. The SIPROTEC 5 device 7VE85 with a 1.5- or 2-channel paralleling function is suitable for plants with a higher power (≥ 10 MVA).

The stage types **Synchrocheck** and **Synchronous/Asynchronous (Sychr./Asycr.)** are preconfigured at the factory.
In addition, the stage type **Extended delta-f options** are available in the function library. This has not been preconfigured.
You can operate a maximum of 2 stages of the stage type **Synchrocheck** or 6 stages of the **Synchronous/asynchronous** in parallel.
As soon as the function is available in the device, the functional measured values are calculated and displayed.



[dw_synfn1-01, 2, en_US]

Figure 7-69 Structure/Embedding of the Function

7.5.3 Connection and Definition

Connection

You can find examples for the synchronization of line and busbar in the following 2 figures. *Figure 7-72* shows an example for the synchronization of 2 busbars via bus coupler.

The synchronization function uses 2 voltages to check the connecting conditions: a voltage of the reference side 1 (V1) as well as a voltage to be used as a reference on side 2 (V2). The reference voltage of side 1 is designated in the synchronization function as V1[61].

This is always the voltage of the measuring point that is connected to the **Sync. voltage 1** interface of the Circuit-breaker function group. The voltage to be set as reference is designated with V2[61]. This is always the voltage of the measuring point that is connected to the **Sync. voltage 2** interface of the **Circuit-breaker** function group. The assignment of the measuring points to the interfaces of the **Circuit-breaker** function group can be configured, see *2.1 Embedding of Functions in the Device*.

The selection of the voltages used for the synchronization depends on the device connection to the primary system:

- Connection of the primary system via 4 voltage inputs and hence use of a 1-phase and a 3-phase measuring point (*Figure 7-70* and *Figure 7-72*):

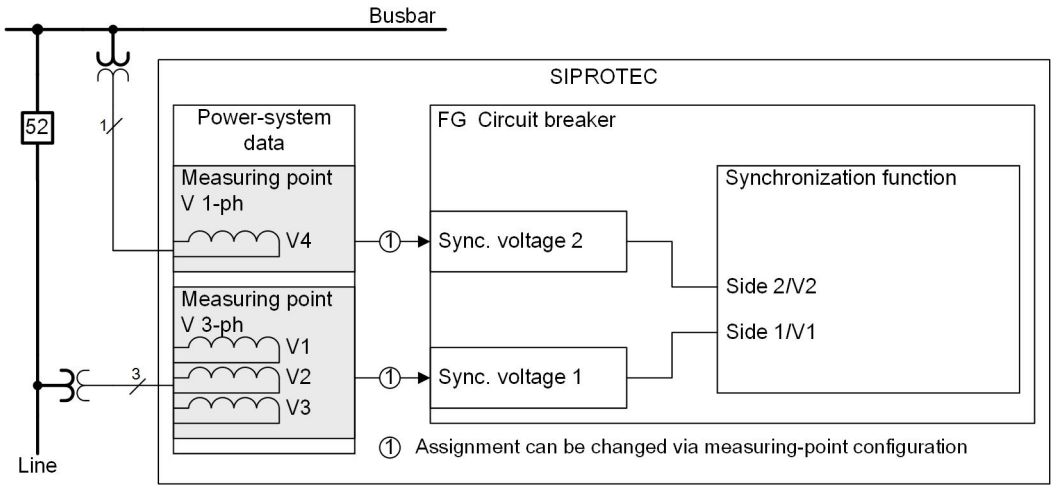
  The voltage connected to the 1-phase measuring point is definitive here. If. for example, this is the phase-to-ground voltage V_A, the voltage V_A is also used by the other side of the 3-phase measuring point.

- Connection of the primary system via 6 voltage inputs and hence use of two 3-phase measuring points (*Figure 7-71*):

  The phase-to-phase voltage V_{AB} of both sides is always used for the test.

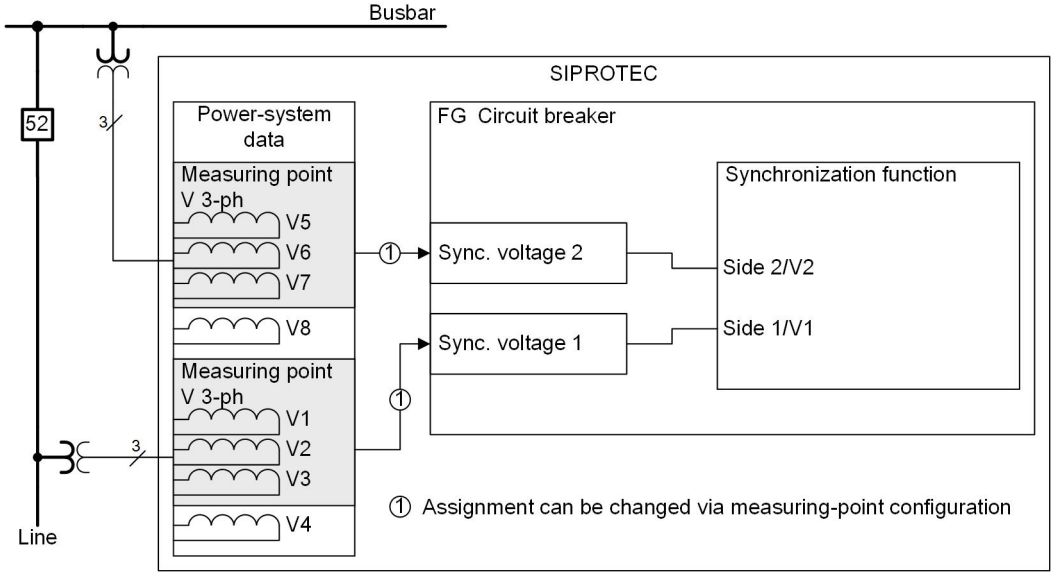
You can connect both the phase-to-ground voltages and the phase-to-phase voltages to the device. The possible interface connections are listed in the Appendix.

61 Do not confuse the designations V1 and V2 with the numbering of the voltage inputs V1 to V4 (*Figure 7-70*) and V1 to V8 (*Figure 7-71*).



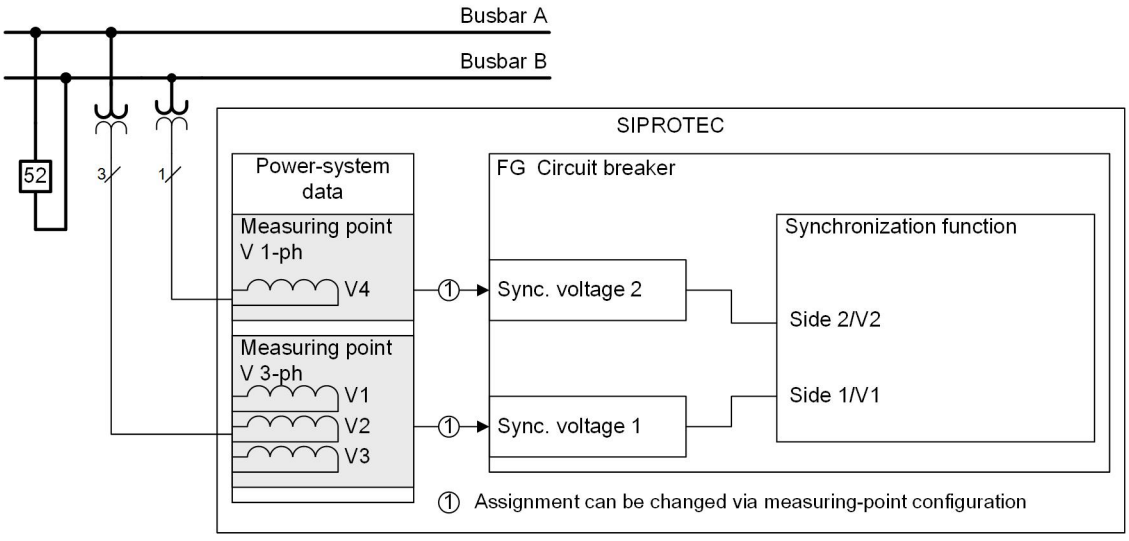
[dw_syns01-01, 2, en_US]

Figure 7-70 Synchronization of Line and Busbar, Connection via 4 Voltage Inputs



[dw_syns02-01, 2, en_US]

Figure 7-71 Synchronization of Line and Busbar, Connection via 6 Voltage Inputs



[dw_syns03-01, 2, en_US]

Figure 7-72 Synchronization of 2 Busbars via Cross-Coupling, Connection via 4 Voltage Inputs

Definition of the Variables

The definition of the variables is important for understanding the following implementation. The reference side 1 indicates the function with 1. This yields the reference values voltageV1, frequencyf1, and phase angle α1. The side to be synchronized indicates the function with 2. The electrical variables of side 2 are then the voltageV2, frequencyf2, and phase angle α2.

When forming the differential variables, the function is oriented to the definition of the absolute measuring error (Δ x = measured value – real value). The reference value and hence the real value is side 1. This results in the following calculation specifications:

Differential voltage dV = V2 – V1

A positive sign means that the voltage V2 is greater than the voltage V1. In other cases, the sign is negative.

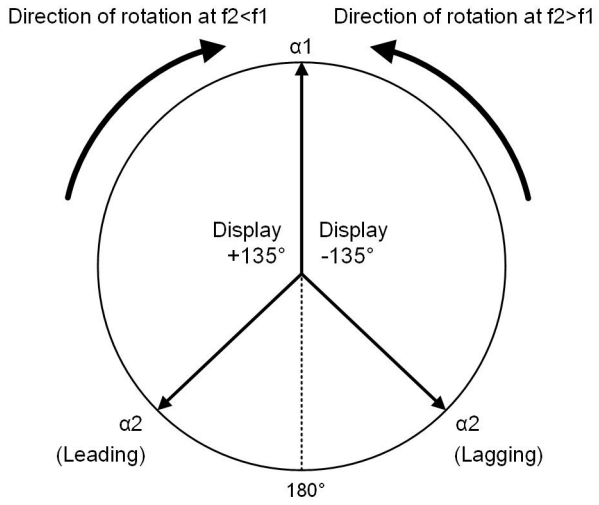
Differential frequency df = f2 – f1

A positive result means that according to the example from *Figure 7-70* the busbar frequency is greater than the line frequency.

Phase-angle difference dα = α2 – α1

The representation is limited to ±180°. A positive result means that α2 **leads** by a maximum of 180°. In the case of a negative value, α2 **lags** by a maximum of 180°. *Figure 7-73* shows the circumstances. The phase angle α1 was added to the zero axis as a reference system.

If asynchronous systems are present and the frequency f2 is greater than f1, the angle dα then changes from the negative value to 0 and then to the positive value. As shown in *Figure 7-73*, the direction of rotation is counterclockwise (mathematically positive). At f2 < f1, the direction of rotation is clockwise.



[dw_synp_04, 2, en_US]

Figure 7-73 Phase-Angle Difference Representation dα

Only positive values are permissible for the setting parameters. Inequalities are used to characterize the setting parameters uniquely. The representation is explained with the example of differential voltage. 2 setting values are necessary to allow unbalanced settings.

The inequality V2 > V1 yields a positive value for dV. The associated parameter is **`Max. voltage diff. V2>V1`**. For the 2nd setting parameter **`Max. voltage diff. V2<V1`**, the inequality V2 < V1 applies. It corresponds to a negative dV.

The procedure is the same for the differential frequency and differential phase angle.

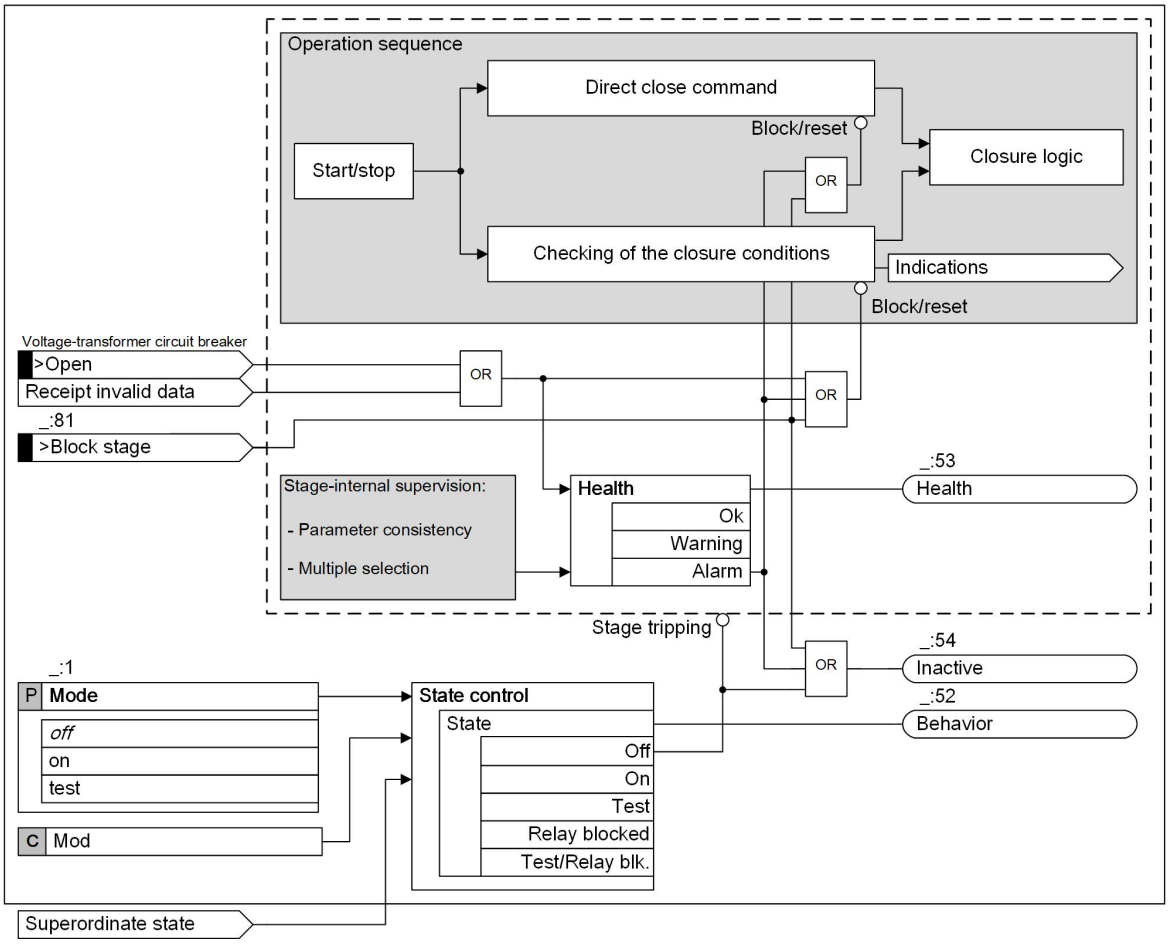
7.5.4 General Functionality

7.5.4.1 Description

Overview of a Synchronization Stage (Sync Stage)

A synchronization stage can be integrated in the following blocks (see *Figure 7-74*):

- Stage control with mode, state control, standby, and blocking (description in this chapter)
- Supervision (description in this chapter)
- Functional sequence for issuing the closing release (see *7.5.6 Sequence of Functions*)



[lo_syn001-01, 6, en_US]

Figure 7-74 Overview of the Stage Logic

Stage Control

The normal stage control is used for a synchronization stage (see *Figure 7-74*).

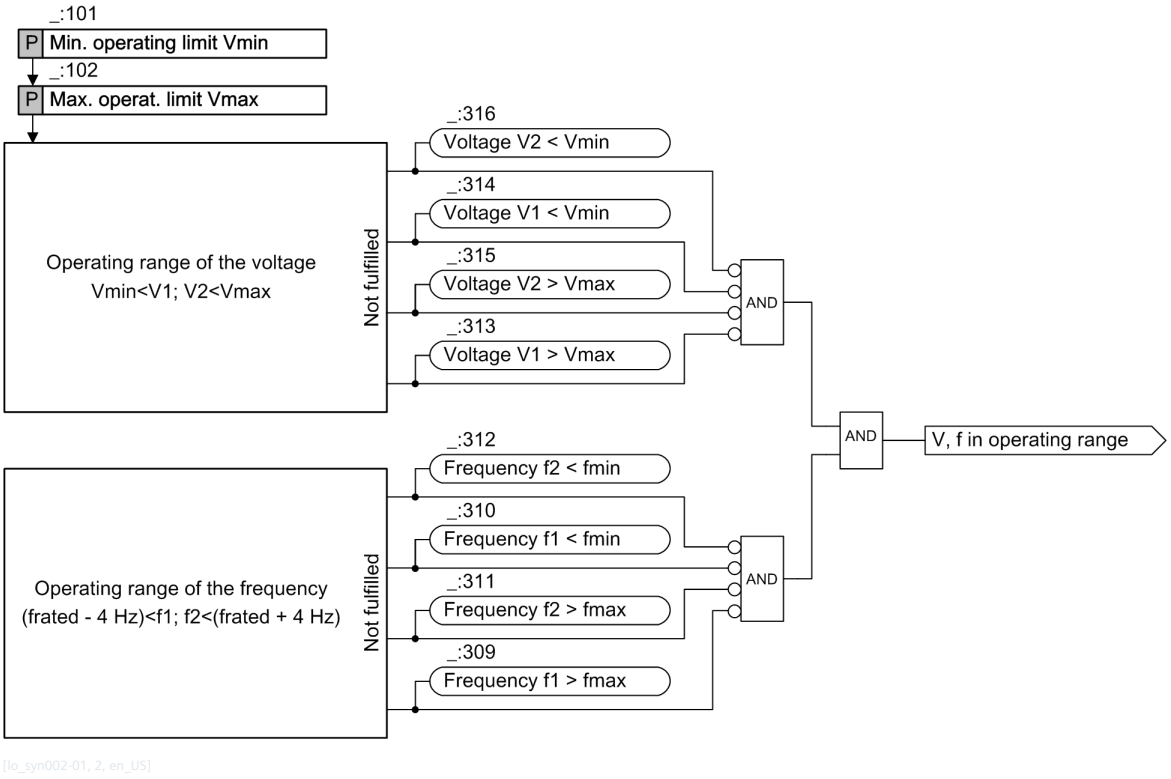
Note the following special features:

- For control via IEC 61850, a parameterized function Synchrocheck is only executed if the service parameter **Synchrocheck** is set to ***true***. The function control also provides the service parameter **Interlock-Check**. If the service parameter **Synchrocheck** is set to ***false***, switching is not synchronized. Siemens recommends checking the desired behavior for control from remote via IEC 61850 before the commissioning.
- As soon as there is a synchronization function available in the device, the measured values are calculated and displayed. One stage must be activated for calculating all Delta settings. It is not necessary to start the stage for this purpose.
- If all synchronization stages are deactivated within the function, closure via the control will no longer be possible, as none of the stages can generate a closing release. If the synchronization function is deleted, the circuit breaker is no longer regarded as subject to compulsory synchronization. In this case, it is possible to activate via the control without synchronization.
- If more than one synchronization stage is activated, the **>Selection** signal must be active for exactly one stage, so that it can be activated via the controls.

You can block the entire synchronization stage via the binary signal **>Block stage**. A started process is completed and the entire stage reset after blocking. The stage must be restarted to initiate a new switching

procedure. The blocking only affects the test process for the closing conditions. The measured values are still calculated and displayed.

Operating Range



[lo_syn002-01, 2, en_US]

Figure 7-75 Logic of the Operating Ranges

The operating range of the synchronization function is defined by the configurable voltage limits **`Min. operating limit Vmin`** and **`Max. operat. limit Vmax`**, as well as by the specified frequency band f_{rated} ±4 Hz.

If one or both voltages are outside the permitted operating range when the measurement is started or a voltage leaves the range, this is displayed via corresponding indications **`Frequency f1 > fmax`**, **`Frequency f1 < fmin`**, **`Voltage V1 > Vmax`**, **`Voltage V1 < Vmin`**, etc. The closing conditions are then not checked.

Supervision

The supervisions listed below are executed in a function-specific manner. If one of the supervisions picks up, the indication *`Health`* goes to ***`Warning`***. The stage is indicated as **`Inactive`**. A closing release or direct close command is not possible in this case.

- For consistency of settings of specific parameters
  Definite threshold-value settings are checked after a parameter change. If there is an inconsistency, the error message **`Setting error`** is issued.
- For multiple selection of the stage at the start time of the synchronization
  If there is a simultaneous selection of multiple closed synchronization stages at the start time, the error message **`Multiple selection`** is issued.

Measuring-Voltage Failure

If a voltage-transformer fault (measuring-voltage failure) is recorded via the binary input signal **`>Open`** of one of the voltage-measuring points, then the closing conditions of the synchronization stage are no longer

tested. This means that a release of the closure based on the measurement is no longer possible. The readiness of the stage turns to ***Warning***. Direct close command is still possible.

The device-internal supervision function measuring-voltage failure detection (Fuse Failure Monitor) does not have any effect on the synchronization stage.

Functional Measured Values

The functional measured values for the Synchronization function are displayed in their own primary, secondary, and percentage measured value windows. Voltage measurements are always displayed as ph-ph voltages, even if the associated measuring point records phase-to-ground voltages. The functional measured values are determined and displayed as soon as the device is functional. The difference values are calculated as soon as the stage is activated.

Table 7-24 Protection-Specific Values of the Synchronization

Values		Primary	Secondary	% Referenced to
V_1	Reference voltage V_1	kV	V	Rated operating voltage of the primary values
V_2	Voltage to be synchronized V_2	kV	V	Rated operating voltage of the primary values
f_1	Frequency of the voltage V_1	Hz	Hz	Rated frequency
f_2	Frequency of the voltage V_2	Hz	Hz	Rated frequency
dV	Voltage difference V_2–V_1	kV	V	–
df	Frequency difference f_2–f_1	Hz	Hz	–
dα	Angle difference α_2–α_1	°	–	–

Multiple Synchronization Points

The synchronization function can only be used within a Circuit-breaker function group. It always operates on the circuit breaker that is linked to the Circuit-breaker function group. The reference to the circuit breaker is therefore unique. If you wish to switch several circuit breakers (synchronization points) with the device, you must create several Circuit-breaker function groups.

Different Synchronization Conditions per Synchronization Point

Within the synchronization function, you can operate maximum 2 stages of the stage type **Synchrocheck** and maximum 6 stages of the type **Synchronous/asynchronous** in parallel. All setting parameters for a synchronization point are included in each synchronization stage.

If you have to synchronize with different synchronization conditions (parameter settings), several synchronization stages are used for a synchronization point/circuit breaker. In this case, you must define which of the synchronization stages is currently active via the binary signal **>Selection** (synchronization stage x). The closing conditions are checked if the respective stage is activated via the **>Selection** binary signal and the stage is activated.

The fault indication **Multiple selection** is issued upon simultaneous selection of different synchronization stages. If several synchronization stages are activated and the input signal **>Selection** (synchronization stage x) is missing at the starting time, a valid selection is awaited during the supervision time **Max.durat. sync.process**. If this does not come, the process is terminated.

Different Voltage-Transformer Ratios from Both Sides of the Electrical Power System

The synchronization function automatically takes different transformation ratios of the voltage measuring points into account on both sides of the power system. Set the parameter **Voltage adjustment** in the synchronization function for the following cases:

- Without a power transformer between the voltage measuring points of the circuit breaker to be synchronized, if the rated primary voltages are different on both sides of the electrical power system.
- With a power transformer between the voltage measuring points of the circuit breaker to be synchronized, if the transfer ratios of the rated primary voltages on the voltage transformer are different on both sides of the electrical power system.

For more information about the parameter **Voltage adjustment**, refer to *7.5.4.2 Application and Setting Notes*, *Parameter: **Voltage adjustment**, Page 1901*.

Synchronization via a Transformer

There are systems in which a power transformer is located between the voltage measuring points of the circuit breaker to be synchronized. The device automatically considers the different voltage stages by setting the rated primary voltages of the power transformer from 2 sides of the electrical power system. A phase displacement must be taken into account based on the transformer vector group via the parameter **Angle adjust. (transform.)**.

The parameter is defined as -Δα = –(α2 – α1).

To calculate the delta variables Δα and ΔU, the voltage of side 2 is converted to that of side 1 using the settings of the 2 parameters **Angle adjust. (transform.)** and **Voltage adjustment**.

The displayed voltage V2 in the device display is the voltage from the power-transformer side, which is close to the point to be synchronized, and not the measured voltage of the voltage transformer of side 2.

For more information, refer to *7.5.4.2 Application and Setting Notes*.

Different Connection Types on Both Sides

If both the measuring points used by the synchronization functions record different voltages of the 3-phase system, the calculation of the phase-angle difference is automatically considered.

EXAMPLE:

The 1-phase measuring point connected with **Sync-voltage 1** records the phase-to-phase voltage V_{AB}. The 1-phase measuring point connected with **Sync-voltage 2** records V_A. In this case the phase angle between V_{AB} and V_A takes into consideration the delta variable Δα during calculation.

This automation guarantees that several voltage sources can be switched between during running operation, each of which records different voltages.

7.5.4.2 Application and Setting Notes

Stage-Type Selection

The following 2 types of stages are available:

Stage Type	Application
Synchrocheck stage	Select this type of stage to issue, for example, an additional release during a manual reclosing for safety reasons. With this type, the variables ΔV, Δf, and Δα are checked before connecting the 2 parts of the power system.
Synchronous/asynchronous stage	Select this type of stage if it is necessary to differentiate between synchronous and asynchronous systems, depending on the switch position. If galvanically coupled systems are switched in parallel, synchronous systems are present. A typical characteristic of synchronous systems is equality of frequency (Δf ≈ 0). In this state, the conditions Δα and ΔV are checked. If the systems are galvanically isolated, asynchronous systems can be present. At the same time, compliance with the voltage difference ΔV and frequency difference Δf conditions is checked. The time of the direct close command is calculated taking into account the angle difference Δα and the make time of the circuit breaker. The time of the direct close command is calculated such that the voltages are equal at the moment the circuit-breaker poles come into contact (ΔV ≈ 0, Δα ≈ 0).

Configuration of the Voltages V1 (Reference Side) and V2

The voltages V1 and V2 are established via the connection of the measuring points to the interface of the function groups (refer to chapter *7.5.3 Connection and Definition*). The measuring point connected to the interface **Voltage** is the reference side 1 with the reference voltage V1. The measuring point connected to the interface **Sync. voltage** is the side 2 with V2. The definition of the Delta parameters that can be derived from this is also described in chapter *7.5.3 Connection and Definition*.

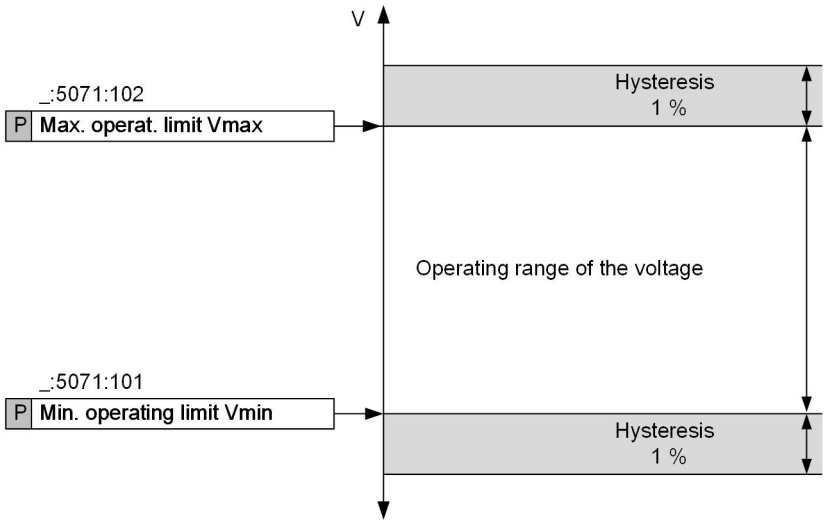
Parameter: `Min. operating limit Vmin`, `Max. operat. limit Vmax`

- Recommended setting value `(_:5071:101) Min. operating limit Vmin` = *90 V*
- Recommended setting value `(_:5071:102) Max. operat. limit Vmax` = *110 V*

The values define the voltage operating range of the synchronization stage. A normal setting is approx. ±10 % of the rated voltage.

NOTE

All voltages connected according to the parameterized measuring-point connection type are subjected to the appropriate Vmin/Vmax test. Therefore, connected phase-to-ground voltages are multiplied by √3, since the threshold values must be set with reference to the rated voltage (phase-to-phase voltage).



[lo_hyster-01, 2, en_US]

If the Synchronization function is started within the hysteresis, no switching is performed as a result of the minimum and maximum operating limit (parameters **Min. operating limit Vmin** and **Max. operat. limit Vmax**). If the Synchronization function is started within the voltage operating range and the voltage exceeds the minimum or maximum operating limit during the synchronization process, selecting can occur in the area of the hysteresis.

Parameter: Max.durat. sync.process

- Default setting **(_:5071:110) Max.durat. sync.process** = ***30 s***

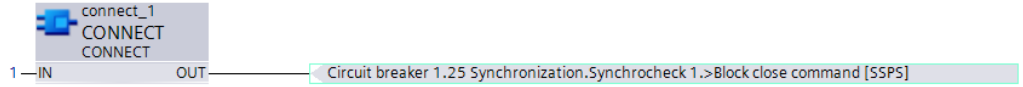
The parameterized conditions must be fulfilled within this time. If the conditions are not fulfilled, no further closing release takes place and the synchronization stage is stopped. If this time is set to ∞, conditions are checked until they are fulfilled. This is also the default setting. Observe the operating conditions when defining the time limitation. This must be defined specifically for each system. If 0 or 0.01 s is set, then all conditions are checked once at the starting time. Thereafter the process is stopped immediately.

If the closure release is assigned, the synchronization is terminated. If the synchrocheck is to continuously display the switching conditions, without issuing a direct close command at synchronization, proceed as follows:

EXAMPLE:

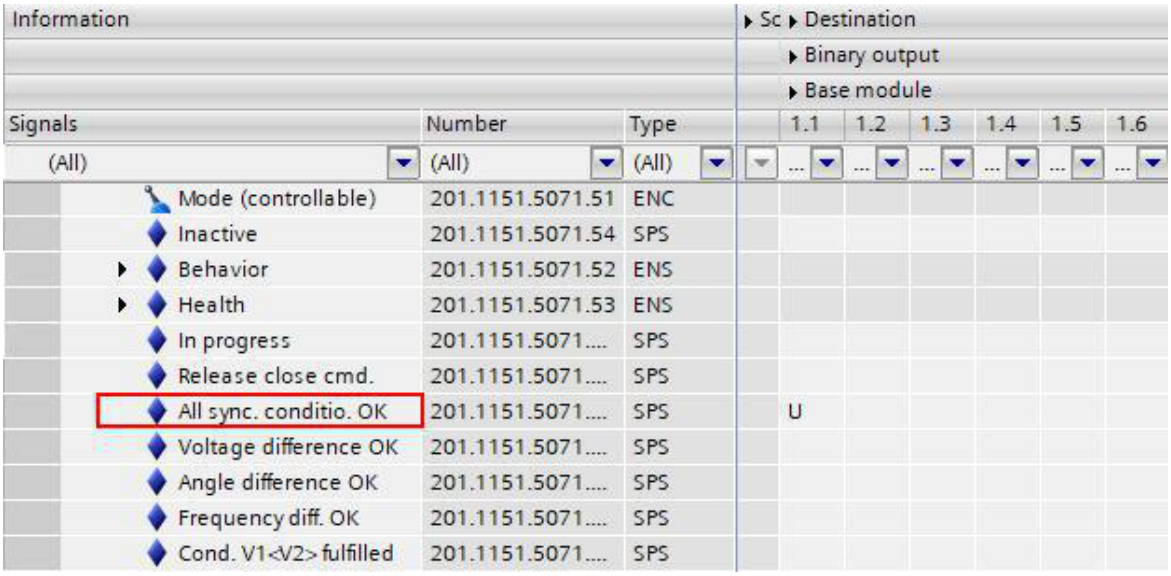
For Continuous Checking of the Switching Conditions without Issuing a Direct Close Command

With the aid of the following CFC chart you can set the input *>Block stage* of the corresponding synchrocheck stage permanently:



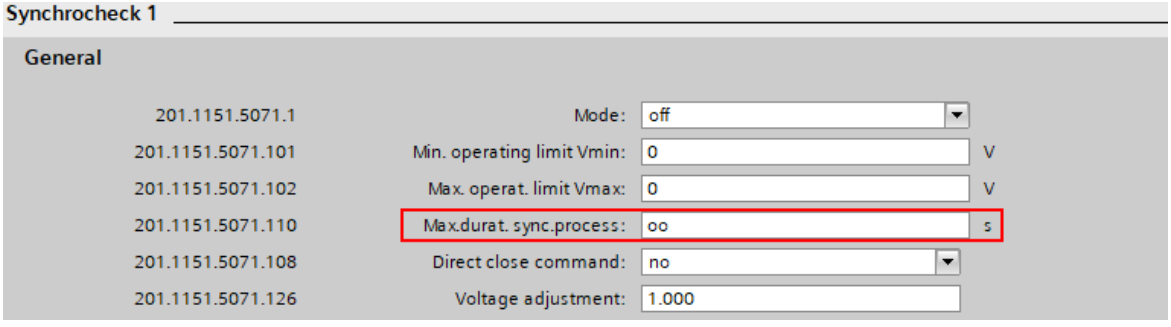
[sc_sync_CFC, 3, en_US]

If you route the indication *All sync. conditio. OK* to the corresponding binary output, you receive a separate release of the closure for an external synchronization unit.



[sc_sync_routing, 2, en_US]

If you wish to permanently report each occasion on which synchronization conditions are reached following the start of synchronization, you set the parameter **`Max.durat. sync.process`** to ∞.



[sc_sync_setting, 2, en_US]

Parameter: `Voltage adjustment`

- Default setting **`(_:5071:126) Voltage adjustment`** = ***`1.00`***

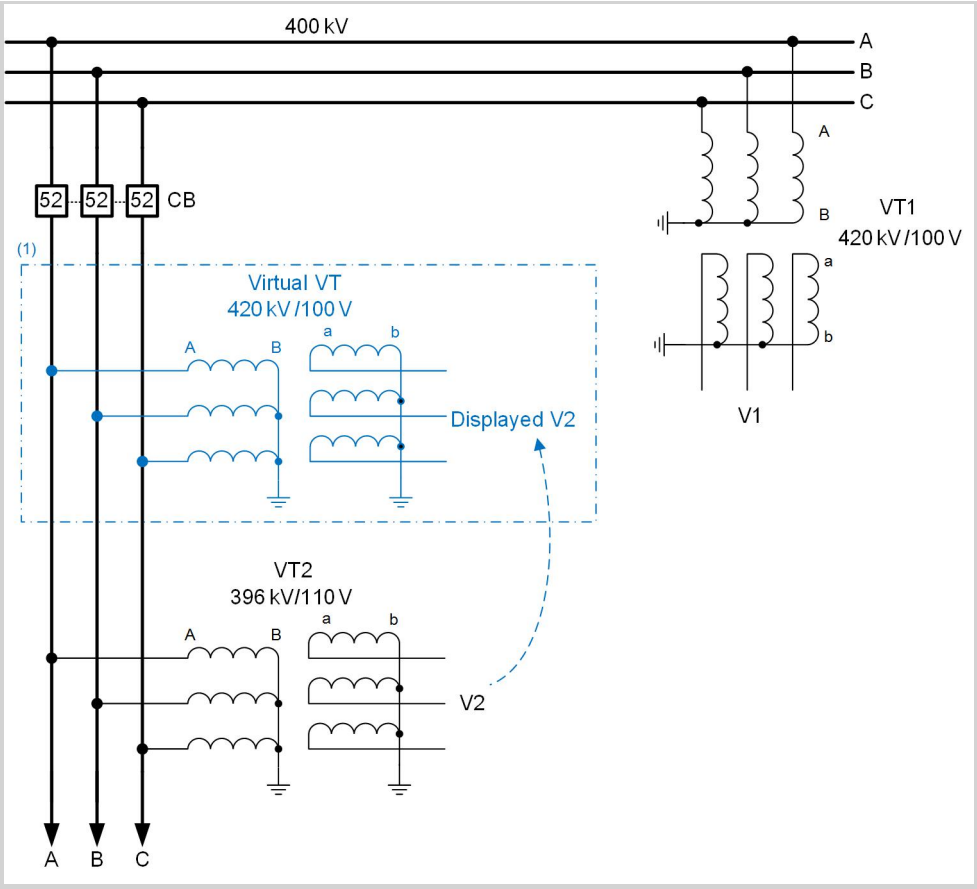
The parameter can be used for correction of amplitude errors, for example, due to indirect measurement (for example, transformer tap changer).

To apply a transformer between measuring points, the **`Voltage adjustment`** parameter is not needed. The transformer ratios are set for the measuring points and the function will take them into account automatically.

To apply a transformer between the voltage measuring points, the transformer ratio does not have to be taken into account. When you set the parameter **`Voltage adjustment`**, the transformer ratio is automatically taken into account. In the following, you can find 2 examples for the setting of the parameter **`Voltage adjustment`**:

Example 1:

In the electrical power system, no power transformer exists between the voltage measuring points of the circuit breaker to be synchronized. The rated primary voltages of 2 sides of the electrical power system are different.



[dw_example w.o. power transformer, 1, en_US]

Figure 7-76 Example: the Electrical Power System without a Power Transformer

(1) The virtual VT does not exist in the primary voltage system. It is just a virtual voltage transformer to show the displayed V2 on the device display. The virtual VT has the same transformer ratio as VT1.

The displayed V2 is a processed voltage from VT2.

$$\text{Voltage adjustment} = \frac{V2_{\text{rated prim.}}}{V1_{\text{rated prim.}}} = \frac{396\ \text{kV}}{420\ \text{kV}} \approx 0.94$$

[fo_ex1_V adjustment, 1, en_US]

With:

$V2_{\text{rated prim.}}$	Rated primary voltage of VT2
$V1_{\text{rated prim.}}$	Rated primary voltage of VT1

For this example, the displayed voltage V2 on the device display is from the virtual VT, not from VT2.

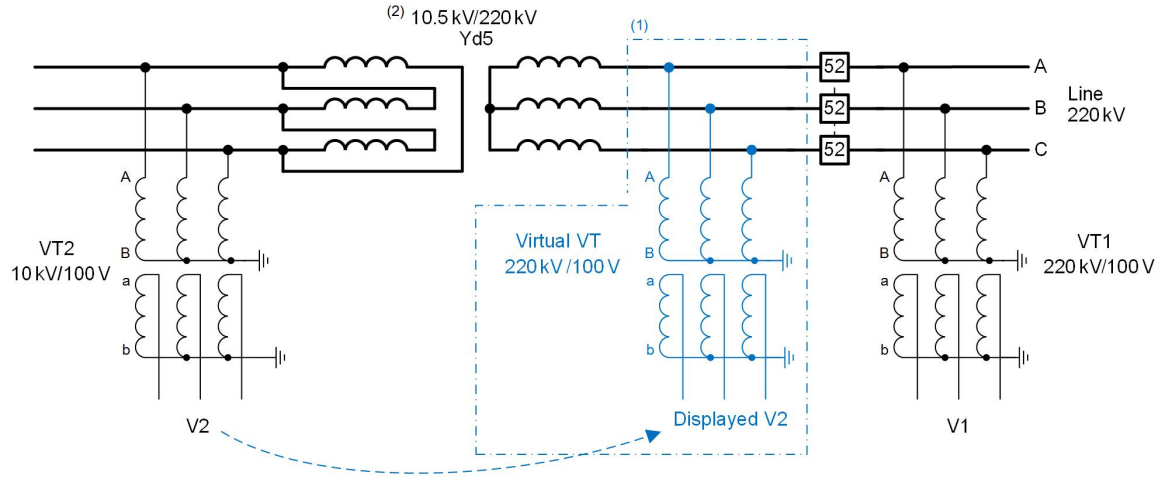
The primary voltages, secondary voltages, and percentage values of the measured values are shown in the following table.

Table 7-25 Primary Voltage, Secondary Voltage, and Percentage Value

Measured Value	Primary Voltage	Secondary Voltage	Percentage Value
V1	400 kV	$\frac{400\,\text{kV}}{420\,\text{kV}/100\,\text{V}} \approx 95.238\,\text{V}$	$\frac{400\,\text{kV}}{420\,\text{kV}} \cdot 100\,\% \approx 95.238\,\%$
V2	400 kV	$\frac{400\,\text{kV}}{396\,\text{kV}/110\,\text{V}} \approx 111.111\,\text{V}$	$\frac{400\,\text{kV}}{396\,\text{kV}} \cdot 100\,\% \approx 101.01\,\%$
Displayed V2	400 kV	$\frac{400\,\text{kV}}{420\,\text{kV}/100\,\text{V}} \approx 95.238\,\text{V}$	$\frac{400\,\text{kV}}{420\,\text{kV}} \cdot 100\,\% \approx 95.238\,\%$

Example 2:

In the electrical power system, a power transformer is located between the voltage measuring points of the circuit breaker to be synchronized. The power transformer ratio differs from the ratio between the rated primary voltages of the voltage transformers of 2 sides of the electrical power system.



[dw_example w. power transformer, 1, en_US]

Figure 7-77 Example: the Electrical Power System with a Power Transformer

(1) The virtual VT does not exist in the primary voltage system. It is just a virtual voltage transformer to show the displayed V2 on the device display. The virtual VT has the same transformer ratio as VT1.

The displayed V2 is a processed voltage from VT2.

(2) This ratio is not the rated transformer ratio on the transformer name plate. This ratio is an actual ratio which considers the tap-changer scenarios when the **Tap changer** function is not used in the device. The rated transformer ratio is 220 kV/10 kV.

$$\text{Voltage adjustment} = \frac{V2_{\text{rated prim.}}}{V1_{\text{rated prim.}}} \cdot R_{PT} = \frac{10\,\text{kV}}{220\,\text{kV}} \cdot \frac{220\,\text{kV}}{10.5\,\text{kV}} \approx 0.95$$

[fo_ex2_V adjustment, 1, en_US]

With:

$V2_{\text{rated prim.}}$	Rated primary voltage of VT2
$V1_{\text{rated prim.}}$	Rated primary voltage of VT1
R_{PT}	Transformer ratio of the power transformer

For this example, the displayed voltage V2 on the device display is from the virtual VT, not from VT2.

The primary voltages, secondary voltages, and percentage values of the measured values are shown in the following table.

Table 7-26 Primary Voltage, Secondary Voltage, and Percentage Value

Measured Value	Primary Voltage	Secondary Voltage	Percentage Value
V1	220 kV	$\frac{220\,\text{kV}}{220\,\text{kV}/110\,\text{V}} = 110\,\text{V}$	$\frac{220\,\text{kV}}{220\,\text{kV}} \cdot 100\,\% = 100\,\%$
V2	10.5 kV	$\frac{10.5\,\text{kV}}{10\,\text{kV}/100\,\text{V}} = 105\,\text{V}$	$\frac{10.5\,\text{kV}}{10\,\text{kV}} \cdot 100\,\% = 105\,\%$
Displayed V2	220 kV	$\frac{220\,\text{kV}}{220\,\text{kV}/110\,\text{V}} = 110\,\text{V}$	$\frac{220\,\text{kV}}{220\,\text{kV}} \cdot 100\,\% = 100\,\%$

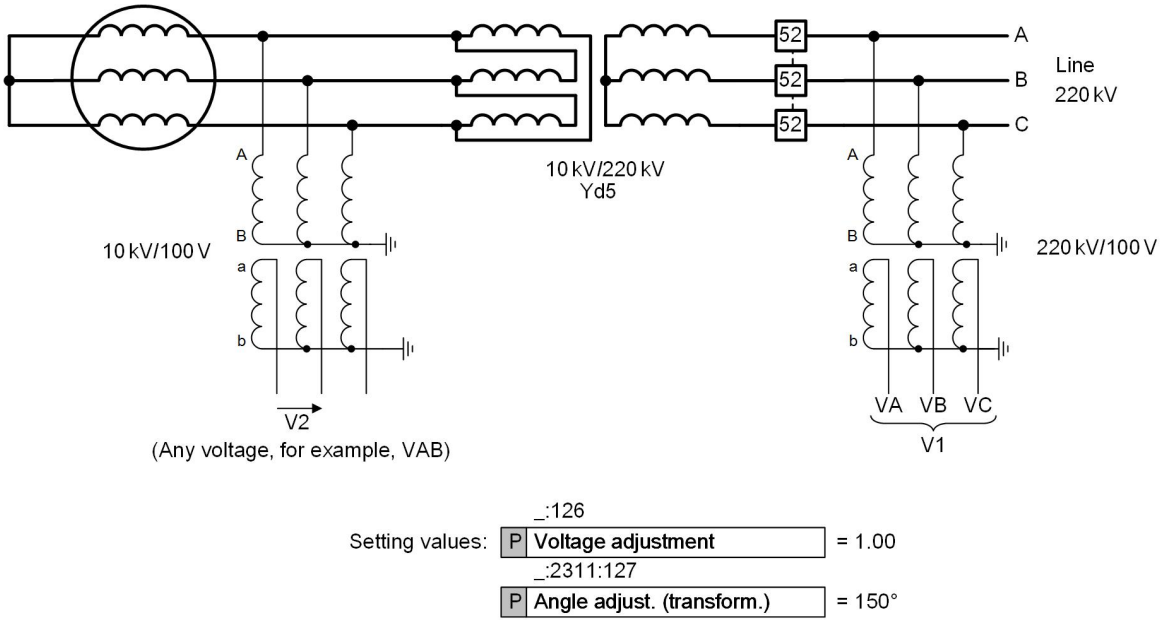
Parameter: **`Angle adjust. (transform.)`**

- Default setting **`(_:2311:127) Angle adjust. (transform.)`** = *0* °

The parameter can be applied under the following conditions:

- 1. Phase-angle rotation by power transformer between the measuring points
- 2. Correction of phase-angle errors

1. Phase-angle rotation by power transformer between the measuring points:



[dw_transformer between the measuring points, 2, en_US]

Figure 7-78 Transformer between the Measuring Points

If there is a power transformer between the voltage transformers of the circuit breaker to be synchronized, you then have to correct the phase-angle rotation for a vector group deviating from 0. *Figure 7-78* shows such an application. The **`Angle adjust. (transform.)`** parameter is used to save the phase-angle rotation.

The transformer vector group is defined from the upper-voltage side to the undervoltage side. If the reference voltage transformer V1 is connected on the upper-voltage side of the transformer (as in *Figure 7-78*), enter the phase-angle rotation directly according to the vector group. A vector-group figure of 5, for example, means an angular rotation of 5 · 30° = 150°. Set this value for the **`Angle adjust. (transform.)`** parameter.

If the voltage connection V1 is on the undervoltage side due to the system, you then have to apply the extension angle with 360°. A transformer with vector group 5 yields an angular adjustment of 360° – (5 · 30°) = 210°.

2. Correction of phase-angle errors:

You can correct a phase-angle error between the voltage transformers in increments. Ascertain a possible correction value during commissioning.

Parameter: CB make time

- Default setting **(_:5041:113) CB make time** = ***0.060 s***

If you are to interconnect under asynchronous system conditions with the device as well, the make time of the circuit breaker must be taken into account. The device uses this to calculate the time of the direct close command, so that the voltages are in phase at the moment of closure of the switch poles. Note that apart from the operating time of the switch, this also includes the pickup time of an auxiliary relay that may be upstream. You can determine the make time using the protection device (see commissioning notes in *11.23 Primary and Secondary Testing of the Synchronization Function*).

This parameter only occurs for the stage type **Synchronous/asynchronous**.

7.5.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:127	General:Angle adjust. (transform.)		-179.0 ° to 180.0 °	0.0 °
General				
_:5071:1	Synchrocheck 1:Mode		• off • on • test	off
_:5071:101	Synchrocheck 1:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:5071:102	Synchrocheck 1:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:5071:110	Synchrocheck 1:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:5071:108	Synchrocheck 1:Direct close command		• no • yes	no
_:5071:126	Synchrocheck 1:Voltage adjustment		0.500 to 2.000	1.000
General				
_:5041:1	Sychr./Asycr.1:Mode		• off • on • test	off
_:5041:101	Sychr./Asycr.1:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:5041:102	Sychr./Asycr.1:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:5041:110	Sychr./ Asycr.1:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:5041:108	Sychr./Asycr.1:Direct close command		• no • yes	no
_:5041:126	Sychr./Asycr.1:Voltage adjustment		0.500 to 2.000	1.000

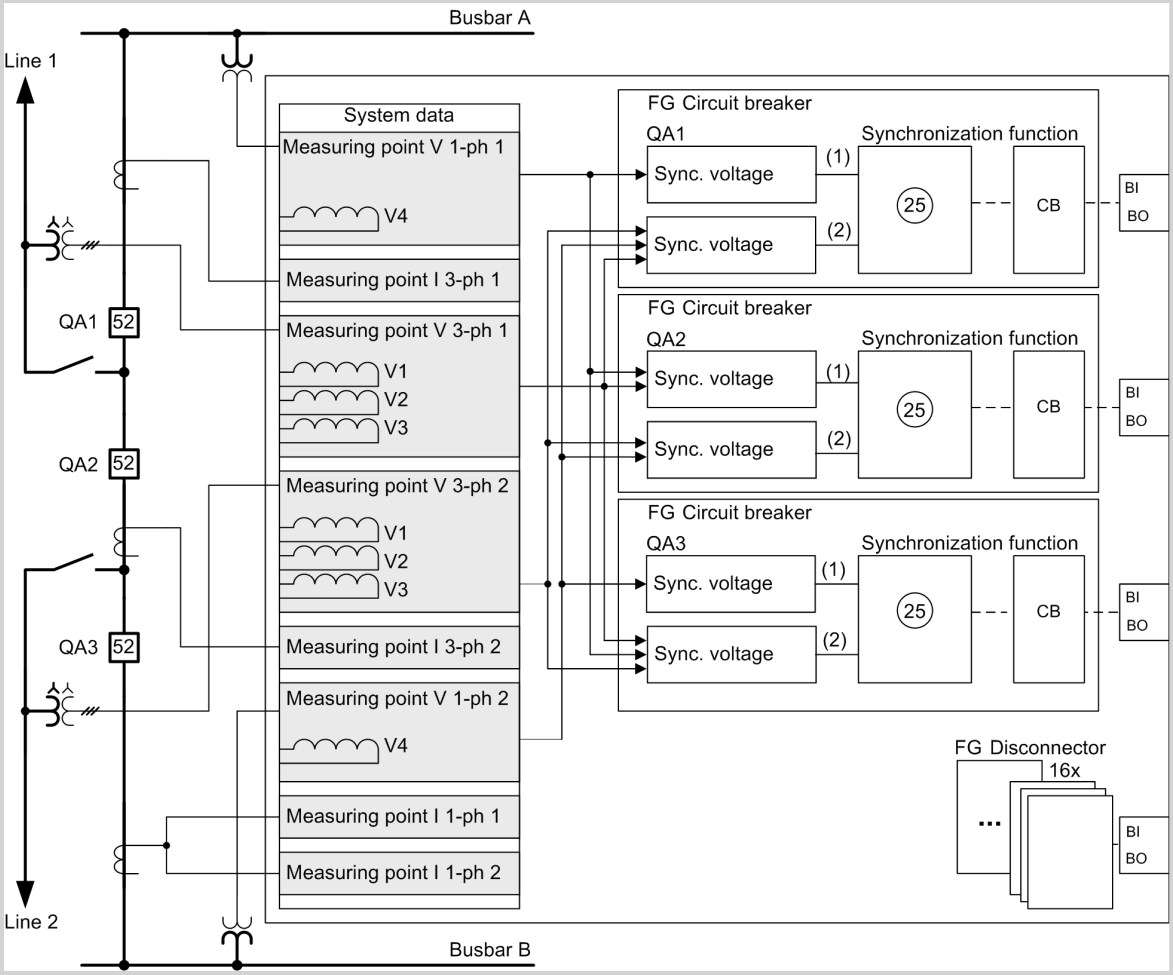
7.5.5 Dynamic Measuring-Point Switching

Dynamic measuring-point switching provides the capability to connect the voltages used in the Synchrocheck function to various measuring points. In this way, for example, it is possible to use the correct voltage on the basis of the switch position on the switching devices. If more than 1 measuring point is connected to *V sync1* or *V sync2*, you must create the **`V sync select.`** function block in the function group **Circuit breaker**.

Selection of the desired voltage measuring points (*V sync1* and *V sync2*) for the function group **Circuit breaker** is controlled via Continuous Function Chart.

Example

Figure 7-79 shows an example of a synchrocheck in a breaker-and-a-half arrangement. If circuit breaker QA2 is to be closed, the reference voltages must be selected from several possible measuring points. This selection of measuring points is dependent on the switch positions of all circuit breakers and disconnectors.



[dwdynmsu-140212-01.tif, 1, en_US]

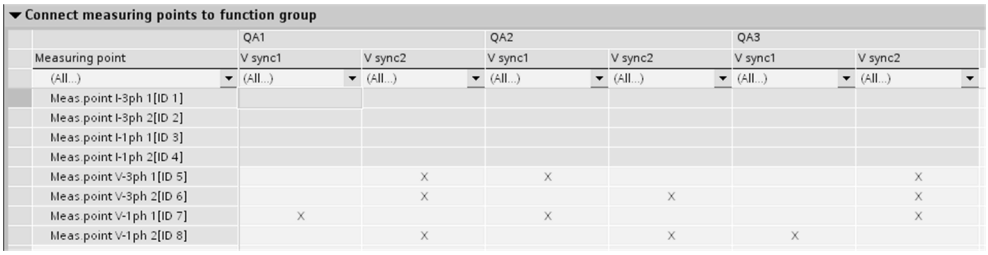
Figure 7-79 Synchronization in a Breaker-and-a-Half Arrangement

Each synchronization function requires 2 comparison voltages. For the circuit breaker QA2 located in the middle, there are 2 options for each side (V_{sync1} and V_{sync2}). The selection of synchronization voltages for each side depends on the position of the circuit breaker and the disconnectors.

For circuit breakers QA1 and QA3, the busbar voltage (V_{sync1}) is available for one side, and 3 voltages (V_{sync2}) are available for the other side.

Connecting Measuring Points to Circuit-Breaker Function Group

The following figure shows the connection of the function group **Circuit breaker** with several measuring points in DIGSI. The ID of each measuring point appears in parentheses after the name.



[scdynms2-211212-01.tif, 1, en_US]

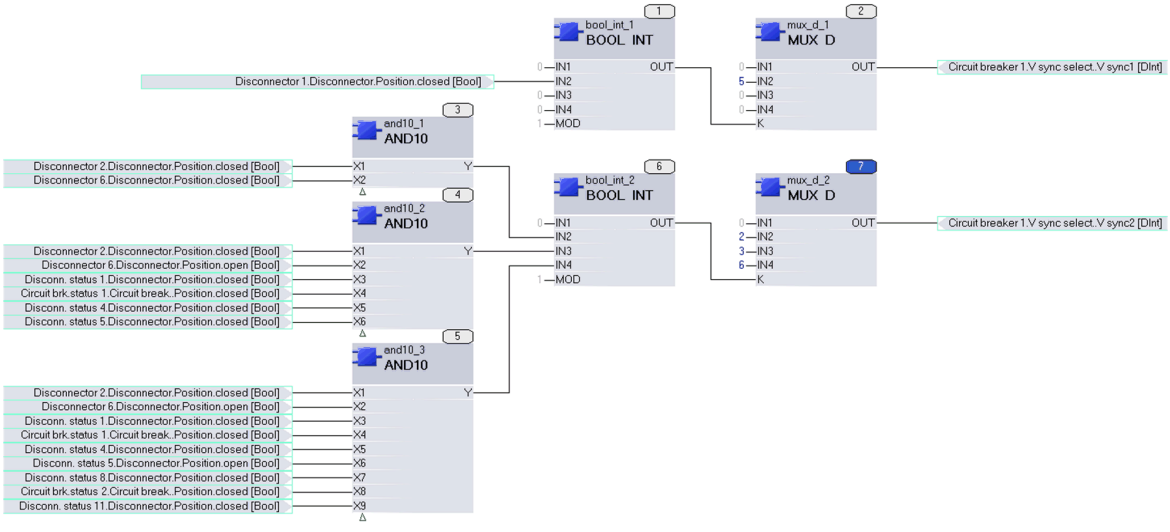
Figure 7-80 Connecting the Measuring Points with the Function Group Circuit-Breaker

There are consistency checks that validate the connections of voltage measuring points to the function group:

- The connection type must be identical for all measuring points connected to the same interface.
- It is not permitted to route a measuring point to the function group using the option VN.
- The rated voltage (primary and secondary) must be identical for all measuring points connected to the same interface.
- If more than 1 measuring point is connected to 1 voltage interface, a function block must be expanded to enable selection of the synchronization voltage.

CFC Control

The voltages are selected by CFC logic on the basis of the measuring point IDs. If more than one measuring point is connected to interfaces V_{sync1} or V_{sync2} of the function group **Circuit breaker**, the function block **V sync select.** has to be removed from the library in the function group **Circuit breaker**. A CFC logic (see following example) has to define IDs for the *V sync1* or *V sync2* inputs of this function block in order to ensure the correct measuring point connection for the Synchrocheck function.

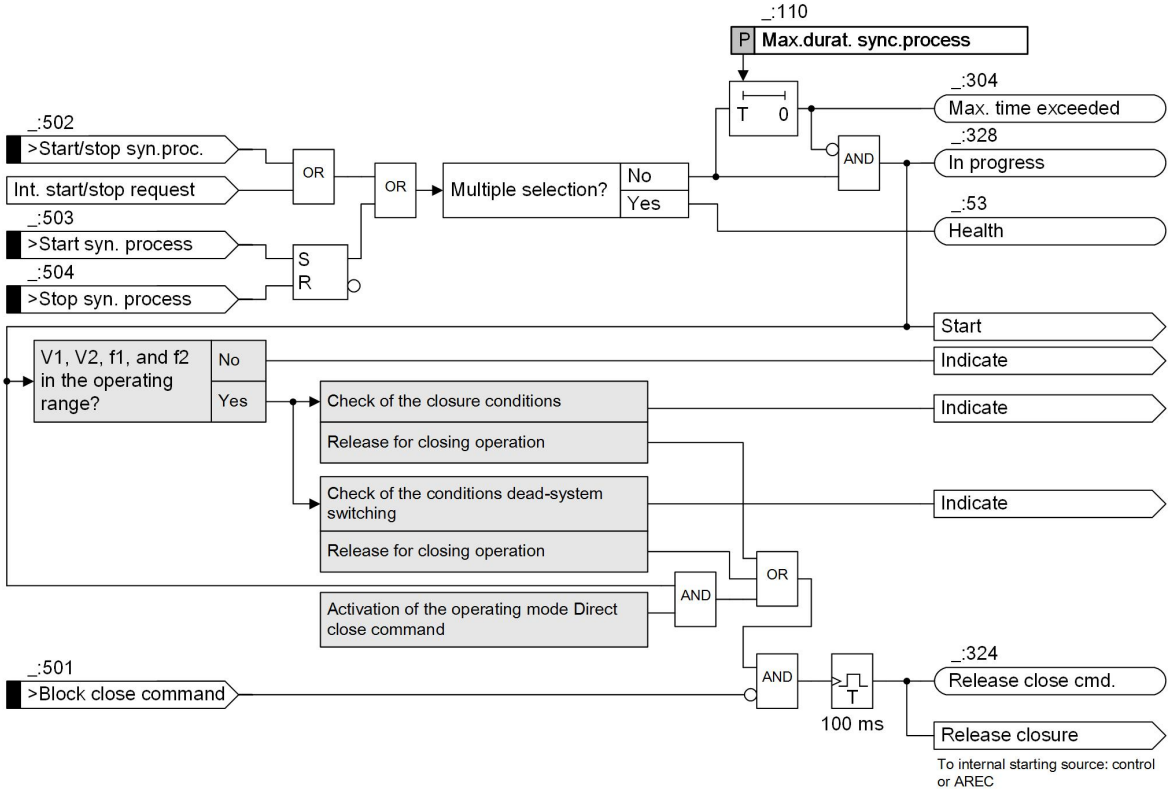


[scdynmsx-160212-01.tif, 1, en_US]

Figure 7-81 CFC Logic: Voltage Selection Using Measuring Point ID

If (defined by the switch or disconnector positions) no measuring point can be selected, the ID0 is used. If ID0 is selected, the indication *(_:2311:304) Blocked no V selected* is set. The synchrocheck is blocked. If you have activated the parameter **(_:5071:108) Direct close command**, unsynchronized switching is still possible.

7.5.6 Sequence of Functions



[lo_synf01_01, 6, en_US]

Figure 7-82 Sequence of Functions

Start

The synchronization stage must be started to check the closing conditions. The synchronization stage can be started device-internally by the control or externally via binary input signals (see *7.5.12 Interaction with Control and External Triggering*).

At the start, the system checks whether there is a multiple selection of the synchronization stage (see **Supervision** in *7.5.4.1 Description*). If this is the case, the process is terminated. After a successful start, the indication **`In progress`** is cleared and the supervision time for the maximum duration of the synchronization process (parameter **`Max.durat. sync.process`**) is started. The system also checks whether the voltages and frequencies are in the operating range (see *7.5.4.1 Description*). If this is not the case, the closing conditions are not checked.

Checking the Closing Conditions, Closure

After starting, the parameterized closing conditions are checked, depending on the selected operating mode (see *7.5.8.1 Description* to *7.5.11 Direct Close Command*). Every condition fulfilled is explicitly indicated here. Conditions not fulfilled are also indicated. If all conditions are fulfilled, the synchronization stage sets the indication **`All sync. conditio. OK`**. The indication is active until all conditions are fulfilled. The further behavior for issuing the release for closing depends on the type of the stage (see *7.5.7.1 Description* and *7.5.8.1 Description*). The release is signaled via the **`Release close cmd.`** indication. This indication is active for 100 ms. With an internal start, the control performs the actual closure, depending on the internal starting source.

Switching to Dead Line/Busbar

If operating modes for switching to dead parts of an electrical power system are configured, the associated conditions are also checked after the start (see *7.5.10.1 Description*). The fulfilled conditions are signaled. An

adjustable supervision time starts after the closure conditions are fulfilled (parameter **Supervision time**). If the conditions remain valid until expiry of the time, the function gives the release for closure after expiry of the time.

Direct Close Command

If the **Direct close command** operation is active, the function instantaneously initiates the release for closure after the successful start (see chapter *7.5.11 Direct Close Command*). A combination of direct close command with other release conditions is not advisable, as these conditions are bypassed by the direct close command.

End of the Process

If the function is started via the device-internal control, these functions also terminate the synchronization process upon closure. The process is terminated via the corresponding binary signals in case of external starting.

If the supervision time (**Max.durat. sync.process** parameter) has expired, the process is also completed and the indication **Max. time exceeded** is issued. A renewed synchronization is only possible if the stage is restarted.

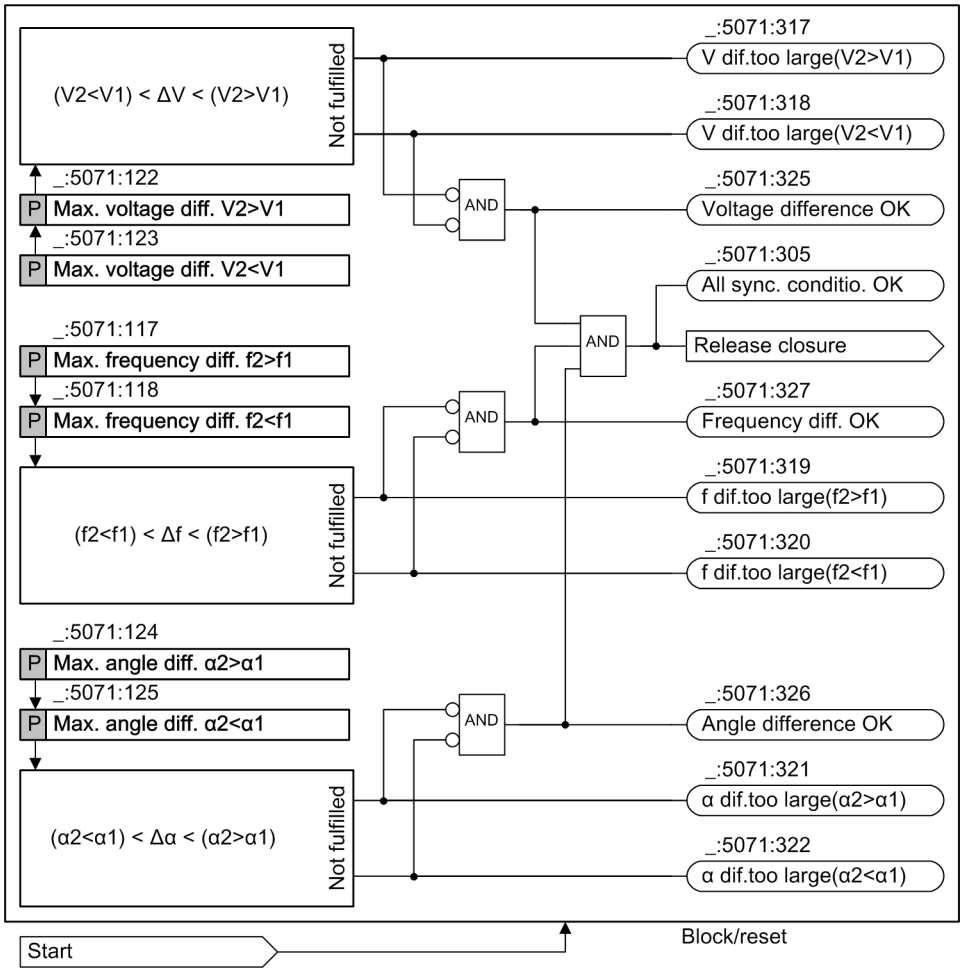
Blocking Closure

You can use the input signal *>Block close command* to block the release signal for the closure (signal **Release close cmd.**) as well as the closure itself. The measurement continues to operate during the blocking. If the blocking is revoked and the release conditions are still fulfilled, the release is given for closure.

7.5.7 Stage Synchrocheck

7.5.7.1 Description

Checking Closing Conditions



[lo_synche-01, 2, en_US]

Figure 7-83 Closing Conditions for the Synchrocheck Function

With this operating mode, the values ΔV, Δf, and Δα are checked before connecting the 2 parts of the electrical power system. The indication **`All sync. conditio. OK`** signals that the setting values (conditions) have been reached and that the release for closure has been given (see **Checking the Closing Conditions, Closure** in *7.5.6 Sequence of Functions*).

Every fulfilled condition is signaled individually via the indications **`Voltage difference OK`**, **`Frequency diff. OK`**, and **`Angle difference OK`**.

If a condition is not fulfilled, detailed information on why the condition is not fulfilled is provided via indications. If the differential voltage is outside the setting limits, for example, the indication **`V dif.too large(V2<V1)`** is issued. The indication indirectly contains information that the voltage V2 has to be increased for a successful synchronization.

With the **Expanded delta-f options** stage type configured and an activated **`(_:140) Limit dfdiff/dt for sync. op`** parameter, the frequency difference rate of change is also checked. If the permissible frequency change rate (parameter **`(_:141) Max. value dfdiff/dt syn`**) is exceeded, the indication **`(_:329) dfdiff/dt too large`** is issued.

Continuous Supervision

With the parameter **Continuous supervision** selected, even if there is no start command for the signal *start*, the device can continuously monitor the voltage difference, frequency difference, and angle difference of the circuit breaker. Meanwhile, the indications *in progress*, *release close command*, and *max. duration time expired* are not issued.

If you want to release the close command, a start command for the signal *start* is necessary.

If you keep the default setting, then the stage **Synchrocheck** runs as normal.

7.5.7.2 Application and Setting Notes

Parameter: Sync. operating mode

- Default setting **Sync. operating mode** = *on*

With the parameter **Sync. operating mode**, you can switch the operating mode of the synchronization condition *on* or *off*. The operating mode is activated in the default setting.

Parameter: Maximum Differential Values of Voltage, Frequency and Angle

- Default setting **(_:5071:122) Max. voltage diff. V2>V1** = *5.0 V*
- Default setting **(_:5071:123) Max. voltage diff. V2<V1** = *5.0 V*
- Default setting **(_:5071:117) Max. frequency diff. f2>f1** = *0.10 Hz*
- Default setting **(_:5071:118) Max. frequency diff. f2<f1** = *0.10 Hz*
- Default setting **(_:5071:124) Max. angle diff. α2>α1** = *10°*
- Default setting **(_:5071:125) Max. angle diff. α2<α1** = *10°*

2 parameters are available for the differential values voltage, frequency, and angle. Unbalanced closing ranges can be set with this, if required.

The permissible differential values must ensure that no protection tripping or damage occurs in the system owing to compensation processes (circulating current) and power swings after interconnection of the parts of the power system. The settings must not be configured too closely on the other side so that necessary closures are not blocked.

Typical differential values are selected in the default setting. Depending on the system, the settings must be checked and adjusted, if necessary.

7.5.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Synchrocheck #:Mode		• off • on • test	off
_:113	Synchrocheck #:Continuous supervision		• false • true	false
_:101	Synchrocheck #:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:102	Synchrocheck #:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:110	Synchrocheck #:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:108	Synchrocheck #:Direct close command		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:126	Synchrocheck #:Voltage adjustment		0.500 to 2.000	1.000
De-en.gized switch.				
_:105	Synchrocheck #:Close cmd. at V1< & V2>		• no • yes	no
_:106	Synchrocheck #:Close cmd. at V1> & V2<		• no • yes	no
_:107	Synchrocheck #:Close cmd. at V1< & V2<		• no • yes	no
_:103	Synchrocheck #:V1, V2 without voltage		0.300 V to 170.000 V	5.000 V
_:104	Synchrocheck #:V1, V2 with voltage		0.300 V to 340.000 V	80.000 V
_:109	Synchrocheck #:Supervision time		0.00 s to 60.00 s	0.10 s
Synchr. conditions				
_:115	Synchrocheck #:Sync. operating mode		• off • on	on
_:122	Synchrocheck #:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:123	Synchrocheck #:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:117	Synchrocheck #:Max. frequency diff. f2>f1		0.000 Hz to 2.000 Hz	0.100 Hz
_:118	Synchrocheck #:Max. frequency diff. f2<f1		0.000 Hz to 2.000 Hz	0.100 Hz
_:124	Synchrocheck #:Max. angle diff. α2>α1		0 ° to 90 °	10 °
_:125	Synchrocheck #:Max. angle diff. α2<α1		0 ° to 90 °	10 °

7.5.7.4 Information List

No.	Information	Data Class (Type)	Type
Synchrocheck #			
_:81	Synchrocheck #:>Block stage	SPS	I
_:500	Synchrocheck #:>Selection	SPS	I
_:502	Synchrocheck #:>Start/stop syn.proc.	SPS	I
_:503	Synchrocheck #:>Start syn. process	SPS	I
_:504	Synchrocheck #:>Stop syn. process	SPS	I
_:506	Synchrocheck #:>Op. mode 'V1<V2>'	SPS	I
_:505	Synchrocheck #:>Op. mode 'V1>V2<'	SPS	I
_:507	Synchrocheck #:>Op. mode 'V1<V2<'	SPS	I
_:508	Synchrocheck #:>Op. mode 'dir.cls.cmd'	SPS	I
_:501	Synchrocheck #:>Block close command	SPS	I
_:51	Synchrocheck #:Mode (controllable)	ENC	C
_:54	Synchrocheck #:Inactive	SPS	O
_:52	Synchrocheck #:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:53	Synchrocheck #:Health	ENS	O
_:328	Synchrocheck #:In progress	SPS	O
_:324	Synchrocheck #:Release close cmd.	SPS	O
_:305	Synchrocheck #:All sync. conditio. OK	SPS	O
_:325	Synchrocheck #:Voltage difference OK	SPS	O
_:326	Synchrocheck #:Angle difference OK	SPS	O
_:327	Synchrocheck #:Frequency diff. OK	SPS	O
_:307	Synchrocheck #:Cond. V1<V2> fulfilled	SPS	O
_:306	Synchrocheck #:Cond. V1>V2< fulfilled	SPS	O
_:308	Synchrocheck #:Cond. V1<V2< fulfilled	SPS	O
_:309	Synchrocheck #:Frequency f1 > fmax	SPS	O
_:310	Synchrocheck #:Frequency f1 < fmin	SPS	O
_:311	Synchrocheck #:Frequency f2 > fmax	SPS	O
_:312	Synchrocheck #:Frequency f2 < fmin	SPS	O
_:313	Synchrocheck #:Voltage V1 > Vmax	SPS	O
_:314	Synchrocheck #:Voltage V1 < Vmin	SPS	O
_:315	Synchrocheck #:Voltage V2 > Vmax	SPS	O
_:316	Synchrocheck #:Voltage V2 < Vmin	SPS	O
_:317	Synchrocheck #:V dif.too large(V2>V1)	SPS	O
_:318	Synchrocheck #:V dif.too large(V2<V1)	SPS	O
_:319	Synchrocheck #:f dif.too large(f2>f1)	SPS	O
_:320	Synchrocheck #:f dif.too large(f2<f1)	SPS	O
_:329	Synchrocheck #:dfdiff/dt too large	SPS	O
_:321	Synchrocheck #:α dif.too large(α2>α1)	SPS	O
_:322	Synchrocheck #:α dif.too large(α2<α1)	SPS	O
_:304	Synchrocheck #:Max. time exceeded	SPS	O
_:323	Synchrocheck #:Setting error	SPS	O

7.5.8 Stage Synchronous/Asynchronous

7.5.8.1 Description

A distinction according to synchronous and asynchronous systems can be made with this type of stage.

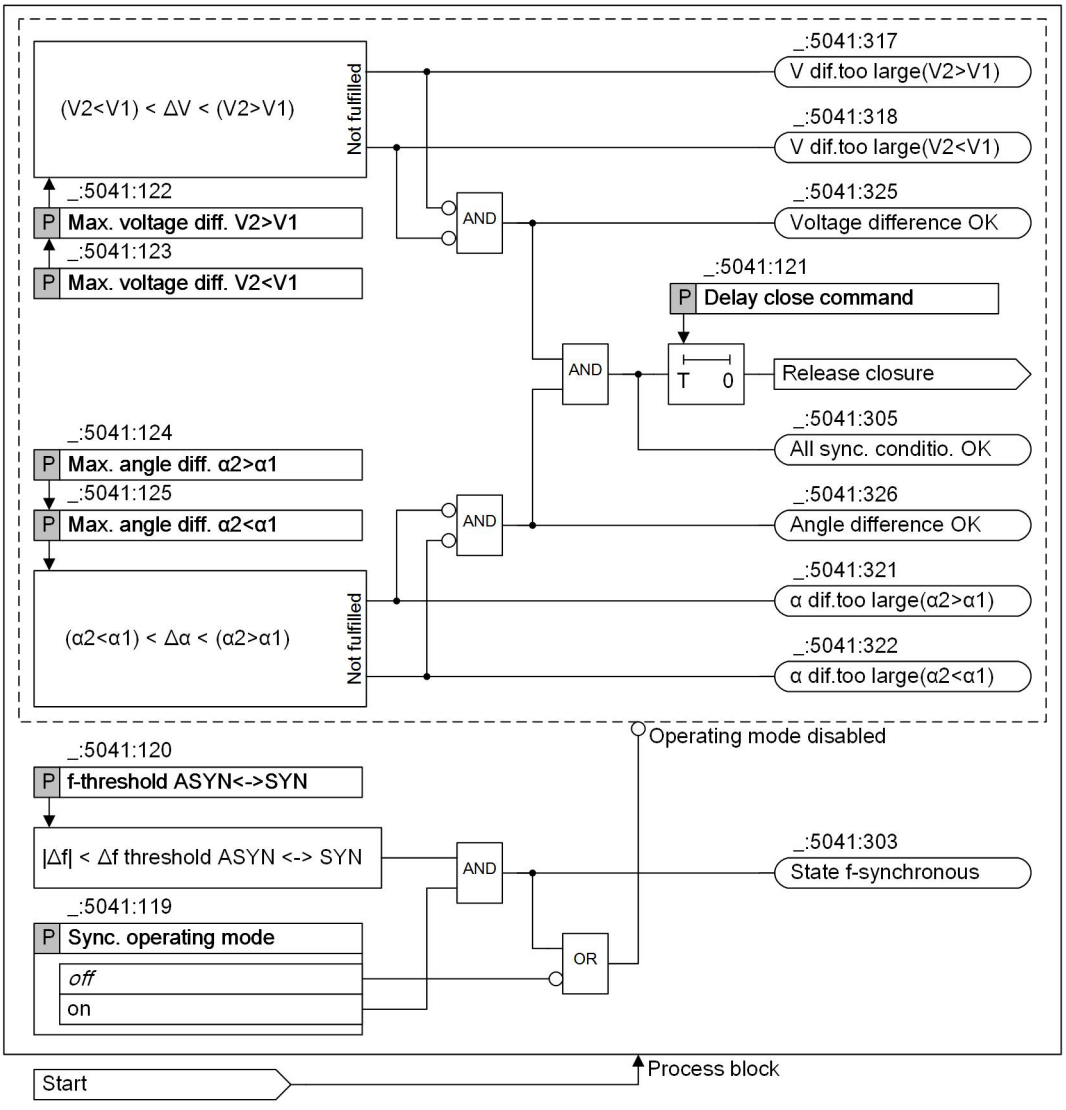
If galvanically coupled systems are switched in parallel, synchronous systems are present. A typical characteristic for synchronous systems is equality of frequency ($\Delta f \approx 0$). If the frequency difference falls below the setting value of the **f-threshold ASYN<->SYN** parameter, synchronous systems are to be assumed. If the frequency difference exceeds the setting value of the **f-threshold ASYN<->SYN** parameter, asynchronous systems are to be assumed. This status occurs in galvanically isolated systems, for example.

Both states have their own operating mode with its own closing conditions. Both operating modes can be switched on and off separately (parameter **Sync. operating mode** and **Async. operating mode**). The following combinations result from this:

Sync. operating mode	**Async. operating mode**	Functionality
on	***on***	If the frequency difference is below the set threshold value **f-threshold ASYN<->SYN**, the operating mode synchronous is active. In other cases, the operating mode asynchronous is active.

off	***on***	Regardless of the frequency difference and the threshold value **f-threshold ASYN<->SYN**, the operating mode is exclusively active asynchronously.
on	***off***	If the frequency difference is below the set threshold value **f-threshold ASYN<->SYN**, the operating mode synchronous is active. In other cases, the stage is inactive, that is, a switching release cannot be issued.
off	***off***	Both operating modes are deactivated. No activation release can be given via these operating modes either.

Checking the Closing Conditions in Synchronous Systems



[lo_synsyn-01, 3, en_US]

Figure 7-84 Closing Conditions when Switching Synchronous Systems

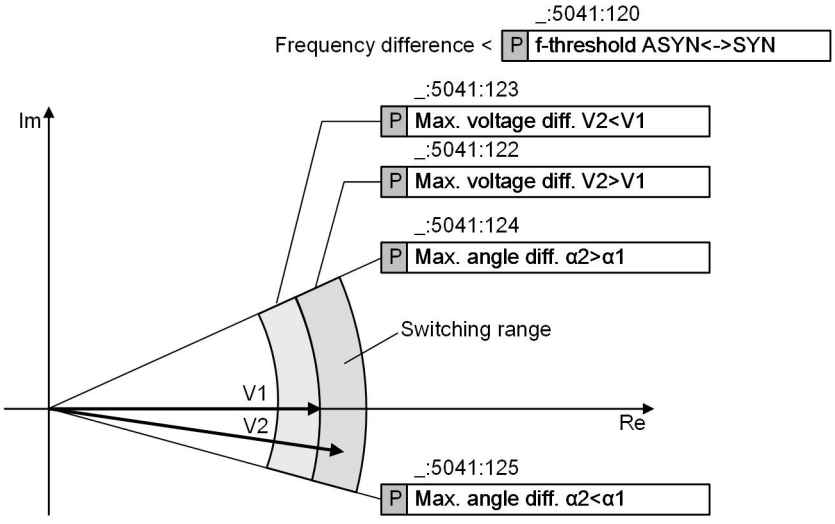
The frequency difference is very low in the synchronous systems operating mode. It is below the threshold value **f-threshold ASYN<->SYN**. The status is signaled via the **State f-synchronous** indication.

The parameters ΔV and Δα are checked for issuing an activation release (see *Figure 7-85*). The indication **All sync. conditio. OK** signals that both setting values (conditions) are reached. If the conditions remain fulfilled over the set time delay (parameter **Delay close command**), the release for closing is given (see also *7.5.7.1 Description*).

Every condition fulfilled is signaled individually via the indications **Voltage difference OK** and **Angle difference OK**.

If a condition is not fulfilled, detailed information on why the condition is not fulfilled is provided via indications. If the differential voltage is outside the setting limits, for example, the indication **V dif.too large(V2<V1)** is issued. The indication indirectly contains information that the voltage V2 has to be increased for a successful synchronization.

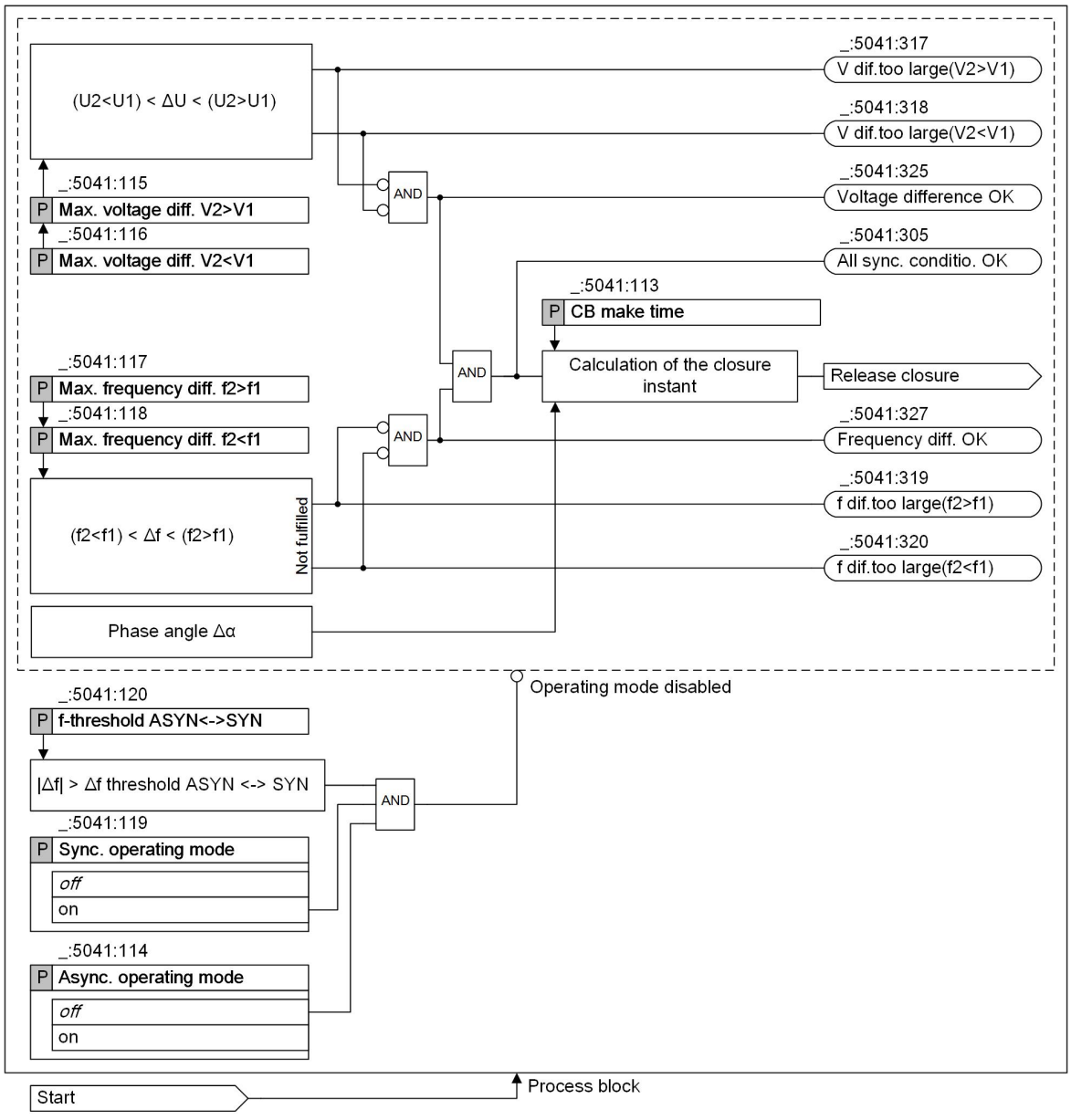
With the **Expanded delta-f options** stage type configured and an activated **(_:142) Limit dfdiff/dt for asyn. op** parameter, the frequency difference rate of change is also checked. If the permissible frequency change rate (parameter **(_:143) Max. value dfdiff/dt asyn**) is exceeded, the indication **(_:329) dfdiff/dt too large** is generated.



[lo_synzus-01, 2, en_US]

Figure 7-85 Connecting Under Synchronous System Conditions

Checking Closing Conditions in Asynchronous Systems



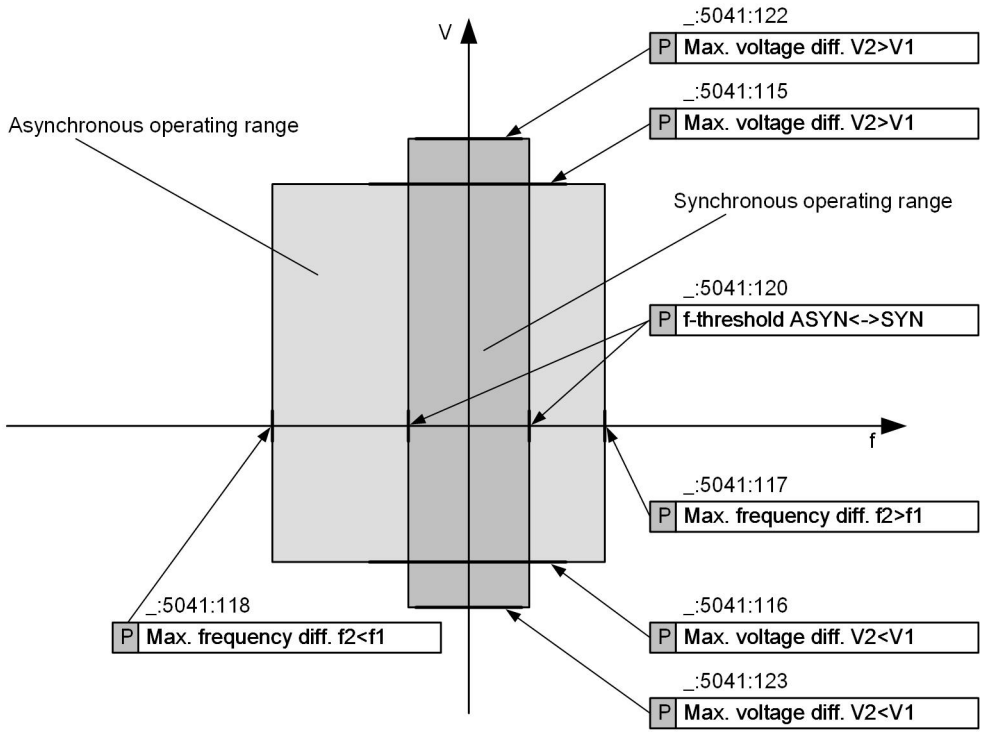
[lo_synasy-01, 4, en_US]

Figure 7-86 Closing Conditions when Switching Asynchronous Systems

In this operating mode, compliance with the voltage difference ΔV and frequency difference Δf conditions is checked. The function calculates the time point of the close command taking into account the angular difference Δα and the make time of the circuit breaker. This is calculated so that the voltage phasors are equal at the moment of pole contact by the circuit breaker (ΔV ≈ 0, Δα ≈ 0).

Ranges in the Voltage-Frequency Diagram (V-f Diagram)

Figure 7-87 shows the setting parameters for synchronous and asynchronous conditions in the V-f diagram. The frequency band is very narrow owing to the functional principle in the case of synchronous systems.



[lo_synarb-01, 2, en_US]

Figure 7-87 Operating Range under Synchronous and Asynchronous Conditions for Voltage (V) and Frequency (f)

Continuous Supervision

With the parameter **Continuous supervision** activated, even if there is no start command for the signal *start*, the device can continuously monitor the synchronous condition of the circuit breaker. Meanwhile, the indications *in progress*, *release close command*, and *max. duration time expired* are not issued.

If you want to release the close command, a start command for the signal *start* is necessary.

If you keep the default setting, then the stage **Synchronous/Asynchronous** runs as normal.

7.5.8.2 Application and Setting Notes

Parameter: Synchronous operating mode, Asynchronous operating mode

- Default setting **(_:5041:119) Sync. operating mode** = *on*
- Default setting **(_:5041:114) Async. operating mode**= *on*

The operating modes of the stages can be activated or deactivated via the parameters. The operating modes are deactivated in the default setting for safety reasons.

The following combination options are possible:

Sync. operating mode	Async. operating mode	Description
on	***on***	If the frequency difference is below the set threshold value **f-threshold ASYN<->SYN**, the operating mode **synchronous** is active. In other cases, the operating mode **asynchronous** is active. If you wish to interconnect galvanically isolated systems, then select this operating mode.
off	***on***	Regardless of the frequency difference and the threshold value **f-threshold ASYN<->SYN**, the **asynchronous** operating mode is exclusively active. The make time of the circuit breaker is always taken into account for determining the connecting point. Select this operating mode if you wish to activate machines, for example generators or asynchronous motors. However, if synchronous conditions with a low Δf are present, a close command is generated in this operating mode without a kick pulse.
on	***off***	Use this operating mode for galvanically connected systems. Closure is only possible with synchronous systems (with low Δf).
off	***off***	Both operating modes are deactivated. No closing release can therefore be given via this operating mode. This configuration is only advisable for special applications. Select this operating mode if you only wish to switch, for example de-energized parts of the power system.

Parameter for asynchronous operation: Max. voltage diff. of voltage and frequency

- Default setting **(_:5041:115) Max. voltage diff. V2>V1** = ***2.0 V***
- Default setting **(_:5041:116) Max. voltage diff. V2<V1** = ***2.0 V***
- Default setting **(_:5041:117) Max. frequency diff. f2>f1** = ***0.10 Hz***
- Default setting **(_:5041:118) Max. frequency diff. f2<f1** = ***0.10 Hz***

For more information, see **Parameter for synchronous operation**.

Parameter for synchronous operation: Maximum voltage diff. of voltage and angle

- Default setting **(_:5041:122) Max. voltage diff. V2>V1** = ***5.0 V***
- Default setting **(_:5041:123) Max. voltage diff. V2<V1** = ***5.0 V***
- Default setting **(_:5041:124) Max. angle diff. α2>α1** = ***10***°
- Default setting **(_:5041:125) Max. angle diff. α2<α1** = ***10***°

2 parameters are available for the differential values voltage, frequency, and angle. Unbalanced closing ranges can be set with this, if required.

The permissible differential values must ensure that no protection tripping or damage occurs in the system owing to compensation processes (circulating current) and power swings after interconnection of the parts of the power system. The settings must not be configured too closely on the other side so that necessary closures are not blocked.

Typical differential values are selected in the default setting. Depending on the system, the settings must be checked and adjusted, if necessary.

Parameter: Switchover between synchronous and asynchronous operation

- Recommended setting value **(_:5041:120) f-threshold ASYN<->SYN** = ***0.01 Hz***

This parameter is used to set the frequency difference for switching over between synchronous and asynchronous operation.

Siemens recommends using the default setting of ***0.01 Hz***.

7.5.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Sychr./Asycr.#:Mode		• off • on • test	off
_:127	Sychr./Asycr.#:Continuous supervision		• false • true	false
_:101	Sychr./Asycr.#:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:102	Sychr./Asycr.#:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:110	Sychr./ Asycr.#:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:108	Sychr./Asycr.#:Direct close command		• no • yes	no
_:126	Sychr./Asycr.#:Voltage adjustment		0.500 to 2.000	1.000
De-en.gized switch.				
_:105	Sychr./Asycr.#:Close cmd. at V1< & V2>		• no • yes	no
_:106	Sychr./Asycr.#:Close cmd. at V1> & V2<		• no • yes	no
_:107	Sychr./Asycr.#:Close cmd. at V1< & V2<		• no • yes	no
_:103	Sychr./Asycr.#:V1, V2 without voltage		0.300 V to 170.000 V	5.000 V
_:104	Sychr./Asycr.#:V1, V2 with voltage		0.300 V to 340.000 V	80.000 V
_:109	Sychr./Asycr.#:Supervision time		0.00 s to 60.00 s	0.10 s
Asynchr. op.mode				
_:114	Sychr./Asycr.#:Async. operating mode		• off • on	on
_:113	Sychr./Asycr.#:CB make time		0.010 s to 0.600 s	0.060 s
_:115	Sychr./Asycr.#:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:116	Sychr./Asycr.#:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:117	Sychr./Asycr.#:Max. frequency diff. f2>f1		0.000 Hz to 4.000 Hz	0.100 Hz

Addr.	Parameter	C	Setting Options	Default Setting
_:118	Sychr./Asycr.#:Max. frequency diff. f2<f1		0.000 Hz to 4.000 Hz	0.100 Hz
Synchr. op.mode				
_:119	Sychr./Asycr.#:Sync. operating mode		• off • on	on
_:120	Sychr./Asycr.#:f-threshold ASYN<->SYN		0.010 Hz to 0.200 Hz	0.010 Hz
_:122	Sychr./Asycr.#:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:123	Sychr./Asycr.#:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:124	Sychr./Asycr.#:Max. angle diff. α2>α1		0 ° to 90 °	10 °
_:125	Sychr./Asycr.#:Max. angle diff. α2<α1		0 ° to 90 °	10 °
_:121	Sychr./Asycr.#:Delay close command		0.00 s to 60.00 s	0.00 s

7.5.8.4 Information List

No.	Information	Data Class (Type)	Type
Sychr./Asycr.#			
_:81	Sychr./Asycr.#:>Block stage	SPS	I
_:500	Sychr./Asycr.#:>Selection	SPS	I
_:502	Sychr./Asycr.#:>Start/stop syn.proc.	SPS	I
_:503	Sychr./Asycr.#:>Start syn. process	SPS	I
_:504	Sychr./Asycr.#:>Stop syn. process	SPS	I
_:506	Sychr./Asycr.#:>Op. mode 'V1<V2>'	SPS	I
_:505	Sychr./Asycr.#:>Op. mode 'V1>V2<'	SPS	I
_:507	Sychr./Asycr.#:>Op. mode 'V1<V2<'	SPS	I
_:508	Sychr./Asycr.#:>Op. mode 'dir.cls.cmd'	SPS	I
_:501	Sychr./Asycr.#:>Block close command	SPS	I
_:51	Sychr./Asycr.#:Mode (controllable)	ENC	C
_:54	Sychr./Asycr.#:Inactive	SPS	O
_:52	Sychr./Asycr.#:Behavior	ENS	O
_:53	Sychr./Asycr.#:Health	ENS	O
_:328	Sychr./Asycr.#:In progress	SPS	O
_:324	Sychr./Asycr.#:Release close cmd.	SPS	O
_:305	Sychr./Asycr.#:All sync. conditio. OK	SPS	O
_:303	Sychr./Asycr.#:State f-synchronous	SPS	O
_:325	Sychr./Asycr.#:Voltage difference OK	SPS	O
_:326	Sychr./Asycr.#:Angle difference OK	SPS	O
_:327	Sychr./Asycr.#:Frequency diff. OK	SPS	O
_:307	Sychr./Asycr.#:Cond. V1<V2> fulfilled	SPS	O
_:306	Sychr./Asycr.#:Cond. V1>V2< fulfilled	SPS	O
_:308	Sychr./Asycr.#:Cond. V1<V2< fulfilled	SPS	O
_:309	Sychr./Asycr.#:Frequency f1 > fmax	SPS	O
_:310	Sychr./Asycr.#:Frequency f1 < fmin	SPS	O

No.	Information	Data Class (Type)	Type
_:311	Sychr./Asycr.#:Frequency f2 > fmax	SPS	O
_:312	Sychr./Asycr.#:Frequency f2 < fmin	SPS	O
_:313	Sychr./Asycr.#:Voltage V1 > Vmax	SPS	O
_:314	Sychr./Asycr.#:Voltage V1 < Vmin	SPS	O
_:315	Sychr./Asycr.#:Voltage V2 > Vmax	SPS	O
_:316	Sychr./Asycr.#:Voltage V2 < Vmin	SPS	O
_:317	Sychr./Asycr.#:V dif.too large(V2>V1)	SPS	O
_:318	Sychr./Asycr.#:V dif.too large(V2<V1)	SPS	O
_:319	Sychr./Asycr.#:f dif.too large(f2>f1)	SPS	O
_:320	Sychr./Asycr.#:f dif.too large(f2<f1)	SPS	O
_:329	Sychr./Asycr.#:dfdiff/dt too large	SPS	O
_:321	Sychr./Asycr.#:α dif.too large(α2>α1)	SPS	O
_:322	Sychr./Asycr.#:α dif.too large(α2<α1)	SPS	O
_:304	Sychr./Asycr.#:Max. time exceeded	SPS	O
_:323	Sychr./Asycr.#:Setting error	SPS	O

7.5.9 Expanded Checks (df/dt and Smoothing of Oscillations)

When configuring the function block **Expanded delta-f options**, you can expand the synchronization checks to include the following aspects:

- Limitation of the frequency change rate

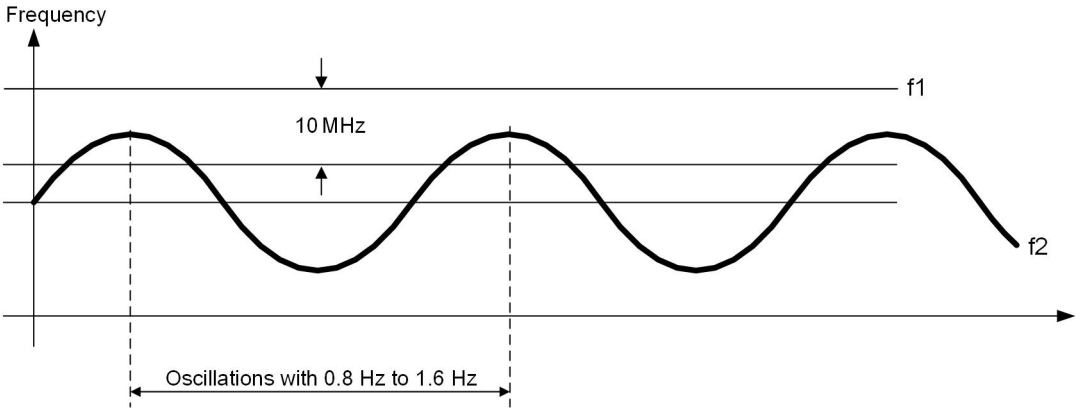
  With this option, you can define additional upper limits for the rate of permissible frequency difference change. The release checks for both stage types take these additional upper limits into consideration. Both activation (parameters **(_:140) Limit dfdiff/dt for sync. op** and **(_:142) Limit dfdiff/dt for asyn. op**) and the upper limits (parameters **(_:141) Max. value dfdiff/dt syn** and **(_:143) Max. value dfdiff/dt asyn**) for the frequency change rate are adjustable selectively for synchronous and asynchronous conditions. Both stage types consider the frequency change rate when issuing the release for switching and indicate when the rate is exceeded.

  If you also activate the option to compensate for low-frequency oscillations (parameter **(_:150) Suppr. frequ. oscillations**), the frequency change rate is stabilized in the presence of such oscillations. Stabilization is in effect for asynchronous as well as synchronous operating modes.

- Compensation for low-frequency oscillations

  If you activate this option (parameter **(_:150) Suppr. frequ. oscillations**), low-frequency oscillations, for example, as a consequence of power swings in the range of 0.8 Hz to 1.6 Hz, are detected and smoothed. This stabilizes the release checks in the presence of frequently changing violations of upper and lower limits for the specified frequency threshold values. The option affects the frequency check of the stage type **Synchrocheck** and the synchronous operating mode of the stage type **Synchronous/Asynchronous**. It does not affect the asynchronous operating mode.

  In the example of the following figure, the synchrocheck function would initiate energization, if the allowed frequency difference was set to 10 mHz without the parameter **Suppr. frequ. oscillations** as soon as the frequency f2 enters the 10-mHz band. If the parameter **Suppr. frequ. oscillations** is activated, energization is not initiated, since the average value of f2 is outside the band.



[dw_synfre-01, 2, en_US]

Figure 7-88 Example: Frequency Difference between the Constant Frequency f1 and the Sinusoidal Oscillating Frequency f2

With this option active, the range of function measured values is expanded by the smoothed frequency. Release of switching in synchronous networks occurs after one second at the earliest. This time is needed to smooth the frequency measured values.

The actual frequency can be larger or smaller than the smoothed value at any instant. The parameter **Max. diff. "f threshold"** makes it possible to limit the increase in instantaneous frequency value in relation to the respective frequency threshold value.

7.5.10 Closing at De-Energized Line/Busbar

7.5.10.1 Description

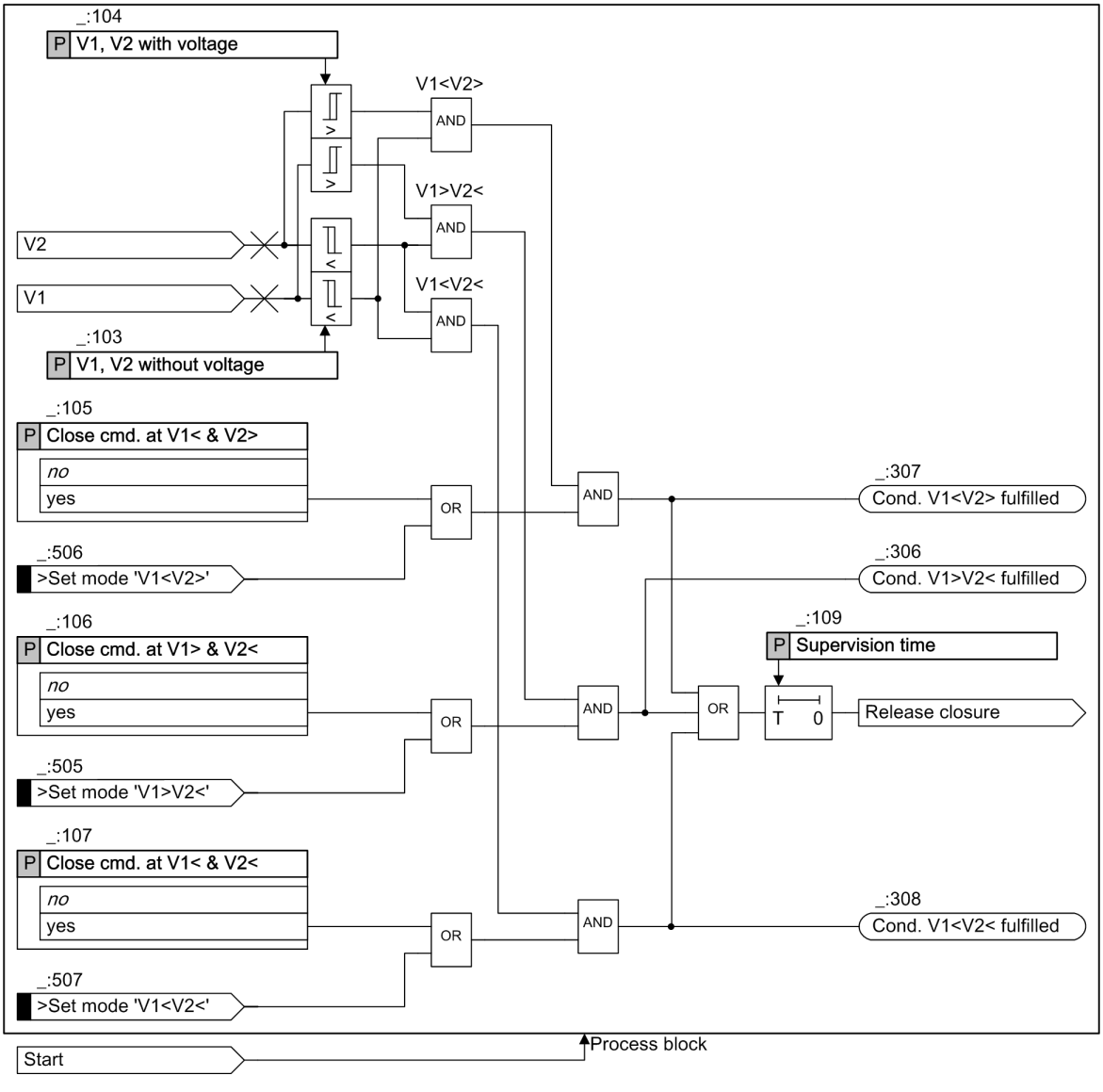
If at least one of 2 parts of an electrical power system is de-energized, the parts of the electrical power system can be connected together via the following operating modes.

If the measured voltage is less than the threshold **V1, V2 without voltage**, the zero potential of the part of the electrical power system is detected. In this case, all phases are compared to the parameter **V1, V2 without voltage**. The energized side must be in the defined operating range with respect to voltage and frequency (see chapter *7.5.4.1 Description*) and all phases must exceed the threshold **V1, V2 with voltage**.

The following additional closing conditions can be selected, which are then applied next to the closing conditions for the synchronism:

Settings	Description
Close cmd. at V1> & V2<	Closing release under the condition that the part V_1 of the power system is energized and the part of the electrical power system U_2 is de-energized.
Close cmd. at V1< & V2>	Closing release under the condition that the part V_1 of the power system is de-energized and the part of the electrical power system U_2 is energized.
Close cmd. at V1< & V2<	Closing release provided mains adapters V_1 and V_2 are de-energized.

Each of these conditions can be made effective individually via parameters or binary input. You can also set parameters for combinations, for example a release for closure, if **Close cmd. at V1> & V2<** or **Close cmd. at V1< & V2>** has been fulfilled.



[lo_syn003-01, 2, en_US]

Figure 7-89 Release Conditions for Switching to De-Energized Line/Busbar

The indications **Cond. V1>V2< fulfilled**, **Cond. V1<V2> fulfilled** and **Cond. V1<V2< fulfilled** indicate that the relevant conditions are fulfilled.

If the following 2 conditions are met, these indications refresh automatically:

- You set the parameter **Sync. operating mode** to ***on***.
- You select the parameter **Continuous supervision**.

You can use the **Supervision time** parameter to set a supervision time for which the closing conditions must at least be fulfilled with de-energized connection, before closing is allowed.

7.5.10.2 Application and Setting Notes

If at least one of 2 parts of an electrical power system is de-energized, the parts of the electrical power system can be connected together via the following operating modes. The above potential release conditions are independent of one another and can also be combined.



NOTE

For reasons of safety, the releases have been deactivated in the default setting and are therefore at ***no***. Even if you wish to apply one of these operating modes, Siemens recommends leaving the setting at ***no*** for reasons of safety. Set the operating mode only dynamically via the assigned binary input signal (for example **>Operating mode 'U1>U2<'**) (see also *Figure 7-89*). This prevents one of these operating modes from being incorrectly activated statically thereby resulting in an incorrect switching.

Parameter: **Close cmd. at V1< & V2>**

- Recommended setting value **(_:5071:105) Close cmd. at V1< & V2>** = ***no***

Settings	Description
no	No release for closing is possible via this operating mode.
yes	If part V1of the power system is de-energized and part V2 of the power system is energized, the release for closure is given upon starting the synchronization stage after the supervision time has passed. The setting depends on the operational requirements. Note the above information.

Parameter: **Close cmd. at V1> & V2<**

- Recommended setting value **(_:5071:106) Close cmd. at V1> & V2<** = ***no***

Settings	Description
no	No release for closing is possible via this operating mode.
yes	If part V1of the power system is energized and part V2 of the power system is de-energized, the release for closure is given upon starting the synchronization stage after the supervision time has passed. The setting depends on the operational requirements. Note the above information.

Parameter: **Close cmd. at V1< & V2<**

- Recommended setting value **(_:5071:107) Close cmd. at V1< & V2<** = ***no***

Settings	Description
no	No release for closing is possible via this operating mode.
yes	If the parts V1 and V2 of the power system are de-energized, the release for closure is given upon starting the synchronization stage after the supervision time has passed. The setting depends on the operational requirements. Note the above information.

Parameter: V1, V2 with voltage

- Recommended setting value **(_:5071:104) V1, V2 with voltage** = ***80 V***

The setting value indicates the voltage above which a part of the power system (feeder or busbar) can be regarded as activated with certainty.

You must set the value below the minimum expected operational undervoltage. Siemens therefore recommends a setting value of approx. 80 % of the rated voltage. All voltages connected according to the parameterized measuring-point connection type are subjected to the appropriate Vmin/Vmax test.

Parameter: V1, V2 without voltage

- Recommended setting value **(_:5071:103) V1, V2 without voltage** = ***5 V***

The setting value indicates the voltage below which a part of the power system (feeder or busbar) can be regarded as deactivated with certainty.

Siemens recommends a setting value of approx. 5 % of the rated voltage for this. All voltages connected according to the parameterized measuring-point connection type are subjected to the appropriate Vmin/Vmax test.

Parameter: Supervision time

- Recommended setting value **(_:5071:109) Supervision time** = ***0.1 s***

The parameter defines a supervision time for which the above additional closing conditions have to be at least fulfilled at de-energized switching, before the release for closing is given. In order to include transient phenomena, Siemens recommends a value of ***0.1 s***.

Parameter: Direct close command

- Recommended setting value **(_:5071:108) Direct close command** = ***no***

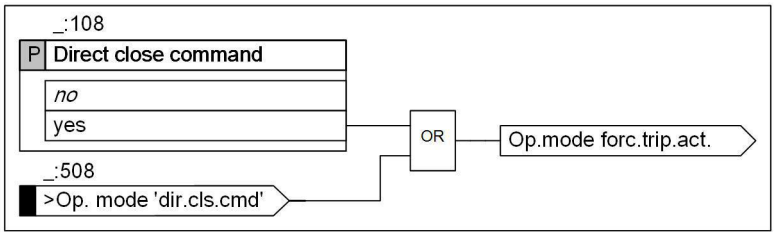
In this operating mode, the function initiates a closing release without any testing upon start of the synchronization stage. The closure occurs immediately.

NOTE

For safety reasons, Siemens recommends leaving the setting at***no***. If a direct close command is necessary, Siemens recommends only using this operating mode dynamically via the binary input signal **>Op. mode 'dir.cls.cmd'** (see *Figure 7-91*). This prevents this operating mode from being incorrectly activated statically thereby resulting in an incorrect switching.

7.5.11 Direct Close Command

You can activate the operating mode direct close command statically via the **Direct close command** parameter or dynamically with the binary input signal **>Op. mode 'dir.cls.cmd'** (see *Figure 7-90*).



[lo_syndir_01, 2, en_US]

Figure 7-90 Activation of the Operating Mode Direct Close Command

The operating mode **Direct close command** function initiates a closure release without any testing upon start of the synchronization stage. The closure occurs immediately.

The combination **Direct close command** with other operating modes is not recommended, as the other operating mode is bypassed.

If the synchronization function is defective (standby of the sync stage = alarm or warning), a direct close command is executed or not executed, depending on the type of fault (see also supervisions in chapter *7.5.4.1 Description*).

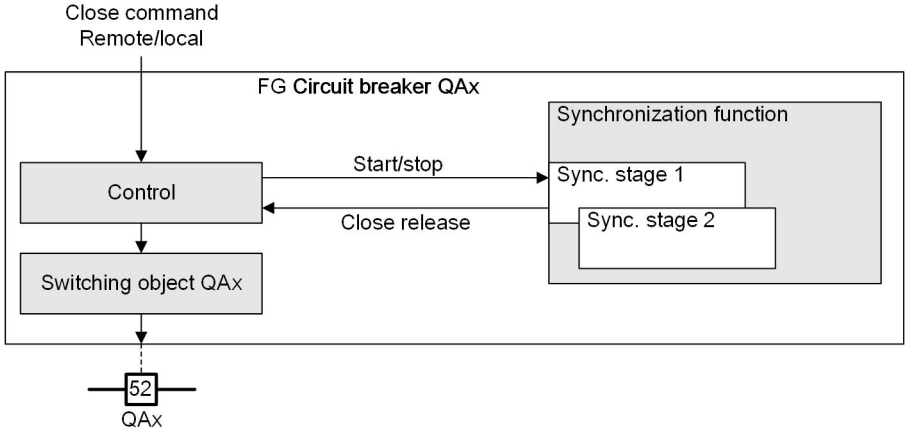
7.5.12 Interaction with Control and External Triggering

With Control

The control and synchronization functions are always located in a **Circuit-breaker** function group. The control and also the synchronization function always operate with the circuit breaker, which is linked to the function group **Circuit breaker**.

As soon as the synchronization function is in the **Circuit-breaker** function group, the circuit breaker is subject to compulsory synchronization. If all synchronization stages are deactivated, the circuit breaker cannot be activated via the control, as no release can be generated for the closure. The circuit breaker is no longer subject to compulsory synchronization after deletion of the synchronization function. Closure without synchronization is then possible via the control.

If closure is to be synchronized via the control, the control automatically generates an internal signal which starts the synchronization function. The functional sequence is described in chapter *7.5.6 Sequence of Functions*. After fulfilling all closing conditions, the synchronization sends a release signal to the control, which closes the circuit breaker and then stops and synchronization function.



[lo_synaw1-01, 3, en_US]

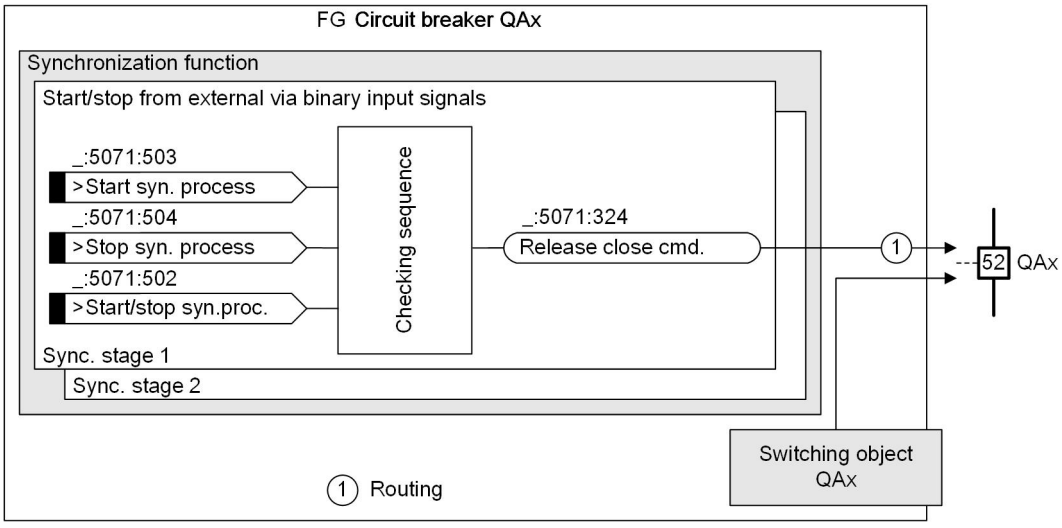
Figure 7-91 Interaction of the Control with the Synchronization Function

With External Control

You have the option of controlling the synchronization function externally via binary input signals. This can be done as follows:

- Edge-controlled
- Via the signals **>Start syn. process** and **>Stop syn. process**
- State-controlled via the signal **>Start/stop syn.proc.** (see also *7.5.6 Sequence of Functions*).

The start is followed by the functional sequence (see *7.5.6 Sequence of Functions*). If the conditions are fulfilled, the output signal **Release close cmd.** is output. The switched object QAx of the function group **Circuit breaker** is not closed. The output signal **Release close cmd.** must be explicitly routed to the binary output in order to close the circuit breaker.



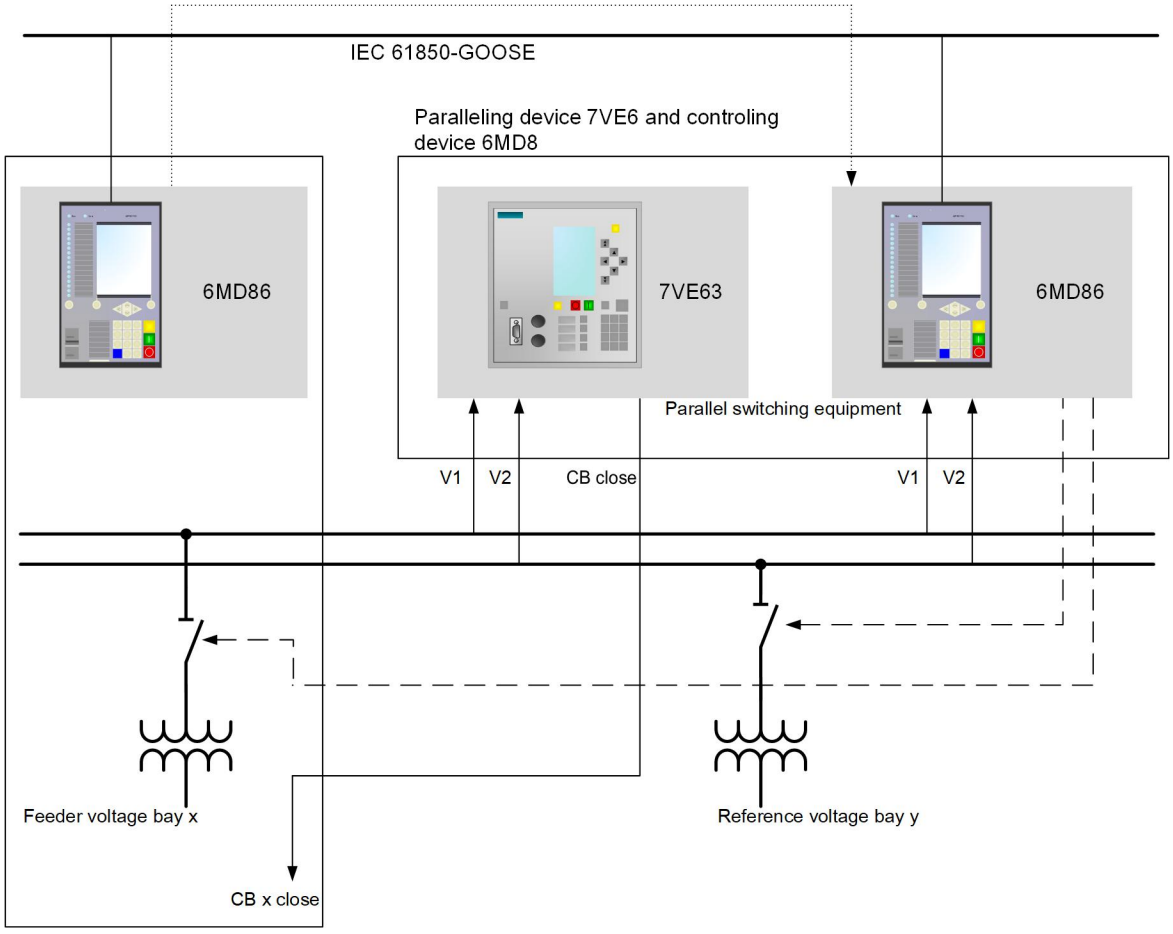
[lo_synaw3-01, 3, en_US]

Figure 7-92 Interaction of the Synchronization Function with External Control

7.5.13 External Synchronization

7.5.13.1 Description

The purpose of the **External synchronization** function is to control an external synchronization device.



[dw_ctrl_ext_sync_device, 3, en_US]

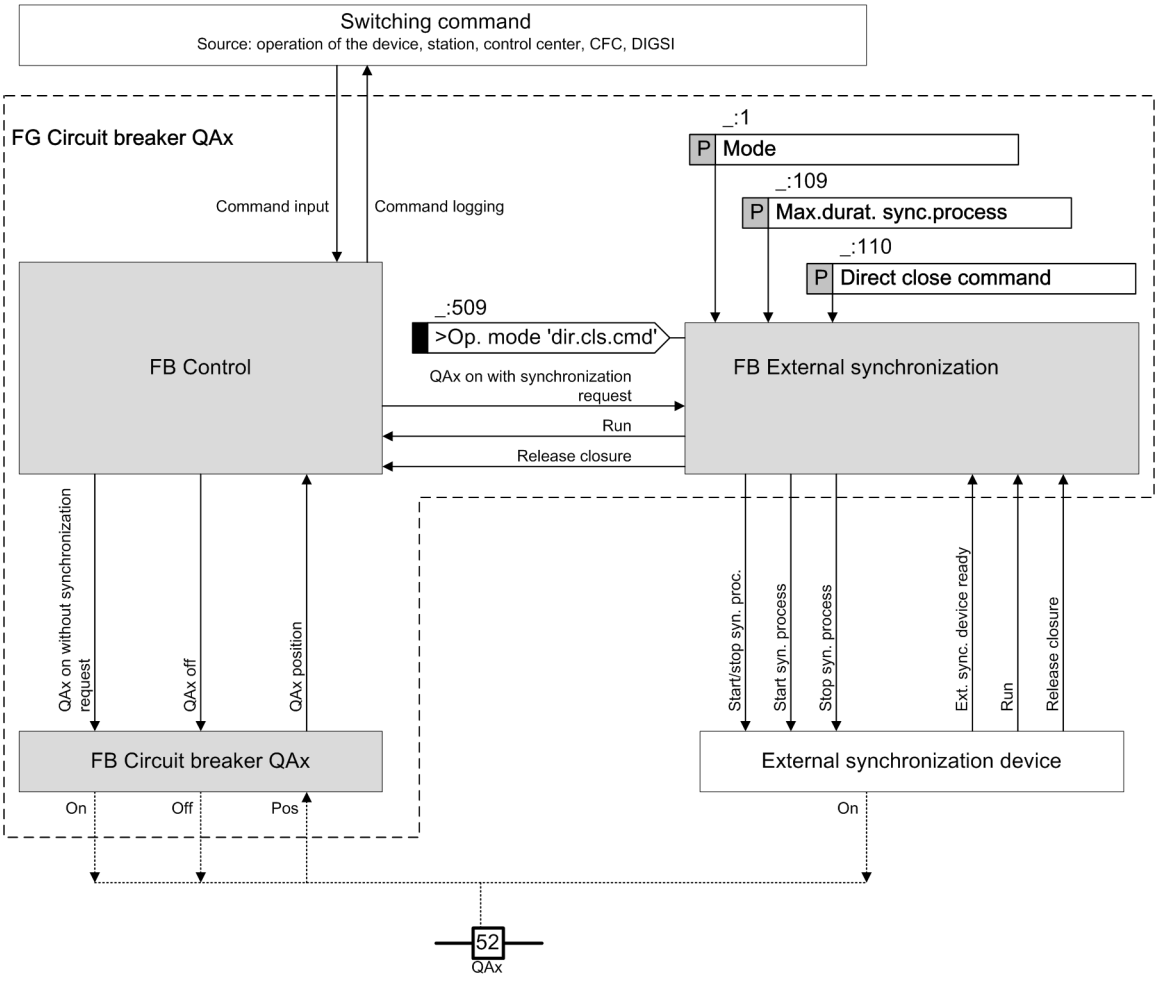
Figure 7-93 Triggering an External Synchronization Device

The bay controller in bay x should switch the circuit breaker in bay x in synchrony. The synchronization check is carried out in the central paralleling device 7VE6. In addition to the paralleling device, another central bay controller ensures the switching of the correct measuring voltages and the routing of the CB close command from the 7VE6 to the correct circuit breaker in bay x. The bay controller x provides the information to the central bay controller via IEC61850-GOOSE.

The **External synchronization** is designed as a function block which can be used in the Circuit-breaker function group. The additional **External synchronization** function block integrates the external synchronization into command processing, so that the corresponding feedback can be forwarded to the command source.

If a circuit-breaker close command with a synchronization requirement is present, the external synchronization device is started. After successfully checking the synchronization conditions, the close command is issued from the external synchronization device to the circuit breaker. If a circuit-breaker close command without synchronization requirement is present, the circuit-breaker close command is issued directly from the **Circuit-breaker** function group to the circuit breaker. Also, each circuit-breaker trip command is issued directly to the circuit breaker.

In case of a failure of the external synchronization device, you can also close the circuit breaker directly without considering the synchronization conditions.

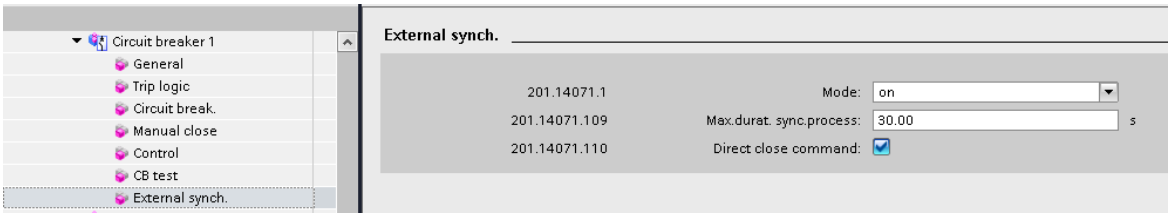


[dw_extsyn-02, 1, en_US]

Figure 7-94 Interaction between Control and External Synchronization

Parameterization with DIGSI

In the DIGSI library, the function is visible inside the **Circuit-breaker** function group as the **External synchronization** function block. You can instantiate the function block in the **Circuit-breaker** function group and the **Circuit-breaker (control)** function group. You can instantiate only 1 **External synchronization** function block within these function groups at a time.



[scextsyn-041116-01, 1, en_US]

Figure 7-95 Instantiating the **External Synchronization** Function Block in the **Circuit-Breaker** Function Group

It is not possible to jointly instantiate the **External synchronization** function block with the **25 synchronization** function in the same **Circuit-breaker** function group.

Notes for Optional Input Interconnections

You have the option of connecting the input signals *>Close cmd. released* and *>In progress*. If you omit these interconnections, observe the following instructions:

Input *>Close cmd. released*:

If you do not interconnect the input signal *>Close cmd. released* the execution of a circuit-breaker close command with synchronization requirement is confirmed directly (execution successful: OPR+), as soon as the output signal *Start syn. process* is set. In this case, the **(_:109) Max.durat. sync.process** setting has no meaning. If you use a control model with feedback monitoring, consider that the feedback monitoring will start immediately when the *Start syn. process* signal is tripped. The **(_:4201:103) Feedback monitoring time** setting must therefore be set higher than the maximum synchronization time of the external synchronization device plus the circuit-breaker make time. If *>Close cmd. released* is not routed, the output *Start/stop syn. proc.* is not set.

Input*>In progress*:

The interconnection of the input signal *>In progress* is intended to check whether the synchronization device has received the *Start syn. process* signal. If you do not interconnect this input signal and the external synchronization device rejects a start command, the negative acknowledgment of the circuit-breaker close command does not occur until the maximum synchronization time (parameter **(_:109) Max.durat. sync.process**) has expired.

Input *>Op. mode 'dir.cls.cmd'*:

In case of a failure of the external synchronization device, you can also close the circuit breaker directly without considering the synchronization conditions. To do this, activate the input signal *>Op. mode 'dir.cls.cmd'* or the parameter **(_:110) Direct close command**. The close command is then issued directly by the bay controller.

7.5.13.2 Application and Setting Notes (External Synchronization)

Parameter: Mode

- Default setting **(_:1) Mode** = ***on***

With the **Mode** parameter, you switch the external synchronization function on or off. If you set the **Mode** parameter to ***off***, a circuit-breaker close command with synchronization requirement is rejected.

Parameter: Max.durat. sync.process

- Default setting **(_:109) Max.durat. sync.process** = ***30 s***

The **Max.durat. sync.process** parameter defines the maximum synchronization time. The time starts when the **External synchronization** function block sends a close command to the external synchronization device. The command must be executed within this time. If the close command is not executed within this time, the **External synchronization** function block sends a command to cancel closing to the external synchronization device.

Parameter: Direct close command

- Default setting **(_:110) Direct close command** = ***no***

In case of a failure of the external synchronization device the **Direct close command** parameter is used to close the circuit breaker directly without considering the synchronization conditions. If the parameter is activated a close command with synchronization requirement will not be transmitted to the external synchronization device, but directly carried out by the bay controller.

7.5.13.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Syn./Asy.bal.#:Mode		• off • on • test	off
_:101	Syn./Asy.bal.#:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:102	Syn./Asy.bal.#:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:110	Syn./ Asy.bal.#:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:108	Syn./Asy.bal.#:Direct close command		• no • yes	no
_:126	Syn./Asy.bal.#:Voltage adjustment		0.500 to 2.000	1.000
De-en.gized switch.				
_:105	Syn./Asy.bal.#:Close cmd. at V1< & V2>		• no • yes	no
_:106	Syn./Asy.bal.#:Close cmd. at V1> & V2<		• no • yes	no
_:107	Syn./Asy.bal.#:Close cmd. at V1< & V2<		• no • yes	no
_:103	Syn./Asy.bal.#:V1, V2 without voltage		0.300 V to 170.000 V	5.000 V
_:104	Syn./Asy.bal.#:V1, V2 with voltage		0.300 V to 340.000 V	80.000 V
_:109	Syn./Asy.bal.#:Supervision time		0.00 s to 60.00 s	0.10 s
Asynchr. op.mode				
_:114	Syn./Asy.bal.#:Async. operating mode		• off • on	off
_:113	Syn./Asy.bal.#:CB make time		0.010 s to 0.600 s	0.060 s
_:115	Syn./Asy.bal.#:Max. voltage diff. V2>V1		0.000 V to 170.000 V	2.000 V
_:116	Syn./Asy.bal.#:Max. voltage diff. V2<V1		0.000 V to 170.000 V	2.000 V
_:117	Syn./Asy.bal.#:Max. frequency diff. f2>f1		0.000 Hz to 4.000 Hz	0.100 Hz
_:118	Syn./Asy.bal.#:Max. frequency diff. f2<f1		0.000 Hz to 4.000 Hz	0.100 Hz
Synchr. op.mode				
_:119	Syn./Asy.bal.#:Sync. operating mode		• off • on	off
_:120	Syn./Asy.bal.#:f-threshold ASYN<->SYN		0.010 Hz to 0.200 Hz	0.010 Hz

Addr.	Parameter	C	Setting Options	Default Setting
_:122	Syn./Asy.bal.#:Max. voltage diff. V2>V1		0.000 V to 170.000 V	2.000 V
_:123	Syn./Asy.bal.#:Max. voltage diff. V2<V1		0.000 V to 170.000 V	2.000 V
_:124	Syn./Asy.bal.#:Max. angle diff. α2>α1		0 ° to 90 °	10 °
_:125	Syn./Asy.bal.#:Max. angle diff. α2<α1		0 ° to 90 °	10 °
_:121	Syn./Asy.bal.#:Delay close command		0.00 s to 60.00 s	0.00 s
Balancing V				
_:131	Syn./Asy.bal.#:Balancing voltage V2		• off • transformer tap • balancing pulses	off
_:132	Syn./Asy.bal.#:T V pulse min		0.01 s to 1.00 s	0.10 s
_:133	Syn./Asy.bal.#:T V pulse max		0.01 s to 60.00 s	1.00 s
_:134	Syn./Asy.bal.#:dV per second		0V/sto0 V/s	0 V/s
_:135	Syn./Asy.bal.#:T pause V		0.10 s to 60.00 s	5.00 s
_:136	Syn./ Asy.bal.#:Smoothing		1 to 100	1
_:137	Syn./Asy.bal.#:(V/ Vrated)/(f/frated)		1.00 to 1.40	1.10
Balancing f				
_:141	Syn./Asy.bal.#:Balancing frequency f2		• off • balancing pulses	off
_:142	Syn./Asy.bal.#:T f pulse min		0.01 s to 1.00 s	0.10 s
_:143	Syn./Asy.bal.#:T f pulse max		0.01 s to 60.00 s	1.00 s
_:144	Syn./Asy.bal.#:df/dt of the controller		0.05 Hz/s to 5.00 Hz/s	1.00 Hz/s
_:145	Syn./Asy.bal.#:T pause f		0.10 s to 60.00 s	5.00 s
_:146	Syn./Asy.bal.#:Δf set point for balancing		-1.00 Hz to 1.00 Hz	0.04 Hz
_:147	Syn./ Asy.bal.#:Smoothing		1 to 100	1
_:148	Syn./Asy.bal.#:T close without balancing		1.00 s to 100.00 s	5.00 s
_:149	Syn./Asy.bal.#:Release for the kick pulse		• off • on	off
_:150	Syn./Asy.bal.#:Δf for the kick pulse		-1.00 Hz to 1.00 Hz	0.04 Hz
_:151	Syn./Asy.bal.#:Stabiliza-tion		0 to 1000	0

Addr.	Parameter	C	Setting Options	Default Setting
External sync.				
_:1	External sync.:Mode		• off • on • test	on
_:109	External sync.:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:110	External sync.:Direct close command		• 0 • 1	false

7.5.13.4 Information List

No.	Information	Data Class (Type)	Type
External sync.			
_:506	External sync.:>Synch. device ready	SPS	I
_:508	External sync.:>In progress	SPS	I
_:507	External sync.:>Close cmd. released	SPS	I
_:509	External sync.:>Op. mode 'dir.cls.cmd'	SPS	I
_:52	External sync.:Behavior	ENS	O
_:54	External sync.:Health	ENS	O
_:55	External sync.:Start syn. process	SPS	O
_:56	External sync.:Stop syn. process	SPS	O
_:57	External sync.:Start/stop syn. proc.	SPS	O

7.5.14 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:127	General:Angle adjust. (transform.)		-179.0 ° to 180.0 °	0.0 °
General				
_:5071:1	Synchrocheck 1:Mode		• off • on • test	off
_:5071:113	Synchrocheck 1:Contin-uous supervision		• false • true	false
_:5071:101	Synchrocheck 1:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:5071:102	Synchrocheck 1:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:5071:110	Synchrocheck 1:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:5071:108	Synchrocheck 1:Direct close command		• no • yes	no
_:5071:126	Synchrocheck 1:Voltage adjustment		0.500 to 2.000	1.000

Addr.	Parameter	C	Setting Options	Default Setting
De-en.gized switch.				
_:5071:105	Synchrocheck 1:Close cmd. at V1< & V2>		• no • yes	no
_:5071:106	Synchrocheck 1:Close cmd. at V1> & V2<		• no • yes	no
_:5071:107	Synchrocheck 1:Close cmd. at V1< & V2<		• no • yes	no
_:5071:103	Synchrocheck 1:V1, V2 without voltage		0.300 V to 170.000 V	5.000 V
_:5071:104	Synchrocheck 1:V1, V2 with voltage		0.300 V to 340.000 V	80.000 V
_:5071:109	Synchrocheck 1:Supervision time		0.00 s to 60.00 s	0.10 s
Synchr. conditions				
_:5071:115	Synchrocheck 1:Sync. operating mode		• off • on	on
_:5071:122	Synchrocheck 1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:5071:123	Synchrocheck 1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5071:117	Synchrocheck 1:Max. frequency diff. f2>f1		0.000 Hz to 2.000 Hz	0.100 Hz
_:5071:118	Synchrocheck 1:Max. frequency diff. f2<f1		0.000 Hz to 2.000 Hz	0.100 Hz
_:5071:124	Synchrocheck 1:Max. angle diff. α2>α1		0 ° to 90 °	10 °
_:5071:125	Synchrocheck 1:Max. angle diff. α2<α1		0 ° to 90 °	10 °
General				
_:5041:1	Sychr./Asycr.1:Mode		• off • on • test	off
_:5041:127	Sychr./Asycr.1:Continuous supervision		• false • true	false
_:5041:101	Sychr./Asycr.1:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:5041:102	Sychr./Asycr.1:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:5041:110	Sychr./ Asycr.1:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:5041:108	Sychr./Asycr.1:Direct close command		• no • yes	no
_:5041:126	Sychr./Asycr.1:Voltage adjustment		0.500 to 2.000	1.000
De-en.gized switch.				
_:5041:105	Sychr./Asycr.1:Close cmd. at V1< & V2>		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:5041:106	Sychr./Asycr.1:Close cmd. at V1> & V2<		• no • yes	no
_:5041:107	Sychr./Asycr.1:Close cmd. at V1< & V2<		• no • yes	no
_:5041:103	Sychr./Asycr.1:V1, V2 without voltage		0.300 V to 170.000 V	5.000 V
_:5041:104	Sychr./Asycr.1:V1, V2 with voltage		0.300 V to 340.000 V	80.000 V
_:5041:109	Sychr./Asycr.1:Supervision time		0.00 s to 60.00 s	0.10 s
Asynchr. op.mode				
_:5041:114	Sychr./Asycr.1:Async. operating mode		• off • on	on
_:5041:113	Sychr./Asycr.1:CB make time		0.010 s to 0.600 s	0.060 s
_:5041:115	Sychr./Asycr.1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:5041:116	Sychr./Asycr.1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5041:117	Sychr./Asycr.1:Max. frequency diff. f2>f1		0.000 Hz to 4.000 Hz	0.100 Hz
_:5041:118	Sychr./Asycr.1:Max. frequency diff. f2<f1		0.000 Hz to 4.000 Hz	0.100 Hz
Synchr. op.mode				
_:5041:119	Sychr./Asycr.1:Sync. operating mode		• off • on	on
_:5041:120	Sychr./Asycr.1:f-threshold ASYN<->SYN		0.010 Hz to 0.200 Hz	0.010 Hz
_:5041:122	Sychr./Asycr.1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:5041:123	Sychr./Asycr.1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5041:124	Sychr./Asycr.1:Max. angle diff. α2>α1		0 ° to 90 °	10 °
_:5041:125	Sychr./Asycr.1:Max. angle diff. α2<α1		0 ° to 90 °	10 °
_:5041:121	Sychr./Asycr.1:Delay close command		0.00 s to 60.00 s	0.00 s

7.5.15 Information List

No.	Information	Data Class (Type)	Type
Measurements			
_:2311:303	General:Multiple selection	SPS	O
_:2311:304	General:Blocked no V selected	SPS	O
_:2311:329	General:V1	MV	O
_:2311:330	General:f1	MV	O
_:2311:331	General:V2	MV	O

No.	Information	Data Class (Type)	Type
_:2311:332	General:f2	MV	O
_:2311:300	General:dV	MV	O
_:2311:301	General:df	MV	O
_:2311:302	General:dα	MV	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Synchrocheck 1			
_:5071:81	Synchrocheck 1:>Block stage	SPS	I
_:5071:500	Synchrocheck 1:>Selection	SPS	I
_:5071:502	Synchrocheck 1:>Start/stop syn.proc.	SPS	I
_:5071:503	Synchrocheck 1:>Start syn. process	SPS	I
_:5071:504	Synchrocheck 1:>Stop syn. process	SPS	I
_:5071:506	Synchrocheck 1:>Op. mode 'V1<V2>'	SPS	I
_:5071:505	Synchrocheck 1:>Op. mode 'V1>V2<'	SPS	I
_:5071:507	Synchrocheck 1:>Op. mode 'V1<V2<'	SPS	I
_:5071:508	Synchrocheck 1:>Op. mode 'dir.cls.cmd'	SPS	I
_:5071:501	Synchrocheck 1:>Block close command	SPS	I
_:5071:51	Synchrocheck 1:Mode (controllable)	ENC	C
_:5071:54	Synchrocheck 1:Inactive	SPS	O
_:5071:52	Synchrocheck 1:Behavior	ENS	O
_:5071:53	Synchrocheck 1:Health	ENS	O
_:5071:328	Synchrocheck 1:In progress	SPS	O
_:5071:324	Synchrocheck 1:Release close cmd.	SPS	O
_:5071:305	Synchrocheck 1:All sync. conditio. OK	SPS	O
_:5071:325	Synchrocheck 1:Voltage difference OK	SPS	O
_:5071:326	Synchrocheck 1:Angle difference OK	SPS	O
_:5071:327	Synchrocheck 1:Frequency diff. OK	SPS	O
_:5071:307	Synchrocheck 1:Cond. V1<V2> fulfilled	SPS	O
_:5071:306	Synchrocheck 1:Cond. V1>V2< fulfilled	SPS	O
_:5071:308	Synchrocheck 1:Cond. V1<V2< fulfilled	SPS	O
_:5071:309	Synchrocheck 1:Frequency f1 > fmax	SPS	O
_:5071:310	Synchrocheck 1:Frequency f1 < fmin	SPS	O
_:5071:311	Synchrocheck 1:Frequency f2 > fmax	SPS	O
_:5071:312	Synchrocheck 1:Frequency f2 < fmin	SPS	O
_:5071:313	Synchrocheck 1:Voltage V1 > Vmax	SPS	O
_:5071:314	Synchrocheck 1:Voltage V1 < Vmin	SPS	O
_:5071:315	Synchrocheck 1:Voltage V2 > Vmax	SPS	O
_:5071:316	Synchrocheck 1:Voltage V2 < Vmin	SPS	O
_:5071:317	Synchrocheck 1:V dif.too large(V2>V1)	SPS	O
_:5071:318	Synchrocheck 1:V dif.too large(V2<V1)	SPS	O
_:5071:319	Synchrocheck 1:f dif.too large(f2>f1)	SPS	O
_:5071:320	Synchrocheck 1:f dif.too large(f2<f1)	SPS	O
_:5071:321	Synchrocheck 1:α dif.too large(α2>α1)	SPS	O
_:5071:322	Synchrocheck 1:α dif.too large(α2<α1)	SPS	O
_:5071:304	Synchrocheck 1:Max. time exceeded	SPS	O
_:5071:323	Synchrocheck 1:Setting error	SPS	O

No.	Information	Data Class (Type)	Type
Sychr./Asycr.1			
_:5041:81	Sychr./Asycr.1:>Block stage	SPS	I
_:5041:500	Sychr./Asycr.1:>Selection	SPS	I
_:5041:502	Sychr./Asycr.1:>Start/stop syn.proc.	SPS	I
_:5041:503	Sychr./Asycr.1:>Start syn. process	SPS	I
_:5041:504	Sychr./Asycr.1:>Stop syn. process	SPS	I
_:5041:506	Sychr./Asycr.1:>Op. mode 'V1<V2>'	SPS	I
_:5041:505	Sychr./Asycr.1:>Op. mode 'V1>V2<'	SPS	I
_:5041:507	Sychr./Asycr.1:>Op. mode 'V1<V2<'	SPS	I
_:5041:508	Sychr./Asycr.1:>Op. mode 'dir.cls.cmd'	SPS	I
_:5041:501	Sychr./Asycr.1:>Block close command	SPS	I
_:5041:51	Sychr./Asycr.1:Mode (controllable)	ENC	C
_:5041:54	Sychr./Asycr.1:Inactive	SPS	O
_:5041:52	Sychr./Asycr.1:Behavior	ENS	O
_:5041:53	Sychr./Asycr.1:Health	ENS	O
_:5041:328	Sychr./Asycr.1:In progress	SPS	O
_:5041:324	Sychr./Asycr.1:Release close cmd.	SPS	O
_:5041:305	Sychr./Asycr.1:All sync. conditio. OK	SPS	O
_:5041:303	Sychr./Asycr.1:State f-synchronous	SPS	O
_:5041:325	Sychr./Asycr.1:Voltage difference OK	SPS	O
_:5041:326	Sychr./Asycr.1:Angle difference OK	SPS	O
_:5041:327	Sychr./Asycr.1:Frequency diff. OK	SPS	O
_:5041:307	Sychr./Asycr.1:Cond. V1<V2> fulfilled	SPS	O
_:5041:306	Sychr./Asycr.1:Cond. V1>V2< fulfilled	SPS	O
_:5041:308	Sychr./Asycr.1:Cond. V1<V2< fulfilled	SPS	O
_:5041:309	Sychr./Asycr.1:Frequency f1 > fmax	SPS	O
_:5041:310	Sychr./Asycr.1:Frequency f1 < fmin	SPS	O
_:5041:311	Sychr./Asycr.1:Frequency f2 > fmax	SPS	O
_:5041:312	Sychr./Asycr.1:Frequency f2 < fmin	SPS	O
_:5041:313	Sychr./Asycr.1:Voltage V1 > Vmax	SPS	O
_:5041:314	Sychr./Asycr.1:Voltage V1 < Vmin	SPS	O
_:5041:315	Sychr./Asycr.1:Voltage V2 > Vmax	SPS	O
_:5041:316	Sychr./Asycr.1:Voltage V2 < Vmin	SPS	O
_:5041:317	Sychr./Asycr.1:V dif.too large(V2>V1)	SPS	O
_:5041:318	Sychr./Asycr.1:V dif.too large(V2<V1)	SPS	O
_:5041:319	Sychr./Asycr.1:f dif.too large(f2>f1)	SPS	O
_:5041:320	Sychr./Asycr.1:f dif.too large(f2<f1)	SPS	O
_:5041:321	Sychr./Asycr.1:α dif.too large(α2>α1)	SPS	O
_:5041:322	Sychr./Asycr.1:α dif.too large(α2<α1)	SPS	O
_:5041:304	Sychr./Asycr.1:Max. time exceeded	SPS	O
_:5041:323	Sychr./Asycr.1:Setting error	SPS	O

7.6 User-Defined Function Block [Control]

7.6.1 Overview of Functions

The **User-defined function block [control]** allows the switching-authority check of a control command, the check of whether the position has been reached, a double-activation blocking, and the definition of interlocking conditions for user-defined controllables.

7.6.2 Function Description

The **User-defined function block [control]** is located in the folder **User-defined functions** in the DIGSI 5 Library.

You can instantiate the user-defined function blocks on the top level (in parallel to other function groups) as well as within function groups and functions.

The task of the function block is to check the switching authority and the interlocking conditions for the user-defined control commands instantiated within it. For these control commands, the function block checks whether the required switch position is equal to the current switch position (actual/set point comparison).
If you activate the double-activation blocking, commands from switching objects and user-defined control signals will be rejected as long as a command is still being performed for one of the other switching objects for which double-activation blocking has also been set.

With the binary release signals, you can determine a switchgear interlocking protection for all the user-defined control signals instantiated in the function block. Unlike the switching devices (circuit breaker, disconnector), there is only one release input here, since there is only one switching direction for the signal types INC and APC. The signal types DPC, SPC, and BSC have 2 switching directions, but still only one release input. This release input can be operated based on the result of a logic created in the CFC, or can be directly connected to a binary input or a variable. If the input **>Enable** is activated, the switching command can be performed. If it is not activated, the switching command is rejected, with the reason *Interlocking violation*.

This applies in a similar way to the input **>Enable (fixed)**, although with this input, the interlocking cannot be revoked by key switch S1 or an *unlocked* switching authority.

The following table shows the reaction of the function to the assignment of its inputs.

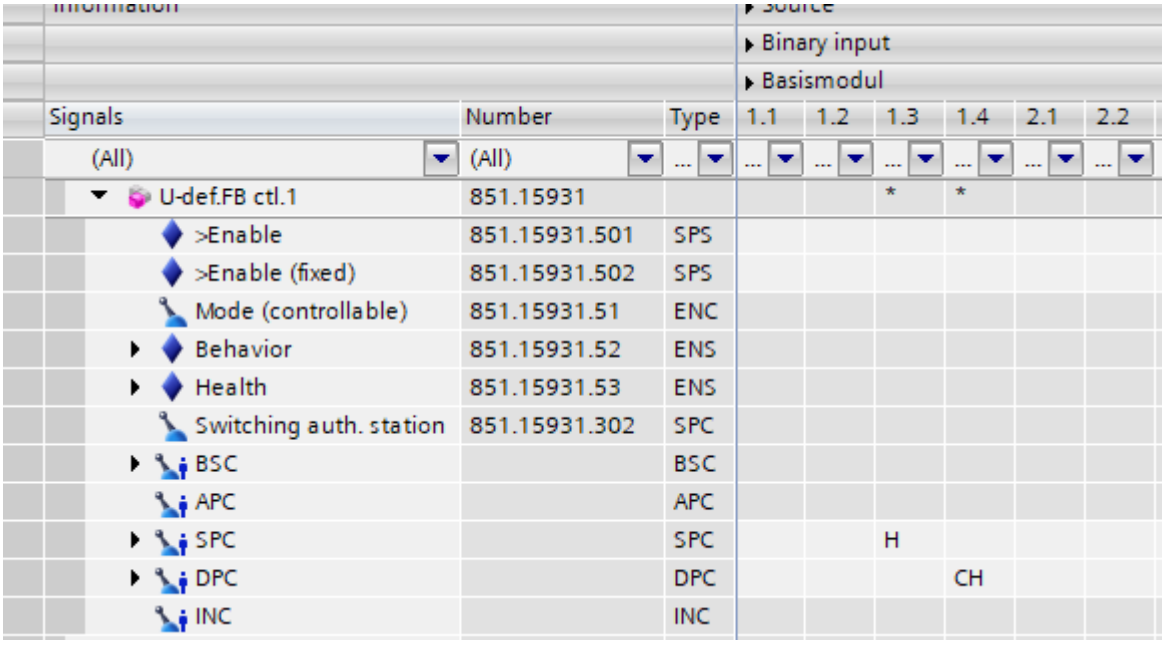
Input >Enable	Input >Enable (fixed)	Effect on control command
1	0	Rejected
0	1	Successful if device mode = *unlocked* Rejected if device mode = *locked*
1	1	Successful
0	0	Rejected



NOTE

The default setting for the state of the inputs is **1**, that is, the switching commands are not locked.

You can instantiate every user-defined signal (for example, SPS, DPC, INC) in the function block and route the corresponding indications (see following figure).



Information			Source					
			Binary input					
			Basismodul					
Signals	Number	Type	1.1	1.2	1.3	1.4	2.1	2.2
(All)	(All)	...	...	...	...	...	...	...
U-def.FB ctl.1	851.15931				*	*		
>Enable	851.15931.501	SPS						
>Enable (fixed)	851.15931.502	SPS						
Mode (controllable)	851.15931.51	ENC						
Behavior	851.15931.52	ENS						
Health	851.15931.53	ENS						
Switching auth. station	851.15931.302	SPC						
BSC		BSC						
APC		APC						
SPC		SPC			H			
DPC		DPC				CH		
INC		INC						

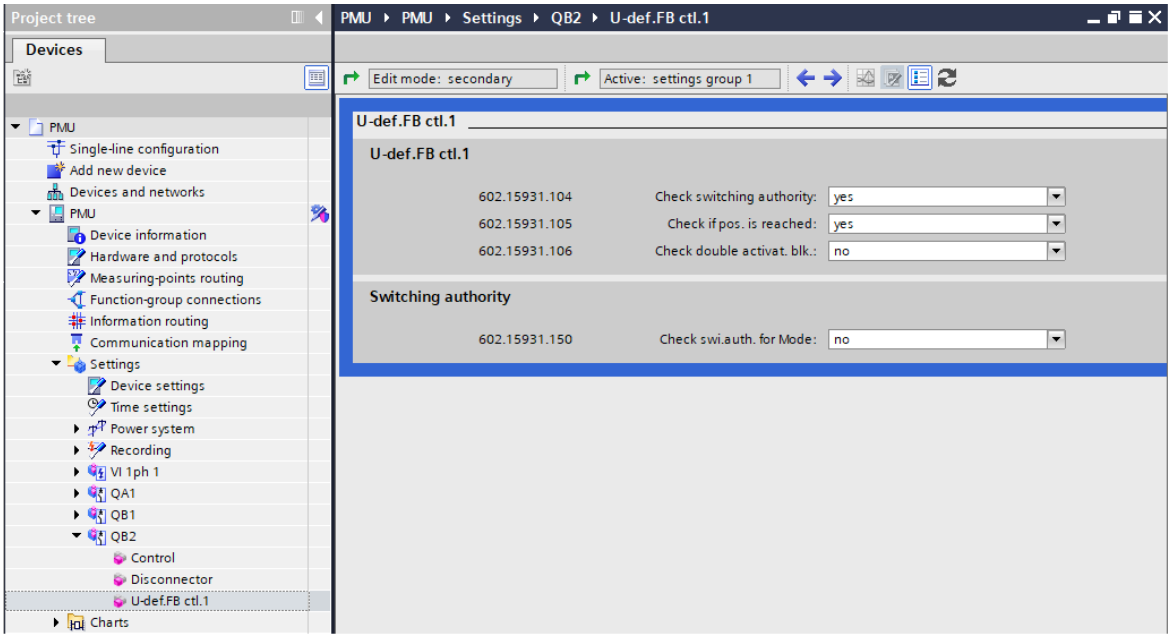
[sc_user_01, 1, en_US]

Figure 7-96 Information Routing with Inserted User-Defined Function Block [Control]: Process Indications and Some Single-Point Indications

7.6.3 Application and Setting Notes

The function block contains the parameters **(_:104) Check switching authority**, **(_:105) Check if pos. is reached**, **(_:106) Check double activat. blk.**, and **(_:150) Check swi.auth. for Mode**. The parameter settings **Check switching authority** and **Check if pos. is reached** affect all controllables instantiated **in the** function block. Other signal types are not affected by these parameters and objects.

On the other hand, the parameter setting **Check swi.auth. for Mode** affects the controllable **Mode (controllable)** of the function block.



[sc_user_02, 1, en_US]

Figure 7-97 Parameterization Options of the User-Defined Function Block [Control]

Parameter: **`Check switching authority`**

- Default setting **`(_:104) Check switching authority`** = ***`yes`***

With the **`Check switching authority`** parameter, you determine whether the command source of switching commands must be checked (see chapter *7.4.1 Command Checks and Switchgear Interlocking Protection*).

Parameter: **`Check if pos. is reached`**

- Default setting **`(_:105) Check if pos. is reached`** = ***`yes`***

With the **`Check if pos. is reached`** parameter, you check at a switching command whether the switching direction equals the current position.

Parameter: **`Check double activat. blk.`**

- Default setting **`(_:106) Check double activat. blk.`** = ***`no`***

With the **`Check double activat. blk.`** parameter, you check whether commands from switching objects and user-defined control signals should be rejected, as long as a command is still being executed for one of the other objects.

Parameter: **`Check swi.auth. for Mode`**

- Default setting **`(_:150) Check swi.auth. for Mode`** = ***`no`***

With the **`Check swi.auth. for Mode`** parameter, you specify whether the switching authority for the command source must be checked when switching the controllable **`Mode (controllable)`** to the mode ***`On`***, ***`Off`***, or ***`Test`***. If you set the parameter **`Check swi.auth. for Mode`** to ***`yes`***, the switching command is only executed with the appropriate switching authority (see chapter *7.4.1 Command Checks and Switchgear Interlocking Protection*).

7.6.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
U-def.FB ctl.#				
_:104	U-def.FB ctl.#:Check switching authority		• no • yes • advanced	yes
_:105	U-def.FB ctl.#:Check if pos. is reached		• no • yes	yes
_:106	U-def.FB ctl.#:Check double activat. blk.		• no • yes	no
Switching authority				
_:150	U-def.FB ctl.#:Check swi.auth. for Mode		• no • yes	no
_:151	U-def.FB ctl.#:Swi.dev. related sw.auth.		• 0 • 1	false
_:152	U-def.FB ctl.#:Specific sw. authorities		• 0 • 1	true
_:115	U-def.FB ctl.#:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:153	U-def.FB ctl.#:Num. of specific sw.auth.		2 to 5	2
_:155	U-def.FB ctl.#:Ident. sw.auth. 1		Freely editable text	
_:156	U-def.FB ctl.#:Ident. sw.auth. 2		Freely editable text	
_:157	U-def.FB ctl.#:Ident. sw.auth. 3		Freely editable text	
_:158	U-def.FB ctl.#:Ident. sw.auth. 4		Freely editable text	
_:159	U-def.FB ctl.#:Ident. sw.auth. 5		Freely editable text	
_:154	U-def.FB ctl.#:Multiple specific sw.auth.		• 0 • 1	false

7.6.5 Information List

No.	Information	Data Class (Type)	Type
U-def.FB ctl.#			
_:501	U-def.FB ctl.#:>Enable	SPS	I
_:502	U-def.FB ctl.#:>Enable (fixed)	SPS	I
_:503	U-def.FB ctl.#:>Sw. authority local	SPS	I
_:504	U-def.FB ctl.#:>Sw. authority remote	SPS	I
_:505	U-def.FB ctl.#:>Sw. mode interlocked	SPS	I
_:506	U-def.FB ctl.#:>Sw. mode non-interl.	SPS	I
_:51	U-def.FB ctl.#:Mode (controllable)	ENC	C

No.	Information	Data Class (Type)	Type
_:52	U-def.FB ctl.#:Behavior	ENS	O
_:53	U-def.FB ctl.#:Health	ENS	O
_:302	U-def.FB ctl.#:Switching auth. station	SPC	C
_:308	U-def.FB ctl.#:Enable sw. auth. 1	SPC	C
_:309	U-def.FB ctl.#:Enable sw. auth. 2	SPC	C
_:310	U-def.FB ctl.#:Enable sw. auth. 3	SPC	C
_:311	U-def.FB ctl.#:Enable sw. auth. 4	SPC	C
_:312	U-def.FB ctl.#:Enable sw. auth. 5	SPC	C
_:313	U-def.FB ctl.#:Switching authority	ENS	O
_:314	U-def.FB ctl.#:Switching mode	ENS	O

7.7 CFC-Chart Settings

7.7.1 Overview of Functions

If you want to process a parameter in a CFC chart and this parameter is to be changeable during runtime using DIGSI or HMI, you can use the function blocks **CFC chart of Boolean parameters**, the **CFC chart of integer parameters** and the **CFC chart of floating-point parameters**. Instantiate the appropriate function block depending on the parameter value needed (logical, integer, or floating point). In this way, the current value of the parameter can then be used in the CFC chart at runtime.

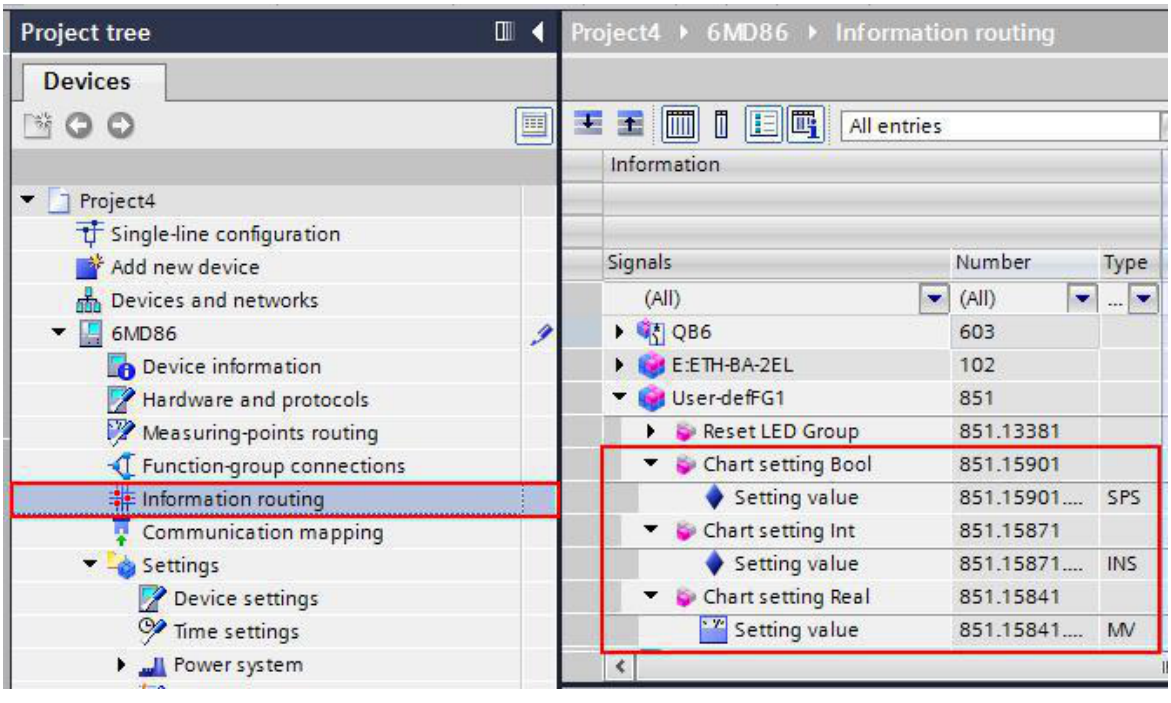
7.7.2 Function Description

You can find the CFC-chart parameters **`Chrt sett.Bool`**, **`Chart setting Int`**, and **`Chrt sett.real`** in the DIGSI library in the **User-defined functions** folder. Drag and drop the desired function block into a function group or a function. Set the appropriate parameter value of the function block in DIGSI using the parameter editor or via HMI under the **Settings** menu item. You can then use the parameter as an input signal in CFC charts.

With **Exp. options**, you define the range and the unit of the value. This prevents users from entering incorrect setting values.

NOTE

The user-defined function groups and the user-defined functions can be used to group the CFC-chart parameters. You can rename for the function block and change the parameter value in the DIGSI Information routing matrix to suit your specific application.



[sc_cfc_param, 1, en_US]

Figure 7-98 CFC-Chart Parameters within Information Routing

7.7.3 Application and Setting Notes

Parameter: **Chrt sett.Bool**

- Default setting **Chrt sett.Bool** = ***False***

You can use the parameter **Chrt sett.Bool** in a CFC chart as an input signal with a Boolean value. This input value can then be changed during the runtime of the CFC chart.

Parameter: **Chart setting Int**

- Default setting **Chart setting Int** = ***10***

You can use the parameter **Chart setting Int** in a CFC chart as an input signal with an integer value. This input value can then be changed during the runtime of the CFC chart.

Parameter: **Chrt sett.real**

- Default setting **Chrt sett.real** = ***100.000***

You can use the parameter **Chrt sett.real** in a CFC chart as an input signal with a floating-point number. This input value can then be changed during the runtime of the CFC chart.

7.7.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Chrt sett.Bool				
_:105	Chrt sett.Bool:Value		• 0 • 1	false

Addr.	Parameter	C	Setting Options	Default Setting
Chart setting Int				
_:105	Chart setting Int:Value		-2147483648 to 2147483647	10

Addr.	Parameter	C	Setting Options	Default Setting
Chrt sett.real				
_:105	Chrt sett.real:Value		-10000000000.000 % to 10000000000.000 %	100.000 %

7.7.5 Information List

No.	Information	Data Class (Type)	Type
Chrt sett.Bool			
_:305	Chrt sett.Bool:Setting value	SPS	O

No.	Information	Data Class (Type)	Type
Chart setting Int			
_:305	Chart setting Int:Setting value	INS	O

No.	Information	Data Class (Type)	Type
Chrt sett.real			
_:305	Chrt sett.real:Setting value	MV	O

7.8 Tap Changers

7.8.1 Function Description

With the device control function, you can change a transformer tap by moving it higher or lower and monitor the proper execution of the adjusting commands.

The function has built-in comprehensive options for measuring the tap changer position as well as supervision and monitoring functions. The supervision and monitoring functions are used to check the voltage and supply information about the tap position for adaptive matching of the transformer differential protection

The following options are provided for control:

- Direct user commands via the device keypad or routed binary inputs
- User-defined conditions via the CFC

If the tap changer reaches the end positions, the control function issues the *(_:301) End higher pos.reached* or *(_:302) End lower pos.reached* indication.

The transformer tap controller is controlled by the function group **Tap changer**, which you can select from the DIGSI library (group **Switching devices**).

Tap changer 1	161		*	*	*	*
Tap changer	161.5461		*	*	*	*
>Acquisition blocking	161.5461.500	SPS				
>Enable	161.5461.501	SPS				
>Reset AcqBlk&Subst	161.5461.504	SPS				
Health	161.5461.53	ENS				
End higher pos.reached	161.5461.301	SPS				
End lower pos.reached	161.5461.302	SPS				
Position	161.5461.308	BSC	X	X	X	X
acquisition blk. active		SPS				
manual update active		SPS				
Higher command	161.5461.305	SPS				
Lower command	161.5461.306	SPS				
Command active	161.5461.307	SPS				
Motor sup. time expired	161.5461.309	SPS				
Trigger motor prot. sw.	161.5461.310	SPS				
Position failure	161.5461.311	SPS				
Op.ct.	161.5461.312	INS				
Reset failure	161.5461.319	SPC				
Switching auth. station	161.5461.317	SPC				

[sc_tssdig, 1, en_US]

Figure 7-99 Tap Changer Functionality in the DIGSI Information Matrix

The central element is the Controllable **Position** of type BSC (Binary Controlled Step Position Information, based on IEC 61850). You connect this Controllable in the matrix to the desired number of binary inputs that indicate the current tap position.

For more information, refer to*7.8.2 Application and Setting Notes*.

The **Position** Controllable also contains parameters. If you wish to change the settings, you must select the Controllable in the DIGSI information matrix and change the settings by way of the Properties dialog. The taps are controlled via the commands **Higher command** and **Lower command**, each of which must be connected to one binary output.

Example

The following 2 figures show a CFC chart as an example for transformer tap control with the routing of the function keys for stepping up or stepping down.

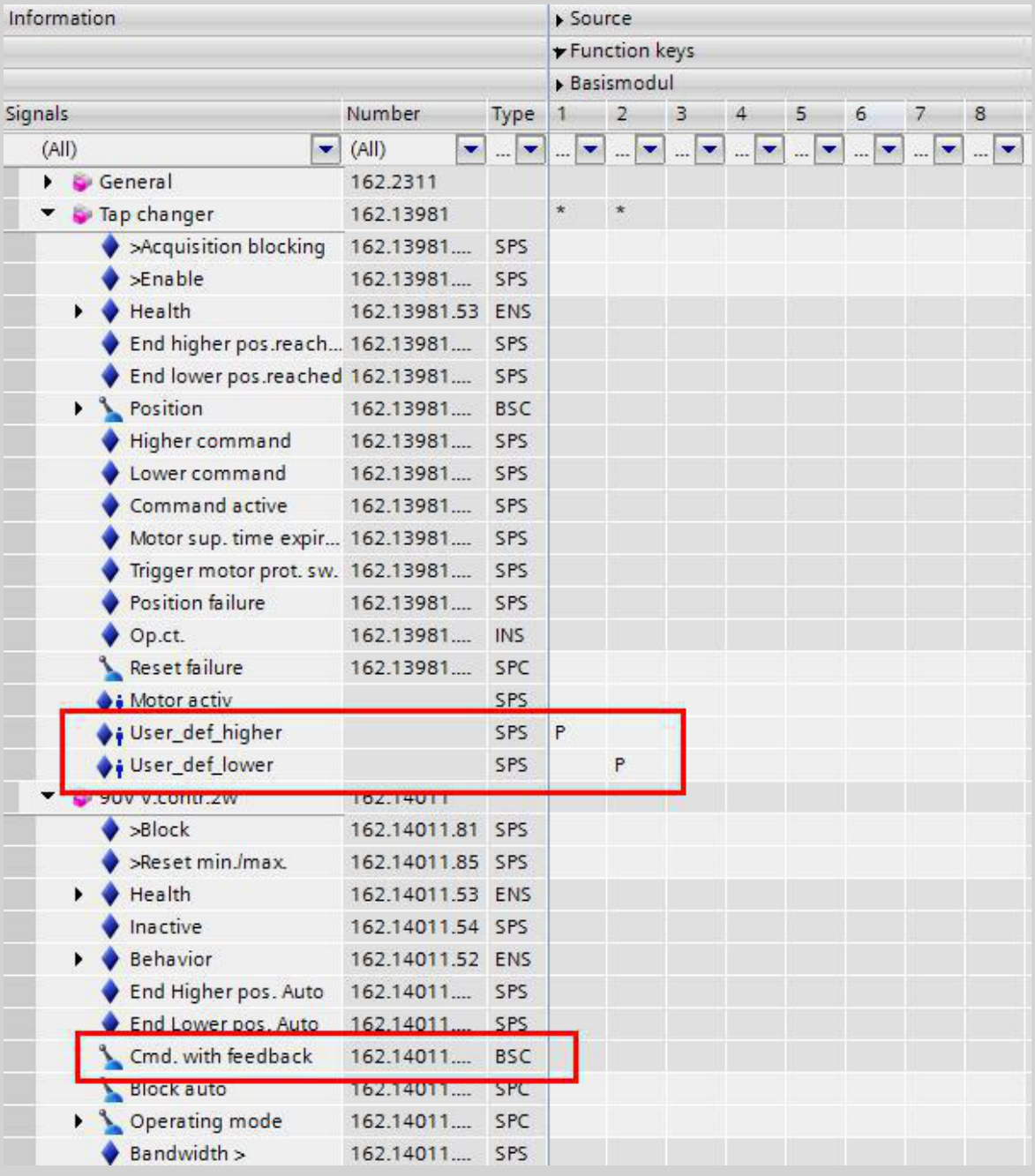


Figure 7-100 Routing of the Function Keys and CFC Signals

To use the function keys, you create 2 user-defined single-point indications (SPS). These are used for the function keys (for example, <F1>, Higher function key and <F2>, Lower function key) and as the input signals for the appropriate CFC blocks. In addition, you must use the controllable **`Cmd. with feedback`** for the CFC chart and set the control model to ***`direct w. enh. security`***.

You can select the control direction using the following values at the **Val** input of the **BSC_DEF** building block:

- 1 means **step up**
- 0 means **step down**

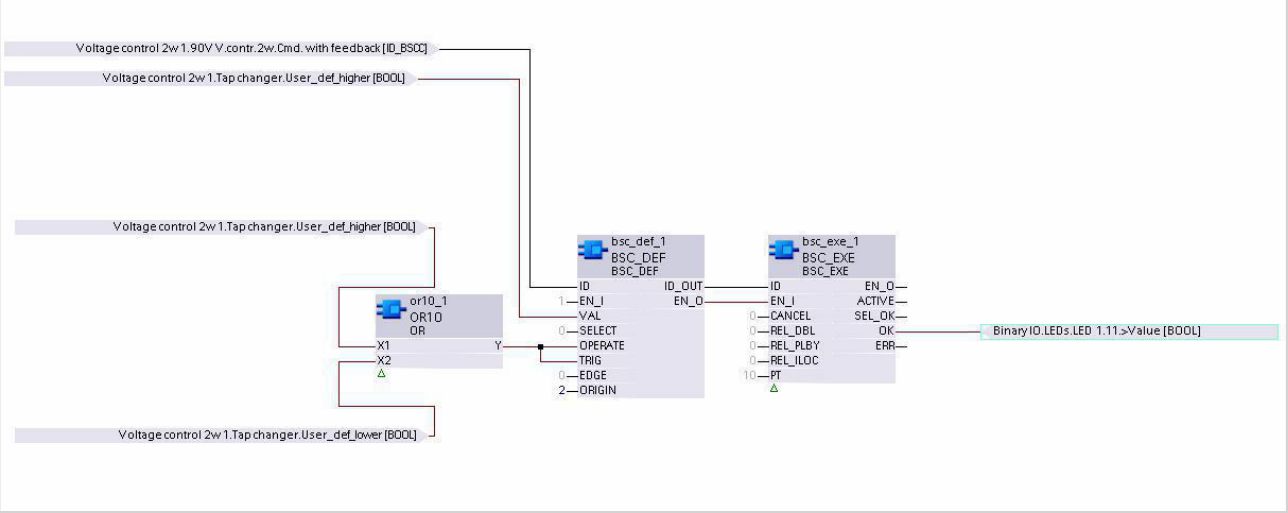


Figure 7-101 CFC Chart

Pressing the function keys to step up or down incrementally can be displayed using this simple CFC chart.

Motor Supervision Time

The runtime of the motor-drive mechanism can be monitored from the device. This function is used to identify failures of the motor-drive mechanism during the switching procedure and to trip actions if necessary. To use the **`Motor supervision time`**, you must route the motor sliding contact (most significant binary input) and set the proper motor runtime.

The motor sliding contact is active until the tap changer has reached the new position. This time is compared to the **`Motor supervision time`**. If the new tap position is not reached within the motor runtime, the *`Motor sup. time expired`* indication is set. The *`Trigger motor prot. sw.`* indication with which the motor can be switched off is output for a duration of 1.5 s.

Adjusting-Command Supervision

Adjusting-command supervision is used for checking the proper operation of the tap-changer mechanism. The **Tap changer** function calculates the next logical tap position as a result of the higher/lower tap command. The time of position detection is determined as a function of the availability of the motor sliding contact. After resetting the active motor sliding contact, the **Tap changer** function reads the new tap position value. If the value for the calculated tap position could not be received within the parameterized time **`Motor supervision time`**, the error message *`Position failure`* is output.

The following position errors of the tap changer are taken into consideration during this:

- Invalid tap position: The tap position is outside the predefined range of **`minimum value`** and **`maximum value`**
- Adjusting command in the wrong direction (for example, if a higher tap was commanded and the tap changer responds with a lower position and vice versa)
- No operation of the tap changer (for example, if the tap-changer motor is defective or the position indication is not functioning)
- Illogical tap-change operation (for example, if no logical tap position following the previous position is indicated)

The value of 0 during an unexpected interruption of the auxiliary voltage represents a special case. An invalid tap-changer position without a corresponding adjusting command is signaled in the **Position** controllable only as an invalid tap position.

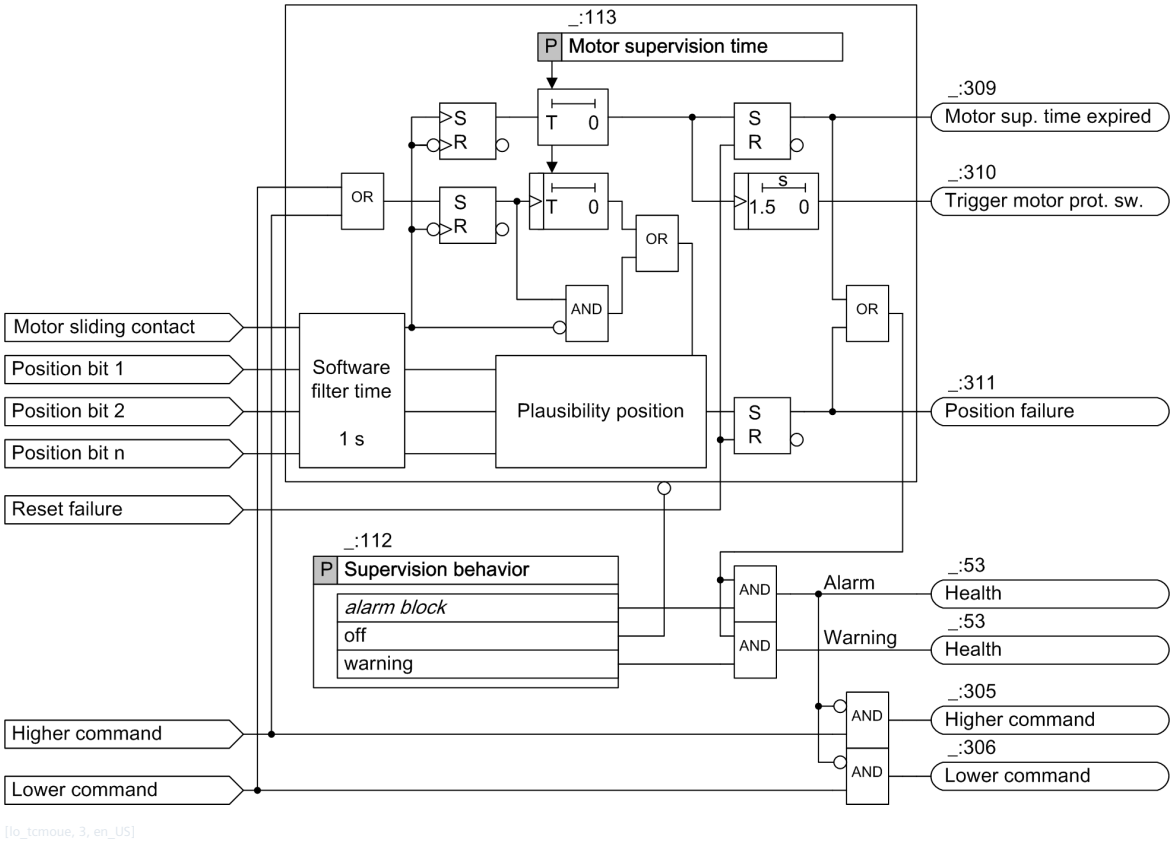


Figure 7-102 Position and Motor Supervision Logic

The user-defined signals **Higher command** and **Lower command** are provided via a CFC chart (refer to *7.8.1 Function Description*).

Supervision Behavior

Depending on the setting of the **Supervision behavior** parameter, the function reaches a health state of **Alarm** or **Warning**. You can set the parameter **Supervision behavior** to ***off***, ***alarm block*** or ***warning***.

In the ***alarm block*** mode, the function is set to the health state **Alarm**. All tap-changer commands are blocked.

In the ***warning*** mode, the function is set to the health state **Warning**. Executing tap-changer commands is still possible.

You can manually reset the health state of ***alarm block*** or ***warning*** using the controllable **Reset errors** (Main menu → Device functions → Reset functions → Tap changer). As an alternative to this, you can also switch off the supervision function and then switch it on again.

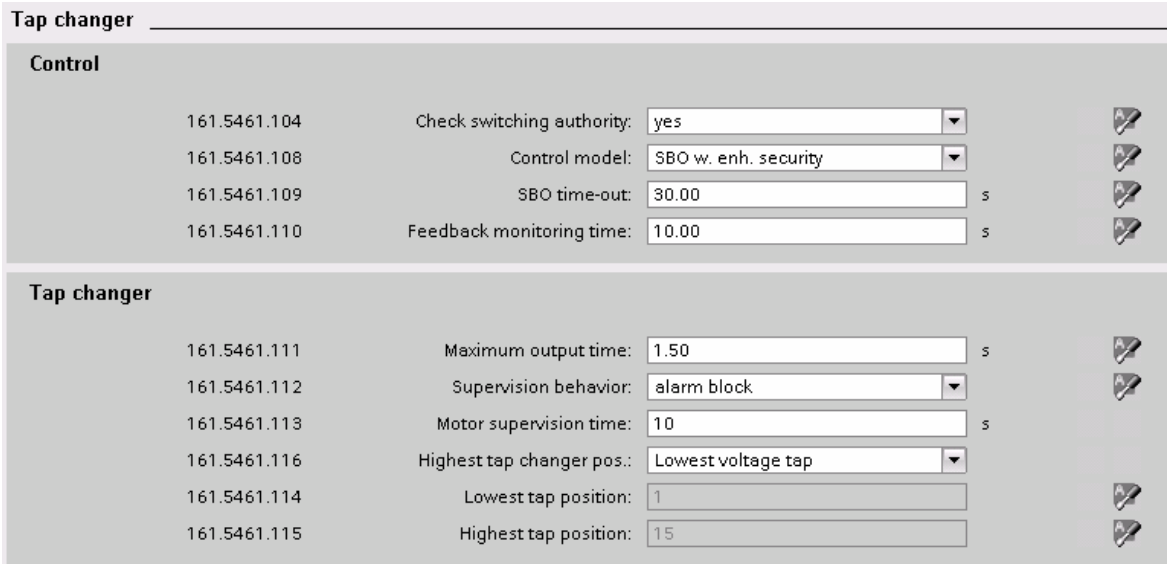
Operating Counter

The device counts the number of successfully completed adjusting commands with the *Op.Ct.* switching cycle counting value. The counting and memory levels are protected against an auxiliary-voltage failure. The switching cycle counting value can be set to 0 or to any other starting value.

You can access the statistical values via the operation panel on the device (measured values/statistics), via DIGSI, or using various communication protocols.

7.8.2 Application and Setting Notes

Parameters of the Tap Changer Function Group



[scstuslt-100713-01.tif, 2, en_US]

Figure 7-103 Parameters of the Tap Changer

NOTE

If run positions, this means internal tap changer positions without voltage changes, are available, the following must be observed:

If these tap changer positions contain a suffix a and c or + and -, and additional switching pulses are not required, adjust the parameter for the feedback and motor supervision time to the actual motor runtime when passing through a run position. Siemens recommends parameterization with capturing of the motor sliding contact.

Parameter: `Check switching authority`

- Default setting **`(_:104) Check switching authority`** = ***`yes`***

With the **`Check switching authority`** parameter, you specify whether the switching authority (on site, remote) is checked in the case of an adjusting command (see also chapter *7.4.1 Command Checks and Switchgear Interlocking Protection*).

Parameter: `Control model`

- Default setting **`(_:108) Control model`** = ***`SBO w. enh. security`***

Use the **`Control model`** parameter to specify the control model according to IEC 61850-7-2. The following selection options are available:

- ***`direct w. normal secur.`***
- ***`SBO w. normal secur.`***
- ***`direct w. enh. security`***
- ***`SBO w. enh. security`***
- ***`status only`***

Parameter: SBO time-out

- Default setting **(_:109) SBO time-out** = ***30 s***

With this setting, you specify the time for detecting the time-out of the SBO command. The range of values extends from 0.01 s to 1800.00 s. This is the time that can elapse between command acceptance and command execution (command model as per IEC 61850-7-2).

Parameter: Feedback monitoring time

- Default setting **(_:110) Feedback monitoring time** = ***10 s***

Reaching a new tap position after the switching command is monitored. If a new tap position is not reached, you specify with this setting the time when the command is canceled. The range of values extends from 0.01 s to 1800.00 s.

Parameter: Maximum output time

- Default setting **(_:111) Maximum output time** = ***1.50 s***

This parameter specifies the maximum output time. The range of values extends from 0.01 s to 1800.00 s. For activating motors to change the tap position, a time of 1.50 s is practical.

Parameter: Supervision behavior

- Default setting **(_:112) Supervision behavior** = ***alarm block***

You can select whether the supervision is switched off (***off***) or if only a warning is indicated (***warning***). With the ***alarm block*** setting, an alarm indication is generated and the function is blocked.

Parameter: Motor supervision time

- Default setting **(_:113) Motor supervision time** = ***10 s***

After the motor supervision time has elapsed, the indication *Motor sup. time expired* is displayed. You can find additional information in *7.8.1 Function Description*. The range of values extends from 5 s to 100 s.

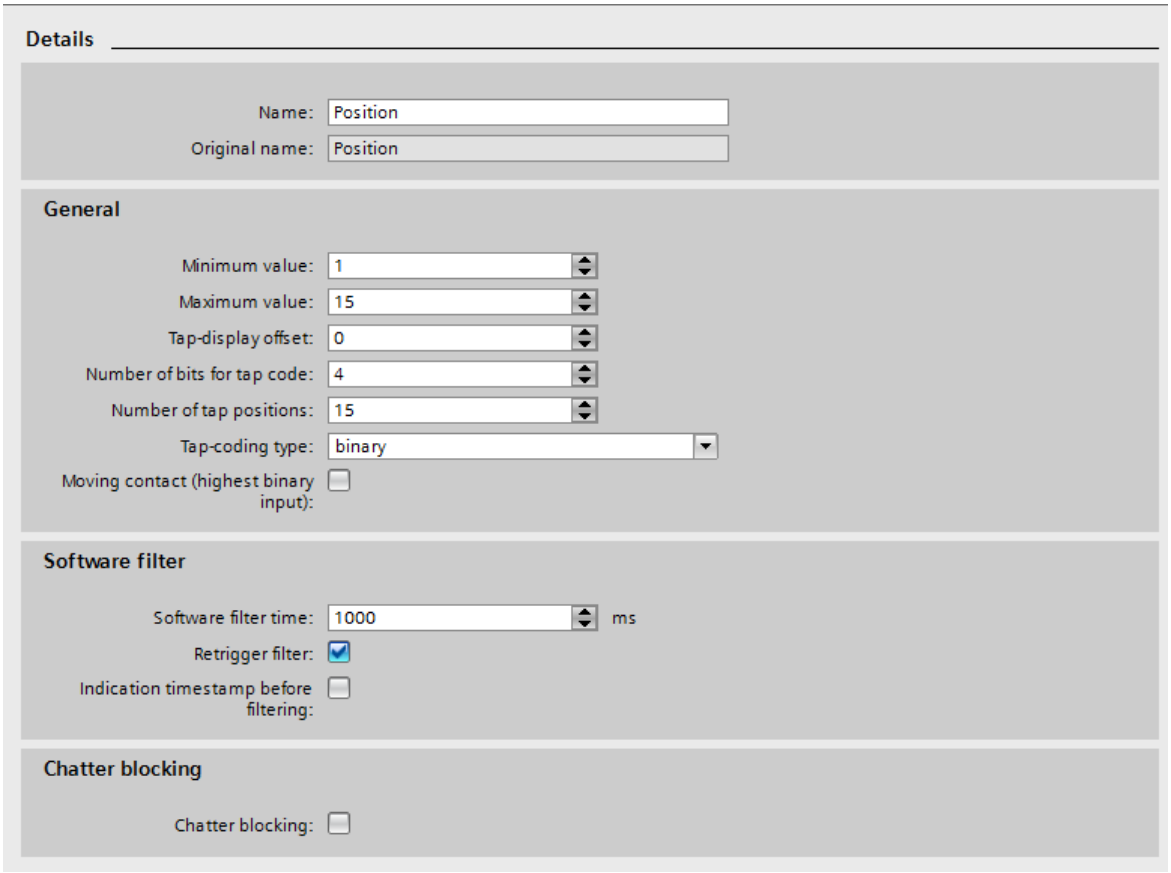
Parameter: Highest tap changer pos.

- Default setting **(_:116) Highest tap changer pos.** = ***Lowest voltage tap***

With the **Highest tap changer pos.** parameter, you specify whether the lowest or highest voltage is present at the highest tap changer position.

Additional Settings (Properties Dialog Position)

Additional settings are assigned to the controllable *Position*. To display and adjust the settings, select *Position* in the DIGSI information matrix and select the Properties dialog. To do this, click the **Properties** tab.



[sc_deegts, 1, en_US]

Figure 7-104 Properties Dialog

Parameter: `Minimum value`

- Default setting **`Minimum value`** = ***1***

Parameter: `Maximum value`

- Default setting **`Maximum value`** = ***15***

The parameters **`Minimum value`** and **`Maximum value`** are initially calculated by DIGSI 5 on the basis of the tap coding, the **`Number of tap positions`** and the **`Tap-display offset`**. They represent the allowed control area of the position value. Positions outside this area are defined as invalid. This control area can be further restricted within the initially set physical range (see **`Number of tap positions`** and **`Tap-display offset`**).

Parameter: `Tap-display offset`

- Default setting **`Tap-display offset`** = ***0***

If you want to move the height of the displayed value in a positive or the negative direction with respect to the height of the actual value, enter the value for this in the **`Tap-display offset`** field.

Parameter: `Number of bits f. tap code`

- Default setting **`Number of bits f. tap code`** = ***4***

With the **`Number of bits f. tap code`** parameter, you set the number of bits you need for encoding the transformer taps. The number is dependent on the selected **Encoding** and on the **Moving contact**. For example, you need 3 bits for 7 binary-encoded transformer taps. The range of values extends from 2 to 32.

Parameter: `Number of tap positions`

- Default setting **`Number of tap positions`** = ***`15`***

With the **`Number of tap positions`** parameter, you set the number of transformer taps. The range of values extends from 2 to 127. The output of the tap position is limited from -63 to +63. If the number of taps is > 63, set the **`Tap-display offset`** parameter so that the output of the tap position is within the range of -63 to +63.

Parameter: `Tap-coding type`

- Default setting **`Tap-coding type`** = ***`binary`***

In the **`Tap-coding type`** list box, select the interpretation type of the indication pending at the binary input.
You can select from the following options:

- ***`binary`***
- ***`1-of-n`***
- ***`BCD`***
- ***`table`***
- ***`BCD signed`***
- ***`gray`***

The tap changer position can also be routed via a GOOSE signal (BSC) or a 20-mA measuring transducer input.
You can find more information on this in the document **Measuring the transformer tap changer using an analog measuring transducer input in SIPROTEC 5** in the Download area under *`SIPROTEC 5 and DIGSI 5 downloads`* → *`SIPROTEC 5 General`* → *`Application Notes`* → *`Control`*.
A selection of tap-coding types is described in greater detail using examples in the following text.

Routing of the Binary Inputs (Tap-Coding Type binary)

The following table shows the routing of 3 binary inputs (BI 1 to BI 3) with 4 transformer tap positions designated 3 to 6. BI4 is the moving contact. The encoding is in ***`binary`***.

Table 7-27 Routing of the Binary Inputs (Tap-Coding Type binary)

	Example					
	BI1	BI2	BI3	BI4	BI5	BI6
Tap changer	X	X	X	X	–	–
Meaning	Bit 1	Bit 2	Bit 3	Moving contact	–	–
Tap = 1	1	0	0		–	–

With 3 binary inputs, a maximum of 2^3 -1 = 7 tap positions can be mapped in binary code. If all routed binary inputs indicate 0, this is interpreted as a connection error and is reported by Position **---** or **-64** with quality **invalid**. The representation of transformer taps should start with the metered value 3. You must configure the information properties as follows for the example:

Tap-coding type:	binary
Number of tap positions:	7
Number of bits f. tap code:	4
Tap-display offset:	2
Moving contact (highest binary input):	Yes

The 3 binary inputs must be numbered sequentially, for example, BI 1, BI 2, BI 3, and BI 4 for the moving contact.

Routing of the Binary Inputs (Tap-Coding Type BCD)

The following table shows the routing of 6 binary inputs (BI 1 to BI 6) with 39 transformer tap positions designated 1 to 39. The encoding is in ***BCD***. BI 7 is the moving contact.

Table 7-28 Routing of the Binary Inputs (Tap-Coding Type BCD)

	Example						
	BI1	BI2	BI3	BI4	BI5	BI6	BI7
Tap changer	X	X	X	X	X	X	X
Meaning	BCD 1	BCD 2	BCD 4	BCD 8	BCD 10	BCD 20	Moving contact
Tap = 21	1	0	0	0	0	1	–

With 6 binary inputs, a maximum of 39 tap positions can be mapped with the tap-coding type of BCD. This yields the number of tap positions from 1 to 39. If all routed binary inputs indicate 0, this is detected as tap 0. The 7 binary inputs must be numbered sequentially, for example, BI 1, BI 2, BI 3, BI 4, BI 5, BI 6, and BI 7 for the moving contact.

Tap-coding type:	BCD
Number of tap positions:	39
Number of bits f. tap code:	7
Tap-display offset:	0
Moving contact (highest binary input):	Yes

Individual Tap-Coding Type (table)

With the ***table*** parameter setting, you can specify an individual **Tap-coding type**.

In the **Representation of encoding** section, select the number system in which your code table entries will take place, alternatively:

- ***Binary (2 characters)***
- ***Octal (8 characters)***
- ***Decimal (10 characters)***
- ***Hexadecimal (16 characters)***

The selected option is valid for all inputs in the **Encoding** column.

If you change the number system and there are already entries in this column, these will be converted to the new number system. The selection area becomes visible as soon as you have selected the setting ***table*** in the **Tap-coding type** list box.

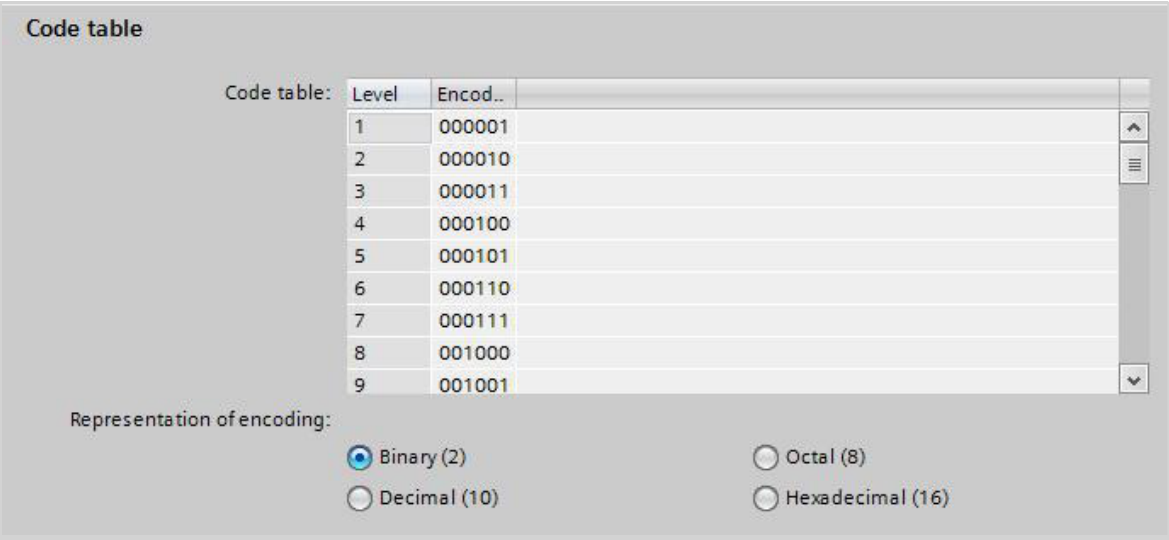


Figure 7-105 Code Table for the Tap-Coding Type table

NOTE

If the binary inputs used for encoding are all inactive, this indicates an invalid tap position (regardless of the display offset). For an invalid tap position, the display shows the position **---** or **-64** with quality **invalid**, exception BCD signed, see *Routing of the Binary Inputs (Tap-Coding Type BCD signed), Page 1954*.

Enter the encoding for the tap in the **Encoding** column in the **Code table**. Enter the value according to the number system previously selected. Select the desired number of taps and number of bits for tap coding. Taps with the same encoding and taps with 0 coding are not permitted.

Routing of the Binary Inputs (Tap-Coding Type BCD signed)

The following table shows the routing of 3 binary inputs (BI 1 to BI -3) with 7 transformer tap positions designated 3 to 3. The encoding uses ***BCD signed***.

Table 7-29 Routing of the Binary Inputs (Tap-Coding Type BCD signed)

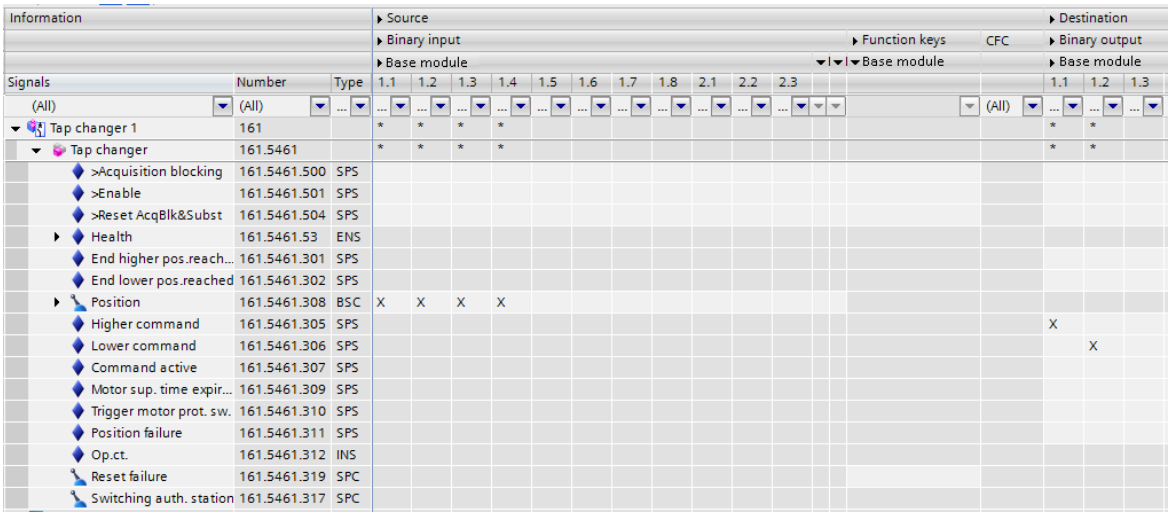
	Example					
	BI1	BI2	BI3	BI4	BI5	BI6
Tap changer	X	X	X	–	–	–
Meaning	BCD 1	BCD 2	Sign	–	–	–
Tap = 1	1	0	1	–	–	–

Using 3 binary inputs, a maximum of 7 tap positions can be mapped with the tap coding type of BCD signed. This yields the number of tap positions from -3 to 3. If all routed binary inputs indicate 0, this is recognized as tap 0. The 3 binary inputs must be numbered sequentially.

Tap-coding type:	BCD signed
Number of tap positions:	7
Number of bits f. tap code:	3
Tap-display offset:	0
Moving contact (highest binary input):	No

Routing the Tap Position to Binary Outputs

For the output of the adjusting commands, route the information **step up** and **step down** on one relay each, see following figure.



Information			Source														Destination		
			Binary input											Function keys	CFC		Binary output		
			Base module											Base module			Base module		
Signals	Number	Type	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.1	2.2	2.3				1.1	1.2	1.3
(All)	(All)														(All)				
Tap changer 1	161		*	*	*	*											*	*	
Tap changer	161.5461		*	*	*	*											*	*	
>Acquisition blocking	161.5461.500	SPS																	
>Enable	161.5461.501	SPS																	
>Reset AcqBlk&Subst	161.5461.504	SPS																	
Health	161.5461.53	ENS																	
End higher pos.reach...	161.5461.301	SPS																	
End lower pos.reached	161.5461.302	SPS																	
Position	161.5461.308	BSC	X	X	X	X													
Higher command	161.5461.305	SPS															X		
Lower command	161.5461.306	SPS																X	
Command active	161.5461.307	SPS																	
Motor sup. time expir...	161.5461.309	SPS																	
Trigger motor prot. sw.	161.5461.310	SPS																	
Position failure	161.5461.311	SPS																	
Op.ct.	161.5461.312	INS																	
Reset failure	161.5461.319	SPC																	
Switching auth. station	161.5461.317	SPC																	

[sc_trass7, 1, en_US]

Figure 7-106 Routing the Tap Setting Commands

Parameter: `Moving contact (highest binary input)`

- Default setting **`Moving contact (highest binary input)`** = ***no***

If the tap position is only to be recognized as valid and implemented when the motor sliding contact signals that it has reached the taps, then activate the **`Moving contact (highest binary input)`** option. If this parameter is set, the new position is only labeled with an ***** when the moving contact drops out.

Parameter: `Software filter time`

- Default setting **`Software filter time`** = ***1000 ms***

With this parameter, you set the **`Software filter time`** for capturing the tap position. The range of values extends from 0 ms to 100 000 ms. Within this time, brief changes on the binary inputs are suppressed.

Parameter: `Retrigger filter`

- Default setting **`Retrigger filter`** = ***Yes***

With this parameter, you switch retriggering of the filtering time by a position change on or off.

Parameter: `Indication timestamp before filtering`

- Default setting **`Indication timestamp before filtering`** = ***no***

With this parameter, you specify whether the hardware filtering time is accounted for in the time stamp of position capture.

Parameter: `Chatter blocking`

- Default setting **`Chatter blocking`** = ***no***

With this parameter, you switch **`Chatter blocking`** on or off.

7.8.3 Settings (Properties Dialog)

The settings listed here can only be reached and changed by way of the **Properties** dialog of the **Position** Controllable.

Addr.	Parameter	C	Range of Values	Default Setting
General Information				
-	Minimum value		Calculated	-
-	Maximum value		Calculated	-
-	Tap-display offset		–63 to +63	0
-	Number of bits f. tap code		2 to 32	4
-	Number of tap positions		2 to 63	15
-	Tap-coding type		• binary • 1-of-n • BCD • table • BCD signed • gray	binary
Software filter				
-	Software filter time		0 ms to 100 000 ms	1000 ms

NOTE

You can find more detailed information on the process monitor in chapter *5.5.4 Process Monitor (FG Line)*.

7.8.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Control				
_:104	Tap changer:Check switching authority		• no • yes • advanced	yes
_:108	Tap changer:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:109	Tap changer:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:110	Tap changer:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Tap changer				
_:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s
_:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block

Addr.	Parameter	C	Setting Options	Default Setting
_:113	Tap changer:Motor supervision time		5 s to 100 s	10 s
_:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap
_:114	Tap changer:Lowest tap position		-64 to 64	1
_:115	Tap changer:Highest tap position		-64 to 64	15
Switching authority				
_:117	Tap changer:Swi.dev. related sw.auth.		• 0 • 1	false
_:118	Tap changer:Specific sw. authorities		• 0 • 1	true
_:119	Tap changer:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:120	Tap changer:Num. of specific sw.auth.		2 to 5	2
_:121	Tap changer:Multiple specific sw.auth.		• 0 • 1	false

7.8.5 Information List

No.	Information	Data Class (Type)	Type
Tap changer			
_:500	Tap changer:>Acquisition blocking	SPS	I
_:501	Tap changer:>Enable	SPS	I
_:507	Tap changer:>Sw. authority local	SPS	I
_:508	Tap changer:>Sw. authority remote	SPS	I
_:509	Tap changer:>Sw. mode interlocked	SPS	I
_:510	Tap changer:>Sw. mode non-interl.	SPS	I
_:504	Tap changer:>Reset AcqBlk&Subst	SPS	I
_:53	Tap changer:Health	ENS	O
_:301	Tap changer:End higher pos.reached	SPS	O
_:302	Tap changer:End lower pos.reached	SPS	O
_:308	Tap changer:Position	BSC	C
_:305	Tap changer:Higher command	SPS	O
_:306	Tap changer:Lower command	SPS	O
_:307	Tap changer:Command active	SPS	O
_:309	Tap changer:Motor sup. time expired	SPS	O
_:310	Tap changer:Trigger motor prot. sw.	SPS	O
_:311	Tap changer:Position failure	SPS	O
_:312	Tap changer:Op.ct.	INS	O
_:313	Tap changer:Switching authority	ENS	O
_:314	Tap changer:Switching mode	ENS	O
_:319	Tap changer:Reset failure	SPC	C

No.	Information	Data Class (Type)	Type
_:317	Tap changer:Switching auth. station	SPC	C
_:320	Tap changer:Enable sw. auth. 1	SPC	C
_:321	Tap changer:Enable sw. auth. 2	SPC	C
_:322	Tap changer:Enable sw. auth. 3	SPC	C
_:323	Tap changer:Enable sw. auth. 4	SPC	C
_:324	Tap changer:Enable sw. auth. 5	SPC	C

7.9 Voltage Controller

7.9.1 Overview of Functions

The transformer voltage controller functionality (ANSI 90V) is used to control power transformers (two-winding transformers, three-winding transformers, grid coupling transformers) and auto transformers using a motor-operated tap changer. In addition, the voltage control can be used for two-winding transformers connected in parallel.

The function provides automatic voltage control within a specified voltage range on the secondary side of the transformers or, as an alternative, at a remote load point (Z compensation or R/X compensation) in the network. In order to compensate for the voltage variations in the meshed system, use the ***LDC-Z*** procedure (Z compensation). For voltage drops on the line, use the ***LDC-XandR*** procedure (R/X compensation).

The control principle is based on the fact that a higher or lower adjusting command to the tap changer, as a function of the voltage change (ΔV) per tap, causes a voltage increase or decrease.

The voltage control operates on a tap-for-tap basis and compares the measured actual voltage (Vact) with the specified target voltage (Vtarget). If the voltage difference is greater than the set bandwidth (B), a higher or lower adjusting command is sent to the tap changer once the set time delay (T1) has elapsed. Specifying the time delay (T1) depends on the set controller response (inverse or linear), so as to avoid unnecessary adjusting commands during brief voltage deviations from the target value and for coordination with other automatic voltage controllers in the system.

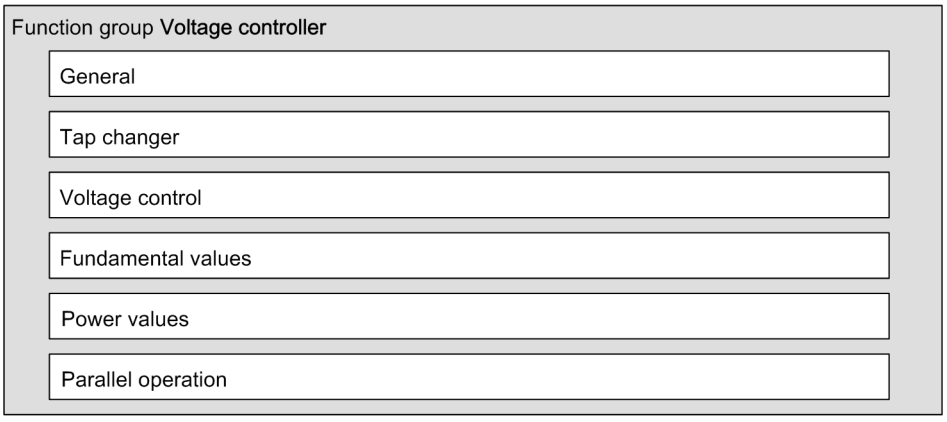
The voltage controller function also monitors the currents on the upper-voltage side and the low-voltage side of the transformer to block the voltage controller during impermissible operating states (overcurrent/under-current/undervoltage). The voltage controller function also has limiting values that, in special operating cases, suppress higher adjusting commands in the case of overvoltage and lower adjusting commands in the case of undervoltage.

You can also use the voltage controller function for parallel control of up to 8 two-winding transformers in different groups. You can carry out parallel control based on the Master-Follower method or using circulating reactive current minimization method. You can find more detailed information about parallel control in *7.9.3.9 Parallel Operation*.

7.9.2 Structure of the Function

The **Two-winding transformer voltage controller**, **Three-winding transformer voltage controller**, and **Grid coupling transformer voltage controller** function groups consist of 5 function blocks. Depending on the application, the function groups are preconfigured in the relevant application template by the manufacturer or can be copied into the corresponding device project during engineering.

The following figure shows, for example, the functional scope of the **Two-winding transformer voltage controller** function group.



[dwvolctl-060913-01.vsd, 3, en_US]

Figure 7-107 Structure/Embedding of the Function Group

The functions **General** (GAPC), **Tap changer** (YLTC), and **Voltage controller** (ATCC) are logical node points in IEC 61850-8-1.

The tap changer (YLTC) is the interface between the voltage controller (ATCC) and the motor-operated tap changer of the transformer (OLTC). This means that the voltage controller (ATCC) sends higher and lower adjusting commands to the tap changer. This tap changer issues command pulses to the motor-operated tap changer of the transformer (OLTC). The tap changer (YLTC) measures the tap positions and monitors the action of the motor-operated tap changer (OLTC).

The **Parallel control** function is needed for the parallel operation of 2 to 8 transformers. The **Parallel control** function can only be instantiated in the **Voltage controller** function group.

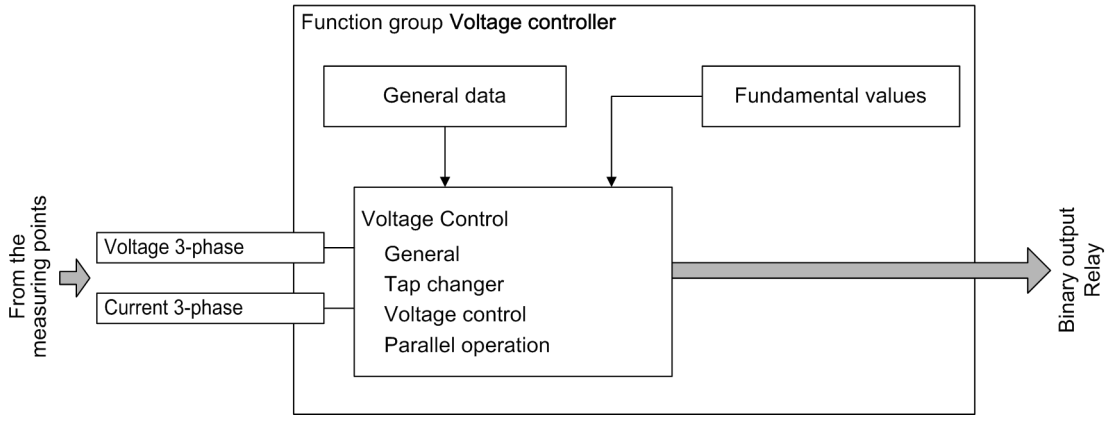
The function group has interfaces to the following measuring points:

- **Two-winding transformer**:
  - Voltage, 3-phase
  - Current, 3-phase (optional)
- **Three-winding transformer**:
  - 2 x voltage, 3-phase
  - 2 x current, 3-phase (optional)
- **Grid coupling transformer**:
  - 2 x voltage, 3-phase
  - 2 x current, 3-phase

Optionally, you can assign the tap changer to a **Transformer side** function group. In this way, the current of the upper-voltage side is also monitored and the differential protection pickup blocks the voltage controller automatically.

The **Voltage controller (ATCC)** function group operates only with a 3-phase voltage connection and uses the positive-sequence voltage as control variable. Due to power-system unbalances, the positive-sequence voltage provides a more stable value. For version 8.01 and higher, you can select the control variable, depending on the connection type, via a selection parameter in the **Voltage controller** function group.

Figure 7-108 shows these interfaces as a block structure.



[dwvocnti-060913-01.vsd, 3, en_US]

Figure 7-108 Structure of the Voltage Control Function Group

You can find the information and functional measured values of the voltage controller in the DIGSI routing matrix.

7.9.3 Function Description

7.9.3.1 General

If the load is increased in an electricity-supply system, the voltage is reduced and vice versa. The power transformers are usually equipped with transformer tap changers (OLTC) so as to keep the power-system voltage at a constant level.

As a result, the transformer ratio is changed in predefined steps. Changes to the transformer taps cause the voltage to change.

The Voltage control function is intended to control transformers with motor-operated transformer tap changers.

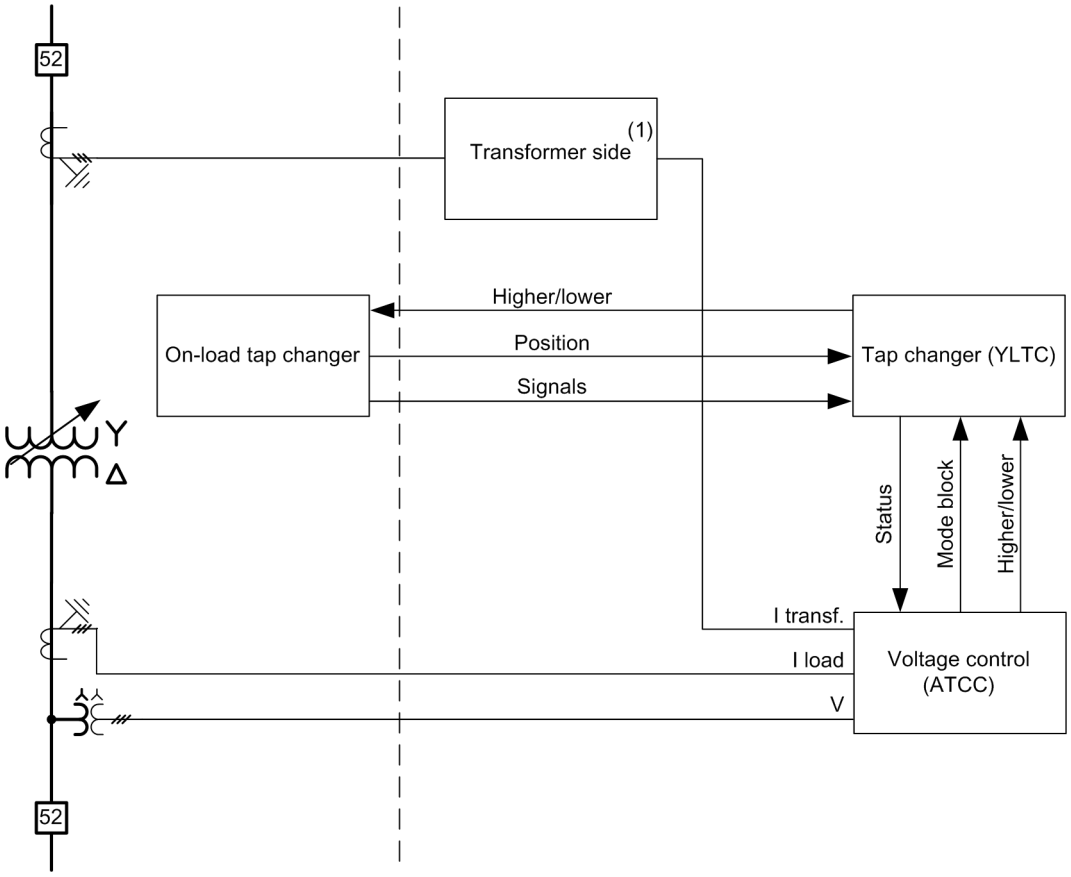
This function is designed to control the following:

- For two-winding transformers (2W): the voltage on the secondary circuit of the power transformer and parallel control of several transformers feeding the same busbar or a nodal point of a system
- For three-winding transformers (3W): the voltage of the secondary winding 1 or winding 2
- For grid coupling transformers (GC): voltage of winding 1 or winding 2, selectively depending on the power direction

Control operation is based on a step-by-step principle. To move the tap changer one position higher or lower, a single control pulse is issued to the motor-drive mechanism of the tap changer. The length of the control pulse can be set over a large range so as to handle the different types of tap-changer drives. The control pulse is issued if the measured voltage deviates from the set reference value by more than the preset voltage range for more than a given time period.

The voltage can be controlled at the voltage measuring point or at the load point in the electrical power system. In this case, the load-point voltage is calculated on the basis of the measured load current and the known impedance between the voltage measuring point and the load point.

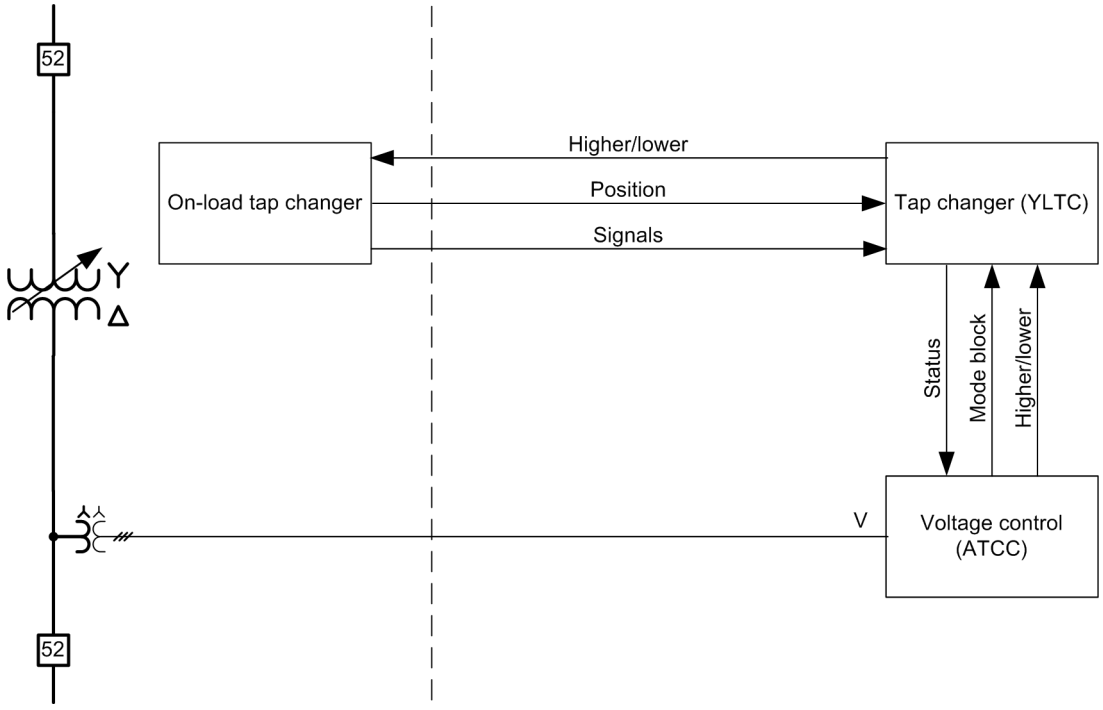
The following figures show possible configurations of the voltage controller for two-winding transformers with and without current measurement.



[dwkonlst-060913.vsd, 1, en_US]

Figure 7-109 Voltage-Controller Constellation for Two-Winding Transformers with Current Measurement for Load Compensation at the End of the Line

(1) Only if a transformer side is present



[dwkonlsK-060913.vsd, 1, en_US]

Figure 7-110 Voltage-Controller Constellation for Two-Winding Transformers without Current Measurement

Three-Winding Transformers

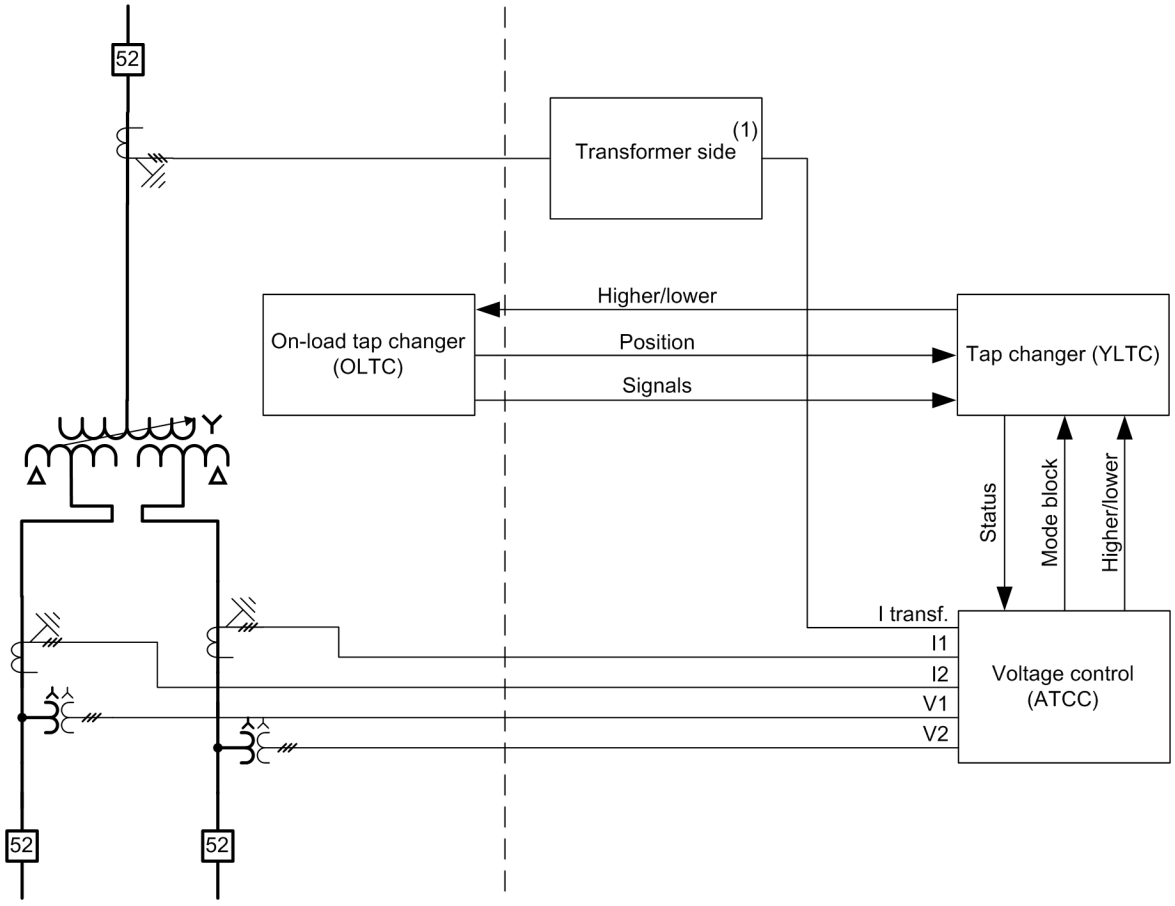
Three-winding transformers are special power transformers that have 2 separate windings on the secondary circuit and typically supply 2 different busbars. The voltage levels on the secondary circuit of the power transformers can either be the same or different. In addition to designs with 2 tap changers on the secondary circuits, in most cases, three-winding transformers are equipped with only one tap changer or on-load tap changer on the primary side. It is therefore necessary to feed both voltages of the secondary windings to the voltage measuring inputs (V1, V2) and to specify one of them, depending on the busbar situation, to the voltage controller as the control variable.

The voltages of side 1 and 2 of the three-winding transformer are simultaneously monitored. In the process, the voltage to be controlled can be automatically selected via the load current of both sides or by using one parameter. This parameter is the settings group switching via binary input, protocol, or function keys. The uncontrolled voltage can be monitored in parallel to ensure that it remains within the defined voltage limits.

If a current measuring point is assigned to a function group, the voltage to be controlled can be automatically selected dependent on the load.

For automatic on-load tap changing, the voltage of the transformer side into which the larger load current flows is controlled. The respective uncontrolled voltage is monitored for undervoltage and overvoltage.

In contrast to overvoltage on the controlled side, for overvoltage on the uncontrolled side, the higher adjusting command is blocked and no fast step down to a lower tap occurs. In case of undervoltage on the uncontrolled side, the lower adjusting commands are blocked if this behavior is activated for undervoltage supervision.



[dw_V-constell-3wind-with-imeas.vsd, 2, en_US]

Figure 7-111 Voltage-Controller Constellation for Three-Winding Transformers with Current Measurement for Load Compensation at the End of the Line

(1) Only if a transformer side is available

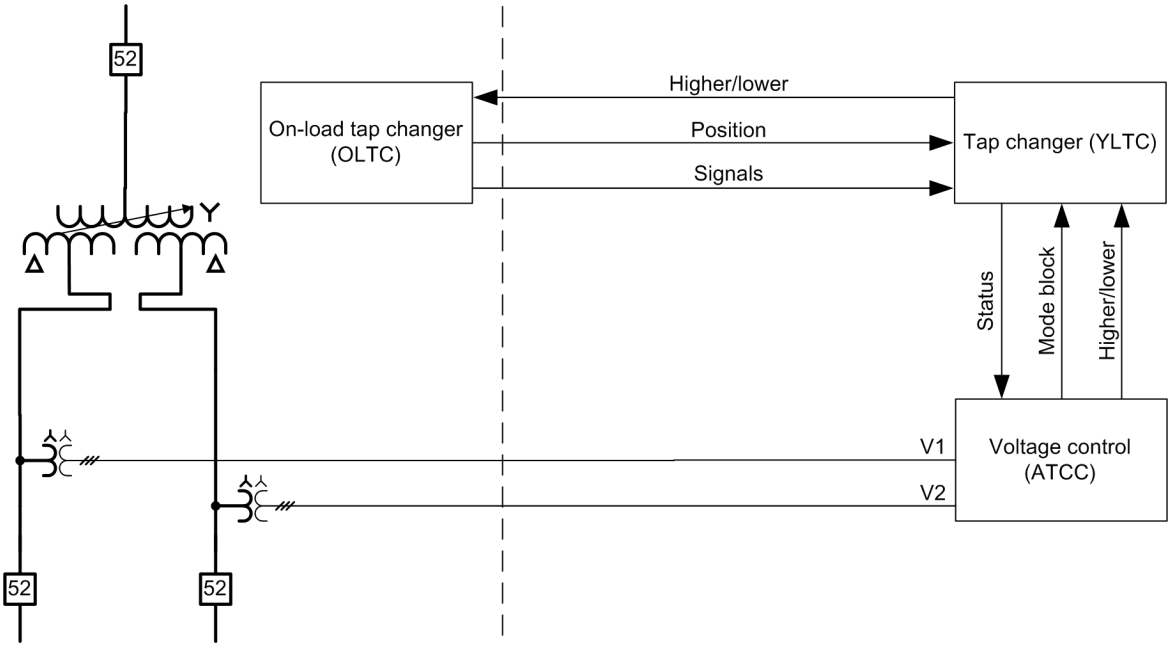
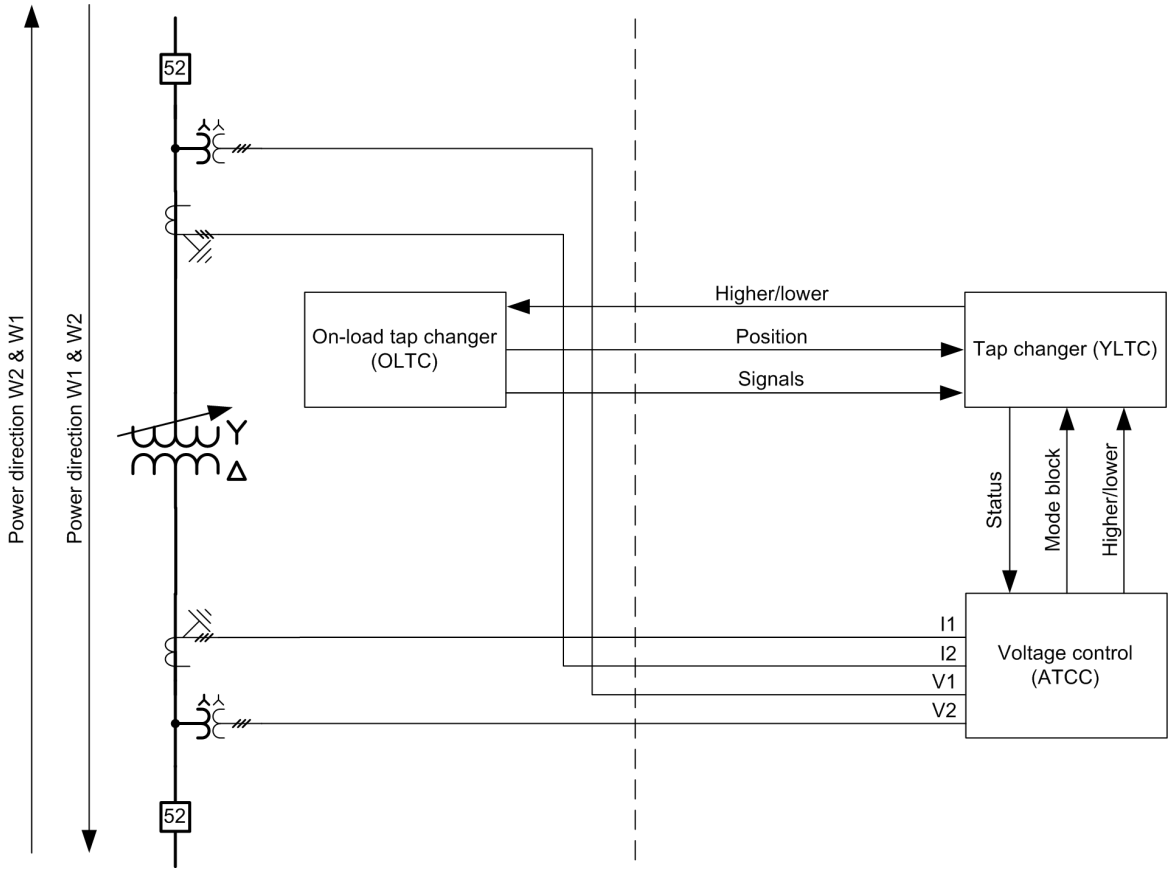


Figure 7-112 Voltage-Controller Constellation for Three-Winding Transformers without Current Measurement

Grid Coupling Transformers

Grid coupling transformers are special power transformers that connect 2 electrical power systems to one another. The load-side voltage is controlled. The power flow can change during operation. That is why both voltages and currents, winding 1 and winding 2, voltage measuring inputs (V1, V2) and current measuring inputs (I1 and I2) must be fed. A voltage must be specified as a function of the load situation to the voltage controller as the control variable.

The voltages of the windings 1 and 2 of the grid coupling transformers are simultaneously monitored. In the process, you can select the voltage to be controlled using one parameter. This parameter can be changed using the settings group switching via the binary input, protocol, or function keys.



[dw_V-constell-2wind-coupl-transf.vsd, 1, en_US]

Figure 7-113 Voltage-Controller Constellation for Grid Coupling Transformers

On-Load Tap Changer

On-load tap changers are used to set the desired tap of a stepped winding of the transformer while under load. During switchover, the desired tap of the stepped winding is first selected by means of the tap selector. Next, the on-load tap changer switches over from the current-carrying tap to the selected tap. During this switchover, one tap of the stepped winding is briefly bridged by an ohmic resistor so that the load switchover takes place without current interruption. Physically, the tap changer is installed in the transformer tank or in a separate tank.

Tap Changer

The **Tap changer** function issues the adjusting commands to the on-load tap changer and receives the corresponding feedback. The function of the tap changer inside the voltage controller corresponds to that of the separate tap changer. The higher and lower adjusting commands are generated by the voltage controller. The **`Check switching authority`**, **`Control model`**, **`SBO time-out`**, and **`Feedback monitoring time`** parameters are set only in the voltage controller.

You can find more information in chapter *7.9.4.1 General*.

Voltage Controller

The Voltage controller function controls the voltage within the bandwidth and within the set voltage limits. Using the **`Mode`** parameter, you can turn the voltage controller on or off or set it for test mode.

With the **`Number of target voltage`** parameter, you can specify up to 4 target voltages. You can only activate one of these target voltages at a time using function key, communication, or a binary input. Use the **`Set point mode active`** parameter to specify a valid target voltage via a communication network.

If the voltage controller is switched off, adjusting commands cannot be given to the tap changer in automatic operation or in manual operation. The set on-site or remote switching authority is independent of this.

You can set the voltage controller operating mode using the **Operating mode** parameter or the **Operating mode** command to automatic operation or manual operation. In automatic operation, the voltage is controlled automatically in accordance with the set parameters.

Three-Winding Transformer Voltage Controller

For the two-winding transformer voltage controller, the measurands that are used to manage the feedback control are permanently defined.

With the voltage controller for the three-winding transformer, these measurands can be specified using one parameter (parameter **Winding selection** = ***Winding 1*** or ***Winding 2***) or they can be automatically selected (**Winding selection** = ***WithMaxLoad***).

The winding is automatically selected by evaluating the load current in the windings. If the load current in one of the two windings is greater than the load current in the other winding by 5 % of the rated current for 10 s, then the winding voltage is controlled using the larger load current.

Grid Coupling Transformer Voltage Controller

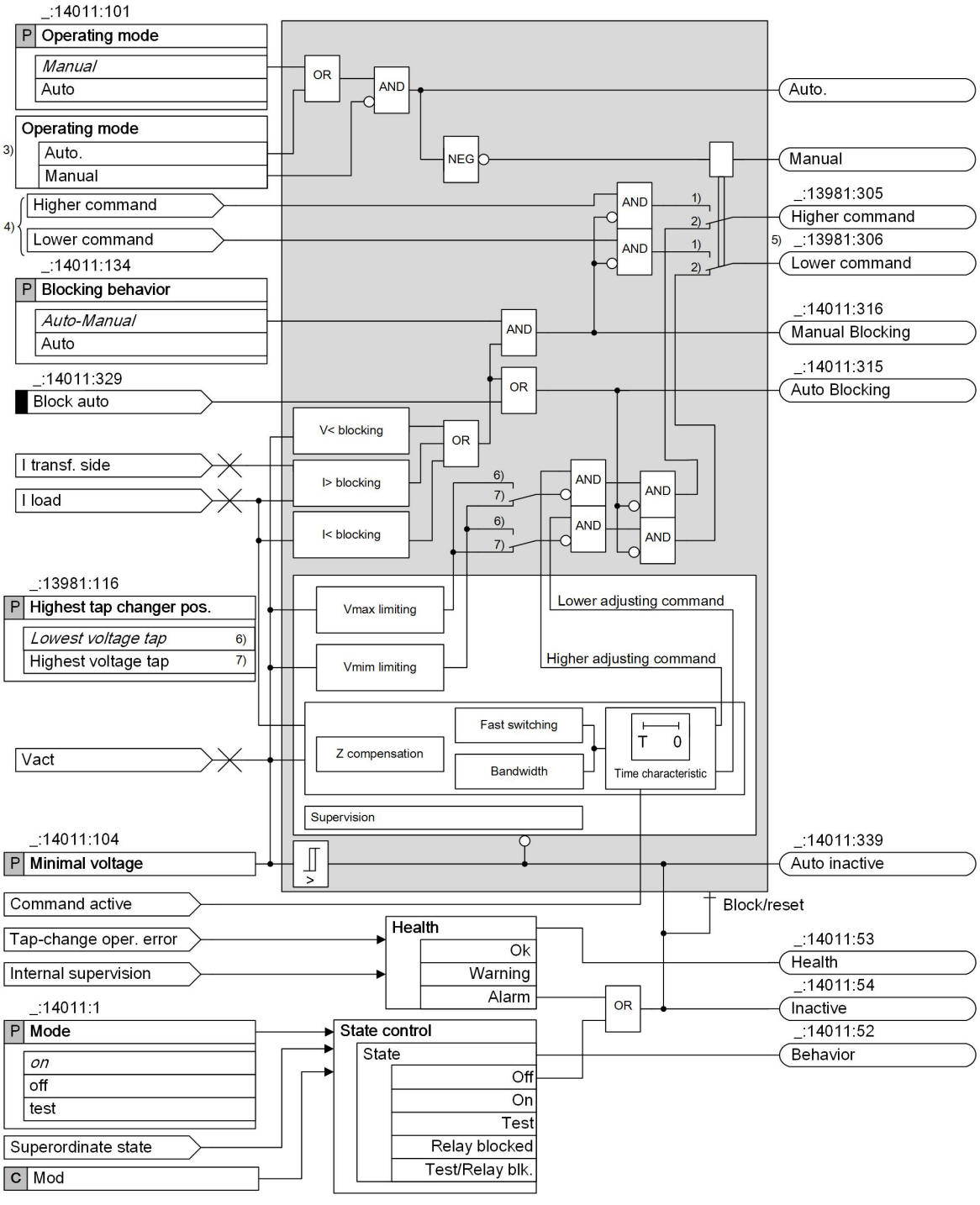
For the two-winding transformer voltage controller, the measurands that are used to manage the feedback control are permanently defined.

With the grid coupling transformer voltage controller, these measurands can be selected using a parameter (parameter **Winding selection** = ***Winding 1*** or ***Winding 2***).

You can change the winding selection during operation using the settings group switching.

You can monitor the power-flow direction. If the difference in the power of ***Winding 1*** and ***Winding 2*** is greater than 10 % of the rated power on the control side, the indication *Power-flow superv.* appears and the function switches to alarm status.

7.9.3.2 Logic of the Function



[lo_volt-control, 7, en_US]

Figure 7-114 Superordinate Logic of the Voltage Controller

1) Manual operation
2) Automatic operation
3) Controllable
4) Command
5) Position and motor supervision (*7.8.1 Function Description*)

In accordance with the IEC 61850 standard, DOI LTCBlk (**Block automatic operation** command), automatic control can be blocked with a command.

The voltage controller measures the actual voltage (Vact) and compares it to the target voltage (Vtarget). If the difference between the measured voltage (control deviation D) is greater than the set bandwidth (B), a higher or lower adjusting command is sent to the tap changer once the set time delay (T1) has elapsed.

You can change the settings for control during operation with the settings group switching.

You can switchover the settings groups via the following alternatives:

- Via the on-site operation panel directly on the device
- Via an online DIGSI connection to the device
- Via binary inputs
- Via a communication connection to substation automation technology (IEC 60870-5-103, IEC 61850)

You can find more information on this in chapter *3.11.1 Settings-Group Switching*.

Measuring-Voltage Selection

The control measurand can be selected, depending on the connection type, via a selection parameter in the **Voltage controller** function group. The associated current is automatically selected for the set voltage type.

The load voltage calculated for the line compensation is likewise influenced by selection with the **`Measured value`** parameter. The load current (I_{load}) and the voltage to be controlled at the transformer are replaced according to the following table:

$$V_{load}\,[\%] = \sqrt{\left[V_{Bus}\,[\%] - \frac{\sqrt{3}\cdot I_{load}\cdot(R\cos\varphi + X\sin\varphi)}{V_{rated,obj.}}\cdot 100\,\%\right]^2 + \left[\frac{\sqrt{3}\cdot I_{load}\cdot(X\cos\varphi - R\sin\varphi)}{V_{rated,obj.}}\cdot 100\,\%\right]^2}$$

[fo_vload_in_percent, 1, en_US]

	Measured value	Load current	Control voltage	Angle
Connection type	V_1	I_1	$\sqrt{3}\cdot V_1$	$\varphi = \varphi_{V1} - \varphi_{I1}$
Phase-to-ground V_A, V_B, V_C	V_A	I_A	$\sqrt{3}\cdot V_A$	$\varphi = \varphi_{VA} - \varphi_{IA}$
	V_B	I_B	$\sqrt{3}\cdot V_B$	$\varphi = \varphi_{VB} - \varphi_{IB}$
	V_C	I_C	$\sqrt{3}\cdot V_C$	$\varphi = \varphi_{VC} - \varphi_{IC}$
Phase-to-ground V_A, V_B, V_C	$V_{A\text{-}B\ calc}$	I_A	Calculated $V_{A\text{-}B}$	$\varphi = \varphi_{VA} - \varphi_{IA}$
	$V_{B\text{-}C\ calc}$	I_B	Calculated $V_{B\text{-}C}$	$\varphi = \varphi_{VB} - \varphi_{IB}$
	$V_{C\text{-}A\ calc}$	I_C	Calculated $V_{C\text{-}A}$	$\varphi = \varphi_{VC} - \varphi_{IC}$
Phase-to-phase $V_{A\text{-}B}$, $V_{B\text{-}C}$, $V_{C\text{-}A}$	$V_{A\text{-}B\ meas}$	I_A	Measured $V_{A\text{-}B}$	$\varphi = \varphi_{VA\text{-}VB} - \varphi_{xA} - \varphi_{IA}$
	$V_{B\text{-}C\ meas}$	I_B	Measured $V_{B\text{-}C}$	$\varphi = \varphi_{VB\text{-}VC} - \varphi_{xB} - \varphi_{IB}$
	$V_{C\text{-}A\ meas}$	I_C	Measured $V_{C\text{-}A}$	$\varphi = \varphi_{VC\text{-}VA} - \varphi_{xC} - \varphi_{IC}$

The angle φ_x is between the angles of the phase-to-phase voltage $\varphi_{VA\text{-}VB}$ and the phase-to-ground voltage φ_{VA}. If the 3-phase voltage is symmetric, then the angle $\varphi_x = 30°$. If the measured voltage is not symmetric, then you can use the following formula for calculating the angle φ_x:

$$\varphi_{xa} = \arccos\left[\frac{3V_{ab}^2 - V_{bc}^2 + V_{ca}^2}{2\cdot V_{ab}\sqrt{2(V_{ab}^2 + V_{ca}^2) - V_{bc}^2}}\right]$$

[fo_angle_bet_phases, 1, en_US]

7.9.3.3 Control Response

Control Deviation

The control deviation is calculated from the present actual voltage and the target voltage in relation to the rated voltage.

$$D = \frac{V_{act} - V_{target}}{V_{rated}} 100\ \%$$

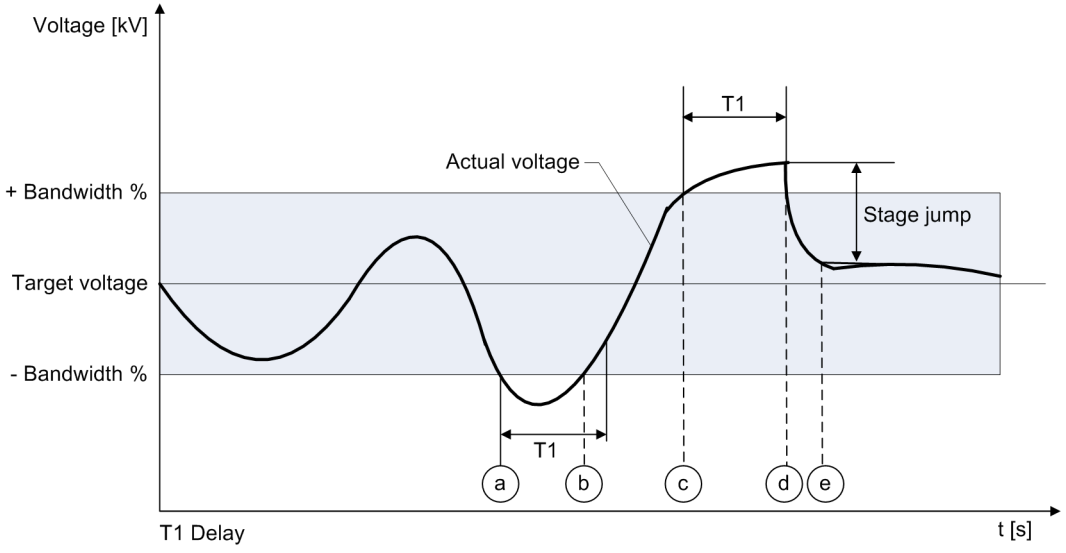
[fokonisk-211013, 2, en_US]

D = Control deviation

Bandwidth

To minimize the number of switching operations by the tap changer, a permitted bandwidth is defined. If the actual voltage is within the bandwidth, no adjusting control commands are issued to the tap changer. If the actual voltage exceeds the defined bandwidth, an adjusting command is issued after the set time delay **`T1 delay`**. If the actual voltage returns to the voltage range of the bandwidth before **`T1 delay`** elapses, no adjusting control command is issued.

If the actual voltage returns to the voltage range of the bandwidth within the time delay T1, the running time delay T1 continues to count down, starting at the already elapsed time. If the actual voltage returns again to the set bandwidth while the time is counting down, the time delay T1 is started at the remaining time. In this way, the time delay is reduced in the event of frequent violations of the lower limit of the bandwidth. With the **`Set point mode active`** parameter, you can specify a valid bandwidth via a communication network.



[dwistspn-060913-01.vsd, 1, en_US]

Figure 7-115 Actual-Voltage Curve during Control Deviation

(a) Actual voltage outside the bandwidth
(b) Actual voltage before T1 elapses within the bandwidth - no switching
(c) Actual voltage outside the bandwidth, T1 begins to elapse
(d) Actual voltage outside the bandwidth after T1, switching procedure initiated
(e) Switching procedure concluded, actual voltage within the bandwidth

Linear, Inverse

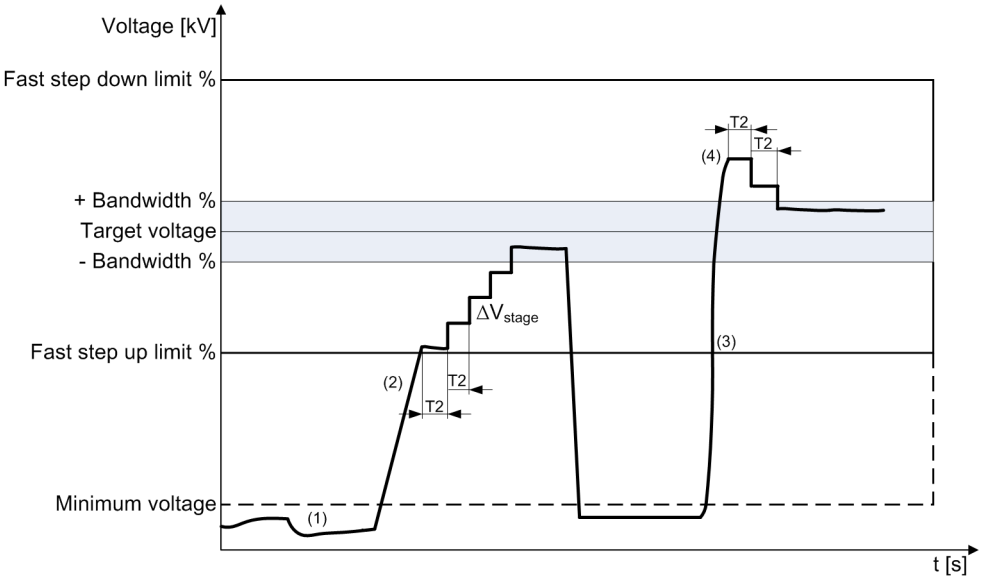
With **linear** control response, the voltage controller reacts independently of the control deviation after the set time **`T1 delay`**. If more than one tap-position change is required to bring the actual voltage back within the bandwidth, the set time **`T2 delay`** takes effect.

With **inverse** control response, the time **T1 delay** depends on the magnitude of the control deviation. Small deviations are tolerated for longer than larger ones. If the time delay is very small in accordance with the set characteristic curve, the time **T1 Inverse Min** takes effect.

The set **inverse** characteristic curve is a function of the parameter **T1 delay**. The characteristic curves arising for different settings of the time **T1 delay** are shown in chapter *7.9.4.1 General*, margin title Parameter: **T1 characteristic**.

Zero Potential or Voltage Recovery

If the actual voltage is not within the defined bandwidth after a voltage recovery, it can be necessary for the voltage controller to send the 1st adjusting command with the T2 time. For this purpose, the parameter **Regulate with T2 at start** must be activated.



[dw_istgro-130215, 1, en_US]

Figure 7-116 Actual-Voltage Curve during Control with T2

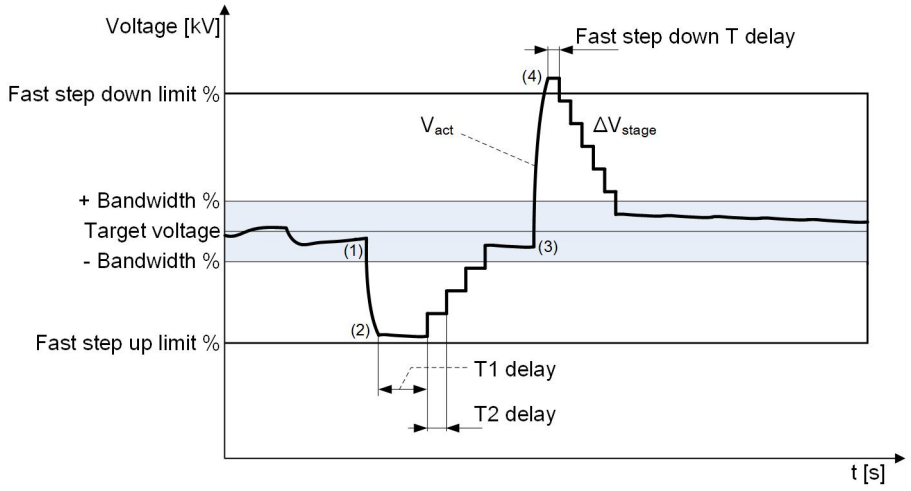
(1) Actual voltage below the minimum voltage

(2) After switching on, the change to a higher tap occurs with time T2

(3) After the voltage recovery, the actual voltage is above the bandwidth

(4) Actual voltage outside the bandwidth. A fast step down mode is carried out with the time T2 until the bandwidth is reached.

Larger Voltage Deviations



[dwistgro-060913-01.vsd, 3, en_US]

Figure 7-117 Actual-Voltage Curve During Larger Control Deviations

(1) Actual voltage outside the bandwidth

(2) The change to a higher tap occurs after T1 and then T2

(3) Actual voltage inside the bandwidth

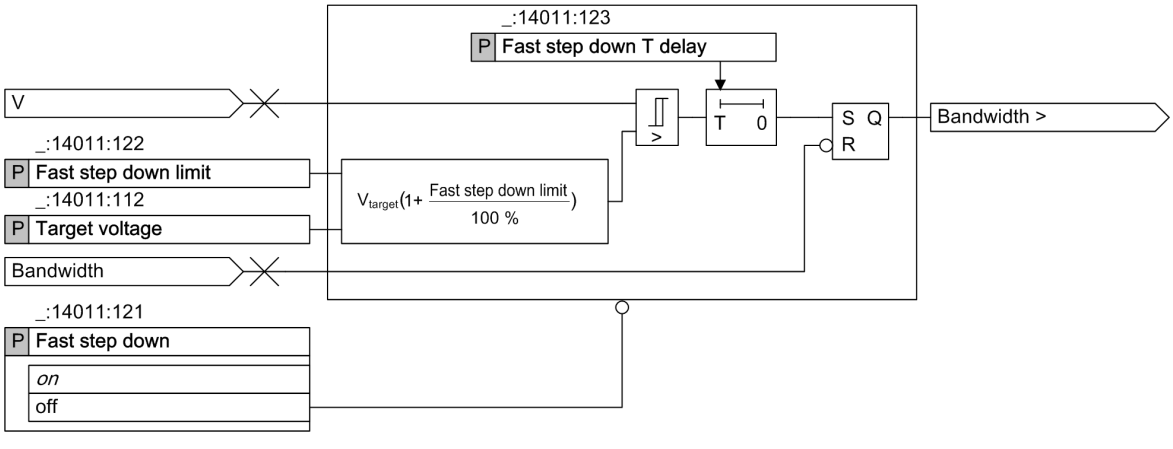
(4) Actual voltage outside the limit for a fast step down. A fast step down mode is carried out until the bandwidth is reached.

Fast Step Up Mode and Fast Step Down Mode

The fast step down mode and the fast step up mode allow a quick reaction to abnormal voltage situations. *Figure 7-117* shows such a situation at point (4). A fast step down mode occurs until the bandwidth has been reached. The tap-position time between 2 consecutive lower adjusting commands results from the following 2 conditions:

- The completion of a tap change command after the new valid position was detected
- The measurement time for capturing the new actual voltage

The activity of the fast step down mode and the fast step up mode is displayed with the indications *(_:14011:308) Fast Step Down active* and *(_:14011:307) Fast Step Up active*.



[losnlruk-090913-01.vsd, 2, en_US]

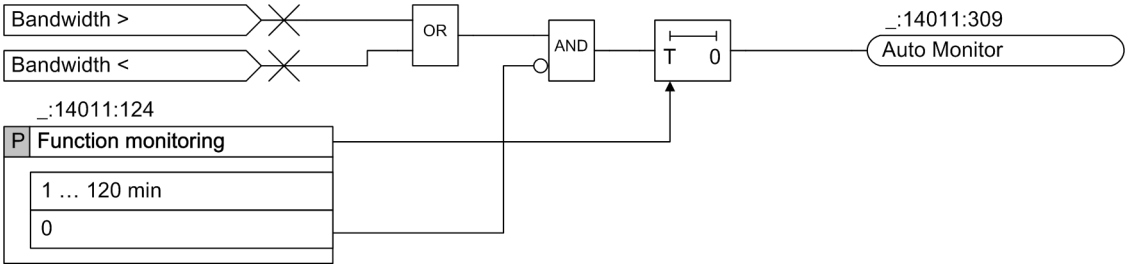
Figure 7-118 Logic of the Fast Step Down Mode

The fast step up mode works in a similar fashion.

7.9.3.4 Function Supervision

Automatic Operation

If the actual voltage exceeds or falls below the set bandwidth for longer than the set time delay, this situation is shown by the indication *(_:14011:309) Auto Monitor*. If the actual voltage returns to the voltage range, the indication is reset. You can switch off the function monitor with a time delay = 0 min.



[lofktueb-090913-01.vsd, 1, en_US]

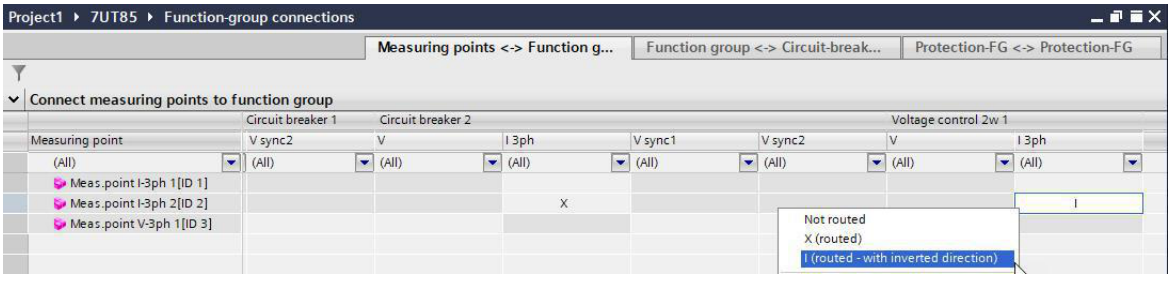
Figure 7-119 Logic of the Function Supervision for Automatic Operation

7.9.3.5 Dynamic Voltage Control (DVC)

The increasing use of renewable energy sources is a new challenge for the energy distribution system. The decentralized energy infeeds can lead to a change in the direction of the power flow, especially in medium-voltage systems. Thus, a strong infeed can lead to overvoltages in the individual nodal points and the limits according to the power-quality standard DIN EN 50160 can be reached. A dynamic procedure can be used to adapt the voltage target value. Thus, a voltage dip in case of higher load or a voltage increase due to decentralized infeed can be compensated.

*Figure 7-120*shows an example of an application. The decentralized generating units are in the medium-voltage and the low-voltage network. The active power is defined as positive (+P) in the direction of the medium-voltage busbar.

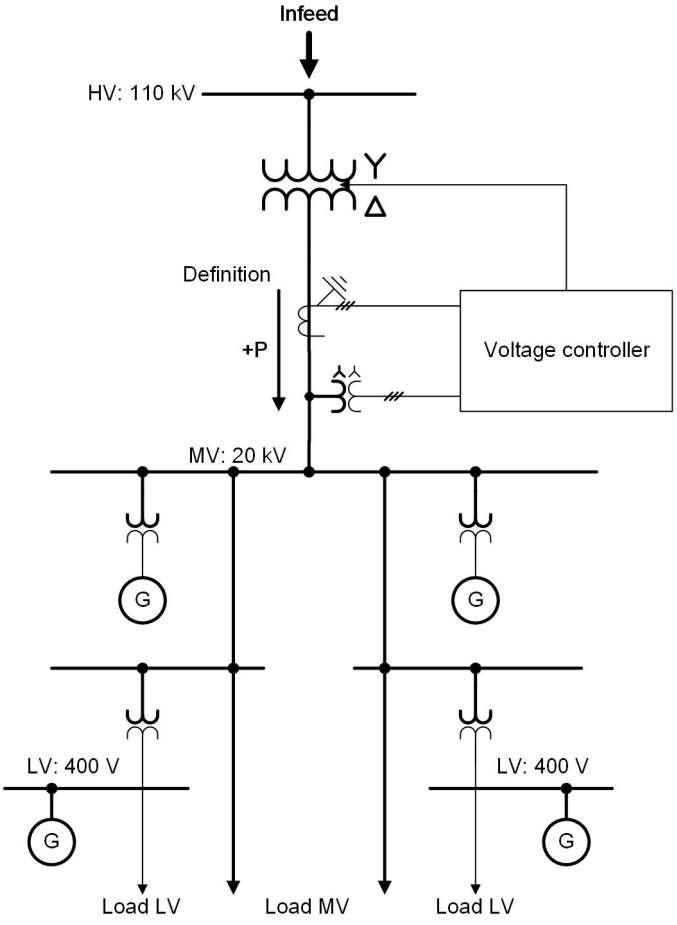
The direction of the current (neutral point of the transformer) is defined in the direction of the protected object transformer. If you use, for example, the LDC or the DVC method in the voltage controller, you must take into account the direction of the current for correct functioning.



[scfuncgrpconn-260221, 1, en_US]

Figure 7-120 Setting the Direction of the Current in the Function-Group Connections

To fit the definition of the power direction, in this case, the current measuring point must be inverted in the **Measuring-points routing** of DIGSI 5.



[dw_dsg-controller, 1, en_US]

Figure 7-121 Infeed Application Example

HS: High voltage
MS: Medium voltage
NS: Low voltage

If the transformer feeds into the medium-voltage system (+P), the voltage drops on the busbar depending on the load. According to the characteristic curve in *Figure 7-120*, the voltage controller ($V_{target\ comp} > V_{target}$ (with P = 0)) increases the voltage.

If the decentralized generating units have a high infeed, this can lead to a power reversal. The medium-voltage system now feeds into the high-voltage system. The high infeed increases the voltage on the medium-voltage busbar. In this scenario, the measured active power is negative (-P). According to the characteristic curve in *Figure 7-120*, the voltage controller ($V_{target\ comp} > V_{target}$ (with P = 0)) decreases the voltage.

With the dynamic voltage control (DVC), the voltage target value of the voltage controller is adapted via a characteristic curve depending on the power direction. Depending on the measured positive or negative active power, the calculation of the dynamic voltage target value $V_{target\ comp}$ is based on one of the 2 linear equations (see *Figure 7-120*).

NOTE

As a prerequisite for the dynamic voltage control (DVC), the voltage and current must be measured by the device. The dynamic voltage control cannot be activated in parallel to the LDC function or the paralleling function.

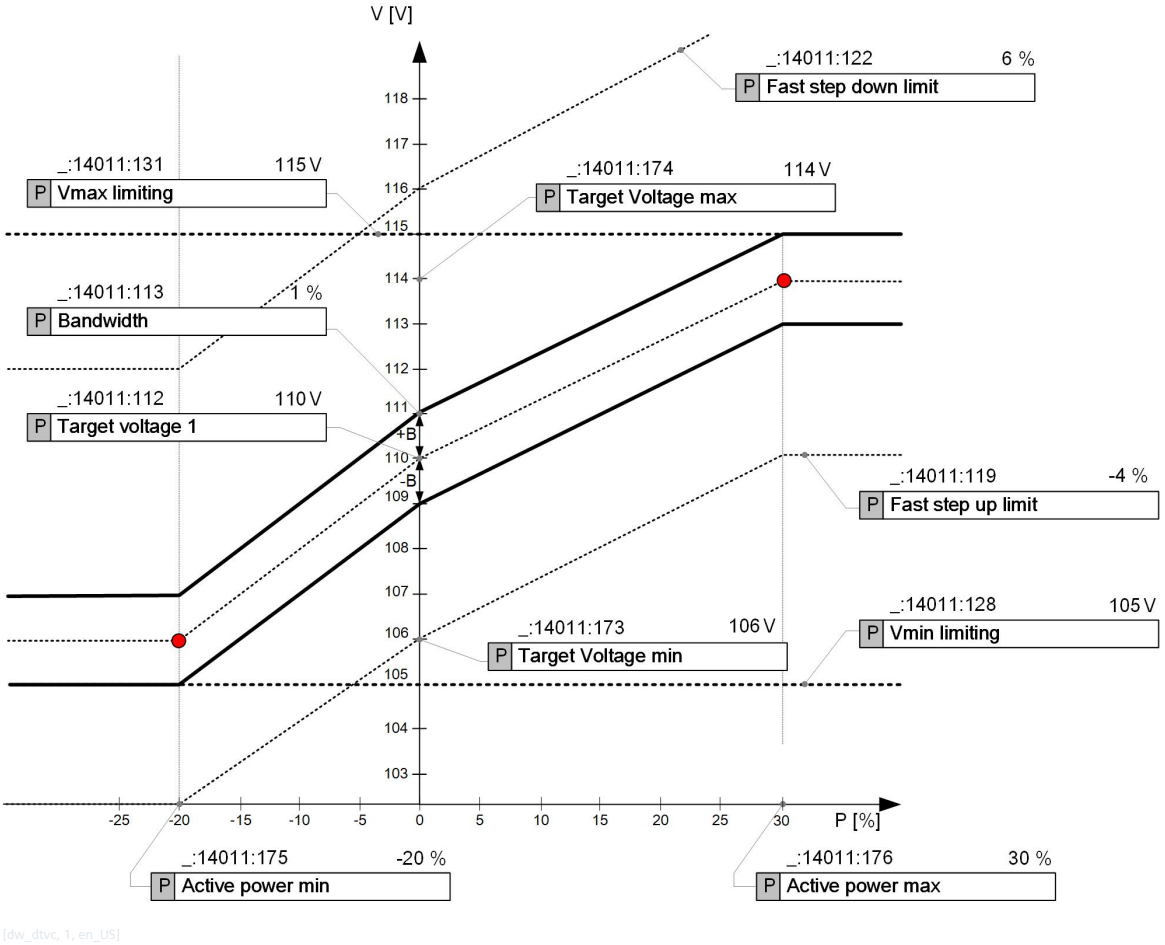


Figure 7-122 Characteristic Curve of the Dynamic Voltage Control

Behavior when Falling below Active power min (P_{min})

If the measured active power P_{meas} falls below the set value for P_{min}, the voltage value at P_{min} is taken as the current voltage target value:

$P_{meas} \leq P_{min} \Rightarrow V_{target\ min}$ is $V_{target\ comp}$

Behavior when Exceeding Active power max (P_{max})

If the measured active power P_{meas} exceeds the set value for P_{max}, the voltage value at P_{max} is taken as the current voltage target value:

$P_{meas} \geq P_{max} \Rightarrow V_{target\ max}$ is $V_{target\ comp}$

Behavior for a Measured Active Power P_{meas} = 0 MW

If the measured active power P_{meas} = 0 MW, the function takes the voltage target value V_{target} set in the voltage controller.

Linear Behavior of the Voltage Controller in Case of Negative Active Power

If the measured active power P_{meas} is in the range $P_{min} \leq P_{meas} \leq 0$, the value for the voltage target value is calculated as follows:

$$V_{target\ comp} = \left(\frac{V_{target} - V_{target\ min}}{0 - P_{min}}\right) \cdot P_{meas} + V_{target}$$

[fo_Vtargetcomp_Pmin, 2, en_US]

Linear Behavior of the Voltage Controller in Case of Positive Active Power

If the measured active power P_{meas} is in the range $0 \leq P_{meas} \leq P_{max}$, the value for the voltage target value is calculated as follows:

$$V_{target\ comp} = \left(\frac{V_{target\ max} - V_{target}}{P_{max} - 0}\right) \cdot P_{meas} + V_{target}$$

[fo_Vtargetcomp_Pmax, 1, en_US]

7.9.3.6 Line Compensation

When using line compensation, the voltage drop of a phase that is connected to a transformer can be included. In this case, 2 processes are available:

- Z compensation (LDC-Z)
- X and R compensation (LDC-XandR)



NOTE

Line compensation is only active if power is flowing in the direction of the line.

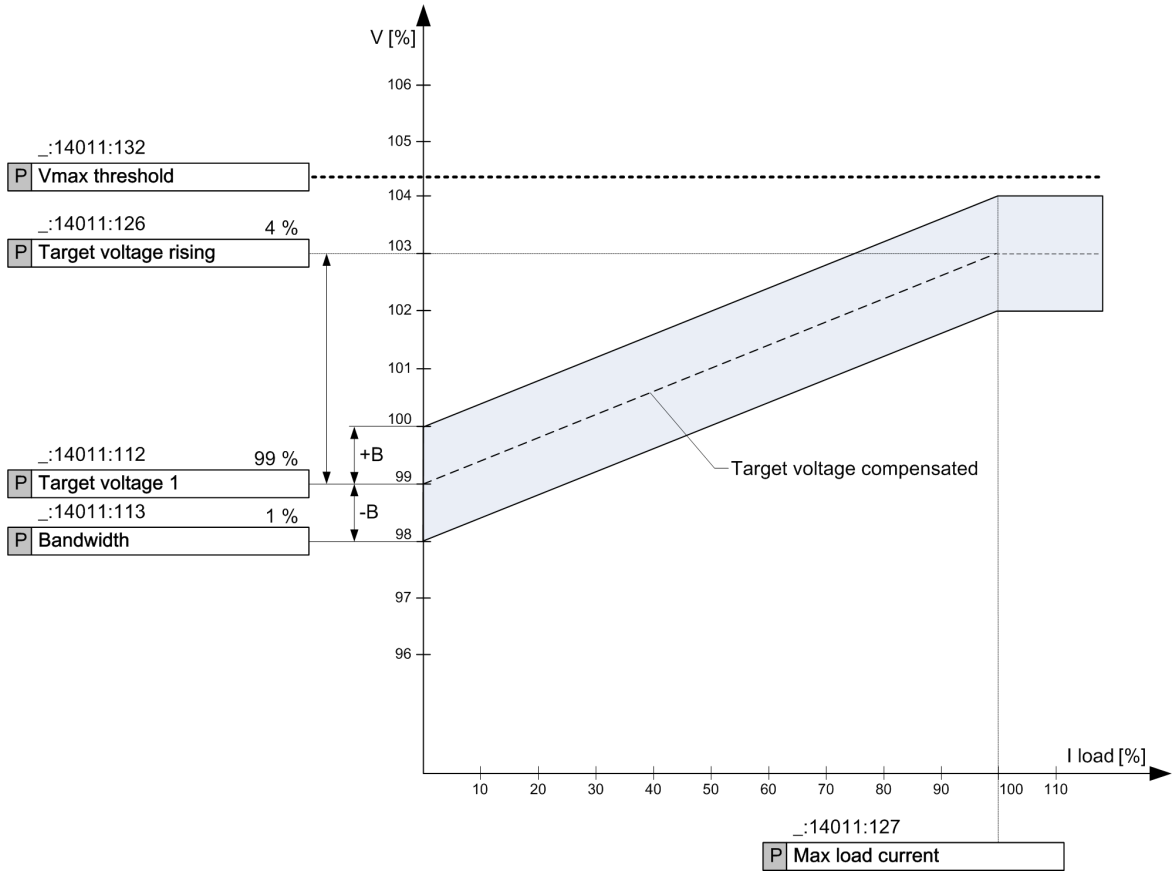
Z Compensation (LDC-Z)

Z compensation allows you to include the voltage drop of a line connected to the transformer. You can switch the **Z compensation** on or off. If cos φ is roughly constant, you can use the **Z compensation**. Setting the parameters requires the calculation of the voltage increase (**`Target voltage rising`**) taking into consideration the load current (**`Max load current`**).

The parameter **`Target voltage rising`** represents the voltage drop across the line as a % under rated load.

You can find more information and the calculation in chapter *7.9.4.1 General*.

In case of active **Z compensation**, you must limit the maximum permitted voltage increase in relation to the target voltage to avoid too high voltage at the transformer. To do this, set the parameter **`Max load current`**. In addition, the parameter **`Vmax threshold`** is active. If the actual voltage exceeds this threshold value, no more higher adjusting commands are issued.

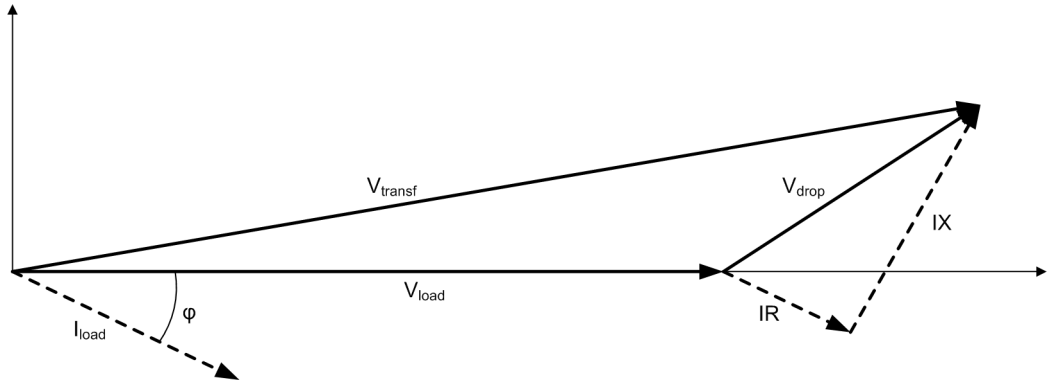


[dwregchr-090913-01.vsd, 3, en_US]

Figure 7-123 Control Characteristic with Z Compensation

X and R Compensation (LDC-XandR)

During the application of the **X and R compensation**, you need the phase data. With this data, it is possible to precisely compensate the voltage drop of the transmission lines. This method of line compensation also operates with negative active-power values. The following figure shows the effect of this compensation type.



[dw-line-drop-kompensation-250214-01.vsd, 2, en_US]

Figure 7-124 Phasor Diagram of the X and R Compensation

V_{transf}	Voltage on the transformer, voltage to be controlled
V_{load}	Voltage of load point (target voltage, $V_{load} = V_{transf} - V_{drop}$)
V_{drop}	Voltage drop of the phase
IR, IX	Voltage drop due to R and X of the line

I_{load}	Load current
φ	Rotor angle

You can also use **X and R compensation** for parallel control of transformers. If the X value is positive, the voltage losses of the phase are compensated. If you are implementing parallel control with **X and R compensation**, then the X value is negative and considers the voltage increase from the busbar to the transformer.

If the **X and R compensation** you must limit the maximum permitted voltage increase in relation to the target voltage in order to avoid a voltage at the transformer that is too high. To do this, set the parameter **`Vmax threshold`**. If the actual voltage exceeds this threshold value, no more higher adjusting commands are issued.

7.9.3.7 Limiting Values

The limiting values cause no higher or lower adjusting commands to be given to the tap changer in the event of an upper limit violation (**`Vmax threshold`**) or lower limit violation (**`Vmin threshold`**). In this way, changing taps under abnormal voltage conditions and changing taps in the incorrect direction (for example, in the event of wiring errors) is prevented.

The lower and upper tap changer limits are included in the limiting values. The parameters **`Lower tap-position limit`** and **`Higher tap-position limit`** cause an additional restriction of the control range.

7.9.3.8 Blockings

The blockings prevent tap positions under abnormal network conditions. The following blocking functions are available:

- Undervoltage
- Overcurrent, load current
- Overcurrent on one transformer side
- Undercurrent
- External blocking (binary input)
- Blocking command LTCBlock IEC 61850
- Blocking in the event of pickup of the transformer differential protection

Using the parameter **`Blocking behavior`**, you specify whether the blockings are to take effect only in automatic operation (***`Auto`***) or in both automatic and manual operation (***`Auto-Manual`***).

Overcurrent blocking prevents tap-change operations in the event of an overload. For the current blockings, the positive-sequence system of the load current and of the current on the upper-voltage side of transformers is calculated.

By assigning the tap changer to the transformer side, you also arrange the current of the upper-voltage side. Perform this assignment in the appropriate **Transformer side** function group (see *5.1.3 Function-Group Type Transformer Side*). Here, you must use the tap changer of the voltage controller.

Undervoltage blocking prevents tap-change operations in the event of a network collapse. The output signals of the voltage controller are blocked and, depending on the operating mode, the indication *`Auto Blocking`* and/or *`Manual Blocking`* is issued.

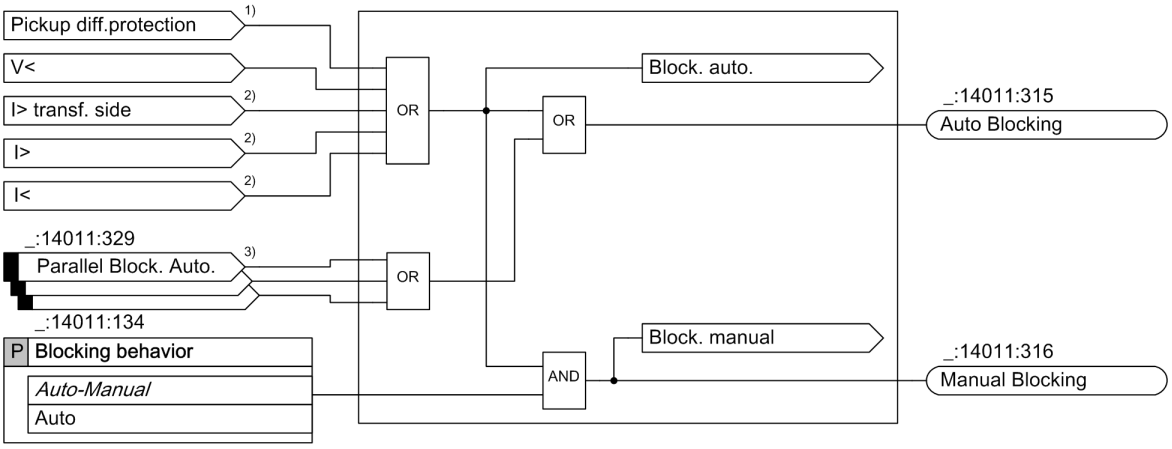


Figure 7-125 Logic Blockings

1) If transformer differential protection is available
2) If a current measurement is available
3) If parallel proxys are available (max. 7)

If assignment of the tap changer for the transformer side is available, the current of the upper-voltage side is also monitored and the differential-protection pickup automatically blocks the voltage controller.

Additional Blockings for the Three-Winding Transformer Voltage Controller

The blockings described in the above sections also apply to the controlled winding of the three-winding transformer. In addition, the blockings for undervoltage, minimum voltage, and overcurrent are used for the measurands of the uncontrolled side.

Additional Blockings for the Grid Coupling Transformer Voltage Controller

For voltage control in grid coupling transformers, the voltages and currents of both windings are always used for the blockings.

7.9.3.9 Parallel Operation

General

The parallel operation of 2 or more power transformers is intended to increase the electrical throughput or short-circuit power at a power-system node. An additional reason for the parallel operation of transformers is a reserve in the event of a failure of a transformer.

If power peaks are to be expected in the power system, multiple transformers can be connected in parallel on different busbars. This allows several feeders to be supplied simultaneously. You can control up to 8 transformers in parallel in one group. The evaluation of the measured and status values takes place via the IEC 61850 GOOSE communication.

If for the transformers used the tap positions differ, therefore creating a different transformation ratio, the no-load voltages on the low-voltage side will be different. A circulating reactive current flows via the transformers. Since the transformer impedance consists mainly of leakage inductance, the current is inductive. These currents can result in the overloading of the transformer.

The parallel operation is intended for two-winding transformers. For this application, additionally instantiate the function **Parallel operation**. For each of the transformers connected in parallel you need an additional function block **`ParallelProxy`**. The 1st **`ParallelProxy`** is preinstantiated. For a configuration with 8 transformers working in parallel, you can instantiate a maximum of 7 **`ParallelProxy`**. The exchange of the necessary information takes place via this proxy. 8 transformers can be configured to a maximum of 4 groups.

For the **Parallel operation** the following 2 methods are available:

- **Master-follower method**
- **Method of minimizing the circulating reactive current**

Table 7-30 Conditions for the Use of Both Methods

Requirements for the Transformers			Requirement for the Voltage Controller		Method
Voltage change per tap	Rated power	Short-circuit voltage deviation	Current measurement	Tap position	
Same	Same or different	<10 %	Optional	Necessary	Master/Follower
Different	Same or different	Different	Necessary	Recommended	Minimizing circulating reactive current

As the preceding table shows, before selecting the method, you must check whether the corresponding requirements are met. If you place transformers in parallel, whose short-circuit voltages differ by more than 10 % from each other, then Siemens recommends the **Method of minimizing circulating reactive current**.

Control of the Function

You can control the **Parallel operation** function using setting values or commands.

	Parameters	Values
With setting values	Parallel mode	Master, No mode, Follower, Circulat. react current
	Parallel mode changeable	by setting, controllable
	Force master changeable	by setting, controllable
With command	Parallel operation (ParOp)	independent, parallel
	Set master (ForceMast)	off, on
	Parallel groups (ParGrp)	1 to 4

The state of the control is reported as:

- No mode
- Independent
- Master
- Follower
- Circulating reactive current

If the **Parallel operation** is connected via the communication to further transformers, the state is checked for correctness. If this is not the case, an inconsistency indication is output. The communication to the transformers of a group is also monitored. If a fault is present, this is reported.

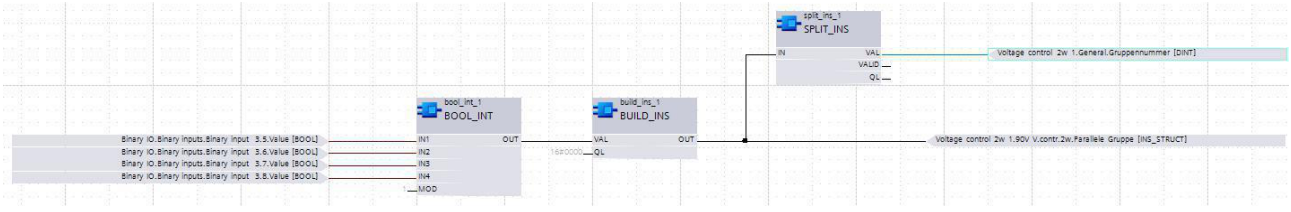
Voltage control 2w 1	162	
General	162.2311	
Tap changer	162.13981	
90V V.contr.2w	162.14011	
Fundamental	162.1501	
Power values	162.2261	
90V Parallel operat.	162.2721	
ParallelProxy1	162.2721.1...	
Health	162.2721.1...	ENS
Behavior	162.2721.1...	ENS
Parallel mode active	162.2721.1...	SPS
Parallel Auto Blocking	162.2721.1...	SPS
Error tap difference	162.2721.1...	SPS
Remote Health	162.2721.1...	INS
>Block	162.2721.1...	SPS
Parallel operation	162.2721.1...	SPC
Parallel group	162.2721.1...	INC
Remote parallel mode	162.2721.1...	INS
Operating mode	162.2721.1...	SPC
Cmd. with feedback	162.2721.1...	BSC
Remote para. transf. id	162.2721.1...	INS
V act.	162.2721.1...	MV
1/X trf.	162.2721.1...	MV
I load	162.2721.1...	MV
PhAng	162.2721.1...	MV
ParallelProxy2	162.2721.1...	

[sc_infogroup, 1, en_US]

Figure 7-126 Assigned Control Modules in Information Routing

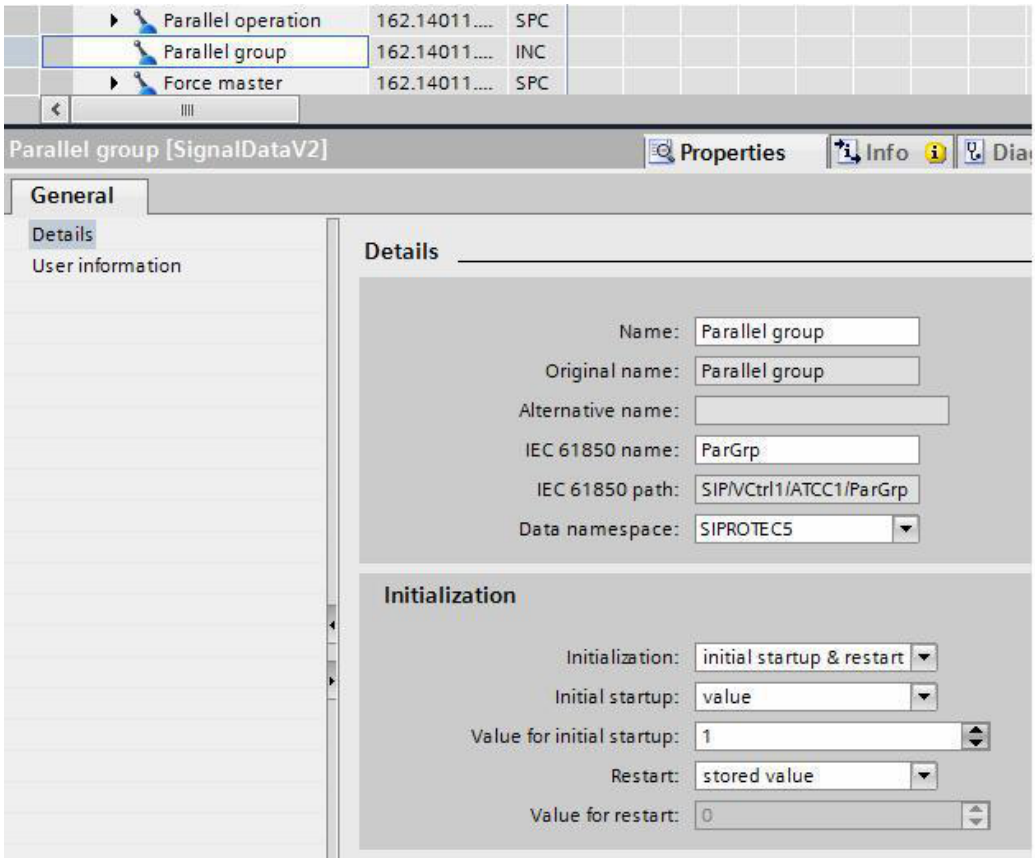
Grouping

Each transformer in the parallel operation is assigned to a group. The group number can be set by a superordinate control system or locally using a CFC logic. Once the group assignment is fixed, enter a value for the initial start via the Properties tab of the command **`Parallel group`** in the information routing of DIGSI 5.



[sccfcgrouprel, 1, en_US]

Figure 7-127 CFC Chart for Group Assignment and Group Display

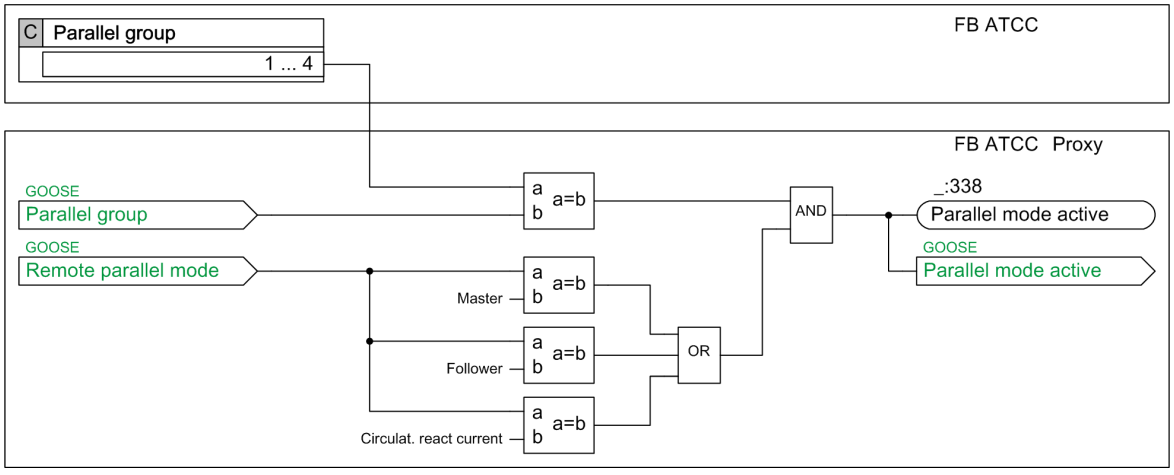


[sc_para_grouping_vc, 1, en_US]

Figure 7-128 Properties Tab of the Parallel Group

During operation you can change this assignment by command, depending on the switching state of the transformers.

Logic of the Function



[lo_proxy-logic-part_01, 1, en_US]

Figure 7-129 Grouping Logic

Parallel-Operation Detection via Group Inputs

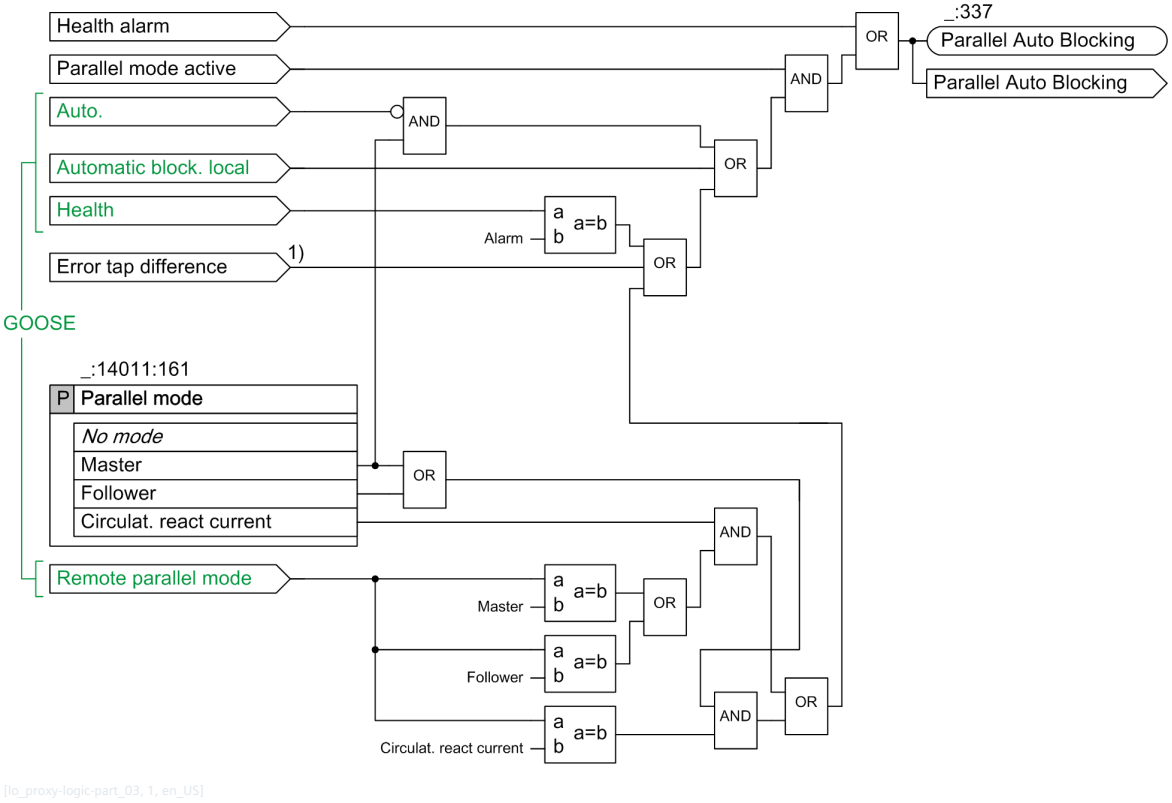
You can control up to 8 transformers in parallel in one group or in 4 groups without detecting the system topology. The devices in parallel operation use exclusively the information transmitted from devices of the

same parallel-operation group via GOOSE. The groups of the transformers to be controlled in parallel are set and changed using the control **Parallel group**, where you assign the device to a parallel-operation group. This can be done *remotely* or *locally* on the device. If ***No mode*** is set for the parallel operation, no group assignment takes place.

Parallel-Operation Detection via Topology

In addition, you have the option to detect the group assignment in parallel operation based on the position of the disconnectors and circuit breakers. To report its status, every disconnector and circuit breaker is equipped with a circuit-breaker auxiliary contact. These binary signals can be processed in a CFC chart and dynamically adapted to the switching state of the system.

The signals *Parallel group*, *Remote parallel mode* and *Parallel mode active* are transmitted via the GOOSE communication between the other transformers in the group.



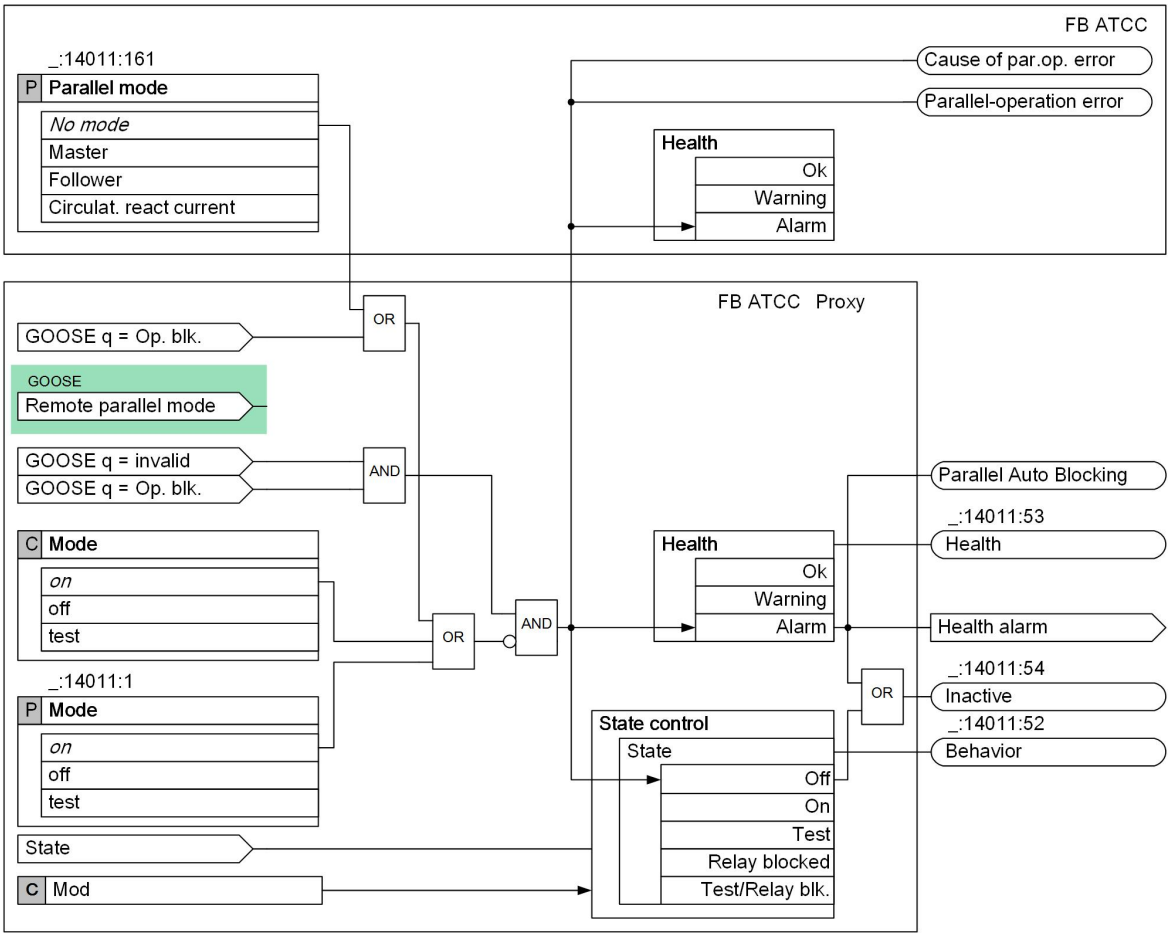
[lo_proxy-logic-part_03, 1, en_US]

Figure 7-130 Logic of the Blocking of Automatic Operation in the ParallelProxy

1) Only applies to the **Master-follower method**

The signals *automatic operation*, *automatic-block. local*, *Health* and *Remote parallel mode* are transmitted via the GOOSE communication between the other transformers in the group.

If the other voltage controllers in the group are set to the mode ***No mode*** or the communication is disturbed, the automatic operation is blocked. The blocking is reported. If a fault in the tap position is detected via the difference in the tap positions of the transformers, the indication *Error tap difference* is issued.



[lo_proxy-logic-part_02, 2, en_US]

Figure 7-131 Logic of the Parallel-Operation State Detection

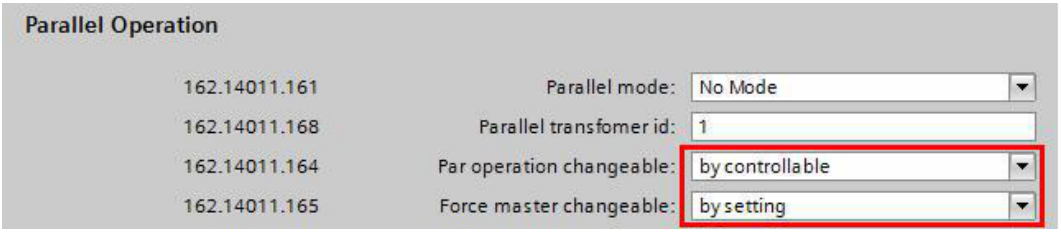
Controlling Locally/Remote

The parallel operation can be done with a parameter or via the control. With the parameter setting ***controllable***, you can also use a binary input and the status signal of a circuit breaker with a CFC block (*Figure 7-134*).

First, for the control of the **Parallel operation**, set the parameters **`Parallel mode changeable`** and **`Force master changeable`**.

You can select one of the 2 options:

- ***by setting***
- ***controllable***

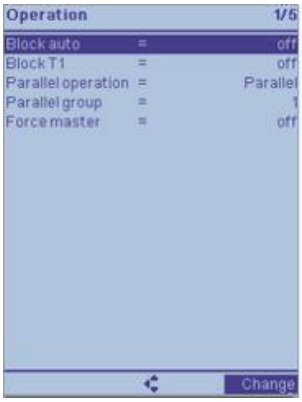


[sc_para_oper_change, 1, en_US]

Figure 7-132 Selection for Parallel Operation

If you set **`Parallel mode changeable`** to ***`controllable`***, you can read and change the settings for the parallel operation on the device under the following path:

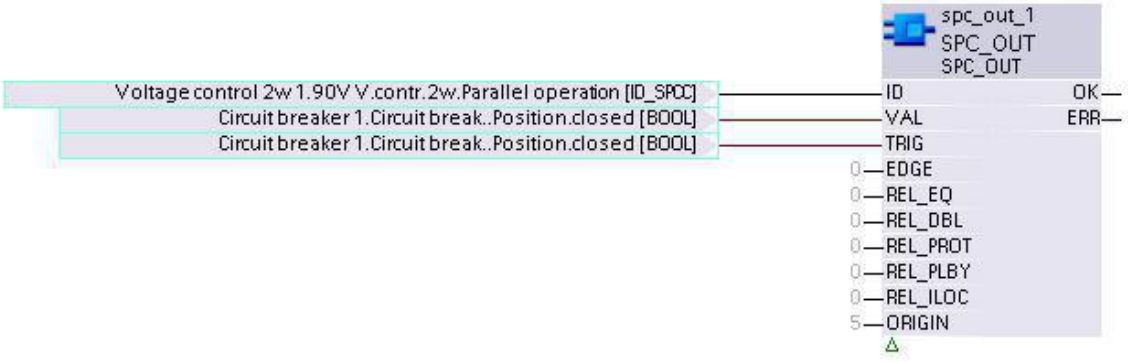
- Main menu → Commands → Functionality → Voltage cont. 2w1 → Operation



[sc_para_hmi_oper, 1, en_US]

Figure 7-133 Menu Item for Parallel Operation on the Device Display

Figure 7-134 shows an example of a CFC chart for switching to parallel mode via the binary input of the circuit breaker.



[sc_switchparop_cfc, 1, en_US]

Figure 7-134 CFC Chart

Master-Follower Method

As a prerequisite for the application of this method, the following values must be almost equal:

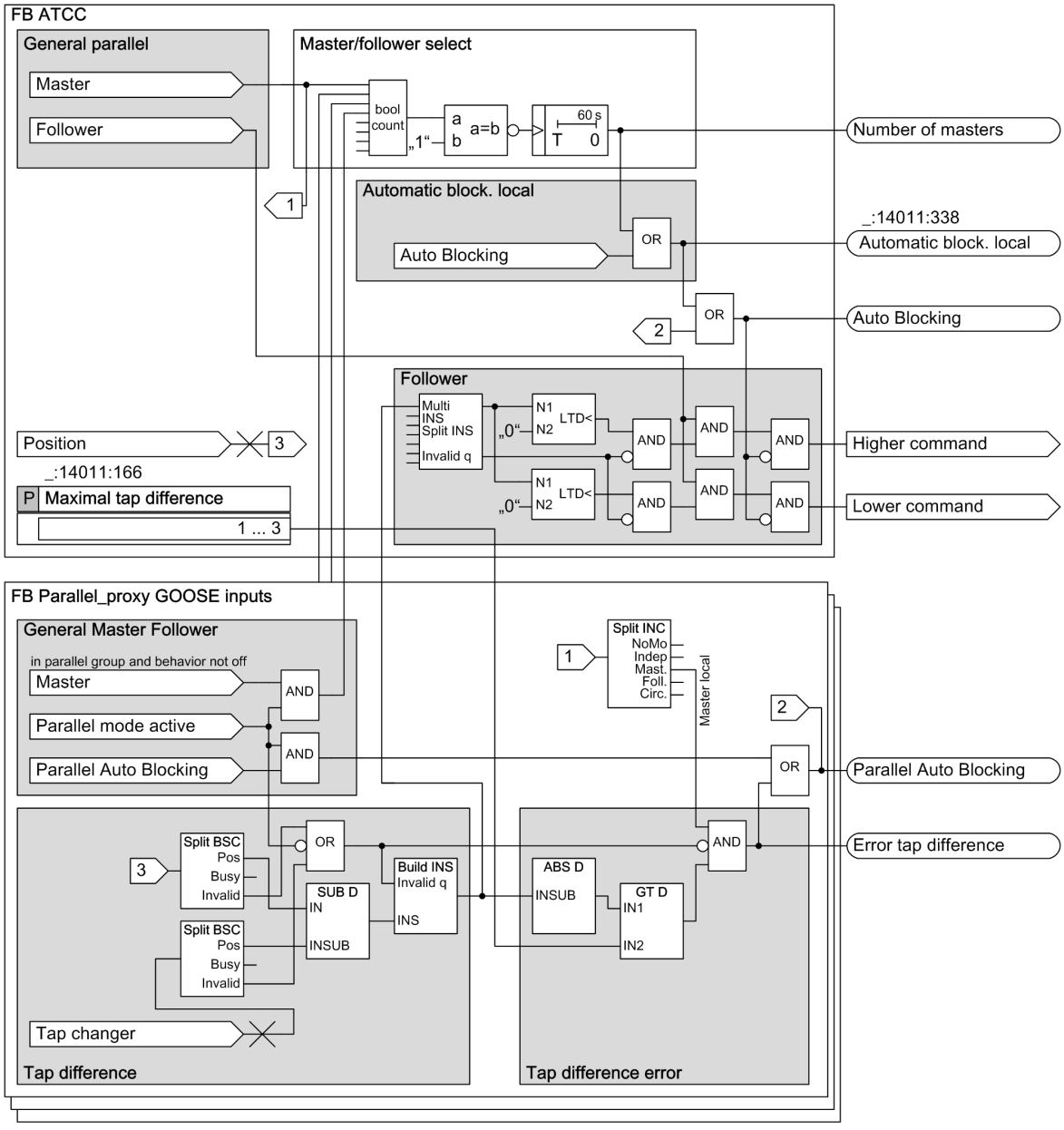
- Transformation ratios of the transformers used
- Number of the taps
- Voltage differential between the taps

The **Master-Follower method** regulates the Follower devices to the same tap position as the Master transformer. One voltage controller takes the lead (Master device), whilst the other voltage controllers (Follower devices) follow its tap position (Master-Follower method). The Master device controls the busbar voltage automatically according to the same principles of the available voltage-controller functionality for a two-winding transformer. Compared with the Master-Slave method, this method has the advantage that losing a higher/lower adjusting command (for example due to communication loss or auxiliary-voltage failure of the Follower device) does not result in asynchronicity of the transformers.

The **Master-Follower method** is suitable for transformers of the same design. If transformers of different power are controlled with the **Master-Follower method**, you must be aware that the same tap positions will

result in the same ratios. The relative short-circuit voltages of the transformers must not deviate significantly from each other (max. 10 %).

Logic of the Master-Follower Method



[lo_parallel_voltage_contrl-master-follower, 1, en_US]

Figure 7-135 Logic of the Master-Follower Method

The **Master-Follower method** can be blocked using the automatic function in the systems control. In case of a communication failure the function is also blocked.

The Master device controls the voltage of the transformer. The Follower device updates the tap position of the Master device. When doing so, the maximum tap-position difference between the transformers is taken into account. If the tap-position difference is exceeded for a predefined time, an error is reported (*Error tap difference*). If the supervision of a group detects that there is more than one Master device, this is reported and the automatic operation is blocked.

Manual Operation Master-Follower

Changing the tap of the tap changer using the Master device leads to an adjustment of the taps by all follower devices within the group.

If a communication error is present, a tap change can be done by the Follower device by switching to manual operation. In the Master device and all Follower devices the **Automatic mode** is blocked.

Method of Minimizing Circulating Reactive Current

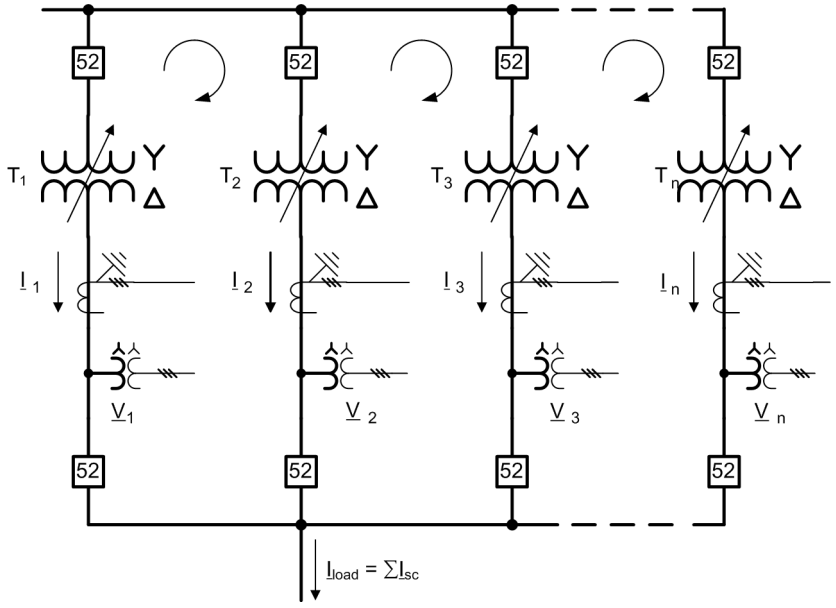
If the ratios of the transformers connected in parallel are different (>10 %), Siemens recommends the method of **Minimizing circulating reactive current**. The prerequisite for the method of **Minimizing circulating reactive current** is a data exchange between the ATCC function blocks (one ATCC function for each transformer in the parallel group). The data exchange for ATCC functions in different devices occurs via the GOOSE communication of the IEC 61850 protocol. All data of the devices in a group is exchanged cyclically via GOOSE, both analog and binary signals are exchanged.

The following advantages can be achieved with the method of **Minimizing circulating reactive current** for parallel voltage control:

- Setting the load voltage to a preset value
- Minimizing the circulating reactive current for transformers operated in parallel

Calculation of the Circulating Reactive Current

To calculate the circulating reactive current, the measured values of the individual transformers must be transmitted between the affected voltage controllers. The suitable reference variable for all transformers in a parallel group is the bus voltage. With this, there is a common reference between all devices within one parallel transformer group. The measured bus voltage is the reference value of the devices used.



[dw_CCM_01, 1, en_US]

Figure 7-136 Detection of the Circulating Reactive Current of a Parallel Group

The following formulas are used to calculate the circulating reactive current.

For each device, a direct-axis reactance relating to the control side of the transformer is calculated from the following 3 parameters:

- Rated apparent power S_{rated} of the transformer
- Rated voltage V_{rated} of the transformer
- Short-circuit voltage of the transformer V_{SC} in percent

If the ohmic longitudinal resistance is neglected, the direct-axis reactance of the transformer T_k (k = 1,2,3 ... n in the example) relating to the control side results in:

$$X_k = \frac{V_{rated}^2}{S_{rated}} \cdot \frac{v_k}{100\ \%}$$

[fo_reakccm, 1, en_US]

This direct-axis resistance is transferred to the other voltage controllers as a measured value with GOOSE. This value is displayed as a check. To determine the total load current, from each voltage controller the measured current with magnitude and phase angle is transferred as a GOOSE CMV measured value.
The total load current results in:

$$\bar{I}_L = \sum_{k=1}^{N} \bar{I}_k$$

[fo_summccm, 1, en_US]

The total inductive susceptance, the total susceptance of all transformers results in:

$$B_P = \sum_{k=1}^{N} \frac{1}{X_k}$$

[fo_suszccm, 1, en_US]

The partial load current value of the individual transformers results from the ratio between susceptance and total susceptance multiplied with the total load current. Only the inductive value, namely the imaginary part $Im(\bar{I}_A)$ of the calculated total load current is used.

$$I_{LkImag} = Im(\bar{I}_L) \frac{1}{X_k \cdot B_P}$$

[fo_loadcurccm, 1, en_US]

The circulating reactive current at transformer k is the difference of the current measured at the transformer and the calculated partial load current I_{LkImag}. This is multiplied with -1 so that its positive no-load voltage difference results in a positive circulating reactive current:

$$I_{CRCk} = -1 \cdot \left(Im(\bar{I}_k) - I_{LkImag} \right)$$

[fo_ccmtrafo, 1, en_US]

where:

I_{LkImag}	Calculated inductive part (imaginary part) of the partial load current of transformer k
I_{KBSk}	Circulating reactive current
I_{kImag}	Measured inductive part of the current at transformer k
$\bar{I}_{SC}$	Measured current at the transformer
X	Reactance of the transformer
k	1, 2, 3, ... 8 (number of the transformer)

Calculation of the Control Deviation

The control deviation D_{KBSk} is calculated from the calculated circulating reactive current I_{KBSk}:

$$D_{CRCk} = \text{Reactive I control factor}_k \cdot \frac{I_{CRCk} \cdot (X_k + \frac{1}{B_p - B_k}) \cdot \sqrt{3}}{V_{rated}} \cdot 100\ \%$$

[fo_regelabwdcc, 1, en_US]

where:

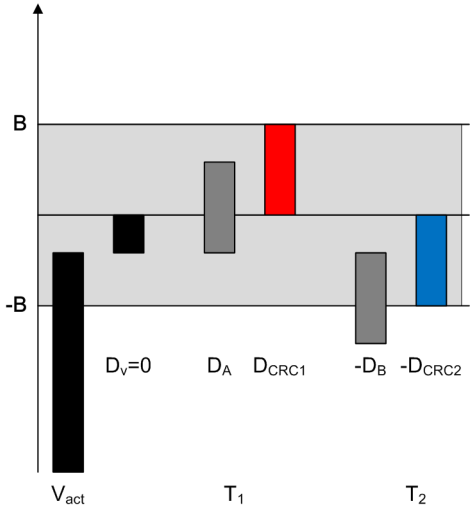
X_k	Reactance of the transformer
B_p	Total susceptance (total susceptance value) of all parallel transformers (sum of the reciprocals of the transformer reactance)
B_k	Susceptance of the transformer (reciprocal of the reactance)
V_{rated}	Rated voltage of the transformer

With the parameter **Reactive I control factor** you can adjust the control deviation D_{KBSk} so that the circulating reactive current caused by a tap difference results in exceeding the control bandwidth. A **Reactive I control factor** which is set too high can affect the control stability. In most cases, control quality and control stability are available with the default setting of 1.

The sum of the control deviation resulting from voltage deviation D_V and the control deviation D_{KBSk}, caused by the circulating reactive current, results in:

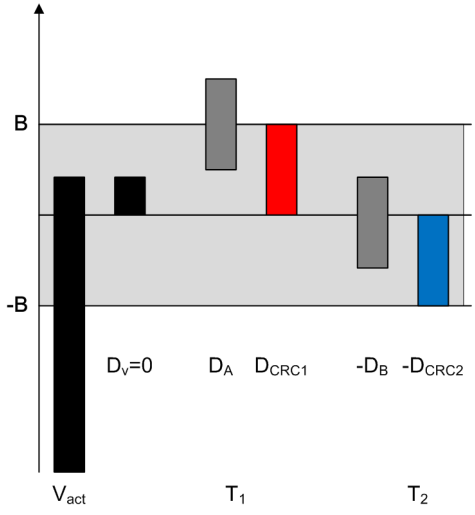
$D_k = D_{KBSk} + D_V$

and is compared with the set bandwidth. The following 2 diagrams explain the summations of the control deviation at negative and positive voltage deviation. A possible control deviation initiated by the circulating reactive current, is on transformer T_1 in contrast to transformer T_2. This results for both voltage controllers in a different total deviation.



Negative voltage deviation $-D_V$

Changing to higher tap of T_2 with $D_V + D_{KBS2} < -B$



Positive voltage deviation D_V

Changing to lower tap of T_1 with $D_V + D_{KBS1} > B$

For the calculation of the voltage deviation, the voltages of all voltage controllers are transferred with GOOSE as a measured value and an average value is calculated. The voltage can be monitored. If the data are not plausible the voltage controller is blocked after a time delay which can be set.

Error Behavior

If the value of the circulating reactive current exceeds the set time delay **Circul. current time delay** for a longer time than the threshold value **Circul. current threshold**, the indication *Circul. current blocking* is issued and the voltage control blocked.

If the circulating reactive current value drops below the preset value, the signal is automatically reset. This can be achieved using the manual control of the tap changer.

Blocking the Tap Changer in Case of a Fault

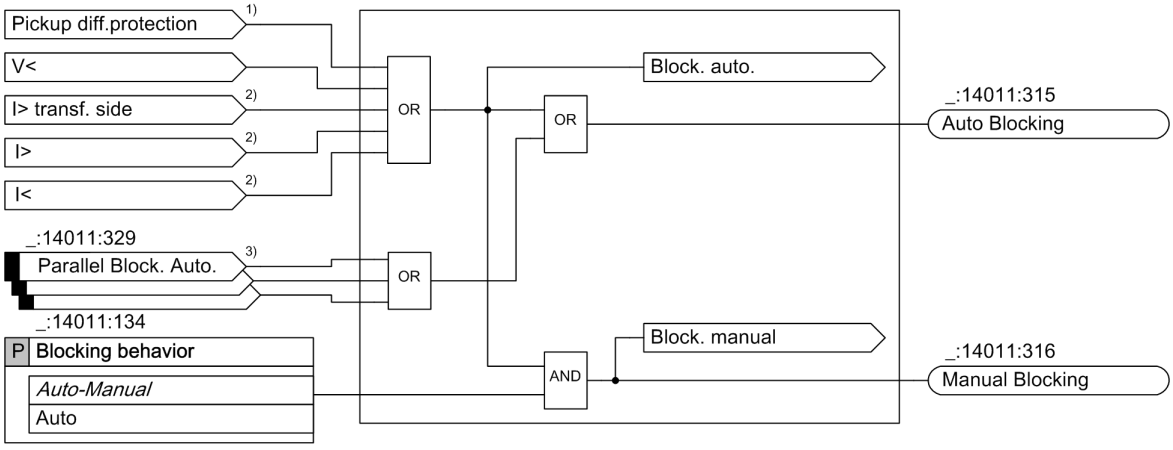
To activate the supervision functions in Follower mode when used with the transformer differential protection, you must set the parameter **Blocking** in the voltage controller function to ***Auto-Manual***.



[scblockVC-240117-01, 1, en_US]

Figure 7-137 Parameter in the Voltage Controller

The blockings prevent tap positions under abnormal network conditions.



[loblokir-090913-01.vsd, 2, en_US]

Figure 7-138 Blocking Logic

1) If transformer differential protection is available
2) If a current measurement is available
3) If parallel proxies are available (max. 7)

In addition to the blockings present with a parallel operation the number of proxies used is taken into account.

Maintenance of Transformers Connected in Parallel

If you want to take the device out of service and disconnect it from the power supply, you must first functionally log off the device. Once you functionally log off the device, all data objects generated in the device (state and measured values) receive the quality attribute **`OperatorBlocked`** = *TRUE*. This also applies to the output from CFC charts.

If objects are transferred via a GOOSE message, the receiver devices can analyze the quality. After a switch off of the transmitting device, the receiver devices detect that the transmitting device has been functionally logged off and did not fail. Now the receiving objects can automatically be set to defined states.

Table 7-31 Decommissioning

Binary input	>Device funct.logoff on 91.507 SPS >Dev. funct.logoff off 91.508 SPS
Controllable/device display	Device logoff 91.319 SPC Logged off via BI 91.313 SPS Logged off via control 91.314 SPS Device logged off 91.315 SPS

NOTE

Decommissioning the device is only allowed if the **`Parallel mode`** of the voltage controller is set to ***`No mode`***. After the decommissioning you must commission the voltage controller again.

The decommissioning can be done with binary input indications or via the control.

Supervision of the Communication

A communication fault can occur in the following cases:

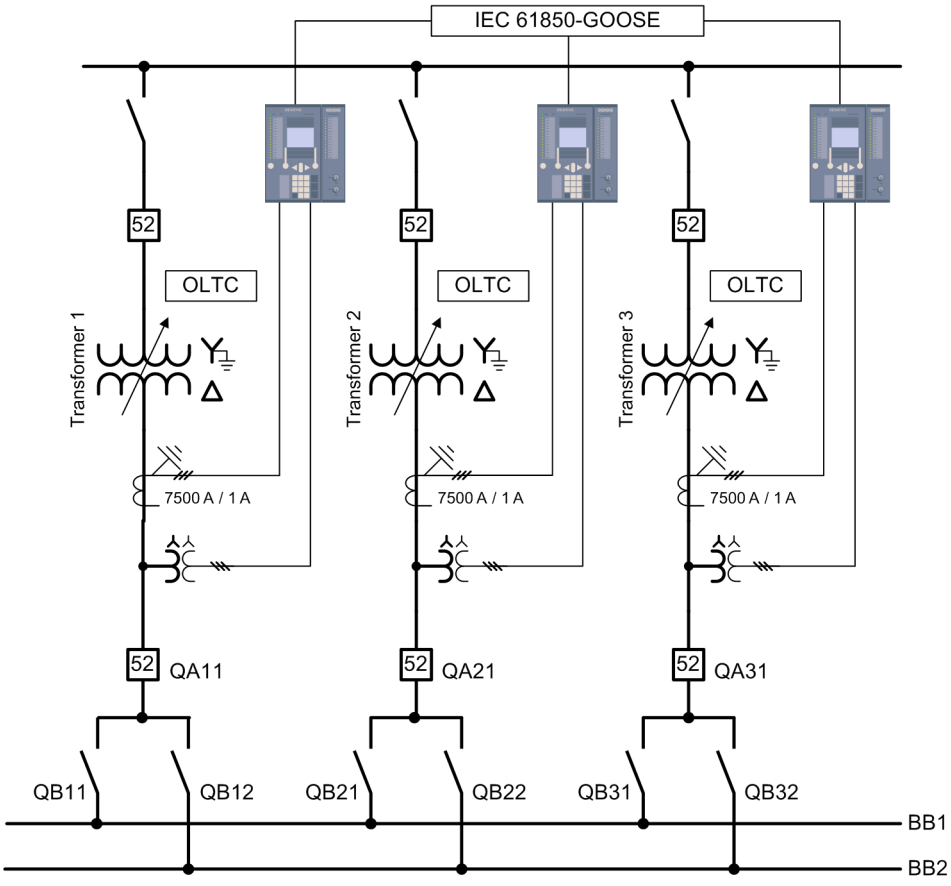
- The connection between 2 SIPROTEC 5 devices is interrupted.
- A hard- or software error is present in the device.
- The supply voltage of one or more devices is not present.

If the receipt of GOOSE messages is disturbed, a GOOSE time-out is signaled and all GOOSE messages arriving are signaled as *invalid*. If **No mode** is set in one of the devices, then the parallel operation is not blocked. If a communication error is present, the parallel mode in the Master and Follower device cannot be determined. In this case the operating mode **automatic operation** in the Master and Follower device is blocked for security reasons. Once the communication error has been cleared, the blocking is removed.

For more information about setting a GOOSE connection between the devices, refer to the following chapter.

7.9.3.10 Creating a GOOSE Later Binding for Parallel Control

To create the GOOSE later binding between the devices for parallel control, proceed as described in the following example:

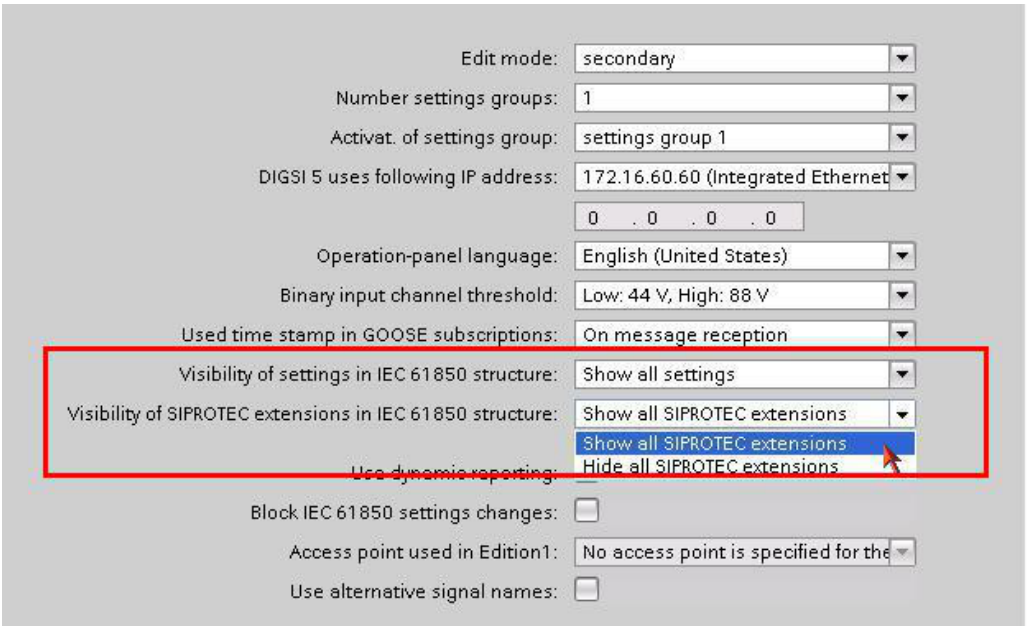


[dw_overview_sys-config_and_iec61850-goose, 1, en_US]

Figure 7-139 Example of a Parallel Control

Step 1

- Create the 1st device for parallel control in the DIGSI 5 project.
- Create the configurations and make the necessary settings for the IEC 61850 structure.

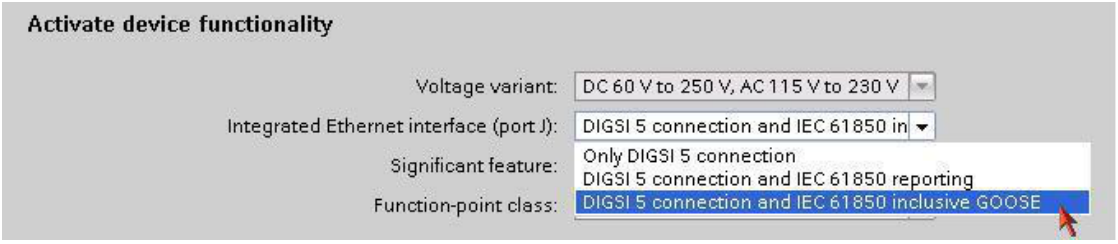


[sc_para_dev_set, 1, en_US]

Figure 7-140 IEC 61850 Structure Settings

For using Port J for the GOOSE communication:

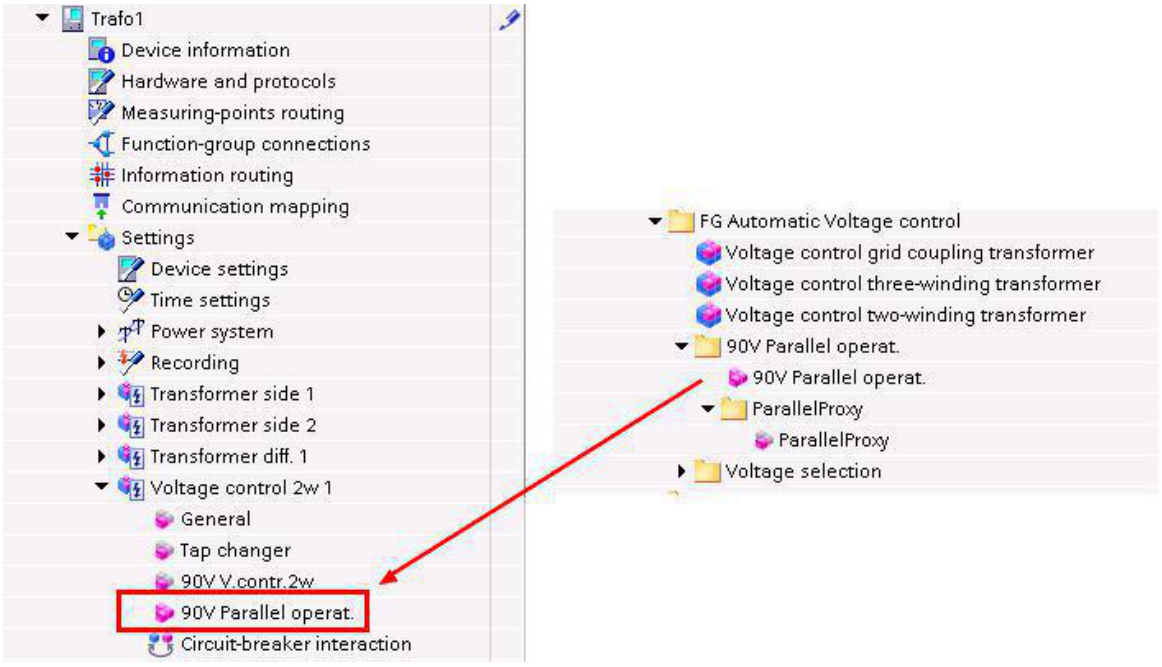
- Activate the device functionality for Port J.



[sc_para_dev_func, 1, en_US]

Figure 7-141 Setting for the Integrated Ethernet Interface

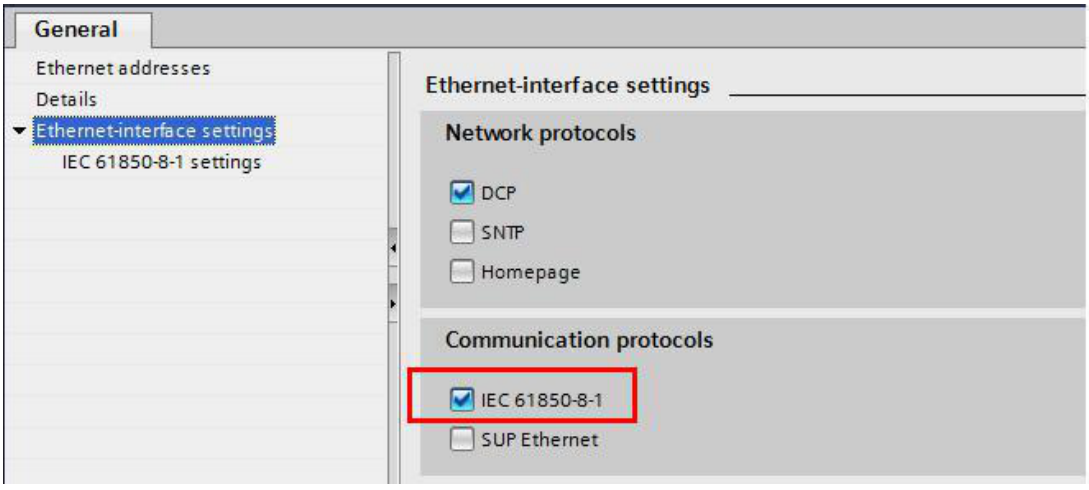
- Instantiate the voltage controller function for the two-winding transformer and the **`Parallel control`** function and the proxies that are necessary for parallel operation. One **`ParallelProxy`** is required for each transformer to be controlled in parallel, that is, for 3 transformers in the project, it must be additionally instantiate 2 **`ParallelProxies`**.



[sc_para_instanz, 1, en_US]

Figure 7-142 Selecting Parallel Control

- Make the necessary communication settings.



[sc_para_com_prot, 1, en_US]

Figure 7-143 Ethernet-interface settings

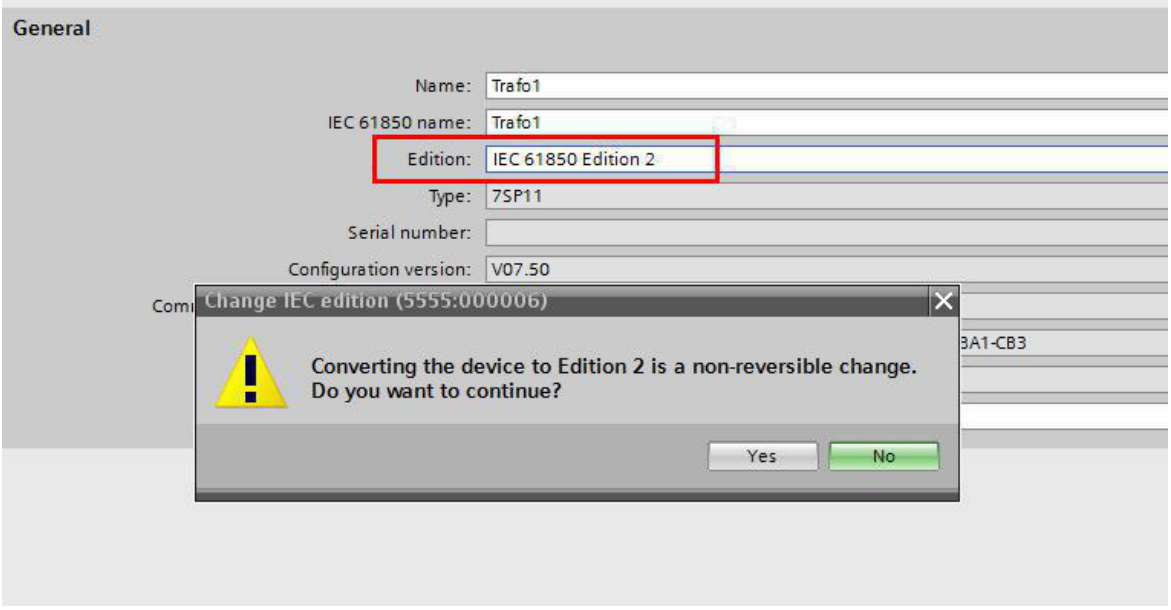
NOTE

Note that you must assign a separate IP address for each device.

NOTE

Note the hardware equipment of the device and the settings for the IEC 61850 communication (IEC 61850 Edition 2 required).

- Under **Device Information** in DIGSI, change IEC 61850 Edition 1 to Edition 2.



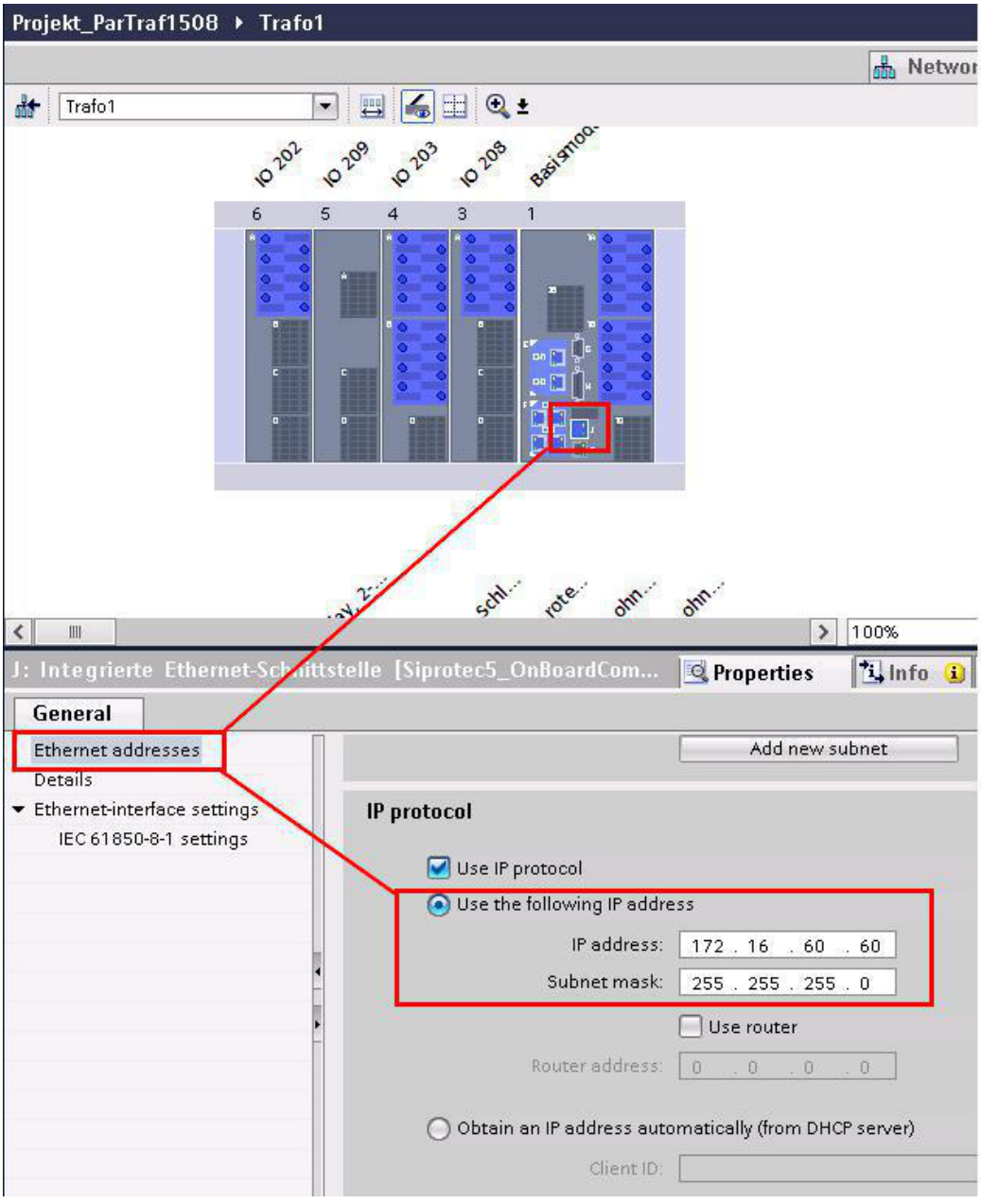
[sc_change_edition, 1, en_US]

Figure 7-144 Changing the IEC 61850 Edition

- Confirm the conversion to IEC 61850 Edition 2 with *Yes*.

Step 2

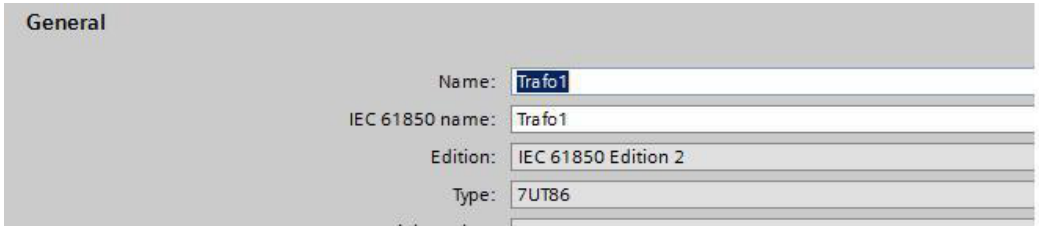
- Copy the 1st device as many times as are needed for the parallel transformers. The copied devices contain the same settings.
- Adapt the IP addresses of the copied devices in the project tree under **Hardware and protocols**.



[sc_para_ether_port], 1, en_US]

Figure 7-145 Adapting the IP Address

- Adapt the entries of the copied devices for the other transformers (device name and IEC 61850 name).



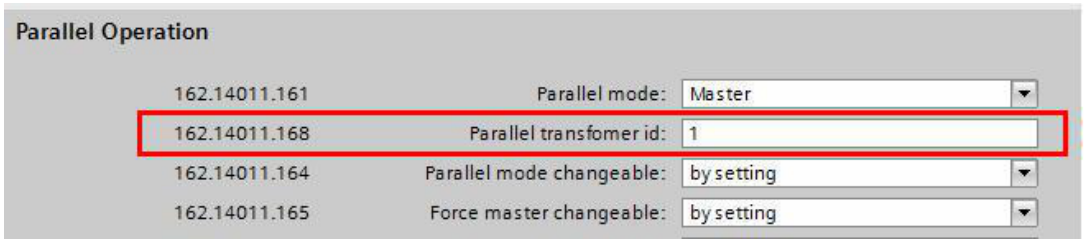
[sc_lbnametrafo, 1, en_US]

Figure 7-146 Adapting the Devices in DIGSI

- Assign a unique transformer ID for the other transformers in the copied devices.

NOTE

Note that in the Master-Follower method, you must configure one device as the Master device and the additional devices as Follower devices.

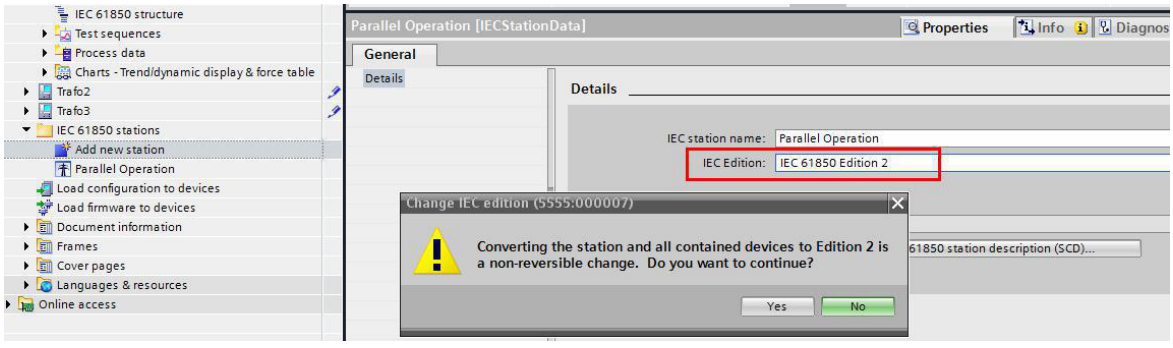


[sc_par_trafo_id, 1, en_US]

Figure 7-147 Adapting the Parallel Transformer ID in DIGSI

Step 3

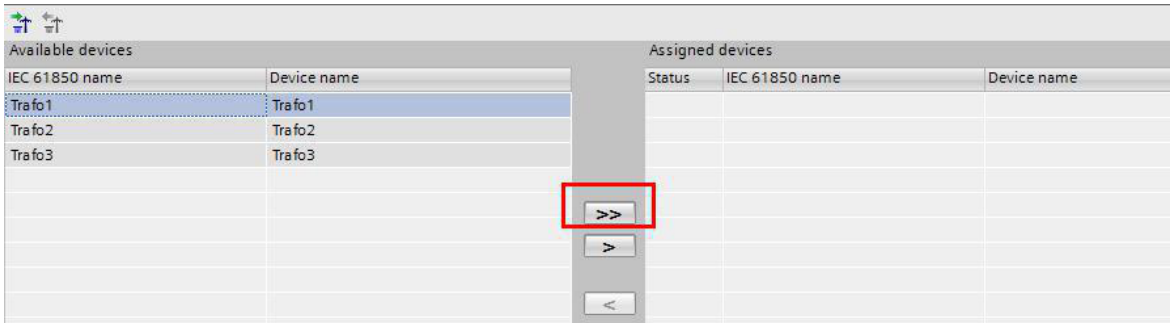
- Double-click *Add new station*.
- Double-click the first IEC 61850 station.
- Change the IEC 61850 station name for example in parallel operation.
- Change IEC 61850 Edition 1 to Edition 2.



[sc_par_stat_iec_edi, 1, en_US]

Figure 7-148 Selecting the IEC 61850 Edition

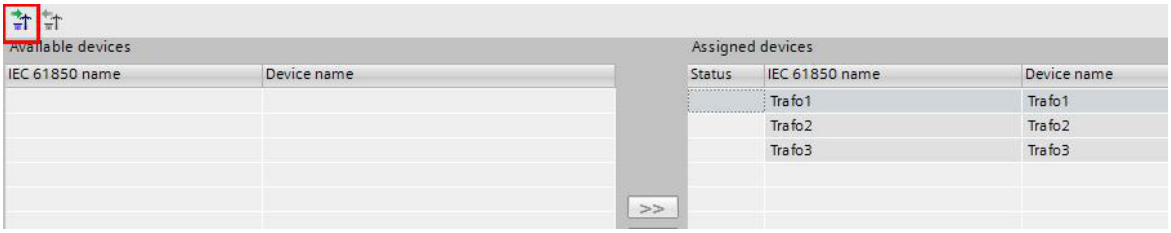
- Confirm the conversion to IEC 61850 Edition 2 with *Yes*.
- Use **>>** to assign the devices to the IEC 61850 station.



[sc_par_assign_syscon, 1, en_US]

Figure 7-149 Assigning the Devices

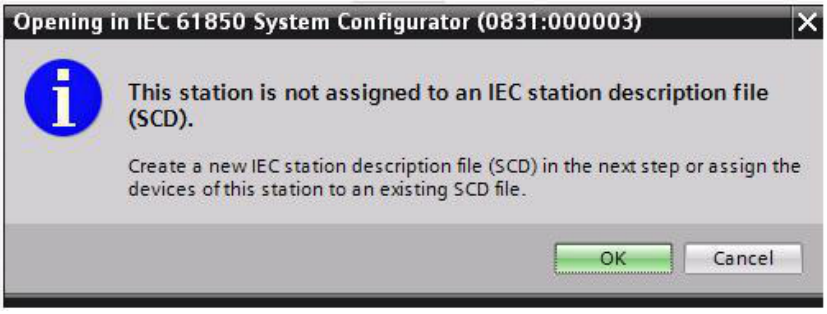
- Export the IEC 61850 station as an ICD file to the IEC 61850 System Configurator.



[sc_par_exp_syscon, 1, en_US]

Figure 7-150 Export to the IEC 61850 System Configurator

If the following dialog appears, confirm with OK and specify a storage location for the SCD file.

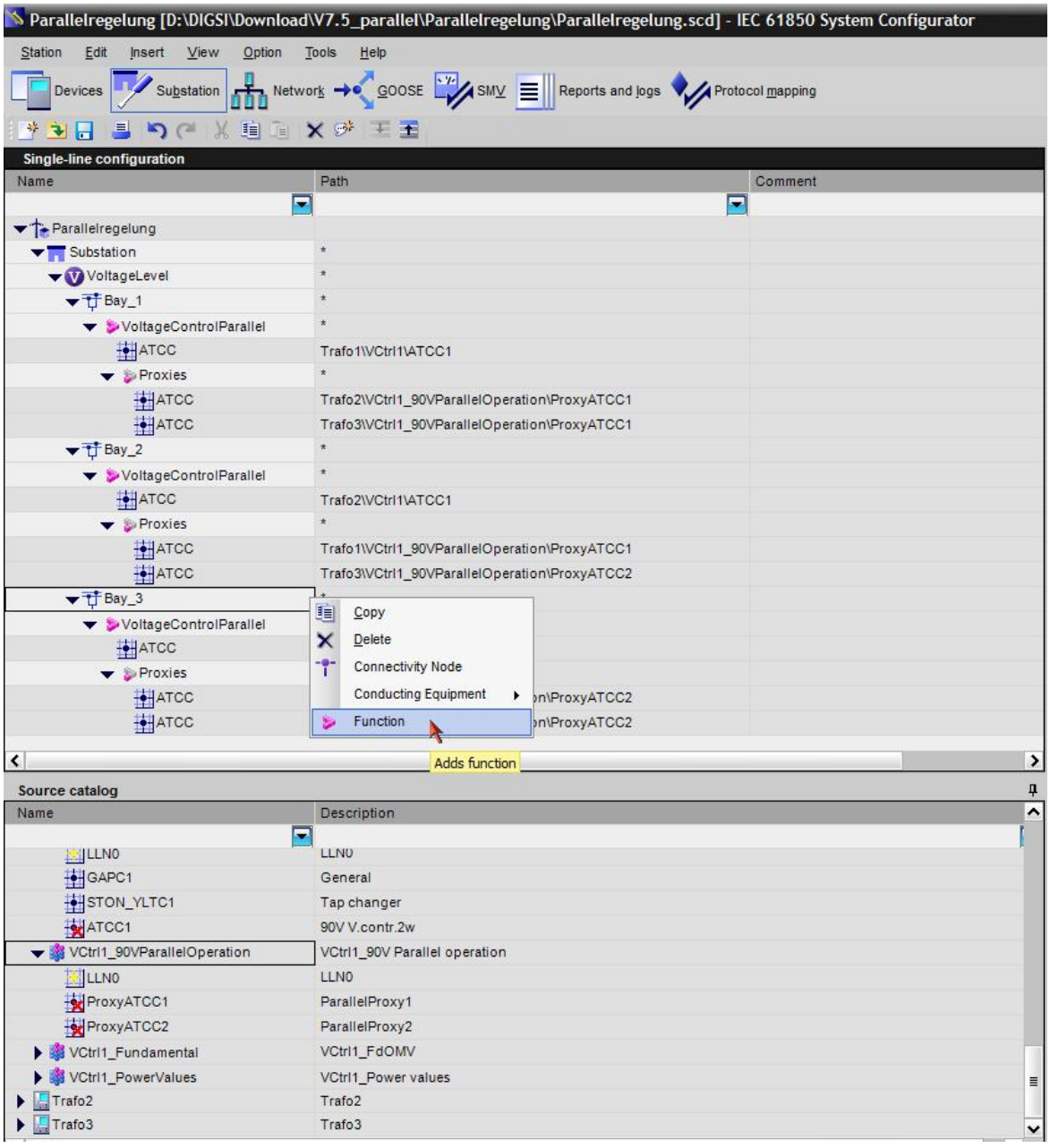


[sc_para_assinged, 1, en_US]

Figure 7-151 Export dialog

Step 4

- Import the ICD files into the system configurator. After the export to the system configurator, the configurator starts automatically.
- Create a single-line configuration in the system configurator.



[sc_para_single_line_konfig, 1, en_US]

Figure 7-152 Creating a Single-Line Configuration in the System Configurator

- Create a substation. Right-click Parallel operation and select *Substation*.
- Create the individual bays (bays 1-3) and instantiate for each a function and subfunction.
- Rename the *function* to *VoltageControlParallel*.
- Rename the *subfunction* to *Proxies*.

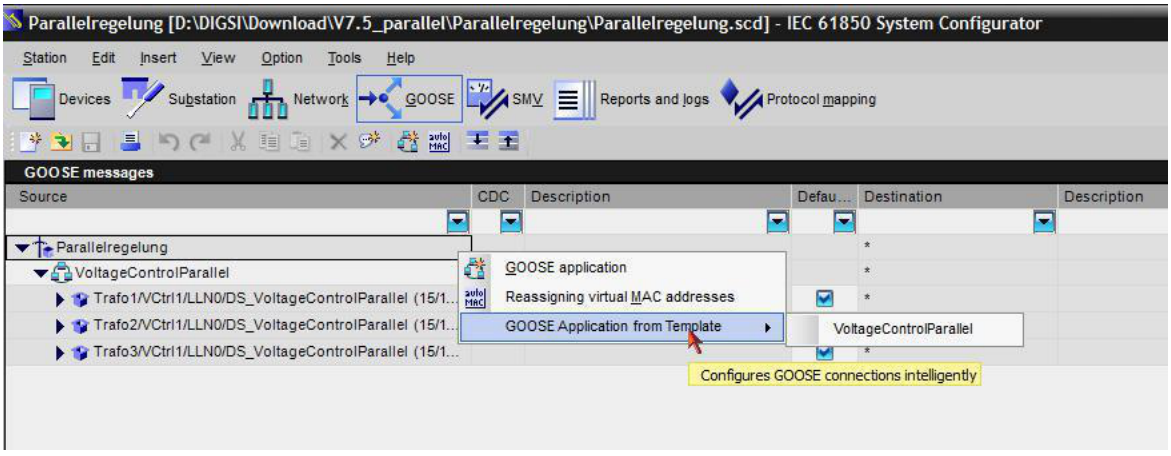
NOTE

If you use the specified function and subfunction names, the GOOSE application will be created without faults.

- Connect the LN *Trafo1\VCtrl1\ATCC1* of the device to the function and the other LN *Trafo2\Ctrl_90VParalleloperation\ProxyATCC1* to the proxies according to *Figure 7-152*.

Step 5

- Create a new GOOSE application and subsequently perform the GOOSE later binding using the application template. With the GOOSE application template, all the links between the devices and the proxies are automatically connected.
- Set all the settings for GOOSE communication between the Master and the Follower devices in the IEC 61850 System Configurator.
- If you have done all the links and settings in the IEC 61850 System Configurator, save the project and close the IEC 61850 System Configurator.

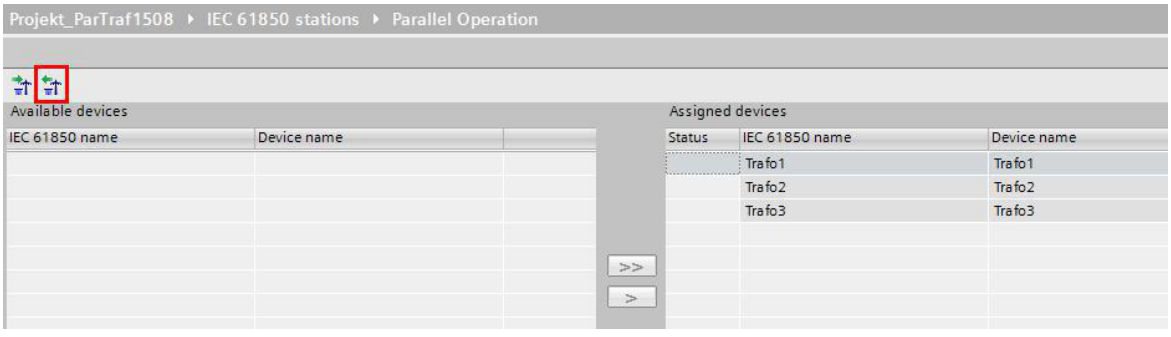


[sc_parasyscon_goose, 1, en_US]

Figure 7-153 Creating the GOOSE Application

Step 6

- Import the SCD file generated and stored in the IEC 61850 System Configurator back to DIGSI.



[sc_para_import, 1, en_US]

Figure 7-154 Import from the IEC 61850 System Configurator into DIGSI

- Load the created configuration to the devices.

7.9.3.11 Functional Measured Values

You can read the current status of the measured values for the two-winding transformer, the parallel control/proxy, the three-winding and grid coupling transformer at any time. The following tables show you the available measured values.

Measured Values, Two-Winding Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
V act.	Current, measured positive-sequence voltage (referenced to phase-to-phase)	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	%	%	Voltage difference referenced to the rated voltage of the controlled winding
I load	Current measured load current (positive-sequence system)	A	A	Load current referenced to the rated value of the function
V max	Maximum positive-sequence voltage ever measured (referenced to phase-to-phase)	kV	V	Maximum voltage of the winding referenced to the rated voltage of the winding
V min	Minimum positive-sequence voltage ever measured (reference to phase-to-phase)	kV	V	Minimum voltage of the winding referenced to the rated voltage of the winding
V target	Calculated target voltage with consideration of Z compensation	kV	V	Target voltage of the winding referenced to the rated voltage of the winding
PhAng	Phase angle of the currently measured load current	°	°	-
I load Σ	Sum of the currently measured load currents. Active when line compensation is activated.	A	A	Load current referenced to the rated current of the function
I circul.	Currently measured circulating reactive current	A	A	Circulating reactive current
Vact.m	Currently measured control voltage	kV	V	Current voltage of the control referenced to the rated voltage of the function
ΔV act V	Voltage difference	%	%	Voltage difference referenced to the rated voltage of the function
ΔV act C	Voltage difference	%	%	Voltage difference referenced to the rated voltage of the function

The function measured values V max and V min can be reset with the input indication *>Reset min./max.*.
For the **two-winding transformer**, you can find the measured values under the following menu entries of the device:

- Main menu → Measurements → Voltage control 2w → 90V V.contr.2w
- Main menu → Measurements → Voltage control 2w → Statistics → 90V V.contr.2w

Measured Values for Parallel Control, Proxy

Measured Value	Description	Primary	Secondary	% Referenced to
V act.	Actual voltage of winding	kV	V	Target voltage of the primary system referenced to the rated voltage of the function
1/X trf.	Susceptance, internal value for GOOSE transmission	1/Ω		

Measured Value	Description	Primary	Secondary	% Referenced to
I load	Load current	A	-	Load current referenced to the rated current of the function
PhAng	Phase angle of the load current relative to the voltage with a power factor of 1.0	°	°	Phase angle of the load current 100 % = 180°

For the **parallel control**, you can find the measured values under the following menu entries of the device:

- Main menu → Measurements → Voltage control 2w → Functional measured values → Parallel operation

Measured Values, Three-Winding Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
Vact.w1	Actual voltage of winding 1	kV	V	Target voltage of the primary system referenced to the rated voltage
Vact.w2	Actual voltage of winding 2	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	%	%	Voltage difference referenced to the rated voltage of the controlled winding
I load w1	Load current of winding 1	A	A	Load current referenced to the rated current of winding 1
I load w2	Load current of winding 2	A	A	Load current referenced to the rated current of winding 2
Vmax 1	Maximum voltage of winding 1	kV	V	Maximum voltage of winding 1 referenced to the rated voltage of winding 1
Vmax 2	Maximum voltage of winding 2	kV	V	Maximum voltage of winding 2 referenced to the rated voltage of winding 2
Vmin 1	Minimum voltage of winding 1	kV	V	Minimum voltage of winding 1 referenced to the rated voltage of winding 1
Vmin 2	Minimum voltage of winding 2	kV	V	Minimum voltage of winding 2 referenced to the rated voltage of winding 2
V tar.w1	Target voltage of winding 1	kV	V	Target voltage of winding 1 referenced to the rated voltage of winding 1
V tar.w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

The function measured values Vmax 1, Vmax 2, Vmin 1, and Vmin 2 can be reset with the input indication *>Reset min./max.*.

For the **three-winding transformer**, you can find the measured values under the following menu entries of the device:

- Main menu → Measurements → Voltage control 3w → 90V V.contr.3w
- Main menu → Measurements → Voltage control 3w → Statistics → 90V V.contr.3w

Measured Values Grid Coupling Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
Vact.w1	Actual voltage of winding 1	kV	V	Target voltage of the primary system referenced to the rated voltage
Vact.w2	Actual voltage of winding 2	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	%	%	Voltage difference referenced to the rated voltage of the controlled winding
I load w1	Load current of winding 1	A	A	Load current referenced to the rated current of winding 1
I load w2	Load current of winding 2	A	A	Load current referenced to the rated current of winding 2
Vmax 1	Maximum voltage of winding 1	kV	V	Maximum voltage of winding 1 referenced to the rated voltage of winding 1
Vmax 2	Maximum voltage of winding 2	kV	V	Maximum voltage of winding 2 referenced to the rated voltage of winding 2
Vmin 1	Minimum voltage of winding 1	kV	V	Minimum voltage of winding 1 referenced to rated voltage of winding 1
Vmin 2	Minimum voltage of winding 2	kV	V	Minimum voltage of winding 2 referenced to rated voltage of winding 2
V tar.w1	Target voltage of winding 1	kV	V	Target voltage of winding 1 referenced to the rated voltage of winding 1
V tar.w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

The function measured values Vmax 1, Vmax 2, Vmin 1, and Vmin 2 can be reset with the input indication *>Reset min./max.*.

For the **grid coupling transformer**, you can find the measured values under the following menu entries of the device:

- Main menu → Measurements → Voltage control gc → 90V V.contr.gc
- Main menu → Measurements → Voltage control gc → Statistics → 90V V.contr.gc

Fundamental-Component Values and Power Measured Values

The fundamental-component values and power measured values are always present in the **Two-winding transformer voltage controller**, **Three-winding transformer voltage controller**, and **Grid coupling transformer voltage controller** function groups. Furthermore, you can find the fundamental-component values and power measured values for winding 1 and winding 2 in the **Three-winding transformer voltage controller** and **Grid coupling transformer voltage controller** function groups. These values cannot be deleted.

The following tables show *Table 7-32* and *Table 7-33* the total scope for the case in which a 3-phase voltage measuring point is also connected.

Table 7-32 Possible Fundamental Values for the Voltage Controller Function Group

Fundamental-Component Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
I_N	Zero-sequence current	A	A	Rated operating current of the primary system
V_A, V_B,V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary system
V_N	Measured neutral-point displacement voltage	kV	V	Rated operating voltage of the primary system/√3

Table 7-33 Possible Power Measured Values of the Voltage Controller Function Group

Power Measured Value		Primary	Secondary	% Referenced to
P_{total}	Active power (total power)	MW	W	Active power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q_{total}	Reactive power (total power)	Mvar	var	Reactive power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S_{total}	Apparent power (total power)	MVA	VA	Apparent power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active power factor	(abs)	(abs)	100 % corresponds to cos φ = 1

7.9.4 Application and Setting Notes

7.9.4.1 General

The following application and setting notes refer to a two-winding transformer. The additional parameters for a three-winding transformer or a grid coupling transformer are marked correspondingly.

Parameter: Rated current

- Default setting **(_:2311:101) Rated current** = ***1000.00 A***

Parameter: Rated voltage

- Default setting **(_:2311:102) Rated voltage** = ***400.00 kV***

The measured values of the voltage controller can be displayed as primary values, secondary values, or in percent. With the **Rated current** and **Rated voltage** parameters, you set the reference value for the percentage values.

Additional Parameters for the Three-Winding Transformer or the Grid Coupling Transformer
Winding 1 **Parameter:** Rated current • Default setting **(_:2311:101) Rated current** = ***1000.00 A*** **Parameter:** Rated voltage • Default setting **(_:2311:103) Rated voltage** = ***400.00 kV*** **Winding 2** **Parameter:** Rated current • Default setting **(_:2311:102) Rated current** = ***1000.00 A*** **Parameter:** Rated voltage • Default setting **(_:2311:104) Rated voltage** = ***400.00 kV*** The measured values of the voltage controller can be displayed as primary values, secondary values, or in percent. With the **Rated current** and **Rated voltage** parameters, you set the reference value for the percentage values.

Tap Changer

The parameters of the tap changer inside the voltage controller correspond to those of the tap changer in chapter *7.8.2 Application and Setting Notes*.

For the tap changer inside the voltage controller, the parameters for the control model are copies of those from the voltage controller. This concerns the parameters:

- Checking the switching authority
- Control model
- SBO[62] Time-out
- Feedback.monitor.time

General

Parameter: Mode

- Default setting **(_:14011:1) Mode** = ***on***

With the **Mode** parameter, you switch the voltage controller in ***on***, ***off***, or in ***test*** operation.

Parameter: Operating mode

- Default setting **(_:14011:101) Operating mode** = ***Manual***

With the **Operating mode** parameter, you specify whether the voltage controller operates in ***Auto*** or in ***Manual*** mode.

Parameter: Minimal voltage

- Default setting **(_:14011:104) Minimal voltage** = ***5 %***

With the **Minimal voltage** parameter, you specify the threshold value at which the voltage controller operates. If the value is below the set threshold value, the entire measurement is not displayed and the binary output *Auto inactive* is activated.

62 In the IEC 61850 standard, reservation is known as Select Before Operate (SBO).

Three-Winding Transformer only:

Parameter: Winding selection

- Default setting **(_:15601:157) Winding selection** = ***Winding 1***

With the **Winding selection** parameter, you specify whether the voltage controller controls the voltage of ***Winding 1*** or ***Winding 2***. With the ***WithMaxLoad*** parameter, the voltage to be controlled is selected automatically depending on the load current. With this method, you can toggle using the parameter **Winding selection** or the controllable *Automatic winding selection*.

If the controllable *Automatic winding selection* is set to **Off** or is not set, you can influence the winding to be controlled using the following 2 options:

- Using the **Winding selection** parameter
- Using the *Manual winding selection* controllable

The function value *Active winding* shows the winding selection.

Grid Coupling Transformer only:

Parameter: Winding selection

- Default setting **(_:16351:161) Winding selection** = ***Winding 1***

With the **Winding selection** parameter, you specify whether the voltage controller controls the voltage of ***Winding 1*** or ***Winding 2***.

You may select the winding to be controlled using the **Winding selection** parameter or the *Manual winding selection* controllable. The function value *Active winding* shows the winding selection.

7.9.4.2 Controlling

Parameter: Check switching authority

- Default setting **(_:107) Check switching authority** = ***yes***

With the **Check switching authority** parameter, you specify whether the switching authority (**On-site**, **Remote**) is checked during an adjusting command.

Parameter: Control model

- Default setting **(_:109) Control model** = ***SBO w. enh. security***

This parameter **Control model** specifies the control model according to IEC 61850-7-2 that corresponds to the behavior of the data (SBO – Select Before Operate).

You can select one of the following settings:

- ***direct w. normal secur.***
- ***SBO w. normal secur.***
- ***direct w. enh. security***
- ***SBO w. enh. security***

Parameter: SBO time-out

- Default setting **(_:110) SBO time-out** = ***30.00 s***

This parameter specifies the time for detecting the time-out of the SBO command. The range of values extends from 0.01 s to 1800.00 s. This is the time that can elapse between command acceptance and command execution (command model as per IEC 61850-7-2).

Parameter: Feedback monitoring time

- Default setting **(_:111) Feedback monitoring time** = ***10.00 s***

Reaching a new tap position after the adjusting command is monitored via the feedback-monitoring time. If a new tap position is not reached, the command is canceled after this time.

7.9.4.3 Voltage Controller

Parameter: Measured value

- Default setting **(_:14011:100) Measured value** = ***positive-seq. voltage***

With the parameter **Measured value**, you select the control voltage with which the voltage controller operates. Depending on the connection type, you can select the following settings between measured and calculated voltage.

positive-seq. voltage
VA measured
VB measured
VC measured
VAB measured
VBC measured
VCA measured
VAB calculated
VBC calculated
VCA calculated

Parameter: Number of target voltage

- Default setting **(_:14011:156) Number of target voltage** = ***1***

With this parameter, you specify the number of available **target voltages** (**1** to **4**). You can select a target voltage from those available using the function key, communication, or binary input.

NOTE

Keep in mind that the parameter **Number of target voltage** cannot be influenced by way of the settings group switching.

You can specify the **target voltages** (**1** to **4**) in primary, secondary, or in percent.

For the activation of the target voltage 1 to 4 via a binary input, you need a CFC chart.

Parameter: Target voltage 1

- Default setting **(_:14011:112) Target voltage 1** = ***110.000 V***

With the **Target voltage 1**parameter, you specify the voltage to be reached by the voltage controller.

Parameter: Target voltage 2

- Default setting **(_:14011:157) Target voltage 2** = ***110.000 V***

With the **Target voltage 2** parameter, you specify the 2nd voltage to be reached by the voltage controller.

Parameter: Target voltage 3

- Default setting **(_:14011:158) Target voltage 3** = ***110.000 V***

With the **Target voltage 3** parameter, you specify the 3rd voltage to be reached by the voltage controller.

Parameter: Target voltage 4

- Default setting **(_:14011:159) Target voltage 4** = ***110.000 V***

With the **Target voltage 4** parameter, you specify the 4th voltage to be reached by the voltage controller.

Three-Winding Transformer only:

Parameter: Number of target voltage

- Default setting **(_:15601:164) Number of target voltage** = *1*

With this parameter, you specify the number of available **target voltages** (**1 W1/2** to **4 W1/2**). You can select a target voltage from those using the function key, communication, or binary input.

Note:

Keep in mind that the parameter **Number of target voltage** cannot be influenced by way of the settings group switching.

You can specify the **target voltages** (**1 W1/2** to **4 W1/2**) in primary, secondary, or in percent.

For the activation of the target voltage 1 to 4 via a binary input, you need a CFC chart.

Parameter: Target voltage 1 w1

- Default setting **(_:15601:112) Target voltage 1 w1** = *110.000 V*

Parameter: Target voltage 1 w2

- Default setting **(_:15601:146) Target voltage 1 w2** = *110.000 V*

Parameter: Target voltage 2 w1

- Default setting **(_:15601:165) Target voltage 2 w1** = *110.000 V*

Parameter: Target voltage 2 w2

- Default setting **(_:15601:168) Target voltage 2 w2** = *110.000 V*

Parameter: Target voltage 3 w1

- Default setting **(_:15601:166) Target voltage 3 w1** = *110.000 V*

Parameter: Target voltage 3 w2

- Default setting **(_:15601:169) Target voltage 3 w2** = *110.000 V*

Parameter: Target voltage 4 w1

- Default setting **(_:15601:167) Target voltage 4 w1** = *110.000 V*

Parameter: Target voltage 4 w2

- Default setting **(_:15601:170) Target voltage 4 w2** = *110.000 V*

Grid Coupling Transformer only:

Parameter: Number of target voltage

- Default setting **(_:16351:164) Number of target voltage** = *1*

With this parameter, you specify the number of available **target voltages** (**1 W1/2** to **4 W1/2**). You can select a target voltage from those using the function key, communication, or binary input.

Note:

Keep in mind that the parameter **Number of target voltage** cannot be influenced by way of the settings group switching.

You can specify the **target voltages** (**1 W1/2** to **4 W1/2**) in primary, secondary, or in percent.

For the activation of the target voltage 1 to 4 via a binary input, you need a CFC chart.

Parameter: Target voltage 1 w1

- Default setting **(_:16351:112) Target voltage 1 w1** = *110.000 V*

Parameter: Target voltage 1 w2

- Default setting **(_:16351:146) Target voltage 1 w2** = *110.000 V*

Parameter: Target voltage 2 w1

- Default setting **(_:16351:165) Target voltage 2 w1** = *110.000 V*

Parameter: Target voltage 2 w2

- Default setting **(_:16351:168) Target voltage 2 w2** = *110.000 V*

Parameter: Target voltage 3 w1

- Default setting **(_:16351:166) Target voltage 3 w1** = *110.000 V*

Parameter: Target voltage 3 w2

- Default setting **(_:16351:169) Target voltage 3 w2** = *110.000 V*

Parameter: Target voltage 4 w1

- Default setting **(_:16351:167) Target voltage 4 w1** = *110.000 V*

Parameter: Target voltage 4 w2

- Default setting **(_:16351:170) Target voltage 4 w2** = *110.000 V*

Parameter: Bandwidth

- Default setting **(_:113) Bandwidth** = *1.0 %*

With the **Bandwidth** parameter, you specify the voltage range where no control action higher or lower is to occur at the **Target voltage 1**. If the actual voltage is outside the bandwidth referenced to the **Target voltage 1**, a correction is made.

Calculation of the **Bandwidth**:



NOTE

When calculating the **Bandwidth** B, keep the maximum accepted voltage deviation in the electrical power system and the tap voltage of the tap changer on the secondary side of the transformer in mind. Select the bandwidths so that it is not passed through within an increment.

NOTE

Instable Controlling (Hunting)

The tolerance band is defined by the double bandwidth. If you select the bandwidth – and thus the admissible control deviation D – such that the tolerance band is smaller than the increment of the transformer, then, with the next increment operation, the voltage controller adjusts over the other side of the band after exceeding the tolerance band. In this case, stable controlling is not possible. This operation is also referred to as ***Hunting***. Also note that the load of the tap changer, – that is the number of increments performed – increases the lower the bandwidth.

On the secondary side, the increment ΔV_{sec} is not linear. The largest $\Delta V_{max,sec}$ in an increment results with the increment to the highest stage (smallest ratio) and with maximum power-system voltage on the primary side.

$$\Delta V_{max,sec} = \left[\frac{V_{rated,sec}}{V_{N,prim}} - \frac{V_{rated,sec}}{V_{(N-1),prim}}\right] \cdot V_{max,prim}$$

[fobdnvrz-150816, 1, en_US]

If the control deviation and the bandwidth are thus correlated, this results in a minimal bandwidth that is to be set:

$$B \geq 0.6 \cdot \frac{\Delta V_{max,sec}}{V_{rated,obj}} \cdot 100\ \%$$

[fospnvrz-150816, 1, en_US]

$V_{rated,sec}$	Secondary rated voltage of the transformer
$V_{N,prim}$	Primary tap voltage of the transformer of stage N
$V_{(N-1),prim}$	Primary tap voltage of the transformer of stage N-1
$V_{max,prim}$	Maximum primary voltage of the transformer
$V_{max,sec}$	Maximum secondary voltage of the transformer

Parameter: T1 characteristic

- Default setting **(_:114) T1 characteristic** = ***Linear***

Parameter: T1 delay

- Default setting **(_:115) T1 delay** = ***40 s***

You can adjust the control action so that the smallest number of adjusting commands possible is necessary. To do so, use **T1 characteristic** to set the control response and **T1 delay** to set a time delay.

In the ***Linear*** setting (linear control response), the control response is independent of the voltage deviation. A constant time delay applies here.

In the ***Inverse*** setting (inverse control response), the time delay is a function of the voltage deviation referenced to **Target voltage 1**. The greater the control deviation, the faster the control response. The control quality improves, but the switching frequency increases. If the voltage control is blocked during the time delay, the accumulated time delay **T1 delay** is reset.

The effective time delay is the result of:

$$t_{1_delay} = \frac{T_1 \cdot B}{|D|}$$

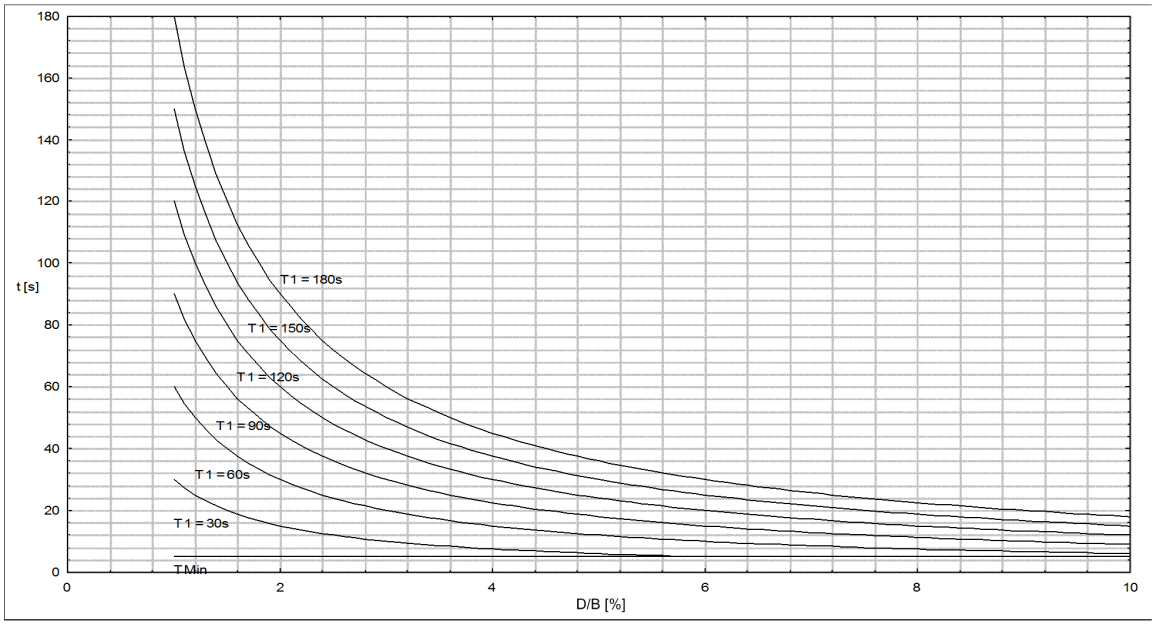
[fovrzzet-211013, 2, en_US]

T_1 – Parameter **T1 delay**

$$D = \frac{V_{act} - V_{target}}{V_{rated}} 100\ \%$$

[fokonisk-211013, 2, en_US]

D = Control deviation



[dwrglchr-160913-01.vsd, 2, en_US]

Figure 7-155 Inverse Control Characteristic

Parameter: T1 Inverse Min

- Default setting **(_:116) T1 Inverse Min** = ***5 s***

With the **T1 Inverse Min** parameter, you define the minimum time delay for the control action. This time applies only to the control response ***Inverse*** and the response cannot be shorter.

Parameter: T2 delay

- Default setting **(_:117) T2 delay** = ***5 s***

With the **T2 delay** parameter, you set the time the tap changer has to wait from one tap position to the next. During this time, several adjusting commands can be sent to the tap changer in one direction, which permits a correction of the actual voltage. The time delay T2 has an independent characteristic. The time T2 is generally set shorter than the time T1. If the time T2 is switched off by a setting equal to 0, the delay T1 is always active. If the voltage control is blocked during the time delay, the accumulated time delays **T1 delay** and **T2 delay** are reset.

Parameter: Fast step up

- Default setting **(_:118) Fast step up** = ***off***

Parameter: Fast step up limit

- Default setting **(_:119) Fast step up limit** = ***-6.0 %***

Parameter: Fast step up T delay

- Default setting **(_:120) Fast step up T delay** = ***2.0 s***

With this parameter, you specify the time delay of the fast step-up mode. If the actual voltage is less than the value of the limit for the fast step-up mode (_:119), the fast step up mode is activated. A fast step-up mode is not activated if the value drops below the voltage limit for only a brief period within the time delay. If the voltage control is blocked during the time delay, the accumulated time delay **Fast step up T delay** is reset.

Parameter: Fast step down

- Default setting **(_:121) Fast step down** = ***on***

Parameter: Fast step down limit

- Default setting **(_:122) Fast step down limit** = ***6.0 %***

Parameter: Fast step down T delay

- Default setting **(_:123) Fast step down T delay** = ***0.0 s***

With this parameter, you specify the time delay of the fast step-down mode. If the actual voltage is greater than the value of the limit for the fast step-down mode (_:122), the fast step-down mode is activated. A fast step-down mode is not activated if the voltage limit is exceeded for only a brief period within the time delay. If the voltage control is blocked during the time delay, the accumulated time delay **Fast step down T delay** is reset.

Parameter: Function monitoring

- Default setting **(_:124) Function monitoring** = ***15 min***

You can delay the pickup of the function monitor. With the **Function monitoring** = ***0 min*** parameter, the function monitor is switched off.

Grid Coupling Transformer only:
Parameter: Power-flow supervision • Default setting **(_:16351:162) Power-flow supervision** = ***on*** With the **Power-flow supervision** parameter, you monitor the power flow. You can switch the parameter on or off.

Parameter: Regulate with T2 at start

- Default setting **(_:14011:155) Regulate with T2 at start** = ***on***

With the **Regulate with T2 at start** parameter, you can activate a shorter time than T1. This can be necessary for controlling a voltage recovery or after switching on a transformer. If voltage was not present beforehand, this setting controls with the shorter time T2 when starting the control action. You can switch this functionality on or off. If you always want to use the time T2 for control, you must set the *Block T1* controllable to ***On***.

For the three-winding transformer, the address of the parameter **Regulate with T2 at start** is _:15601:163 and it is _:16351:163 for the grid coupling transformer.

Parameter: Set point mode active

- Default setting **(_:14011:160) Set point mode active** = ***on***

With the **Set point mode active** = ***on*** parameter, you send a target voltage to the voltage controller via a communication network. The voltage controller uses the specified voltage value as the target voltage and the specified bandwidth instead of the parameterized bandwidth. If the voltage controller does not receive any valid voltage values or bandwidth, it uses the original target voltage or bandwidth respectively. You can enable or disable the parameter.

For the three-winding transformer, the address of the parameter **Set point mode active** is _:15601:171 and it is _:16351:171 for the grid coupling transformer.

7.9.4.4 Dynamic Voltage Control (DVC)

Parameter: DVC mode

- Default setting **(_:14011:177) DVC mode** = ***off***

With the parameter **DVC mode**, you can adapt the voltage target value of the voltage controller via a characteristic curve depending on the power direction. You can activate or deactivate the dynamic voltage control with the settings ***on*** (activate) or ***off*** (deactivate).

Parameter: Active power max

- Default setting **(_:14011:176) Active power max** = ***30 %***

With the parameter **Active power max**, you define the maximum value of the active power in percent.

Parameter: Active power min

- Default setting **(_:14011:175) Active power min** = ***-20 %***

With the parameter **Active power min**, you define the minimum value of the active power in percent.

Parameter: Target Voltage max

- Default setting **(_:14011:174) Target Voltage max** = ***114 V***

With the parameter **Target Voltage max**, you define the maximum value of the target voltage.

Parameter: Target Voltage min

- Default setting **(_:14011:173) Target Voltage min** = ***106 V***

With the parameter **Target Voltage min**, you define the minimum value of the target voltage.

Only Three-Winding Transformer:

Parameter: DVC mode

- Default setting **(_:15601:178) DVC mode** = ***off***

With the parameter **DVC mode**, you can adapt the voltage target value of the voltage controller via a characteristic curve depending on the power direction. You can activate or deactivate the dynamic voltage control with the settings ***on*** (activate) or ***off*** (deactivate).

Parameter: Active power max w1

- Default setting **(_:15601:185) Active power max w1** = ***30 %***

Parameter: Active power min w1

- Default setting **(_:15601:183) Active power min w1** = ***-20 %***

Parameter: Active power max w2

- Default setting **(_:15601:186) Active power max w2** = ***30 %***

Parameter: Active power min w2

- Default setting **(_:15601:184) Active power min w2** = ***-20 %***

Parameter: Target Voltage min w1

- Default setting **(_:15601:179) Target Voltage min w1** = ***106 V***

Parameter: Target Voltage max w1

- Default setting **(_:15601:181) Target Voltage max w1** = ***114 V***

Parameter: Target Voltage min w2

- Default setting **(_:15601:180) Target Voltage min w2** = ***106 V***

Parameter: Target Voltage max w2

- Default setting **(_:15601:182) Target Voltage max w2** = ***114 V***

Only Grid Coupling Transformer:

Parameter: DVC mode

- Default setting **(_:16351:178) DVC mode** = ***off***

With the parameter **DVC mode**, you can adapt the voltage target value of the voltage controller via a characteristic curve depending on the power direction. You can activate or deactivate the dynamic voltage control with the settings ***on*** (activate) or ***off*** (deactivate).

Parameter: Active power max w1

- Default setting **(_:16351:185) Active power max w1** = ***30 %***

Parameter: Active power min w1

- Default setting **(_:16351:183) Active power min w1** = ***-20 %***

Parameter: Active power max w2

- Default setting **(_:16351:186) Active power max w2** = ***30 %***

Parameter: Active power min w2

- Default setting **(_:16351:184) Active power min w2** = ***-20 %***

Parameter: Target Voltage min w1

- Default setting **(_:16351:179) Target Voltage min w1** = ***106 V***

Parameter: Target Voltage max w1

- Default setting **(_:16351:181) Target Voltage max w1** = ***114 V***

Parameter: Target Voltage min w2

- Default setting **(_:16351:180) Target Voltage min w2** = ***106 V***

Parameter: Target Voltage max w2

- Default setting **(_:16351:182) Target Voltage max w2** = ***114 V***

7.9.4.5 Line Compensation

Parameter: Line drop compensation

- Default setting **(_:14011:125) Line drop compensation** = ***off***

You can use the **Line drop compensation** parameter to select the correction procedure of the load-dependent line voltage drop. There are 2 procedures available for selection: ***LDC-Z*** and ***LDC-XandR***. The setting of the parameter **Set point mode active** is also taken into account here.

For setting the parameter **Line drop compensation** = ***LDC-Z***, consider the following parameter:

Parameter: Target voltage rising

- Default setting **(_:14011:126) Target voltage rising** = ***4.0 %***

With the **Target voltage rising** parameter, you set the voltage drop across the line. The value represents the voltage rising in % of the **Target voltage 1** that occurs at rated load. Only the magnitude of the current is considered. The set value is added to **Target voltage 1**.

Target voltage rising [%] = ΔV_{load} [%], if I_{load} = 100 %

$$\text{Target voltage rising}\,[\%] = \left(V_{SetComp}[\%] - V_{Set}[\%]\right) \cdot \frac{100\ \%}{I_{load}[\%]}$$

[foschlst-211013, 2, en_US]

where:

$V_{SetComp}$	Target voltage at the end of the line
V_{Set}	Target voltage
I_{load}	Load current in %

With the following equation, you can determine the percentage of the primary load current of the line from the rated current of the transformer k (k = 1, 2, ..., 8).

$$I_{load\,k}\ (\%) = \frac{I_{load}}{I_{rated\,k}} \cdot 100\ \%$$

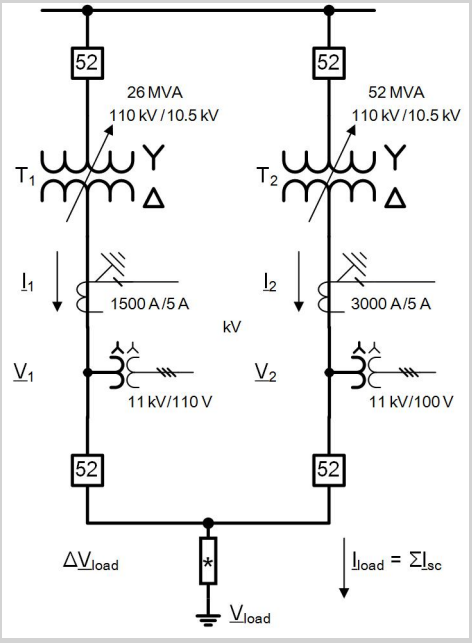
[fo_ibs_load_cur_perc, 1, en_US]

where:

I_{load}	Primary load current
I_{rated}	Rated current of the transformer

Example

Application example of the LDC-Z line compensation for the voltage control of 2 transformers connected in parallel.



[dw_target_voltage_2exam, 2, en_US]

Figure 7-156 LDC-Z Line Compensation with 2 Parallel Transformers

In the example, a load current of I_{load} = 1430 A results in a voltage drop of V_{load} = 500 V.

Value	Transformer T_1	Transformer T_2
	$I_{load\ T1}\ (\%) = \frac{1430\ A}{1430\ A} 100\ \%$	$I_{load\ T2}\ (\%) = \frac{1430\ A}{2859\ A} 100\ \%$
I_{load}(%)	100 %	50 %
	$\Delta V_{load\ T1}\ (\%) = \frac{500\ V}{11\,000\ V} \cdot \frac{100\ \%}{100\ \%}$	$\Delta V_{load\ T2}\ (\%) = \frac{500\ V}{11\,000\ V} \cdot \frac{100\ \%}{50\ \%}$
Target voltage rising ΔV_{load}(%)	4.8 %	9.6 %

NOTE

Make sure that you configure the parameter **Max load current** on the voltage controller on the transformer T_1 to 200 %, as this summation load current is used for the line compensation.

Parameter: LDC is calculated

- Default setting **(_:14011:172) LDC is calculated** = ***on target voltage***

For the parameter **LDC is calculated**, you can select between the settings ***on target voltage*** and ***on measured voltage***. The voltage compensation is added to the target voltage with the setting ***on target voltage***, and to the measured voltage with the setting ***on measured voltage***.

Parameter: Max load current

- Default setting **(_:14011:127) Max load current** = ***100.0 %***

With the setting of the parameter **Max load current**, you can prevent the voltage at the transformer from becoming too high in the event of extraordinarily high load current. If the load current exceeds the set value, no additional load-current compensation is calculated.

For setting the parameter **Line drop compensation** = ***LDC-XandR***, consider the following parameters:

Parameter: R line

- Default setting **(_:14011:153) R line** = ***0.00 Ω***

With the **R line** parameter, you to set the ohmic resistance of the line.

Parameter: X line

- Default setting **(_:14011:154) X line** = ***0.00 Ω***

With the **X line** parameter, you set the reactance for the line to be protected.

In order to determine the voltage drop by the line, entering the parameters **R line** and **X line** is necessary for the procedure **Line drop compensation** = ***LDC-XandR***. If the primary values are known and you would like to set the secondary values, use the following formula for the calculation:

$$X_{sec} = \frac{Ratio_I}{Ratio_V} X_{prim}$$

[fo-I-V-Ratio-250214, 1, en_US]

As an example, calculate X_{sec} with the following parameters:

Current transformer ratio	: 1000 A/1 A
Voltage transformer ratio	: 380 kV/0.1 kV
X_{prim}	: 21 Ω

Therefore, the result for X_{sec} is:

$$X_{sec} = \frac{1000\,A/1\,A}{380\,kV/0.1\,kV} 21\,\Omega = 5.53\,\Omega$$

[fo-I-V-Ratio_Value-250214, 1, en_US]

If you are implementing a parallel control with the X and R compensation, then the X value is negative and considers the voltage rising from the busbar to the transformer.

Additional Parameters for the Three-Winding Transformer and for the Grid Coupling Transformer

Parameter: Line drop compensation

- Default setting **(_:125) Line drop compensation** = ***off***

For setting the parameter **Line drop compensation** = ***LDC-Z***, consider the following parameters:

Parameter: Target voltage rising w1

- Default setting **(_:126) Target voltage rising w1** = ***4.0%***

Parameter: Target voltage rising w2

- Default setting **(_:147) Target voltage rising w2** = ***4.0%***

Parameter: Max load current

- Default setting **(_:127) Max load current** = ***100.0 %***

For setting the parameter **Line drop compensation** = ***LDC-XandR***, consider the following parameters:

Parameter: R line w1

- Default setting **(_:153) R line w1** = ***0.0 Ω***

Parameter: R line w2

- Default setting **(_:155) R line w2** = ***0.0 Ω***

Parameter: X line w1

- Default setting **(_:154) X line w1** = ***0.0 Ω***

Parameter: X line w2

- Default setting **(_:156) X line w2** = ***0.0 Ω***

7.9.4.6 Limiting Values

Parameter: Lower tap-position limit

- Default setting **(_:14011:102) Lower tap-position limit** = ***1***

Parameter: Higher tap-position limit

- Default setting **(_:14011:103) Higher tap-position limit** = ***1***

With the parameters **Lower tap-position limit** and **Higher tap-position limit**, you can restrict the taps available in automatic operation. For example, using the parameter **Higher tap-position limit**, changes to higher taps to excessive ratios that would result in overvoltages in the event of a sudden loss of load are blocked.

Parameter: Vmin limiting

- Default setting **(_:14011:128) Vmin limiting** = ***on***

Parameter: Vmin threshold

- Default setting **(_:14011:129) Vmin threshold** = ***105.000 V***

Parameter: Vmin time delay

- Default setting **(_:14011:130) Vmin time delay** = ***10 s***

Parameter: Vmax limiting

- Default setting **(_:14011:131) Vmax limiting** = ***on***

Parameter: Vmax threshold

- Default setting **(_:14011:132) Vmax threshold** = ***115.000 V***

Parameter: Vmax time delay

- Default setting **(_:14011:133) Vmax time delay** = ***10 s***

The voltage limits are necessary only for special control situations. The overvoltage limit prevents a change to a higher tap by the voltage controller if the limiting value **Vmax threshold** is exceeded. The undervoltage limit prevents a change to a lower tap by the voltage controller if the voltage drops below the limiting value **Vmin threshold**.

Additional Parameters for the Three-Winding Transformer and for the Grid Coupling Transformer
Parameter: Vmin threshold w1 • Default setting **(_:129) Vmin threshold w1** = ***105.000 V***
Parameter: Vmin threshold w2 • Default setting **(_:148) Vmin threshold w2** = ***105.000 V***
Parameter: Vmax threshold w1 • Default setting **(_:132) Vmax threshold w1** = ***115.000 V***
Parameter: Vmax threshold w2 • Default setting **(_:149) Vmax threshold w2** = ***115.000 V***

7.9.4.7 Blockings

Parameter: Blocking behavior

- Default setting **(_:14011:134) Blocking behavior** = ***Auto-Manual***

If the corresponding voltage limits are exceeded in either direction, the blockings prevent a change to a lower or higher tap. On the one hand, this prevents excessive wear of the contacts of the tap changer and, on the other hand, it prevents a system incident. With the parameter **Blocking behavior**, you set whether these blockings are effective only in automatic operation or in both automatic and manual operation.

Parameter: V< Blocking

- Default setting **(_:14011:135) V< Blocking** = ***on***

Parameter: V< Threshold

- Default setting **(_:14011:136) V< Threshold** = ***90.000 V***

Parameter: V< Time delay

- Default setting **(_:14011:137) V< Time delay** = ***0 s***

Parameter: I> Blocking

- Default setting **(_:14011:138) I> Blocking** = ***on***

Parameter: I> Threshold

- Default setting **(_:14011:139) I> Threshold** = ***150 %***

Parameter: I> Time delay

- Default setting **(_:14011:140) I> Time delay** = ***0 s***

If the load current exceeds the threshold value **I> Threshold** for the time **I> Time delay**, the overcurrent blocking prevents changing to a higher or lower tap. Set the threshold value **I> Threshold** in % in relation to the rated current. To do this, set the parameter **I reference** for % values.

Parameter: I< Blocking

- Default setting **(_:14011:141) I< Blocking** = ***off***

Parameter: I< Threshold

- Default setting **(_:14011:142) I< Threshold** = ***10 %***

Parameter: I< Time delay

- Default setting **(_:14011:143) I< Time delay** = ***10 s***

If the load current drops below the threshold value **I< Threshold** for the time **I< Time delay**, the undercurrent blocking prevents changing to a higher or lower tap. Set the threshold value **I< Threshold** in % in relation to the rated current. To do this, set the parameter **I reference** for % values.

Additional Pararmeters for Three-Winding Transformers and for Grid Coupling Transformers
Parameter: V< Threshold w1
• Default setting **(_:136) V< Threshold w1** = ***90.000 V***
Parameter: V< Threshold w2
• Default setting **(_:150) V< Threshold w2** = ***90.000 V***

You can find the parameter and information lists in chapter *7.9.5 Settings*.

7.9.4.8 Parallel Control

Parameter: Parallel mode

- Default setting **(_:14011:161) Parallel mode** = ***No mode***

With the **Parallel mode** parameter, you can switch the voltage controller into one of the following modes:

No mode

Master

Follower

Circulat. react current

Parameter: Parallel-transfomer id

- Default setting **(_:14011:168) Parallel-transfomer id** = ***1***

The **Parallel-transfomer id** parameter indicates the ID of the transformer.

With this parameter, you identify individual transformers in a parallel group. Transformers belonging to the same parallel group must be uniquely identifiable based on the ID. The unique identification applies to all transformers which communicate via GOOSE.

Parameter: Parallel mode changeable

- Default setting **(_:14011:164) Parallel mode changeable** = ***by setting***

With the **Parallel mode changeable** parameter, you influence the parallel control ***by setting*** or via the setting ***controllable***.

Parameter: Force master changeable

- Default setting **(_:14011:165) Force master changeable** = ***by setting***

With the **Force master changeable** parameter, you determine ***by setting*** or via the setting ***controllable*** which device is the Master in the parallel operation. In a group of transformers working in parallel, only one device can be the Master. The presence of a Master is monitored.

Parameter: Maximal tap difference

- Default setting **(_:14011:166) Maximal tap difference** = ***2***

With the **Maximal tap difference** parameter, you set the maximum permissible difference of the tap-changer positions between the transformers of a group.

Parameter: Reactive I control factor

- Default setting **(_:14011:169) Reactive I control factor** = ***1.00***

The voltage deviation between the transformers is influenced with the parameter **Reactive I control factor**. This means that a deviation from one stage exceeds the bandwidth of the voltage controller. This allows the control deviation D_{CRC}, initiated by the circulating reactive current, to be adjusted individually for each parallel operation.

Parameter: VT supervision

- Default setting **(_:14011:146) VT supervision** = ***on***

With the **VT supervision** parameter, you switch the voltage supervision ***on*** or ***off***. The average voltage of all voltage controllers is compared with the measured voltage as a criterion and is blocked if it exceeds the setting value. Siemens recommends setting the **VT supervision** parameter to ***on*** to minimize the circulating reactive current.



NOTE

In the Master-Follower Method, you can use this parameter only if the follower is also measuring the voltage.

Parameter: VT supervision threshold

- Default setting **(_:14011:147) VT supervision threshold** = ***10.0 %***

With the **VT supervision threshold** parameter, you set the threshold value for the voltage supervision.

Parameter: VT supervision time delay

- Default setting **(_:14011:148) VT supervision time delay** = ***10 s***

With the **VT supervision time delay** parameter, you set the time for which exceeding the voltage supervision threshold does not lead to a blocking.

Parameter: Circul. current blocking

- Default setting **(_:14011:149) Circul. current blocking** = ***on***

With the **Circul. current blocking** parameter, you switch the supervision of the circulating reactive current off or on.

Parameter: Circul. current threshold

- Default setting **(_:14011:150) Circul. current threshold** = ***50 %***

With the **Circul. current threshold** parameter, you set the level of the circulating reactive current at which the supervision should pick up.

Parameter: Circul. current time delay

- Default setting **(_:14011:151) Circul. current time delay** = ***60 s***

With the **Circul. current time delay** parameter, you set the time for which exceeding the threshold value of the circulating reactive current supervision does not lead to a blocking.

7.9.5 Settings

Two-Winding Transformer and Parallel Control

Addr.	Parameter	C	Setting Options	Default Setting
Ref. for %-values				
_:2311:101	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:102	General:Rated voltage		0.10 kV to 1200.00 kV	400.00 kV
_:2311:106	General:Rated app. power transf.		0.20 MVA to 5000.00 MVA	692.82 MVA
_:2311:108	General:Imp(Z): short circuit imp.		1.00 % to 20.00 %	10.00 %
_:2311:124	General:Freq tracking group ID		1 to 100	1
Tap changer				
_:13981:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s

Addr.	Parameter	C	Setting Options	Default Setting
_:13981:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:13981:113	Tap changer:Motor supervision time		5 s to 100 s	10 s
_:13981:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap
_:13981:114	Tap changer:Lowest tap position		-64 to 64	1
_:13981:115	Tap changer:Highest tap position		-64 to 64	15
General				
_:14011:1	90V V.contr.2w:Mode		• off • on • test	on
_:14011:101	90V V.contr.2w:Operating mode		• Manual • Auto	Manual
_:14011:104	90V V.contr.2w:Minimal voltage		0 % to 100 %	5 %
_:14011:100	90V V.contr.2w:Measured value		• positive-seq. voltage • VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated	positive-seq. voltage
Control tap changer				
_:14011:107	90V V.contr.2w:Check switching authority		• no • yes	yes
_:14011:109	90V V.contr.2w:Control model		• direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:14011:110	90V V.contr.2w:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:14011:111	90V V.contr.2w:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Voltage Control				
_:14011:156	90V V.contr.2w:Number of target voltage		• 1 • 2 • 3 • 4	1

Addr.	Parameter	C	Setting Options	Default Setting
_:14011:112	90V V.contr.2w:Target voltage 1		10.000 V to 340.000 V	110.000 V
_:14011:157	90V V.contr.2w:Target voltage 2		10.000 V to 340.000 V	110.000 V
_:14011:158	90V V.contr.2w:Target voltage 3		10.000 V to 340.000 V	110.000 V
_:14011:159	90V V.contr.2w:Target voltage 4		10.000 V to 340.000 V	110.000 V
_:14011:113	90V V.contr.2w:Band-width		0.2 % to 10.0 %	1.0 %
_:14011:114	90V V.contr.2w:T1 char-acteristic		• Linear • Inverse	Linear
_:14011:115	90V V.contr.2w:T1 delay		5 s to 600 s	40 s
_:14011:116	90V V.contr.2w:T1 Inverse Min		5 s to 100 s	5 s
_:14011:117	90V V.contr.2w:T2 delay		0 s to 100 s	5 s
_:14011:118	90V V.contr.2w:Fast step up		• off • on	off
_:14011:119	90V V.contr.2w:Fast step up limit		-50.0 % to 0.0 %	-6.0 %
_:14011:120	90V V.contr.2w:Fast step up T delay		0.0 s to 10.0 s	2.0 s
_:14011:121	90V V.contr.2w:Fast step down		• off • on	on
_:14011:122	90V V.contr.2w:Fast step down limit		0.0 %to 50.0 %	6.0 %
_:14011:123	90V V.contr.2w:Fast step down T delay		0.0 s to 10.0 s	0.0 s
_:14011:124	90V V.contr.2w:Function monitoring		0 min to 120 min	15 min
_:14011:155	90V V.contr.2w:Regulate with T2 at start		• off • on	on
_:14011:160	90V V.contr.2w:Set point mode active		• off • on	on
Parallel operation				
_:14011:161	90V V.contr.2w:Parallel mode		• No mode • Master • Follower • Circulat. react current	No mode
_:14011:168	90V V.contr.2w:Parallel-transfomer id		1 to 8	1
_:14011:164	90V V.contr.2w:Parallel mode changeable		• by setting • controllable	by setting
_:14011:165	90V V.contr.2w:Force master changeable		• by setting • controllable	by setting
_:14011:166	90V V.contr.2w:Maximal tap difference		1 to 9	2

Addr.	Parameter	C	Setting Options	Default Setting
_:14011:169	90V V.contr.2w:Reactive I control factor		0.01 to 100.00	1.00
_:14011:146	90V V.contr.2w:VT supervision		• off • on	on
_:14011:147	90V V.contr.2w:VT supervision threshold		0.5 % to 10.0 %	10.0 %
_:14011:148	90V V.contr.2w:VT supervision time delay		1 s to 600 s	10 s
_:14011:149	90V V.contr.2w:Circul. current blocking		• off • on	on
_:14011:150	90V V.contr.2w:Circul. current threshold		10 % to 500 %	50 %
_:14011:151	90V V.contr.2w:Circul. current time delay		0 s to 1000 s	60 s
Line drop comp.				
_:14011:125	90V V.contr.2w:Line drop compensation		• off • LDC-Z • LDC-XandR	off
_:14011:126	90V V.contr.2w:Target voltage rising		0.0 %to 20.0 %	4.0 %
_:14011:127	90V V.contr.2w:Max load current		0.0 % to 500.0 %	100.0 %
_:14011:153	90V V.contr.2w:R line		0.00 Ω to 30.00 Ω	0.00 Ω
_:14011:154	90V V.contr.2w:X line		-30.00 Ω to 30.00 Ω	0.00 Ω
_:14011:172	90V V.contr.2w:LDC is calculated		• on target voltage • on measured voltage	on target voltage
Dyn. voltage control				
_:14011:177	90V V.contr.2w:DVC mode		• off • on	off
_:14011:173	90V V.contr.2w:Target Voltage min		10.000 V to 340.000 V	106.000 V
_:14011:174	90V V.contr.2w:Target Voltage max		10.000 V to 340.000 V	114.000 V
_:14011:175	90V V.contr.2w:Active power min		-100.00 % to 0.00 %	-20.00 %
_:14011:176	90V V.contr.2w:Active power max		0.00 % to 100.00 %	30.00 %
Limiting				
_:14011:102	90V V.contr.2w:Lower tap-position limit		-128 to 127	1
_:14011:103	90V V.contr.2w:Higher tap-position limit		-128 to 127	15
_:14011:128	90V V.contr.2w:Vmin limiting		• off • on	on
_:14011:129	90V V.contr.2w:Vmin threshold		10.000 V to 340.000 V	105.000 V
_:14011:130	90V V.contr.2w:Vmin time delay		0 s to 20 s	10 s

Addr.	Parameter	C	Setting Options	Default Setting
_:14011:131	90V V.contr.2w:Vmax limiting		• off • on	on
_:14011:132	90V V.contr.2w:Vmax threshold		10.000 V to 340.000 V	115.000 V
_:14011:133	90V V.contr.2w:Vmax time delay		0 s to 20 s	10 s
Blocking				
_:14011:134	90V V.contr.2w:Blocking behavior		• Auto • Auto-Manual	Auto-Manual
_:14011:135	90V V.contr.2w:V< Blocking		• off • on	on
_:14011:136	90V V.contr.2w:V< Threshold		10.000 V to 340.000 V	90.000 V
_:14011:137	90V V.contr.2w:V< Time delay		0 s to 20 s	0 s
_:14011:138	90V V.contr.2w:I> Blocking		• off • on	on
_:14011:139	90V V.contr.2w:I> Threshold		10 % to 500 %	150 %
_:14011:140	90V V.contr.2w:I> Time delay		0 s to 20 s	0 s
_:14011:141	90V V.contr.2w:I< Blocking		• off • on	off
_:14011:142	90V V.contr.2w:I< Threshold		3 % to 100 %	10 %
_:14011:143	90V V.contr.2w:I< Time delay		0 s to 20 s	10 s

Three-Winding Transformer

Addr.	Parameter	C	Setting Options	Default Setting
Winding 1				
_:2311:101	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:103	General:Rated voltage		0.10 kV to 1200.00 kV	400.00 kV
Winding 2				
_:2311:102	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:104	General:Rated voltage		0.10 kV to 1200.00 kV	400.00 kV
Rated values				
_:2311:137	General:Freq tracking group ID		1 to 100	1
Tap changer				
_:13981:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s
_:13981:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:13981:113	Tap changer:Motor supervision time		5 s to 100 s	10 s

Addr.	Parameter	C	Setting Options	Default Setting
_:13981:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap
_:13981:114	Tap changer:Lowest tap position		-64 to 64	1
_:13981:115	Tap changer:Highest tap position		-64 to 64	15
General				
_:15601:1	90V V.contr.3w:Mode		• off • on • test	on
_:15601:101	90V V.contr.3w:Operating mode		• Manual • Auto	Manual
_:15601:104	90V V.contr.3w:Minimal voltage		0 % to 100 %	5 %
_:15601:173	90V V.contr.3w:Measured value winding 1		• positive-seq. voltage • VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated	positive-seq. voltage
_:15601:174	90V V.contr.3w:Measured value winding 2		• positive-seq. voltage • VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated	positive-seq. voltage
_:15601:157	90V V.contr.3w:Winding selection		• Winding 1 • Winding 2 • WithMaxLoad	Winding 1
_:15601:161	90V V.contr.3w:Winding selection		• Winding 1 • Winding 2	Winding 1
Control tap changer				
_:15601:107	90V V.contr.3w:Check switching authority		• no • yes	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:15601:109	90V V.contr.3w:Control model		• direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:15601:110	90V V.contr.3w:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:15601:111	90V V.contr.3w:Feed-back monitoring time		0.01 s to 1800.00 s	10.00 s
Voltage Control				
_:15601:164	90V V.contr.3w:Number of target voltage		• 1 • 2 • 3 • 4	1
_:15601:112	90V V.contr.3w:Target voltage 1 w1		10.000 V to 340.000 V	110.000 V
_:15601:165	90V V.contr.3w:Target voltage 2 w1		10.000 V to 340.000 V	110.000 V
_:15601:166	90V V.contr.3w:Target voltage 3 w1		10.000 V to 340.000 V	110.000 V
_:15601:167	90V V.contr.3w:Target voltage 4 w1		10.000 V to 340.000 V	110.000 V
_:15601:146	90V V.contr.3w:Target voltage 1 w2		10.000 V to 340.000 V	110.000 V
_:15601:168	90V V.contr.3w:Target voltage 2 w2		10.000 V to 340.000 V	110.000 V
_:15601:169	90V V.contr.3w:Target voltage 3 w2		10.000 V to 340.000 V	110.000 V
_:15601:170	90V V.contr.3w:Target voltage 4 w2		10.000 V to 340.000 V	110.000 V
_:15601:113	90V V.contr.3w:Band-width		0.2 % to 10.0 %	1.0 %
_:15601:114	90V V.contr.3w:T1 char-acteristic		• Linear • Inverse	Linear
_:15601:115	90V V.contr.3w:T1 delay		5 s to 600 s	40 s
_:15601:116	90V V.contr.3w:T1 Inverse Min		5 s to 100 s	5 s
_:15601:117	90V V.contr.3w:T2 delay		0 s to 100 s	5 s
_:15601:118	90V V.contr.3w:Fast step up		• off • on	off
_:15601:119	90V V.contr.3w:Fast step up limit		-50.0 % to 0.0 %	-6.0 %
_:15601:120	90V V.contr.3w:Fast step up T delay		0.0 s to 10.0 s	2.0 s
_:15601:121	90V V.contr.3w:Fast step down		• off • on	on
_:15601:122	90V V.contr.3w:Fast step down limit		0.0 %to 50.0 %	6.0 %
_:15601:123	90V V.contr.3w:Fast step down T delay		0.0 s to 10.0 s	0.0 s

Addr.	Parameter	C	Setting Options	Default Setting
_:15601:124	90V V.contr.3w:Function monitoring		0 min to 120 min	15 min
_:15601:162	90V V.contr.3w:Power-flow supervision		• off • on	on
_:15601:163	90V V.contr.3w:Regulate with T2 at start		• off • on	on
_:15601:171	90V V.contr.3w:Set point mode active		• off • on	on
Line drop comp.				
_:15601:125	90V V.contr.3w:Line drop compensation		• off • LDC-Z • LDC-XandR	off
_:15601:172	90V V.contr.3w:LDC is calculated		• on target voltage • on measured voltage	on target voltage
_:15601:126	90V V.contr.3w:Target voltage rising w1		0.0 %to 20.0 %	4.0 %
_:15601:147	90V V.contr.3w:Target voltage rising w2		0.0 %to 20.0 %	4.0 %
_:15601:127	90V V.contr.3w:Max load current		0.0 % to 500.0 %	100.0 %
_:15601:153	90V V.contr.3w:R line w1		0.0 Ω to 30.0 Ω	0.0 Ω
_:15601:154	90V V.contr.3w:X line w1		-30.0 Ω to 30.0 Ω	0.0 Ω
_:15601:155	90V V.contr.3w:R line w2		0.0 Ω to 30.0 Ω	0.0 Ω
_:15601:156	90V V.contr.3w:X line w2		-30.0 Ω to 30.0 Ω	0.0 Ω
Dyn. voltage control				
_:15601:178	90V V.contr.3w:DVC mode		• off • on	off
_:15601:179	90V V.contr.3w:Target Voltage min w1		10.000 V to 340.000 V	106.000 V
_:15601:181	90V V.contr.3w:Target Voltage max w1		10.000 V to 340.000 V	114.000 V
_:15601:183	90V V.contr.3w:Active power min w1		-100.00 % to 0.00 %	-20.00 %
_:15601:185	90V V.contr.3w:Active power max w1		0.00 % to 100.00 %	30.00 %
_:15601:180	90V V.contr.3w:Target Voltage min w2		10.000 V to 340.000 V	106.000 V
_:15601:182	90V V.contr.3w:Target Voltage max w2		10.000 V to 340.000 V	114.000 V
_:15601:184	90V V.contr.3w:Active power min w2		-100.00 % to 0.00 %	-20.00 %
_:15601:186	90V V.contr.3w:Active power max w2		0.00 % to 100.00 %	30.00 %

Addr.	Parameter	C	Setting Options	Default Setting
Limiting				
_:15601:102	90V V.contr.3w:Lower tap-position limit		-128 to 127	1
_:15601:103	90V V.contr.3w:Higher tap-position limit		-128 to 127	15
_:15601:128	90V V.contr.3w:Vmin limiting		• off • on	on
_:15601:129	90V V.contr.3w:Vmin threshold w1		10.000 V to 340.000 V	105.000 V
_:15601:148	90V V.contr.3w:Vmin threshold w2		10.000 V to 340.000 V	105.000 V
_:15601:130	90V V.contr.3w:Vmin time delay		0 s to 20 s	10 s
_:15601:131	90V V.contr.3w:Vmax limiting		• off • on	on
_:15601:132	90V V.contr.3w:Vmax threshold w1		10.000 V to 340.000 V	115.000 V
_:15601:149	90V V.contr.3w:Vmax threshold w2		10.000 V to 340.000 V	115.000 V
_:15601:133	90V V.contr.3w:Vmax time delay		0 s to 20 s	10 s
Blocking				
_:15601:134	90V V.contr.3w:Blocking behavior		• Auto • Auto-Manual	Auto-Manual
_:15601:135	90V V.contr.3w:V< Blocking		• off • on	on
_:15601:136	90V V.contr.3w:V< Threshold w1		10.000 V to 340.000 V	90.000 V
_:15601:150	90V V.contr.3w:V< Threshold w2		10.000 V to 340.000 V	90.000 V
_:15601:137	90V V.contr.3w:V< Time delay		0 s to 20 s	0 s
_:15601:138	90V V.contr.3w:I> Blocking		• off • on	on
_:15601:139	90V V.contr.3w:I> Threshold		10 % to 500 %	150 %
_:15601:140	90V V.contr.3w:I> Time delay		0 s to 20 s	0 s
_:15601:141	90V V.contr.3w:I< Blocking		• off • on	off
_:15601:142	90V V.contr.3w:I< Threshold		3 % to 100 %	10 %
_:15601:143	90V V.contr.3w:I< Time delay		0 s to 20 s	10 s

Grid Coupling Transformer

Addr.	Parameter	C	Setting Options	Default Setting
Winding 1				
_:2311:101	General:Rated current		0.20 A to 100000.00 A	1000.00 A

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:103	General:Rated voltage		0.10 kV to 1200.00 kV	400.00 kV
Winding 2				
_:2311:102	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:104	General:Rated voltage		0.10 kV to 1200.00 kV	400.00 kV
Rated values				
_:2311:137	General:Freq tracking group ID		1 to 100	1
Tap changer				
_:13981:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s
_:13981:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:13981:113	Tap changer:Motor supervision time		5 s to 100 s	10 s
_:13981:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap
_:13981:114	Tap changer:Lowest tap position		-64 to 64	1
_:13981:115	Tap changer:Highest tap position		-64 to 64	15
General				
_:16351:1	90V V.contr.gc:Mode		• off • on • test	on
_:16351:101	90V V.contr.gc:Operating mode		• Manual • Auto	Manual
_:16351:104	90V V.contr.gc:Minimal voltage		0 % to 100 %	5 %
_:16351:173	90V V.contr.gc:Measured value winding 1		• positive-seq. voltage • VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated	positive-seq. voltage

Addr.	Parameter	C	Setting Options	Default Setting
_:16351:174	90V V.contr.gc:Measured value winding 2		• positive-seq. voltage • VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated	positive-seq. voltage
_:16351:157	90V V.contr.gc:Winding selection		• Winding 1 • Winding 2 • WithMaxLoad	Winding 1
_:16351:161	90V V.contr.gc:Winding selection		• Winding 1 • Winding 2	Winding 1
Control tap changer				
_:16351:107	90V V.contr.gc:Check switching authority		• no • yes	yes
_:16351:109	90V V.contr.gc:Control model		• direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:16351:110	90V V.contr.gc:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:16351:111	90V V.contr.gc:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Voltage Control				
_:16351:164	90V V.contr.gc:Number of target voltage		• 1 • 2 • 3 • 4	1
_:16351:112	90V V.contr.gc:Target voltage 1 w1		10.000 V to 340.000 V	110.000 V
_:16351:165	90V V.contr.gc:Target voltage 2 w1		10.000 V to 340.000 V	110.000 V
_:16351:166	90V V.contr.gc:Target voltage 3 w1		10.000 V to 340.000 V	110.000 V
_:16351:167	90V V.contr.gc:Target voltage 4 w1		10.000 V to 340.000 V	110.000 V
_:16351:146	90V V.contr.gc:Target voltage 1 w2		10.000 V to 340.000 V	110.000 V
_:16351:168	90V V.contr.gc:Target voltage 2 w2		10.000 V to 340.000 V	110.000 V
_:16351:169	90V V.contr.gc:Target voltage 3 w2		10.000 V to 340.000 V	110.000 V
_:16351:170	90V V.contr.gc:Target voltage 4 w2		10.000 V to 340.000 V	110.000 V

Addr.	Parameter	C	Setting Options	Default Setting
_:16351:113	90V V.contr.gc:Band-width		0.2 % to 10.0 %	1.0 %
_:16351:114	90V V.contr.gc:T1 char-acteristic		• Linear • Inverse	Linear
_:16351:115	90V V.contr.gc:T1 delay		5 s to 600 s	40 s
_:16351:116	90V V.contr.gc:T1 Inverse Min		5 s to 100 s	5 s
_:16351:117	90V V.contr.gc:T2 delay		0 s to 100 s	5 s
_:16351:118	90V V.contr.gc:Fast step up		• off • on	off
_:16351:119	90V V.contr.gc:Fast step up limit		-50.0 % to 0.0 %	-6.0 %
_:16351:120	90V V.contr.gc:Fast step up T delay		0.0 s to 10.0 s	2.0 s
_:16351:121	90V V.contr.gc:Fast step down		• off • on	on
_:16351:122	90V V.contr.gc:Fast step down limit		0.0 %to 50.0 %	6.0 %
_:16351:123	90V V.contr.gc:Fast step down T delay		0.0 s to 10.0 s	0.0 s
_:16351:124	90V V.contr.gc:Function monitoring		0 min to 120 min	15 min
_:16351:162	90V V.contr.gc:Power-flow supervision		• off • on	on
_:16351:163	90V V.contr.gc:Regulate with T2 at start		• off • on	on
_:16351:171	90V V.contr.gc:Set point mode active		• off • on	on
Line drop comp.				
_:16351:125	90V V.contr.gc:Line drop compensation		• off • LDC-Z • LDC-XandR	off
_:16351:172	90V V.contr.gc:LDC is calculated		• on target voltage • on measured voltage	on target voltage
_:16351:126	90V V.contr.gc:Target voltage rising w1		0.0 %to 20.0 %	4.0 %
_:16351:147	90V V.contr.gc:Target voltage rising w2		0.0 %to 20.0 %	4.0 %
_:16351:127	90V V.contr.gc:Max load current		0.0 % to 500.0 %	100.0 %
_:16351:153	90V V.contr.gc:R line w1		0.0 Ω to 30.0 Ω	0.0 Ω
_:16351:154	90V V.contr.gc:X line w1		-30.0 Ω to 30.0 Ω	0.0 Ω
_:16351:155	90V V.contr.gc:R line w2		0.0 Ω to 30.0 Ω	0.0 Ω
_:16351:156	90V V.contr.gc:X line w2		-30.0 Ω to 30.0 Ω	0.0 Ω
Dyn. voltage control				
_:16351:178	90V V.contr.gc:DVC mode		• off • on	off

Addr.	Parameter	C	Setting Options	Default Setting
_:16351:179	90V V.contr.gc:Target Voltage min w1		10.000 V to 340.000 V	106.000 V
_:16351:181	90V V.contr.gc:Target Voltage max w1		10.000 V to 340.000 V	114.000 V
_:16351:183	90V V.contr.gc:Active power min w1		-100.00 % to 0.00 %	-20.00 %
_:16351:185	90V V.contr.gc:Active power max w1		0.00 % to 100.00 %	30.00 %
_:16351:180	90V V.contr.gc:Target Voltage min w2		10.000 V to 340.000 V	106.000 V
_:16351:182	90V V.contr.gc:Target Voltage max w2		10.000 V to 340.000 V	114.000 V
_:16351:184	90V V.contr.gc:Active power min w2		-100.00 % to 0.00 %	-20.00 %
_:16351:186	90V V.contr.gc:Active power max w2		0.00 % to 100.00 %	30.00 %
Limiting				
_:16351:102	90V V.contr.gc:Lower tap-position limit		-128 to 127	1
_:16351:103	90V V.contr.gc:Higher tap-position limit		-128 to 127	15
_:16351:128	90V V.contr.gc:Vmin limiting		• off • on	on
_:16351:129	90V V.contr.gc:Vmin threshold w1		10.000 V to 340.000 V	105.000 V
_:16351:148	90V V.contr.gc:Vmin threshold w2		10.000 V to 340.000 V	105.000 V
_:16351:130	90V V.contr.gc:Vmin time delay		0 s to 20 s	10 s
_:16351:131	90V V.contr.gc:Vmax limiting		• off • on	on
_:16351:132	90V V.contr.gc:Vmax threshold w1		10.000 V to 340.000 V	115.000 V
_:16351:149	90V V.contr.gc:Vmax threshold w2		10.000 V to 340.000 V	115.000 V
_:16351:133	90V V.contr.gc:Vmax time delay		0 s to 20 s	10 s
Blocking				
_:16351:134	90V V.contr.gc:Blocking behavior		• Auto • Auto-Manual	Auto-Manual
_:16351:135	90V V.contr.gc:V< Blocking		• off • on	on
_:16351:136	90V V.contr.gc:V< Threshold w1		10.000 V to 340.000 V	90.000 V
_:16351:150	90V V.contr.gc:V< Threshold w2		10.000 V to 340.000 V	90.000 V
_:16351:137	90V V.contr.gc:V< Time delay		0 s to 20 s	0 s
_:16351:138	90V V.contr.gc:I> Blocking		• off • on	on

Addr.	Parameter	C	Setting Options	Default Setting
_:16351:139	90V V.contr.gc:I> Threshold		10 % to 500 %	150 %
_:16351:140	90V V.contr.gc:I> Time delay		0 s to 20 s	0 s
_:16351:141	90V V.contr.gc:I< Blocking		• off • on	off
_:16351:142	90V V.contr.gc:I< Threshold		3 % to 100 %	10 %
_:16351:143	90V V.contr.gc:I< Time delay		0 s to 20 s	10 s

7.9.6 Information List

Two-Winding Transformer and Parallel Control

No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Tap changer			
_:13981:500	Tap changer:>Acquisition blocking	SPS	I
_:13981:501	Tap changer:>Enable	SPS	I
_:13981:52	Tap changer:Behavior	ENS	O
_:13981:53	Tap changer:Health	ENS	O
_:13981:301	Tap changer:End higher pos.reached	SPS	O
_:13981:302	Tap changer:End lower pos.reached	SPS	O
_:13981:308	Tap changer:Position	BSC	C
_:13981:305	Tap changer:Higher command	SPS	O
_:13981:306	Tap changer:Lower command	SPS	O
_:13981:307	Tap changer:Command active	SPS	O
_:13981:309	Tap changer:Motor sup. time expired	SPS	O
_:13981:310	Tap changer:Trigger motor prot. sw.	SPS	O
_:13981:311	Tap changer:Position failure	SPS	O
_:13981:312	Tap changer:Op.ct.	INS	O
_:13981:319	Tap changer:Reset failure	SPC	C
90V V.contr.2w			
_:14011:81	90V V.contr.2w:>Block	SPS	I
_:14011:85	90V V.contr.2w:>Reset min./max.	SPS	I
_:14011:53	90V V.contr.2w:Health	ENS	O
_:14011:54	90V V.contr.2w:Inactive	SPS	O
_:14011:339	90V V.contr.2w:Auto inactive	SPS	O
_:14011:52	90V V.contr.2w:Behavior	ENS	O
_:14011:301	90V V.contr.2w:End Higher pos. Auto	SPS	O
_:14011:302	90V V.contr.2w:End Lower pos. Auto	SPS	O
_:14011:326	90V V.contr.2w:Cmd. with feedback	BSC	C
_:14011:329	90V V.contr.2w:Block auto	SPC	C
_:14011:312	90V V.contr.2w:Operating mode	SPC	C

No.	Information	Data Class (Type)	Type
_:14011:305	90V V.contr.2w:Bandwidth >	SPS	O
_:14011:306	90V V.contr.2w:Bandwidth <	SPS	O
_:14011:307	90V V.contr.2w:Fast Step Up active	SPS	O
_:14011:308	90V V.contr.2w:Fast Step Down active	SPS	O
_:14011:309	90V V.contr.2w:Auto Monitor	SPS	O
_:14011:310	90V V.contr.2w:Vmin Limiting	SPS	O
_:14011:311	90V V.contr.2w:Vmax Limiting	SPS	O
_:14011:315	90V V.contr.2w:Auto Blocking	SPS	O
_:14011:316	90V V.contr.2w:Manual Blocking	SPS	O
_:14011:317	90V V.contr.2w:V< Blocking	SPS	O
_:14011:318	90V V.contr.2w:I> Blocking	SPS	O
_:14011:319	90V V.contr.2w:I< Blocking	SPS	O
_:14011:366	90V V.contr.2w:VT supervision	SPS	O
_:14011:367	90V V.contr.2w:Circul. current blocking	SPS	O
_:14011:320	90V V.contr.2w:V act.	MV	O
_:14011:333	90V V.contr.2w:Vact.m	MV	O
_:14011:321	90V V.contr.2w:ΔV act.	MV	O
_:14011:334	90V V.contr.2w:ΔV act V	MV	O
_:14011:335	90V V.contr.2w:ΔV act C	MV	O
_:14011:322	90V V.contr.2w:I load	MV	O
_:14011:364	90V V.contr.2w:PhAng	MV	O
_:14011:336	90V V.contr.2w:I load Σ	MV	O
_:14011:365	90V V.contr.2w:I circul.	MV	O
_:14011:323	90V V.contr.2w:V max	MV	O
_:14011:324	90V V.contr.2w:V min	MV	O
_:14011:325	90V V.contr.2w:V target	MV	O
_:14011:354	90V V.contr.2w:Target voltage 1	SPC	C
_:14011:355	90V V.contr.2w:Target voltage 2	SPC	C
_:14011:356	90V V.contr.2w:Target voltage 3	SPC	C
_:14011:357	90V V.contr.2w:Target voltage 4	SPC	C
_:14011:358	90V V.contr.2w:Set target voltage	APC	C
_:14011:368	90V V.contr.2w:Set bandwidth	APC	C
_:14011:359	90V V.contr.2w:Block T1	SPC	C
_:14011:337	90V V.contr.2w:No. of master is not 1	SPS	O
_:14011:338	90V V.contr.2w:Automatic block. local	SPS	O
_:14011:328	90V V.contr.2w:Parallel operation	SPC	C
_:14011:331	90V V.contr.2w:Parallel group	INC	C
_:14011:332	90V V.contr.2w:Force master	SPC	C
_:14011:360	90V V.contr.2w:Local parallel mode	ENS	O
_:14011:363	90V V.contr.2w:Local para. transf. id	INS	O
_:14011:361	90V V.contr.2w:Cause of par.op. error	ENS	O
_:14011:362	90V V.contr.2w:Parallel-operation error	SPS	O

Three-Winding Transformer

No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Tap changer			
_:13981:500	Tap changer:>Acquisition blocking	SPS	I
_:13981:501	Tap changer:>Enable	SPS	I
_:13981:52	Tap changer:Behavior	ENS	O
_:13981:53	Tap changer:Health	ENS	O
_:13981:301	Tap changer:End higher pos.reached	SPS	O
_:13981:302	Tap changer:End lower pos.reached	SPS	O
_:13981:308	Tap changer:Position	BSC	C
_:13981:305	Tap changer:Higher command	SPS	O
_:13981:306	Tap changer:Lower command	SPS	O
_:13981:307	Tap changer:Command active	SPS	O
_:13981:309	Tap changer:Motor sup. time expired	SPS	O
_:13981:310	Tap changer:Trigger motor prot. sw.	SPS	O
_:13981:311	Tap changer:Position failure	SPS	O
_:13981:312	Tap changer:Op.ct.	INS	O
_:13981:319	Tap changer:Reset failure	SPC	C
90V V.contr.3w			
_:15601:81	90V V.contr.3w:>Block	SPS	I
_:15601:85	90V V.contr.3w:>Reset min./max.	SPS	I
_:15601:53	90V V.contr.3w:Health	ENS	O
_:15601:54	90V V.contr.3w:Inactive	SPS	O
_:15601:371	90V V.contr.3w:Auto inactive	SPS	O
_:15601:52	90V V.contr.3w:Behavior	ENS	O
_:15601:301	90V V.contr.3w:End Higher pos. Auto	SPS	O
_:15601:302	90V V.contr.3w:End Lower pos. Auto	SPS	O
_:15601:332	90V V.contr.3w:Cmd. with feedback	BSC	C
_:15601:335	90V V.contr.3w:Block auto	SPC	C
_:15601:336	90V V.contr.3w:Operating mode	SPC	C
_:15601:305	90V V.contr.3w:Bandwidth >	SPS	O
_:15601:306	90V V.contr.3w:Bandwidth <	SPS	O
_:15601:307	90V V.contr.3w:Fast Step Up active	SPS	O
_:15601:308	90V V.contr.3w:Fast Step Down active	SPS	O
_:15601:309	90V V.contr.3w:Auto Monitor	SPS	O
_:15601:357	90V V.contr.3w:Power-flow superv.	SPS	O
_:15601:310	90V V.contr.3w:Vmin Limiting w1	SPS	O
_:15601:311	90V V.contr.3w:Vmin Limiting w2	SPS	O
_:15601:312	90V V.contr.3w:Vmax Limiting w1	SPS	O
_:15601:313	90V V.contr.3w:Vmax Limiting w2	SPS	O
_:15601:314	90V V.contr.3w:Auto Blocking	SPS	O
_:15601:315	90V V.contr.3w:Manual Blocking	SPS	O
_:15601:316	90V V.contr.3w:V< Blocking w1	SPS	O
_:15601:317	90V V.contr.3w:V< Blocking w2	SPS	O

No.	Information	Data Class (Type)	Type
_:15601:318	90V V.contr.3w:I> Blocking	SPS	O
_:15601:319	90V V.contr.3w:I< Blocking	SPS	O
_:15601:320	90V V.contr.3w:Vact.w1	MV	O
_:15601:321	90V V.contr.3w:Vact.w2	MV	O
_:15601:322	90V V.contr.3w:ΔV act.	MV	O
_:15601:323	90V V.contr.3w:I load w1	MV	O
_:15601:324	90V V.contr.3w:I load w2	MV	O
_:15601:325	90V V.contr.3w:Vmax 1	MV	O
_:15601:326	90V V.contr.3w:Vmax 2	MV	O
_:15601:327	90V V.contr.3w:Vmin 1	MV	O
_:15601:328	90V V.contr.3w:Vmin 2	MV	O
_:15601:372	90V V.contr.3w:PhAng 1	MV	O
_:15601:373	90V V.contr.3w:PhAng 2	MV	O
_:15601:329	90V V.contr.3w:V tar.w1	MV	O
_:15601:330	90V V.contr.3w:V tar.w2	MV	O
_:15601:358	90V V.contr.3w:Target voltage 1 w1	SPC	C
_:15601:359	90V V.contr.3w:Target voltage 2 w1	SPC	C
_:15601:360	90V V.contr.3w:Target voltage 3 w1	SPC	C
_:15601:361	90V V.contr.3w:Target voltage 4 w1	SPC	C
_:15601:362	90V V.contr.3w:Target voltage 1 w2	SPC	C
_:15601:363	90V V.contr.3w:Target voltage 2 w2	SPC	C
_:15601:364	90V V.contr.3w:Target voltage 3 w2	SPC	C
_:15601:365	90V V.contr.3w:Target voltage 4 w2	SPC	C
_:15601:366	90V V.contr.3w:Set target voltage w1	APC	C
_:15601:367	90V V.contr.3w:Set target voltage w2	APC	C
_:15601:374	90V V.contr.3w:Set bandwidth	APC	C
_:15601:368	90V V.contr.3w:Block T1	SPC	C
_:15601:356	90V V.contr.3w:Winding act.	INS	O
_:15601:369	90V V.contr.3w:Winding selec. manual	SPC	C
_:15601:370	90V V.contr.3w:Winding selec. auto	SPC	C

Grid Coupling Transformer

No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Tap changer			
_:13981:500	Tap changer:>Acquisition blocking	SPS	I
_:13981:501	Tap changer:>Enable	SPS	I
_:13981:52	Tap changer:Behavior	ENS	O
_:13981:53	Tap changer:Health	ENS	O
_:13981:301	Tap changer:End higher pos.reached	SPS	O
_:13981:302	Tap changer:End lower pos.reached	SPS	O
_:13981:308	Tap changer:Position	BSC	C
_:13981:305	Tap changer:Higher command	SPS	O

No.	Information	Data Class (Type)	Type
_:13981:306	Tap changer:Lower command	SPS	O
_:13981:307	Tap changer:Command active	SPS	O
_:13981:309	Tap changer:Motor sup. time expired	SPS	O
_:13981:310	Tap changer:Trigger motor prot. sw.	SPS	O
_:13981:311	Tap changer:Position failure	SPS	O
_:13981:312	Tap changer:Op.ct.	INS	O
_:13981:319	Tap changer:Reset failure	SPC	C
90V V.contr.gc			
_:16351:81	90V V.contr.gc:>Block	SPS	I
_:16351:85	90V V.contr.gc:>Reset min./max.	SPS	I
_:16351:53	90V V.contr.gc:Health	ENS	O
_:16351:54	90V V.contr.gc:Inactive	SPS	O
_:16351:371	90V V.contr.gc:Auto inactive	SPS	O
_:16351:52	90V V.contr.gc:Behavior	ENS	O
_:16351:301	90V V.contr.gc:End Higher pos. Auto	SPS	O
_:16351:302	90V V.contr.gc:End Lower pos. Auto	SPS	O
_:16351:332	90V V.contr.gc:Cmd. with feedback	BSC	C
_:16351:335	90V V.contr.gc:Block auto	SPC	C
_:16351:336	90V V.contr.gc:Operating mode	SPC	C
_:16351:305	90V V.contr.gc:Bandwidth >	SPS	O
_:16351:306	90V V.contr.gc:Bandwidth <	SPS	O
_:16351:307	90V V.contr.gc:Fast Step Up active	SPS	O
_:16351:308	90V V.contr.gc:Fast Step Down active	SPS	O
_:16351:309	90V V.contr.gc:Auto Monitor	SPS	O
_:16351:357	90V V.contr.gc:Power-flow superv.	SPS	O
_:16351:310	90V V.contr.gc:Vmin Limiting w1	SPS	O
_:16351:311	90V V.contr.gc:Vmin Limiting w2	SPS	O
_:16351:312	90V V.contr.gc:Vmax Limiting w1	SPS	O
_:16351:313	90V V.contr.gc:Vmax Limiting w2	SPS	O
_:16351:314	90V V.contr.gc:Auto Blocking	SPS	O
_:16351:315	90V V.contr.gc:Manual Blocking	SPS	O
_:16351:316	90V V.contr.gc:V< Blocking w1	SPS	O
_:16351:317	90V V.contr.gc:V< Blocking w2	SPS	O
_:16351:318	90V V.contr.gc:I> Blocking	SPS	O
_:16351:319	90V V.contr.gc:I< Blocking	SPS	O
_:16351:320	90V V.contr.gc:Vact.w1	MV	O
_:16351:321	90V V.contr.gc:Vact.w2	MV	O
_:16351:322	90V V.contr.gc:ΔV act.	MV	O
_:16351:323	90V V.contr.gc:I load w1	MV	O
_:16351:324	90V V.contr.gc:I load w2	MV	O
_:16351:325	90V V.contr.gc:Vmax 1	MV	O
_:16351:326	90V V.contr.gc:Vmax 2	MV	O
_:16351:327	90V V.contr.gc:Vmin 1	MV	O
_:16351:328	90V V.contr.gc:Vmin 2	MV	O
_:16351:372	90V V.contr.gc:PhAng 1	MV	O
_:16351:373	90V V.contr.gc:PhAng 2	MV	O

No.	Information	Data Class (Type)	Type
_:16351:329	90V V.contr.gc:V tar.w1	MV	O
_:16351:330	90V V.contr.gc:V tar.w2	MV	O
_:16351:358	90V V.contr.gc:Target voltage 1 w1	SPC	C
_:16351:359	90V V.contr.gc:Target voltage 2 w1	SPC	C
_:16351:360	90V V.contr.gc:Target voltage 3 w1	SPC	C
_:16351:361	90V V.contr.gc:Target voltage 4 w1	SPC	C
_:16351:362	90V V.contr.gc:Target voltage 1 w2	SPC	C
_:16351:363	90V V.contr.gc:Target voltage 2 w2	SPC	C
_:16351:364	90V V.contr.gc:Target voltage 3 w2	SPC	C
_:16351:365	90V V.contr.gc:Target voltage 4 w2	SPC	C
_:16351:366	90V V.contr.gc:Set target voltage w1	APC	C
_:16351:367	90V V.contr.gc:Set target voltage w2	APC	C
_:16351:374	90V V.contr.gc:Set bandwidth	APC	C
_:16351:368	90V V.contr.gc:Block T1	SPC	C
_:16351:356	90V V.contr.gc:Winding act.	INS	O
_:16351:369	90V V.contr.gc:Winding selec. manual	SPC	C
_:16351:370	90V V.contr.gc:Winding selec. auto	SPC	C

7.10 Point-on-Wave Switching

The **Point-on-wave switching** function in SIPROTEC 5 is used to reduce increased electrodynamic and dielectric loads which are caused by non-optimal switching of circuit breakers in the network. In extreme cases, these loads reduce the reliability and life of the equipment installed in the network or lead to unnecessary opening operations by the protection device. To avoid effects such as overvoltages and inrush currents, this function can control the closing and opening instants of circuit breakers.

Table 7-34 Avoided Effects in Different Load Types

Load Type	Switching Operation	Avoided Effect
Inductive load:	Opening	Restriking, overvoltage
Transformer, reactance coil	Closing	Inrush current
Capacitive load:	Opening	Restriking, overvoltage
Capacitor bank, unloaded lines/cables, filter	Closing	Overvoltage, inrush current

The **Point-on-wave switching** function is always started via a control command, either from the device internal control or from an external control function. Protection functions generally directly trip the circuit breaker and have no interaction with the **Point-on-wave switching** function.

You can find more information about this function in the *Point-on-Wave Switching Function Manual*.

8 Supervision Functions

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8.1 Overview

SIPROTEC 5 devices are equipped with an extensive and integrated supervision concept. Continuous supervision:

- Ensures the availability of the technology used
- Avoids subfunction and overfunction of the device
- Protects persons and primary technical devices
- Offers effective assistance during commissioning and testing

The following areas are monitored:

- Supervision the resource consumption of the application
- Supervision of the secondary system, including the external auxiliary power supply
- Supervision of device hardware
- Supervision of device firmware
- Supervision of hardware configuration
- Supervision of communication connections

When the supervision functions pick up, that will be displayed and also indicated. Error responses are defined for the device. The error responses are grouped in defect severities.

The supervision functions work selectively. When the supervision functions pick up - as far as possible - only the affected parts of the hardware and firmware are blocked. If this is not possible, the device goes out of operation into a secure state (fallback mode). In addition to safety, this warrants a high degree of availability.

8.2 Resource-Consumption Supervision

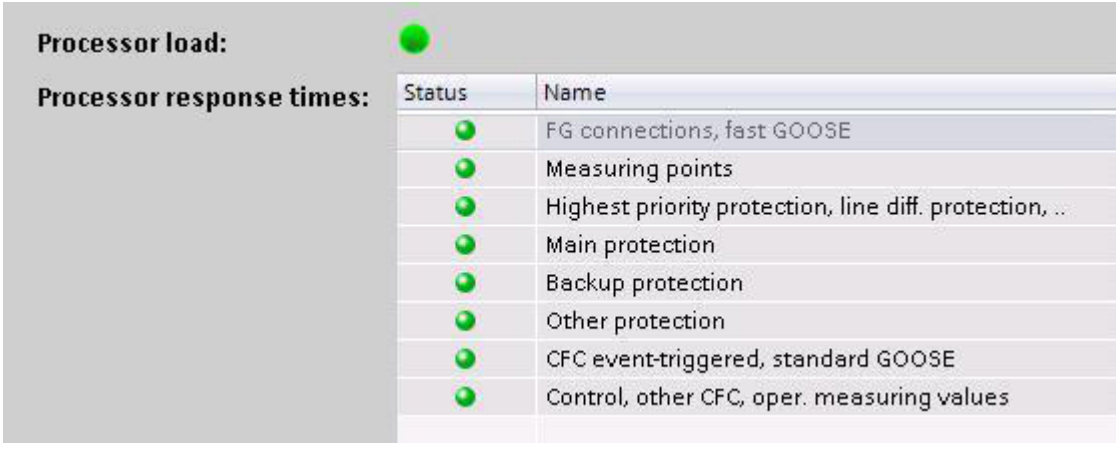
8.2.1 Load Model

SIPROTEC 5devices are freely configurable. A load model is integrated in DIGSI 5. The load model prevents you from overloading the device with an excessively large application.

The load model shows the device utilization and the response times for device functions. If it determines that an application created is likely to overload the device, DIGSI prevents the application from being loaded into the device.

In this rare case, you must then reduce the application in order to be able to load it into the device.

The load model can be found in the DIGSI 5 project tree under **Name of the device** → **Device information**. In the operating range, select the **Resource consumption** setting sheet. The following figure shows an example of the view of the load model in DIGSI 5:



[sc_lastmo_01, 1, en_US]

Figure 8-1 Visualization of the Load Model in DIGSI

A green total display for the processor response time indicates that the device is not overloaded by the present application. On the other hand, if you see a red exclamation mark, the planned application is overloading the device.

The list below the total display shows the individual functional areas. These areas combine functions with the same real-time requirements. A green display in front of an area (see *Figure 8-1*) indicates that the response times of the functions grouped in this area can be maintained. A red exclamation mark indicates that functions may have longer response times than specified in the Technical data for the device. In such a case, loading of the application into the device is blocked.

The following table provides an overview of the functional areas and the most important influencing quantities on device utilization:

Functional Area	Short Description	Change in Load
CFC event-triggered, fast	CFC charts that must be processed especially fast (for example, to invoke interlockings between protection functions)	Adding or removing CFC charts in the fast event-triggered process range • Create CFC chart • Delete CFC chart • Change the process range in the properties of the CFC chart Add to or remove from CFC charts in the fast event-triggered process area
Measuring points	Provision of measured values for protection, control, and measurement functions	Adding or removing • Measuring points (in the Measuring-points routing Editor) • Function groups that provide measured-value preprocessing for insertable functions (for example, Line function group and Circuit-breaker function group)
• FG connections • Fast GOOSE	• Interaction between individual function groups, for example, between the Line function group and the Circuit-breaker function group • Fast GOOSE communication	Adding or removing • Protection functions and their stages • Circuit-breaker function groups • Fast GOOSE connections
Protection Communication	Signal transmission via protection communication and differential protection communication	Adding or removing • Communication modules for the protection interface (in the DIGSI 5 Hardware and logs view) • Routings to the protection interface • Functions of theTransformer differential protection
Transformer Differential Protection	Transformer Differential Protection	Adding or removing differential protection functions
Main protection	Protection functions with high requirements for fast operate times	Adding or removing • Functions and zones of the distance protection; functions and tripping stages of the ground-fault protection • Power-swing blocking, functions and tripping stages of instantaneous high-current tripping
Backup protection	Protection functions with average requirements for fast operate times	Adding or removing • Functions and stages of overcurrent protection • Synchronization function
Other protection	Protection functions with low requirements for fast operate times	Adding or removing • Overload protection functions • Functions and stages of voltage protection • All functions not listed previously

Functional Area	Short Description	Change in Load
CFC event-triggered, standard GOOSE	CFC charts with a maximum processing time of 40 ms	Adding or removing CFC charts in the event-triggered process range • Create CFC chart • Delete CFC chart • Change the process range in the properties of the CFC chart Add to or remove from CFC charts in the event-triggered process area
• Control • Other CFC chart • Operational measured values	• Control and interlocking • CFC charts in the area of control, measured-value preprocessing, and event-controlled • Operational measured values	Adding or removing • Function blocks for control and interlocking • CFC charts in the control area • Switching devices (except circuit breakers), for example, Disconnector function groups • Operational measured values • CFC charts in the measured values area

If the load model displays a warning, bear in mind the following general instructions:

The areas named in the table are listed in descending order of real-time requirements. If a warning appears to the effect that the guaranteed response times may be exceeded in an area, you can return to the permitted area by taking the following measures:

- Reduce the functional scope in the marked area (red exclamation mark)
- Reduce the functional scope in another area with higher real-time requirements

When you have reduced the application, check the display in resource consumption! If a function or stage has been switched off, it will continue to represent a load for the area. If you do not need the function or stage, delete it rather than switching it off.

Use the general **Circuit-breaker** function group only in the following cases:

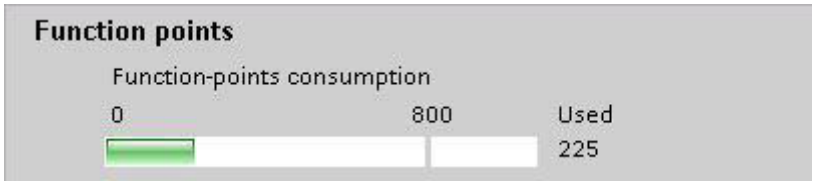
- Interaction with a protection-function group is essential.
  That is to say, operate indications of protection functions cause the circuit breaker assigned to the **Circuit-breaker** function group to be switched off.
- You want to use functions such as the automatic reclosing function or circuit-breaker failure protection in the **Circuit-breaker** function group.

If a circuit breaker is only to be modeled for control purposes, use the **Circuit-breaker [state only]** function group.

8.2.2 Function Points

When you order a SIPROTEC 5 device, you are also ordering a function-points account for use of additional functions.

The following figure illustrates consumption of function points in the current application with respect to the existing function-points account.



[sc_fpunkt, 1, en_US]

Figure 8-2 Resource Overview: Function-Points Consumption

The remaining white bar shows the function points that have not yet been used up by your configuration. The number of function points available in a device depends on the device purchase order (position 20 of the product code). You can also order function points subsequently, and so increase the function-points account for the device.

NOTE

Find out the function-points requirement for the desired application before ordering the device. For this, you can use the device configurator. Alternatively, you order the device with 0 function points and create the license file with the required point credits ad hoc using the SIPROTEC function point manager (refer to *2.2 Application Templates/Adaptation of Functional Scope*).

8.2.3 CFC Resources

Task Levels of the CFC Function

A CFC chart, and thus the configured CFC function, runs in the SIPROTEC 5 device on exactly one of the 4 task levels. The individual task levels differ, on the one hand, in the priority of processing tasks and, on the other, in the cyclic or event-triggered processing of the CFC charts.

You can select between the following task levels:

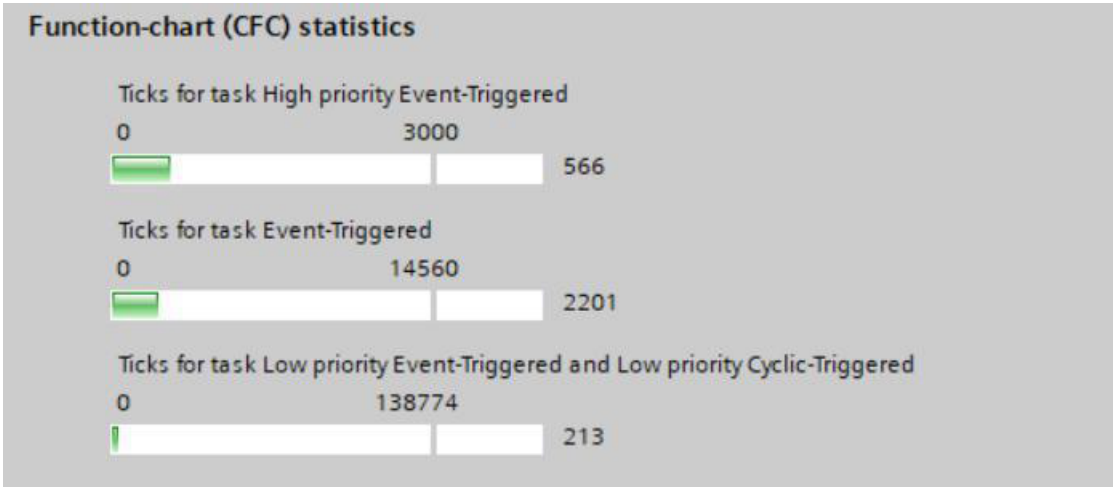
Task Level	Description
High priority Event-triggered	Use the ***High priority Event-triggered*** task level for time-critical tasks, for example, if a signal should block a protection function within 2 ms to 3 ms. Functions on this task level are processed in an event-triggered way with the highest priority. Each change to a logical input signal is immediately processed. Processing can interrupt the execution of protection functions and functions on the ***Event-Triggered*** task level.
Event-triggered	Use the ***Event-triggered*** task level preferably for logic functions that need not be executed with highest priority. Each change to a logical input signal is immediately processed. Protection functions or functions on the ***High priority Event-triggered*** task level can disrupt processing. Functions on the ***Event-triggered*** task level are typically processed within a maximum of 5 ms in all devices. For busbar protection or line protection, the functions on the ***Event-triggered*** task level are processed within a maximum of 10 ms.
Low priority Cyclic-triggered	Use the ***Low priority Cyclic-triggered*** task level for processing measured values. Functions on this task level are processed cyclically every 500 ms.
Low priority Event-triggered	Use the ***Low priority Event-triggered*** task level preferably for logic functions that should be executed with lower priority than functions in the ***Event-triggered*** task level. If the available ticks of the ***Event-triggered*** task level shown in the following figure are sufficient for the required CFC functionality, you do not need to use the ***Low priority Event-triggered*** task level.

All CFC function blocks can be assigned to all the task levels. There are no device-specific function blocks. If enough ticks are available, all CFC charts can be created in the same task level. A tick is the measure of the performance requirement of CFC blocks.

The number of available ticks for each task is calculated depending on the created device configuration. This calculation is based on the previously described load model. In this process, it is recommended to create all selected functions and objects first followed by configuration of the CFC charts so that a realistic information about the remaining system capacitance for CFC charts is available. Significantly exceeding the typical response time is prevented by the load model by limiting the number of CFC function blocks in the corresponding task level via the number of ticks available.

The typical response times for CFC tasks are listed in the Technical Data.

The following figure shows an example of the CFC chart capacitances in DIGSI calculated by the load model. The ticks available for each task are shown here. The green bars represent the ticks used in the task levels. You reach this dialog with the following call: Device → Device information → Resource consumption.



[sc_cfc-statistic, 2, en_US]

Figure 8-3 CFC Statistics

NOTE

High priority Event-triggered CFC charts have the highest priority and are processed before all other tasks. At this level, a considerable smaller number of ticks are available than at all other tasks. It is recommended to configure only very-high-priority logic functions at this task and to configure the other logic functions in any other level.

NOTE

Empty CFC charts also consume system resources. Empty charts that are not required any more should be deleted.

8.3 Supervision of the Secondary System

8.3.1 Overview

The secondary circuits establish a connection to the power system from the point of view of the device. The measuring-input circuits (currents, voltages) as well as the command circuits to the circuit breakers are monitored for the correct function of the device. The connection to the station battery is ensured with the supervision of the external auxiliary voltage. The secondary system has the following supervision systems:

Measuring circuits (voltage):

- Measuring-voltage failure
- Voltage-transformer circuit breaker
- Voltage balance
- Voltage sum
- Voltage rotating field

Measuring circuits (current):

- Broken conductor of the current circuits
- Current balance
- Current sum
- Current rotating field
- Saturation detection

Trip Circuits

When the supervisions listed in the previous section pick up, corresponding warning indications are output. Some supervisions lead directly to the blocking of affected protection functions or to the marking of measuring points that have become invalid, so that affected protection functions can go into a secure state.

A detailed description of the supervision mechanisms and their error responses can be found in the respective function descriptions.

External Auxiliary Voltage

The supervision of the external auxiliary voltage is described in Error Responses and Corrective Measures starting with *8.8.1 Overview*.

8.3.2 Measuring-Voltage Failure

8.3.2.1 Overview of Functions

The **Measuring-voltage failure detection** function monitors the voltage transformer secondary circuits:

- Non-connected transformers
- Pickup of the voltage transformer circuit breaker (in the event of short circuits in the secondary circuit)
- Broken conductor in one or more measuring loops

All these events cause a voltage of 0 in the voltage transformer secondary circuits which can lead to failures of the protection functions.

Each of the following protection functions has the parameter **Blk. by meas.-volt. failure**. Using the setting value of the parameter, you can specify whether the protection functions react to a measuring-voltage failure or not (block/not block).

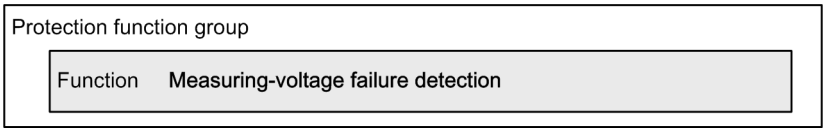
- Directional Overcurrent Protection, Phases
- Overvoltage Protection with Negative-Sequence Voltage
- Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage
- Undervoltage Protection with 3-Phase Voltage
- Overvoltage Protection with Positive-Sequence Voltage
- Voltage-Dependent Overcurrent Protection, Phases
- Overvoltage Protection with Negative-Sequence Voltage
- Overvoltage Protection with Positive-Sequence Voltage
- Undervoltage-Controlled Reactive-Power Protection

The following protection functions are automatically blocked in the case of a measuring-voltage failure:

- Distance protection
- Directional Negative-Sequence Protection
- Ground-Fault Protection for High-Resistance Ground Faults in Grounded Systems

8.3.2.2 Structure of the Function

The function is part of protection function groups which are connected with a 3-phase voltage and current measuring point.

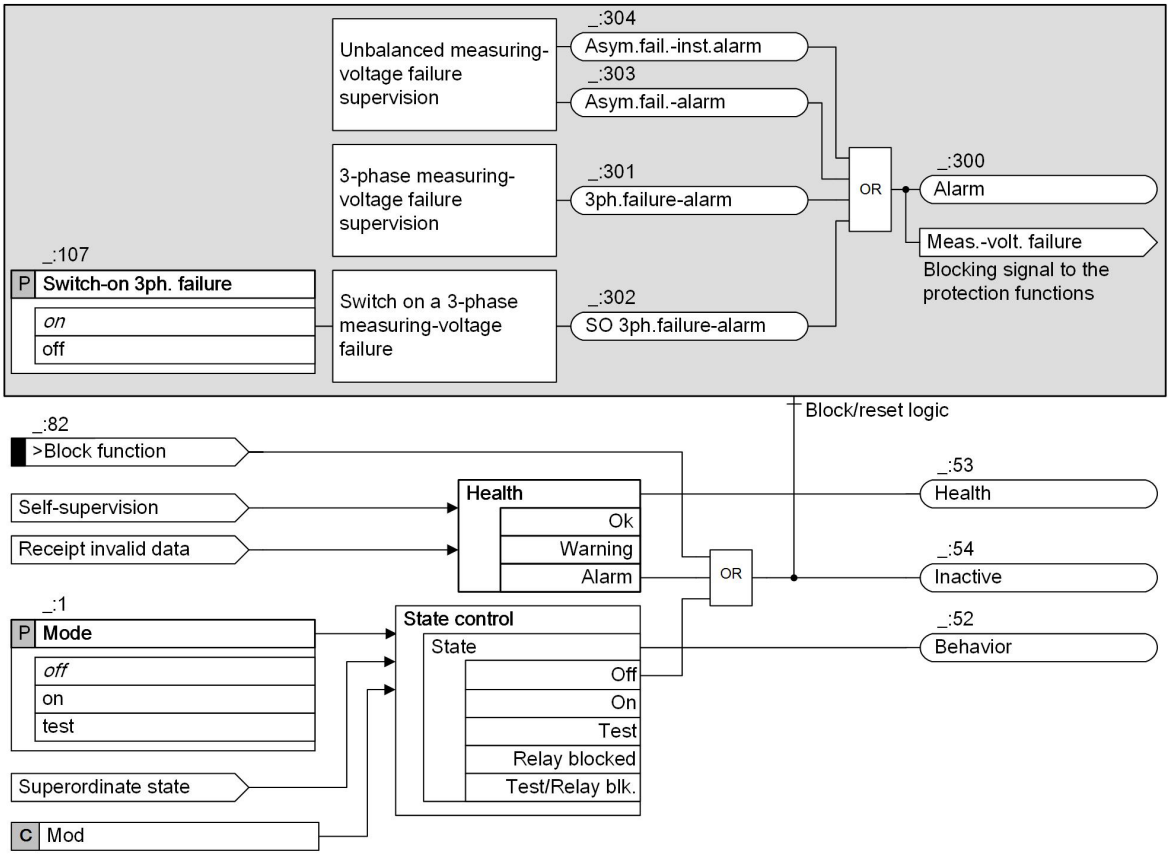


[dw_strffm, 1, en_US]

Figure 8-4 Structure/Embedding of the Function

The function is broken down into 3 subfunctions (see *Figure 8-5*):

- Supervision for unbalanced measuring-voltage failure
- Supervision for 3-phase measuring-voltage failure
- Supervision for switching onto a 3-phase measuring-voltage failure



[lo_ffm-3p_zusamm, 3, en_US]

Figure 8-5 Breakdown of the Measuring-Voltage Failure Detection Function

Each subfunction creates its own monitoring indication. The function summarizes these indications via the group indication **Alarm**.

The response to the detection of a measuring-voltage failure is explained in the specific protection-function descriptions.

8.3.2.3 Unbalanced Measuring-Voltage Failure

Logic

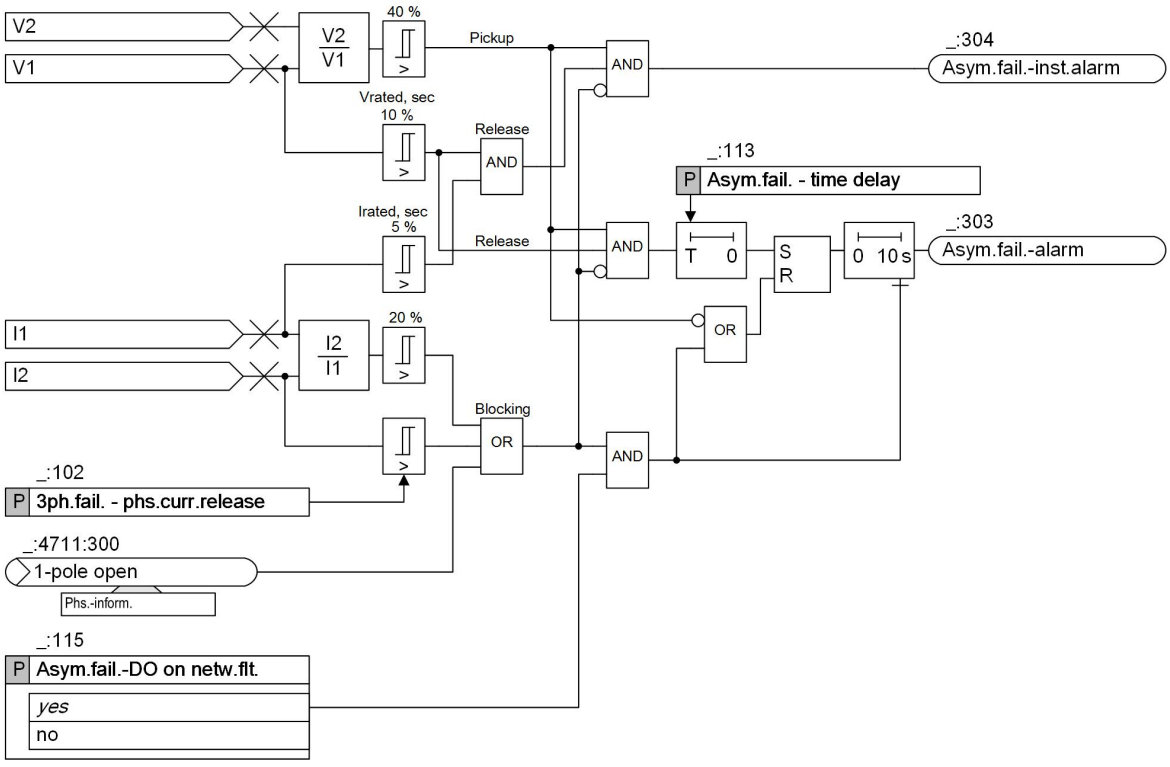


Figure 8-6 Logic Diagram Unbalanced Measuring-Voltage Failure Detection

The criterion for detection of an unbalanced measuring-voltage failure is the voltage unbalance. This unbalance is determined based on the ratio between negative and positive-sequence voltage. If the threshold value is exceeded and the monitoring is released and not blocked, the monitoring picks up (see *Figure 8-6*). The indication *Asym.fail.-inst.alarm* is output.

The monitoring is released as soon as a certain minimum voltage is exceeded. This prevents a spurious response in the presence of low voltage measurands or a measurand of 0 (for example, circuit breaker open). Instantaneous monitoring also requires the presence of a minimum current. This prevents a spurious instantaneous pick up of the monitoring in the presence of a weak infeed (current < 10 % of rated current) combined with a power-system incident.

If the voltage unbalance is blocked by unbalanced faults in the primary system, the supervision is blocked. The device detects an unbalanced fault based on the ratio between negative-sequence and positive-sequence current.

Delay/Seal-In

In the presence of a weak infeed (current < 10 % of rated current), certain protection functions require more time for detection of a system incident. For this purpose, monitoring can be delayed using the parameter **Asym.fail. - time delay**.

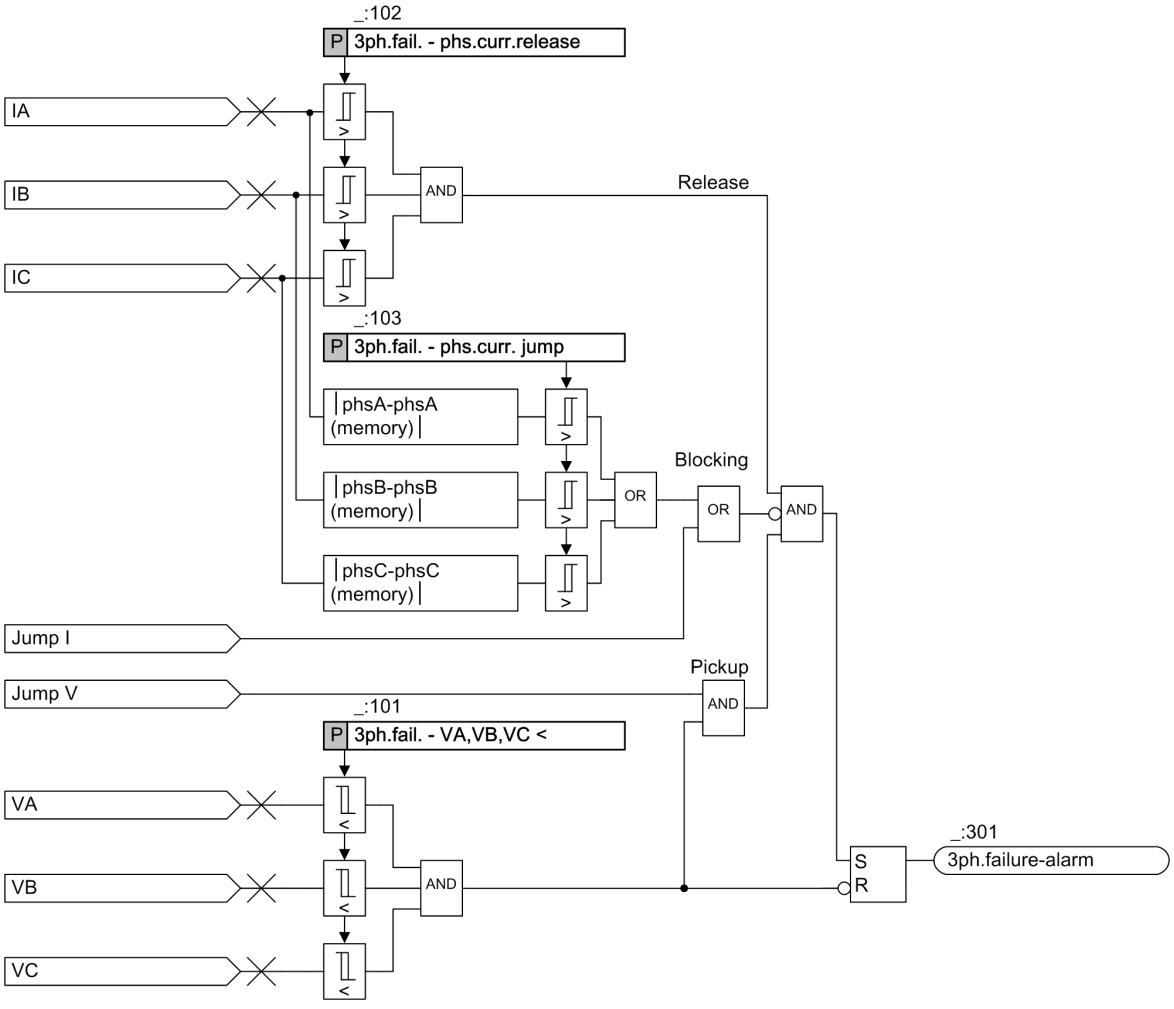
If a system incident is detected during the time delay, the supervision drops off. This is because the function assumes that the unbalance - and consequently the pickup of the supervision - is due to the system incident.

After the time delay has elapsed, it definitely assumes a measuring-voltage failure. Monitoring seals in and the *Asym.fail.-alarm* indication is output. The dropout does not happen until the voltage unbalance has disappeared after a seal-in time of 10 s. In the presence of 3-pole close-in faults outside the protection zone, this seal-in time prevents the monitoring from dropping off too quickly and thus releasing the protection functions.

The sealing-in function can be deactivated using the **Asym.fail.-DO on netw.flt.** parameter. As soon as a system incident is detected, the monitoring drops off instantaneously.

8.3.2.4 3-Phase Measuring-Voltage Failure

Logic



[lo_symmet, 1, en_US]

Figure 8-7 Logic Diagram 3-Phase Measuring-Voltage Failure

Balanced Fault – VA, VB, VC <

A 3-phase measuring-voltage failure is detected if the following criteria are fulfilled simultaneously:

- All 3 phase-to-ground voltages drop below the threshold value **3ph.fail. - VA,VB,VC <**
- A jump of the voltage (signal **Jump V**)

If these criteria are fulfilled and the monitoring is released and not blocked, the **3ph.failure-alarm** indication is output. When the voltage returns (even as 1-phase), the monitoring drops out.

Release by Phase Current

When all phase currents exceed the threshold value **3ph.fail. - phs.curr.release** the monitoring is released.

If the device incorporates the distance-protection function, the device checks the input threshold value **3ph.fail. - phs.curr.release** against the minimum current setting of the distance protection for

plausibility. The threshold value **3ph.fail. - phs.curr.release** must be set to less than or equal to the release current of the distance protection.

For more information see *Distance protection* *6.15.2.1 Overview of Functions* .

Blocking in the Case of a System Incident

In the case of a 3-phase system incident, supervision must be blocked. The device detects a 3-phase system incident with a jump in the current. This change is detected via the internal signal **Jump I** or when the change in current of a phase current exceeds the threshold value **3ph.fail. - phs.curr. jump**. The change in current of phase currents is formed from the difference between the present current phasor and the current phasor of the previous period. This allows to take into account a jump of the current phase.

NOTE

If a voltage-transformer circuit breaker is installed in the secondary circuit of the voltage transformers, its position is communicated to the device via a binary input (see chapter *8.3.4.1 Overview of Functions*).

8.3.2.5 Switching onto a 3-Phase Measuring-Voltage Failure, Low Load

Logic

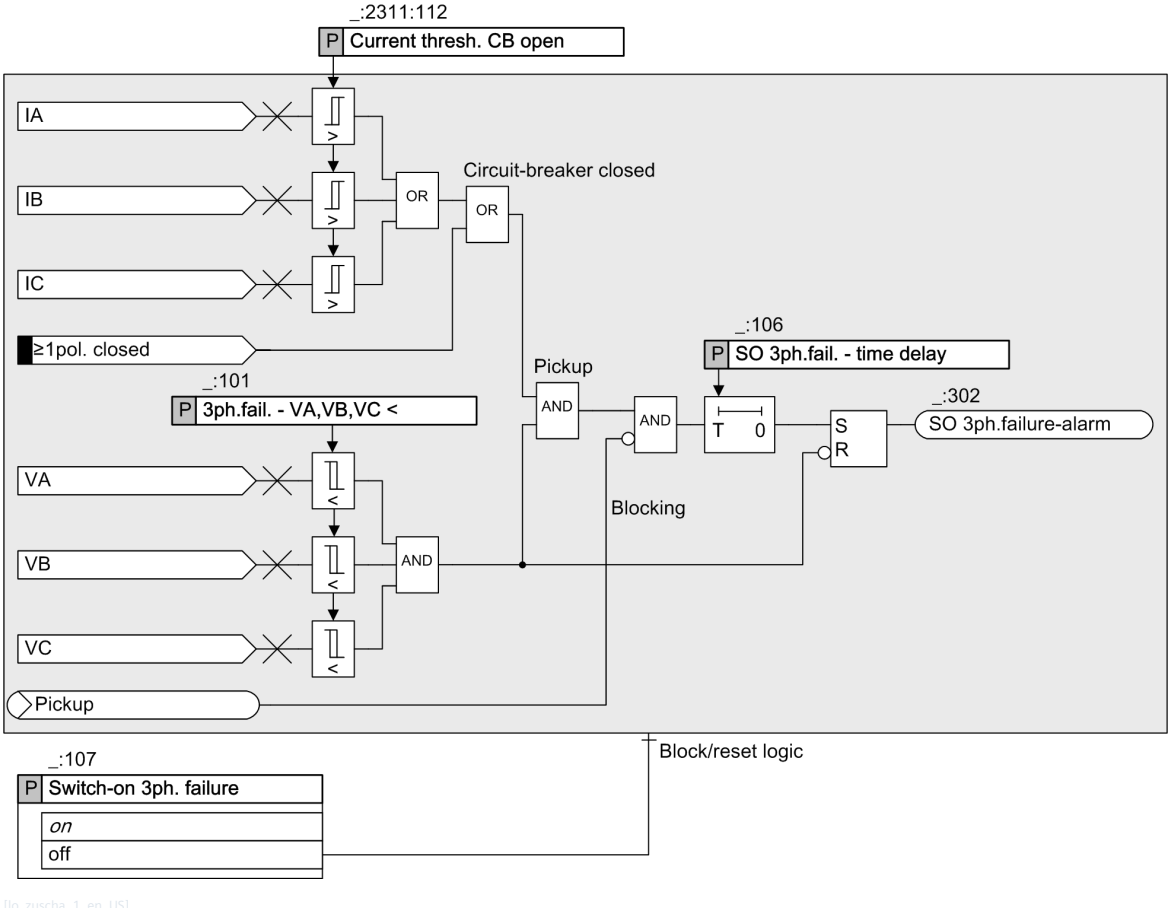


Figure 8-8 Logic Diagram Switching to 3-Phase Measuring-Voltage Failure

Switching onto a 3-phase measuring-voltage failure is detected if the following criteria are fulfilled simultaneously:

- All 3 phase-to-ground voltages have dropped below the threshold value **3ph.fail. - VA,VB,VC <**.
- The circuit breaker is detected to be in closed position. The detection takes place either via the phase currents or via the **≥1-pole closed** signal, which is generated via the circuit-breaker auxiliary contacts.
  For more detailed information, refer to *5.5.4.6 Circuit-Breaker Condition for the Protected Object*.

A voltage jump – such as in a 3-phase measuring-voltage failure with closed circuit breaker (refer to *8.3.2.4 3-Phase Measuring-Voltage Failure*) – does not occur in the case of switching to a 3-phase measuring-voltage failure. If the monitoring is not blocked, the time delay **SO 3ph.fail. - time delay** is started. After the time has elapsed, the indication **SO 3ph.failure-alarm** is displayed. A dropout of the monitoring is only possible by a recovery of the voltage.

The supervision is blocked as soon as a pickup of a protection function is detected within a protection function group and the time delay of the supervision has not yet elapsed.

This subfunction also covers the situation of a low load with 3-phase measuring-voltage failure and closed circuit breaker, because the circuit-breaker position is also determined from the circuit-breaker auxiliary contacts. The subfunction for detecting a 3-phase measuring-voltage failure (refer to *8.3.2.4 3-Phase Measuring-Voltage Failure*) is not released in this situation, for example, because the current flow is too low.

This subfunction can be switched on or off separately using the **Switch-on 3ph. failure** parameter.

8.3.2.6 Application and Setting Notes

Parameter: Asym.fail. - time delay

- Recommended setting value **(_:113) Asym.fail. - time delay** = ***10.00 s***

The **Asym.fail. - time delay** parameter allows you to set the time during which a system incident detected after the occurrence of the unbalance resets the monitoring. This setting is important in the case of weak infeed (current < 10 % of rated current) in order to give certain protection functions (such as distance protection) more time for detecting system incidents. As long as the time delay runs, it is assumed that the unbalance is due to a system incident.

As soon as the time has elapsed, the supervision assumes a measuring-voltage failure and seals in.

Siemens recommends using the default setting.

If you want the seal-in function to operate sooner or at once, you can reduce the time.

Parameter: Asym.fail.-DO on netw.flt.

- Recommended setting value **(_:115) Asym.fail.-DO on netw.flt.** = ***No***

Parameter Value	Description
no	After elapse of the time delay the supervision function seals in. Even if the system incident criterion is fulfilled, the protection functions concerned will remain blocked. This avoids an unselective tripping of the protection functions due to an absence of the measuring voltage in the case of an unbalanced system incident. This is the default setting.
yes	The seal-in function is switched off. The supervision drops out immediately when a system incident is detected. With this setting, the unbalanced measuring-voltage failure is only reported, and in the event of a double failure (measuring-voltage failure and system incident in parallel), unselective tripping is preferred.

Parameter: 3ph.fail. - VA,VB,VC <

- Recommended setting value **(_:101) 3ph.fail. - VA,VB,VC <** = ***5 V***

The **3ph.fail. - VA,VB,VC <** parameter allows you to set the pickup value of the monitoring.

Siemens recommends using the default setting.

If you expect major disturbances acting upon the voltage inputs, you can increase this value. Increasing the values makes the supervision more sensitive to 3-phase system incidents.

Parameter: 3ph.fail. - phs.curr.release

- Recommended setting value **(_:102) 3ph.fail. - phs.curr.release** = ***0.1 A*** for I_{rated} = 1 A or ***0.5 A*** for I_{rated} = 5 A

The **3ph.fail. - phs.curr.release** parameter is used to define the phase current threshold above which the monitoring is released.

Siemens recommends using the default setting.

If the device incorporates the **Distance protection** function, this value must be set to less than or equal to the release current of the distance protection.

For more information, refer to chapter *Distance protection*, *6.15.2.1 Overview of Functions* .

Parameter: 3ph.fail. - phs.curr. jump

- Recommended setting value **(_:103) 3ph.fail. - phs.curr. jump** = ***0.1 A*** for I_{rated} = 1 A or ***0.5 A*** for I_{rated} = 5 A

The **3ph.fail. - phs.curr. jump** parameter is used to set the differential current between the present current phasor and the stored phasor (from the previous period). If the value is exceeded, the function detects a system incident and blocks the monitoring.

Siemens recommends using the default setting.

Parameter: SO 3ph.fail. - time delay

- Recommended setting value **(_:106) SO 3ph.fail. - time delay** = ***3.00 s***

The **SO 3ph.fail. - time delay** parameter allows you to set the delay of the monitoring.

Siemens recommends using the default setting.



NOTE

Adapt the **SO 3ph.fail. - time delay** parameter to the inherent time of protection functions which are intended to block the monitoring function.

Note that with parameter values 0 s blocking of the monitoring function via a protection stimulation will not be possible any more.

Parameter: Operating mode

This parameter **(_:4711:101) Operating mode** and its settings are described in chapter *Process monitor*.

For more information, refer to the chapters starting at *5.5.4.1 Overview of Functions*.

Parameter: Switch-on 3ph. failure

- Recommended setting value **(_:107) Switch-on 3ph. failure** = ***on***

Parameter Value	Description
on	The subfunction **Switching to a 3-phase measuring-voltage failure** is active. In the case of low loads, the subfunction for detection of a 3-phase measuring-voltage failure is not released, for example, because the current flow is too low. In this situation, the subfunction **Switching to a 3-phase measuring-voltage failure** can perform the monitoring task. Siemens recommends switching that subfunction on.
off	With the setting ***off*** the subfunction **Switching to a 3-phase measuring-voltage failure** is not active.

8.3.2.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Mes.v.fail.det				
_:1	Mes.v.fail.det:Mode		• off • on • test	on
_:115	Mes.v.fail.det:Asym.fail.-DO on netw.flt.		• no • yes	yes
_:113	Mes.v.fail.det:Asym.fail. - time delay		0.00 s to 30.00 s	10.00 s
_:102	Mes.v.fail.det:3ph.fail. - phs.curr.release	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:103	Mes.v.fail.det:3ph.fail. - phs.curr. jump	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:101	Mes.v.fail.det:3ph.fail. - VA,VB,VC <		0.300 V to 340.000 V	5.000 V
_:107	Mes.v.fail.det:Switch-on 3ph. failure		• off • on	on
_:106	Mes.v.fail.det:SO 3ph.fail. - time delay		0.01 s to 30.00 s	3.00 s
_:114	Mes.v.fail.det:Asym.fail.-dropout delay		10.00 s to 10.00 s	10.00 s

8.3.2.8 Information List

No.	Information	Data Class (Type)	Type
Mes.v.fail.det			
_:82	Mes.v.fail.det:>Block function	SPS	I
_:54	Mes.v.fail.det:Inactive	SPS	O
_:52	Mes.v.fail.det:Behavior	ENS	O
_:53	Mes.v.fail.det:Health	ENS	O
_:300	Mes.v.fail.det:Alarm	SPS	O
_:304	Mes.v.fail.det:Asym.fail.-inst.alarm	SPS	O
_:303	Mes.v.fail.det:Asym.fail.-alarm	SPS	O
_:301	Mes.v.fail.det:3ph.failure-alarm	SPS	O
_:302	Mes.v.fail.det:SO 3ph.failure-alarm	SPS	O

8.3.3 Signaling-Voltage Supervision

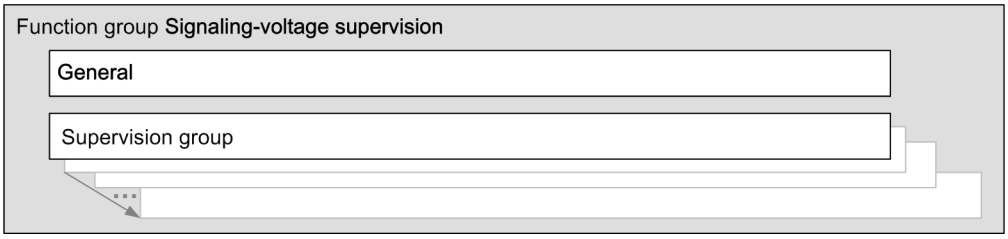
8.3.3.1 Overview of Functions

Signaling-voltage supervision is used to evaluate the validity of binary signals connected to the SIPROTEC device via binary inputs. For this purpose, one binary input is used to monitor the signaling voltage. If the signaling voltage fails, the associated binary signals are marked as invalid and a **Signaling-voltage malfunction** indication is issued.

Several signaling-voltage supervision groups can be created in one SIPROTEC device. Each of these groups monitors an adjustable area with binary inputs.

8.3.3.2 Structure of the Function

The **Signaling-voltage supervision** function group contains, besides the general functionality, one preinstantiated **Supervision group** stage. The **Supervision group** stage can be instantiated in DIGSI 5 multiple times.

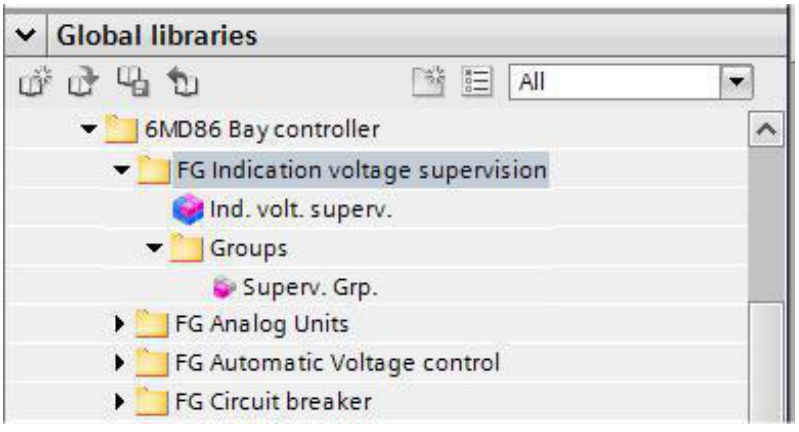


[dw_ivsstr, 1, en_US]

Figure 8-9 Structure/Embedding of the Function Group

8.3.3.3 Function Description

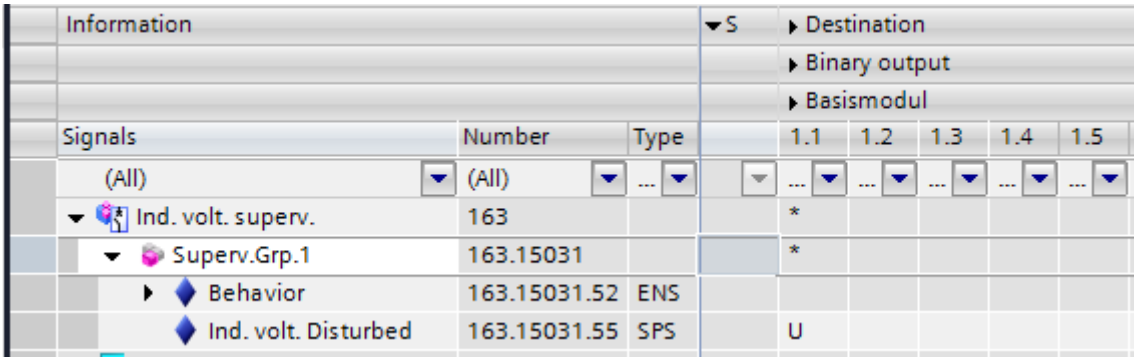
You can instantiate the **`Signaling-voltage supervision`** function group in the Global DIGSI 5 library. It contains 1 pre-instantiated **`Superv.Grp.`** function block (see the following figure). You can instantiate a maximum of 25 supervision groups.



[sc_ivslib, 1, en_US]

Figure 8-10 Entry in the Global Library

Following the instantiation of the function group in the DIGSI project tree, it appears in the information routing of DIGSI (see the following figure). The status indications of the supervision groups can be routed here, for example, to existing binary outputs and/or logs.

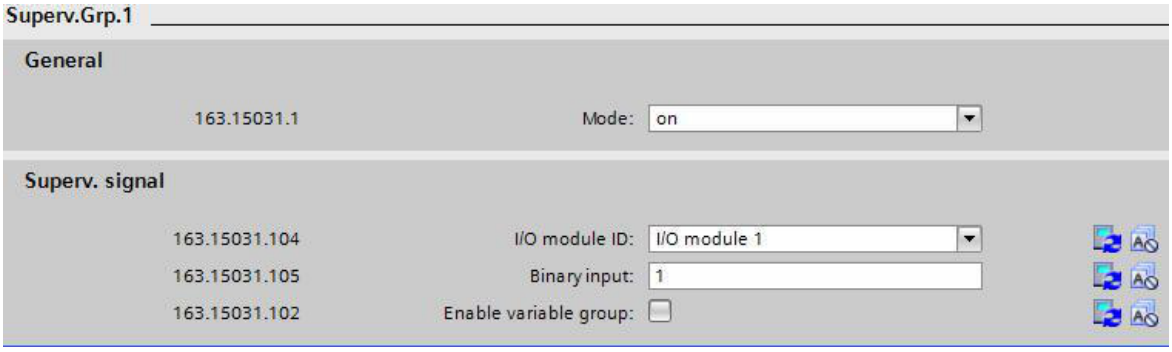


[sc_ivsrou, 1, en_US]

Figure 8-11 Information Routing

Set the binary input used for signaling-voltage supervision within one input/output module using the setting option (see the following figure). This binary input monitors the presence of the signaling voltage. If the signaling voltage fails, this sets the quality attribute for all other binary inputs of the parameterized input/output module to ***invalid***. The signal status of each of these binary inputs is frozen with its last valid value prior to the occurrence of the fault. The quality attribute of the binary inputs for other input/output modules are not taken into consideration by this.

If the signaling voltage again exceeds the binary threshold, the quality attribute of the binary inputs is reset to ***valid***.



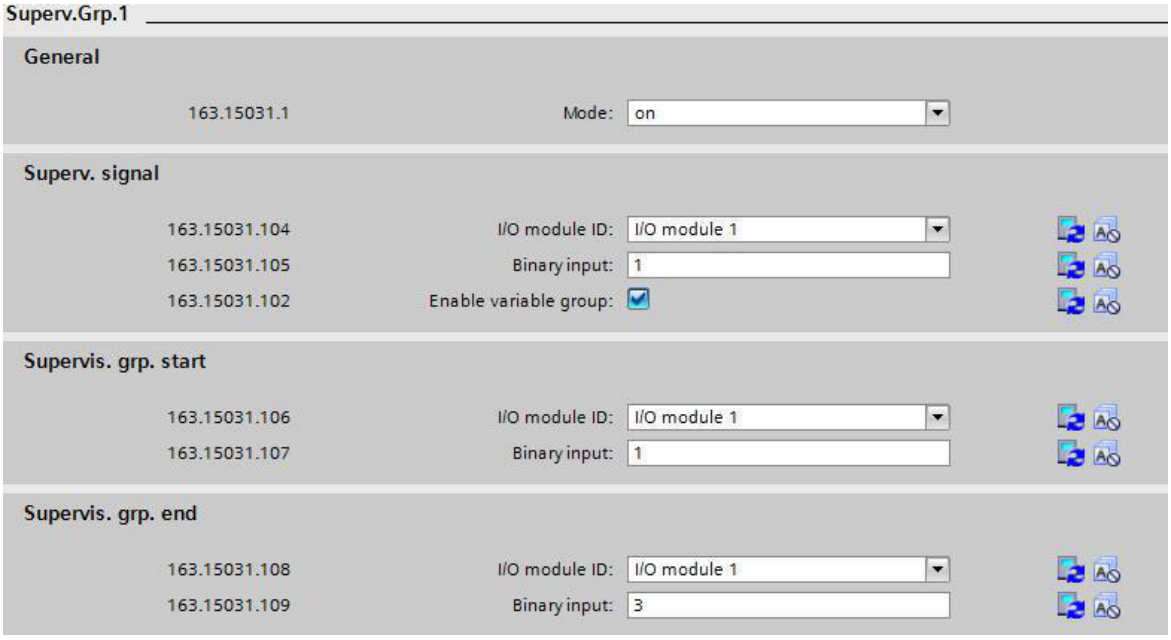
[sc_ivsgrp, 2, en_US]

Figure 8-12 Parameterization Menu of the Supervision Group (I)

NOTE

Each status change of the monitored binary inputs is delayed by 3 ms.

You can also combine binary inputs across modules in one **Superv.Grp.** function block and define any binary input within this group for supervision of the signaling voltage. For this purpose, place a check mark at the parameter **(_:102) Enable variable group** when configuring the supervision group. This extends the parameterization menu by the sections **Supervis. grp. start** and **Supervis. grp. end** (see the following figure).



[sc_gruppe_de, 2, en_US]

Figure 8-13 Parameterization Menu of the Supervision Group (II)

There, for example, you are able to combine 1 to n different binary inputs into one supervision group. When doing so, the binary inputs on the input/output modules assignable to a supervision group must be related logically. With 3 input/output modules, for example, this allows only consecutive binary inputs to be grouped on the modules 1 and 2 or 2 and 3, but no binary inputs on modules 1 and 3. The binary inputs used for supervision can be located on any input/output module within the group defined in this manner.

If you have to monitor several binary inputs that, for example, work with different signaling voltages from different sources, then you can also instantiate and configure several **Superv.Grp.** function blocks within the **Signaling-voltage supervision** function group accordingly.

Within different supervision groups, only those consecutive binary inputs that are not already assigned to another supervision group can be grouped. The overlapping of binary inputs in different supervision groups is not permitted.

Error parameters are displayed to you by inconsistency indications in DIGSI.

Example

There are 4 input/output modules available.

Binary inputs of input/output modules 1 and 2 are already combined in supervision group 1. The 2 last binary inputs on module 2 are not included in the grouping.

In supervision group 2, only these 2 binary inputs of the input/output module 2 not used in supervision group 1 as well as further consecutive binary inputs of the input/output modules 3 and 4 can be combined.

8.3.3.4 Application and Setting Notes

Parameter (General): Mode

- Default setting **(_:1) Mode** = ***on***

With the **Mode** parameter, you specify whether you want to activate, deactivate, or test the supervision of the signaling voltage for the appropriate group. If you put the group into test mode, the *Sig. volt. disturbed* indication is given a test flag.

Parameter (Supervision Signal): I/O module ID

- Default setting **(_:104) I/O module ID** = ***I/O module 1***

Using the **I/O module ID** parameter, you specify the I/O module for which you want to activate supervision of the signaling voltage. Counting of the I/O modules starts in increasing order with the binary inputs of the base module. The binary inputs of the PS201 power-supply module permanently installed in the base module count as the 2nd I/O module followed by additional I/O modules (3 to n) on expansion boards of the device.

Parameter (Supervision Signal): Binary input

- Default setting **(_:105) Binary input** = ***1***

Using the **Binary input** parameter, you specify the binary input responsible for teh supervision of the signaling voltage for the parameterized I/O module. The quality attribute of all other binary inputs for this module are set to **valid** or **invalid** depending on the presence of the signaling voltage at the parameterized binary input.

Parameter (Supervision Signal): Enable variable group

- Default setting **(_:102) Enable variable group** = ***untrue***

You can activate the parameter **Enable variable group** by placing the checkmark. If you have not set the check mark (default setting), only these 2 parameters are available for the configuration of the supervision signal. If you have set the check mark, the parameter menu is extended by the areas **Start supervision group** and **End supervision group**. You can then use that to carry out the grouping of binary inputs for supervision groups explained in the function description.

Parameter (Start Supervision Group): I/O module ID

- Default setting **(_:106) I/O module ID** = ***I/O module 1***

Parameter **I/O module ID** is used to define the first I/O module that you want to assign to a supervision group. As the counting of the I/O module starts in ascending order with the binary inputs of the base module, this is the module with the lowest counter number that you can use for carrying out a grouping.

Parameter (Start Supervision Group): Binary input

- Default setting **(_:107) Binary input** = ***1***

Parameter **Binary input** is used to define the lowest binary input for the first I/O module (see **(_:106) I/O module ID**) that you want to assign to a supervision group.

Parameter (End Supervision Group): I/O module ID

- Default setting **(_:108) I/O module ID** = ***I/O module 1***

Parameter **I/O module ID** is used to define the last I/O module that you want to assign to a supervision group. As the counting of the I/O module starts in ascending order with the binary inputs of the base module, this is the module with the highest counter number that you can use for carrying out a grouping.

Parameter (End Supervision Group): Binary input

- Default setting **(_:109) Binary input** = ***1***

Parameter **Binary input** is used to define the highest binary input for the last I/O module (see **(_:108) I/O module ID**) that you want to assign to a supervision group.

8.3.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Superv.Grp.#:Mode		• off • on • test	on

Addr.	Parameter	C	Setting Options	Default Setting
Superv. signal				
_:104	Superv.Grp.#:I/O module ID		• I/O module 1 • I/O module 2 • I/O module 3 • I/O module 4 • I/O module 5 • I/O module 6 • I/O module 7 • I/O module 8 • I/O module 9 • I/O module 10 • I/O module 11 • I/O module 12 • I/O module 13 • I/O module 14 • I/O module 15	I/O module 1
_:105	Superv.Grp.#:Binary input		1 to 256	1
_:102	Superv.Grp.#:Enable variable group		• 0 • 1	false
Supervis. grp. start				
_:106	Superv.Grp.#:I/O module ID		• I/O module 1 • I/O module 2 • I/O module 3 • I/O module 4 • I/O module 5 • I/O module 6 • I/O module 7 • I/O module 8 • I/O module 9 • I/O module 10 • I/O module 11 • I/O module 12 • I/O module 13 • I/O module 14 • I/O module 15	I/O module 1
_:107	Superv.Grp.#:Binary input		1 to 256	1

Addr.	Parameter	C	Setting Options	Default Setting
Supervis. grp. end				
_:108	Superv.Grp.#:I/O module ID		• I/O module 1 • I/O module 2 • I/O module 3 • I/O module 4 • I/O module 5 • I/O module 6 • I/O module 7 • I/O module 8 • I/O module 9 • I/O module 10 • I/O module 11 • I/O module 12 • I/O module 13 • I/O module 14 • I/O module 15	I/O module 1
_:109	Superv.Grp.#:Binary input		1 to 256	1

8.3.3.6 Information List

No.	Information	Data Class (Type)	Type
Superv.Grp.1			
_:15031:52	Superv.Grp.1:Behavior	ENS	O
_:15031:54	Superv.Grp.1:Health	ENS	O
_:15031:55	Superv.Grp.1:Sig. volt. disturbed	SPS	O

8.3.4 Voltage-Transformer Circuit Breaker

8.3.4.1 Overview of Functions

The function **Voltage-transformer circuit breaker** detects the tripping of the voltage-transformer circuit breaker due to short circuits in the voltage-transformer secondary circuits.

The **Voltage-transformer circuit breaker** function works independently of **Measuring-voltage failure detection** and should be used – if possible – in parallel to it.

The tripping of the voltage-transformer circuit breaker impacts the quality of the recorded measured-value data (refer to *3.4 Processing Quality Attributes*).

The following protection functions are automatically blocked if the voltage-transformer circuit breaker trips:

- Distance protection
- Directional negative-sequence protection
- Ground-fault protection for high-resistive faults in grounded systems

For the following functions the reaction (block/not block) can be set within the function in cases of a tripping of the voltage-transformer circuit breaker:

- Directional overcurrent protection, phases
- Overvoltage protection with negative-sequence voltage

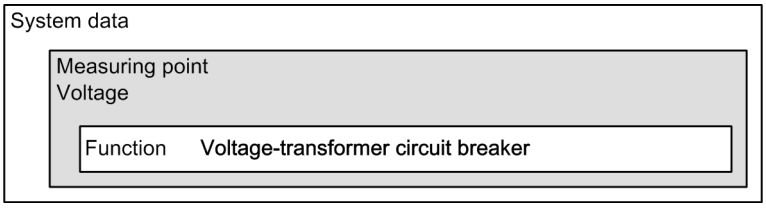
- Overvoltage protection with zero-sequence voltage/residual voltage
- Undervoltage protection with 3-phase voltage
- Undervoltage protection with positive-sequence voltage

NOTE

If the voltage signal is generated using the optional Merging unit function, the quality of the voltage signal is sent as ***invalid*** in the sampled value stream, depending on the status of the voltage-transformer circuit breaker. For more information about configuring the voltage-transformer circuit breaker function for devices with merging unit and process-bus client, refer to the *Process Bus manual*.

8.3.4.2 Structure of the Function

The *Figure 8-14* shows the position of the function in the device. Every voltage measuring point contains the **Voltage-transformer circuit breaker** function.



[dw_mcbstr, 1, en_US]

Figure 8-14 Structure/Embedding of the Function

8.3.4.3 Function Description

The tripping of the voltage-transformer circuit breaker is captured via the binary input signal **>Open**. With an active input signal the information about the measuring-voltage failure is relayed to the affected functions (see *8.3.4.1 Overview of Functions*). The response to the detection of a measuring-voltage failure is explained in the specific protection-function descriptions.

Response Time of the Voltage-Transformer Circuit Breaker

The response time of the voltage-transformer circuit breaker can be slower than the pickup time of the distance protection. This bears the risk of an overfunction. The response time is communicated to the device with the **Response time** parameter. For a timely detection of the tripping of the voltage-transformer circuit breaker, the pickup of the distance protection is delayed by that response time.

8.3.4.4 Application and Setting Notes

The function is always active and need not be switched on.

Input Signal: >Open

- Input signal: **(_:500) >Open**

The input signal **>Open** must be connected to the tripping of the voltage-transformer circuit breaker. As a rule, this occurs via the routing to a binary input.

Parameter: Response time of the voltage-transformer circuit breaker

- Recommended setting value **(_:101) Response time** = ***0 ms***

When the voltage-transformer circuit breaker drops out, the device must block the distance protection immediately to prevent an unwanted tripping of the distance protection due to the absence of the measuring voltage while the load current is flowing.

The blocking must be faster than the 1st stage of the distance protection. This requires an extremely short response time of the miniature circuit breaker (≤ 4 ms at 50 Hz, ≤ 3 ms at 60 Hz rated frequency). If the circuit-breaker auxiliary contact does not fulfill this requirement, you have to set the response time accordingly.

8.3.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
VT miniatureCB				
_:101	VT miniatureCB:Response time		0.00 s to 0.03 s	0.00 s

8.3.4.6 Information List

No.	Information	Data Class (Type)	Type
Definite-T #			
_:500	VT miniatureCB:>Open	SPS	I

8.3.5 Broken-Wire Detection

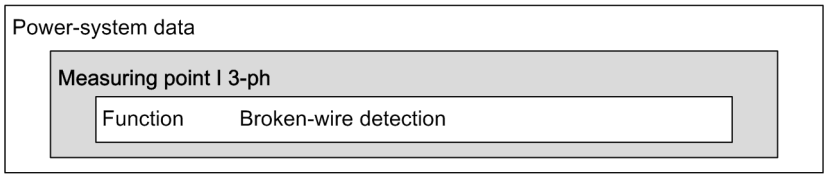
8.3.5.1 Overview of Functions

The **Broken-wire detection** detects interruptions in the secondary circuit of the current transformers during steady-state operation. In addition to creating a hazard due to high voltages in the secondary circuit, such interruptions can mimic the presence of differential currents for the differential protection, as caused by short circuits in the protected object. To prevent overfunctions due to faulty current values, the affected protection functions are blocked, for example the Line differential protection and the Distance protection.

An interruption in the secondary circuit of the current transformer cannot always be distinguished from a broken conductor in the primary circuit. If the function **Line differential protection** is instantiated in the device, additional messages from the opposite end of the line improve the ability to differentiate between both cases.

8.3.5.2 Structure of the Function

The **Broken-wire detection** function is located in the power-system data of each 3-phase current measuring point.



[dw_bwsjsk_3_en_US]

Figure 8-15 Structure/Embedding of the Function

8.3.5.3 Function Description

Broken-Wire Detection

The function **Broken-wire detection** searches for current interruptions at all current measuring points. For this purpose, the instantaneous values of the currents are checked for their plausibility. In addition, further criteria must be met before a wire break can be detected and signaled with assurance.

Detection:

A wire break initially manifests itself as a sudden decrease of the current below the minimum threshold of 0.06 $I/I_{rated.}$ A plausibility test with the instantaneous values from the previous cycle confirms that the current has fallen below the minimum threshold. If the criteria for a wire break are satisfied, the affected phase is marked with **Broken wire suspected**. The following messages are generated: *(_:301) Phs A BW suspected*, *(_:302) Phs B BW suspected*, and/or *(_:303) Phs C BW suspected*, and *(_:307) Broken wire suspected*.

Resetting:

A broken-wire suspicion is reset by phase current flowing again, by a binary input signal, or by a controllable.

Broken-Wire Check

To prevent unwanted pickup of this monitoring function caused by special operating conditions, for example fault, maintenance, test, etc., the function checks various criteria.

If at least one of the following criteria is met, the broken-wire suspicion is reset including any associated protection blocking.

Local resetting criteria:

- At least one protection function has picked up.
- All circuit breakers assigned to the protection function group are open.
  For applications using a 1 1/2 circuit-breaker layout, both circuit breakers must be open.
- A wire break is detected on another phase of a local current measuring point.
- A voltage jump at a local voltage measuring point
- A current jump of the associated zero-sequence current
  This reset criterion applies only for **CT connection** = ***3-phase + IN-separate***.
- A current jump on the same phase of another local current measuring point
- The current in at least one phase is greater than 2.5 I_{rated}.

Additional reset criteria when using the function Line differential protection:

Criteria at the opposite end of the line can contradict a broken wire suspicion and cause resetting. The request to reset is transmitted via the protection interface.

Additional reset criteria:

- A wire break is detected on one phase of a current measuring point at the opposite end of the line.
- A wire break is detected on one phase of a voltage measuring point at the opposite end of the line.
- A jump is detected on one phase of a current measuring point at the opposite end of the line.
- The current in at least one phase at the opposite end of the line is greater than 2.5 I_{rated}.

Additional reset criteria in the FG Transformer side:

- A wire break is detected on one phase of the other transformer sides.
- A current jump is detected on one phase of the other transformer sides.
- A voltage jump is detected on one phase of the other transformer sides.
- The current in one phase of the measuring points of another transformer side is greater than 2.5 I_{rated}.
- At least one protection function has picked up.
- The neutral-point current is greater than 2.5 I_{rated}.

If a broken wire suspicion detected is not reset by a reset criterion, the wire break is assured. The messages *(_:304) Phase A broken wire*, *(_:305) Phase B broken wire*, and/or *(_:306) Phase C broken wire*, and *(_:308) Broken wire confirmed* are generated and maintained stable for a duration of at least 3 system periods.

Blocking the Protection

The decision to block the protection is performed phase-segregated for each 3-phase current measuring point of the device.

The parameter **(_:5581:101) Mode of blocking** controls the blocking behavior:

- ***not blocking***
  - Wire break is only signaled.
- ***blocking***
  - Each broken-wire suspicion causes the affected protection functions to be blocked.

8.3.5.4 Application and Setting Notes

Parameter: Mode

- Recommended setting value **(_:1) Mode** = ***off***

The parameter **Mode** is used to switch the **Broken-wire detection** to ***on*** or ***off*** or to activate the state ***test***.

Parameter: Mode of blocking

- Recommended setting value **(_:101) Mode of blocking** = ***blocking***

With the parameter **Mode of blocking**, you control the behavior when a broken-wire suspicion occurs, refer to *Blocking the Protection, Page 2063*. Siemens recommends using the default setting. The setting options are ***blocking*** and ***not blocking***.

8.3.5.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Brk.wire det.				
_:1	Brk.wire det.:Mode		• off • on • test	off
_:101	Brk.wire det.:Mode of blocking		• blocking • not blocking	blocking

8.3.5.6 Information List

No.	Information	Data Class (Type)	Type
Brk.wire det.			
_:82	Brk.wire det.:>Block function	SPS	I
_:83	Brk.wire det.:>Reset broken wire	SPS	I
_:55	Brk.wire det.:Reset broken wire	SPC	C
_:54	Brk.wire det.:Inactive	SPS	O
_:52	Brk.wire det.:Behavior	ENS	O
_:53	Brk.wire det.:Health	ENS	O
_:301	Brk.wire det.:Phs A BW suspected	SPS	O
_:302	Brk.wire det.:Phs B BW suspected	SPS	O
_:303	Brk.wire det.:Phs C BW suspected	SPS	O
_:304	Brk.wire det.:Phase A broken wire	SPS	O
_:305	Brk.wire det.:Phase B broken wire	SPS	O
_:306	Brk.wire det.:Phase C broken wire	SPS	O
_:307	Brk.wire det.:Broken wire suspected	SPS	O
_:308	Brk.wire det.:Broken wire confirmed	SPS	O
_:51	Brk.wire det.:Mode (controllable)	ENC	C

8.3.6 Voltage-Balance Supervision

8.3.6.1 Overview of Functions

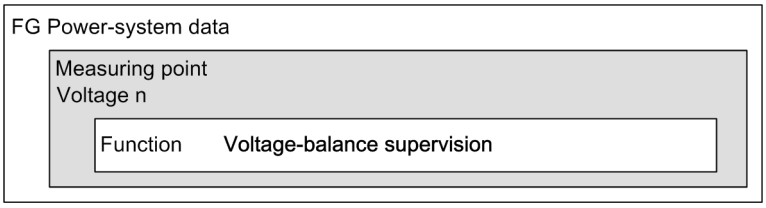
In healthy system operation, a certain balance between voltages can be assumed.
The **Voltage-balance supervision** function detects the following errors:

- Unbalance of phase-to-phase voltages in the secondary circuit
- Connection errors during commissioning or short circuits and interruptions in the secondary circuit

The voltage measurement is based on the RMS values of the fundamental component.

8.3.6.2 Structure of the Function

The **Voltage-balance supervision** function is located in the **Power-system data** of each 3-phase voltage measuring point.

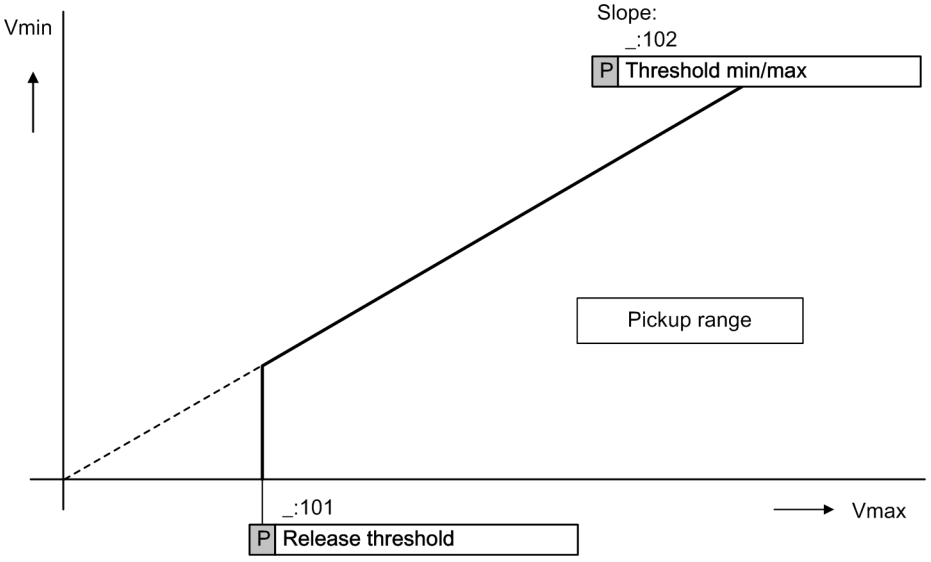


[dw_strusy, 2, en_US]

Figure 8-16 Structure/Embedding of the Function

8.3.6.3 Function Description

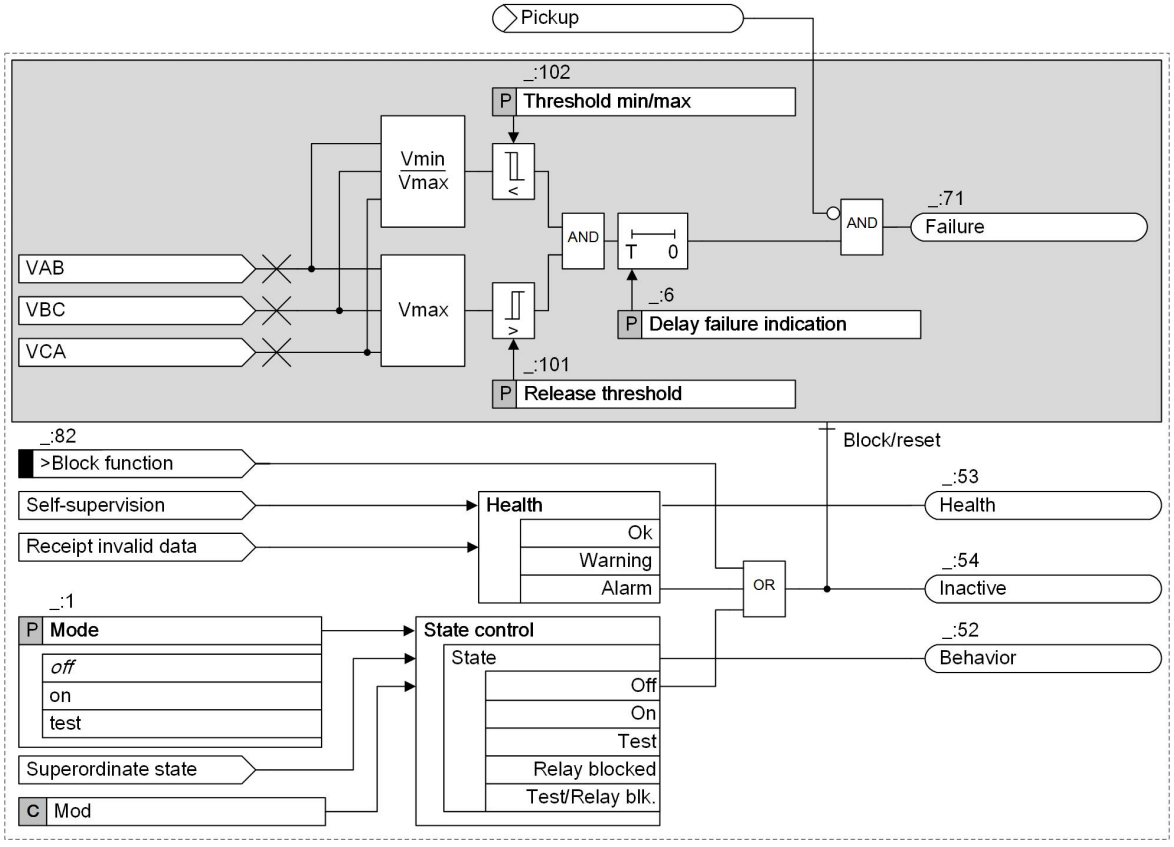
The voltage balance is checked by a magnitude supervision function. This function relates the smallest phase-to-phase voltage to the largest phase-to-phase voltage. Unbalance is detected if
|Vmin| / |Vmax| < **`Threshold min/max`**, as long as Vmax > **`Release threshold`**



[lo_kenuns, 1, en_US]

Figure 8-17 Characteristic of the Voltage-Balance Supervision

Logic



[lo_sp_asym, 5, en_US]

Figure 8-18 Logic Diagram of the Voltage-Balance Supervision

The **Threshold min/max** parameter is the criterion by which a phase-to-phase voltage unbalance is measured. The device calculates the ratio between the minimum (V_{min}) and the maximum (V_{max}) phase-to-phase voltage.

Enter the lower limit of the maximum phase-to-phase voltage (V_{max}) with the parameter **Release threshold**. This specifies the lower limit of the operating range of this function.

Delay failure indication

If it falls below the balance factor **Threshold min/max** and at the same time the maximum phase-to-phase voltage exceeds the **Release threshold**, the delay of the failure indication (parameter: **Delay failure indication**) starts. If both conditions persist during this time, the indication **Failure** is generated.

Blocking the Function

The following blockings reset the picked up function completely:

- Externally or internally via the binary input signal *>Block function*
- A protection pickup
  The pickup signal of a protection function blocks the *Failure* indication.

8.3.6.4 Application and Setting Notes

Parameter: Threshold min/max

- Recommended setting value **(_:102) Threshold min/max** = *0.75*

The **Threshold min/max** parameter is used to set the ratio between the minimum (V_{min}) and the maximum (V_{max}) phase-to-phase voltage. Siemens recommends using the default setting.

Parameter: Release threshold

- Recommended setting value **(_:101) Release threshold** = ***50 V***

With the **Release threshold** parameter you set the lower limit of the maximum phase-to-phase voltage (V_{max}). Siemens recommends using the default setting.

Parameter: Delay failure indication

- Recommended setting value **(_:6) Delay failure indication** = ***5.00 s***

Set the **Delay failure indication** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

8.3.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. balan. V				
_:1	Supv. balan. V:Mode		• off • on • test	off
_:101	Supv. balan. V:Release threshold		0.300 V to 170.000 V	50.000 V
_:102	Supv. balan. V:Threshold min/max		0.58 to 0.95	0.75
_:6	Supv. balan. V:Delay failure indication		0.00 sto 100.00 s	5.00 s

8.3.6.6 Information List

No.	Information	Data Class (Type)	Type
Supv. balan. V			
_:82	Supv. balan. V:>Block function	SPS	I
_:54	Supv. balan. V:Inactive	SPS	O
_:52	Supv. balan. V:Behavior	ENS	O
_:53	Supv. balan. V:Health	ENS	O
_:71	Supv. balan. V:Failure	SPS	O

8.3.7 Voltage-Sum Supervision

8.3.7.1 Overview of Functions

In healthy system operation, the sum of all voltages at one measuring point must be approximately 0. The **Voltage-sum supervision** monitors the sum of all voltages of one measuring point in the secondary circuit. It detects connection errors during commissioning or short circuits and interruptions in the secondary circuit. For summation of the voltages, the 3 phase-to-ground voltages and the residual voltage (da-dn - voltage of an open-circuited delta winding) are required.

The voltage measurement is based on the RMS values of the fundamental component.

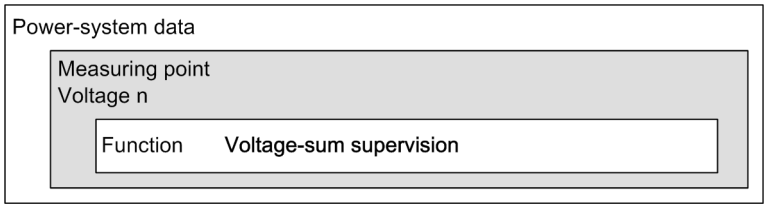
NOTE

For the **Voltage-sum supervision**, the externally generated residual voltage must be connected to the 4th voltage measuring input.

For the **Voltage-sum supervision** to work correctly, the **`Matching ratio Vph / VN`** parameter must be set accordingly.

8.3.7.2 Structure of the Function

The **Voltage-sum supervision** function is located in the **Power-system data** function group of each 3-phase voltage measuring point.

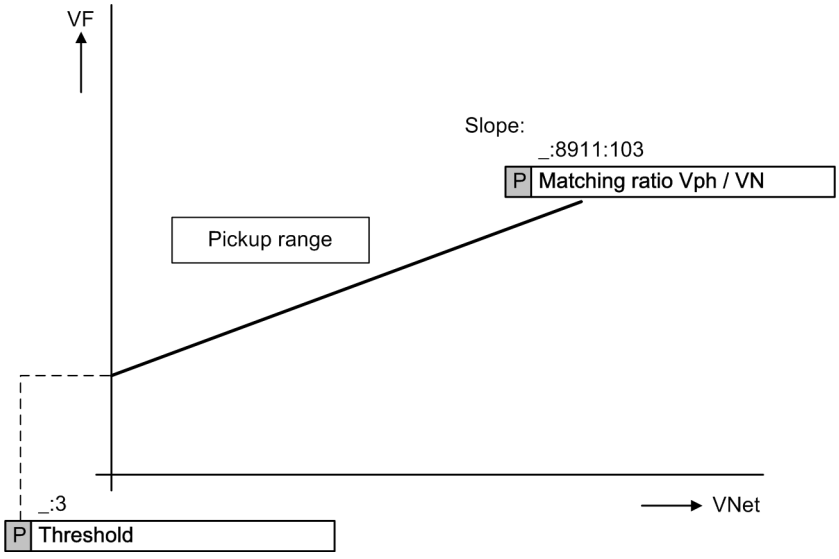


[dw_strvss, 2, en_US]

Figure 8-19 Structure/Embedding of the Function

8.3.7.3 Function Description

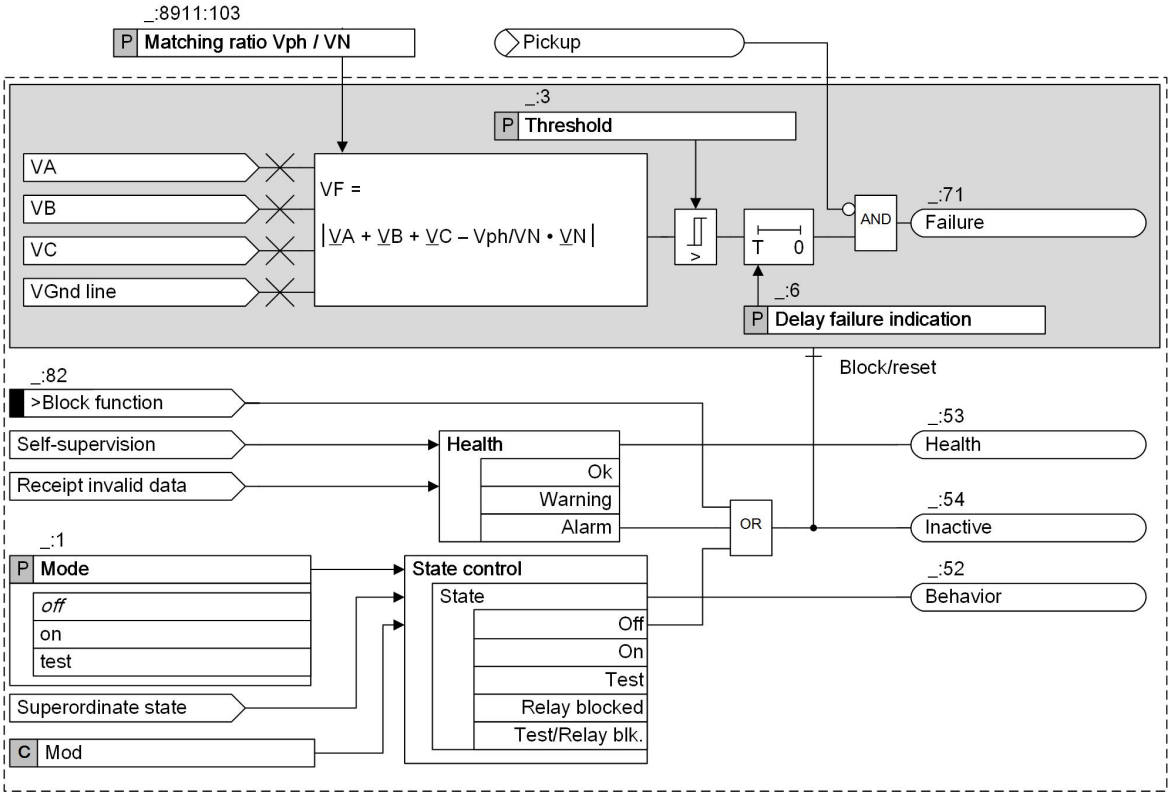
The voltage sum is generated by addition of the voltage phasors. Errors in the voltage circuits are detected if VF = |$\underline{V}$A + $\underline{V}$B + $\underline{V}$C - Vph/VN • $\underline{V}$N| > **`Threshold`**, where Vph/VN forms the **`Matching ratio Vph / VN`** parameter.



[lo_kenvss-01.tif, 1, en_US]

Figure 8-20 Characteristic of the Voltage-Sum Supervision

Logic



[lo_volt-sum-supervision, 5, en_US]

Figure 8-21 Logic Diagram of the Voltage-Sum Supervision

The device measures the phase-to-ground voltage and the ground voltage of the lines to be protected. The sum of the 4 voltages must be 0.

Threshold

If the calculated fault voltage (V_F) exceeds the **Threshold** the parameter **Delay failure indication** triggers the indication **Failure**.

The device calculates the fault voltage (V_F) with the formula:

VF = |VA + VB + VC - Vph/UN • UN|, where Vph/VN forms the **Matching ratio Vph / VN** parameter.

The **Matching ratio Vph / VN** parameter takes into account the differing transformation ratios between the residual voltage input and the phase-voltage inputs.

You can find more information in this respect in chapter *8.3.7.1 Overview of Functions*).

Delay failure indication

When the threshold value for the delay of the failure indication (parameter: **Delay failure indication**) is exceeded, the indication **Failure** is generated.

Blocking the Function

The following blockings reset the picked up function completely:

- Externally or internally via the binary input signal *>Block function*
- A protection pickup
  The pickup signal of a protection function blocks the *Failure* indication.

8.3.7.4 Application and Setting Notes

Parameter: Threshold

- Recommended setting value **(_:3) Threshold** = ***25 V***

The **Threshold** parameter is used to set the voltage which the device uses to recognize the calculated fault voltage (V_F) as a failure of the voltage sums. Siemens recommends using the default setting.

Parameter: Delay failure indication

- Recommended setting value **(_:6) Delay failure indication** = ***5.00 s***

Set the **Delay failure indication** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

8.3.7.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. sum V				
_:1	Supv. sum V:Mode		• off • on • test	off
_:3	Supv. sum V:Threshold		0.300 V to 170.000 V	43.300 V
_:6	Supv. sum V:Delay failure indication		0.00 sto 100.00 s	5.00 s

8.3.7.6 Information List

No.	Information	Data Class (Type)	Type
Supv. sum V			
_:82	Supv. sum V:>Block function	SPS	I
_:54	Supv. sum V:Inactive	SPS	O
_:52	Supv. sum V:Behavior	ENS	O
_:53	Supv. sum V:Health	ENS	O
_:71	Supv. sum V:Failure	SPS	O

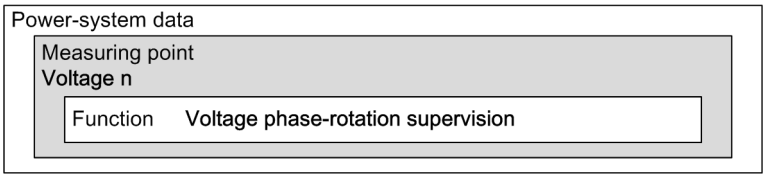
8.3.8 Voltage Phase-Rotation Supervision

8.3.8.1 Overview of Functions

The **Voltage phase-rotation supervision** function monitors the phase sequence of the secondary-circuit voltages by monitoring the sequence of the zero crossings (with same sign) of the voltages. This enables the device to detect connections that were inverted during commissioning. The criterion for the check is the setting of the **Phase sequence** parameter.

8.3.8.2 Structure of the Function

The **Voltage phase-rotation supervision** function is located in the **Power-system data** of each 3-phase voltage measuring point.

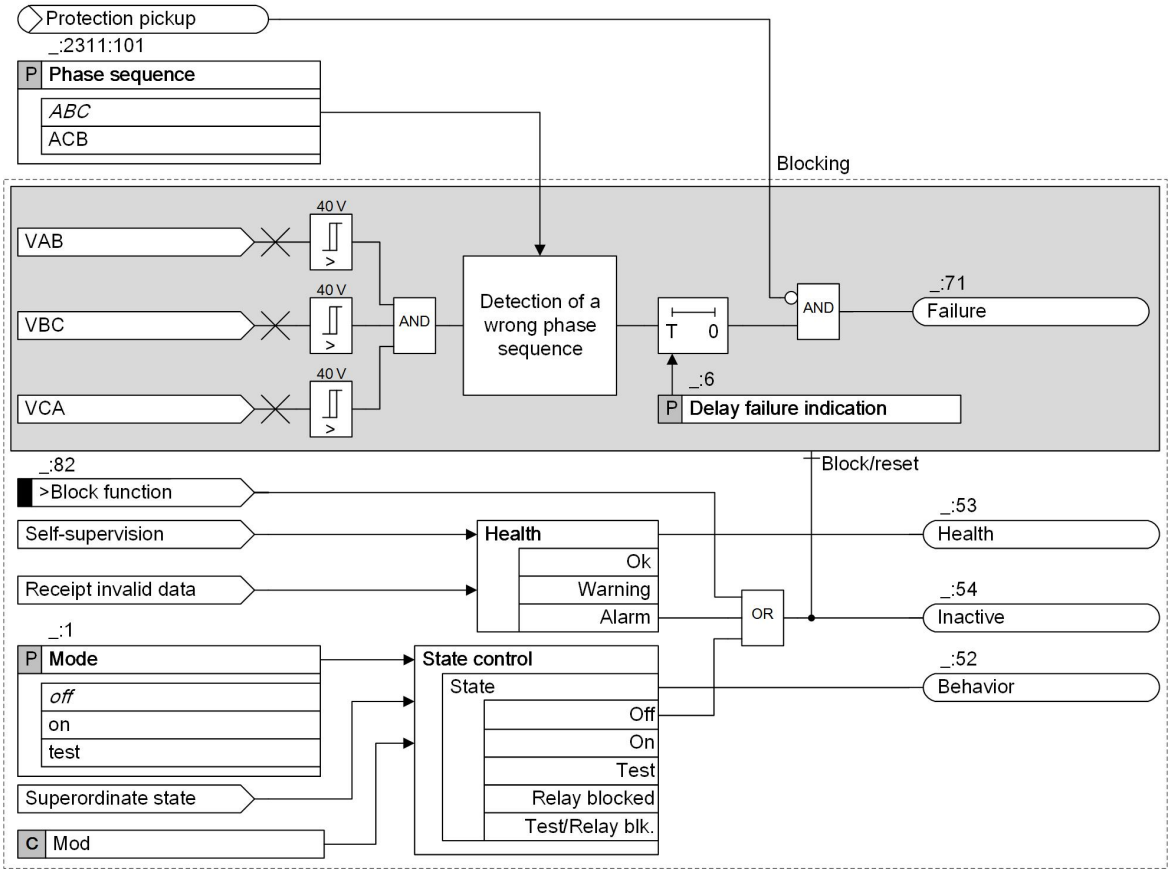


[dw_strvrs, 3, en_US]

Figure 8-22 Structure/Embedding of the Function

8.3.8.3 Function Description

Logic



[lo_volt-phs-rotation-supervision, 5, en_US]

Figure 8-23 Logic Diagram of the Voltage Phase-Rotation Supervision

The phase rotation is important for protection functions which process phase, loop, and directional information. You can set the phase sequence with the **Phase sequence** parameter in the function block **General** of the power-system data (see chapter *6.1 Power-System Data*).

To supervise the phase rotation, the device compares the measured phase sequence with the set phase sequence. For abnormal phase sequences, the indication *Failure* is generated.

The connection of the voltages to the device does not depend on the selected phase sequence. The connection diagrams are shown in chapter *A Appendix*.

Release Condition

The supervision of the voltage phase rotation is carried out when all measured phase-to-phase voltages are greater than 40 V.

Blocking of the Function

The following blockings reset the function completely:

- Via the binary input signal *>Block function* from an external or internal source
- Via a protection pickup
  The pickup signal from a protection function blocks the indication *Failure*.

Delay failure indication

When the device detects an inverted phase-rotation direction for the duration of the **Delay failure indication**, the indication *Failure* is generated.

8.3.8.4 Application and Setting Notes

Parameter: Delay failure indication

- Recommended setting value **(_:6) Delay failure indication** = *5.00 s*

Set the **Delay failure indication** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

8.3.8.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. ph.seq.V				
_:1	Supv. ph.seq.V:Mode		• off • on • test	off
_:6	Supv. ph.seq.V:Delay failure indication		0.00 s to 100.00 s	5.00 s

8.3.8.6 Information List

No.	Information	Data Class (Type)	Type
Supv. ph.seq.V			
_:82	Supv. ph.seq.V:>Block function	SPS	I
_:54	Supv. ph.seq.V:Inactive	SPS	O
_:52	Supv. ph.seq.V:Behavior	ENS	O
_:53	Supv. ph.seq.V:Health	ENS	O
_:71	Supv. ph.seq.V:Failure	SPS	O

8.3.9 Auxiliary Direct-Voltage Supervision

8.3.9.1 Overview of Functions

The function **Auxiliary direct-voltage supervision**:

- Measures the auxiliary direct-voltage of a substation battery system
- Provides sampled values for fault recording
- Monitors the battery direct-voltage by checking whether the measured voltage is greater or smaller than the specified threshold

The direct-voltage input is located on the plug-in module type ANAI-CE-2EL (1 input per module).

Once you have configured the plug-in module ANAI-CE-2EL, the function **Auxiliary direct-voltage supervision** is visible under the function group **Analog units**. You can find the function group **Analog units** in the **Settings** folder of the device in the DIGSI 5 project tree.

8.3.9.2 Structure of the Function

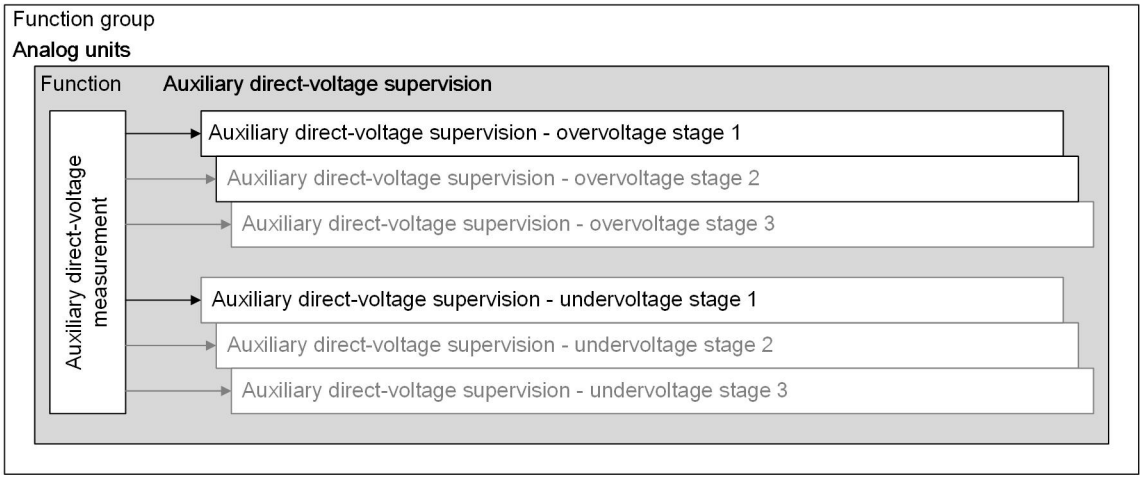
The function **Auxiliary direct-voltage supervision** can work only in the function group **Analog units**.

The function comes factory-set with 1 fixed function block **Auxiliary direct-voltage measurement**, 1 stage **Auxiliary direct-voltage supervision - overvoltage**, and 1 stage **Auxiliary direct-voltage supervision - undervoltage**.

The following stages can be operated simultaneously within the function:

- 3 stages **Auxiliary direct-voltage supervision - overvoltage**
- 3 stages **Auxiliary direct-voltage supervision - undervoltage**

Stages that are not preconfigured are shown in gray in the following figure. The stages are identical in structure.

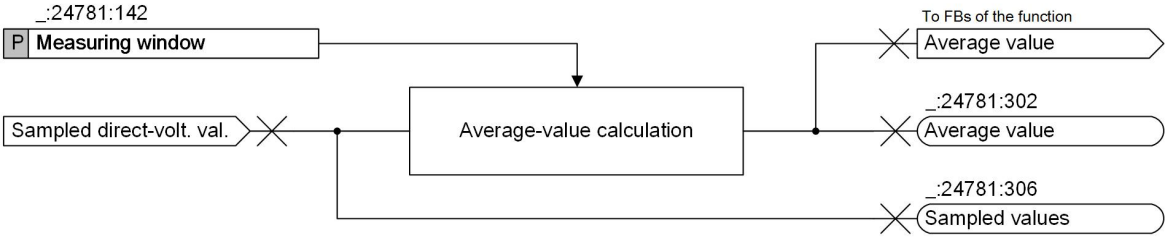


[dw_DC supervision_Structure, 1, en_US]

Figure 8-24 Structure/Embedding of the Function

8.3.9.3 Auxiliary Direct-Voltage Measurement

Logic



[lo_DC voltage measurement, 1, en_US]

Figure 8-25 Logic Diagram of the Function Block Auxiliary Direct-Voltage Measurement

Calculation of Average Direct-Voltage Values

The FB **Auxiliary direct-voltage measurement** receives the sampled direct-voltage values from the interface of the plug-in module ANAI-CE-2EL and calculates an average value by a settable time interval (via the parameter **`Measuring window`**).

The calculation formula is:

$$V_{avg} = \frac{1}{m}\sum_{n=1}^{m} V_n$$

[fo_DC_volt_supervision, 1, en_US]

Where

V_{avg}	Average direct-voltage value
V_n	Sampled direct-voltage value in a measuring window
m	Number of sampled values in a measuring window

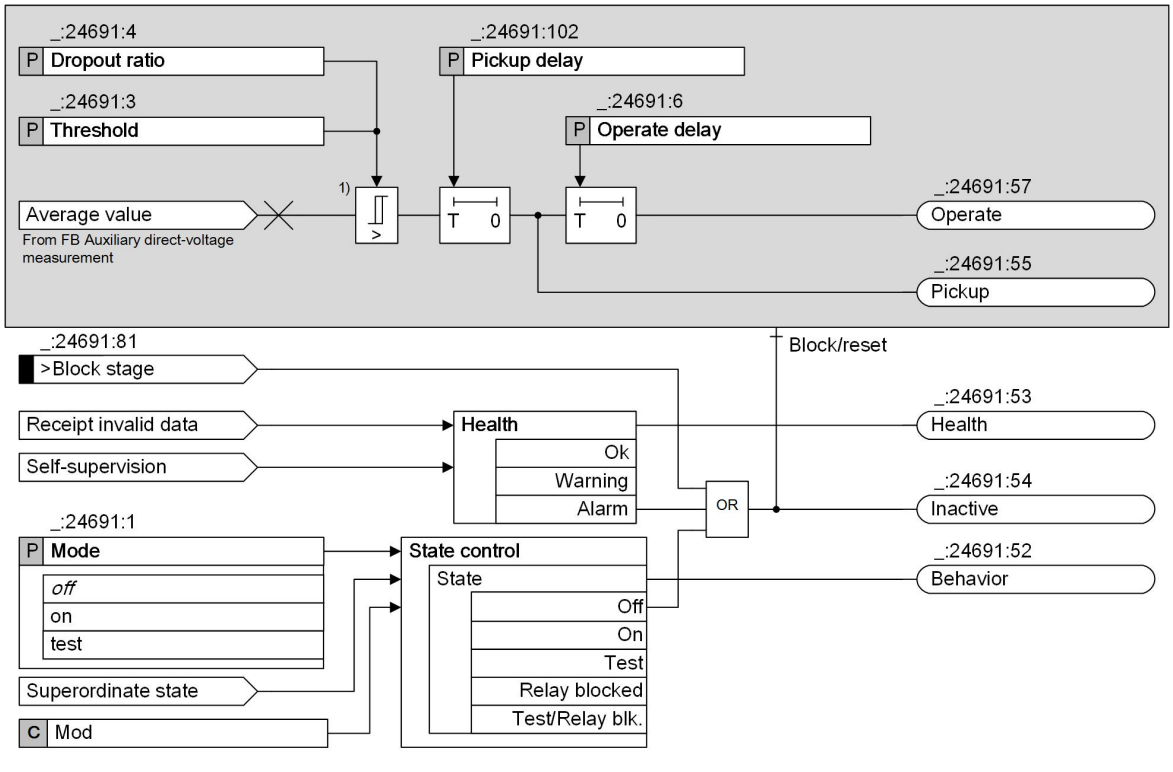
Functional Measured Value

Value	Description
Average value	Average value calculated from the sampled direct-voltage values

8.3.9.4 Stage Description

Logic

The logic of the stage **Auxiliary direct-voltage supervision - overvoltage** is the same as that of the stage **Auxiliary direct-voltage supervision - undervoltage**. The following figure shows the logic of the stage **Auxiliary direct-voltage supervision - overrvoltage** as an example.



[lo_DC supervision, 1, en_US]

Figure 8-26 Logic Diagram of the Stage Auxiliary Direct-Voltage Supervision - Overvoltage

(1) For the stage **Auxiliary direct-voltage supervision - undervoltage**, the symbol is:



Measurand

The stage obtains the average direct-voltage value from the FB **Auxiliary direct-voltage measurement**.

Pickup, Operate, Dropout

The stage compares the average direct-voltage value with the **Threshold**:

- **Overvoltage** stage
  If the average direct-voltage value exceeds the **Threshold**, the pickup delay (specified by the parameter **Pickup delay**) starts. If the value keeps exceeding the **Threshold** during the pickup delay, the pickup signal is issued.
- **Undervoltage** stage
  If the average direct-voltage value falls below the **Threshold**, the pickup delay (specified by the parameter **Pickup delay**) starts. If the value stays below the **Threshold** during the pickup delay, the pickup signal is issued.

Once the pickup signal is issued, the operate delay (specified by the parameter **Operate delay**) starts. After the expiration of the operate delay, the operate signal is issued.

With the parameter **Dropout ratio**, you can define the ratio of the dropout threshold to the **Threshold**.



NOTE

The pickup of the stages does not result in fault logging. The operate indications of the stages do not go into the trip logic of the device.

Blocking of the Stage

You can block the stage externally or internally via the binary input signal **>Block stage**. In the event of blocking, the picked up stage is reset.

8.3.9.5 Application and Setting Notes

Recording of Sampled Direct-Voltage Values

The recording of sampled direct-voltage values cannot be started via the pickup of stages. If you want to record the sampled direct-voltage values, you could use other starting methods. For more information about the methods, refer to *3.5 Fault Recording*.

Parameter: Measuring window

- Default setting **(_:24781:142) Measuring window** = ***20 ms***

With the parameter **Measuring window**, you set the measuring window that is used to determine the average value from the sampled values. If this parameter is set to ***20 ms***, the average value is calculated from the sampled values in the measuring window of 20 ms.

Extending the measuring window can improve the measurement accuracy but will increase the pickup time. If there are no specific requirements, Siemens recommends using the default setting of 20 ms.

Parameter: Threshold

- Default setting **(_:24691:3) Threshold** = ***264.0 V*** (for the **Overvoltage** stage)
- Default setting **(_:24721:3) Threshold** = ***176.0 V*** (for the **Undervoltage** stage)

Set the parameter **Threshold** for the specific application.

Parameter: Dropout ratio

- Default setting **(_:24691:4) Dropout ratio** = ***0.95*** (for the **Overvoltage** stage)
- Default setting **(_:24721:4) Dropout ratio** = ***1.05*** (for the **Undervoltage** stage)

For the **Overvoltage** stage, the recommended setting value of ***0.95*** is appropriate for most applications. To achieve high-precision measurements, the **Dropout ratio** can be reduced, for example, to ***0.98***.

For the **Undervoltage** stage, the recommended setting value of ***1.05*** is appropriate for most applications. To achieve high-precision measurements, the **Dropout ratio** can be reduced, for example, to ***1.02***.

Parameter: Pickup delay

- Default setting **(_:24691:102) Pickup delay** = ***0.00 s***

With the parameter **Pickup delay**, you define a time interval during which a pickup is not generated if the voltage exceeds the threshold (for the **Overvoltage** stage) or falls below the threshold (for the **Undervoltage** stage).

With the pickup delay, you can achieve that a short auxiliary-voltage disturbance will not be reported. If you want to detect all disturbances, use the default value of ***0.00 s***.

Parameter: Operate delay

- Default setting **(_:24691:6) Operate delay** = ***1.00 s***

The parameter **Operate delay** determines the time during which the pickup conditions must be met to issue the operate indication. The operate indication is issued when this time expires.

NOTE

The pickup of the stages does not result in fault logging. The operate indications of the stages do not go into the trip logic of the device.

8.3.9.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-DC measurem.				
_:24781:142	V-DC measurem.:Measuring window		• 10 ms • 20 ms • 40 ms • 60 ms • 80 ms • 100 ms	20 ms
Aux.V sup. V>1				
_:24691:1	Aux.V sup. V>1:Mode		• off • on • test	off
_:24691:3	Aux.V sup. V>1:Threshold		10.0 V to 295.0 V	264.0 V
_:24691:4	Aux.V sup. V>1:Dropout ratio		0.90 to 0.99	0.95
_:24691:102	Aux.V sup. V>1:Pickup delay		0.00 s to 60.00 s	0.00 s
_:24691:6	Aux.V sup. V>1:Operate delay		0.00 s to 60.00 s	1.00 s
Aux.V sup. V<1				
_:24721:1	Aux.V sup. V<1:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:24721:3	Aux.V sup. V<1:Threshold		10.0 V to 295.0 V	176.0 V
_:24721:4	Aux.V sup. V<1:Dropout ratio		1.01 to 1.10	1.05
_:24721:102	Aux.V sup. V<1:Pickup delay		0.00 s to 60.00 s	0.00 s
_:24721:6	Aux.V sup. V<1:Operate delay		0.00 s to 60.00 s	1.00 s

8.3.9.7 Information List

No.	Information	Data Class (Type)	Type
V-DC measurem.			
_:24781:302	V-DC measurem.:Average value	MV	O
_:24781:306	V-DC measurem.:Sampled values	SAV	O
_:24781:300	V-DC measurem.:Behavior	ENS	O
_:24781:303	V-DC measurem.:Health	ENS	O
Aux.V sup. V>1			
_:24691:81	Aux.V sup. V>1:>Block stage	SPS	I
_:24691:51	Aux.V sup. V>1:Mode (controllable)	ENC	C
_:24691:54	Aux.V sup. V>1:Inactive	SPS	O
_:24691:52	Aux.V sup. V>1:Behavior	ENS	O
_:24691:53	Aux.V sup. V>1:Health	ENS	O
_:24691:55	Aux.V sup. V>1:Pickup	ACD	O
_:24691:57	Aux.V sup. V>1:Operate	ACT	O
Aux.V sup. V<1			
_:24721:81	Aux.V sup. V<1:>Block stage	SPS	I
_:24721:51	Aux.V sup. V<1:Mode (controllable)	ENC	C
_:24721:54	Aux.V sup. V<1:Inactive	SPS	O
_:24721:52	Aux.V sup. V<1:Behavior	ENS	O
_:24721:53	Aux.V sup. V<1:Health	ENS	O
_:24721:55	Aux.V sup. V<1:Pickup	ACD	O
_:24721:57	Aux.V sup. V<1:Operate	ACT	O

8.3.10 Current-Balance Supervision

8.3.10.1 Overview of Functions

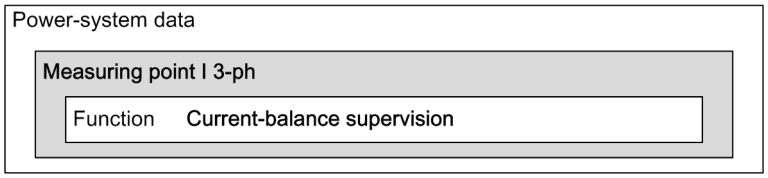
In healthy network operation, a certain balance between currents can be assumed.
The **Current-balance supervision** function detects the following errors:

- Unbalance of phase currents in the secondary circuit
- Connection errors during commissioning or short circuits and interruptions in the secondary circuit

The current measurement is based on the RMS values of the fundamental component.

8.3.10.2 Structure of the Function

The **Current-balance supervision** function is located in the **Power-system data** of each 3-phase current measuring point.



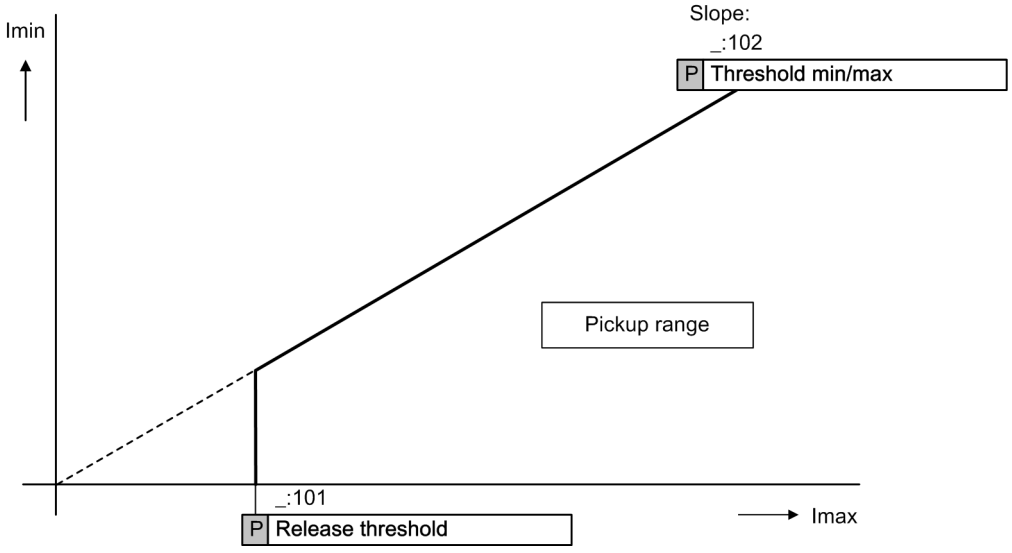
[dw_str_sym, 3, en_US]

Figure 8-27 Structure/Embedding of the Function

8.3.10.3 Function Description

The current balance is checked by a magnitude monitoring function. This function relates the smallest phase current to the largest phase current. Unbalance is detected if

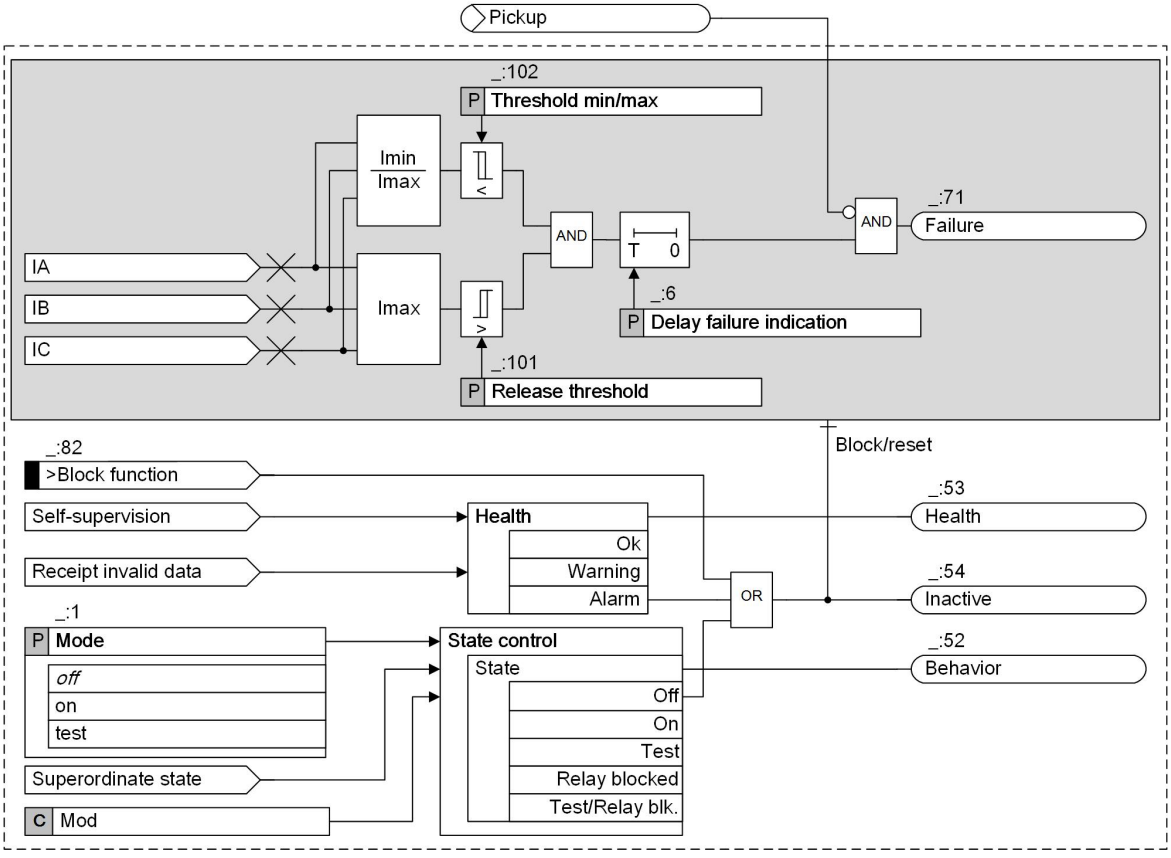
|Imin| / |Imax| < **Threshold min/max**, as long as Imax > **Release threshold**.



[lo_symmke, 1, en_US]

Figure 8-28 Characteristic of the Current-Balance Supervision

Logic



[lo_cb_symm, 4, en_US]

Figure 8-29 Logic Diagram of the Current-Balance Supervision

The **Threshold min/max** parameter is the criterion by which unbalance in the phase currents is measured. The device calculates the ratio between the minimum (I_{min}) and the maximum (I_{max}) phase current.

Enter the lower limit of the maximum phase current (I_{max}) with the parameter **Release threshold**. This specifies the lower limit of the operating range of this function.

Delay failure indication

If it falls below the balance factor **Threshold min/max** at the same time as the maximum phase current exceeds the **Release threshold**, the operate delay of the failure indication (parameter **Delay failure indication**) starts. If both conditions persist during this time, the indication **Failure** is generated.

Blocking the Function

The following blockings completely reset the picked up function:

- Externally or internally via the binary input signal *>Block function*
- A protection pickup
  The pickup signal of a protection function blocks the indication *Failure*.

8.3.10.4 Application and Setting Notes

Parameter: Threshold min/max

- Recommended setting value **(_:102) Threshold min/max** = *0.5*

The **Threshold min/max** parameter is used to set the ratio between the minimum (I_{min}) and the maximum (I_{max}) phase current.

Parameter: Release threshold

- Recommended setting value **(_:101) Release threshold** = ***0.5 A*** for I_{rated} = 1 A or ***2.5 A*** for I_{rated} = 5 A

The **Release threshold** parameter is used to set the lower limit of the maximum phase current (I_{max}).

Parameter: Delay failure indication

- Recommended setting value **(_:6) Delay failure indication** = ***5.00 s***

Set the **Delay failure indication** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided.

8.3.10.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. balan. I				
_:1	Supv. balan. I:Mode		• off • on • test	off
_:101	Supv. balan. I:Release threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	2.500 A
_:102	Supv. balan. I:Threshold min/max		0.10 to 0.95	0.50
_:6	Supv. balan. I:Delay failure indication		0.00 s to 100.00 s	5.00 s

8.3.10.6 Information List

No.	Information	Data Class (Type)	Type
Supv. balan. I			
_:82	Supv. balan. I:>Block function	SPS	I
_:54	Supv. balan. I:Inactive	SPS	O
_:52	Supv. balan. I:Behavior	ENS	O
_:53	Supv. balan. I:Health	ENS	O
_:71	Supv. balan. I:Failure	SPS	O

8.3.11 Current-Sum Supervision

8.3.11.1 Overview of Functions

In healthy system operation, the sum of all currents at one measuring point must be approximately 0. The **Current-sum supervision** function monitors the sum of all currents of one measuring point in the secondary circuit. It detects connection errors during commissioning or short circuits and interruptions in the secondary circuit.

For summation of the currents, the device requires the phase currents and the ground current of the current transformer neutral point or of a separate ground-current transformer at this measuring point. Select the following connection variant:

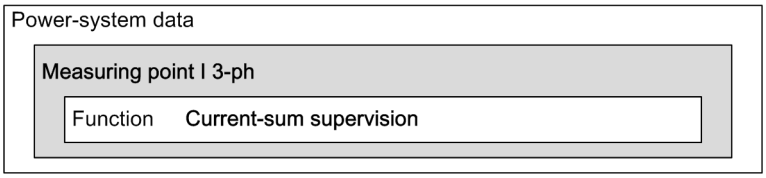
- Current-transformer connections connected to 3 current transformers and the neutral point (see *Figure A-10* in the *Attachment*)

NOTE

For current-sum supervision, the ground current of the line to be protected must be connected to the 4th current measurement input (I_N).

8.3.11.2 Structure of the Function

The **Current-sum supervision** function is located in the **Power-system data** of each 3-phase current measurement point.

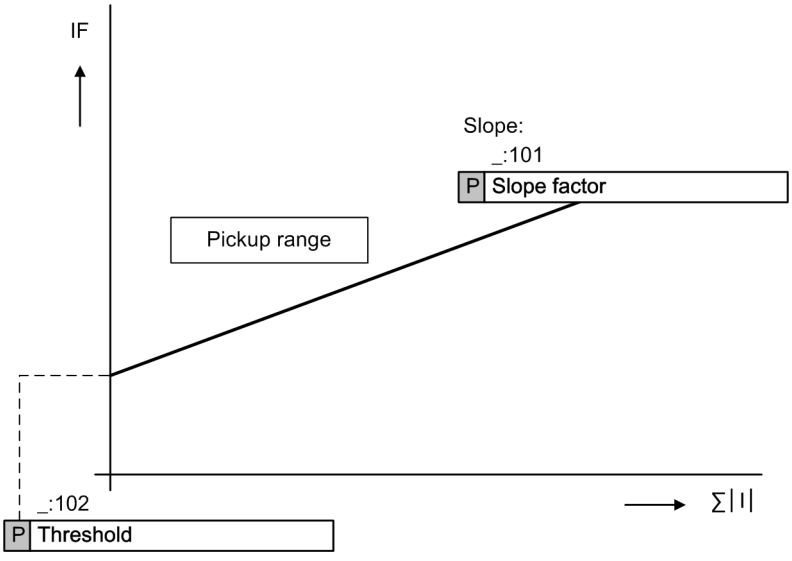


[dw_str_css, 3, en_US]

Figure 8-30 Structure/Embedding of the Function

8.3.11.3 Function Description

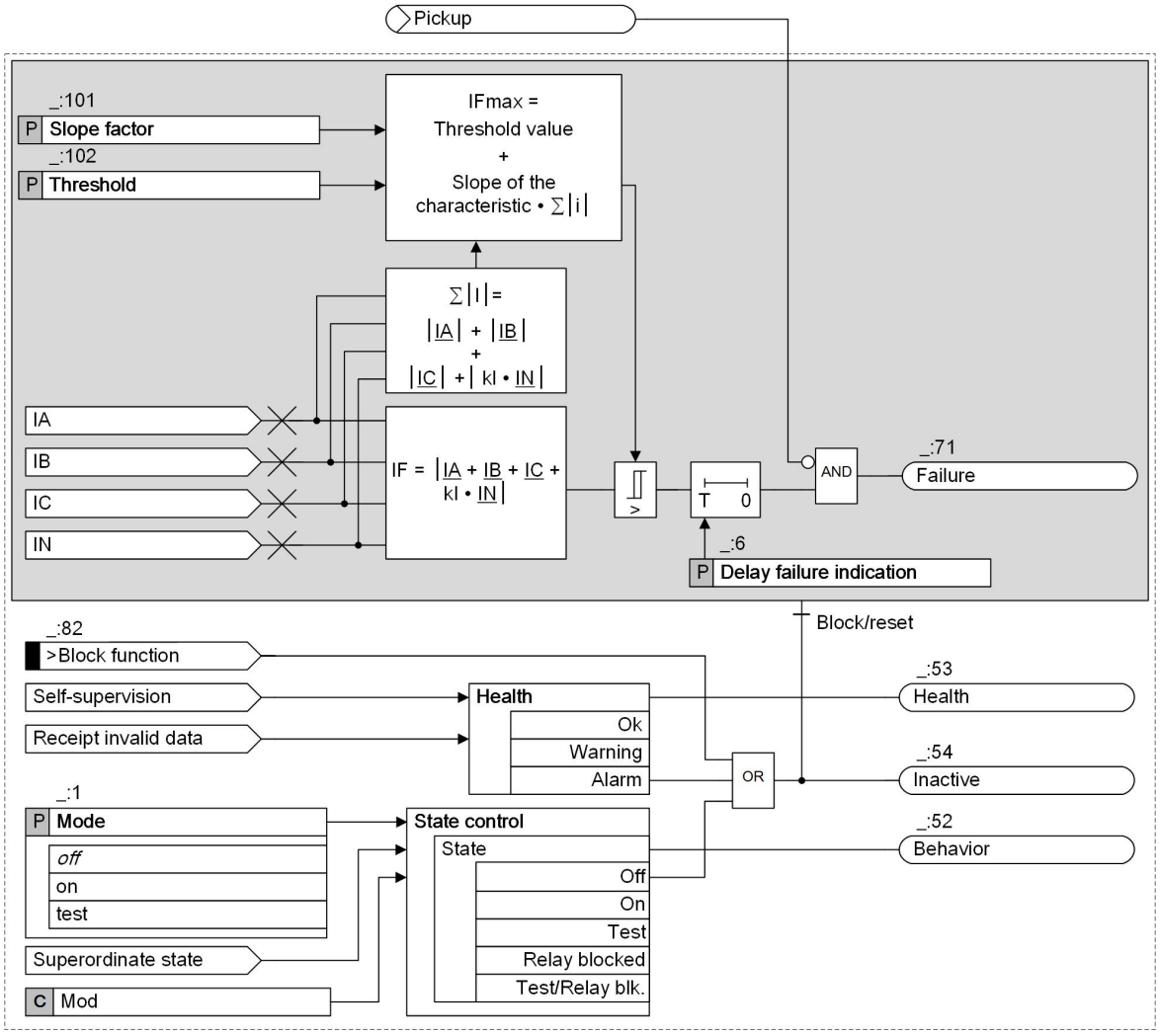
The current sum is generated by addition of the current phasors. Errors in the current circuits are detected if IF = |IA + IB + IC + kI• IN| > **Threshold** + **Slope factor** •Σ | I |.



[lo_kensum, 1, en_US]

Figure 8-31 Characteristic of the Current-Sum Supervision

Logic



[lo_cs_summ, 4, en_US]

Figure 8-32 Logic Diagram of the Current-Sum Supervision

Slope of the Characteristic Curve

The **Slope factor** • Σ | I | part takes into account permissible current-proportional transformation errors of the transformer, which can occur in the case of high short-circuit currents.

The **Slope factor** and **Threshold** parameters are used to set the fault-current limit (I_{Fmax}) for the current-sum supervision. The device calculates this fault current limit with the formula:

I_{Fmax} = **Threshold** + **Slope factor** • Σ| I |

The device uses the current inputs (IA, IB, IC and IN) to calculate:

- The fault current IF = |IA + IB + IC + kI• IN|
- The maximum current Σ| I | = | IA| + |IB| +| IC| + |kI• IN|

with $\mathbf{k_I}$ taking into account a possible difference from the transformation ratio of a separated ground-current transformer (I_N), for example, cable type current transformer.

- Transformation ratio of zero-sequence current converter: $Ratio_N$
- Transformation ratio of phase-current converter: $Ratio_{ph}$

$$k_I = \frac{Ratio_N}{Ratio_{ph}}$$

[fo_glchki, 1, en_US]

Threshold

The **Threshold** parameter is the lower limit of the operating range of the **Current-sum supervision** function.

Delay failure indication

When the calculated fault current (I_F) exceeds the calculated fault current limit (I_{Fmax}), the delay of the failure indication (parameter: **Delay failure indication**) starts. If the threshold-value violation persists for that time, the **Failure** indication is generated.

Blocking the Function

The following blockings reset the picked up function completely:

- Externally or internally via the binary input signal *>Block function*
- A protection pickup
  The pickup signal of a protection function blocks the *Failure* indication.

8.3.11.4 Application and Setting Notes

Parameter: Slope factor

- Recommended setting value **(_:101) Slope factor** = ***0.1***

The **Slope factor** parameter is used to set the ratio between the minimum (I_{min}) and the maximum (I_{max}) phase current. This function calculates the RMS values.

Parameter: Threshold

- Recommended setting value **(_:102) Threshold** = ***0.1 A*** for I_{rated} = 1 A or ***0.5 A*** for I_{rated} = 5 A

The **Threshold** parameter is used to set the maximum phase current (I_{max}).

Parameter: Delay failure indication

- Recommended setting value **(_:6) Delay failure indication** = ***5.00 s***

Set the **Delay failure indication** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided.

8.3.11.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. sum I				
_:1	Supv. sum I:Mode		• off • on • test	off
_:102	Supv. sum I:Threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A

Addr.	Parameter	C	Setting Options	Default Setting
_:101	Supv. sum I:Slope factor		0.00 to 0.95	0.10
_:6	Supv. sum I:Delay failure indication		0.00 s to 100.00 s	5.00 s

8.3.11.6 Information List

No.	Information	Data Class (Type)	Type
Supv. sum I			
_:82	Supv. sum I:>Block function	SPS	I
_:54	Supv. sum I:Inactive	SPS	O
_:52	Supv. sum I:Behavior	ENS	O
_:53	Supv. sum I:Health	ENS	O
_:71	Supv. sum I:Failure	SPS	O

8.3.12 Current Phase-Rotation Supervision

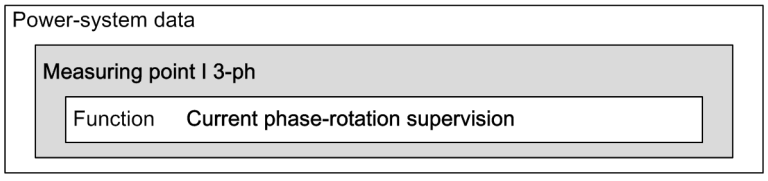
8.3.12.1 Overview of Functions

The **Current phase-rotation supervision** function monitors the phase sequence of the secondary-circuit currents by monitoring the sequence of the zero crossings (with same sign) of the currents. This enables the device to detect connections that were inverted during commissioning. The criterion for the check is the setting of the **`Phase sequence`** parameter.

The current measurement is based on the RMS values of the fundamental component.

8.3.12.2 Structure of the Function

The **Current phase-rotation supervision** function is located in the **Power-system data** of each 3-phase current measurement point.

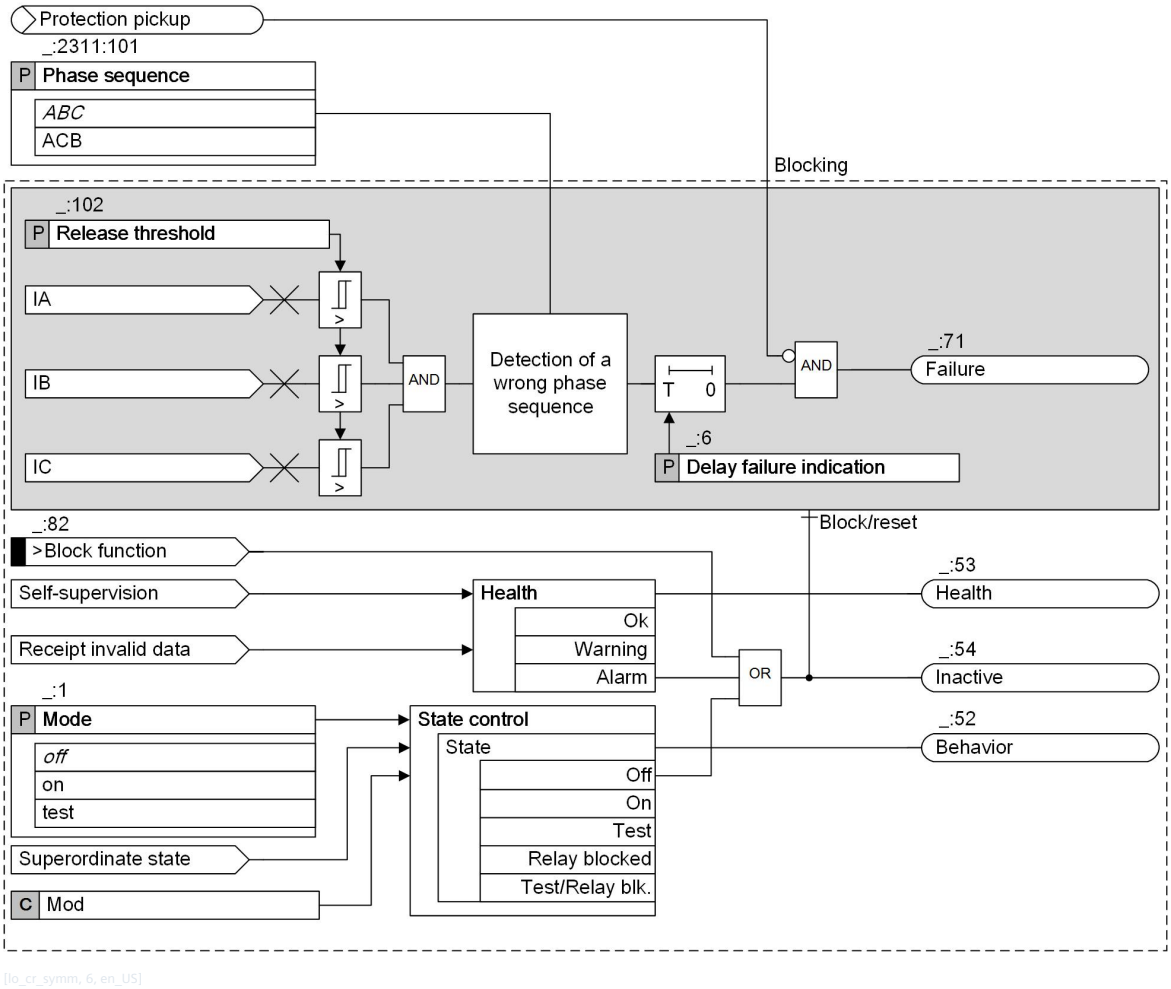


[dw_str_crs, 4, en_US]

Figure 8-33 Structure/Embedding of the Function

8.3.12.3 Function Description

Logic



[lo_cr_symm, 6, en_US]

Figure 8-34 Logic Diagram of the Current Phase-Rotation Supervision

The phase rotation is important for protection functions which process phase, loop, and directional information. You can set the phase sequence with the **`Phase sequence`** parameter in the function block **General** of the power-system data (see *6.1 Power-System Data*).

To supervise the phase rotation, the device compares the measured phase sequence with the set phase sequence. For abnormal phase sequences, the indication *`Failure`* is generated.

The connection of the currents to the device does not depend on the selected phase sequence. For connection diagrams see *A Appendix*.

Release Condition

The supervision of the current phase rotation is carried out when all measured phase currents are greater than the value of the **`Release threshold`** parameter.

Blocking of the Function

The following blockings reset the function completely:

- Via the binary input signal *`>Block function`* from an external or internal source
- Via a protection pickup
  The pickup signal from a protection function blocks the indication *`Failure`*.

Delay failure indication

When the device detects an inverted phase sequence for the duration of the **Delay failure indication**, the indication *Failure* is generated.

8.3.12.4 Application and Setting Notes

Parameter: Release threshold

- Default setting **(_:102) Release threshold** = ***0.500 A*** for I_{rated} = 1 A or ***2.50 A*** for I_{rated} = 5 A

With the **Release threshold** parameter, you specify the lower limit of the phase current for phase-rotation supervision.

Parameter: Delay failure indication

- Default setting **(_:6) Delay failure indication** = ***5.00 s***

Set the **Delay failure indication** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

8.3.12.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. ph.seq.I				
_:1	Supv. ph.seq.I:Mode		• off • on • test	off
_:6	Supv. ph.seq.I:Delay failure indication		0.00 s to 100.00 s	5.00 s
_:102	Supv. ph.seq.I:Release threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.500 A
		5 A @ 100 Irated	0.15 A to 50.00 A	2.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.500 A
		5 A @ 50 Irated	0.15 A to 50.00 A	2.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	2.500 A

8.3.12.6 Information List

No.	Information	Data Class (Type)	Type
Supv. ph.seq.I			
_:82	Supv. ph.seq.I:>Block function	SPS	I
_:54	Supv. ph.seq.I:Inactive	SPS	O
_:52	Supv. ph.seq.I:Behavior	ENS	O
_:53	Supv. ph.seq.I:Health	ENS	O
_:71	Supv. ph.seq.I:Failure	SPS	O

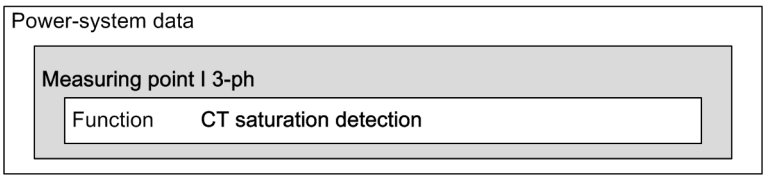
8.3.13 Saturation Detection

8.3.13.1 Overview of Functions

The **Saturation detection** function evaluates the profile of the current signals and determines whether the current transformer is saturated.

Protection functions such as the **Line differential protection** require this information for their selective function.

8.3.13.2 Structure of the Function



[dwstr saett, 2, en_US]

Figure 8-35 Structure of the Function

The **Saturation detection** function is located in the **Power-system data** of each 3-phase current measuring point.

The **Saturat. det.** block is visible in the measuring point **Current 3-phase** only if the **I-DIFF fast 2** stage is instantiated in the **Line differential protection** function or if the **S-DIFF fast 2** stage is instantiated in the **Stub-differential protection** function.

8.3.13.3 Function Description

If current-transformer saturation occurs, this leads to an erroneous representation of the primary-current history. With this, typical signal distortions of the current-signal profile occur.

The **Saturation detection** function searches for these typical signal distortions in the current signals of the 3 phases. If the **Saturation detection** function detects the typical signal distortions, it transmits corresponding internal information to the protection functions. The protection functions evaluate this information and react if saturation is detected.

The **Saturation detection** does not operate until a configurable minimum current (parameter: **CT saturation threshold**) is exceeded.

8.3.13.4 Application and Setting Notes

Parameter: CT saturation threshold

- Default setting **(_:17731:101) CT saturation threshold** = ***8.0 A***

The **CT saturation threshold** parameter is in the **Saturat. det.** block and is only visible if the **I-DIFF fast 2** stage is instantiated in the **Line differential protection** function or if the **S-DIFF fast 2** stage is instantiated in the **Stub-differential protection** function.

With the **CT saturation threshold** parameter, you set the current threshold for the saturation detection. If the set value is exceeded, the saturation detection becomes active.

Calculate the setting value for the parameter **CT saturation threshold** according to the following formula:

$$I_{saturation\ >} = \frac{n'}{k_{CT}} \cdot I_{rated}$$

[fo_sup isaet, 1, en_US]

where:

k_{CT} Minimum current factor

n' Effective accuracy limiting factor

The effective accuracy limiting factor n´ is calculated as follows:

$$n' = n \cdot \frac{S_{rated} + S_i}{S' + S_i}$$

[fo_saet n, 1, en_US]

where:

n	Rated overcurrent factor
S_{rated}	Rated burden of the current transformers [VA]
S_i	Inherent burden of the current transformers [VA]
S'	Actually connected burden (protection device + secondary lines)

The minimum current factor k_{CT} establishes the relationship between the different classes of conventional primary current transformers and the expected minimum current that can result in saturation of the transformer.

Closed iron core transformers such as **X**, **P**, **PX**, **PS** and **TPS** are combined in the current-transformer class **TPX**. These transformers have a large amount of remanence and a large secondary time constant.

Conventional current transformers with an anti-remanence gap such as the **TPY** and the **PR** limit the maximum possible remanence to 10 %. The minimum expected current that can result in saturation of the transformer is greater for this current-transformer class.

Due to its linear characteristic curve, the current-transformer class of the linear transformers **TPZ** transforms the alternating-current component of the primary current very well. The direct-current component of the current is greatly reduced. Depending on the connected burden, saturation occurs just below the operational overcurrent.

The following table shows the minimum current factor k_{CT} for the different current-transformer classes:

Current-Transformer Class	TPX	TPY	TPZ
k_{CT}	5	3	1.5

8.3.13.5 Settings

Measuring Point I-3ph

Addr.	Parameter	C	Setting Options	Default Setting
Saturat. det.				
_:17731:101	Saturat. det.:CT saturation threshold	1 A @ 100 Irated	1.200 A to 100.000 A	8.000 A
		5 A @ 100 Irated	6.00 A to 500.00 A	40.00 A
		1 A @ 50 Irated	1.200 A to 50.000 A	8.000 A
		5 A @ 50 Irated	6.00 A to 250.00 A	40.00 A

8.3.14 Trip-Circuit Supervision

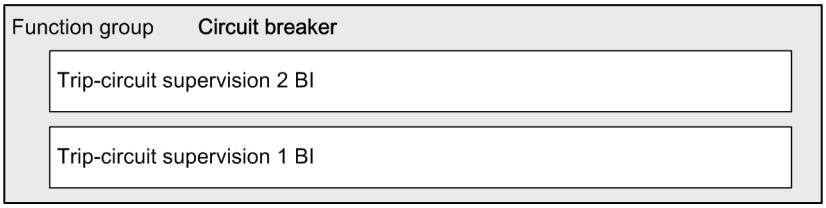
8.3.14.1 Overview of Functions

The **Trip-circuit supervision** function recognizes disruptions in the trip circuit. When 2 binary inputs are used, the function recognizes all disruptions in the trip circuit. If only 1 binary input is available, it will not recognize disruptions at the circuit breaker.

The control voltage for the circuit breaker must be greater than the sum of the minimum voltage drops at the binary inputs $V_{Ctrl} > 2\ V_{BImin}$. At least 19 V are required for each binary input. This makes the supervision usable only with a system-side control voltage of > 38 V.

8.3.14.2 Structure of the Function

The trip-circuit supervision is integrated into the **Circuit-breaker** function group. Depending on the number of available binary inputs, it works with 1 or 2 binary inputs.



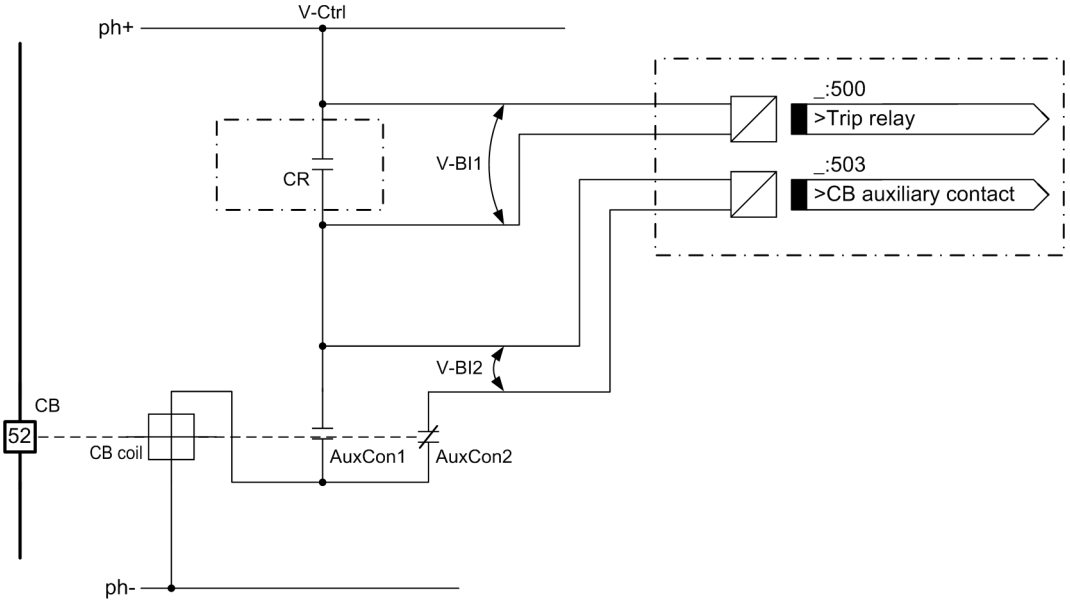
[dw_tcsueb, 1, en_US]

Figure 8-36 Structure/Embedding of the Function

8.3.14.3 Trip-Circuit Supervision with 2 Binary Inputs

In order to recognize disruptions in the trip circuit for each switch position, you need 2 binary inputs. One input is connected parallel to the respective command relay of the protection, the other parallel to the circuit-breaker auxiliary contact.

The following figure shows the principle of the trip-circuit supervision with 2 binary inputs.



[dw_tcs_2be, 3, en_US]

Figure 8-37 Principle of Trip-Circuit Supervision with 2 Binary Inputs

CR	Command relay
CB	Circuit breaker (open)
CB coil	Circuit-breaker coil
AuxCon1	Circuit-breaker auxiliary contact (make contact)
AuxCon2	Circuit-breaker auxiliary contact (break contact)
V-Ctrl	Control voltage (tripping voltage)
V-BI1	Input voltage for binary input 1
V-BI2	Input voltage for binary input 2

Supervision with 2 binary inputs identifies disruptions in the trip circuit and the outage of the control voltage. It also monitors the reaction of the circuit breaker by way of the position of the circuit-breaker auxiliary contacts.

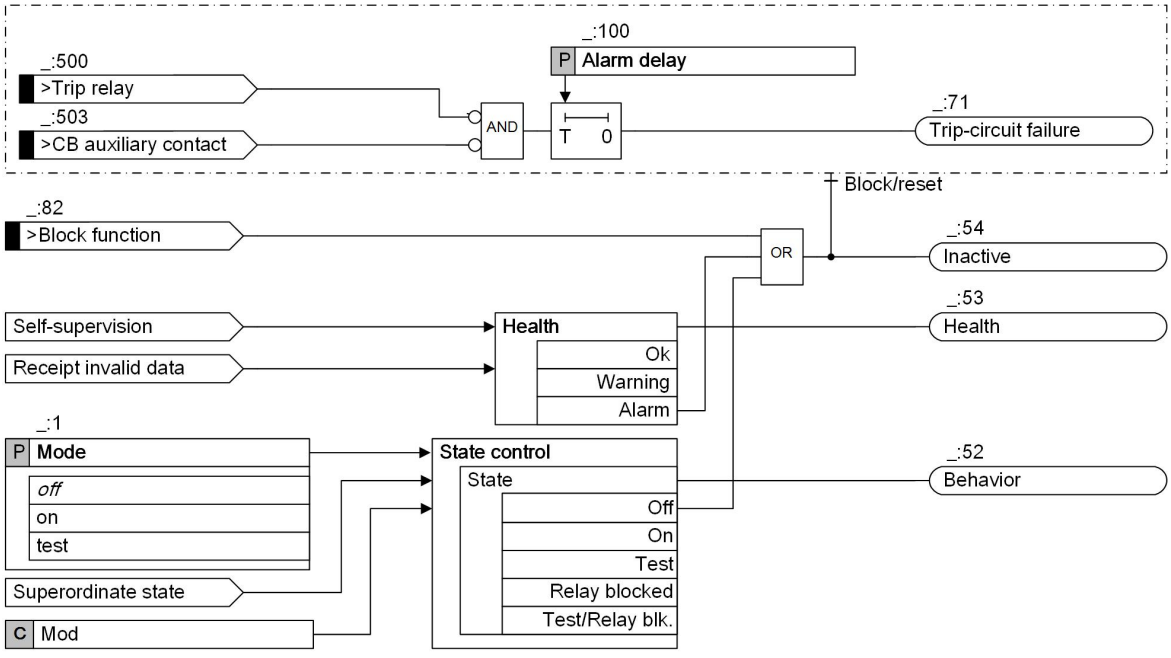
Depending on the switch position of the command relay and circuit breaker, the binary inputs are either activated (**H**) or not (**L**). If both binary inputs are not activated, there is a fault. The fault can be a disruption or a short circuit in the trip circuit, an outage of the battery voltage or a fault in the mechanics of the circuit breaker. With intact trip circuits, this state will occur only briefly while the command relay is closed and the circuit breaker has not yet been opened.

No.	Command Relay (CR)	CB	AuxCon1	AuxCon2	BI 1	BI 2	Dynamic State	Static State
1	Open	ON	Closed	Open	H	L	Normal operation with closed circuit breaker	
2	Open	OFF	Open	Closed	H	H	Normal operation with open circuit breaker	
3	Closed	ON	Closed	Open	L	L	Transmission or fault	Fault
4	Closed	OFF	Open	Closed	L	H	CR successfully activated the circuit breaker	

With the **`Alarm delay`** parameter, you can set the time delay. After fixing the fault in the trip circuit, the failure indication will automatically expire after the same time.

If the binary input signals *`>Trip relay`* or *`>CB auxiliary contact`* are not routed on the binary inputs of the device, then the *`Input sig. not routed`* indication is generated and the **Trip-circuit supervision** function is ineffective.

The following figure shows the logic diagram of the trip-circuit supervision with 2 binary inputs.



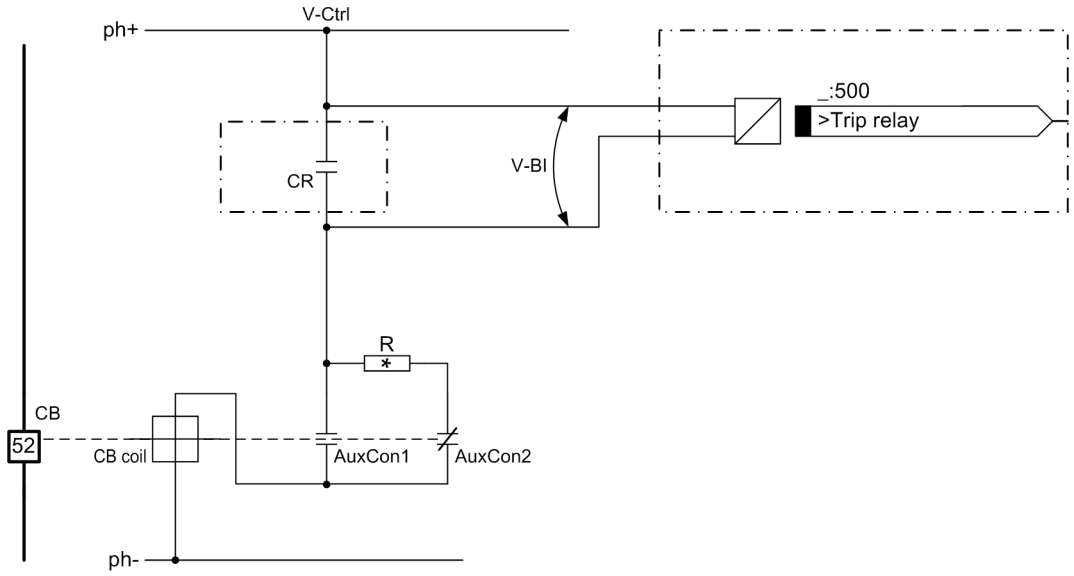
[lo_tcs_2be, 2, en_US]

Figure 8-38 Logic Diagram of Trip-Circuit Supervision with 2 Binary Inputs

8.3.14.4 Trip-Circuit Supervision with 1 Binary Input

When using 1 binary input, you will not identify any disruptions on the circuit breaker. The binary input is connected in parallel with the respective command relay of the protection device. The circuit-breaker auxiliary contact is bridged with a high-resistance equivalent resistance R.

The following figure shows the principle of the trip-circuit supervision with 1 binary input.



[dw_tcs_1be, 3, en_US]

Figure 8-39 Principle of Trip-Circuit Supervision with 1 Binary Input

CR	Command relay
CB	Circuit breaker (open)
CB coil	Circuit-breaker coil
AuxCon1	Circuit-breaker auxiliary contact (make contact)
AuxCon2	Circuit-breaker auxiliary contact (break contact)
V-Ctrl	Control voltage (tripping voltage)
V-BI	Input voltage for binary input
R	Equivalent resistance

The supervision with 1 binary input identifies disruptions in the trip circuit and the outage of the control voltage.

In normal operation, the binary input is activated with the command relay open and the trip circuit intact (**H**). The supervision circuit is closed with the equivalent resistance R or with the auxiliary contact AuxCon1 of the closed circuit breaker. The binary input is not activated while the command relay is closed (**L**). If the binary input is not activated for a prolonged time, there is a disruption in the trip circuit or the control voltage has failed.

No.	Command Relay	CB	AuxCon1	AuxCon2	BI	Dynamic State	Static State
1	Open	ON	Closed	Open	H	Normal operation with closed circuit breaker	
2	Open	OFF	Open	Closed	H	Normal operation with open circuit breaker	
3	Closed	ON	Closed	Open	L	Transmission or fault	Fault
4	Closed	OFF	Open	Closed	L	CR successfully activated the circuit breaker	

Use the parameter **`Blk.by trip/open cmd from`** to set the conditions under which the trip-circuit supervision is blocked. The following conditions can cause a blocking of the trip-circuit supervision function:

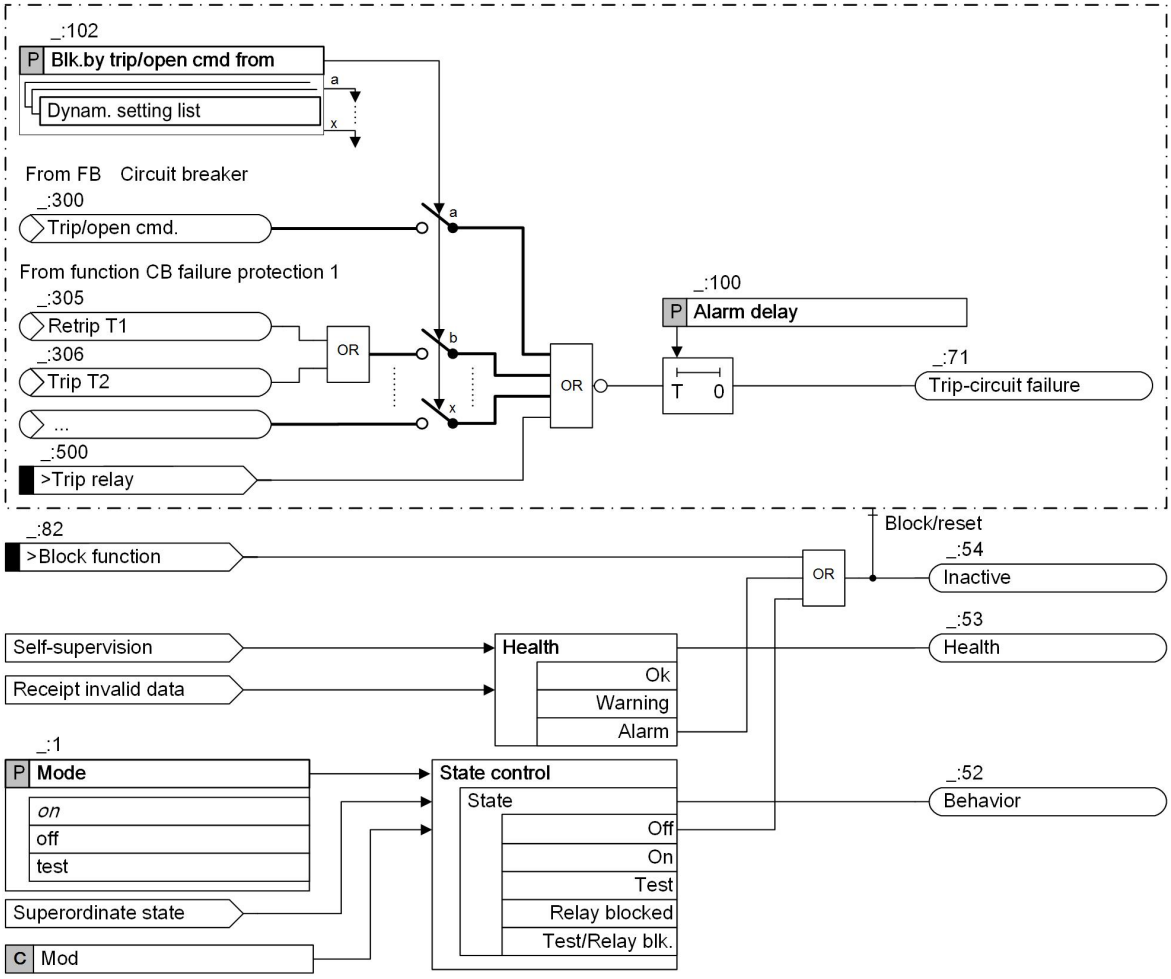
- The *`Trip/open cmd.`* of the circuit breaker is activated.
- One of the trip commands of the circuit-breaker failure protection is activated.

As long as the trip-circuit supervision function is blocked, the closed contact of the command relay does not cause a failure indication.

If the command contacts of other devices work in parallel on the trip circuit, the failure indication must be delayed. With the **`Alarm delay`** parameter, you can set the time delay. After fixing the fault in the trip circuit, the failure indication will automatically expire after the same time.

If the binary input signal *`>Trip relay`* is not routed to a binary input of the device (**information routing** in DIGSI 5), then the *`Input sig. not routed`* indication is generated and the **Trip-circuit supervision** function is not in effect.

The following figure shows the logic diagram of the trip-circuit supervision with 1 binary input.



[lo_tcs_1be, 2, en_US]

Figure 8-40 Logic Diagram of Trip-Circuit Supervision with 1 Binary Input

Equivalent Resistance R

The equivalent resistance R must be dimensioned such that the circuit-breaker coil is no longer activated when the circuit breaker is open. Simultaneously, the binary input must still be activated when the command relay is open.

In order to ensure the minimum voltage for activating the binary input, R_{max} results in:

$$R_{max} = \left(\frac{V_{Ctrl} - V_{BI\,min}}{I_{BI(High)}} \right) - R_{CBC}$$

[fo_r_max, 1, en_US]

So that the circuit-breaker coil does not remain activated, R_{min} results in:

$$R_{min} = R_{CBC} \cdot \left(\frac{V_{Ctrl} - V_{CBC(Low\ max)}}{V_{CBC(Low\ max)}} \right)$$

[fo_r_min, 1, en_US]

with:

V_{Ctrlst}	Control voltage for the trip circuit
$V_{BI\ min}$	Minimum activate voltage for BI
R_{CBC}	Ohm's resistance of the CB coil
$I_{BI(High)}$	Constant current with activated BI
$V_{CBC\ (Low\ max)}$	Maximum voltage at the CB coil that does not lead to a tripping

You can calculate the optimal value for the equivalent resistance R from the 2 values R_{min} and R_{max}:

$$R = \frac{R_{max} + R_{min}}{2}$$

[fo_r, 1, en_US]

The following applies for the power consumption of the equivalent resistance R:

$$P_R = I^2 \cdot R = \left(\frac{V_{Ctrl}}{R + R_{CBC}} \right)^2 \cdot R$$

[fo_pr, 1, en_US]

8.3.14.5 Application and Setting Notes

Parameter: Alarm delay

- Recommended setting value **(_:100) Alarm delay** = ***2 s*** (Trip-circuit supervision with 2 binary inputs)
- Recommended setting value **(_:100) Alarm delay** = ***300 s*** (Trip-circuit supervision with 1 binary input)

With the parameter **Alarm delay**, you can set the time for the delayed output of the indication *Trip-circuit failure*.

For **Trip-circuit supervision with 2 binary inputs**, you set the **Alarm delay** parameter so that the short-term transient states do not cause the function to activate.

For the **Trip-circuit supervision with 1 binary input,** you set the **Alarm delay** so that the longest duration of a trip command is bridged without fail. This ensures that the indication is emitted only if the trip circuit is actually interrupted.

Parameter: Blk.by trip/open cmd from

- Possible settings, application-dependent

The parameter works only with the trip-circuit supervision with 1 binary input.

Use the parameter **Blk.by trip/open cmd from** to set the conditions under which the trip-circuit supervision is blocked. The following conditions can cause a blocking of the trip-circuit supervision function:

- The *Trip/open cmd.* of the circuit breaker is activated.
- One of the trip commands of the circuit-breaker failure protection is activated.
- One of the trip commands of the circuit-breaker reignition protection is activated.

The circuit-breaker failure protection is set to protect a different trip circuit than the local circuit breaker. Using the configuration options of the **Blk.by trip/open cmd from** parameter, multiple trip-circuit supervision functions can be operated in parallel. For instance, a trip-circuit supervision function dedicated to a local

circuit breaker can also be operated parallel to a higher-level circuit breaker upon which the circuit-breaker failure protection acts.

8.3.14.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
74TC sup.1BI #				
_:1	74TC sup.1BI #:Mode		• off • on • test	on
_:100	74TC sup.1BI #:Alarm delay		0.50 s to 600.00 s	300.00 s
_:102	74TC sup.1BI #:Blk.by trip/open cmd from		Setting options depend on configuration	
74TC sup.2BI #				
_:1	74TC sup.2BI #:Mode		• off • on • test	on
_:100	74TC sup.2BI #:Alarm delay		0.50 s to 30.00 s	2.00 s

8.3.14.7 Information List

No.	Information	Data Class (Type)	Type
74TC sup.1BI #			
_:82	74TC sup.1BI #:>Block function	SPS	I
_:500	74TC sup.1BI #:>Trip relay	SPS	I
_:54	74TC sup.1BI #:Inactive	SPS	O
_:52	74TC sup.1BI #:Behavior	ENS	O
_:53	74TC sup.1BI #:Health	ENS	O
_:71	74TC sup.1BI #:Trip-circuit failure	SPS	O
_:301	74TC sup.1BI #:Input sig. not routed	SPS	O
74TC sup.2BI #			
_:82	74TC sup.2BI #:>Block function	SPS	I
_:500	74TC sup.2BI #:>Trip relay	SPS	I
_:503	74TC sup.2BI #:>CB auxiliary contact	SPS	I
_:54	74TC sup.2BI #:Inactive	SPS	O
_:52	74TC sup.2BI #:Behavior	ENS	O
_:53	74TC sup.2BI #:Health	ENS	O
_:71	74TC sup.2BI #:Trip-circuit failure	SPS	O
_:301	74TC sup.2BI #:Input sig. not routed	SPS	O

8.3.15 Closing-Circuit Supervision

8.3.15.1 Overview of Functions

The function **Closing-circuit supervision** detects disruptions in the closed circuit of the circuit breaker.

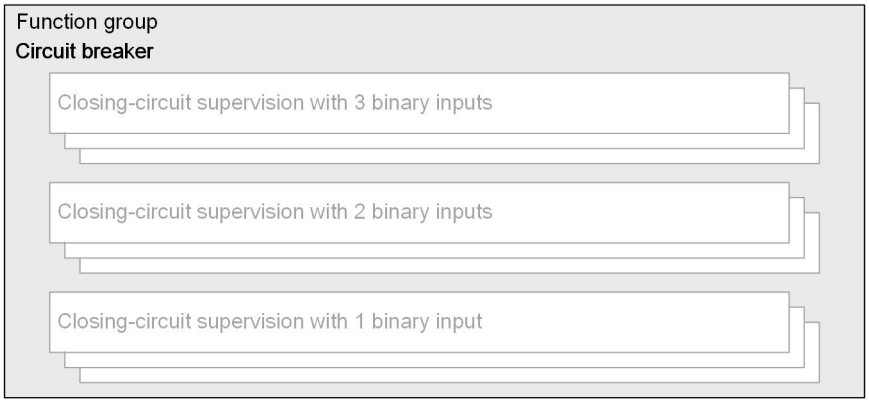
The control voltage for the closed circuit must be greater than the sum of the minimum voltage drops at the binary inputs, that is, $V_{Ctrl} > 2 \cdot V_{high}$ or $V_{Ctrl} > 3 \cdot V_{high}$ depending on the number of available binary inputs .

8.3.15.2 Structure of the Function

The function **Closing-circuit supervision** is integrated into the function group **Circuit breaker**. Depending on the available number of the binary inputs, the function works with 3 binary inputs, 2 binary inputs or 1 binary input.

The following stages can be operated simultaneously in the function group **Circuit breaker**:

- Maximum of 3 stages **Closing-circuit supervision with 3 binary inputs**
- Maximum of 3 stages **Closing-circuit supervision with 2 binary inputs**
- Maximum of 3 stages **Closing-circuit supervision with 1 binary input**



[dw_CCS_structure_3BI, 1, en_US]

Figure 8-41 Structure/Embedding of the Function

8.3.15.3 Closing-Circuit Supervision with 3 Binary Inputs

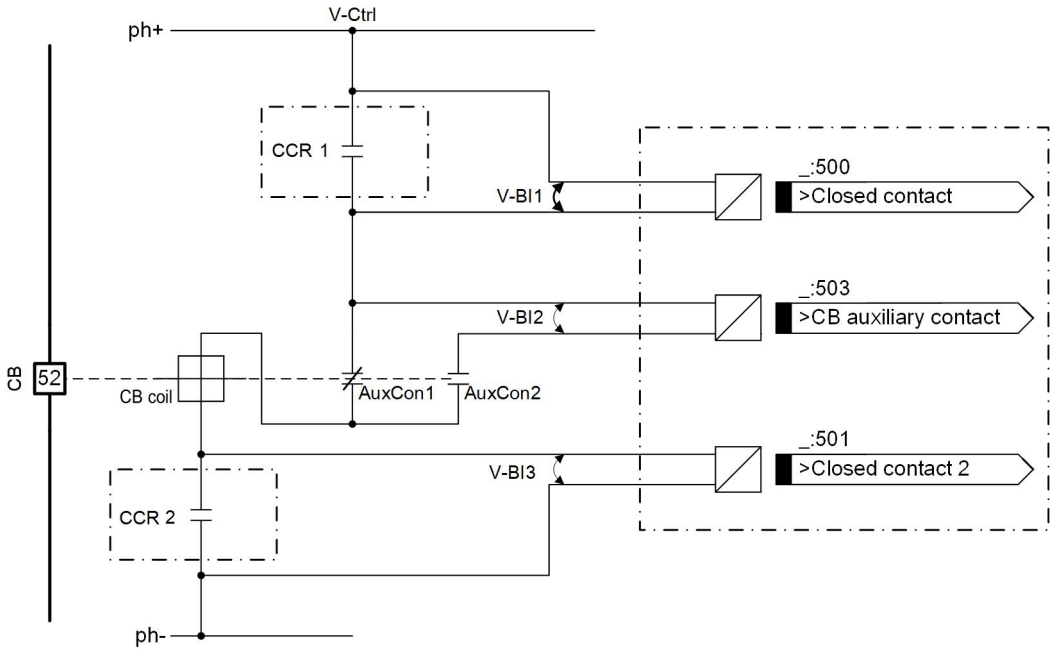
Precondition

To use the function block **Closing-circuit supervision with 3 binary inputs**, set the control voltage larger than 3 times the voltage of the binary input ($V_{Ctrl} > 3 \cdot V_{high}$).

In the following descriptions, the minimum V_{high} of the binary input is 19 V.

Closing-Circuit Supervision with 3 Binary Inputs

In order to recognize disruptions in the closed circuit for each switch position, you need 3 binary inputs. 2 inputs are connected parallel to the respective command relays of the protection, another is connected parallel to the circuit-breaker auxiliary contact.



[dw_closed-circuit supervision_3BIs, 2, en_US]

Figure 8-42 Principle of the Closing-Circuit Supervision with 3 Binary Inputs

CCR 1	Closed-command relay 1
CCR 2	Closed-command relay 2
CB	Circuit breaker (closed)
CB coil	Circuit-breaker coil
AuxCon1	Circuit-breaker auxiliary contact (closed if the CB is closed)
AuxCon2	Circuit-breaker auxiliary contact (open if the CB is closed)
V-Ctrl	Control voltage (tripping voltage)
V-BI1	Input voltage for binary input 1
V-BI2	Input voltage for binary input 2
V-BI3	Input voltage for binary input 3

The stage **Closing-circuit supervision with 3 binary inputs** identifies disruptions in the closed circuit and the outage of the control voltage. It also monitors the reaction of the circuit breaker by way of the position of the circuit-breaker auxiliary contacts.

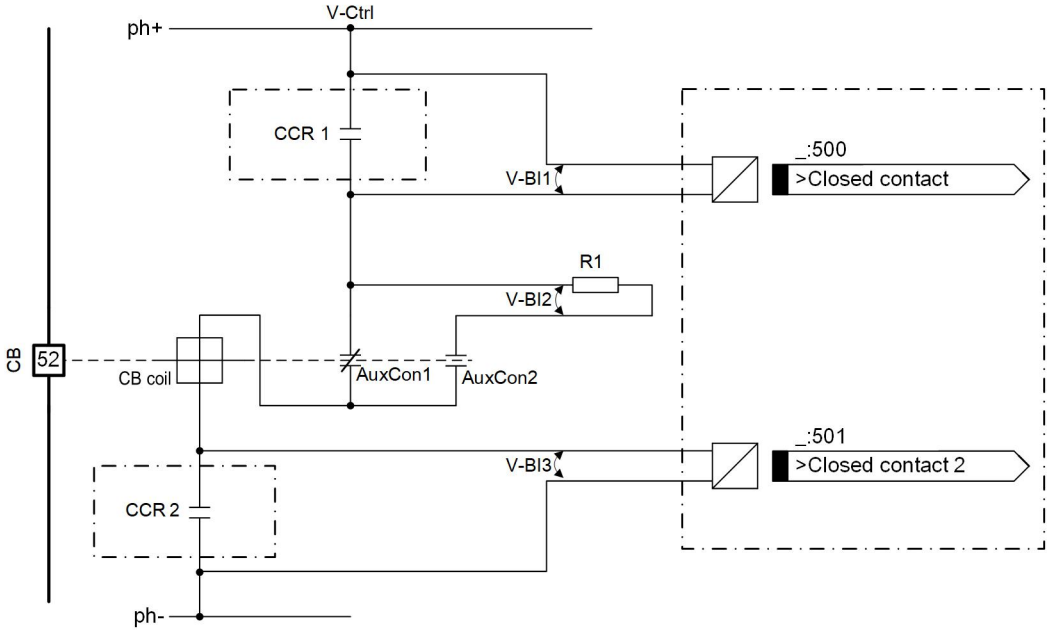
Depending on the switch position of the closed-command relay and the circuit breaker, the binary inputs are either activated (**H**) or deactivated (**L**). If both binary inputs are deactivated, a fault occurs. The fault can be a disruption or a short circuit in the closed circuit, a failure of the voltage of the binary inputs or a fault in the mechanics of the circuit breaker. With intact closed circuits, this state occurs only briefly while the command relay is closed and the circuit breaker is not opened.

Closed Command	CB	AuxCon1	AuxCon2	>Closed contact	>Closed contact 2	>CB auxiliary contact	State
No	Closed	Closed	Open	H	H	H	Normal operation with closed circuit breaker
No	Open	Open	Closed	H	H	L	Normal operation with open circuit breaker
Yes	Open	Open	Closed	L	L	L	Transient process
Yes	Closed	Closed	Open	L	L	H	Transient process
No	–	–	–	L	L	–	Fault

Closed Command	CB	AuxCon1	AuxCon2	>Closed contact	>Closed contact 2	>CB auxiliary contact	State
No	–	–	–	H	L	–	Fault
No	–	–	–	L	H	–	Fault

Closing-Circuit Supervision with 2 Binary Inputs and 1 Resistance

In *Figure 8-42*, when the circuit breaker is closed, the binary input *>CB auxiliary contact* is used to form the complete supervision circuit and limit the inductive current. Therefore, the function **Closing-circuit supervision** also works with 2 binary inputs and 1 resistance.



[dw_closed-circuit supervision_2BIs, 2, en_US]

Figure 8-43 Principle of the Closing-Circuit Supervision with 2 Binary Inputs and 1 Resistance

CCR 1	Closed-command relay 1
CCR 2	Closed-command relay 2
CB	Circuit breaker (closed)
CB coil	Circuit-breaker coil
AuxCon1	Circuit-breaker auxiliary contact (closed if the CB is closed)
AuxCon2	Circuit-breaker auxiliary contact (open if the CB is closed)
R	Equivalent resistance
V-Ctrl	Control voltage (tripping voltage)
V-BI1	Input voltage for binary input 1
V-BI2	Input voltage for binary input 2
V-BI3	Input voltage for binary input 3

Equivalent Resistance R

The equivalent resistance R must be dimensioned in such a way that the circuit-breaker coil is no longer activated when the circuit breaker is open. Simultaneously, the binary input must still be activated when the command relay is open.

In order to ensure the minimum voltage for activating the binary input, R_{max} results in:

$$R_{max} = \left(\frac{V_{Ctrl} - 2 \cdot V_{BImin}}{I_{BI(High)}}\right) - R_{CBC}$$

[fo_closed_circuit_supervision_1, 2, en_US]

If there is no closed command, the current flows via the binary inputs. Then the circuit current is limited to 2.5 mA at most. The closed circuit-breaker coil remains activated.
The following formula applies for the power consumption of the equivalent resistance R:

$$P_R = I^2 \times R$$

[fo_closed_circuit_supervision_2, 1, en_US]

In the following examples, you can find the calculation of R under different control voltages.

- **The control voltage is 110 V.**
  In the following example, if R_{CBC} is 90 Ω, R_{max} is calculated as follows:

  $$R_{max} = \left(\frac{V_{Ctrl} - 2 \cdot V_{BImin}}{I_{BI(High)}}\right) - R_{CBC} = \frac{110\ V - 2 \cdot 19\ V}{2.5\ mA} - 0.09\ k\Omega = 28.71\ k\Omega$$

  [fo_closed_circuit_supervision_RMax_110V, 2, en_US]

  Siemens recommends the resistance R of 18 kΩ, then the calculated maximum power is 0.11 W.

  $$P_R = I^2 \times R = \frac{2.5\ mA \cdot 2.5\ mA \cdot 18\ k\Omega}{1000} = 0.11\ W$$

  [fo_closed_circuit_supervision_PR_110V, 1, en_US]

  If the closed-command relay is open, the maximum voltage on the circuit-breaker coil and the minimum voltage on each binary input is calculated as follows:

  $$V_{CBCmax} = 1.5 \cdot 0.09\ k\Omega \cdot 2.5\ mA = 0.34\ V$$

  [fo_closed_circuit_supervision_Vmax_110V, 3, en_US]

  The circuit-breaker coil is not activated.

  $$V_{CBCmin} = \left[0.8 \cdot V_{CTR} - I_{BI(High)} \cdot (1.5 \cdot R_{CBC} + R)\right] \cdot 0.5 = \left[0.8 \cdot 110\ V - 2.5\ mA \cdot (1.5 \cdot 0.09\ k\Omega + 18\ k\Omega)\right] \cdot 0.5 = 21.33\ V$$

  [fo_closed_circuit_supervision_Vmin_110V, 3, en_US]

  The binary input is activated.

- **The control voltage is 220 V.**
  In the following example, if R_{CBC} is 36 Ω, R_{max} is calculated as follows:

$$R_{max} = \left(\frac{V_{Ctrl} - 2 \cdot V_{BImin}}{I_{BI(High)}}\right) - R_{CBC} = \frac{220\ V - 2 \cdot 19\ V}{2.5\ mA} - 0.36\ k\Omega = 72.44\ k\Omega$$

[fo_closed_circuit_supervision_RMax_220V, 2, en_US]

Siemens recommends the resistance R of 51 kΩ, then the calculated maximum power is 0.32 W.

$$P_R = I^2 \times R = \frac{2.5\ mA \cdot 2.5\ mA \cdot 51\ k\Omega}{1000} = 0.32\ W$$

[fo_closed_circuit_supervision_PR_220V, 1, en_US]

If the closed-command relay is open, the maximum voltage on the circuit-breaker coil and the minimum voltage on each binary input is calculated as follows:

$$V_{CBCmax} = 1.5 \cdot 0.36\ k\Omega \cdot 2.5\ mA = 1.35\ V$$

[fo_closed_circuit_supervision_Vmax_220V, 3, en_US]

The circuit-breaker coil is not activated.

$$V_{CBCmin} = \left[0.8 \cdot V_{CTR} - I_{BI(High)} \cdot (1.5 \cdot R_{CBC} + R)\right] \cdot 0.5 = [0.8 \cdot 220\ V - 2.5\ mA \cdot (1.5 \cdot 0.36\ k\Omega + 51\ k\Omega)] \cdot 0.5 = 23.58\ V$$

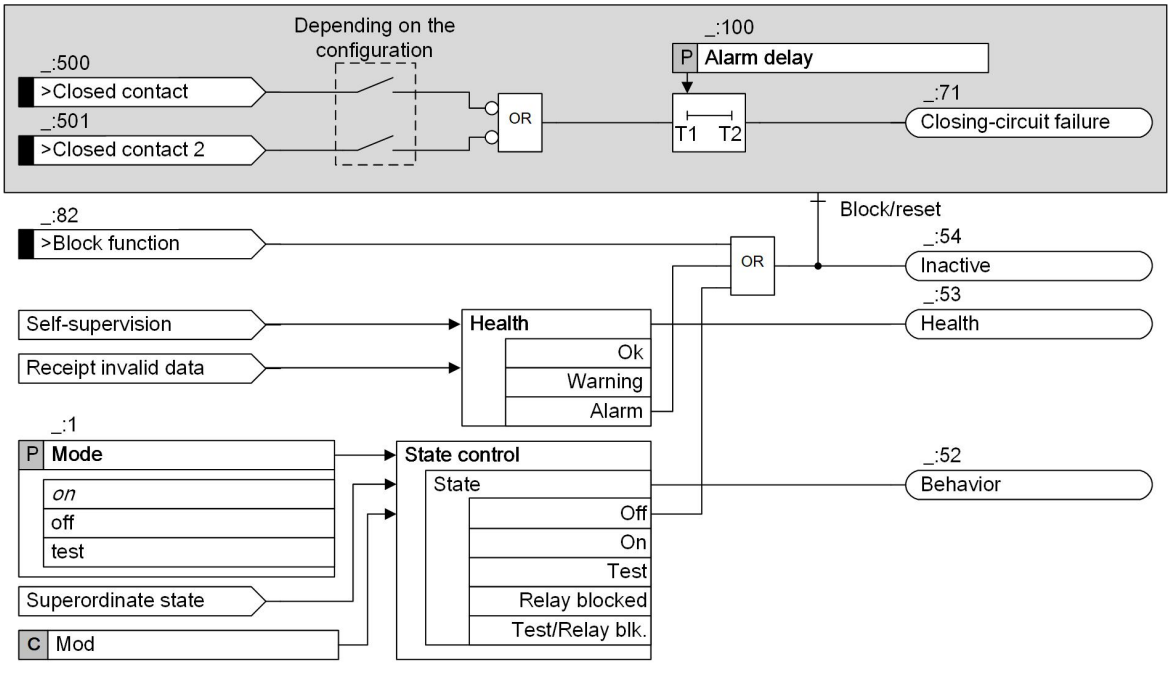
[fo_closed_circuit_supervision_Vmin_220V, 3, en_US]

The binary input is activated.

Logic

With the parameter **`Alarm delay`**, you can set the time delay. After fixing the faults in the closed circuit, the failure indication automatically expires after the **`Alarm delay`** time.

If the binary input signal *`>Closed contact`* or *`>Closed contact 2`* is not routed to the binary input of the device (**Information routing** in DIGSI 5), the function **Closing-circuit supervision** does not work.



[lo_closed-circuit supervision_3BIs, 4, en_US]

Figure 8-44 Logic Diagram of the Stage Closing-Circuit Supervision with 3 Binary Inputs

The indication *Closing-circuit failure* is generated when the following 2 conditions are met:

- The binary input signal *>Closed contact* or *>Closed contact 2* is deactivated.
- The **Alarm delay** has elapsed.

The indication *Closing-circuit failure* disappears only when the following 2 conditions are met:

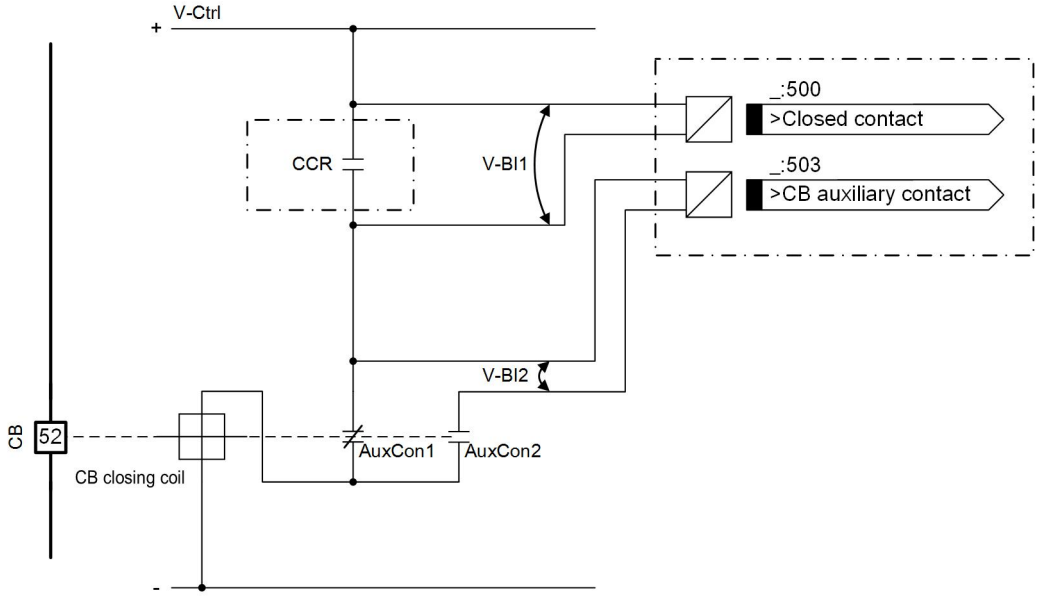
- The binary input signals *>Closed contact* and *>Closed contact 2* are activated.
- The **Alarm delay** has elapsed.

8.3.15.4 Closing-Circuit Supervision with 2 Binary Inputs

Principle

In order to detect disruptions in the closed circuit for each switch position, 2 binary inputs are necessary:

- One binary input is connected in parallel to the close-command relay.
- Another binary input is connected in series with the circuit-breaker auxiliary contact.



[dw_CCS_2BI, 1, en_US]

Figure 8-45 Principle of the Closing-Circuit Supervision with 2 Binary Inputs

CCR	Close-command relay
CB	Circuit breaker
CB closing coil	Circuit-breaker closing coil
AuxCon1	Circuit-breaker auxiliary contact 1 (open if the CB is closed)
AuxCon2	Circuit-breaker auxiliary contact 2 (closed if the CB is closed)
V-Ctrl	Control voltage for the closed circuit
V-BI1	Input voltage for binary input 1
V-BI2	Input voltage for binary input 2

The stage **Closing-circuit supervision with 2 binary inputs** detects disruptions in the closed circuit. It also monitors the reaction of the circuit breaker via the position of the circuit-breaker auxiliary contacts.

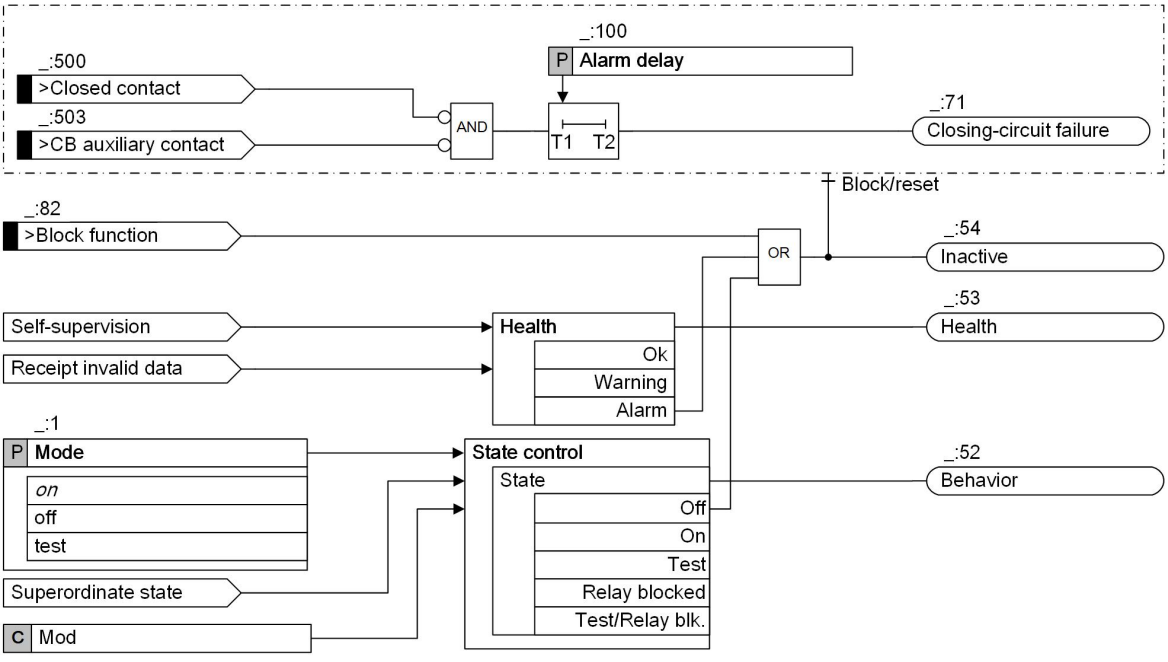
Depending on the switch position of the close-command relay and the circuit breaker, the binary inputs are either activated (H) or deactivated (L). If both binary inputs are deactivated, a fault occurs. The fault can be one of the following conditions:

- A disruption
- An outage of the battery voltage
- An adhesion present on the contact surface of the CCR

The following table shows all the states of the closed circuit:

CCR	CB	AuxCon1	AuxCon2	>Closed contact	>CB auxiliary contact	Dynamic State	Static State
Open	Open	Closed	Open	H	L	Normal operation with an open circuit breaker	
Open	Closed	Open	Closed	H	H	Normal operation with a closed circuit breaker	
Closed	Open	Closed	Open	L	L	Transient	Fault
Closed	Closed	Open	Closed	L	H	Transient, CCR is activated	

Logic



[lo_CCS_2BI, 3, en_US]

Figure 8-46 Logic Diagram of the Stage Closing-Circuit Supervision with 2 Binary Inputs

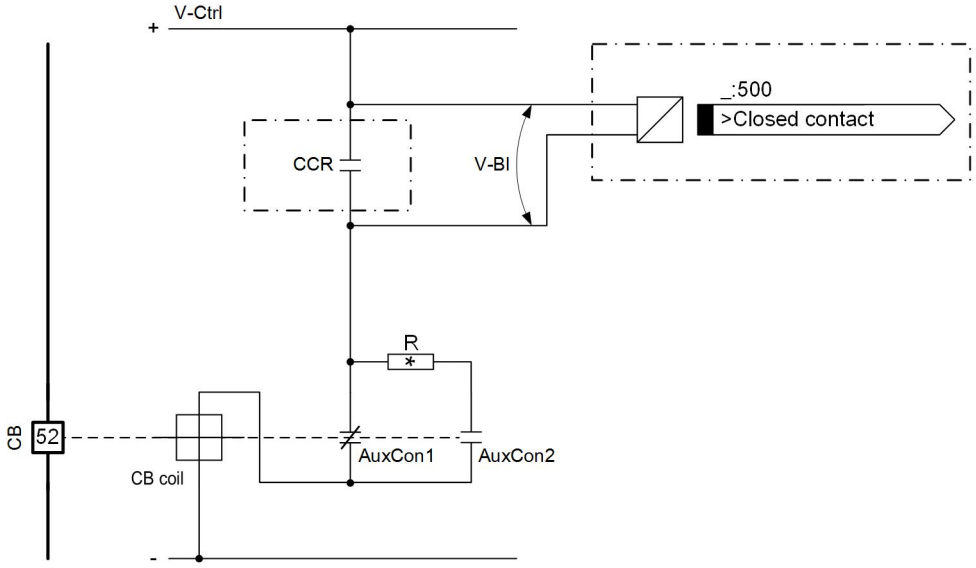
The indication *Closing-circuit failure* is generated when the following 2 conditions are met:

- The binary inputs **>Closed contact** and **>CB auxiliary contact** are both deactivated.
- The **Alarm delay** has elapsed.

8.3.15.5 Closing-Circuit Supervision with 1 Binary Input

Principle

In the stage **Closing-circuit supervision with 1 binary input**, 1 binary input is used to detect the disruption in the closed circuit. The binary input is connected parallel to the close-command relay. The circuit-breaker auxiliary contact is bridged with an equivalent resistance R.



[dw_CCS_1BI, 1, en_US]

Figure 8-47 Principle of the Closing-Circuit Supervision with 1 Binary Input

CCR	Close-command relay
CB	Circuit breaker
CB closing coil	Circuit-breaker closing coil
AuxCon1	Circuit-breaker auxiliary contact 1 (open if the CB is closed)
AuxCon2	Circuit-breaker auxiliary contact 2 (closed if the CB is closed)
V-Ctrl	Control voltage for the closed circuit
V-BI	Input voltage for binary input
R	Equivalent resistance

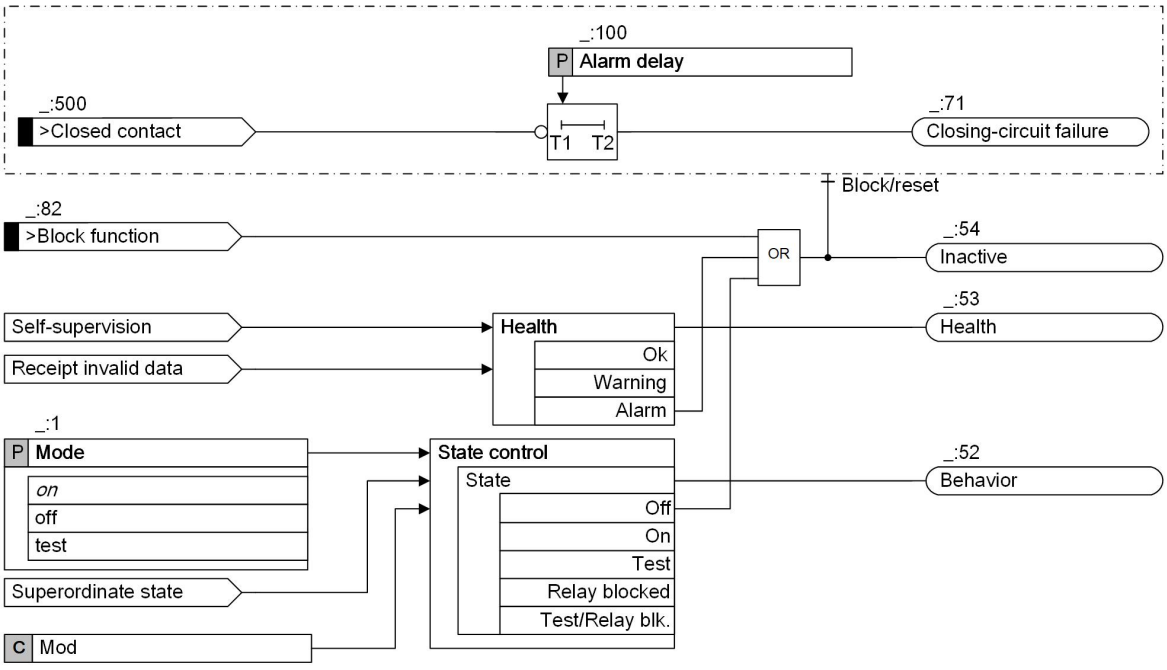
Depending on the switch position of the close-command relay, the binary input is either activated (H) or deactivated (L). If the binary input is deactivated, a fault occurs. The fault can be one of the following conditions:

- A disruption
- An outage of the battery voltage
- An adhesion present on the contact surface of the CCR

The following table shows all the states of the closed circuit:

CCR	CB	AuxCon1	AuxCon2	>Closed contact	Dynamic State	Static State
Open	Open	Closed	Open	H	Normal operation with an open circuit breaker	
Open	Closed	Open	Closed	H	Normal operation with a closed circuit breaker	
Closed	Open	Closed	Open	L	Transient	Fault
Closed	Closed	Open	Closed	L	Transient, CCR is activated	

Logic



[lo_CCS_1BI, 3, en_US]

Figure 8-48 Logic Diagram of the Stage Closing-Circuit Supervision with 1 Binary Input

The indication *Closing-circuit failure* is generated when the following 2 conditions are met:

- The binary input **>Closed contact** is deactivated.
- The **Alarm delay** has elapsed.

Equivalent Resistance R

The equivalent resistance R must be dimensioned such that the circuit-breaker closing coil is no longer activated when the circuit breaker is open. Simultaneously, the binary input must still be activated when the command relay is open.

In order to ensure the minimum voltage for activating the binary input, R_{max} results in:

$$R_{max} = \left(\frac{V_{Ctrl} - V_{BImin}}{I_{BImax}}\right) - R_{CBC}$$

[fo_CCS_general_Rmax, 1, en_US]

Because the circuit-breaker closing coil does not remain activated, R_{min} results in:

$$R_{min} = R_{CBC} \cdot \left(\frac{V_{Ctrl} - V_{CBC(Lowmax)}}{V_{CBC(Lowmax)}}\right)$$

[fo_CCS_general_Rmin, 1, en_US]

You can calculate the optimal value for the equivalent resistance R from the 2 values R_{min} and R_{max}:

$$R = \frac{R_{max} + R_{min}}{2}$$

[fo_CCS_general_R, 1, en_US]

The following equation applies for the power consumption of the equivalent resistance R:

$$P_R = I^2 \cdot R = \left(\frac{V_{Ctrl}}{R_{CBC} + R}\right)^2 \cdot R$$

[fo_CCS_general_P, 1, en_US]

With:

V_{Ctrl}	Control voltage for the closed circuit
V_{BImin}	The minimum voltage to activate the binary input
I_{BImax}	The maximum current to activate the binary input
R_{CBC}	The resistance of the circuit-breaker closing coil
$V_{CBC(Lowmax)}$	The maximum voltage flow through the circuit-breaker closing coil, which does not result in the closing of the circuit breaker

8.3.15.6 Application and Setting Notes

Parameter: Alarm delay

- Default setting **(_:100) Alarm delay** = ***2.00 s*** (Closing-circuit supervision with 3 binary inputs)
- Default setting **(_:100) Alarm delay** = ***2.00 s*** (Closing-circuit supervision with 2 binary inputs)
- Default setting **(_:100) Alarm delay** = ***300.00 s*** (Closing-circuit supervision with 1 binary input)

With the parameter **Alarm delay**, you can set the time for the delayed output of the indication *Closing-circuit failure*.

For the stage **Closing-circuit supervision with 2 binary inputs** or **Closing-circuit supervision with 3 binary inputs**, set the parameter **Alarm delay** so that the short-term transient states do not cause the function to activate.

For the stage **Closing-circuit supervision with 1 binary input**, set the parameter **Alarm delay** so that the longest duration of a close command is bridged without fail. This setting ensures that the function is activated only when the closed circuit is disrupted.

8.3.15.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
74CC sup.1BI #				
_:1	74CC sup.1BI #:Mode		• off • on • test	on
_:100	74CC sup.1BI #:Alarm delay		0.50 s to 600.00 s	300.00 s
74CC sup.2BI #				
_:1	74CC sup.2BI #:Mode		• off • on • test	on
_:100	74CC sup.2BI #:Alarm delay		0.50 s to 30.00 s	2.00 s

Addr.	Parameter	C	Setting Options	Default Setting
74CC sup.3BI #				
_:1	74CC sup.3BI #:Mode		• off • on • test	on
_:100	74CC sup.3BI #:Alarm delay		0.50 s to 30.00 s	2.00 s

8.3.15.8 Information List

No.	Information	Data Class (Type)	Type
74CC sup.1BI #			
_:82	74CC sup.1BI #:>Block function	SPS	I
_:500	74CC sup.1BI #:>Closed contact	SPS	I
_:54	74CC sup.1BI #:Inactive	SPS	O
_:52	74CC sup.1BI #:Behavior	ENS	O
_:53	74CC sup.1BI #:Health	ENS	O
_:71	74CC sup.1BI #:Closing-circuit failure	SPS	O
74CC sup.2BI #			
_:82	74CC sup.2BI #:>Block function	SPS	I
_:500	74CC sup.2BI #:>Closed contact	SPS	I
_:503	74CC sup.2BI #:>CB auxiliary contact	SPS	I
_:54	74CC sup.2BI #:Inactive	SPS	O
_:52	74CC sup.2BI #:Behavior	ENS	O
_:53	74CC sup.2BI #:Health	ENS	O
_:71	74CC sup.2BI #:Closing-circuit failure	SPS	O
74CC sup.3BI #			
_:82	74CC sup.3BI #:>Block function	SPS	I
_:500	74CC sup.3BI #:>Closed contact	SPS	I
_:503	74CC sup.3BI #:>CB auxiliary contact	SPS	I
_:501	74CC sup.3BI #:>Closed contact 2	SPS	I
_:51	74CC sup.3BI #:Mode (controllable)	ENC	C
_:54	74CC sup.3BI #:Inactive	SPS	O
_:52	74CC sup.3BI #:Behavior	ENS	O
_:53	74CC sup.3BI #:Health	ENS	O
_:71	74CC sup.3BI #:Closing-circuit failure	SPS	O

8.4 Supervision of the Device Hardware

8.4.1 Overview

The correct state of the device hardware is a requirement for the correct functioning of the device. The failure or erroneous function of a hardware component leads to device malfunctions.
The following modules of the device hardware are monitored:

- Base module
- Expansion modules
- Plug-in modules on the interface locations

The error responses result, depending on type and degree of the error, as follows:
Hardware errors where the device remains in operation.
The error is indicated. The signals/data affected by the failure are marked as **invalid**. In this way, the affected protection functions can go into a secure state. Such errors are, for example:

- Failure communication module (module x)
- Measuring-transducer module failure (module x)
- USB interface
- Integrated Ethernet interface
- Real-time clock device
- A/D converter (fast current sum)
- Battery voltage
- Faulty or missing compensation values (magnitude/phase)

Failures which can partially be corrected by a restart of the device. The device goes briefly out of operation.
Such errors are, for example:

- Memory error (RAM) in the base module
- Defective module
- Module-connection error (PCB Link)
- Control circuit error binary output
- Outage of an internal auxiliary voltage



NOTE

If the error has not be rectified after 3 unsuccessful attempts, the system automatically recognizes it as a severe device malfunction. The device goes permanently out of operation into a secure state (fallback mode).

Fatal device errors with outage of central components: The device goes permanently out of operation into a secure state (fallback mode).
Such errors are, for example:

- Memory error (flash) in the base module
- CPU/Controller/FPGA error in the base module
- 3 unsuccessful restarts in a row

You can find the detailed description of the error responses in table form at the end of this chapter. You will find corresponding corrective measures there.

Device Operating Hours

The *Device operating hours* statistical value counts the operating hours of the physical device. The starting time and the time in Fallback mode are not considered.

You can neither reset nor change the statistical value.

8.4.2 Analog-Channel Supervision via Fast Current-Sum

8.4.2.1 Overview of Functions

The function **Supervision of the device-internal analog-digital converters** it performs the following tasks:

- Supervision of the correct functioning of the device-internal analog-digital converters, based on the sum of all currents of one measuring point in the secondary circuit.
- Detection of failures in the device-internal measuring circuits (for example, analog-digital converter)
- Blocking of protection and control functions that process the measured values from this current measuring point (for example, differential protection). This avoids an overfunction of the device.

The supervision principle is based on fast current-sum supervision with connection of the neutral-point current to the 4th current measuring input. In order to ensure that even the fast tripping stages of the protection functions can be blocked in time before a spurious pickup, the fast current measurement is based on instantaneous values.

For **Analog-digital converter supervision**, the neutral-point current of the line to be protected must be connected to the 4th current measuring input (I_N). The 4th current measuring input must be routed via the current-transformer neutral point (I_N neutral point) (see next figure).



Current transformer 3-phase: connection = 3-phase + IN

[ti_phase_2, 4, en_US]

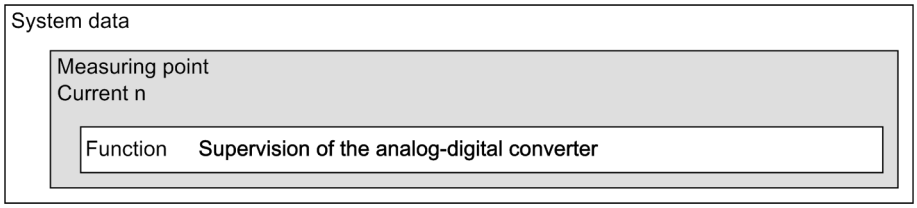
Figure 8-49 Connection to a 3-Phase Current Transformer and Measured Zero-Sequence Current (Current in Common Return Conductor)

NOTE

The analog channel supervision via fast current sum is only available when the 4th current input is a protection-class current transformer. In the DIGSI 5 project tree, under **Device** → **Measuring-point routing**, set the connection type ***3-phase + IN*** for the current measuring point. When using this function, check the correct connection of the neutral conductor/ground current by supplying an asymmetrical current. Otherwise, a 1-pole or 2-pole fault could result in an unwanted blocking of the protection.

8.4.2.2 Structure of the Function

The **Supervision of the device-internal analog-digital converters** function is located in the **Power-system data** function group of each 3-phase current measuring point.



[dw_schstr, 1, en_US]

Figure 8-50 Structure/Embedding of the Function

8.4.2.3 Function Description

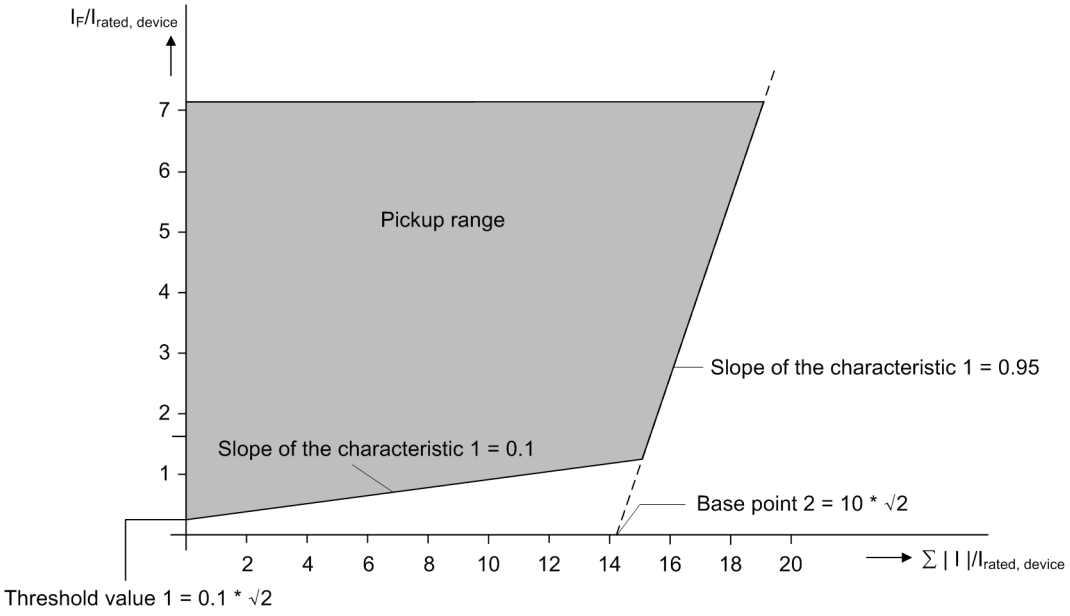
Errors in the current circuits are detected if

$I_F = |iA + iB + iC + iN| >$ **Threshold value** + **Slope of the characteristic 1** •Σ| i | and

$I_F >$ **Slope of the characteristic 2** • (Σ| i | - **Base point 2**)

The device uses the current inputs (iA, iB, iC, and iN) to calculate:

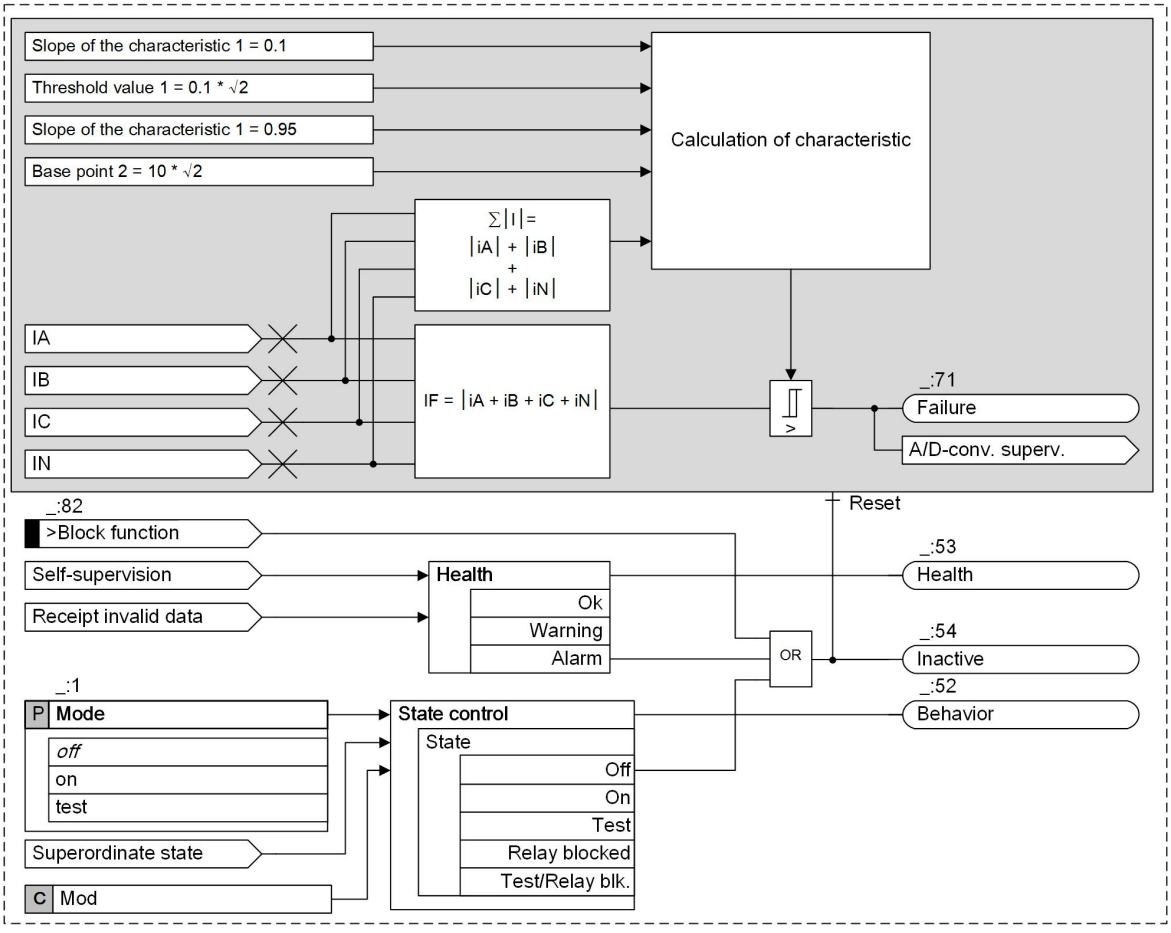
- Fault current $I_F = |iA + iB + iC + iN|$
- Maximum current Σ| i | = |iA|+|iB|+|iC|+ |iN|



[lo_kenisu, 2, en_US]

Figure 8-51 Characteristic Curve of the Supervision of the Device-Internal Analog-Digital Converters

Logic



[lo_sumsch, 4, en_US]

Figure 8-52 Logic Diagram of the Supervision of the Device-Internal Analog-Digital Converters

When the output signal **`A/D converter monit.`** is active, certain protection functions are blocked to avoid failures (see *12.84 Analog Channel Supervision via Fast Current Sum*).

NOTE

The parameters are set in the device and cannot be changed.

It is not necessary to change the parameters as a function of the application.

Threshold Value

The **threshold value** is the lower limit of the operating range of the **Supervision of the device-internal analog-digital converters** function.

The **threshold value** is permanently set to 10 % of the device rated current.

Slope of the Characteristic 1

The component **Slope of the characteristic 1** • Σ | i | accounts for permissible errors of the current input that can occur in the event of slight overcurrents.

The **Slope of the characteristic 1** is permanently set to 0.1.

Slope of the Characteristic 2

The component **Slope of the characteristic 2** accounts for permissible errors of the current input that can occur in the event of large overcurrents (high short-circuit currents).

The **Slope of the characteristic 2** is permanently set to 0.95. The base point of the **Slope of the characteristic 2** is permanently set to 10.

8.5 Supervision of Device Firmware

The device firmware determines essentially the functionality of the device.
The following supervisions ensure the stable function of the device:

- Supervisions of the data and version consistency
- Supervision of the undisturbed sequential activity of the device firmware
- Supervision of the available processor performance

When you start the device, load data via the interfaces and these supervisions of the device firmware will be in effect during the continuous operation. Depending on the type and severity of error, the following error responses will result:

Firmware failures where the device remains in operation.

The error is indicated. The signals/data affected by the failure are marked as **invalid**. In this way, the affected protection functions can go into a secure state. Such errors are, for example, errors in time synchronization (loss and errors).

Failures which can partially be corrected by a restart of the device. The device goes briefly out of operation.

Such errors are, for example:

- Device startup with faulty new parameter set. The old parameter set is still present.
- Overloading of the processor
- Program-sequence error

Fatal firmware error. The device goes permanently out of operation into a secure state (fallback mode).

Such errors are, for example:

- Device startup with faulty new parameter set. No usable parameter set is present.
- Device startup with version error
- CFC-runtime error
- 3 unsuccessful restarts in a row

You can find the detailed description, in table form, of the fault responses at the end of chapter *8.8 Error Responses and Corrective Measures*. You will find corresponding corrective measures there.

8.6 Supervision of Hardware Configuration

The modular hardware concept requires adherence to some rules within the product family and the modular system. Configuration errors show that the hardware configuration saved in the device does not agree with the hardware actually detected. Impermissible components and unallowed combinations must be detected just as missing configured components are.

Depending on the type and severity of error, the following error responses will result: The identified hardware configuration errors are assigned to the defect severities as follows:

Configuration errors for which the device remains in operation.

The failure is indicated. The signals/data affected by the failure are marked as **invalid**. In this way, the affected protection functions can go into a secure state. Such errors are, for example, errors in the IE-converter configuration (normal/sensitive).

Fatal configuration error: The device goes permanently out of operation into a secure state (fallback mode).

Such errors are, for example:

- Missing hardware module (module x)
- Incorrect hardware module (module x)
- Incorrect hardware combination
- Incorrect plug-in module (module x)

You can find the detailed description of the error responses in table form at the end of this chapter. You will find corresponding corrective measures there. You can resolve configuration errors through another synchronization with DIGSI.

8.7 Supervision of Communication Connections

SIPROTEC 5 devices offer extensive communication options via fixed and optional interfaces. Beyond the hardware supervision , the transferred data must be monitored with respect to their consistency, failure, or outage.

Supervision

With the supervision of the communication connections, every communication port is monitored selectively.

- Failures are detected and indicated via the operational log. The device remains in operation!
- Additionally, each port is equipped with a separate communication log which displays details of the failures, for example the error rate.

Marking Fault Signals/Data

The signals/data affected by the failure are marked as **invalid**. In this way, the affected protection functions can go into a secure state. In the following, some examples are named:

- GOOSE signals can automatically be set to defined values in case of disturbed IEC 61850 communication.
- Disturbed protection interfaces set phasor values, analog measured values, and binary information to **invalid**, for example for the differential protection. Binary signal traces can be set to defined values in cases of failures.
- Disturbed time-synchronization signals can lead to an automatic change of the source of time synchronization.

You can correct communication failures by checking the external connections or by replacing the affected communication modules.

For further information on error responses, refer to to *8.8.4 Defect Severity 3*. Corresponding corrective measures are also be described there.

8.8 Error Responses and Corrective Measures

8.8.1 Overview

When device errors occur and the corresponding supervision functions pick up, this is displayed on the device and also indicated. Device errors can lead to corruption of data and signals. These data and signals are marked and tagged as **invalid**, so that affected functions automatically go into a secure state. If the supervision functions pick up, this will lead to defined error responses.

How Do Device Errors Make Themselves Noticeable

In case of a device error the supervision functions of the device pickup. The device responds according to the type and severity of the error. To report an error, supervision functions use outputs on the device and indications.

Run LED (green)	The external auxiliary voltage is present. The device is ready for operation.
Error LED (red)	The device is not ready for operation. The life contact is open.
Life contact	Signaling of device readiness following successful device startup.
Group-warning indication *Group warning*	The device remains in operation and signals an error via the prerouted LED and the log.
Log of the device	Indications of causes for defects and corrective measures

Determination of Causes for Defects and Corrective Measures

To determine the cause for defect and the corresponding corrective measure, proceed step by step.

Step 1: Pick up of supervisions leads to one of the following defect severities in all cases.

- **Defect severity 1:**
  Internal or external device error that is reported. The device remains in operation.
- **Defect severity 2:**
  Severe device failure, the device restarts (reset) to correct the cause for defect.
- **Defect severity 3:**
  Severe device failure, the device goes to a safe condition (fallback mode), as the correction of defects cannot be implemented by a restart. In fallback mode, the protection and automated functions are inactive. The device is out of operation.
- **Defect severity 4:**
  Severe device-external failure, the device switches the protection and automatic functions to inactive for safety, but remains in operation. Normally, the user can correct the fault by himself.

Step 2: For every defect severity, you will find detailed tables with information about causes for defects, error responses, and corrective measures in the following chapters.

Table 8-1 Error Responses

	Group-Warning Indication Group Warning	Indication in Operational Log	Indication in Device-Diagnosis Log	Indication of the Life Contact	All Protection and Automation Functions are inactive	Device restart (Reset)	Fallback Mode
Defect Severity 1	x	x	x	–	–	–	–
Defect Severity 2	–	–	x	x	During the starting time of the device	x	–
Defect Severity 3	–	–	x	x	x	–	x
Defect Severity 4	–	x	–	x	x	–	–

8.8.2 Defect Severity 1

Defect severity 1 faults allow the continued safe operation of the device. Defect severity 1 faults are indicated. The device remains in operation.

When the supervision functions pick up, corrupted data and signals are marked as **invalid**. In this way, the affected functions can go into a secure state. Whether functions are blocked is decided in the appropriate function itself. For more detailed information, refer to the function descriptions.

Life contact	Remains activated
Red error LED	Is not activated

Log

For every device fault, a corresponding supervision indication is generated. The device records these indications with a real-time stamp in the operational log. In this way they are available for further analyses. If supervisions in the communication interfaces area of the device pick up, there is a separate communication log available for each port. Extended diagnostic indications and measured values are available there. The device-diagnosis log contains expanded fault descriptions. There you also receive recommendations of corresponding corrective measures for each detected device error.

There is further information on handling the logs in *3.1 Indications*.

Group-Warning Indication Group Warning

As delivered, all monitoring indications of Defect Severity 1 are routed to the signal `(_:301)` **`Group warning`**. In this way, a device error can be indicated with only one indication. The majority of supervision indications are permanently connected to the **`Group warning`** (**Group warning** column = fixed). However, some supervision indications are routed flexibly to the **`Group warning`** via a logic block chart (**Group warning** column = CFC). If necessary, the routings via a CFC chart can be taken from the group indication again.

In delivery condition, the **`Group warning`** is routed to an LED.

The following logic diagram shows the correlation.

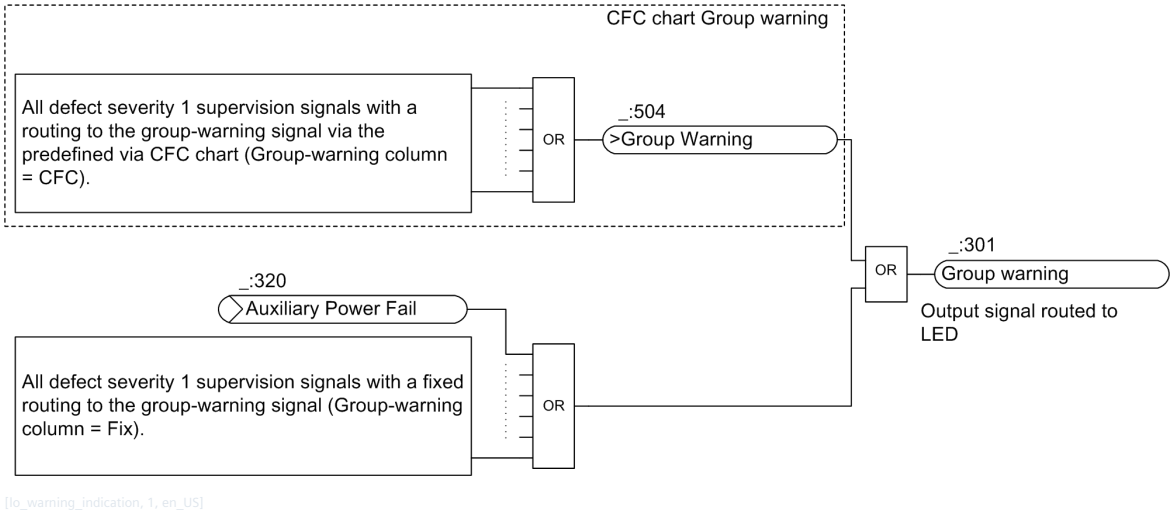


Figure 8-53 Forming the Warning Group Indication Group Warning

Overview of Errors

Indication	Type	Group Warning	Explanation
General:			
(_:53) **Health**	ENS	CFC	If the **Health** of an individual function block, for example a protection stage or an individual function, goes to the *Warning* or *Alarm* state, this state generates up to the general group indication **Health** (_:53) via the associated function group. Check from the operational log from which function or function block the error originates. In the associated function description, there is additional information as to why the Standby of the function or a function block can change.
(_:53) **Health** = ***Warning***	SPS		
(_:53) **Health** = ***Alarm***	SPS		

Indication		Type	Group Warning	Explanation
Device:				
	_:320 **Auxiliary Power Fail**	SPS	Fixed	Fault with the auxiliary power supply: Check the external power supply. This message does not appear if the device has a redundant PS204 power supply module, and is replaced by the messages described below for a device with PS204.
	(_:305) **Battery failure**	SPS		Battery fault: Replace the device battery. To avoid data loss, Siemens recommends replacing the device battery with the device supply voltage switched on. You can find more information on battery disposal in the hardware manual from version V07.80 (order number: C53000-G5040-C002-D).
	_:312 **Compensation error** x	ENS		Calibration error in module x: Contact the Customer Support Center. **Quality**: Measured values are marked with the quality attribute of *questionable* (measured value display with ≈).
	_:314 **Offset error** x	ENS		Offset error on module x: If this indication persists after the device start, contact the Customer Support Center. **Quality**: Measured values are marked with the quality attribute of *questionable* (measured value display with ≈).
	_:306 **Clock fail**	SPS		Internal time failure • Check the time settings first. • Then replace the device battery. • If the fault is not remedied, contact the Customer Support Center. **Quality**: The internal time is marked with the quality attribute of *Clock Failure*.
	(_:319) **Error memory**	SPS		Checksum (cyclic redundancy check) error in monitored memory areas of the device
	Measuring transducer error (x)	ENS		Hardware failure on the measuring-transducer module on plug-in module position E/F/M/N/P: Contact the Customer Support Center.

Indication	Type	Group Warning	Explanation
Device with redundant PS204 power supply module:			
_:330 **Power sup. Module fail.** x	INS	CFC	Internal device error on the power supply module at position x[63]: • The device remains in operation because it has a redundant power supply module, provided it is intact. • Exchange the defective power supply module so that redundancy is reestablished!
_:331 **Power sup. Module OK** x	INS		No internal device error in the power supply module at position x[63].
_:332 **Pow. sup. aux. pow. fail.** x	INS		Error in the external auxiliary power supply module at position x[63]: • The device remains in operation because it has a redundant power supply module, provided it is intact. • Check the auxiliary power supply module.
_:333 **Power sup.aux.pow.OK** x	INS		The external auxiliary power supply module at position x[63] is OK.
_:334 **Power sup. Module fail.** x	SPS	Fixed	At least one power supply module has an internal device error
_:335 **Pow. sup. aux. pow. fail.** x	SPS	Fixed	At least one power supply module does not have an adequate auxiliary power supply
Handling an alarm:			
(_:504) **>Group Warning**	SPS	Fixed	Input signal for user-defined generation of group warning
Time sync.:			
(_:305) **Time sync. error**	SPS	Fixed	Time synchronization error, the timing master is faulty: • Check the external time source first. • Check the external connections. • If the fault is not remedied, contact the Customer Support Center. **Quality**: The internal time is marked with the quality attribute of *Clock not synchronized*.
Power-system data:meas. point I-3ph:superv. Bal. I: (_:71) **Failure**	SPS	CFC	Current balance failure (see *8.3.10.1 Overview of Functions*)
Power-system data:meas. point I-3ph:superv. Phsseq.I: (_:71) **Failure**	SPS	CFC	Failure of the current phase-rotation supervision system (see *8.3.12.1 Overview of Functions*)
Power-system data:meas. point I-3ph:superv. Sum I (_:71) **Failure**	SPS	CFC	Failure of the current sum (see *8.3.11.1 Overview of Functions*)

[63] x refers to the PCB assembly slot (x =1,2,3,...)

Indication	Type	Group Warning	Explanation
Power-system data:meas. point I-3ph:superv.ADC sum.I: (_:71) **Failure**	SPS	CFC	Failure of the fast current sum (see *8.4.2.1 Overview of Functions*) The failure indication indicates a fault in the analog-digital converter at the power input. • Check the exterior wiring. • If the fault is not remedied, contact the Customer Support Center. **Quality**: The internally managed current measured values are marked with the *invalid* quality attribute. **Blocking**: The protection functions based on current measurement are blocked.
Power-system data:meas. point V-3ph: Volt.Trans.Cir.B: (_:500) **>Open**	SPS	CFC	Voltage-transformer circuit breaker is open. **Blocking**: Appropriate functions are either blocked definitely or the blocking can be set individually.
Power-system data:meas. point V-3ph: Superv. of Bal. V: (_:71) **Failure**	SPS	CFC	Failure of the voltage balance (see *8.3.6.1 Overview of Functions*)
Power-system data:meas. point V-3ph: Superv. Phsseq.V: (_:71) **Failure**	SPS	CFC	Failure of the voltage phase-rotation supervision (see *8.3.8.1 Overview of Functions*)
Power-system data:meas. point V-3ph: Superv. of Sum V: (_:71) **Failure**	SPS	CFC	Failure of the voltage sum (see *8.3.7.1 Overview of Functions*)
2 devices prot. comm.: Protection interface #:			Protection interface connection defective: • Check the connections and the external communication infrastructure. • If the fault is not remedied, contact the Customer Support Center. **Transferred Signals**: Faulty or not received telegrams are detected at the receive end and discarded. They do not result in failure of the applications. Configured binary signals are reset after a time that can be set.
(_:303) **Connection broken**	SPS	CFunctionC[64]	
(_:316) **Error rate / min exc.**	SPS		
(_:317) **Error rate / hour exc.**	SPS		
(_:318) **Time delay exceeded**	SPS		
(_:320) **Time delay jump**	SPS		
Motor: Mess.Volt.Fail detected: (_:300) **Failure**	SPS	CFC	Measuring-voltage failure detected: Check the exterior wiring. **Blocking**: Appropriate functions are either blocked definitely (for example, distance protection) or the blocking can be set individually.
Device: (_:343) SEU happened	SPS		SEU memory fault: Cosmic radiation can result in a Single Event Upset, which can be detected through bit flips (changes in the status of a bit) in the memory blocks. A reset to reinitialize the memory is initiated. You will find additional explanations on the physical background in a special SEU whitepaper.

8.8.3 Defect Severity 2

Faults of defect severity 2 are fatal device faults that lead to an immediate restart of the device (reset).

64 The indications are not pre-routed in the logic block chart. The indications must be added to by the user in the logic block chart!

This occurs when the device data is corrupted (for example, RAM memory), if a restart prevents restoration of data consistency. The device goes briefly out of operation, a failure is avoided.

Life contact	Is terminated during the restart
Red error LED	Is activated during the restart



NOTE

If the fault of defect severity 2 has not been removed after 3 unsuccessful restarts (reset), the fault is automatically assigned to defect severity 3. The device will automatically turn to the fallback mode.

Log

For every device error with a subsequent restart (reset), only the restart can be detected in the operational log. The actual supervision indication is entered in the device-diagnosis log at the point in time of the fault detection and before the restart. These indications are recorded with a real-time stamp and are thus available for later analyses. The device-diagnosis log contains expanded fault descriptions. There, you also receive recommendations of corresponding corrective measures for each detected device error.

For further information on handling the logs, refer to chapter *3*.

Overview of Errors

Number	Device-Diagnosis Log
826	Processor error on the base module: If the fault occurs numerous times, contact the Customer Support Center.
830	FPGA hardware error on the base module: Contact the Customer Support Center.
834	Memory error (short term): Reset initiated.
3823	Program run error: If the fault occurs numerous times, contact the Customer Support Center.
826	CPU overload: If the fault occurs numerous times, contact the Customer Support Center.
11160	SEU memory fault (short term): Reset initiated
Miscellaneous	Internal firmware error: If the fault occurs numerous times, contact the Customer Support Center.

8.8.4 Defect Severity 3

Faults of defect severity 3 are fatal device faults that lead to device immediately going into the fallback mode. The signal *(:301) Physical health* goes to the ***Alarm*** state. The ***Warning*** state is not supported for this signal.

Fatal device errors are errors that cannot be resolved by a restart of the device. In this case, contact the Customer Support Center. The device goes permanently out of operation, a failure is avoided. In the fallback mode, minimal operation of the device via the on-site operation panel and DIGSI is possible. In this way, for example, you can still read out information from the device-diagnosis log.

Life contact	Is terminated in the fallback mode
Red error LED	Is activated in the fallback mode

Log

For every device error that immediately leads to entry into the fallback mode, entries from supervision messages and the signal *(:301) Physical health* into the operational log are not possible. The actual supervision indication is entered in the device-diagnosis log at the point in time of the fault detection, that

is, before entry into the fallback mode. These indications are recorded with a real-time stamp and are thus available for later analyses. The device-diagnosis log contains expanded fault descriptions. There, you are offered recommendations of corresponding corrective measures for each detected device error.

You can find further information on handling the logs in chapter *3.1 Indications*.

Overview of Errors

Number	Device-Diagnosis Log
2822	Memory error (continuous) Contact the Customer Support Center.
4727, 5018-5028	Hardware failure at module 1-12: Contact the Customer Support Center.
4729	Device bus error (repeated): • Check the module configuration and the module connections. • Contact the Customer Support Center.
4733	Incorrect hardware configuration: Synchronize the hardware configuration of the device with DIGSI.
5037-5048	Wrong module 1-12 detected: Synchronize the hardware configuration of the device with DIGSI.
5031-5035	Identified wrong plug-in module on plug-in module position E/F/M/N/P: Synchronize the hardware configuration of the device with DIGSI.
	Wrong application configuration: Search for the cause in the operational log and load a valid configuration to the device.
3640, 4514	Data-structure error: Contact the Customer Support Center.
956	Firmware-version error: Contact the Customer Support Center.
2013, 2025	Signature error: Contact the Customer Support Center.
	CFC error: In DIGSI, check your CFC chart for the cause.
5050-5061	Binary-output error in module 1 - 12: Contact the Customer Support Center.
5088, 5089	A missing display configuration was established: Synchronize the hardware configuration of the device with DIGSI.

8.8.5 Defect Severity 4 (Group Alarm)

Errors of defect severity 4 are not device failures in the classical meaning. These errors do not affect the device hardware and are not detected or reported by internal device supervision functions. The condition of the defect severity 4 – the group alarm – is set user-specifically by the binary input signal *(_:503) >Group alarm*. If the binary input signal is reset, the device is no longer in the *Group alarm* condition and all functions return to the normal operating state.

If the group alarm is generated, the device reacts as follows:

- The group indication *(_:300) Group alarm* is generated and recorded in the operational log.
- The life contact is terminated.
- The red Error LED is activated.
- All protection and automation functions are blocked.

- The device remains in operation, does not carry out any restart (reset), and does not switch to the safe condition (Fallback mode).
- The signals managed internally are marked with the ***invalid*** quality attribute. Signals managed internally are, for example, measured values, binary input and output signals, GOOSE and CFC signals.

In the delivery condition, every device has the CFC chart **Process mode inactive**, that initiates the Group alarm (see chapter *8.9 Group Indications*).

Life contact	Is terminated in case of Group alarm
Red error LED	Is initiated in case of Group alarm

Log

The group indication *(_:300) Group alarm* is recorded in the operational log. Depending on the cause of the initiation, further information can be found in the operational log.
You can find further information on handling the logs in chapter *3*.

8.9 Group Indications

The following group indications are available:

- *(_:300) Group alarm*
- *(_:301) Group warning*
- *(_:302) Group indication*

You can find the signals in the DIGSI 5 project tree under **Name of the device** → **Information routing**. In the working area, you can find the signals under **Alarm handling** (see the following figure).

Information			Source		
			Binary input		
			Basismodul		
Signals	Number	Type	1.1	1.2	1.3
(All)	(All)	...	...	...	...
General	91				
Device	4171				
Alarm handling	5971				
>Group Alarm	5971.503	SPS			
>Group Warning	5971.504	SPS			
>Group Indication	5971.505	SPS			
Behavior	5971.52	ENS			
Health	5971.53	ENS			
Group alarm	5971.300	SPS			
Group warning	5971.301	SPS			
Group indication	5971.302	SPS			

[sc_grwarn, 1, en_US]

Figure 8-54 Group Monitoring Indication in the DIGSI 5 Information Routing Matrix

Group Indication Group Alarm

The indication *(_:300) Group alarm* is the group indication for defect severity 4 monitoring. This monitoring has a special purpose, as it is set user-specifically by a binary input signal and not by internal device supervision. Nevertheless, the response of the device is serious, such as blocking all protection and automatic functions (refer to *8.8.5 Defect Severity 4 (Group Alarm)*).

If the binary input signal *(_:503) >Group Alarm* is set, the group indication *(_:300) Group alarm* becomes active. If the binary input signal *(_:503) >Group Alarm* is reset, the signal *(_:300) Group alarm* is also reset and the device returns to the normal operating state.

In the delivery condition, every device has the CFC chart **Process mode inactive** that initiates the *>Group Alarm*. This CFC chart checks whether the device is still accidentally in the simulation or commissioning mode.

You can adapt the CFC chart as needed. You can find the CFC chart in the DIGSI 5 project tree under **Name of the device** → **Charts**.

Group Indication Group Warning

The indication *(_:301) Group warning* is the group indication for defect severity 1 monitoring. Some error messages of defect severity 1 are firmly linked to the signal *(_:301) Group warning*, others are connected flexibly in the device delivery condition via a CFC chart. This assignment is described in chapter *8.8.2 Defect Severity 1*.

In the delivery condition, every device has the CFC chart **Group warning**, that initiates the *Group warning*.

You can adapt the CFC chart as needed. You can find the CFC chart in the DIGSI 5 project tree under **Name of the device** → **Charts**.

The group-warning indication *(_:301) Group warning* is prerouted to an LED of the base module.

Group Indication

The *Group indication* is exclusively for user-specific purposes. There is no internal device supervision function that activates this indication. If the binary input signal *(_:505) >Group indication* is set, the indication *(_:302) Group indication* becomes active and is recorded in the operational log. This warning indication does not result in blocking a protection function. If the binary input signal is reset, the signal *(_:302) Group indication* drops out. Using a CFC chart, you can define when the binary input signal *(_:505) >Group indication* is to be set.

9 Measured Values, Energy Values, and Supervision of the Primary System

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9.12	Circuit-Breaker Monitoring	2177
9.13	Disconnector-Switch Monitoring	2237

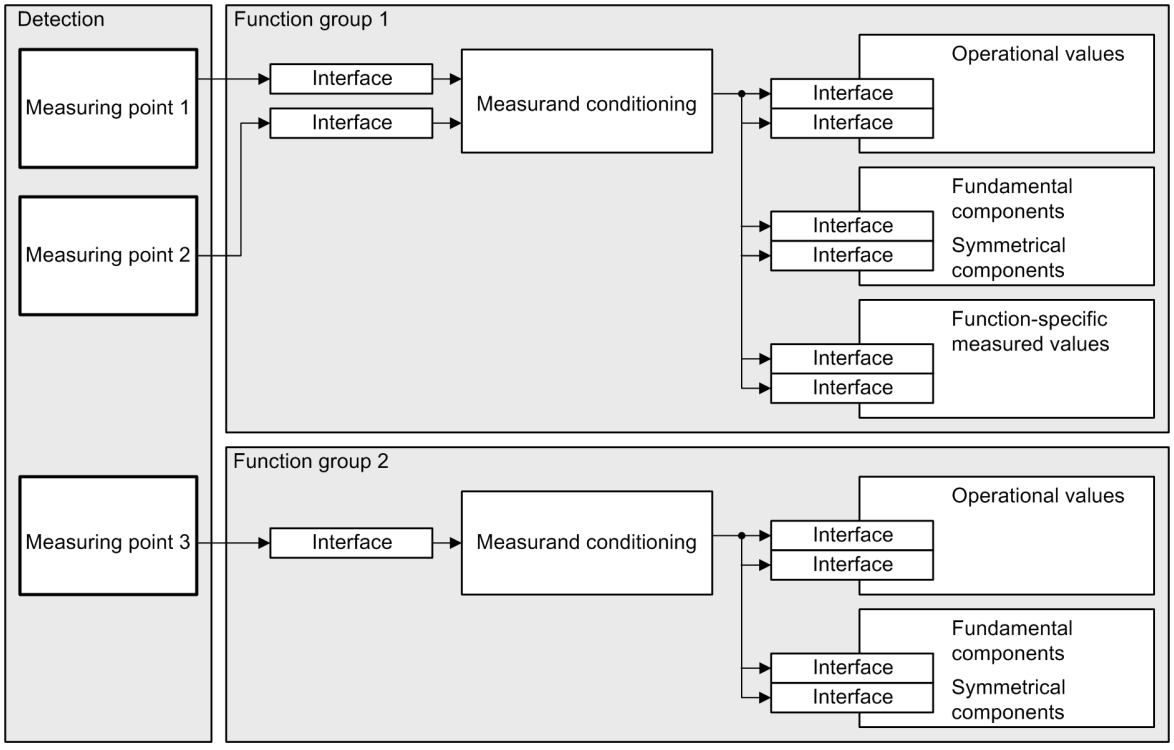
9.1 Overview of Functions

The measurands are recorded at the measuring points and forwarded to the function groups.

Within the function groups, further measurands are calculated from these measured values, which are required for the functions of this function group. This is how, for example, the electric power is calculated from the voltage and current measurands.

Measuring transducers are an exception as they already form various calculation parameters from the analog current and voltage inputs themselves.

You can find basic instructions for recording and editing process data in *2.1 Embedding of Functions in the Device*.



[dw_om_verf, 1, en_US]

Figure 9-1 Structure of Measured-Value Acquisition and Processing

For the display, the measured values of a SIPROTEC 5 device are summed up in the following groups:

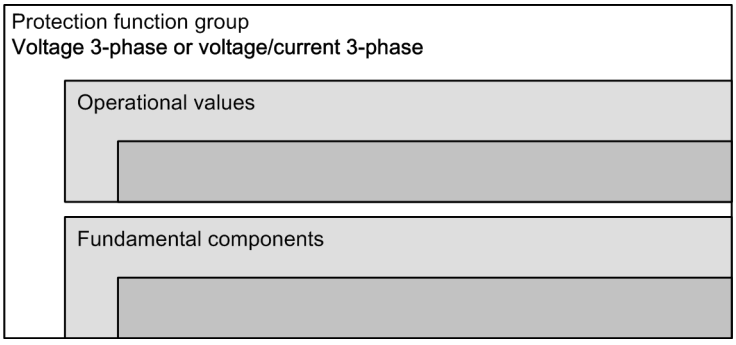
- Operational measured values
- Fundamental and symmetrical components
- Function-specific measured values
- Minimum values, maximum values, average values
- Energy metered values
- User-defined measured and metered values
- Statistical values

9.2 Structure of the Function

Depending on the interconnection of the function groups, these can contain different measured-value groups. 2 typical function groups are displayed below.

3-Phase Voltage and Voltage/Current 3-Phase Function Groups

In the simplest version, the **3-phase voltage** and **Voltage/current 3-phase** function groups obtain the measured values of the 3-phase voltage and current system and contain the following measured-value groups:



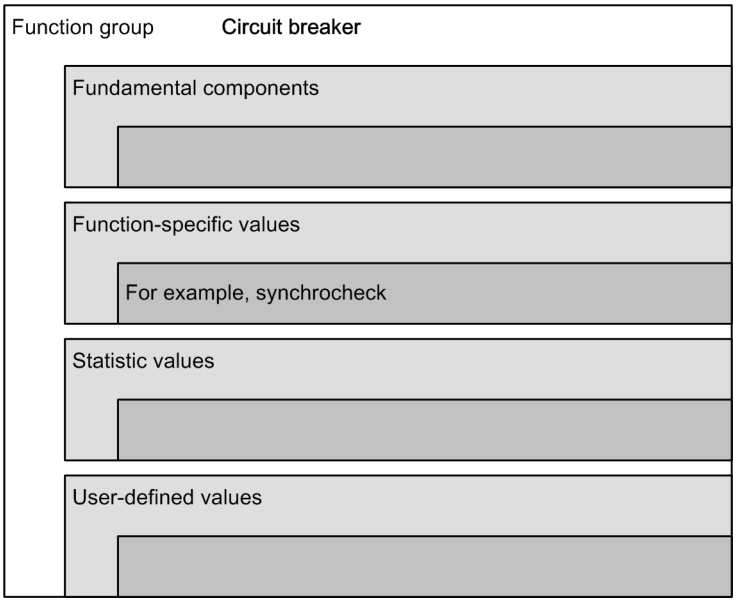
[dw_om_vstr, 1, en_US]

Figure 9-2 Structure of Measured Values in Function Groups

The **Operational measured values** and **Fundamental components** measured-value groups can be inserted from the DIGSI 5 library into the **3-phase voltage** and **Voltage/current 3-phase** function groups.
Details regarding the individual measured-value groups can be found in the tables in the following chapters.

Circuit-Breaker Function Group

The **Circuit-breaker** function group may contain the following measured values:



[dw_om_vls1, 1, en_US]

Inversion of Output-Related Measured and Statistical Values

The calculated, directional values in the operational measured values (power, power factor, energy and minimum, maximum, and average values based on these) are normally defined as positive in the direction of the protected object. This requires that the connection polarity for the used measuring points be correctly set

(see also parameter **(_:8881:116) Neutr.point in dir.of ref.obj** of the measuring point current, 3-phase). It is, however, possible, to set the "forward" direction for the protection functions and the positive direction for the powers, etc., differently, for example, such that the active power consumption (from the line to the busbar) is displayed positively. Then set the option ***reversed*** in the affected function groups at the parameter **P, Q sign**. With the setting ***not reversed*** (default setting), the positive direction for the powers etc. corresponds to the "forward" direction for the protection functions.

The affected values are given in detail in the chapters *9.3 Operational Measured Values* - *9.10 Statistical Values of the Primary System*.

9.3 Operational Measured Values

Operational measured values are assigned to different function groups.

The values can be displayed as primary and secondary values and as percentage values. They are updated every 180 ms.

The frequency is calculated using the filter algorithm, which is derived from the voltage or current. The voltage input has higher priority than the current input. If no voltage or current is present, the value contains the last valid frequency. **–** is displayed on the user interface.

The operational measured values are calculated according to the following definition equations:

RMS values

$$X = \sqrt{\frac{1}{T}\int_{t}^{t+T} x^2(t)\,dt}$$

Active power (per phase)

$$P_{phsx} = \frac{1}{T}\int_{t}^{t+T} v_{phsx}(t) \cdot i_{phsx}(t)\,dt$$

With x = 1 to 3

$v_{phsx}(t)$ – Instantaneous value of the phase voltage, that is, v_A, v_B, v_C

$i_{phsx}(t)$ – Instantaneous value of the phase current, that is, i_A, i_B, i_C

Active power (total)

$$P_{total} = \sum_{x=1}^{3} P_{phsx}$$

Apparent power (per phase)

$$S_{phsx} = V_{phsx} \cdot I_{phsx}$$

With V_{phsx} – RMS value of the phase-to-ground voltage (true RMS):

$$V_{phsx} = \frac{V}{\sqrt{3}}$$

With x = A to C

I_{phsx} – RMS value of the phase current (true RMS); with x = A to C

Apparent power (total)

$$S_{total} = \sum_{x=1}^{3} S_{phsx}$$

Reactive power (per phase)

$$Q_{phsx} = \sum_{n} V_n \cdot I_n \cdot \sin(\varphi_n)$$

With:

n – Harmonic order (up to n = 50)

φ_n – Angle difference between voltage and current of the nth harmonic

Reactive power (total)

$$Q_{total} = \sum_{x=1}^{3} Q_{phsx}$$

Power factor

$$\lambda = \frac{|P|}{S}$$

Active factor

$$\cos\varphi = \frac{P}{S}$$

NOTE

With the parameter **`P, Q sign`** in the function block **General** of the respective function group, the sign of the following measured values can be inverted (see chapter *5.5 Function-Group Type Line* in the subchapter *5.5.2 Structure of the Function Group*, section on the **Inversion of Output-Related Measured and Statistical Values**):

- Active power (total): P total
- Active power (phase-related): P_A, P_B, P_C
- Reactive power (total): Q total
- Reactive power (phase-related): Q_A, Q_B, and Q_C

9.4 Fundamental and Symmetrical Components

The fundamental components are calculated from the frequency-tracked instantaneous values through a Fourier filter (integration interval: one period). The results are phasor values that are described by way of the amount and phase angle.

In accordance with the transformation matrix, the symmetrical components are calculated from the voltage and current phasors. These are also phasor quantities.

Fundamental Components

Table 9-1 Fundamental Components

Values		Primary	Secondary	Phase Angle	% Referenced to
$\underline{V}_A$, $\underline{V}_B$, $\underline{V}_C$	Phase-to-ground voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{V}_N$	Measured neutral-point displacement voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{V}_{12}$, $\underline{V}_{23}$, $\underline{V}_{31}$	Phase-to-phase voltage	kV	V	°	Rated operating voltage of the primary values
$\underline{I}_A$, $\underline{I}_B$, $\underline{I}_C$	Phase currents	A	A	°	Rated operating current of the primary values
$\underline{I}_N$	Neutral-point phase current	A	A	°	Rated operating current of the primary values

Symmetrical Components

Table 9-2 Symmetrical Components

Values		Primary	Secondary	Phase Angle	% Referenced to
$\underline{V}_0$	Zero-sequence component of the voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{V}_1$	Positive-sequence component of the voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{V}_2$	Negative-sequence component of the voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{I}_0$	Zero-sequence component of the current	A	A	°	Rated operating current of the primary values
$\underline{I}_1$	Positive-sequence component of the current	A	A	°	Rated operating current of the primary values
$\underline{I}_2$	Negative-sequence component of the current	A	A	°	Rated operating current of the primary values

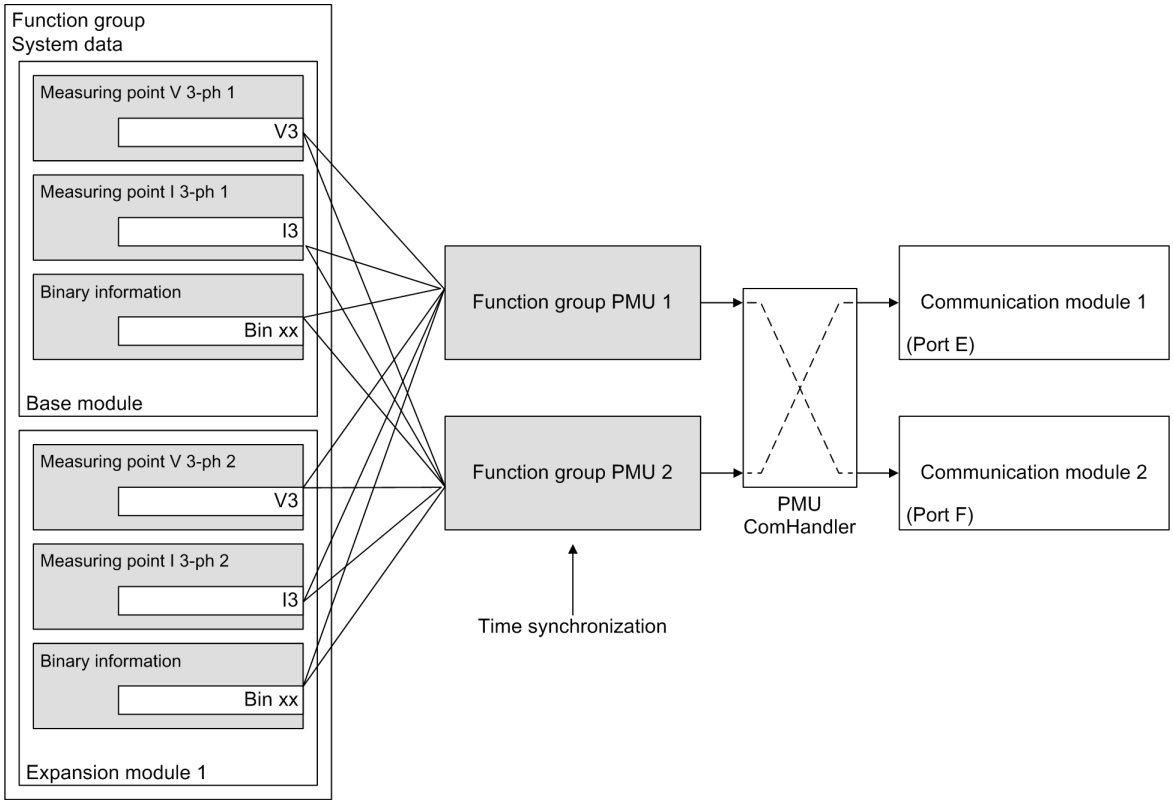
9.5 Phasor Measurement Unit (PMU)

9.5.1 Overview of Functions

A Phasor Measurement Unit (PMU) measures the phasor values of current and voltage. These values get a high precision time stamp and together with the values of power frequency, power frequency change rate and optional binary data that are also time stamped are transmitted to a central analysis station. The standardized transmission protocol IEEEC 37.118 is used to do this.

9.5.2 Structure of the Function Group

The **PMU** function group is activated by selecting the protocol *IEEE C37.118PMU* on an Ethernet module (electrical or optical). The PMU obtains the measured values from the measuring points and the precise time from time synchronization. The time-stamped synchrophasors for current and voltage are formed from this and transferred together with additional values via the communication module to a server (PDC, Phasor Data Concentrator).



[dw_strpmu, 2, en_US]

Figure 9-3 Structure/Embedding of the Function

9.5.3 Function Description

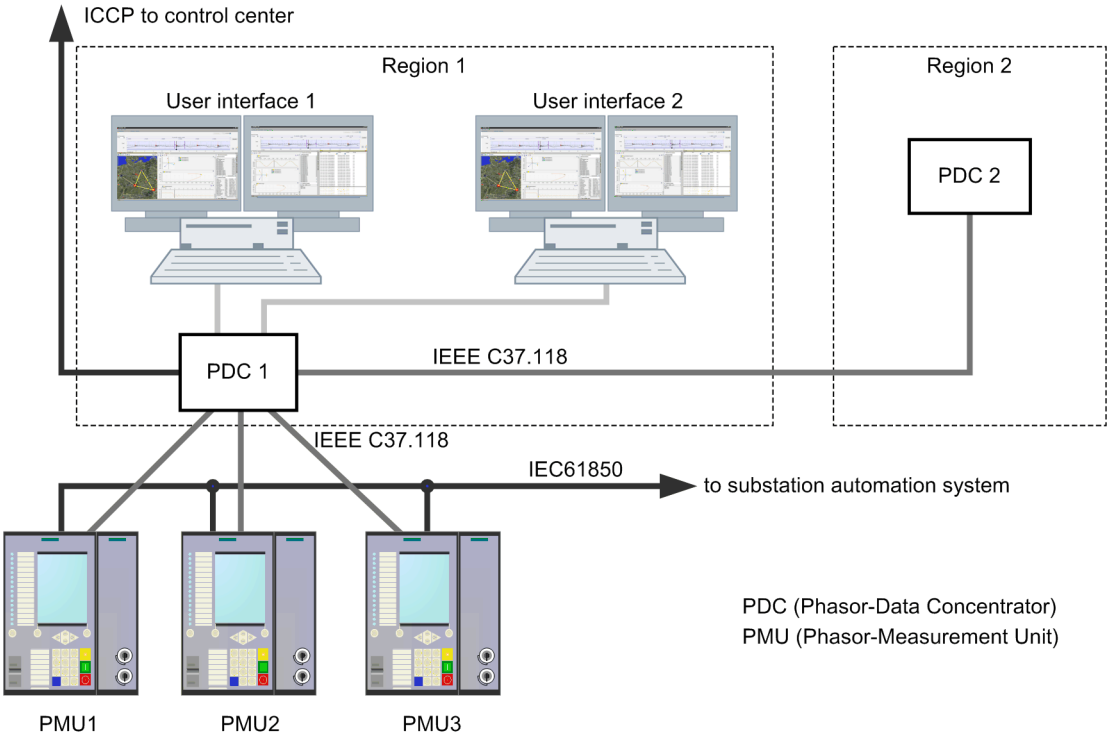
The synchrophasors, sent from the **PMU** in a continuous data stream to a PDC, are provided with time stamps and thus are comparable with the measured values of other PMUs. The power frequency, the power frequency change rate and optional binary information are also transmitted as time-stamped measured values. Therefore, you receive an overview of the transient processes in a distributed energy transfer system, for example network fluctuations and compensating processes.

The following table shows the differences between the PMU measured values and the remaining measured values of the device.

Table 9-3 Comparison of Synchrophasors and Conventional Measured Values

Synchrophasors of the PMU	Measured Values from the Measuring Points
Continuous updating (measured value of current) with, for example, 10 values per second (reporting rate)	Slow updating (typically every 5 seconds)
Every measured value has a time stamp	No time stamp for the measured values
Phasor values of current and voltage (amplitude and phase angle)	RMS values without phase angle

The following figure shows the structure of such a Wide Area Monitoring System. The data delivered from the PMUs on the PDC are transmitted via the Inter-Control Center Communications Protocol (ICCP) according to DIN EN 60870-6 to the network control center.



[dw_strwam, 1, en_US]

Figure 9-4 Structure of a Wide-Area Monitoring System with Phasor Measurement Units

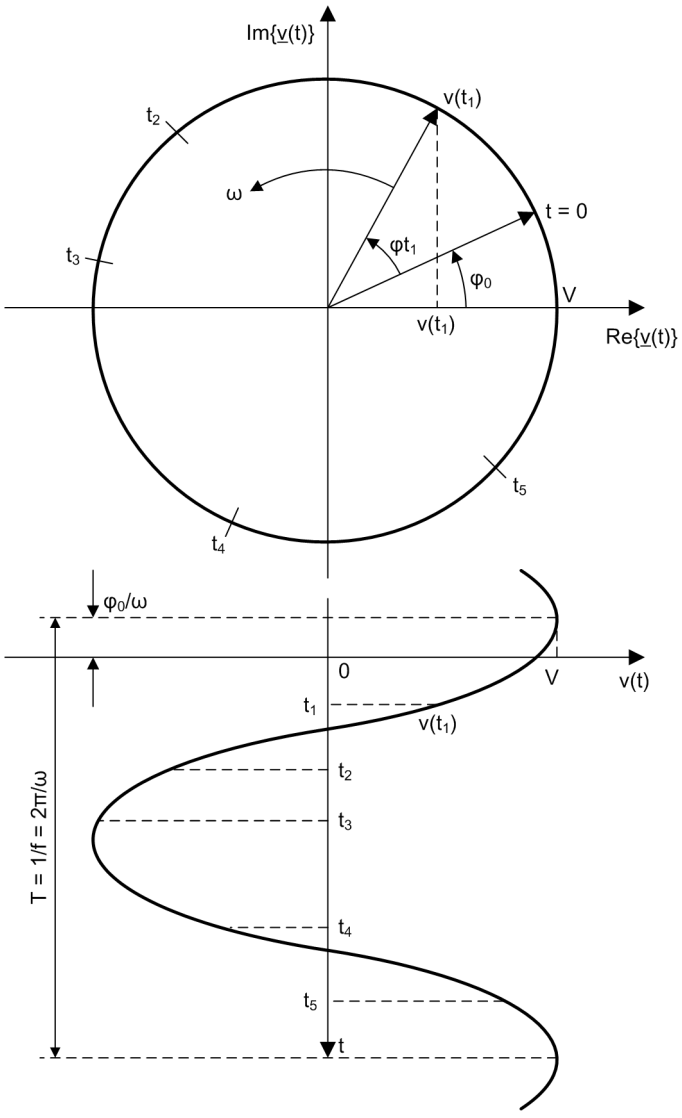
The phasor measurement units each have 2 communication interfaces: an Ethernet module for synchrophasor communication via IEEE C37.118 and another module for communication with the substation automation technology, for example, through the IEC 61850 protocol. If you use an ETH-BD-2FO communication module, you can activate IEEE C37.118 and IEC 61850-8-1 on the same module.

The central evaluation system, for example SIGUARD PDP Phasor Data Processor, receives the data, files, archives them and graphically displays them on a User Interface. In this system, a self-checking function may also be performed, for example, on undamped power swings. The further distribution of information to other PDCs or to a control center is done here.

To maintain the required maximum errors (TVE) required in the standard IEEE C37.118, the time tolerance relative to the UTC time reference (UTC = Universal Time Coordinated) may be maximum 10 µs. Therefore, the device must be directly synchronized with a GPS precise time signal for the correct function of the PMU.

Phasors

A phasor $u(t) = \underline{U}e^{j\omega t}$ can be displayed as a phasor that moves counterclockwise in the complex plane at the angular frequency ω. Therefore, the voltage function $u(t) = Re\{\underline{u}(t)\}$ is obtained as a projection of the phasor $\underline{u}(t)$ on the real axis.

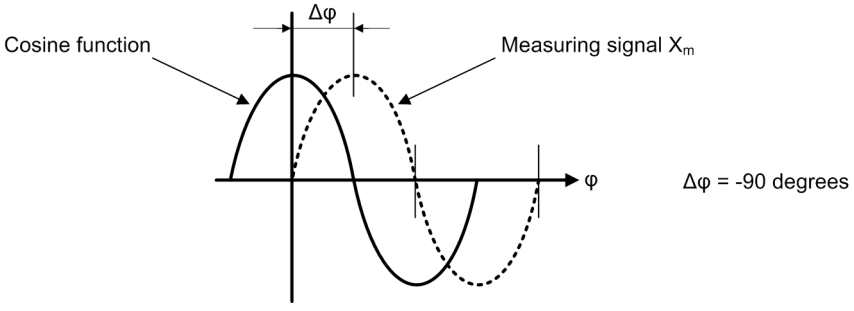


[dw_geopdc, 1, en_US]

Figure 9-5 Geometric Representation of a Phasor

Reference Point for Determining the Angle

The phase angle of a measuring signal X_m is determined relative to a cosine function having a rated frequency, which is synchronized with the UTC time reference (see *Figure 9-6*).



[dw_utcphi, 1, en_US]

Figure 9-6 Determination of Phase Angle ρ of Measuring Signal X_m Relative to the Cosine Function

The number of phasors that are transmitted per second is configurable. The transmission rate is defined according to IEEE C37.118 as the reporting rate. The reporting rate defines the number of phasors that are transmitted per second. Extremely precise time synchronization is essential so that phasor measurement can be carried out to enable phasors from different sites to be compared via GPS.

Reporting Rate

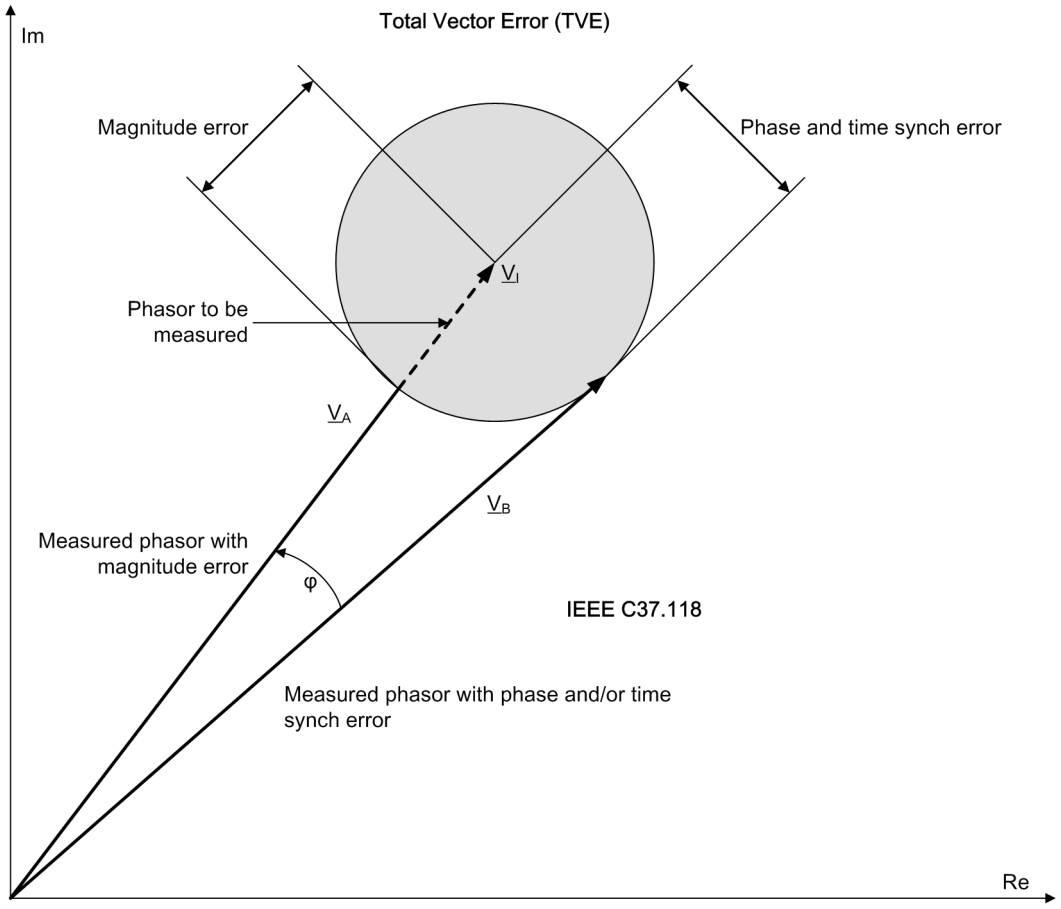
You use the configurable reporting rate (parameter **(_:10621:102) Reporting rate**) to specify the number of telegrams that are generated and sent to the PDC per second. It is adjustable, depending on the rated frequency, and applies to all currents and voltages of the relevant **PMU** function group. If several **PMU** function groups are created on the device, these can work with different reporting rates.

Total Vector Error (TVE)

The TVE describes the error between the actual and the measured values of the input signal. The Synchrophasor Standard IEEE 37.118 defines upper limiting values of 120 % V_N and 200 % I_N, among other things. Up to these limiting values, the TVE of 1 % must not be exceeded for stationary signals. The standard defines the 2 performance classes, Class P and Class M, as ranges within which influencing variables are acceptable and the TVE of ≤1 % must be maintained. The SIPROTEC 5 devices support Class P and Class M, which specify the following influencing variables for a TVE of 1 %:

- Signal frequency (relative to f_N)
- Signal magnitude (relative to 100 % nominal magnitude) for voltage and current
- Phase angle (relative to 0°)
- Harmonic distortions (relative to < 0.2 % (THD) up to the 50th harmonic

The following figure graphically represents the total vector error. As well as the amplitude, the TVE also enters into the angle error.



[dw_klatve, 1, en_US]

Figure 9-7 Representation of the Total Vector Error

The TVE is defined as follows:

$$TVE = \sqrt{\frac{\left(X_{r(n)} - X_r\right)^2 + \left(X_{i(n)} - X_i\right)^2}{X_r^2 + X_i^2}}$$

[fo_utcphi_new, 1, en_US]

Where:

- $X_{r(n)}$ = Real part of measured signal
- $X_{i(n)}$ = Imaginary part of measured signal
- X_r = Real part, input signal
- X_i = Imaginary part, input signal

Variables that influence the TVE are:

- Amplitude errors
- Phase errors
- Synchronization accuracy (deviation from the UTC)

Synchronization accuracy is affected by a GPS timer and the precise correction of the time delay within the GPS receiver module, as well as by the optimal mounting arrangement of the GPS antenna.

9.5.4 Transmitted Data

The following data is transmitted from the PMU to the PDC:

- Current and voltage phasors
- Frequency
- Frequency rate of change
- Analog-channel data (active/reactive power)
- Binary information

The current and voltage channels transferred from a **PMU** function group are selected through the **Function group connections** editor in DIGSI 5. The frequency and frequency change rate are determined once per PMU. In this case, only the current and voltage channels selected via the **Function group connections** editor for this PMU are taken into consideration. You may route the binary information in the information routing matrix of DIGSI 5. You can instantiate the analog-channel data from the Global DIGSI 5 library in the **PMU** function group.

The channel used for specifying the frequency is selected dynamically during the device runtime. Each channel is checked for the presence of a signal in the following order:

1. 3-phase voltage measuring points
2nd 1-phase voltage measuring points
3rd 3-phase current measuring points
4th 1-phase current measuring points

The 1st measuring point found with a valid signal is used for specifying the frequency in the **PMU** function group.

In the case of 3-phase measuring points, the positive-sequence system can also be transmitted instead of or in addition to 3 individual sychrophasors. You can make the selection using the **(_:10621:103) Positive sequence** parameter, see *9.5.8 Application and Setting Notes*, *Parameter: Positive sequence, Page 2154*.

9.5.5 PMU Communication (IEEE C37.118)

PMU communication according to standard IEEE C37.118 is a client-server communication format in which the PDC (Phasor Data Concentrator) functions as both the client and the server.

Once the PDC has been successfully connected to the device PMU and the PMU configuration data has been queried, the PDC initiates transmission of the synchrophasor data by sending a close command to the PMU. If you use the method of spontaneous data transmission via UDP, data output starts immediately after the device boots without a close command to the PMU.

The values and names for the values are transmitted for the phasors, binary information, and analog channels. The names for the phasors and binary information are automatically generated by the respective PMU function groups. You must enter the analog-channel names yourself.

If necessary, you can edit the names for the phasors, binary information, and analog-channel data and assign your own designations for them. For more information, see chapter *9.5.6 Parameterizing the PMU with DIGSI*.

As an example, the names (generated) for measuring points or binary information may be as follows:

Table 9-4 Possible Measuring-Points Names

Name Displayed in the DIGSI Function Group Connections	Depending on the Connection Type, Name Transferred to the PDC (in case it cannot be assigned automatically)
Measuring point V-3ph 1[ID 1]	MP-V3ph VAB ID01 MP-V3ph VBC ID01 MP-V3ph VCA ID01 MP-V3ph VA ID01 MP-V3ph VB ID01 MP-V3ph VC ID01 MP-V3ph V1 ID01 MP-V3ph VN ID01
Measuring point I-3ph 1[ID 2]	MP-I3ph IA ID02 MP-I3ph IB ID02 MP-I3ph IC ID02 MP-I3ph I1 ID02 MP-I3ph IN ID02
Measuring point I-1ph 1[ID 3]	MP-I1ph ID03
Measuring point V-1ph 1[ID 4]	MP-V1ph ID04

Table 9-5 Possible Binary-Information Names

Path Displayed in DIGSI 5 (Can Be Edited)	Name Transferred to the PDC
PMU 1: Transf.bin.1: >BinaryInfo.6	BIN-01-INFO-6
PMU 1: Transf.bin.2: >BinaryInfo.8	BIN-02-INFO-8
PMU 1: Transf.bin.10: >BinaryInfo.3	BIN-10-INFO-3

Data is transmitted continuously from the PMU to the PDC at the configured reporting rate. The transmission is terminated by a corresponding trip command from the PDC or when the connection between the PDC and the PMU is interrupted.

Communication between the PMU and the PDC can be passed via TCP or UDP protocols.

The following ports are used for data transmission by default:

- TCP: Port 4712
- UDP: Port 4713

You can configure the ports anyway you wish in a range of 1 to 65535 using the **`TCP port`** and **`UDP port`** parameters.



NOTE

When configuring the ports, do not set any ports already being used by other communication protocols. Configuring ports used elsewhere prevents communication with the PMU. In this case, data packets from the PDC cannot be received, and inquiries from the PMU cannot be transmitted.

If you are using the UDP protocol for communication between the PMU and the PDC, you can set either ***`command mode`*** or ***`asynchronous response mode`*** as the **`communication mode`**. In ***`asynchronous response mode`***, data can be transmitted continuously to preset PDC destination addresses in IEEE C37.118

format without a PDC having to request transmission of the synchrophasor data via a close command to the PMU.

Up to 4 different PDCs can be connected to one device PMU at the same time. The IP addresses of the maximum 4 PDCs are set in the **PMU** function group. If 4 device PMUs are configured, this enables support for up to 16 PDCs.

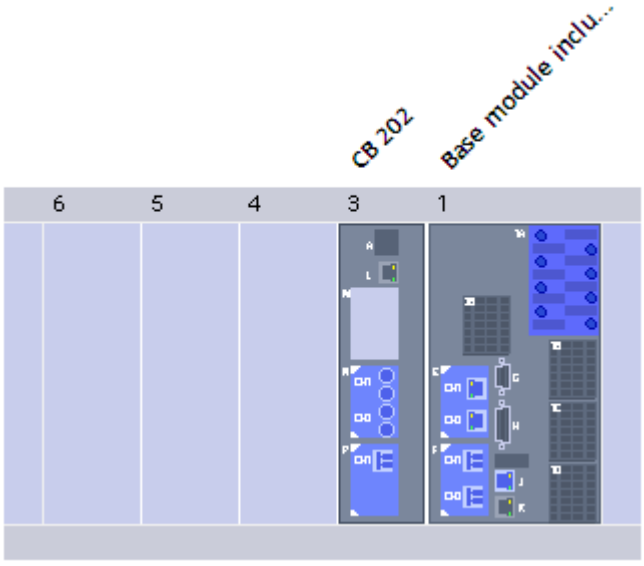
9.5.6 Parameterizing the PMU with DIGSI

You configure and parameterize the Phasor Measurement Unit with DIGSI. After a device has been added in a DIGSI project, one or more communication modules that support synchrophasors can be configured as PMUs. The device module supports a maximum of 2 communication modules that can be configured as PMUs. If more than 2 PMUs are needed, the device must be expanded with a CB202 plug-in module assembly (expansion module), which can accommodate 2 more communication modules.

The following communication modules support synchrophasors:

- ETH-BA-2EL (2 x Ethernet electric, RJ45)
- ETH-BB-2FO (2 x Ethernet optical, 2 km, LC duplex)
- ETH-BD-2FO (2 x Ethernet optical, 2 km, LC duplex)

These modules are then freely assignable to ports E, F, N, or P of the device, see *Figure 9-8*. You can view the selected port in the **`(_:10621:104) Port`**. This parameter is automatically managed by DIGSI and cannot be changed.



[sc_commod, 1, en_US]

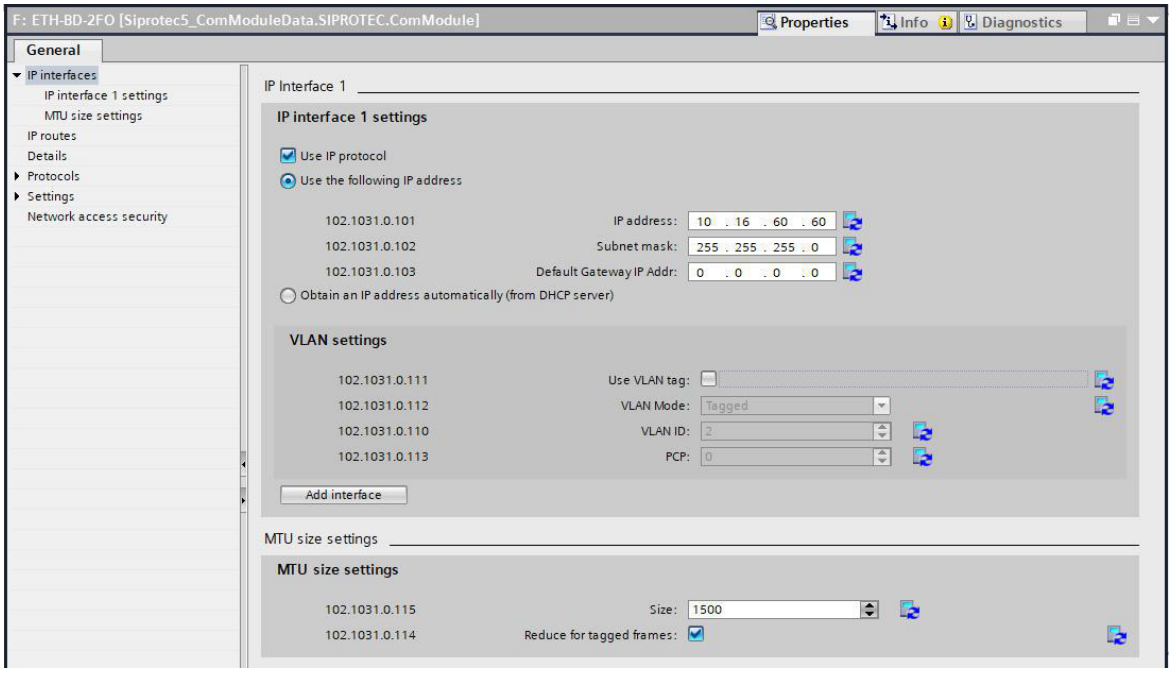
Figure 9-8 Placement of Communication Modules

NOTE

Port M of the CB202 plug-in module assembly is used to accommodate measuring-transducer modules and cannot be used for the installation of communication modules.

Addressing

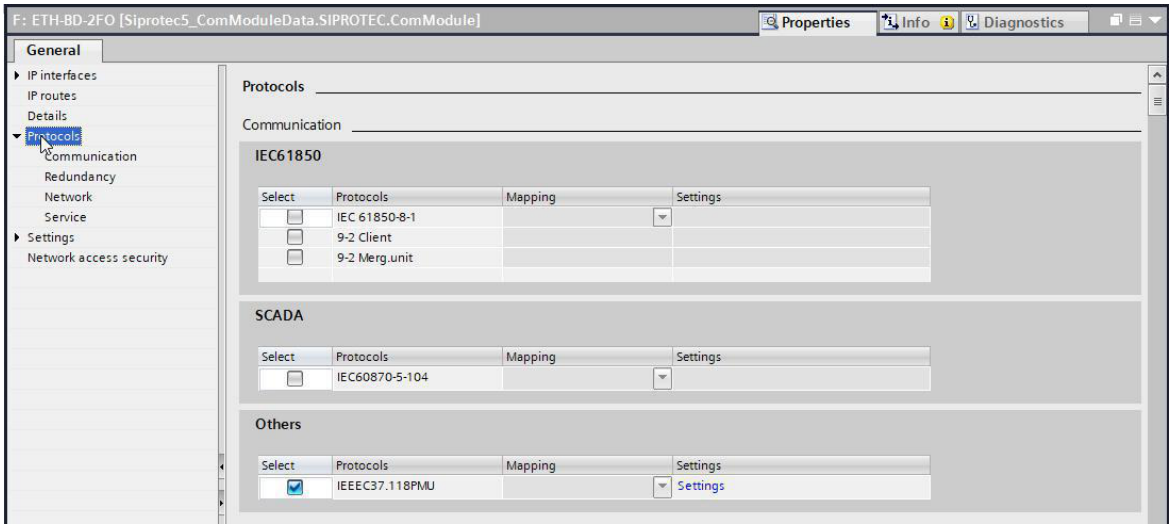
You must configure the respective Ethernet address (IP address, subnet mask, etc.) for each communication module in DIGSI. This is done in the DIGSI **General settings** properties dialog of the communication module in item **Ethernet addresses** and so forms the IP address for the respective PMU.



[sc_ethern, 2, en_US]

Figure 9-9 Ethernet-Address Configuration

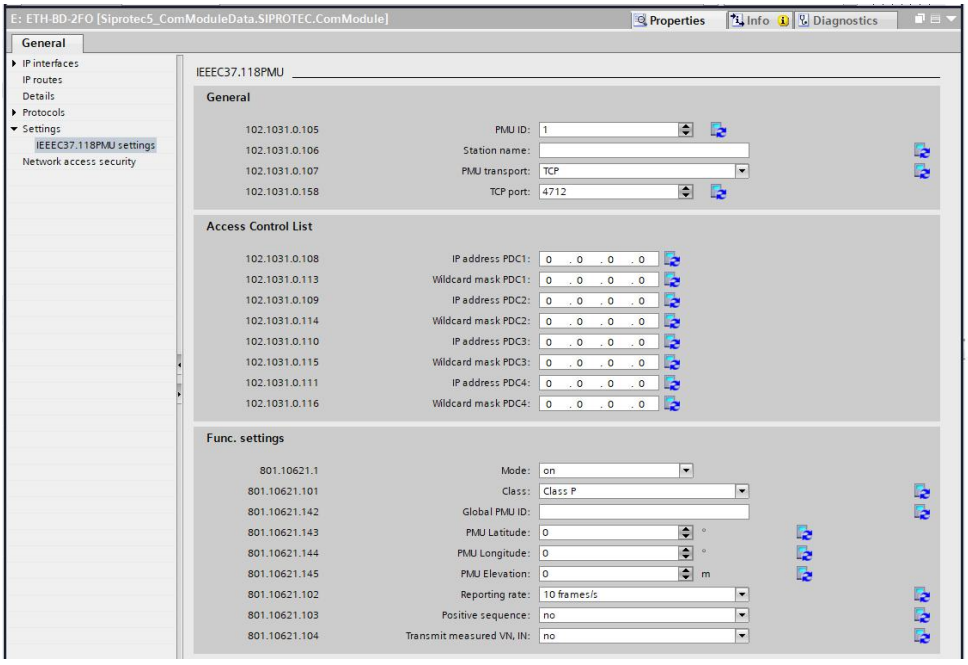
In the *Protocols – Communication* menu, select the synchrophasor protocol; see the following figure.



[sc_protoc, 2, en_US]

Figure 9-10 Protocol Selection

After you have selected the synchrophasor protocol for the communication module, a settings dialog for PMU-specific configuration opens in *Settings*; see the following figure.



[sc_wildcard, 3, en_US]

Figure 9-11 PMU-Specific Configuration

You configure the specific settings for the communication protocol in the top section of this settings dialog. In the bottom section, you specify the corresponding PMU-specific settings.

In order to permit a better configuration of larger wide-area supervision systems, changes have been implemented in the IEEE C37.118 communication configuration that permit a flexible IP configuration without the loss of safety aspects in the networks administered.

Configurable placeholders are allowed for every PDC/IP address with the ***TCP*** PMU transmission protocol in general and with ***UDP*** in the **Communication mode** ***Commanded operation***. These placeholders allow you to define a range of IP addresses where they are accepted within these accesses. The purpose of this is to permit each individual device or system access within the respective network without limits with regard to their hierarchy level. Therefore, with regard to security aspects, the limitation to individual IP addresses is eliminated. You are thus allowed to configure complete sections of IP addresses in each PMU and, as a result, very flexible when making changes to the configuration of the entire network, for example. The placeholder character must follow consecutively at the bit level, starting with the bit with the lowest value.

EXAMPLE of Placeholder Characters:

Example 1:

- binary 00000000.00000000.00000000.00101011 is not permitted
- binary 00000000.00000000.00000000.00111111 is permitted

Example 2:

- The PDC IP address is: 192.172.16.1
- Placeholder: 0.0.0.127

The device accepts requests within the IP address range of 192.172.16.1 to 192.172.16.127.

Example 3:

- The PDC IP address is: 192.172.16.100
- Placeholder: 0.0.0.3

The device accepts requests within the IP address range of 192.172.16.100 to 192.172.16.103.

If a PDC attempts to establish a connection to the device, the PDC IP addresses and corresponding placeholders are checked in the same order as they had been configured (IP address PDC1, IP address PDC2, IP address PDC3). Running through the list is stopped with the first match of the IP address, placeholder, and requested IP-address range and the connection is built-up. If there are no matches, the attempt to connect is rejected.

If you have configured the IP address 0.0.0.0 and the placeholder 255.255.255.255, every IP address received is accepted as valid. This could be of use in the course of commissioning measures.

NOTE

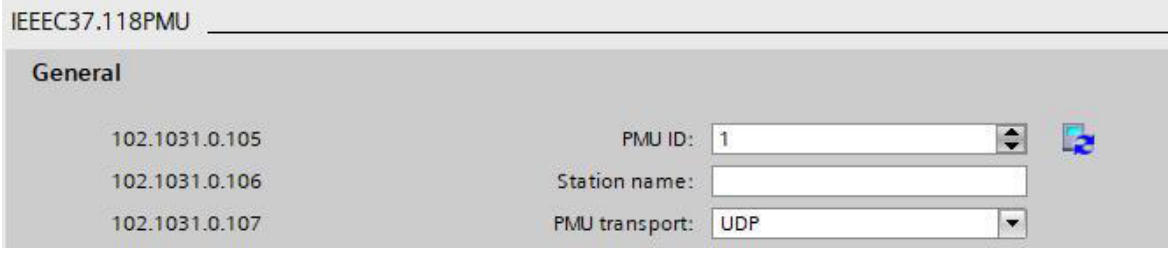
You must have configured at least one IP address to establish a connection between the device and the PDC.

If you set ***UDP*** as the transmission protocol, you can transmit PMU data to groups of PDCs using IP multicast.

Using multicast, considerably more PDCs can be reached via one communication module than when every PDC connects in unicast mode. Usually, the address range from 224.0.0.0 to 239.255.255.255 is used.

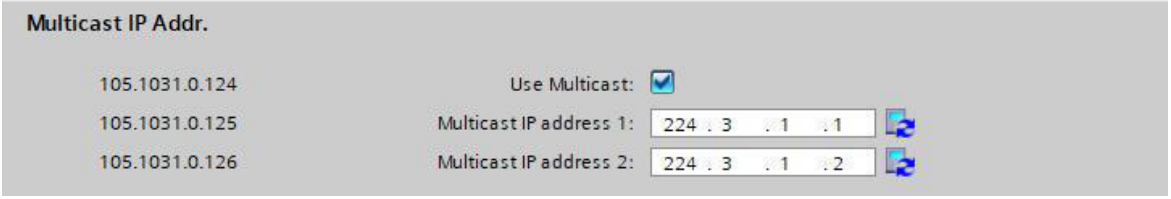
NOTE

The router used must support the **IGMP** (Internet Group Management Protocol) V3 protocol.



[sc_PMU_multicast01, 1, en_US]

Make a checkmark at the ***Use multicast*** parameter. If ***Use multicast*** is checked, you can set up to 2 multicast IP addresses. If you do not put the checkmark in place, the settings for the multicast IP addresses are not displayed.



[sc_PMU_multicast03, 1, en_US]

NOTE

DIGSI does not check the validity of the set multicast IP address. A multicast IP address of 0.0.0.0 is ignored.

You can set the settings for the multicast IP addresses and the PDC IP addresses in the Access Control List. If ***Use multicast*** is active, all data packages of the PMU are transmitted to the parameterized multicast IP addresses, but not to the PDC IP addresses. Commands from PDCs in the Access Control List are processed as if operating without multicast. Responses are only transmitted by way of the multicast IP addresses. In the ***Command mode*** UDP communication mode, you need at least one additional PDC IP address in the Access Control List to start PMU data transmission (see *Figure 9-12*).

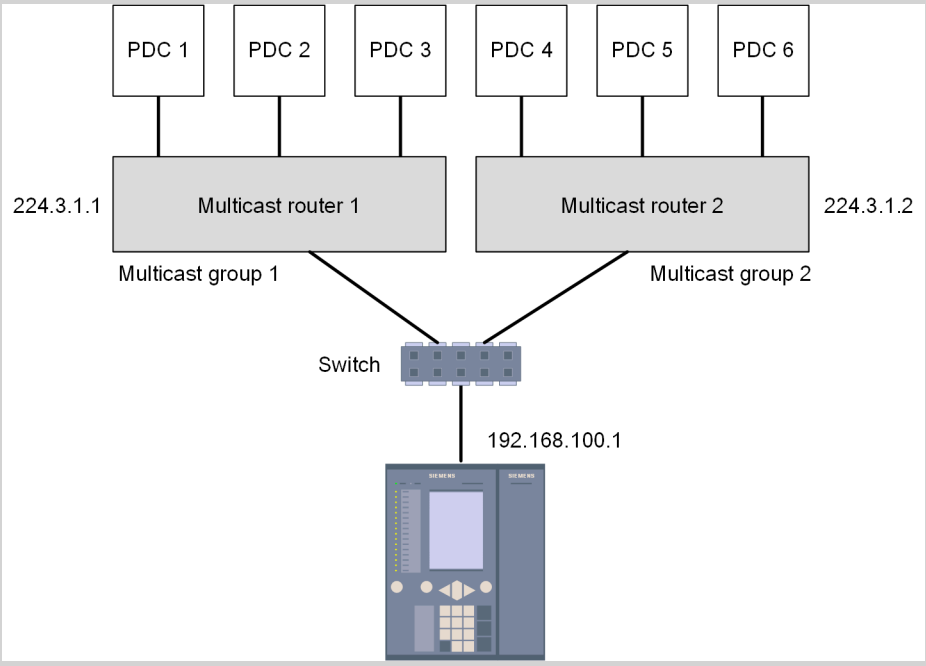


[sc_PMU_Multicast_Access, 1, en_US]

Figure 9-12 Access Control List

EXAMPLE

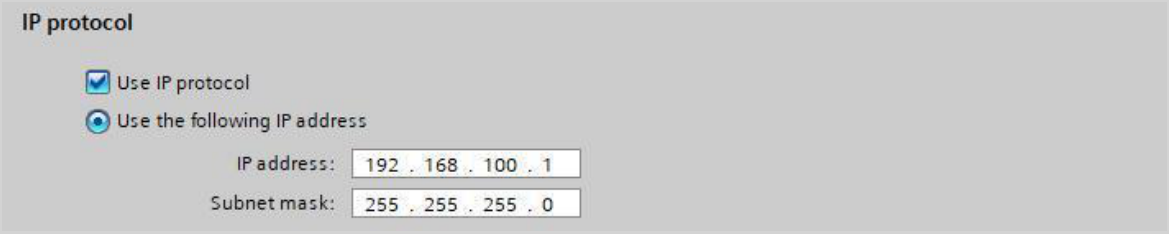
Multicast Operation



[dw_PMU_multicast_config_with_whitelist_PDC, 1, en_US]

Figure 9-13 PMU Multicast Configuration in Asynchronous Response Mode

Select the communication module in the **Hardware and protocols** menu in DIGSI. Set the IP address of the PMU (**192.168.100.1**) under **Properties → Ethernet addresses**.



[sc_IP_comm-mode_de, 1, en_US]

After you have selected the synchrophasor protocol for the communication module, a settings dialog for PMU-specific configuration opens in ***Settings***; see the following figure. Set the communication mode to ***Asynchronous response mode***.

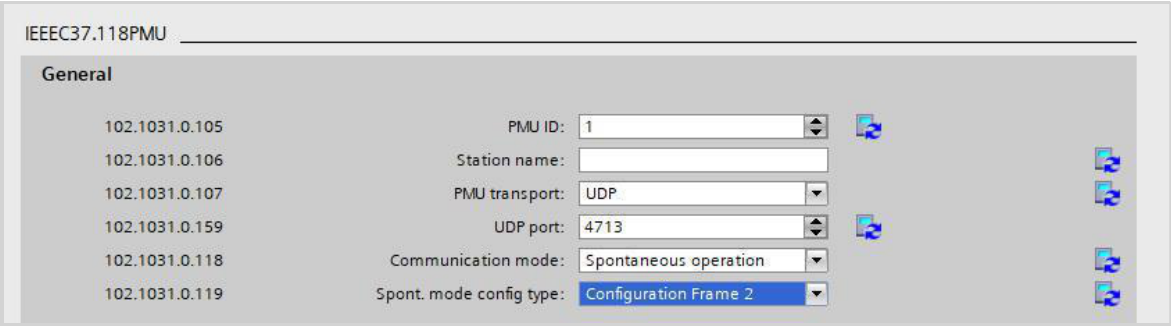


Figure 9-14 PMU Settings

In the following dialog, you set the IP addresses of the multicast routers:

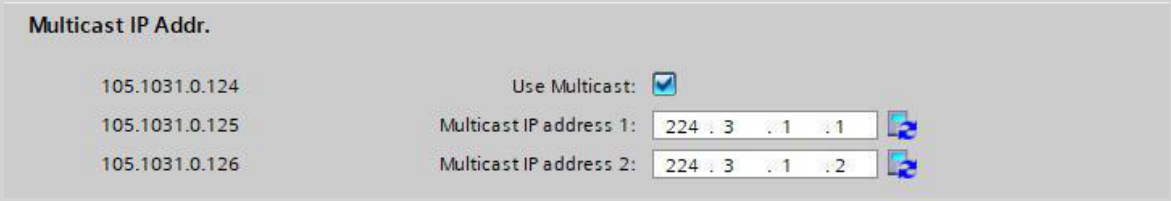


Figure 9-15 Additional Multicast IP Addresses During PMU Transport: UDP and Multicast

If you are using the **asynchronous data transmission method**, set the **`PMU transport`** parameter to ***`UDP`*** and the **`Communication mode`** parameter to ***`Spontaneous operation`***. The PMU data are then sent cyclically via UDP to every PDC/IP address permanently configured in DIGSI. You may not configure placeholders for PDC/IP address ranges in this communication mode.

Data output starts immediately after the device has booted. In this way, a starting signal from the PDC is not necessary to start data transmission.

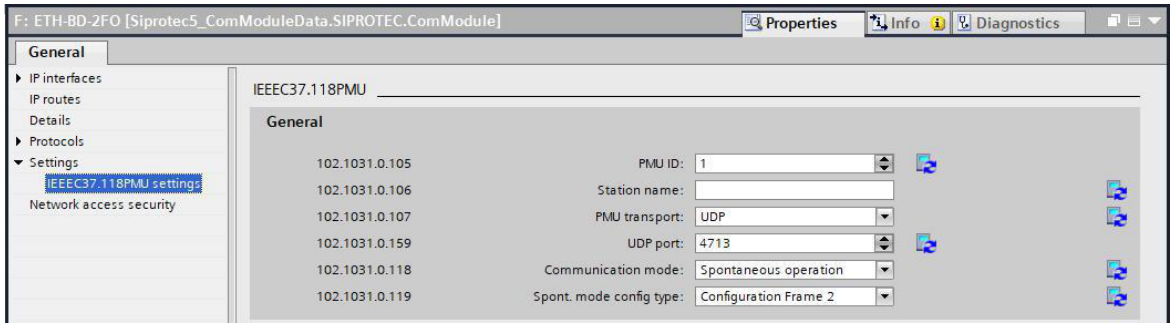


Figure 9-16 PMU Configuration for Spontaneous Transmission

The configuration dataset is transmitted 1x per minute. With the **`Spont. mode config type`** parameter, you select the type for the configuration data record. With the **`Reporting rate`** parameter, you configure the number of cyclic repetitions of the data packages. As UDP is a connectionless protocol, a preconfigured destination device with its PDC/IP address is not required to be physically present and/or connected. This allows uninterrupted provision of the data without bidirectional communication.

NOTE

If you have not configured valid PDC/IP addresses and still activate option for spontaneous data transmission, no cyclic data telegrams are sent.

NOTE

It is possible to configure IP addresses for various PDCs that are not present in the same subnetwork as the COM module. Such configurations are considered valid and can be loaded into the device. However, if the device transmits spontaneous data and configuration packages to these IP addresses, the PDC cannot be reached with the deviating subnetwork destination addresses.

NOTE

Commands or requests from an invalid PMU IP address are ignored.

EXAMPLE

COM-Module Address Configuration

- IP address: **192**.168.100.1
- Subnet mask: **255**.255.255.0

PDC Address Configuration

- IP address for PDC1: **192**.168.100.160
- IP address for PDC2: **86**.168.100.161

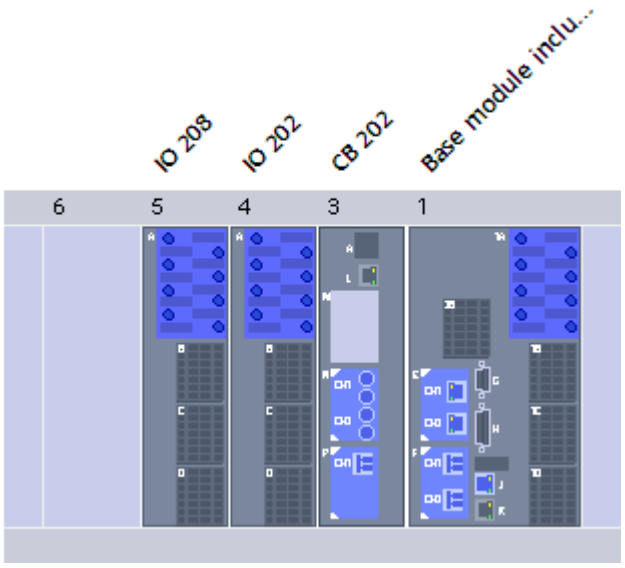
Only PDC1 receives the data because the IP address is in the same subnetwork as the COM module.

PDC2 cannot be reached because the subnetwork address (**86**.x) differs from the subnetwork address of the COM module (**192**.x). The PMU cannot transmit data to this address.

In addition to the PDCs IP addresses, the port can also be configured, which ensures the communication between the PMU and PDC. You can find the TCP or UDP port parameter in place for this purpose, depending on the configured transmission protocol. With the parameters, you can configure the port in a range of 1 to 65 535. The setting for these parameters is stored, even when the parameter is not visible due to the configuration of the transmission protocol. If, for example, TCP has been configured as a transmission protocol, the TCP port is not visible, but the setting has been stored in the background in DIGSI and is still available for use later on.

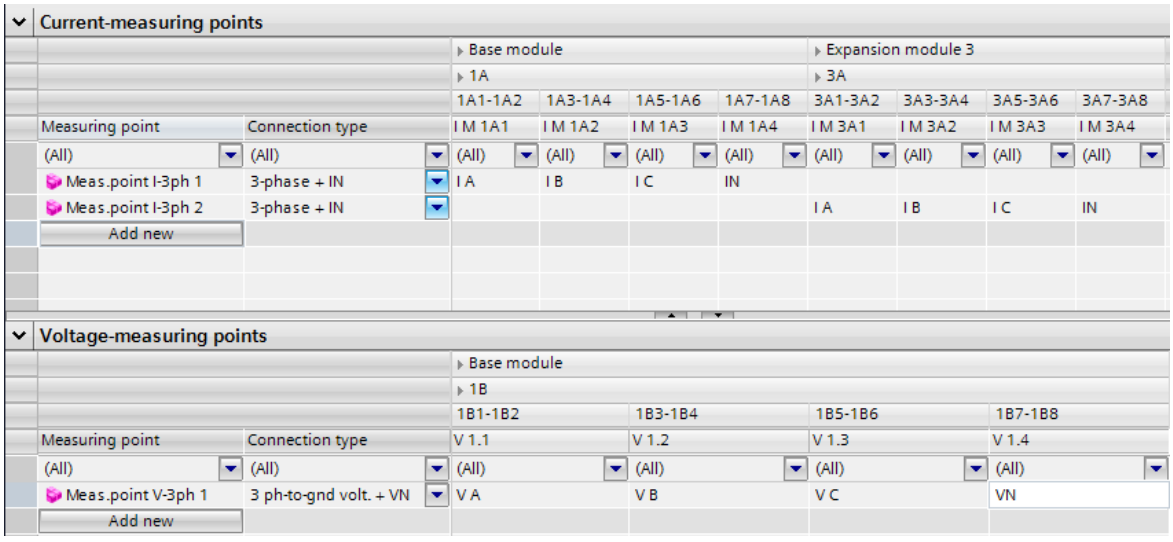
Measuring-Point Assignment

After adding measuring points to the device, you can assign these measuring points to each configured PMU. *Figure 9-17* shows an example of how the device configuration can be supplemented with 2 additional input/output modules. You connect the current and voltage inputs of these I/O modules to measuring points via the DIGSI routing matrix, see example in *Figure 9-18*.



[sc_addios, 1, en_US]

Figure 9-17 Adding Additional Input/Output Modules



[sc_routin, 1, en_US]

Figure 9-18 Assignment of the Current and Voltage Inputs of the Added Input/Output Modules on Measuring Points

NOTE

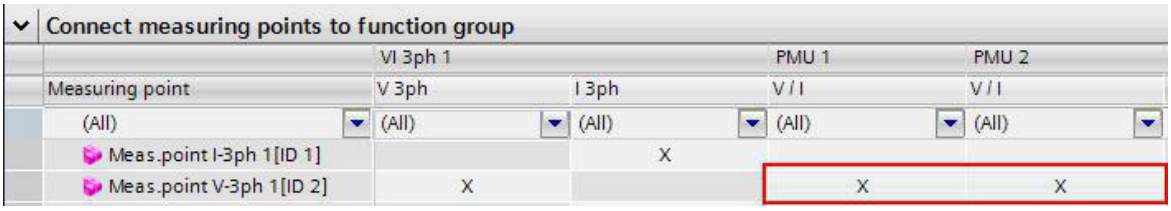
Consider that the maximum amount of measuring points that can be routed is limited by the device.

The maximum numbers of measuring points that can be routed for one PMU are:

- 20 x 3-phase voltage measuring points
- 20 x 3-phase current measuring points
- 40 x 1-phase voltage measuring points
- 40 x 1-phase current measuring points

You can assign all supported measuring points to any PMU, see the following figure. Each PMU must be connected to at least one measuring point, and the total number of phasors (a 3-phase measuring point = 4

phasors) must not exceed 80 per PMU. The limitation of the load model must also be considered, depending on the device configuration.



[sc_fgconn, 1, en_US]

Figure 9-19 Connecting Measuring Points to the Configured PMU Function Groups

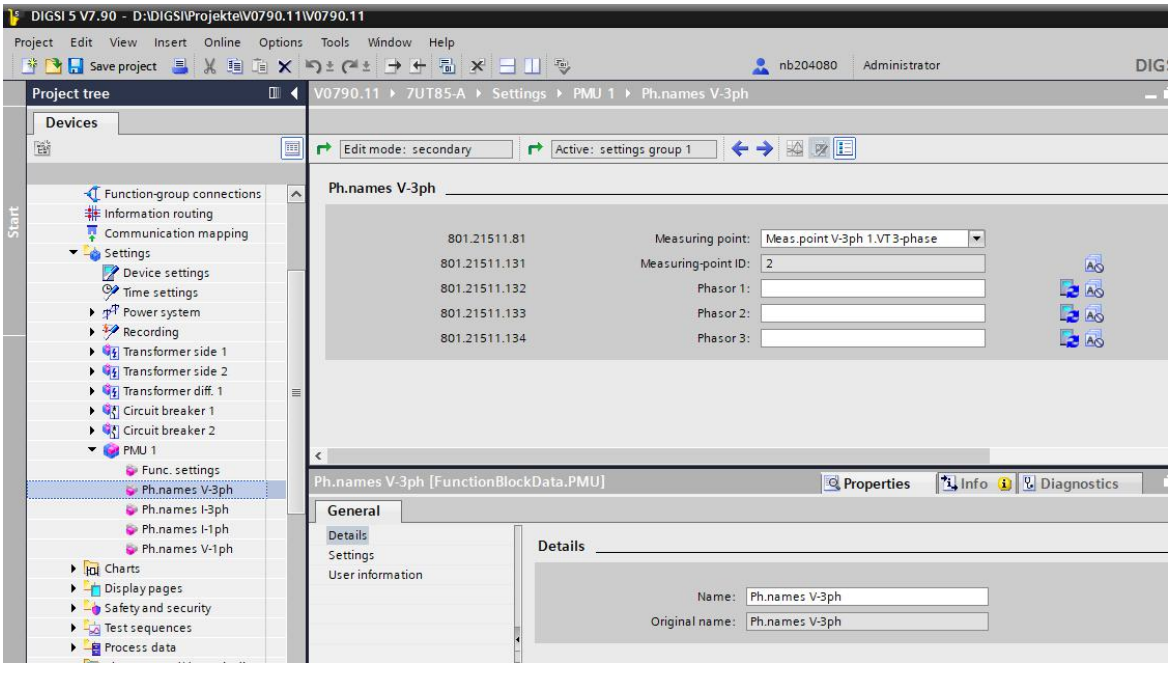
When these setting steps have been completed, the PMUs are fully configured. The **PMU** is a function group that functions independently of all the other function groups instantiated in the device.

Changing the Channel Names of Phasors

You can edit the names of the individual phasor channels for voltages and currents in DIGSI. Clearly structured channel designations support the testing and commissioning of PMU systems. Furthermore, only the names visible in the IEEE C37.118 interface can be changed. The function block designations themselves cannot.

The IEEE C37.118 defines the ASCII character set for changing the channel names. Due to the protocol, the designation length is limited to 255 ASCII characters per channel for CFG3, and to 16 ASCII characters per channel for CFG2.

In order to define your own channel names, firstly instantiate the required number of **Phasor names** function blocks in the **PMU** function group. Assignment to the corresponding measuring points is performed by the *Measuring point* selection. For this purpose, DIGSI shows all measuring points routed to the PMU in the function group connections (see following figure).



[sc_phasor_edit, 1, en_US]

Figure 9-20 Options for Editing the Names of the Individual Phasors

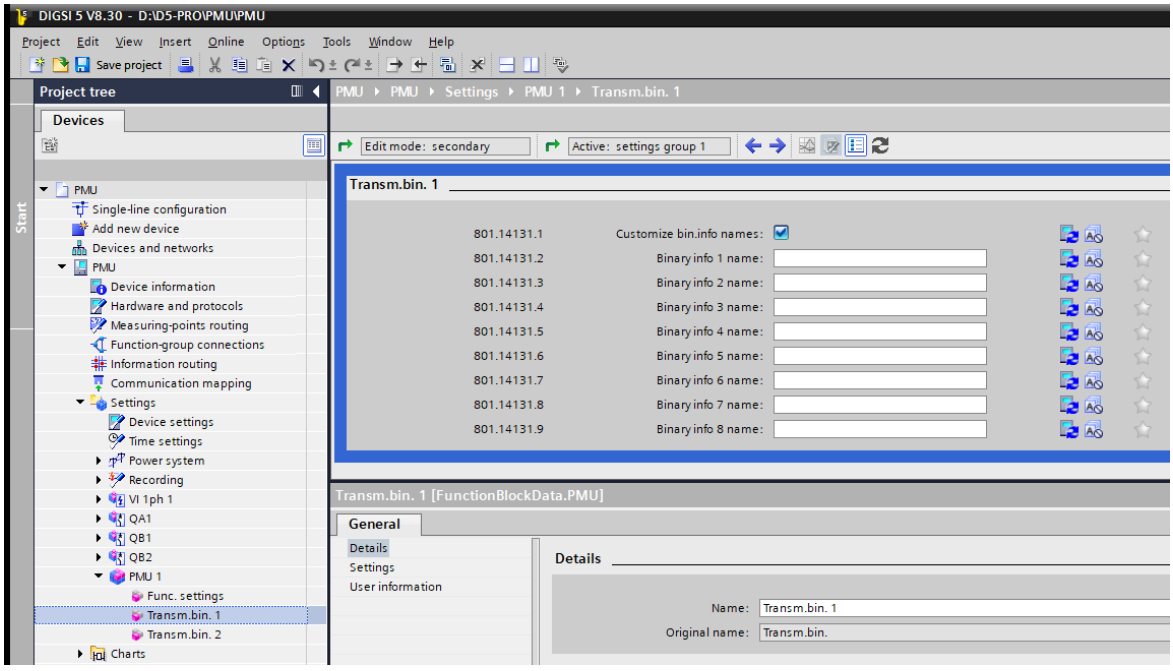
NOTE

You can only rename each individual phasor when you set the parameter **`Positive sequence`** to ***`no`*** or ***`additionally`*** in the function settings. Otherwise you will only be offered one single phasor for each 3-phase measuring point for renaming.

Changing the Channel Names of Binary Channels

You can edit the names of the binary channels in DIGSI. Clearly structured channel designations support the testing and commissioning of PMU systems. You can edit the names of the binary channels visible in the IEEE C37.118 interface in DIGSI. To do this, tick the **`My binary info names`** check box in the **Binary info transmission** function block (see *Figure 9-21*).

The IEEE C37.118 defines the ASCII character set for changing the channel names. Due to the protocol, the designation length is limited to 255 ASCII characters per channel for CFG3, and to 16 ASCII characters per channel for CFG2.

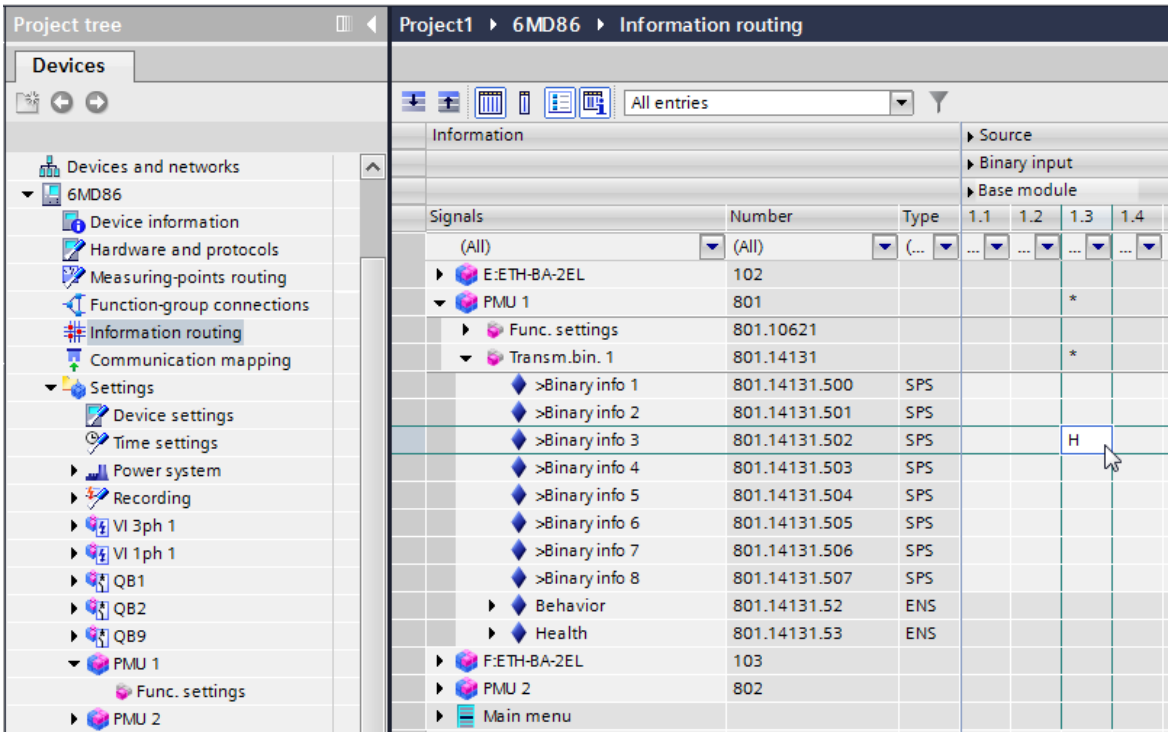


[sc_PMU_bin_info_edit, 1, en_US]

Figure 9-21 Options for Editing the Names of the Individual Binary Channels

Routing Binary Signals

You can connect binary inputs via DIGSI information routing to binary channels of the PMU. As an alternative, you can also route the binary inputs via a function chart (CFC). You will find, in the **Phasor Measurement Unit (PMU)** folder, the **Binary information transmission** function block in the DIGSI function library (see the following figure). You can instantiate this function block up to 10 times in one **PMU** function group. Each of these function blocks contains 8 options for routing binary channels.



[sc_pmu_bif, 1, en_US]

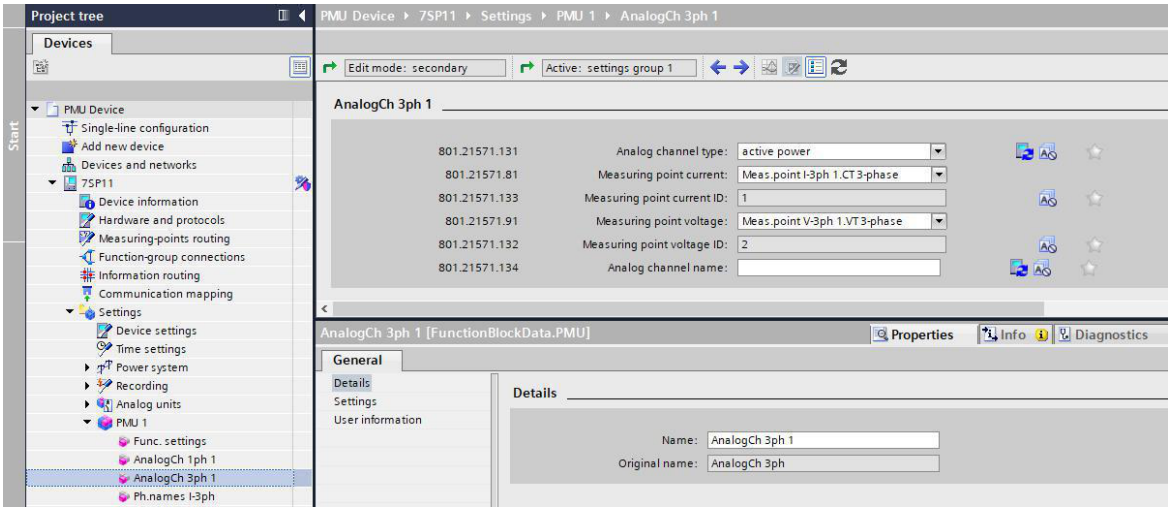
Figure 9-22 Information Routing in DIGSI 5

Routing Analog-Channel Data

In a **PMU** function group, you can instantiate the analog-channel data using the FBs **AnalogCh 1ph** or **AnalogCh 3ph**. In this case, a maximum of 30 instances per function-block type can be used.

With the parameters of the FBs **AnalogCh 1ph** or **AnalogCh 3ph**, you can assign the measuring points. You can only use the measuring points that have previously been assigned to the **PMU** function group.

You can also adjust whether the active or reactive power must be transmitted and assign a name to the analog channel. Due to the protocol, the designation length is limited to 255 ASCII characters for CFG3 and to 16 ASCII characters for CFG2.



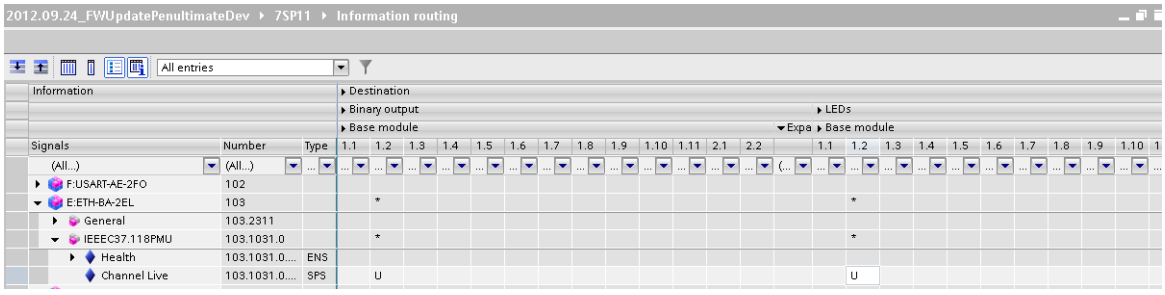
[sc_analog_channel, 1, en_US]

Figure 9-23 Routing Analog-Channel Data

Routing Indications

The routable indication *ChannelLive* of the PMU log

- raises when the PMU is connected to the PDC
- clears when the connection to the PDC is interrupted.

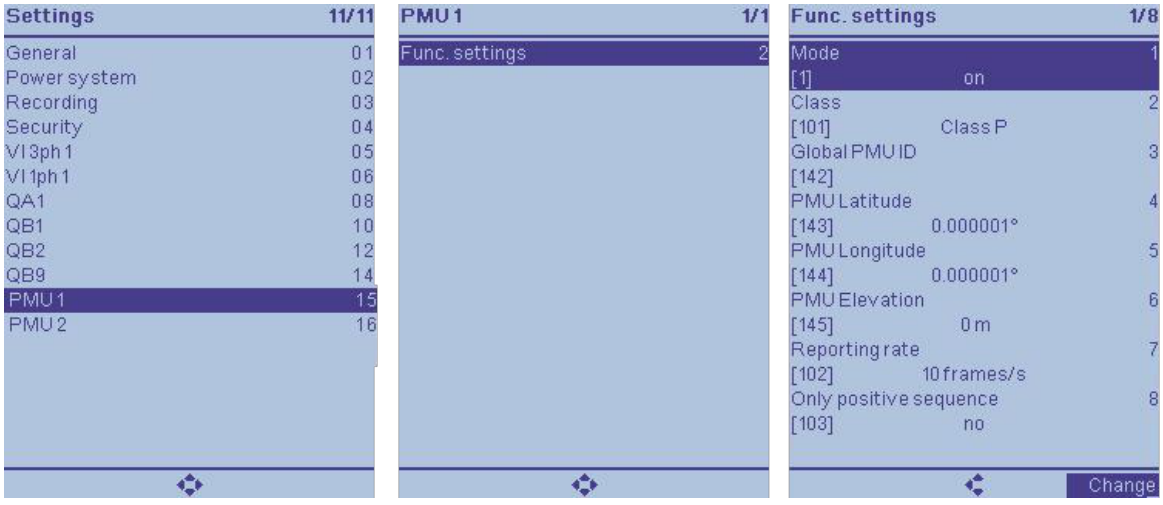


[sc_parami, 1, en_US]

Figure 9-24 Log Indication for Display of the PMU/PDC Connection

9.5.7 Parameterizing the PMU on the Device

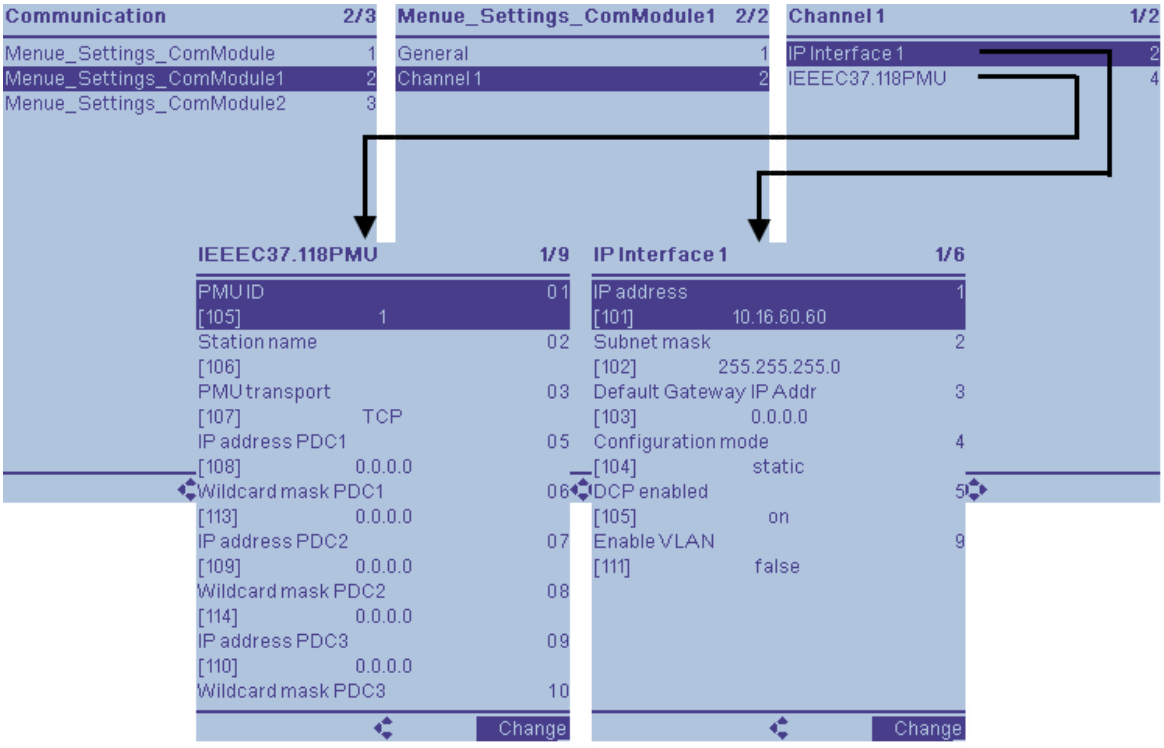
You can also change the PMU settings directly on the device. To do this, select the desired PMU instance on the device display. By selecting menu item **Settings** you then access the editable setting values (see *Figure 9-25*). Note that the parameter **`Port`** cannot be changed, because this corresponds to the physical slot position of the communication module in question.



[sc_devpmu, 2, en_US]

Figure 9-25 Changing the PMU Setting Values via the Device Display

You can also change the communication settings in the same way. To do this, select the corresponding communication port in the **Communication** menu on the device display. From the **Channel 1** menu item, you can then access the detailed setting options for the IP or PMU communication settings (see *Figure 9-26*).



[sc_compmu, 2, en_US]

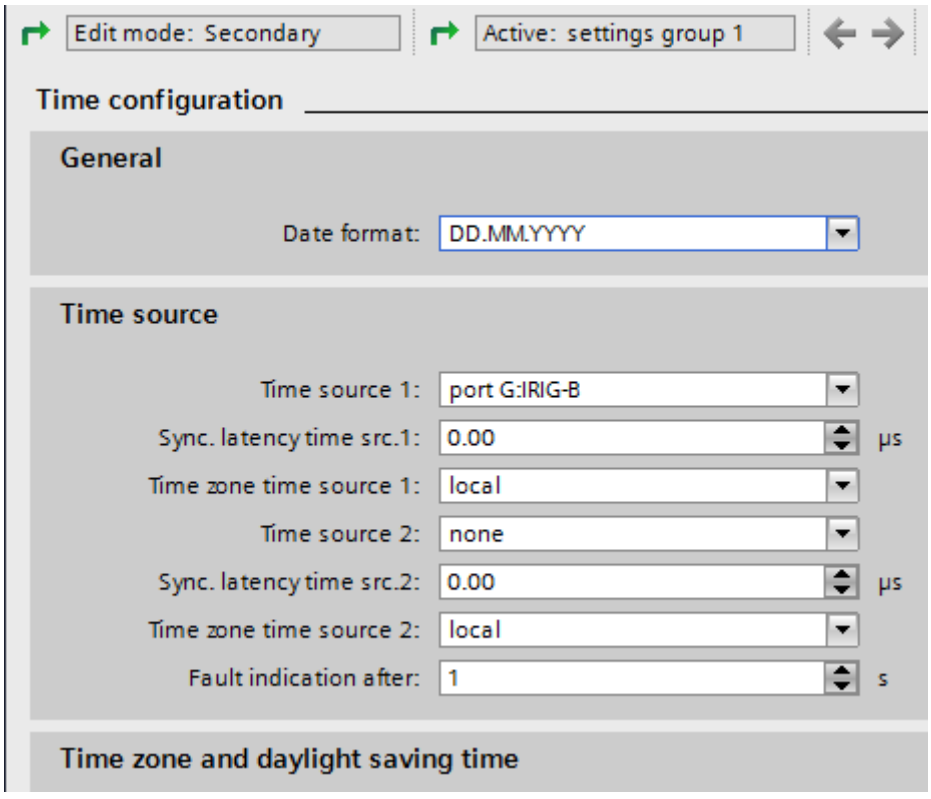
Figure 9-26 Changing the Communication Setting Values via the Device Display

9.5.8 Application and Setting Notes

Time Synchronization

In order to ensure the time accuracy of the PMU, you must select **IRIG-B** as the protocol for the GPS clock (*Figure 9-27*) or, if an ETH-BD-2FO communication module is present, IEEE 1588 (*Figure 9-28*). With other settings, the **PMU function** function group indicates that it is not time synchronized.

Setting Time Synchronization – IRIG-B



[sc_setting time source, 1, en_US]

Figure 9-27 Setting Time Synchronization – IRIG-B

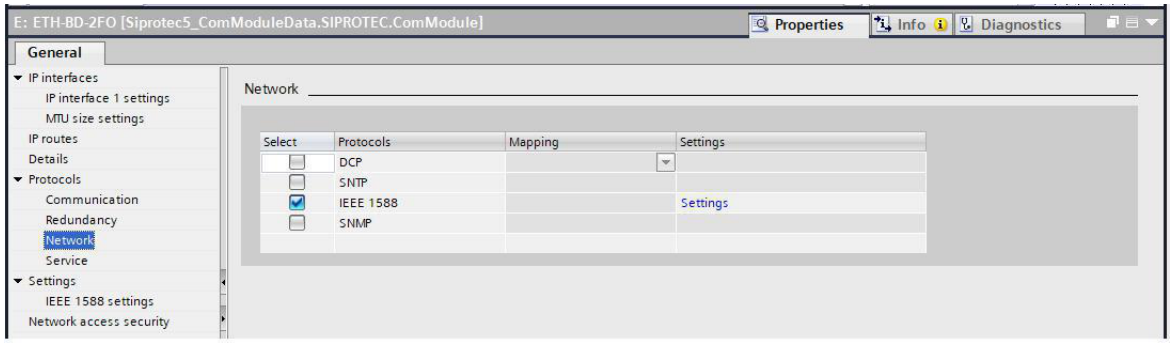
To detect a lack of synchronization quickly, also set the waiting time for the failure indication of the loss of time synchronization to the smallest possible value, thus to 1 s.

Setting Time Synchronization – IEEE 1588 (Precision Time Protocol (PTP))

Activate IEEE 1588 on the ETH-BD-2FO communication module.

NOTE

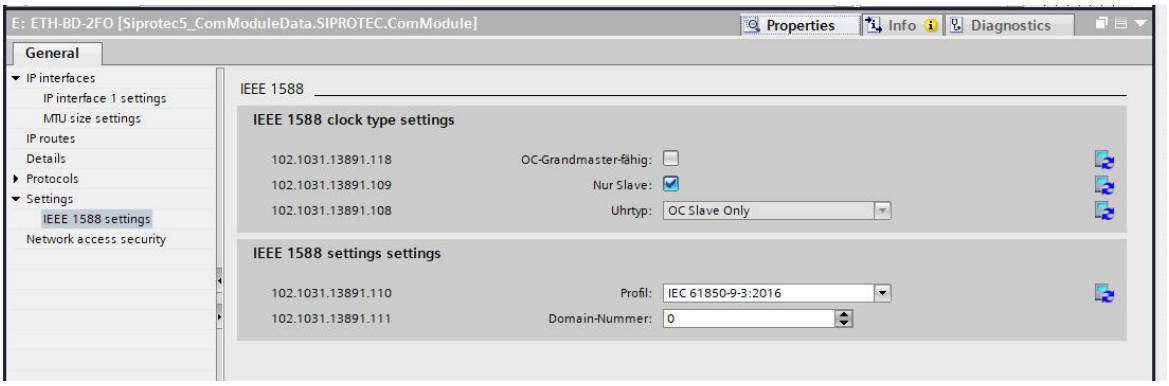
For PMU applications, use the IEEE 1588 protocol on the communication modules ETH-BD-2FO, ETH-BA-2FO (revision 2), or ETH-BB-2FO (revision 2), because the IEEE 1588 protocol that can be activated on the other modules does not deliver the required accuracy.



[sc_activate_ieee_1588, 1, en_US]

Figure 9-28 IEEE 1588 Activation for the ETH-BD-2FO Module

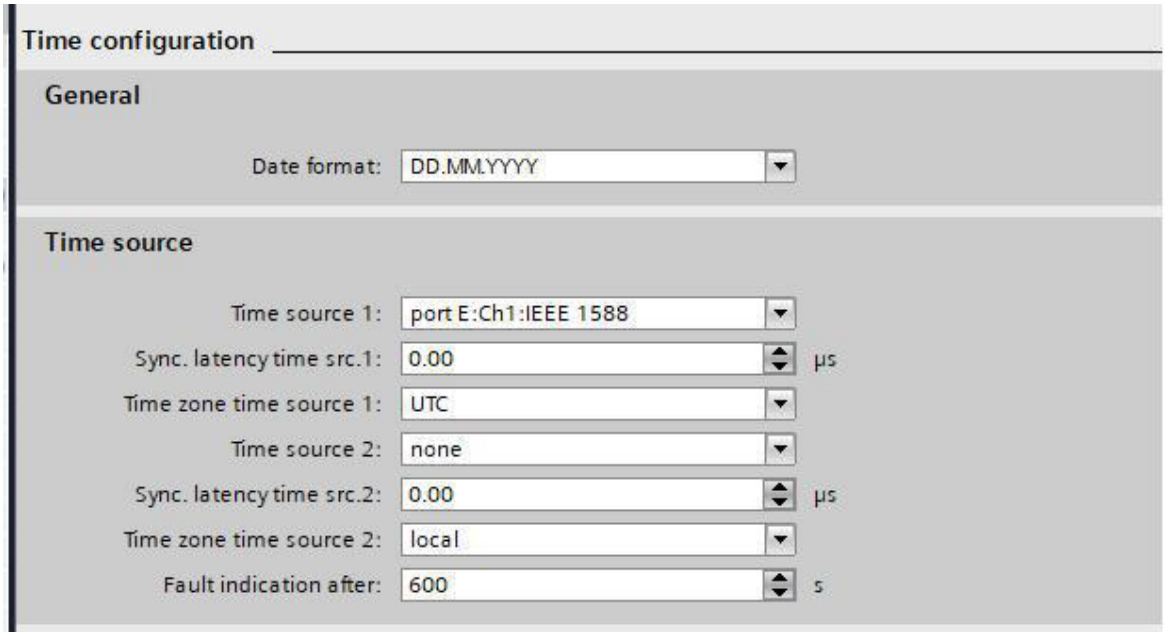
Ensure that the domain number in the IEEE 1588 settings matches that of the switch used.



[sc_para_ieee_1588, 1, en_US]

Figure 9-29 IEEE 1588 settings on the ETH-BD-2FO module

Select IEEE 1588 as the time source in the time configuration.



[sc_choose_of_time, 1, en_US]

Figure 9-30 Selection of Time Source

When selecting the switch used, make sure it supports the PTP standard IEEE 1588. Siemens recommends the RUGGEDCOM RSG2488.

Parameter: Mode

- Default setting **(_:10621:1) Mode** = ***on***

With the parameter **Mode**, you activate or deactivate the PMU, or you switch it to test mode. The possible setting values are ***on***, ***off*** and ***test***. In Test mode, the PMU data is marked as invalid.

Parameter: Reporting rate

- Default setting **(_:10621:102) Reporting rate** = ***10 frames/s***

With the parameter **Reporting rate**, you specify the number of telegrams that are compiled and sent to the PDC per second.

NOTE

Different setting values are shown or hidden, depending on the rated frequency set. You can set a reporting rate of 200 frames/s (50 Hz) or 240 frames/s (60 Hz) only when using an ETH-BD-2FO module.

Parameter: Positive sequence

- Default setting **(_:10621:103) Positive sequence** = ***no***

With the parameter **Positive sequence**, you can set whether the PMU transmits the positive-sequence system. The following setting values can be used:

Parameter Value	Meaning
no	The PMU only transmits the 3 individual synchrophasors for the 3-phase measuring points.
only	The PMU only transmits the positive-sequence system instead of the 3 individual synchrophasors for the 3-phase measuring points.
additionally	The PMU transmits the positive-sequence system in addition to the 3 individual synchrophasors for the 3-phase measuring points.

The setting you make here is then valid for all PMUs with 3-phase measuring points.

Parameter: Transmit measured VN, IN

- Default setting **(_:10621:104) Transmit measured VN, IN** = ***no***

This parameter is only visible if you route the **Measuring point V-3ph** or the **Measuring point I-3ph** with VN or IN to the **PMU** in DIGSI 5. The routing option is in the DIGSI 5 project tree in **Device Name** → **Function-group connections** in the **Measuring points** ↔ **Function group** settings sheet.

With this parameter, you define whether or not the **PMU** transmits VN and IN.

Parameter: Class

- Default setting **(_:10621:101) Class** = ***Class P***

With the parameter **Class**, you set which performance class is used for the calculation of the measured values. ***Class P*** is the standard case for PMUs. In this case, filters are used that provide a short response time and that are therefore suitable for recording dynamic processes. ***Class M*** is intended for applications that are unfavorably affected by alias effects and in which short response times are not relevant.

Parameter: Global PMU ID

- Default setting **(_:10621:142) Global PMU ID** = ***Freely editable text***

With the parameter **Global PMU ID**, you enter a global ID for the PMU, which can contain up to 16 characters.

Parameter: PMU Latitude

- Default setting **(_:10621:143) PMU Latitude** = ***0.00000000*** **°**

With the parameter **PMU Latitude**, you set the latitude to a value between -90,00000000 ° and +90,00000000 °.

Parameter: PMU Longitude

- Default setting **(_:10621:144) PMU Longitude** = ***0.00000000*** **°**

With the parameter **PMU Longitude**, you set the current longitude to a value between -180,00000000 ° and +180,00000000 °.

Parameter: PMU Elevation

- Default setting **(_:10621:145) PMU Elevation** = *0.00 m*

With the parameter **PMU Elevation**, you set the current height above sea level to a value between -50 000.00 m and +50 000.00 m.

Parameter: Port

This parameter cannot be set, because the **Port** results from the physical position where the corresponding communication module is inserted.

9.5.9 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Func. settings				
_:10621:1	Func. settings:Mode		• off • on • test	on
_:10621:101	Func. settings:Class		• Class P • Class M	Class P
_:10621:142	Func. settings:Global PMU ID		Freely editable text	
_:10621:143	Func. settings:PMU Latitude		-90.000000 ° to 90.000000 °	0.000000 °
_:10621:144	Func. settings:PMU Longitude		-180.000000 ° to 180.000000 °	0.000000 °
_:10621:145	Func. settings:PMU Elevation		-50000.00 m to 50000.00 m	0.00 m
_:10621:102	Func. settings:Reporting rate		• 1 frame/s • 5 frames/s • 6 frames/s • 10 frames/s • 12 frames/s • 15 frames/s • 20 frames/s • 25 frames/s • 30 frames/s • 50 frames/s • 60 frames/s • 100 frames/s • 120 frames/s • 200 frames/s • 240 frames/s	10 frames/s
_:10621:103	Func. settings:Positive sequence		• no • only • additionally	no
_:10621:105	Func. settings:Transmit measured VN, IN		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:10621:104	Func. settings:Port		• port F • port E • port P • port N	port F
_:10621:141	Func. settings:Freq tracking group ID		1 to 100	1

9.5.10 Information List

No.	Information	Data Class (Type)	Type
General			
_:10621:52	Func. settings:Behavior	ENS	O
_:10621:53	Func. settings:Health	ENS	O

9.6 Average Values

9.6.1 Function Description of Average Values

Average values can be formed based on different measurands:

- Operational measured values
- Symmetrical components

Through the settings, you can set how and when the average values are formed. The settings describe:

- Time slot over which the average value is formed
  (Parameter: **Average calc. interval**)
- Update interval for the display of the average values
  (Parameter: **Average update interval**)
- Synchronization time for establishing the date of commencement updating information, for example, at the top of the hour (hh:00) or at one of the other times (hh:15, hh:30, hh:45).
  (Parameter: **Average synchroniz. time**)

Average values are formed through the following measurands:

- Operational measured values except for phase-related ratings
- Amounts of the symmetrical components

You reset the average value formation via the

- Binary input >Reset average value
- DIGSI
- The integrated operation panel



NOTE

With the **P, Q sign** parameter in the function block **General**, the sign of the following measured values of the respective function group can be inverted (see Chapter *9.2 Structure of the Function* Structure of the Function, section Inversion of Output-Related Measured and Statistical Values):

- Active power (total): P total
- Reactive power (total): Q total

9.6.2 Application and Setting Notes for Average Values

The average value formation functionality is not preconfigured with the devices in the function group. If you use the functionality, you must load it from the library into the respective function group.
The following settings listed for the calculation of the average values can be set with DIGSI and at the device. You find the setting parameters in DIGSI in the project tree under **Settings > Device settings**.

Parameter: Average calc. interval

- Default setting: **(_:104) Average calc. interval** = ***60 min***

Parameter Value	Description
1 min to 60 min	Time slot for averaging, for example 60 minutes

Parameter: Average update interval

- Default setting: **(_:105) Average update interval** = ***60 min***

Parameter Value	Description
1 min to 60 min	Update interval for displaying the average value, for example 60 minutes

Parameter: Average synchroniz. time

- Default setting: **(_:106) Average synchroniz. time** = ***hh:00***
  The parameter describes the synchronization time for average value formation.

Parameter Value	Description
hh:00	The parameter **Average update interval** will be effective on the full hour
hh:15	The parameter **Average update interval** will be effective 15 minutes after the full hour
hh:30	The parameter **Average update interval** will be effective 30 minutes after the full hour
hh:45	The parameter **Average update interval** will be effective 45 minutes after the full hour



NOTE

The average value calculation restarts after

- Changing one of the 3 settings for the average-value calculation
- Resetting the device (initial or normal reset)
- Changing the time
- Resetting the average values

The average values are reset immediately. The display changes to "---".

The following examples explain how to set parameters and to make a change.

Average calc. interval = **60 min**
Average update interval = **30 min**
Average synchroniz. time = ***hh:15***.

A new average value is formed every 30 min, at hh:15 (15 min after the top of the hour) and hh:45 (15 min before the top of the hour). All measured values obtained during the last 60 min are used for average value formation.
If these settings are changed to 11:03:25, for instance, the average values are first reset and "---" appears in the display. The 1st average value is then formed at 12:15:00.
In this example, the **Average synchroniz. time** = ***hh:45*** acts as described above for = ***hh:15***.

Average calc. interval = **60 min**
Average update interval = **60 min**
Average synchroniz. time = ***hh:15***.

A new average value is formed every 60 min at hh:15 (15 min after the top of the hour). All measured values obtained during the last 60 min are used for average value formation.
If these settings are changed to 11:03:25, for instance, the average values are first reset and "---" appears in the display. The 1st average value is then formed at 12:15:00.

Average calc. interval = **5 min**
Average update interval = **10 min**
Average synchroniz. time = ***hh:00***.

A new average value is formed every 10 min at hh:00, hh:10, hh:20, hh:30, hh:40, hh:50. All measured values obtained during the last 5 min are used to form the average value.

If these settings are changed to 11:03:25, for instance, the average values are first reset and "---" appears in the display. The 1st average value is then formed at 11:10:00.

9.7 Minimum/Maximum Values

9.7.1 Function Description of Minimum/Maximum Values

Minimum and maximum values can be formed based on different measured or calculated measurands:

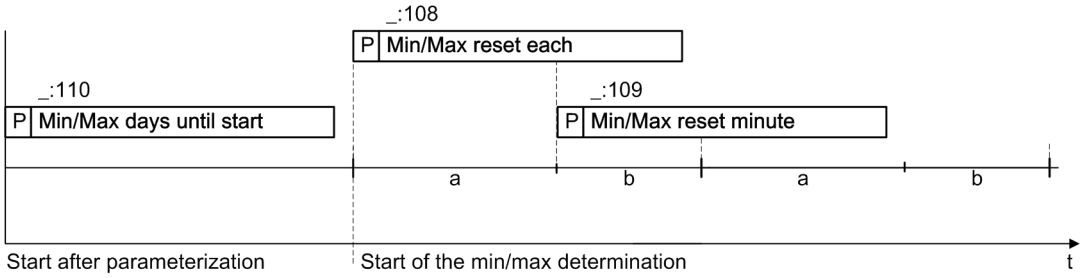
- Operational measured values
- Symmetrical components
- Selected values

You can set which measurand will be used. The measurands for the minimum/maximum formation are loaded from DIGSI.

Calculation and resetting of the minimum and maximum values are controlled through settings. The settings describe the following points:

- Memories of the minimum/maximum values are reset to 0 cyclically or not at all.
  (Setting **`Min/Max cyclic reset`**)
- Point in time when the memories of the minimum/maximum values are reset to 0.
  (Setting **`Min/Max reset each`** and setting **`Min/Max reset minute`**)
- Point in time at which the cyclical reset procedure of the minimum/maximum values begins (after the parameterization)
  (Setting **`Min/Max days until start`**)

The following figure shows the effect of the settings.



[dw_min_max, 1, en_US]

Figure 9-31 Minimum and Maximum-Value Formation

Minimum and maximum values are time-stamped.

Minimum/maximum values are formed through:

- Operational measured values except for phase-related ratings
- Amounts of the symmetrical components
- Average values

The minimum and maximum values are reset on a regular basis or via the

- Binary input >Reset min/max
- DIGSI
- The integrated operation panel

NOTE

With the **P, Q sign** parameter in the function block **General**, the sign of the following measured values of the respective function group can be inverted (see Chapter *9.2 Structure of the Function* Structure of the Function, section Inversion of Output-Related Measured and Statistical Values):

- Minimum/maximum values of the active and reactive power:
  Min:Ptotal, Max:Ptotal, Min:Qtotal, Max:Qtotal
- Minimum/maximum values of the average values of the active and reactive power:
  AverageMin:Ptotal, AverageMax:Ptotal, AverageMin:Qtotal, AverageMax:Qtotal

9.7.2 Application and Setting Notes for Minimum/Maximum Values

The minimum/maximum values functionality is not preconfigured. If you want to use the functionality, you must load it from the library into the respective function group.

The following settings listed for the calculation of the minimum/maximum values can be set with DIGSI or at the device. You find the setting parameters in DIGSI in the project tree under **Settings > Device settings**.

Parameter: Min/Max cyclic reset

- Default setting: **(_:107) Min/Max cyclic reset** = ***yes***

Parameter Value	Description
Yes	Cyclical resetting of the minimum and maximum value memories is activated
No	Cyclical resetting of the minimum and maximum value memories is deactivated None of the following parameters are visible

Parameter: Min/Max reset each

- Default setting: **(_:108) Min/Max reset each** = ***1 day***

Parameter Value	Description
1 day to 365 days	Resetting of the minimum value and the maximum value, cyclically on all specified days, for example each day (1 day)

Parameter: Min/Max reset minute

- Default setting: **(_:109) Min/Max reset minute** = ***0 min***

Parameter Value	Description
0 min to 1439 min	Resetting the minimum value and the maximum value at the specified minute of the day, which is stated in the parameter **Min/Max Reset takes place every**, for example 0 min 0 min (= 00.00)

Parameter: Min/Max days until start

- Default setting: **(_:110) Min/Max days until start** = ***1 day***

Parameter Value	Description
1 day to 365 days	Indication of when the cyclical reset procedure of the minimum values and maximum values begins, for example in 1 day (after the parameterization)

9.8 Energy Values

9.8.1 Function Description of Energy Values

The device continually determines the values for the active and reactive energy from the power-measured values. It calculates the exported and imported electrical energy. The calculation (summation over time) begins immediately after the device startup. You can read the present energy values on the device display or through DIGSI, delete the energy value (set to 0), or set it to any initial value. After input, the energy-value calculation will continue with the new setting values.

Energy values can be transferred to a control center through an interface. The energy values are converted into energy metered values. Here the following applies:

$$\text{Energy metered value} = \frac{\text{Energy value}}{S_{N,obj.}} \cdot 60000 \frac{\text{Pulses}}{\text{h}}$$

[fo_omverg, 1, en_US]

Through the settings, you set how the metered values are processed. The setting parameters apply for all energy metered values of the device, and do not have a function-group specific effect. You determine the following points:

- Parameter **`Energy restore time`**

  Hour-related point in time; at this point in time, the device will provide a metered value at the communication interface for transmission. After this, it will be transferred in accordance with the selected log.

  Note: If the parameter is activated through a time setting, the parameter **`Energy restore interval`** will be deactivated automatically.

- Parameter **`Energy restore interval`**

  Adjustable period in minutes until the first and every further transfer of the metered value to the communication interface of the device. After this, it will be transferred in accordance with the selected log.

  Note: The transfer interval is used alternatively to the transfer time, and deactivates the set transfer time. The display of the device is always up to date.

  You will find these parameters in the device settings under **measured values**.

In addition, restoring can be triggered via a routable binary input (*>Restoring*). The rising edge of the binary input leads to restoring, that is, provision of the energy-metered value at the communication interface.

The metered-value memory and the energy values can be set to 0 via a binary input (*>Resetting*) if there is a rising edge.

Note: The binary inputs affect all energy/energy metered values simultaneously.

The following energy values are available:

Energy Values		Primary
Wp+	Active energy, output	kWh, MWh, GWh
Wp-	Active energy, input	kWh, MWh, GWh
Wq+	Reactive energy, output	kvarh, Mvarh, Gvarh
Wq-	Reactive energy, input	kvarh, Mvarh, Gvarh

In compliance with IEC 61850, when individually measured values are missing, the quality of the energy-metered values changes to the state **Questionable**.

This quality state is retained until a new meter content is specified for the energy value by:

- Confirmation of the current meter content via **Set**
- **Setting** a new counter status
- **Resetting** the counter status to 0

NOTE

With the **P, Q sign** parameter in the function block **General**, the sign of the following measured values of the respective function group can be inverted (see chapter *9.2 Structure of the Function*, section on the Inversion of Output-Related Measured and Statistical Values):

- Active energy, output: Wp+
- Active energy, input: Wp-
- Reactive energy, output: Wq+
- Reactive energy, input: Wq-

9.8.2 Application and Setting Notes for Energy Values

The set parameters apply for all electricity meters of the device. You find the setting parameters in DIGSI in the project tree under **Settings > Device settings**.

Parameter: Energy restore interval

- Default setting: **(_:111) Energy restore interval** = ***10 min***

Parameter Value	Description
0 min	Restoring deactivated
60 min	Cyclical restoring after the set time 1 minute to 60 minutes

Note: If the parameter is activated through a time setting, the parameter **Energy restore time** is not in effect and will be deactivated automatically.

Parameter: Energy restore time

- Default setting: **(_:112) Energy restore time** = ***none***

Parameter Value	Description
none	Deactivated
hh:00	Restoring on the full hour
hh:15	Restoring 15 minutes after the full hour
hh:30	Restoring 30 minutes after the full hour
hh:45	Restoring 45 minutes after the full hour

Note: If the parameter is activated through a time setting, the parameter **Energy restore interval** is not in effect and will be deactivated automatically.

Parameter: Energy restore

- Default setting: **(_:120) Energy restore** = ***latest value***

Parameter Value	Description
latest value	Restoring of the current energy value
delta value	Restoring the difference value between the current energy value and the energy value of the last restoring operation

Parameter: Energy restore by A.time

- Default setting: **(_:121) Energy restore by A.time** = ***false***

Parameter Value	Description
False	Restoring deactivated
True	The cyclic restoring after the set time of the parameter **(_:111) Energy restore interval**will also be synchronized with the system time. Example: **Energy restore interval** = 30 min; current system time: 12:10 o'clock First restore: 12:30 o'clock; next restore: 13:00 o'clock etc.

Note: When the parameter is activated, the following setting values are possible for the parameter **(_:111) Energy restore interval**: 1 min; 2 min; 3 min; 4 min; 5 min; 6 min; 10 min; 12 min; 15 min; 20 min; 30 min; 60 min.

Input Signals: >Restoring and >Resetting

Binary Inputs	Description
>Restoring	The restoring of the metered values is initiated via a binary input.
>Reset	The metered value memory is set to 0 through the binary input.

You route these logical signals in the DIGSI routing matrix. Open the function group, for example, Line, where you created the energy value. There, under the tab **Measured values** you will find the tab **Energy, 3-phase**. In this tab, you will find the logical signals in addition to the measured values.

9.9 User-Defined Metered Values

9.9.1 Function Description of Pulse-Metered Values



NOTE

You can define additional metered values through DIGSI for user-specific applications.

Use pulse meters; then you can define the respective metered values through DIGSI and set parameters for them analogously to the energy values. You can read out the metered values on the display of the device or via DIGSI.

Through settings, you can individually set how each pulse-metered value is processed:

- Parameter **Restore time**

  Hour-related point in time when the device will provide a metered value at the communication interface for transmission. After this, the transfer takes place in accordance with the selected protocol.

  Note: If the parameter is activated through a time setting, the parameter **Restore interval** will automatically be deactivated.

- Parameter **Restore interval**

  Adjustable period in minutes until the first and every further transfer of the metered value to the communication interface of the device. After this, it will be transferred in accordance with the selected log.

  Note: If the parameter is activated through a time setting, the parameter **Restore time** will automatically be deactivated.

In addition, restoring can be triggered via a routable binary input (**>Restore trigger**) or via a logical internal binary input. The rising edge of the binary input leads to restoring and thus to provision of the metered value at the communication interface.

The counter pulse of any external/internal pulse generator is connected to the device via a routable binary input (**>Pulse input**). If this does not deliver any plausible values, this can be signaled to the device via another routable binary input (**>External error**).

In compliance with IEC 61850, in the event of an external error, the quality of the pulse-metered value changes to the state **Questionable**. No more pulses are added as long as the external error persists. Once the external fault condition has been cleared, pulses are added again.

The quality of the pulse-metered value remains **Questionable** until a new meter content is specified for the pulse-metered value by:

- Confirmation of the current meter content via **Setting**
- **Setting** a new meter content
- **Resetting** the meter content to 0

- Parameter **Edge trigger**

  Through settings, you can select between counting only with a rising edge or with rising and falling edges on the pulse input.

The pulse counter can be reset to 0. You can perform this resetting via the rising edge of a routable binary input (**>Reset**) or via operation on the device.

To display the counting amount at the device display, use DIGSI to set the desired weighting of the counter pulses, the unit of the metered value and a multiplication factor for every pulse generator. You can also assign a user-specific name.

To do this, open the functional area **Pulse-metered value** in DIGSI information routing. (see *Figure 9-32*). Select the metered value and enter the settings under **Properties**.

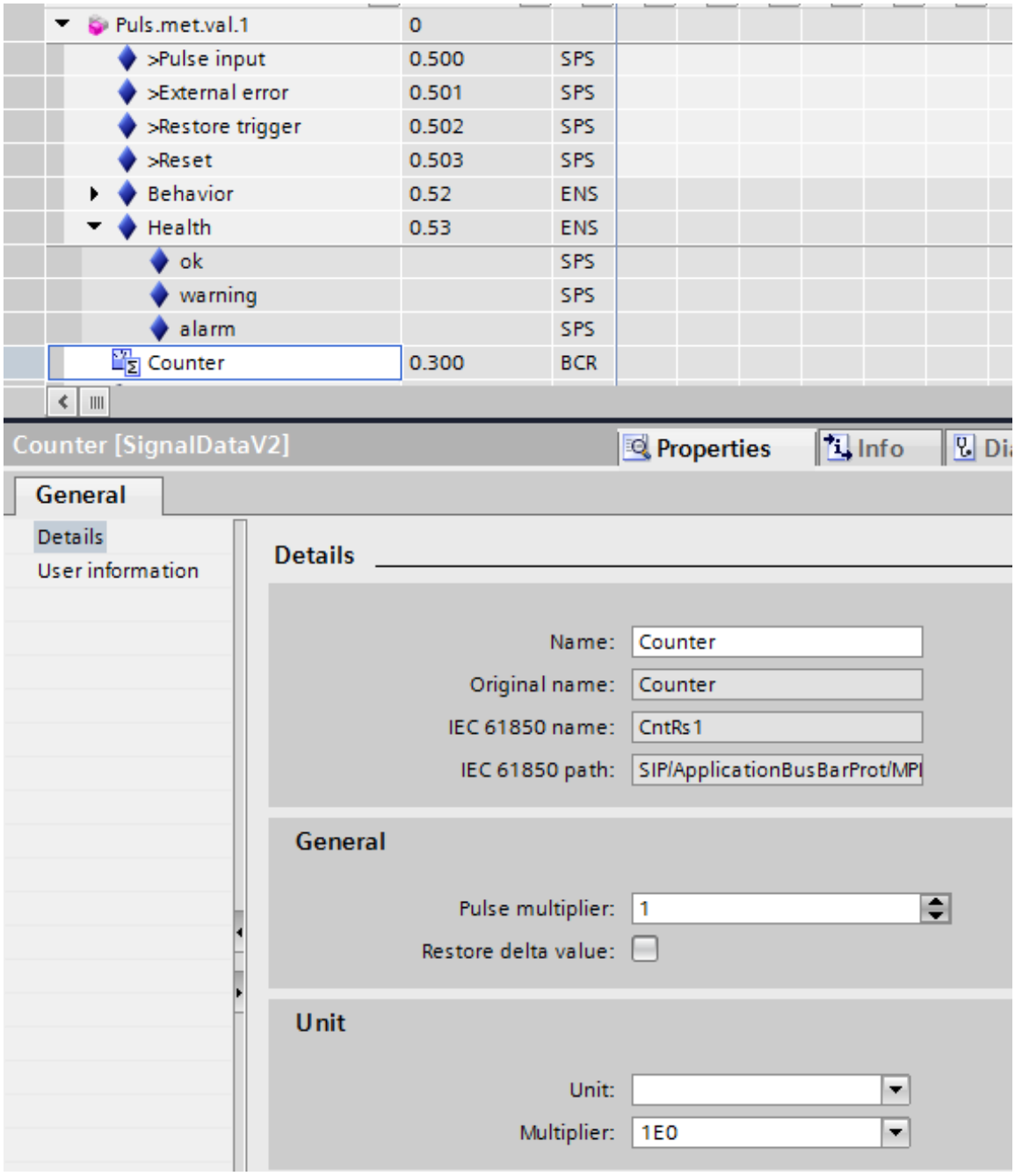


Figure 9-32 Setting with DIGSI, General Settings, Pulse-Metered Values

9.9.2 Application and Setting Notes for Pulse-Metered Values

The functionality **Pulse-metered values** is not preconfigured. If you want to use the functionality, you must load it from the library into the respective function group.

The parameters can be set individually for every pulse counter. You will find the setting parameters in DIGSI in the project tree under **Parameter > Function group**. The maximum repetition rate when detecting the pulse-metered values is 50 Hz.

For pulse-metered values, the following described settings and binary inputs are available.

Parameter: `Restore time`

- Default setting **`(_:101) Restore time`** = ***`none`***

Parameter Value	Description
none	Deactivated
`hh:00`	Transfer on the full hour
`hh:15`	Transfer 15 minutes after the full hour
`hh:30`	Transfer 30 minutes after the full hour
`hh:45`	Transfer 45 minutes after the full hour

Note: If the parameter is activated through a time setting, the parameter **`Restore interval`** is not in effect and will be deactivated automatically.

Parameter: `Restore interval`

- Default setting **`(_:102) Restore interval`** = ***`0 min`***

Parameter Value	Description
0 min	Deactivated
1 min to 60 min	Cyclical transfer after the set time 1 minute to 60 minutes

Note: If the parameter is activated through a time setting, the parameter **`Restore time`** is not in effect and will be deactivated automatically.

Parameter: `Edge trigger`

- Default setting **`(_:103) Edge trigger`** = ***`rising edge`***

Parameter Value	Description
`rising edge`	Counting with rising edge at the pulse input
`rising & falling edge`	Counting with rising and falling edge at the pulse input

Parameter: `Restore by absolute time`

- Default setting: **`(_:104) Restore by absolute time`**= ***`False`***

Parameter Value	Description
`False`	Deactivated
`True`	The cyclic restoring of setting **`Restore interval`** after the set time is also synchronized with the system time. Example: **`Restore interval`** = 30 min; current system time: 12:10 o'clock. First restoring operation: 12:30 o'clock; next restoring operation: 13:00 o'clock, etc.

Input Signals: >Pulse input, >External error, >Restore trigger, >Reset

Binary inputs	Description
`>Pulse input`	Input for the counting pulses of an external pulse generator
`>External error`	Indication that the counter pulses of the external pulse generator are faulty. The indication has an effect on the quality identifier of the pulse value.
`>Restore trigger`	The transfer of the metered values is initiated via a binary input.
`>Reset`	The rising edge at the binary input resets the pulse counter to 0.

The amount of energy indicated by a pulse generator is to be displayed as a measured value.
1 pulse corresponds to 100 Wh.
The pulse weighting, the SI unit, and the factor must be adjusted to one another.
Display value = Calculated metered value * Pulse weighting * Factor * SI unit.

If the check box **Restore delta value** is activated, the differential value is transferred at the restore time set via the communication interface. The difference value is formed by subtracting the counter content of the last restoring operation from the current counter content.

You route the logical signal ***>Pulse input*** to a binary input to which the pulse generator is connected.

Set the following values:

Name	Active Power Meter
Pulse weighting	100
Restore differential value	Activated
SI unit	Wh
Factor	1

The factor is used for adaptation to larger units (for instance, 1000 for kWh). It is adjustable in powers of ten (1, 10, 100, 1000, etc.). The following figure shows the signals that can be arranged in the DIGSI information matrix. Open the function group where you created the pulse-metered value, for example, Line 1. There, you will find the function area **Pulse-metered value**. Here you will also find the logical signals next to the metered value. Select the metered value and enter the settings under **Properties**.

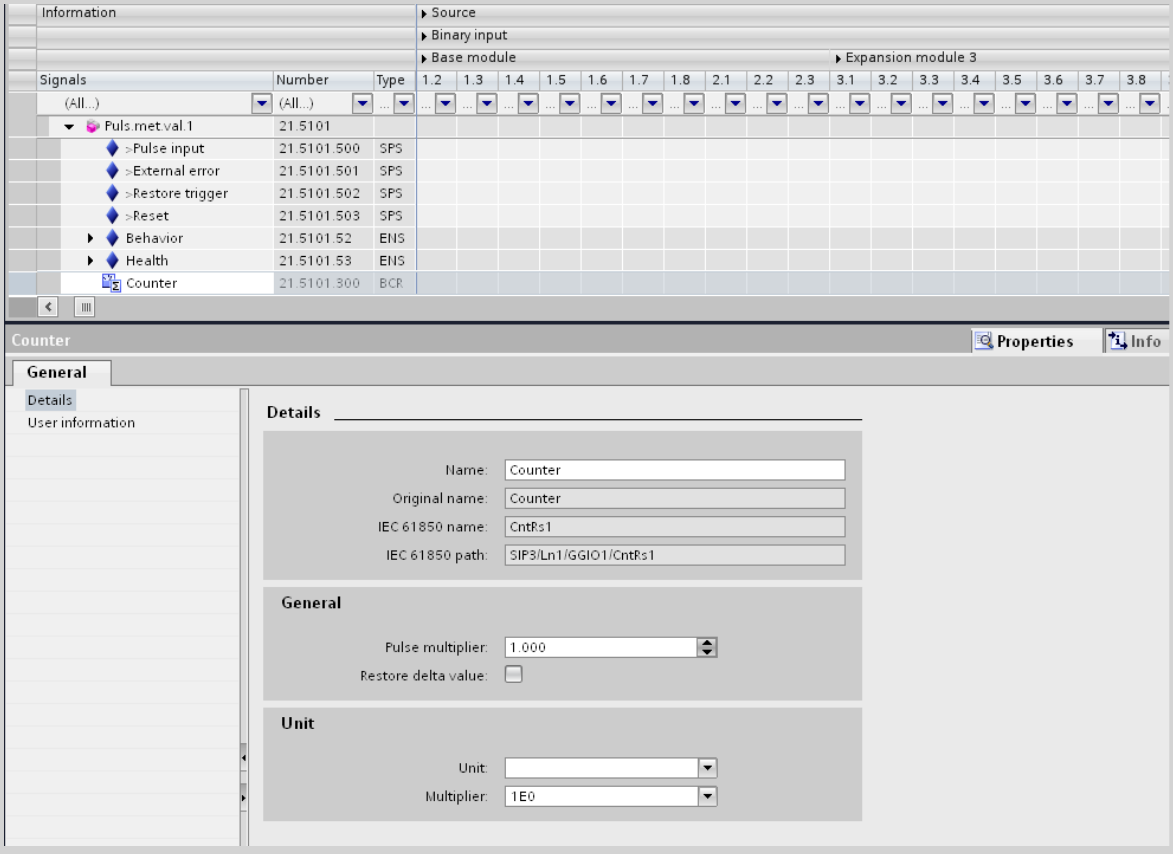


Figure 9-33 Setting with DIGSI

9.10 Statistical Values of the Primary System

The device has statistical values for circuit breakers and disconnectors.

The following values are available for each circuit breaker:

- Total number of trippings of the circuit breaker initiated by the device
- Number of trippings of the circuit breaker initiated by the device, separately for each circuit breaker pole (if 1-pole tripping is possible)
- Total sum of primary breaking currents
- Sum of the primary breaking currents, separately for each breaker pole
- Hours with open circuit breaker
- Hours under load

The following values are available for each disconnector switch:

- Total number of switching operations of the disconnector switch initiated by the device
- Number of switching operations of the disconnector switch initiated by the device, separately for each switch pole (if 1-pole switching is possible)

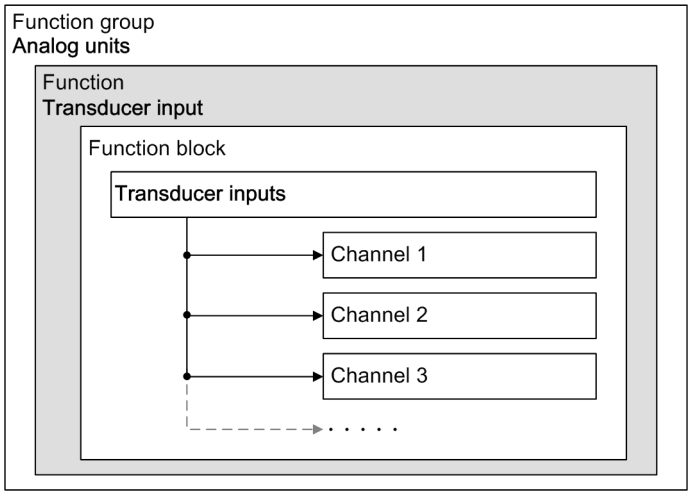
9.11 Measuring Transducers

9.11.1 Overview of Functions

Measuring transducers with an input rated at 20 mA can be used in the devices. 4 such inputs are available as module ANAI-CA-4EL, which can be plugged into a communication module slot (for instance, port E or F). Up to 4 such modules can be plugged in. Typically, slowly changing process variable such as temperature or gas pressure are recorded with such 20-mA measured values and reported to the substation automation technology.

9.11.2 Structure of the Function

The measuring-transducer blocks are embedded in the **Analog units** function group and contain input and output channels that are configurable independently of each other.

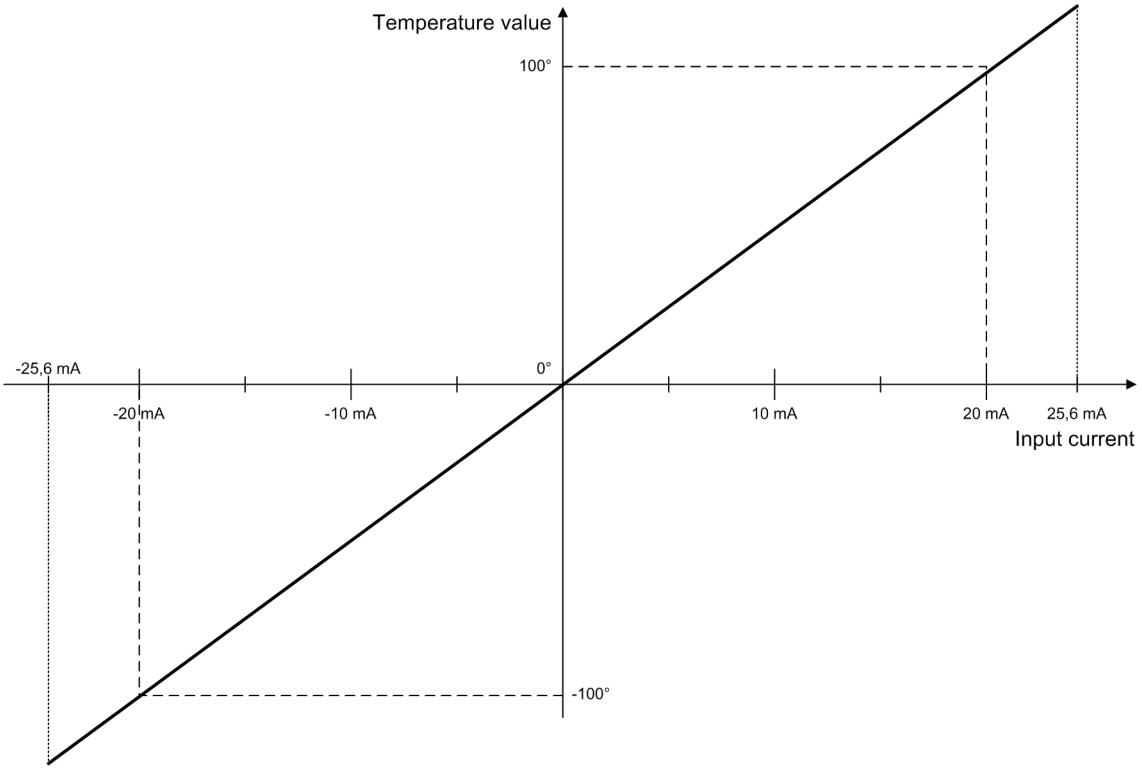


[dw_strumu, 1, en_US]

Figure 9-34 Structure/Embedding of the Function

9.11.3 Function Description

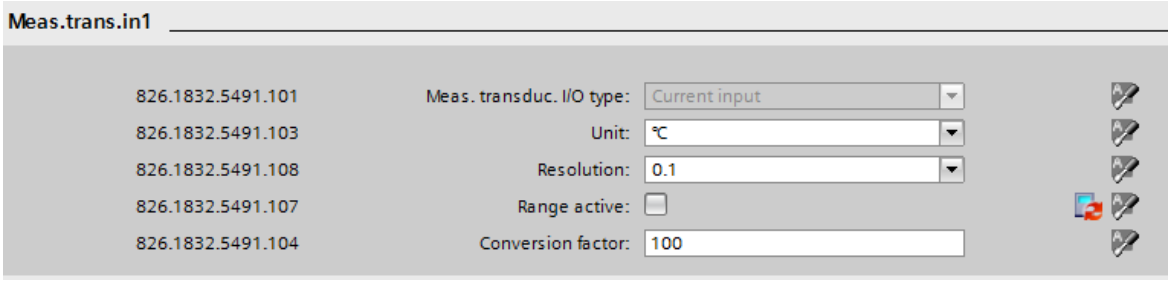
The 20-mA inputs typically transmit a value which represents a physical quantity such as a temperature or a pressure. Therefore, the device must contain a characteristic curve that assigns the physical quantity to the 20-mA value. If the parameter **`Range active`** is not activated (no x in the check box), the function operates over the range -25.6 mA to +25.6 mA. The setting of the range for the scaled value goes from a usable range of -25.6 mA to +25.6 mA. The following figure shows an example.



[dw_klbsp_1, 3, en_US]

Figure 9-35 Characteristic Curve of a 20-mA Input (Example 1)

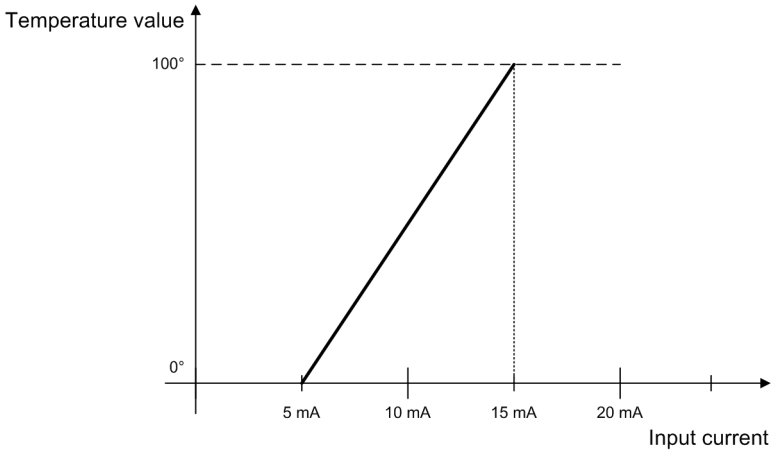
In this example, the measured value 0 mA means a temperature of 0 degrees Celsius and the measured value 20 mA means a temperature of 100 degrees Celsius. Thus, **Unit** = ***°C*** and **Conversion factor** = ***100*** are entered. The resolution (decimal place) of the temperature value can be selected; for one decimal place, select **Resolution** = ***0.1***.



[sc_transd, 1, en_US]

Figure 9-36 Parameter Settings for Example 1

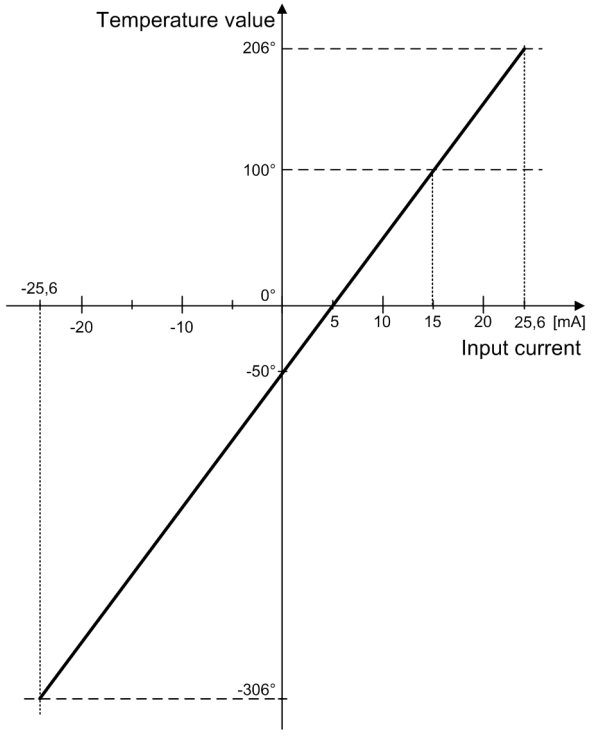
If a value smaller than -25.6 mA or larger than +25.6 mA is applied to the measuring-transducer input, the measured value is marked as outside the range of values. If the parameter **Range active** is activated, the 2 additional parameters **Upper limit** and **Lower limit** appear. Both limiting values indicate the input currents in mA, for which the value set by the **Conversion factor** (**Upper limit**) and the value 0 (**Lower limit**) of the calculated measurand are valid (see following figure).



[dw_kl_example_2, 1, en_US]

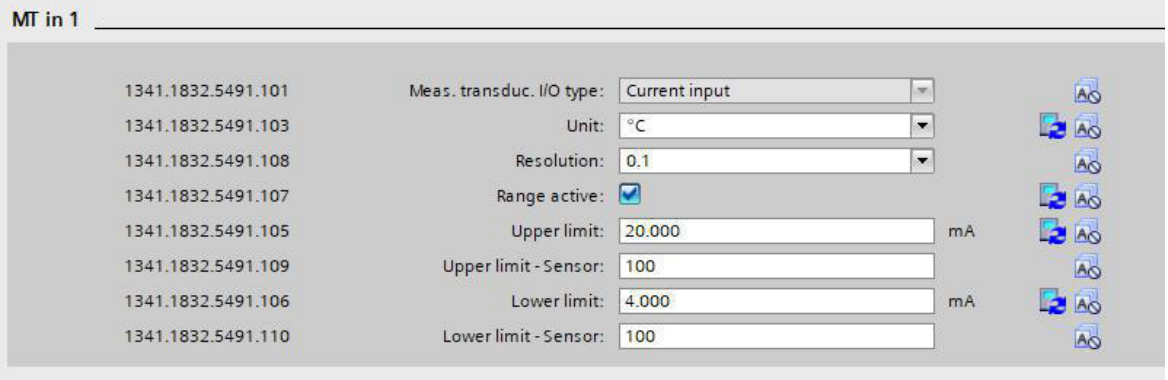
Figure 9-37 Characteristic Curve of a 20-mA Input (Example 2)

In this example, **Range active** is selected. The **Upper limit** is at 15 mA, the **Lower limit** is at 5 mA and the **Conversion factor** remains at 100. Overall, this results in a characteristic curve as shown in the following figure, taking into account all possible valid measured values from -25.6 mA to +25.6 mA. The parameter **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The parameter **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting.



[dw_klges_2, 3, en_US]

Figure 9-38 Total Characteristic Curve in Example 2



[sc_trans2, 2, en_US]

Figure 9-39 Parameter Setting for Example 2

Each measuring-transducer input provides the scaled measured value (these are the temperature values in the examples) and the original current measured value in mA in the information routing for further processing.

Table 9-6 Measuring-Transducer Measured Values

Measured Value		Display
TD scale MV (_:301)		
	Primary	Measured value converted to the sensor
	Secondary	–
	Percent	100 % ≙ parameter **(_:104) Conversion factor** (for **(_:107) Range active** = ***false***)
		100 % ≙ max. absolute value of the parameter **(_:109) Upper limit - Sensor** or of the parameter **(_:110) Lower limit - Sensor** (for **(_:107) Range active** = ***true***)
TD direct MV (_:302)		
	Primary	–
	Secondary	-20.000 mA to +20.000 mA or -10 V to +10 V
	Percent	100 % ≙ 20 mA or 10 V

The measuring-transducer values can be displayed in the display image and processed with CFC charts.

9.11.4 Application and Setting Notes

Parameter: Unit

- Recommended setting value **(_:103) Unit** = ***°C***

With the parameter **Unit**, you set the physical unit of measurement the measured values. The possible setting values are listed in the settings table.

Parameter: Conversion factor

With the parameter **(_:104) Conversion factor**, you set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting **(_:108) Resolution** = ***0.1***

With the parameter **Resolution**, you set the resolution of the scaled values.

Parameter: Range active

- Default setting **(_:107) Range active** = ***false***

If you do not activate the parameter **Range active** (no cross in the check box), the function operates over the range -25.6 mA to +25.6 mA. The setting of the range for the scaled value goes from a usable range of -25.6 mA to +25.6 mA.

If you activate the parameter **Range active**, the 4 additional parameters **Upper limit**, **Upper limit - Sensor**, **Lower limit**, and **Lower limit - Sensor**appear.

Parameter: Upper limitLower limitUpper limit - Sensor and Lower limit - Sensor

- Default setting **(_:105) Upper limit** = ***20.000 mA***
- Default setting **(_:109) Upper limit - Sensor** = ***100***
- Default setting **(_:106) Lower limit** = ***4.000 mA***
- Default setting **(_:110) Lower limit - Sensor** = ***100***

If you activate the parameter **Range active**, the 4 additional parameters **Upper limit**, **Lower limit**, **Upper limit - Sensor**, and **Lower limit - Sensor** appear. The parameter **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The parameter **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting.

If you keep the preset limiting values, the following conditions are possible:

- If the input current is < 2.000 mA
  The function issues the indication ***Broken wire*** and the quality of the output value is invalid. The functions that use the output value as the measured value can be deactivated.
- If the input current is > 2.500 mA
  The indication ***Broken wire*** drops out.

9.11.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MT in #				
_:101	MT in #:Meas. transduc. I/O type		Current input	Current input

Addr.	Parameter	C	Setting Options	Default Setting
_:103	MT in #:Unit		• % • ° • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • in • J • J/Wh • K • l/s • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • W/s • Wh	m

Addr.	Parameter	C	Setting Options	Default Setting
_:108	MT in #:Resolution		• 1 • 0.1 • 0.01 • 0.001	0.1
_:107	MT in #:Range active		• 0 • 1	false
_:104	MT in #:Conversion factor		1 to 10000	100
_:105	MT in #:Upper limit		-20.00 mA to 20.00 mA	20.00 mA
_:109	MT in #:Upper limit - Sensor		-10000 to 10000	100
_:106	MT in #:Lower limit		-20.00 mA to 20.00 mA	4.00 mA
_:110	MT in #:Lower limit - Sensor		-10000 to 10000	100

9.11.6 Information List

No.	Information	Data Class (Type)	Type
MT in #			
_:307	MT in #:Broken wire	SPS	O
_:302	MT in #:TD scale MV	MV	O
_:306	MT in #:TD scale SAV	SAV	O

9.12 Circuit-Breaker Monitoring

9.12.1 Overview of Functions

The **Circuit-breaker monitoring** function:

- Detects the abrasion of the circuit breakers phase-selectively
- Allows an adaptation of maintenance intervals for switching contacts of the circuit breakers according to the real abrasion
- Sends a warning signal when the abrasion of the circuit breaker reaches a certain degree
- Allows the supervision of the circuit-breaker make time
- Allows the supervision of the circuit-breaker break time

One of the main advantages of this function is the reduction of maintenance and service costs.

9.12.2 Structure of the Function

The function **Circuit-breaker monitoring** can be used in the function group **Circuit-breaker**.
The function offers 9 independent operating methods with different methods of measurement:

- **ΣI^x-method**
  Sum of the breaking-current potentials
- **2P-method**
  2 points method for calculating the remaining switching cycles
- **I^2t-method**
  Sum of all breaking-current square integrals
- **Make time**
  Monitoring of the circuit-breaker make time
- **Break time**
  Monitoring of the circuit-breaker break time
- **Pole scatter time open**
  Supervision of the difference in the switch-off times of the individual phases
- **Pole scatter time close**
  Supervision of the difference in the switch-on times of the individual phases
- **Mechanical switching time open**
  Supervision of the switching time open detected via the feedback contacts
- **Mechanical switching time close**
  Supervision of the switching time close detected via the feedback contacts
- **Operation counter**
  Supervision of the number of switching cycles performed

9.12.3 General Functionality

9.12.3.1 Description

Start Criterion for the Function Circuit-Breaker Monitoring

The methods **ΣI^x**, **2P** and **I²t** are started if one of the following criteria is met:

- The circuit breaker is opened via a command or a protection tripping.
- The binary input signal *>Start calc. for open* is initiated, for example, via an external signal.
- The signal for the closed position of the circuit breaker is going. This signal is built via the circuit-breaker auxiliary-contacts. Thus, a manual opening of the circuit breaker is detected.

The methods **Make time**, **Mechanical switching time close** are started if one of the following criteria is met:

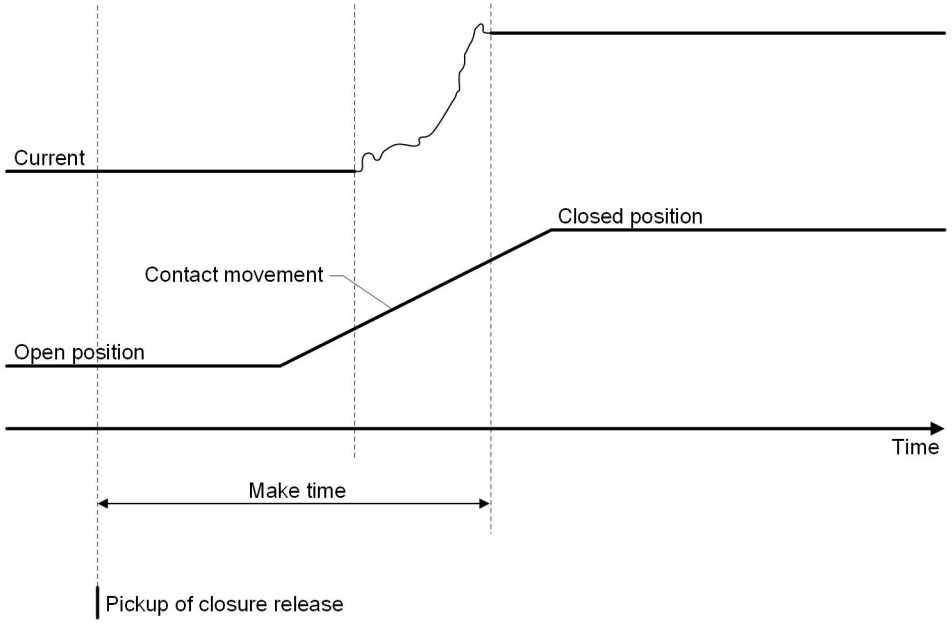
- The circuit breaker is closed via a command.
- The binary input signal *>Start calc. for close* is initiated, for example, via an external signal.

The methods **Break time**, **Mechanical switching time open** and **Pole scatter time open** are started if one of the following criteria is met:

- The circuit breaker is opened via a command.
- The circuit breaker is opened via a protection tripping.
- The binary input signal *>Start calc. for open* is initiated, for example, via an external signal.

Definition of the Times when Opening and Closing the Circuit Breaker

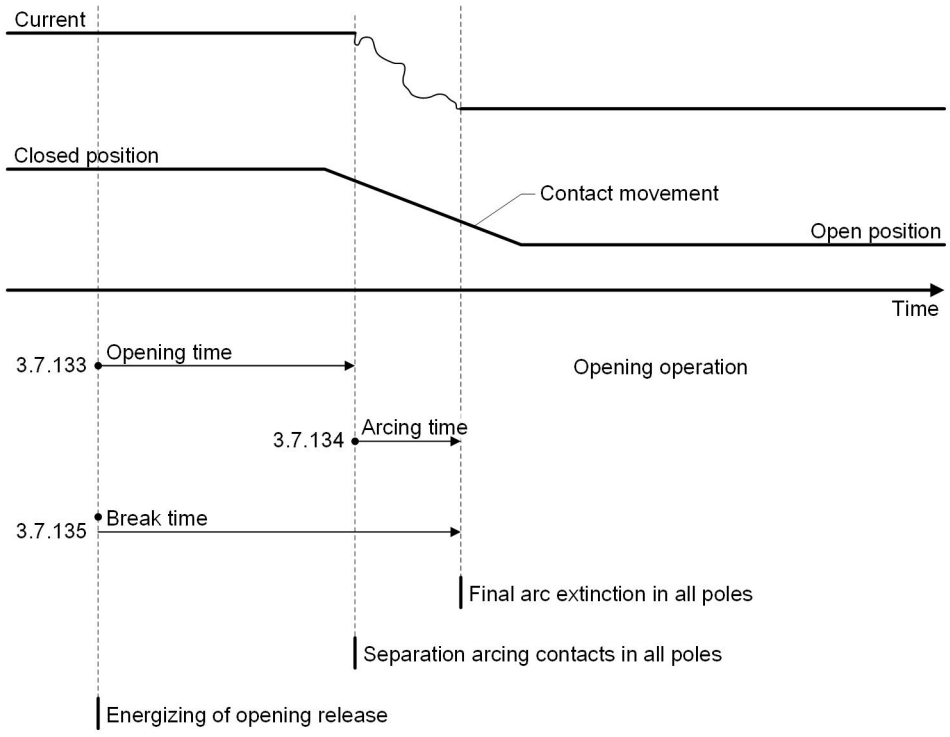
With the paramter **Make time**, you define the point in time when the circuit-breaker poles are closed and the current has reached a constant value.



[dw_maketime, 1, en_US]

Figure 9-40 Definition of Make Time

With the parameter **Opening time**, you define the point in time when the circuit-breaker poles begin to open. With the parameter **Break time**, you define the point in time when the circuit-breaker poles are separated and the arc is extinct. The following graphic shows the relation between these 2 points in time of the circuit breaker.



[dw_breaktime, 1, en_US]

Figure 9-41 Circuit-Breaker Times

9.12.3.2 Application and Setting Notes

Parameter: `Apply PhaseA config to all`

- Default setting **`(_:2311:1) Apply PhaseA config to all`** = ***`inactive`***

If the parameter **`Apply PhaseA config to all`** is activated, all settings of phase A are adopted for phases B and C.

NOTE

The following parameters apply to one phase. The descriptions apply similarly to the parameters of the remaining phases.

Parameter: `Opening time`

- Default setting **`(_:23971:101) Opening time`** = ***`65 ms`***

With the parameter **`Opening time`**, you define the interval between the activation of the shunt release for the circuit breaker and the moment, when the circuit-breaker poles open.

For information on the setting value, refer to the technical data of the used circuit breaker. For futher information, refer to *Figure 9-41*.

Parameter: `Break time`

- Default setting **`(_:23971:102) Break time`** = ***`80 ms`***

With the parameter **`Break time`**, you define the interval between the activation of the shunt release for the circuit breaker and the moment, when the arc extincts (and the circuit-breaker poles are open).

For information on the setting value, refer to the technical data of the used circuit breaker. For further information, refer to *Figure 9-41*.

Parameter: `Make time`

- Default setting **`(_:23971:103) Make time`** = ***`80 ms`***

With the parameter **`Make time`**, you define the typical time interval between the activation of the closing procedure for the circuit breaker and the point in time when the first current flows.

For information on the setting value, refer to the technical data of the used circuit breaker.

9.12.3.3 Settings

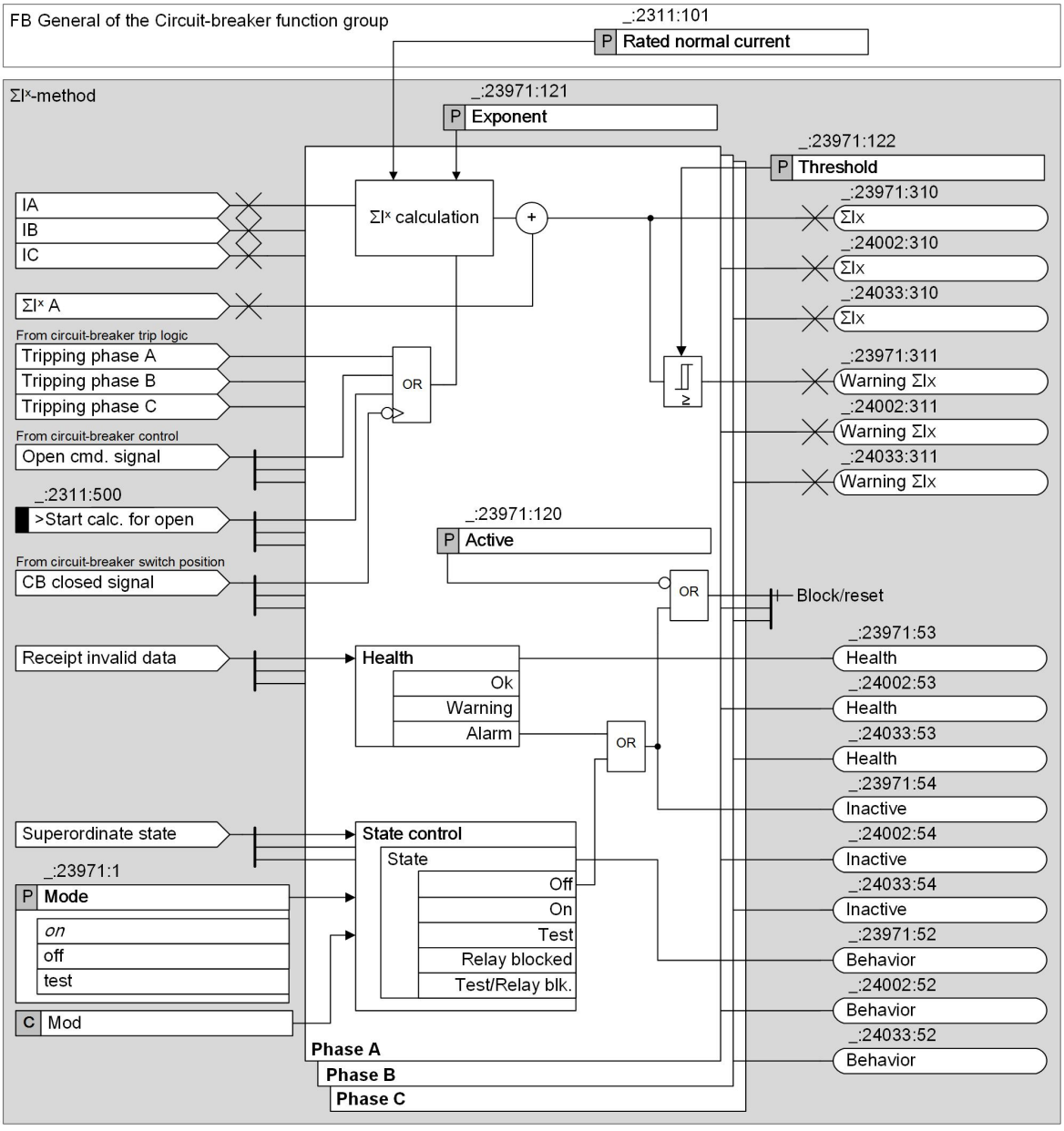
Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:1	General:Apply PhaseA config to all		• 0 • 1	False
`General`				
_:23971:1	Phase A:Mode		• off • on • test	on
_:23971:101	Phase A:Opening time		1 ms to 500 ms	65 ms
_:23971:102	Phase A:Break time		1 ms to 600 ms	80 ms
_:23971:103	Phase A:Make time		1 ms to 600 ms	80 ms
`General`				
_:24002:1	Phase B:Mode		• off • on • test	on
_:24002:101	Phase B:Opening time		1 ms to 500 ms	65 ms
_:24002:102	Phase B:Break time		1 ms to 600 ms	80 ms
_:24002:103	Phase B:Make time		1 ms to 600 ms	80 ms
`General`				
_:24033:1	Phase C:Mode		• off • on • test	on
_:24033:101	Phase C:Opening time		1 ms to 500 ms	65 ms
_:24033:102	Phase C:Break time		1 ms to 600 ms	80 ms
_:24033:103	Phase C:Make time		1 ms to 600 ms	80 ms

9.12.3.4 Information List

No.	Information	Data Class (Type)	Type
`General`			
_:2311:500	General:>Start calc. for open	SPS	I
_:2311:501	General:>Start calc. for close	SPS	I
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O

9.12.4 ΣIx Method

9.12.4.1 Description



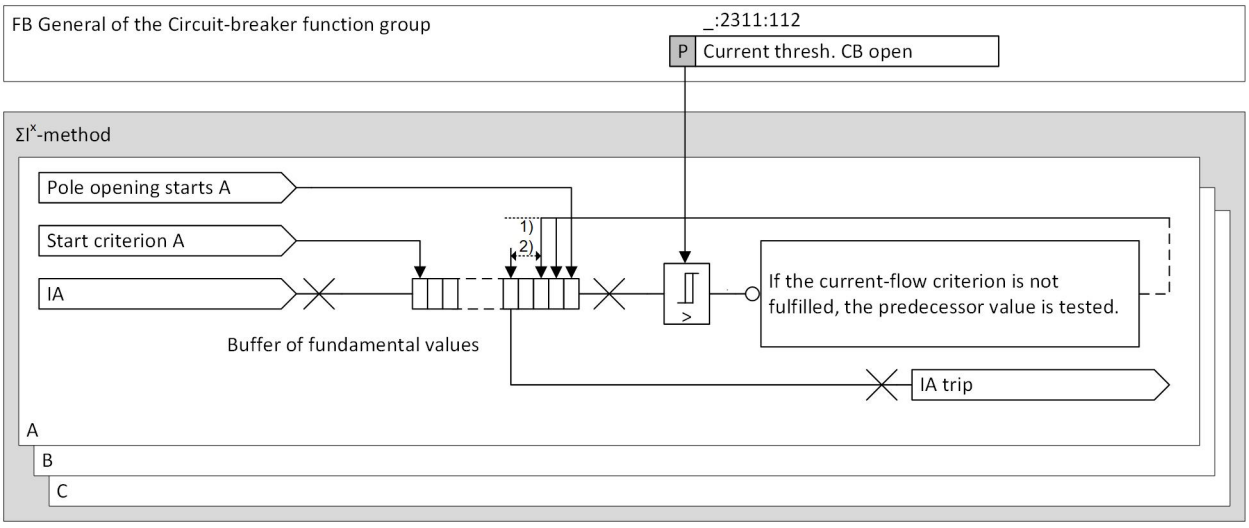
[lo_Ix-calc, 1, en_US]

Figure 9-42 Logic of the ΣIx Method

Determination of the Tripping/Opening Current Value

RMS values of the fundamental components are stored for each phase in a buffer during the time between the start criterion and the pole-opening-starts criterion. With the coming pole-opening-starts criterion, the latest value in the buffer is searched for whose value is above the setting of parameter **`Current thresh. CB open`**. The one period prior value is used as tripping/opening current for further calculation.

If no value within the buffer is above the setting value, this circuit-breaker opening affects only the mechanical lifetime of the circuit breaker and is consequently not considered by this method.



[lo_cb_wixf, 3, en_US]

Figure 9-43 Logic of the Determination of the Tripping Current Value

(1) Current-flow criterion fulfilled
(2) 1 period prior value

Calculation of the Wear

If the **ΣIx-method** stage receives the logic release signal, the determined tripping current is used in the calculation of wear. The calculation results are then added to the existing statistic values of the ΣIx method as follows, with phase A as example.

$$\sum I_A^x = \frac{1}{I_{rated}^x} \sum_{q=1}^{m} I_{A\,trip,q}^x$$

[fo_CB-WI-xA, 1, en_US]

Mit:

x	Parameter exponent
q	No. of circuit-breaker switching cycle
$I_{A\,trip,\,q}^x$	Tripping/opening current of phase A to the power of x in the qth circuit-breaker operation
I_{rated}^x	Rated normal current to the power of x
$\sum I_A^x$	Statistic value of current phase A calculated with the ∑Ix method
m	Total number of switching cycles

The phase-selective ΣIx value is available as statistical value. You can reset or preset the statistics according to the specific application.
To simplify the interpretation of the sum of the tripping current powers, the values are set in relation to the exponentiated rated normal current I_{rated} of the circuit-breaker (see also setting notes).

Circuit-Breaker Maintenance Warning

If the summated ΣIx value of any phase is greater than the threshold, a phase-selective warning signal is generated.

9.12.4.2 Application and Setting Notes

NOTE

The following parameters apply to one phase. The descriptions apply similarly to the parameters of the remaining phases.

Parameter: Active

- Default setting **(_:23971:120) Active** = ***inactive***

With the parameter **Active**, you switch on the method.

Parameter: Exponent

- Default setting **(_:23971:121) Exponent** = ***2.0***

With the parameter **Exponent**, you specify the exponent for the ΣI^x method.

A typical value is the default setting of 2. However, due to practical experiences with individual circuit breakers, slightly different values may be requested.

Parameter: Threshold

- Default setting **(_:23971:122) Threshold** = ***10 000.00***

With the parameter **Threshold**, you define the threshold of the statistic value.

The relation of the tripping current powers to the exponentiated rated normal current I_{rated} allows the limiting value of the ΣI^x method to correspond to the maximum number of make-breaker operations. For a circuit breaker, whose contacts have not yet been worn, the maximum number of make-break operations can be entered directly as limiting value.

9.12.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
ΣIx-method				
_:23971:120	Phase A:Active		• 0 • 1	False
_:23971:121	Phase A:Exponent		1.0 to 3.0	2.0
_:23971:122	Phase A:Threshold		0 to 10000000	10000
ΣIx-method				
_:24002:120	Phase B:Active		• 0 • 1	False
_:24002:121	Phase B:Exponent		1.0 to 3.0	2.0
_:24002:122	Phase B:Threshold		0 to 10000000	10000
ΣIx-method				
_:24033:120	Phase C:Active		• 0 • 1	False
_:24033:121	Phase C:Exponent		1.0 to 3.0	2.0
_:24033:122	Phase C:Threshold		0 to 10000000	10000

9.12.4.4 Information List

No.	Information	Data Class (Type)	Type
Phase A			
_:23971:51	Phase A:Mode (controllable)	ENC	C

No.	Information	Data Class (Type)	Type
_:23971:54	Phase A:Inactive	SPS	O
_:23971:52	Phase A:Behavior	ENS	O
_:23971:53	Phase A:Health	ENS	O
_:23971:300	Phase A:2P abrasion remaining	INS	O
_:23971:301	Phase A:2P abrasion cumulated	MV	O
_:23971:302	Phase A:2P abrasion last sw.op.	MV	O
_:23971:303	Phase A:2P abrasion warning	SPS	O
_:23971:304	Phase A:2P abrasion alarm	SPS	O
_:23971:310	Phase A:ΣIx	BCR	O
_:23971:311	Phase A:Warning ΣIx	SPS	O
_:23971:320	Phase A:ΣI²t	BCR	O
_:23971:321	Phase A:Warning ΣI²t	SPS	O
_:23971:330	Phase A:Make time	MV	O
_:23971:331	Phase A:Make-time warning	SPS	O
_:23971:332	Phase A:Make-time alarm	SPS	O
_:23971:340	Phase A:Break time	MV	O
_:23971:341	Phase A:Break-time warning	SPS	O
_:23971:342	Phase A:Break-time alarm	SPS	O
_:23971:350	Phase A:Aux.-contact time open	MV	O
_:23971:351	Phase A:Aux.c. time open warn.	SPS	O
_:23971:352	Phase A:Aux.c. time open alarm	SPS	O
_:23971:353	Phase A:Reaction time open	MV	O
_:23971:354	Phase A:React. time open warn.	SPS	O
_:23971:355	Phase A:React. time open alarm	SPS	O
_:23971:356	Phase A:Aux.c. travel time open	MV	O
_:23971:360	Phase A:Aux.-cont. time close	MV	O
_:23971:361	Phase A:Aux.c. time close warn.	SPS	O
_:23971:362	Phase A:Aux.c. time close alarm	SPS	O
_:23971:363	Phase A:Reaction time close	MV	O
_:23971:364	Phase A:React. time close warn.	SPS	O
_:23971:365	Phase A:React. time close alarm	SPS	O
_:23971:366	Phase A:Aux.c. travel time close	MV	O
Phase B			
_:24002:51	Phase B:Mode (controllable)	ENC	C
_:24002:54	Phase B:Inactive	SPS	O
_:24002:52	Phase B:Behavior	ENS	O
_:24002:53	Phase B:Health	ENS	O
_:24002:300	Phase B:2P abrasion remaining	INS	O
_:24002:301	Phase B:2P abrasion cumulated	MV	O
_:24002:302	Phase B:2P abrasion last sw.op.	MV	O
_:24002:303	Phase B:2P abrasion warning	SPS	O
_:24002:304	Phase B:2P abrasion alarm	SPS	O
_:24002:310	Phase B:ΣIx	BCR	O
_:24002:311	Phase B:Warning ΣIx	SPS	O
_:24002:320	Phase B:ΣI²t	BCR	O
_:24002:321	Phase B:Warning ΣI²t	SPS	O

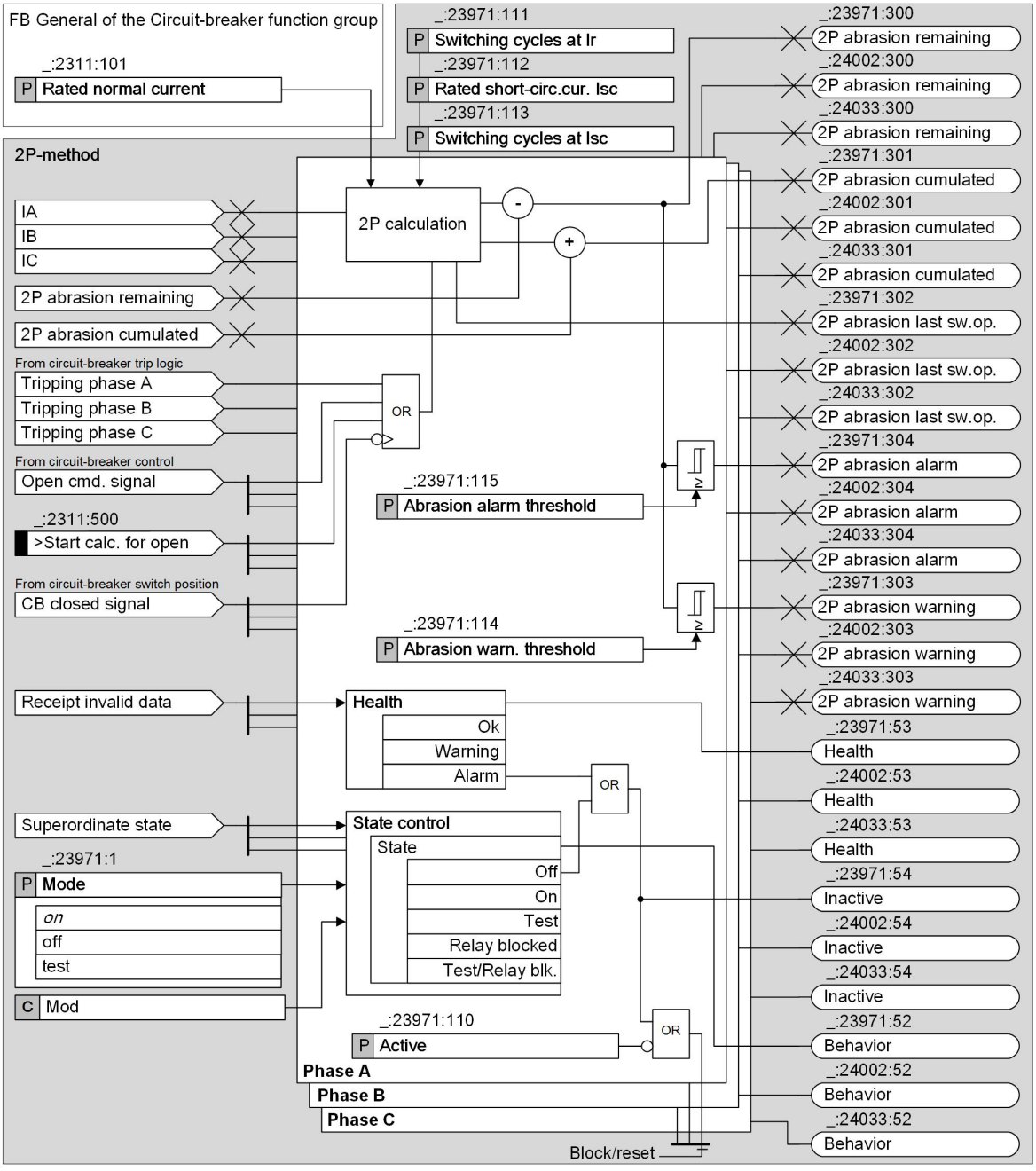
No.	Information	Data Class (Type)	Type
_:24002:330	Phase B:Make time	MV	O
_:24002:331	Phase B:Make-time warning	SPS	O
_:24002:332	Phase B:Make-time alarm	SPS	O
_:24002:340	Phase B:Break time	MV	O
_:24002:341	Phase B:Break-time warning	SPS	O
_:24002:342	Phase B:Break-time alarm	SPS	O
_:24002:350	Phase B:Aux.-contact time open	MV	O
_:24002:351	Phase B:Aux.c. time open warn.	SPS	O
_:24002:352	Phase B:Aux.c. time open alarm	SPS	O
_:24002:353	Phase B:Reaction time open	MV	O
_:24002:354	Phase B:React. time open warn.	SPS	O
_:24002:355	Phase B:React. time open alarm	SPS	O
_:24002:356	Phase B:Aux.c. travel time open	MV	O
_:24002:360	Phase B:Aux.-cont. time close	MV	O
_:24002:361	Phase B:Aux.c. time close warn.	SPS	O
_:24002:362	Phase B:Aux.c. time close alarm	SPS	O
_:24002:363	Phase B:Reaction time close	MV	O
_:24002:364	Phase B:React. time close warn.	SPS	O
_:24002:365	Phase B:React. time close alarm	SPS	O
_:24002:366	Phase B:Aux.c. travel time close	MV	O
Phase C			
_:24033:51	Phase C:Mode (controllable)	ENC	C
_:24033:54	Phase C:Inactive	SPS	O
_:24033:52	Phase C:Behavior	ENS	O
_:24033:53	Phase C:Health	ENS	O
_:24033:300	Phase C:2P abrasion remaining	INS	O
_:24033:301	Phase C:2P abrasion cumulated	MV	O
_:24033:302	Phase C:2P abrasion last sw.op.	MV	O
_:24033:303	Phase C:2P abrasion warning	SPS	O
_:24033:304	Phase C:2P abrasion alarm	SPS	O
_:24033:310	Phase C:ΣIx	BCR	O
_:24033:311	Phase C:Warning ΣIx	SPS	O
_:24033:320	Phase C:ΣI²t	BCR	O
_:24033:321	Phase C:Warning ΣI²t	SPS	O
_:24033:330	Phase C:Make time	MV	O
_:24033:331	Phase C:Make-time warning	SPS	O
_:24033:332	Phase C:Make-time alarm	SPS	O
_:24033:340	Phase C:Break time	MV	O
_:24033:341	Phase C:Break-time warning	SPS	O
_:24033:342	Phase C:Break-time alarm	SPS	O
_:24033:350	Phase C:Aux.-contact time open	MV	O
_:24033:351	Phase C:Aux.c. time open warn.	SPS	O
_:24033:352	Phase C:Aux.c. time open alarm	SPS	O
_:24033:353	Phase C:Reaction time open	MV	O
_:24033:354	Phase C:React. time open warn.	SPS	O
_:24033:355	Phase C:React. time open alarm	SPS	O

No.	Information	Data Class (Type)	Type
_:24033:356	Phase C:Aux.c. travel time open	MV	O
_:24033:360	Phase C:Aux.-cont. time close	MV	O
_:24033:361	Phase C:Aux.c. time close warn.	SPS	O
_:24033:362	Phase C:Aux.c. time close alarm	SPS	O
_:24033:363	Phase C:Reaction time close	MV	O
_:24033:364	Phase C:React. time close warn.	SPS	O
_:24033:365	Phase C:React. time close alarm	SPS	O
_:24033:366	Phase C:Aux.c. travel time close	MV	O

9.12.5 2P Method

9.12.5.1 Description

Logic of the Stage



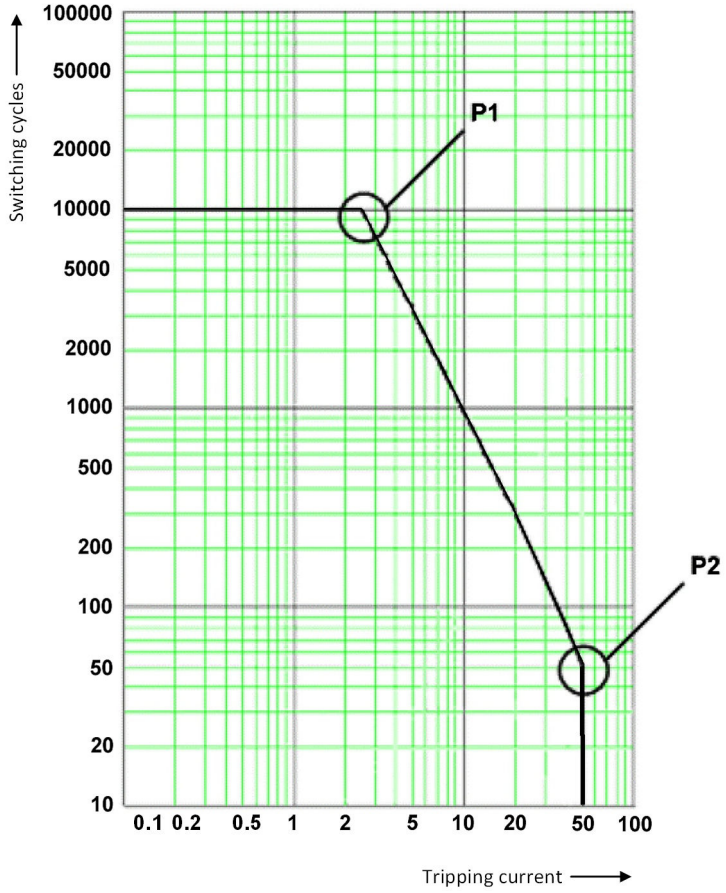
[lo_2P-calc_1, en_US]

Figure 9-44 Logic 2P Method

Calculation of Remaining Switching Cycles

A double-logarithmic diagram provided by the circuit-breaker manufacturer illustrates the relationship of permitted switching cycles and the tripping/opening current, see the following figure. According to the example, this circuit breaker can operate approximately 1000 times at a tripping current of 10 kA.

2 points and their connecting line determine the relationship of switching cycles and tripping current. Point P1 is determined by the number of permitted switching cycles at rated normal current I_{rated}. Point P2 is determined by the maximum number of switching cycles at rated short-circuit breaking current I_{sc}. The 4 associated values can be configured with the parameters **`Rated normal current`**, **`Switching cycles at Ir`**, **`Rated short-circ.cur. Isc`**, and **`Switching cycles at Isc`**.



[dw_CB_WOpC, 2, en_US]

Figure 9-45 Diagram of Switching Cycles for the 2P Method

As shown in the preceding figure, a double-logarithmic diagram, the straight line between P1 and P2 can be expressed by the following exponential function:

$$n = b\left(\frac{I_{rated}}{I_{trip}}\right)^{m}$$

[fo_CB-W2-P1, 2, en_US]

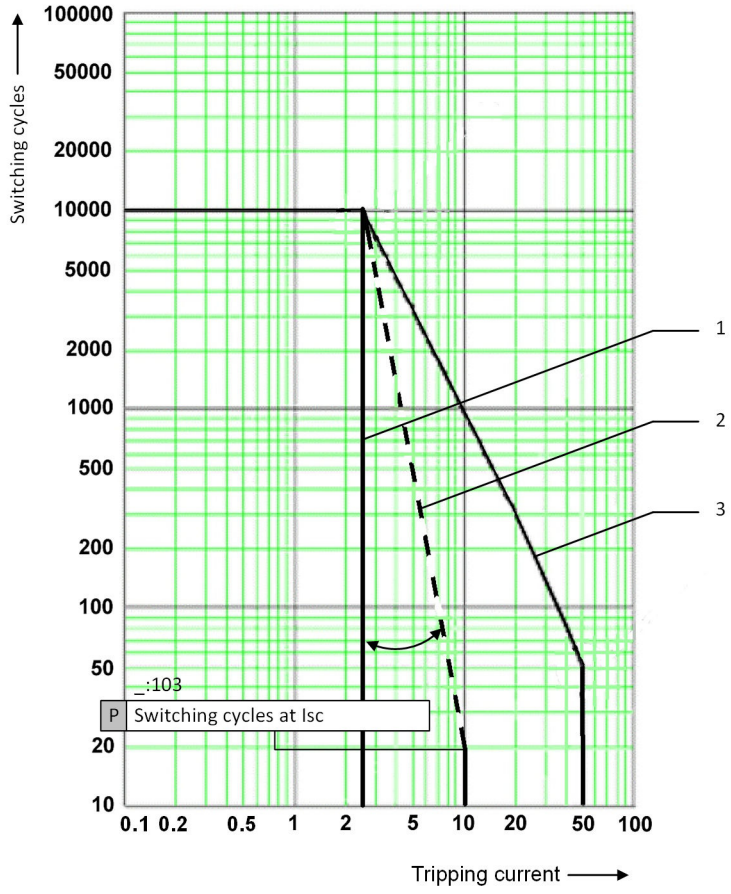
Where:

I_{trip}	Tripping/opening current
I_{rated}	Rated normal current
m	Slope coefficient
b	Switching cycles at rated normal current
n	Number of switching cycles

The general line equation for the double-logarithmic representation can be derived from the exponential function and leads to the coefficients b and m.

NOTE

Since a slope coefficient of m < -4 is technically irrelevant, but could theoretically be the result of incorrect settings, the slope coefficient is limited to -4. If a coefficient is smaller than -4, the exponential function in the switching-cycles diagram is deactivated. The maximum number of switching cycles with I_{sc} is used instead as the calculation result for the current number of switching cycles, as the dashed line with m = -4.48 shows in following figure.



[dw_CB_WSlo, 2, en_US]

Figure 9-46 Value Limitation of Slope Coefficient

(1) Applied function from m < -4
(2) Parameterized function with m = -4.48
(3) Parameterized function with m = -1.77

If the **2P-method** stage receives the logic release signal, the current number of used up switching cycles (in relation to the number of switching cycles at rated normal current) is calculated based on the determined tripping current. This value is subtracted from the the remaining lifetime (switching cycles). The remaining lifetime is available as statistic value. For better understanding, refer to the example below.

You can reset or preset the statistical values according to the specific application. The reset operation changes the statistic values to 0, and not to their default values of 10 000.

The statistic value of the residual switching cycles is calculated according to the following formula:

$$2\text{p wear rest}_{i} = 2\text{p wear rest}_{i-1} - \frac{n_{rated}}{n_{trip}}$$

[fo_CB-2P-wear-rest_01, 2, en_US]

Where:

i	No. of latest circuit-breaker switching cycle
2p wear rest$_i$	Residual switching cycles with rated normal current, after the ith switching cycle
n_{rated}	Overall permissible switching cycles at rated normal current
n_{trip}	Overall permissible switching cycles at tripping current I_{trip}
n_{rated}/n_{trip}	Lost switching cycles referring to rated normal current

EXAMPLE

For calculating the residual switching cycles of a circuit breaker, the following is assumed:
P1 (2.5 kA, 10 000)
P2 (50.0 kA, 50)
The circuit breaker has made 100 opening operations with rated normal current, 2 tripping operations with rated short-circuit breaking current, and 3 tripping operations with 10 kA tripping current. Then, the residual switching cycles with rated normal current are:

$$\text{2p wear rest} = n_{rated} - \left(100\frac{n_{rated}}{n_{2.5\,kA}}\right) - \left(2\frac{n_{rated}}{n_{50\,kA}}\right) - \left(3\frac{n_{rated}}{n_{10\,kA}}\right)$$

$$= 10\,000 - \left(100\frac{10\,000}{10\,000}\right) - \left(2\frac{10\,000}{50}\right) - \left(3\frac{10\,000}{861}\right) = 9465$$

[fo_CB-2P-wear-rest_02, 2, en_US]

There are still 9465 possible break operations at rated normal current.

Cumulated Abrasion and Abrasion of the Last Switching Operation

In addition to the remaining switching cycles, the cumulated wear and the wear of the last switching operation is calculated. These are available as percentage values ***2P abrasion cumulated*** and ***2P abrasion last sw.op.***.

Circuit-Breaker Maintenance Warning and Alarm

If the adjustable threshold values are undershot, phase-selective warnings and alarms are generated.

9.12.5.2 Application and Setting Notes

NOTE

The following parameters apply to one phase. The descriptions apply similarly to the parameters of the remaining phases.

Parameter: `Active`

- Default setting **`(_:23971:110) Active`** = ***inactive***

With the parameter **`Active`**, you switch on the method.

Parameter: `Switching cycles at Ir`

- Default setting **`(_:23971:111) Switching cycles at Ir`** = ***10 000***

With the parameter **`Switching cycles at Ir`**, you define the number of permitted switching cycles at rated normal current.
You can find the information on the setting value in the technical data of the used circuit breaker.

Parameter: Rated short-circ.cur. Isc

- Default setting **(_:23971:112) Rated short-circ.cur. Isc** = ***25 000 A***

With the parameter **Rated short-circ.cur. Isc**, you define the rated short-circuit breaking current.
You can find the information on the setting value in the technical data of the used circuit breaker.

Parameter: Switching cycles at Isc

- Default setting **(_:23971:113) Switching cycles at Isc** = ***50***

With the parameter **Switching cycles at Isc**, you define the number of permitted switching cycles at rated short-circuit breaking current.
You can find the information on the setting value in the technical data of the used circuit breaker.

Parameter: Abrasion warn. threshold

- Default setting **(_:23971:114) Abrasion warn. threshold** = ***1000***

With the parameter **Abrasion warn. threshold**, you define the threshold value for the remaining switching cycles with rated operating current. If the statistical value is below the threshold value, a warning signal is generated.

Parameter: Abrasion alarm threshold

- Default setting **(_:23971:115) Abrasion alarm threshold** = ***500***

With the parameter **Abrasion alarm threshold**, you define the threshold value for the remaining switching cycles with rated operating current. If the statistical value is below the threshold value, an alarm signal is generated.

Example

Here is an example that shows you how to set the threshold parameters. Assuming a circuit breaker with the same technical data as provided in the example for residual switching cycles, 50 breaking operations with rated short-circuit breaking current are permitted.
A warning signal should be issued when the number of possible breaking operations with rated short-circuit breaking current is less than 3. For that condition, you set the threshold value based on the following calculation:

$$3 \cdot \frac{n_{rated}}{n_{50\,kA}} = 3 \cdot \frac{10000}{50} = 600$$

[fo_CB-W2-P4, 2, en_US]

9.12.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
2P-method				
_:23971:110	Phase A:Active		• 0 • 1	False
_:23971:111	Phase A:Switching cycles at Ir		100 to 10000000	10000
_:23971:112	Phase A:Rated short-circ.cur. Isc		10 A to 100000 A	25000 A
_:23971:113	Phase A:Switching cycles at Isc		1 to 1000	50
_:23971:114	Phase A:Abrasion warn. threshold		0 to 10000000	100

Addr.	Parameter	C	Setting Options	Default Setting
_:23971:115	Phase A:Abrasion alarm threshold		0 to 10000000	50
2P-method				
_:24002:110	Phase B:Active		• 0 • 1	False
_:24002:111	Phase B:Switching cycles at Ir		100 to 10000000	10000
_:24002:112	Phase B:Rated short-circ.cur. Isc		10 A to 100000 A	25000 A
_:24002:113	Phase B:Switching cycles at Isc		1 to 1000	50
_:24002:114	Phase B:Abrasion warn. threshold		0 to 10000000	100
_:24002:115	Phase B:Abrasion alarm threshold		0 to 10000000	50
2P-method				
_:24033:110	Phase C:Active		• 0 • 1	False
_:24033:111	Phase C:Switching cycles at Ir		100 to 10000000	10000
_:24033:112	Phase C:Rated short-circ.cur. Isc		10 A to 100000 A	25000 A
_:24033:113	Phase C:Switching cycles at Isc		1 to 1000	50
_:24033:114	Phase C:Abrasion warn. threshold		0 to 10000000	100
_:24033:115	Phase C:Abrasion alarm threshold		0 to 10000000	50

9.12.5.4 Information List

No.	Information	Data Class (Type)	Type
Phase A			
_:23971:51	Phase A:Mode (controllable)	ENC	C
_:23971:54	Phase A:Inactive	SPS	O
_:23971:52	Phase A:Behavior	ENS	O
_:23971:53	Phase A:Health	ENS	O
_:23971:300	Phase A:2P abrasion remaining	INS	O
_:23971:301	Phase A:2P abrasion cumulated	MV	O
_:23971:302	Phase A:2P abrasion last sw.op.	MV	O
_:23971:303	Phase A:2P abrasion warning	SPS	O
_:23971:304	Phase A:2P abrasion alarm	SPS	O
_:23971:310	Phase A:ΣIx	BCR	O
_:23971:311	Phase A:Warning ΣIx	SPS	O
_:23971:320	Phase A:ΣI²t	BCR	O
_:23971:321	Phase A:Warning ΣI²t	SPS	O
_:23971:330	Phase A:Make time	MV	O
_:23971:331	Phase A:Make-time warning	SPS	O
_:23971:332	Phase A:Make-time alarm	SPS	O

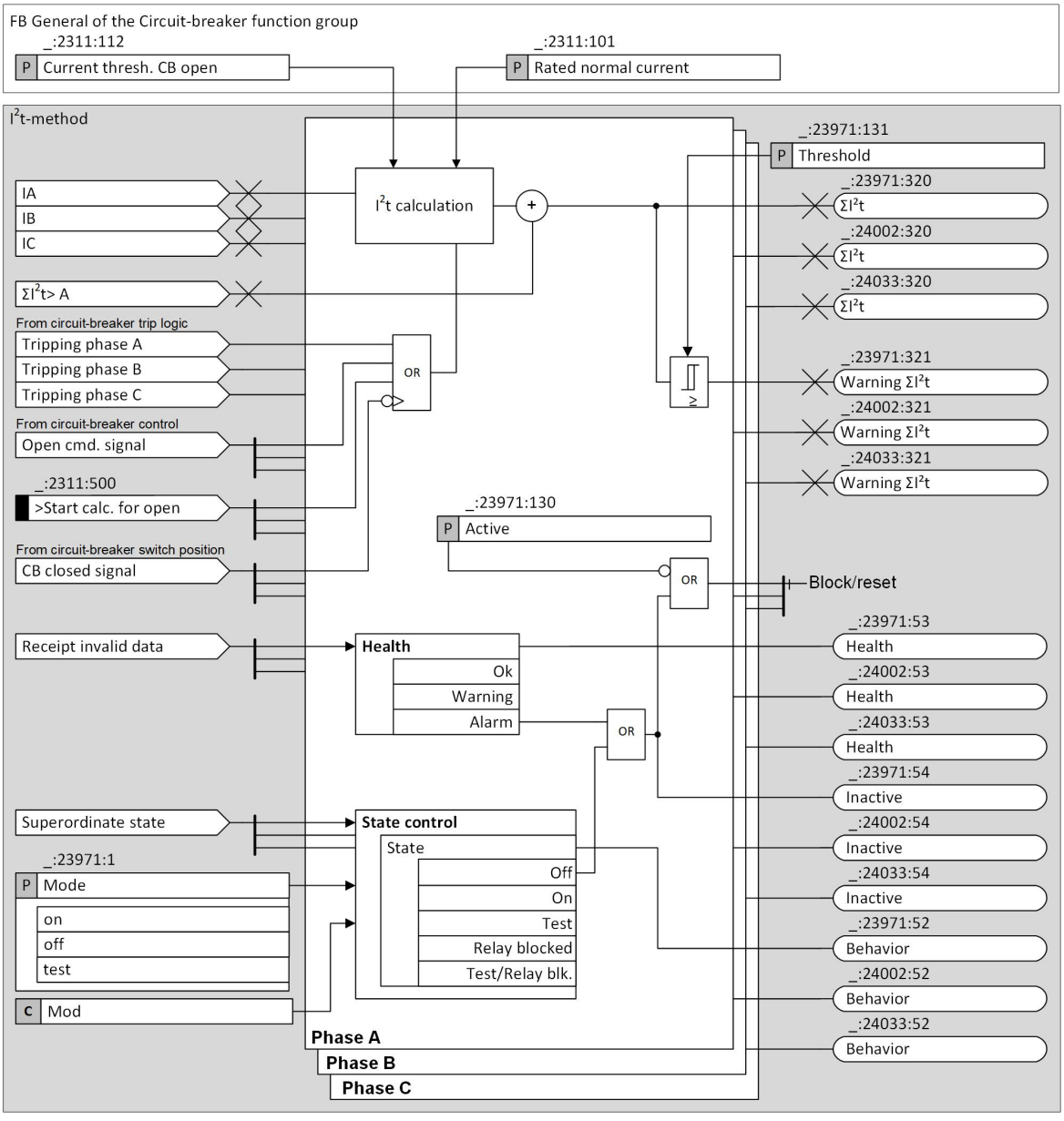
No.	Information	Data Class (Type)	Type
_:23971:340	Phase A:Break time	MV	O
_:23971:341	Phase A:Break-time warning	SPS	O
_:23971:342	Phase A:Break-time alarm	SPS	O
_:23971:350	Phase A:Aux.-contact time open	MV	O
_:23971:351	Phase A:Aux.c. time open warn.	SPS	O
_:23971:352	Phase A:Aux.c. time open alarm	SPS	O
_:23971:353	Phase A:Reaction time open	MV	O
_:23971:354	Phase A:React. time open warn.	SPS	O
_:23971:355	Phase A:React. time open alarm	SPS	O
_:23971:356	Phase A:Aux.c. travel time open	MV	O
_:23971:360	Phase A:Aux.-cont. time close	MV	O
_:23971:361	Phase A:Aux.c. time close warn.	SPS	O
_:23971:362	Phase A:Aux.c. time close alarm	SPS	O
_:23971:363	Phase A:Reaction time close	MV	O
_:23971:364	Phase A:React. time close warn.	SPS	O
_:23971:365	Phase A:React. time close alarm	SPS	O
_:23971:366	Phase A:Aux.c. travel time close	MV	O
Phase B			
_:24002:51	Phase B:Mode (controllable)	ENC	C
_:24002:54	Phase B:Inactive	SPS	O
_:24002:52	Phase B:Behavior	ENS	O
_:24002:53	Phase B:Health	ENS	O
_:24002:300	Phase B:2P abrasion remaining	INS	O
_:24002:301	Phase B:2P abrasion cumulated	MV	O
_:24002:302	Phase B:2P abrasion last sw.op.	MV	O
_:24002:303	Phase B:2P abrasion warning	SPS	O
_:24002:304	Phase B:2P abrasion alarm	SPS	O
_:24002:310	Phase B:ΣIx	BCR	O
_:24002:311	Phase B:Warning ΣIx	SPS	O
_:24002:320	Phase B:ΣI²t	BCR	O
_:24002:321	Phase B:Warning ΣI²t	SPS	O
_:24002:330	Phase B:Make time	MV	O
_:24002:331	Phase B:Make-time warning	SPS	O
_:24002:332	Phase B:Make-time alarm	SPS	O
_:24002:340	Phase B:Break time	MV	O
_:24002:341	Phase B:Break-time warning	SPS	O
_:24002:342	Phase B:Break-time alarm	SPS	O
_:24002:350	Phase B:Aux.-contact time open	MV	O
_:24002:351	Phase B:Aux.c. time open warn.	SPS	O
_:24002:352	Phase B:Aux.c. time open alarm	SPS	O
_:24002:353	Phase B:Reaction time open	MV	O
_:24002:354	Phase B:React. time open warn.	SPS	O
_:24002:355	Phase B:React. time open alarm	SPS	O
_:24002:356	Phase B:Aux.c. travel time open	MV	O
_:24002:360	Phase B:Aux.-cont. time close	MV	O
_:24002:361	Phase B:Aux.c. time close warn.	SPS	O

No.	Information	Data Class (Type)	Type
_:24002:362	Phase B:Aux.c. time close alarm	SPS	O
_:24002:363	Phase B:Reaction time close	MV	O
_:24002:364	Phase B:React. time close warn.	SPS	O
_:24002:365	Phase B:React. time close alarm	SPS	O
_:24002:366	Phase B:Aux.c. travel time close	MV	O
Phase C			
_:24033:51	Phase C:Mode (controllable)	ENC	C
_:24033:54	Phase C:Inactive	SPS	O
_:24033:52	Phase C:Behavior	ENS	O
_:24033:53	Phase C:Health	ENS	O
_:24033:300	Phase C:2P abrasion remaining	INS	O
_:24033:301	Phase C:2P abrasion cumulated	MV	O
_:24033:302	Phase C:2P abrasion last sw.op.	MV	O
_:24033:303	Phase C:2P abrasion warning	SPS	O
_:24033:304	Phase C:2P abrasion alarm	SPS	O
_:24033:310	Phase C:ΣIx	BCR	O
_:24033:311	Phase C:Warning ΣIx	SPS	O
_:24033:320	Phase C:ΣI²t	BCR	O
_:24033:321	Phase C:Warning ΣI²t	SPS	O
_:24033:330	Phase C:Make time	MV	O
_:24033:331	Phase C:Make-time warning	SPS	O
_:24033:332	Phase C:Make-time alarm	SPS	O
_:24033:340	Phase C:Break time	MV	O
_:24033:341	Phase C:Break-time warning	SPS	O
_:24033:342	Phase C:Break-time alarm	SPS	O
_:24033:350	Phase C:Aux.-contact time open	MV	O
_:24033:351	Phase C:Aux.c. time open warn.	SPS	O
_:24033:352	Phase C:Aux.c. time open alarm	SPS	O
_:24033:353	Phase C:Reaction time open	MV	O
_:24033:354	Phase C:React. time open warn.	SPS	O
_:24033:355	Phase C:React. time open alarm	SPS	O
_:24033:356	Phase C:Aux.c. travel time open	MV	O
_:24033:360	Phase C:Aux.-cont. time close	MV	O
_:24033:361	Phase C:Aux.c. time close warn.	SPS	O
_:24033:362	Phase C:Aux.c. time close alarm	SPS	O
_:24033:363	Phase C:Reaction time close	MV	O
_:24033:364	Phase C:React. time close warn.	SPS	O
_:24033:365	Phase C:React. time close alarm	SPS	O
_:24033:366	Phase C:Aux.c. travel time close	MV	O

9.12.6 I2t Method

9.12.6.1 Description

Logic of the Stage



[lo_I2t-calc_2, en_US]

Figure 9-47 Logic of the I²t Method

Calculation of the Wear

The I²t method evaluates the wear of a circuit breaker based the sampled measuring values of the phase currents during the arc time. The duration of the arc time is defined by the difference between the 2 settings of parameters **`Break time`** and **`Opening time`** (see also *Start Criterion for the Function Circuit-Breaker Monitoring, Page 2178*). The stage determines the ending point of the arc time by searching backward the zero-crossing point of the phase currents after it receives the logic release signal. Then, the squared fault currents during the arc time are integrated phase-selectively. The integrals are referred to the squared rated normal current of the circuit breaker as shown in the following formula, with phase A as example.

$$I^2t_{L1} \cdot \frac{1}{I^2_{rated}} = \int_{\text{Start arc time}}^{\text{End arc time}} i^2_{L1}(t)\,dt$$

[fo_CB-WI-2T, 2, en_US]

Where:

I_{rated}	Rated normal current
$i_A(t)$	Sampled measured current value of phase A

The calculated squared tripping current integrals are added to the existing statistic values.You can reset or preset the statistic value according to the specific application.

Circuit-Breaker Maintenance Warning

If the statistic value of any phase lies above the threshold, a phase-selective warning signal is generated.

9.12.6.2 Application and Setting Notes

Parameter: `Active`

- Default setting **`(_:23971:130) Active`** = ***`inactive`***

With the parameter **`Active`**, you switch on the method.

Parameter: `Threshold`

- Default setting **`(_:24033:131) Threshold`** = ***`10 000.00 I/Ir*s`***

With the parameter **`Threshold`**, you specify the maximum permitted integral of squared sampled measured values of the phase currents. The same applies to the threshold values of the other phases.

9.12.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`I2t-method`				
_:23971:130	Phase A:Active		• 0 • 1	False
_:23971:131	Phase A:Threshold		0.00 I/Ir*s to 21400000.00 I/Ir*s	10000.00 I/Ir*s
`I2t-method`				
_:24002:130	Phase B:Active		• 0 • 1	False
_:24002:131	Phase B:Threshold		0.00 I/Ir*s to 21400000.00 I/Ir*s	10000.00 I/Ir*s
`I2t-method`				
_:24033:130	Phase C:Active		• 0 • 1	False
_:24033:131	Phase C:Threshold		0.00 I/Ir*s to 21400000.00 I/Ir*s	10000.00 I/Ir*s

9.12.6.4 Information List

No.	Information	Data Class (Type)	Type
`Phase A`			
_:23971:51	Phase A:Mode (controllable)	ENC	C

No.	Information	Data Class (Type)	Type
_:23971:54	Phase A:Inactive	SPS	O
_:23971:52	Phase A:Behavior	ENS	O
_:23971:53	Phase A:Health	ENS	O
_:23971:300	Phase A:2P abrasion remaining	INS	O
_:23971:301	Phase A:2P abrasion cumulated	MV	O
_:23971:302	Phase A:2P abrasion last sw.op.	MV	O
_:23971:303	Phase A:2P abrasion warning	SPS	O
_:23971:304	Phase A:2P abrasion alarm	SPS	O
_:23971:310	Phase A:ΣIx	BCR	O
_:23971:311	Phase A:Warning ΣIx	SPS	O
_:23971:320	Phase A:ΣI²t	BCR	O
_:23971:321	Phase A:Warning ΣI²t	SPS	O
_:23971:330	Phase A:Make time	MV	O
_:23971:331	Phase A:Make-time warning	SPS	O
_:23971:332	Phase A:Make-time alarm	SPS	O
_:23971:340	Phase A:Break time	MV	O
_:23971:341	Phase A:Break-time warning	SPS	O
_:23971:342	Phase A:Break-time alarm	SPS	O
_:23971:350	Phase A:Aux.-contact time open	MV	O
_:23971:351	Phase A:Aux.c. time open warn.	SPS	O
_:23971:352	Phase A:Aux.c. time open alarm	SPS	O
_:23971:353	Phase A:Reaction time open	MV	O
_:23971:354	Phase A:React. time open warn.	SPS	O
_:23971:355	Phase A:React. time open alarm	SPS	O
_:23971:356	Phase A:Aux.c. travel time open	MV	O
_:23971:360	Phase A:Aux.-cont. time close	MV	O
_:23971:361	Phase A:Aux.c. time close warn.	SPS	O
_:23971:362	Phase A:Aux.c. time close alarm	SPS	O
_:23971:363	Phase A:Reaction time close	MV	O
_:23971:364	Phase A:React. time close warn.	SPS	O
_:23971:365	Phase A:React. time close alarm	SPS	O
_:23971:366	Phase A:Aux.c. travel time close	MV	O
Phase B			
_:24002:51	Phase B:Mode (controllable)	ENC	C
_:24002:54	Phase B:Inactive	SPS	O
_:24002:52	Phase B:Behavior	ENS	O
_:24002:53	Phase B:Health	ENS	O
_:24002:300	Phase B:2P abrasion remaining	INS	O
_:24002:301	Phase B:2P abrasion cumulated	MV	O
_:24002:302	Phase B:2P abrasion last sw.op.	MV	O
_:24002:303	Phase B:2P abrasion warning	SPS	O
_:24002:304	Phase B:2P abrasion alarm	SPS	O
_:24002:310	Phase B:ΣIx	BCR	O
_:24002:311	Phase B:Warning ΣIx	SPS	O
_:24002:320	Phase B:ΣI²t	BCR	O
_:24002:321	Phase B:Warning ΣI²t	SPS	O

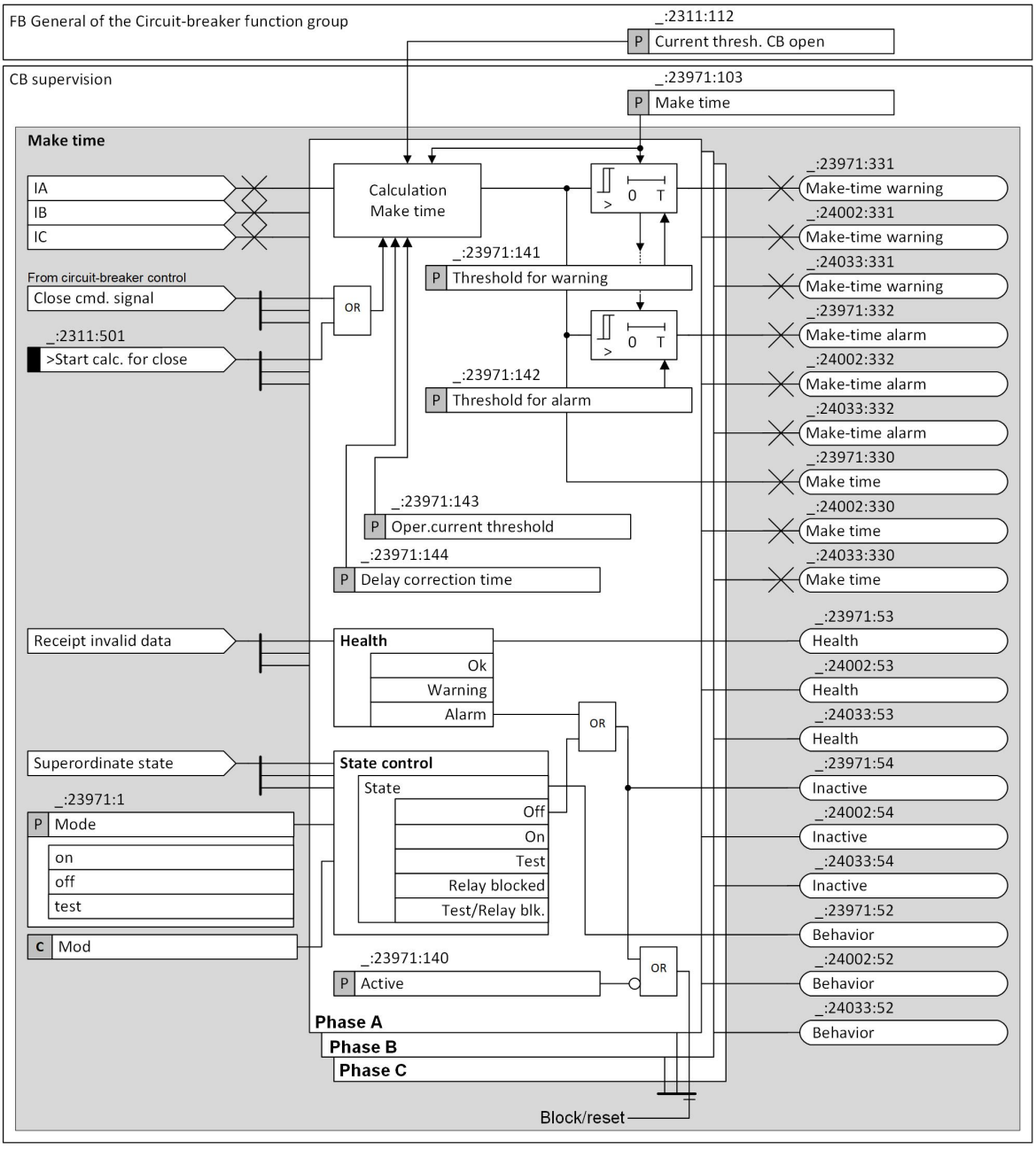
No.	Information	Data Class (Type)	Type
_:24002:330	Phase B:Make time	MV	O
_:24002:331	Phase B:Make-time warning	SPS	O
_:24002:332	Phase B:Make-time alarm	SPS	O
_:24002:340	Phase B:Break time	MV	O
_:24002:341	Phase B:Break-time warning	SPS	O
_:24002:342	Phase B:Break-time alarm	SPS	O
_:24002:350	Phase B:Aux.-contact time open	MV	O
_:24002:351	Phase B:Aux.c. time open warn.	SPS	O
_:24002:352	Phase B:Aux.c. time open alarm	SPS	O
_:24002:353	Phase B:Reaction time open	MV	O
_:24002:354	Phase B:React. time open warn.	SPS	O
_:24002:355	Phase B:React. time open alarm	SPS	O
_:24002:356	Phase B:Aux.c. travel time open	MV	O
_:24002:360	Phase B:Aux.-cont. time close	MV	O
_:24002:361	Phase B:Aux.c. time close warn.	SPS	O
_:24002:362	Phase B:Aux.c. time close alarm	SPS	O
_:24002:363	Phase B:Reaction time close	MV	O
_:24002:364	Phase B:React. time close warn.	SPS	O
_:24002:365	Phase B:React. time close alarm	SPS	O
_:24002:366	Phase B:Aux.c. travel time close	MV	O
Phase C			
_:24033:51	Phase C:Mode (controllable)	ENC	C
_:24033:54	Phase C:Inactive	SPS	O
_:24033:52	Phase C:Behavior	ENS	O
_:24033:53	Phase C:Health	ENS	O
_:24033:300	Phase C:2P abrasion remaining	INS	O
_:24033:301	Phase C:2P abrasion cumulated	MV	O
_:24033:302	Phase C:2P abrasion last sw.op.	MV	O
_:24033:303	Phase C:2P abrasion warning	SPS	O
_:24033:304	Phase C:2P abrasion alarm	SPS	O
_:24033:310	Phase C:ΣIx	BCR	O
_:24033:311	Phase C:Warning ΣIx	SPS	O
_:24033:320	Phase C:ΣI²t	BCR	O
_:24033:321	Phase C:Warning ΣI²t	SPS	O
_:24033:330	Phase C:Make time	MV	O
_:24033:331	Phase C:Make-time warning	SPS	O
_:24033:332	Phase C:Make-time alarm	SPS	O
_:24033:340	Phase C:Break time	MV	O
_:24033:341	Phase C:Break-time warning	SPS	O
_:24033:342	Phase C:Break-time alarm	SPS	O
_:24033:350	Phase C:Aux.-contact time open	MV	O
_:24033:351	Phase C:Aux.c. time open warn.	SPS	O
_:24033:352	Phase C:Aux.c. time open alarm	SPS	O
_:24033:353	Phase C:Reaction time open	MV	O
_:24033:354	Phase C:React. time open warn.	SPS	O
_:24033:355	Phase C:React. time open alarm	SPS	O

No.	Information	Data Class (Type)	Type
_:24033:356	Phase C:Aux.c. travel time open	MV	O
_:24033:360	Phase C:Aux.-cont. time close	MV	O
_:24033:361	Phase C:Aux.c. time close warn.	SPS	O
_:24033:362	Phase C:Aux.c. time close alarm	SPS	O
_:24033:363	Phase C:Reaction time close	MV	O
_:24033:364	Phase C:React. time close warn.	SPS	O
_:24033:365	Phase C:React. time close alarm	SPS	O
_:24033:366	Phase C:Aux.c. travel time close	MV	O

9.12.7 Make Time

9.12.7.1 Description

Logic of the Stage



[lo_LS-Überwachung_Einschaltzeit, 2, en_US]

Figure 9-48 Logic of the Make Time

Operating Mode

The stage for the monitoring of the circuit-breaker make time calculates phase-selectively the time between the circuit-breaker closing command and the point in time when the current exceeds the **`Oper.current threshold`**. If this threshold has not been exceeded after 2.5 times the value of the parameter **`Make time`**, the measurement is canceled and the output value *`Make time`* is set to 0 and marked with the quality invalid.

If one phase of the current has exceeded the parameter **Oper.current threshold** or the parameter **Current thresh. CB open** at the time of the circuit-breaker closing command, the measurement is canceled and the output value *Make time* is marked with the quality invalid.

You can define 2 independent thresholds for the monitoring of the measured make time. When these thresholds are exceeded or undershot, the corresponding outputs *Make-time warning* and *Make-time alarm* are activated for 100 ms. These can be routed in the log.

9.12.7.2 Application and Setting Notes

NOTE

The following parameters apply to one phase. The descriptions apply similarly to the parameters of the remaining phases.

Parameter: Active

- Default setting **(_:23971:140) Active** = ***inactive***

With the parameter **Active**, you switch on the method.

Parameter: Threshold for warning

- Default setting **(_:23971:141) Threshold for warning** = ***5 %***

With the parameter **Threshold for warning**, you define the percentage the measured value is allowed to exceed or undershot the parameter **Make time** at the output *Make time*, before the output *Make-time warning* is set. The output *Make-time warning* then drops out after 100 ms.

Parameter: Threshold for alarm

- Default setting **(_:23971:142) Threshold for alarm** = ***10 %***

With the parameter **Threshold for alarm**, you define the percentage the measured value is allowed to exceed or undershot the parameter **Make time** at the output *Make time*, before the output *Make-time alarm* is set. The output *Make-time alarm* then drops out after 100 ms.

Parameter: Oper.current threshold

- Default setting **(_:23971:143) Oper.current threshold** = ***0.100 A***

With the parameter **Oper.current threshold**, you define the current threshold. If the measured value exceeds this threshold, the measured value is detected as flowing operating current. As soon as an operating current flows, the end of the time interval *Make time* is detected.

Parameter: Delay correction time

- Default setting **(_:23971:144) Delay correction time** = ***0.000 s***

With the parameter **Delay correction time**, you define a correction value which will be subtracted from the *Make time* during calculation. This allows you to compensate delays caused by the system, for example, relay residual times, if necessary.

9.12.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Make time				
_:23971:140	Phase A:Active		• 0 • 1	False
_:23971:141	Phase A:Threshold for warning		1 % to 100 %	5 %

Addr.	Parameter	C	Setting Options	Default Setting
_:23971:142	Phase A:Threshold for alarm		1 % to 100 %	10 %
_:23971:143	Phase A:Oper.current threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:23971:144	Phase A:Delay correction time		-50 ms to 50 ms	0 ms
Make time				
_:24002:140	Phase B:Active		• 0 • 1	False
_:24002:141	Phase B:Threshold for warning		1 % to 100 %	5 %
_:24002:142	Phase B:Threshold for alarm		1 % to 100 %	10 %
_:24002:143	Phase B:Oper.current threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:24002:144	Phase B:Delay correction time		-50 ms to 50 ms	0 ms
Make time				
_:24033:140	Phase C:Active		• 0 • 1	False
_:24033:141	Phase C:Threshold for warning		1 % to 100 %	5 %
_:24033:142	Phase C:Threshold for alarm		1 % to 100 %	10 %
_:24033:143	Phase C:Oper.current threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:24033:144	Phase C:Delay correction time		-50 ms to 50 ms	0 ms

9.12.7.4 Information List

No.	Information	Data Class (Type)	Type
Phase A			
_:23971:51	Phase A:Mode (controllable)	ENC	C
_:23971:54	Phase A:Inactive	SPS	O
_:23971:52	Phase A:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:23971:53	Phase A:Health	ENS	O
_:23971:300	Phase A:2P abrasion remaining	INS	O
_:23971:301	Phase A:2P abrasion cumulated	MV	O
_:23971:302	Phase A:2P abrasion last sw.op.	MV	O
_:23971:303	Phase A:2P abrasion warning	SPS	O
_:23971:304	Phase A:2P abrasion alarm	SPS	O
_:23971:310	Phase A:ΣIx	BCR	O
_:23971:311	Phase A:Warning ΣIx	SPS	O
_:23971:320	Phase A:ΣI²t	BCR	O
_:23971:321	Phase A:Warning ΣI²t	SPS	O
_:23971:330	Phase A:Make time	MV	O
_:23971:331	Phase A:Make-time warning	SPS	O
_:23971:332	Phase A:Make-time alarm	SPS	O
_:23971:340	Phase A:Break time	MV	O
_:23971:341	Phase A:Break-time warning	SPS	O
_:23971:342	Phase A:Break-time alarm	SPS	O
_:23971:350	Phase A:Aux.-contact time open	MV	O
_:23971:351	Phase A:Aux.c. time open warn.	SPS	O
_:23971:352	Phase A:Aux.c. time open alarm	SPS	O
_:23971:353	Phase A:Reaction time open	MV	O
_:23971:354	Phase A:React. time open warn.	SPS	O
_:23971:355	Phase A:React. time open alarm	SPS	O
_:23971:356	Phase A:Aux.c. travel time open	MV	O
_:23971:360	Phase A:Aux.-cont. time close	MV	O
_:23971:361	Phase A:Aux.c. time close warn.	SPS	O
_:23971:362	Phase A:Aux.c. time close alarm	SPS	O
_:23971:363	Phase A:Reaction time close	MV	O
_:23971:364	Phase A:React. time close warn.	SPS	O
_:23971:365	Phase A:React. time close alarm	SPS	O
_:23971:366	Phase A:Aux.c. travel time close	MV	O
Phase B			
_:24002:51	Phase B:Mode (controllable)	ENC	C
_:24002:54	Phase B:Inactive	SPS	O
_:24002:52	Phase B:Behavior	ENS	O
_:24002:53	Phase B:Health	ENS	O
_:24002:300	Phase B:2P abrasion remaining	INS	O
_:24002:301	Phase B:2P abrasion cumulated	MV	O
_:24002:302	Phase B:2P abrasion last sw.op.	MV	O
_:24002:303	Phase B:2P abrasion warning	SPS	O
_:24002:304	Phase B:2P abrasion alarm	SPS	O
_:24002:310	Phase B:ΣIx	BCR	O
_:24002:311	Phase B:Warning ΣIx	SPS	O
_:24002:320	Phase B:ΣI²t	BCR	O
_:24002:321	Phase B:Warning ΣI²t	SPS	O
_:24002:330	Phase B:Make time	MV	O
_:24002:331	Phase B:Make-time warning	SPS	O

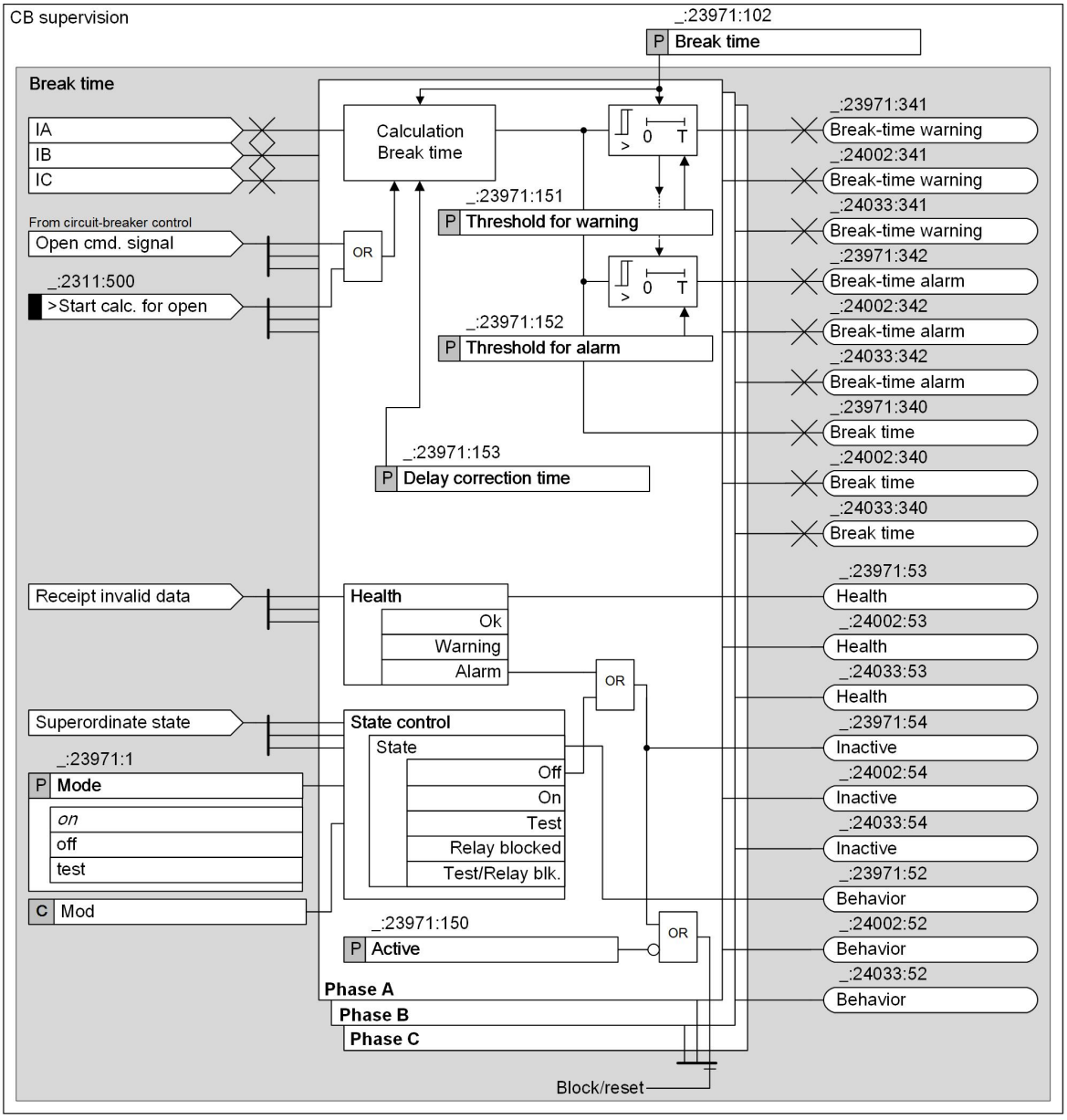
No.	Information	Data Class (Type)	Type
_:24002:332	Phase B:Make-time alarm	SPS	O
_:24002:340	Phase B:Break time	MV	O
_:24002:341	Phase B:Break-time warning	SPS	O
_:24002:342	Phase B:Break-time alarm	SPS	O
_:24002:350	Phase B:Aux.-contact time open	MV	O
_:24002:351	Phase B:Aux.c. time open warn.	SPS	O
_:24002:352	Phase B:Aux.c. time open alarm	SPS	O
_:24002:353	Phase B:Reaction time open	MV	O
_:24002:354	Phase B:React. time open warn.	SPS	O
_:24002:355	Phase B:React. time open alarm	SPS	O
_:24002:356	Phase B:Aux.c. travel time open	MV	O
_:24002:360	Phase B:Aux.-cont. time close	MV	O
_:24002:361	Phase B:Aux.c. time close warn.	SPS	O
_:24002:362	Phase B:Aux.c. time close alarm	SPS	O
_:24002:363	Phase B:Reaction time close	MV	O
_:24002:364	Phase B:React. time close warn.	SPS	O
_:24002:365	Phase B:React. time close alarm	SPS	O
_:24002:366	Phase B:Aux.c. travel time close	MV	O
Phase C			
_:24033:51	Phase C:Mode (controllable)	ENC	C
_:24033:54	Phase C:Inactive	SPS	O
_:24033:52	Phase C:Behavior	ENS	O
_:24033:53	Phase C:Health	ENS	O
_:24033:300	Phase C:2P abrasion remaining	INS	O
_:24033:301	Phase C:2P abrasion cumulated	MV	O
_:24033:302	Phase C:2P abrasion last sw.op.	MV	O
_:24033:303	Phase C:2P abrasion warning	SPS	O
_:24033:304	Phase C:2P abrasion alarm	SPS	O
_:24033:310	Phase C:ΣIx	BCR	O
_:24033:311	Phase C:Warning ΣIx	SPS	O
_:24033:320	Phase C:ΣI²t	BCR	O
_:24033:321	Phase C:Warning ΣI²t	SPS	O
_:24033:330	Phase C:Make time	MV	O
_:24033:331	Phase C:Make-time warning	SPS	O
_:24033:332	Phase C:Make-time alarm	SPS	O
_:24033:340	Phase C:Break time	MV	O
_:24033:341	Phase C:Break-time warning	SPS	O
_:24033:342	Phase C:Break-time alarm	SPS	O
_:24033:350	Phase C:Aux.-contact time open	MV	O
_:24033:351	Phase C:Aux.c. time open warn.	SPS	O
_:24033:352	Phase C:Aux.c. time open alarm	SPS	O
_:24033:353	Phase C:Reaction time open	MV	O
_:24033:354	Phase C:React. time open warn.	SPS	O
_:24033:355	Phase C:React. time open alarm	SPS	O
_:24033:356	Phase C:Aux.c. travel time open	MV	O
_:24033:360	Phase C:Aux.-cont. time close	MV	O

No.	Information	Data Class (Type)	Type
_:24033:361	Phase C:Aux.c. time close warn.	SPS	O
_:24033:362	Phase C:Aux.c. time close alarm	SPS	O
_:24033:363	Phase C:Reaction time close	MV	O
_:24033:364	Phase C:React. time close warn.	SPS	O
_:24033:365	Phase C:React. time close alarm	SPS	O
_:24033:366	Phase C:Aux.c. travel time close	MV	O

9.12.8 Break Time

9.12.8.1 Description

Logic of the Stage



[lo_LS-Überwachung_Ausschaltzeit, 1, en_US]

Figure 9-49 Logic of the Break Time

Operating Mode

The stage for the monitoring of the circuit-breaker break time calculates phase-selective the time between the circuit-breaker opening command and the point to which no load current flows. In the event of a restrike after the current was lost, the measurement of the break time is extended accordingly. If a current is still measured after 2.5 times of the value parameter **`Break time`**, the measurement is canceled and the output value ***`Break time`*** is set to 0 and marked with the quality invalid.

If no load current is measured at the time of the break time command, the measurement for the relevant phase is canceled and the output value ***`Break time`*** is marked with the quality invalid.

You can define 2 independent thresholds for the monitoring of the measured break time. When these thresholds are exceeded or undershot, the corresponding outputs *Break-time warning* and *Break-time alarm* are activated for 100 ms. These can be routed in the log.

9.12.8.2 Application and Setting Notes



NOTE

The following parameters apply to one phase. The descriptions apply similarly to the parameters of the remaining phases.

Parameter: Active

- Default setting **(_:23971:150) Active** = ***inactive***

With the parameter **Active**, you switch on the method.

Parameter: Threshold for warning

- Default setting **(_:23971:151) Threshold for warning** = ***5 %***

With the parameter **Threshold for warning**, you define the percentage the measured value is allowed to exceed or undershot the parameter **Break time** at the output *Break time*, before the output *Break-time warning* is set. The output *Break-time warning* then drops out after 100 ms.

Parameter: Threshold for alarm

- Default setting **(_:23971:152) Threshold for alarm** = ***10 %***

With the parameter **Threshold for alarm**, you define the percentage the measured value is allowed to exceed or undershot the parameter **Break time** at the output *Break time*, before the output *Break-time alarm* is set. The output *Break-time alarm* then drops out after 100 ms.

Parameter: Delay correction time

- Default setting **(_:23971:153) Delay correction time** = ***0.000 s***

With the parameter **Delay correction time**, you define a correction value which will be subtracted from the *Break time* during calculation. This allows you to compensate delays caused by the system, for example, relay residual times, if necessary.

9.12.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Break time				
_:23971:150	Phase A:Active		• 0 • 1	False
_:23971:151	Phase A:Threshold for warning		1 % to 100 %	5 %
_:23971:152	Phase A:Threshold for alarm		1 % to 100 %	10 %
_:23971:153	Phase A:Delay correction time		-50 ms to 50 ms	0 ms
Break time				
_:24002:150	Phase B:Active		• 0 • 1	False
_:24002:151	Phase B:Threshold for warning		1 % to 100 %	5 %

Addr.	Parameter	C	Setting Options	Default Setting
_:24002:152	Phase B:Threshold for alarm		1 % to 100 %	10 %
_:24002:153	Phase B:Delay correction time		-50 ms to 50 ms	0 ms
Break time				
_:24033:150	Phase C:Active		• 0 • 1	False
_:24033:151	Phase C:Threshold for warning		1 % to 100 %	5 %
_:24033:152	Phase C:Threshold for alarm		1 % to 100 %	10 %
_:24033:153	Phase C:Delay correction time		-50 ms to 50 ms	0 ms

9.12.8.4 Information List

No.	Information	Data Class (Type)	Type
Phase A			
_:23971:51	Phase A:Mode (controllable)	ENC	C
_:23971:54	Phase A:Inactive	SPS	O
_:23971:52	Phase A:Behavior	ENS	O
_:23971:53	Phase A:Health	ENS	O
_:23971:300	Phase A:2P abrasion remaining	INS	O
_:23971:301	Phase A:2P abrasion cumulated	MV	O
_:23971:302	Phase A:2P abrasion last sw.op.	MV	O
_:23971:303	Phase A:2P abrasion warning	SPS	O
_:23971:304	Phase A:2P abrasion alarm	SPS	O
_:23971:310	Phase A:ΣIx	BCR	O
_:23971:311	Phase A:Warning ΣIx	SPS	O
_:23971:320	Phase A:ΣI²t	BCR	O
_:23971:321	Phase A:Warning ΣI²t	SPS	O
_:23971:330	Phase A:Make time	MV	O
_:23971:331	Phase A:Make-time warning	SPS	O
_:23971:332	Phase A:Make-time alarm	SPS	O
_:23971:340	Phase A:Break time	MV	O
_:23971:341	Phase A:Break-time warning	SPS	O
_:23971:342	Phase A:Break-time alarm	SPS	O
_:23971:350	Phase A:Aux.-contact time open	MV	O
_:23971:351	Phase A:Aux.c. time open warn.	SPS	O
_:23971:352	Phase A:Aux.c. time open alarm	SPS	O
_:23971:353	Phase A:Reaction time open	MV	O
_:23971:354	Phase A:React. time open warn.	SPS	O
_:23971:355	Phase A:React. time open alarm	SPS	O
_:23971:356	Phase A:Aux.c. travel time open	MV	O
_:23971:360	Phase A:Aux.-cont. time close	MV	O
_:23971:361	Phase A:Aux.c. time close warn.	SPS	O
_:23971:362	Phase A:Aux.c. time close alarm	SPS	O
_:23971:363	Phase A:Reaction time close	MV	O

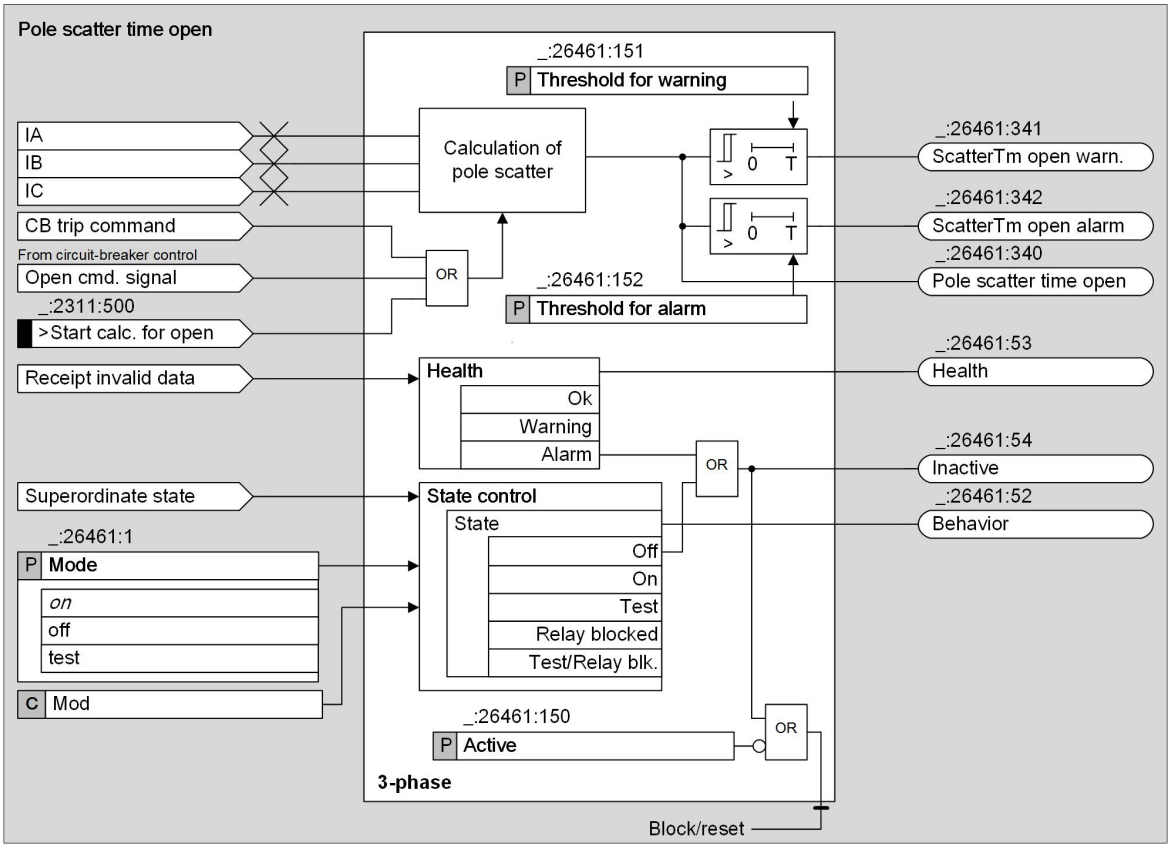
No.	Information	Data Class (Type)	Type
_:23971:364	Phase A:React. time close warn.	SPS	O
_:23971:365	Phase A:React. time close alarm	SPS	O
_:23971:366	Phase A:Aux.c. travel time close	MV	O
Phase B			
_:24002:51	Phase B:Mode (controllable)	ENC	C
_:24002:54	Phase B:Inactive	SPS	O
_:24002:52	Phase B:Behavior	ENS	O
_:24002:53	Phase B:Health	ENS	O
_:24002:300	Phase B:2P abrasion remaining	INS	O
_:24002:301	Phase B:2P abrasion cumulated	MV	O
_:24002:302	Phase B:2P abrasion last sw.op.	MV	O
_:24002:303	Phase B:2P abrasion warning	SPS	O
_:24002:304	Phase B:2P abrasion alarm	SPS	O
_:24002:310	Phase B:ΣIx	BCR	O
_:24002:311	Phase B:Warning ΣIx	SPS	O
_:24002:320	Phase B:ΣI²t	BCR	O
_:24002:321	Phase B:Warning ΣI²t	SPS	O
_:24002:330	Phase B:Make time	MV	O
_:24002:331	Phase B:Make-time warning	SPS	O
_:24002:332	Phase B:Make-time alarm	SPS	O
_:24002:340	Phase B:Break time	MV	O
_:24002:341	Phase B:Break-time warning	SPS	O
_:24002:342	Phase B:Break-time alarm	SPS	O
_:24002:350	Phase B:Aux.-contact time open	MV	O
_:24002:351	Phase B:Aux.c. time open warn.	SPS	O
_:24002:352	Phase B:Aux.c. time open alarm	SPS	O
_:24002:353	Phase B:Reaction time open	MV	O
_:24002:354	Phase B:React. time open warn.	SPS	O
_:24002:355	Phase B:React. time open alarm	SPS	O
_:24002:356	Phase B:Aux.c. travel time open	MV	O
_:24002:360	Phase B:Aux.-cont. time close	MV	O
_:24002:361	Phase B:Aux.c. time close warn.	SPS	O
_:24002:362	Phase B:Aux.c. time close alarm	SPS	O
_:24002:363	Phase B:Reaction time close	MV	O
_:24002:364	Phase B:React. time close warn.	SPS	O
_:24002:365	Phase B:React. time close alarm	SPS	O
_:24002:366	Phase B:Aux.c. travel time close	MV	O
Phase C			
_:24033:51	Phase C:Mode (controllable)	ENC	C
_:24033:54	Phase C:Inactive	SPS	O
_:24033:52	Phase C:Behavior	ENS	O
_:24033:53	Phase C:Health	ENS	O
_:24033:300	Phase C:2P abrasion remaining	INS	O
_:24033:301	Phase C:2P abrasion cumulated	MV	O
_:24033:302	Phase C:2P abrasion last sw.op.	MV	O
_:24033:303	Phase C:2P abrasion warning	SPS	O

No.	Information	Data Class (Type)	Type
_:24033:304	Phase C:2P abrasion alarm	SPS	O
_:24033:310	Phase C:ΣIx	BCR	O
_:24033:311	Phase C:Warning ΣIx	SPS	O
_:24033:320	Phase C:ΣI²t	BCR	O
_:24033:321	Phase C:Warning ΣI²t	SPS	O
_:24033:330	Phase C:Make time	MV	O
_:24033:331	Phase C:Make-time warning	SPS	O
_:24033:332	Phase C:Make-time alarm	SPS	O
_:24033:340	Phase C:Break time	MV	O
_:24033:341	Phase C:Break-time warning	SPS	O
_:24033:342	Phase C:Break-time alarm	SPS	O
_:24033:350	Phase C:Aux.-contact time open	MV	O
_:24033:351	Phase C:Aux.c. time open warn.	SPS	O
_:24033:352	Phase C:Aux.c. time open alarm	SPS	O
_:24033:353	Phase C:Reaction time open	MV	O
_:24033:354	Phase C:React. time open warn.	SPS	O
_:24033:355	Phase C:React. time open alarm	SPS	O
_:24033:356	Phase C:Aux.c. travel time open	MV	O
_:24033:360	Phase C:Aux.-cont. time close	MV	O
_:24033:361	Phase C:Aux.c. time close warn.	SPS	O
_:24033:362	Phase C:Aux.c. time close alarm	SPS	O
_:24033:363	Phase C:Reaction time close	MV	O
_:24033:364	Phase C:React. time close warn.	SPS	O
_:24033:365	Phase C:React. time close alarm	SPS	O
_:24033:366	Phase C:Aux.c. travel time close	MV	O

9.12.9 Pole Scatter Time Open

9.12.9.1 Description

Logic of the Stage

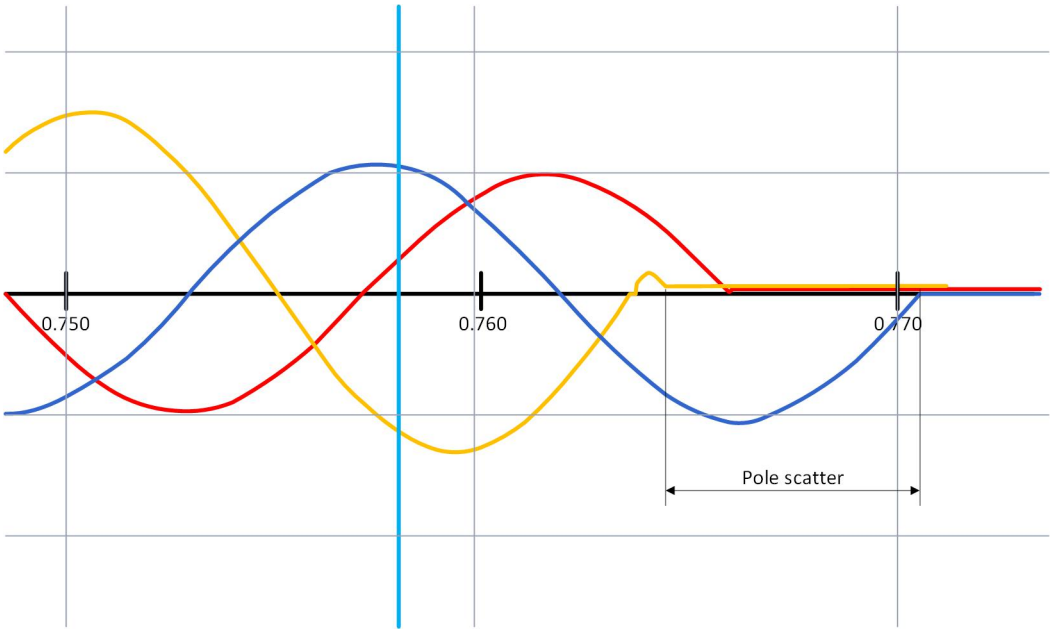


[lo_stage_pole-scatter_open, 1, en_US]

Figure 9-50 Logic of the Stage Pole Scatter Time Open

Operating Mode

The time between the extinction of the current of the first phase until the extinction of the last phase current when opening the circuit breaker is the pole scatter time. A greater time difference can lead to conclusions on the circuit-breaker abrasion.



[dw_charact_pole-scatter, 2, en_US]

Figure 9-51 Pole Scatter Time

The start criterion can be either the trip command of the circuit breaker or the input signal *>Start calc. for open*. You can set 2 independent threshold values for the supervision of the measured pole scatter time. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms.

9.12.9.2 Application and Setting Notes

Parameter: Threshold for warning

- Default setting **(_:26461:151) Threshold for warning** = ***5 ms***

With the parameter **Threshold for warning** , you define from which measured pole scatter time the output *ScatterTm open warn.* is set. The output *ScatterTm open warn.* drops out after 100 ms.

Parameter: Threshold for alarm

- Default setting **(_:26461:152) Threshold for alarm** = ***10 ms***

With the parameter **Threshold for alarm**, you define from which measured pole scatter time the output *ScatterTm open alarm* is set. The output *ScatterTm open alarm* drops out after 100 ms.

9.12.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Pole scatter time open				
_:26461:150	3-Phase:Active		• 0 • 1	unwahr
_:26461:151	3-Phase:Threshold for warning		1 ms to 100 ms	5 ms
_:26461:152	3-Phase:Threshold for alarm		1 ms to 100 ms	10 ms

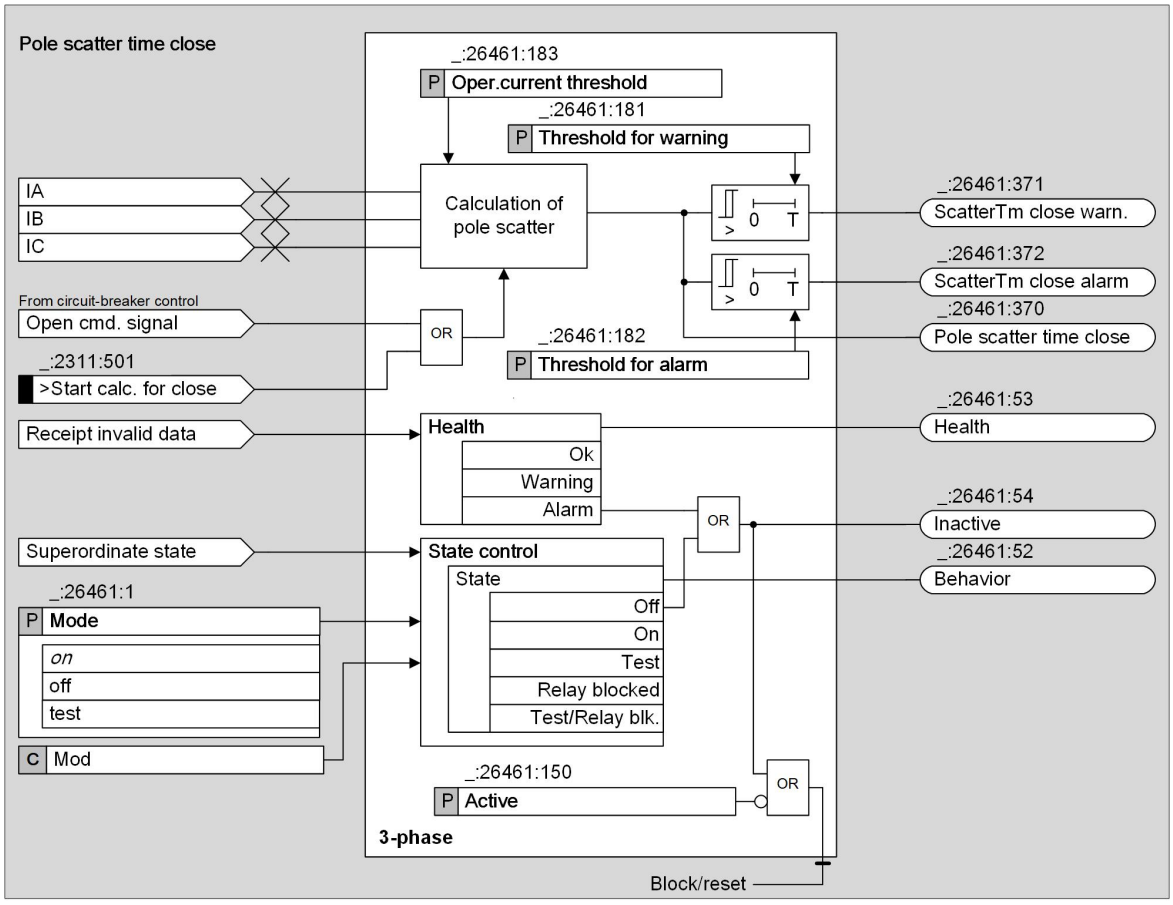
9.12.9.4 Information List

No.	Information	Data Class (Type)	Type
Phase C			
_:24033:51	Phase C:Mode (controllable)	ENC	C
_:24033:54	Phase C:Inactive	SPS	O
_:24033:52	Phase C:Behavior	ENS	O
_:24033:53	Phase C:Health	ENS	O
_:24033:300	Phase C:2P abrasion remaining	INS	O
_:24033:301	Phase C:2P abrasion cumulated	MV	O
_:24033:302	Phase C:2P abrasion last sw.op.	MV	O
_:24033:303	Phase C:2P abrasion warning	SPS	O
_:24033:304	Phase C:2P abrasion alarm	SPS	O
_:24033:310	Phase C:ΣIx	BCR	O
_:24033:311	Phase C:Warning ΣIx	SPS	O
_:24033:320	Phase C:ΣI²t	BCR	O
_:24033:321	Phase C:Warning ΣI²t	SPS	O
_:24033:330	Phase C:Make time	MV	O
_:24033:331	Phase C:Make-time warning	SPS	O
_:24033:332	Phase C:Make-time alarm	SPS	O
_:24033:340	Phase C:Break time	MV	O
_:24033:341	Phase C:Break-time warning	SPS	O
_:24033:342	Phase C:Break-time alarm	SPS	O
_:24033:350	Phase C:Aux.-contact time open	MV	O
_:24033:351	Phase C:Aux.c. time open warn.	SPS	O
_:24033:352	Phase C:Aux.c. time open alarm	SPS	O
_:24033:353	Phase C:Reaction time open	MV	O
_:24033:354	Phase C:React. time open warn.	SPS	O
_:24033:355	Phase C:React. time open alarm	SPS	O
_:24033:356	Phase C:Aux.c. travel time open	MV	O
_:24033:360	Phase C:Aux.-cont. time close	MV	O
_:24033:361	Phase C:Aux.c. time close warn.	SPS	O
_:24033:362	Phase C:Aux.c. time close alarm	SPS	O
_:24033:363	Phase C:Reaction time close	MV	O
_:24033:364	Phase C:React. time close warn.	SPS	O
_:24033:365	Phase C:React. time close alarm	SPS	O
_:24033:366	Phase C:Aux.c. travel time close	MV	O

9.12.10 Pole scatter time close

9.12.10.1 Description

Logic of the Stage



[lo_stage_pole-scatter_close, 1, en_US]

Figure 9-52 Logic of the Stage Pole Scatter Time Close

Operating Mode

The time between reaching the operating current threshold of the first phase and reaching the operating current threshold of the last phase when closing the circuit breaker is the pole scatter time. A change of the time difference can lead to conclusions on the wear condition of the circuit breaker.

The start criterion can be either the close command of the circuit breaker or the input signal *>Start calc. for close*. You can set 2 independent threshold values for monitoring the measured pole scatter time. If a threshold value is exceeded, the corresponding output *Warning/alarm* is activated for 100 ms.

If the calculation is not finished after one second, it is canceled and the output signal *Pole scatter time close* is set to 0 and marked with the quality *invalid*.

9.12.10.2 Application and Setting Notes

Parameter: `Threshold for warning`

- Default setting **`(_:26461:181) Threshold for warning`** = ***5 ms***

With the parameter **`Threshold for warning`**, you define from which measured pole scatter time the output *ScatterTm close warn.* is set. The output *ScatterTm close warn.* drops out after 100 ms.

Parameter: `Threshold for alarm`

- Default setting **`(_:26461:182) Threshold for alarm`** = ***`10 ms`***

With the parameter **`Threshold for alarm`**, you define from which measured pole scatter time the output *`ScatterTm close alarm`* is set. The output *`ScatterTm close alarm`* drops out after 100 ms.

Parameter: `Oper.current threshold`

- Default setting **`(_:26461:183) Oper.current threshold`** = ***`0.1 A`***

With the parameter **`Oper.current threshold`**, you define from which measured current the poles of the circuit breaker are considered to be closed. The pole scattering time is determined from the time span between exceeding the threshold of the 1st phase and exceeding the threshold of the last phase.

9.12.10.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Pole scatter time close`				
_:26461:180	3-Phase: Active		• 0 • 1	false
_:26461:181	3-Phase: Threshold for warning		1 ms to 100 ms	5 ms
_:26461:182	3-Phase: Threshold for alarm		1 ms to 100 ms	10 ms
_:26461:183	3-Phase: Oper.current threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A

9.12.10.4 Information List

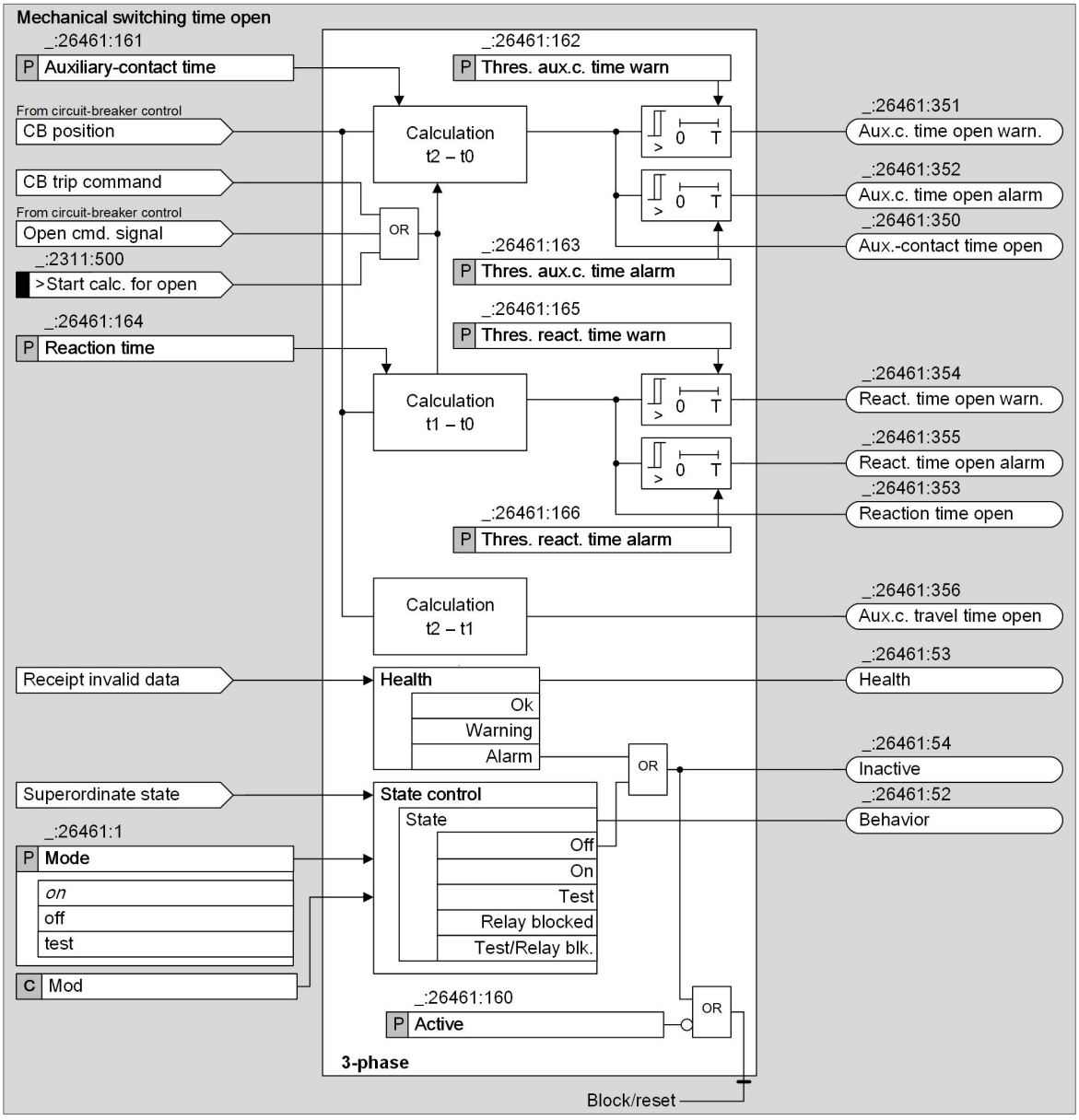
No.	Information	Data Class (Type)	Type
`3-Phase`			
_:26461:51	3-Phase:Mode (controllable)	ENC	C
_:26461:54	3-Phase:Inactive	SPS	O
_:26461:52	3-Phase:Behavior	ENS	O
_:26461:53	3-Phase:Health	ENS	O
_:26461:340	3-Phase:Pole scatter time open	MV	O
_:26461:341	3-Phase:ScatterTm open warn.	SPS	O
_:26461:342	3-Phase:ScatterTm open alarm	SPS	O
_:26461:370	3-Phase:Pole scatter time close	MV	O
_:26461:371	3-Phase:ScatterTm close warn.	SPS	O
_:26461:372	3-Phase:ScatterTm close alarm	SPS	O
_:26461:350	3-Phase:Aux.-contact time open	MV	O
_:26461:351	3-Phase:Aux.c. time open warn.	SPS	O
_:26461:352	3-Phase:Aux.c. time open alarm	SPS	O
_:26461:353	3-Phase:Reaction time open	MV	O
_:26461:354	3-Phase:React. time open warn.	SPS	O
_:26461:355	3-Phase:React. time open alarm	SPS	O
_:26461:356	3-Phase:Aux.c. travel time open	MV	O

No.	Information	Data Class (Type)	Type
_:26461:360	3-Phase:Aux.-cont. time close	MV	O
_:26461:361	3-Phase:Aux.c. time close warn.	SPS	O
_:26461:362	3-Phase:Aux.c. time close alarm	SPS	O
_:26461:363	3-Phase:Reaction time close	MV	O
_:26461:364	3-Phase:React. time close warn.	SPS	O
_:26461:365	3-Phase:React. time close alarm	SPS	O
_:26461:366	3-Phase:Aux.c. travel time close	MV	O

9.12.11 Mechanical Switching Time Open

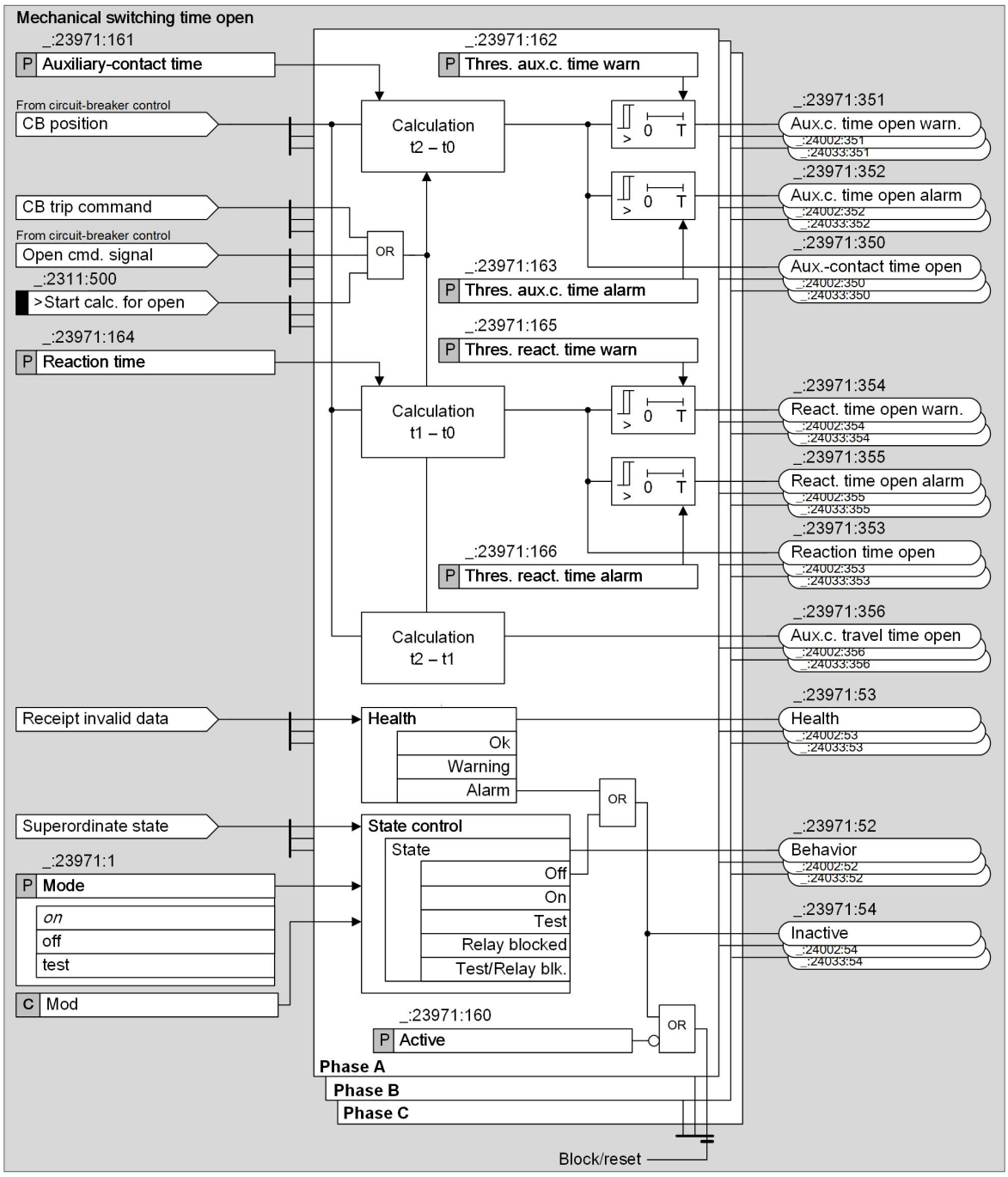
9.12.11.1 Description

Logic of the Stage



[lo_mechanical_Break-time_3phs, 1, en_US]

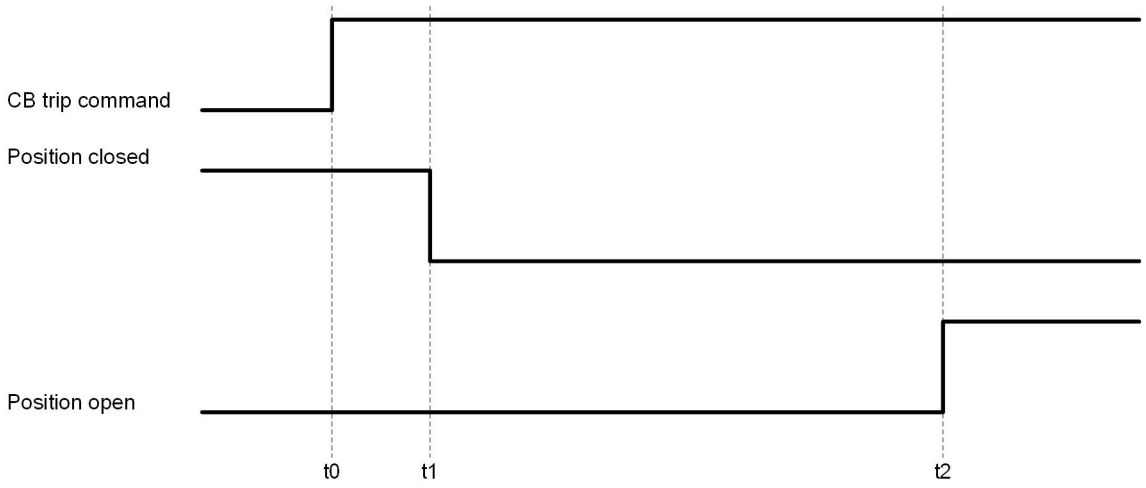
Figure 9-53 Logic of the Stage Mechanical Switching Time Open for Circuit Breakers 3-Pole



[lo_mechanical_Break-time_1phs, 1, en_US]

Figure 9-54 Logic of the Stage Mechanical Switching Time Open for Circuit Breakers 1-Pole

Operating Mode



[dw_charact_cb-breaktime, 1, en_US]

t2 - t0: Auxiliary-contact time opening
t1 - t0: Response time opening
t2 - t1: Auxiliary-contact moving time opening

The stage for supervision of the mechanical switching time opening of the circuit breaker measures the time between the starting criterion (t0) and the point in time when the position of the circuit breaker switches to **Intermediate position** (t1). The stage measures the time between the starting criterion (t0) and the point in time when the position of the circuit breaker switches to **Open** (t2). Additionally, it calculates the auxiliary-contact moving time from the intermediate position (t1) until reaching the position **Open** (t2).

The starting criterion can be either the opening command of the circuit breaker, trip from a protection function or the input signal *>Start calc. for open*.

You can set 2 independent threshold values for the supervision of the measured time t1-t0. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms. You can set 2 independent threshold values for the supervision of the measured time t2-t0. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms. For t2-t1, only the calculated time is to be indicated. There is no warning or alarm threshold.

If you use a 1-pole circuit breaker, the settings and indications are phase-selective. For 3-pole circuit breakers times cannot be determined phase selective. The settings are done in the section **3-phase**.

A precondition for the monitoring of the mechanical switching times is the routing of the open and closed circuit-breaker position in the function group **Circuit breaker**. If you route only one or no circuit-breaker feedbacks, the function **Mechanical switching time open** cannot work and indicates the status *Warning*.

9.12.11.2 Application and Setting Notes

NOTE

The following parameters apply to one phase. The descriptions apply similarly to the parameters of the remaining phases.

Parameter: `Auxiliary-contact time`

- Default setting **`(_:24002:161) Auxiliary-contact time`** = ***35 ms***

With the parameter **`Auxiliary-contact time`**, you define the time period from the circuit-breaker open command until the feedback contacts of the CB indicate **Open**.

Parameter: `Thres. aux.c. time warn`

- Default setting **`(_:24002:162) Thres. aux.c. time warn`** = ***5 ms***

With the parameter **Thres. aux.c. time warn**, you define by how many ms the auxiliary-contact time can be exceeded or undershot before the output ***Aux.c. time open warn.*** is set. The output ***Aux.c. time open warn.*** drops out after 100 ms.

Parameter: Thres. aux.c. time alarm

- Default setting **(_:24002:163) Thres. aux.c. time alarm** = ***10 ms***

With the parameter **Thres. aux.c. time alarm**, you define by how many ms the auxiliary-contact time can be exceeded or undershot before the output ***Aux.c. time open alarm*** is set. The output ***Aux.c. time open alarm*** drops out after 100 ms.

Parameter: Reaction time

- Default setting **(_:24002:164) Reaction time** = ***15 ms***

With the parameter **Reaction time**, you define the time between the circuit-breaker opening command and the indication **Intermediate position** by the feedback contacts of the CB.

Parameter: Thres. react. time warn

- Default setting **(_:24002:165) Thres. react. time warn** = ***3 ms***

With the parameter **Thres. react. time warn**, you define by how many ms the reaction time can be exceeded or undershot before the output ***React. time open warn.*** is set. The output ***React. time open warn.*** drops out after 100 ms.

Parameter: Thres. react. time alarm

- Default setting **(_:24002:166) Thres. react. time alarm** **(_:24033:166) Thres. react. time alarm** = ***5 ms***

With the parameter **Thres. react. time alarm**, you define by how many ms the reaction time can be exceeded or undershot before the output ***React. time open alarm*** is set. The ***React. time open alarm*** drops out after 100 ms.

9.12.11.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Mechanical sw. time open				
_:26461:160	3-Phase:Active		• 0 • 1	unwahr
_:26461:161	3-Phase:Auxiliary-contact time		1 ms to 1000 ms	35 ms
_:26461:162	3-Phase:Thres. aux.c. time warn		1 ms to 1000 ms	5 ms
_:26461:163	3-Phase:Thres. aux.c. time alarm		1 ms to 1000 ms	10 ms
_:26461:164	3-Phase:Reaction time		1 ms to 1000 ms	15 ms
_:26461:165	3-Phase:Thres. react. time warn		1 ms to 1000 ms	3 ms
_:26461:166	3-Phase:Thres. react. time alarm		1 ms to 1000 ms	5 ms
Mechanical sw. time open				
_:23971:160	Phase A:Active		• 0 • 1	unwahr
_:23971:161	Phase A:Auxiliary-contact time		1 ms to 1000 ms	35 ms

Addr.	Parameter	C	Setting Options	Default Setting
_:23971:162	Phase A:Thres. aux.c. time warn		1 ms to 1000 ms	5 ms
_:23971:163	Phase A:Thres. aux.c. time alarm		1 ms to 1000 ms	10 ms
_:23971:164	Phase A:Reaction time		1 ms to 1000 ms	15 ms
_:23971:165	Phase A:Thres. react. time warn		1 ms to 1000 ms	3 ms
_:23971:166	Phase A:Thres. react. time alarm		1 ms to 1000 ms	5 ms
Mechanical sw. time open				
_:24002:160	Phase B:Active		• 0 • 1	unwahr
_:24002:161	Phase B:Auxiliary-contact time		1 ms to 1000 ms	35 ms
_:24002:162	Phase B:Thres. aux.c. time warn		1 ms to 1000 ms	5 ms
_:24002:163	Phase B:Thres. aux.c. time alarm		1 ms to 1000 ms	10 ms
_:24002:164	Phase B:Reaction time		1 ms to 1000 ms	15 ms
_:24002:165	Phase B:Thres. react. time warn		1 ms to 1000 ms	3 ms
_:24002:166	Phase B:Thres. react. time alarm		1 ms to 1000 ms	5 ms
Mechanical sw. time open				
_:24033:160	Phase C:Active		• 0 • 1	unwahr
_:24033:161	Phase C:Auxiliary-contact time		1 ms to 1000 ms	35 ms
_:24033:162	Phase C:Thres. aux.c. time warn		1 ms to 1000 ms	5 ms
_:24033:163	Phase C:Thres. aux.c. time alarm		1 ms to 1000 ms	10 ms
_:24033:164	Phase C:Reaction time		1 ms to 1000 ms	15 ms
_:24033:165	Phase C:Thres. react. time warn		1 ms to 1000 ms	3 ms
_:24033:166	Phase C:Thres. react. time alarm		1 ms to 1000 ms	5 ms

9.12.11.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Start calc. for open	SPS	I
_:2311:501	General:>Start calc. for close	SPS	I
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
3-Phase			
_:26461:51	3-Phase:Mode (controllable)	ENC	C
_:26461:54	3-Phase:Inactive	SPS	O

No.	Information	Data Class (Type)	Type
_:26461:52	3-Phase:Behavior	ENS	O
_:26461:53	3-Phase:Health	ENS	O
_:26461:340	3-Phase:Pole scatter time open	MV	O
_:26461:341	3-Phase:ScatterTm open warn.	SPS	O
_:26461:342	3-Phase:ScatterTm open alarm	SPS	O
_:26461:370	3-Phase:Pole scatter time close	MV	O
_:26461:371	3-Phase:ScatterTm close warn.	SPS	O
_:26461:372	3-Phase:ScatterTm close alarm	SPS	O
_:26461:350	3-Phase:Aux.-contact time open	MV	O
_:26461:351	3-Phase:Aux.c. time open warn.	SPS	O
_:26461:352	3-Phase:Aux.c. time open alarm	SPS	O
_:26461:353	3-Phase:Reaction time open	MV	O
_:26461:354	3-Phase:React. time open warn.	SPS	O
_:26461:355	3-Phase:React. time open alarm	SPS	O
_:26461:356	3-Phase:Aux.c. travel time open	MV	O
_:26461:360	3-Phase:Aux.-cont. time close	MV	O
_:26461:361	3-Phase:Aux.c. time close warn.	SPS	O
_:26461:362	3-Phase:Aux.c. time close alarm	SPS	O
_:26461:363	3-Phase:Reaction time close	MV	O
_:26461:364	3-Phase:React. time close warn.	SPS	O
_:26461:365	3-Phase:React. time close alarm	SPS	O
_:26461:366	3-Phase:Aux.c. travel time close	MV	O
Phase A			
_:23971:51	Phase A:Mode (controllable)	ENC	C
_:23971:54	Phase A:Inactive	SPS	O
_:23971:52	Phase A:Behavior	ENS	O
_:23971:53	Phase A:Health	ENS	O
_:23971:300	Phase A:2P abrasion remaining	INS	O
_:23971:301	Phase A:2P abrasion cumulated	MV	O
_:23971:302	Phase A:2P abrasion last sw.op.	MV	O
_:23971:303	Phase A:2P abrasion warning	SPS	O
_:23971:304	Phase A:2P abrasion alarm	SPS	O
_:23971:310	Phase A:ΣIx	BCR	O
_:23971:311	Phase A:Warning ΣIx	SPS	O
_:23971:320	Phase A:ΣI²t	BCR	O
_:23971:321	Phase A:Warning ΣI²t	SPS	O
_:23971:330	Phase A:Make time	MV	O
_:23971:331	Phase A:Make-time warning	SPS	O
_:23971:332	Phase A:Make-time alarm	SPS	O
_:23971:340	Phase A:Break time	MV	O
_:23971:341	Phase A:Break-time warning	SPS	O
_:23971:342	Phase A:Break-time alarm	SPS	O
_:23971:350	Phase A:Aux.-contact time open	MV	O
_:23971:351	Phase A:Aux.c. time open warn.	SPS	O
_:23971:352	Phase A:Aux.c. time open alarm	SPS	O
_:23971:353	Phase A:Reaction time open	MV	O

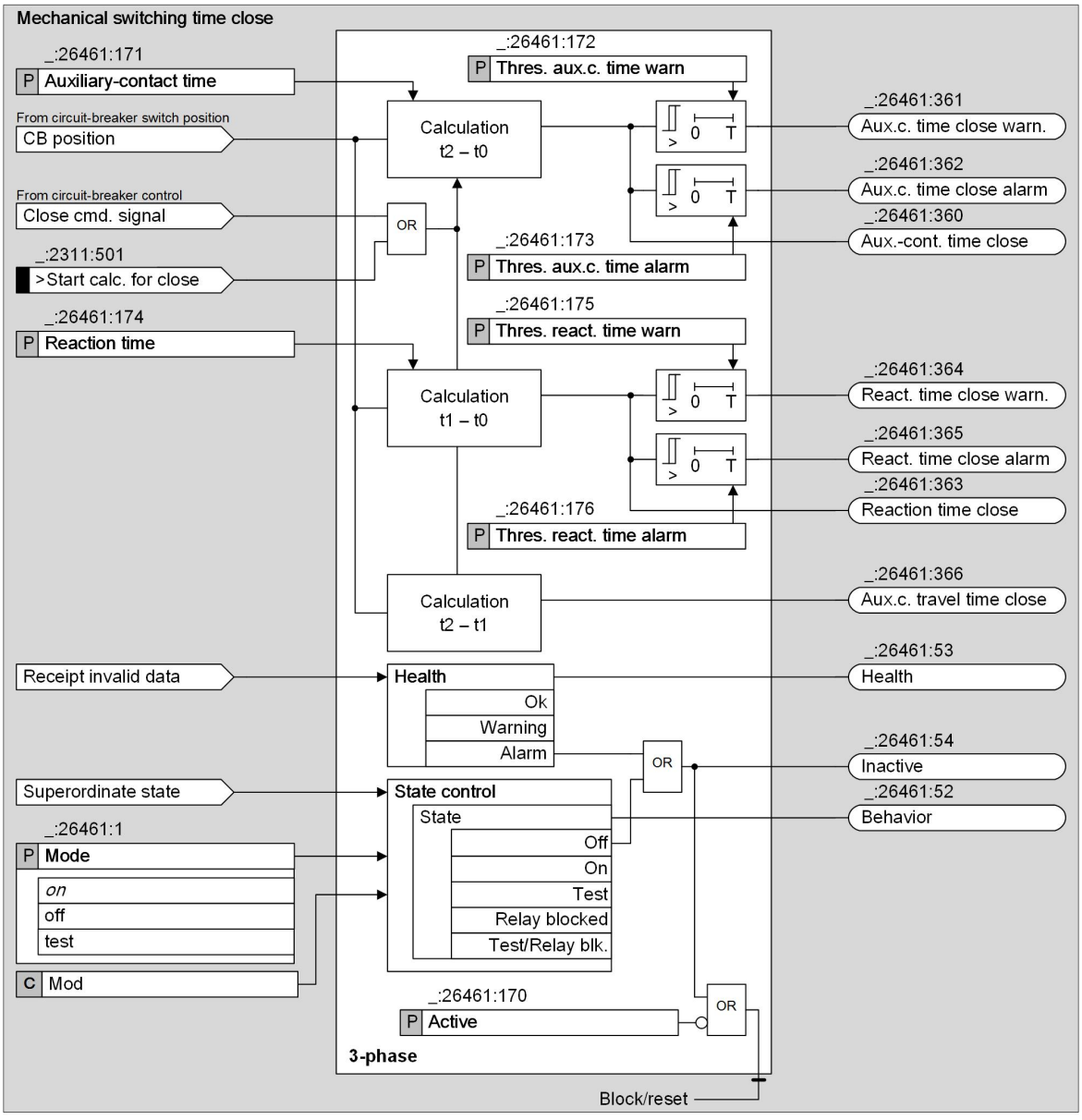
No.	Information	Data Class (Type)	Type
_:23971:354	Phase A:React. time open warn.	SPS	O
_:23971:355	Phase A:React. time open alarm	SPS	O
_:23971:356	Phase A:Aux.c. travel time open	MV	O
_:23971:360	Phase A:Aux.-cont. time close	MV	O
_:23971:361	Phase A:Aux.c. time close warn.	SPS	O
_:23971:362	Phase A:Aux.c. time close alarm	SPS	O
_:23971:363	Phase A:Reaction time close	MV	O
_:23971:364	Phase A:React. time close warn.	SPS	O
_:23971:365	Phase A:React. time close alarm	SPS	O
_:23971:366	Phase A:Aux.c. travel time close	MV	O
Phase B			
_:24002:51	Phase B:Mode (controllable)	ENC	C
_:24002:54	Phase B:Inactive	SPS	O
_:24002:52	Phase B:Behavior	ENS	O
_:24002:53	Phase B:Health	ENS	O
_:24002:300	Phase B:2P abrasion remaining	INS	O
_:24002:301	Phase B:2P abrasion cumulated	MV	O
_:24002:302	Phase B:2P abrasion last sw.op.	MV	O
_:24002:303	Phase B:2P abrasion warning	SPS	O
_:24002:304	Phase B:2P abrasion alarm	SPS	O
_:24002:310	Phase B:ΣIx	BCR	O
_:24002:311	Phase B:Warning ΣIx	SPS	O
_:24002:320	Phase B:ΣI²t	BCR	O
_:24002:321	Phase B:Warning ΣI²t	SPS	O
_:24002:330	Phase B:Make time	MV	O
_:24002:331	Phase B:Make-time warning	SPS	O
_:24002:332	Phase B:Make-time alarm	SPS	O
_:24002:340	Phase B:Break time	MV	O
_:24002:341	Phase B:Break-time warning	SPS	O
_:24002:342	Phase B:Break-time alarm	SPS	O
_:24002:350	Phase B:Aux.-contact time open	MV	O
_:24002:351	Phase B:Aux.c. time open warn.	SPS	O
_:24002:352	Phase B:Aux.c. time open alarm	SPS	O
_:24002:353	Phase B:Reaction time open	MV	O
_:24002:354	Phase B:React. time open warn.	SPS	O
_:24002:355	Phase B:React. time open alarm	SPS	O
_:24002:356	Phase B:Aux.c. travel time open	MV	O
_:24002:360	Phase B:Aux.-cont. time close	MV	O
_:24002:361	Phase B:Aux.c. time close warn.	SPS	O
_:24002:362	Phase B:Aux.c. time close alarm	SPS	O
_:24002:363	Phase B:Reaction time close	MV	O
_:24002:364	Phase B:React. time close warn.	SPS	O
_:24002:365	Phase B:React. time close alarm	SPS	O
_:24002:366	Phase B:Aux.c. travel time close	MV	O
Phase C			
_:24033:51	Phase C:Mode (controllable)	ENC	C

No.	Information	Data Class (Type)	Type
_:24033:54	Phase C:Inactive	SPS	O
_:24033:52	Phase C:Behavior	ENS	O
_:24033:53	Phase C:Health	ENS	O
_:24033:300	Phase C:2P abrasion remaining	INS	O
_:24033:301	Phase C:2P abrasion cumulated	MV	O
_:24033:302	Phase C:2P abrasion last sw.op.	MV	O
_:24033:303	Phase C:2P abrasion warning	SPS	O
_:24033:304	Phase C:2P abrasion alarm	SPS	O
_:24033:310	Phase C:ΣIx	BCR	O
_:24033:311	Phase C:Warning ΣIx	SPS	O
_:24033:320	Phase C:ΣI²t	BCR	O
_:24033:321	Phase C:Warning ΣI²t	SPS	O
_:24033:330	Phase C:Make time	MV	O
_:24033:331	Phase C:Make-time warning	SPS	O
_:24033:332	Phase C:Make-time alarm	SPS	O
_:24033:340	Phase C:Break time	MV	O
_:24033:341	Phase C:Break-time warning	SPS	O
_:24033:342	Phase C:Break-time alarm	SPS	O
_:24033:350	Phase C:Aux.-contact time open	MV	O
_:24033:351	Phase C:Aux.c. time open warn.	SPS	O
_:24033:352	Phase C:Aux.c. time open alarm	SPS	O
_:24033:353	Phase C:Reaction time open	MV	O
_:24033:354	Phase C:React. time open warn.	SPS	O
_:24033:355	Phase C:React. time open alarm	SPS	O
_:24033:356	Phase C:Aux.c. travel time open	MV	O
_:24033:360	Phase C:Aux.-cont. time close	MV	O
_:24033:361	Phase C:Aux.c. time close warn.	SPS	O
_:24033:362	Phase C:Aux.c. time close alarm	SPS	O
_:24033:363	Phase C:Reaction time close	MV	O
_:24033:364	Phase C:React. time close warn.	SPS	O
_:24033:365	Phase C:React. time close alarm	SPS	O
_:24033:366	Phase C:Aux.c. travel time close	MV	O

9.12.12 Mechanical Switching Time Close

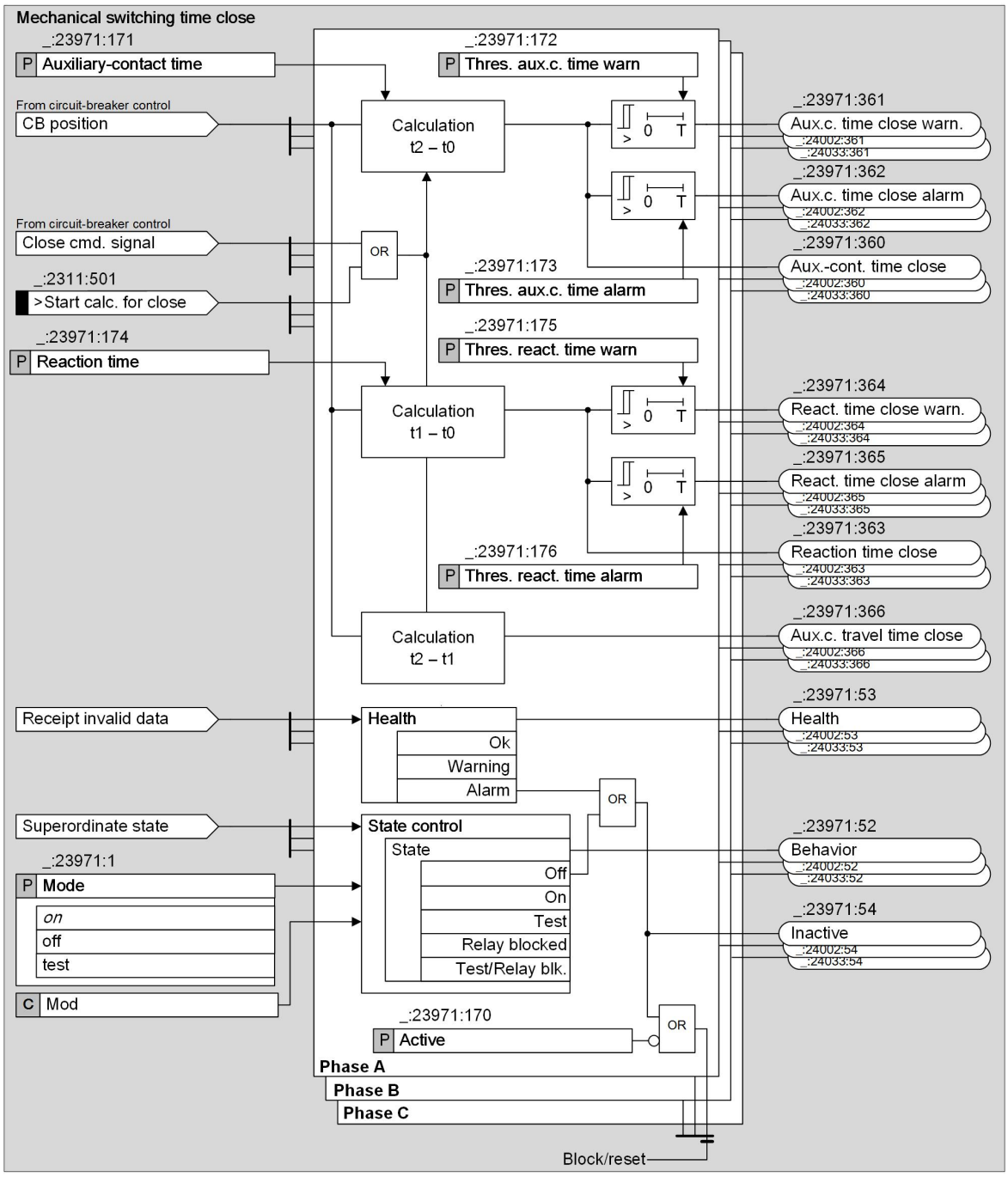
9.12.12.1 Description

Logic of the Stage



[lo_mechanical_Make-time_3phs, 1, en_US]

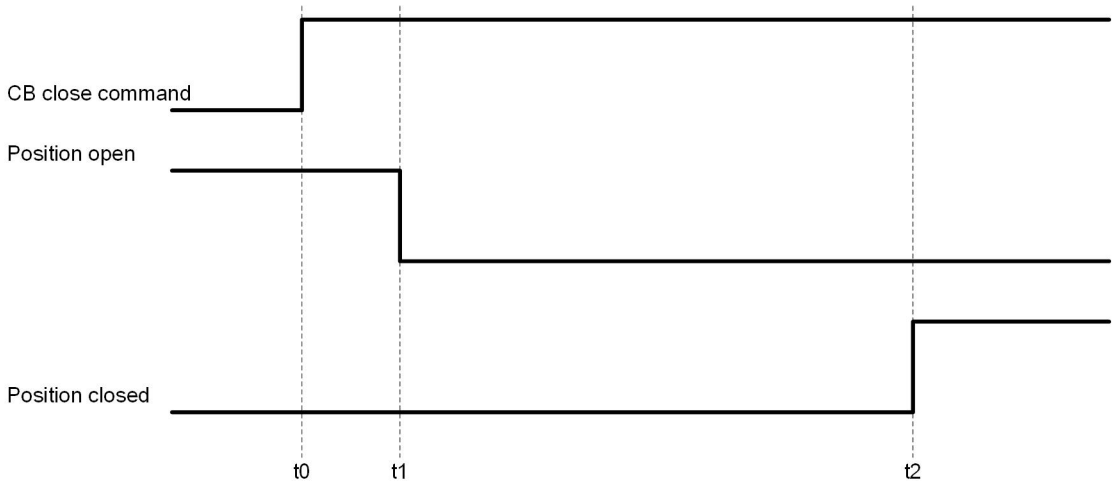
Figure 9-55 Logic of the Stage Mechanical Switching Time Close for Circuit Breakers 3-Pole



[lo_mechanical_Make-time_1phs, 1, en_US]

Figure 9-56 Logic of the Stage Mechanical Switching Time Close for Circuit Breakers 1-Pole

Operating Mode



[dw_charact_cb-maketime, 1, en_US]

t2 - t0: Auxiliary-contact time closing
t1 - t0: Response time closing
t2 - t1: Auxiliary-contact moving time closing

The stage for supervision of the mechanical switching time closing of the circuit breaker measures the time between the closing command of the circuit breaker (t0) and the point in time when the position of the circuit breaker switches to **Intermediate position** (t1). The stage measures the time between the close command of the circuit breaker (t0) and the point in time when the position of the circuit breaker switches to **Close** (t2). Additionally, it calculates the auxiliary-contact moving time from the intermediate position (t1) until reaching the position **Close** (t2).

The starting criterion can be either the closing command of the circuit breaker or the input signal *>Start calc. for close*.

You can set 2 independent threshold values for the supervision of the measured time t1-t0. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms. You can set 2 independent threshold values for the supervision of the measured time t2-t0. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms. For t2-t1, only the calculated time is to be indicated. There is no warning or alarm threshold.

If you use a 1-pole circuit breaker, the settings and indications are phase-selective. For 3-pole circuit breakers times cannot be determined phase selective. The settings are done in the section **3-phase**.

A precondition for the monitoring of the mechanical switching times is the routing of the open and closed circuit-breaker position in the function group **Circuit breaker**. If you route only one or no circuit-breaker feedbacks, the function **Mechanical switching time close** cannot work and indicates the status *Warning*.

9.12.12.2 Application and Setting Notes

NOTE

The following parameters apply to one phase. The descriptions apply similarly to the parameters of the remaining phases.

Parameter: `Auxiliary-contact time`

- Default setting **`(_:23971:171) Auxiliary-contact time`** = ***35 ms***

With the parameter **`Auxiliary-contact time`**, you define the time period from the circuit-breaker close command until the feedback contacts of the CB indicate **Closed**.

Parameter: **Thres. aux.c. time warn**

- Default setting **(_:23971:172) Thres. aux.c. time warn** = ***5 ms***

With the parameter **Thres. aux.c. time warn**, you define by how many ms the auxiliary-contact time can be exceeded or undershot before the output *Aux.c. time close warn.* is set. The output *Aux.c. time close warn.* drops out after 100 ms.

Parameter: **Thres. aux.c. time alarm**

- Default setting **(_:23971:173) Thres. aux.c. time alarm** = ***10 ms***

With the parameter **Thres. aux.c. time alarm**, you define by how many ms the auxiliary-contact time can be exceeded or undershot before the output *Aux.c. time close alarm* is set. The output *Aux.c. time close alarm* drops out after 100 ms.

Parameter: **Reaction time**

- Default setting **(_:23971:174) Reaction time** = ***15 ms***

With the parameter **Reaction time**, you define the time between the circuit-breaker closing command and the indication **Intermediate position** by the feedback contacts of the CB.

Parameter: **Thres. react. time warn**

- Default setting **(_:23971:175) Thres. react. time warn** = ***3 ms***

With the parameter **Thres. react. time warn**, you define by how many ms the reaction time can be exceeded or undershot before the output *React. time close warn.* is set. The output *React. time close warn.* drops out after 100 ms.

Parameter: **Thres. react. time alarm**

- Default setting **(_:23971:176) Thres. react. time alarm** = ***5 ms***

With the parameter **Thres. react. time alarm**, you define by how many ms the reaction time can be exceeded or undershot before the output *React. time close alarm* is set. The *React. time close alarm* drops out after 100 ms.

9.12.12.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Mechanical sw. time close				
_:26461:170	3-Phase:Active		• 0 • 1	unwahr
_:26461:171	3-Phase:Auxiliary-contact time		1 ms to 1000 ms	35 ms
_:26461:172	3-Phase:Thres. aux.c. time warn		1 ms to 1000 ms	5 ms
_:26461:173	3-Phase:Thres. aux.c. time alarm		1 ms to 1000 ms	10 ms
_:26461:174	3-Phase:Reaction time		1 ms to 1000 ms	15 ms
_:26461:175	3-Phase:Thres. react. time warn		1 ms to 1000 ms	3 ms
_:26461:176	3-Phase:Thres. react. time alarm		1 ms to 1000 ms	5 ms
Mechanical sw. time close				
_:23971:170	Phase A:Active		• 0 • 1	unwahr

Addr.	Parameter	C	Setting Options	Default Setting
_:23971:171	Phase A:Auxiliary-contact time		1 ms to 1000 ms	35 ms
_:23971:172	Phase A:Thres. aux.c. time warn		1 ms to 1000 ms	5 ms
_:23971:173	Phase A:Thres. aux.c. time alarm		1 ms to 1000 ms	10 ms
_:23971:174	Phase A:Reaction time		1 ms to 1000 ms	15 ms
_:23971:175	Phase A:Thres. react. time warn		1 ms to 1000 ms	3 ms
_:23971:176	Phase A:Thres. react. time alarm		1 ms to 1000 ms	5 ms
Mechanical sw. time close				
_:24002:170	Phase B:Active		• 0 • 1	unwahr
_:24002:171	Phase B:Auxiliary-contact time		1 ms to 1000 ms	35 ms
_:24002:172	Phase B:Thres. aux.c. time warn		1 ms to 1000 ms	5 ms
_:24002:173	Phase B:Thres. aux.c. time alarm		1 ms to 1000 ms	10 ms
_:24002:174	Phase B:Reaction time		1 ms to 1000 ms	15 ms
_:24002:175	Phase B:Thres. react. time warn		1 ms to 1000 ms	3 ms
_:24002:176	Phase B:Thres. react. time alarm		1 ms to 1000 ms	5 ms
Mechanical sw. time close				
_:24033:170	Phase C:Active		• 0 • 1	unwahr
_:24033:171	Phase C:Auxiliary-contact time		1 ms to 1000 ms	35 ms
_:24033:172	Phase C:Thres. aux.c. time warn		1 ms to 1000 ms	5 ms
_:24033:173	Phase C:Thres. aux.c. time alarm		1 ms to 1000 ms	10 ms
_:24033:174	Phase C:Reaction time		1 ms to 1000 ms	15 ms
_:24033:175	Phase C:Thres. react. time warn		1 ms to 1000 ms	3 ms
_:24033:176	Phase C:Thres. react. time alarm		1 ms to 1000 ms	5 ms

9.12.12.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Start calc. for open	SPS	I
_:2311:501	General:>Start calc. for close	SPS	I
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O

No.	Information	Data Class (Type)	Type
3-Phase			
_:26461:51	3-Phase:Mode (controllable)	ENC	C
_:26461:54	3-Phase:Inactive	SPS	O
_:26461:52	3-Phase:Behavior	ENS	O
_:26461:53	3-Phase:Health	ENS	O
_:26461:340	3-Phase:Pole scatter time open	MV	O
_:26461:341	3-Phase:ScatterTm open warn.	SPS	O
_:26461:342	3-Phase:ScatterTm open alarm	SPS	O
_:26461:370	3-Phase:Pole scatter time close	MV	O
_:26461:371	3-Phase:ScatterTm close warn.	SPS	O
_:26461:372	3-Phase:ScatterTm close alarm	SPS	O
_:26461:350	3-Phase:Aux.-contact time open	MV	O
_:26461:351	3-Phase:Aux.c. time open warn.	SPS	O
_:26461:352	3-Phase:Aux.c. time open alarm	SPS	O
_:26461:353	3-Phase:Reaction time open	MV	O
_:26461:354	3-Phase:React. time open warn.	SPS	O
_:26461:355	3-Phase:React. time open alarm	SPS	O
_:26461:356	3-Phase:Aux.c. travel time open	MV	O
_:26461:360	3-Phase:Aux.-cont. time close	MV	O
_:26461:361	3-Phase:Aux.c. time close warn.	SPS	O
_:26461:362	3-Phase:Aux.c. time close alarm	SPS	O
_:26461:363	3-Phase:Reaction time close	MV	O
_:26461:364	3-Phase:React. time close warn.	SPS	O
_:26461:365	3-Phase:React. time close alarm	SPS	O
_:26461:366	3-Phase:Aux.c. travel time close	MV	O
Phase A			
_:23971:51	Phase A:Mode (controllable)	ENC	C
_:23971:54	Phase A:Inactive	SPS	O
_:23971:52	Phase A:Behavior	ENS	O
_:23971:53	Phase A:Health	ENS	O
_:23971:300	Phase A:2P abrasion remaining	INS	O
_:23971:301	Phase A:2P abrasion cumulated	MV	O
_:23971:302	Phase A:2P abrasion last sw.op.	MV	O
_:23971:303	Phase A:2P abrasion warning	SPS	O
_:23971:304	Phase A:2P abrasion alarm	SPS	O
_:23971:310	Phase A:ΣIx	BCR	O
_:23971:311	Phase A:Warning ΣIx	SPS	O
_:23971:320	Phase A:ΣI²t	BCR	O
_:23971:321	Phase A:Warning ΣI²t	SPS	O
_:23971:330	Phase A:Make time	MV	O
_:23971:331	Phase A:Make-time warning	SPS	O
_:23971:332	Phase A:Make-time alarm	SPS	O
_:23971:340	Phase A:Break time	MV	O
_:23971:341	Phase A:Break-time warning	SPS	O
_:23971:342	Phase A:Break-time alarm	SPS	O
_:23971:350	Phase A:Aux.-contact time open	MV	O

No.	Information	Data Class (Type)	Type
_:23971:351	Phase A:Aux.c. time open warn.	SPS	O
_:23971:352	Phase A:Aux.c. time open alarm	SPS	O
_:23971:353	Phase A:Reaction time open	MV	O
_:23971:354	Phase A:React. time open warn.	SPS	O
_:23971:355	Phase A:React. time open alarm	SPS	O
_:23971:356	Phase A:Aux.c. travel time open	MV	O
_:23971:360	Phase A:Aux.-cont. time close	MV	O
_:23971:361	Phase A:Aux.c. time close warn.	SPS	O
_:23971:362	Phase A:Aux.c. time close alarm	SPS	O
_:23971:363	Phase A:Reaction time close	MV	O
_:23971:364	Phase A:React. time close warn.	SPS	O
_:23971:365	Phase A:React. time close alarm	SPS	O
_:23971:366	Phase A:Aux.c. travel time close	MV	O
Phase B			
_:24002:51	Phase B:Mode (controllable)	ENC	C
_:24002:54	Phase B:Inactive	SPS	O
_:24002:52	Phase B:Behavior	ENS	O
_:24002:53	Phase B:Health	ENS	O
_:24002:300	Phase B:2P abrasion remaining	INS	O
_:24002:301	Phase B:2P abrasion cumulated	MV	O
_:24002:302	Phase B:2P abrasion last sw.op.	MV	O
_:24002:303	Phase B:2P abrasion warning	SPS	O
_:24002:304	Phase B:2P abrasion alarm	SPS	O
_:24002:310	Phase B:ΣIx	BCR	O
_:24002:311	Phase B:Warning ΣIx	SPS	O
_:24002:320	Phase B:ΣI²t	BCR	O
_:24002:321	Phase B:Warning ΣI²t	SPS	O
_:24002:330	Phase B:Make time	MV	O
_:24002:331	Phase B:Make-time warning	SPS	O
_:24002:332	Phase B:Make-time alarm	SPS	O
_:24002:340	Phase B:Break time	MV	O
_:24002:341	Phase B:Break-time warning	SPS	O
_:24002:342	Phase B:Break-time alarm	SPS	O
_:24002:350	Phase B:Aux.-contact time open	MV	O
_:24002:351	Phase B:Aux.c. time open warn.	SPS	O
_:24002:352	Phase B:Aux.c. time open alarm	SPS	O
_:24002:353	Phase B:Reaction time open	MV	O
_:24002:354	Phase B:React. time open warn.	SPS	O
_:24002:355	Phase B:React. time open alarm	SPS	O
_:24002:356	Phase B:Aux.c. travel time open	MV	O
_:24002:360	Phase B:Aux.-cont. time close	MV	O
_:24002:361	Phase B:Aux.c. time close warn.	SPS	O
_:24002:362	Phase B:Aux.c. time close alarm	SPS	O
_:24002:363	Phase B:Reaction time close	MV	O
_:24002:364	Phase B:React. time close warn.	SPS	O
_:24002:365	Phase B:React. time close alarm	SPS	O

No.	Information	Data Class (Type)	Type
_:24002:366	Phase B:Aux.c. travel time close	MV	O
Phase C			
_:24033:51	Phase C:Mode (controllable)	ENC	C
_:24033:54	Phase C:Inactive	SPS	O
_:24033:52	Phase C:Behavior	ENS	O
_:24033:53	Phase C:Health	ENS	O
_:24033:300	Phase C:2P abrasion remaining	INS	O
_:24033:301	Phase C:2P abrasion cumulated	MV	O
_:24033:302	Phase C:2P abrasion last sw.op.	MV	O
_:24033:303	Phase C:2P abrasion warning	SPS	O
_:24033:304	Phase C:2P abrasion alarm	SPS	O
_:24033:310	Phase C:ΣIx	BCR	O
_:24033:311	Phase C:Warning ΣIx	SPS	O
_:24033:320	Phase C:ΣI²t	BCR	O
_:24033:321	Phase C:Warning ΣI²t	SPS	O
_:24033:330	Phase C:Make time	MV	O
_:24033:331	Phase C:Make-time warning	SPS	O
_:24033:332	Phase C:Make-time alarm	SPS	O
_:24033:340	Phase C:Break time	MV	O
_:24033:341	Phase C:Break-time warning	SPS	O
_:24033:342	Phase C:Break-time alarm	SPS	O
_:24033:350	Phase C:Aux.-contact time open	MV	O
_:24033:351	Phase C:Aux.c. time open warn.	SPS	O
_:24033:352	Phase C:Aux.c. time open alarm	SPS	O
_:24033:353	Phase C:Reaction time open	MV	O
_:24033:354	Phase C:React. time open warn.	SPS	O
_:24033:355	Phase C:React. time open alarm	SPS	O
_:24033:356	Phase C:Aux.c. travel time open	MV	O
_:24033:360	Phase C:Aux.-cont. time close	MV	O
_:24033:361	Phase C:Aux.c. time close warn.	SPS	O
_:24033:362	Phase C:Aux.c. time close alarm	SPS	O
_:24033:363	Phase C:Reaction time close	MV	O
_:24033:364	Phase C:React. time close warn.	SPS	O
_:24033:365	Phase C:React. time close alarm	SPS	O
_:24033:366	Phase C:Aux.c. travel time close	MV	O

9.12.13 Operation counter

9.12.13.1 Description

The stage for the supervision of the switching cycles counts the number of switching cycles using the feedback contacts of the circuit breaker.

You can set 2 independent threshold values for the supervision. If a threshold value is exceeded, the corresponding output indication is issued. Use the circuit-breaker statistical values to set and reset the meter. You can also use the input signal *>Reset switch statist.* to reset the meter. You can find the input in the DIGSI 5 Information routing under the FG **Circuit breaker > Circuit break**.

9.12.13.2 Application and Setting Notes

NOTE

The following parameters apply to one phase. The descriptions also apply to the parameters of the other phases.

Parameter: `Threshold for warning`

- Default setting **`(_:26461:151) Threshold for warning`** = ***`9500`***

With the parameter **`Threshold for warning`**, you specify after how many switching cycles the output indication ***`Oper.-counter warning`*** is issued.

Parameter: `(_:26461:152) Threshold for alarm`

- Default setting **`Threshold for alarm`** = ***`10 000`***

With the parameter **`Threshold for alarm`**, you specify after how many switching cycles the output indication ***`Oper.-counter alarm`*** is issued.

9.12.13.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Operation counter`				
_:26461:190	3-Phase:Active		• 0 • 1	false
_:26461:191	3-Phase:Threshold for warning		0 to 999 999 999	9500
_:26461:192	3-Phase:Threshold for alarm		0 to 999 999 999	10 000

9.12.13.4 Information List

No.	Information	Data Class (Type)	Type
`General`			
_:2311:500	General:>Start calc. for open	SPS	I
_:2311:501	General:>Start calc. for close	SPS	I
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
`3-Phase`			
_:26461:51	3-Phase:Mode (controllable)	ENC	C
_:26461:54	3-Phase:Inactive	SPS	O
_:26461:52	3-Phase:Behavior	ENS	O
_:26461:53	3-Phase:Health	ENS	O
_:26461:340	3-Phase:Pole scatter time open	MV	O
_:26461:341	3-Phase:ScatterTm open warn.	SPS	O
_:26461:342	3-Phase:ScatterTm open alarm	SPS	O
_:26461:370	3-Phase:Pole scatter time close	MV	O
_:26461:371	3-Phase:ScatterTm close warn.	SPS	O
_:26461:372	3-Phase:ScatterTm close alarm	SPS	O
_:26461:350	3-Phase:Aux.-contact time open	MV	O
_:26461:351	3-Phase:Aux.c. time open warn.	SPS	O
_:26461:352	3-Phase:Aux.c. time open alarm	SPS	O

No.	Information	Data Class (Type)	Type
_:26461:353	3-Phase:Reaction time open	MV	O
_:26461:354	3-Phase:React. time open warn.	SPS	O
_:26461:355	3-Phase:React. time open alarm	SPS	O
_:26461:356	3-Phase:Aux.c. travel time open	MV	O
_:26461:360	3-Phase:Aux.-cont. time close	MV	O
_:26461:361	3-Phase:Aux.c. time close warn.	SPS	O
_:26461:362	3-Phase:Aux.c. time close alarm	SPS	O
_:26461:363	3-Phase:Reaction time close	MV	O
_:26461:364	3-Phase:React. time close warn.	SPS	O
_:26461:365	3-Phase:React. time close alarm	SPS	O
_:26461:366	3-Phase:Aux.c. travel time close	MV	O
_:26461:380	3-Phase:Operation counter	INS	O
_:26461:381	3-Phase:Oper.-counter warning	SPS	O
_:26461:382	3-Phase:Oper.-counter alarm	SPS	O
Phase A			
_:23971:51	Phase A:Mode (controllable)	ENC	C
_:23971:54	Phase A:Inactive	SPS	O
_:23971:52	Phase A:Behavior	ENS	O
_:23971:53	Phase A:Health	ENS	O
_:23971:300	Phase A:2P abrasion remaining	INS	O
_:23971:301	Phase A:2P abrasion cumulated	MV	O
_:23971:302	Phase A:2P abrasion last sw.op.	MV	O
_:23971:303	Phase A:2P abrasion warning	SPS	O
_:23971:304	Phase A:2P abrasion alarm	SPS	O
_:23971:310	Phase A:ΣIx	BCR	O
_:23971:311	Phase A:Warning ΣIx	SPS	O
_:23971:320	Phase A:ΣI²t	BCR	O
_:23971:321	Phase A:Warning ΣI²t	SPS	O
_:23971:330	Phase A:Make time	MV	O
_:23971:331	Phase A:Make-time warning	SPS	O
_:23971:332	Phase A:Make-time alarm	SPS	O
_:23971:340	Phase A:Break time	MV	O
_:23971:341	Phase A:Break-time warning	SPS	O
_:23971:342	Phase A:Break-time alarm	SPS	O
_:23971:350	Phase A:Aux.-contact time open	MV	O
_:23971:351	Phase A:Aux.c. time open warn.	SPS	O
_:23971:352	Phase A:Aux.c. time open alarm	SPS	O
_:23971:353	Phase A:Reaction time open	MV	O
_:23971:354	Phase A:React. time open warn.	SPS	O
_:23971:355	Phase A:React. time open alarm	SPS	O
_:23971:356	Phase A:Aux.c. travel time open	MV	O
_:23971:360	Phase A:Aux.-cont. time close	MV	O
_:23971:361	Phase A:Aux.c. time close warn.	SPS	O
_:23971:362	Phase A:Aux.c. time close alarm	SPS	O
_:23971:363	Phase A:Reaction time close	MV	O
_:23971:364	Phase A:React. time close warn.	SPS	O

No.	Information	Data Class (Type)	Type
_:23971:365	Phase A:React. time close alarm	SPS	O
_:23971:366	Phase A:Aux.c. travel time close	MV	O
_:23971:370	Phase A:Operation counter	INS	O
_:23971:371	Phase A:Oper.-counter warning	SPS	O
_:23971:372	Phase A:Oper.-counter alarm	SPS	O
Phase B			
_:24002:51	Phase B:Mode (controllable)	ENC	C
_:24002:54	Phase B:Inactive	SPS	O
_:24002:52	Phase B:Behavior	ENS	O
_:24002:53	Phase B:Health	ENS	O
_:24002:300	Phase B:2P abrasion remaining	INS	O
_:24002:301	Phase B:2P abrasion cumulated	MV	O
_:24002:302	Phase B:2P abrasion last sw.op.	MV	O
_:24002:303	Phase B:2P abrasion warning	SPS	O
_:24002:304	Phase B:2P abrasion alarm	SPS	O
_:24002:310	Phase B:ΣIx	BCR	O
_:24002:311	Phase B:Warning ΣIx	SPS	O
_:24002:320	Phase B:ΣI²t	BCR	O
_:24002:321	Phase B:Warning ΣI²t	SPS	O
_:24002:330	Phase B:Make time	MV	O
_:24002:331	Phase B:Make-time warning	SPS	O
_:24002:332	Phase B:Make-time alarm	SPS	O
_:24002:340	Phase B:Break time	MV	O
_:24002:341	Phase B:Break-time warning	SPS	O
_:24002:342	Phase B:Break-time alarm	SPS	O
_:24002:350	Phase B:Aux.-contact time open	MV	O
_:24002:351	Phase B:Aux.c. time open warn.	SPS	O
_:24002:352	Phase B:Aux.c. time open alarm	SPS	O
_:24002:353	Phase B:Reaction time open	MV	O
_:24002:354	Phase B:React. time open warn.	SPS	O
_:24002:355	Phase B:React. time open alarm	SPS	O
_:24002:356	Phase B:Aux.c. travel time open	MV	O
_:24002:360	Phase B:Aux.-cont. time close	MV	O
_:24002:361	Phase B:Aux.c. time close warn.	SPS	O
_:24002:362	Phase B:Aux.c. time close alarm	SPS	O
_:24002:363	Phase B:Reaction time close	MV	O
_:24002:364	Phase B:React. time close warn.	SPS	O
_:24002:365	Phase B:React. time close alarm	SPS	O
_:24002:366	Phase B:Aux.c. travel time close	MV	O
_:24002:370	Phase B:Operation counter	INS	O
_:24002:371	Phase B:Oper.-counter warning	SPS	O
_:24002:372	Phase B:Oper.-counter alarm	SPS	O
Phase C			
_:24033:51	Phase C:Mode (controllable)	ENC	C
_:24033:54	Phase C:Inactive	SPS	O
_:24033:52	Phase C:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:24033:53	Phase C:Health	ENS	O
_:24033:300	Phase C:2P abrasion remaining	INS	O
_:24033:301	Phase C:2P abrasion cumulated	MV	O
_:24033:302	Phase C:2P abrasion last sw.op.	MV	O
_:24033:303	Phase C:2P abrasion warning	SPS	O
_:24033:304	Phase C:2P abrasion alarm	SPS	O
_:24033:310	Phase C:ΣIx	BCR	O
_:24033:311	Phase C:Warning ΣIx	SPS	O
_:24033:320	Phase C:ΣI²t	BCR	O
_:24033:321	Phase C:Warning ΣI²t	SPS	O
_:24033:330	Phase C:Make time	MV	O
_:24033:331	Phase C:Make-time warning	SPS	O
_:24033:332	Phase C:Make-time alarm	SPS	O
_:24033:340	Phase C:Break time	MV	O
_:24033:341	Phase C:Break-time warning	SPS	O
_:24033:342	Phase C:Break-time alarm	SPS	O
_:24033:350	Phase C:Aux.-contact time open	MV	O
_:24033:351	Phase C:Aux.c. time open warn.	SPS	O
_:24033:352	Phase C:Aux.c. time open alarm	SPS	O
_:24033:353	Phase C:Reaction time open	MV	O
_:24033:354	Phase C:React. time open warn.	SPS	O
_:24033:355	Phase C:React. time open alarm	SPS	O
_:24033:356	Phase C:Aux.c. travel time open	MV	O
_:24033:360	Phase C:Aux.-cont. time close	MV	O
_:24033:361	Phase C:Aux.c. time close warn.	SPS	O
_:24033:362	Phase C:Aux.c. time close alarm	SPS	O
_:24033:363	Phase C:Reaction time close	MV	O
_:24033:364	Phase C:React. time close warn.	SPS	O
_:24033:365	Phase C:React. time close alarm	SPS	O
_:24033:366	Phase C:Aux.c. travel time close	MV	O
_:24033:370	Phase C:Operation counter	INS	O
_:24033:371	Phase C:Oper.-counter warning	SPS	O
_:24033:372	Phase C:Oper.-counter alarm	SPS	O

9.13 Disconnector-Switch Monitoring

9.13.1 Overview of Functions

The function **Disconnector supervision**:

- Detects and reports temporal changes in the switching procedure of disconnectors

9.13.2 Structure of the Function

The function **Disconnector supervision** can be used in the function group **Disconnector**.
The function consists of 2 independent operating procedures:

- **Mechanical switching time open**
  Monitoring of the mechanical switching time for the opening operation, detected via the feedback contacts
- **Mechanical switching time close**
  Monitoring of the mechanical switching time for the closing operation, detected via the feedback contacts

9.13.3 General Functionality

9.13.3.1 Description

Start Criterion for the Function Disconnector Supervision

The operating procedure **Mechanical switching time close** is started if one of the following criteria is met:

- The disconnector is closed via a command.
- The binary input signal *>Start calc. for close* is initiated, for example, via an external signal.

The operating procedure **Mechanical switching time open** is started if one of the following criteria is met:

- The disconnector is opened via a command.
- The binary input signal *>Start calc. for open* is initiated, for example, via an external signal.

9.13.3.2 Application and Setting Notes

Parameter: Mode

- Default setting **(_:26671:1) Mode** = ***on***

With the parameter **Mode**, you can switch the disconnector supervision ***on***, ***off***, or in ***test*** mode.

9.13.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:26671:1	Discon. monit.:Mode		• off • on • test	on

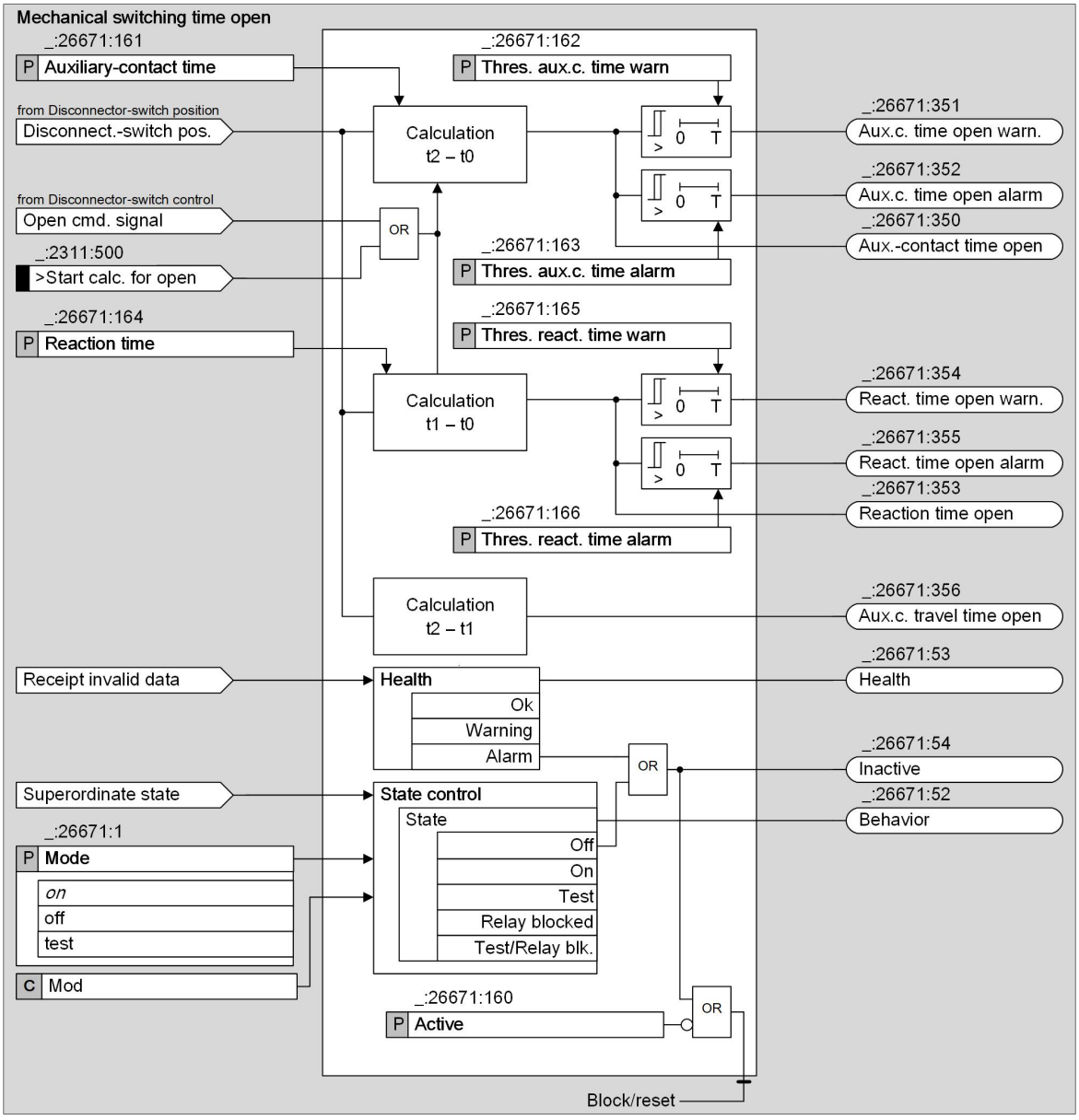
9.13.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Start calc. for open	SPS	I
_:2311:501	General:>Start calc. for close	SPS	I
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O

9.13.4 Mechanical Switching Time Open

9.13.4.1 Description

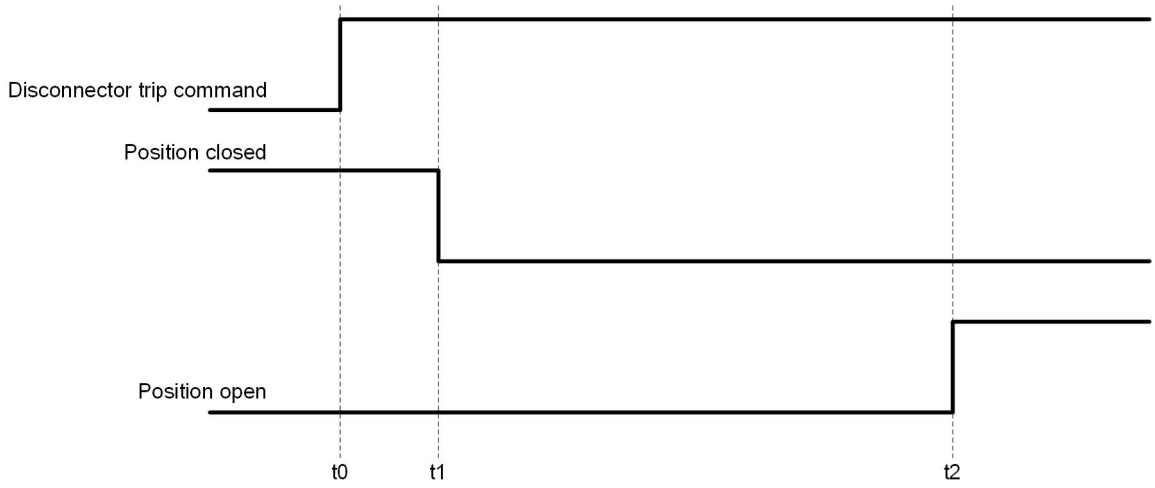
Logic of the Stage



[lo_mechanical_make-time_open, 1, en_US]

Figure 9-57 Logic of the Stage Mechanical Switching Time for Disconnector

Method of Operation



[dw_charact_dcs-maketime_op, 1, en_US]

1) t2 - t0: Auxiliary contact time open operation
2) t1 - t0: Reaction time open operation
3) t2 - t1: Auxiliary contact dead time open operation

The stage for monitoring the **mechanical switching time open** of the disconnector calculates the time between the start criterion (t0) and the time when the disconnector-switch position changes to the **intermediate position** (t1). The stage measures the time between the start criterion (t0) and the time when the disconnector-switch position changes to **open** (t2). Additionally, the stage calculates the time of the auxiliary contacts between the **intermediate position** (t1) until the **open** position is reached (t2).

The start criterion can be either the switching command **open** of the disconnector or the input signal *>Start calc. for open*.

You can define 2 independent threshold values for monitoring the measured time t1-t0. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms. You can define 2 independent threshold values for monitoring the measured time t2-t0. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms. For t2-t1, the calculated time must be displayed. There is no warning or alarm threshold.

For monitoring the mechanical switching times, you must route the open and closed disconnector-switch position in the function group **Disconnector**. If you route only one or no disconnector feedback, the function **Mechanical switching time open** cannot work and issues the state *Warning*.

9.13.4.2 Application and Setting Notes

Parameter: Auxiliary-contact time

- Default setting **(_:26671:161) Auxiliary-contact time** = *10 s*

With the parameter **Auxiliary-contact time**, you to define the duration between the disconnector trip command and the feedback contacts signaling the **open** position.

Parameter: Thres. aux.c. time warn

- Default setting **(_:26671:162) Thres. aux.c. time warn** = *12 s*

With the parameter **Thres. aux.c. time warn**, you define by how many seconds the auxiliary-contact time may be undercut or exceeded for the output *Aux.c. time open warn.* to be set. The output *Aux.c. time open warn.* drops out after 100 ms.

Parameter: Thres. aux.c. time alarm

- Default setting **(_:26671:163) Thres. aux.c. time alarm** = *14 s*

With the parameter **Thres. aux.c. time alarm**, you define by how many seconds the auxiliary-contact time may be undercut or exceeded for the output *Aux.c. time open alarm* to be set. The output *Aux.c. time open alarm* drops out after 100 ms.

Parameter: Reaction time

- Default setting **(_:26671:164) Reaction time** = *2 s*

With the parameter **Reaction time**, you define the duration between the disconnector trip command and the feedback contacts signaling the **intermediate position**.

Parameter: Thres. react. time warn

- Default setting **(_:26671:165) Thres. react. time warn** = *2.4 s*

With the parameter **Thres. react. time warn**, you define by how many seconds the reaction time may be undercut or exceeded for the output *React. time open warn.* to be set. The output *React. time open warn.* drops out after 100 ms.

Parameter: Thres. react. time alarm

- Default setting **(_:26671:166) Thres. react. time alarm** = *2.8 s*

With the parameter **Thres. react. time alarm**, you define by how many seconds the reaction time may be undercut or exceeded for the output *React. time open alarm* to be set. The output *React. time open alarm* drops out after 100 ms.

9.13.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Mechanical sw. time open				
_:26671:160	Discon. monit.:Active		• 0 • 1	false
_:26671:161	Discon. monit.:Auxiliary-contact time		0.02 s to 1800.00 s	10.00 s
_:26671:162	Discon. monit.:Thres. aux.c. time warn		0.02 s to 1800.00 s	12.00 s
_:26671:163	Discon. monit.:Thres. aux.c. time alarm		0.02 s to 1800.00 s	14.00 s
_:26671:164	Discon. monit.:Reaction time		0.02 s to 1800.00 s	2.00 s
_:26671:165	Discon. monit.:Thres. react. time warn		0.02 s to 1800.00 s	2.40 s
_:26671:166	Discon. monit.:Thres. react. time alarm		0.02 s to 1800.00 s	2.80 s

9.13.4.4 Information List

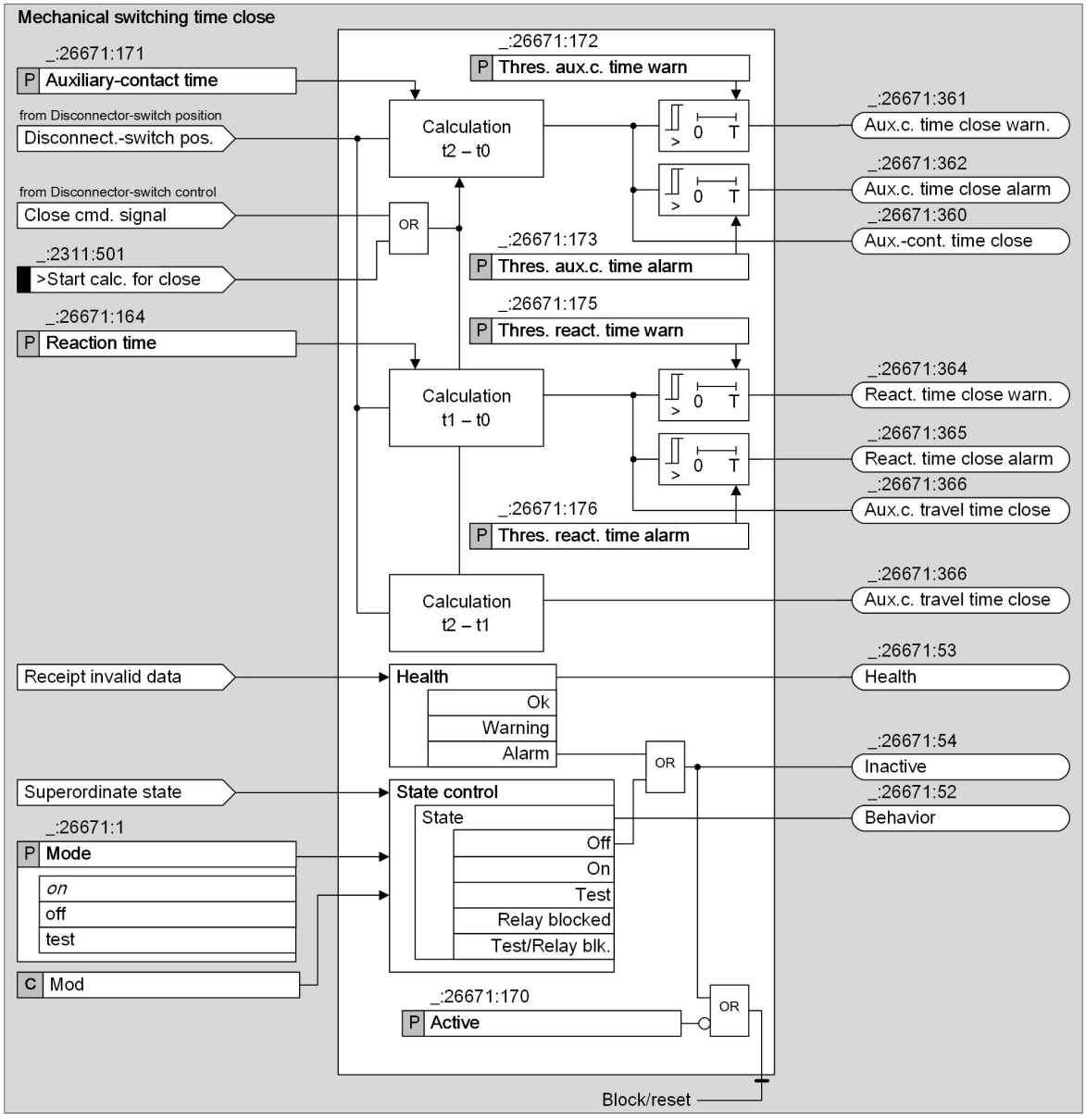
No.	Information	Data Class (Type)	Type
Discon. monit.			
_:26671:51	Discon. monit.:Mode (controllable)	ENC	C
_:26671:54	Discon. monit.:Inactive	SPS	O
_:26671:52	Discon. monit.:Behavior	ENS	O
_:26671:53	Discon. monit.:Health	ENS	O
_:26671:350	Discon. monit.:Aux.-contact time open	MV	O
_:26671:351	Discon. monit.:Aux.c. time open warn.	SPS	O

No.	Information	Data Class (Type)	Type
_:26671:352	Discon. monit.:Aux.c. time open alarm	SPS	O
_:26671:353	Discon. monit.:Reaction time open	MV	O
_:26671:354	Discon. monit.:React. time open warn.	SPS	O
_:26671:355	Discon. monit.:React. time open alarm	SPS	O
_:26671:356	Discon. monit.:Aux.c. travel time open	MV	O

9.13.5 Mechanical Switching Time Close

9.13.5.1 Description

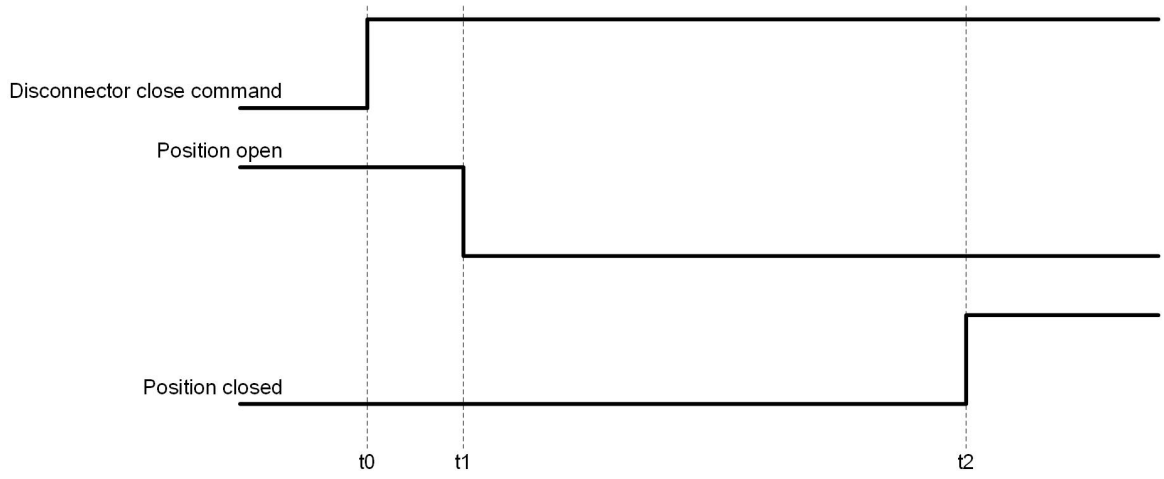
Logic of the Stage



[lo_mechanical_break-time_clo, 1, en_US]

Figure 9-58 Logic of the Stage Mechanical Switching Time Close for Disconnector

Method of Operation



[dw_charact_dcs-breaktime_clo, 1, en_US]

1) t2 - t0: Auxiliary contact time close operation
2) t1 - t0: Reaction time close operation
3) t2 - t1: Auxiliary contact dead time close operation

The stage for monitoring the **mechanical switching time close** of the disconnector measures the time between the disconnector close command (t0) and the time when the disconnector-switch position changes to the **intermediate position**. The stage measures the time between the disconnector close command (t0) and the time when the disconnector-switch position changes to **closed** (t2). Additionally, the stage calculates the time of the auxiliary contacts between the **intermediate position** (t1) until the **closed** position is reached (t2).

The start criterion can be either the disconnector close command or the input signal *>Start calc. for close*.

You can define 2 independent threshold values for monitoring the measured time t1-t0. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms. You can define 2 independent threshold values for monitoring the measured time t2-t0. If a threshold value is exceeded, the corresponding output *Warning/Alarm* is activated for 100 ms. For t2-t1, only the measured time must be reported. There is no warning or alarm threshold.

For monitoring the mechanical switching times, you must route the open and closed disconnector-switch position in the function group **Disconnector**. If you route only one or no disconnector feedback, the function **Mechanical switching time close** cannot work and issues the state *Warning*.

9.13.5.2 Application and Setting Notes

Parameter: Auxiliary-contact time

- Default setting **(_:26671:171) Auxiliary-contact time** = *10 s*

With the parameter **Auxiliary-contact time**, you define the duration between the disconnector close command and the feedback contacts signaling the **closed** position.

Parameter: Thres. aux.c. time warn

- Default setting **(_:26671:172) Thres. aux.c. time warn** = *12 s*

With the parameter **Thres. aux.c. time warn**, you define by how many seconds the auxiliary contact time may be undercut or exceeded for the output *Aux.c. time close warn.* to be set. The output *Aux.c. time close warn.* drops out after 100 ms.

Parameter: Thres. aux.c. time alarm

- Default setting **(_:26671:173) Thres. aux.c. time alarm** = ***14 s***

With the parameter **Thres. aux.c. time alarm**, you define by how many seconds the auxiliary contact time may be undercut or exceeded for the output *Aux.c. time close alarm* to be set. The output *Aux.c. time close alarm* drops out after 100 ms.

Parameter: Reaction time

- Default setting **(_:26671:174) Reaction time** = ***2 s***

With the parameter **Reaction time**, you define the duration between the disconnector close command and the feedback contacts signaling the **intermediate position**.

Parameter: Thres. react. time warn

- Default setting **(_:26671:175) Thres. react. time warn** = ***2.4 s***

With the parameter **Thres. react. time warn**, you define by how many seconds the reaction time may be undercut or exceeded for the output *React. time close warn.* to be set. The output *React. time close warn.* drops out after 100 ms.

Parameter: Thres. react. time alarm

- Default setting **(_:26671:176) Thres. react. time alarm** = ***2.8 s***

With the parameter **Thres. react. time alarm**, you define by how many seconds the reaction time may be undercut or exceeded for the output *React. time close alarm* to be set. The output *React. time close alarm* drops out after 100 ms.

9.13.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Mechanical sw. time close				
_:26671:170	Discon. monit.:Active		• 0 • 1	false
_:26671:171	Discon. monit.:Auxiliary-contact time		0.02 s to 1800.00 s	10.00 s
_:26671:172	Discon. monit.:Thres. aux.c. time warn		0.02 s to 1800.00 s	12.00 s
_:26671:173	Discon. monit.:Thres. aux.c. time alarm		0.02 s to 1800.00 s	14.00 s
_:26671:174	Discon. monit.:Reaction time		0.02 s to 1800.00 s	2.00 s
_:26671:175	Discon. monit.:Thres. react. time warn		0.02 s to 1800.00 s	2.40 s
_:26671:176	Discon. monit.:Thres. react. time alarm		0.02 s to 1800.00 s	2.80 s

9.13.5.4 Information List

No.	Information	Data Class (Type)	Type
Discon. monit.			
_:26671:51	Discon. monit.:Mode (controllable)	ENC	C
_:26671:54	Discon. monit.:Inactive	SPS	O
_:26671:52	Discon. monit.:Behavior	ENS	O
_:26671:53	Discon. monit.:Health	ENS	O

No.	Information	Data Class (Type)	Type
_:26671:360	Discon. monit.:Aux.-cont. time close	MV	O
_:26671:361	Discon. monit.:Aux.c. time close warn.	SPS	O
_:26671:362	Discon. monit.:Aux.c. time close alarm	SPS	O
_:26671:363	Discon. monit.:Reaction time close	MV	O
_:26671:364	Discon. monit.:React. time close warn.	SPS	O
_:26671:365	Discon. monit.:React. time close alarm	SPS	O
_:26671:366	Discon. monit.:Aux.c. travel time close	MV	O

10 Power Quality – Basic

10.1	Voltage Variation	2248
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10.1 Voltage Variation

10.1.1 Overview of Functions

The function **Voltage variation** is used for measuring and monitoring short-duration variations of the voltage in distribution and industrial power systems. The power-quality events such as voltage dips, swells, and interruptions in 3-phase systems are detected.

This measuring function provides the RMS value of the voltage for the minimum value in the event of a voltage dip, the lowest residual voltage in the event of an interruption or the highest swell, as well as the duration of the event.

All events can be logged in operational or user-defined logs. They can enable the fault recorder via binary warning indications, and write their values as tracks.

The values are recorded according to the standard for voltage quality IEC 61000-4-30 class S.

10.1.2 Structure of the Function

The function **Voltage variation** is used in protection function groups with 3-phase voltage measurement.

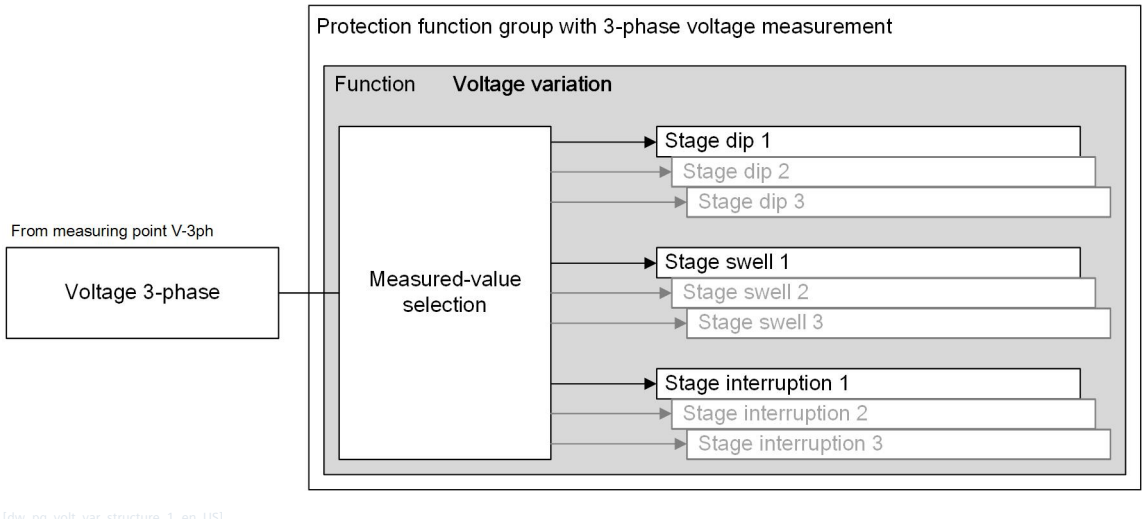
The function comes factory-set with the following stages:

- 1 stage **Dip**
- 1 stage **Swell**
- 1 stage **Interruption**

A maximum of 3 stages **Dip**, 3 stages **Swell**, and 3 stages **Interruption** can be operated simultaneously within the function.

Stages that are not preconfigured are shown in gray in the following figure. The stages are identical in structure.

The measured-value selection is a general functionality and has a uniform effect on the stages (see *Figure 10-1* and *10.1.3.1 Description*). This ensures that all stages of the function receive the same measured values.



{dw_pq_volt_var_structure, 1, en_US}

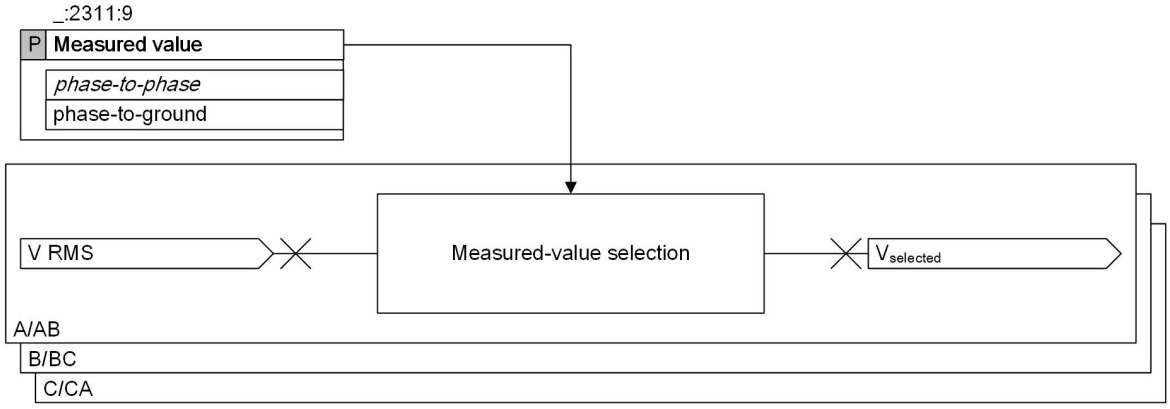
Figure 10-1 Structure/Embedding of the Function

10.1.3 General Functionality

10.1.3.1 Description

Measured-Value Selection

The function provides the option to select between the phase-to-phase and phase-to-ground voltage.



[lo_pq volt_var_general, 1, en_US]

Figure 10-2 Logic Diagram of Measured-Value Selection

The 1-cycle RMS value of the voltage is used in the function.

The setting options of the parameter **Measured value** depend on the connection type of the 3-phase voltage measuring point.

Table 10-1 Setting Options of the Parameter **Measured value**

Connection Type	Setting Options of the Parameter **Measured value**
3 ph-to-gnd voltages 3 ph-to-gnd volt. + VN	• ***phase-to-ground*** • ***phase-to-phase***
3 ph-to-ph voltages 3 ph-to-ph volt. + VN 2 ph-to-ph voltages 2 ph-to-ph volt. + VN	• ***phase-to-phase*** The setting of the parameter is read-only.

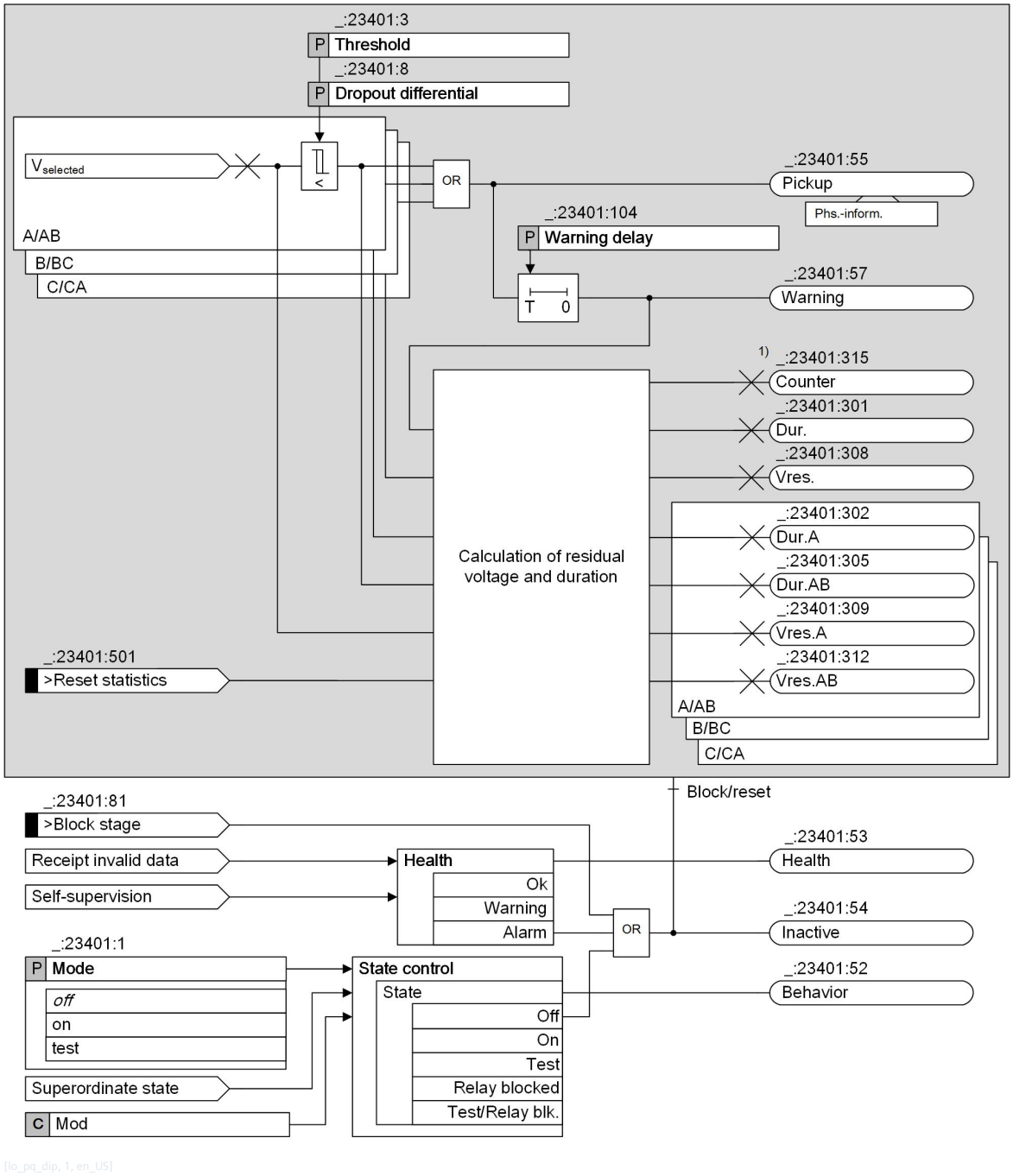
10.1.4 Stage Dip

10.1.4.1 Description

The stage **Dip**:

- Detects a voltage dip in the power system and issues a warning signal for any phase
- Logs the dip duration and the minimum residual voltage for any phase when the voltage-dip event disappears
- Counts the number of voltage-dip events

Logic of the Stage



[lo_pq_dip, 1, en_US]

Figure 10-3 Logic Diagram of the Stage Dip

(1) Counter is a statistical value. It is not reset by the block or reset state of the stage. For more information, refer to *Counter Accumulation, Page 2253*.

Pickup and Warning

If the voltage falls below the threshold value, a signal *Pickup* is issued. After expiration of the time specified by the parameter **Warning delay**, a signal *Warning* is issued.

The phase information of the signal *Pickup* is issued according to the selected measured value:

- The ***phase-to-ground*** voltage is selected as the measured value:
  If a phase-to-ground voltage, for example, VA, falls below the threshold value, the phase information of phase A of the signal *Pickup* is issued.
- The ***phase-to-phase*** voltage is selected as the measured value:
  If a phase-to-phase voltage, for example, VAB, falls below the threshold value, the phase information of phase A and phase B of the signal *Pickup* is issued.

Value Indications

If the signal *Warning* is issued, it is regarded as a voltage-dip event. Once the voltage-dip event disappears (the signal *Warning* drops out), the following value indications are calculated:

- The durations and residual voltages of this event are calculated and can be logged in the operational or user-defined logs if routed.
- The counter of voltage-dip events is increased by 1.

If, after the pickup, the voltage dip disappears during the time delay, the signal *Warning* is not issued and the incident is regarded as a voltage chattering and not as a voltage-dip event. No duration or voltage is calculated and the counter is not increased.

Table 10-2 Value Indications of the Stage Dip

Value	Description	Calculation
Counter	Total number of voltage-dip events This is a statistical value stored in the NVRAM[65].	Refer to *Counter Accumulation, Page 2253*
Dur.	Calculated phase overall duration of a voltage-dip event	Refer to *Duration Calculation, Page 2251*
Dur.A Dur.B Dur.C	Durations of a voltage-dip event for the phases A, B, and C These values are only visible when the ***phase-to-ground*** voltage is selected.	
Dur.AB Dur.BC Dur.CA	Durations of a voltage-dip event for the phases AB, BC, and CA These values are only visible when the ***phase-to-phase*** voltage is selected.	
Vres.	Minimum residual voltage of all phases in a voltage-dip event among the phases A, B, and C or among the phases AB, BC, and CA	These values are percentage values related to the parameter **Rated voltage** (reference voltage) that is set in the function group. Refer to *Residual-Voltage Calculation, Page 2253*.
Vres.A Vres.B Vres.C	Minimum residual voltages in a voltage-dip event for the phases A, B, and C These values are only visible when the ***phase-to-ground*** voltage is selected.	
Vres.AB Vres.BC Vres.CA	Minimum residual voltages in a voltage-dip event for the phases AB, BC, and CA These values are only visible when the ***phase-to-phase*** voltage is selected.	

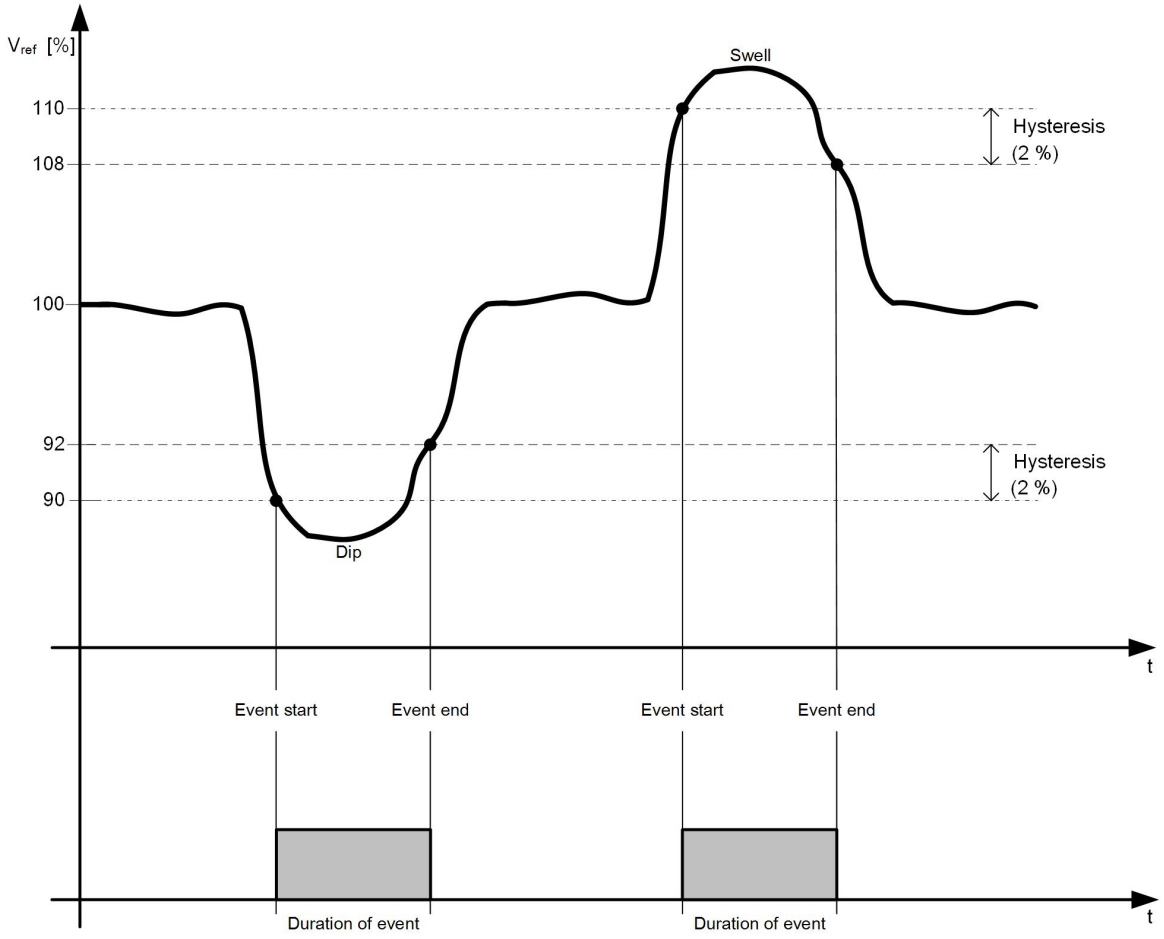
Duration Calculation

The duration of a voltage-dip or voltage-swell event is defined as the duration between the event start and event end, as shown in *Figure 10-4*.

65 NVRAM = Non-Volatile Random Access Memory; RAM, which does not lose the stored data, even when there is no power.

In the figure, it is assumed as follows:

- The dip threshold is 90 % (specified by the parameter **Threshold** of the stage **Dip**).
- The swell threshold is 110 % (specified by the parameter **Threshold** of the stage **Swell**).
- The hysteresis is 2 % (specified by the parameter **Dropout differential** of the respective stage).
- The warning delay is 0 s (specified by the parameter **Warning delay** of the respective stage).



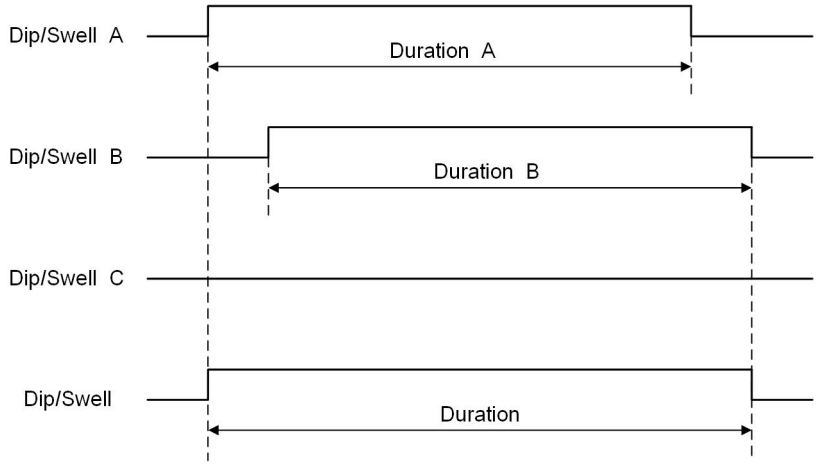
[dw_pq_volt_var_event_duration, 1, en_US]

Figure 10-4 Duration of a Voltage-Dip or Voltage-Swell Event

Where

Event start	The moment when the signal *Pickup* is issued
Event end	The moment when the signal *Pickup* drops out
V_{ref} [%]	The percentage value of the parameter **Rated voltage** (reference voltage) that is set in the function group

Only the durations of picked-up phases as well as the overall duration are calculated and logged. The following figure provides an example of phase-selective duration calculation with the ***phase-to-ground*** voltage selected as the measured value.



[dw_pq_volt_var_phs-selective_dur, 1, en_US]

Figure 10-5 Example of Phase-Selective and Overall Duration Calculation

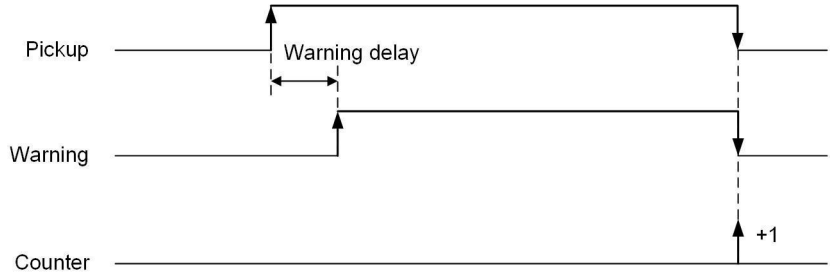
In the preceding example, voltage dips or swells occur only in phases A and B. Therefore, durations of phases A and B and the overall duration are calculated and logged. No duration of phase C is calculated or logged.

Residual-Voltage Calculation

Only picked-up phases calculate the minimum values of the residual voltages. If the values are assigned to a log, they are also logged.

Counter Accumulation

The *Counter* value is increased by 1 when the voltage-variation event disappears, as shown in the following figure.



[dw_pq_counter_accum, 1, en_US]

Figure 10-6 Counter Accumulation

NOTE

The counter is accumulated also when the function is in test mode.

The *Counter* value is retained (not reset) in the following scenarios:

- The parameter **Mode** of the stage is set to *off*.
- The signal *>Block stage* is issued.
- Device restart
- Device power-off and power-on (with battery)

The *Counter* value can be reset based on the following possibilities:

- The signal *>Reset statistics* is issued (in condition that the stage is active).
- HMI reset (in condition that the stage is active)
- DIGSI online reset (in condition that the stage is active)
- Device reset (to factory settings)
- Via protocol (in condition that the stage is active)

Blocking of the Stage

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage is reset.

10.1.4.2 Application and Setting Notes

Evaluation Possibilities – Voltage Variation Function Provides Standard-Relevant Values und Information

The power-quality evaluating standard EN 50160 (grid code) refers to the measuring standard IEC 61000-4-30, with which this function aligns. If you use the default settings of this function, then the measured and logged values are fine for further user-based classifications on EN 50160 or other analysis possibilities of users. For more information, refer to the standard EN 50160.

Parameter: `Threshold`, `Dropout differential`

- Default setting **`(_:23401:3) Threshold`** = ***`90.0 %`***
- Default setting **`(_:23401:8) Dropout differential`** = ***`2.0 %`***

The parameters **`Threshold`** and **`Dropout differential`** are percentage values related to the parameter **`Rated voltage`** (reference voltage) that is set in the function group.

Set the parameters **`Threshold`** and **`Dropout differential`** for the specific application.

According to the standard IEC 61000-4-30, the dip threshold is typically in the range of 85 % to 90 % for troubleshooting or statistical applications, and the hysteresis (**`Dropout differential`**) is typically equal to 2 %.

Parameter: `Warning delay`

- Default setting **`(_:23401:104) Warning delay`** = ***`0.00 s`***

If you do not want to log a voltage-dip event that lasts shorter than a specific time duration, for example, 20 ms, you can set the parameter **`Warning delay`** to ***`0.02 s`***.

10.1.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:9	General:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
Dip 1				
_:23401:1	Dip 1:Mode		• off • on • test	off
_:23401:3	Dip 1:Threshold		10.0 % to 100.0 %	90.0 %
_:23401:8	Dip 1:Dropout differential		1.0 % to 10.0 %	2.0 %
_:23401:104	Dip 1:Warning delay		0.00 s to 60.00 s	0.00 s

10.1.4.4 Information List

No.	Information	Data Class (Type)	Type
Dip 1			
_:23401:81	Dip 1:>Block stage	SPS	I
_:23401:501	Dip 1:>Reset statistics	SPS	I
_:23401:51	Dip 1:Mode (controllable)	ENC	C
_:23401:54	Dip 1:Inactive	SPS	O
_:23401:52	Dip 1:Behavior	ENS	O
_:23401:53	Dip 1:Health	ENS	O
_:23401:55	Dip 1:Pickup	ACD	O
_:23401:57	Dip 1:Warning	SPS	O
_:23401:301	Dip 1:Dur.	MV	O
_:23401:302	Dip 1:Dur.A	MV	O
_:23401:303	Dip 1:Dur.B	MV	O
_:23401:304	Dip 1:Dur.C	MV	O
_:23401:305	Dip 1:Dur.AB	MV	O
_:23401:306	Dip 1:Dur.BC	MV	O
_:23401:307	Dip 1:Dur.CA	MV	O
_:23401:308	Dip 1:Vres.	MV	O
_:23401:309	Dip 1:Vres.A	MV	O
_:23401:310	Dip 1:Vres.B	MV	O
_:23401:311	Dip 1:Vres.C	MV	O
_:23401:312	Dip 1:Vres.AB	MV	O
_:23401:313	Dip 1:Vres.BC	MV	O
_:23401:314	Dip 1:Vres.CA	MV	O
_:23401:315	Dip 1:Counter	INS	O

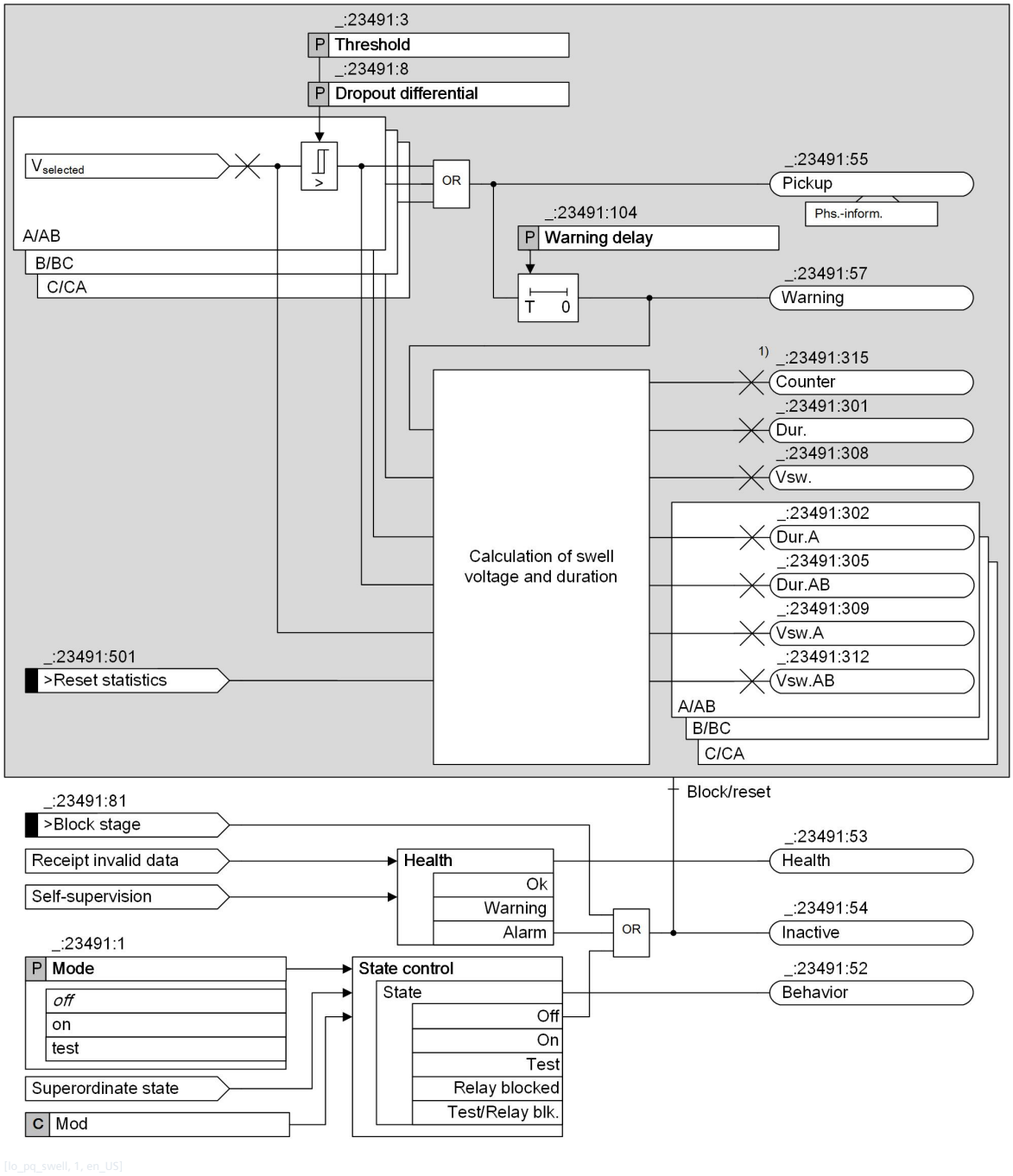
10.1.5 Stage Swell

10.1.5.1 Description

The stage **Swell**:

- Detects a voltage swell in the power system and issues a warning signal for any phase
- Logs the swell duration and the maximum swell voltage for any phase when the voltage-swell event disappears
- Counts the number of voltage-swell events

Logic of the Stage



[lo_pq_swell, 1, en_US]

Figure 10-7 Logic Diagram of the Stage Swell

(1) Counter is a statistical value. It is not reset by the block or reset state of the stage. For more information, refer to *Counter Accumulation, Page 2258*.

Pickup and Warning

If the voltage exceeds the threshold value, a signal *Pickup* is issued. After expiration of the time specified by the parameter **Warning delay**, a signal *Warning* is issued.

The phase information of the signal *Pickup* is issued according to the selected measured value:

- The ***phase-to-ground*** voltage is selected as the measured value:
  If a phase-to-ground voltage, for example, VA, exceeds the threshold value, the phase information of phase A of the signal *Pickup* is issued.
- The ***phase-to-phase*** voltage is selected as the measured value:
  If a phase-to-phase voltage, for example, VAB, exceeds the threshold value, the phase information of phase A and phase B of the signal *Pickup* is issued.

Value Indications

If the signal *Warning* is issued, it is regarded as a voltage-swell event. Once the voltage-swell event disappears (the signal *Warning* drops out), the following value indications are calculated:

- The durations and swell voltages of this event are calculated and can be logged in the operational or user-defined logs if routed.
- The counter of voltage-swell events is increased by 1.

If, after the pickup, the voltage swell disappears during the time delay, the signal *Warning* is not issued and the incident is regarded as a voltage chattering and not as a voltage-swell event. No duration or voltage is calculated and the counter is not increased.

Table 10-3 Value Indications of the Stage Swell

Value	Description	Calculation
Counter	Total number of voltage-swell events This is a statistical value stored in the NVRAM[66].	Similar to the counter accumulation of the stage **Dip**, refer to *Figure 10-6*
Dur.	Calculated phase overall duration of a voltage-swell event	Similar to the duration calculation of the stage **Dip**, refer to *Duration Calculation, Page 2251*
Dur.A Dur.B Dur.C	Durations of a voltage-swell event for the phases A, B, and C These values are only visible when the ***phase-to-ground*** voltage is selected.	
Dur.AB Dur.BC Dur.CA	Durations of a voltage-swell event for the phases AB, BC, and CA These values are only visible when the ***phase-to-phase*** voltage is selected.	
Vsw.	Maximum swell voltage of all phases in a voltage-swell event among the phases A, B, and C or among the phases AB, BC, and CA	These values are percentage values with relation to the parameter **Rated voltage** (reference voltage) that is set in the function group. Refer to *Swell-Voltage Calculation, Page 2258*.
Vsw.A Vsw.B Vsw.C	Maximum swell voltages in a voltage-swell event for the phases A, B, and C These values are only visible when the ***phase-to-ground*** voltage is selected.	
Vsw.AB Vsw.BC Vsw.CA	Maximum swell voltages in a voltage-swell event for the phases AB, BC, and CA These values are only visible when the ***phase-to-phase*** voltage is selected.	

Duration Calculation

For details, refer to *Duration Calculation, Page 2251*.

66 NVRAM = Non-Volatile Random Access Memory; RAM, which does not lose the stored data, even when there is no power.

Swell-Voltage Calculation

Only picked-up phases calculate the maximum values of the swells. If the values are assigned to a log, they are also logged.

Counter Accumulation

For details, refer to *Counter Accumulation, Page 2253*.

Blocking of the Stage

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage is reset.

10.1.5.2 Application and Setting Notes

Evaluation Possibilities – Voltage Variation Function Provides Standard-Relevant Values und Information

The power-quality evaluating standard EN 50160 (grid code) refers to the measuring standard IEC 61000-4-30, with which this function aligns. If you use the default settings of this function, then the measured and logged values are fine for further user-based classifications on EN 50160 or other analysis possibilities of users. For more information, refer to the standard EN 50160.

Parameter: **Threshold**, **Dropout differential**

- Default setting **(_:23491:3) Threshold** = *110.0 %*
- Default setting **(_:23491:8) Dropout differential** = *2.0 %*

The parameters **Threshold** and **Dropout differential** are percentage values related to the parameter **Rated voltage** (reference voltage) that is set in the function group.

Set the parameters **Threshold** and **Dropout differential** for the specific application.

According to the standard IEC 61000-4-30, the swell threshold is typically greater than 110 %, and the hysteresis (**Dropout differential**) is typically equal to 2 %.

Parameter: **Warning delay**

- Default setting **(_:23491:104) Warning delay** = *0.00 s*

If you do not want to log a voltage-swell event that lasts shorter than a specific time duration, for example, 20 ms, you can set the parameter **Warning delay** to *0.02 s*.

10.1.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:9	General:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
Swell 1				
_:23491:1	Swell 1:Mode		• off • on • test	off
_:23491:3	Swell 1:Threshold		100.0 % to 140.0 %	110.0 %
_:23491:8	Swell 1:Dropout differential		1.0 % to 10.0 %	2.0 %
_:23491:104	Swell 1:Warning delay		0.00 s to 60.00 s	0.00 s

10.1.5.4 Information List

No.	Information	Data Class (Type)	Type
Swell 1			
_:23491:81	Swell 1:>Block stage	SPS	I
_:23491:501	Swell 1:>Reset statistics	SPS	I
_:23491:51	Swell 1:Mode (controllable)	ENC	C
_:23491:54	Swell 1:Inactive	SPS	O
_:23491:52	Swell 1:Behavior	ENS	O
_:23491:53	Swell 1:Health	ENS	O
_:23491:55	Swell 1:Pickup	ACD	O
_:23491:57	Swell 1:Warning	SPS	O
_:23491:301	Swell 1:Dur.	MV	O
_:23491:302	Swell 1:Dur.A	MV	O
_:23491:303	Swell 1:Dur.B	MV	O
_:23491:304	Swell 1:Dur.C	MV	O
_:23491:305	Swell 1:Dur.AB	MV	O
_:23491:306	Swell 1:Dur.BC	MV	O
_:23491:307	Swell 1:Dur.CA	MV	O
_:23491:308	Swell 1:Vsw.	MV	O
_:23491:309	Swell 1:Vsw.A	MV	O
_:23491:310	Swell 1:Vsw.B	MV	O
_:23491:311	Swell 1:Vsw.C	MV	O
_:23491:312	Swell 1:Vsw.AB	MV	O
_:23491:313	Swell 1:Vsw.BC	MV	O
_:23491:314	Swell 1:Vsw.CA	MV	O
_:23491:315	Swell 1:Counter	INS	O

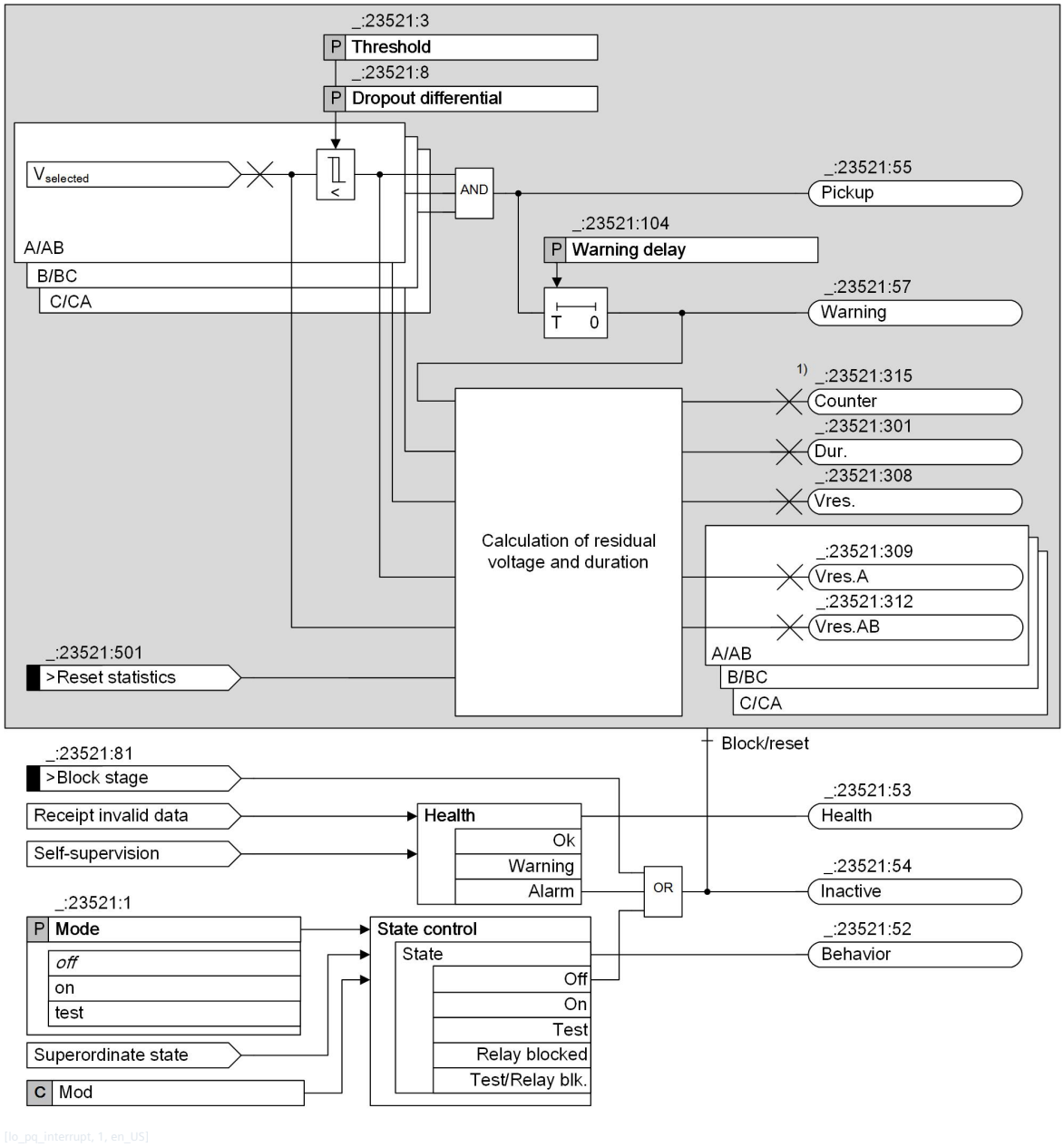
10.1.6 Stage Interruption

10.1.6.1 Description

The stage **Interruption**:

- Detects a voltage interruption in the power system and issues a warning signal
- Logs the interruption duration (not phase-selective) and the minimum residual voltage when the voltage-interruption event disappears
- Counts the number of voltage-interruption events

Logic of the Stage



[lo_pq_interrupt, 1, en_US]

Figure 10-8 Logic Diagram of the Stage Interruption

(1) Counter is a statistical value. It is not reset by the block or reset state of the stage. For more information, refer to *Counter Accumulation, Page 2262*.

Pickup and Warning

If all 3 voltage measured values fall below the threshold value, a signal *Pickup* is issued. After expiration of the time specified by the parameter **Warning delay**, a signal *Warning* is issued. The following measured-value types can be selected:

- The ***phase-to-ground*** voltage is selected as the measured value:
  If all the phase-to-ground voltages VA, VB, and VC fall below the threshold value, the signal *Pickup* is issued.

- The ***phase-to-phase*** voltage is selected as the measured value:
  If all the phase-to-phase voltages VAB, VBC, and VCA fall below the threshold value, the signal *Pickup* is issued.

Value Indications

If the signal *Warning* is issued, it is regarded as a voltage-interruption event. Once the voltage-interruption event disappears (the signal *Warning* drops out), the following value indications are calculated:

- The duration and residual voltages of this event are calculated and can be logged in the operational or user-defined logs if routed.
- The counter of voltage-interruption events is increased by 1.

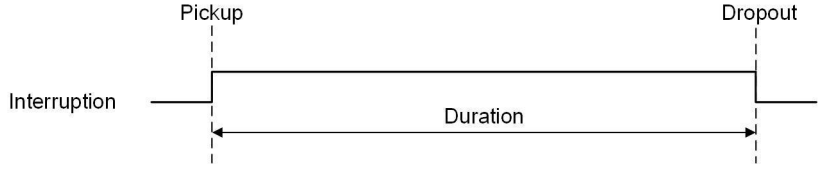
If, after the pickup, the voltage interruption disappears during the time delay, the signal *Warning* is not issued and the incident is regarded as a voltage chattering and not as a voltage-interruption event. No duration or voltage is calculated and the counter is not increased.

Table 10-4 Value Indications of the Stage Interruption

Value	Description	Calculation
Counter	Total number of voltage-interruption events This is a statistical value stored in the NVRAM[67].	Similar to the counter accumulation of the stage **Dip**, refer to *Figure 10-6*
Dur.	Calculated phase overall duration of a voltage-interruption event	Refer to *Duration Calculation, Page 2261*
Vres.	Minimum residual voltage in a voltage-interruption event among the phases A, B, and C or among the phases AB, BC, and CA	These values are percentage values related to the parameter **Rated voltage** (reference voltage) that is set in the function group refer to *Residual-Voltage Calculation, Page 2261*.
Vres.A Vres.B Vres.C	Minimum residual voltages in a voltage-interruption event for the phases A, B, and C These values are only visible when the ***phase-to-ground*** voltage is selected.	
Vres.AB Vres.BC Vres.CA	Minimum residual voltages in a voltage-interruption event for the phases AB, BC, and CA These values are only visible when the ***phase-to-phase*** voltage is selected.	

Duration Calculation

The duration of a voltage-interruption event is defined as the duration between the event start and event end, which is similar to that of a voltage-dip or voltage-swell event. For more details, refer to *Figure 10-4*.



[dw_pq_volt_var_dur_interrupt, 1, en_US]

Figure 10-9 Duration Calculation of the Stage Interruption

Residual-Voltage Calculation

The minimum values of the residual voltages of all phases are calculated. If the values are assigned to a log, they are also logged.

67 NVRAM = Non-Volatile Random Access Memory; RAM, which does not lose the stored data, even when there is no power.

Counter Accumulation

For details, refer to *Counter Accumulation, Page 2253*.

Blocking of the Stage

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage is reset.

10.1.6.2 Application and Setting Notes

Evaluation Possibilities – Voltage Variation Function Provides Standard-Relevant Values und Information

The power-quality evaluating standard EN 50160 (grid code) refers to the measuring standard IEC 61000-4-30, with which this function aligns. If you use the default settings of this function, then the measured and logged values are fine for further user-based classifications on EN 50160 or other analysis possibilities of users. For more information, refer to the standard EN 50160.

Parameter: Threshold, Dropout differential

- Default setting **(_:23521:3) Threshold** = *5.0 %*
- Default setting **(_:23521:8) Dropout differential** = *2.0 %*

The parameters **Threshold** and **Dropout differential** are percentage values related to the parameter **Rated voltage** (reference voltage) that is set in the function group.

Set the parameters **Threshold** and **Dropout differential** for the specific application.

According to the standard IEC 61000-4-30, the interruption threshold can, for example, be set to 5 % or to 10 %, and the hysteresis (**Dropout differential**) is typically equal to 2 %.

Parameter: Warning delay

- Default setting **(_:23521:104) Warning delay** = *0.00 s*

If you do not want to log a voltage-interruption event that lasts shorter than a specific time duration, for example, 20 ms, you can set the parameter **Warning delay** to *0.02 s*.

10.1.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:9	General:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
Interrup. 1				
_:23521:1	Interrup. 1:Mode		• off • on • test	off
_:23521:3	Interrup. 1:Threshold		1.0 % to 20.0 %	5.0 %
_:23521:8	Interrup. 1:Dropout differential		1.0 % to 10.0 %	2.0 %
_:23521:104	Interrup. 1:Warning delay		0.00 s to 60.00 s	0.00 s

10.1.6.4 Information List

No.	Information	Data Class (Type)	Type
Interrup. 1			
_:23521:81	Interrup. 1:>Block stage	SPS	I
_:23521:501	Interrup. 1:>Reset statistics	SPS	I
_:23521:51	Interrup. 1:Mode (controllable)	ENC	C
_:23521:54	Interrup. 1:Inactive	SPS	O
_:23521:52	Interrup. 1:Behavior	ENS	O
_:23521:53	Interrup. 1:Health	ENS	O
_:23521:55	Interrup. 1:Pickup	ACD	O
_:23521:57	Interrup. 1:Warning	SPS	O
_:23521:301	Interrup. 1:Dur.	MV	O
_:23521:308	Interrup. 1:Vres.	MV	O
_:23521:309	Interrup. 1:Vres.A	MV	O
_:23521:310	Interrup. 1:Vres.B	MV	O
_:23521:311	Interrup. 1:Vres.C	MV	O
_:23521:312	Interrup. 1:Vres.AB	MV	O
_:23521:313	Interrup. 1:Vres.BC	MV	O
_:23521:314	Interrup. 1:Vres.CA	MV	O
_:23521:315	Interrup. 1:Counter	INS	O

10.2 Voltage Unbalance

10.2.1 Overview of Functions

In a 3-phase power system, the voltages are normally balanced, as well as the connected loads. In some cases, however, the balanced conditions can be disturbed due to various influences.
Voltage unbalances can be caused by various factors:

- Unbalanced load, for example, caused by different consumers in the individual phases
- Phase failure, for example, due to a tripped 1-phase fuse or a broken conductor
- Faults in the primary system, for example, at the transformer

The function **Voltage unbalance**:

- Detects the voltage-unbalance conditions in the distribution and industrial power systems.
- Monitors the voltage-unbalance conditions.

In the function **Voltage unbalance**, the following stage types are available:

- **V2/V1**: ratio of the negative-sequence voltage to the positive-sequence voltage
- **V0/V1**: ratio of the zero-sequence voltage to the positive-sequence voltage

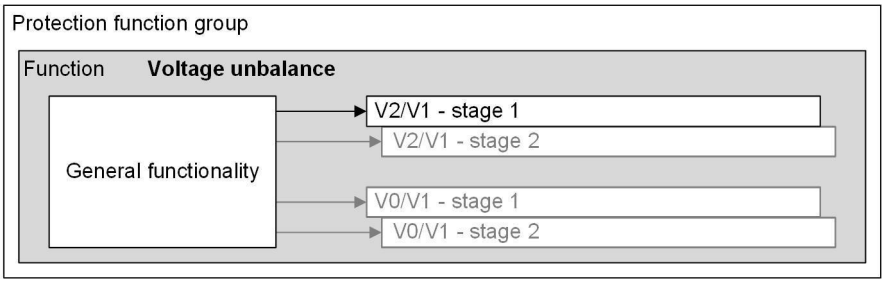
All the measured values are displayed under **Power quality basic** > **Voltage unbalance** of a specific function group in the HMI.
The specific function group in which the function **Voltage unbalance** is instantiated must be connected to the 3-phase voltage measuring point.
The values are recorded according to the standard for voltage quality IEC 61000-4-30 class S.

10.2.2 Structure of the Function

The function **Voltage unbalance** can be used in the protection function groups with 3-phase voltage measurement.
The function **Voltage unbalance** comes factory-set with a stage **V2/V1**.
The following stages can be operated simultaneously within the function:

- 2 stages **V2/V1**
- 2 stages **V0/V1**

The general functionality works across stages on the function level.
The stages are identical in structure. Stages that are not preconfigured are shown in gray in the following figure.



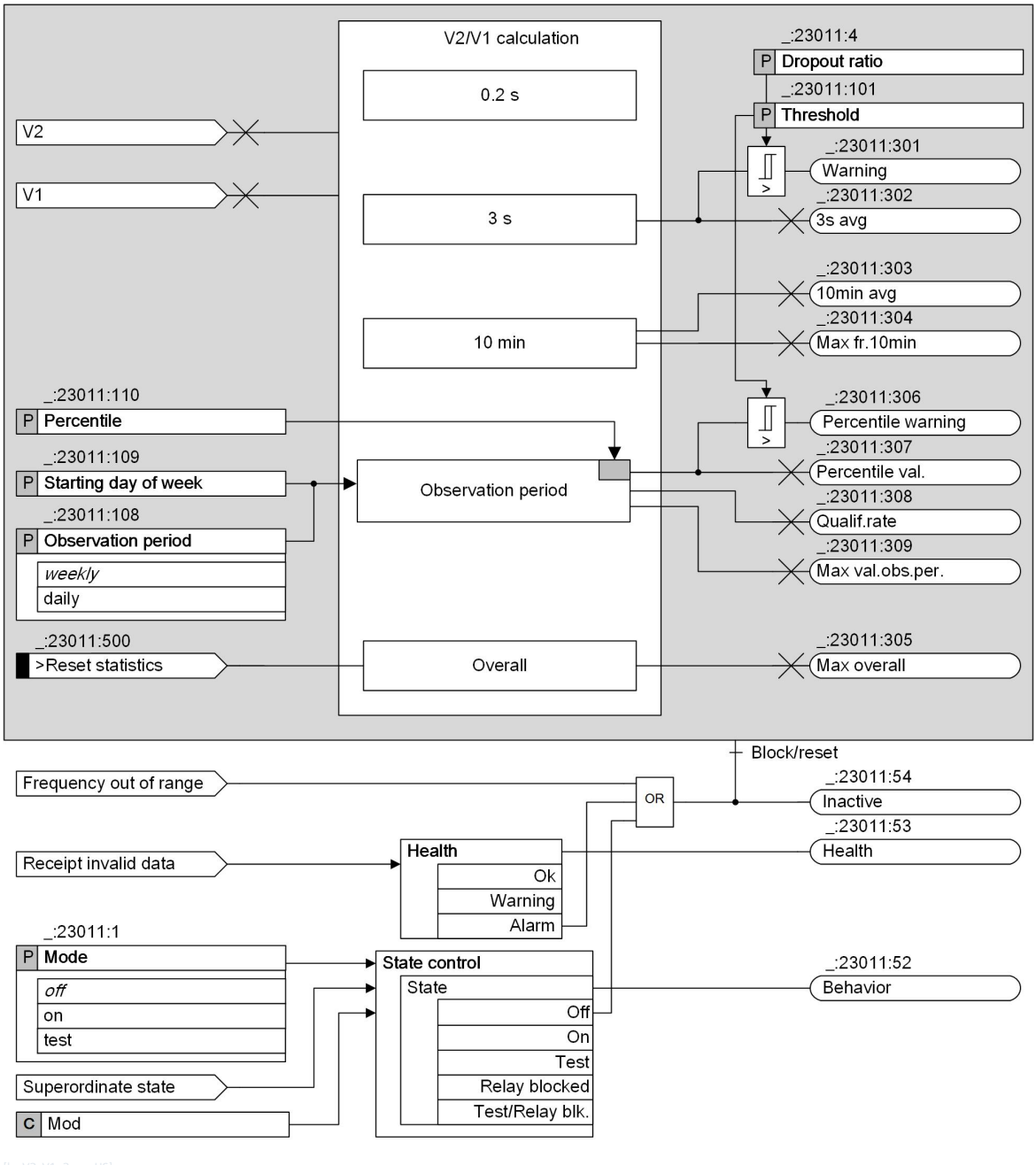
[dw_V_unbalance_structure, 1, en_US]

Figure 10-10 Structure/Embedding of the Function

10.2.3 Stage V2/V1

10.2.3.1 Description

Logic of the Stage



[lo_V2_V1_2, 2, en_US]

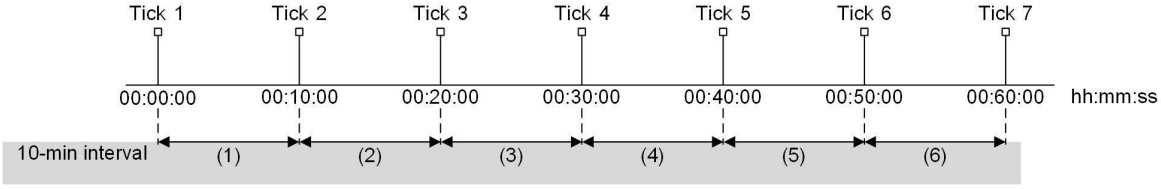
Figure 10-11 Logic Diagram of the Stage **V2/V1**

Measuring Intervals

Measuring Intervals	Description
0.2 s	10 cycles for the 50-Hz system or 12 cycles for the 60-Hz system This interval is the basic measuring interval for this stage. All further measured values are aggregated based on the 0.2-s values.
3 s	150 cycles for the 50-Hz system or 180 cycles for the 60-Hz system This interval is used for the calculation of the 3-s average value.
10 min	The calculation in the 10-min interval is based on the UTC 10-min tick. There is no gap and no overlap between 2 consecutive 10-min intervals. This interval is used for the calculation of the 10-min average value and the maximum 0.2-s value in 10 min.
Observation period	Settable interval of one week or one day
Overall	From the device startup or from the latest reset of statistical values until the current time The maximum value of V2/V1 in overall time is displayed as a statistical value.

Aggregation by the UTC 10-Min Tick

The 10-min average values are aggregated by the UTC 10-min tick according to the standard IEC 61000-4-30. Each 10-min interval begins at a tick.



[dw_tick_interval, 1, en_US]

Figure 10-12 Ticks and 10-Min Intervals in an Hour

Warning of the Voltage Unbalance

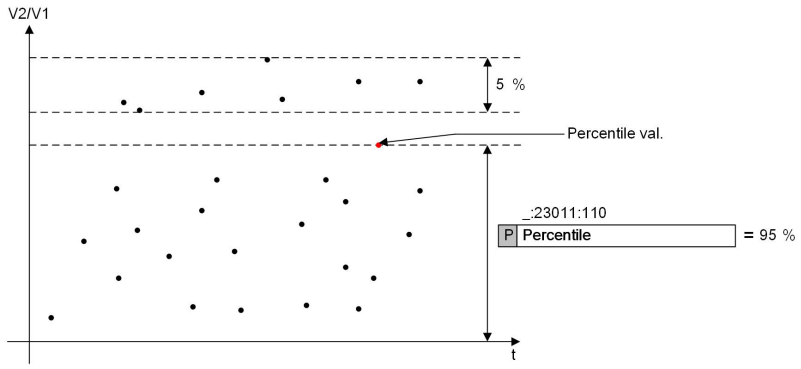
If the 3-s average value exceeds the threshold value, a voltage-unbalance event occurs and the indication *warning* is generated.

If the 3-s average value is smaller than or equal to the result of the threshold value multiplied by the dropout ratio, the indication *warning* for the voltage unbalance disappears.

Observation

A settable observation period of *weekly* or *daily* is provided. In the observation period, the following measured values are observed to determine the voltage-unbalance conditions.

Table 10-5 Observed Values in the Observation Period

Value	Description
Percentile val.	To locate the value *Percentile val.*, you must set the parameter **Percentile**. The following figure shows an example of locating the percentile value: In the figure, all the 10-min average values of V2/V1 in the last observation period are displayed. The parameter **Percentile** is set to 95 %. Then, the value *Percentile val.* is determined as the value that 95 % of the 10-min average values in the last observation period are smaller than or equal to. 
Qualif.rate	Proportion of the 10-min average values that are smaller than the threshold value in the last observation period
Max val.obs.per.	Maximum 0.2-s value in the last observation period

During the observation period, if the value *Percentile val.* of the 10-min average values exceeds the threshold value, a voltage-unbalance event occurs and the indication *Percentile warning* is generated.

Functional Values

Value	Description
Max overall	Maximum 0.2-s value of V2/V1 from the device startup or from the latest reset of statistical values to the current time
3s avg	Average value of V2/V1 in the last 3-s interval, that is, 150 cycles or 180 cycles
10min avg	Average value of V2/V1 in the last 10-min interval
Max fr.10min	Maximum 0.2-s value of V2/V1 in the last 10-min interval
Percentile val.	The value *Percentile val.* is the value that, for example, 95 % (default setting of the parameter **Percentile**) of all 10-min average values in the last observation period are smaller than or equal to. For more information, refer to *Observation, Page 2266*.
Qualif.rate	Proportion of the 10-min average values that are smaller than the threshold value in the last observation period
Max val.obs.per.	Maximum 0.2-s value in the last observation period This value is refreshed at the end of each observation period.

Value Indications

If the indication *Percentile warning* is generated, routed value indications from the table *Table 10-6* can be entered in the log.

Table 10-6 Value Indications

Value	Description
Perc.value abnor.	**Percentile value abnormal** Percentile in case of a warning (percentile is above limiting value) and possible record It is the ame value as *Percentile val.* from the same observation interval.
Qual.rate abnor.	**Quality rate abnormal** Quality rate in case of a warning (percentile is above limiting value) and possible record It is the same value as *Qualif.rate* from the same observation interval.
Max val.obs.per.abnor.	**Maximum value observation period abnormal** Maximum value of the observation period in case of a warning (percentile is above limiting value) and possible record It is the same value as *Max val.obs.per.* from the same observation interval.

The value indications can be routed to the following logs:

- Operational log
- User-defined log 1
- User-defined log 2

Resetting the Statistical Value

The statistical value *Max overall* can be reset via the following methods:

- Via the binary input signal *>Reset statistics*
- Via the **Reset** button for the maximum value of statistic in the operation panel of the device
- Via communication protocols
- Via an online DIGSI connection to the device

Influences Caused by the Change of the Device Time

If the device time is changed, the calculated values in the 10-min intervals and in observation periods are influenced. There are 2 cases:

- After the change, the time is still in the time interval of the calculation.
  The calculation is not influenced and continues. The calculated value is refreshed at the end of the time interval.
- After the change, the time is out of the time interval of the calculation.
  The calculation is influenced and is terminated immediately. Meanwhile, the calculated value is refreshed and the calculation of the next time interval is started.

10.2.3.2 Application and Setting Notes

Evaluation Possibilities – the Stage V2/V1 of the function Voltage Unbalance Provides Standard-Relevant Values and Information

The power-quality evaluating standard EN 50160 (grid code) refers to the measuring standard IEC 61000-4-30, with which this function aligns. If you use the default settings of this function, then the measured and logged values are fine for further user-based evaluations on EN 50160 or other analysis possibilities of users. For more information, refer to the standard EN 50160.

Parameter: Minimum voltage V1

- Default setting **(_:2311:101) Minimum voltage V1** = ***5.000 V***

You can configure the parameter **Minimum voltage V1** in the function block **General**.

With the parameter **Minimum voltage V1**, you set the minimum value of the positive-sequence voltage V1. The calculation in the stage **V2/V1** or **V0/V1** starts only when V1 exceeds the set **Minimum voltage V1**.

Siemens recommends using the default setting.

Parameter: Threshold

- Default setting **(_:23011:101) Threshold** = ***2.00 %***

With the parameter **Threshold**, you set the threshold value to define the degree of voltage unbalance which is not considered as normal any more. If the average value of V2/V1 exceeds the threshold value, a voltage-unbalance event is detected and the indication *Warning* is generated.

According to the standard EN 50160 or IEC TS 62749, Siemens recommends using the default setting.

Parameter: Dropout ratio

- Default setting **(_:23011:4) Dropout ratio** = ***0.95***

With the parameter **Dropout ratio**, you set the dropout ratio for the voltage unbalance. If the average value of V2/V1 is smaller than or equal to the result of the threshold value multiplied by the dropout ratio, the indication *Warning* for the voltage unbalance disappears.

Siemens recommends using the default setting.

Parameter: Observation period

- Default setting **(_:23011:108) Observation period** = ***weekly***

With the parameter **Observation period**, you set the period for the observation.

Parameter Value	Description
weekly	The observation is executed and repeated weekly according to the start day specified by the parameter **Starting day of week**. After the device startup, the first observation starts immediately and ends at the time 00:00:00 of the first starting day. Then, the observation is repeated weekly.
daily	The observation is executed and repeated every day. After the device startup, the first observation starts immediately and ends at the time 00:00:00 of the next day. Then, the observation is repeated day by day.

Parameter: Starting day of week

- Default setting **(_:23011:109) Starting day of week** = ***Sunday***

This parameter is effective only when the parameter **Observation period** is set to ***weekly***.

With the parameter **Starting day of week**, you set the start day of the weekly observation. The start day can be set to any day of the week. For example, it is Tuesday today and the set start day is ***Sunday***, then, the first observation starts from Tuesday to Saturday, and the following observation is executed weekly starting from Sunday.

Parameter: Percentile

- Default setting **(_:23011:110) Percentile** = ***95 %***

With the parameter **Percentile**, you define the range of the 10-min average values that is used to locate the percentile value in the last observation period.

The default setting ***95 %*** is taken as an example. 95 % of the 10-min average values are smaller than or equal to the percentile value in the last observation period.

According to the standard EN 50160 or IEC TS 62749, Siemens recommends using the default setting.

10.2.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Minimum voltage V1		0.300 V to 60.000 V	5.000 V
V2/V1 stage 1				
_:23011:1	V2/V1 stage 1:Mode		• off • on • test	off
_:23011:101	V2/V1 stage 1:Threshold		0.50 % to 10.00 %	2.00 %
_:23011:4	V2/V1 stage 1:Dropout ratio		0.90 to 0.99	0.95
_:23011:108	V2/V1 stage 1:Observation period		• daily • weekly	weekly
_:23011:109	V2/V1 stage 1:Starting day of week		• Sunday • Monday • Tuesday • Wednesday • Thursday • Friday • Saturday	Sunday
_:23011:110	V2/V1 stage 1:Percentile		80 % to 99 %	95 %

10.2.3.4 Information List

No.	Information	Data Class (Type)	Type
V2/V1 stage 1			
_:23011:500	V2/V1 stage 1:>Reset statistics	SPS	I
_:23011:51	V2/V1 stage 1:Mode (controllable)	ENC	C
_:23011:54	V2/V1 stage 1:Inactive	SPS	O
_:23011:52	V2/V1 stage 1:Behavior	ENS	O
_:23011:53	V2/V1 stage 1:Health	ENS	O
_:23011:301	V2/V1 stage 1:Warning	SPS	O
_:23011:305	V2/V1 stage 1:Max overall	MV	O
_:23011:302	V2/V1 stage 1:3s avg	MV	O
_:23011:303	V2/V1 stage 1:10min avg	MV	O
_:23011:304	V2/V1 stage 1:Max fr.10min	MV	O
_:23011:306	V2/V1 stage 1:Percentile warning	SPS	O
_:23011:307	V2/V1 stage 1:Percentile val.	MV	O
_:23011:308	V2/V1 stage 1:Qualif.rate	MV	O
_:23011:309	V2/V1 stage 1:Max val.obs.per.	MV	O
_:23011:310	V2/V1 stage 1:Perc.value abnor.	MV	O
_:23011:311	V2/V1 stage 1:Qual.rate abnor.	MV	O
_:23011:312	V2/V1 stage 1:Max val.obs.per.abnor.	MV	O

10.2.4 Stage V0/V1

10.2.4.1 Description

Logic of the Stage

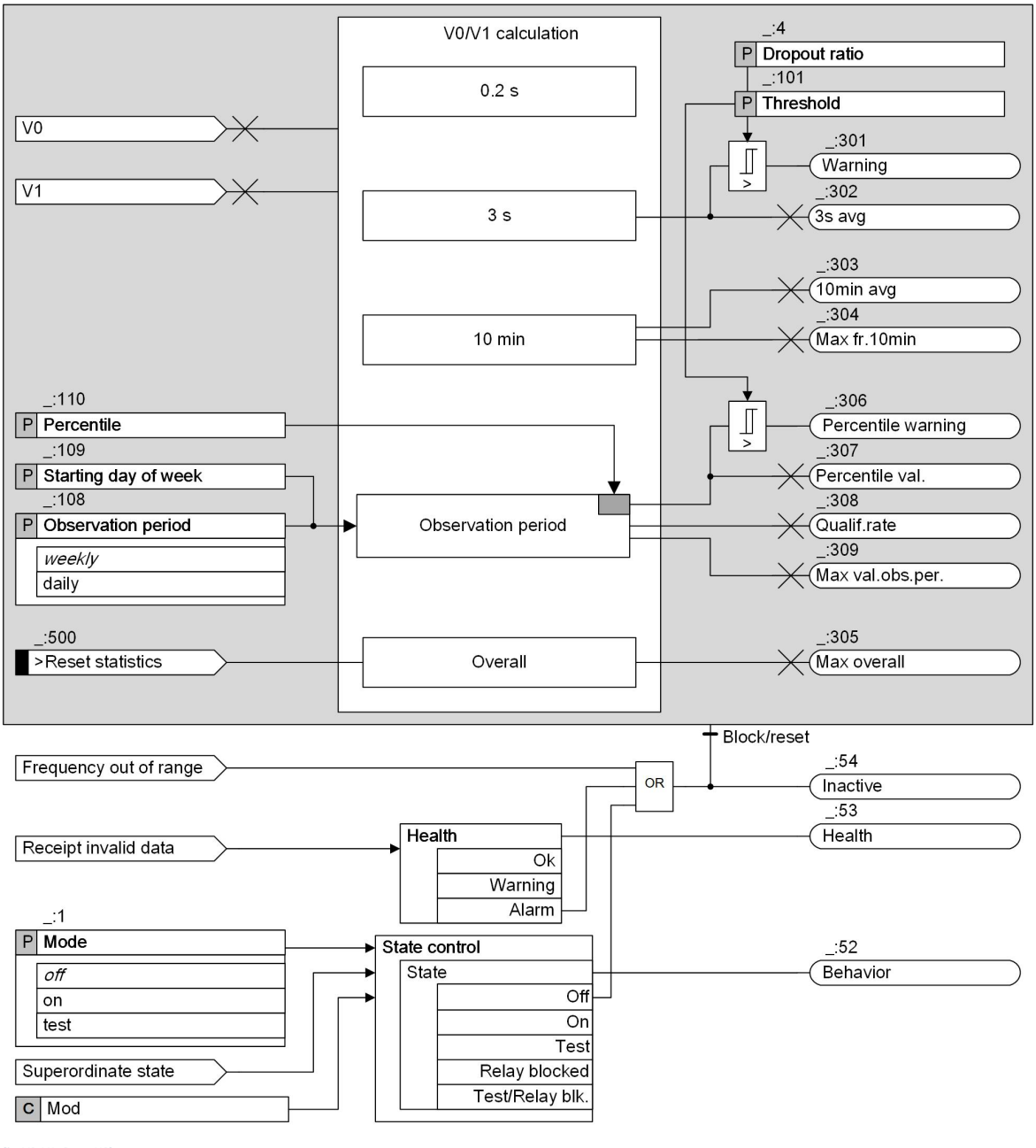


Figure 10-13 Logic Diagram of the Stage **V0/V1**

Measuring Intervals

Measuring Intervals	Description
0.2 s	10 cycles for the 50-Hz system or 12 cycles for the 60-Hz system This interval is the basic measuring interval for this stage. All further measured values are aggregated based on the 0.2-s values.
3 s	150 cycles for the 50-Hz system or 180 cycles for the 60-Hz system This interval is used for the calculation of the 3-s average value.
10 min	The calculation in the 10-min interval is based on the UTC 10-min tick. There is no gap and no overlap between 2 consecutive 10-min intervals. This interval is used for the calculation of the 10-min average value and the maximum 0.2-s value in 10 min.
Observation period	Settable interval of one week or one day
Overall	From the device startup or from the latest reset of statistical values to the current time The maximum value of V0/V1 in overall time is displayed as a statistical value.

Aggregation by the UTC 10-Min Tick

For details, refer to *Aggregation by the UTC 10-Min Tick, Page 2266*.

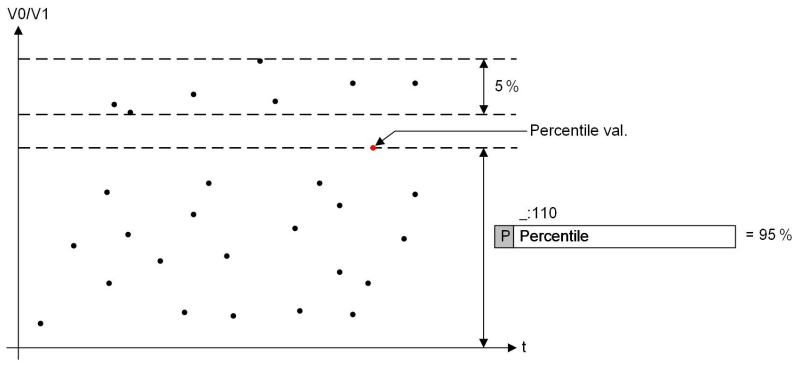
Warning of the Voltage Unbalance

For details, refer to *Warning of the Voltage Unbalance, Page 2266*.

Observation

A settable observation period of *weekly* or *daily* is provided. In the observation period, the following measured values are observed to determine the voltage-unbalance conditions.

Table 10-7 Observed Values in the Observation Period

Value	Description
Percentile val.	To locate the value *Percentile val.*, you must set the parameter **Percentile**. The following figure shows an example of locating the percentile value: In the figure, all the 10-min average values of V0/V1 in the last observation period are displayed. The parameter **Percentile** is set to 95 %. Then, the value *Percentile val.* is determined as the value that 95 % of the 10-min average values in the last observation period are smaller than or equal to. 
Qualif.rate	Proportion of the 10-min average values that are smaller than the threshold value in the last observation period
Max val.obs.per.	Maximum 0.2-s value in the last observation period

During the observation period, if the value *Percentile val.* of the 10-min average values exceeds the threshold value, a voltage-unbalance event occurs and the indication *Percentile warning* is generated.

Functional Values

Value	Description
Max overall	Maximum 0.2-s value of V0/V1 from the device startup or from the latest reset of statistical values to the current time
3s avg	Average value of V0/V1 in the last 3-s interval, that is, 150 cycles or 180 cycles
10min avg	Average value of V0/V1 in the last 10-min interval
Max fr.10min	Maximum 0.2-s value of V0/V1 in the last 10-min interval
Percentile val.	The value *Percentile val.* is the value that, for example, 95 % (default setting of the parameter **Percentile**) of all 10-min average values in the last observation period are smaller than or equal to. For more information, refer to *Observation, Page 2272*.
Qualif.rate	Proportion of the 10-min average values that are smaller than the threshold value in the last observation period
Max val.obs.per.	Maximum 0.2-s value in the last observation period This value is refreshed at the end of each observation period.

Value Indications

For details, refer to *Value Indications, Page 2267*.

Resetting the Statistical Value

For details, refer to *Resetting the Statistical Value, Page 2268*.

Influences Caused by the Change of the Device Time

For details, refer to *Influences Caused by the Change of the Device Time, Page 2268*.

Connection Type

In the stage **V0/V1**, the following connection types of the voltage transformer are available for the 3-phase voltage measuring point:

- *3 ph-to-gnd volt. + VN*
- *3 ph-to-gnd voltages*
- *3 ph-to-ph volt. + VN*
- *2 ph-to-ph volt. + VN*

The following connection types of the voltage transformer are not available for the 3-phase voltage measuring point. If one of the connection types is connected, DIGSI 5 reports an inconsistency:

- *3 ph-to-ph voltages*
- *2 ph-to-ph voltages*

10.2.4.2 Application and Setting Notes

Parameter: `Threshold`

- Default setting **`(_:101) Threshold`** = ***2.00 %***

With the parameter **`Threshold`**, you set the threshold value to define the degree of voltage unbalance which is not considered as normal any more. If the average value of V0/V1 exceeds the threshold value, a voltage-unbalance event is detected and the indication *Warning* is generated.
According to the standard EN 50160 or IEC TS 62749, Siemens recommends using the default setting.

Parameter: `Dropout ratio`

- Default setting **`(_:4) Dropout ratio`** = ***0.95***

With the parameter **`Dropout ratio`**, you set the dropout ratio for the voltage unbalance. If the average value of V0/V1 is smaller than or equal to the result of the threshold value multiplied by the dropout ratio, the indication *Warning* for the voltage unbalance disappears.
Siemens recommends using the default setting.

Parameter: `Observation period`

- Default setting **`(_:108) Observation period`** = ***weekly***

With the parameter **`Observation period`**, you set the period for the observation.

Parameter Value	Description
weekly	The observation is executed and repeated weekly according to the start day specified by the parameter **`Starting day of week`**. After the device startup, the first observation starts immediately and ends at the time 00:00:00 of the first starting day. Then, the observation is repeated weekly.
daily	The observation is executed and repeated every day. After the device startup, the first observation starts immediately and ends at the time 00:00:00 of the next day. Then, the observation is repeated day by day.

Parameter: `Starting day of week`

- Default setting **`(_:109) Starting day of week`** = ***Sunday***

This parameter is effective only when the parameter **Observation period** is set to ***weekly***.

With the parameter **Starting day of week**, you set the start day of the weekly observation. The start day can be set to any day of the week. For example, it is Tuesday today and the set start day is ***Sunday***, then, the first observation starts from Tuesday to Saturday, and the following observation is executed weekly starting from Sunday.

Parameter: Percentile

- Default setting **(_:110) Percentile** = ***95*** **%**

With the parameter **Percentile**, you define the range of the 10-min average values that is used to locate the percentile value in the last observation period.

The default setting ***95*** **%** is taken as an example. 95 % of the 10-min average values are smaller than or equal to the percentile value in the last observation period.

According to the standard EN 50160 or IEC TS 62749, Siemens recommends using the default setting.

10.2.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V0/V1 stage #				
_:1	V0/V1 stage #:Mode		• off • on • test	off
_:101	V0/V1 stage #:Threshold		0.50 % to 10.00 %	2.00 %
_:4	V0/V1 stage #:Dropout ratio		0.90 to 0.99	0.95
_:108	V0/V1 stage #:Observation period		• daily • weekly	weekly
_:109	V0/V1 stage #:Starting day of week		• Sunday • Monday • Tuesday • Wednesday • Thursday • Friday • Saturday	Sunday
_:110	V0/V1 stage #:Percentile		80 % to 99 %	95 %

10.2.4.4 Information List

No.	Information	Data Class (Type)	Type
V0/V1 stage #			
_:500	V0/V1 stage #:>Reset statistics	SPS	I
_:51	V0/V1 stage #:Mode (controllable)	ENC	C
_:54	V0/V1 stage #:Inactive	SPS	O
_:52	V0/V1 stage #:Behavior	ENS	O
_:53	V0/V1 stage #:Health	ENS	O
_:301	V0/V1 stage #:Warning	SPS	O
_:305	V0/V1 stage #:Max overall	MV	O
_:302	V0/V1 stage #:3s avg	MV	O
_:303	V0/V1 stage #:10min avg	MV	O
_:304	V0/V1 stage #:Max fr.10min	MV	O

No.	Information	Data Class (Type)	Type
_:306	V0/V1 stage #:Percentile warning	SPS	O
_:307	V0/V1 stage #:Percentile val.	MV	O
_:308	V0/V1 stage #:Qualif.rate	MV	O
_:309	V0/V1 stage #:Max val.obs.per.	MV	O
_:310	V0/V1 stage #:Perc.value abnor.	MV	O
_:311	V0/V1 stage #:Qual.rate abnor.	MV	O
_:312	V0/V1 stage #:Max val.obs.per.abnor.	MV	O

10.3 THD and Harmonics

10.3.1 Overview of Functions

At the connection point to the public power system, the allowed total harmonic distortion (THD) is limited according to the power-quality related standards. The function **THD and harmonics** can be used to monitor the THD value.

The function **THD and harmonics** serves for the calculation of the following values:

- THD values of the 3-phase currents and 3-phase voltages
- Aggregated THD values of the 3-phase voltages
  If the aggregated THD value exceeds the threshold, a warning is generated.
- 2nd to 20th harmonics of the 3-phase currents and 3-phase voltages

The calculated THD values and harmonics are displayed under **Power quality basic** > **THD and harmonics** of a specific function group in the HMI or via the DIGSI Online-Editor. If routed, the calculated THD values and harmonics are available in the communication protocols and in the fault record. Abnormal values can be logged in the operational or user-defined log if routed.

10.3.2 Structure of the Function

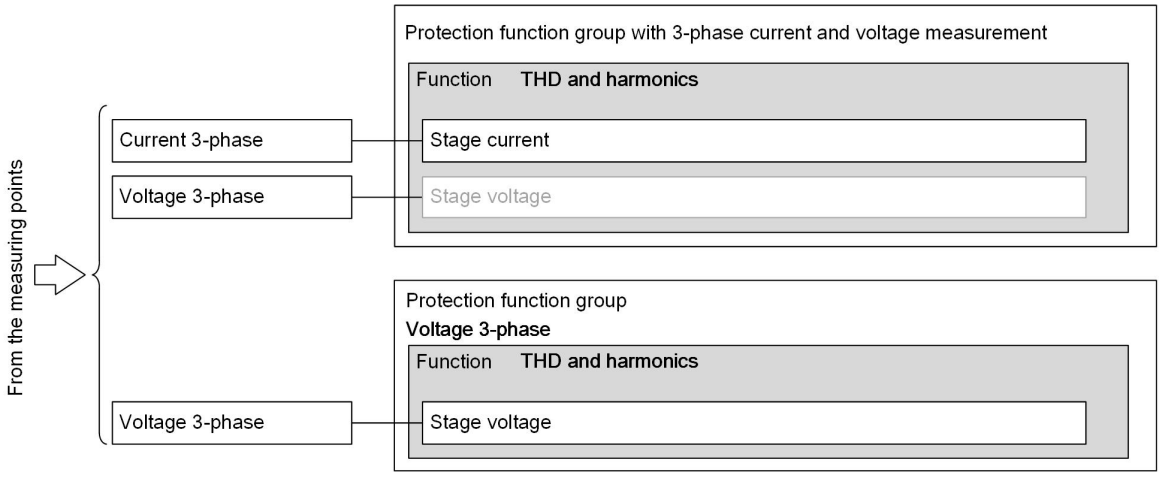
The function **THD and harmonics** can be used in the protection function groups with 3-phase current and voltage measurements and in the protection function group with only 3-phase voltage measurement.

When being used in a function group with 3-phase current and voltage measurements, the function comes factory-set with 1 stage **Current**. The following stages can be operated simultaneously within the function:

- 1 stage **Current**
- 1 stage **Voltage**

When being used in a function group with only 3-phase voltage measurement, the function comes factory-set with 1 stage **Voltage**. Only 1 voltage stage can be operated within the function.

The 2 types of function groups are displayed in the following figure. The stage that is not preconfigured is shown in gray.



[dw_structure_THD harmonic, 3, en_US]

Figure 10-14 Structure/Embedding of the Function

10.3.3 Stage Current

10.3.3.1 Function Description

The stage **Current** calculates and displays the THD values and harmonics for the 3-phase currents.

Calculation of THD Values and Harmonics Values

The THD value of the current is a percentage value calculated as follows:

$$I_{THD} = \frac{\sqrt{\sum_{n=2}^{N} I_n^{\,2}}}{I_s} \cdot 100\ \%$$

[fo_THD value_I, 1, en_US]

Where

N	20 The function supports the THD calculation up to the 20th harmonic.
I_n	Harmonic value of order *n*
I_s	Fundamental-component value

The calculated harmonic values of the current are percentage values that take the fundamental-component value as reference:

$$I_{Harmonic_n} = \frac{I_n}{I_s} \cdot 100\ \%$$

[fo_harmonic ratio_I, 1, en_US]

Functional Measured Values

Table 10-8 Functional Measured Values of the stage **Current**

Value	Description
THD:A THD:B THD:C	THD values of the 3-phase currents for the phases A, B, and C These values are percentage values.
H2:A H2:B H2:C ... H20:A H20:B H20:C	Harmonic values from the 2nd to 20th harmonics of the 3-phase currents for the phases A, B, and C These values are percentage values.

Operating Range

The frequency operating range of the stage **Current** is 0.8 to 1.2 of the rated frequency:

- If the power frequency is in this range, the THD values and harmonics are calculated.
- If the power frequency is out of this range, the THD values and harmonics are shown as "---".

If the fundamental-component value is smaller than 1 % of the rated current, the THD values and harmonics are shown as "---".

10.3.3.2 Information List

No.	Information	Data Class (Type)	Type
Current			
_:22081:52	Current:Behavior	ENS	O
_:22081:53	Current:Health	ENS	O
_:22081:301	Current:THD	WYE	O
_:22081:302	Current:H2	WYE	O
_:22081:303	Current:H3	WYE	O
_:22081:304	Current:H4	WYE	O
_:22081:305	Current:H5	WYE	O
_:22081:306	Current:H6	WYE	O
_:22081:307	Current:H7	WYE	O
_:22081:308	Current:H8	WYE	O
_:22081:309	Current:H9	WYE	O
_:22081:310	Current:H10	WYE	O
_:22081:311	Current:H11	WYE	O
_:22081:312	Current:H12	WYE	O
_:22081:313	Current:H13	WYE	O
_:22081:314	Current:H14	WYE	O
_:22081:315	Current:H15	WYE	O
_:22081:316	Current:H16	WYE	O
_:22081:317	Current:H17	WYE	O
_:22081:318	Current:H18	WYE	O
_:22081:319	Current:H19	WYE	O
_:22081:320	Current:H20	WYE	O

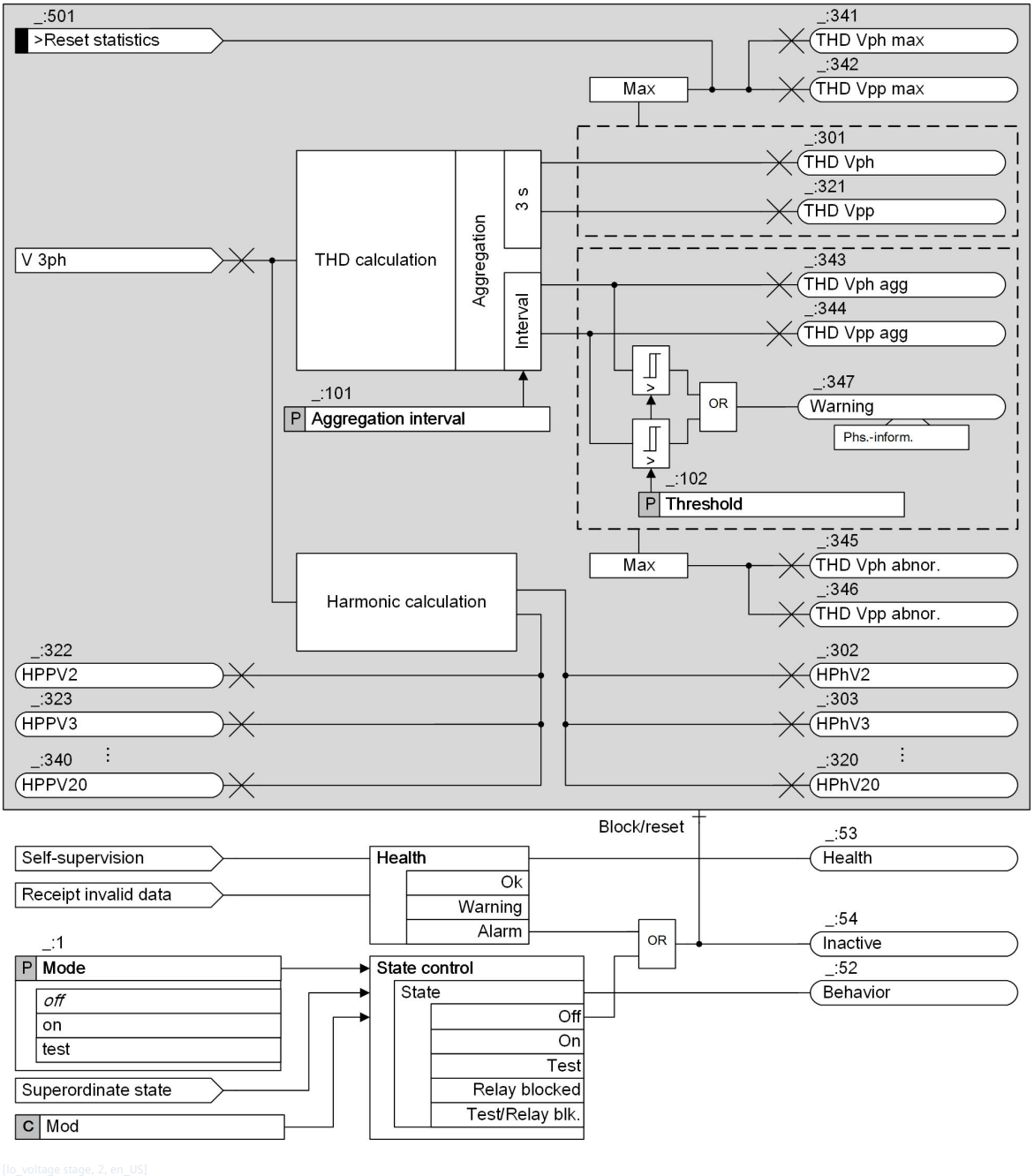
10.3.4 Stage Voltage

10.3.4.1 Function Description

The stage **Voltage**:

- Calculates and displays the THD values and harmonics for the 3-phase voltages.
- Calculates and displays the aggregated THD values for the 3-phase voltages.
- Generates a warning signal if the aggregated THD value exceeds the threshold.

Logic of the Stage



[lo_voltage stage, 2, en_US]

Figure 10-15 Logic Diagram of the stage **Voltage**

Calculation of THD Values and Harmonic Values

The THD value of the voltage is a percentage value. The following table lists the formulas for the calculation of the raw value and the aggregated THD values.

Based on the raw value, the aggregated THD values of the phase-to-phase voltages and the phase-to-ground voltages are calculated.

Table 10-9 Calculation of THD Values

Value	Formula
Raw value	$V_{Raw} = \frac{\sqrt{\sum_{n=2}^{N} V_n^2}}{V_s} \cdot 100\ \%$ • N: 20 The function supports the THD calculation up to the 20th harmonic. • V_n: Harmonic value of order *n* • V_s: Fundamental-component value
THD Vph THD Vpp	$V_{THD} = \frac{1}{N} \sum_{n=0\ (t=0)}^{N\ (t=3\ s)} V_{Raw}\ (n)$ • N: Total number of the raw values over a 3-s interval
THD Vph max THD Vpp max	$V_{THD,\ max} = MAX\ \{V_{THD,\ 1}, V_{THD,\ 2}, V_{THD,\ 3} \ldots\}$
THD Vph agg THD Vpp agg	$V_{THD,\ agg} = \frac{1}{N} \sum_{n=0}^{N} V_{Raw}\ (n)$ • N: Total number of the raw values over the aggregation interval of 1 min or 10 min

The calculated harmonic values of the voltage are percentage values that take the fundamental-component values as reference.

Table 10-10 Calculation of Harmonic Values

Value	Formula
HPhV2 HPhV3 ... HPhV20	$V_{Harmonic_n} = \frac{V_n}{V_s} \cdot 100\ \%$ • V_n: Harmonic value of order *n* • V_s: Fundamental-component value
HPPV2 HPPV3 ... HPPV20	

Functional Values

For the stage **Voltage**, the functional values are divided into 2 submenus:

- Phase-to-ground voltage, as shown in *Table 10-11*.
- Phase-to-phase voltage, as shown in *Table 10-12*.

The functional values are all percentage values. They are calculated using the formulas in the section *Calculation of THD Values and Harmonic Values, Page 2280*.

Table 10-11 Functional Values for the Phase-to-Ground Voltage

Value	Description
THD Vph:A THD Vph:B THD Vph:C	Average THD values of the phase-to-ground voltages for the phases A, B, and C over a 3-s interval
THD Vph max	Maximum 3-s average THD value of the phase-to-ground voltage in the period from the device startup or from the latest reset of this maximum value to the current time
THD Vph agg:A THD Vph agg:B THD Vph agg:C	Average THD values of the phase-to-ground voltages for the phases A, B, and C over the aggregation interval of 1 min or 10 min
HPhV2:A HPhV2:B HPhV2:C ... HPhV20:A HPhV20:B HPhV20:C	Harmonic values from the 2nd to 20th harmonics of the phase-to-ground voltages for the phases A, B, and C

Table 10-12 Functional Values for the Phase-to-Phase Voltage

Value	Description
THD Vpp:AB THD Vpp:BC THD Vpp:CA	Average THD values of the phase-to-phase voltages for the phases AB, BC, and CA over a 3-s intervals
THD Vpp max	Maximum 3-s average THD value of the phase-to-phase voltage in the period from the device startup or from the latest reset of this maximum value to the current time
THD Vpp agg:AB THD Vpp agg:BC THD Vpp agg:CA	Average THD values of the phase-to-phase voltages for the phases AB, BC, and CA over the aggregation interval of 1 min or 10 min
HPPV2:AB HPPV2:BC HPPV2:CA ... HPPV20:AB HPPV20:BC HPPV20:CA	Harmonic values from the 2nd to 20th harmonics of the phase-to-phase voltages for the phases AB, BC, and CA

NOTE

Considering the device resources, do not route non-required harmonic measured values for transmission via communication protocols.

Resetting the Statistical Values

The statistical values *THD Vph max* and *THD Vpp max* can be reset via the following methods:

- Via the binary input signal *>Reset statistics*
- Via the **Reset** button for the maximum value of statistic in the operation panel of the device
- Via communication protocols
- Via an online DIGSI connection to the device

Monitoring of the Aggregation Values

If the aggregated THD value *THD Vph agg* or *THD Vpp agg* exceeds the threshold, a phase-selective indication *Warning* is generated. During the period when the indication *Warning* is active, the maximum aggregated THD value of the phase-to-phase voltages or the phase-to-ground voltages is logged as an abnormal value. The abnormal value can be routed to the following logs:

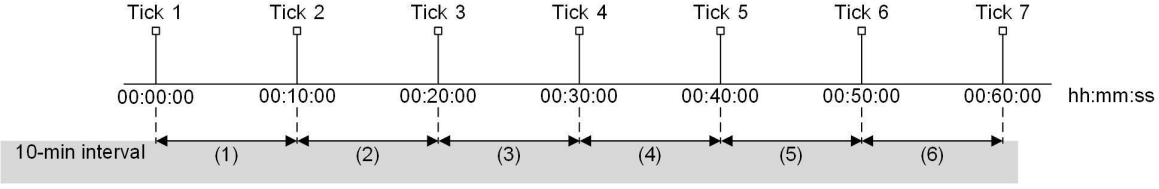
- Operational log
- User-defined log 1
- User-defined log 2

Table 10-13 Abnormal Values

Value	Description
THD Vph abnor.:A THD Vph abnor.:B THD Vph abnor.:C	Abnormal THD values (THD value is above limiting value) of the phase-to-ground voltages for the phases A, B, and C over the aggregation interval of 1 min or 10 min A record is possible.
THD Vpp abnor.:AB THD Vpp abnor.:BC THD Vpp abnor.:CA	Abnormal THD values of the phase-to-phase voltages for the phases AB, BC, and CA over the aggregation interval of 1 min or 10 min A record is possible.

Aggregation by the UTC 10-Min Tick

If the parameter **Aggregation interval** is set to ***10 min***, the THD values are aggregated by the UTC 10-min tick according to the standard IEC 61000-4-30. Each 10-min interval begins at a tick.



[dw_tick_interval, 1, en_US]

Figure 10-16 Ticks and 10-Min Intervals in an Hour

Influences Caused by the Change of the Device Time

If the device time is changed, the calculation of THD values is influenced. There are 2 cases:

- After the change, the time is still in the time interval of the calculation.
  The calculation is not influenced and continues. The calculated value is refreshed at the end of the time interval.
- After the change, the time is out of the time interval of the calculation.
  The calculation is influenced and is terminated immediately. Meanwhile, the calculated value is refreshed and the calculation of the next time interval is started.

Operating Range

The frequency operating range of the stage **Voltage** is 0.8 to 1.2 of the rated frequency:

- If the power frequency is in this range, the THD values and harmonics are calculated.
- If the power frequency is out of this range, the THD values and harmonics are not calculated and are shown as "---". Meanwhile, the function **THD and harmonics** becomes inactive.

If the fundamental-component value is smaller than 5 % of the rated voltage, the THD values and harmonics are shown as "---".

10.3.4.2 Application and Setting Notes

Parameter: `Aggregation interval`

- Default setting **`(_:101) Aggregation interval`** = ***`10 min`***

With the parameter **`Aggregation interval`**, you set the aggregation interval to 1 min or 10 min to determine the THD condition.
According to the standard IEC 61000-4-30, Siemens recommends using the default setting.

Parameter: `Threshold`

- Default setting **`(_:102) Threshold`** = ***`8.0 %`***

With the parameter **`Threshold`**, you set the threshold for the aggregated THD values. If the aggregated THD value exceeds the threshold, the indication *`Warning`* is generated. Meanwhile, the maximum aggregated THD value is logged as an abnormal value.
According to the standard IEC TS 62749, for the low-voltage or medium-voltage system, the THD value should be smaller than or equal to 8 %. Siemens recommends using the default setting.

10.3.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Voltage`				
_:1	Voltage:Mode		• off • on • test	on
_:101	Voltage:Aggregation interval		• 1 min • 10 min	10 min
_:102	Voltage:Threshold		1.0 % to 25.0 %	8.0 %

10.3.4.4 Information List

No.	Information	Data Class (Type)	Type
`Voltage`			
_:501	Voltage:>Reset statistics	SPS	I
_:51	Voltage:Mode (controllable)	ENC	C
_:54	Voltage:Inactive	SPS	O
_:52	Voltage:Behavior	ENS	O
_:53	Voltage:Health	ENS	O
_:347	Voltage:Warning	ACT	O
_:301	Voltage:THD Vph	WYE	O
_:341	Voltage:THD Vph max	MV	O
_:343	Voltage:THD Vph agg	WYE	O
_:345	Voltage:THD Vph abnor.	WYE	O
_:321	Voltage:THD Vpp	DEL	O
_:342	Voltage:THD Vpp max	MV	O
_:344	Voltage:THD Vpp agg	DEL	O
_:346	Voltage:THD Vpp abnor.	DEL	O
_:302	Voltage:HPhV2	WYE	O
_:303	Voltage:HPhV3	WYE	O
_:304	Voltage:HPhV4	WYE	O
_:305	Voltage:HPhV5	WYE	O

No.	Information	Data Class (Type)	Type
_:306	Voltage:HPhV6	WYE	O
_:307	Voltage:HPhV7	WYE	O
_:308	Voltage:HPhV8	WYE	O
_:309	Voltage:HPhV9	WYE	O
_:310	Voltage:HPhV10	WYE	O
_:311	Voltage:HPhV11	WYE	O
_:312	Voltage:HPhV12	WYE	O
_:313	Voltage:HPhV13	WYE	O
_:314	Voltage:HPhV14	WYE	O
_:315	Voltage:HPhV15	WYE	O
_:316	Voltage:HPhV16	WYE	O
_:317	Voltage:HPhV17	WYE	O
_:318	Voltage:HPhV18	WYE	O
_:319	Voltage:HPhV19	WYE	O
_:320	Voltage:HPhV20	WYE	O
_:322	Voltage:HPPV2	DEL	O
_:323	Voltage:HPPV3	DEL	O
_:324	Voltage:HPPV4	DEL	O
_:325	Voltage:HPPV5	DEL	O
_:326	Voltage:HPPV6	DEL	O
_:327	Voltage:HPPV7	DEL	O
_:328	Voltage:HPPV8	DEL	O
_:329	Voltage:HPPV9	DEL	O
_:330	Voltage:HPPV10	DEL	O
_:331	Voltage:HPPV11	DEL	O
_:332	Voltage:HPPV12	DEL	O
_:333	Voltage:HPPV13	DEL	O
_:334	Voltage:HPPV14	DEL	O
_:335	Voltage:HPPV15	DEL	O
_:336	Voltage:HPPV16	DEL	O
_:337	Voltage:HPPV17	DEL	O
_:338	Voltage:HPPV18	DEL	O
_:339	Voltage:HPPV19	DEL	O
_:340	Voltage:HPPV20	DEL	O

10.4 Total Demand Distortion

10.4.1 Overview of Functions

At the connection point to the public power system, the allowed total demand distortion (TDD) is limited according to the power-quality related standards. The function **Total demand distortion** can be used to monitor the TDD value.

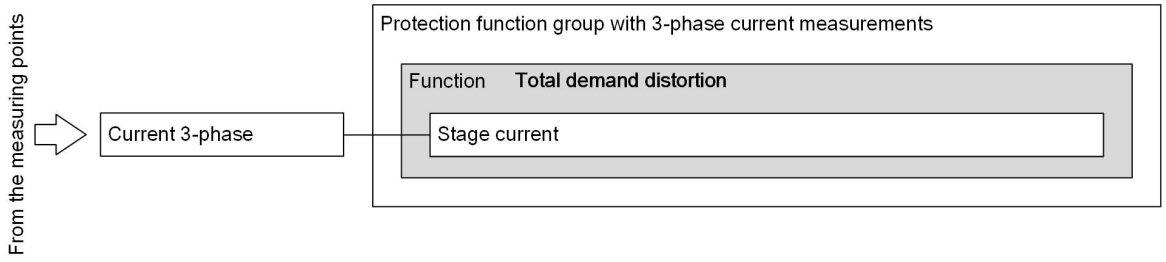
The function **Total demand distortion** serves for calculating the following values of the 3-phase currents:

- 3-s TDD value
- TDD value within an interval
  If the TDD value **`TDD intvl.`** exceeds the threshold value, a warning is generated.

The TDD values are displayed under **Power quality basic** > **TDD** of a specific function group in the HMI or via the DIGSI Online-Editor. If routed, the TDD values are available in the communication protocols and the fault records. Abnormal values can be logged in the operational log or user-defined logs.

10.4.2 Structure of the Function

The function **Total demand distortion** can be used in the protection function groups with 3-phase current measurements. When being used in such a function group, the function comes factory-set with 1 stage **Current**.

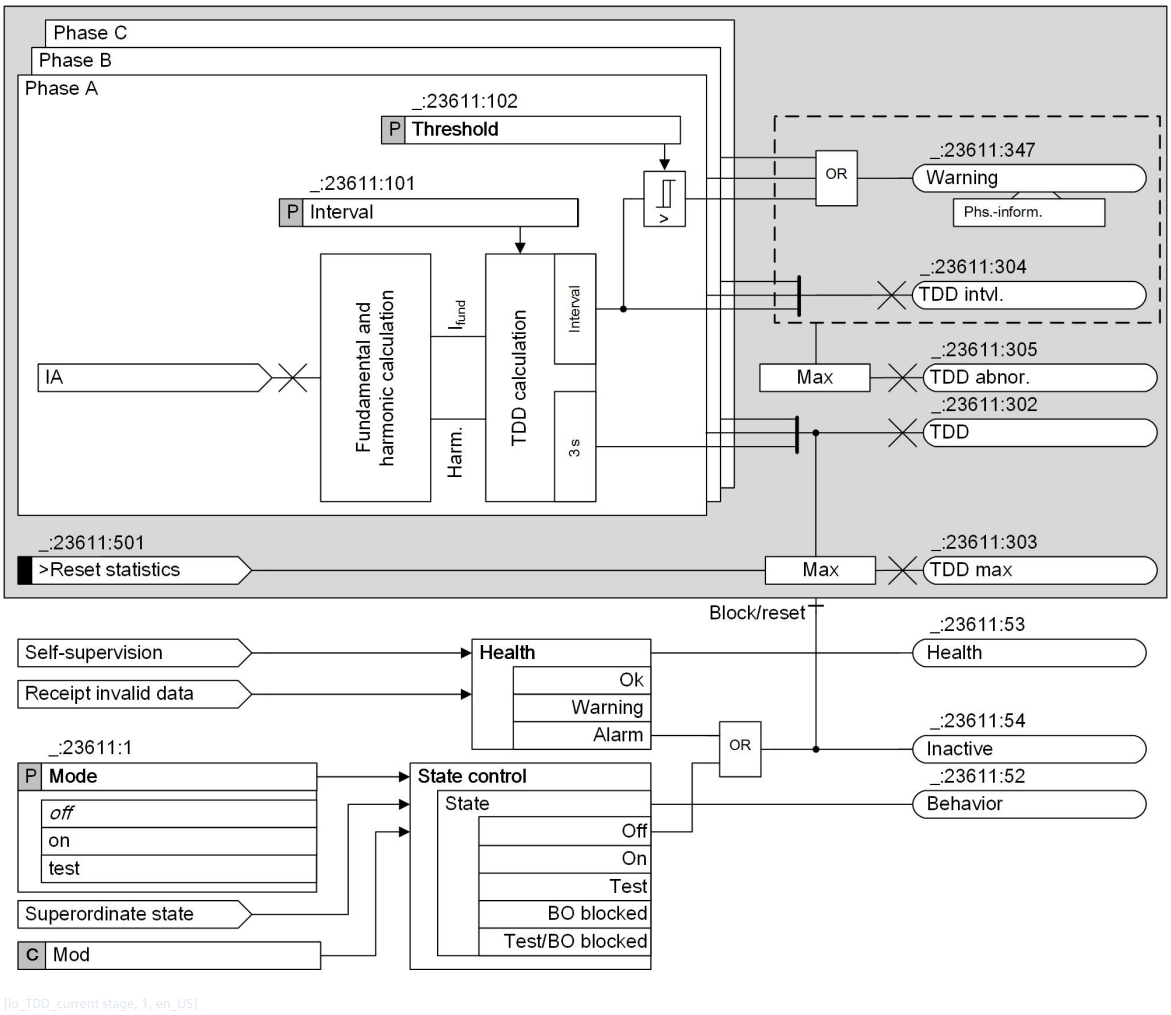


[dw_TDD_structure, 1, en_US]

Figure 10-17 Structure/Embedding of the Function

10.4.3 Stage Current

Logic of the Stage



[lo_TDD_current stage, 1, en_US]

Figure 10-18 Logic Diagram of the Stage Current

Calculation of TDD Values

Both the 3-s TDD value and the TDD value within an intervall are calculated as follows:

$$I_{TDD} = \frac{\sqrt{\sum_{k=2}^{N}[\text{mean}(I_k)]^2}}{I_{lmax}}$$

[fo_TDD_I, 1, en_US]

Where

N	20 The function supports the TDD calculation up to the 20th harmonic.
I_k	Harmonic value of order *k*
I_{lmax}	Maximum fundamental-component value of the demand load current over an interval
mean(I_k)	Arithmetic mean value of each order harmonic component over the whole interval

Functional Values

All functional values are given in percentage.

Table 10-14 Functional Values of the Stage Current

Value	Description
TDD:A TDD:B TDD:C	TDD values for phases A, B, and C over the 3-s intervals
TDD intvl.:A TDD intvl.:B TDD intvl.:C	TDD values for phases A, B, and C over the 15-min or 30-min interval
TDD max	Maximum TDD value in the period from the device startup or from the latest reset of this maximum value to the current time This value is the maximum value of the *TDD* which is calculated over the 3-s intervals.

Resetting the Statistical Values

The statistical value *TDD max* can be reset with the following methods:

- Via the binary input signal *>Reset statistics*
- Via the **Reset** button for the maximum value of the statistic in the operation panel of the device
- Via communication protocols
- Via an online DIGSI connection to the device

Supervision of the TDD Value within an interval

The stage **Current** monitors the TDD value **TDD intvl.** within an interval and generates the phase-selective indication *Warning* if **TDD intvl.** exceeds the threshold.

When the indication *Warning* drops out, the maximum TDD value since the beginning of this indication which contains the maximum value of all phases, is entered as an abnormal value in the log (if the value is routed). You can route the abnormal value to the following logs:

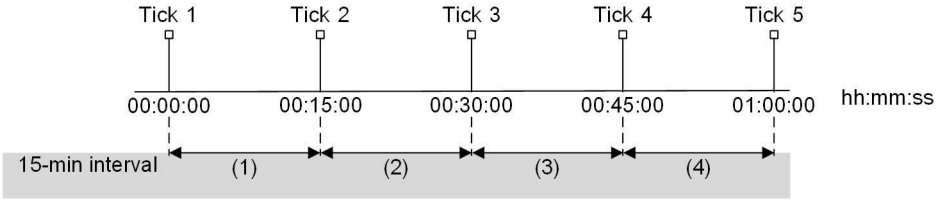
- Operational log
- User-defined log 1
- User-defined log 2

Table 10-15 Abnormal Value

Value	Description
TDD abnor.:A TDD abnor.:B TDD abnor.:C	**TDD abnormal** Maximum TDD value **TDD intvl.** during the event as long as the indication *Warning* indication is active

Aggregation by the UTC 15-Min Tick

Based on the experience in THD values which are aggregated by the UTC 10-min tick according to the IEC 61000-4-30 standard, the parameter **Interval** in TDD is set to ***15 min*** by default. Each 15-min interval begins at a tick. The following figure shows the ticks and the 15-min intervals in an hour.



[dw_TDD_tick_interval, 1, en_US]

Figure 10-19 Ticks and 15-Min Intervals in an Hour

Influences Caused by the Change of the Device Time

If the device time is changed, the calculation of TDD values is influenced. There are 2 cases:

- After the change, the time is still in the time interval of the calculation.
  The calculation is not influenced and continues. The calculated value is refreshed at the end of the time interval.
- After the change, the time is out of the time interval of the calculation.
  The calculation is influenced and is terminated immediately. Meanwhile, the calculated value is refreshed and the calculation of the next time interval is started.

Operating Range

The frequency operating range of the stage **Current** is 0.8 to 1.2 of the rated frequency:

- If the power frequency is in this range, the TDD values are calculated.
- If the power frequency is out of this range, the TDD values are not calculated and are shown as `---`. Meanwhile, the function **Total demand distortion** becomes inactive.

If the fundamental-component value is smaller than 1 % of the rated current, TDD values and harmonics are set to `---`.

10.4.4 Application and Setting Notes

Parameter: _:23611:101 Interval

- Default setting **Interval** = ***15 min***

With the parameter **Interval**, you set the interval to 15 min or 30 min to determine the TDD condition.

Parameter: _:23611:102 Threshold

- Default setting **Threshold** = ***5.0 %***

With the parameter **Threshold**, you set the threshold for the TDD value. If the demand TDD values exceed the threshold value, the indication *Warning* is generated. Meanwhile, the maximum TDD value is taken as the abnormal value and is shown in the DIGSI 5 information lists.

Siemens recommends using the default setting.

10.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage				
_:23611:1	Stage:Mode		• off • on • test	off
_:23611:101	Stage:Interval		• 15 min • 30 min	15 min
_:23611:102	Stage:Threshold		1.0 % to 25.0 %	5.0 %

10.4.6 Information List

No.	Information	Data Class (Type)	Type
Stage			
_:23611:501	Stage:>Reset statistics	SPS	I
_:23611:51	Stage:Mode (controllable)	ENC	C
_:23611:54	Stage:Inactive	SPS	O
_:23611:52	Stage:Behavior	ENS	O
_:23611:53	Stage:Health	ENS	O
_:23611:347	Stage:Warning	ACT	O
_:23611:302	Stage:TDD	WYE	O
_:23611:303	Stage:TDD max	MV	O
_:23611:304	Stage:TDD intvl.	WYE	O
_:23611:305	Stage:TDD abnor.	WYE	O

11 Functional Tests

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11.1 General Notes

Various tests have to be performed for commissioning to warrant the correct function of the device.

For tests using secondary test equipment, make sure that no other measurands are locked in and trip and close commands to the circuit breakers are interrupted, unless otherwise indicated.

Secondary tests can never replace primary tests because they cannot include connection faults. They can be used to check the setting values.

Primary tests may be done only by qualified personnel who are familiar with the commissioning of protection systems, with the operation of the system, and with safety regulations and provisions (switching, grounding, etc.).

Switching operations also have to be performed for the commissioning. The described tests require that these be capable of being performed safely. They were not conceived for operational checks.

11.2 Enabling/Disabling the Application/Test Mode for the Entire Device

Siemens recommends to enable the test mode for the entire device before you start testing protection functions.

You can enable or disable the test mode for the entire device as follows:

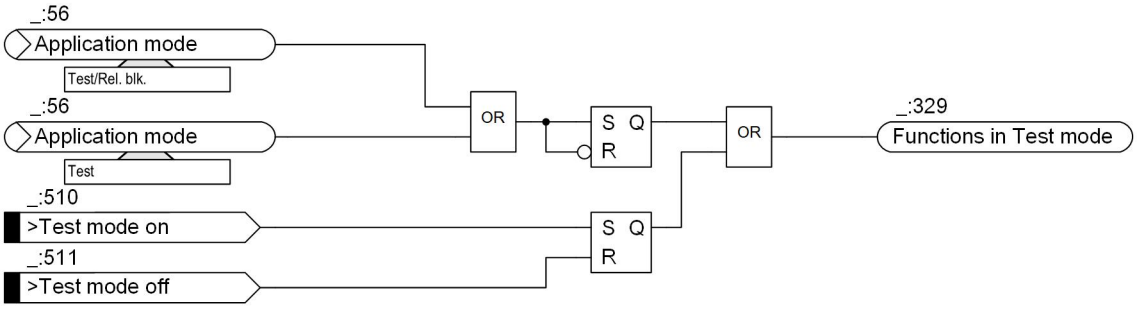
- Via the on-site operation panel under **Device functions > Operating states >** *Application mode* = ***Test*** or ***Test/Relay blk.***
- Via the binary inputs *(_:91:510) General:>Test mode on* and *(_:91:511) General:>Test mode off*

  You can find the binary inputs in the DIGSI information routing under **General**.
- Via communication (IEC 61850) with the controllable *(_:91:56) General:Application mode*

  You can find the controllable in the DIGSI information routing under **General**.

When the test mode for the entire device is enabled, the indication *(_:91:329) Functions in Test mode* is generated.

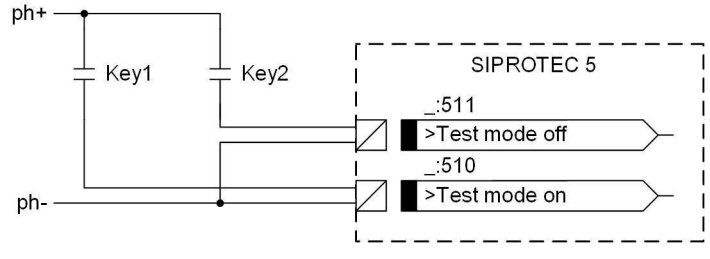
In the test mode of the device all device indications are marked with a test bit. This prevents the circuit breaker from switching unintentionally or protection functions from starting unintended actions. If you enable or disable the test mode for the entire device using the controllable *(_:91:56) General:Application mode*, the device stores the state of the controllable in a voltage-fail-safe memory.



[lo_application_mode_device, 1, en_US]

Figure 11-1 Logic Diagram: Enabling/Disabling the Test Mode for the Entire Device

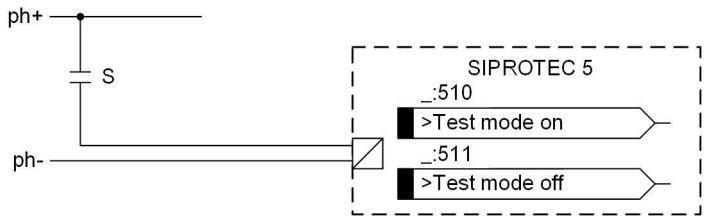
The following figures show possible variants for enabling and disabling the test mode for the entire device using binary inputs. The following figure shows the use of push-buttons **Ta1** and **Ta2**:



[lo_application_mode_device_taster, 1, en_US]

Figure 11-2 External Wiring of Push-Buttons for Enabling/Disabling the Test Mode for the Entire Device

The following figure shows the use of a switch **S**. Route the logical binary input *(_:91:510) General:>Test mode on* as **H** (high-active) and the logical binary input *(_:91:511) General:>Test mode off* as **L** (low-active) to a physical binary input.



[lo_application_mode_device_switch, 1, en_US]

Figure 11-3 External Wiring of Switches for Enabling/Disabling the Test Mode for the Entire Device

11.3 Checking System Integration

In addition to the protection setting and the correct routing of the signals, proper system integration is important. When checking the system integration, Siemens recommends the following procedure:

- ✧ The device must placed in the operating area at least 2 hours before you apply voltage for the first time. By allowing thermal equilibrium to be established, you avoid moisture and condensation on the device. Perform the connection checks on a completely installed device with the system switched off and grounded.

You will find connection examples of the current transformer circuits in the manual's appendix. Also observe the connector pin-outs (see Appendix *A.4 Standard Variant for 7UT82* , *A.5 Standard Variants for 7UT85*, *A.6 Standard Variants for 7UT86* and *A.7 Standard Variants for 7UT87*).

Proceed as follows in order to check the system connections:



DANGER

Hazardous voltages.

Noncompliance with the following measures can lead to death, serious physical injury or significant material damage.

- ✧ Only qualified individuals who are familiar with and follow the safety regulations and precautionary measures may perform checks.



CAUTION

Exercise caution when operating the device without a battery on a battery charging device.

Noncompliance with the following measure can cause impermissibly high voltages and, as a result, destruction of the device.

- ✧ Do not operate devices on a battery charging device without a battery connected (you will find limiting values in the Technical Data).

- ✧ Switch off the circuit breaker for the supply auxiliary voltage and the measuring voltage.

Measure all current and voltage transformer supply cables according to system and connection diagram:

- ✧ Check the connections of all sets of 3-phase current transformers to the device inputs. Are they connected correctly and do they match the configuration (measuring point assignment)?
- ✧ Check the connections of all sets of 1-phase current transformers to the device inputs. Are they connected correctly and do they match the configuration?
- ✧ Check whether the grounding of the current transformer is correct. Grounding in the direction of the protected object is preferred.
- ✧ Check whether the polarity of the current transformer connections is identical in each set of transformers.
- ✧ Check whether the phase allocation of all sets of 3-phase current transformers is correct.
- ✧ Check whether the polarity of all sets of 1-phase current transformers is correct (if used).
- ✧ Check whether the grounding of the voltage transformer is correct (if used).
- ✧ Check whether the polarity of the voltage transformer connections is identical and correct (if used).
- ✧ Check whether the phase allocation of the voltage transformer is correct (if used).
- ✧ If the test switch for the secondary test of the device is used, check its functions.

NOTE

Ensure that the current-transformer secondary lines are automatically short-circuited in the setting **Test**.

- ✧ Loop the ammeter into the supply line for auxiliary voltage and select a range from 2.5 A to 5 A.
- ✧ Switch on the circuit breaker for the supply auxiliary voltage.
- ✧ Check the voltage level and polarity on the device terminals or the connection modules.

The current consumption must correspond to the quiescent power consumption of the device. A short swing of the phasor is uncritical and displays the charging current inrush to the storage capacities.

- ✧ Switch off the circuit breaker for the supply auxiliary voltage.
- ✧ Remove the ammeter and restore the normal auxiliary voltage connection.
- ✧ Switch on the voltage-transformer circuit breaker (if used).
- ✧ Check the direction of the rotating field at the device terminals.
- ✧ Switch off the circuit breaker for the transformer voltage and supply auxiliary voltage.
- ✧ Check the trip lines to the circuit breakers.
- ✧ Check the control lines from and to other devices.
- ✧ Check the signaling wires.
- ✧ Switch on the circuit breaker for the transformer voltage and supply auxiliary voltage again.

11.4 Commissioning Notes Transformer Differential Protection

11.4.1 Secondary Tests

Secondary tests can never replace the primary tests described in the following *11.4.2 Primary Tests*, because they cannot include connection faults.
Secondary tests are used to check the following:

- Checking the setting values
- Proper response of the protection function
- Engineering (for example, routing the respective logic signals, display images with measured values, logics in CFC, and much more)

If you want to perform secondary tests, observe the following instructions.

NOTE

For tests with secondary test equipment, ensure that no other measurands are connected and the trip commands to the circuit breakers are open; otherwise, the circuit breaker could be activated.

Perform the tests with the current setting values for the device. If these values are not (yet) present, check with the default values.

NOTE

The measuring accuracy to be achieved depends on the electrical data of the used test sources. The accuracies stated in the Technical Data can be expected only if the reference conditions stipulated in VDE 0435/part 303 and IEC 60255 are ensured and precision instruments are used. The specified tolerances refer to the default data for the protected objects. If the rated current of the protected object in relation to the current transformer's rated current deviates considerably from the device's rated current, you must assume higher response tolerances.

For differential protection, you can check each side separately. This corresponds to the simulation of a fault supplied from one side. If a side has several measuring points, the measuring inputs not included in the test carry no current. The pickup value is tested by slowly increasing the test current.

NOTE

Tests of currents via quadruple device-rated current (or a maximum of 20 A) lead to an overload of the input circuits and may be performed only briefly. You can find more information in chapter *12.2 Transformer Differential Protection*. Interrupt testing to allow cool-down!

The set pickup values refer to symmetrical 3-phase current in the case of 3-phase protected objects.
If you are testing parameters set during operation, you must ensure that the setting value for the differential protection refers to the rated current of the protected object. The rated current is the primary current that results formally from:

$$I_{rated,obj} = \frac{S_{rated,obj}\,[MVA] \cdot 1000}{\sqrt{3} \cdot V_{rated,obj}\,[kV]}\,[A]$$

[fonennsl-170712-01.tif, 1, en_US]

$S_{rated,obj}$	Rated apparent power of the protected object
$V_{rated,obj}$	Rated voltage of the protected object or the winding being observed

For a winding with voltage control, the calculated voltage applies in accordance with *6.2.4 Application and Setting Notes*.

For transformers, the actual pickup values for 1-phase or 2-phase testing also depend on the vector group of the transformer. For 1-phase testing, the pickup values also depend on the treatment of the winding neutral point and the processing of the neutral point current.
To obtain the actual pickup value, multiply the setting value by a vector-group factor k_{SG} according to the following formula:

$$\frac{I_{\text{rated transf.}}}{I_{\text{rated transf. prim}}} k_{SG}$$

[foscgrfa-170712-01.tif, 1, en_US]

The following table shows this factor k_{SG} as a function of the vector group and the type of fault for 3-phase transformers.

Table 11-1 Correction Factor k_{SG} for the Vector Group (SG) and Fault Type

Fault Type	Reference Winding (High Voltage)	Even SG Number (0, 2, 4, 6, 8, 10)	Odd SG Number (1, 3, 5, 7, 9, 11)
3-phase	1	1	1
2-phase	1	1	$\sqrt{3}/2 \approx 0.866$
1-phase with I_0 elimination	3/2 = 1.5	3/2 = 1.5	$\sqrt{3} \approx 1.73$
1-phase without I_0 elimination	1	1	$3/(1+\sqrt{3}) \approx 1.1$

Example:

3-phase transformer	S_{rated} = 57 MVA
Vector group	Yd5
High voltage	V_{rated} = 110 kV
Current transformer	300 A/1 A
Undervoltage	V_{rated} = 25 kV
Current transformer	1500 A/1 A

The following applies to the upper-voltage winding:

$$I_{\text{rated transf.}} \frac{S_{\text{rated transf.}}\,[\text{MVA}] \cdot 1000}{\sqrt{3} \cdot V_{\text{rated winding}}\,[\text{kV}]}\,[\text{A}] = \frac{57\,[\text{MVA}] \cdot 1000}{\sqrt{3} \cdot 110\,[\text{kV}]}\,[\text{A}] = 299\ \text{A}$$

[foobersp-170712-01.tif, 1, en_US]

Here the rated current of the winding = rated current of current transformer. Thus, for a 3-phase or 2-phase test, the pickup value corresponds to the setting value **`threshold value`** of the device (k_{SG} = 1 for reference winding) with reference to the device rated current. For the threshold value the designation IDIFF> is used.
For a 1-phase test with residual current elimination, 1.5 times the value is to be expected as a pickup value.
The following applies to undervoltage:

$$I_{\text{rated transf.}} \frac{S_{\text{rated transf.}}\,[\text{MVA}] \cdot 1000}{\sqrt{3} \cdot V_{\text{rated winding}}\,[\text{kV}]}\,[\text{A}] = \frac{57\,[\text{MVA}] \cdot 1000}{\sqrt{3} \cdot 25\,[\text{kV}]}\,[\text{A}] = 1316\ \text{A}$$

[fountrsp-170712-01.tif, 1, en_US]

For the secondary test of this winding, the theoretical pickup value refers to device's rated value.

$$\frac{I_{\text{pickup}}}{I_{\text{rated device}}} = \frac{I_{\text{rated transf.}}}{I_{\text{rated transf., prim}}} \cdot k_{VG} \cdot \text{IDiff} >= \frac{1316\ \text{A}}{1500\ \text{A}} \cdot k_{VG} \cdot \text{IDiff} >= 0.877 \cdot k_{VG} \cdot \text{IDiff} >$$

[fothanwt-041016-01, 1, en_US]

Due to the odd vector-group numbers, the following pickup values apply (see *Table 11-1*):

3-phase $k_{SG} = 1$

$$\frac{I_{pickup}}{I_{rated\ device}} = 0.877 \cdot IDIFF>$$

[fo3phasw-170712-01.tif, 1, en_US]

2-phase $k_{SG} = \sqrt{3}/2$

$$\frac{I_{pickup}}{I_{rated\ device}} = 0.760 \cdot IDIFF>$$

[fo2phasw-170712-01.tif, 1, en_US]

1-phase $k_{SG} = \sqrt{3}$

$$\frac{I_{pickup}}{I_{rated\ device}} = 1.52 \cdot IDIFF>$$

[fo1phasw-170712-01.tif, 1, en_US]

11.4.2 Primary Tests

If secondary test equipment is connected to the device, remove it and switch the test switch to the operating position.

NOTE

Be aware that a trip results in case of incorrect connections.

Preparation of Current Tests

So that the differential protection is effective as short-circuit protection for the first excitation of the protected object under a voltage load, perform the current tests in the case of initial commissioning before switching on the voltage for the first time. If the current tests are possible only when the protected object is switched on, for example, with network transformers when no test source for low voltage is available, then commission an external backup protection on the supply side first, for example, overcurrent protection. This backup protection works on the supply circuit breaker. The trip circuits of other protection equipment, for example, Buchholz protection, must also remain active

Repeat the current tests in the case of protected objects with more than 2 measuring points. All sides of the protected object must be included at least once in the current flow test. You do not have to check every possible current path. Siemens recommends beginning with measuring point 1 of the main protected object and testing it against each of the others. When a side has more than measuring point, you must include each at least once in the test. The remaining measuring points carry no current.

If other 3-phase protected objects are present, these are checked separately in accordance with their topology.

The test setup varies, depending on the use case.

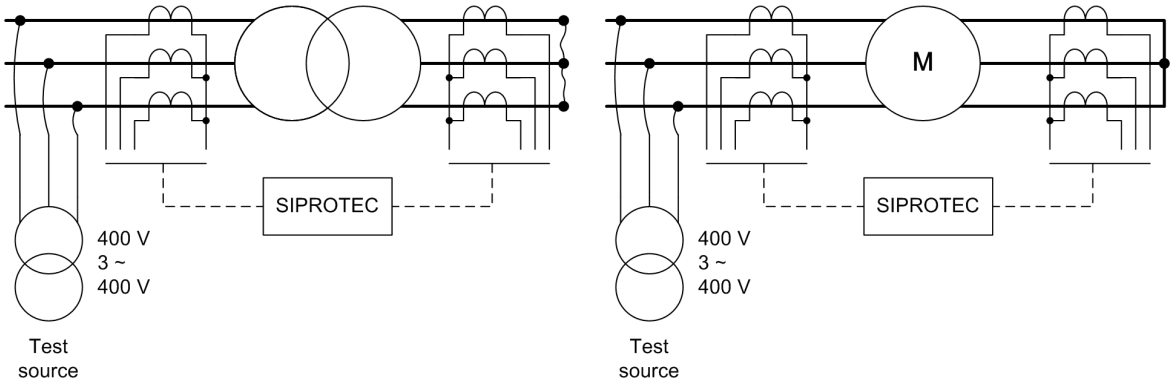
DANGER

Dead components hazardous due to capacitive coupling of other system parts!

Failure to comply with the safety notes, can result in death, severe injury, or considerable material damage.

✧ Primary tests may be performed only on dead and grounded system parts!

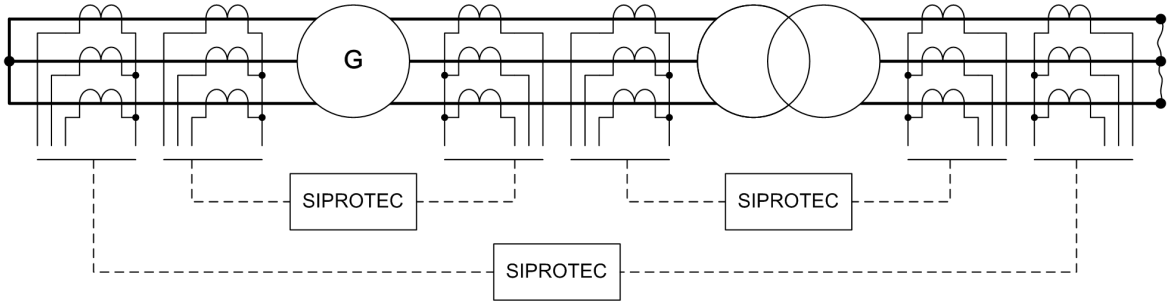
✧ Preferably, perform an undervoltage test on network transformers and asynchronous machines in which the protected object insulated from the line is supplied with current by a test source for low voltage. This symmetrical test source produces the test current via a loadable 2-pole cross connector externally incorporated to the protection range or via the motor neutral point. The test current source is connected in transformers on the upper-voltage side, the 2-pole cross connector on the low-voltage side.



[dwprfnsq-120202-01.tif, 1, en_US]

Figure 11-4 Test Setup With Low-Voltage Source – Example of Transformer and Motor

✧ For generator transformers and synchronous machines, perform the tests for short-circuits, with the machine itself serving as test current source. The test current is produced briefly by means of a loadable 2-pole cross connector incorporated externally to the protection range, with generator's rated current.



[dwprfgen-120202-01.tif, 1, en_US]

Figure 11-5 Test Setup in Power System with Generator as Voltage Source – Example

Performance of Current Tests

✧ Before you begin with the first current test, check the polarity setting for the measuring points and compare them to the actual current connections.

For the commissioning tests, a flowing current of at least 2 % of the device's rated current per phase is necessary.

NOTE

These tests cannot replace a visual check of the correct current transformer connections. Completed checks of the system connections are therefore a prerequisite.

The SIPROTEC 5 device makes operational measured values available. With these operational measured values, quick commissioning without external instrumentation is possible.

The following procedure is intended for 3-phase protected objects, namely, for measuring point 1 against measuring point 2. For transformers, it is assumed that side 1 is the upper-voltage side of the transformer. The remaining possible current circuits are tested analogously.

- ✧ Switch the test current on, or bring the generator to rated speed and excite it to test current. Acquisition of measured values in the SIPROTEC 5 device must not cause pick up. If a failure indication is present, you can see in the logs what causes come into question.

  – In the case of indications from balance supervisions, the primary system may actually be unbalanced. If this is a normal operating condition, then set the corresponding supervision function to be less sensitive.

  – The rotating field is clockwise (phase sequence: A, B, C). If the line has a phase sequence A, C, B, you must account for this when setting the power-system data. Incorrect direction of rotation is indicated. Check the phase assignment of the measurands and correct the affected measuring point after switching off. Then repeat the measurement.

Amount Measurement with Test Current Switched On:

Compare the currents displayed by the device under **Operational measured values** with those actually flowing.

This applies to all measuring points that belong to the tested current path. If deviations result which cannot be explained through measuring tolerances, there is a connection fault or an error in the test setup:

- ✧ Switch off the test source and the protected object. Ground the protected object or shut down the generator.
- ✧ Check the assignment of the measuring point currently being tested.
- ✧ Check the parameters for the compensation.
- ✧ Check and correct the connections and test setup.

  If a considerable ground current 3I0 occurs, the polarity of individual phases has been reversed at the corresponding measuring point:

  3I0 ≈ phase current → 1 or 2 phase currents are missing;

  3I0 ≈ double phase current → 1 or 2 phase currents are reversed;
- ✧ Repeat the measurement and check the amounts again.

Angle Measurement for Measuring Point 1 with Test Current Switched On

- ✧ Check the angles displayed by the device for measuring point 1 under **Measured values**. All angles refer to I_A.

  The following results must appear:

  $\varphi_A \approx 0°$

  $\varphi_B \approx 240°$

  $\varphi_C \approx 120°$

  If the angles are not correct, polarity faults are present in the connection of individual phase currents at the measuring point.
- ✧ Switch off the test source and the protected object. Ground the protected object or shut down the generator.
- ✧ Check and correct the connections and test setup.
- ✧ Repeat the measurement and check the angle.

Angle Measurement for Measuring Point 2 with Test Current Switched On

✧ Check the angles displayed by the device for measuring point 2 under **Measured values**. All angles refer to I_A.

Ensure that the currents into the protected object are always defined as positive. If the test current flows through, currents of the same phase at measuring point 2 are shifted by 180° with respect to measuring point 1.

The following results must appear:

$\varphi_A \approx 180°$

$\varphi_B \approx 60°$

$\varphi_C \approx 300°$

Measured via a transformer, depending on the vector group, approximately the results according to the following table.

If the angles are not correct, polarity faults are present in the connection of individual phase currents at the measuring point.

Table 11-2 Angle Display Depending on Protected Object (3-Phase)

Phase Angle	Protected Object											
	Generator/Motor/ short line	Transformer with vector-group numbers[68]										
		0	1	2	3	4	5	6	7	8	9	10	11
φ_{AM2}	180°	180°	150°	120°	90°	60°	30°	0°	330°	300°	270°	240°	210°
φ_{BM2}	60°	60°	30°	0°	330°	300°	270°	240°	210°	180°	150°	120°	90°
φ_{CM2}	300°	300°	270°	240°	210°	180°	150°	120°	90°	60°	30°	0°	330°

If the angles are not correct, there are polarity faults or a phase inversion in the connection of measuring point 2 or the other side to be tested at the tested measuring point.

- If deviations are present in individual phases, a polarity fault is present in the connection of these phase currents or an acyclic phase inversion is present.
- If all angles deviate by the same amount, there is a cyclic inversion of all 3 phases or an incorrect vector group in transformers. In the last case, check the vector-group adaptation. Also pay attention to the assignment of the measuring points to the sides and the assignment of the sides to the protected object.
- If all angles differ by 180°, the polarity of a set of current transformers for the second measuring point is not correct. You can fix this by testing and correcting the corresponding parameters of the substation configuration.

If you presume a connection fault:

✧ Switch off the test source and the protected object. Ground the protected object or shut down the generator.

✧ Check and correct the connections and test setup.

✧ Check the settings for the corresponding current transformer data.

✧ Repeat the measurement and check the angle.

Repeat all tests previously described until all measuring points for the main protected object are included in a test at least once.

Measuring Differential and Restraint Currents

To complete the symmetrical tests, check the differential and restraint current measurands. If the previous symmetrical measurements also reveal the connection fault, errors in the adaptation and in the vector-group assignment cannot be excluded.

[68] If the upper-voltage side is defined as side 1, the angles are valid. Otherwise, 360° minus the stated angle is valid.

The differential and restraint currents refer to the rated current of the protected object. Observe this when comparing the test currents. For more than 2 sides, the rated current of the protected object equals the highest rated current of all sides of the protected object.

✧ Read out the differential and restraint currents under **Measured values**.

– The differential currents **IDiffA:**, **IDiffB:**, **IDiffC:** must be low, at least one order of magnitude less than the test currents flowing through. Ideally, they are 0.

– The restraint currents **IStabA:**, **IStabB:**, **IStabC:** correspond to the test current flowing through.

– If differential currents occur on the order of magnitude of the restraint currents, there is a polarity reversal in the current transformer or current transformers on one side. Again check the polarity and correct it after short-circuiting all 6 current transformers. If you have made changes to current transformers, repeat the angle test.

– If substantial differential currents occur that are approximately the same in all phases, a faulty adaptation of the measurands is present. Faults in the vector-group adaptation in transformers are already discovered in the winding test. Check the settings of the device relevant for current adaptation. These are the data of the protected object:

✧ Finally, switch off the test source and the protected object or shut down the generator.

✧ If parameter settings have been changed for the tests, reset them to the values necessary for operation.

NOTE

Ensure that you perform the intended tests for each current path.

Zero-Sequence Current Test on the Protected Object

If the neutral point of a winding or side is grounded in the case of 3-phase protected objects, the following zero-sequence current tests are required. If several neutral points are grounded, you must perform the zero-sequence current tests for each of the grounded windings.

✧ If the neutral-point current is available and is conducted to the device via a 1-phase current input, the polarity of the ground current connection is essential for taking the neutral point current into account. This applies to the differential and restricted ground-fault protection.

✧ If no neutral point current is available, the zero-sequence current tests serve to verify the correct treatment of the zero-sequence currents in the differential protection.

NOTE

Be aware that a trip results in case of incorrect connections.

Preparation of the Zero-Sequence Current Tests

✧ Perform the zero-sequence current measurements from the side or 3-phase measuring point for which the neutral point is grounded. For auto transformers, perform the measurement from the upper-voltage side. For transformers, a delta winding must be present (d-winding or stabilizing winding). The windings not included in the test remain open, since the delta winding creates the impedance of the zero-sequence current path by itself.

The test setup varies, depending on the use case. *Figure 11-6* to *Figure 11-12* schematically show an example of the test setup on a grounded star-delta transformer. The neutral-point current is included in the measurement. If the neutral point is not accessible, it is left out (compare *Figure 11-6* with *Figure 11-7*).

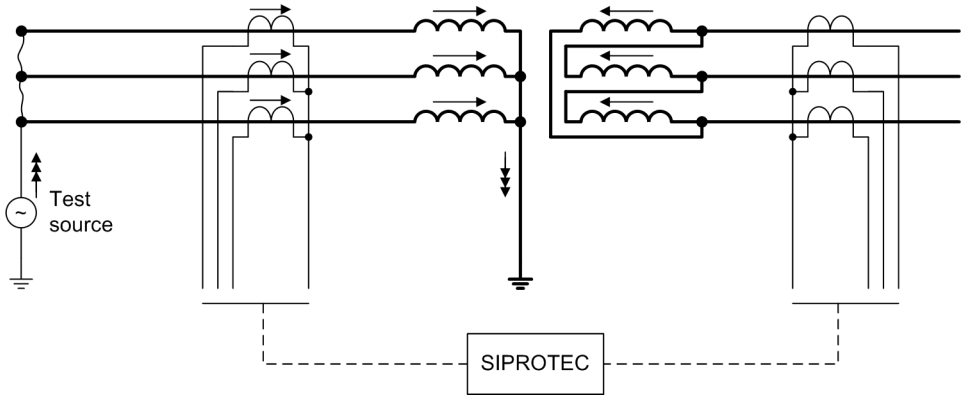
DANGER

Dead components hazardous due to capacitive coupling of other system parts!

Failure to comply with the safety notes, can result in death, severe injury or considerable material damage.

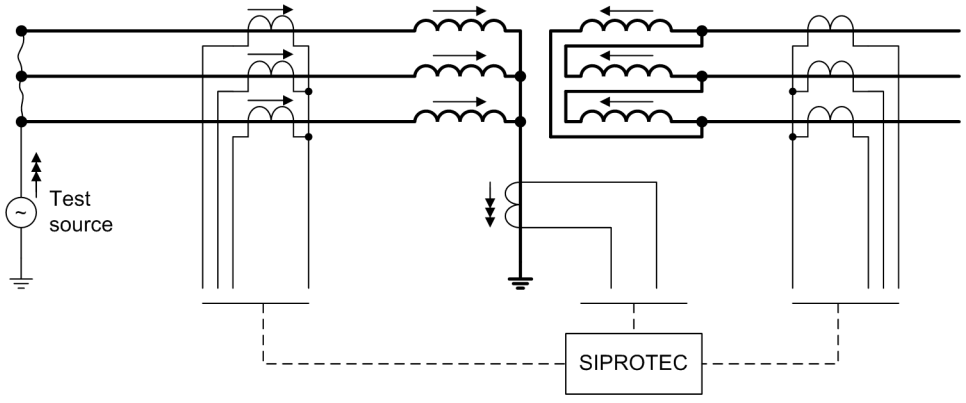
✧ Primary tests may be performed only on dead and grounded system parts!

✧ Observe the following examples for measuring zero-sequence current.



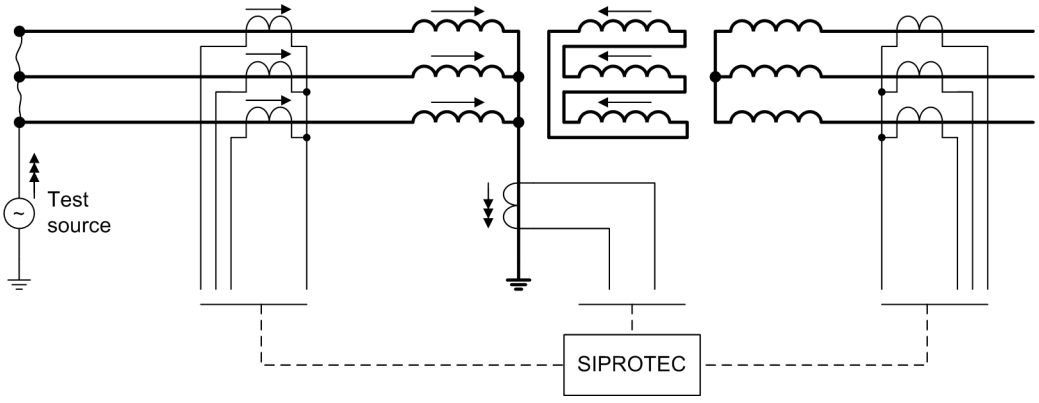
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Figure 11-6 Measurement of Zero-Sequence Current on a Star-Delta Transformer - Without Neutral-Point Current Measurement



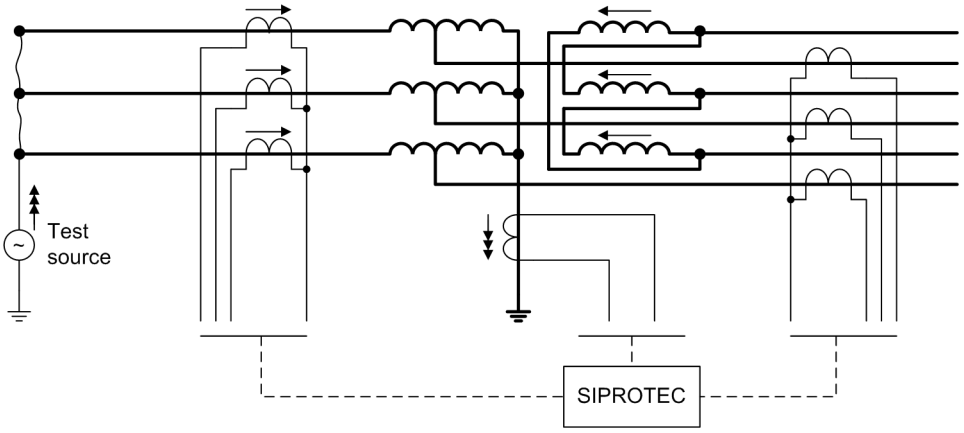
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Figure 11-7 Zero-Sequence Current Measurement on a Star-Delta Transformer



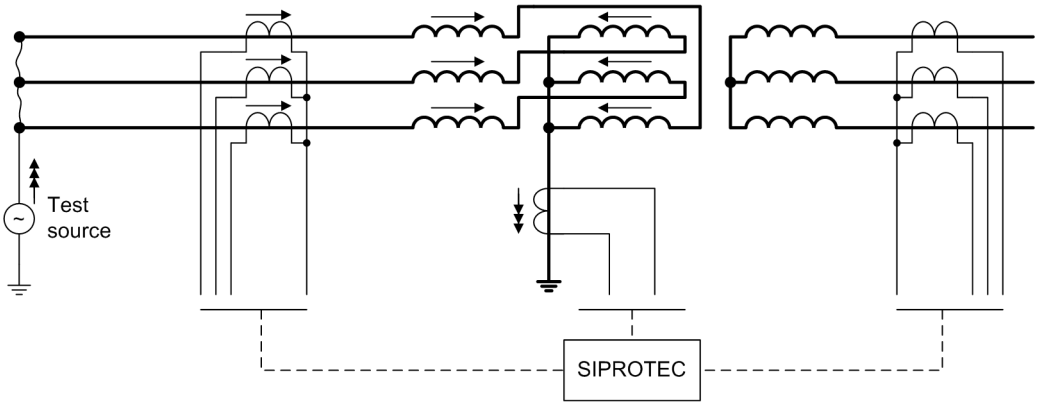
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Figure 11-8 Zero-Sequence Current Measurement on a Star-Delta Transformer with Stabilizing Winding



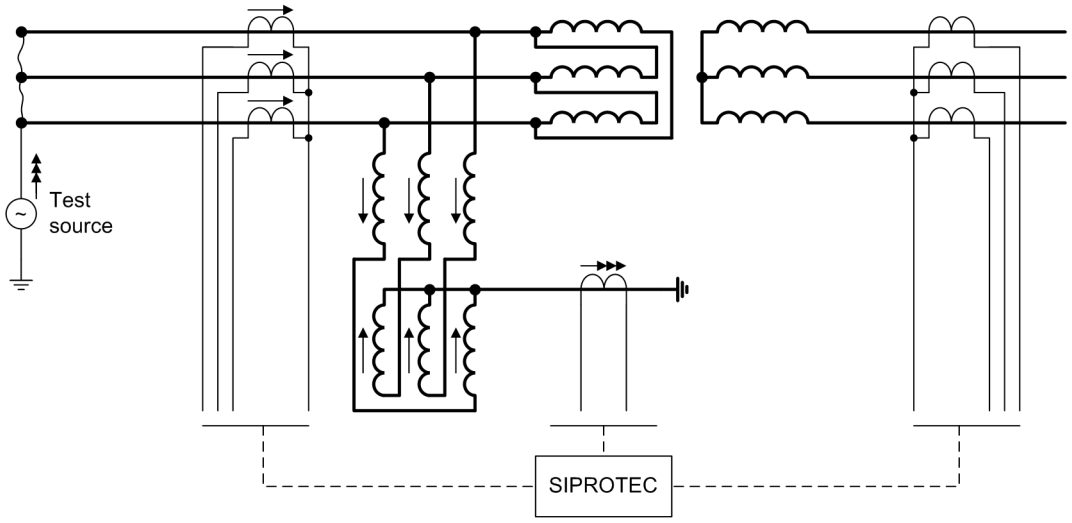
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Figure 11-9 Zero-Sequence Current Measurement on an Auto Transformer with Stabilizing Winding



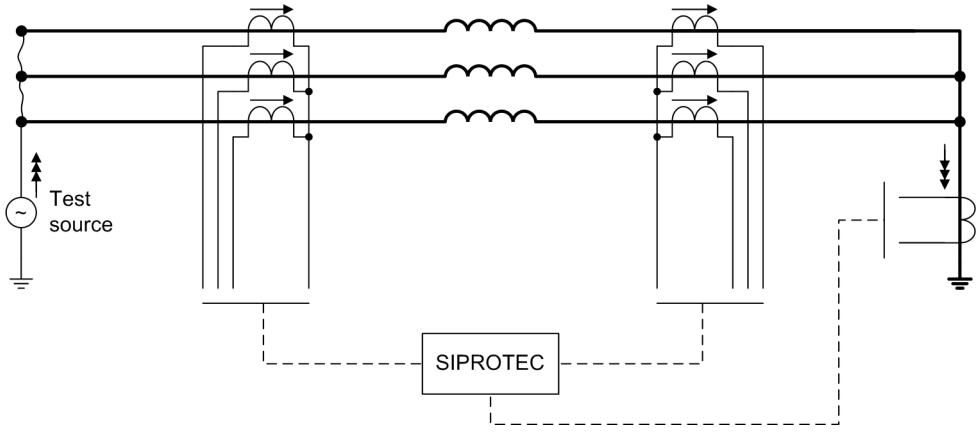
[dwnmzzwk-120202-01.tif, 1, en_US]

Figure 11-10 Zero-Sequence Current Measurement on a Zigzag Winding



[dwnmdrwk-170712-01.tif, 1, en_US]

Figure 11-11 Zero-Sequence Current Measurement on a Delta Winding with Artificial Neutral Point in the Protection Range



[dwnmgelr-120202-01.tif, 1, en_US]

Figure 11-12 Zero-Sequence Current Measurement on a Grounded Longitudinal Reactance (Reactor, Generator, Motor)

Performance of Zero-Sequence Current Tests

For the commissioning tests, a zero-sequence current at a level of at least 2 % of the device's rated current per phase is required, for example, the test current must be at least 6 %.

NOTE

The following tests cannot replace a visual check of the correct current transformer connections. The completed checks are a prerequisite.

- ✧ Switch on the test current.
- ✧ Perform the amount measurement with the test current switched on.
- ✧ Compare the currents displayed by the device under **Measured values** with those actually flowing:
- All phase currents of the tested measuring point correspond to approx. 1/3 of the test current.
- 3I0 of the tested measuring point corresponds to the test current.

- Phase currents and zero-sequence current on the untested measuring point are approx. 0 on transformers.
- The current of the 1-phase current input – to the extent included in the measurement – corresponds to the test current.

Deviations can only occur with the 1-phase measuring input (if measured), since connection faults in the phase currents were already recognized in the symmetric test.

In the case of deviations:

✧ Switch off the test source and the protected object. Ground the protected object or shut down the generator.

✧ Check the assignment of the additional measuring input currently being tested.

✧ Check the parameters for the compensation.

✧ Check and correct the connections and test setup.

✧ Repeat the measurement and check the amounts again.

Check Differential Protection

The tests described in the following encompass the current differential protection, not the restricted ground-fault protection. The tests represented in the previous figures must have the following results. Ensure that the test current corresponds to 3I0.

✧ Zero-sequence current elimination

In the function group **Transformer side**, the neutral point is set as (parameter: **`Neutral point`** = ***grounded***) grounded, and in the function group **Transformer**, there is the parameter **`Meas. gnd. current side 1`** = ***no***. The matrices are shown below.

$$\begin{pmatrix} I_{Diff,C} \\ I_{Diff,B} \\ I_{Diff,A} \end{pmatrix} = \left| \begin{pmatrix} I_{A,S1} \\ I_{B,S1} \\ I_{C,S1} \end{pmatrix} + \begin{pmatrix} I_{A,S2} \\ I_{B,S2} \\ I_{C,S2} \end{pmatrix} \right| = \left| \frac{1}{3} \begin{pmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{pmatrix} \begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \right| = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

[fomatnse-170712-01.tif, 1, en_US]

$$\begin{pmatrix} I_{rest,A} \\ I_{rest,B} \\ I_{rest,C} \end{pmatrix} = \left| \begin{pmatrix} I_{A,max} \\ I_{B,max} \\ I_{C,max} \end{pmatrix} \right| = \left| \frac{1}{3} \begin{pmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{pmatrix} \begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix} \right| = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

[fomznel2-170712-01.tif, 1, en_US]

✧ Zero-sequence current correction

In the function group **Transformer side**, the neutral point is set as (parameter: **`Neutral point`** = ***grounded***) grounded, and in the function group **Transformer**, there is the parameter **`Meas. gnd. current side 1`** = ***yes***. The differential and restraint currents measured result from the one-sided test to 0. In the following, the matrices are represented. $\underline{I}_E$ is the measured zero-sequence current through the current transformer in the neutral point:

$$\begin{pmatrix} I_{Diff,A} \\ I_{Diff,B} \\ I_{Diff,C} \end{pmatrix} = \left| \begin{pmatrix} I_{A,S1} \\ I_{B,S1} \\ I_{C,S1} \end{pmatrix} + \begin{pmatrix} I_{A,S2} \\ I_{B,S2} \\ I_{C,S2} \end{pmatrix} \right| = \left| \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix} + \frac{1}{3} \begin{pmatrix} I_{Gnd} \\ I_{Gnd} \\ I_{Gnd} \end{pmatrix} \right| = \left| \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix} + \frac{1}{3} \begin{pmatrix} -3I_0 \\ -3I_0 \\ -3I_0 \end{pmatrix} \right| = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

[fomansko-170712-01.tif, 1, en_US]

$$\begin{pmatrix} I_{rest,A} \\ I_{rest,B} \\ I_{rest,C} \end{pmatrix} = \left| \begin{pmatrix} I_{A,max} \\ I_{B,max} \\ I_{C,max} \end{pmatrix} \right| = \left| \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix} + \frac{1}{3} \begin{pmatrix} I_{Gnd} \\ I_{Gnd} \\ I_{Gnd} \end{pmatrix} \right| = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

[fomansk2-170712-01.tif, 1, en_US]

If there is a polarity reversal on the current transformer at the neutral point, a value that corresponds to 2/3 of the test current (3I0) results for the differential and restraint current per phase. The following matrices illustrate the situation.

$$\begin{pmatrix} I_{Diff,A} \\ I_{Diff,B} \\ I_{Diff,C} \end{pmatrix} = \left| \begin{pmatrix} I_{A,S1} \\ I_{B,S1} \\ I_{C,S1} \end{pmatrix} + \begin{pmatrix} I_{A,S2} \\ I_{B,S2} \\ I_{C,S2} \end{pmatrix} \right| = \left| \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix} + \frac{1}{3} \begin{pmatrix} I_{Gnd} \\ I_{Gnd} \\ I_{Gnd} \end{pmatrix} \right| = \left| \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix} + \frac{1}{3} \begin{pmatrix} 3I_0 \\ 3I_0 \\ 3I_0 \end{pmatrix} \right| = 2 \begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix}$$

[fomzvrpo-061112-01.tif, 1, en_US]

$$\begin{pmatrix} I_{rest,A} \\ I_{rest,B} \\ I_{rest,C} \end{pmatrix} = \left| \begin{pmatrix} I_{A,max} \\ I_{B,max} \\ I_{C,max} \end{pmatrix} \right| = \left| \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix} + \frac{1}{3} \begin{pmatrix} I_{Gnd} \\ I_{Gnd} \\ I_{Gnd} \end{pmatrix} \right| = 2 \begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix}$$

[fomzvrp2-061112-01.tif, 1, en_US]

11.5 Generator Differential Protection

11.5.1 Secondary Tests

Secondary tests can never replace the primary tests described in the following *11.5.2 Primary Tests*, because they cannot include connection faults. They are used to check the setting values, the proper reaction of the protection function, the engineering (for example, routing of the corresponding logical signals, display images with measured values, logics in the CFC, etc.) If you want to perform secondary tests, observe the following instructions.

NOTE

For tests with secondary test equipment, make sure that no other measurands are connected and the trip commands to the circuit breakers are interrupted; otherwise, the circuit breaker could be activated.

Perform the tests with the current setting values for the device. If these values are not (yet) available, check with the default values.

NOTE

The measuring accuracy to be achieved depends on the electrical data of the used test sources. The accuracies stated in the Technical Data can be expected only if the reference conditions stipulated in VDE 0435/part 303 and in IEC 60255 are ensured and if precision instruments are used. The specified tolerances refer to the default data for the protected objects. If the protected-object rated current that refers to the rated current of the current transformer deviates considerably from the device rated current, you must expect higher response tolerances.

For differential protection, you can check each side separately. This corresponds to the simulation of a fault supplied from one side. If a side has several measuring points, the measuring inputs not included in the test carry no current. The pickup value is tested by slowly increasing the test current.

NOTE

Tests of currents greater than 4 times the device-rated current (or a maximum of 20 A) lead to an overload of the input circuits and may be performed only briefly. You can find further information in the Technical Data. Interrupt testing to allow cool-down!

The set pickup values refer to the symmetrical 3-phase current in the case of 3-phase protected objects.

If you are testing parameters set during operation, you must note that the setting value for the differential protection refers to the rated current of the protected object. The rated current is the primary current that results formally from:

$$I_{rated,obj} = \frac{S_{rated,obj}\,[MVA] \cdot 1000}{\sqrt{3} \cdot V_{rated,obj}\,[kV]}\,[A]$$

[fonennsl-170712-01.tif, 1, en_US]

$S_{rated,Obj}$	Rated apparent power of the protected object
$V_{rated,Obj}$	Rated voltage of the protected object or the winding being observed

If you wish to check the characteristic curve, Siemens recommends using the standard testing programs of digital test equipment. For the manual checking of points on the characteristic curve, feed in a current **flowing through** which corresponds to a current value on the stabilization axis. Then change the phase angle of the test current on one side until the necessary differential current is reached. Check a value above and below the point on the characteristic curve which is to be tested with a tolerance of 5 %.

11.5.2 Primary Tests

Restricted primary testing is possible for generator protection applications. A wiring fault in the connection to the system could be a possible cause of the fault. With the system at a standstill, you can apply a test current of approx. 10 % to 20 % of the rated current directly to the current-transformer terminals and to the connected current transformer by means of a primary testing equipment. Simulate a load (current flowing through). The differential current must be 0 and the restraint current is the current which is fed in.

To prevent overfunction on initial switch-on, for example due to the incorrect installation of a transformer, Siemens recommends switching the differential protection to test mode. The protection function operates, but does not issue a trip command. Check the differential and the restraint current with the protection measured values in the fault log. The differential current must be 0 and the restraint current must correspond to the actually flowing generator current.

If the differential protection is functioning correctly, switch the protection function **ON**.



NOTE

If the differential protection is disabled (for example, function in test mode), an overcurrent protection must be active as short-circuit protection (without delay and set via the starting current).

11.6 Commissioning Notes Motor Differential Protection

11.6.1 Secondary Tests

Secondary tests can never replace the primary tests described in the following *11.6.2 Primary Tests*, because they cannot include connection faults. They are used to control the setting values, the proper reaction of the protection function, engineering (for example, routing of the appropriate logical signals, display images with measured values, logics in the CFC, etc.). If you want to perform secondary tests, observe the following instructions.

NOTE

For tests with secondary test equipment, ensure that no other measurands are connected and the trip commands to the circuit breakers are open, otherwise the circuit breakers could be activated.

Perform the tests with the current setting values for the device. If these values are not (yet) present, check with the default values.

NOTE

The measuring accuracy to be attained depends on the electrical data of the test sources. The accuracies stated in the Technical Data can be expected only if the reference conditions stipulated in VDE 0435/ part 303 and IEC 60255 are ensured and precision instruments are used. The stated tolerances refer to the default data for the protected objects. If the rated current of the protected object in relation to the rated current of the current transformer deviates considerably from the rated current of the device, you must assume higher response tolerances.

For differential protection, you can check each side separately. This corresponds to the simulation of a fault supplied from one side. If a side has several measuring points, the measuring inputs not included in the test carry no current. The pickup value is tested by increasing the test current slowly.

NOTE

Tests of currents exceeding quadruple device rated current (or a maximum of 20 A) lead to an overload of the input circuits and may be performed only briefly. You can find further information in the Technical Data. Interrupt testing to allow cool-down!

The set pickup values refer to symmetrical 3-phase current in the case of 3-phase protected objects.

If you are testing parameters set during operation, you must ensure that the setting value for the differential protection refers to the rated current of the protected object. The rated current is the primary current that results formally from:

$$I_{rated,obj} = \frac{S_{rated,obj}\,[MVA] \cdot 1000}{\sqrt{3} \cdot V_{rated,obj}\,[kV]}\,[A]$$

[fonennsl-170712-01.tif, 1, en_US]

$S_{rated,obj.}$	Rated apparent power of the protected object
$V_{rated,obj}$	Rated voltage of the protected object or the winding being observed

If you wish to check the characteristic curve, Siemens recommends the use of the standard testing programs of digital test equipment. For the manual checking of points on the characteristic curve, feed in a **through** current which corresponds to a current value on the stabilization axis. Then change the phase angle of the test current on one side, so that the necessary differential current is achieved. Check a value with a tolerance of 5 % above and below the point on the characteristic curve which is to be tested.

11.6.2 Primary Tests

Restricted primary testing is possible for motor protection applications. A wiring fault in the connection to the system could be a possible cause of the fault. With the system at a standstill, you can apply a test current of approx. 10 % to 20 % of the rated current directly to the transformer terminals and connected transformer by means of a primary testing device. Simulate a load (through current). The differential current must be zero and the restraint current is the current which is fed in.

To rule out overfunction on initial switch-on, for example, due to the incorrect installation of a transformer, Siemens recommends switching the differential protection to test mode. The protection function operates, but does not issue a trip command. With the protection measured values in the fault log, check the differential and the restraint current. The differential current must be 0 and the restraint current must correspond to the actual motor current.

If the differential protection is functioning correctly, switch the protection function **ON**.



NOTE

If the differential protection is disabled (for example, function in test mode), an overcurrent protection must be active as short-circuit protection (without delay and set via the starting current).

11.7 Functional Test Line Differential Protection

11.7.1 Test Options and Test Modes

The function **Line differential protection** also requires the measurands from remote devices and thus differs from most protection functions that only use local measurands.

The following test options are possible for testing the function **Line differential protection**:

- Test with all line ends and with applied test currents, see *11.7.2 Functional Test in All Devices*
- Only test of the local line end with applied test currents, see *11.7.3 Functional Test in the Local Device*
- Inspection of the current operating point with all line ends with applied process variables, see *11.7.4 Checking the Operating Point*

SIPROTEC 5 supports the testing of functions using various test modes. The following test options are available for performing the 3 aforementioned test options:

- The device provides the test mode for the entire device, see *11.2 Enabling/Disabling the Application/Test Mode for the Entire Device* and *3.11.2.1 Overview*.
- The function **Line differential protection** provides the special *Test local device* test mode.
- The function **Line differential protection** provides the special *Check op. point* test mode. This test mode replaces the previous *Test all devices*, see *Table 11-3*.

The following chapters describe the test procedure and the use of the different test modes.

If you switch the entire device or a protection function to test mode, all device protection functions or the protection function adopt the ***Test*** state. All indications are marked with a test bit. This prevents the circuit breaker from switching unintentionally or protection functions from starting unintended actions.

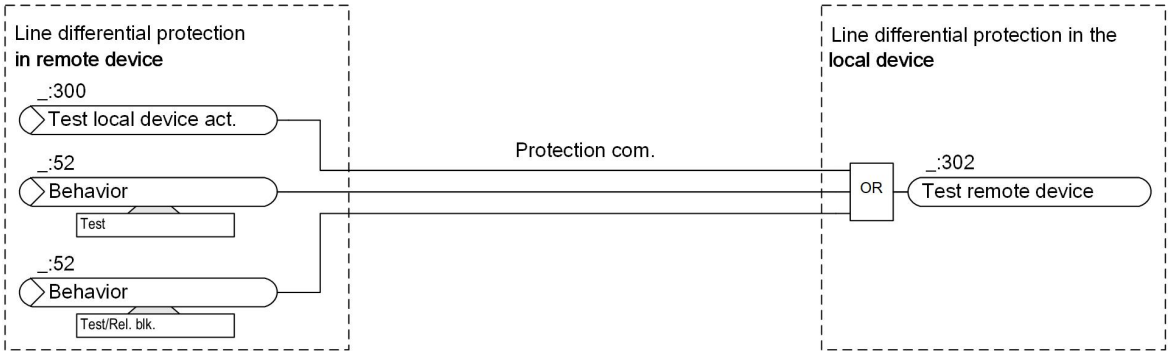
With the parameter **(_:151) Oper.bin.outp. under test**, you define whether the functions in ***Test*** state can activate relay outputs. If the parameter **(_:151) Oper.bin.outp. under test** and the test mode are activated for the entire device, all functions – including the relay outputs – are in ***Test*** state. If the parameter **(_:151) Oper.bin.outp. under test** is not active and the test mode is activated for the entire device, all functions – except the relay outputs – are in ***Test*** state. The relay outputs adopt the **Test/Relay blk.** state.

You can set the parameter **(_:151) Oper.bin.outp. under test** as follows:

- Via the operating dialog in DIGSI **> Settings > Device settings > Test support**:
  Place a check mark on parameter **(_:151) Oper.bin.outp. under test**.
- Via the on-site operation panel under **Settings > General > Test support > (_:151) Oper.bin.outp. under test**

For further information, refer to *Parameter: Oper.bin.outp. under test , Page 265*.

Depending on the selected procedure, the device supports testing of the function with different indications. If the function **Line differential protection** of a remote device is in ***Test*** or ***Test/Relay blk.*** state, or if the indication *(_:2311:300) Test local device act.* has been generated in a remote device, the local device generates the indication *(_:2311:302) Test remote device*.



[lo_generate-remote-device-test-message, 1, en_US]

Figure 11-13 Logic Diagram for Creation of the Indication *Test remote device*

If you use the function group **Advanced protection communication type 1 (line diff. protection)**, you will receive further helpful indications. The following indications are available in the information routing under **Prot. com (type 1).device comb.device n**:

- *(_:22711:328) Line diff. test*
  The indication shows for each device whether the function **Line differential protection** is in ***Test*** or in ***Test/Relay blk.*** state.
- *(_:22711:329) Local line diff. test*
  This indication shows for each device whether the function **Line differential protection** is in special *Test local device* test mode.

With version V9.40 and higher, the texts for the following binary inputs, controllables, and indications are changed as follows:

Table 11-3 Text Changes with Version V9.40 and Higher

Address	Text up to Version V9.3x	Text for Version V9.40 and Higher
_:2311:501	*>Test all devices on*	*>Check op. point on*
_:2311:502	*>Test all devices off*	*>Check op. point off*
_:2311:308	*Test all devices*	*Check op. point*
_:2311:301	*Test all devices activ*	*Check op. point active*
_:2311:304	*BI: Test all devices*	*BI: Check op. point*
_:2311:305	*Ctrl: Test all devices*	*Ctrl: Check op. point*

11.7.2 Functional Test in All Devices

11.7.2.1 General Information

For this test, the parameter **(_:2311:108) Action on Behavior = test** = ***Test loc. device man.*** must be set in each device of the device combination, see *Parameter: Action on Behavior = test, Page 732*.

If you want to test the function **Line differential protection** with all line ends, you must switch all devices of the device combination into test mode. See *11.2 Enabling/Disabling the Application/Test Mode for the Entire Device*.

If the test mode for the entire device is enabled in all devices of the device combination, the function **Line differential protection** to be tested is ***active*** again and is ready for the test.

These tests require action steps on all devices.

The indication *(_:2311:302) Test remote device* shows that the function **Line differential protection** in a remote device is already in ***Test*** or ***Test/Relay blk.*** state.

11.7.2.2 Procedure

Test Preparation and Implementation

Initial state:

- **I** and optionally **V** of the system are connected to the current and voltage inputs of the protection device.
- The function **Line differential protection** is ***active*** in all devices.

Proceed as follows:

✧ Switch on the test mode of the entire device in one device of the device combination, see *11.2 Enabling/Disabling the Application/Test Mode for the Entire Device*.
→ The function **Line differential protection** is ***Inactive*** in all devices.

✧ Switch on the test mode of the entire device in all other devices of the device combination.
→ The function **Line differential protection** is ***active*** and in ***Test*** state in all devices.

✧ Disconnect the system transformers from the current and voltage inputs of the protection device and short-circuit the system current transformer.

✧ Start your tests and apply test currents and test voltages.

Procedure after Completion of the Tests

Initial state:

- The function **Line differential protection** is ***active*** and in ***Test*** state in all devices.

Proceed as follows:

✧ Complete your tests and remove the test currents and test voltages.

✧ Connect **I** and optionally **V** of the system to the current and voltage inputs of the protection device.

✧ Switch off the test mode of the entire device in one device of the device combination, see *11.2 Enabling/Disabling the Application/Test Mode for the Entire Device*.
→ The function **Line differential protection** is ***Inactive*** in all devices.

✧ Switch off the test mode of the entire device in all other devices of the device combination.
→ The function **Line differential protection** is ***active*** in all devices.

11.7.3 Functional Test in the Local Device

11.7.3.1 General Information

Use the special *Test local device* test mode to test the function **Line differential protection** in the local device with applied test currents. The local currents are interpreted as differential currents. The measured values of the remote devices are not used.



NOTE

This special test mode only makes sense when the entire device has been set into test mode. Otherwise, applied test currents also affect all other protection functions and can lead to unintentional pickup.

For further information, refer to *11.2 Enabling/Disabling the Application/Test Mode for the Entire Device*.

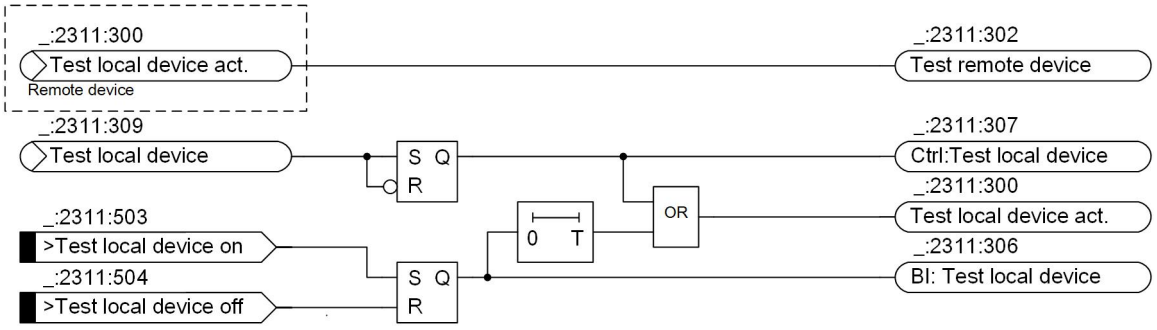
You can test the function **Line differential protection** in the local device such that during the test the functions **Line differential protection** of the remote devices are either ***active*** or ***Inactive***.

Carry out all action steps on site on the device to be tested.

You can enable or disable the special *Test local device* test mode as follows:

- Via the operating dialog in DIGSI (online): **Online accesses > Interface > Device > Device information, Test and operation, Check local devices**
- Via the on-site operation panel under: **Main menu > Device functions > Line n > Line differential protection > Test local device**
- Via the communication by using the *(_:2311:309) Test local device* controllable
- Via the binary inputs *(_:2311:503) >Test local device on* and *(_:2311:504) >Test local device off*

The following figure shows the binary inputs, controllables, and indications linked to the *Test local device* test mode:



[lo Ldiff test device local, 2, en_US]

Figure 11-14 Logic Diagram for Enabling/Disabling the *Test local device* Test Mode

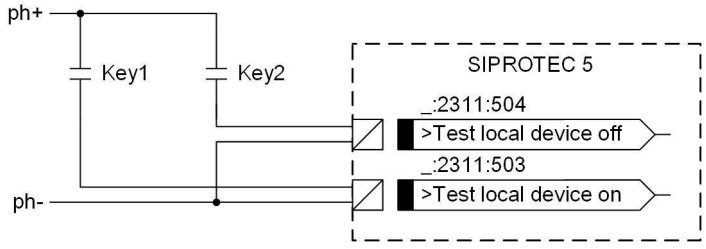
The indications *Ctrl:Test local device* or *BI: Test local device* indicate via which path the test mode test local device has been activated.

If you activate this special test mode in DIGSI, either via the communication interface or via on-site operation by the *Test local device* controllable, the device will issue the indication *Ctrl:Test local device*. The device stores the state of the *Test local device* controllable in a voltage-fail-safe memory.

If you enable or disable this special test mode via the binary inputs *>Test local device on* and *>Test local device off*, the device issues the indication *BI: Test local device*. If the *Test local device* test mode is enabled, the device generates the indication *Test local device act.*. The status indications of the instantiated **I-DIFF** stages indicate ***Test*** or ***Test/Relay blk.***.

The functions **Line differential protection** are not effective in the remote devices and report this state with the indications *Inactive* and *Test remote device*.

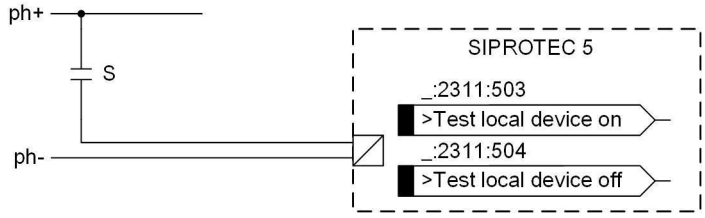
The following figures show possible variants of enabling/disabling the *test local device* test mode via binary inputs. The following figure shows the use of push-buttons **Ta1** and **Ta2**:



[lo_application_mode_device_taster_test-local-device, 1, en_US]

Figure 11-15 External Wiring of Push-Buttons for Enabling/Disabling the *Test local device* Test Mode

The following figure shows the use of a switch **S**. Route the logical binary input *>Test local device on* as **H** (high-active) and the logical binary input *>Test local device off* as **L** (low-active) to a physical binary input.



[lo_application_mode_device_ext-switch, 1, en_US]

Figure 11-16 External Wiring of Switches for Enabling/Disabling the *Test local device* Test Mode

11.7.3.2 Functional Test in Case of Non-Effective Line Differential Protection in the Remote Devices – Procedure 1

You can test the function **Line differential protection** in the local device while the line differential protection in the remote devices is ***Inactive***.

Test Preparation and Implementation

If the parameter **Action on Behavior = test** = ***Test loc. device man.***, Siemens recommends the following procedure for test preparation:

Initial state:

- **I** and optionally **V** of the system are connected to the current and voltage inputs of the protection device.
- The function **Line differential protection** is ***active*** in all devices.

Proceed as follows:

✧ Switch on the test mode for the entire device in the local device, see *11.2 Enabling/Disabling the Application/Test Mode for the Entire Device*.
→ The function **Line differential protection** is ***Inactive*** in all devices.

✧ Disconnect the system transformers from the current and voltage inputs of the protection device and short-circuit the system current transformer.

✧ Switch on the *Test local device* test mode in the local device, see *11.7.3.1 General Information* .
→ The function **Line differential protection** is ***active*** and in ***Test*** state in the local device only.
→ The function **Line differential protection** is ***Inactive*** in the remote devices.

✧ Start your tests and apply test currents and test voltages.

Steps after Completion of the Tests

Initial state:

- The function **Line differential protection** is ***active*** and in ***Test*** state in the local device only.
- The function **Line differential protection** is ***Inactive*** in the remote devices.

Proceed as follows:

✧ Complete your tests and remove the test currents and test voltages.

✧ Switch off the *Test local device* test mode in the local device, see *11.7.3.1 General Information* .
→ The function **Line differential protection** is ***Inactive*** in all devices.

✧ Connect **I** and optionally **V** of the system to the current and voltage inputs of the protection device.

✧ Switch off the test mode of the entire device in the local device, see *11.2 Enabling/Disabling the Application/Test Mode for the Entire Device*.
→ The function **Line differential protection** is ***active*** in all devices.

11.7.3.3 Functional Test in Case of Non-Effective Line Differential Protection in the Remote Devices – Procedure 2

You can test the function **Line differential protection** in the local device while the line differential protection in the remote devices is ***Inactive***.

Test Preparation and Implementation

Siemens recommends this procedure if you use a test switch to test the local function **Line differential protection**.

For further information, refer to *11.7.5 Use of Test Switches*.

If the parameter **Action on Behavior = test** = ***Test loc. device autom.***, Siemens recommends the following procedure for test preparation:

Initial state:

- **I** and optionally **V** of the system are connected to the current and voltage inputs of the protection device.
- The function **Line differential protection** is ***active*** in all devices.

Proceed as follows:

✧ Toggle the test switch.

→ The test switch disconnects the **I** and optionally the **V** of the system from the current and voltage inputs of the protection device.

→ The test switch enables the test mode for the entire device in the local device, see *11.7.3.1 General Information* .

If the parameter **Action on Behavior = test** = ***Test loc. device autom.***, the *Test local device* test mode is automatically enabled, see *Parameter: Action on Behavior = test, Page 732*

→ The function **Line differential protection** is ***active*** and in ***test*** state in the local device only.

→ The function **Line differential protection** is ***Inactive*** in the remote devices.

✧ Start your tests and apply test currents and test voltages.

Steps after Completion of the Tests

Initial state:

- The function **Line differential protection** is ***active*** and in ***Test*** state in the local device only.
- The function **Line differential protection** is ***Inactive*** in the remote devices.

Proceed as follows:

✧ Complete your tests and remove test currents and test voltages.

✧ Toggle the test switch.

→ The test switch disables the test mode for the entire device in the local device, see *11.7.3.1 General Information* .

→ The test switch connects the **I** and optionally the **V** of the system to the current and voltage inputs of the protection device.

Since the parameter **Action on Behavior = test** = ***Test loc. device autom.***, the *Test local device test mode is automatically disabled.*

→ The function **Line differential protection** is ***active*** in all devices.

11.7.3.4 Functional Test in Case of Effective Line Differential Protection in the Remote Devices – Procedure 1

You can test the function **Line differential protection** in the local device while the line differential protection in the remote devices remains ***active***. Log off the function **Line differential protection** of the local device to be tested from to the remote **line differential protection** functions, see *6.7.15 Logging Off the Local Line Differential Protection*. The current sum in the remote devices is then calculated without the logged out function.

For this operating mode, the feeder protected by the local line differential protection must be de-energized. This is because after logout, local currents must not influence the current sum of the remaining protected object, which might lead to unwanted tripping.

Test Preparation and Implementation

If the parameter **Action on Behavior = test** = ***Test loc. device man.***, Siemens recommends the following procedure for test preparation:

Initial state:

- **I** and optionally **V** of the system are connected to the current and voltage inputs of the protection device.
- The function **Line differential protection** is ***active*** in all devices.

Proceed as follows:

✧ Disconnect the feeder.

✧ Log off the function **Line differential protection** to be tested from the local device, see *6.7.15 Logging Off the Local Line Differential Protection*.

→ The function **Line differential protection** is ***active*** in the remote devices.

→ The function **Line differential protection** is ***Inactive*** in the local device.

✧ Switch on the test mode for the entire device in the local device, see *11.2 Enabling/Disabling the Application/Test Mode for the Entire Device*.

✧ Disconnect the system transformers from the current and voltage inputs of the protection device and short-circuit the system current transformer.

✧ Enable the *Test local device* test mode in the local device, see *11.7.3.1 General Information* .

→ The function **Line differential protection** is ***active*** and in ***Test*** state in the local device.

→ The function **Line differential protection** is ***active*** in the remote devices.

✧ Start your tests and apply test currents and test voltages.

Steps after Completion of the Tests

Initial state:

- The function **Line differential protection** is ***active*** and in ***Test*** state in the local device only.
- The function **Line differential protection** is ***Inactive*** in the remote devices.

Proceed as follows:

✧ Complete your tests and remove test currents and test voltages.

✧ Disable the *Test local device* test mode in the local device, see *11.7.3.1 General Information* .

→ The function **Line differential protection** is ***Inactive*** in the local device.

✧ Disable the test mode for the entire device in the local device, see *11.2 Enabling/Disabling the Application/Test Mode for the Entire Device*.

✧ Log on the tested function **Line differential protection** at the local device again, see *6.7.15 Logging Off the Local Line Differential Protection*.

→ The function **Line differential protection** is ***active*** in all devices.

✧ Reconnect the feeder.

11.7.3.5 Functional Test in Case of Effective Line Differential Protection in the Remote Devices – Procedure 2

You can test the function **Line differential protection** in the local device while the line differential protection in the remote devices remains ***active***. Log off the function **Line differential protection** of the local device to be tested from to the remote functions **Line differential protection**, see *6.7.15 Logging Off the Local Line Differential Protection*. The current sum in the remote devices is then calculated without the logged out function.

For this operating mode, the feeder protected by the local line differential protection must be de-energized. This is because after logout, local currents must not influence the current sum of the remaining protected object, which might lead to unwanted tripping.

Test Preparation and Implementation

Siemens recommends this procedure if you use a test switch to test the local function **Line differential protection**.

For further information, refer to *11.7.5 Use of Test Switches*.

If the parameter **(_:2311:108) Action on Behavior = test** = ***Test loc. device autom.***, Siemens recommends the following procedure for test preparation:

Initial state:

- **I** and optionally **V** of the system are connected to the current and voltage inputs of the protection device.
- The function **Line differential protection** is ***active*** in all devices.

Proceed as follows:

✧ Disconnect the feeder.

✧ Log off the function **Line differential protection** to be tested from the local device, see *6.7.15 Logging Off the Local Line Differential Protection*.

→ The function **Line differential protection** is ***active*** in the remote devices.

→ The function **Line differential protection** is ***Inactive*** in the local device.

✧ Toggle the test switch.

→ The test switch disconnects **I** and optionally **V** of the system from the current and voltage inputs of the protection device.

→ The test switch enables the test mode for the entire device in the local device, see *11.7.3.1 General Information* .

→ The setting value of the parameter **(_:2311:108) Action on Behavior = test** = ***Test loc. device autom.*** automatically enables the *Test local device* test mode.

✧ Start your tests and apply the test currents and test voltages.

Steps after Completion of the Tests

Initial state:

- The function **Line differential protection** is ***active*** and in ***Test*** state in the local device only.
- The function **Line differential protection** is ***active*** in the remote devices.

Proceed as follows:

✧ Complete your tests and remove the test currents and test voltages.

✧ Toggle the test switch.

→ The test switch disables the test mode for the entire device in the local device, see *11.7.3.1 General Information* .

→ The test switch connects **I** and optionally **V** of the system to the current and voltage inputs of the protection device.

→ The setting value of the parameter **(_:2311:108) Action on Behavior = test** = ***Test loc. device autom.*** automatically disables the *Test local device* test mode.

→ The function **Line differential protection** is ***Inactive*** in the local device.

✧ Log on the tested function **Line differential protection** at the local device again, see *6.7.15 Logging Off the Local Line Differential Protection*.

→ The function **Line differential protection** is ***active*** in all devices.

✧ Reconnect the feeder.

11.7.4 Checking the Operating Point

Use the special *Check op. point* test mode to check the differential current and the restraint current, for example, after setting changes prior to commissioning and with connected process variables (**V** and **I** of the system). In DIGSI 5, the current operating point in the differential protection characteristic curve can be checked, see *Figure 11-20*.

This test mode is not intended for testing with test currents and test voltages.

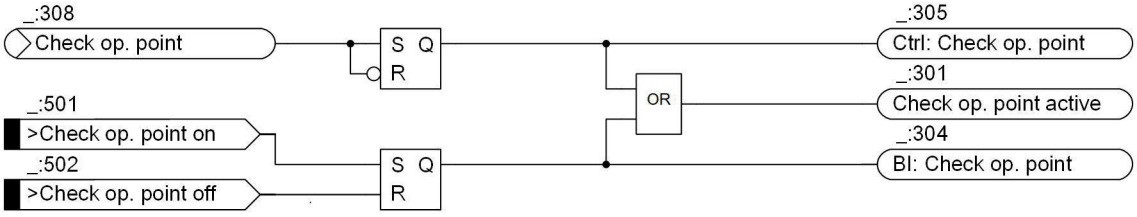
In this test mode, line differential protection works with all line ends, but does not generate any operate indications.

The special *Check op. point* test mode is only enabled/disabled at one device of the device combination. Meaning that you carry out all action steps on site on the device to be tested. The functions **Line differential protection** in the remote devices are automatically set to this test mode via the protection communication.

You can enable or disable the special *Check op. point* test mode as follows:

- Via the operating dialog in DIGSI (online): **Online access > Interface > Device > Device information, Test and operation, Check all devices**
- Via the on-site operation panel under: **Main menu > Device functions > Line n > Line differential protection > Check op. point**
- Via the communication by using the *(_:2311:308) Check op. point* controllable
- Via the binary inputs *(_:2311:501) >Check op. point on* and *(_:2311:502) >Check op. point off*

The following figure shows the binary inputs, controllables, and indications linked to the *Check op. point* test mode:



[lo_switch-on-off_special-test-mode_esting-work-point, 1, en_US]

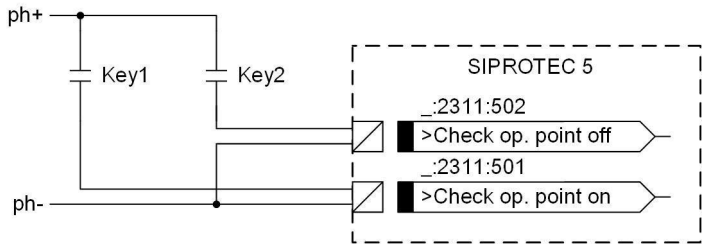
Figure 11-17 Logic Diagram for Enabling/Disabling the Special Check Op. Point Test Mode

The indications *Ctrl: Check op. point* or *BI: Check op. point* indicate via which path the Check op. point test mode has been activated.

If you activate this special test mode in DIGSI, either via the communication interface or via on-site operation by the *Check op. point* controllable, the device issues the indication *Ctrl: Check op. point*. The device stores the state of the *Check op. point* controllable in a voltage-fail-safe memory.

If you enable or disable this special test mode via the binary inputs *>Check op. point on* and *>Check op. point off*, the device issues the indication *BI: Check op. point*. If the *Check op. point* test mode is enabled, the device generates the indication *Check op. point active*. During the test, the indications of the functioon **Line differential protection** are marked with a test bit in all devices. The status indications of the instantiated **I-DIFF** stages show ***Test*** or ***Test/Relay blk***..

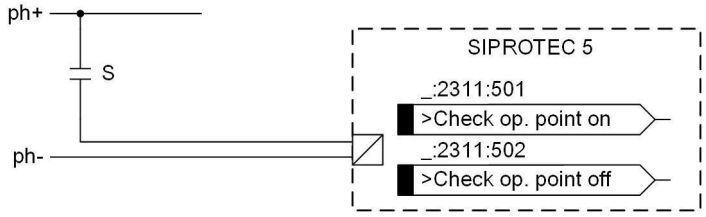
The following figures show possible variants of enabling/disabling the *Check op. point* test mode via binary inputs. The following figure shows the use of push-buttons **Ta1** and **Ta2**:



[lo_application_mode_device_taster_work-point, 1, en_US]

Figure 11-18 External Wiring of Push-Buttons for Enabling/Disabling the *Check op. point* Test Mode

The following figure shows the use of a switch **S**. Route the logical binary input *>Check op. point on* as **H** (high-active) and the logical binary input *>Check op. point off* as **L** (low-active) to a physical binary input.



[lo_application_mode_device_ext-switch_work-point, 1, en_US]

Figure 11-19 External Wiring of Switches for Enabling/Disabling the *Check op. point* Test Mode

Test Preparation

Prior to starting the test, **V** and **I** of the system must be connected to the current and voltage inputs of the protection device and the function **Line differential protection** must be ***active*** in all devices.

✧ Switch on the special *Check op. point* test mode for the function **Line differential protection**.
→ The function **Line differential protection** is ***active*** and in ***Test*** state in all devices.

✧ Start with checking the operating point.

NOTE

If the local function **Line differential protection** is logged off, it is not possible for you to enable the special *Check op. point* test mode. The device rejects the activation.

Performing the Check

You can check the differential and restraint current directly on the device or with DIGSI 5.

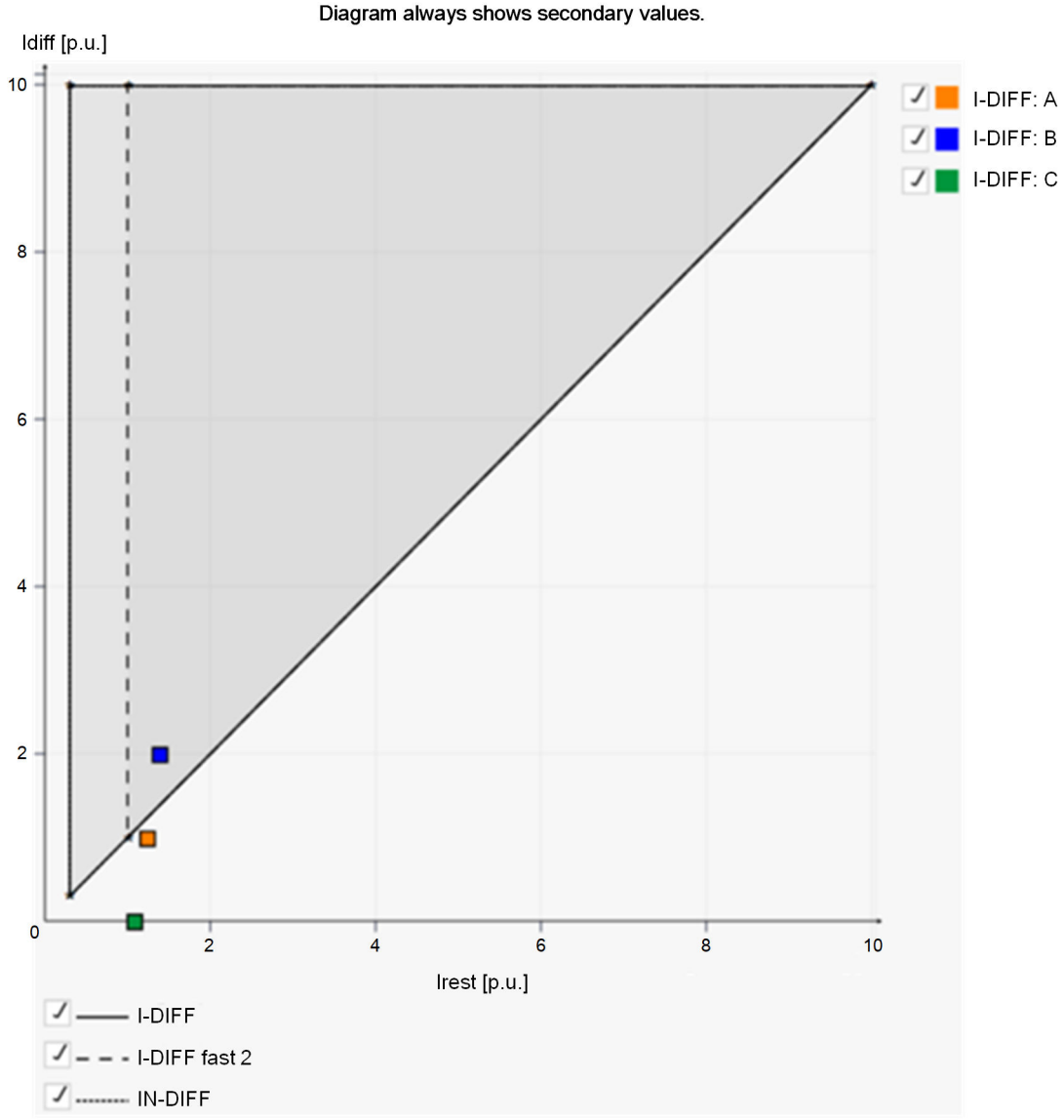
- **Checking on the Device:**
  On the device, you can find the differential current and restraint current under **Operational measured values > Measurements > Line 1 > Functional neasured values > Line diff. protection**

- **Checking with DIGSI 5:**

  When using DIGSI 5 to check the differential and restraint current, first establish the connection with the device. You can find the operational measured values of the line differential protection under **Name of device > Measurements > Line 1**.

  In the working area, you can find the operational measured values of the function under **Functional measured values > Line diff. protection**.

  In DIGSI 5 the operating points (OP) derived from the differential and restraint current can also be checked in the graphic display of the differential protection characteristic curve. You can find the differential protection characteristic curve in DIGSI 5 in the project tree under **Online device (Name of device) > Test suite > Protection functions > Line 1 > Line diff. protection**. The following differential protection characteristic curve shows the operating points:



[dw_charac_line-diff-prot, 1, en_US]

Figure 11-20 Characteristic Curve of the Line Differential Protection

To ensure reliable functioning of line differential protection, the operating point must be located inside the working area and clearly below the tripping lines.

If the differential current monitoring function operates or the operating point lies within the tripping area, proceed as follows:

✧ Check the pickup value of the stage.

✧ Check the polarity of the current transformer.

✧ Verify that the differential current is generated by the primary system.

Possible causes of a differential current are:

- The charging current of the line
  The charging current is represented as a permanent differential current when voltage is applied to the line.
- Asynchronous communication networks
  Such asynchronicity can be created by coupling larger communication networks.
- Unbalances in the runtimes for the protection communication that have always existed but not been noticed.

Completion of the Tests

The function **Line differential protection** is ***active*** and in ***Test*** state in all devices.

✧ Complete the test.

✧ Switch off the special *Check op. point* test mode for the function **Line differential protection**.
→ The function **Line differential protection** is ***active*** in all devices.

11.7.5 Use of Test Switches

When activated, a test switch has the following functions:

- Disconnects the current and voltage inputs of the protection device from the measurands **V** and **I** of the system and connects them to the outputs of a current and voltage generator for testing.
- Disconnects the protection device from the circuit breaker.
- Activates a test mode.

If you want to use a test switch for testing the entire line differential protection and for testing the function **Line differential protection** in the local device, Siemens recommends the following:

✧ Set the parameter **(_:2311:108) Action on Behavior = test** = ***Test loc. device man.***.

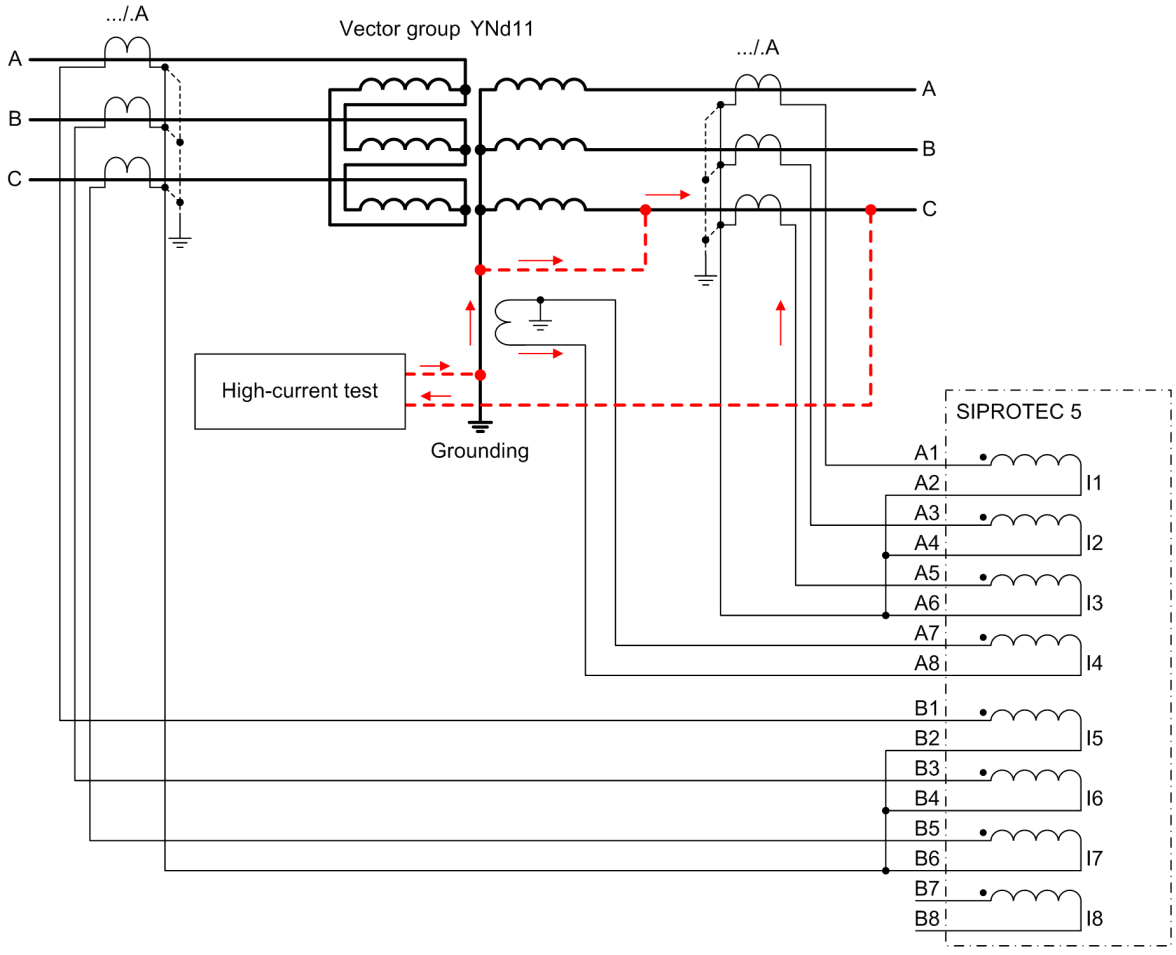
✧ Use the test switch to switch the test mode for the entire device on or off.

✧ You need to switch the special ***Test local device*** test mode on and off manually, see *11.7.3 Functional Test in the Local Device*.

11.8 Commissioning Notes for Restricted Ground-Fault Protection

In addition to the protection setting and the correct routing of the signals, proper system integration is important. When checking the system integration, Siemens recommends the following procedure:

- **Polarity test** of the current transformers and assurance that the positive definition (to the protected object) is maintained. With a 3-phase connection, the current-transformer neutral point points to the protected object. For the current transformer at the neutral point, it is important that the side of the current transformer that is connected to terminal A7 is in the direction of ground (see *Figure 11-21*).
- **Checking the pickup value** can be performed by feeding in a neutral-point current.
- **Checking stability with an external fault** is possible by feeding in a current, if no bushing-type transformers are present on the transformer. The *Figure 11-21* shows test proposal. A trip may not occur.



[dwhighct-170712-01.tif, 3, en_US]

Figure 11-21 Test with High-Current Test Equipment

If a generator step-up transformer is protected, the generator can be used as test source. During a shutdown, an external 1-phase short circuit is built in. After this, the generator is excited and a minimum current is supplied. This minimum current lies under the permissible negative-sequence current. Set the restricted ground-fault protection to the lower setting value. If the test current must be greater due to system conditions, the test takes place briefly (only a few seconds). Reestablish the original states after the test (primary plant, protection setting).

With smaller primary transformer rated currents, the test can take place by means of external supply (400 V method). Set the protection to the minimum threshold value.

11.9 Direction Test of the Phase Quantities (Current and Voltage Connection)

The proper connection of the current and voltage transformer is checked with load current over the line to be protected or the protected object . For this, the line or the protected object must be switched on. A load current of at least 0.1 I_{rated} has to flow over the line or the protected object ; it should be ohmic to ohmic inductive. The direction of the load current has to be known. In case of doubt, meshed and ring systems should be unraveled. The line or the protected object remains switched on the for the duration of the measurements.

The direction can be derived directly from the operational measured value. First make sure that the power measured values correspond to the power direction. Normally, it can be assumed that the forward direction (measuring direction) goes from the busbar toward the line or the protected object .

Using the power measured values at the device or DIGSI 5, make sure that it corresponds to the power direction:

- **P** is positive if the active power flows in the line or protected object.
- **P** is negative if the active power flows to the busbar or out of the protected object.
- **Q** is positive if the inductive reactive power flows in the line or protected object.
- **Q** is negative if the inductive reactive power flows to the busbar or out of the protected object.

If the power measured values have a different sign than expected, then the power flow is opposite the current-direction definition. This can be the case, for example, at the opposite end of the undervoltage side of a transformer . The current-transformer neutral point then points in the direction of the protected object (for example transformer).

If the values are not as expected, it may be due to a polarity reversal at the voltage connection.

As a final step, switch off the system.

11.10 Direction Test of Ground Quantities for Directional Ground-Fault Functions

11.10.1 Overview

If the CT and VT connections are in the way that the ground quantities (3I0 and V0) are calculated by the device from the phase quantities, then, no additional directional test is required. Testing according to *11.9 Direction Test of the Phase Quantities (Current and Voltage Connection)* is sufficient.

If the ground current IN or the ground voltage VN is directly measured via a device input (usually I4 or V4), the correct polarity of the ground current and the ground voltage path must be checked.



DANGER

Live system parts! Capacitive coupled voltages on dead parts!

Noncompliance with the following measures can lead to death, serious physical injury, or considerable material damage.

✧ Primary measures may be performed only on dead and grounded system parts.

11.10.2 Directional Testing for Solid or Resistive-Grounded Systems

Primary Test

The primary test is used for the evaluation of the correct polarity of the transformer connections for the determination of the ground-fault direction.

To generate a zero-sequence voltage V0, the e-n winding of one phase in the voltage-transformer set (for example, phase A) is bypassed, see *Figure 11-22*. If no connection on the e–n windings of the voltage transformer is provided, the corresponding phase is disconnected on the secondary side, see *Figure 11-23*. Only the current of the transformer in the phase of which the voltage is missing is transferred via the current circuit. If the line carries resistive-inductive load, the protection is subject to the same conditions as existing during a ground fault in line direction.

For directional testing, the **Directional ground-fault protection** function (67N) is configured and at least one stage is switched on. The pickup threshold of the stage must be below the load current of the line. If not, the binary input signal *(_:2311:501) >Test of direction* can be activated to lower the threshold temporarily for testing means without changing the respective parameter.

After switching the line on and off again, you can check the pickup signal of the directional protection stage in the fault log. A forward information must be logged. If no pickup information is logged at all, the 3I0 or U0 threshold is not exceeded.

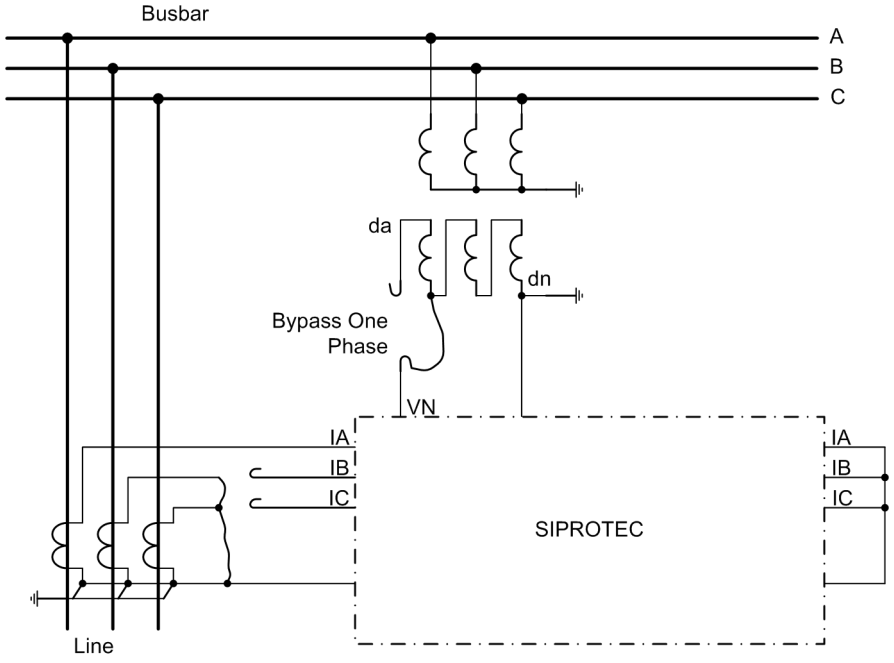
If a wrong direction is logged, one of the following conditions may have occurred:

- The direction of the load flow is from the line towards the busbar.
- The ground-current connection is incorrect.
- The voltage connection is incorrect.



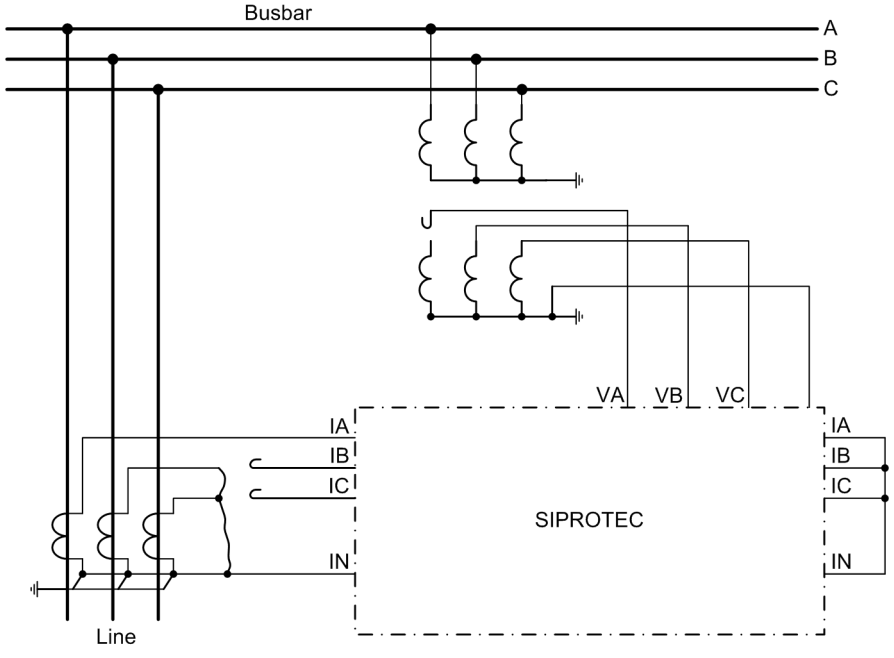
NOTE

Siemens recommends not to change parameter settings for the test. However, if parameters were changed for this test, they must be returned to their original state after completing the test!



[dw_conn_polarit1_diagram, 1, en_US]

Figure 11-22 Polarity Testing, Example with Current Transformers Configured in a Holmgreen-Connection and VTs with Broken-Delta Connection



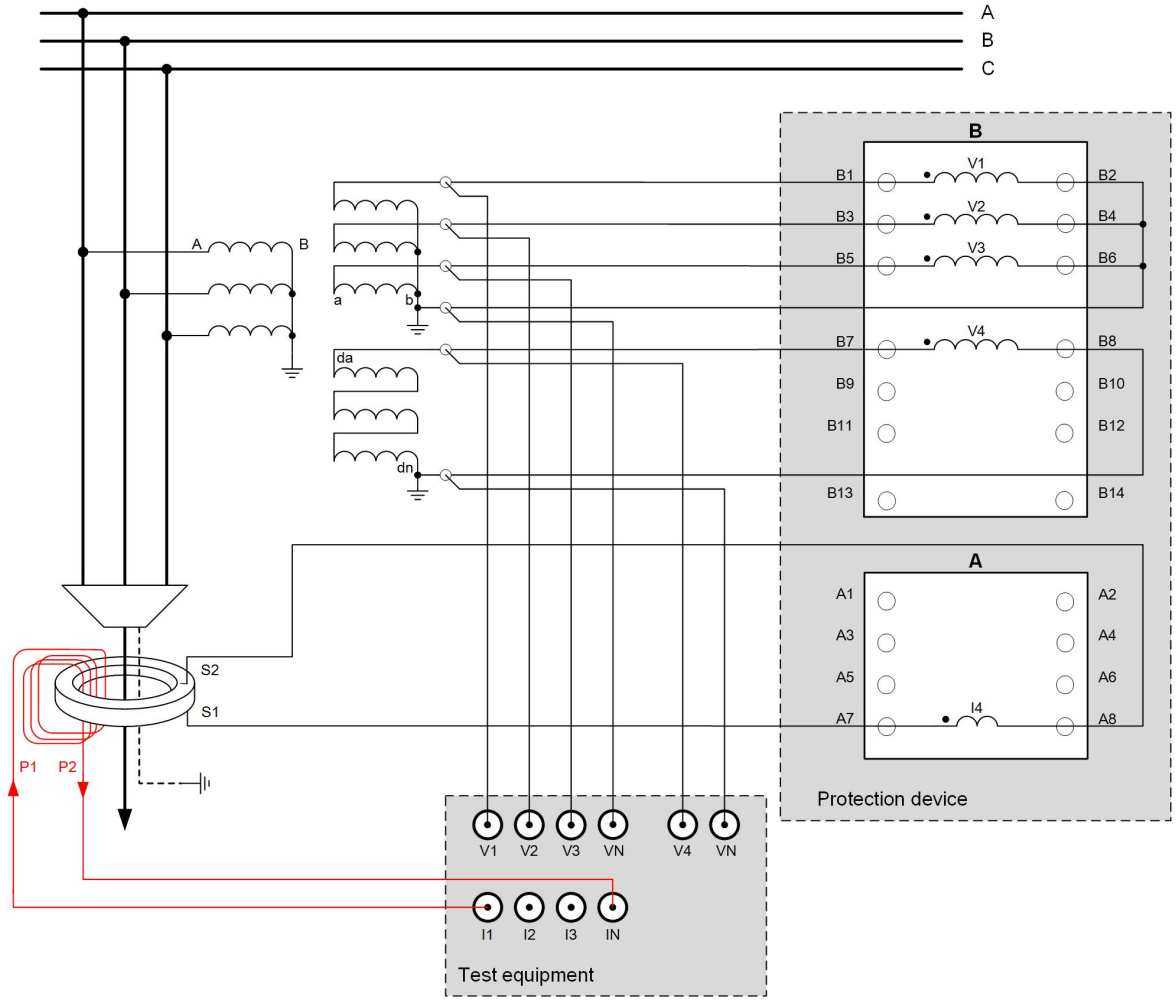
[dw_conn_polarit2, 1, en_US]

Figure 11-23 Polarity Testing, Example with Current Transformers Configured in a Holmgreen-Connection and VTs with Star Connection

11.10.3 Directional Testing for Isolated or Resonant-Grounded Systems

Secondary Test with Core Balance Current Transformer

The secondary test is used for the evaluation of the correct ground-fault direction of the directional ground-fault protection functions. With this test, a core balance current transformer that is incorrectly connected can also be found.



[dw_secondary_test_SGFP, 2, en_US]

Figure 11-24 Connection with Primary Current Injection

In the preceding figure, the red pilot wire must be wired only for the testing purpose through the core balance current transformer.

- ✧ Make the connections of the test equipment according to *Figure 11-24*.
- ✧ Route the pilot wire through the core balance current transformer in the direction towards the protection object (towards the feeder).
- ✧ To achieve a higher measured ground current, route the pilot wire multiple times through the core balance current transformer.
- ✧ The equivalent primary test current is the test current of the test device multiplied by the number of pilot-wire windings.
- ✧ Inject the test quantities according to the following table. Select the quantities according to the networking grounding and direction to be tested.

Neutral Point	Isolated				Resonant-Grounded			
Direction	Forward		Reverse		Forward		Non-faulty	
V_A (V1)	0 V	0°	0 V	0°	0 V	0°	0 V	0°
V_B (V2)	100 V	-150°	100 V	-150°	100 V	-150°	100 V	-150°
V_C (V3)	100 V	+150°	100 V	+150°	100 V	+150°	100 V	+150°
$V_{da/dn}$ (V4)	100 V	+180°	100 V	+180°	100 V	+180°	100 V	+180°
I_A = 3I0 (I1[69]), see *Figure 11-24*	2 A	+90°	2 A	-90°	1 A	0°	2 A	-90°

✧ You can check the test result by the direction information from the log.

Primary Test

The primary test is used for the evaluation of the correct polarity of the transformer connections for the determination of the ground-fault direction.

For directional testing, the **Directional sensitive ground-fault detection** function (67Ns) is configured and a directional stage is switched on. For example, the directional 3I0> stage with cos φ or sin φ measurement.

The most reliable test is the one with a primary ground fault. Proceed as follows:

✧ Isolate the line and ground it on both sides; on the farthest line end it must remain open during the entire test.

✧ Place a **1-phase** ground fault bridge on the line. For overhead lines, this can be done at an arbitrary location, in any case behind the current transformer (as seen from the busbar of the feeder to be tested). For cables, the grounding is done on the farthest end (sealing end).

✧ Remove the protective grounding from the line.

✧ Switch on the circuit breaker on the line to be tested.

✧ Check direction indicator (LED if routed).

✧ Check the indication *(_:302) Ground fault* in the ground-fault log or fault log with regard to its direction. The indication *(_:302) Ground fault forward* must be logged as direction information.

If *backward* is determined as the direction, either with the current connections or the voltage connections, there is an inversion in the neutral path. For the display *unknown*, the ground current is probably too low.

✧ Switch the line off and ground it.

This completes the test.

69 Refers to I1 of the test equipment.

11.11 Commissioning Hints for Voltage Control

11.11.1 Secondary Tests

11.11.1.1 General

Secondary tests can never replace the primary tests described in the following (*11.11.2 Primary Tests*), because you cannot exclude connection faults.

Secondary tests are used for the following purposes:

- Checking the setting values
- Checking the correct reaction of the protection function, limits, indications, blocking, and voltage control functions
- Checking the engineering (for example, routing of the respective logic signals, display images with measured values and CFC logics)
- With parallel control check of the communication

Note the following information during the secondary tests:



NOTE

For tests with secondary test equipment, make sure that no other measurands are connected and that the trip commands to the circuit breakers are interrupted. Otherwise, the circuit breaker may be activated.

If the tap-changer position is not updated manually during the secondary test, you must deactivate the tap-changer supervision. Otherwise, the voltage control is blocked after every switching procedure.



NOTE

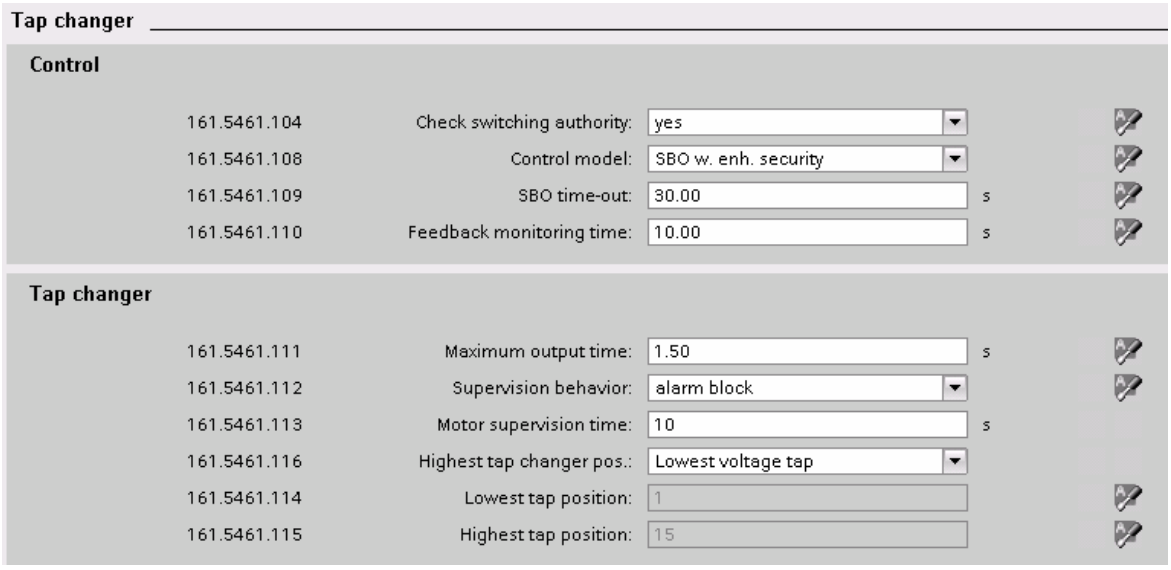
Once you have completed the secondary test, you must activate the tap-changer supervision again.

11.11.1.2 Checking the Transformer Tap Position

General

For this test, the transformer must be de-energized, that is, circuit breakers and disconnectors are switched off/opened, protected against re-energizing and the maintenance grounding switch should be closed.

During the functional test of the on-load tap changer, the most important setting parameters for the tap-changer supervision such as **Motor supervision time**, **Highest tap changer pos.**, and **Maximum output time** must be checked and adjusted.



[scstuslt-100713-01.tif, 2, en_US]

Figure 11-25 Parameters of the Tap Changer

Tap-Position Display

You can route the current tap position as a position indication on a display page or into the operating indications. If no signal is present or the function is blocked, the device reports a position error. The display then indicates an invalid tap position with **---** (*Figure 11-26*). You can find information on which conditions lead to an invalid tap position in *7.8.1 Function Description* .



[sc_osop_valid_position, 1, en_US]

Figure 11-26 Invalid Tap-Changer Position in the Device Display

Parameterize BCD Code

If the tap position of the tap changer is transmitted to the SIPROTEC 5 device via BCD code with prefix, then it is sufficient to assign the binary inputs with the corresponding functions according to the routing. Corresponding functions are for example:

- BCD1
- BCD2
- BCD4

- BCD8
- BCD10
- BCD20
- BCD40
- BCDminus
- Sliding contact

You can find a short introduction into parameter setting and routing of the binary inputs for the tap position in chapter *7.8.2 Application and Setting Notes*.

Besides the tap-position display via ***BCD with prefix***, the SIPROTEC 5 device offers the option to code the tap position as follows:

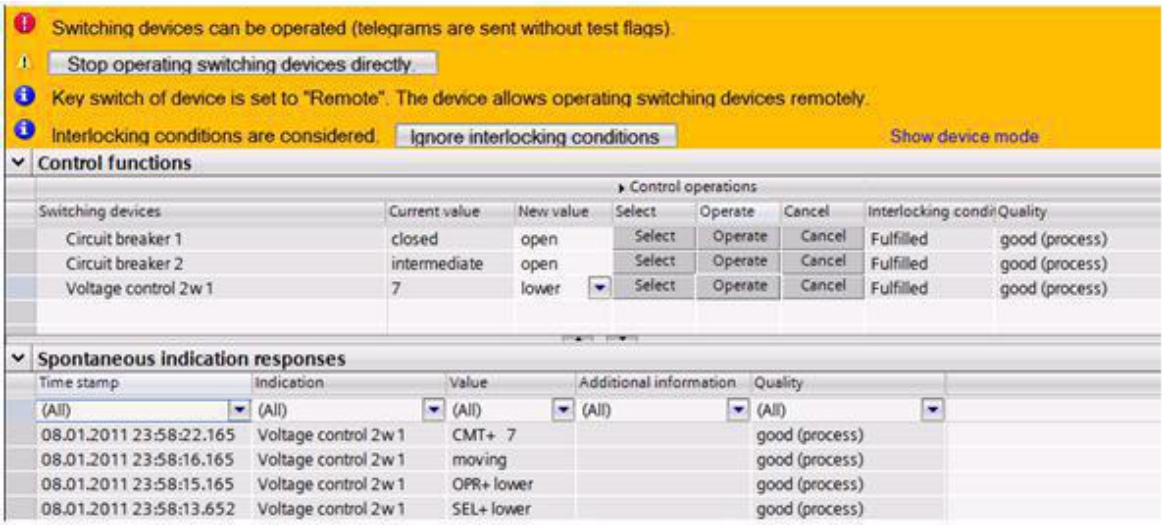
- Binary
- 1-of-n
- BCD
- Table
- Gray Code
- IEC 61850 GOOSE indication (Type BSC)

Optionally, you can also use an mA signal or a resistance-coded tap-position display. An ANAI module must be installed for the analog integration of the tap-position signal.

Checking the Tap Position

The active binary input is marked with a cross in the device menu under the entry **Binary IO**. Siemens recommends driving through all positions of the tap changer completely, if possible, thereby testing the correct tap-changer position indication once the parameterization of the tap position detection is finished and the tap-position display is activated.

You can carry out the tap-position check from the on-site operation panel or from the DIGSI Online-Editor. If you are using the DIGSI Online-Editor, set the switching authority of the device to ***Remote*** and the operating mode of the voltage controller to ***Manual***.



[sc_ibs_contr_func, 1, en_US]

Figure 11-27 DIGSI Online-Editor

Checking Sliding Contact

The device can monitor the runtime of the motor drive. This function is used to identify failures of the motor-drive mechanism during the switching procedure and to initiate actions (for example, blocking) if required. If you want to use the motor supervision time, you must route the motor run signal (most significant binary input) and set the motor runtime.

The maximum motor runtime can be calculated by measuring – during commissioning – how long the tap changer needs from the time point of the incremental command until completion of the tap changing. The tap changer needs approx. 7 s to 10 s for one tap-position change. Select the runtime to be 2 s to 3 s longer than the measured time. This takes into account a tolerance for the aging of the tap changer. If the tap changer has a run-through setting, select the motor lead time based on the run-through time of the switching tap (+ tolerance time).

If the tap-changer position is not manually updated during the secondary test, you must deactivate the tap-changer supervision. Otherwise, the voltage control is blocked after every switching procedure.

NOTE

Once you have completed the secondary test, you must activate the tap-changer supervision again.

11.11.1.3 Check of the Voltage-Control Function

The measured control deviation D results from the following formula:

$$D\ (\%) = \frac{V_{\text{act-prim}} - V_{\text{target-prim}}}{V_{\text{rated}}} \cdot 100\ \%$$

[fo_ibs_regelab, 1, en_US]

where:

$V_{\text{act-prim}}$	Actual voltage, primary
$V_{\text{target-prim}}$	**90V V.contr.2w** → **Target voltage** primary
V_{rated}	**90V V.contr.2w** → **General**:**Rated voltage**

With the **3-phase measuring point voltage** set to **VT connection** = ***3 ph-to-gnd volt. + VN***, the measured voltage primary $V_{\text{act-prim}}$ results from the ratio of the voltage transformer parameters **Rated secondary voltage** $V_{\text{CT-sec}}$ and **Rated primary voltage** $V_{\text{CT-prim}}$.

$$V_{\text{act-prim}} = V_{\text{act-sec}} \cdot \frac{\sqrt{3} \cdot V_{\text{CT-sec}}}{V_{\text{CT-prim}}}$$

[fo_ibs_prim_measur_volt, 1, en_US]

NOTE

The parameter **Measured value** has an effect on the secondary check, and therefore this checking example relates to the positive-sequence voltage.

This results in the secondary voltage $V_{\text{act-sec}}$ to be fed in depending on the control deviation D to be achieved with the connection type **VT connection** = ***3 ph-to-gnd volt. + VN / 3 ph-to-gnd voltages*** being:

$$V_{\text{act-sec}} = \left[\frac{D\ (\%) \cdot V_{\text{rated}}}{100\ \%} + V_{\text{target-prim}}\right] \cdot \frac{V_{\text{CT-sec}}}{\sqrt{3} \cdot V_{\text{CT-prim}}}$$

[fo_ibs_prim_measur_volt_2, 1, en_US]

This results in the secondary voltage $V_{\text{act-sec}}$ to be fed in depending on the control deviation D to be achieved with the connection type **VT connection** = ***3 ph-to-ph voltages*** being:

$$V_{act\text{-}sec} = \left[\frac{D\ (\%) \cdot V_{rated}}{100\ \%} + V_{target\text{-}prim}\right] \cdot \frac{V_{CT\text{-}sec}}{V_{CT\text{-}prim}}$$

[fo_ibs_prim_measur_volt_3, 1, en_US]

Table 11-4 Example Settings for the Power-System Data

Parameters	Value
Power-system data → **VT 3-phase:Rated primary voltage** $V_{CT\text{-}prim}$	15 kV
Power-system data → **VT 3-phase:Rated secondary voltage** $V_{CT\text{-}sec}$	110 kV
Voltage cont. 2W → **General:Rated voltage** V_{rated}	10.5 kV
Target voltage 1 V_{target}	11 kV

This results in the secondary voltage $V_{act\text{-}sec}$ with a phase-to-ground connection being:

$$V_{act\text{-}sec} = \left[\frac{D\ (\%) \cdot 10\ 500\ V}{100\ \%} + 11\ 000\ V\right] \cdot \frac{110\ V}{\sqrt{3} \cdot 15\ 000\ V}$$

[fo_ibs_prim_measur_volt_4, 1, en_US]

11.11.1.4 Further Tests

Control Deviation

- Check the control deviation D = 0 % at set point value infeed.
- Check the measured value of the control deviation D online in DIGSI or on the on-site operation panel of the device.

Secondary infeed values for the example:
Voltage-transformer connection phase-to-ground: $V_{act\text{-}sec}$ = 46.6 V
Voltage-transformer connection phase-to-phase: $V_{act\text{-}sec}$ = 46.6 V ·√3 = 80.7 V

Command Outputs

- Check the output of the **Lower adjusting command** after the parameterizable time **T1**.

With a set **bandwidth B** of 1 %, this results in the secondary pickup value:
Voltage-transformer connection phase-to-ground: $V_{act\text{-}sec}$ > 47.1 V
Voltage-transformer connection phase-to-phase: $V_{act\text{-}sec}$ > 47.1 V ·√3 = 81.5 V

- Check the output of the **Higher adjusting command** after the parameterizable time **T1**.

With a set **bandwidth B** of 1 %, this results in the secondary pickup value:
Voltage-transformer connection phase-to-ground: $V_{act\text{-}sec}$ < 46.1 V
Voltage-transformer connection phase-to-phase: $V_{act\text{-}sec}$ < 46.1 V ·√3 = 79.8 V

- Check the output of the **Lower adjusting command** after the parameterizable time **Fast step down T delay**.

For the set parameter **Fast step down limit** = ***6*** **%** the following secondary pickup values result:
Voltage-transformer connection phase-to-ground: $V_{act\text{-}sec}$ > 49.3 V
Voltage-transformer connection phase-to-phase: $V_{act\text{-}sec}$ > 49.3 V ·√3 = 85.3 V

- Check the output of the **Higher adjusting command** after the parameterizable time **Fast step up T delay**.

For the set parameter **Fast step up limit** = ***-6*** **%**, the following secondary pickup values result:
Voltage-transformer connection phase-to-ground: $V_{act\text{-}sec}$ < 49.3 V

Voltage-transformer connection phase-to-phase: $V_{act\text{-}sec} < 49.3\ V \cdot \sqrt{3} = 85.3\ V$

Blockings

- Check the undervoltage blocking **V< Blocking**.

For the set parameter **V< Blocking** = ***8 kV*** the following secondary pickup values result:
Voltage-transformer connection phase-to-ground: $V_{act\text{-}sec} < 58.7\ V$
Voltage-transformer connection phase-to-phase: $V_{act\text{-}sec} < 58.7\ V \cdot \sqrt{3} = 101.6\ V$

- Check the overcurrent blocking.

NOTE

The overcurrent blocking works with the maximum current of all phases, for this reason check the phases A, B, and C separately.

Example

Settings	Value
Power-system data → **CT 3-phase**:**Rated primary current** $I_{CT\text{-}prim}$	7500 A
Power-system data → **CT 3-phase**:**Rated secondary current** $I_{CT\text{-}sec}$	1 A
Voltage cont. 2W → **General**:**Rated current** I_{rated}	5500 A

$$I_{act\text{-}sec} = I_{rated} \cdot \frac{I> \text{Threshold}}{100\ \%} \cdot \frac{I_{CT\text{-}sec}}{I_{CT\text{-}prim}}$$

[fo_ibs_overcur_block, 1, en_US]

If you set the parameter **I> Threshold** to ***150 %***, this results in an infeed current secondary of $I_{act\text{-}sec} > 1.1\ A$ for this example.

Line Compensation

- Check the **Z Compensation**.

The parameter **Target voltage rising** represents the voltage drop across the line as a % under rated load. With a voltage drop primary of 504 V across the line at rated current, according to the setting notes in *7.9.4.5 Line Compensation*, this results in a setting value of 4.8 %.
The secondary current to be fed in at a load current for the 100 % load case results in:

$$I_{act\text{-}sec} = I_{rated} \cdot \frac{I_{CT\text{-}sec}}{I_{CT\text{-}prim}}$$

[fo_ibs_load_current, 1, en_US]

where:

$I_{CT\text{-}prim}$ Power-system data → **CT 3-phase**:**Rated primary current**
$I_{CT\text{-}sec}$ Power-system data → **CT 3-phase**:**Rated secondary current**
I_{rated} Voltage cont. 2W → **General**:**Rated current**

The secondary voltage to be fed in for the 100 % load case with a control deviation D [%] to be tested for the voltage-transformer connection phase-to-ground results in:

$$V_{act\text{-}sec} = \left(\frac{(\text{Target voltage rising}\ [\%] + D\ \%) \cdot V_{rated}}{100\ \%} + V_{target\text{-}prim} \right) \cdot \frac{V_{CT\text{-}sec}}{\sqrt{3} \cdot V_{CT\text{-}prim}}$$

[fo_ibs_sec_volt, 1, en_US]

For the voltage-transformer connection phase-to-phase, the reference must be multiplied with the factor √3. With a control deviation of D = 0 % to be tested and a setting value **Target voltage rising** of ***4.8 %*** in the example, this results in a secondary infeed voltage for the voltage-transformer connection phase-to-ground of:

$$V_{act\text{-}sec} = \left(\frac{4.8\ \% \cdot 10\,500\ V}{100\ \%} + 11\,000\ V\right) \cdot \frac{110\ V}{\sqrt{3} \cdot 15\,000\ V} = 48.7\ V$$

[fo_ibs_sec_volt_values, 1, en_US]

The infeed current for the 100 % load case is $I_{act\text{-}sec}$ = 0.733 A.

- Check the **X and R compensation**.

The control deviation results from the difference of the measured voltage $V_{act\text{-}prim}$ and a calculated compensated target voltage $V_{target\text{-}comp}$.

$$D = \frac{V_{act\text{-}prim} - V_{target\text{-}comp}}{V_{rated} \cdot 100\ \%}$$

[fo_ibs_target_comp, 1, en_US]

The calculated compensated target voltage is calculated from a numerically determined voltage V_{load} at the end of the line:

$V_{target\text{-}comp} = (V_{act\text{-}prim} - V_{load}) + V_{target}$

This numerically determined voltage V_{load} at the end of the line is determined form the parameters **X line**, **R line**, the flowing current $I_{act\text{-}prim}$ and the rotor angle φ.

The measured voltage at the voltage controller results from the dependency to the numerically determined voltage V_{load} and the flowing current $I_{act\text{-}prim}$ to:

$$V_{act\text{-}prim} = \sqrt{3} \cdot |\Delta V| + \sqrt{3 \cdot |\Delta V|^2 + V_{load}^2 - 3 \cdot I_{act\text{-}prim}^2 \cdot (X^2 + R^2)}$$

[fo_ibs_volt_prim_calcul, 1, en_US]

with $|\Delta V| = I_{act\text{-}prim} \cdot (\cos\varphi \cdot R + \sin\varphi \cdot X)$

If in the formula for V_{load} you insert the target voltage V_{set}, for the resulting control deviation this results in D = 0 %.

- Using the on-site operation panel or in DIGSI check whether the operational measured value ΔV has the value 0.

If you set the previous example values and for the parameter **R line** the value ***0.10 Ω*** and for the parameter **X line** the value ***0.15 Ω***, then this results in the following secondary infeed values at a rated load current of 5500 A and a cosφ = 0.707:

With a phase-to-ground connection

$$V_{act\text{-}sec} = V_{act\text{-}prim} \cdot \frac{V_{CT\text{-}sek}}{\sqrt{3} \cdot V_{CT\text{-}prim}} = 53.68\ V$$

[fo_ibs_input_values_LE, 1, en_US]

with $I_{act\text{-}sec}$ = 734 mA and φ_{load} = -45°

With a phase-to-phase connection

$$V_{act\text{-}sec} = V_{act\text{-}prim} \cdot \frac{V_{CT\text{-}sec}}{V_{CT\text{-}prim}} = 92.98\ V$$

[fo_ibs_input_values_LL, 1, en_US]

with $I_{act\text{-}sec}$ = 734 mA and φ_{load} = -75°

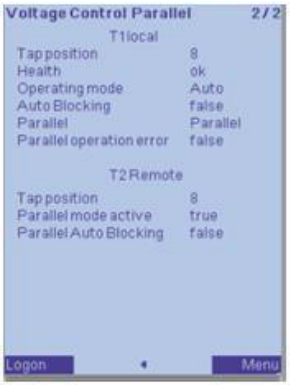
11.11.1.5 Voltage-Control Function for Parallel Transformers

Checking Settings of the Voltage Controller within a Group and of the GOOSE Communication

- For the functional test of **Voltage cont.2w**, route the indications *Health*, Local parallel mode, *Parallel-operation error*, and *Auto Blocking* to an LED.
- Check this routing.
- Route the GOOSE input indication *Cmd. with feedback* under **Voltage reg.2w** → **Parallel control** → **ParallelProxy** on one display page.

The tap positions received from the other voltage controllers are shown under:
Voltage reg.2w → **Parallel control** → **ParallelProxy**

- Switch all affected voltage controllers to parallel mode.



[sc_ibs_tap_changer_pos, 1, en_US]

Figure 11-28 Example of a User-Defined Display Page

If the indication *Parallel-operation error* is reported, the following causes are possible:

- Communication error
- Parallel-mode error – inconsistent setting **Parallel mode**
- Parameter **Parallel-transfomer id** inconsistent or identical on 2 voltage controllers
- Master error (number of Masters in the group ≠ 1), only with **Master-Follower method**
- Measured value invalid (for example with line compensation no current transformer assigned in the remote voltage controller)
- Mode error (inconsistent test mode of the voltage controllers)

You can find the reason for the indication in the operational log of the indication *Cause of par.op. error*.

NOTE

If the indication *Auto Blocking* and in **ParallelProxy**, the indication *Parallel Auto Blocking* are reported, the possible cause is that the remote voltage controller is blocked or the Follower-device with the **Master-Follower method** is in the ***Manual*** mode.

Checking Remote Measured Values

You can check the measured values received via GOOSE in the DIGSI Online Editor or on the on-site operation panel of the device under the following path:
Main menu → **Measurements** → **Voltage cont.2w** → **Function values** → **Parallel operat.** → **ParallelProxy**

Fundamental | **Function values** | Statistics | User-def. valu... | Power values

Measurements	Value	Quality	Number
Function values			
90V V.contr.2w			
V act.	11.001 kV	good (process)	162.14011.320
Vact.m	11.003 kV	good (process)	162.14011.333
ΔV act.	0 %	good (process)	162.14011.321
ΔVactV	0 %	good (process)	162.14011.334
ΔVactC	0 %	good (process)	162.14011.335
I load	5494 A	good (process)	162.14011.322
PhAng	0 °	good (process)	162.14011.364
I load Σ	16487 A	good (process)	162.14011.336
I circul.	-7 A	good (process)	162.14011.365
V target	11.000 kV	good (process)	162.14011.325
90V Parallel operat.			
ParallelProxy1			
V act.	11005.80 V	good (process)	162.2721.17971.88
I load	5497.9 A	good (process)	162.2721.17971.90
PhAng	0.1 °	good (process)	162.2721.17971.91
ParallelProxy2			
V act.	11001.60 V	good (process)	162.2721.17972.88
I load	5495.4 A	good (process)	162.2721.17972.90
PhAng	0.2 °	good (process)	162.2721.17972.91

[sc_ibs_func_value, 1, en_US]

Figure 11-29 Functional Measured Values in DIGSI

Checking the Voltage-Control Function for Parallel Transformers

First you must check the tracking of the transformer taps in the operating mode ***Manual***. Proceed as follows:

- Switch the Master device to the operating mode ***Manual***.
- Switch the Follower devices to the operating mode ***Auto***.
- On the Master device, start a *Tap-position up command* for the tap changer.

The voltage controllers in Follower mode of the same group must also change to a higher tap once the new tap-changer position is reached.

- Check the tap position of the Follower devices on the device display of the on-site operation panel.
- Repeat the test with a *Tap-position down command*.

Checking the Voltage-Control Function of the Master-Follower Method

- Carry out the test items of the Voltage-controller function in *11.11.1.1 General* in the Master device.

NOTE

During this test note that the measured control voltage **Vact.m** is averaged from the measured voltages of all parallel voltage controllers and therefore the secondary voltage must be fed in with all voltage controllers.

Checking the Line Compensation

To check the **Z Compensation** (LDC-Z), proceed as follows:

The parameter **Target voltage rising** represents the voltage drop across the line as a % under rated load.

Since the rated load current in the Master and the Follower devices can be different, you must calculate the parameter **Target voltage rising** separately for each voltage controller.

- Next, based on the following reference, determine how high the percentage of the primary load current of the line is compared with the rated current of a transformer k (k = 1, 2, ..., 8).

$$I_{load\,k}\ (\%) = \frac{I_{load}}{I_{rated\,k}} \cdot 100\ \%$$

[fo_ibs_load_cur_perc, 1, en_US]

$$\Delta V_{load}\ (\%) = \frac{\Delta V_{prim}}{V_{target}} \cdot \frac{100\ \%}{I_{load}\ (\%)}$$

[fo_ibs_prim_load_voltage, 1, en_US]

The following calculation values result from the *Example, Page 2014*, which is shown in the setting notes in the chapter **Z Compensation**.

Parameters	Transformer T_1	Transformer T_2
Power-system data → **VT 3-phase:Rated primary voltage** $V_{CT\text{-}prim}$	11 kV	11 kV
Power-system data → **VT 3-phase:Rated secondary voltage** $V_{CT\text{-}sec}$	110 V	100 V
Power-system data → **CT 3-phase:Rated primary current** $I_{CT\text{-}prim}$	1500 A	3000 A
Power-system data → **CT 3-phase:Rated secondary current** $I_{CT\text{-}sec}$	1 A	5 A
Voltage cont. 2w → **General:Rated voltage** V_{rated}	10.5 kV	10.5 kV
Voltage cont. 2w → **General:Rated app. power transf.** S_{rated}	26 MVA	52 MVA
Voltage cont. 2w → **General:Rated current** I_{rated}	1430 A	2859 A
Target voltage V_{target}	11 kV	11 kV
Target voltage rising	4.8%	9.6%

- Based on the following table check the input currents and voltages for each voltage controller:

	Transformer T_1 Independent T_2 = off (I_2 = 0)	Transformer T_2 Independent T_1 = off (I_1 = 0)	Transformer T_1 Master Transformer T_2 Follower	
Input Values, Secondary				
I_{sec}	0.953 A	2.383 A	0.635 A	3.1833 A
Phase-to-ground V_{sec}	33.198 V	60.359 V	34.641 V	62.984 V
Phase-to-phase V_{sec}	57.501 V	104.54 V	60 V	109.1 V
Functional Measured Values				
V_{actual}	11.5 kV	11.5 kV	12.0 kV	12.0 kV
I_{load}	1430 A	1430 A	953 A	1910 A
$I_{load\sum}$	–	–	2860 A	2860 A
ΔV_{actual}	0 %	0 %	0 %	0 %
V_{target}	11.5 kV	11.5 kV	12.0 kV	12.0 kV

You can find more information in *7.9.4.5 Line Compensation*.

Checking the Voltage-Control Function with the Method of Minimizing the Circulating Reactive Current

The following secondary test is used to check the setting values. The current is fed into one voltage controller respectively and this current has a phase angle of -90° to the voltage.

- Also check the functional measured values for the circulating reactive current for the voltage controllers where no current is being fed in.

The following simplification results:
The current on one voltage controller is the total load current (I_{load}= I_k) and therefore the measured circulating reactive current has a dependency with the primary load current on a transformer:

$$I_{CRCk} = -1 \cdot \mathrm{Im}\left(I_{load\text{-}prim}\right)\left(1 - \frac{1}{X_k \cdot B_p}\right)$$

[fo_ibs_ccm_trafo, 1, en_US]

Where:

$B_p = \sum_{k=1}^{N} \frac{1}{X_k}$ Total susceptance value

X_k Transformer reactance on transformer k

The control deviation D_{CRCk} resulting from the circulating reactive current is determined in the voltage controller numerically according to the following formula:

$$D_{CRCk} = \text{Reactive I control factor}_k \cdot \frac{I_{CRCk} \cdot (X_k + \frac{1}{B_p - B_k}) \cdot \sqrt{3}}{V_{rated}} \cdot 100\ \%$$

[fo_regelabwdcc, 1, en_US]

The primary current to be fed in at a desired control deviation D_{CRCk} results:

$$\mathrm{Im}\left(I_{k\text{-}prim}\right) = -1 \cdot \frac{D_{CRCk} \cdot V_{rated}}{\text{Reactive I control factor}_k \cdot 100\ \% \cdot \sqrt{3} \cdot \left(1 - \frac{1}{X_k \cdot B_p}\right) \cdot \left(X_k + \frac{1}{B_p - \frac{1}{X_k}}\right)}$$

[fo_ibs_regelabwd_ccm, 1, en_US]

The current to be fed in is calculated from the following reference, with the phase angle to voltage being $\angle I_{actual\text{-}sec} = -90°$

$$I_{act\text{-}sec} = I_{k\text{-}prim} \cdot \frac{I_{CT\text{-}sec}}{I_{CT\text{-}prim}}$$

[fo_ibs_load_cur_prim, 1, en_US]

Example

Table 11-5 Example Values

Parameters	Transformer T_1	Transformer T_2
Power-system data → **VT 3-phase:Rated primary voltage** $V_{CT\text{-}prim}$	22 kV	11 kV
Power-system data → **VT 3-phase:Rated secondary voltage** $V_{CT\text{-}sec}$	110 V	100 V

Parameters	Transformer T_1	Transformer T_2
Power-system data → **CT 3-phase:Rated primary current** $I_{CT\text{-}prim}$	1500 A	3000 A
Power-system data → **CT 3-phase:Rated secondary current** $I_{CT\text{-}sec}$	1 A	5 A
Voltage cont. 2w → **General:Rated voltage** V_{rated}	10.5 kV	10.5 kV
Voltage cont. 2w → **General:Rated app. power transf.** S_{rated}	26 MVA	52 MVA
Voltage cont. 2w → **General:Rated current** I_{rated}	1430 A	2859 A
Target voltage V_{target}	11 kV	11 kV

For the transformer T_1 this results in the primary current at a desired control deviation of 1 % and the parameter **Reactive I control factor** = *1*:

$$\mathrm{Im}\left(I_{T1\text{-}prim}\right) = \frac{-1 \cdot 1\,\% \cdot 10\,500\ \mathrm{V}}{1 \cdot 100\,\% \cdot \sqrt{3} \cdot \left(1 - \frac{1}{0.42\ \Omega \cdot 6.38 \cdot \frac{1}{\Omega}}\right) \cdot \left(0.42\ \Omega + \frac{1}{6.38 \cdot \frac{1}{\Omega} - \frac{1}{0.42\ \Omega}}\right)}$$

[fo_ibs_regelabwd_ccm_values, 1, en_US]

- Check the function values in all voltage controllers according to the following table:

	Secondary Test Infeed Transformer T_1 for D = 1 %		Secondary Test Infeed Transformer T_2 for D = 1 %	
Input values, secondary	T_1	T_2	T_1	T_2
I_{sec}	0.09622 A -90° ph-gnd -150° ph-ph	0 A	0 A	0.4041 A -90° ph-gnd -150° ph-ph
Phase-to-ground V_{sec}	31.754 V	57.735 V	31.754 V	57.735 V
Phase-to-phase V_{sec}	55 V	100 V	55 V	100 V
Functional Measured Values				
V_{actual}	11.0 kV	11.0 kV	11.0 kV	11.0 kV
I_{load}	144 A	0 A	0 A	243 A
Phase angle	90°	–	–	0°
$I_{load\Sigma}$	144 A	144 A	243 A	243 A
I_{CRC}	90 A	-90 A	-91 A	91 A
ΔV_{act}	1 %	-1 %	-1 %	1 %
$\Delta V_{act\ u}$	0 %	0 %	0 %	0 %
$\Delta V_{act\ k}$	1 %	-1 %	-1 %	1 %

Checking the Pickup Value of the Circulating Reactive Current Blocking

If the value of the circulating reactive current exceeds the threshold value **Circul. current threshold** for a longer time than the set time delay **Circul. current time delay**, the indication *Circul. current blocking* is issued and the voltage control is blocked.

$$|I_{CRCk}| > \frac{\text{Circulating reactive current threshold}}{100\ \%} \cdot I_{rated}$$

[fo_ibs_ccm_cur_thresh, 1, en_US]

Therefore the secondary infeed current, where the phase angle to the voltage $\angle I_{act\text{-}sec} = -90°$, results in:

$$I_{k\,sec} > -1 \cdot \frac{\frac{\text{Circulating reactive current threshold}}{100\ \%} \cdot I_{rated\,k}}{\left(1 - \frac{1}{X_k \cdot B_p}\right)} \cdot \frac{I_{CT\text{-}sec}}{I_{CT\text{-}prim}}$$

[fo_ibs_ccm_cur_inp, 1, en_US]

The calculation from the values of *Table 11-5* for the transformer T_1 with a pickup value of 50 % results in:

$$I_{T1\text{-}sec} > -1 \cdot \frac{\frac{50\ \%}{100\ \%} \cdot 1430\ A}{\left(1 - \frac{1}{0.42\ \Omega \cdot 6.38\ \frac{1}{\Omega}}\right)} \cdot \frac{1\ A}{1500\ A}$$

[fo_ibs_ccm_cur_inp_value, 1, en_US]

With $I_{sec} > 0.76$ mA and $\angle_{act\text{-}sec} = -90°$

11.11.2 Primary Tests

If secondary test equipment is connected to the device, remove it or switch the test switch to the operating position.

- To be able to control the on-load tap changer manually, switch the voltage controller to the ***Manual*** operating mode.

NOTE

Be aware that a trip occurs in case of incorrect connections.

Checking the Polarity of the Voltage Transformer and Current Transformer

The correct connection of the current and voltage transformers is tested using the load current via the feeder to be controlled. For this, you must switch on the line or the protected object. A load current of at least 0.1 · I_{rated} must flow through the line or the protected object. The load current should be ohmic to ohmic inductive. The direction of the load current must be known. If there is a doubt, open meshed or ring systems.

The line or the protected object remains switched on for the duration of the measurements. You can derive the direction directly from the operational measured values.

- Make sure in DIGSI 5 or on the device with the following path that the power measured values correspond to the power direction:

  Main menu → **`Measured Values`** → **`Voltage cont.2w`** → **`Power values`**.

If active power flows in the line or the protected object, the power direction for **P** must be positive. If inductive reactive power flows in the line or the protected object, the power direction for **Q** must be positive. If the power measured values have a different sign than expected, then the power flow is opposite the current-direction definition. This can be the case, for example, at the opposite end of the low-voltage side of a transformer. The current-transformer neutral point then points in the direction of the protected object (for example, transformer). In this case, you must connect the **Measuring point I-3ph** in an inverted way to the function group **Voltage controller** in the function-group assignment (see chapter *Interface Between Function Group and Measuring Point, Page 59*).

Checking the Tap Direction and the Set Bandwidth

- Set the bandwidth according to the formula in chapter *7.9.4.3 Voltage Controller*.

The tap direction and the set bandwidth are checked with the following functional test.
With the correct tap direction, there will be a voltage increase when changing to a higher tap or a voltage reduction when changing to a lower tap.

- First switch the voltage controller to the ***Manual*** operating mode.
- Switch the tap changer to a higher or lower tap on the on-site operation panel or in the DIGSI Online-Editor until the voltage set point value is reached.
- Keep switching the tap changer higher until the bandwidth is exceeded.
  The difference in the control deviation I$\Delta V(n+1) - \Delta V(n)$I at a tap setting must be smaller than double the bandwidth.
- Switch the voltage controller to the ***Auto*** operating mode.
  After the parameterized time **T1**, the voltage controller should change to lower taps until the control deviation drops below the bandwidth.
- Switch the voltage controller back to the ***Manual*** operating mode.
  Keep switching the tap changer lower until the value drops below the bandwidth. The difference in the control deviation I$\Delta V(n-1) - \Delta V(n)$I at a tap setting must be smaller than double the bandwidth.
- Switch the voltage controller to the ***Auto*** operating mode.
  After the parameterized time **T1**, the voltage controller must change to higher taps until the control deviation drops below the bandwidth.

Checking the Circulating Reactive Current Sensitivity in Parallel Operation

The prerequisites for correct function of the parallel operation are the commissioning of the voltage controller in single operation and that the secondary tests have been completed.
For the functional test, the voltage controllers must be in the same parallel group according to the topology and the ***Manual*** mode as well as the **Method of minimizing the circulating reactive current** must be activated. In most cases, the default setting of the parameter **Reactive I control factor** is sufficient, since an optimal adjustment to the configuration takes place because of the entry of the parameter **General**:**Imp(Z): short circuit imp.** of the transformer.
If the control deviation is still larger than double the bandwidth due to the circulating reactive current at a tap-position difference of 1, alternating tap changing may take place. In this case, reduce the parameter **Reactive I control factor**.



NOTE

Carry out the following tests only at low load current.

- With all voltage controllers, approach ***one*** tap position which corresponds to the same no-load voltage to keep the circulating reactive current as low as possible and to reach the voltage set point value.
- Set one of the tap changers to a higher or lower tap. This results in a circulating reactive current.
  - If the difference of the circulating reactive current control deviation I$\Delta V_{actK}(n+1) - \Delta V_{actK}(n)$I is smaller than the set bandwidth, increase the parameter **Reactive I control factor**.
  - If the difference of the circulating reactive current control deviation I$\Delta V_{actK}(n+1) - \Delta V_{actK}(n)$I is larger than double the bandwidth, reduce the parameter **Reactive I control factor**.
- Repeat this test for all voltage controllers.

- With all voltage controllers, approach a *minimum* tap position where the same no-load voltages result everywhere, and repeat the following tests.
  - If the difference of the circulating reactive current control deviation $|\Delta V_{actK}(n+1) - \Delta V_{actK}(n)|$ is smaller than the set bandwidth, increase the parameter **Reactive I control factor**.
  - If the difference of the circulating reactive current control deviation $|\Delta V_{actK}(n+1) - \Delta V_{actK}(n)|$ is larger than double the bandwidth, reduce the parameter **Reactive I control factor**.
- Repeat this test for all voltage controllers.
- With all voltage controllers, approach a *maximum* tap position where the same no-load voltages result everywhere, and repeat the following tests.
  - If the difference of the circulating reactive current control deviation $|\Delta V_{actK}(n+1) - \Delta V_{actK}(n)|$ is smaller than the set bandwidth, increase the parameter **Reactive I control factor**.
  - If the difference of the circulating reactive current control deviation $|\Delta V_{actK}(n+1) - \Delta V_{actK}(n)|$ is larger than double the bandwidth, reduce the parameter **Reactive I control factor**.
- Repeat this test for all voltage controllers.

Since the transformer reactance can change slightly with the tap position, the points with *maximum* and *minimum* tap position mentioned in the preceding section are used to check the stable control.

Checking the Tap Direction and the Set Bandwidth in Parallel Operation with the Master-Follower Method

The following prerequisites apply for the following test:

- All transformers are switched on.
- All transformers feed to the same busbar.
- All voltage controllers are in parallel mode.
- The Master device is in the ***Manual*** operating mode.
- The Follower devices are in the ***Auto*** operating mode.



NOTE

Carry out these tests only at low load current.

The test sequence corresponds to the sequence under *Checking the Tap Direction and the Set Bandwidth, Page 2344*.

- In addition, test the manually updated tap position of the Follower devices.

If the current is measured on the involved voltage controllers, the line compensation or the circulating reactive current blocking is activated, you must check the currents.



NOTE

If a circulating reactive current forms despite the same tap position, there is an error in the tap-position assignment.

Performance of Current Tests

DANGER

Live system parts! Capacitive coupled voltages on dead parts!

Non-observance of the safety notes will result in death, severe injury, or considerable material damage.

✧ Primary measures may be performed only on dead and grounded system parts.

NOTE

These tests cannot replace a visual check of the correct current-transformer connections. Therefore, completed checks of the system connections are a prerequisite.

The SIPROTEC 5 device provides operational measured values. With these operational measured values, a fast commissioning without external instrumentation is possible.

The following procedure is intended for 3-phase protected objects, that is, for measuring point 1 against measuring point 2. For transformers, it is assumed that side 1 is the upper-voltage side of the transformer. The other possible current circuits are tested in an analog way.

- Read out the differential and restraint currents under:
  Main menu → **`Measured values`**.
- Check the direction information of the *(_:302) Ground fault* indication in the fault log or in the ground-fault log. The direction information *forward* must be logged for the *(_:302) Ground fault* indication.
  If *backward* is determined as the direction, there is an inversion in the neutral path either for the current connections or for the voltage connections. If *unknown* is displayed, the ground current is probably too low.
- Switch off the line and ground it.

This completes the test.

11.12 Functional Test Protection Communication

11.12.1 Checking the Protection-Data Communication

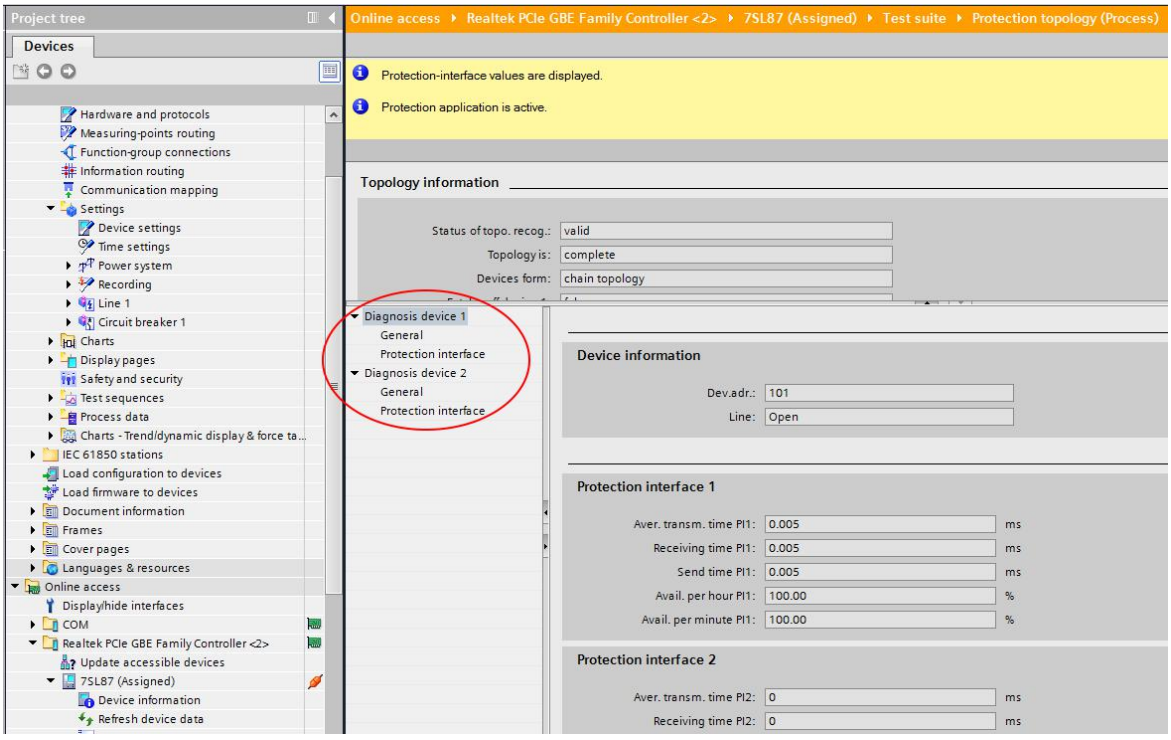
Checking the Protection-Data Communication

If the devices are connected to one another via the protection interface and switched on, they contact each other automatically. If, for example, device 1 recognizes device 2, the successful connection is indicated (see next figure). Accordingly, each device signals to all devices that aProtection-data communication is available.

The following information is provided via the protection interfaces by the devices in the device combination:

- Address of the device in the device combination
- Circuit-breaker switch position (open/closed/undefined); only for protection interfaces of type 1
- Availability of the protection-interface communication within the last minute, as percentage
  Availability of the protection-interface communication within the last hour, as percentage
- Signal-transit time in the transmission and reception direction of the telegrams between the local device and the neighboring device

You can find this diagnostic data in DIGSI under the following menu structure:



[sc_protec, 1, en_US]

Figure 11-30 Diagnostic Data of the Protection-Interface Channels – Device Address

NOTE

To reset the measured values for the protection interface directly in the device, proceed as follows:
Device functions > x Device protection comm. > Protection interface y > Release measured values.

Proper communication of the devices among each other can be supervised during operation.

✧ Check the connections for each protection interface in DIGSI 5.

If a connection is successfully established, the **Status of topo recog.** field shows the indication *valid* in DIGSI 5 (see *Figure 11-30*).

If 2 devices are parameterized incorrectly, the **Status of topo recog.** field shows the indication *invalid* (see *Figure 11-30*).

In *Figure 11-31* there is no protection-data communication between device 1 and device 2, that is, the protection interfaces 1 and 2 of device 1 do not receive data. The transmission of protection data is interrupted and differential protection is ineffective. One reason for this can be a remote control with DIGSI via the protection interface. In this case, the protection connection is interrupted and the connection is used exclusively for DIGSI.

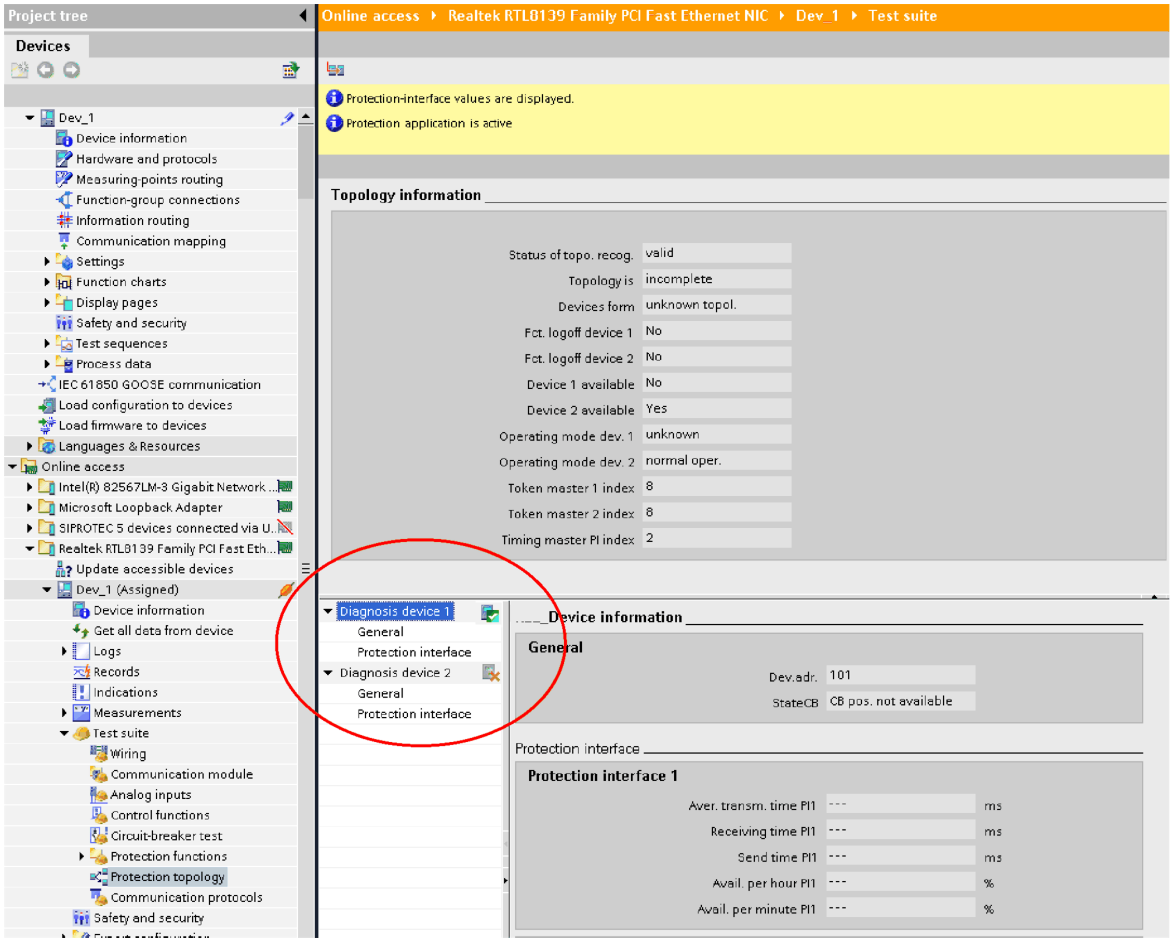


Figure 11-31 Protection-Data CommunicationDeactivated

11.12.2 Directional Test

In the case of protection interfaces of type 1 and type 2, the complex phasors of the voltage and current measuring point are exchanged between devices of one communication topology in order to be able to carry out a directional test during commissioning, for example. DIGSI 5 depicts this in the form of a phasor diagram. You can only route the measuring point to the protection interface. For 1 1/2 circuit-breaker layouts, a measuring point can therefore be transferred and checked optionally. You can also check and test the 2nd measuring point by rerouting. Furthermore, communication with DIGSI 5 can take place via the protection interface to other devices of the constellation. For this purpose, the protection-interface connection is interrupted and DIGSI 5 uses this connection for communication with the remote device.

✧ After completing the remote connection by DIGSI 5, the system switches back over to protection communication.

11.13 Functional Test for Overexcitation Protection

Secondary Test

NOTE

While performing the secondary test, ensure that the data of the protected object refer to the protection function.

This means that a mismatch between the voltage transformer and the protected object will be corrected automatically. For instance, when applying the secondary rated voltage and the rated frequency, this must not result in a V/f value of 1.

The mismatch of the voltage transformer must be taken into consideration when selecting the test voltage. Multiply the secondary test voltage with the following 'k' factor.

$$k = \frac{V_{rated,obj}}{V_{rated,transf.}}$$

[fo_kfakuf, 1, en_US]

Example

$V_{rated,obj}$ = 110 kV; $V_{rated,\ transf.}$ = 100 kV

It follows from the above that k = 1.1. For example, when verifying the nominal conditions if the secondary rated voltage is 100 V, a voltage of 1.1 * 100 V = 110 V must be supplied. The measured value of the function **Measured value V/f** must display 1.0000.

NOTE

When checking the dependent stage, ensure it is associated with a **thermal replica**. When repeating a test, always reset the replica, using the binary input indication **>Reset therm. replica** (_:13951:501).

Primary Test

The plausibility check between instantaneous overexcitation and the displayed operational measured value is used to verify the functionality of overexcitation.

Instantaneous overexcitation is a result of the following function:

$$\frac{V}{f} \cdot \frac{f_{rated}}{V_{rated}}$$

[fo_moweuf, 1, en_US]

where:

V	Instantaneous voltage
V_{rated}	Primary rated voltage of the protected object
f	Instantaneous frequency in f
f_{rated}	Rated frequency

11.14 Functional Test of Thermal Overload Protection

Secondary Test

For the secondary test for the overload protection, note that all setting parameters refer to primary variables of the protected object. The protection device extracts the current transformer ratio from the power-system data and internally performs the adjustments to device nominal variables. Take these characteristics into account for the test.

✧ Reset the thermal memory before you repeat the test. This is possible, for instance, via the binary input indication **>Reset thermal replica**. If the function is reparameterized or is switched off, the thermal replica will also be reset.

Test without Previous Load

✧ Test the operate time at 1.5 $I/I_{rated, obj.}$

In the example, the following power-system data are assumed:

$I_{rated, obj}$ = 483 A

$I_{rated, transf.prim}$ = 750 A

$I_{rated, transf.sec}$ = 1 A

The primary test current is 1.5 * 483 A = 724.5 A. This results in a secondary current of 724.5 A *1A/750A = 0.966 A. A secondary current of 0.966 A must therefore be supplied.

✧ Calculate the operate time with the following formula. Enter only primary variables here.

✧ Set $I_{previous\ load}$ = 0. The setting parameters reveal the **K-factor** (for example, 1.1) and the **Thermal time constant** (for example, 600 s or 10 min).

✧ Test from the cold state.

$$t = \tau_{th} \cdot \ln\left(\frac{\frac{1}{k^2}\left(\frac{I}{I_{rated,obj.}}\right)^2 - \frac{1}{k^2}\left(\frac{I_{preload}}{I_{rated,obj.}}\right)^2}{\frac{1}{k^2}\left(\frac{I}{I_{rated,obj.}}\right)^2 - 1}\right) = 600\,s \cdot \ln\left(\frac{\frac{1}{1.1^2}\left(\frac{1.5 I_{rated,obj.}}{I_{rated,obj.}}\right)^2 - 0}{\frac{1}{1.1^2}\left(\frac{1.5 I_{rated,obj.}}{I_{rated,obj.}}\right)^2 - 1}\right) = 600\ s \cdot 0.772 = 463\ s$$

[fo_auslpr, 2, en_US]

✧ At a current of 0.966 A supplied on the secondary side, the protection function must trip after 463 s.

Test with Previous Load

✧ The object rated current ($I_{previous\ load} = I_{rated, obj}$) flows at a previous load of 1 (100 %).

✧ Supply 483 A *1 A/750 A = 0.644 A in this case.

After a finite time (greater than 5 τ_{th}), the stationary previous load sets in.

K-factor

✧ If you abruptly increase the supplied secondary current from 0.644 A to 0.966 A (1.5 $I/I_{rated, obj}$), the overload protection will trip in the following time.

$$t = \tau_{th} \cdot \ln\left(\frac{\frac{1}{k^2}\left(\frac{I}{I_{rated,obj.}}\right)^2 - \frac{1}{k^2}\left(\frac{I_{preload}}{I_{rated,obj.}}\right)^2}{\frac{1}{k^2}\left(\frac{I}{I_{rated,obj.}}\right)^2 - 1}\right) = 600\,s \cdot \ln\left(\frac{\frac{1}{1.1^2}\left(\frac{1.5 I_{rated,obj.}}{I_{rated,obj.}}\right)^2 - \frac{1}{1.1^2}\left(\frac{1.0 I_{rated,obj.}}{I_{rated,obj.}}\right)^2}{\frac{1}{1.1^2}\left(\frac{1.5 I_{rated,obj.}}{I_{rated,obj.}}\right)^2 - 1}\right) = 600\,s \cdot 0.184 = 110\,s$$

[fo_auslpr, 2, en_US]

NOTE

Owing to the relatively large time constants in practice, the tests are carried out with significantly reduced time constants. Reset the original setting value after completing the tests.

11.15 Functional Test Hotspot Calculation

11.15.1 Secondary Test

NOTE

For the secondary test of the **Hotspot calculation** function, note that all setting parameters refer to the primary variables of the protected object. The protection device considers the current transformer ratio from the power-system data and adapts the data to the device-rated variables. Take this behavior into account for the test.

- Reset the thermal memory before you repeat the test. This is possible, for instance, via the binary input indication *>Reset thermal replica*. If you change the settings of the function or switch it off, the thermal image is also reset.
- Check the calculated hotspot temperature at a load current of $1.5 \cdot I/I_{rated, Obj}$.

Once the oil or turn time constant has expired, the hotspot temperature comes from the measured oil temperature and the temperature difference between the hotspot and the top-oil temperature.

Example

If the measured oil temperature is a uniform 70 °C, a temperature differential results between the hotspot and the top-oil temperature of:

IEC 60076-7

$\Delta\Theta_{H,V}(t) = K^{Y}H_{gr}$

$Y = 1.6$

$H_{gr} = 22$

$K = 1.6$

IEEE C57.91 2011

$\Delta\Theta_{H,V}(t) = K^{2m}H_{gr}$

$m = 0.8$

$H_{gr} = 22$

$K = 1.5$

In steady state, the hotspot temperature settles to $\Theta_h(t) = 114$ °C.

NOTE

Owing to the relatively large time constants in practice, the tests are carried out with significantly reduced time constants. Reset the original setting value after completing the test.

11.16 Reverse-Power Protection

11.16.1 Secondary Test

When performing the secondary test, note that the setting value for the reverse power refers to the machine variables. Due to the mismatching of the current transformer, you must check with reduced currents. You can deduce the reduction from the ratio $I_{rated,\ generator}$/ $I_{rated,\ CT}$. Check the reverse-power protection at rated voltage.

If the voltage transformer is not adjusted to the rated generator voltage, correct the secondary voltage, too. Use the following ratio:

$V_{rated,\ generator}/V_{rated,\ VT}$

11.16.2 Primary Test

For measurements on the protection current transformers and with sensitive setting of the reverse-power protection, Siemens recommends determining the reverse power and the angle-correction values. Regardless of the generator excitation, that is regardless of the reactive power Q, the reverse power P as a pure active power is constant. The resulting characteristic curve is a straight line that runs parallel to the Q axis. Due to possible angle errors of current transformers and voltage transformers, the protection device does not measure a constant active power. The current flowing at this time, which can be assumed as being proportional to the reactive power, has a substantial influence.

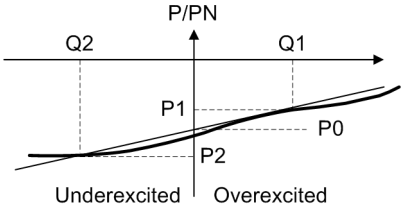
The deviations are determined with 3 measurements and the correcting quantity φ_{corr} is determined from the results.

To calculate the correction angle, enter the active power and reactive power measured with the device in the following table.

Use the functional measured values **`P1avg`** and **`Q1avg`** (type averaged).

Table 11-6 Value Table for Angle Correction

State	Reverse Power	Reactive Power
Reactive power near zero	P_0 =	Q_0 =
Overexcited	P_1 =	Q_1 =
Underexcited	P_2 =	Q_2 =



[dw_rpp_correction_angle, 2, en_US]

Figure 11-32 Determining the Correction Angle φ_{corr}



CAUTION

Be careful if you operate the turbine without a certain minimum steam flow (cooling effect).

Operating the turbine without a certain minimum steam flow (cooling effect) can overheat the turbine blades!

✧ The consumption of reverse power for a turbo-generator set is only allowed for a short time!

CAUTION

If the generator is underexcited, there is the risk of an out-of-step condition!

Non-observance of the following measures can result in minor personal injury or material damage.

✧ The following measures prevent the risk of an out-of-step condition.

✧ Regulate the driving power to 0 by closing the control valves. The generator draws its reverse power from the electrical power system.

✧ Change the excitation until the reactive power Q = 0. As a control measurement, read the active power P_0 and the reactive power Q_0 with the sign, and enter the values in *Table 11-6*.

✧ Increase the excitation slowly until reaching approx. 30 % of the rated apparent power of the generator (overexcited).
Read the reverse power P_1 with the sign (negative) and the reactive power Q_1 with the sign (positive) in the functional measured values and note these 2 values in the values table.

✧ Reduce the excitation slowly until reaching approx. 30 % of the rated apparent power of the generator (underexcited).
Read the reverse power P_2 with the sign (negative) and the reactive power Q_2 with the sign (negative) in the functional measured values and note these 2 values in the values table.

✧ Run the generator again at no-load excitation and select the desired operating state.

✧ With the measured value pairs (P_1, Q_1 and P_2, Q_2), calculate the correction angle ϕ_{corr} with the following formula:

$$\varphi_{corr} = \arctan \frac{P_1 - P_2}{Q_1 - Q_2}$$

[fo_RPP correction angle, 2, en_US]

NOTE

Insert the power values with the signs that you read previously!

✧ Enter this angle φ_{corr} with the same sign as the new correction angle (parameter ***(_:2311:101) Angle correction***):

Setting value ***(_:2311:101) Angle correction*** = φ_{corr}

✧ You can determine the pickup value of the reverse-power protection from the measured values P1 and P2.

Use the following formula: $P_{pickup} = (P_1+P_2)/4$

Set the value as pickup value: Parameter **(_:991:3) Threshold** = ***Ppickup***

Check of the Reverse-Power Protection

With a generator that is connected to the power system, the reverse power results from closing the control valves or from closing the quick stop.

✧ In both cases, check the consumed active power (reverse power). The valves could be leaking.

✧ Repeat the reverse-power measurement to confirm that the settings are correct.

- ✧ To check the efficiency of the reverse-power protection on the basis of the indications, use the parameter **(_:991:1) Mode** to switch the reverse-power protection to ***test*** .
  Proceed as follows:
- ✧ Start the generator and synchronize it with the power system.
- ✧ Close the control valves.
- ✧ From the functional measured value, take the reverse power that was measured by the protection device as the active power. Use 50 % of the functional measured value as setting value for the reverse-power protection.
- ✧ Increase the driving power up to normal operation.
- ✧ Check the quick-stop criterion.
  Proceed as follows:



NOTE

Make sure that the binary input **>Stop valve closed** is properly routed. The quick-stop criterion (the pressure-operated switch or the limit switch on the quick-stop valve) must control this binary input.

- ✧ Close the quick-stop valve.
- ✧ From the functional measured value **P1avg** , take the reverse power that was measured by the protection device as the active power.
- ✧ If – contrary to expectations – this value is smaller than the reverse power when the control valves are closed, take 50 % of this value as the setting value for the reverse-power protection.
- ✧ Shut down the machine by activating the reverse-power protection. Set the parameter **(_:991:1) Mode** to ***on*** .

11.17 Primary and Secondary Tests of the Circuit-Breaker Failure Protection

Integration of the Protection Function into the Station

The integration of the protection function into the station must be tested in the real-life application. Because of the multitude of possible applications and possible system configurations, the required tests cannot be described here in detail.

NOTE

Always keep the local conditions, the station plans, and protection plans in mind.

NOTE

Siemens recommends isolating the circuit breaker of the tested feeder at both ends before starting the tests. Line disconnector switches and busbar disconnector switches must be open so that the circuit breaker can be operated without risk.

General Precautions

CAUTION

Tests on the local circuit breaker of the feeder cause a trip command to the output to the adjacent (busbar) circuit breakers.

Noncompliance with the following measure can result in minor personal injury or material damage.

✧ In a first step, interrupt the trip commands to the adjacent (busbar) circuit breakers, for example, by disconnection of the corresponding control voltages.

For testing the circuit-breaker failure protection, it must be ensured that the protection (external protection device or device-internal protection functions) cannot operate the circuit breaker. The corresponding trip command must be interrupted.

Although the following list does not claim to be complete, it can also contain points, which have to be ignored in the current application.

Test Modes

The device and the function can be switched to test mode. These test modes support the test of the function in different ways:

Test Modes	Explanation
Device in test mode	This operating mode is relevant for the following tests: 1. Approach of current thresholds in the case of an external start: Supervision of the binary input signals in the case of an external start is disabled. This setting allows a static activation of the starting signals in order to approach the current threshold. 2. Check whether the issued trip commands actuate the corresponding circuit breakers, because the device contacts are also actuated in the device test mode.
CBFP function in test mode (device is NOT in test mode)	This operating mode is important for function tests in which the generated operate indications are NOT supposed to actuate the binary outputs.

NOTE

When the function or device is in test mode, all indications are given a test bit.

NOTE

In the mode **Device in test mode**, the operate indications generated by the function operate the binary outputs.

The function must also be tested in its normal, switched-on condition.

Consider the following in this case:

- ✧ The device contacts are actuated.
- ✧ Binary input signal supervision (in the case of an external start) is enabled and blocks the function.
- ✧ All indications generated are generated without test bit.

Circuit-Breaker Auxiliary Contacts

When circuit-breaker auxiliary contacts are connected to the device, they make an essential contribution to the reliability of the circuit-breaker failure protection, provided that their settings are set accordingly.

- ✧ Make sure that the correct assignment has been checked.

Internal Starting Conditions (Trip Command from Internal Protection Function)

The internal start can be tested by means of tripping a protection function, for example, the main protection function of the device.

- ✧ Check the settings for circuit-breaker failure protection. See also chapter *6.62.4 Application and Setting Notes*.
- ✧ For the circuit-breaker failure protection to be able to pick up, a phase current (see current-flow criterion) must be present. This can be generated by a device-internal test sequence (see description in the *Operating manual*). It can also be a secondary test current.
- ✧ Generate the trip for the protection function. This can be generated within the device by a test sequence (see description in the *Operating manual*) or by creating corresponding secondary test values.
- ✧ The trip command(s) and their time delay compared to the pickup, depending on the parameterization.

External Starting Conditions (Trip Command from External Protection Function)

If external protection devices are also able to start the circuit-breaker failure protection, the external starting conditions require checking.

- ✧ Check the settings for circuit-breaker failure protection.
  See also chapter *6.62.4 Application and Setting Notes*.
- ✧ For the circuit-breaker failure protection to be able to pick up, a phase current (see current-flow criterion) must be present. This can be generated by a device-internal test sequence (see description in the *Operating manual*). It can also be a secondary test current.
- ✧ Activate the binary input or inputs to which the start signal and possibly also the release signal for the CBFP function are routed. This can be done in 2 ways:
  – 1) Via internal test sequences
  – 2) By controlling the binary input or inputs via an auxiliary voltage
- ✧ Check the start input signal, and if available, check the enable input signal in the spontaneous or fault messages.
- ✧ Check the pickup indication in spontaneous or fault indications.
- ✧ The trip command(s) and their time delay compared to the pickup, depending on the parameterization.

Start by Trip Command from the External Protection

- ✧ Check the static and - in case of 2-channel operation - also the dynamic supervision of the binary input signals. For this purpose, induce pickup of the supervision and check the supervision indications and the ready signal in the event log buffer.

Start by Trip Command from the External Protection without Current Flow

- ✧ If start is possible without current flow: (see **Start by trip command from the external protection**).

Repetition of the Local Tripping (T1)

- ✧ Make sure that the trip repeat signal controls a 2nd circuit (2nd coil) for switching off the circuit breaker.

Backup Tripping in the Case of a Circuit-Breaker Failure (T2)

For tests in the station, it is important to check that the distribution of trip commands to the adjacent circuit breakers in the case of a circuit-breaker failure is correct. The adjacent circuit breakers are all circuit breakers, which must be tripped in order to ensure interruption of the short-circuit current if the feeder circuit-breaker fails. They are therefore the circuit breakers of all feeders which feed the busbar or busbar section to which the feeder with the fault is connected.

A general detailed test guide cannot be specified because the layout of the adjacent circuit breakers depends largely on the system topology.

- ✧ With multiple busbars, the trip distribution logic for the adjacent circuit breakers must be checked.

  The test has to check for every busbar section that, in case of a failure of the feeder circuit-breaker under observation, only those circuit breakers which are connected to the same busbar section are tripped.

Backup Tripping on Circuit-Breaker Failure (T2), Tripping of the Opposite End

If the trip command of the circuit-breaker failure protection must also trip the circuit breaker at the opposite end of the tested feeder, the communication channel for this remote trip has to be tested as well.

- ✧ It is practical to test the communication channel for the remote trip while transmitting other signals in accordance with *11.12.1 Checking the Protection-Data Communication*.

Termination

- ✧ All temporary measures taken for testing must be undone, such as special switch positions, interrupted trip commands, changes to setting values, or individually switched off protection functions.

11.18 Circuit-Breaker Test

The **Circuit-breaker test** function enables you to easily perform a complete test of the trip circuit, the closing circuit, and the circuit breaker. For this, the circuit-breaker test carries out an automatic opening and closing cycle or an only-open cycle of the circuit breaker during operation. You can also include a current-flow criterion in the test. The effect of the current-flow criterion is to ensure the circuit-breaker test is only carried out if the current flow across the circuit breaker is below the parametrizable threshold.

NOTE

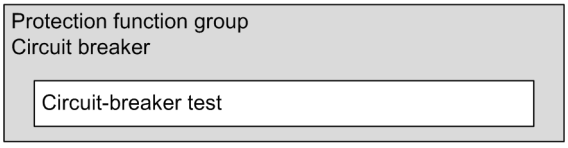
If the circuit-breaker auxiliary contacts are not connected, a circuit breaker that has been opened can be permanently closed.

The following test program is available for you to carry out the circuit-breaker test.

No.	Test Program
1	3-phase open/closed cycle

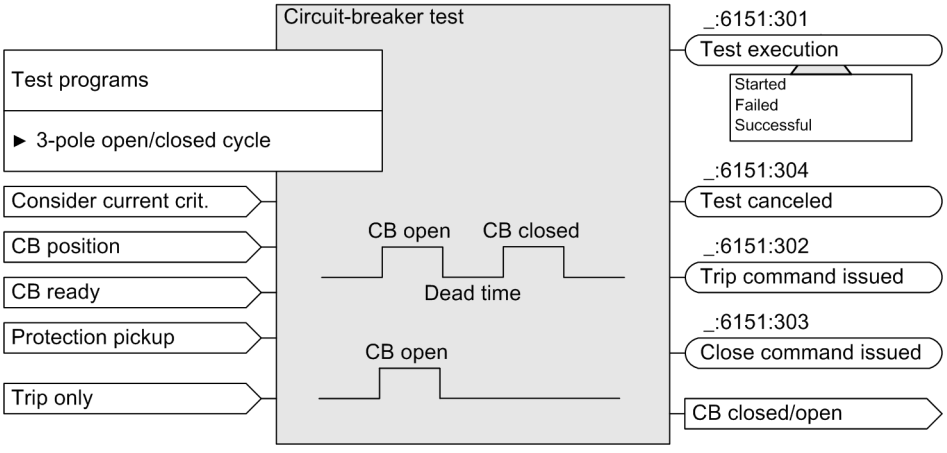
Structure of the Function

The **Circuit-breaker test** function is used in protection function groups for circuit breakers.



[dw_cbch01, 1, en_US]

Figure 11-33 Embedding of the Function



[dw_zecbc3p2, 2, en_US]

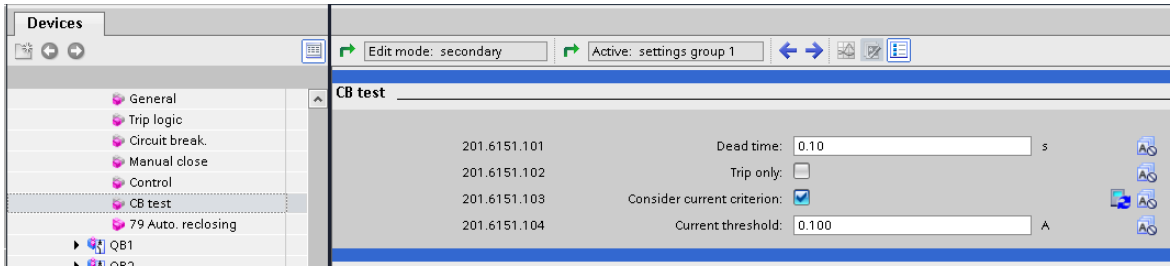
Figure 11-34 Structure of the Function

Test Procedure

The following conditions must be satisfied before the circuit-breaker test can start:

- ✧ If a circuit-breaker auxiliary contact signals the position of the breaker pole to the device via the binary inputs of the signal **`Position`**, the test cycle is not initiated unless the circuit breaker is closed.
- ✧ If the circuit-breaker auxiliary contact has not been routed, you must ensure that the circuit breaker is closed.
- ✧ The circuit breaker must be ready for an open-closed-open or only-open cycle (indication **`>Ready`**).

✧ A protection function must not have been picked up in the circuit-breaker protection function group responsible for the circuit breaker.

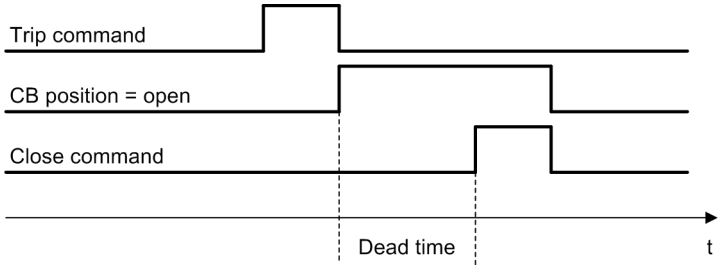


[sc_cbtest3p, 1, en_US]

Figure 11-35 Settings for the Circuit-Breaker Test

Figure 11-36 shows the progression over time of an open-close cycle. If you activated the **(_:6151:102) Trip only** option, the close command will not be executed and the dead time will not be taken into account.

If a circuit-breaker auxiliary contact is connected, the function waits for the indication circuit breaker **Position** = ***open*** after the trip command is generated. When the indication **Position** = ***open*** is received, the close command is transmitted after a dead time (parameter **(_:6151:101) Dead time**) for an open-close cycle. If the feedback from the circuit-breaker positions is not received within the maximum transmission time (**Dead time** + 2 · **Output time** + 5 s), the circuit-breaker test is aborted and considered to be failed. The proper functioning of the circuit breaker is monitored via the feedback on the circuit-breaker positions.



[dw_cbch03, 1, en_US]

Figure 11-36 Progress over Time of a Circuit-Breaker Test Cycle

Use the **(_:6151:103) Consider current criterion** parameter to ensure the circuit-breaker test is only carried out when the current flowing through the circuit breaker does not exceed a specific current threshold (parameter **(_:6151:104) Current threshold**). Otherwise, the circuit-breaker test is not started.

✧ If the current-flowcriterion is deactivated, the current threshold is not evaluated. The circuit-breaker test is performed irrespective of the current-flow level through the circuit breaker.

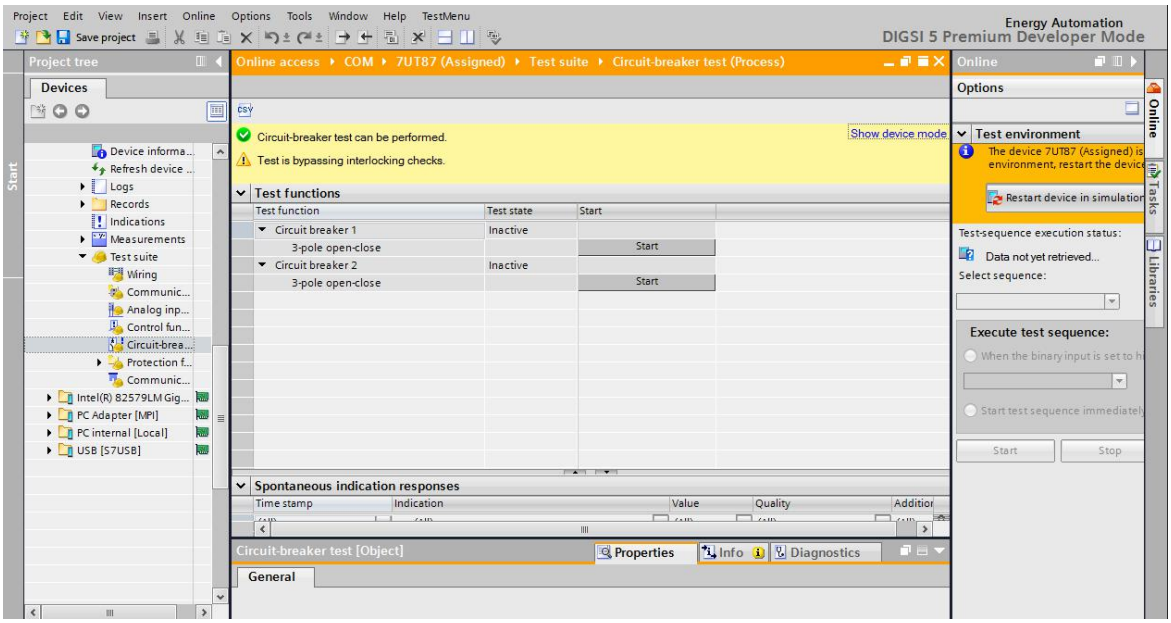
NOTE

The circuit-breaker test does not perform a synchrocheck even if the synchrocheck has been configured in the protection-function groups for circuit breakers. This can cause stability problems in the system during a 3-pole interruption. Therefore, a 3-pole circuit-breaker test should be very short, or not performed at all under load.

You can start the test program as follows:

- Via the device-control panel
- Via DIGSI
- Via communication protocols
- Via control commands, which you can also connect in the CFC

The following figure illustrates operation of the circuit-breaker test in DIGSI.



[sc_cb_3pol, 1, en_US]

Figure 11-37 Circuit-Breaker Test in the Test Suite in DIGSI

- ✧ Select the function in the project tree on the left in the online access.
- ✧ Start the desired test program in the upper portion of the working area.
- ✧ The corresponding feedback is displayed in the bottom portion of the working area. Additional information about the behavior of other functions while the circuit-breaker test is being performed can be read in the operational log.

11.19 Functional Test of the Inrush-Current Detection

General

- ✧ For the test, make sure that the test current reflects the typical inrush current.
- ✧ Perform the test with transient signals. These can be recorded inrush currents or simulated currents from a transient system model.
- ✧ When using synthetic signals, observe the notes on the individual measuring principles.

Harmonic Analysis

- ✧ Superimpose on the fundamental-component current a test current of double frequency (2nd harmonic) and test the pickup behavior with this.
- ✧ Cause a threshold value excess (internal pickup) for one of the protection functions that you want to block.

  - or -

- ✧ Apply a test current with a load current as lead (current step).

The inrush current detection creates a blocking signal.

CWA Process

- ✧ Create a test current that has flat ranges of a minimum width of 3 ms simultaneously in all 3 phase currents.

The inrush current detection creates a blocking signal.

11.20 Functional Test of Transient Ground-Fault Protection

General

This function requires the correct polarity of the ground current IN and the neutral-point displacement voltage VN respectively the zero-sequence voltage V0.For the direction test of these quantities, refer to *11.17 Primary and Secondary Tests of the Circuit-Breaker Failure Protection*.

The function is based on the evaluation of the transient in the zero-sequence system after the ground-fault ignition.

For issuing the signal *(_:13021:302) Ground fault*, the following 2 conditions must be met:

- There is a transient in the ground quantities.
- The fundamental compoment of the zero-sequence voltage V0 exceeds the threshold **(_:13021:103) V0> threshold value**.

The following 2 methods are available for testing of the signal *(_:13021:302) Ground fault*:

- Replaying real transient ground-fault recordings to the device
- Using secondary test equipment which allows to simulate transients ground faults

However, the setting of parameter **(_:13021:103) V0> threshold value** cannot be tested precisely with the mentioned 2 methods, since this test requires a static V0. An easy way to test the setting is described in the following.

Secondary Test

This test must be carried out by injecting static secondary quantities. The test equipment needs to be configured in a way that it generates zero-sequence current 3I0 and zero-sequence voltage V0, which are injected to the SIPROTEC 5 device. By carrying out a shot, for example, a status change from zero-sequence values of 0 A and 0 V to the values not equal to zero, a transient is generated. The signal *(_:13021:302) Ground fault* is issued as long as the static zero-sequence voltage of the 2nd state is greater than the set threshold. As amplitude for the secondary 3I0, 100 mAis a suitable value. In this test, the directional result contained in the signal *(_:13021:302) Ground fault* is not defined and relevant, since the task is to test the setting of parameter **(_:13021:103) V0> threshold value** only.

For testing the threshold, shots must be carried out with a static V0 slightly below the threshold and slightly above the threshold, for example, to 98 % and 102 % of the threshold value or to a threshold value of -0.2 V and +0.2 V (the greater absolute deviation of the threshold value must be selected) .

Consider that the V0 threshold is defined according to the definition of the symmetrical components. A full neutral-point displacement voltage VN of 100 V causes V0 = 57.7 V.

Example

- **(_:13021:103) V0> threshold value** = 15 V
- 3 shots from 0 to V0 = 14.7 V and 3I0 = 100 mA
  No signal *(_:13021:302) Ground fault* is issued.
- 3 shots from 0 to V0 = 15.3 V and 3I0 = 100 mA
  Signal *(_:13021:302) Ground fault* is issued

If the test result is not as expected, check the injected static V0 voltage via the operational measurement of the device which contains the zero-sequence components.

11.21 Functional Test of the Trip-Circuit Supervision

General

- ✧ For the test, make sure that the switching threshold of the binary inputs is clearly below half the rated value of the control voltage.

2 Binary Inputs

- ✧ Make sure that the binary inputs used are isolated.

1 Binary Input

- ✧ Make sure that, in the circuit of the 2nd circuit-breaker auxiliary contact, an equivalent resistance R is connected.
- ✧ Observe the dimensioning notes under the section **Equivalent resistance R**.

11.22 Functional Test for the Phase-Rotation Reversal

- ✧ Check the phase sequence (direction of rotating field) at the device terminals. It must correspond to the setting of the **Phase sequence** parameter.
- ✧ The output indication *Phase sequence ABC* or *Phase sequence ACB* displays the determined phase sequence. This must correspond to the phase sequence that was set.
- ✧ You can also determine the phase sequence via the **Symmetrical components** measured values. If you obtain negative-sequence system variables (V_2, I_2) and no positive-sequence system variables (V_1, I_1) with symmetrical 3-phase infeed, the setting parameter **Phase sequence** does not correspond to the connection.

11.23 Primary and Secondary Testing of the Synchronization Function

Measuring the Circuit-Breaker Make Time

Under asynchronous system conditions, the circuit-breaker make time must be measured and set correctly. This achieves an exact parallel switching with a phase angle 0°. If switching occurs only in synchronous system conditions, this section can be skipped.

The make time can be determined via the following 2 methods:

- By reading from a fault record (recommended method)
- With external timer

1. A simple option for determining the make time involves reading the time between the close command and closure of the switch pole via the fault record. The time determined here is the real make time and not the operating time of the circuit breaker. You do not have to add any further time.

Siemens recommends the following procedure:

✧ Establish a condition in which the circuit breaker can be closed without hazard.

✧ If V2 is switched through, activate the operating mode **Close cmd. at V1< & V2>** for the synchronization stage[70] or by setting it to ***yes***.

If V1 is switched through, activate the operating mode **Close cmd. at V1> & V2<**.

✧ Make sure that the fault recorder is turned on. Via a temporary CFC chart, link the signal **Release close cmd.** of the active synchronization stage to the binary input signal **>Manual start** (of the fault recorder). With the release of closure, a fault record of the parameterized duration is set up (the default setting of 500 ms is more than adequate for this).

✧ Starting the synchronization stage. The device activates immediately.

✧ Read the fault record and determine the make time via SIGRA (see *Figure 11-38*).

Use the 2 cursors and the time-measuring function for this. Position the first cursor on the raising close command. The occurrence of the 2nd voltage signals the closed power-switching poles. Place the 2nd cursor on the raising 2nd voltage.

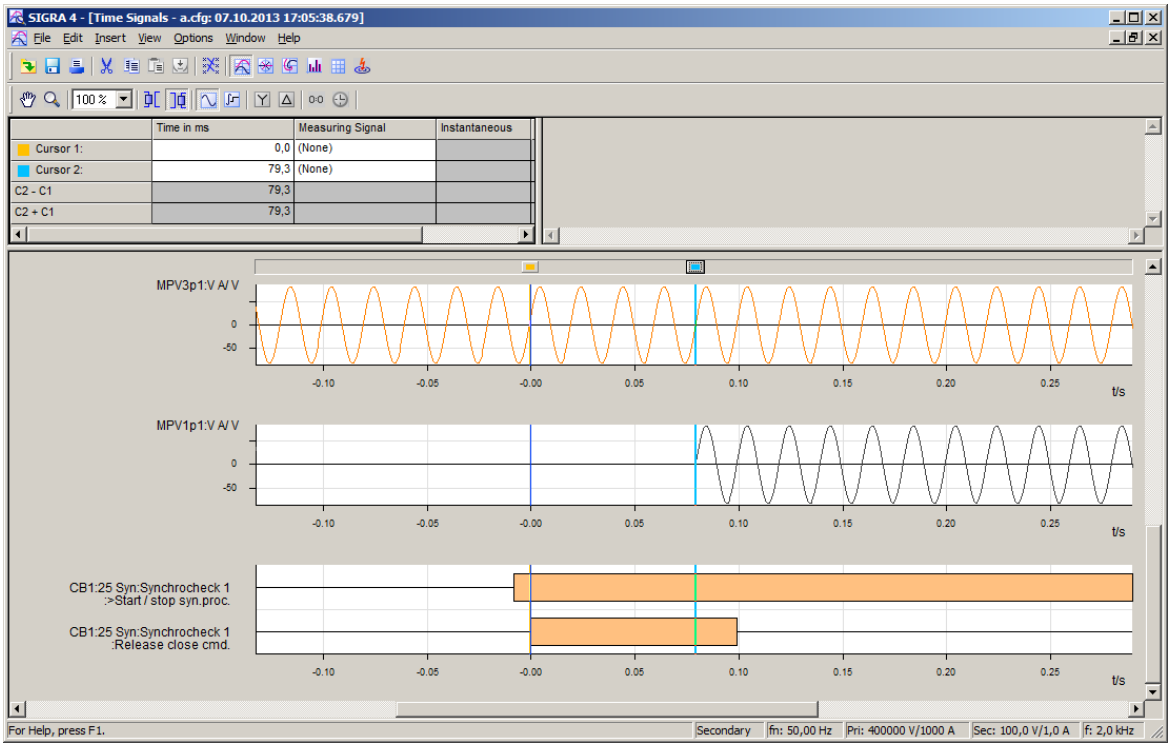
✧ Set the determined time with the parameter **CB make time**.

Proceed in the same way for all other synchronization stages.

✧ Set the parameter **Close cmd. at V1< & V2>** or parameter **Close cmd. at V1< & V2<** back to its source value.

✧ Delete the CFC chart.

70 Synchronization stage represents the stage **Synchrocheck**, **Synchronous/Asynchronous (Sychr./Asycr.)**, or **Synchronous/asynchronous with balancing commands (Syn./Asy.bal.)**.



[sc_syn001-01, 2, en_US]

Figure 11-38 Measurement of the Circuit-Breaker Make Time

2. The configuration in *Figure 11-39* is suitable for measuring the circuit-breaker operating time with an external timer. Set the timer to the range 1 s or a tripping of 1 ms.

Connect the circuit breaker manually. The timer is started simultaneously by this. After the poles of the circuit breaker close, the voltage V_{Line} appears. The timer is then stopped.

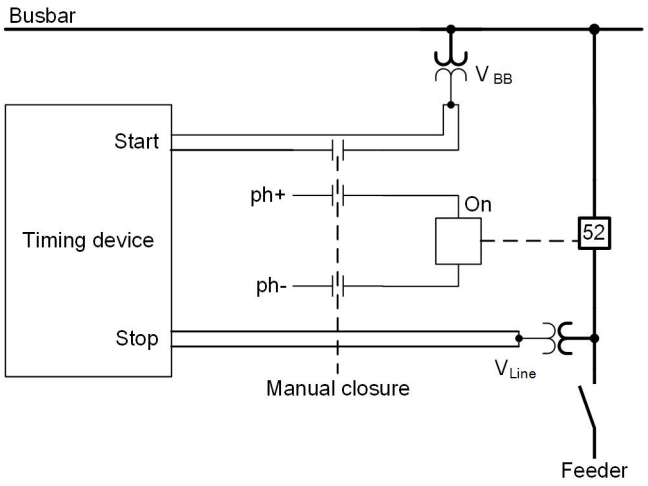
If the timer is not stopped owing to an unfavorable closing moment, repeat the attempt.

Siemens recommends calculating the average value from several (3 to 5) successful switching attempts.

NOTE

Add the OOT (Output Operating Time) of the protected device to the measured time. The OOT exclusively depends in good approximation on the binary output used for the close command. You can find the OOTs for different binary outputs in *12 Technical Data*. Set the total time with the parameter **`CB make time`**. Proceed in the same way for all other synchronization stages used in the device.

Siemens recommends sending the close command via the hard-wired connection. If you use a GOOSE signal to send the close command, consider the time delay caused by the GOOSE communication while setting the parameter **`CB make time`**.



[dw_synae6-01, 2, en_US]

Figure 11-39 Measurement of the Circuit-Breaker Make Time

Checking the Measurement Chain

The measurement chain for the voltage measurement must be checked. As soon as one of the synchronization stages to be used is closed, all the necessary functional measured values are calculated. The synchronization stage, thus, does not have to be started for this check.

Proceed as follows when checking the measurement chain as a primary or secondary test:

a) As primary test

- ✧ Establish a synchronous state by closing the circuit breaker, if possible.
- ✧ Check the functional measured values within the synchronization function:
  – The delta values must be 0.
  – Check the voltages V1 and V2 for plausible values in comparison with the operational measured values for the voltage.
  – Check the frequencies f1 and f2 for plausible values in comparison with the operational measured value for the frequency.

b) As secondary test

- ✧ Establish a synchronous state by applying synchronous voltage values at both measuring points.
- ✧ Check the functional measured values within the synchronization function:
  – The delta values must be 0.
  – Check the voltages V1 and V2 for plausible values in comparison with the operational measured values for the voltage.
  – Check the frequencies f1 and f2 for plausible values in comparison with the operational measured value for the frequency.

Blind Switching Attempts when Used in Machines

Perform blind switching attempts when using the function in machines.

Prerequisite:

- ✧ You have checked the setting values again.
- ✧ The circuit breaker is switched off. The close command for the circuit breaker is interrupted (disconnecting the close command). The system voltage is switched through for the measurement.

a) Attempt with asynchronous systems:

- ✧ Via manual control, set the generator to a speed slightly below the permitted frequency difference according to the setting values **Max. frequency diff. f2>f1** and **Max. frequency diff. f2<f1**. The generator is excited to line voltage. You can read out the values in the operational measured values.
- ✧ Start the synchronization stage, for example, externally with binary input signal or via the integrated controller. You can use a synchronoscope to trigger the start at synchronism, that is, at **12 o'clock**. The duration until the close command then corresponds to a cycle with the duration 1/Δf. At a frequency difference of 0.1 Hz, the duration is thus 10 s.
- ✧ Insofar as permissible, perform this attempt several time for oversynchronous switching and subsynchronous switching.
- ✧ The switching performance can be checked with an external recorder or the integrated fault recording function. You have to start the fault recording explicitly.
- ✧ You can repeat the blind switching attempts at the limits of the permissible voltage difference.

b) Attempt with synchronous systems:

- ✧ Start the synchronization stage, for example, externally with binary input signal or via the integrated controller.
- ✧ Check the proper release for activation with the message log or via a fault record. You have to start the fault recording explicitly. All activation conditions have to be fulfilled within the time **Delay close command**.

  If you observe the change between synchronous and asynchronous operation, raise the changeover threshold **f-threshold ASYN<->SYN** slightly.

c) Attempt with synchrocheck:

- ✧ If you use this function in conjunction with the manual synchronization, check the proper release for closure.
- ✧ Synchronize the generator manually. Start the synchronization stage externally via a binary input. Check the proper release for closure with the indication log or via the fault record. You have to start the fault recording explicitly.

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12.1 General Device Data

12.1.1 Analog Inputs

Current Inputs

All current, voltage, and power data are specified as RMS values.			
Rated frequency f_{rated}	50 Hz, 60 Hz		
Protection-class current transformers	Rated current I_{rated}	Measuring range of the modular devices	Measuring range of the non-modular devices
	5 A 1 A	0 A to 500 A 0 A to 100 A	0 A to 250 A 0 A to 50 A
Instrument transformers	5 A 1 A	0 A to 8 A 0 A to 1.6 A	0 A to 8 A 0 A to 1.6 A
Burden for rated current	Approx. 0.1 VA		
Thermal rating (protection and instrument transformers)	20 A continuously		
	25 A for 3 min		
	30 A for 2 min		
	150 A for 10 s		
	500 A for 1 s		
Dynamic load-carrying capacity	1250 A one half wave		

GIS Low-Power Current Input (via Module IO240)

All current, voltage, and power data are specified as RMS values.		
Rated frequency f_{rated}	50 Hz, 60 Hz	
GIS-LPCT input	Primary rated current I_{rated}	Measuring range
	Kr · GIS-LPCT secondary rated value Kr = Transformation ratio of the GIS-LPCT (DIGSI setting) Refer to the GIS manual for the GIS-LPCT secondary rated value.	K_{pcr} = 50 (protection channel) K_{pcr} = 1.6 (measuring channel)
Power consumption per current circuit at rated current	Max. 40 mVA Burden = 9.5 kΩ	
Thermal rating	Max. input voltage = 20 V	
Accuracy	Class 5TPE (protection channel) Class 0.2S (measuring channel)	

Optical Current Input (via Module IO245)

All current, voltage, and power data are specified as RMS values.			
Rated frequency f_{rated}	50 Hz, 60 Hz		
Rated current I_{rated}	Depending on the TOCT design		
Measuring range	Measuring channel	Protection channel	
	1.6 · I_{rated}	100 · I_{rated}	
Accuracy	Measuring channel	Protection channel	
	0.5, 0.2, 0.2S	< 10 kA	> 10 kA
		Comparable to measuring channel	5TPE

Voltage Input

All current, voltage, and power data are specified as RMS values.		
Rated frequency f_{rated}	50 Hz, 60 Hz	
Input and output modules	IO102, IO202, IO208, IO211, IO214	IO215
Measuring range	0 V to 200 V	0 V to 7.07 V
Burden	< 0.1 VA	< 0.01 VA
Thermal rating	230 V continuously	20 V continuously

GIS Low-Power Voltage Input (via Module IO240)

All current, voltage, and power data are specified as RMS values.		
Rated frequency f_{rated}	50 Hz, 60 Hz	
GIS-LPVT input	Primary rated voltage V_{rated}	Measuring range
	Kr · GIS-LPVT secondary rated value Kr = Transformation ratio of the GIS-LPVT (DIGSI setting) Refer to the GIS manual for the GIS-LPVT secondary rated value.	$K_{pcr} = 2$
Power consumption per current circuit at rated current	Max. 1 mVA Burden = 50 Ω	
Thermal rating	Max. input current = 4.4 mA	
Accuracy	Class 0.1	

RCVT Voltage Input (via Module IO240 or IO245)

All current, voltage, and power data are specified as RMS values.		
Rated frequency f_{rated}	50 Hz, 60 Hz	
RCVT input	Primary rated voltage V_{rated}	Measuring range
	100/√3 V L-N	$2 \cdot V_{rated}$
Burden	2 MΩ/50 pF	
Thermal rating	200 V L-N	
Accuracy	Class 0.1	

Measuring-Transducer Inputs (via Module ANAI-CA-4EL)

Insulation class	PELV (Protective Extra Low Voltage) (according to IEC 60255-27)
Connector type	8-pin terminal spring
Input channels	4 differential current inputs
Measuring range	DC -20 mA to +20 mA
Tolerance	0.5 % of the measuring range
Maximum measuring range	DC -25.6 mA to +25.6 mA
Input impedance	140 Ω
ADC type	16-Bit Delta-Sigma
Permissible potential difference between channels	DC 20 V
Galvanic separation from ground/ housing	AC 500 V, DC 700 V
Permissible overload	DC 100 mA continuously
Sampling rate	5 Hz

Fast Measuring Transducer Inputs, Voltage (via Module ANAI-CE-2EL, Channel 2, and IO218)

Insulation class	HLV (Hazardous Live Voltage) (in accordance with IEC 60255-27)
Input channels	1 DC voltage input, ANAI-CE-2EL, channel 2 (CH2) 3 DC voltage inputs, IO218
Measuring range	DC 0 V to + 300 V
Tolerance	0.2 % of measuring range
Input impedance	260 kΩ
Galvanic separation against ground/housing	DC 4.6 kV
Max. permissible voltage against ground on the measuring inputs	DC 300 V
Sampling rate	16 kHz

Inputs for Optical Sensors for Arc Protection (via Module ARC-CD-3FO)

Connector type	AVAGO AFBR-4526Z
Number of transceivers	3
Fiber type	Plastic Optical Fiber (POF) 1 mm
Receiver	
Maximum	-10 dBm ± 2 dBm
Minimum	-40 dBm ± 2 dBm
Spectrum	400 nm to 1100 nm
Attenuation	In the case of plastic optical fibers, you can expect a path attenuation of 0.2 dB/m. Additional attenuation comes from the plug and sensor head.
Optical budget[71]	Minimal 25 dB
Analog sampling rate	16 kHz
ADC type	10-bit successive approximation
Transmitter	
Type	LED
Wavelength	λ = 650 nm
Transmitter power	Minimum 0 dBm Maximum 2 dBm
Numerical aperture	0.5 [72]
Signal rate connection test	1 pulse per second
Pulse duration connection test	11 µs

Fast Measuring Transducer Inputs, Voltage/Current (via IO210, IO212)



NOTE

Current and voltage must not be connected at the same time to one measuring transducer input. Instead, only connect either current or voltage. For EMC reasons, do not connect a line to an unused input (current or voltage).

Use shielded cables.

71 All values in combination with sensors approved by Siemens.

72 Numerical aperture (NA = sin θ (launch angle))

Table 12-1 Fast Measuring Transducer Inputs, Voltage

Differential voltage input channels	IO210: 4[73] IO212: 8[74]
Measuring range	DC -10 V to +10 V
Fault	< 0.5 % of measuring range
Input impedance	48 kΩ
Max. permissible voltage with respect to ground on the measuring inputs	300 V
Permissible overload	DC 20 V continuously DC 60 V continuously (IO210 MU3 terminal point C9)

Table 12-2 Fast Measuring Transducer Inputs, Current

Differential current input channels	IO210: 4[75] IO212: 8[76]
Measuring range	DC -20 mA to +20 mA
Fault	< 0.5 % of measuring range
Input impedance, current	12 Ω
Permissible potential difference between channels	DC 3.5 kV
Galvanic separation with respect to ground/housing	DC 3.5 kV
Permissible current overload	DC 100 mA continuously

Table 12-3 Combined Data for Fast Measuring Transducer Voltage/Current Inputs

Conversion principle	Delta-sigma (16 bit)
Insulation test voltage between the channels	DC 3.5 kV
Insulation test voltage with respect to ground/housing	DC 3.5 kV
Measured value repetition	62.5 µs
Insulation class IO210	ELV (Extra Low Voltage) (as per IEC 60255-27)
Insulation class IO212	SELV (as per IEC 60255-27)

Table 12-4 Measuring Transducer Inputs, Current (via Module IO218)

Insulation class	PELV (Protective Extra Low Voltage) (acc. to IEC 60255-27)
Input channels	7 current inputs with common ground (MUx inputs and RTD not galvanically separated)
Measuring range	DC 0 mA to +20 mA
Tolerance	0.5 % of measuring range (MU1 to MU3) Typ. 1.0 % (max. 2.6 %) of measuring range (MU4 to MU7)
Maximum measuring range	DC 0 mA to +24.5 mA
Input impedance	12 Ω
ADC type	12-bit SAR

73 The IO210 has 4 fast measuring transducer inputs. They can be used either as a voltage or current input.
74 The IO212 has 8 fast measuring transducer inputs. They can be used either as a voltage or current input.
75 The IO210 has 4 fast measuring transducer inputs. They can be used either as a voltage or current input.
76 The IO212 has 8 fast measuring transducer inputs. They can be used either as a voltage or current input.

Permissible potential difference between channels	DC 20 V
Galvanic separation against ground/housing	AC 500 V, DC 700 V
Permissible overload	DC 100 mA continuously
Sampling rate	16 kHz (MU1 to MU3) 5 Hz (MU4 to MU7)

Temperature Inputs

Settings	Value	Note
Insulation class	PELV (Protective Extra Low Voltage) (acc. to IEC 60255-27)	With IO218: RTD and MUx inputs not galvanically separated.
Measurement mode	• Pt 100 Ω • Ni 100 Ω • Ni 120 Ω 3-wire connection, shielded cables	–
Temperature measuring range	-65 °C to +710 °C	For PT100
	-50 °C to +250 °C	For NI100
	-50 °C to +250 °C	For NI120

Temperature Inputs (via Module IO240)

Settings	Value
Sensor Type	PT100 (Class F 0.3 EN 60751) 4-wire shielded cable connection
Measurement range	-50 °C to +180 °C
Accuracy	±1 °C

Optical Temperature Input (via Module IO245)

Setting	Value
Sensor type	Optical GaAs (Gallium Arsenide) sensor Single cable with multi-mode fiber optic (OM1)
Measuring range	-50 °C to +150 °C
Accuracy	±2 °C

LPIT Digital Input (via Module IO240)

Shield Cover Input	
Sensor type	Dry contact input
Measurement type	Output voltage of 1 mA current injection @ max. DC 5 V

Insulation of LPIT Digital Input (via Module IO245)

Insulation (All Inputs)	
Configuration	The LPVT inputs are isolated from PE and the operator according to the requirements of IEC 61869-1 (AC 3 kV, 50 Hz, 1 min) and IEC 60255-27 for a rated voltage of 300 V despite the low-level signaling voltages. All channels are protected with differential-mode and common-mode voltage-limiting devices.
Test levels (type test)	AC 3250 V, 50 Hz, 1 min 6000 V 1.2/50 µs peak impulse

12.1.2 Supply Voltage

Integrated Power Supply			
For modular devices, the following modules contain a power supply: PS201 – Power supply of the base module and of the 1st device row PS203 – Power supply of the 2nd device row PS204 – Redundant power supply CB202 – Plug-in module assembly with integrated power supply, for example, to accommodate communication modules			
Permissible voltage ranges (PS201, PS203, PS204, CB202)	DC 19 V to DC 60 V	DC 48 V to DC 300 V AC 80 V to AC 265 V, 50 Hz/60 Hz	
Auxiliary rated voltage V_H (PS201, PS203, PS204, CB202)	DC 24 V/DC 48 V	DC 60 V/DC 110 V/DC 125 V/DC 220 V/ DC 250 V or AC 100 V/AC 115 V/AC 230 V, 50 Hz/60 Hz	
Permissible voltage ranges (PS101) Only for non-modular devices	DC 19 V to DC 60 V	DC 48 V to 150 V	DC 88 V to DC 300 V AC 80 V to AC 265 V, 50 Hz/60 Hz
Auxiliary rated voltage V_H (PS101) Only for non-modular devices	DC 24 V/DC 48 V	DC 60 V/DC 110 V/ DC 125 V	DC 110 V/ DC 125 V/ DC 220 V/DC 250 V or AC 100 V/AC 115 V/ AC 230 V, 50 Hz/60 Hz
Superimposed alternating voltage, peak-to-peak, IEC 60255-11, IEC 61000-4-17	≤ 15 % of the DC auxiliary rated voltage (applies only to direct voltage)		
Inrush current	≤ 18 A		
Recommended external protection	Miniature circuit breaker 6 A, characteristic C according to IEC 60898		
Internal fuse			
–	DC 24 V to DC 48 V	DC 60 V to DC 125 V	DC 24 V to DC 48 V AC 100 V to AC 230 V
PS101 Only for non-modular devices	4 A inert, AC 250 V, DC 150 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	2 A time-lag, AC 250 V, DC 300 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	
PS201, PS203, CB202 (to device version xA)	4 A inert, AC 250 V, DC 150 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	2 A time-lag, AC 250 V, DC 300 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	
PS201, PS203, PS204 (Device version xB and higher)	4 A inert, AC 250 V, DC 150 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	3.15 A time-lag, AC 250 V, DC 300 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	

Integrated Power Supply			
Power consumption (life relay active)			
–	DC	AC 230 V/50 Hz	AC 115 V/50 Hz
1/3 module, non-modular Without plug-in modules	7 W	16 VA, 7 W	12.5 VA, 7 W
1/3 base module, modular Without plug-in modules	13 W	55 VA, 13 W	40 VA, 13 W
1/6 expansion module	3 W	6 VA, 3 W	6 VA, 3 W
1/6 plug-in module assembly without plug-in modules (modules CB202)	3.5 W	14 VA, 3.5 W	7 VA, 3.5 W
Plug-in module for base module or plug-in module assembly (for example, communication module)	< 5 W	< 6 VA, < 5 W	< 6 VA, < 5 W
Stored-energy time for auxiliary voltage outage or short circuit, modular devices IEC 61000-4-11 IEC 61000-4-29		For V ≥ DC 24 V ≥ 50 ms For V ≥ DC 110 V ≥ 50 ms For V ≥ AC 115 V ≥ 50 ms	
Stored-energy time for auxiliary voltage outage or short circuit, non-modular devices IEC 61000-4-11 IEC 61000-4-29		For V ≥ DC 24 V ≥ 20 ms For V ≥ DC 60 V ≥ 50 ms For V ≥ AC 115 V ≥ 200 ms	

Power Supply for External Measuring Transducers (via Module IO218)

Insulation class	PELV (Protective Extra Low Voltage) (acc. to IEC 60255-27)
Output voltage	DC 24 V, common ground with MU inputs
Tolerance	10 %
Output current	Max. 210 mA, sustained short-circuit protection
Continuous power	Max. 5 W (at temperatures > 55 °C max. 2.5 W)

12.1.3 Binary Inputs

Standard Binary Input

Rated voltage range	DC 24 V to 250 V The binary inputs of SIPROTEC 5 are bipolar, with the exception of the binary inputs on the modules IO230, IO231, IO232, and IO233.	
Current consumption, picked up	Approx. DC 0.6 mA to 2.5 mA (independent of the control voltage)	
Max. power consumption	0.6 W	
Pickup time	Approx. 3 ms	
Dropout time[77]	Capacitive load (supply-line capacitance)	Dropout time
	< 5 nF	< 4 ms
	< 10 nF	< 6 ms
	< 50 nF	< 10 ms
	< 220 nF	< 35 ms

77 Pay attention to the specified dropout times for time-critical applications with active-low signals. If necessary, provide for active discharge of the binary input (for example, a resistor in parallel with the binary input or using a change-over contact).

Control voltage for all modules with binary inputs, except module IO233	Adapt the binary-input threshold to be set in the device to the control voltage.	
	Range 1 for 24 V, 48 V, and 60 V control voltage	V_{low} ≤ DC 10 V V_{high} ≥ DC 19 V
	Range 2 for 110 V and 125 V control voltage	V_{low} ≤ DC 44 V V_{high} ≥ DC 88 V
	Range 3 for 220 V and 250 V control voltage	V_{low} ≤ DC 88 V V_{high} ≥ DC 176 V
Control voltage for binary inputs of the IO233 module	Range for 125 V control voltage	V_{low} ≤ DC 85 V V_{high} ≥ DC 105 V
Maximum admissible voltage	DC 300 V	
The binary inputs contain interference suppression capacitors. To ensure EMC immunity, use the marked terminals shown in the terminal diagrams/connection diagrams to connect 2 or more binary inputs to the a common potential.		

Special Binary Input with Maximized Robustness against Electrical Disturbances and Failures (IO216)

Rated voltage range	DC 220 V The special binary inputs of the SIPROTEC 5 with maximized robustness against electrical disturbances and failures are bipolar and available only on the module IO216.	
Input impedance	50 kΩ to 60 kΩ	
Rejection pulse charge	> 200 µC	
Current consumption, excited	Approx. DC 1.2 mA to 2.0 mA (additionally to the current consumption of the input impedance)	
Power consumption, max.	1.5 W at DC 242 V	
Pickup time	Approx. 3 ms	
Dropout time[78]	Capacitive load (supply-line capacitance)	Dropout time
	< 5 nF	< 3 ms
	< 10 nF	< 4 ms
	< 50 nF	< 5 ms
	< 220 nF	< 10 ms
Control voltage for the module IO216	Range for 220 V control voltage	
	Threshold pickup	158 V to 170 V
	Threshold dropout	132 V to 154 V
Maximum permitted voltage	DC 300 V	
The binary inputs contain interference suppression capacitors. To ensure EMC immunity, use the terminals shown in the terminal diagrams/connection diagrams to connect the binary inputs to the common potential.		

12.1.4 Relay Outputs

Standard Relay (Type S)

Rated voltage (AC and DC)	250 V
Rated current (continuous) and total permissible current for contacts connected to common potential	5 A

78 For time-critical applications with low-active signals, consider the specified dropout times. If necessary, provide for active discharge of the binary input (for example, a resistor in parallel to the binary input or using a change-over contact).

Permissible current per contact (switching on and holding)	30 A for 1 s (make contact only)
Short-time current across closed contact	250 A for 30 ms
Breaking capacity	Max. 30 W (L/R = 40 ms) Max. 360 VA (power factor ≥ 0.35, 50 Hz to 60 Hz)
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	Make time: typical: 8 ms; maximum: 10 ms Break time: typical: 2 ms; maximum: 5 ms
Max. rated data of the output contacts in accordance with UL certification	DC 24 V, 5 A, general purpose DC 48 V, 0.8 A, general purpose DC 240 V, 0.1 A, general purpose AC 240 V, 5 A, general purpose AC 120 V, 1/6 hp AC 250 V, 1/2 hp B300 R300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V
Safety/monitoring	2-channel activation

Fast Relay (Type F)

Rated voltage (AC and DC)	250 V
Rated current (continuous) and total permissible current for contacts connected to common potential	5 A
Permissible current per contact (switching on and holding)	30 A for 1 s (make contact only)
Short-time current across closed contact	250 A for 30 ms
Breaking capacity	Max. 30 W (L/R = 40 ms) Max. 360 VA (power factor ≥ 0.35, 50 Hz to 60 Hz)
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	Make time: typical: 4 ms; maximum: 5 ms Break time: typical: 2 ms; maximum: 5 ms
Max. rated data of the output contacts in accordance with UL certification	AC 120 V, 5 A, general purpose AC 250 V, 5 A, general purpose AC 250 V, 1/2 hp B300 R300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V
Safety/monitoring	2-channel activation with cyclic testing (make contact only)

High-Speed Relay with Semiconductor Acceleration (Type HS)

Rated voltage	AC 200 V, DC 250 V
Rated current (continuous)	5 A (in accordance with UL approval) 10 A (not UL approved; AWG 14 / 2.5 mm^2copper conductors necessary)
Permissible current per contact (switching on and holding)	30 A for 1 s
Short-time current across closed contact	250 A for 30 ms
Breaking capacity	Max. 2500 W (L/R = 40 ms)

Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	Make time: typical: 0.2 ms; maximum: 0.2 ms Break time: typical: 9 ms; maximum: 9 ms
Max. rated data of the output contacts in accordance with UL certification	B150 Q300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V
Safety/monitoring	2-channel activation

Power Relay (for Direct Control of Motor Switches)

Rated voltage (AC and DC)	250 V
Rated current (continuous) and total permissible current for contacts connected to common potential	5 A
Switching power for permanent and periodic operation In order to prevent any damage, the external protection circuit must switch off the motor in case the rotor is blocked.	250 V/4.0 A 220 V/4.5 A 110 V/5.0 A 60 V/5.0 A 48 V/5.0 A 24 V/5.0 A
Turn on switching power for 30 s, recovery time until switching on again is 15 minutes. For short-term switching operations, an impulse/pause ratio of 3 % must be considered. In order to prevent any damage, the external protection circuit must switch off the motor in case the rotor is blocked.	100 V/9.0 A 60 V/10.0 A 48 V/10.0 A 24 V/10.0 A
Permissible current per contact (switching on and holding)	30 A for 1 s
Short-time current across closed contact	250 A for 30 ms
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	≤ 16 ms
Max. rated data of the output contacts in accordance with UL certification	DC 300 V, 4.5 A – 30 s ON, 15 min OFF DC 250 V, 1 hp Motor – 30 s ON, 15 min OFF DC 110 V, 3/4 hp Motor – 30 s ON, 15 min OFF DC 60 V, 10 A, 1/2 hp Motor – 30 s ON, 15 min OFF DC 48 V, 10 A, 1/3 hp Motor – 30 s ON, 15 min OFF DC 24 V, 10 A, 1/6 hp Motor – 30 s ON, 15 min OFF
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V
Safety/monitoring	2-channel activation
The power relays operate in interlocked mode, that is, only one relay of each switching pair picks up at a time thereby avoiding a power-supply short circuit.	

12.1.5 Design Data

Masses

	Device Size Weight of the Modular Devices				
Type of construction	1/3	1/2	2/3	5/6	1/1
Flush-mounting device	4.4 kg	7.2 kg	9.9 kg	12.7 kg	15.5 kg

	Device Size Weight of the Modular Devices				
Surface-mounted device with integrated on-site operation panel	7.4 kg	11.7 kg	15.9 kg	20.2 kg	24.5 kg
Surface-mounted device with detached on-site operation panel	4.7 kg	7.8 kg	10.8 kg	13.9 kg	17.0 kg

Devices with IO240 weigh 0.9 kg more.

	Size	Weight
Detached on-site operation panel	1/3	1.9 kg
Detached on-site operation panel	1/6	1.1 kg

	Device Size Weight of the Non-Modular Devices 7xx81, 7xx82
Type of construction	1/3
Flush-mounting device	3.6 kg
Bracket for non-modular surface-mounting version	1.9 kg

Dimensions of the Base and Expansion Modules

Type of Construction		Max. Total Width x Max. Total Height x Max. Total Depth[79], Each Rounded up to the Next Full mm (in Inches)
Flush-mounting device	Base module	150 mm x 266 mm x 231 mm (5.91 x 10.47 x 9.09)
	Base module with IO240	150 mm x 266 mm x 277 mm (5.91 x 10.47 x 10.91)
	Base module with IO111	150 mm x 266 mm x 243 mm (5.91 x 10.47 x 9.57)
	Expansion module	75 mm x 266 mm x 231 mm (2.95 x 10.47 x 9.09)
	Expansion module with IO240, IO218	75 mm x 266 mm x 277 mm (2.95 x 10.47 x 10.91)
	Expansion module with IO111	75 mm x 266 mm x 243 mm (2.95 x 10.47 x 9.57)
Surface-mounted device with integrated on-site operation panel	Base module	150 mm x 315 mm x 341 mm (5.91 x 12.4 x 13.43)
	Expansion module	75 mm x 315 mm x 341 mm (2.95 x 12.4 x 13.43)

79 Including current terminal, excluding USB port cover

Type of Construction		Max. Total Width x Max. Total Height x Max. Total Depth[79], Each Rounded up to the Next Full mm (in Inches)
Surface-mounted device with detached on-site operation panel	Base module	150 mm x 315 mm x 231 mm (5.91 x 12.4 x 9.09)
	Base module with IO240	150 mm x 315 mm x 277 mm (5.91 x 12.4 x 10.91)
	Base module with IO111	150 mm x 315 mm x 243 mm (5.91 x 12.4 x 9.57)
	Expansion module	75 mm x 315 mm x 231 mm (2.95 x 12.4 x 9.09)
	Expansion module with IO240, IO218	75 mm x 315 mm x 277 mm (2.95 x 12.4 x 10.91)
	Expansion module with IO111	75 mm x 315 mm x 243 mm (2.95 x 12.4 x 9.57)

Dimensions of the Device Rows

Type of Construction	Max. Total Width x Max. Total Height x Max. Total Depth[80], Rounded to full mm (in Inches)				
Device width	1/3	1/2	2/3	5/6	1/1
Flush-mounting device	150 mm x 266 mm x 231 mm (5.91 x 10.47 x 9.09)	225 mm x 266 mm x 231 mm (8.86 x 10.47 x 9.09)	300 mm x 266 mm x 231 mm (11.81 x 10.47 x 9.09)	375 mm x 266 mm x 231 mm (14.76 x 10.47 x 9.09)	450 mm x 266 mm x 231 mm (17.72 x 10.47 x 9.09)
Flush-mounting device with IO240, IO218	150 mm x 266 mm x 277 mm (5.91 x 10.47 x 10.91)	225 mm x 266 mm x 277 mm (8.86 x 10.47 x 10.91)	300 mm x 266 mm x 277 mm (11.81 x 10.47 x 10.91)	375 mm x 266 mm x 277 mm (14.76 x 10.47 x 10.91)	450 mm x 266 mm x 277 mm (17.72 x 10.47 x 10.91)
Flush-mounting device with IO111	150 mm x 266 mm x 243 mm (5.91 x 10.47 x 9.57)	225 mm x 266 mm x 243 mm (8.86 x 10.47 x 9.57)	300 mm x 266 mm x 243 mm (11.81 x 10.47 x 9.57)	375 mm x 266 mm x 243 mm (14.76 x 10.47 x 9.57)	450 mm x 266 mm x 243 mm (17.72 x 10.47 x 9.57)
Surface-mounted device with integrated on-site operation panel	150 mm x 315 mm x 341 mm (5.91 x 12.4 x 13.43)	225 mm x 315 mm x 343 mm[81] (8.86 x 12.4 x 13.43)	300 mm x 315 mm x 343 mm[81] (11.81 x 12.4 x 13.43)	375 mm x 315 mm x 343 mm[81] (14.76 x 12.4 x 13.43)	450 mm x 315 mm x 343 mm[81] (17.72 x 12.4 x 13.43)
Surface-mounted device with detached on-site operation panel	150 mm x 315 mm x 231 mm (5.91 x 12.4 x 9.09)	225 mm x 315 mm x 231 mm (8.86 x 12.4 x 9.09)	300 mm x 315 mm x 231 mm (11.81 x 12.4 x 9.09)	375 mm x 315 mm x 231 mm (14.76 x 12.4 x 9.09)	450 mm x 315 mm x 231 mm (17.72 x 12.4 x 9.09)

79 Including current terminal, excluding USB port cover
80 Including current terminal, excluding USB port cover
81 Including connecting rail

Type of Construction	Max. Total Width x Max. Total Height x Max. Total Depth[80], Rounded to full mm (in Inches)				
Surface-mounted device with detached on-site operation panel with IO240, IO218	150 mm x 315 mm x 277 mm (5.91 x 12.4 x 10.91)	225 mm x 315 mm x 277 mm (8.86 x 12.4 x 10.91)	300 mm x 315 mm x 277 mm (11.81 x 12.4 x 10.91)	375 mm x 315 mm x 277 mm (14.76 x 12.4 x 10.91)	450 mm x 315 mm x 277 mm (17.72 x 12.4 x 10.91)
Surface-mounted device with detached on-site operation panel with IO111	150 mm x 315 mm x 243 mm (5.91 x 12.4 x 9.57)	225 mm x 315 mm x 243 mm (8.86 x 12.4 x 9.57)	300 mm x 315 mm x 243 mm (11.81 x 12.4 x 9.57)	375 mm x 315 mm x 243 mm (14.76 x 12.4 x 9.57)	450 mm x 315 mm x 243 mm (17.72 x 12.4 x 9.57)

Plug-In Module Dimensions

Type of Construction	Max. Width x Max. Height x Max. Depth (in Inches)
USART-Ax-xEL, ETH-Bx-xEL	61 mm x 45 mm x 121 mm (2.4 x 1.77 x 4.76)
USART-Ax-xFO, ETH-Bx-xFO (without protective cover)	61 mm x 45 mm x 133 mm (2.4 x 1.77 x 5.24)
ANAI-CA-4EL, ANAI-CE-2EL	61 mm x 45 mm x 120 mm (2.4 x 1.77 x 4.72)
ARC-CD-3FO	61 mm x 45 mm x 121 mm (2.4 x 1.77 x 4.76)

Minimum Bending Radii of the Connecting Cables Between the On-Site Operation Panel and the Base Module

Fiber-optic cable	R = 50 mm Pay attention to the length of the cable protection sleeve, which you must also include in calculations.
D-Sub cable	R = 50 mm (minimum bending radius)

Degree of Protection According to IEC 60529

For equipment in the surface-mounting housing	IP54[82] for front
For equipment in the flush-mounting housing	IP54[82] for front
For operator protection (back side)	IP2x for current terminal (installed) IP2x for voltage terminal (installed)
Degree of pollution, IEC 60255-27	2
Maximum operating altitude above sea level	2000 m (6561.68 ft)

UL Note

Type 1 if mounted into a door or front cover of an enclosure. When expanding the device with the 2nd device row, then they must be mounted completely inside an enclosure.

80 Including current terminal, excluding USB port cover

82 The supplied plug-in strips must be used for expansion modules with LEDs.

Tightening Torques for Terminal Screws

Type of Line	Current Terminal	Voltage Terminal with Spring-Loaded Terminals	Voltage Terminal with Screw Connection
Stranded wires with ring-type lug	2.7 Nm	No ring-type lug	No ring-type lug
Stranded wires with boot-lace ferrules or pin-type lugs	2.7 Nm	1.0 Nm	0.6 Nm
Solid conductor, bare (2 mm^2)	2.0 Nm	1.0 Nm	–
Blank stranded wire	Not permitted	1 Nm	0.6 Nm

NOTE

For current and voltage terminals, the maximum speed of the tool must not exceed 640 rpm.

NOTE

Use copper cables only.

Torques for Other Screw Types

Screw Type	Torque
M4 x 20	1.2 Nm
M4 x 8	1.2 Nm
M2.5 x 6	0.39 Nm
Countersunk screw, M2.5 x 6	0.39 Nm
Countersunk screw, M2.5 x 8	0.39 Nm
Collar screw, M4 x 20	0.7 Nm

12.2 Transformer Differential Protection

Setting Values

Operate curve			
Threshold value	$I/I_{rated,obj}$	0.05 to 2.00	Increments of 0.01
Slope 1		0.00 to 0.80	Increments of 0.01
Intersection 1 Irest	$I/I_{rated,obj}$	0.00 to 5.00	Increments of 0.01
Slope 2		0.25 to 0.95	Increments of 0.01
Intersection 2 Irest	$I/I_{rated,obj}$	1.00 to 20.00	Increments of 0.01
Startup detection			
Startup detection threshold value	$I/I_{rated,obj}$	0.1 to 2.0	Increments of 0.1
Characteristic curve increase factor		1.0 to 5.0	Increments of 0.1
Maximum starting time		0.1 s to 180.0 s	Increments of 0.1 s
DC-component detection			
Characteristic curve increase factor DC		1.0 to 5.0	Increments of 0.1
Inrush-current detection			
2nd harmonic content		10 % to 45 %	Increments of 1 %
Crossblk. time 2nd har.		0.00 s to 200.00 s or ∞	Increments of 0.01 s
Overexcitation blocking			
3rd harmonic content		10 % to 80 %	Increments of 1 %
Crossblk. time 3rd har.		0.00 s to 200.00 s or ∞	Increments of 0.01 s
5th harmonic content		10 % to 80 %	Increments of 1 %
Crossblk. time 5th har.		0.00 s to 200.00 s or ∞	Increments of 0.01 s
Idiff limit 3rd, 5th harm.	$I/I_{rated,obj}$	0.5 to 20.0	Increments of 0.1
Detection of external faults			
Add-on stabilization threshold value	$I/I_{rated,obj}$	1.00 to 20.00	Increments of 0.01
Add-on stabilization time		0.00 s to 5.00 s or ∞	Increments of 0.01 s
Crossblk. time additional stabilization		0.00 s to 2.00 s or ∞	Increments of 0.01 s
Operate curve		See *Figure 12-1*	

Functional Measured Values

Measured Value	Description
_:2311:300 A, B, C	Differential current
_:2311:301 A, B, C	Restraint current

I-DIFF Fast

Threshold value	$I/I_{rated,obj}$	0.5 to 35.0	Increments of 0.1
Tripping delay		0.00 s to 60.00 s	Increments of 0.01 s

I-DIFF Unrestrained

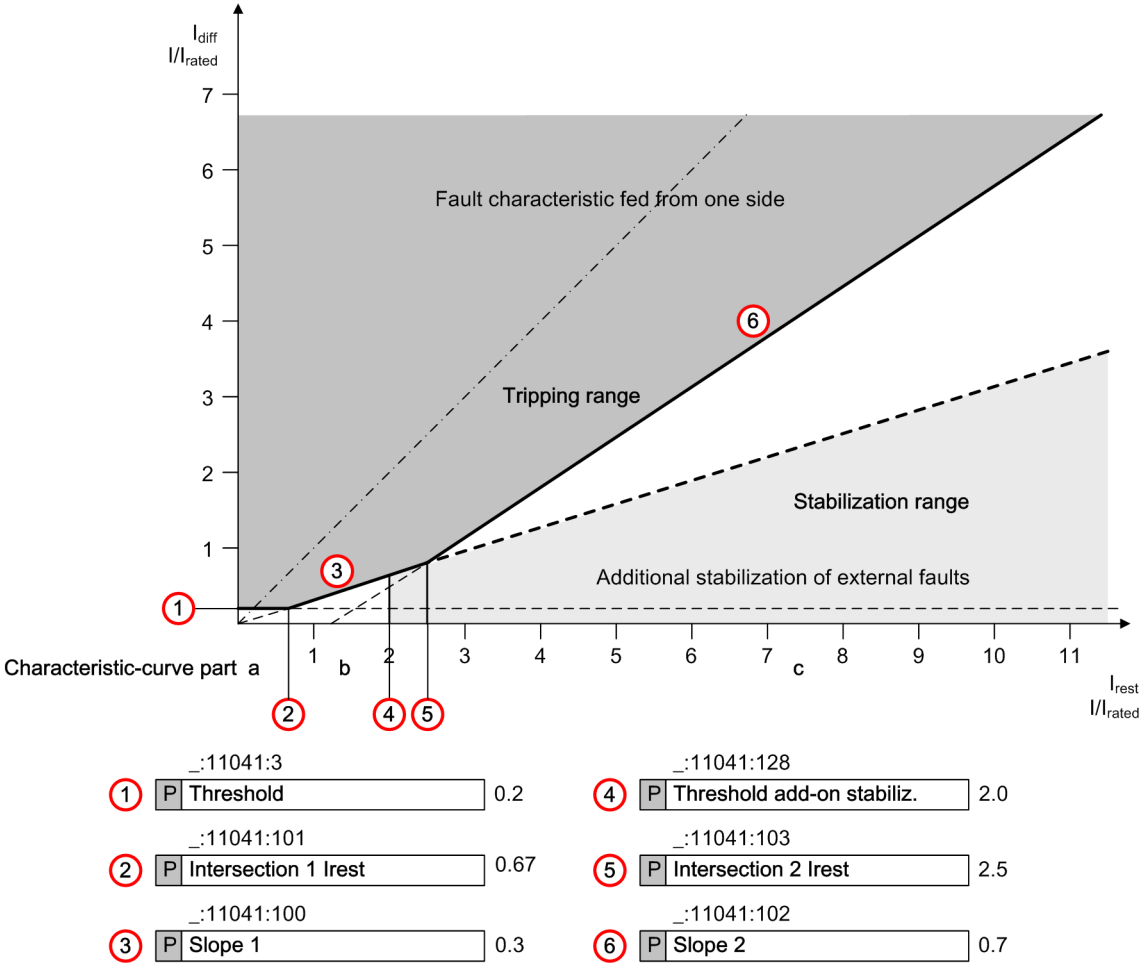
Threshold value	$I/I_{rated,obj}$	0.5 to 35.0	Increments of 0.1
Tripping delay		0.00 s to 60.00 s	Increments of 0.01 s

Response Tolerance

For preset characteristic curve parameters; for 2 sides with 1 measuring point each	
I-DIFF stage and characteristic curve	2 % of the setting value
I-DIFF fast stage	2 % of the setting value

Time Delays

I-DIFF stage	0.00 s to 60.00 s	Increments of 0.01 s
I-DIFF fast stage	0.00 s to 60.00 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	



[dwdifaus-030912-01.tif, 2, en_US]

Figure 12-1 Operate Curve of the Differential Protection

Operate Times

Operate times for one-sided supply		
I-DIFF stage, min	50 Hz 60 Hz	23 ms + OOT[83] 20 ms + OOT
I-DIFF fast stage, min	50 Hz 60 Hz	8 ms + OOT 8 ms + OOT
I-DIFF unrestrained stage, min	50 Hz 60 Hz	8 ms + OOT 8 ms + OOT
Dropout time, approx.	50 Hz 60 Hz	29 ms 26 ms
Dropout ratio	Approx. 0.7	

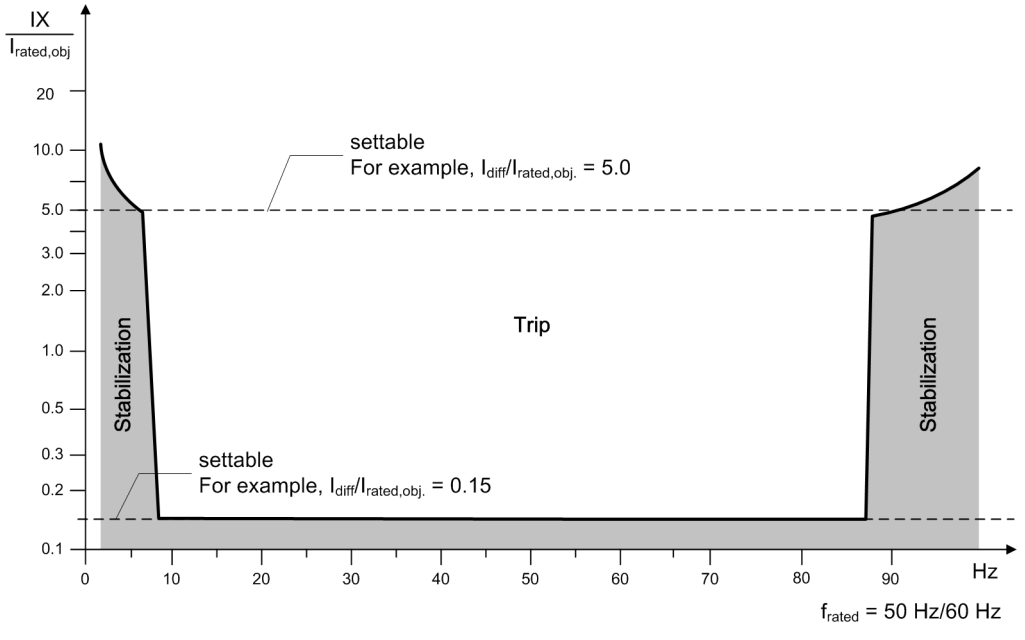
Adaptation for Transformers

Vector-group adaptation	0 to 11 (x 30°)	Increments of 1
Neutral-point treatment	Grounded or not grounded (for each winding)	

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Frequency tracking	10 Hz to 90 Hz



[dw_trdffq, 2, en_US]

Figure 12-2 Frequency Influence when Using Transformer Differential Protection

83 Refer to protection functions, for example overcurrent protection

12.3 Restricted Ground-Fault Protection

Setting Values

Threshold value[84]	0.05 A to 2.00 A	Increments of 0.01 A
Gradient	0.00 to 0.95	Increments of 0.01
Operate curve	See figure	
Pickup tolerance (for preset characteristic curve parameters; for 2 sides with 1 measuring point each)	2 %	
Tripping delay	0.00 s to 60.00 s or ∞ (no tripping)	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	

Functional Measured Values

Measured Value	Description
(_:306) I REF,operate	Operate quantity of the restricted ground-fault protection from the angle criterion and can be displayed in the fault record
(_:307) I Angle,REF	Stabilizing value (angle) of the restricted ground-fault protection from the angle criterion and can be displayed in the fault record
(_:311) I REF,Trip operate	Operate quantity of the restricted ground-fault protection when OFF; will be issued in the log
(_:312) I angle,REF operate	Stabilizing value of the restricted ground-fault protection when OFF; will be issued in the log
(_:301) I diff.	Differential current; can be displayed in the fault record
(_:302) I restr.	Restraint current; can be displayed in the fault record

Dropout Ratio

Threshold value	0.7

Dropout

The greater dropout differential (= **`| pickup value – dropout threshold |`**) of the following 2 criteria applies:

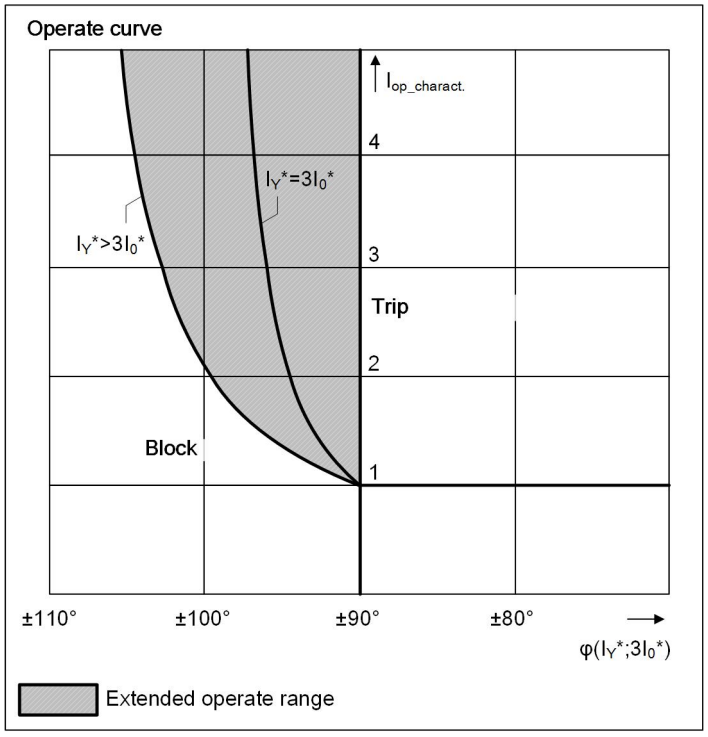
Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % applies for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformers	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)

Times

7UT82/7UT85/7UT86/7UT87		
Frequency	50 Hz	60 Hz
	Operate time	Operate time

84 The specified setting limit can be dynamically further limited, depending on the transformer adaptation factor, (for this refer to chapter *6.4.4 Application and Setting Notes*).

At 1.5 · setting value threshold value	33 ms + OOT	32 ms + OOT
At 2.5 · setting value threshold value	27 ms + OOT	26 ms + OOT
Dropout time approx.	30 ms	25 ms



[dw_ausken, 3, en_US]

Figure 12-3 Restricted Ground-Fault Protection Operate Curve Depending on the Phase Angle between I_Y* and $3I_0$* with Extended Operate Range

12.4 Motor Differential Protection

Setting Values

Operate Curve			
Threshold value	$I/I_{rated,obj}$	0.05 to 2.00	Increments of 0.01
Slope 1		0.00 to 0.80	Increments of 0.01
Intersection 1 Irest	$I/I_{rated,obj}$	0.00 to 5.00	Increments of 0.01
Slope 2		0.25 to 0.95	Increments of 0.01
Intersection 2 Irest	$I/I_{rated,obj}$	1.00 to 20.00	Increments of 0.01
Startup detection			
Startup detection threshold value	$I/I_{rated,obj}$	0.1 to 2.0	Increments of 0.1
Characteristic curve increase factor		1.0 to 5.0	Increments of 0.1
Maximum starting time		0.1 s to 180.0 s	Increments of 0.1 s
DC-component detection			
Characteristic curve increase factor DC		1.0 to 5.0	Increments of 0.1
Detection of external faults			
Add-on stabilization threshold value	$I/I_{rated,obj}$	1.00 to 20.00	Increments of 0.01
Add-on stabilization time		0.00 s to 5.00 s or ∞	Increments of 0.01 s
Crossblk. time additional stabilization		0.00 s to 2.00 s or ∞	Increments of 0.01 s
Operate curve		See figure	

I-DIFF Fast

Threshold value	$I/I_{rated,obj}$	0.5 to 35.0	Increments of 0.1
Tripping delay		0.00 s to 60.00 s	Increments of 0.01 s

I-DIFF Unrestrained

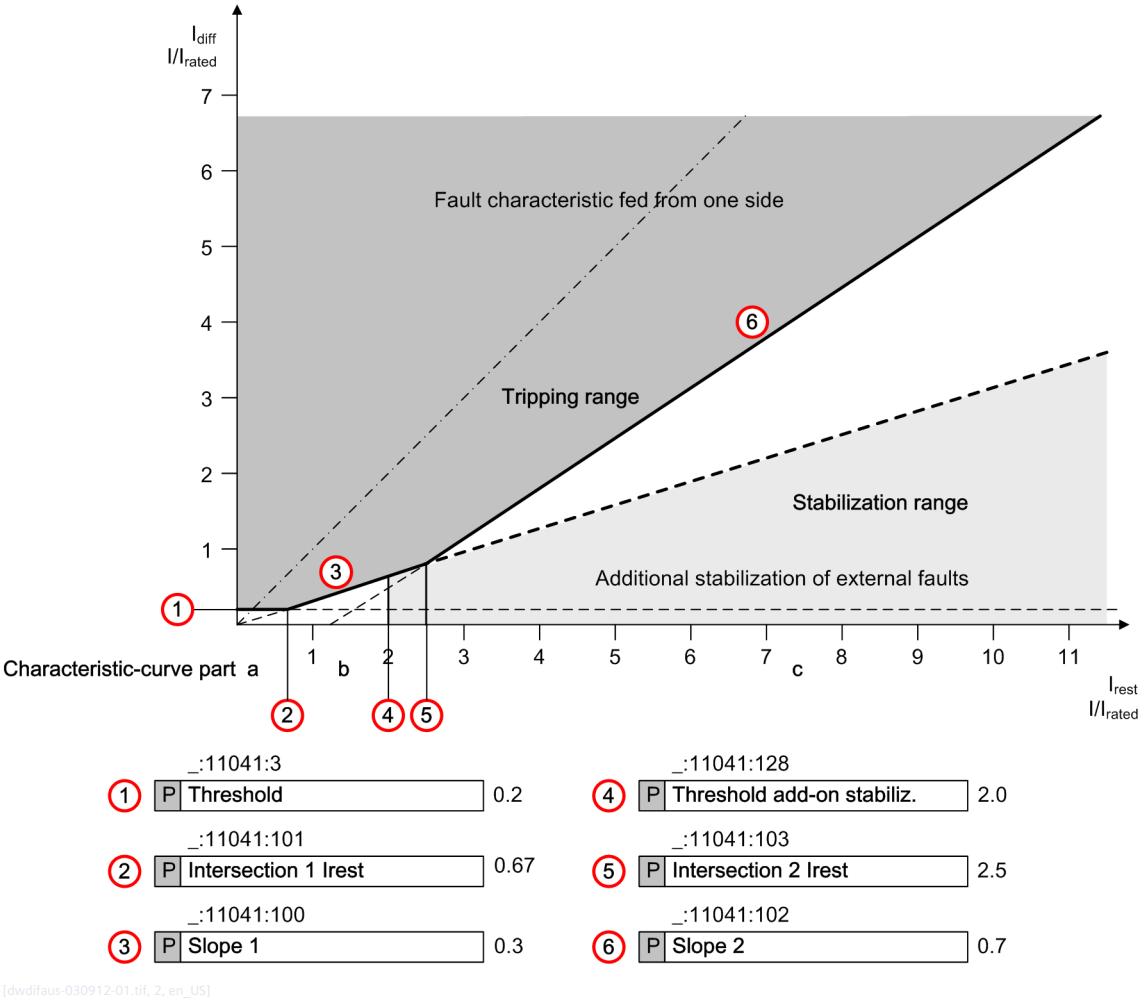
Threshold value	$I/I_{rated,obj}$	0.5 to 35.0	Increments of 0.1
Tripping delay		0.00 s to 60.00 s	Increments of 0.01 s

Response Tolerance

For preset characteristic curve parameters; for 2 sides with 1 measuring point each	
I-DIFF stage and characteristic curve	2 % of the setting value
I-DIFF fast stage	2 % of the setting value

Time Delays

I-DIFF stage	0.00 s to 60.00 s	Increments of 0.01 s
I-DIFF fast stage	0.00 s to 60.00 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	



[dwdifaus-030912-01.tif, 2, en_US]

Figure 12-4 Operate Curve of the Differential Protection

Operate Times

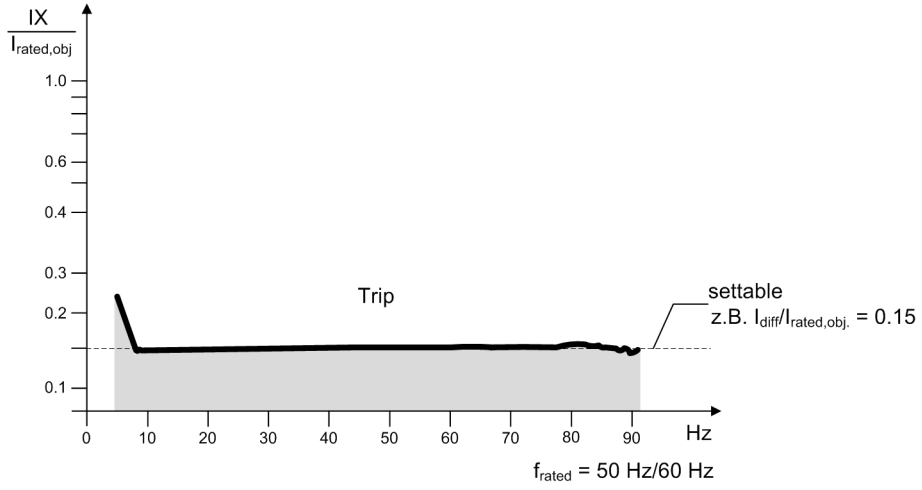
Operate times for one-sided supply		
I-DIFF stage, min	50 Hz 60 Hz	23 ms + OOT[85] 20 ms + OOT
I-DIFF fast stage, min	50 Hz 60 Hz	8 ms + OOT 8 ms + OOT
I-DIFF unrestrained stage, min	50 Hz 60 Hz	8 ms + OOT 8 ms + OOT
Dropout time, approx.	50 Hz 60 Hz	29 ms + OOT 26 ms + OOT
Dropout ratio	Approx. 0.7	

85 Refer to protection functions, for example overcurrent protection

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Frequency tracking	10 Hz to 90 Hz



[scmodffq-010316-01, 1, en_US]

Figure 12-5 Frequency Influence When Using Motor Differential Protection

12.5 Generator Differential Protection

Setting Values

Operate curve			
Threshold value	$I/I_{rated,obj}$	0.05 to 2.00	Increments of 0.01
Slope 1		0.00 to 0.80	Increments of 0.01
Intersection 1 Irest	$I/I_{rated,obj}$	0.00 to 5.00	Increments of 0.01
Slope 2		0.25 to 0.95	Increments of 0.01
Intersection 2 Irest	$I/I_{rated,obj}$	1.00 to 20.00	Increments of 0.01
Startup detection			
Startup detection threshold value	$I/I_{rated,obj}$	0.1 to 2.0	Increments of 0.1
Characteristic curve increase factor		1.0 to 5.0	Increments of 0.1
Maximum starting time		0.1 s to 180.0 s	Increments of 0.1 s
DC-component detection			
Characteristic curve increase factor DC		1.0 to 5.0	Increments of 0.1
Detection of external faults			
Add-on stabilization threshold value	$I/I_{rated,obj}$	1.00 to 20.00	Increments of 0.01
Add-on stabilization time		0.00 s to 5.00 s or ∞	Increments of 0.01 s
Crossblk. time additional stabilization		0.00 s to 2.00 s or ∞	Increments of 0.01 s
Operate curve		See figure *Figure 12-6*	

I-DIFF Fast

Threshold value	$I/I_{rated,obj}$	0.5 to 35.0	Increments of 0.1
Tripping delay		0.00 s to 60.00 s	Increments of 0.01 s

I-DIFF Unrestrained

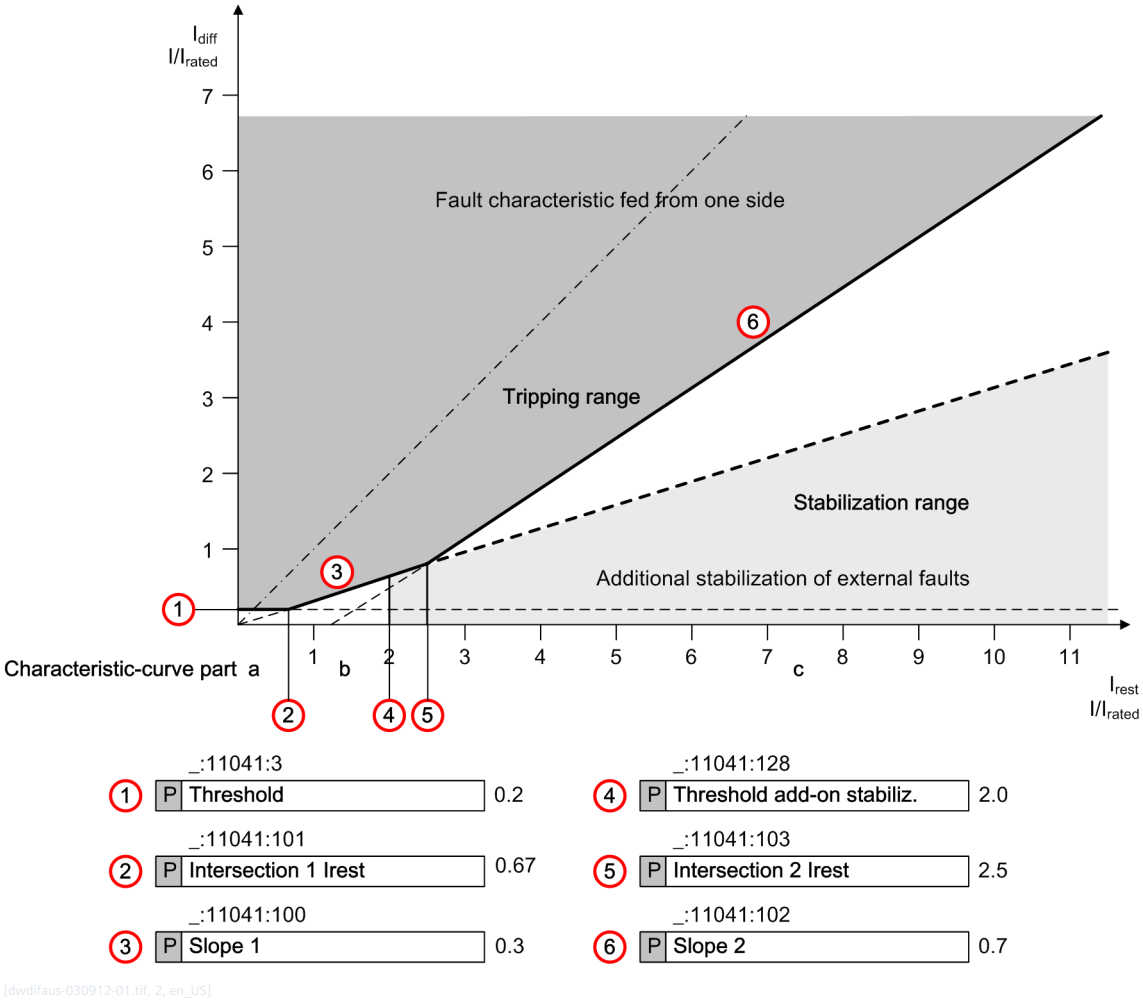
Threshold value	$I/I_{rated,obj}$	0.5 to 35.0	Increments of 0.1
Tripping delay		0.00 s to 60.00 s	Increments of 0.01 s

Response Tolerance

For preset characteristic curve parameters; for 2 sides with 1 measuring point each	
I-DIFF stage and characteristic curve	2 % of the setting value
I-DIFF fast stage	2 % of the setting value

Time Delays

I-DIFF stage	0.00 s to 60.00 s	Increments of 0.01 s
I-DIFF fast stage	0.00 s to 60.00 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	



[dwdifaus-030912-01.tif, 2, en_US]

Figure 12-6 Operate Curve of the Differential Protection

Operate Times

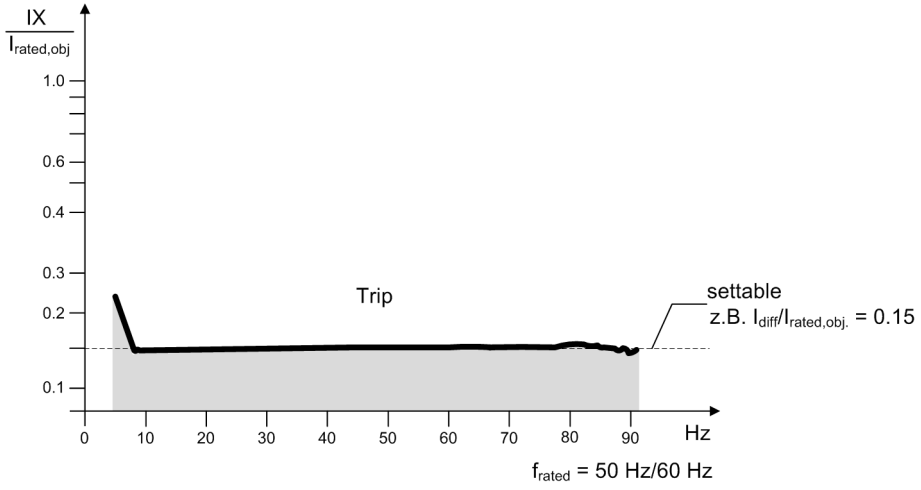
Operate times for one-sided supply		
I-DIFF stage, min	50 Hz 60 Hz	23 ms + OOT[86] 20 ms + OOT
I-DIFF fast stage, min	50 Hz 60 Hz	8 ms + OOT 8 ms + OOT
I-DIFF unrestrained stage, min	50 Hz 60 Hz	8 ms + OOT 8 ms + OOT
Dropout time, approx.	50 Hz 60 Hz	29 ms + OOT 26 ms + OOT
Dropout ratio	Approx. 0.7	

86 Refer to protection functions, for example overcurrent protection

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Frequency tracking	10 Hz to 90 Hz



[scmodffq-010316-01, 1, en_US]

Figure 12-7 Frequency Influence when Using Generator Differential Protection

12.6 Line Differential Protection

Tripping Thresholds Stage I-DIFF, Stage IN-DIFF, StageIN-DIFF unrest, Stage I2-DIFF

Threshold value	10.0 % to 2000.0 % of $I_{rated\ Operation}$	Increments of 0.1 %
Threshold value upon switching	10.0 % to 2000.0 % of $I_{rated\ Operation}$	Increments of 0.1 %

Tripping Thresholds, Stage I-DIFF fast 2

Threshold value	50.0 % to 10 000.0 % of $I_{rated\ Operation}$	Increments of 0.1 %
Threshold value upon switching	50.0 % to 10 000.0 % of $I_{rated\ Operation}$	Increments of 0.1 %

Tripping Thresholds, Stage I-DIFF fast

Threshold value	80.0 % to 10 000.0 % of $I_{rated\ Operation}$	Increments of 0.1 %
Threshold value upon switching	80.0 % to 10 000.0 % of $I_{rated\ Operation}$	Increments of 0.1 %

Trigger-Value Tolerances

When using up to 3 line ends	5 % of the setting value or 1 % of I_{rated} for each line end
When using up to 6 line ends	10 % of the setting value or 1 % of I_{rated} for each line end

Operating Times

The tripping times depend on the number of line ends, the communication speed, and the configured output contacts. The following data assume a transmission rate of at least 512 kbit/s.

Tripping times of the stages `I-DIFF`, `IN-DIFF`, `IN-DIFF unrest`, `I2-DIFF`		
When using 2 line ends	Minimum (50 Hz/60 Hz)	26 ms/23 ms + OOT[87]
	Typical (50 Hz/60 Hz)	28 ms/25 ms + OOT
When using 3 line ends	Minimum (50 Hz/60 Hz)	26 ms/23 ms + OOT
	Typical (50 Hz/60 Hz)	30 ms/27 ms + OOT
When using 6 line ends	Minimum (50 Hz/60 Hz)	31 ms/27 ms + OOT
	Typical (50 Hz/60 Hz)	37 ms/34 ms + OOT
Dropout times of the stages `I-DIFF`, `IN-DIFF`, `IN-DIFF unrest`, `I2-DIFF`		
For all line ends	Typical	34 ms to 49 ms + OOT

Tripping times of the stages `I-DIFF fast`/`I-DIFF fast 2`		
When using 2 line ends	Minimum	8 ms + OOT
	Typical	11 ms + OOT
When using 3 line ends	Minimum	8 ms + OOT
	Typical	11 ms + OOT
When using 6 line ends	Minimum	13 ms + OOT
	Typical	19 ms + OOT
Dropout times of the stages `I-DIFF fast`/`I-DIFF fast 2`		
For all line ends	Typical	34 ms to 49 ms + OOT

87 OOT (Output Operating Time): Additional time delay of the output medium used, for example, 1 ms with electronic relays.

Time Delays

Delay of the stage I-DIFF	0.00 s to 60.00 s	Increments of 0.01 s
Delay of the stages I-DIFF fast/I-DIFF fast 2	0.00 s	Not adjustable
Delay of 1-phase pickup in resonant-grounded/isolated systems	0.00 s to 0.50 s	Increments of 0.01 s
Delay of the stages **IN-DIFF**, **IN-DIFF unrest**, **I2-DIFF**	0.00 s to 60.00 s or ∞ (no tripping)	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	

Self-Stabilization (except IN-DIFF Unrest Stage)

Transformer Error for Each Line End of the Protected Object		
Error transmission ratio	1.00 to 10.00	Increments of 0.01
Transformer error A	0.5 % to 50.0 %	Increments of 0.1 %
Transformer error B	0.5 % to 50.0 %	Increments of 0.1 %
Other stabilizing values (adaptive self-stabilization)	Frequency deviations, runtime differences, harmonics, synchronism quality, jitter	

Adjustments for Transformers in the Protection Range

Vector group adjustment (V and I)	0 to 11	Increments of 1
Zero-sequence current elimination	Yes or no	

Adjustment of the Charging-Current Compensation

Additional rest. current Ic-rest./Ic-rated	1.0 to 4.0	Increments of 0.1
Total line length	0.1 km to 1000.0 km	Increments of 0.1 km

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	Operating range with rated accuracy
$0.8 \le f/f_{rated} \le 0.9$ $1.1 \le f/f_{rated} \le 1.2$	Normal operating range without rated accuracy
$0.0 \le f/f_{rated} \le 0.8$	Stable operation without rated accuracy

Measured Value of the I-DIFF Stage

In order to clarify failures, the **I-DIFF** stage provides the following measured values:

Measured Value	Description
(_:3451:300) I diff.	Differential current
(_:3451:301) I restr.	Restraint current (overall restraint)
(_:3451:307) I local	Value of local current phasor
(_:3451:308) I l.restr.	Local restraint current
(_:3451:309) I l.cTerr.	Partial component of the local restraint current that considers the transformer fault.

Measured Value	Description
(_:3451:310) I l.distor.	Subcomponent of the local restraint current that considers the fault caused by signal distortion. Each deviation of the signal form from the sinus shape is interpreted as a signal distortion. The deviation between the actual signal form and the sinus shape will be converted to a percentage of the stabiliza-tion.
(_:3451:311) I sync.	Subcomponents of the overall restraint that are caused by faults during the time synchronization of the current phasor.

Measured Values of the Stage IN-DIFF

In order to clarify failures, the stage **IN-DIFF** provides the following measured values:

Measured Value	Description
(_:300) IN diff.	Ground differential current
(_:301) IN restr	Ground restraint current (overall restraint)
(_:307) IN local	Value of local ground-current phasor
(_:308) IN l.restr	Local ground restraint current
(_:309) IN l.CT	Partial component of the local ground restraint current that considers the transformer v.
(_:310) IN l.dist	Subcomponent of the local ground restraint current that considers the fault caused by signal distortion. Each deviation of the signal form from the sinus shape is interpreted as a signal distortion. The deviation between the actual signal form and the sinus shape will be converted to a percentage of the stabilization.
(_:311) IN sync	Subcomponent of the overall restraint that is caused by faults during the time synchronization of the ground-current phasors.

Measured Values of the Stage IN-DIFF Unrest

In order to clarify failures, the stage **IN-DIFF Unrest** provides the following measured values:

Measured Value	Description
(_:300) IN diff.	Ground differential current
(_:301) IN threshold	Threshold value (pickup value)
(_:307) IN local	Value of local ground-current phasor

Measured Values of the Stage I2-DIFF

In order to clarify failures, the stage **I2-DIFF** provides the following measured values:

Measured Value	Description
(_:300) 3I2 diff.	Negative-sequence differential current
(_:301) 3I2 restr	Negative-sequence restraint current (overall restraint)
(_:307) 3I2 local	Value of local negative-sequence current phasor
(_:308) 3I2 l.rest	Local negative-sequence restraint current
(_:309) 3I2 l.CT	Partial component of the local negative-sequence restraint current that considers the transformer fault.
(_:310) 3I2 l.dist	Subcomponent of the local negative-sequence restraint current that considers the fault caused by signal distortion. Each deviation of the signal form from the sinus shape is interpreted as a signal distortion. The deviation between the actual signal form and the sinus shape will be converted to a percentage of the stabilization.
(_:311) 3I2 sync	Subcomponents of the overall restraint that are caused by faults during the time synchronization of the current phasor.

12.7 Stub-Differential Protection

Tripping Thresholds of the S-DIFF Stage

Threshold value	10.0 % to 2 000.0 % of $I_{rated\ Operation}$	Increments of 0.1 %

Tripping Thresholds of the S-DIFF fast 2 Stage

Threshold value	80.0 % to 10 000.0 % of $I_{rated\ Operation}$	Increments of 0.1 %

Tolerances of the Tripping Thresholds

5 % of the setting value or 1 % of I_{rated}

Operating Times

The reported tripping times assume the issuance of commands via high-speed relays (type HS).

Tripping Times of the S-DIFF Stage	
Minimum (50 Hz/60 Hz)	26 ms/23 ms + OOT[88]
Typical (50 Hz/60 Hz)	28 ms/25 ms + OOT
Dropout Times of the S-DIFF Stage	
Typical	34 ms to 49 ms + OOT

Tripping Times of the Stages S-DIFF fast/S-DIFF fast 2	
Minimum	8 ms + OOT
Typical	11 ms + OOT
Dropout Times of the Stages S-DIFF fast/S-DIFF fast 2	
Typical	34 ms to 49 ms + OOT

Time Delays

Tripping delay of the S-DIFF stage	0.00 s to 60.00 s	Increments of 0.01 s
Tolerance	1 % of the setting value or 10 ms	

Self-Stabilization

Transformer Error for Each Line End of the Protected Object		
Error transmission	1.00 to 10.00	Increments of 0.01
Transformer error A	0.5 % to 50.0 %	Increments of 0.1 %
Transformer error B	0.5 % to 50.0 %	Increments of 0.1 %
Other stabilizing values (adaptive self-stabilization)	Frequency deviations, harmonic components	

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	Operating range with rated accuracy
$0.8 \le f/f_{rated} \le 0.9$ $1.1 \le f/f_{rated} \le 1.2$	Normal operating range without rated accuracy
$0.0 \le f/f_{rated} \le 0.8$	Stable operation without rated accuracy

88 OOT (Output Operating Time): Additional time delay of the output medium used, for example, 5 ms with fast relays

12.8 Ground-Fault Protection for High-Resistance Ground Faults in Grounded Systems

Setting Values for All Stage Types

Directional mode	Forwards, backwards, non-directional	
Method of Measurement	Fundamental component over 1 cycle filter (standard filter)	
	Fundamental component over 2 cycle filters	
Stabilization with conductor currents	0 % to 30 %	Increments of 1 %

Threshold value (pickup value)	For transformer type I-sensitive and $I_{N\text{-rated}}$ = 1 A	For $I_{ph\text{-rated}}$ = 1 A	0.003 A to 100.000 A	Increments of 0.001 A
		For $I_{ph\text{-rated}}$ = 5 A	0.003 A to 500.000 A	Increments of 0.001 A
	For transformer type I-sensitive and $I_{N\text{-rated}}$ = 5 A	For $I_{ph\text{-rated}}$ = 1 A	0.015 A to 100.000 A	Increments of 0.001 A
		For $I_{ph\text{-rated}}$ = 5 A	0.015 A to 500.000 A	Increments of 0.001 A
	For transformer type I-protection and $I_{N\text{-rated}}$ = 1 A		0.030 A to 100.000 A	Increments of 0.001 A
	For transformer type I-protection and $I_{N\text{-rated}}$ = 5 A		0.150 A to 500.000 A	Increments of 0.001 A

Settings Values for Stage Type 3I0 Definite Time-Overcurrent Protection

Time delay	0.000 s to 60.000 s	Increments of 0.001 s

Setting Values for Stage Type 3I0-IEC/ANSI

Type of characteristic curve	Characteristic curves according to IEC (see *Table 12-5*) and ANSI (see *Table 12-6*)	
Time multiplier	0.05 to 15.00	Increments of 0.01
Additional delay	0.000 s to 60.000 s	Increments of 0.001 s

Setting Values for Stage Type 3I0 Logarithmic Inverse

Characteristic curve: see *Figure 12-8*		
Threshold value multiplier	1.00 to 4.00	Increments of 0.01
Time multiplier	0.00 to 15.00	Increments of 0.01
Minimum time of the characteristic curve	0.000 s to 60.000 s	Increments of 0.001 s
Maximum time of the characteristic curve	0.000 s to 60.000 s	Increments of 0.001 s
Additional delay	0.000 s to 60.000 s	Increments of 0.001 s

Setting Values for Stage Type S0-Inverse

Characteristic curve: see *Figure 12-9*		
Threshold value multiplier	1.00 to 4.00	Increments of 0.01
S ref for Sr-characteristic	1.000 VA to 100.000 VA	Increments of 0.001 VA
k factor	0.000 s to 60.000 s	Increments of 0.001 s
Additional delay	0.000 s to 60.000 s	Increments of 0.001 s

Setting Values for Stage Type V0 Inverse

Characteristic curve: see *Figure 6-199*		
V0> threshold value	0.300 V to 340.00 V	Increments of 0.01
Min. zero-seq. volt. V0	0.000 V to 340.00 V	Increments of 0.001 VA
Time delay directional	0.00 s to 60.00 s	Increments of 0.01 s
Time delay non-direct.	0.00 s to 60.00 s	Increments of 0.01 s

Setting Values for Direction Determination

At angular measurement between measuring and reference values:			
Minimum zero voltage V0		0.150 V to 20.000 V	Increments of 0.001 V
Minimum transformer neutral point current IY	For I_{rated} = 1 A	0.030 A to 10.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 50.00 A	Increments of 0.01 A
Minimum negative-sequence system voltage V2		0.150 V to 20.000 V	Increments of 0.001 V
Minimum negative-sequence system current I2	For I_{rated} = 1 A	0.030 A to 10.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 50.00 A	Increments of 0.01 A
Upper limit angle forwards, β		0° to 360°	Increments of 1°
Lower limit angle forwards, α		0° to 360°	Increments of 1°
At angular measurement with zero power S0:			
Zero power for forwards direction		0.10 VA to 10.00 VA	Increments of 0.01 VA
Compensation angle		0° to 360°	Increments of 1°

Characteristic Curves

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

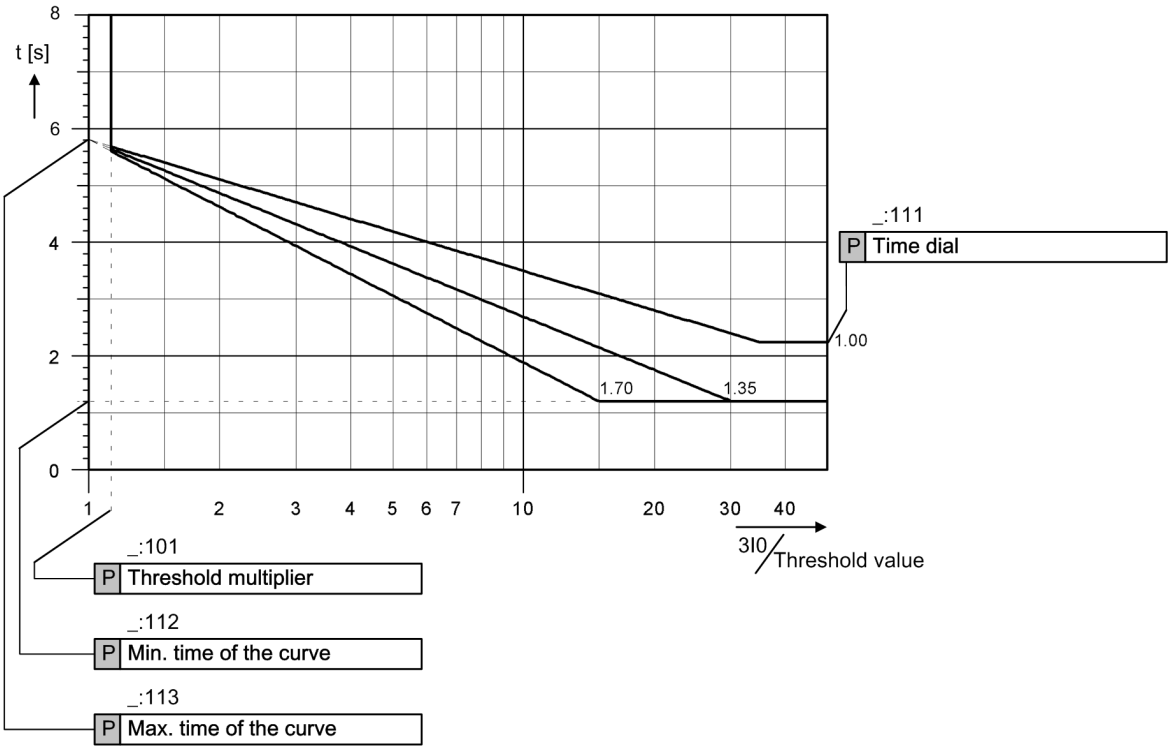
You can select from the following tripping and dropout characteristic curves:

Table 12-5 Standard Characteristic Curves to IEC

Normal inverse: type A	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-10*
Very inverse: type B	
Extremely inverse: type C	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-11*
Long-term inverse	

Table 12-6 Standard Characteristic Curves to ANSI/IEEE

Extremely inverse: type C	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-13*
Long time inverse: type B	
Long-term inverse	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-14*
Moderately inverse	
Very inverse	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-15*
Extremely inverse	
Uniformly inverse	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-16*



t = Maximum time of the characteristic curve – time multiplier • In (3I0/threshold value)

[logfpke1-030311-01.tif, 1, en_US]

Figure 12-8 Operate Curves of the Independent Overcurrent Protection with Logarithmic Inverse Characteristic Curve

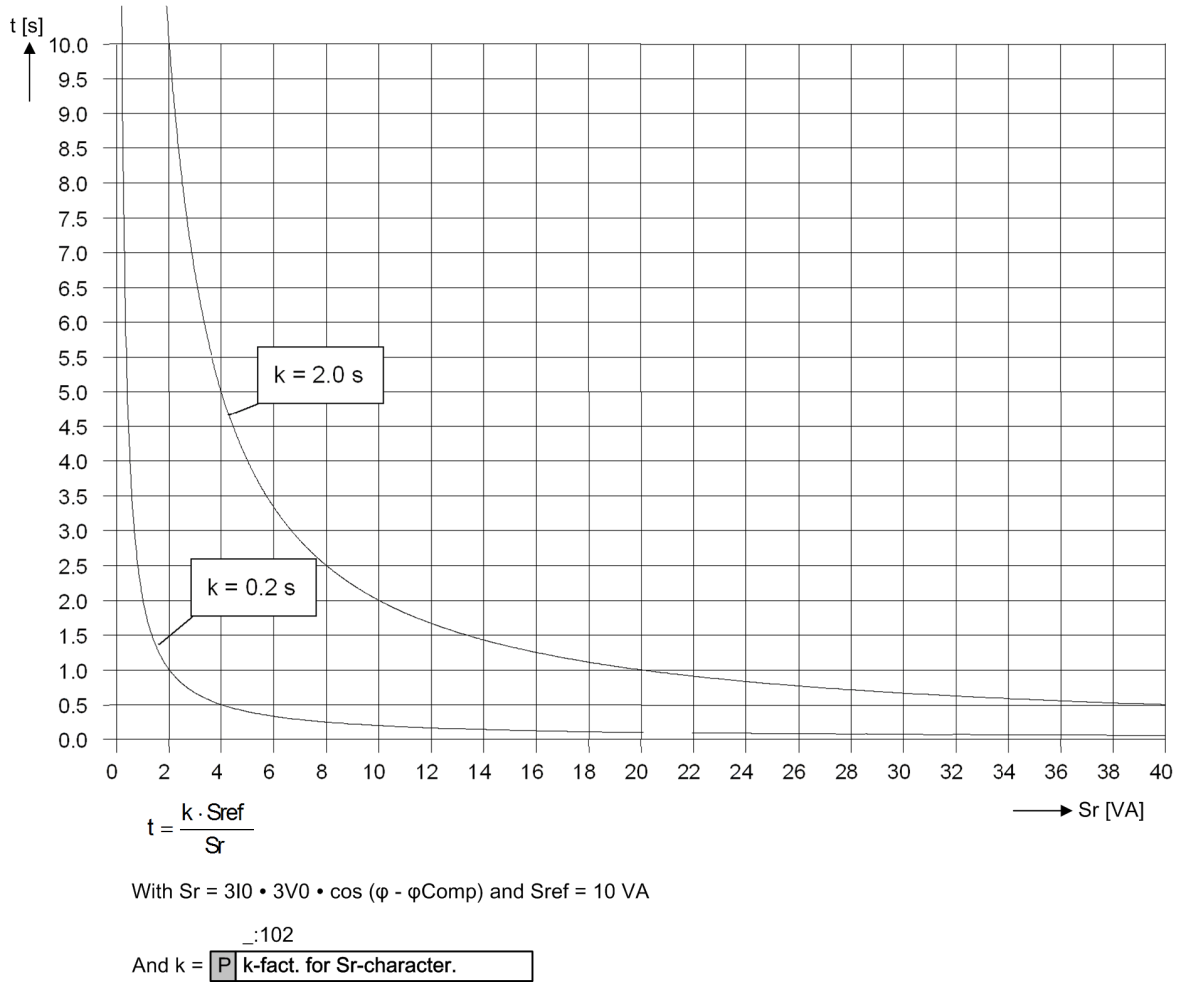


Figure 12-9 Operate Curve of the Zero Power Protection

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Values for Stage Type 3I0 Definite Time-Overcurrent Protection

Operate time with time delay = 0 ms	Fundamental component over 1 cycle filter (standard filter)	Approx. 25 ms + OOT[89] at 50 Hz Approx. 25 ms + OOT at 60 Hz
	Fundamental component over 2 cycle filters	Approx. 30 ms + OOT
Extension of the operate time during operation with transformer inrush-current detection		Approx. 10 ms
Dropout Time	Fundamental component over 1 cycle filter (standard time)	Approx. 20 ms + OOT
	Fundamental component over 2 cycle filters	Approx. 40 ms + OOT

Operating Range

f_{rated} ± 20%	Active
Outside of f_{rated} ± 20%	Not active

Tolerances

Threshold values:	
Response, release threshold value for zero-sequence current 3I0 with normal-sensitive ground-current transformer	1 % of the setting value or 1 % of the rated current
Response, release threshold value for zero-sequence current 3I0 with sensitive ground-current transformer	1 % of the setting value or 0.2 % of the rated current
Minimum zero voltage V0	1 % of the setting value or 0.1 V
Minimum transformer neutral point current IY	1% of the setting value or 1 % of the rated current
Minimum negative-sequence system voltage V2	1 % of the setting value or 0.1 V
Minimum negative-sequence system current I2	1 % of the setting value or 1 % of the rated current
Times:	
Independent time delays	1 % of the setting value or 10 ms
Current-dependent time delay, Characteristic curves to IEC, ANSI/IEEE and logarithmic inverse characteristic curve For ≤ 2 I/I_{3I0P} ≤ 20 and T_{3I0P} ≥ 1 s	5 % of the set point value ± 10 ms
Current-dependent time delay, Characteristic curve: logarithmic-inverse	3 % of the set point value ± 10 ms
S0-dependent time delay	3 % of the set point value ± 10 ms
V0-dependent time delay	3 % of the set point value ± 10 ms

Limit angle for direction determination via angular measurement between measuring and reference value	± 1,5°
Zero power for forwards direction	5% of the setting value ± 0.02 VA

Influencing Variables for the Thresholds

Transient excess pickup in method of measurement = fundamental component over 1 cycle filter (standard filter), for τ > 100 ms (with complete displacement)	< 5 %

89 OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.9 Teleprotection with Ground-Fault Protection

Permissive Overreach Transfer Trip

Adjustable process	Permissive overreach transfer trip, directional Unblock procedure, directional	
Transmission extension	0.00 s to 60.00 s	Increments of 0.01 s
Transmission delay	0.00 s to 60.00 s	Increments of 0.01 s
Trans. blk. pickup delay	0.00 s to 60.00 s	Increments of 0.01 s
Trans. blk. dropout delay	0.00 s to 60.00 s	Increments of 0.01 s
Delay	0.00 s to 60.00 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	
The times set are pure delay times.		

Permissive Overreach Transfer Trip via the Protection Interface

Trans. blk. dropout delay		
Adjustable method	Directional comparison	
Transmission extension	0.00 s to 60.00 s	Increments of 0.01 s
Release delay	0.000 s to 60.000 s	Increments of 0.001 s
Trans. blk. pickup delay	0.00 s to 60.00 s	Increments of 0.01 s
Trans. blk. dropout delay	0.00 s to 60.00 s	Increments of 0.01 s
Delay	0.00 s to 60.00 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	
The times set are pure delay times.		

12.10 Directional Intermittent Ground-Fault Protection

Setting Values

Threshold value 3I0>	For current transformer type **protection** and I_{rated} = 1 A		0.030 A to 35.000 A	Increments of 0.001 A
	For current transformer type **protection** and I_{rated} = 5 A		0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
No.of pulses for interm.GF			2 to 10	Increments of 1
Pickup extension time			0.00 s to 10.00 s	Increments of 0.01 s
Sum of extended PU times			0.00 s to 180.00 s	Increments of 0.01 s
Reset time			0.00 s to 600.00 s	Increments of 0.01 s
No. of pulses for operate			2 to 100	Increments of 1
Minimum operate delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Pickup time	Approx. 30 ms + OOT[90] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active with reduced sensitivity

90 OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

Tolerances

Currents	3I0 via protection-class current transformers: 1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
	3I0 via sensitive current transformer: 1 % of the setting value or 0.1 mA (I_{rated} = 1 A) or 0.5 mA (I_{rated} = 5 A)
Times	1 % of the setting value or ± 10 ms

12.11 Non-Directional Intermittent Ground-Fault Protection

Setting Values

Threshold value 3I0> interm.	For current transformer type **protection** and I_{rated} = 1 A		0.030 A to 35.000 A	Increments of 0.001 A
	For current transformer type **protection** and I_{rated} = 5 A		0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Number of pickups until intermittent ground fault			2 to 10	Increments of 1
Pickup extension time			0.00 s to 10.00 s	Increments of 0.01 s
Sum of extended pickup times			0.00 s to 180.00 s	Increments of 0.01 s
Reset time			0.00 s to 600.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[91] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active with reduced sensitivity

91 OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

Tolerances

Currents	-3I0 via protection-class current transformers: 1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
	-3I0 via sensitive current transformer: 1 % of setting value or 0.1 mA (I_{rated} = 1 A) or 0.5 mA (I_{rated} = 5 A)
Times	1 % of the setting value or ± 10 ms

12.12 Sensitive Ground-Fault Detection

12.12.1 General

Setting Values

Decay time V0			0.03 s to 0.20 s	Increments of 0.01 s
Dropout delay			0.00 s to 60.00 s	Increments of 0.01 s
Core balance current transformer current 1 Core balance current transformer current 2	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Core balance current transformer angle correction F1 Core balance current transformer angle correction F2			0.0° to 5.0°	Increments of 0.1°

Times

Pickup times	Approx. 25 ms + OOT[92] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Dropout times	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances [93]
$f < 10\ Hz$ $f > 90\ Hz$	Active with less sensitivity [94]

Tolerances

Currents	-3I0 via sensitive current transformer: 1 % of the setting value or 0.1 mA (I_{rated} = 1 A) or 0.5 mA (I_{rated} = 5 A)
	-3I0 via protection-class current transformers: 1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Voltages	1 % of the setting value or 0.05 V

92 OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

93 Transient ground-fault stage is inactive

94 Transient ground-fault stage is inactive

Times	1 % of the setting value or ±10 ms
Direction-calculation angle error[95]	≤ 1° at 3I0 > 5 mA, V0 = 0.6 V ≤ 2° at 3I0 ≤ 5 mA, V0 = 0.6 V

12.12.2 Directional 3I0 Stage with cos φ or sin φ Measurement

Setting Values

Direction method of measurement			cos φ sin φ	–
Threshold value 3I0> Minimum directional 3I0> for direction determination	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Threshold value V0>			0.300 V to 200.000 V	Increments of 0.001 V
Time delay of the direction determination			0.00 s to 60.00 s	Increments of 0.01 s
α1 constraint of the direction range α2 constraint of the direction range			1° to 15°	Increments of 1°
Angle correction φ			-45° to 45°	Increments of 1°
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

95 Not applicable to *12.12.4 Directional 3I0 Stage with φ(V0,3I0) Measurement*

Times

Operate time with time delay = 0 ms	Approx. 38 ms + OOT[96] at 50 Hz Approx. 35 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

12.12.3 Directional Transient Ground-Fault Stage

Setting Values

3I0> threshold value 3I0> threshold for operate	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.000 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.00 A to 175.00 A	Increments of 0.01 A
	Sensitive current transformer for I_N	$I_{N\text{-}rated}$ = 1 A	0.000 A to 1.600 A	Increments of 0.001 A
		$I_{N\text{-}rated}$ = 5 A	0.000 A to 8.000 A	Increments of 0.001 A
Threshold value V0>			0.300 V to 200.000 V	Increments of 0.001 V
Maximum operational V0			0.300 V to 200.000 V	Increments of 0.001 V
Dropout delay			0.00 s to 60.00 s	Increments of 0.01 s
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 115 ms + OOT[97] at 50 Hz Approx. 112 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT at 50 Hz Approx. 15 ms + OOT at 60 Hz

96 OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

97 OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.12.4 Directional 3I0 Stage with φ(V0,3I0) Measurement

Setting Values

Threshold value 3I0>	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Min. V0> for direction determination			0.300 V to 200.000 V	Increments of 0.001 V
Time delay of the direction determination			0.00 s to 60.00 s	Increments of 0.01 s
Rotation angle of the reference voltage			-180° to 180°	Increments of 1°
Forward range +/-			0° to 180°	Increments of 1°
Tripping delay			0.00 s to 100.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 23 ms + OOT[98] at 50 Hz Approx. 21 ms + OOT at 60 Hz
Extension of operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 21 ms + OOT at 50 Hz Approx. 20 ms + OOT at 60 Hz

Tolerances

Direction-calculation angle error	≤ 1° at 3I0 ≥ 10 mA, V0 = 0.6 V ≤ 2° at 2 mA < 3I0 < 10 mA, V0 = 0.6 V ≤ 3° at 3I0 ≤ 2 mA, V0 = 0.6 V

98 OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.12.5 Directional Y0 Stage with G0 or B0 Measurement (Admittance)

Setting Values

Direction method of measurement			B0 G0	–
Release Threshold value 3I0>	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Threshold value V0>			0.300 V to 200.000 V	Increments of 0.001 V
Threshold value Y0>			0.10 mS to 100.00 mS	Increments of 0.01 mS
Time delay of direction determination			0.00 s to 60.00 s	Increments of 0.01 s
α1 constraint of direction range α2 constraint of direction range			1° to 15°	Increments of 1°
Angle correction φ			-45° to 45°	Increments of 1°
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 39 ms + OOT[99] at 50 Hz Approx. 35 ms + OOT at 60 Hz
Extension of operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

99 OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Tolerances

Admittance	1 % of the setting value or 0.05 mS (I_{rated} = 1 A) or 0.25 mS (I_{rated} = 5 A)

12.12.6 Directional Stage with Phasor Measurement of a Harmonic

Setting Values

Min. 3I0> of the selected harmonic phasor	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Dropout ratio of the direction determination in terms of the zero-sequence harmonic current			0.10 to 0.95	Increments of 0.01
Threshold value V0>			0.300 V to 200.000 V	Increments of 0.001 V
Time delay of the direction determination			0.00 s to 60.00 s	Increments of 0.01 s
Extension of the direction result			0.00 s to 60.00 s	Increments of 0.01 s
Forward range +/-			0° to 90°	Increments of 1°
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 70 ms + OOT[100] at 50 Hz Approx. 60 ms + OOT at 60 Hz
Dropout time	Approx. 30 ms + OOT at 50 Hz Approx. 20 ms + OOT at 60 Hz

[100] OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Tolerances

Zero-sequence harmonic current 3I0harm.	-3I0harm. via sensitive current transformer: 1 % of the setting value or 0.1 mA (I_{rated} = 1 A) or 0.5 mA (I_{rated} = 5 A)
	-3I0harm. via protection-class current transformers: 1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
V0 fundamental-component value	1 % of the setting value or 0.05 V
Direction-calculation angle error of the 3rd, 5th, or 7th harmonic phasor	≤ 1° at 3I0harm. > 5 mA ≤ 2° at 3I0harm. ≤ 5 mA

12.12.7 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage

Setting Values

Threshold value[101]	0.300 V to 200.000 V	Increments of 0.001 V
Time delay	0.00 s to 100.00 s	Increments of 0.01 s
Pickup delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01
V< faulty ph-gnd vltg.	0.300 V to 200.000 V	Increments of 0.001 V
V> healthy ph-gnd. vltg.	0.300 V to 200.000 V	Increments of 0.001 V

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	
Standard filter, true RMS value	Approx. 25 ms + OOT[102] at 50 Hz Approx. 22 ms + OOT at 60 Hz
2 cycle filters	Approx. 45 ms + OOT at 50 Hz Approx. 39 ms + OOT at 60 Hz
Dropout time	
Standard filter, true RMS value	Approx. 20 ms + OOT at 50 Hz Approx. 16.6 ms + OOT at 60 Hz
2 cycle filters	Approx. 31.06 ms + OOT at 50 Hz Approx. 27.06 ms + OOT at 60 Hz

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

101 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.

102 OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.12.8 Non-Directional 3I0 Stage

Setting Values

Method of Measurement			Fundamental component RMS value	
Threshold value 3I0>	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For transformer type I-sensitive and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For transformer type I-sensitive and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Pickup delay			0.00 s to 60.00 s	Increments of 0.01 s
Tripping delay			0.00 s to 100.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[103] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

12.12.9 Non-Directional Y0 Stage

Setting Values

V0> threshold value	0.300 V to 200.000 V	Increments of 0.001 V
Threshold Y0>	0.10 mS to 100.00 mS	Increments of 0.01 mS

[103] OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Pickup delay	0.00 s to 60.00 s	Increments of 0.01 s
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[104] at 50 Hz Approx. 29 ms + OOT at 60 Hz
Extension of operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

Current Operating Range

Minimum 3I0 threshold value for Y0 calculation	Protection-class current transformers	30 mA sec. (I_{rated} = 1 A)
		150 mA sec. (I_{rated} = 5 A)
	Sensitive current transformer	1 mA sec. (I_{rated} = 1 A)
		5 mA sec. (I_{rated} = 5 A)

Tolerances

Admittance	1 % of the setting value or 0.05 mS (I_{rated} = 1 A) or 0.25 mS (I_{rated} = 5 A)

12.12.10 Non-Directional 3I0 Harmonic Stage

Setting Values

3I0 harm. threshold	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
3I0 harm. dropout ratio			0.10 to 0.95	Increments of 0.01
Pickup extension time			0.00 s to 60.00 s	Increments of 0.01 s
Operate delay			0.00 s to 60.00 s	Increments of 0.01 s
Stabilization counter			1 to 10	Increments of 1

[104] OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms and stabilization counter = 4	Approx. 70 ms + OOT[105] at 50 Hz Approx. 60 ms + OOT at 60 Hz
Dropout time	Approx. 40 ms + OOT at 50 Hz Approx. 30 ms + OOT at 60 Hz

Tolerances

Zero-sequence harmonic current 3I0harm.	-3I0harm. via sensitive current transformer: 1 % of the setting value or 0.1 mA (I_{rated} = 1 A) or 0.5 mA (I_{rated} = 5 A)
	-3I0harm. via protection-class current transformers: 1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)

12.12.11 Pulse-Pattern Detection Stage

Setting Values

V0> threshold value			0.300 V to 200.000 V	Increments of 0.001 V
3I0> threshold value	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
3I0 delta pulse off-on			2 % to 50%	Increments of 1 %
Pulse-on duration Pulse-off duration			0.20 s to 10.00 s	Increments of 0.01 s

[105] OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

No. of pulses for operate Monitoring time(in pulses)	2 to 100	Increments of 1
Max.tolera.pulse-on or off	0.02 s to 2.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate delay = 0 ms	Approx. 2.5 s + 0.3 s + OOT[106] at 50 Hz and 60 Hz[107]
Dropout time	Approx. 32 ms + OOT at 50 Hz and 60 Hz

12.12.12 Intermittent Ground-Fault Blocking Stage

Setting Values

Threshold	For current transformer type **protection** and I_{rated} = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
	For current transformer type **protection** and I_{rated} = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	0.001 A to 1.600 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	0.005 A to 8.000 A	Increments of 0.001 A
No.of pulses for interm.GF		2 to 50	Increments of 1
Reset time		1.00 s to 600.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

106 OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

107 After the first valid pulse is detected, the function picks up. For the typical settings 1.00 s of Pulse-on duration, 1.50 s of Pulse-off duration, and 0.15 s of Max.tolera.pulse-on or off, the inherent pickup time is approx. 1 s + 1.5 s + 2 · 0.15 s + OOT

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active with reduced sensitivity

Tolerances

Currents	3I0 via protection-class current transformers: 1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
	3I0 via sensitive current transformer: 1 % of the setting value or 0.2 mA (I_{rated} = 1 A) or 1 mA (I_{rated} = 5 A)
Times	1 % of the setting value or ± 10 ms

12.13 Distance Protection

Residual Compensation

Kr	-0.33 to 11.00	Increments of 0.01
Kx	-0.33 to 11.00	Increments of 0.01
K0	0.000 to 11.000	Increments of 0.001
Angle (K0)	-180.00° to +180.00°	Increments of 0.01°
	Configurable separately for each zone	

Parallel-Line Matching

KmR	0.00 to 8.00	Increments of 0.01
KmX	0.00 to 8.00	Increments of 0.01
Km0	0.000 to 8.000	Increments of 0.001
Angle (Km0)	-180.00° to +180.00°	Increments of 0.01

Phase Preference

For double ground faults in a grounded system	Block leading phase from ground Block lagging phase from ground Release all loops involved Release phase-to-ground loops involved Release phase-to-phase loops involved
For double ground faults in isolated or resonant-grounded system	C(A) acyclic A(C) acyclic B(A) acyclic A(B) acyclic C(B) acyclic B(C) acyclic C(A) cyclic A(C) cyclic All loops involved

Ground-Fault Detection

Threshold value 3I0>	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
Threshold value V0>		0.300 V to 200.000 V	Increments of 0.001 V
Measuring tolerances for sinusoidal measurands		± 5 %	

Pickup Method

Overcurrent pickup			
Iph>>	1 A @ 50 and 100 Irated	0.250 Ato 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	1.25 A to 175.00 A	Increments of 0.01 A
Dropout ratios		Approx. 0.95	
Measuring tolerances for sinusoidal measurands		± 5 %	

Voltage- and phase angle-dependent current pickup (V/I/ϕ) (optional)			
Characteristic		Cascaded with adjustable slopes	
Minimum phase current Iph>	1 A @ 50 and 100 Irated	0.100 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.50 A to 175.00 A	Increments of 0.01 A
Current in short circuit angle range Iϕ	1 A @ 50 and 100 Irated	0.100 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.50 A to 175.00 A	Increments of 0.01 A
Undervoltage phase-to-ground (individually separated according to Iph>, Iph>>, and Iϕ>)		0.500 V to 200.000 V	Increments of 0.001 V
Undervoltage phase-to-phase (individually separated according to Iph>, Iph>>, and Iϕ>)		1.000 V to 200.000 V	Increments of 0.001 V
Lower threshold angle ϕ>		30.0° to 60.0°	Increments of 0.1°
Upper threshold angle ϕ<		90.0° to 120.0°	Increments of 0.1°
Dropout ratios			
Iph>, Iϕ>		Approx. 0.95	
Phase-to-ground voltage Phase-to-phase voltage		Approx. 1.05	
Measuring tolerances for sinusoidal measurands			
Amounts of V, I		± 5 %	
Angle ϕ		± 3°	
Impedance pickup (optional)			
Minimum phase current Iph>	1 A @ 50 and 100 Irated	0.050 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.25 A to 175.00 A	Increments of 0.01 A
Under consideration of the respective direction, the limits of the zones that are set the furthest, are the most important ones.			
Dropout ratio		Approx. 1.05	

Distance Measurement

Characteristic		Quadrilateral, MHO, or circular characteristic curve	
Minimum phase current I>	1 A @ 50 and 100 Irated	0.050 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.25 A to 175.00 A	Increments of 0.01 A
φ_{Dist} = Angle of distance-protection characteristic		30.0° to 90.0°	Increments of 0.1°
Quadrilateral setting ranges:			
X reach = reach of reactance	For I_{rated} = 1 A	0.050 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.010 Ω to 120.000 Ω	
R (ph-ph) = Phase-to-phase resistance reserve	For I_{rated} = 1 A	0.050 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.010 Ω to 120.000 Ω	
R (ph-gnd) = Phase-to-ground resistance reserve	For I_{rated} = 1 A	0.050 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.010 Ω to 120.000 Ω	
α_{Pole} = Zone inclination		0° to 45°	Increments of 1°

Direction determination for polygon:			
For all fault types		With actual short-circuit, buffered or cross-polarized voltages	
Directional sensitivity		Dynamically unlimited, stationary about 1 V	
Every zone can be configured as forward, reverse, or non-directional.			
Setting ranges for MHO characteristic:			
Z_r impedance reach	For I_{rated} = 1 A	0.050 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.010 Ω to 120.00 Ω	
Polarization		With buffered or cross-polarized voltages	
Setting ranges for circular characteristic curve:			
Zr impedance reach	For I_{rated} = 1 A	0.100 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.020 Ω to 120.00 Ω	
Angle for R-reserve		10.0° to +90.0°	Increments of 0.1°
Every zone can be configured as forward or backward.			
Load cutout (for impedance pickup):			
R_{load} = Minimum load resistance	For I_{rated} = 1 A	0.050 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.010 Ω to 120.000 Ω	
φload = Maximum load angle		20.0° to 60.0°	Increments of 0.1°
Dropout ratios			
- Currents		Approx. 0.95	
- Impedances		Approx. 1.05	
Measured-value correction		For ground-current coupling in parallel lines	
Measuring tolerances for sinusoidal measurands		$\left\|\frac{\Delta X}{X}\right\| \le 5\%$ for $30^\circ \le \varphi_{sc} \le 90^\circ$	
		$\left\|\frac{\Delta R}{R}\right\| \le 5\%$ for $0^\circ \le \varphi_{sc} \le 60^\circ$	
		$\left\|\frac{\Delta Z}{Z}\right\| \le 5\%$ for $-30^\circ \le \varphi_{sc} - \varphi_{line} \le 30^\circ$	

Times

Shortest operate time	Approx. 9 ms + OOT[108] at 50 Hz Approx. 8 ms (60 Hz) + OOT	
Dropout time	Approx. 30 ms	
Incremental times	0.00 s to 60.00 s; ∞ for all zones	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	
The set times are pure time delays.		

Frequency Operating Range

0.9 f/f_{rated} to 1.1 f/f_{rated}	According to specified tolerances
0.8 $f/f_{rated} \le f < 0.9$ f/f_{rated} 1.1 $f/f_{rated} \le f \le 1.2$ f/f_{rated}	Slightly expanded tolerances
$f < 0.8$ f_{rated} $f > 1.2$ f_{rated}	Active

[108] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.14 Impedance Protection

Setting Values

Min. phase-current thresh	1 A @ 100 Irated	0.030 A to 100.000 A	Increments of 0.001 A
	5 A @ 100 Irated	0.15 A to 500.00 A	Increments of 0.01 A
	1 A @ 50 Irated	0.030 A to 50.000 A	Increments of 0.001 A
	5 A @ 50 Irated	0.15 A to 250.00 A	Increments of 0.01 A
X reach (ph-g) = reach of reactance, phase-to-ground	For I_{rated} = 1 A	0.100 Ω to 600.000 Ω	Increments of 0.001 A
	For I_{rated} = 5 A	0.020 Ω to 120.000 Ω	Increments of 0.001 A
X reach (ph-ph) = reach of reactance, phase-to-phase	For I_{rated} = 1 A	0.100 Ω to 600.000 Ω	Increments of 0.001 A
	For I_{rated} = 5 A	0.020 Ω to 120.000 Ω	Increments of 0.001 A
R reach (ph-g) = reach of resistance, phase-to-ground	For I_{rated} = 1 A	0.100 Ω to 600.000 Ω	Increments of 0.001 A
	For I_{rated} = 5 A	0.020 Ω to 120.000 Ω	Increments of 0.001 A
R reach (ph-ph) = reach of resistance, phase-to-phase	For I_{rated} = 1 A	0.100 Ω to 600.000 Ω	Increments of 0.001 A
	For I_{rated} = 5 A	0.020 Ω to 120.000 Ω	Increments of 0.001 A

Dropout Ratios

Currents	About 0.95
Voltage	About 1.05
Impedances	About 1.05

Times

Operate time with time delay = 0 ms	Approx. 30 ms + OOT [109] at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Voltage	0.5 % of the setting value or 0.05 V
Impedances Measurement tolerances for sinusoidal values	$\left\|\frac{\Delta X}{X}\right\| \le 5\%$ for $30^\circ \le \varphi_{sc} \le 90^\circ$
	$\left\|\frac{\Delta R}{R}\right\| \le 5\%$ for $0^\circ \le \varphi_{sc} \le 60^\circ$

[109] OOT (Output Operating Time) additional delay of the used output medium, such as 5 ms with quick-acting relay

12.15 Power-Swing Blocking

General

Measuring principle	Cyclic supervision of impedance curves for monotony, continuity, and jump
Detectable power-swing frequency	0.1 Hz to 12 Hz for symmetrical operation, up to 7 Hz during 1-pole dead times and unbalanced faults
Power-swing blocking	Can be set separately for each distance-protection zone

Times

Power-swing detection time	≥ 2.5 power-system cycles
Dropout time	≥ 5.5 power-system cycles in case of unbalanced faults ≥ 5.5 power-system cycles in case of balanced faults Max. 5 s after leaving the pickup range of the distance protection

12.16 External Trip Initiation

Setting Values

Tripping delay	0.00 s to 60.00 s	Increments of 0.01 s

Times

Operate time with time delay = 0 ms - At initiation via binary input signal	Approx. 10 ms + OOT[110]

Tolerance

Sequence tolerance for time delays	1 % of the setting value or 10 ms

110 OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relay, see Chapter *12.1.4 Relay Outputs*

12.17 External Trip Initiation with Current-Flow Criterion

Setting Values

Tripping delay	0.00 s to 60.00 s	Increments of 0.01 s

Times

Operate time with time delay = 0 ms - At initiation via binary input signal	Approx. 10 ms + OOT[111].

Tolerance

Processing tolerance for time delays			1 % of the setting value or 10 ms
Threshold I>	Protection-class current transformers	At I_{rated} = 1 A	1 % of the setting value or 5 mA
		At I_{rated} = 5 A	1 % of the setting value or 25 mA
	Sensitive current transformer	At I_{rated} = 1 A	1 % of the setting value or 0.1 mA
		At I_{rated} = 5 A	1 % of the setting value or 0.5 mA

111 OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relay, see chapter *12.1.4 Relay Outputs*

12.18 Overcurrent Protection, Phases

12.18.1 Stage with Definite-Time Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	–
Threshold value[112]	1 A @ 50 and 100 Irated	0.030 A to 40.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 200.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Operate delay		0.00 s to 100.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s
Pickup delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT [113] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

112 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

113 OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value, no filter applied (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value with filter for the compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	2 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[114] (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1.5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A) [115]
Up to 50th harmonic, f_{rated} = 50 Hz	3% of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A) [116]
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A) [117]
Pickup delay	1 % of the setting value or 10 ms
Dropout delay	1 % of the setting value or 10 ms
Operate delay for the basic stage	1 % of the setting value or 10 ms

114 In case that the filter response exactly matches the user-defined gain factors

115 In case that the user-defined gain factor is set below 3. The tolerance increases, if the gain factor is larger.

116 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

117 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

Operate delay for the advanced stage	Operate delay mode = Running dur. DO-delay	1 % of the setting value or 10 ms
	Operate delay mode = Frozen dur. DO-delay	1 % of the reference value or 10 ms (Reference value = Setting value + Frozen time)

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.18.2 Stage with Inverse-Time Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 40.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 200.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.00 to 15.00	Increments of 0.01
Pickup delay		0.00 s to 60.00 s	Increments of 0.01 s
Minimum time of the curve		0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

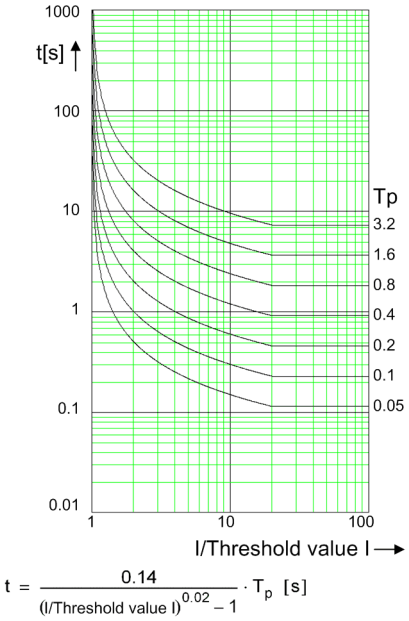
Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

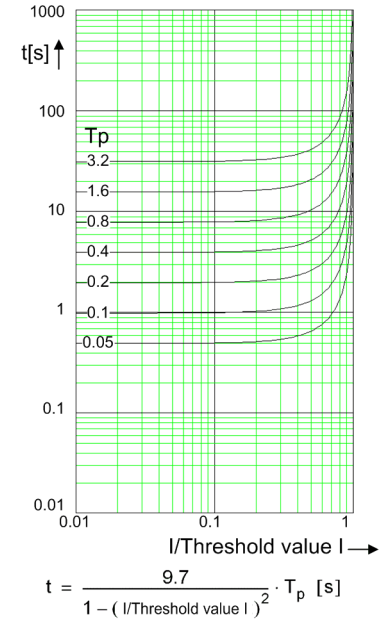
Operate Curves and Dropout-Time Characteristic Curves according to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

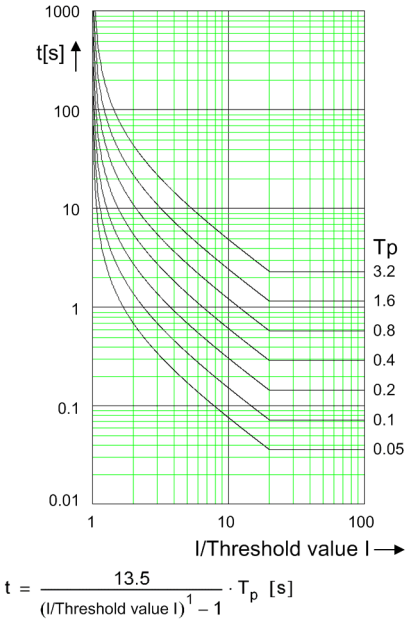
NORMAL INVERSE: Type A



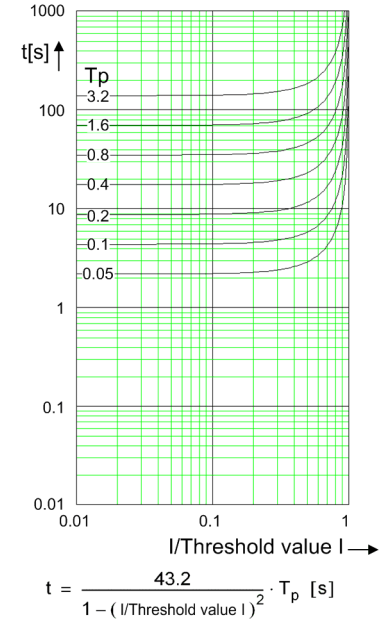
RESET NORMAL INVERSE: Type A



VERY INVERSE: Type B



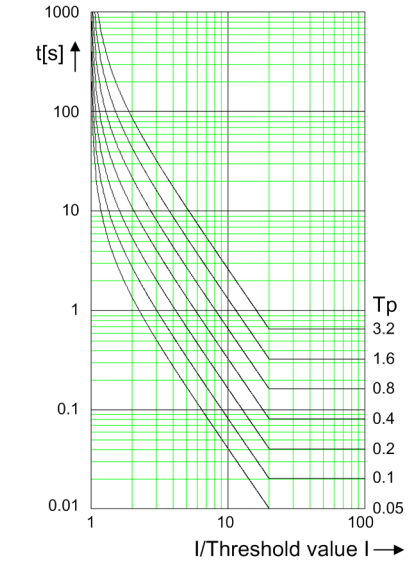
RESET VERY INVERSE: Type B



[dw_ocp_ki1, 1, en_US]

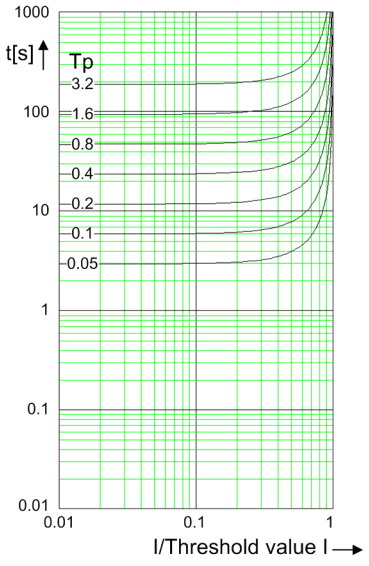
Figure 12-10 Operate Curves and Dropout-Time Characteristic Curves According to IEC

EXTREMELY INVERSE: Type C



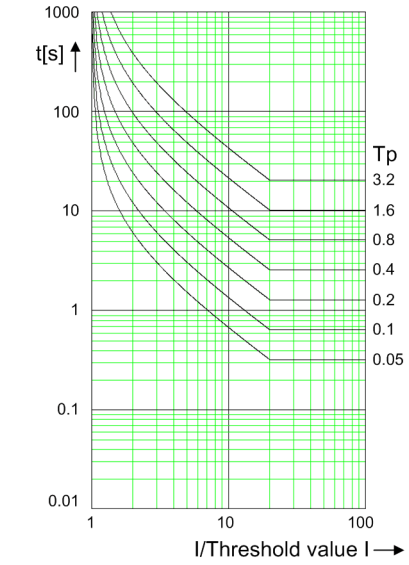
$$t = \frac{80}{(I/\text{Threshold value } I)^2 - 1} \cdot T_p \ [s]$$

RESET EXTREMELY INVERSE: Type C



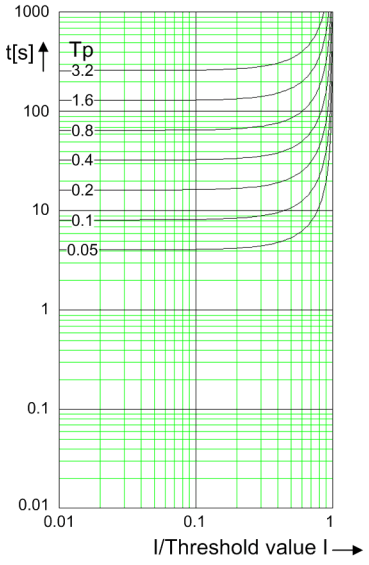
$$t = \frac{58.2}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

LONG-TIME INVERSE: Type B



$$t = \frac{120}{(I/\text{Threshold value } I)^1 - 1} \cdot T_p \ [s]$$

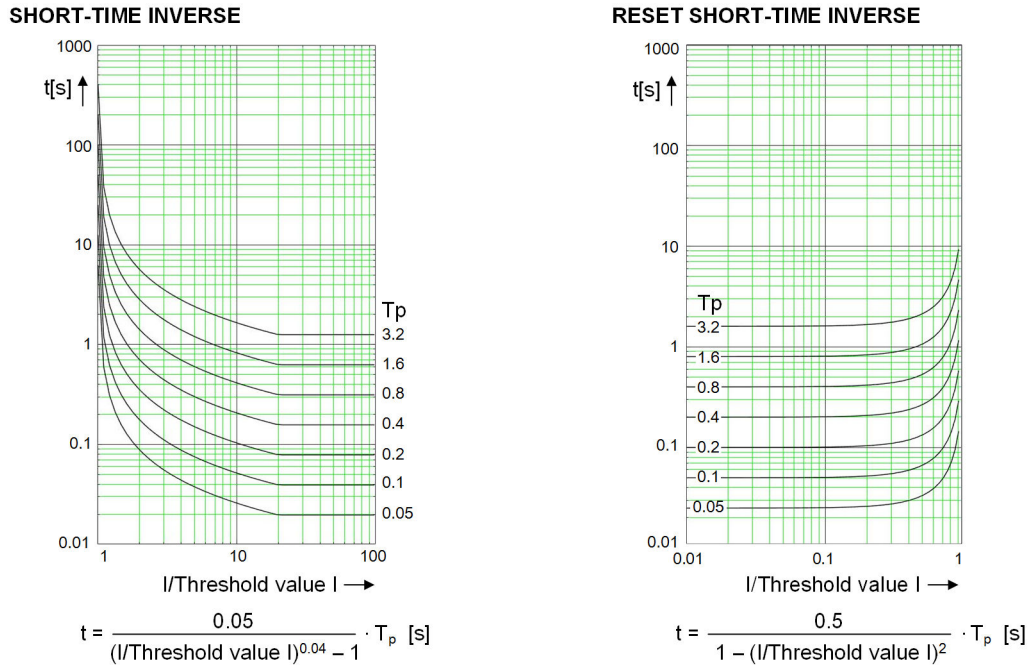
RESET LONG-TIME INVERSE: Type B



$$t = \frac{80}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

[dw_ocp_ki2, 1, en_US]

Figure 12-11 Operate Curves and Dropout-Time Characteristic Curves According to IEC

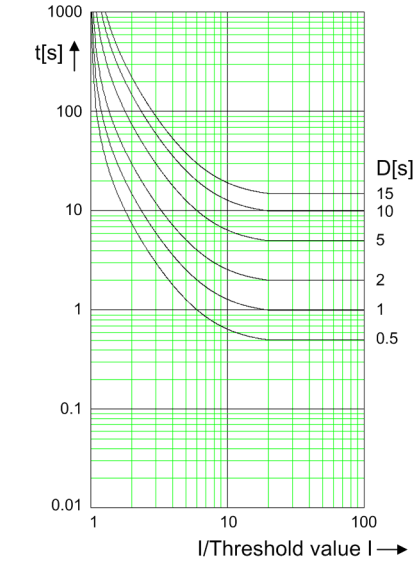


[dw_iec-short-inverse, 1, en_US]

Figure 12-12 Operate Curves and Dropout-Time Characteristic Curves According to IEC (Advanced Stage)

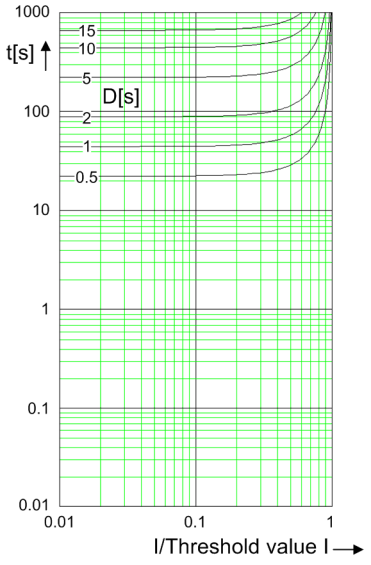
Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Inverse: Type C



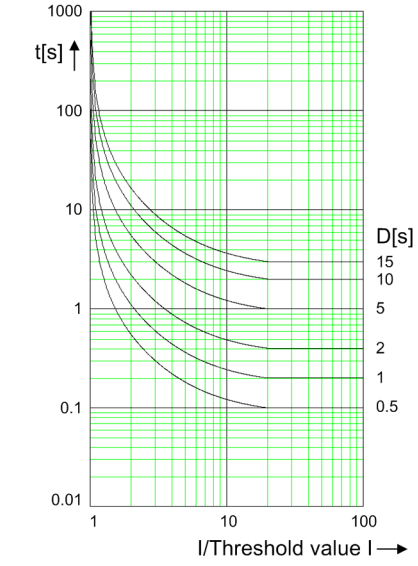
$$t = \left(\frac{44.6705}{\left(\text{I/Threshold value I} \right)^{2.0938} - 1} + 0.8983 \right) \cdot D \quad [s]$$

RESET INVERSE: Type C



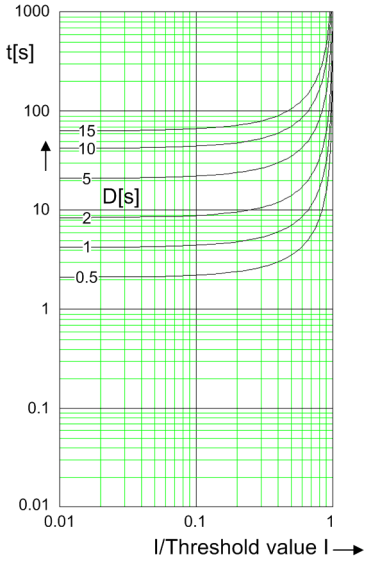
$$t = \frac{44}{1 - \left(\text{I/Threshold value I} \right)^{2.0938}} \cdot D \quad [s]$$

SHORT INVERSE



$$t = \left(\frac{1.3315}{\left(\text{I/Threshold value I} \right)^{1.2969} - 1} + 0.16965 \right) \cdot D \quad [s]$$

RESET SHORT INVERSE

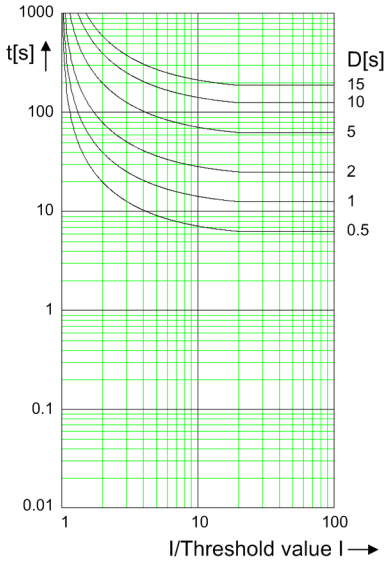


$$t = \frac{4.155}{1 - \left(\text{I/Threshold value I} \right)^{1.2969}} \cdot D \quad [s]$$

[dw_ocp_ka1, 2, en_US]

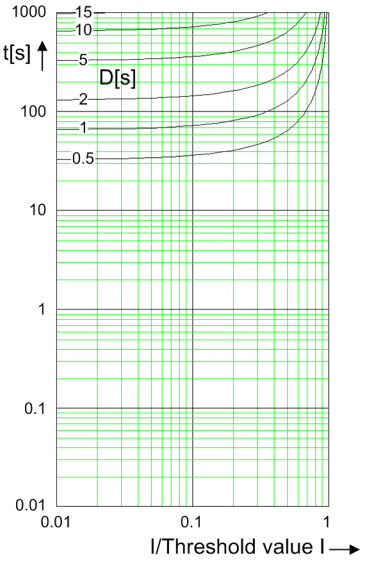
Figure 12-13 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

LONG INVERSE



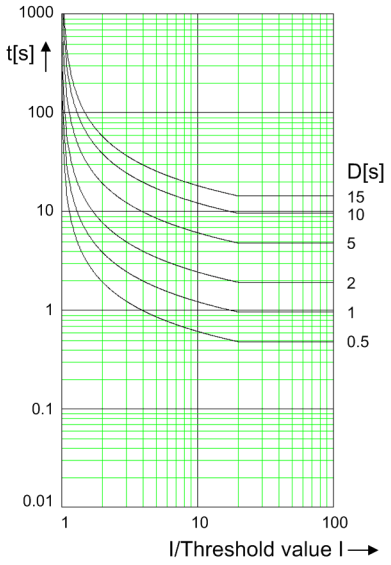
$$t = \left(\frac{28.0715}{\left(\text{I/Threshold value I} \right)^{1} - 1} + 10.9296 \right) \cdot D \quad [s]$$

RESET LONG INVERSE



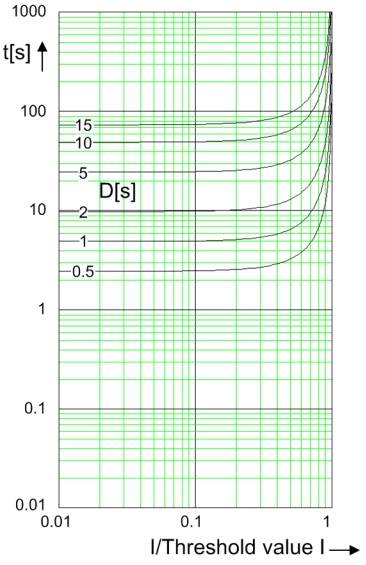
$$t = \frac{64.5}{1 - \left(\text{I/Threshold value I} \right)^{1}} \cdot D \quad [s]$$

MODERATELY INVERSE



$$t = \left(\frac{0.0515}{\left(\text{I/Threshold value I} \right)^{0.02} - 1} + 0.114 \right) \cdot D \quad [s]$$

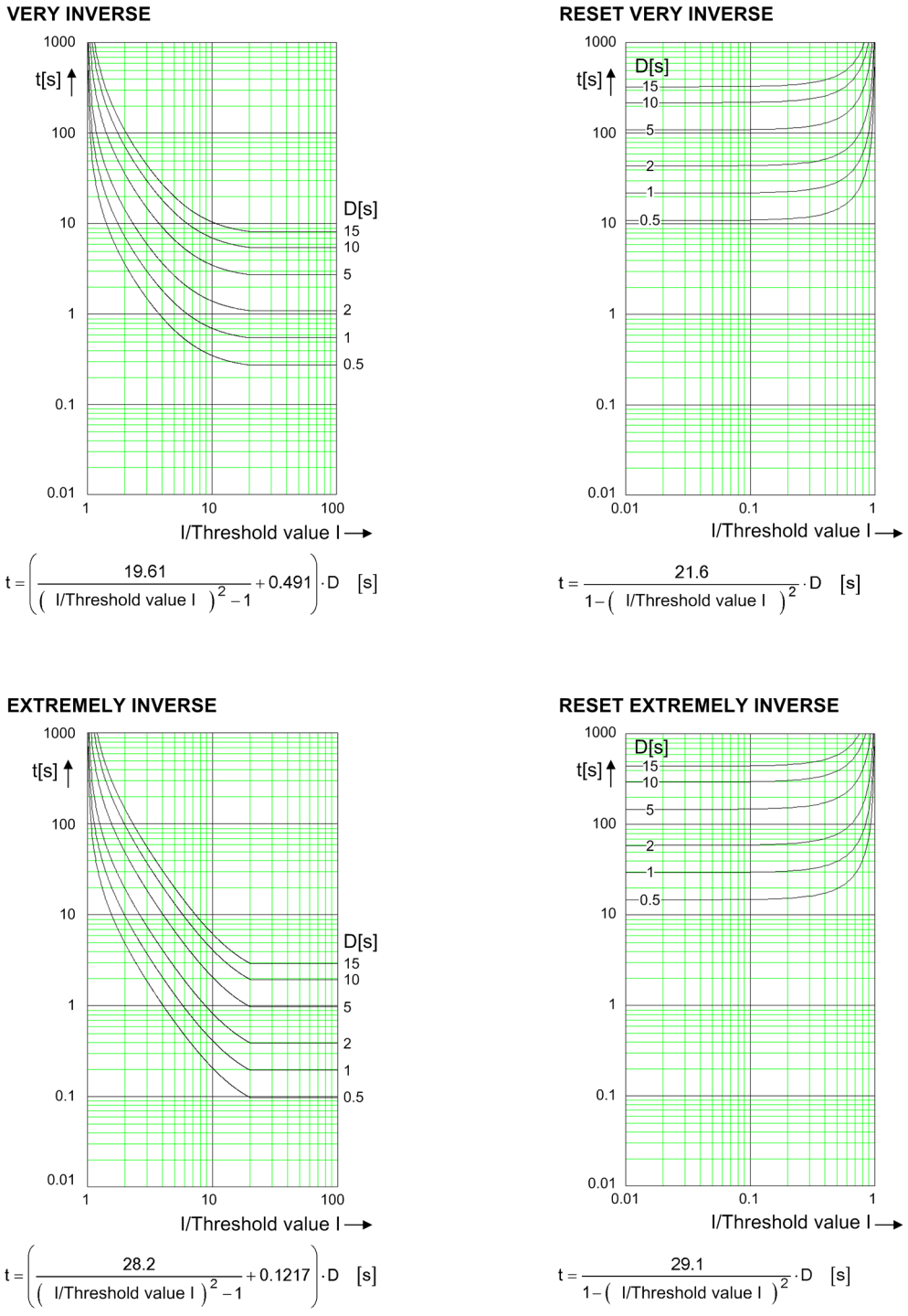
RESET MODERATELY INVERSE



$$t = \frac{4.85}{1 - \left(\text{I/Threshold value I} \right)^{2}} \cdot D \quad [s]$$

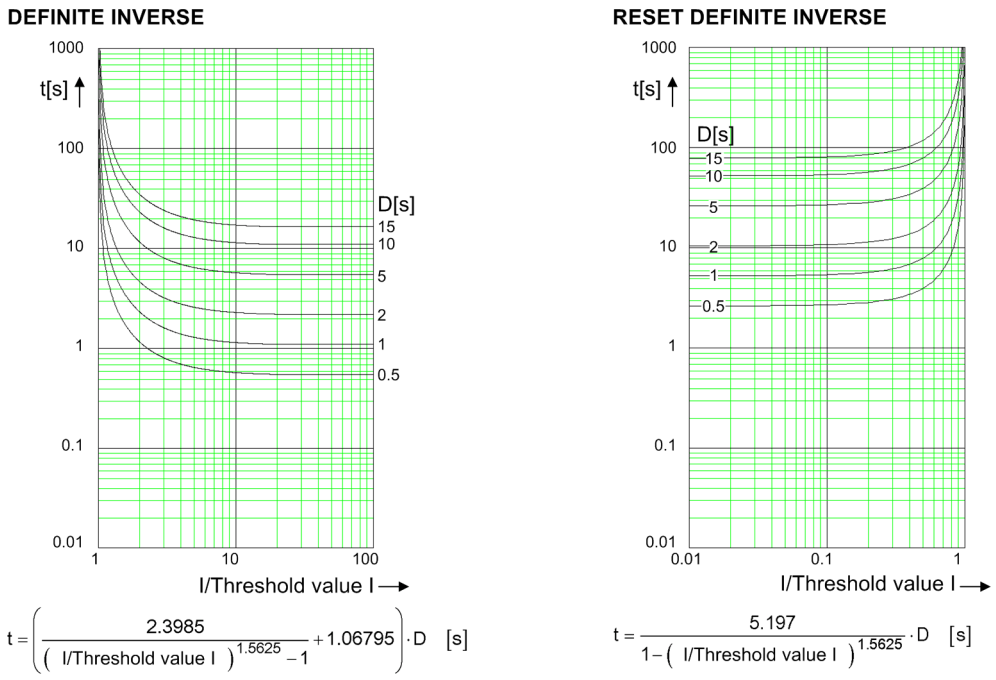
[dw_ocp_ka2, 2, en_US]

Figure 12-14 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE



[dw_ocp_ka3, 2, en_US]

Figure 12-15 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE



Note: IGnd threshold stands for ground fault instead ot the I threshold.

[dw_ocp_ka4, 2, en_US]

Figure 12-16 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

NOTE

In the preceding operate curves according to IEC and ANSI/IEEE, the inverse-time delays for **I/Threshold value I** > 20 are identical to the inverse-time delay for **I/Threshold value I** = 20.

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value, no filter applied (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)

Currents, method of measurement = RMS value with filter for the compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	2 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[118] (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1.5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A) [119]
Up to 50th harmonic, f_{rated} = 50 Hz	3% of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A) [120]
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A) [120]
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.18.3 Stage with User-Defined Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

118 In case that the filter response exactly matches the user-defined gain factors

119 In case that the user-defined gain factor is set below 3. The tolerance increases, if the gain factor is larger.

120 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 40.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 200.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Absolute pickup value	1 A @ 50 and 100 Irated	0.000 A to 40.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.00 A to 200.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.000 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.000 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.00 p.u. to 20.00 p.u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value or 95 % of the absolute pickup value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value, no filter applied (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value with filter for the compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	2 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[121] (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1.5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A) [122]
Up to 50th harmonic, f_{rated} = 50 Hz	3% of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A) [123]
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A) [124]
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

121 In case that the filter response exactly matches the user-defined gain factors

122 In case that the user-defined gain factor is set below 3. The tolerance increases, if the gain factor is larger.

123 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

124 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

12.19 Overcurrent Protection, Ground

12.19.1 Stage with Definite-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[125]	1 A @ 50 and 100 Irated	0.010 A to 40.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.05 A to 200.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.002 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	5 mA sec. (I_{rated} = 1 A) or 25 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[126] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

125 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

126 OOT (Output Operating Time): additional delay of the output medium used, see *12.1.4 Relay Outputs*

Tolerances

3I0 measured via I4[127], method of measurement = fundamental component		1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
3I0 measured via I4[128], method of measurement = RMS value (33 % harmonics, in relation to fundamental component)		
Up to 30th harmonic		1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz		3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz		4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Pickup delay		1 % of the setting value or 10 ms
Dropout delay		1 % of the setting value or 10 ms
Operate delay for the basic stage		1 % of the setting value or 10 ms
Operate delay for the advanced stage	Operate delay mode = Running dur. DO-delay	1 % of the setting value or 10 ms
	Operate delay mode = Frozen dur. DO-delay	1 % of the reference value or 10 ms (Reference value = Setting value + Frozen time)

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.19.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[129]	1 A @ 50 and 100 Irated	0.010 A to 40.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.05 A to 200.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.002 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.00 to 15.00	Increments of 0.01
Minimum time of the curve		0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

127 Slightly expanded tolerances will occur during the calculation of 3I0, maximum factor of 2

128 Slightly expanded tolerances will occur during the calculation of 3I0, maximum factor of 2

129 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	5 mA sec. (I_{rated} = 1 A) or 25 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Normal inverse: type A	See *Figure 12-10* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*
Very inverse: type B	
Extremely inverse: type C	See *Figure 12-11* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*
Long-time inverse: type B	
Short-time inverse (Only in the advanced stage)	See *Figure 12-12* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*

Operate Curves and Dropout-Time Characteristic Curves according to ANSI/IEEE

Inverse: type C	See *Figure 12-13* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*
Short inverse	
Long inverse	See *Figure 12-14* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*
Moderately inverse	
Very inverse	See *Figure 12-15* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*
Extremely inverse	
Definite inverse	See *Figure 12-16* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

3I0 measured via I4[130], method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
3I0 measured via I4[131], method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)

130 Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

131 Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for 2 ≤ I/threshold value I ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.19.3 Stage with User-Defined Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.010 A to 40.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.05 A to 200.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.002 A to 8.000 A	Increments of 0.001 A
Absolute pickup value	1 A @ 50 and 100 Irated	0.000 A to 40.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.00 A to 200.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.000 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.000 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.00 p.u. to 20.00 p. u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p. u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value or 95 % of the absolute pickup value
Minimum absolute dropout differential	
Protection-class current transformer	5 mA sec. (I_{rated} = 1 A) or 25 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

3I0 measured via I4[132], method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
3I0 measured via I4[133], method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

132 Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

133 Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

12.20 Overcurrent Protection, 1-Phase

12.20.1 Stage with Definite-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[134]	1 A @ 50 and 100 Irated	0.010 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.05 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.002 A to 8.000 A	Increments of 0.001 A
Dropout ratio (fixed)		0.95	–
Time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 15 ms + OOT[135] at 50 Hz Approx. 14 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT at 50 Hz Approx. 17 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

134 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

135 OOT (Output Operating Time): additional delay of the output medium used, see *12.1.4 Relay Outputs*

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A) valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1 A) or 0.5 mA (I_{rated} = 5 A) valid for sensitive current transformers
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.20.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[136]	1 A @ 50 and 100 Irated	0.010 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.05 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.002 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

136 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

For more information about the operate curves and dropout characteristic curves according to IEC, refer to *12.18.2 Stage with Inverse-Time Characteristic Curve*.

Operate Curves and Dropout Characteristic Curves According to ANSI/IEEE

For more information about the operate curves and dropout characteristic curves according to ANSI/IEEE, refer to *12.18.2 Stage with Inverse-Time Characteristic Curve*.

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A) valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1 A) or 0.5 mA (I_{rated} = 5 A) valid for sensitive current transformers
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Operate time for $2 \le I/I$ threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.20.3 Stage with Inverse-Time Overcurrent Protection with Logarithmic-Inverse Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.010 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.050 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.002 A to 8.000 A	Increments of 0.001 A
Characteristic curve: see *Figure 12-17*			
Threshold value multiplier		1.00 to 4.00	Increments of 0.01
Time dial		0.000 s to 60.000 s	Increments of 0.001 s
Minimum time of the characteristic curve		0.000 s to 60.000 s	Increments of 0.001 s
Maximum time of the characteristic curve		0.000 s to 60.000 s	Increments of 0.001 s
Additional time delay		0.000 s to 60.000 s	Increments of 0.001 s

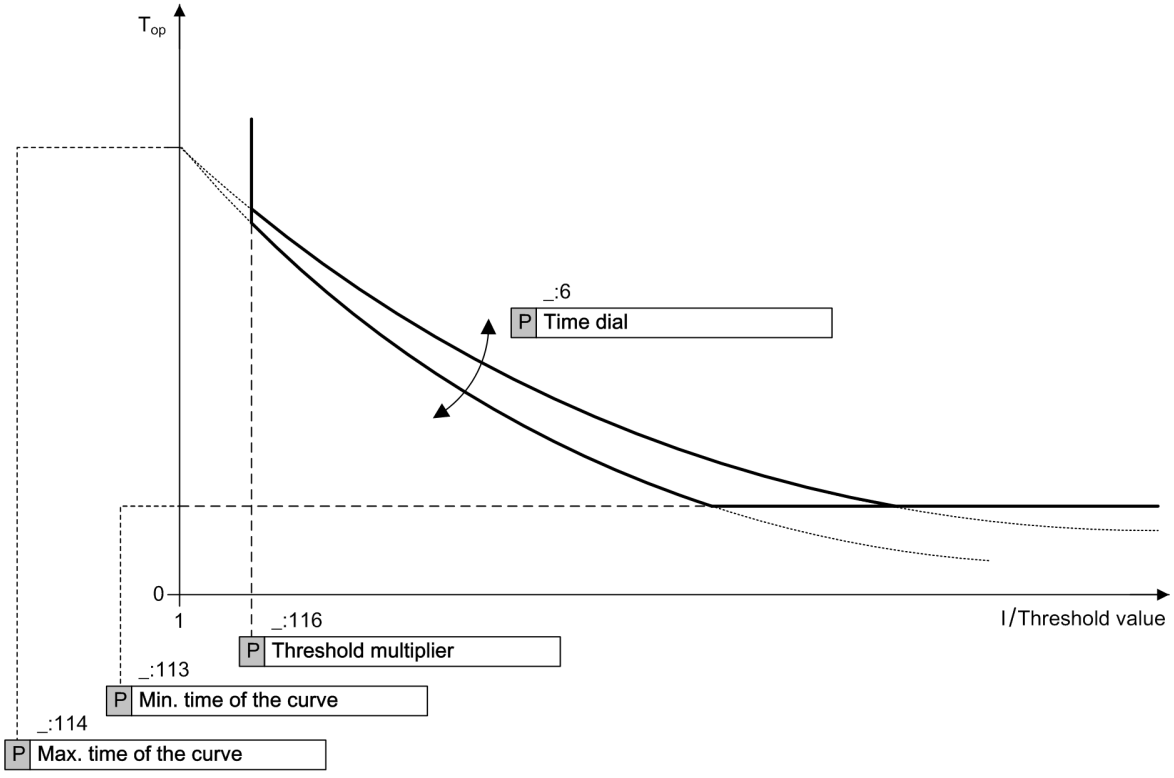


Figure 12-17 Operate Curve of Logarithmic Inverse-Time Characteristic

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 90 Hz	Slightly expanded tolerances
f < 10 Hz f > 90 Hz	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A) valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1 A) or 0.5 mA (I_{rated} = 5 A) valid for sensitive current transformers
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Inverse-time operate time to logarithmic inverse-time characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Inverse-time dropout time to logarithmic inverse-time characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.20.4 Stage with User-Defined Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.010 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.05 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.002 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.00 p.u. to 66.67 p. u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p. u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 90 Hz	Slightly expanded tolerances
f < 10 Hz f > 90 Hz	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A) valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1 A) or 0.5 mA (I_{rated} = 5 A) valid for sensitive current transformers
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

12.21 Overcurrent Protection, 1-Phase (Fast Stage)

Setting Values

Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio (fixed)		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 8 ms + OOT[137]
Dropout time	Approx. 25 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Pickup tolerance, current	5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A)
Time delays	1 % of the setting value or 10 ms

[137] OOT (Output Operating Time): additional time delay of the output medium used, for example, 5 ms with fast relay

12.22 Voltage-Dependent Overcurrent Protection, Phases

Setting Values for All Stage Types

Method of measurement		Fundamental component RMS value	–
Overcurrent threshold value	For I_{rated} = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
Time delay		0.10 s to 60.00 s	Increments of 0.01 s

Setting Values for Inverse-Time Overcurrent Protection Stages

Method of measurement	Fundamental component RMS value	–
Dropout ratio of undervoltage[138]	1.01 to 1.20	Increments of 0.01
Undervoltage threshold value[138]	0.300 V to 175.000 V	Increments of 0.001 V
Dropout	Disk emulation Instantaneous	–
Time multiplier	0.05 to 15.00	Increments of 0.01

Setting Values for Definite-Time Overcurrent Protection Stages

Seal-in voltage	0.300 V to 175.000 V	Increments of 0.001 V
Phase-to-phase voltage	0.300 V to 175.000 V	Increments of 0.001 V
Negative-sequence voltage V2	0.300 V to 200.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Duration of V-seal-in time	0.10 s to 60.00 s	Increments of 0.01 s

Dropout for Inverse-Time Overcurrent Protection Stages

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	
Current	95 % of 1.1 · threshold value
Voltage[138]	105 % of threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer [138]	150 mV sec.

Reset of the Integration Timer for Inverse-Time Overcurrent Protection Stages

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

[138] The value is for the inverse-time overcurrent voltage-released stage.

Dropout for Definite-Time Overcurrent Protection Stages

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Operate Curves and Dropout Characteristic Curves According to IEC

Extension of the operate time during operation with inrush-current detection	Approx. 10 ms

The operate curves and dropout characteristic curves according to IEC can be found in the chapter *Technical Data* under *Inverse-Time Overcurrent Protection*.

Operate Curves and Dropout Characteristic Curves According to ANSI/IEEE

The operate curves and dropout characteristic curves according to IEC can be found in the chapter *Technical Data* under *Inverse-Time Overcurrent Protection*.

Times for Definite-Time Overcurrent Protection Stages

Operate time with time delay = 0 ms, typical	Approx. 25 ms + OOT[139] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Operate time with time delay = 0 ms, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)

[139] OOT (Output Operating Time): additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Voltage	0.5 % of the setting value or 0.05 V
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.23 Directional Overcurrent Protection, Phases

12.23.1 Stage with Definite-Time Characteristic Curve

Setting Values

Rotation angle of the reference voltage		-180° to +180°	Increments of 1°
Directional mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value[140]	1 A @ 50 and 100 Irated	0.030 A to 40.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 200.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Direction Determination

Type	With healthy voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°
Dropout differential forward/reverse range	1°
Directional sensitivity	For 1 and 2-phase short circuits: unlimited For 3-phase short circuits: dynamically unlimited, stationary Approx. 13 V phase-to-phase

140 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT [141] at 50 Hz Approx. 31 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Time delay	1 % of the setting value or 10 ms
Direction-determination angle error	1 °

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.23.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Rotation angle of the reference voltage	-180° to +180°	Increments of 1°
Directional mode	Forward Backward	–
Method of measurement	Fundamental component RMS value	–

[141] OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

Threshold value[142]	1 A @ 50 and 100 Irated	0.030 A to 40.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 200.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.00 to 15.00	Increments of 0.01
Minimum time of the curve		0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Normal inverse: type A	See *Figure 12-10* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*
Very inverse: type B	
Extremely inverse: type C	See *Figure 12-11* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*
Long-time inverse: type B	
Short-time inverse (Only in the advanced stage)	See *Figure 12-12* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*

Operate Curves and Dropout-Time Characteristic Curves according to ANSI/IEEE

Inverse: type C	See *Figure 12-13* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*
Short inverse	
Long inverse	See *Figure 12-14* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*
Moderately inverse	
Very inverse	See *Figure 12-15* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*
Extremely inverse	
Definite inverse	See *Figure 12-16* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*

142 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

Direction Determination

Type	With healthy voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°
Dropout differential forward/reverse range	1°
Directional sensitivity	For 1 and 2-phase short circuits: unlimited For 3-phase short circuits: dynamically unlimited, stationary Approx. 13 V phase-to-phase

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT [143] at 50 Hz Approx. 31 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Operate time for 2 ≤ I/threshold value I ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/threshold value I ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Direction-determination angle error	1°

[143] OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.23.3 Stage with User-Defined Characteristic Curve

Setting Values

Rotation angle of the reference voltage		-180° to +180°	Increments of 1°
Directional mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value[144]	1 A @ 50 and 100 Irated	0.030 A to 40.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 200.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate characteristic curve		2 to 30	Increments of 1
X values of the operate curve		1.00 p.u. to 66.67 p.u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

144 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

Direction Determination

Type	With healthy voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°
Dropout differential forward/reverse range	1°
Directional sensitivity	For 1-phase and 2-phase short circuits: unlimited For 3-phase short circuits stationary: dynamically unlimited Approx. 13 V phase-to-phase

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT [145] at 50 Hz Approx. 31 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Operate time for 2 ≤ I/threshold value I≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Dropout time for I/threshold value I ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Direction-determination angle error	1°

[145] OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.24 Directional Overcurrent Protection, Ground

12.24.1 Stage with Definite-Time Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 40.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 200.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Time delays	1 % of the setting value or 10 ms
Direction-determination angle error	1°

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.24.2 Stage with Inverse-Time Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 40.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 200.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Type of characteristic curve		Characteristic curves according to IEC and ANSI	

Dropout	Disk emulation Instantaneous	–
Time multiplier	0.00 to 15.00	Increments of 0.01
Minimum time of the curve	0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Normal inverse: type A	See *Figure 12-10* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*
Very inverse: type B	
Extremely inverse: type C	See *Figure 12-11* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*
Long-time inverse: type B	
Short-time inverse (Only in the advanced stage)	See *Figure 12-12* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*

Operate Curves and Dropout-Time Characteristic Curves according to ANSI/IEEE

Inverse: type C	See *Figure 12-13* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*
Short inverse	
Long inverse	See *Figure 12-14* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*
Moderately inverse	
Very inverse	See *Figure 12-15* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*
Extremely inverse	
Definite inverse	See *Figure 12-16* in chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.24.3 Stage with Inverse-Time Overcurrent Protection with Logarithmic-Inverse Characteristic Curve

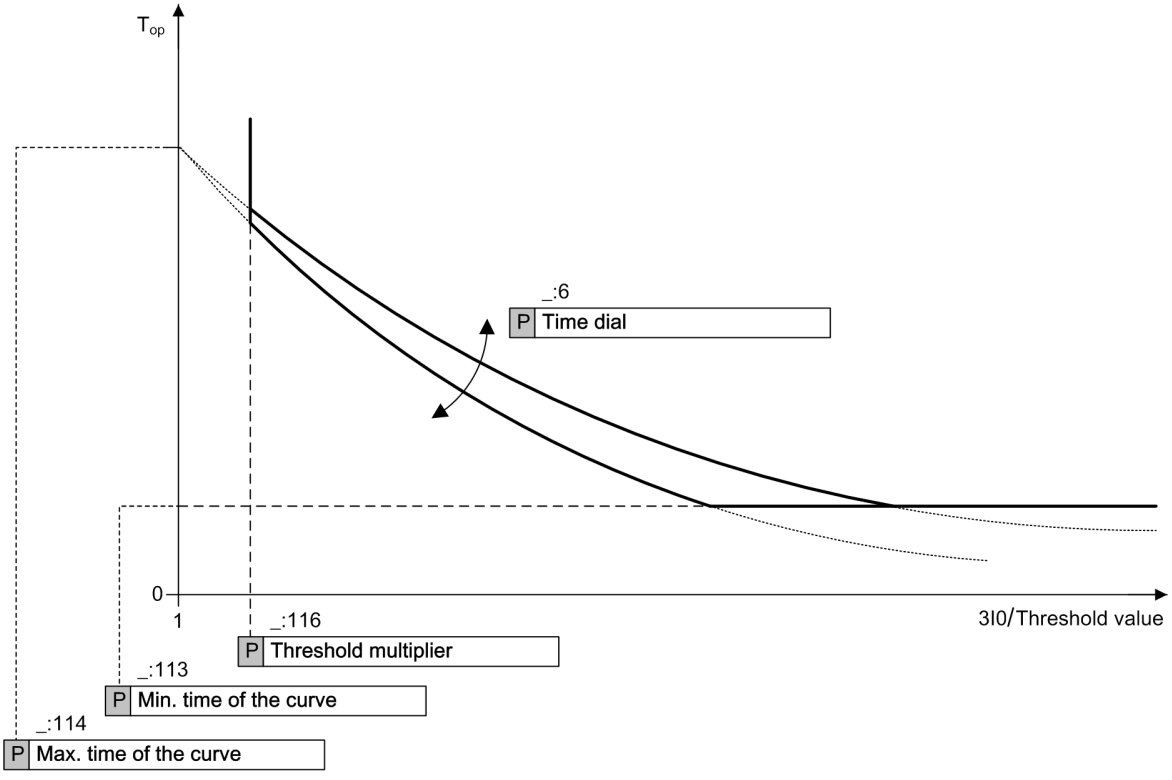
Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode	Forward Reverse	–
Method of measurement	Fundamental component RMS value	–

Threshold value	1 A @ 50 and 100 Irated	0.030 A to 40.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 200.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Characteristic curve: see *Figure 12-18*			
Threshold value multiplier		1.00 to 4.00	Increments of 0.01
Time multiplier		0.000 s to 60.000 s	Increments of 0.001 s
Minimum time of the characteristic curve		0.000 s to 60.000 s	Increments of 0.001 s
Maximum time of the characteristic curve		0.000 s to 60.000 s	Increments of 0.001 s
Additional time delay		0.000 s to 60.000 s	Increments of 0.001 s



[dw_loginv, 3, en_US]

Figure 12-18 Operate Curve of Logarithmic Inverse-Time Characteristic

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Inverse-time operate time to logarithmic inverse-time characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Inverse-time dropout time to logarithmic inverse-time characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

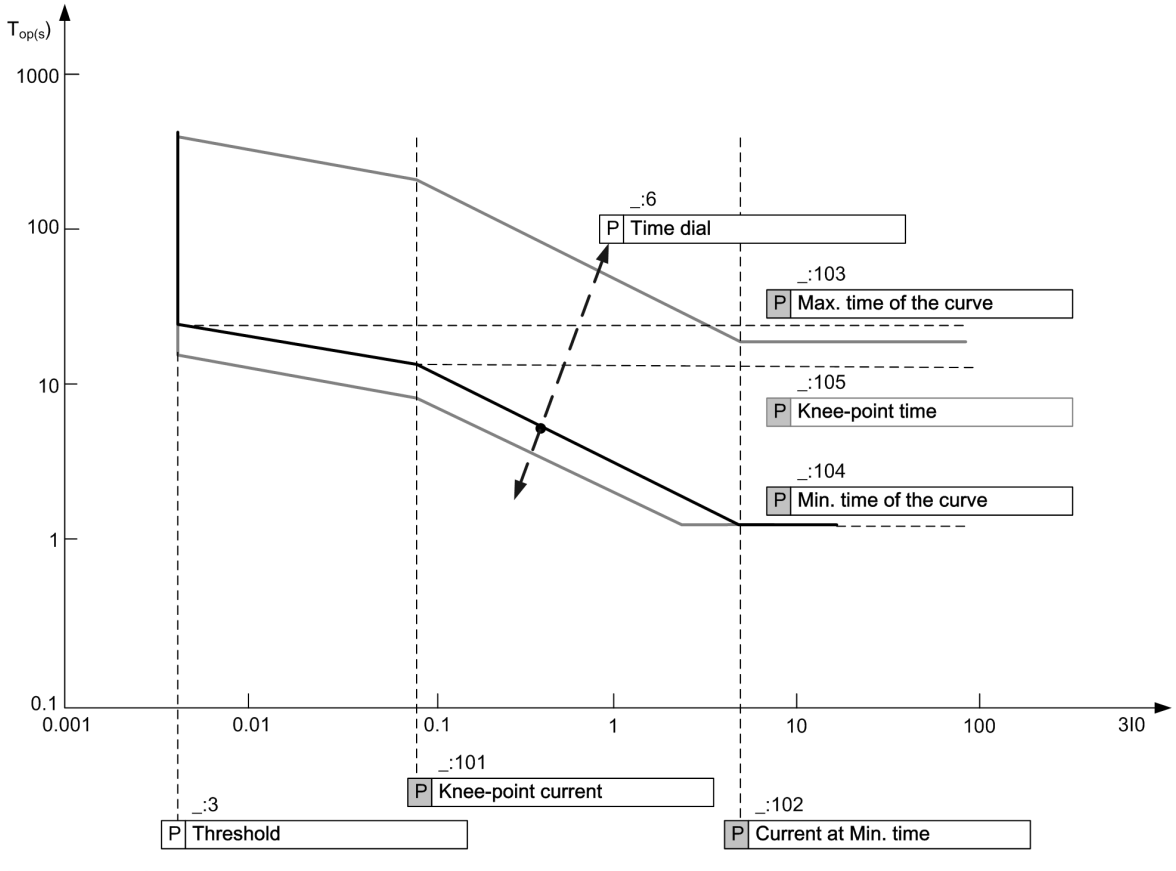
12.24.4 Stage with Knee-Point Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold value	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 40.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 200.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Characteristic curve: see *Figure 12-19*			
Minimum time of the characteristic curve		0.00 s to 30.00 s	Increments of 0.01 s
Knee-point time of the curve		0.00 s to 100.00 s	Increments of 0.01 s
Maximum time of the characteristic curve		0.00 s to 200.00 s	Increments of 0.01 s
Knee-point value		0.030 A to 40.000 A	Increments of 0.001 A
Current at minimum time of the curve		0.030 A to 40.000 A	Increments of 0.001 A
Time multiplier		0.05 to 1.50	Increments of 0.01



[dw_drloinkn_1, en_US]

Figure 12-19 Operate Curve of the Logarithmic Inverse Time with Knee-Point Characteristic (In the Example of **`Threshold = 0.004 A`**)

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Inverse-time operate time to logarithmic inverse time with knee-point characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Inverse-time dropout time to logarithmic inverse time with knee-point characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.24.5 Stage with User-Defined Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 40.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 200.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01
X values of the operate curve		1.00 p. u. to 66.67 p. u.	Increments of 0.01 p. u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p. u. to 0.95 p. u.	Increments of 0.01 p. u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Threshold Values

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.25 Positive-Sequence Overcurrent Protection

12.25.1 Stage with Definite-Time Characteristic Curve

Setting Values for Protection Stage

Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT [146] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Current	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Time delays	1 % of the setting value or 10 ms

[146] OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

12.25.2 Stage with Inverse-Time Characteristic Curve

Setting Values for Protection Stage

Threshold	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Reset		instantaneous disk emulation	–
Time dial		0.00 to 15.00	Increments of 0.01

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate and Dropout Characteristic Curves

You can select from the following operate and dropout characteristic curves:

Table 12-7 Standard Characteristic Curves according to IEC

Normal inverse: type A	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-10*
Very inverse: type B	
Extremely inverse: type C	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-11*
Long-time inverse: type B	

Table 12-8 Standard Characteristic Curves according to ANSI

Inverse: type C	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-13*
Short inverse	
Long inverse	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-14*
Moderately inverse	
Very inverse	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-15*
Extremely inverse	
Definite inverse	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-16*

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT [147] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Current	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Time delays	1 % of the setting value or 10 ms

147 OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

12.26 Negative-Sequence Protection

12.26.1 Stage with Definite-Time Characteristic Curve

Setting Values

Reference value for I_2 (I_{ref})		Rated object current $I_{rated, obj.}$ Positive-sequence current I_1	
Threshold		5.0 % to 999.9 % I_2/I_{ref}	Increments of 0.1
Dropout ratio		0.40 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Release current (minimum current release)	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Maximum phase current (maximum current limiting)	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Dropout for the Threshold

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

- Dropout differential derived from the parameter **`Dropout ratio`**
- Dropout differential of 0.5 % of the object rated current

Dropout for the Release Current

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Pickup time	Approx. 40 ms + OOT[148] at 50 Hz
	Approx. 35 ms + OOT at 60 Hz
Dropout time	Approx. 35 ms + OOT

148 OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Current Operating Range

Current range	At least one phase current ≥ setting value $I_{release}$
	All phase currents ≤ setting value $I_{ph, max}$

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Pickup value	
$I_2/I_{rated, obj}$	Approx. 1% of the setting value or 0.3% of the absolute value
I_2/I_1	Approx. 1 % of the setting value or 0.5 % of the absolute value ($I_1 > 50$ mA ($I_{rated} = 1$ A) or 250 mA ($I_{rated} = 5$ A))
Time delays	1 % of the setting value or 10 ms

12.26.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Reference value for I_2 (I_{ref})		Rated object current $I_{rated,obj.}$ Positive-sequence current I_1	
Threshold		5.0 % to 999.9 % I_2/I_{ref}	Increments of 0.1
Reset		Disk emulation Instantaneous	
Time dial		0.05 to 15.00	Increments of 0.01
Release current (minimum current release)	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Maximum phase current (maximum current limiting)	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Dropout for the Threshold

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

- Dropout of 95 % of 1.1 · threshold value
- Dropout differential of 0.5 % of the object rated current

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Dropout for the Release Current

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Pickup time	Approx. 40 ms + OOT[149] at 50 Hz
	Approx. 35 ms + OOT at 60 Hz
Dropout time	Approx. 35 ms + OOT

Operate and Dropout Characteristic Curves

You can select from the following operate and dropout characteristic curves:

Table 12-9 Standard Characteristic Curves to IEC

Normal inverse: type A	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-10*
Very inverse: type B	
Extremely inverse: type C	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-11*
Long-time inverse: type B	

Table 12-10 Standard Characteristic Curves to ANSI

Inverse: type C	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-13*
Short inverse	
Long inverse	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-14*
Moderately inverse	
Very inverse	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-15*
Extremely inverse	
Definite inverse	See chapter *12.18.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-16*

Extension of the Operating Time

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

[149] OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Current Operating Range

Current range	At least one phase current ≥ setting value $I_{release}$
	All phase currents ≤ setting value $I_{ph, max}$

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Reference value = rated current	
Pickup value	Approx. 1 % of the setting value or 0.3 % of the absolute value
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the setting value or + 2 % of the current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the setting value or + 2 % of the current tolerance or 30 ms
Reference value = pos. seq. current	
Pickup value	Approx. 1 % of the setting value or 0.5 % of the absolute value (I1 > 50 mA (I_{rated} = 1 A) or 250 mA (I_{rated} = 5 A))
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms

12.27 Directional Negative-Sequence Protection with Definite-Time Delay

Setting Values

Directional mode	Forward, backward, non-directional	
Stabilization with phase currents	0 % to 30 %	Increments of 1 %

Threshold value (pickup value) at $I_{N\text{-rated}}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
Threshold value (pickup value) at $I_{N\text{-rated}}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A

Extension time of the blocking after a 1-pole pause	0.00 s to 60.00 s	Increments of 0.01 s

Setting Values for Direction Determination

Minimum negative-sequence system voltage V2		0.150 V to 20.000 V	Increments of 0.001 V
Minimum negative-sequence system current I2	For I_{rated} = 1 A	0.030 A to 10.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 50.00 A	Increments of 0.01 A
Upper limit angle forward, β		0° to 360°	Increments of 1°
Lower limit angle forward, α		0° to 360°	Increments of 1°

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

- Dropout differential derived from the parameter **`Dropout ratio`**
- Dropout differential of 0.5 % of the object rated current

Times

Operate time with time delay = 0 ms	Approx. 40 ms + OOT[150] at 50 Hz Approx. 40 ms + OOT at 60 Hz
Dropout time	Approx. 39 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Threshold values:	
Negative-sequence voltage V2	1 % of the setting value or 0.05 V
Negative-sequence current I2	2 % of the setting value or 10 mA at I_{rated} = 1 A
	1 % of the setting value or 50 mA at I_{rated} = 5 A

[150] OOT (Output Operating Time) Additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Times:	
Independent time delays	1 % of the setting value or 10 ms

Limit angle in determining the direction	1°

12.28 Undercurrent Protection

Setting Values

Method of measurement		fundamental comp. RMS value	–
Threshold value I<	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Pickup delay		0.00 s to 60.00 s	Increments of 0.01 s
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s
Measurement repetition		0 to 10	Increments of 1

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with **`Measurement repetition`** = 0	Approx. 25 ms + OOT[151] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

151 OOT (Output Operating Time): additional delay of the output medium used, for example, 5 ms with fast relays, see chapter Relay Outputs

Tolerances

Currents, method of measurement = fundamental component	1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % portion harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A)
Time delays	1 % of the setting value or 10 ms

12.29 Overexcitation Protection

Setting Values

Threshold value (Inverse-time characteristic curve pickup)		$\frac{V/V_{rated}}{f/f_{rated}}$	1.00 to 1.20	Increments of 0.01
Threshold value (Definite-time characteristic curve pickup)		$\frac{V/V_{rated}}{f/f_{rated}}$	1.00 to 1.40	Increments of 0.01
Time delay (warning delay and tripping delay)			0.00 s to 60.00 s	Increments of 0.01 s
Characteristic value pairs			2 to 30	
	Ranges of values	V/f	1.00 p.u. to 10.00 p.u.	Increments of 0.01 p.u.
		t	0 s to 100 000 s	Increments of 1 s
Cooling time therm. replica			0 s to 100 000 s	Increments of 1 s

Functional Measured Values

Measured Value	Description
(_:2311:322) V/f	Value calculated from voltage and frequency.
(_:13591) Therm.charact.	Thermal tripping of the overexcitation protection. If the value reaches 100 %, tripping occurs.

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Operating Times

Operate times/dropout times		
Operate time at frequency	50 Hz	60 Hz
Minimum	33 ms + OOT[1]	30 ms + OOT[152]
Dropout time	10 ms + OOT[1]	10 ms + OOT[1]

Dropout Ratios

Warning, tripping (independent stage)	Approx. 0.98

Operate Curve

Thermal replica	For default setting refer to the following characteristic curve *Figure 12-20*

Tolerances

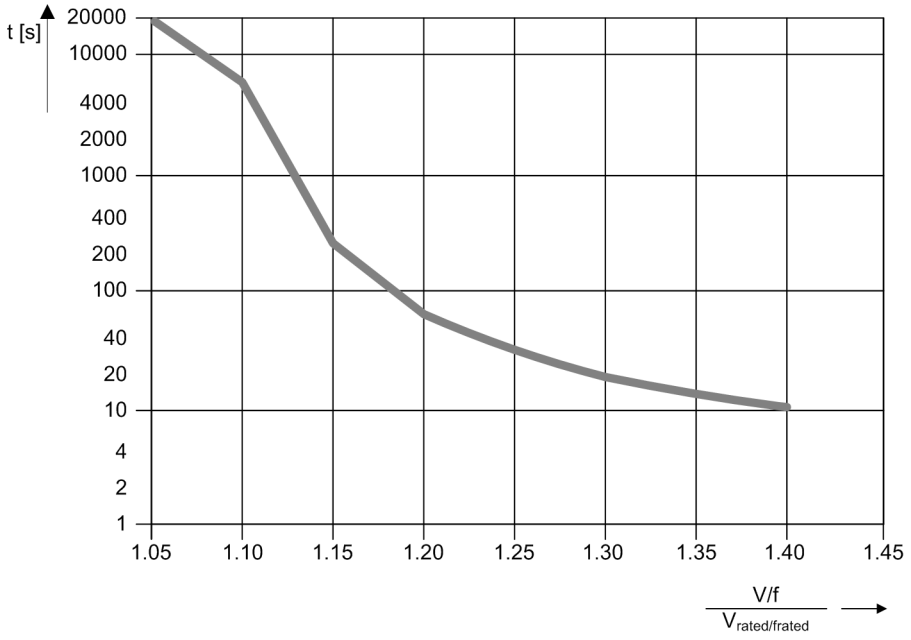
V/f pickup	2 % of the setting value
Time delays	1 % of the setting value or 10 ms (min. 1.5 periods)
Thermal replica	5 % based on V/f ± 600 ms

[152] Refer to protection functions, for example overcurrent protection

Voltage measurement accuracy	0.5 % of the setting value or 0.5 V in the range fn ± 10 %
Frequency measurement accuracy	1.0 % of the setting value or 1.0 Hz in the frequency range 10 Hz to 90 Hz

Influencing Quantities

Auxiliary direct voltage in the 0.8 range	≤ 1 %
Time delays	≤ 0.5 %/10 K
Thermal replica	≤ 1 %
Harmonics	
up to 10 % of 3rd harmonics up to 10 % of 5th harmonics	≤ 1 % ≤ 1 %



[dw_rsasuf, 1, en_US]

Figure 12-20 Operate Curve from the Thermal Replica of the Overexcitation Protection (Default Setting)

12.30 Unbalanced-Load Protection

Setting Values

Maximum continuously perm. I2	3.0 % to 30.0 % $I2/I_{rated,machine}$	Increments of 0.1 %
Unbalanced load factor K	1.0 s to 100.0 s	Increments of 0.1 s
Warning delay	0.0 s to 60.0 s; ∞	Increments of 0.1 s
Cooling time thermal replica	0 s to 50 000 s	Increments of 1 s

Dropout

$I2_{perm} \cdot I_{rated.machine} \leq 10$ mA	Dropout value = $0.5 \cdot I2_{perm} \cdot I_{rated,machine}$
10 mA < $I2_{perm} \cdot I_{rated.machine} \leq 100$ mA	Dropout value = $I2_{perm} \cdot I_{rated,machine}$ - 5 mA
$I2_{perm} \cdot I_{rated.machine} > 100$ mA	Dropout value = $0.95 \cdot I2_{perm} \cdot I_{rated,machine}$

Operate Characteristics

Characteristic of the thermal replica	$t_{I2\,Perm} = \frac{K}{\left(I_2/I_{rated\,,machine}\right)^2}$	
Where:	t_{I2perm}	Permissible application time of the negative-sequence current
	K	Unbalanced load factor K
	$I2/I_{rated,machine}$	Unbalanced load (negative-sequence current/rated current of the machine)

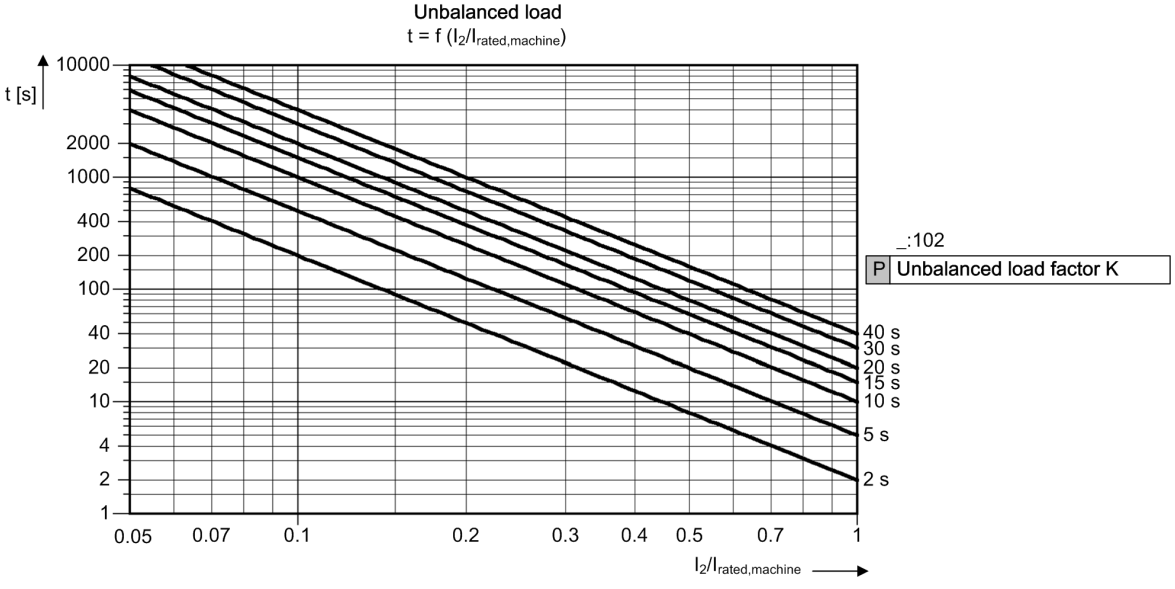


Figure 12-21 Thermal Characteristic for Unbalanced Load Protection

Times

Pickup time of the warning stage	Approx. 60 ms + OOT[153] at 50 Hz Approx. 50 ms + OOT at 60 Hz
Dropout time	Approx. 50 ms or better

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Negative-sequence current I_2	The value can be any of the following: • ≤ 1% of the setting value • 3 mA at I_{rated} = 1 A • 15 mA at I_{rated} = 5 A
Warning delay	1 % of the setting value or 10 ms
Time for $I2/I2_{perm} \leq 10$	< (5 % of the reference value + 2 % of the current tolerance) or 100 ms

Influencing Variables for the Thresholds

Harmonics	
– Up to 10 % 3rd harmonic	≤ 1 %
– Up to 10 % 5th harmonic	≤ 1 %

[153] OOT (Output Operating Time): additional delay of the output medium used, for example, 5 ms with fast relays

12.31 Instantaneous High-Current Tripping

Setting Values

Threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 50 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio	0.50 to 0.90	Increments of 0.01	

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time for current > 2 · √2· threshold value	Approx. 8 ms + OOT[154]

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Response tolerance, current	5 % of the setting value or 10 mA at I_{rated} = 1 A 5 % of the setting value or 50 mA at I_{rated} = 5 A
Time delays	1 % of the setting value or 10 ms

[154] OOT (Output Operating Time) Additional delay of the output medium used, see *12.1.4 Relay Outputs*

12.32 Overvoltage Protection with 3-Phase Voltage

Setting Values for the Function

Stabilization counter	0 to 10	Increments of 1

Setting Values for Stage Type Definite-Time Overvoltage Protection

Measured value	Phase-to-phase Phase-to-ground	
Method of measurement	Fundamental component RMS value	
Pickup mode	1 out of 3 3 out of 3	
Pickup value[155]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 300.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Setting Values for Stage Type Inverse-Time Overvoltage Protection

Measured value	Phase-to-phase Phase-to-ground	
Method of measurement	Fundamental component RMS value	
Pickup mode	1 out of 3 3 out of 3	
Pickup value	0.300 V to 340.000 V	Increments of 0.001 V
Pickup factor	1.00 to 1.20	Increments of 0.01
Characteristic constant k	0.00 to 300.00	Increments of 0.01
Characteristic constant α	0.010 to 5.000	Increments of 0.001
Characteristic constant c	0.000 to 5.000	Increments of 0.001
Time multiplier	0.05 to 15.00	Increments of 0.01
Additional time delay	0.00 s to 60.00 s	Increments of 0.01 s
Reset time	0.00 s to 60.00 s	Increments of 0.01 s

Operate Curve for Stage Type Inverse-Time Overvoltage Protection

$$T_{op} = T_{inv} + T_{add}$$

Where

T_{op} Operate delay

T_{inv} Inverse-time delay

T_{add} Additional time delay (parameter **`Additional time delay`**)

$$T_{inv} = T_p \left(\frac{k}{\left(\frac{V}{V_{thresh}}\right)^{\alpha} - 1} + c \right) [s]$$

[155] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.

Where

T_{inv}	Inverse-time delay
T_p	Time multiplier (parameter **Time dial**)
V	Measured voltage
V_{thresh}	Threshold value (parameter **Threshold**)
k	Curve constant k (parameter **Charact. constant k**)
α	Curve constant α (parameter **Charact. constant α**)
c	Curve constant c (parameter **Charact. constant c**)

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms, typical	Approx. 25 ms + OOT[156] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Operate time with time delay = 0 ms, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances for Stage Type Definite-Time Overvoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

Tolerances for Stage Type Inverse-Time Overvoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Operate time for 1.2 ≤ V/V threshold value ≤ 20	5 % of the setting value or 30 ms
Reset time delay	1 % of the setting value or 10 ms

[156] OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.33 Overvoltage Protection with Positive-Sequence Voltage

Setting Values

Pickup value	0.300 V to 200.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms, typical	Approx. 25 ms + OOT[157] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Operate time with time delay = 0 ms, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

[157] OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.34 Overvoltage Protection with Negative-Sequence Voltage

Setting Values for the Function

Measuring window	1 cycle to 10 cycles	Increments of 1 cycle

Setting Values

Pickup value of V2	0.300 V to 200.000 V	Increments of 0.001 V
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup times	55 ms to 210 ms + OOT [158] (depends on the measuring-window length) at 50 Hz 48 ms to 185 ms + OOT (depends on the measuring-window length) at 60 Hz
Dropout time	20 ms to 70 ms + OOT (depends on the measuring-window length)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Voltages	0.50 % of the setting value or 0.050 V
Time delays	1.00 % of the setting value or 10 ms

[158] OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

12.35 Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage

Setting Values for the Function

Measuring window	1 cycle to 10 cycles	Increments of 1 cycle
Minimum voltage V1	0.300 V to 60.000 V	Increments of 0.001 V

Setting Values for Stage Types

Pickup value of V2/V1	0.50 % to 100.00 %	Increments of 0.01 %
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup times	55 ms to 210 ms + OOT[159] (depends on the measuring-window length) at 50 Hz 48 ms to 190 ms + OOT (depends on the measuring-window length) at 60 Hz
Dropout times	22 ms to 55 ms + OOT (depends on the measuring-window length) at 50 Hz 18 ms to 45 ms + OOT (depends on the measuring-window length) at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Voltages	0.50 % of the setting value or 0.050 V
Time delays	1.00 % of the setting value or 10 ms

[159] OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

12.36 Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage

Setting Values for Stage Type Definite-Time Overvoltage Protection

Method of measurement	fundamental comp. fund. comp. long filter RMS value	
Blk. by meas.-volt. failure	no yes	
Detection of faulty phase	no yes	
Threshold[160]	0.300 V to 200.000 V	Increments of 0.001 V
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s
Pickup delay	0.00 s to 320.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01
V< faulty ph-to-gnd volt.	0.300 V to 200.000 V	Increments of 0.001 V
V> healthy ph-to-gnd volt.	0.300 V to 200.000 V	Increments of 0.001 V

Setting Values for Stage Type Inverse-Time Overvoltage Protection

Method of measurement	fundamental comp. fund. comp. long filter RMS value	
Blk. by meas.-volt. failure	no yes	
Detection of faulty phase	no yes	
Threshold[160]	0.300 V to 200.000 V	Increments of 0.001 V
Pickup factor	1.00 to 1.20	Increments of 0.01
Charact. constant k	0.00 to 300.00	Increments of 0.01
Charact. constant α	0.010 to 5.000	Increments of 0.001
Charact. constant c	0.000 to 5.000	Increments of 0.001
Time dial	0.05 to 15.00	Increments of 0.01
Additional time delay	0.00 s to 60.00 s	Increments of 0.01 s
Reset time	0.00 s to 60.00 s	Increments of 0.01 s
V< faulty ph-to-gnd volt.	0.300 V to 200.000 V	Increments of 0.001 V
V> healthy ph-to-gnd volt.	0.300 V to 200.000 V	Increments of 0.001 V

Operate Curve for Stage Type Inverse-Time Overvoltage Protection

$$T_{op} = T_{inv} + T_{add}$$

Where

T_{op} Operate delay

T_{inv} Inverse-time delay

T_{add} Additional time delay (parameter **`Additional time delay`**)

[160] If you have selected the **Method of measurement** = **RMS value**, do not set the threshold value under 10 V.

$$T_{inv} = T_p \left(\frac{k}{\left(\frac{V}{V_{thresh}}\right)^{\alpha} - 1} + c \right) [s]$$

Where

T_{inv}	Inverse-time delay
T_p	Time multiplier (parameter **`Time dial`**)
V	Zero-sequence voltage
V_{thresh}	Threshold value (parameter **`Threshold`**)
k	Curve constant k (parameter **`Charact. constant k`**)
α	Curve constant α (parameter **`Charact. constant α`**)
c	Curve constant c (parameter **`Charact. constant c`**)

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	
Standard filter, true RMS value, typical	Approx. 25 ms + OOT[161] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Standard filter, true RMS value, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz
2 cycle filters, typical	Approx. 40 ms + OOT at 50 Hz Approx. 35 ms + OOT at 60 Hz
2 cycle filters, maximum	Approx. 45 ms + OOT at 50 Hz Approx. 40 ms + OOT at 60 Hz
Dropout time	
Standard filter, true RMS value, typical	Approx. 20 ms + OOT at 50 Hz Approx. 17 ms + OOT at 60 Hz
Standard filter, true RMS value, maximum	Approx. 25 ms + OOT at 50 Hz Approx. 20 ms + OOT at 60 Hz
2 cycle filters, typical	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
2 cycle filters, maximum	Approx. 35 ms + OOT at 50 Hz Approx. 30 ms + OOT at 60 Hz

[161] OOT (Output Operating Time): additional delay of the output medium used, see *12.1.4 Relay Outputs*

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances for Stage Type Definite-Time Overvoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

Tolerances for Stage Type Inverse-Time Overvoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Operate time for $1.2 \leq V/V$ threshold value ≤ 20	5 % of the setting value or 30 ms
Reset time delay	1 % of the setting value or 10 ms

12.37 Overvoltage Protection with Any Voltage

Setting Values

Measured value[162]	Measured phase-to-ground voltage V_A Measured phase-to-ground voltage V_B Measured phase-to-ground voltage V_C Measured phase-to-phase voltage V_{AB} Measured phase-to-phase voltage V_{BC} Measured phase-to-phase voltage V_{CA} Measured phase-to-phase voltage V_{AB} Measured phase-to-phase voltage V_{BC} Measured phase-to-phase voltage V_{CA} Calculated voltage V0	
Method of measurement	Fundamental component RMS value	
Pickup value[163]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms, typical	Approx. 25 ms + OOT[164] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Operate time with time delay = 0 ms, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

162 If the function **Overvoltage protection with any voltage** is used in a 1-phase function group, the measured-value parameter is not visible.

163 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.

164 OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

12.38 Undervoltage Protection with 3-Phase Voltage

Setting Values for the Function

Stabilization counter	0 to 10	Increments of 1

Setting Values for Stage Type Definite-Time Undervoltage Protection

Measured value		Phase-to-phase Phase-to-ground	
Method of measurement		Fundamental component RMS value	
Current-flow criterion		On Off	
Threshold value I>	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold value[165]		0.300 V to 175.000 V	Increments of 0.001 V
Time delay		0.00 s to 300.00 s	Increments of 0.01 s
Dropout ratio		1.01 to 1.20	Increments of 0.01

Setting Values for Stage Type Inverse-Time Undervoltage Protection

Measured value		Phase-to-phase Phase-to-ground	
Method of measurement		Fundamental component RMS value	
Current-flow criterion		On Off	
Threshold value I>	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold		0.300 V to 175.000 V	Increments of 0.001 V
Pickup factor		0.80 to 1.00	Increments of 0.01
Characteristic constant k		0.00 to 300.00	Increments of 0.01
Characteristic constant α		0.010 to 5.000	Increments of 0.001
Characteristic constant c		0.000 to 5.000	Increments of 0.001
Time multiplier		0.05 to 15.00	Increments of 0.01
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s
Reset time		0.00 s to 60.00 s	Increments of 0.01 s

Operate Curve

$T_{op}=T_{Inv}+T_{add}$

Where:

T_{op} Operate delay

[165] If you have selected the **Method of measurement** = **RMS value**, do not set the threshold value under 10 V.

T_{Inv} Inverse-time delay

T_{add} Additional time delay (parameter **Additional time delay**)

$$T_{Inv} = T_p \left(\frac{k}{1 - \left(\frac{V}{V_{Thresh}} \right)^{\alpha}} + c \right) [s]$$

[fo_uvp_3ph_inverse, 2, en_US]

Where

T_{Inv} Inverse-time delay

T_p Time multiplier (parameter **Time dial**)

V Measured undervoltage

V_{Thresh} Threshold value (parameter **Threshold**)

k Curve constant k (parameter **Charact. constant k**)

α Curve constant α (parameter **Charact. constant α**)

c Curve constant c (parameter **Charact. constant c**)

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms, typical	Approx. 25 ms + OOT[166] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Operate time with time delay = 0 ms, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10 \text{ Hz} \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90 \text{ Hz}$	Slightly expanded tolerances
$f < 10 \text{ Hz}$ $f > 90 \text{ Hz}$	Inactive, maintained; Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

[166] OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Tolerances for Stage Type Definite-Time Undervoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1 A) or 0.5 mA (I_{rated} = 5 A), valid for instrument transformers
Time delays	1 % of the setting value or 10 ms

Tolerances for Stage Type Inverse-Time Undervoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1 A) or 0.5 mA (I_{rated} = 5 A), valid for instrument transformers
Operate time for $0 < V/V_{Thresh} < 0.9$	5 % of the setting value or 30 ms
Reset time delay	1 % of the setting value or 10 ms

12.39 Undervoltage Protection with Positive-Sequence Voltage

Setting Values

Threshold value		0.300 V to 200.000 V	Increments of 0.001 V
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio		1.01 to 1.20	Increments of 0.01
Current-flow criterion		On Off	
Threshold value I>	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms, typical	Approx. 25 ms + OOT[167] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Operate time with time delay = 0 ms, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive, maintained; Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

[167] OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1 A) or 0.5 mA (I_{rated} = 5 A), valid for instrument transformers
Time delays	1 % of the setting value or 10 ms

12.40 Undervoltage Protection with Any Voltage

Setting Values

Measured value	Measured phase-to-ground voltage V_A Measured phase-to-ground voltage V_B Measured phase-to-ground voltage V_C Measured phase-to-phase voltage V_{AB} Measured phase-to-phase voltage V_{BC} Measured phase-to-phase voltage V_{CA} Calculated phase-to-phase voltage V_{AB} Calculated phase-to-phase voltage V_{BC} Calculated phase-to-phase voltage V_{CA} Calculated voltage V0	
Method of measurement	Fundamental component RMS value	
Threshold value[168]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	1.01 to 1.20	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms, typical	Approx. 25 ms + OOT[169] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Operate time with time delay = 0 ms, maximum	Approx. 30 ms + OOT at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time, typical	Approx. 25 ms + OOT
Dropout time, maximum	Approx. 30 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive, maintained; Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

168 If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.

169 OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

12.41 Rate-of-Voltage-Change Protection

Setting Value for the Function

Measuring window	2 periods to 50 periods	Increments of 1 period

Setting Values for Stage Types

dV/second	0.500 V to 200.000 V	Increments of 0.001 V
Dropout delay	0.00 s to 60.00 s	Increments of 0.01 s
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The larger dropout differential (= **`| pickup value - dropout threshold |`**) of the following 2 criteria is used:	
Dropout differential derived from `Dropout ratio`	90 % for the **`dV/second`** parameter
Minimum absolute dropout differential	0.15 V per second

Times

Pickup time	• At 50 Hz: Pickup time = Measuring window + 120 ms + OOT[170] Max. 220 ms + OOT with the default measuring window of 5 periods • At 60 Hz: Pickup time = Measuring window + 100 ms + OOT Max. 183.3 ms + OOT with the default measuring window of 5 periods
Dropout time	• At 50 Hz: Dropout time = Measuring window + 120 ms + OOT Max. 220 ms + OOT with the default measuring window of 5 periods • At 60 Hz: Dropout time = Measuring window + 100 ms + OOT Max. 183.3 ms + OOT with the default measuring window of 5 periods

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

170 OOT (Output Operating Time): Additional delay of the output medium used, for example, 5 ms with fast relays, see chapter *12.1.4 Relay Outputs*

Tolerances

Threshold	1 % of the setting value or 0.05 V/s with a measuring window ≥ 5 periods For a measuring window < 5 periods, a slightly expanded tolerance results.
Time delays	1 % of the setting value or 10 ms

Functional Measured Value

Value	Description
dV/s	Calculated voltage change per second

12.42 Undervoltage-Controlled Reactive-Power Protection

Setting Values

Threshold value	Power Q	1.00 % to 200.00 %	Increments of 0.01 %
	Voltage of protection stage	3.000 to 175.000	Increments of 0.001 V
	Voltage of reclosure stage	3.000 V to 340.000 V	Increments of 0.001 V
Current I_1 release threshold value	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s
Release time delay of reclosure stage		0.00 s to 3600.00 s	Increments of 0.01 s

Dropout Ratio

Protection stage	
Reactive-power flow Q	Approx. 0.95
Voltage	Approx. 1.02
Release current	Approx. 0.95

Reclosure stage	
Voltage	Approx. 0.98
Release current	Approx. 0.95

Times

Pickup time	Approx. 55 ms + OOT[171] at 50 Hz Approx. 45 ms + OOT at 60 Hz
Dropout time	Approx. 55 ms + OOT at 50 Hz Approx. 45 ms + OOT at 60 Hz

Tolerances

Current I_1	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Voltage	0.5 % of the setting value or 0.05 V
Power Q	0.5 % S_{rated} ± 3 % of the setting value (S_{rated}: rated apparent power)
Time delays	1 % of the setting value or 10 ms
Reclosure time delay	1 % of the setting value or 10 ms

[171] OOT (Output Operating Time): additional delay of the output medium used, for example 5 ms with fast relays

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

12.43 Voltage-Comparison Supervision

Times

Alarm times	Approx. 3 ms to 12 ms + OOT [172]at 50 Hz Approx. 2.5 ms to 10 ms + OOT at 60 Hz
Dropout time	20 ms

Frequency Operating Range

10 Hz ≤ f ≤ 90 Hz	According to specified tolerances
f < 10 Hz	Inactive
f > 90 Hz	

Tolerances

Pickup threshold	
Voltage	0.5 % of the setting value or 0.05 V

[172] OOT (Output Operating Time): extra delay of the output medium used

12.44 Fault Locator

Setting Values

You can find the following settings in the line data of the **Line** protection function group: • Reactance per unit length of the line per kilometer or per mile • Line length for the correct output of the fault distance as a percentage of the line length • Residual compensation factors in the setting format Kr and Kx or K0 and angle (K0)	
Parallel-line compensation (optional)	For connection and disconnection
Consideration of the load current in the case of 1-phase ground faults	Correction of the X value, for connection and disconnection

Fault Distance

Output of the fault distance (line length)	In Ω primary In km, miles or in percent [173]

Tolerances

Measuring tolerances during sinusoidal measurands and error duration > 25 ms at 60 Hz or > 30 ms at 50 Hz	1.5 % from fault location at $V_K/V_{rated} \geq 0.01$ and one of the following scenarios: • Metal fault • Non-metal fault during single-side infeed without load

[173] The output of the fault distance in km, miles and percent presupposes a homogeneous line.

12.45 Fault Locator Plus

Setting Values

• Cb per length unit, C0 per length unit, and X per length unit of the line per kilometer or per mile • Line angle in ° • Line length for the correct output of the fault distance in km or miles and percent of the line length • The residual compensation factors in the setting format Kr and Kx or K0 and angle (K0)	
Parallel-line compensation (optional), only with instantiation of the function in the FG **line**	For connection or disconnection
Consideration of the load current in the case of 1-phase ground faults	Correction of the X value, for connection and disconnection

Output Values

Output of the fault distance (line length), for non-homogeneous lines with indication of the line section	In km, miles, or percent
Output of the fault resistance, fault contact resistance, and fault reactance	In Ω primary and secondary

Tolerances

Measuring tolerances during sinusoidal measurands and fault duration > 25 ms at 60 Hz or > 30 ms at 50 Hz	1.5 % from fault location[174] with $V_K/V_{rated} \geq 0.01$ and $I_F/I_{rated} \geq 0.1$

[174] Tolerance referenced to the total line length

12.46 Overfrequency Protection

Setting Values

Pickup values f>	Angle difference method	
	40.00 Hz to 90.00 Hz	Increments of 0.01 Hz
	Filtering method	
	40.00 Hz to 70.00 Hz	Increments of 0.01 Hz
Dropout differential	20 mHz to 2 000 mHz	Increments of 10 mHz
Time delay T	0.00 s to 600.00 s	Increments of 0.01 s
Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V

Times

Pickup times f>	Angle difference method	
	50 Hz 60 Hz	Approx. 70 ms + OOT[175] Approx. 60 ms + OOT
	Filtering method	
	50 Hz 60 Hz	Approx. 79 ms + OOT Approx. 65 ms + OOT
Dropout times f>	60 ms to 80 ms	

Dropout

The larger dropout differential (= **| pickup value – dropout threshold |**) of the following 2 criteria is used:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not present, a dropout ratio of 99.97 % applies to the overfrequency protection.	
Minimum absolute dropout differential	5 mHz

Operating Ranges

Voltage range	5 V to 230 V (phase-phase)	
Frequency range	Angle difference method	10 Hz to 90 Hz
	Filtering method	25 Hz to 80 Hz

Tolerances

Frequency f>	
f_{rated} - 0.20 Hz < f < f_{rated} + 0.20 Hz	± 5 mHz at V = V_{rated}
f_{rated} - 3.0 Hz < f < f_{rated} + 3.0 Hz	± 10 mHz at V = V_{rated}
Time delay T(f>)	1 % of the setting value or 10 ms
Minimum voltage	1 % of the setting value or 0.5 V

[175] OOT (Output Operating Time): Additional delay of the output medium used, for example, 5 ms with fast relays, see chapter *12.1.4 Relay Outputs*

12.47 Underfrequency Protection

Setting Values

Pickup values f<	30.00 Hz to 70.00 Hz	Increments of 0.01 Hz
Dropout differential	20 mHz to 2 000 mHz	Increments of 10 mHz
Time delay T	0.00 s to 600.00 s	Increments of 0.01 s
Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V

Times

Pickup times f<	Angle difference method	
	50 Hz 60 Hz	Approx. 70 ms + OOT[176] Approx. 60 ms + OOT
	Filtering method	
	50 Hz 60 Hz	Approx. 75 ms + OOT Approx. 64 ms + OOT
Dropout times f<	60 ms to 80 ms	

Dropout

The larger dropout differential (= **`| pickup value – dropout threshold |`**) of the following 2 criteria is used:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not present, a dropout ratio of 100.03 % applies to the underfrequency protection.	
Minimum absolute dropout differential	5 mHz

Operating Ranges

Voltage range	5 V to 230 V (phase-phase)	
Frequency range	Angle difference method	10 Hz to 90 Hz
	Filtering method	25 Hz to 80 Hz

Tolerances

Frequency f<	
f_{rated} - 0.20 Hz < f < f_{rated} + 0.20 Hz	± 5 mHz at V = V_{rated}
f_{rated} - 3.0 Hz < f < f_{rated} + 3.0 Hz	± 10 mHz at V = V_{rated}
Time delay T(f<)	1 % of the setting value or 10 ms
Minimum voltage	1 % of the setting value or 0.5 V

176 OOT (Output Operating Time): Additional delay of the output medium used, for example, 5 ms with fast relays, see chapter *12.1.4 Relay Outputs*

12.48 Underfrequency Load Shedding

Setting Values for the Function

Minimum voltage	0.300 p.u. to 0.900 p.u.	Increments of 0.001 p.u.
Minimum current	0.020 p.u. to 0.200 p.u.	Increments of 0.001 p.u.
Power angle	-30° to 30°	Increments of 1°
Positive power direction	inv. to CT neu.pnt sett. acc. to CT neu.pnt sett.	
Threshold value for the df/dt-rising rate or df/dt-falling rate	0.1 Hz/s to 20.0 Hz/s	Increments of 0.1 Hz/s
df/dt measuring window	2 periods to 5 periods	Increments of 1 period
df/dt dropout differential	0.02 Hz/s to 0.99 Hz/s	Increments of 0.10 Hz/s
f < stabilization counter	1 to 20	Increments of 1

Setting Values for the Stage

Pickup threshold	40.00 Hz to 70.00 Hz	Increments of 0.01 Hz
Dropout differential	20 mHz to 2000 mHz	Increments of 10 mHz
Time delay	0.00 s to 60.00 s	Increments of 0.01 s

Times

Pickup times with stabilization counter = 6	Approx. 85 ms + OOT[177] at 50 Hz Approx. 80 ms + OOT at 60 Hz
Dropout time	Approx. 80 ms + OOT at 50 Hz Approx. 75 ms + OOT at 60 Hz

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	
Frequency	0.01 Hz
df/dt-rising rate and df/dt-falling rate	0.1 Hz/s
Voltage V1	105 % of the threshold value
Current I1	105 % of the threshold value at φ ≤ 0 95.23 % of the threshold value at φ > 0
Power angle	1°
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Tolerances

Frequency f<	
f_{rated} - 0.20 Hz < f < f_{rated} + 0.20 Hz	± 5 mHz at V = V_{rated}

[177] OOT (Output Operating Time): additional time delay of the output medium used, for example, 5 ms with fast relay

f_{rated} - 3.0 Hz < f < f_{rated} + 3.0 Hz	± 10 mHz at V = V_{rated}
df/dt, measuring window > 3 periods	Approx. 3 % or 0.06 Hz/s
df/dt, measuring window ≤ 3 periods	Approx. 5 % or 0.06 Hz/s
Minimum voltage	0.5 % of the setting value or 0.05 V
Minimum current	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Power angle	1°
Time delays	1 % of the setting value or 10 ms

Frequency Operating Range

0.9 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 90 Hz	Slightly expanded tolerances
f < 10 Hz f > 90 Hz	Active

12.49 Rate of Frequency Change Protection

Setting Values for the Function

Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V
Measuring window	2 periods to 5 periods	Increments of 1 period

Setting Values for Stage Types

Threshold value	0.100 Hz/s to 20.000 Hz/s	Increments of 0.025 Hz/s
Dropout differential	0.02 Hz/s to 0.99 Hz/s	Increments of 0.01 Hz/s
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

Frequency	Parameterizable dropout differential
Minimum voltage	
The larger dropout differential (= **`| pickup value – dropout threshold |`**) of the following 2 criteria is used:	
Dropout differential derived from `Dropout ratio`	105 % for the **Minimum voltage** parameter
Minimum absolute dropout differential	150 mV secondary

Times

Pickup time	Approx. 160 ms + OOT[178] to 220 ms + OOT (depends on measuring window length) at 50 Hz Approx. 140 ms + OOT to 200 ms + OOT (depends on measuring window length) at 60 Hz
Dropout time	Approx. 160 ms + OOT to 220 ms + OOT (depends on measuring window length) at 50 Hz Approx. 140 ms + OOT to 200 ms + OOT (depends on measuring window length) at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Threshold, measuring window > 3 periods	Approx. 3 % or 0.060 Hz/s
Threshold, measuring window ≤ 3 periods	Approx. 5 % or 0.060 Hz/s

178 OOT (Output Operating Time): Additional delay of the output medium used, for example, 5 ms with fast relays, see chapter *12.1.4 Relay Outputs*

Minimum voltage	1 % of the setting value or 0.5 V
Time delays	1 % of the setting value or 10 ms

Functional Measured Value

Value	Description
df/dt	Calculated rate of frequency change

12.50 Instantaneous Tripping at Switch onto Fault

Setting Values

Tripping delay	0.00 s to 60.00 s	Increments of 0.01 s

Tolerances

Times	< 1 % of the setting value or 10 ms

12.51 Thermal Overload Protection, 3-Phase – Advanced

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values/Increments for the Protection Stage

Threshold current warning	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold thermal warn.		50 % to 100 %	Increments of 1 %
Dropout threshold operate		50 % to 99 %	Increments of 1 %
Emerg. start T overtravel		0 s to 15 000 s	Increments of 10 s
K-factor acc. to IEC 60225-149		0.10 to 4.00	Increments of 0.01
Thermal time constant		10 s to 60 000 s	Increments of 1 s
Cooling time constant		10 s to 60 000 s	Increments of 1 s
Imax thermal	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Imin cooling	1 A @ 50 and 100 Irated	0.000 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.00 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.000 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.000 A to 8.000 A	Increments of 0.001 A
Temperature rise at Irated		40 K to 200 K	Increments of 1 K
Default temperature		-55°C to 55°C	Increments of 1°C
Minimal temperature		-55°C to 40°C	Increments of 1°C

Dropout Ratios

Tripping threshold (fixed at 100 %)	Dropout if value drops below operate indication dropout threshold
Thermal warning threshold	About 0.99 of the setting value
Current warning threshold	About 0.95 of the setting value

Frequency Range of the Input Signals

The function captures input signals up to the 50th harmonic.

Tolerances

No filter applied (33 % harmonics, in relation to the fundamental component)		
With reference to $k \cdot I_{rated}$	Up to 30th harmonic	2 % or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), 2 % class acc. to IEC 60255-149
	Up to 50th harmonic, f_{rated} = 50 Hz	4 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 4 % class acc. to IEC 60255-149
	Up to 50th harmonic, f_{rated} = 60 Hz	5 % or 25 mA (I_{rated} = 1 A) or 125 mA (I_{rated} = 5 A), 5 % class acc. to IEC 60255-149
With the filter for compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)		
With reference to $k \cdot I_{rated}$	Up to 30th harmonic	2 % or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), 2 % class acc. to IEC 60255-149
	Up to 50th harmonic, f_{rated} = 50 Hz	3 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 3 % class acc. to IEC 60255-149
	Up to 50th harmonic, f_{rated} = 60 Hz	4 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 4 % class acc. to IEC 60255-149
With the filter for gain of harmonics including compensation of the amplitude attenuation[179] (33 % harmonics, in relation to the fundamental component)		
With reference to $k \cdot I_{rated}$	Up to 30th harmonic	2 % or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), 2 % class acc. to IEC 60255-149[180]
	Up to 50th harmonic, f_{rated} = 50 Hz	4 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 4 % class acc. to IEC 60255-149[181]
	Up to 50th harmonic, f_{rated} = 60 Hz	5 % or 25 mA (I_{rated} = 1 A) or 125 mA (I_{rated} = 5 A), 5 % class acc. to IEC 60255-149[181]
With reference to the operate time	Up to 30th harmonic	3 % or 1 s for $I/(k \cdot I_{rated}) > 1.25$, 3 % class acc. to IEC 60255-149

179 In case that the filter response exactly matches the user-defined gain factor.

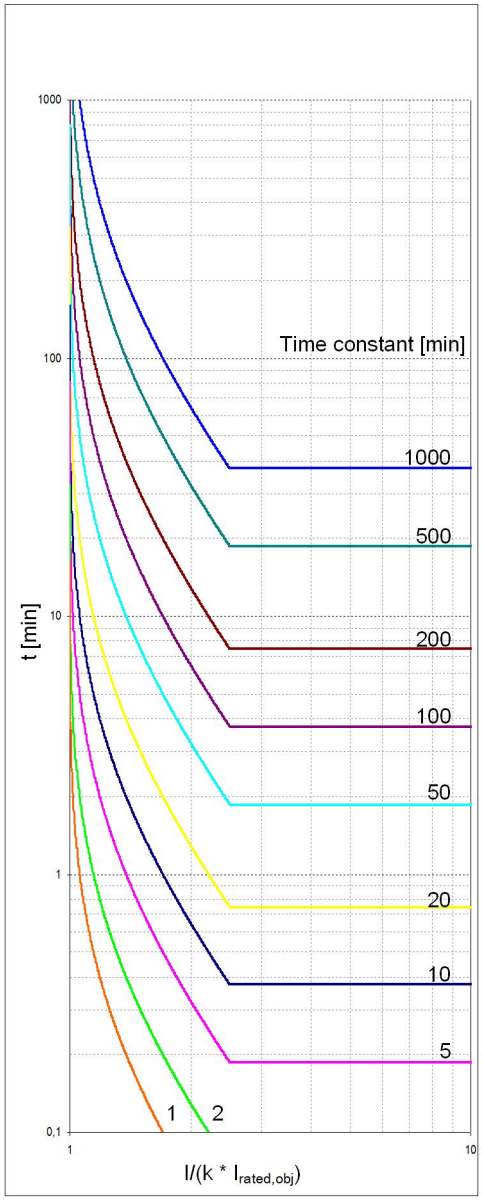
180 In case that the user-defined gain factor is set below 3. The tolerance is increased if the gain factor is larger.

181 In case that the user-defined gain factor is set below 7. The tolerance is increased if the gain factor is larger.

Operate Curve

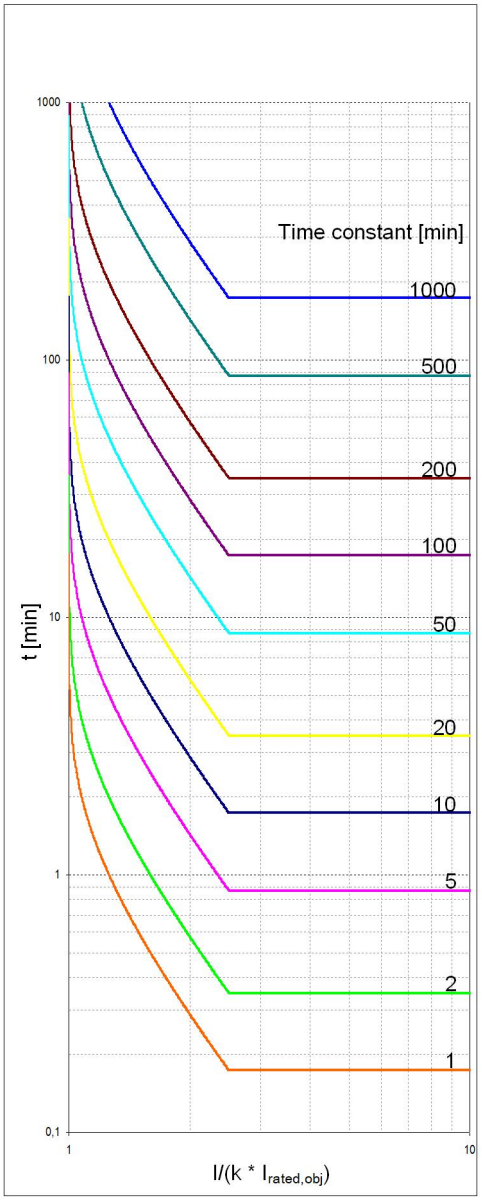
Operate curve	$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj.}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - 1}$	
Where	t	Operate time
	τ_{th}	Time constant
	I	Current load current
	$I_{preload}$	Preload current
	k	Setting factor according to VDE 0435 part 3011 or IEC 60255-149 (K factor)
	$I_{rated, obj}$	Rated current of the protected object

Table 12-11 Operate Curve Overload Protection



With 80 % preload temperature ($\theta_{preload}$) and with $I_{max, therm} = 2.5 \cdot k \cdot I_{rated}$

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{1}{k \cdot I_{rated,obj}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{1}{k \cdot I_{rated,obj}}\right)^2 - 1} \text{ [min]}$$



Without preload and with $I_{max, therm} = 2.5 \cdot k \cdot I_{rated}$

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{1}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{1}{k \cdot I_{rated,obj}}\right)^2 - 1} \text{ [min]}$$

Frequency Operating Range

Unlimited

12.52 Thermal Overload Protection, User-Defined Characteristic Curve

Setting Values

Threshold current warning	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold thermal warn.		50 % to 100 %	Increments of 1 %
Dropout threshold operate		50 % to 99 %	Increments of 1 %
Emerg. start T overtravel		0 s to 15 000 s	Increments of 10 s
Imax thermal	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Imin cooling	1 A @ 50 and 100 Irated	0.000 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.00 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.000 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.000 A to 8.000 A	Increments of 0.001 A
Curve based on preload		1 % to 100 %	Increments of 1 %
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.011 p.u. to 20.00 p. u.	Increments of 0.001 p.u.
Y values of the operate curve		1.00 s to 20 000.00 s	Increments of 0.01 s

Dropout Ratios

Tripping threshold value (fixed at 100 %)	Dropout if value drops below operate indication dropout threshold
Thermal warning threshold value	About 0.99 of the setting value
Current warning threshold value	About 0.95 of the setting value

Frequency Range of the Input Signals

The function captures input signals up to the 50th harmonic.

Tolerances

With reference to $k \cdot I_{rated}$	For I_{rated} = 1 A	2 % or 10 mA, class 2 % acc. to IEC 60255-149
	For I_{rated} = 5 A	2 % or 50 mA, class 2 % acc. to IEC 60255-149
With reference to operate time		3 % or 1 s, class 3 % acc. to IEC 60255-149 for $I/(k \cdot I_{rated}) > 1.25$

Frequency Operating Range

Unlimited

12.53 Thermal Overload Protection, 1-Phase

Setting Values/Increments for the Protection Stage

Threshold current warning	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold thermal warn.		50 % to 100 %	Increments of 1 %
Dropout threshold operate		50 % to 99 %	Increments of 1 %
K-factor acc. to IEC 60225-149		0.10 to 4.00	Increments of 0.01
Thermal time constant		10 s to 60 000 s	Increments of 1 s
Imax thermal	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Temperature rise at Irated		40 K to 200 K	Increments of 1 K
Default temperature		-55°C to 55°C	Increments of 1°C
Minimal temperature		-55°C to 40°C	Increments of 1°C

Dropout Ratios

Tripping threshold (fixed at 100 %)	Dropout if value drops below operate indication dropout threshold
Thermal warning threshold	About 0.99 of the setting value
Current warning threshold	About 0.95 of the setting value

Frequency Range of the Input Signals

The function captures input signals up to the 50th harmonic.

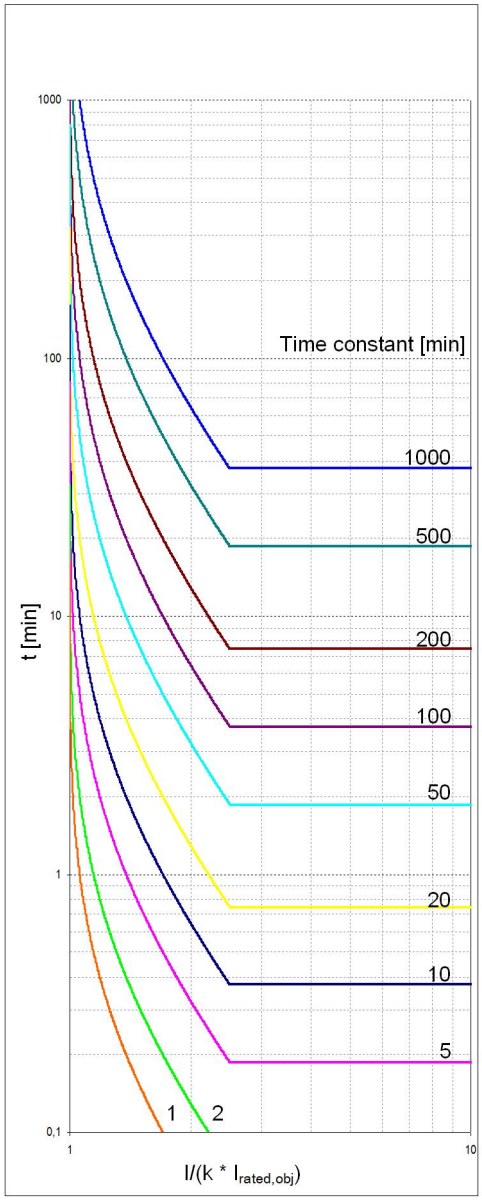
Tolerances

With reference to $k \cdot I_{rated}$	Up to 30th harmonic	2 % or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), 2 % class acc. to IEC 60255-149
	Up to 50th harmonic, f_{rated} = 50 Hz	4 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 4 % class acc. to IEC 60255-149
	Up to 50th harmonic, f_{rated} = 60 Hz	5 % or 25 mA (I_{rated} = 1 A) or 125 mA (I_{rated} = 5 A), 5 % class acc. to IEC 60255-149
With reference to the operate time	Up to 30th harmonic	3 % or 1 s for $I/(k \cdot I_{rated}) > 1.25$, 3 % class acc. to IEC 60255-149

Operate Curve

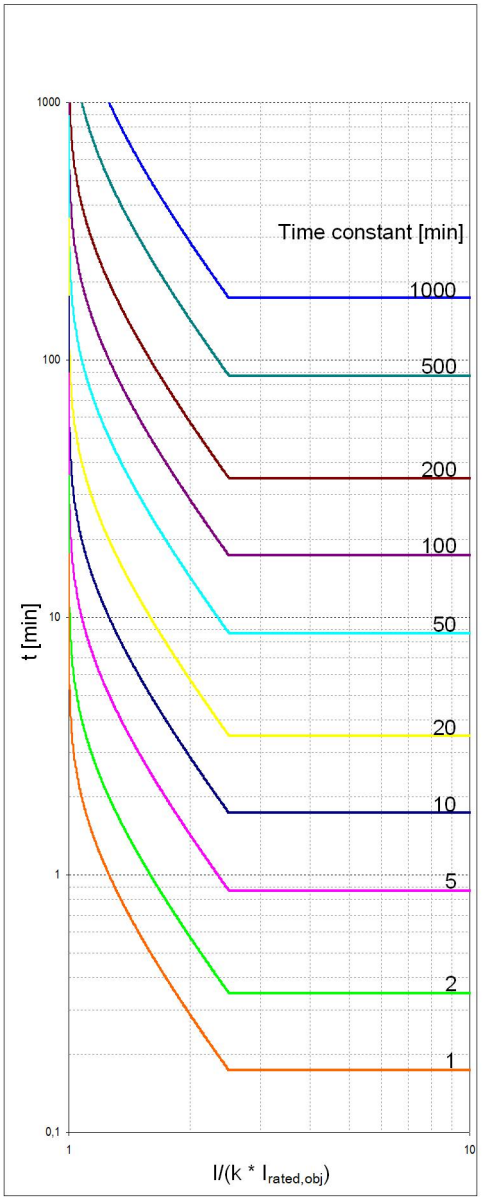
Operate curve	$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj.}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - 1}$	
Where	t	Operate time
	τ_{th}	Time constant
	I	Current load current
	$I_{preload}$	Preload current
	k	Setting factor according to VDE 0435 part 3011 or IEC 60255-8 (k factor)
	$I_{rated, obj}$	Rated current of the protected object

Table 12-12 Operate Curve Overload Protection



With 80 % preload temperature ($\theta_{preload}$) and with $I_{max, therm} = 2.5 \cdot k \cdot I_{rated}$

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{1}{k \cdot I_{rated,obj}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{1}{k \cdot I_{rated,obj}}\right)^2 - 1} \text{ [min]}$$



Without preload and with $I_{max, therm} = 2.5 \cdot k \cdot I_{rated}$

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{1}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{1}{k \cdot I_{rated,obj}}\right)^2 - 1} \text{ [min]}$$

Frequency Operating Range

Unlimited

12.54 Function Group Analog Units

20-mA Inputs, Ethernet Interface 7XV5674-0KK00-1AA1

Max. number of connected 20-mA units	4
Max. number of channels per 20-mA unit	12

20-mA Unit Serial 7XV5674-0KK30-1AA1 (RS485) and 7XV5674-0KK40-1AA1 (Fiberglass)

Max. number of connected 20-mA units	4
Max. number of channels per 20-mA unit	12

RTD Unit (Ziehl TR1200) 7XV5662-6AD10

Max. number of connected RTD units	4
Max. number of sensors per RTD unit	12
Sensor type	Pt 100 to EN 60751; connection of Ni 100 and Ni 120 sensors possible. The measured values must be converted in the evaluation unit.

Temperature Measured Values

Unit of measurement for temperature	°C or °F, adjustable
Pt 100	-199 °C to 800 °C (-326 °F to 1472 °F)
Ni 100	-54 °C to 278 °C (-65 °F to 532 °F)
Ni 120	-52 °C to 263 °C (-62 °F to 505 °F)
Resolution	1 °C or 1 °F
Tolerance	±0.5 % of the measured value ±1 °C (±0.56 °F)

12.55 Temperature Supervision

Setting Values

Pickup value	-50 °C to 250 °C -58 °F to 482 °F	Increments of 1°C Increments of 1°F
Time delay	0 s to 60 s or ∞	Increments of 1 s

Dropout

Dropout differential	3 °C or 6 °F

Tolerances

Tripping delay	±1 % of the setting value or ±10 ms
Measured temperature value	±0.5 % of the setting value or ±1 °C or ±2 °F

12.56 Hotspot Calculation

Setting Values

Emerg. start T overtravel		0 s to 15 000 s	Increments of 1 s
HST Warning Threshold	°C	80 °C to 140 °C	Increments of 1 °C
	°F	176 °F to 284 °F	Increments of 1 °F
HST Alarm Threshold	°C	80 °C to 140 °C	Increments of 1 °C
	°F	176 °F to 284 °F	Increments of 1 °F
Aging Warning Threshold		0.125 to 128.000	Increments of 0.001
Aging Alarm Threshold		0.125 to 128.000	Increments of 0.001
Turn time constant		0 min to 30 min	Increments of 1 min

IEC 60076-7

y Turn exponent	1.6 to 2.0	Increments of 0.1
Temperature gradient	20 to 50	Increments of 1
Factor k21	1.0 to 5.0	Increments of 0.1
Factor k22	1.0 to 5.0	Increments of 0.1
Oil time constant	50 min to 500 min	Increments of 1 min

IEEE C57.91 2011

m Turn exponent	0.8 to 1.0	Increments of 0.1
Temperature gradient	20 to 50	Increments of 1

Functional Measured Values

Measured Value	Description
(_:13531:307) Tmp.A	Hotspot temperature for phase A in °C or °F (depending on the setting)
(_:13531:308) Tmp.B	Hotspot temperature for phase B in °C or °F (depending on the setting)
(_:13531:309) Tmp.C	Hotspot temperature for phase C in °C or °F (depending on the setting)
(_:13531:310) TmpMa	Hotspot temperature for the 3 phases in °C or °F (depending on the setting)
(_:13531:311) AgRate	Relative aging rate
(_:13531:305) RsWarn	Load margin until warning indication in percent
(_:13531:306) RsAlm	Load margin until alarm indication in percent

Frequency Operating Range

Frequency tracking	10 Hz to 90 Hz

Measured Temperatures

Temperature unit of the measurement	°C or °F
Resolution	1 °C or 1 °F
Tolerance	± 0.5 % of the measured value or ± 1 K

Dropout Ratio

Alarm threshold	Approx. 0.99 of the setting value
Warning threshold	Approx. 0.99 of the setting value

Power Factor

The accuracy of the power factor calculation is a function of the accuracy of the current measurement.

Operate Time

Synthesizing the hotspot temperature is a slow process. The measuring interval is 300 ms. The operate time is a function of the oil temperature and the load increase.

12.57 Circuit-Breaker Failure Protection

Starting Conditions

For circuit-breaker failure protection	3-pole tripping internal or external[182]

Setting Values

Phase-current threshold values	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Sensitive threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Supervision time of release signal		0.00 s to 1.00 s	Increments of 0.01 s
Time delays T1		0.000 s to 60.000 s	Increments of 0.001 s
Time delays T2		0.050 s to 60.000 s	Increments of 0.001 s
Supervision times of the binary inputs		0.05 s to 60.00 s	Increments of 0.01 s

Setting Values

Phase-current threshold values	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	1 A @ 50 Irated		
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	5 A @ 50 Irated		
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Sensitive threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	1 A @ 50 Irated		
	5 A @ 100 Irated	0.15 A to 175.00A	Increments of 0.01 A
	5 A @ 50 Irated		
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Supervision time of release signal		0.00 s to 1.00 s	Increments of 0.01 s
Time delays T1		0.000 s to 60.000 s	Increments of 0.001 s
Time delays T2		0.050 s to 60.000 s	Increments of 0.001 s
Supervision times of the binary inputs		0.05 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup threshold – dropout threshold |**) of the following 2 criteria applies:

[182] Via binary inputs

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies to the current threshold values.	
Minimum absolute dropout differential	
Protection-class current transformers	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument transformers	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Circuit-Breaker Supervision

Position supervision via circuit-breaker auxiliary contacts	
For 3-pole CB tripping	One input each for make contact and break contact

NOTE

The circuit-breaker failure protection can also work without the circuit-breaker auxiliary contacts stated.

Auxiliary contacts are required for circuit-breaker failure protection in cases where the current flow is absent or too low for tripping (for example with a transformer or a Buchholz protection).

Times

Pickup time, in the case of an internal start Pickup time, in the case of an external start	< 1 ms < 5 ms
Typical dropout time	< 15 ms
Dropout time, via circuit-breaker auxiliary contact criterion[183]	< 5 ms

NOTE

Using the setting ***`Direct release`*** with the parameters **`3I0 criterion`** or **`I2 criterion`** can result in extended dropout times.

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Threshold values, dropout thresholds	2 % of the setting value or 1 % of the rated current
Times	1 % of the setting value or 10 ms

[183] The use of the transformer connection types **2ph, 2p. CT + IN-sep** result in slightly expanded tolerances

12.58 Circuit-Breaker Restrike Protection

Setting Values

Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Monitoring duration		1.00 s to 600.00 s	Increments of 0.01 s
Position recognition delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s
Trip delay time		0.05 s to 60.00 s	Increments of 0.01 s
Retrip delay time		0.00 s to 60.00 s	Increments of 0.01 s
Minimum operate (trip) time		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Threshold	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Time delays	1 % of the setting value or 10 ms

12.59 Pole Discrepancy Protection

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active with reduced sensitivity

Tolerances

Pickup times with current check	≤ 40 ms
Pickup times without current check	≤ 20 ms
Time delays for the 1-pole discrepancy	1 % of the parameter **Delay for 1 pole open** or 10 ms
Time delays for the 2-pole discrepancy	1 % of the parameter **Delay for 2 poles open** or 10 ms

12.60 Arc Protection

Setting Values

Threshold I>	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold 3I0>>	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
External trip initiation		no current light	
Operating mode		light only current and light	
Sensor		point sensor line sensor custom	
Threshold light		-28.00 dB to 0.00 dB	Increments of 0.01
Channel		Possible settings, application-dependent	

Dropout

The larger dropout differential (= **`| pickup threshold – dropout threshold |`**) of the following 2 criteria is used:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 90 % applies to the current threshold values.	
Minimum absolute dropout differential	
Protection-class current transformers	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument transformers	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Shortest operate time Operating mode = light only	Approx. 2.6 ms + OOT [184]
Shortest operate time Operating mode = Current and light	Approx. 4.0 ms + OOT at 50 Hz Approx. 3.8 ms + OOT at 60 Hz

184 OOT (Output Operating Time): Additional delay of the output medium used, for example, 5 ms with fast relay, see chapter *12.1.4 Relay Outputs*

12.61 Power-Plant Disconnection Protection

Setting Values

Threshold P1>		50.00 % to 100.00 %	Increments of 0.01 %
Threshold P1<		0.00 % to 60.00 %	Increments of 0.01 %
Threshold Vph-ph<		0.300 V to 175.000 V	Increments of 0.001 V
Threshold I>	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 50 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold dP1<		-100.00 % to -30.00 %	Increments of 0.01 %
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s
Operate curve		2 to 5	Increments of 1

Functional Measured Values

Functional measured values are available to you so that you can better evaluate the behavior of the function. You can collect these functional measured values in a fault record for example.

Measured Value	Description
P1(t)	Positive-sequence system active power, which is evaluated by the function. The measured value is calculated every 1/4 cycle.
dP1(t)	Continuous representation of the active-power change, starting from the trigger time. With this, you can evaluate the change of the active-power difference at the prefault instant (t_{prior}).
dP1(t)max	This measured value flows into the characteristic curve. It represents the maximum active power during the duration of the fault.

Times

Pickup times	
Characteristic curve = no	Approx. 28 ms + OOT[185] at 50 Hz Approx. 25 ms + OOT at 60 Hz
Characteristic curve = yes	Approx. 26 ms + OOT at 50 Hz Approx. 24 ms + OOT at 60 Hz
Dropout times	
Characteristic curve = no	Approx. 18 ms + OOT at 50 Hz Approx. 19 ms + OOT at 60 Hz
Characteristic curve = yes	Approx. 22 ms + OOT at 50 Hz Approx. 20 ms + OOT at 60 Hz

Tolerance

I>	1 % of the dropout value or 0.005 I_{rated}
P1>	0.5 % S_{rated} or ±3 % of the setting value when Q < 0.5 S_{rated}

185 OOT (Output Operating Time): additional delay of the output medium used

Vph-ph<	0.5 % of the dropout value or 0.05 V
dP1<	0.5 % S_{rated} or ±3 % of the setting value when Q < 0.5 S_{rated}
P1<	0.5 % S_{rated} or ±3 % of the setting value when Q < 0.5 S_{rated}

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

12.62 Inrush-Current Detection

Setting Values

Operat.-range limit Imax	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Content 2nd harmonic		10 % to 45 %	Increments of 1 %
Duration of the crossblock function		0.03 s to 200.00 s	Increments of 0.01 s

Times

Operating times	Approx. 29 ms

Pickup

Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	Setting value or at least
Protection-class current transformers	$I_{1st\ harm}$ = 10 mA sec. and $I_{2nd\ harm}$ = 10 mA sec. (I_{rated} = 1 A) $I_{1st\ harm}$ = 50 mA sec. and $I_{2nd\ harm}$ = 50 mA sec. (I_{rated} = 5 A)
Instrument transformers	$I_{1st\ harm}$ = 1 mA sec. and $I_{2nd\ harm}$ = 1 mA sec. (I_{rated} = 1 A) $I_{1st\ harm}$ = 5 mA sec. and $I_{2nd\ harm}$ = 5 mA sec. (I_{rated} = 5 A)

Dropout

The greater dropout differential (= **`| pickup threshold – dropout threshold |`**) of the following criteria is used:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overcurrent protection and a dropout ratio of 105 % applies for the undercurrent protection.	
Minimum absolute dropout differential	
Protection-class current transformers	5 mA sec. (I_{rated} = 1 A) or 25 mA sec. (I_{rated} = 5 A)
Instrument transformers	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	0.75
Protection-class current transformers	$I_{2nd\ harm}$ = 5 mA sec. (I_{rated} = 1 A) or $I_{2nd\ harm}$ = 25 mA sec. (I_{rated} = 5 A)
Instrument transformers	$I_{2nd\ harm}$ = 0.5 mA sec. (I_{rated} = 1 A) or $I_{2nd\ harm}$ = 2.5 mA sec. (I_{rated} = 5 A)

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Current measurement I_{max}	1 % of the setting value or 5 mA
Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	1 % of the setting value
Time delays	1 % of the setting value or 10 ms

12.63 2nd Harmonic Detection Ground

Setting Values

Measured value	IN measured 3I0 calculated	
2nd harmonic content	10 % to 45 %	Increments of 1 %

Times

Operating times	Approx. 29 ms

Pickup

Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	Setting value or at least
Protection-class current transformer	$I_{1st\ harm}$ = 10 mA sec. and $I_{2nd\ harm}$ = 10 mA sec. (I_{rated} = 1 A) $I_{1st\ harm}$ = 50 mA sec. and $I_{2nd\ harm}$ = 50 mA sec. (I_{rated} = 5 A)
Instrument transformers	$I_{1st\ harm}$ = 1 mA sec. and $I_{2nd\ harm}$ = 1 mA sec. (I_{rated} = 1 A) $I_{1st\ harm}$ = 5 mA sec. and $I_{2nd\ harm}$ = 5 mA sec. (I_{rated} = 5 A)

Dropout

The greater dropout differential (= **`| pickup threshold – dropout threshold |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overcurrent protection and a dropout ratio of 105 % applies for the undercurrent protection.	
Minimum absolute dropout differential	
Protection-class current transformers	5 mA sec. (I_{rated} = 1 A) or 25 mA sec. (I_{rated} = 5 A)
Instrument transformers	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Harmonics: $I_{2nd\ harm}/I_{1st\ harm}$	0.75 or
Protection-class current transformers	$I_{2nd\ harm}$ = 5 mA sec. (I_{rated} = 1 A) or $I_{2nd\ harm}$ = 25 mA sec. (I_{rated} = 5 A)
Instrument transformers	$I_{2nd\ harm}$ = 0.5 mA sec. (I_{rated} = 1 A) or $I_{2nd\ harm}$ = 2.5 mA sec. (I_{rated} = 5 A)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Harmonics: $I_{2nd\ harm}/I_{1st\ harm}$	1 % of the setting value for setting values $I_{2nd\ harm}/_{1st\ harm}$

12.64 2nd Harmonic Detection 1-Phase

Setting Values

Measured value	I	
2nd harmonic content	10 % to 45 %	Increments of 1 %

Times

Operating times	Approx. 29 ms

Pickup

Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	Setting value or at least
Protection-class current transformers	$I_{1st\ harm}$ = 10 mA sec. and $I_{2nd\ harm}$ = 10 mA sec. (I_{rated} = 1 A) $I_{1st\ harm}$ = 50 mA sec. and $I_{2nd\ harm}$ = 50 mA sec. (I_{rated} = 5 A)
Instrument transformers	$I_{1st\ harm}$ = 1 mA sec. and $I_{2nd\ harm}$ = 1 mA sec. (I_{rated} = 1 A) $I_{1st\ harm}$ = 5 mA sec. and $I_{2nd\ harm}$ = 5 mA sec. (I_{rated} = 5 A)

Dropout

The greater dropout differential (= **`| pickup threshold – dropout threshold |`**) of the following criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overcurrent protection and a dropout ratio of 105 % applies for the undercurrent protection.	
Minimum absolute dropout differential	
Protection-class current transformers	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument transformers	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Harmonics: $I_{2nd\ harm}/I_{1st\ harm}$	0.75 or
Protection-class current transformers	$I_{2nd\ harm}$ = 5 mA sec. (I_{rated} = 1 A) or $I_{2nd\ harm}$ = 25 mA sec. (I_{rated} = 5 A)
Instrument transformers	$I_{2nd\ harm}$ = 0.5 mA sec. (I_{rated} = 1 A) or $I_{2nd\ harm}$ = 2.5 mA sec. (I_{rated} = 5 A)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 90 Hz	Slightly expanded tolerances
f < 10 Hz f > 90 Hz	Inactive

Tolerances

Harmonics: $I_{2nd\ harm}/I_{1st\ harm}$	1 % of the setting value for setting values $I_{2nd\ harm}/I_{1st\ harm}$

12.65 Power Protection (P,Q), 3-Phase

Setting Values

Measured value	Positive sequence power Power of phase A Power of phase B Power of phase C	
Threshold	-200.0 % to -1.0 % 1.0 % to 200.0 %	Increments of 0.1
Tilt-power characteristic	-89.0° to +89.0°	Increments of 0.1°
Dropout delay time	0.00 s to 60.00 s	Increments of 0.01 s
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	Upper stage: 0.90 to 0.99 Lower stage: 1.01 to 1.10	Increments of 0.01 Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio`	
Minimum absolute dropout differential	0.5 % S_{rated}

Times

Pickup times	Approx. 55 ms + OOT[186] at 50 Hz Approx. 45 ms + OOT at 60 Hz
Dropout times	Approx. 55 ms + OOT at 50-Hz Approx. 45 ms + OOT at 60 Hz

Tolerances

Power	0.5 % S_{rated} or ±2 % of the setting value (S_{rated}: rated apparent power)
Time delays	1 % of the setting value or 10 ms

Variables That Influence Pickup Values

Auxiliary DC voltage in the range $0.8 \le V_{aux.}/V_{aux.,rated} \le 1.15$	≤ 1 %
Frequency in the range $0.95 \le f/f_{rated} \le 1.05$	≤ 1 %
Harmonics - Up to 10 % of 3rd harmonics - Up to 10 % of 5th harmonics	 ≤ 1 % ≤ 1 %

[186] OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz < f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f$	Slightly expanded tolerances
$f \leq 10\ Hz$	Inactive

12.66 Reverse-Power Protection

Setting Values

Reverse power $P_{reverse}$ (p.u.)	-0.30 % to -30.00 %	Increments of 0.01 %
Angle correction	-10.00 ° to 10.00 °	Increments of 0.01 °
Minimum voltage V1	0.300 V to 60.000 V	Increments of 0.001 V
Tripping delay	0.00 s to 60.00 s	0.00 s to 60.00 s
Tripping delay with quick stop	0.00 s to 60.00 s	0.00 s to 60.00 s
Dropout delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.40 to 0.99	Increments of 0.01

Dropout

Reverse power $P_{reverse}$ (p.u.)	Parameterizable dropout differential

Times

Pickup times	Approx. 360 ms at f = 50 Hz Approx. 300 ms at f = 60 Hz
Dropout times	Approx. 360 ms at f = 50 Hz Approx. 300 ms at f = 60 Hz

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Reverse power	0.15 % S_{rated} or 5 % of the setting value when $Q < 0.5\ S_{rated}$
Time delays	1 % or 10 ms

12.67 Current-Jump Detection

Times

Pickup time	Approx. 10 ms + OOT[187] at 50 Hz Approx. 8 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Currents	3 % of setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) for amplitude changes of sinusoidal measurands
Pulse time	1 % of the setting value or 10 ms

[187] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.68 Voltage-Jump Detection

Times

Pickup time	Approx. 10 ms + OOT[188] at 50 Hz Approx. 8 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

Tolerances

Voltages	2 % of the setting value or 0.100 V for amplitude changes of sinusoidal measurands
Pulse time	1 % of the setting value or 10 ms

[188] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.69 Vector-Jump Protection

Setting Values

Threshold V1 min	0.300 V to 175.000 V	Increments of 0.001 V
Threshold V1 max	0.300 V to 175.000 V	Increments of 0.001 V
Threshold Δφ	2.0° to 30.0°	Increments of 0.1°
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s
T Reset	0.00 s to 60.00 s	Increments of 0.01 s
T Block	0.00 s to 60.00 s	Increments of 0.01 s
I< Threshold	0.030 A to 35.000 A at 1 A 0.150 A to 175.000 A at 5 A	Increments of 0.001 A

Times

Pickup times	Approx. 80 ms + OOT[189] at 50 Hz Approx. 66.8 ms + OOT at 60 Hz
Dropout times	Approx. 80 ms + OOT at 50 Hz Approx. 66.8 ms + OOT at 60 Hz

Frequency Operating Range

f_{rated} - 3 Hz ≤ f or f_{rated} ≤ f_{rated} + 3 Hz	According to specified tolerances
f < f_{rated} - 3 Hz or f > f_{rated} + 3 Hz	Inactive

Tolerances

Angle jump	0.5° at V > 0.5 V_{rated}
Voltage blocking	1 % of the setting value or 0.500 V
Undercurrent release	For I_{rated} = 1 A: 1 % of the setting value or 10 mA For I_{rated} = 5 A: 1 % of the setting value or 50 mA
Time delay T	1 % or 10 ms

[189] OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.70 Synchronization Function

Operating Modes

Synchrocheck
Switching synchronous systems
Switching asynchronous systems
De-energized switching
Direct closing command

Setting Values

Supervision/Delay times:		
Max.durat. sync.process	0.00 s to 3 600.00 s or ∞ (ineffective)	Increments of 0.01 s
Supervision time de-energized switching	0.00 s to 60.00 s	Increments of 0.01 s
Closure delay	0.00 s to 60.00 s	Increments of 0.01 s
Voltage threshold values:		
Upper voltage limit V_{max}	0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V
Lower voltage limit V_{min}	0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V
V<, for off-circuit conditions V>, for voltage present	0.300 V to 170.000 V (phase-to-phase) 0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V Increments of 0.001 V
Differential values, changeover threshold values asynchronous/synchronous:		
Voltage differences V2 > V1; V2 < V1	0.000 V to 170.000 V	Increments of 0.001 V
Frequency difference f2 > f1; f2 < f1	0.000 Hz to 2.000 Hz (synchronous) 0.000 Hz to 4.000 Hz (asynchronous)	Increments of 0.001 Hz
Angle difference α2 > α1; α2 < α1	0° to 90°	Increments of 1°
Adjustments of the sides:		
Angle adjustment	-179.0° to 180.0°	Increments of 0.1°
Voltage adjustment	0.500 to 2.000	Increments of 0.001
Circuit breaker		
Make time of the circuit breaker	0.010 s to 0.600 s	Increments of 0.001 s

Dropout Ratio

Min./max. operating limit	1 % of the setting value
Voltage differential	10 % of the setting value or 0.5 V
De-energized/energized	5 % of the setting value
Frequency difference	3 mHz
Angle difference	0.1°

Measured Values of the Synchronization Function

Reference voltage V1 • Range • Tolerance at rated frequency	In kV primary, in V secondary or in % V_{rated} Display always as phase-to-phase voltage 10 % to 120 % of V_{rated} ≤ 1 % of the measured value or 0.5 % V_{rated}
Voltage to be synchronized V2 • Range • Tolerance at rated frequency	In kV primary, in V secondary or in % V_{rated} Display always as phase-to-phase voltage 10 % to 120 % of V_{rated} ≤ 1 % of the measured value or 0.5 % V_{rated}
Frequency of the voltage V1f1 • Range • Tolerance at rated frequency	f1 in Hz 25 Hz ≤ f ≤ 70 Hz 1 mHz
Frequency of the voltage V1f2 • Range • Tolerance at rated frequency	f2 in Hz 25 Hz ≤ f ≤ 70 Hz 1 mHz
Voltage difference V2-V1 • Range • Tolerance at rated frequency	In kV primary, in V secondary or in % V_{rated} Display always as phase-to-phase voltage in relation to side 1 10 % to 120 % of V_{rated} ≤ 1 % of the measured value or 0.5 % V_{rated}
Frequency difference f2-f1 • Range • Tolerance at rated frequency	In mHz f_{rated} ± 10 % 1 mHz
Angle difference λ2-λ1 • Range • Tolerance at rated frequency	In ° -180° to +180° 0.5°

Times

Measuring time, after switching on the variables	Approx. 80 ms

Operating Range

Voltage	20 V to 340 V
Frequency	f_{rated} - 4 Hz ≤ f_{rated} ≤ f_{rated} + 4 Hz

Tolerances

Tolerances of the voltage settings	2 % of the pickup value or 1 V
Voltage difference V2>V1; V2<V1	1 V
Frequency difference f2>f1; f2<f1	10 mHz
Angle difference α2>α1; α2<α1	1°
Tolerance of all time settings	10 ms
Max. phase displacement angle	5° for Δf ≤ 1 Hz 10° for Δf > 1 Hz

12.71 Voltage Controller

Setting Values

General Information		
I reference for % values[190]	0.20 A to 100000.00 A	Increments of 0.01 A
V reference for % values[191]	0.20 kV to 1200.00 kV	Increments of 0.01 kV
Rated app. power transf.[192]	0.20 MVA to 5000.00 MVA	Increments of 0.01 MVA
Volt. cont. 2W		
Target voltage 1	10.000 V to 340.000 V Tolerance: IδI ≤ 0.5 % of the setting value or 0.05 V	Increments of 0.001 V
Target voltage 2		
Target voltage 3		
Target voltage 4		
Volt. cont. 3W and GC		
Target voltage 1 w1	10.000 V to 340.000 V Tolerance: IδI ≤ 0.5 % of the setting value or 0.05 V	Increments of 0.001 V
Target voltage 2 w1		
Target voltage 3 w1		
Target voltage 4 w1		
Target voltage 1 w2		
Target voltage 2 w2		
Target voltage 3 w2		
Target voltage 4 w2		
Volt. cont. 2W, 3W, and GC		
Bandwidth	0.2 % to 10.0 %	Increments of 0.1 %
T1 delay	5 s to 600 s	Increments of 1 s
T1 Inverse Min	5 s to 100 s	Increments of 1 s
T2 delay	0 s to 100 s	Increments of 1 s
Fast step down limit	0.0 % to 50.0 %	Increments of 0.1 %
Fast step down T delay	0.0 s to 10.0 s	Increments of 0.1 s
Fast step up limit	-50.0 % to 0.0 %	Increments of 0.1 %
Fast step up T delay	0.0 s to 10.0 s	Increments of 0.1 s
Function monitoring	0 min to 120 min	Increments of 1 min
Line compensation LDC-Z		
Target voltage rising	0.0 % to 20.0 %	Increments of 0.1 %
Max load current	0.0 % to 500.0 %	Increments of 0.1 %
Line compensation LDC-XandR (two-winding transformer)		
R line	0.00 Ω to 30.00 Ω	Increments of 0.01 Ω
X line	-30.00 Ω to 30.00 Ω	Increments of 0.01 Ω
Line compensation LDC-XandR		
R line	0.0 Ω to 30.0 Ω	Increments of 0.1 Ω
X line	-30.0 Ω to 30.0 Ω	Increments of 0.1 Ω
Limiting values		
Vmin threshold	10.000 V to 340.000 V Tolerance: IδI ≤ 0.5 % of the setting value or 0.05 V	Increments of 0.001 V

190 Only visible in the voltage-control operation without parallel operation
191 Only visible in the voltage-control operation without parallel operation
192 Only visible in the voltage-control operation without parallel operation

Vmin time delay	0 s to 20 s Tolerance: IδI ≤ 1 % of the setting value or 10 ms	Increments of 1 s
Vmax threshold	10.000 V to 340.000 V Tolerance: IδI ≤ 0.5 % of the setting value or 0.05 V	Increments of 0.001 V
Vmax time delay	0 s to 20 s Tolerance: IδI ≤ 1 % of the setting value or 10 ms	Increments of 1 s
Blockings		
V< Threshold	10.000 V to 340.000 V Tolerance: IδI ≤ 0.5 % of the setting value or 0.05 V	Increments of 0.001 V
V< Time delay	0 s to 20 s Tolerance: IδI ≤ 1 % of the setting value or 10 ms	Increments of 1 s
I> Threshold	10 % to 500 %	Increments of 1 %
I> Time delay	0 s to 20 s Tolerance: IδI ≤ 1 % of the setting value or 10 ms	Increments of 1 s
I< Threshold	3 % to 100 %	Increments of 1 %
I< Time delay	0 s to 20 s Tolerance: IδI ≤ 1 % of the setting value or 10 ms	Increments of 1 s
Parallel control		
Parallel-transfomer id	0 to 8	Increments of 1
Maximal tap difference	1 to 9	Increments of 1
Reactive I control factor	0.01 to 100.00	Increments of 0.01
VT supervision threshold	0.5 % to 10.0 %	Increments of 0.1 %
VT supervision time delay	1 s to 600 s	Increments of 1 s
Circul. current threshold	10 % to 500 %	Increments of 1 %
Circul. current time delay	0 s to 1000 s	Increments of 1 s

Measured Values, Two-Winding Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
V act.	Current, measured positive-sequence voltage (referenced to phase-to-phase)	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	%	%	Voltage difference referenced to the rated voltage of the controlled winding
I load	Current measured load current (positive-sequence system)	A	A	Load current referenced to the rated value of the function
V max	Maximum positive-sequence voltage ever measured (referenced to phase-to-phase)	kV	V	Maximum voltage of the winding referenced to the rated voltage of the winding
V min	Minimum positive-sequence voltage ever measured (reference to phase-to-phase)	kV	V	Minimum voltage of the winding referenced to the rated voltage of the winding

Measured Value	Description	Primary	Secondary	% Referenced to
V target	Calculated target voltage with consideration of Z compensation	kV	V	Target voltage of the winding referenced to the rated voltage of the winding
PhAng	Phase angle of the currently measured load current	°	°	-
I load Σ	Sum of the currently measured load currents. Active when line compensation is activated.	A	A	Load current referenced to the rated current of the function
I circul.	Currently measured circulating reactive current	A	A	Circulating reactive current
Vact.m	Currently measured control voltage	kV	V	Current voltage of the control referenced to the rated voltage of the function
ΔV act V	Voltage difference	%	%	Voltage difference referenced to the rated voltage of the function
ΔV act C	Voltage difference	%	%	Voltage difference referenced to the rated voltage of the function

Measured Values for Parallel Control, Proxy

Measured Value	Description	Primary	Secondary	% Referenced to
V act.	Actual voltage of winding	kV	V	Target voltage of the primary system referenced to the rated voltage of the function
1/X trf.	Susceptance, internal value for GOOSE transmission	1/Ω		
I load	Load current	A	-	Load current referenced to the rated current of the function
PhAng	Phase angle of the load current relative to the voltage with a power factor of 1.0	°	°	Phase angle of the load current 100 % = 180°

Measured Values, Three-Winding Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
Vact.w1	Actual voltage of winding 1	kV	V	Target voltage of the primary system referenced to the rated voltage
Vact.w2	Actual voltage of winding 2	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	%	%	Voltage difference referenced to the rated voltage of the controlled winding
I load w1	Load current of winding 1	A	A	Load current referenced to the rated current of winding 1
I load w2	Load current of winding 2	A	A	Load current referenced to the rated current of winding 2
Vmax 1	Maximum voltage of winding 1	kV	V	Maximum voltage of winding 1 referenced to the rated voltage of winding 1

Measured Value	Description	Primary	Secondary	% Referenced to
Vmax 2	Maximum voltage of winding 2	kV	V	Maximum voltage of winding 2 referenced to the rated voltage of winding 2
Vmin 1	Minimum voltage of winding 1	kV	V	Minimum voltage of winding 1 referenced to the rated voltage of winding 1
Vmin 2	Minimum voltage of winding 2	kV	V	Minimum voltage of winding 2 referenced to the rated voltage of winding 2
V tar.w1	Target voltage of winding 1	kV	V	Target voltage of winding 1 referenced to the rated voltage of winding 1
V tar.w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

Measured Values Grid Coupling Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
Vact.w1	Actual voltage of winding 1	kV	V	Target voltage of the primary system referenced to the rated voltage
Vact.w2	Actual voltage of winding 2	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	%	%	Voltage difference referenced to the rated voltage of the controlled winding
I load w1	Load current of winding 1	A	A	Load current referenced to the rated current of winding 1
I load w2	Load current of winding 2	A	A	Load current referenced to the rated current of winding 2
Vmax 1	Maximum voltage of winding 1	kV	V	Maximum voltage of winding 1 referenced to the rated voltage of winding 1
Vmax 2	Maximum voltage of winding 2	kV	V	Maximum voltage of winding 2 referenced to the rated voltage of winding 2
Vmin 1	Minimum voltage of winding 1	kV	V	Minimum voltage of winding 1 referenced to rated voltage of winding 1
Vmin 2	Minimum voltage of winding 2	kV	V	Minimum voltage of winding 2 referenced to rated voltage of winding 2
V tar.w1	Target voltage of winding 1	kV	V	Target voltage of winding 1 referenced to the rated voltage of winding 1
V tar.w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

Dropout Ratio

Threshold of the voltage limit	About 0.98 of the setting value
Threshold of the current limit	About 0.95 of the setting value

12.72 Current-Balance Supervision

Setting Values

Release threshold	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	1 A @ 50 Irated		
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	5 A @ 50 Irated		
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold min/max		0.10 to 0.95	Increments of 0.01
Delay failure indication		0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Overcurrent dropout ratio	Approx. 0.97
Undercurrent dropout ratio	Approx. 1.05

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.73 Voltage-Balance Supervision

Setting Values

Release threshold	0.300 V to 170.000 V	Increments of 0.001 V
Threshold min/max	0.58 to 0.95	Increments of 0.01
Delay failure indication	0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Overvoltage dropout ratio	Approx. 0.97
Undervoltage dropout ratio	Approx. 1.05

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.74 Current-Sum Supervision

Setting Values

Slope factor		0.00 to 0.95	Increments of 0.01
Threshold	1 A @ 50 and100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and100 Irated	0.15 A to 50.00 A	Increments 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Delay failure indication		0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Dropout ratio	Approx. 0.97

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.75 Voltage-Sum Supervision

Setting Values

Threshold	0.300 V to 170.000 V	Increments of 0.001 V
Delay failure indication	0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Dropout ratio	Approx. 0.97

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.76 Current Phase-Rotation Supervision

Setting Values

Release threshold	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Delay failure indication		0.00 s to 100.00 s	Increments of 0.01 s
Phase sequence		A B C A C B	

Dropout Ratio

Release-threshold dropout ratio	Approx. 0.97

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.77 Voltage Phase-Rotation Supervision

Setting Values

Tripping delay	0.00 s to 100.00 s	Increments of 0.01 s
Phase-rotation direction	A B C A C B	

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.78 Auxiliary Direct-Voltage Supervision

Setting Value for the FB Auxiliary Direct-Voltage Measurement

Measuring window	10 ms, 20 ms, 40 ms, 60 ms, 80 ms, 100 ms

Setting Values for the Stages

Threshold	10.0 V to 295.0 V	Increments of 0.1 V
Dropout ratio for the **Overvoltage** stage	0.90 to 0.99	Increments of 0.01
Dropout ratio for the **Undervoltage** stage	1.01 to 1.10	Increments of 0.01
Pickup delay Operate delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

Dropout differential is derived from the parameter **`Dropout ratio`**.

Times

Pickup time	(1 to 2) · **`Measuring window`** + OOT[193] Example for **`Measuring window`** of 20 ms: Pickup time = 20 ms to 40 ms + OOT
Dropout time	(1 to 2) · **`Measuring window`** + OOT Example for **`Measuring window`** of 20 ms: Dropout time = 20 ms to 40 ms + OOT

Tolerances

Direct voltage	0.2 % of the setting value or 50 mV
Operate delay	1 % of the setting value or 10 ms

[193] OOT (Output Operating Time): additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.79 Trip-Circuit Supervision

Setting Values

Number of monitored circuits per circuit-breaker function group	1 to 3	
Operating mode per circuit	With 1 binary input With 2 binary inputs	
Pickup and dropout time	About 1 s to 2 s	
Adjustable indication delay with 1 binary input	1.00 s to 600.00 s	Increments of 0.01 s
Adjustable indication delay with 2 binary inputs	1.00 s to 600.00 s	Increments of 0.01 s

12.80 Closing-Circuit Supervision

Setting Values (Closing-circuit supervision with 1 binary input or 2 binary inputs)

Operating mode per circuit	With 1 binary input With 2 binary inputs	
Adjustable indication delay with 1 binary input	1.00 s to 600.00 s	Increments of 0.01 s
Adjustable indication delay with 2 binary inputs	1.00 s to 30.00 s	Increments of 0.01 s

Setting Values (Closing-circuit supervision with 3 binary inputs)

Number of monitored circuits per circuit breaker function group	1 to 3	
Operating mode per circuit	With 2 binary inputs and 1 resistance With 3 binary inputs	
Pickup and dropout time	Approx. 1 s to 2 s	
Adjustable indication delay with 2 binary inputs and 1 resistance	1.00 s to 30.00 s	Increments of 0.01 s
Adjustable indication delay with 3 binary inputs	1.00 s to 30.00 s	Increments of 0.01 s

12.81 Protection Interface and Protection Topology

Setting Values

Mode	On Off	
Synchronization	External synchron. off Telegr. and ext. synch. Telegr. or ext. synch. External synch. only	
Blocking of the unbalanced runtimes	Yes No	
Maximum signal runtime threshold	0.1 ms to 30.0 ms	Increments of 0.1 ms
Maximum runtime difference	0.000 ms to 3.000 ms	Increments of 0.001 ms
Fault indication after	0.05 s to 2.00 s	Increments of 0.01 s
Transm. fail. alarm after	0.0 s to 6.0 s	Increments of 0.1 s
Max. error rate/h	0.000 % to 100.000 %	Increments of 0.001 %
Max. error rate/min	0.000 % to 100.000 %	Increments of 0.001 %

Transmission Rate

Direct connection:	
Transmission rate	2048 kbit/s
Connection via communication networks:	
Supported network interfaces	IP protection communication
	C37.94 at 64 kBit/s or 128 kBit/s or 512 kBit/s
	G703.1 at 64 kBit/s G703-T1 at 1.455 MBit/s G703-E1 at 2.048 MBit/s
	X.21 at 64 kBit/s or 128 kBit/s or 512 kBit/s
	Pilot wires at 128 kbit/s
Transmission rate	Transmission rate 64 kBit/s at G703.1 1.455 MBit/s at G703-T1 2.048 MBit/s at G703-E1
	512 kBit/s or 128 kBit/s or 64 kBit/s at X.21
	128 kBit/s for pilot wires

Transmission Times for Remote Data

Measured with a minimum of 512 kbit/s

Priority 1:		
Response time, total approx.		
For 2 ends	Minimum	3 ms + OOT[194]
	Typical	5 ms + OOT
For 3 ends	Minimum	5 ms + OOT
	Typical	9 ms + OOT
For 6 ends	Minimum	10 ms + OOT
	Typical	13 ms + OOT

194 OOT (Output Operating Time): Additional delay of the output medium used, for example, 1 ms with electronic relays

Dropout times, total approx.		
For 2 ends	Typical	15 ms + OOT
For 3 ends	Typical	15 ms + OOT
For 6 ends	Typical	21 ms + OOT

Priority 2		
Response time, total approx.		
For 2 ends	Minimum	4 ms + OOT
	Typical	11 ms + OOT
For 3 ends	Minimum	7 ms + OOT
	Typical	13 ms + OOT
For 6 ends	Minimum	12 ms + OOT
	Typical	18 ms + OOT
Dropout times, total approx.		
For 2 ends	Typical	19 ms + OOT
For 3 ends	Typical	20 ms + OOT
For 6 ends	Typical	27 ms + OOT

Priority 3[195]		
Response time, total approx.		
For 2 ends	Minimum	
	Typical	95 ms + OOT
For 3 ends	Minimum	
	Typical	145 ms + OOT
For 6 ends	Minimum	
	Typical	195 ms + OOT
Dropout times, total approx.		
For 2 ends	Typical	95 ms + OOT
For 3 ends	Typical	145 ms + OOT
For 6 ends	Typical	195 ms + OOT

195 Times cannot be determined because the signals are transmitted in fragments.

12.82 Date and Time Synchronization

Date format	DD.MM.YYYY (Europe)
	MM/DD/YYYY (USA)
	YYYY-MM-DD (China)
Time source 1, Time source 2	None IRIG B 002(003) IRIG B 006(007) IRIG B 005(004) with extension according to IEEE C37.118-2005 DCF77 PI (protection interface) [196] SNTP IEC 60870-5-103 DNP3 IEEE 1588 T104
Time zone 1, time zone 2	Local
	UTC
Fault indication after	0 s to 3600 s
Time zone and daylight saving time	Manually setting the time zones
Time zone offset with respect to GMT	-720 min to 840 min
Switching over to daylight saving time	Active
	Inactive
Beginning of daylight saving time	Input: day and time
End of daylight saving time	Input: day and time
Offset daylight saving time	0 min to 120 min [15 min. steps]

[196] if provided

12.83 Phasor Measurement Unit

Accuracy

IEEE Standard for Synchrophasor Measurements
IEEE Std C37.118.1a™-2014

Data Transfer

IEEE Standard for Synchrophasor Data transfer
IEEE Std C37.118.2™-2011

12.84 Analog Channel Supervision via Fast Current Sum

Times

Pickup times	Approx. 2 ms (faster than the fastest protection function)
Dropout time	Approx. 100 ms

Blockings

Blocked functions	All functions that process the measured values from this current measuring point (for example, differential protection).

12.85 Measuring-Voltage Failure Detection

Setting Values

3ph.fail. - VA,VB,VC <		0.300 V to 340.000 V	Increments of 0.001 V
3ph.fail. - phs.curr.release	1 A @ 50 and100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
3ph.fail. - phs.curr. jump	1 A @ 50 and100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Asym.fail. - time delay		0.00 s to 30.00 s	Increments of 0.01 s
SO 3ph.fail. - time delay		0.00 s to 30.00 s	Increments of 0.01 s

Dropout

The larger dropout differential (= **`| pickup value – dropout threshold |`**) of the following 2 criteria is used:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies to the current threshold value and a dropout ratio of 105 % applies to the voltage threshold value.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup time	Approx. 10 ms + OOT[197] at 50 Hz Approx. 10 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Times

Use in function group **Line**	
Pickup time	Approx. 10 ms + OOT[198] at 50 Hz Approx. 9 ms + OOT at 60 Hz

Use in other function group types	
Pickup time	Approx. 20 ms + OOT[199] at 50 Hz Approx. 18 ms + OOT at 60 Hz

197 OOT (Output Operating Time) Additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

198 OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relays, see chapter *12.1.4 Relay Outputs*

199 OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relays, see chapter *12.1.4 Relay Outputs*

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Active

Tolerances

Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Voltages	0.5 % of the setting value or 0.5 V
Time delays	1 % of the setting value or 10 ms

12.86 Voltage-Transformer Circuit Breaker

Setting Values

Response time	0.000 s to 0.030 s	Increments of 0.001 s

12.87 Broken-Wire Detection

Setting Values

Mode of blocking	***blocking*** ***not blocking***

Frequency Operating Range

40 Hz < f_{rated} < 70 Hz	All functions processing the measured values of this current measuring point, for example, line differential protection, transformer differential protection, distance protection

Blockings

Blocked functions	All functions processing the measured values of this current measuring point, for example, line differential protection, transformer differential protection, distance protection

12.88 Operational Measured Values and Statistical Values

The following applies to the tolerances of the currents and voltages:

- The values apply both to the RMS values and the absolute value and phase angle of the fundamental components.
- These values were determined for pure sinusoidal signals – without harmonics.
- All measured values additionally have a tolerance of 1 DIGIT.

Voltages

V_A, V_B, V_C **Voltage range**	V secondary < 200 V
Secondary rated voltage Measuring range Frequency range	100 V to 125 V 0.1 V_{rated} to 2 V_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range
V_{AB}, V_{BC}, V_{CA} **Voltage range**	V secondary < 200 V
Secondary rated voltage Measuring range Frequency range	100 V to 125 V 0.1 V_{rated} to 2 V_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range
V_1, V_2, V_0 **Voltage range**	V secondary < 200 V
Secondary rated voltage Measuring range Frequency range	100 V to 125 V 0.1 V_{rated} to 2 V_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.25 % of the measured value in the above mentioned measuring range or 0.05 V
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.35 % of the measured value in the above mentioned measuring range or 0.05 V

Currents, Instrument Transformers

I_A, I_B, I_C, $3I_0$ **Current range**	A secondary < 1.6 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A 0.1 I_{rated} to 1.6 I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.15 % of the measured value in the above mentioned measuring range or 0.001 I_{rated}
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range or 0.002 I_{rated}
I_1, I_2, I_0 **Current range**	A secondary < 1.6 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A 0.1 I_{rated} to 1.6 I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above mentioned measuring range or 0.001 I_{rated}
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.35 % of the measured value in the above mentioned measuring range or 0.002 I_{rated}

Currents, Protection-Class Current Transformer

I_A, I_B, I_C, $3I_0$ **Current range**	A secondary < 100 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A 0.1 I_{rated} to 5 I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above mentioned measuring range or 0.001 I_{rated}
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.35 % f the measured value in the above mentioned measuring range or 0.002 I_{rated}
I_1, I_2, I_0 **Current range**	A secondary < 100 I_{rated}

Rated currents Measuring range Frequency range	1 A, 5 A 0.1 I_{rated} to 5 I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.25 % of the measured value in the above mentioned measuring range or 0.001 I_{rated}
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.4 % of the measured value in the above mentioned measuring range or 0.002 I_{rated}

Currents, Sensitive Ground-Current Transformer

$3I_0$ Current range	A secondary < 1.6 I_{rated}
Rated currents Measuring range Frequency range	1 A. 5 A 0.1 I_{rated} to 1.6 I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.15 % of the measured value in the above mentioned measuring range or 0.001 I_{rated}
Frequency range (expanded)	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range or 0.002 I_{rated}

Phase Angle

ΦV	°
Frequency range	47.5 Hz to 52.5 Hz at f_{rated} = 50 Hz 57.5 Hz to 62.5 Hz at f_{rated} = 60 Hz
Tolerance ΦV	0.2° at rated voltage
ΦI	°
Frequency range	47.5 Hz to 52.5 Hz at f_{rated} = 50 Hz 57.5 Hz to 62.5 Hz at f_{rated} = 60 Hz
Tolerance ΦI	0.2° at rated current

Power Values

Active power P	W secondary
Voltage range Current range Frequency range Power factor	0.8 V_{rated} to 1.2 V_{rated} 0.1 I_{rated} to 2 I_{rated} 45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz $\lvert\cos\varphi\rvert \geq 0.707$
Tolerance	0.5 % of S_{rated} in the above mentioned measuring range
Reactive power Q	var secondary

Voltage range Current range Frequency range Power factor	0.8 V_{rated} to 1.2 V_{rated} 0.1 I_{rated} to 2 I_{rated} 45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz |cosφ| ≤ 0.707
Tolerance	0.5 % of S_{rated} in the above mentioned measuring range
Apparent power S	VA secondary
Voltage range Current range Frequency range	0.8 V_{rated} to 1.2 V_{rated} 0.01 I_{rated} to 2 I_{rated} 45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.5 % of S_{rated} in the above mentioned measuring range

Power Factor

Voltage range	0.8 V_{rated} to 1.2 V_{rated}
Current range	0.1 I_{rated} to 2 I_{rated}
Frequency range	45 Hz to 55 Hz at f_{rated} = 50 Hz 55 Hz to 65 Hz at f_{rated} = 60 Hz
Tolerance	0.02 in the above mentioned measuring range

Frequency

Frequency f	Hz
Range	f_{rated} ± 0.20 Hz
Tolerance	± 2 mHz at V = V_{rated} or at I = I_{rated}
Range	f_{rated} ± 3.00 Hz
Tolerance	± 5 mHz at V = V_{rated} or at I = I_{rated}
Range	25 Hz to 80 Hz; operational measured values 10 Hz to 90 Hz; functional measured values, system frequency
Tolerance	± 10 mHz at V = V_{rated} or at I = I_{rated}

Statistical Values of the Device

Device operating hours	h
Range	0 h to 9999999 h
Tolerance	1 h

Statistical Values, Circuit Breaker

Op.cnt. (operation counter)	
Range	0 to 999999999
Tolerance	None
∑I Off (sum of the primary currents switched off)	A, kA, MA, GA, TA, PA primary
Range	0 to 9.2^{e+15}

Operating hours	h
Range	0 h to 9999999 h
Tolerance	1 h
Circuit breaker open hours	h
Range	0 h to 9999999 h
Tolerance	1 h

Statistical Values, Disconnector

Op.cnt. (operation counter)	
Range	0 to 999999999
Tolerance	None

12.89 Energy Values

Active energy W_p	kWh, MWh, GWh
Measuring range Voltage range Current range Frequency range	|cosφ| ≥ 0.01 (0.8 to 1.2) · V_{rated} (0.1 to 2) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 69 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.5 % of the measured value in the above mentioned measuring range

Reactive energy W_q	kvarh, Mvarh, Gvarh
Measuring range Voltage range Current range Frequency range	|cosφ| ≤ 0.984 (0.8 to 1.2) · V_{rated} (0.1 to 2) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	1.0 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 69 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	1.5 % of the measured value in the above mentioned measuring range

Pulse metered values	
Maximum detection speed	50/s

12.90 Power Quality – Basic

12.90.1 Voltage Variation

The function **Voltage variation** complies with Class S according to IEC 61000-4-30.

Setting Values

Threshold of the **Dip** stage	10.0 % to 100.0 %	Increments of 0.1 %
Threshold of the **Swell** stage	100.0 % to 140.0 %	Increments of 0.1 %
Threshold of the **Interruption** stage	1.0 % to 20.0 %	Increments of 0.1 %
Dropout differential	1.0 % to 10.0 %	Increments of 0.1 %
Warning delay	0.00 s to 60.00 s	Increments of 0.01 s

Tolerances

Threshold value	1 % of the parameter **`Rated voltage`** that is set in the function group Class S according to IEC 61000-4-30
Warning delay	1 % of the setting value or 10 ms
Dip, swell, or interruption duration	2 network cycles Class S according to IEC 61000-4-30 (For the stage **Interruption**, Class S is met when the threshold value of the stage **Interruption** is set to be equal to or greater than 3 %.)
Residual or swell voltage	1 % of the parameter **`Rated voltage`** that is set in the function group Class S according to IEC 61000-4-30

Frequency Operating Range

$0.85\ f_{rated} \le f \le 1.15\ f_{rated}$	According to specified tolerances
$10\ Hz \le f < 0.85\ f_{rated}$ $1.15\ f_{rated} < f \le 90\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 90\ Hz$	Inactive

12.90.2 Voltage Unbalance

The function **Voltage Unbalance** complies with Class S according to IEC 61000-4-30.

Setting Value for the Function

Value	Setting Range	Increment
Minimum voltage V1	0.300 V to 60.000 V	0.001 V

Setting Values for the Stages

Value	Setting Range	Increment
Threshold	0.50 % to 10.00 %	0.01 %
Dropout ratio	0.90 to 0.99	0.01
Observation period	• daily • weekly	–

Value	Setting Range	Increment
Starting day of week	• Sunday • Monday • Tuesday • Wednesday • Thursday • Friday • Saturday	–
Percentile	80 % to 99 %	1 %

Tolerance

For all functional values in the measuring interval of 3 s or 10 min	
V2/V1, V0/V1	±0.15 % Class S according to IEC 61000-4-30

Dropout Ratio

Dropout ratio of warning	5 % of the setting value or 0.25

Frequency Operating Range

0.85 $f_{rated} \le f \le 1.15\ f_{rated}$	According to specified tolerances
10 Hz ≤ f < 0.85 f_{rated} 1.15 f_{rated} < f ≤ 90 Hz	Slightly expanded tolerances
f < 10 Hz f > 90 Hz	Inactive

12.90.3 THD and Harmonics

Setting Value for the Stage Voltage

Value	Setting Range	Increment
Threshold	1.0 % to 25.0 %	0.1
Aggregation interval	• 1 min • 10 min	–

Stage Current

Current range (Ia, Ib, Ic)	Sensitive transformer: 0.01 I_{rated} to 1.6 I_{rated} Protection transformer: 0.01 I_{rated} to 2 I_{rated}	
Tolerance THD value	$I_{fund.} \ge 0.1\ I_{rated}$	0.5 % in the measured range
	0.01 $I_{rated} \le I_{fund.} < 0.1\ I_{rated}$	2.0 % in the measured range
Tolerance harmonic value (2nd to 20th)	$I_{fund.} \ge 0.1\ I_{rated}$	0.5 % in the measured range
	0.01 $I_{rated} \le I_{fund.} < 0.1\ I_{rated}$	2.0 % in the measured range

Stage Voltage

Voltage range (Va, Vb, Vc)	0.1 V_{rated} to 2 V_{rated}
Tolerance THD value	0.5 % in the measured range
Tolerance harmonic value (2nd to 20th)	0.5 % in the measured range

Frequency Operating Range

$0.85\ f_{rated} \le f \le 1.15\ f_{rated}$	According to specified tolerances
$0.8\ f_{rated} \le f < 0.85\ f_{rated}$ $1.15\ f_{rated} < f \le 1.2\ f_{rated}$	Slightly expanded tolerances
$f < 0.8\ f_{rated}$ $f > 1.2\ f_{rated}$	Inactive

12.90.4 Total Demand Distortion

Setting Value for the Stage Voltage

Value	Setting Range	Increment
Threshold	1.0 % to 25.0 %	0.1
Interval	• 15 min • 30 min	–

Stage Current

Current range (Ia, Ib, Ic)	Sensitive transformer: 0.01 I_{rated} to 1.6 I_{rated} Protection transformer: 0.01 I_{rated} to 2 I_{rated}	
Tolerance of the TDD value	$I_{fund.} \ge 0.1\ I_{rated}$	0.5 % in the measured range
	$0.01\ I_{rated} \le I_{fund.} < 0.1\ I_{rated}$	2.0 % in the measured range

Frequency Operating Range

$0.85\ f_{rated} \le f \le 1.15\ f_{rated}$	According to specified tolerances
$0.8\ f_{rated} \le f < 0.85\ f_{rated}$ $1.15\ f_{rated} < f \le 1.2\ f_{rated}$	Slightly expanded tolerances
$f < 0.8\ f_{rated}$ $f > 1.2\ f_{rated}$	Inactive

12.91 Circuit-Breaker Monitoring

Setting Values

Threshold value	ΣI^x-method	0 to 10 000 000	Increments of 1
	2P-method	0 to 10 000 000	Increments of 1
	I^2t-method	0.00 I/Ir*s to 21 400 000.00 I/Ir*s	Increments of 0.01
	Make time	1 % to 100 %	Increments of 1 %
	Break time	1 % to 100 %	Increments of 1 %
	Pole scatter time open	1 ms to 100 ms	Increments of 1 ms
	Pole scatter time close	1 ms to 100 ms	Increments of 1 ms
	Mechanical switching time open	1 ms to 1000 ms	Increments of 1 ms
	Mechanical switching time close	1 ms to 1000 ms	Increments of 1 ms
CB opening time		1 ms to 500 ms	Increments of 1 ms
CB break time		1 ms to 600 ms	Increments of 1 ms
CB make time		1 ms to 600 ms	Increments of 1 ms
Exponent for ΣI^x method		1.0 to 3.0	Increments of 0.1
Switching cycles at I_r		100 to 10 000 000	Increments of 1
Rated short-circuit current I_{sc}		10 A to 100 000 A	Increments of 1 A
Switching cycles at I_{sc}		1 to 1000	Increments of 1
Operating current threshold	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.01 A
Delay correction time		-50 ms to 50 ms	Increments of 1 ms
Auxiliary-contact time		1 ms to 1000 ms	Increments of 1 ms
Response time		1 ms to 1000 ms	Increments of 1 ms

Tolerances

Tolerance of the measured value Make time	± 2 ms
Tolerance of the measured value Break time	± 2 ms
Tolerance of the measured value Pole scatter time	± 2 ms
Tolerance of the measured value Aux.-contact time	± 2 ms
Tolerance of the measured value response time	± 2 ms

12.92 Disconnector Supervision

Setting Values

Threshold value	Mechanical switching time open	0.02 s to 1800.00 s	Increments of 0.01 s
	Mechanical switching time close	0.02 s to 1800.00 s	Increments of 0.01 s
Auxiliary contact time		0.02 s to 1800.00 s	Increments of 0.01 s
Reaction time		0.02 s to 1800.00 s	Increments of 0.01 s

Tolerances

Tolerance of the make-time measured value	±2 ms
Tolerance of the break-time measured value	±2 ms
Tolerance of the reaction-time measured value	±2 ms

12.93 CFC

Typical response times and maximum number of ticks of the CFC task levels:

Task Level	Time (in ms)	Ticks for CP100/CP150	Ticks CP300
High priority Event-triggered	<1	500	1000
Event-triggered	<10	12 367	12 023
Low priority Event-triggered	<10	117 564 in total	112 996 in total
Measurement	250		

The times describe the response time of a typical CFC chart at the respective task level. The maximum number of ticks applies to a typical load for the device based on the application template **3-winding trans. (Diff. Protection, CBFP, REF, DIS)**

The task level ***Measurement*** runs in cycles every 500 ms. All other task levels are event-triggered.

In order to estimate the tick consumption of a CFC chart, you can use the following formula:

$$T_{Chart} = 5 \cdot n_{Inp} + 5 \cdot n_{Outp} + T_{TLev} + \sum_i T_{int} + \sum_j T_{Block}$$

Where:

n_{Inp} Number of indications routed as input in the CFC chart

n_{Outp} Number of indications routed as output in the CFC chart

T_{TLev} 101 Ticks in the High priority Event-triggered level
104 Ticks in the Event-triggered level
54 Ticks in Measurement level
74 Ticks in the Low priority Event-triggered level

T_{int} Number of internal connections between 2 CFC blocks in one chart

T_{Block} Used ticks per CFC block (see *Table 12-13*)

Table 12-13 Ticks of the Individual CFC Blocks

Element	Ticks
ABS_D	2.3
ABS_R	1.5
ACOS_R	6.9
ADD_D4	3.4
ADD_R4	3.3
ADD_XMV	6.4
ALARM	1.8
AND_SPS	1.1
AND10	2.9
APC_DEF	1.2
APC_EXE	1.0
APC_INFO	3.9
ASIN_R	1.3
ATAN_R	1.2
BLINK	1.3
BOOL_CNT	2.0
BOOL_INT	1.5
BSC_DEF	1.3

Element	Ticks
BSC_EXE	1.1
BSC_INFO	2.7
BUILD_ACD	2.9
BUILD_ACT	2.2
BUILD_BSC	1.2
BUILD_CMV	2.3
BUILD_DEL	2.1
BUILD_DPS	1.4
BUILD_ENS	1.3
BUILD_INS	0.5
BUILD_Q	0.8
BUILD_SPS	0.6
BUILD_WYE	3.2
BUILD_XMV	2.9
BUILDC_Q	3.0
CHART_STATE	5.9
CMP_DPS	1.5
CON_ACD	0.7
CON_ACT	0.5
CONNECT	0.4
COS_R	2.5
CTD	1.8
CTU	1.6
CTUD	2.3
DINT_REAL	3.0
DINT_UINT	3.0
DIV_D	2.9
DIV_R	1.6
DIV_XMV	2.2
DPC_DEF	0.4
DPC_EXE	0.4
DPC_INFO	1.1
DPC_OUT	1.3
DPS_SPS	1.0
DRAGI_R	1.7
ENC_DEF	3.6
ENC_EXE	3.8
EQ_D	1.0
EQ_R	1.9
EXP_R	1.5
EXPT_R	2.7
F_TRGM	0.3
F_TRIG	0.3
FF_D	0.9
FF_D_MEM	1.4
FF_RS	0.7
FF_RS_MEM	1.2

Element	Ticks
FF_SR	0.8
FF_SR_MEM	1.1
GE_D	0.9
GE_R	1.1
GT_D	0.9
GT_R	1.2
HOLD_D	1.1
HOLD_R	1.0
INC_INFO	0.9
LE_D	1.1
LE_R	1.1
LIML_R	1.5
LIMU_R	1.5
LN_R	3.3
LOG_R	1.2
LOOP	1.5
LT_D	0.9
LT_R	0.9
MAX_D	0.9
MAX_R	1.4
MEMORY_D	0.9
MEMORY_R	1.1
MIN_D	0.7
MIN_R	1.3
MOD_D	1.5
MUL_D4	2.5
MUL_R4	2.7
MUL_XMV	2.8
MUX_D	1.2
MUX_R	0.9
NAND10	3.5
NE_D	0.9
NE_R	0.9
NEG	1.2
NEG_SPS	0.8
NL_LZ	3.8
NL_MV	5.6
NL_ZP	2.7
NOR10	3.2
OR_DYN	1.1
OR_SPS	1.3
OR10	2.6
R_TRGM	0.4
R_TRIG	0.4
REAL_DINT	3.0
REAL_SXMV	3.0
SIN_R	0.8

Element	Ticks
SPC_DEF	0.4
SPC_EXE	0.4
SPC_INFO	0.4
SPC_OUT	0.4
SPLIT_ACD	3.4
SPLIT_ACT	1.0
SPLIT_BSC	1.3
SPLIT_CMV	2.2
SPLIT_DEL	2.0
SPLIT_DPS	1.0
SPLIT_INS	0.5
SPLIT_Q	0.7
SPLIT_SPS	0.8
SPLIT_WYE	2.6
SPLIT_XMV	2.1
SQRT_R	0.6
SUB_D	1.3
SUB_R	1.6
SUB_XMV	2.4
SUBST_B	1.0
SUBST_BQ	1.5
SUBST_D	1.0
SUBST_R	1.0
SUBST_XQ	1.4
SXMV_REAL	3.0
TAN_R	1.1
TLONG	2.2
TOF	1.0
TON	1.1
TP	2.5
TSHORT	1.9
UINT_DINT	3.0
XOR2	2.6

12.94 Point-on-Wave Switching

You can find more information about the technical data of the **Point-on-wave switching** function in the *Point-on-Wave Switching Function Manual*.

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A.1 Order Configurator and Order Options

Order Configurator

The order configurator assists you in the selection of SIPROTEC 5 products. The order configurator is a Web application that can be used with any browser. The order configurator can be used to configure complete devices or individual components, such as communication modules, expansion modules, or other accessories. At the end of the configuration process, the product code and a detailed presentation of the configuration result are provided. The product code unambiguously describes the selected product and also serves as an order number.

Ordering Options

The following ordering options are possible for SIPROTEC 5 products:

- Device
- Single part
- DIGSI 5
- Functional enhancement



NOTE

To order single parts in the order configurator, use the **Single part** link.

Individual parts are:

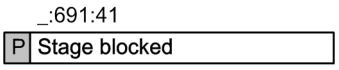
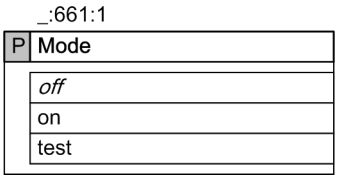
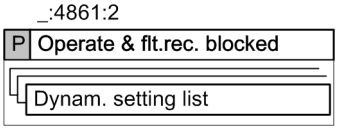
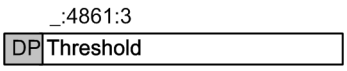
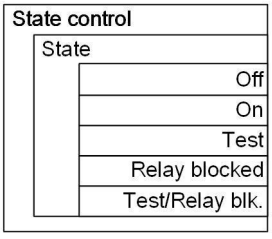
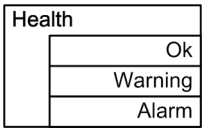
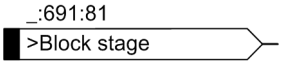
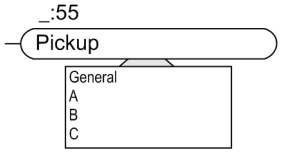
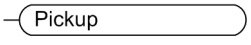
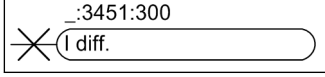
- Expansion module
- Plug-in module
- Sensors for arc protection
- Operation panel
- Terminal
- Accessories

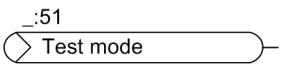
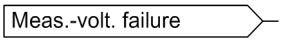
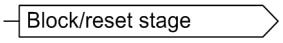
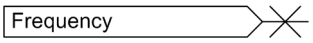
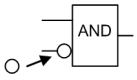
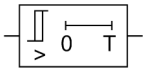
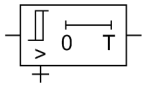
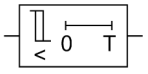
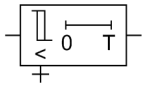
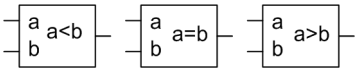
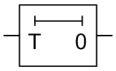
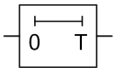
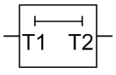
A.2 Typographic and Symbol Conventions

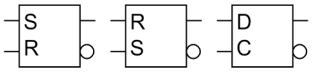
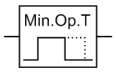
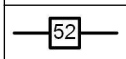
The following typefaces are used to characterize parameters in the text:

Mode	Parameter name
_:661:1	Parameter address _ stands for the address combination from function group:function 661, for example, stands for the address of the setting parameter
off	Parameter state

The following symbols are used in drawings:

Icon	Description
	Parameter
	Parameters with setting values The default setting is in the 1st position and is displayed in italics.
	Parameters with application-dependent setting values
	Dynamic settings
	State logic
	Health of a function, stage, or function block
	External binary input signal with indication number
	External output signal with indication number and additional information
	External output signal without indication number
	Measured output value

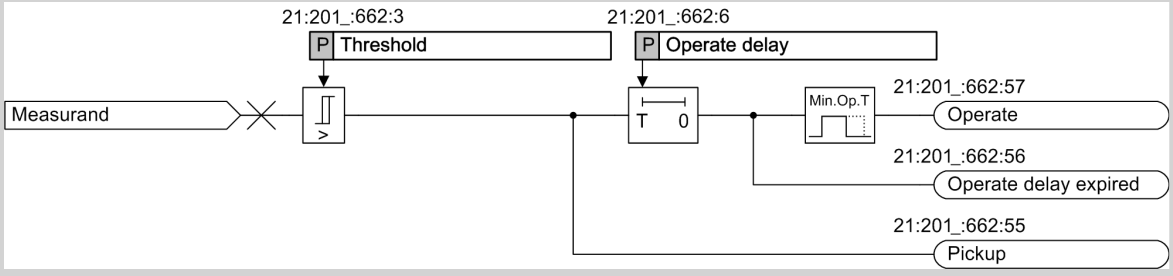
Icon	Description
	Binary input signal derived from an external output signal
	Internal input signal
	Internal output signal
	Analog input signal
	Reset/block a logic element
	AND gate
	OR gate
	XOR gate
	Negation
	Threshold stage exceeded
	Threshold stage exceeded with reset of input
	Threshold stage shortfall
	Threshold stage shortfall with reset of input
	Threshold stage exceeded with dropout delay
	Threshold stage exceeded with dropout delay and reset of input
	Threshold stage shortfall with dropout delay
	Threshold stage shortfall with dropout delay and reset of input
	Comparators
	Pickup delay
	Dropout delay
	Pickup and dropout delay

Icon	Description
	Trigger the pulse of duration T with a positive signal edge
	Trigger the pulse of duration T with a negative signal edge
	SR-flip-flop, RS-flip-flop, D-flip-flop
	Characteristic curve
	Minimum operate time
	Circuit breaker open
	Circuit breaker closed

A.3 Available Protection and Control Functions in the Transformer Differential Protection Function Groups

EXAMPLE

The structure of the text and reference number is shown in the protection-function group **Line** as an example of the parameter **`Threshold value`** and the indication **`Pickup`** of the 2nd definite-time overcurrent protection stage of the function **Overcurrent protection, phases** (see *Figure 2-9*). Only one function and one function group exist in the device. The representation of the stage is simplified.



[lo_stuumz_1_en_US]

Figure A-1 Stage of the Overcurrent Protection Function, Phases (without Representation of Stage Control)

The following table shows the texts and numbers of the hierarchy elements concerned:

	Name	Number of the Type	Instance Number
Protection function group	Line	2	1
Function	Overcurrent 3ph	20	1
Stage	Definite-time overcurrent protection	66	2
Settings	Threshold value	3	–
Indication	Pickup	55	–

The instance numbers arise as follows:

- Function group: Line **1**
  1 instance, because only one **Line** function group exists in the device
- Function: Overcurrent 3ph **1**
  1 instance, because only one **Overcurrent 3ph** function exists in the **Line** function group
- Stage: Definite-time overcurrent protection **2**
  2 instances, because 2 definite-time overcurrent protection stages exist in the **Overcurrent 3ph** function (here the 2nd instance as an example)

This results in the following texts and numbers (including the instance numbers):

Parameter:	**Number**
Line 1:Overcurrent 3-ph 1:Definite-time overcurrent protection 2:Threshold value	21:201:662:3
Indication:	**Number**
Line 1:Overcurrent 3-ph 1:Definite-time overcurrent protection 2:Pickup	21:201:662:55

The structure is simplified accordingly for parameters and indications with fewer hierarchy levels.

The following table gives you an overview of the protection and control functions which are available in the function groups of the devices 7UT82, 7UT85, 7UT86, and 7UT87.

Table A-1 Functions in the Function Groups

			Function Group FG																	
			90	91	92	93	94	95	96	97	86	87	81	83	82	59	58	16	2	20
ANSI	Protection Function FN	Protection function number in DIGSI	Transformer Diff.	Transformer Side	Transformer Neutral Point	Auto Transformer Diff.	Auto Transformer Auto Side	Auto Transformer Comp. Side	Auto Transformer Ground Side	Auto Transformer Neutral Point	Motor Diff.	Motor Side	Voltage 3ph	Voltage-Current 1ph	Voltage-Current 3ph	Generator Diff.	Generator Side	Voltage Controller	Line	Circuit Breaker
21/21N	Distance protection [3pol., grounded]	88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
	Distance protection [isolated, compensated]	89	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
	RM Distance protection [grounded]	190	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
21T	Impedance protection for transformer	220	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–
24	Overexcitation protection	199	–	1	–	–	1	1	–	–	–	1	1	–	1	–	1	–	1	–
25	Synchrocheck, Paralleling function	115	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
27	Undervoltage Protection – 3-Phase	13	–	2	–	–	2	2	–	–	–	2	2	–	2	–	2	–	2	–
	Undervoltage Protection, positive-sequence system	15	–	2	–	–	2	2	–	–	–	2	2	–	2	–	2	–	2	–
	Undervoltage Protection, 3-phase, universal, Vx	18	–	4	–	–	4	4	–	–	–	4	4	–	4	–	4	–	4	–
27/Q	27/Q protection	206	–	2	–	–	2	2	–	–	–	2	–	–	2	–	–	–	2	–
32/37	Power Protection (P,Q), 3-Phase	117	–	2	–	–	2	2	–	–	–	2	–	–	2	–	1	–	2	–
32R	Reverse-power protection	33	–	2	–	–	2	2	–	–	–	2	–	–	2	–	–	–	2	–
37	Undercurrent protection	191	–	2	–	–	2	2	–	–	–	2	–	–	2	–	2	–	2	–
38	Temperature Supervision	170	1	1	1	1	1	1	1	1	1	1	1	–	1	1	1	–	4	–
46	Negative-Sequence Overcurrent Protection	30	–	2	–	–	2	2	2	–	–	2	–	–	2	–	1	–	2	–
	Unbalanced-load protection (thermal)	32	–	2	–	–	2	2	2	–	–	2	–	–	2	–	1	–	2	–
47	Overvoltage protection with negative-sequence voltage	8	–	2	–	–	2	2	–	–	–	2	2	–	2	–	2	–	2	–
	Overvoltage Protection with Positive-Sequence Voltage	250	–	2	–	–	2	2	–	–	–	2	2	–	2	–	2	–	2	–
49	Thermal overload protection, 3-phase	60	–	1	–	–	1	1	1	–	–	1	–	–	1	–	1	–	1	–
	Thermal overload protection, 1-phase		–	–	1	–	–	–	–	1	–	–	–	1	–	–	–	–	–	–
	Thermal overload protection, user-defined characteristic curve	1782	–	1	–	–	1	1	1	–	–	1	–	–	1	–	1	–	1	–

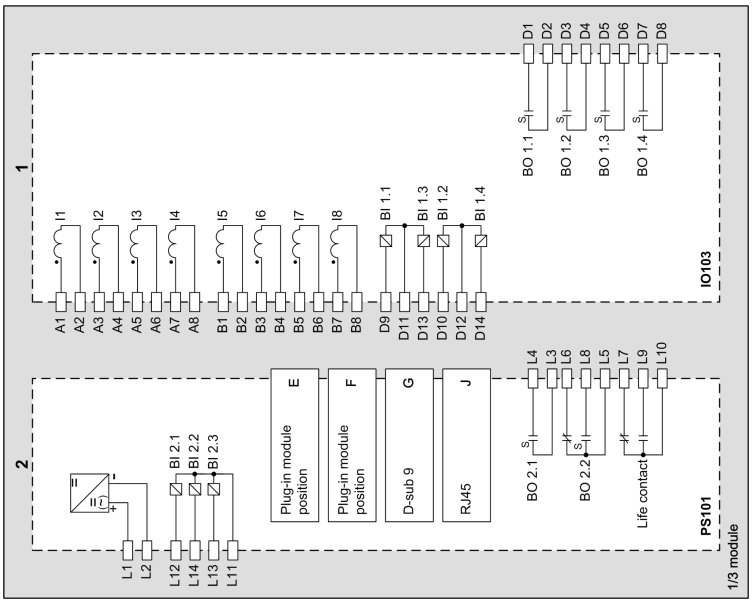
			Function Group FG																	
			90	91	92	93	94	95	96	97	86	87	81	83	82	59	58	16	2	20
ANSI	Protection Function FN	Protection function number in DIGSI	Transformer Diff.	Transformer Side	Transformer Neutral Point	Auto Transformer Diff.	Auto Transformer Auto Side	Auto Transformer Comp. Side	Auto Transformer Ground Side	Auto Transformer Neutral Point	Motor Diff.	Motor Side	Voltage 3ph	Voltage-Current 1ph	Voltage-Current 3ph	Generator Diff.	Generator Side	Voltage Controller	Line	Circuit Breaker
49H	Hotspot calculation	200	–	2	–	–	2	2	–	–	-	2	–	–	2	–	–	–	2	–
50BF	Circuit-breaker failure protection	438	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
	Circuit-breaker monitoring	343	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
50RS	Circuit-breaker restrike protection	1509	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
50/51 TD	Overcurrent Protection, Phases	20	–	2	–	–	2	2	2	–	–	2	–	–	2	–	2	–	2	–
50N/51N TD	Overcurrent protection, ground	21	–	2	–	–	2	2	2	–	–	2	–	–	2	–	–	–	2	–
50Ns/ 51Ns	Sensitive ground-current protection for systems with resonant-grounded or isolated neutral	187	–	2	–	–	2	2	2	–	–	2	–	2	2	–	–	–	2	–
50HS	Instantaneous high-current tripping	97	–	1	–	–	1	1	1	–	–	1	–	–	1	–	–	–	1	–
50N/51N TD	Overcurrent protection, 1-phase	189	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–
51V	Voltage-dependent overcurrent – phase	205	–	2	–	–	2	2	–	–	–	2	–	–	2	–	1	–	2	–
59	Overvoltage Protection with 3-Phase Voltage	5	–	2	–	–	2	2	–	–	–	2	2	–	2	–	2	–	2	–
	Overvoltage Protection with Positive-Sequence Voltage	6	–	2	–	–	2	2	–	–	–	2	2	–	2	–	2	–	2	–
	Overvoltage protection, 3-phase, universal, Vx	12	–	4	–	–	4	4	–	–	–	4	4	–	4	–	4	–	4	–
59N	Overvoltage Protection with Zero-Sequence Voltage/ Residual Voltage	10	–	2	–	–	2	2	–	–	–	2	2	–	2	–	2	–	2	–
60	Voltage-comparison supervision	273	–	1	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–
67	Directional overcurrent protection, phases	197	–	2	–	–	2	2	–	–	–	2	–	–	2	–	2	–	2	–
67N	Directional overcurrent protection, ground	174	–	2	–	–	2	2	–	–	–	2	–	–	2	–	–	–	2	–
	Ground-Fault Protection for High-Resistance Ground Faults in Grounded Systems	111	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–

			Function Group FG																
			90	91	92	93	94	95	96	97	86	87	81	83	82	59	58	16	2	20
ANSI	Protection Function FN	Protection function number in DIGSI	Transformer Diff.	Transformer Side	Transformer Neutral Point	Auto Transformer Diff.	Auto Transformer Auto Side	Auto Transformer Comp. Side	Auto Transformer Ground Side	Auto Transformer Neutral Point	Motor Diff.	Motor Side	Voltage 3ph	Voltage-Current 1ph	Voltage-Current 3ph	Generator Diff.	Generator Side	Voltage Controller	Line	Circuit Breaker
67Ns	Sensitive ground-fault detection for resonant-grounded and isolated systems • V0> • V0>dir.harm. • Pulse detect. • cosine/sine φ • Transient ground fault • φ(V,I) • Admittance	186	–	2	–	–	2	2	–	–	–	2	–	2	2	–	–	–	2	–
	Intermittent ground-fault prot.	213	–	–	–	–	–	–	–	–	–	–	–	2	2	–	–	–	2	–
	Directional intermittent ground-fault protection	224	–	–	–	–	–	–	–	–	–	–	–	2	2	–	–	–	2	–
68	68 P.swing blk	531	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
74CC	Circuit-breaker closing-circuit supervision	2112	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
74TC	Trip-circuit supervision	444	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
79	Automatic Reclosing	136	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
81O	Overfrequency Protection	1	–	2	–	–	2	2	–	–	–	2	2	–	2	–	2	–	2	–
81U	Underfrequency Protection	3	–	2	–	–	2	2	–	–	–	2	2	–	2	–	2	–	2	–
81R	Rate of frequency change protection	195	–	2	–	–	2	2	–	–	–	2	2	–	2	–	2	–	2	–
85/21	Teleprotection with distance protection	128/ 129	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
85/27	Echo and Tripping in the Event of Weak Infeed	133	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
85/67N	Teleprotection with Ground-Fault Protection, directional	130/ 132	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
87G	Generator differential protection	241	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–
87L	Line differential protection for 2 line ends	82	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
87M	Motor Differential Protection	208	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–
87 STUB	STUB Differential protection (for breaker-and-a-half layouts)	143	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–

			Function Group FG																	
			90	91	92	93	94	95	96	97	86	87	81	83	82	59	58	16	2	20
ANSI	Protection Function FN	Protection function number in DIGSI	Transformer Diff.	Transformer Side	Transformer Neutral Point	Auto Transformer Diff.	Auto Transformer Auto Side	Auto Transformer Comp. Side	Auto Transformer Ground Side	Auto Transformer Neutral Point	Motor Diff.	Motor Side	Voltage 3ph	Voltage-Current 1ph	Voltage-Current 3ph	Generator Diff.	Generator Side	Voltage Controller	Line	Circuit Breaker
87T[200]	Transformer differential protection (7UT87)	169	2	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
87N T	Restricted Ground-Fault Protection	1008	–	1	–	1	–	1	–	–	–	–	–	–	1	–	–	–	–	–
90 V	Voltage control two-winding transformer	1401	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
	Voltage control three-winding transformer	1560	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
	Voltage control grid coupling transformer	1635	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
FL	Fault Locator, Single-Ended	867	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	–
FL plus	Fault locator plus	161	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	–
SOTF	Instantaneous Tripping at Switch onto Fault	134	–	2	–	–	2	2	2	–	–	2	–	–	2	–	–	–	2	–
AFD	Arc protection	215	–	1	–	–	1	–	–	–	–	–	–	–	1	–	–	–	1	–
	Inrush-Current Detection	414	–	1	–	–	1	1	1	–	–	1	–	–	1	–	1	–	1	–
	2nd Harmonic Ground Detection	2205	–	1	–	–	1	1	1	–	–	1	–	–	1	–	1	–	1	–
	THD and harmonics	218	–	1	–	–	1	1	1	–	–	1	–	–	1	–	1	–	1	–
	Vector-Jump Protection	281	–	1	–	–	–	–	–	–	–	–	1	–	1	–	1	–	–	–
	Current-jump detection	1044	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	5	–
	Voltage-jump detection	1047	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	5	–
	Point-on-wave switching	290	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	External trip initiation	28	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	–	9	–

[200] Notes on the maximum number of instances, refer to *6.2.2 Structure of the Function*.

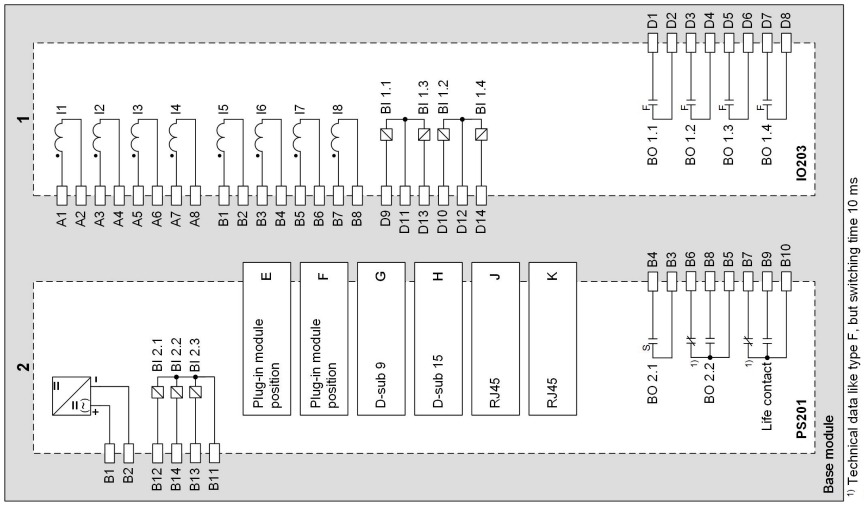
A.4 Standard Variant for 7UT82



[svut82typ01-210114-01, 1, en_US]

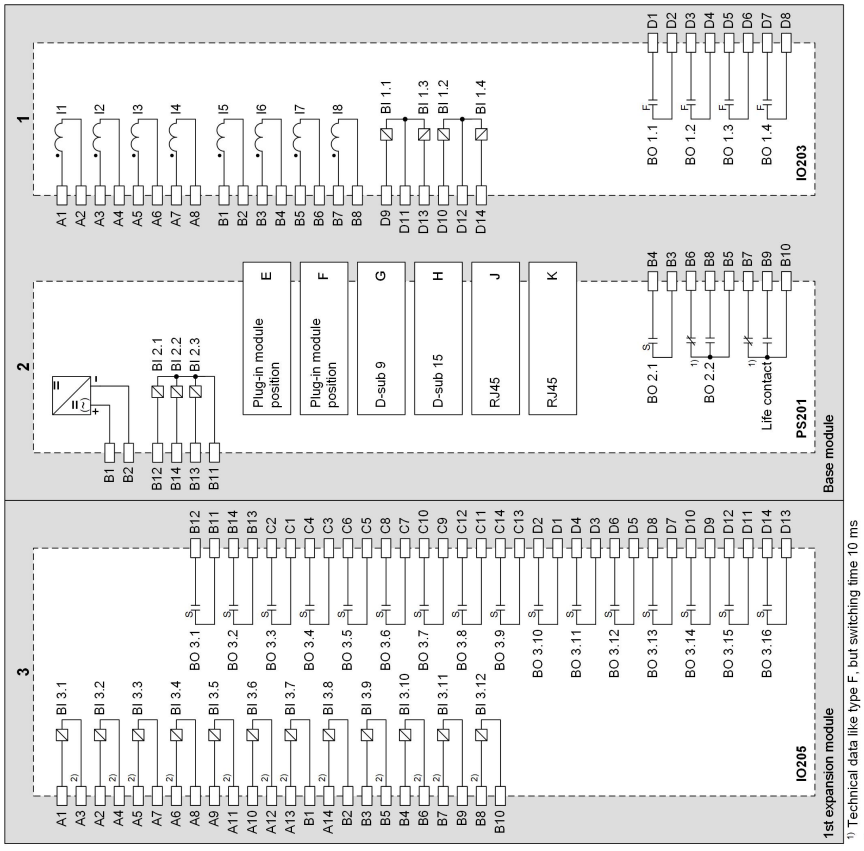
Figure A-2 Standard Variant 7UT82

A.5 Standard Variants for 7UT85



[svSTyp51-130813-01, 2, en_US]

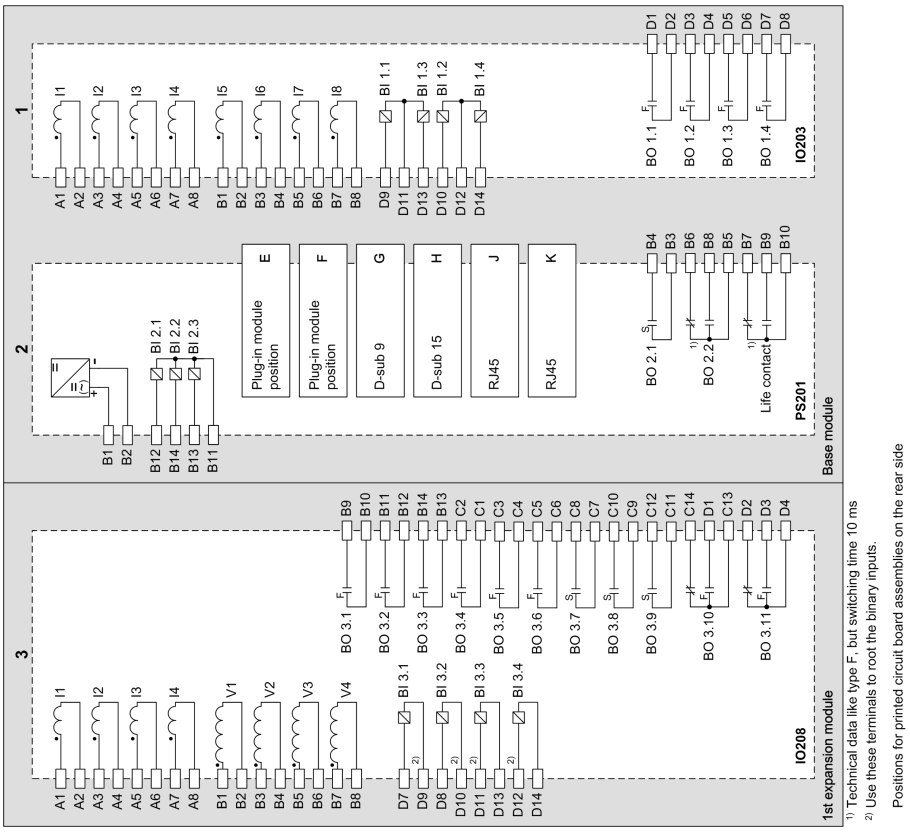
Figure A-3 Standard Variant Type 1



[svSTyp52-130813-01, 2, en_US]

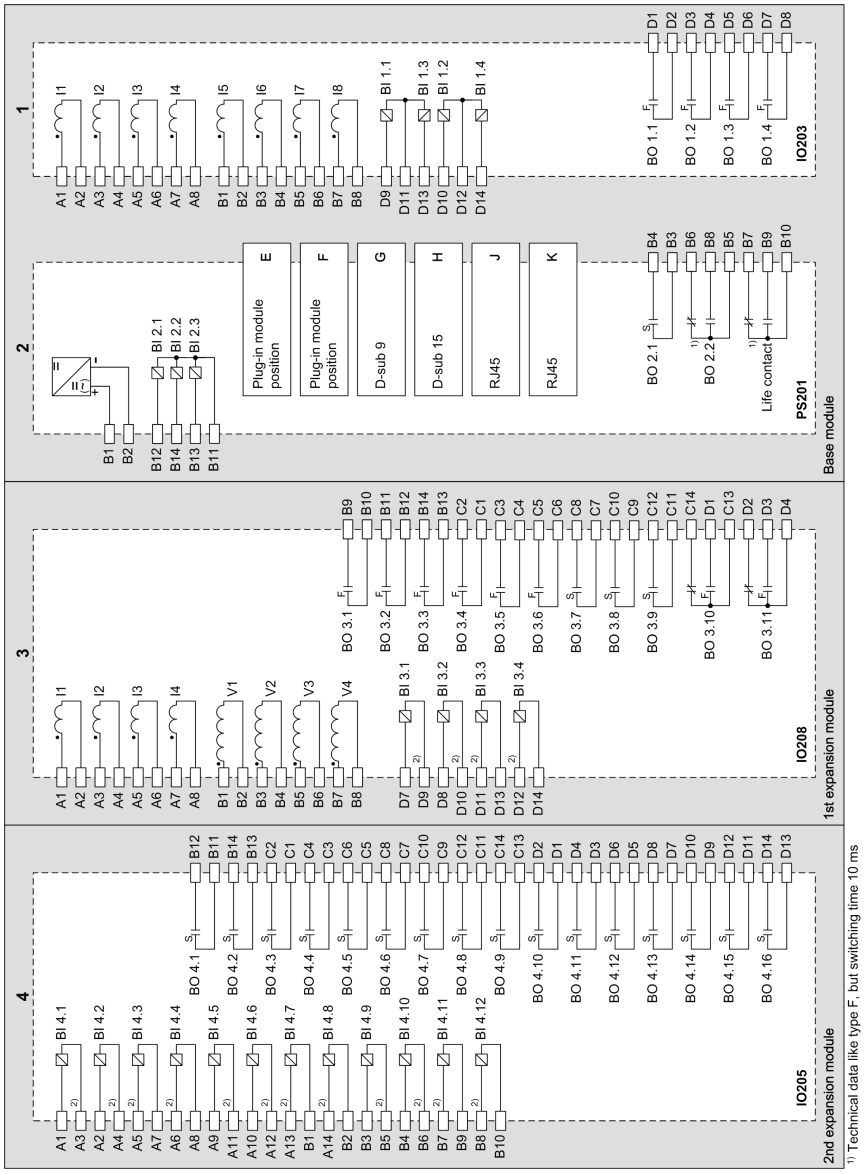
Figure A-4 Standard Variant Type 2

A.6 Standard Variants for 7UT86



[svSTyp61-130813-01, 1, en_US]

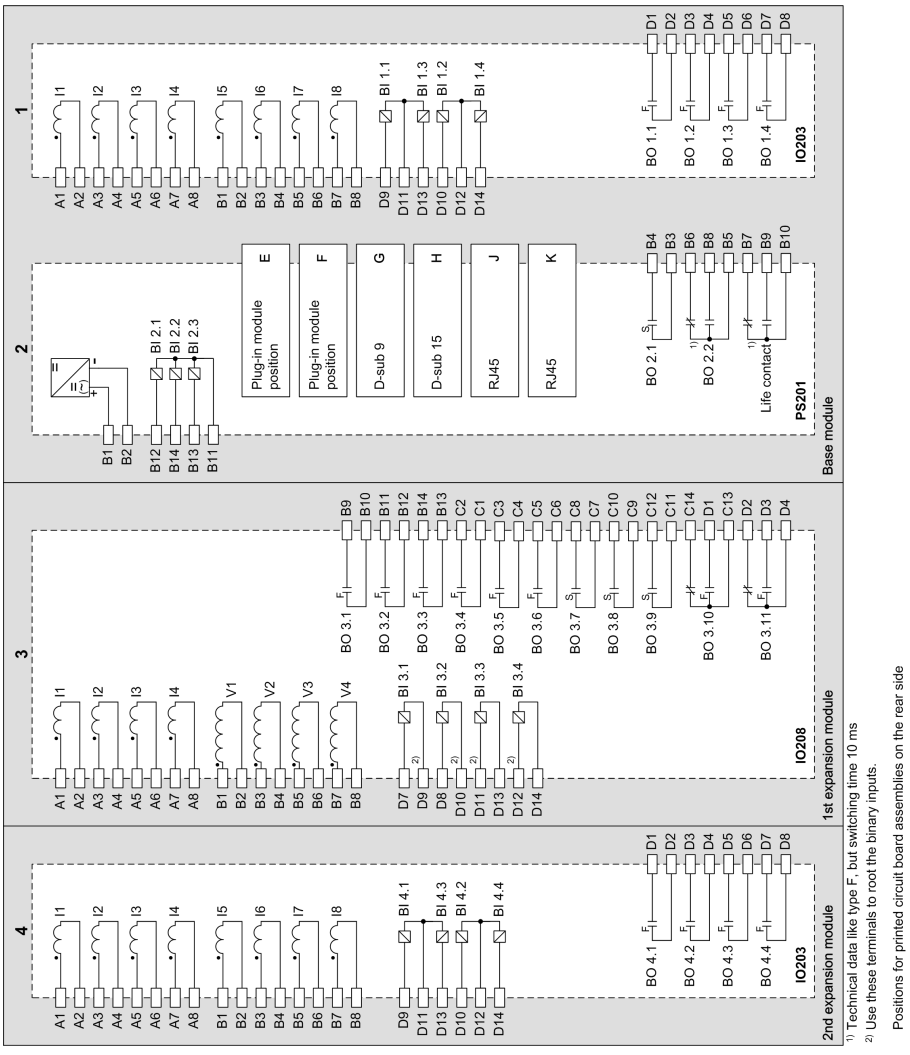
Figure A-5 Standard Variant Type 1



[svSTyp62-130813-01, 1, en_US]

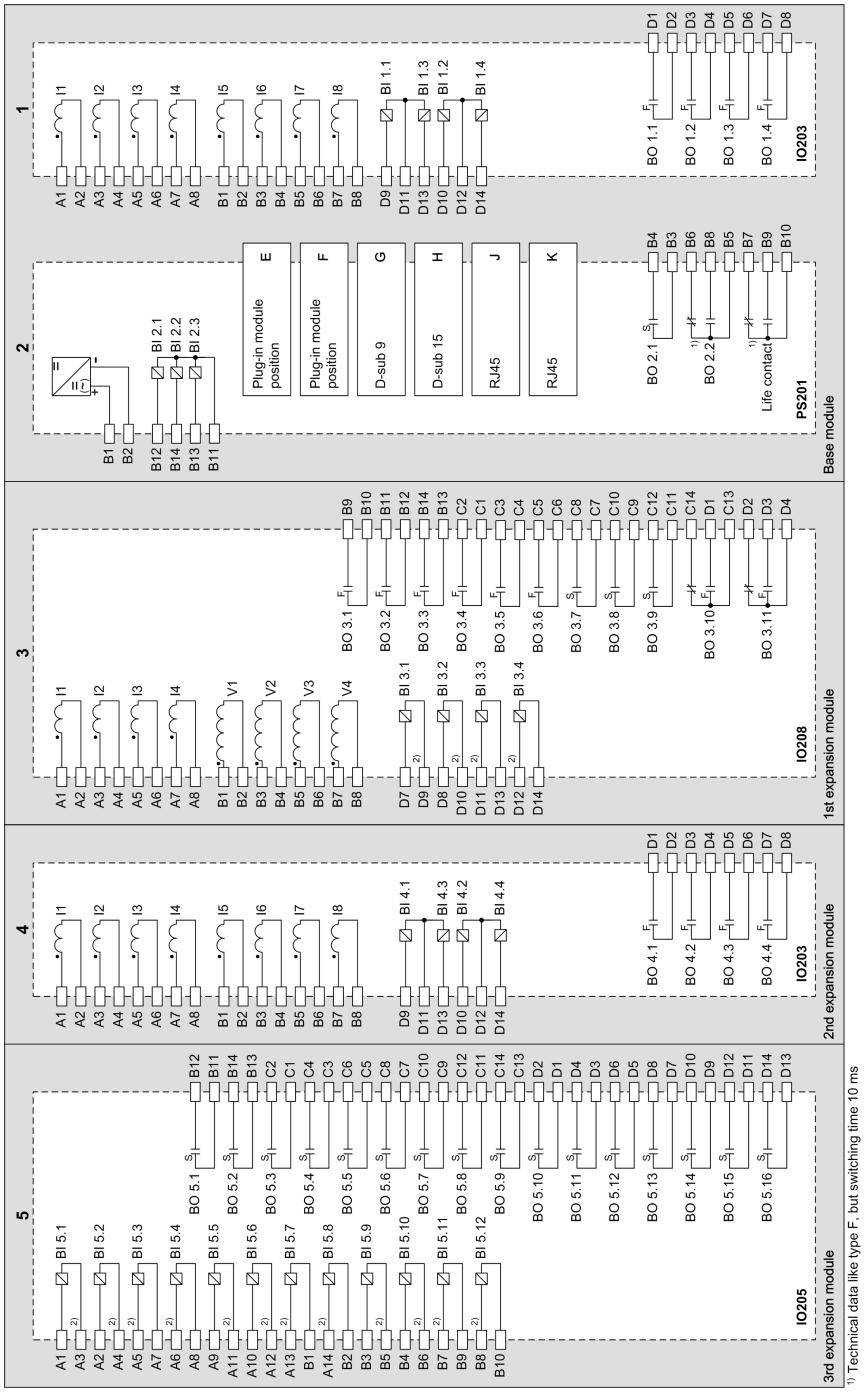
Figure A-6 Standard Variant Type 2

A.7 Standard Variants for 7UT87



[svSTyp71-130813-01, 1, en_US]

Figure A-7 Standard Variant Type 1



[svSTyp72-130813-01, 1, en_US]

Figure A-8 Standard Variant Type 2

A.8 Requirements for Current Transformers

The protection functions require current transformers that are dimensioned properly. This section describes the characteristics required for the dimensioning of the current transformer. The specified rules pertaining to dimensioning apply the definition of a protection current transformer from IEC 61869-2 (previously IEC 60044-1 and IEC 60044-6) as well as IEC TR 61869-100. Dimensioning according to ANSI C57.13 is also described.

Current Transformers

Parameter	Description
ALF	Accuracy limit factor
ALF'	Operational accuracy limit factor The operational accuracy limit factor is derived from the connected burden R_{bc}: $ALF' \approx ALF \cdot \frac{R_{ct} + R_b}{R_{ct} + R_{bc}}$
R_{ct}	Secondary winding resistance; corrected to 75 °C or another temperature as per the specification
R_b	Rated resistive burden
R_{bc}	Connected resistive operating burden
S_r	Rated power
K_{SSC}	Rated symmetrical short-circuit current factor $K_{SSC} = \frac{I_{psc}}{I_{pr}}$
I_{psc}	Rated primary short-circuit current
I_{pr}	Rated primary current
I_{sr}	Rated secondary current
K_{td}	Transient dimensioning factor
E_k	Rated knee-point EMF
V_{tc}	Current terminal voltage with 20-fold rated current and connected burden R_{bc} (ANSI C57.13)

Protected Object

Parameter	Description
$I_{SC\ Int}$	Maximum symmetrical short-circuit current in the event of an internal fault
$I_{SC\ Ext}$	Maximum symmetrical short-circuit current in the event of an external fault (a fault current flowing through)
I_{rTr}	Rated current of the transformer
v_{sc}	Short-circuit voltage of the transformer
I_{rG}	Rated current of the generator
$x''_{d\ Sat}$	Saturated direct-axis synchronous reactance of the generator
I_{rM}	Rated current of the motor
I_{AM}	Motor starting current
$I_{AM\ trans}$	Max. motor starting current (transient starting current after starting from a standstill)
K_{hr}	Additional dimensioning factor to consider high remanence values for current transformers with $K_R \geq 80\ \%$

You can find detailed descriptions in the following sections:

- Current transformer requirements for transformer differential protection,
  (*Requirements for Transformer Differential Protection to Dimension the Phase and Neutral-Point Current Transformers, Page 2616*)
- Current transformer requirements for generator differential protection,
  (*Requirements for the Generator Differential Protection to Dimension the Phase Current Transformers, Page 2621*)
- Current transformer requirements for motor differential protection,
  (*Requirements for Motor Differential Protection for Dimensioning the Phase Current Transformers , Page 2624*)
- Requirements for the core balance current transformer,
  (*Requirements for the Core Balance Current Transformer for Sensitive Ground-Fault Detection, Page 2627*)

Requirements for Transformer Differential Protection to Dimension the Phase and Neutral-Point Current Transformers

The requirements for current transformers are derived from observing the internal and external short circuit. The protection system must remain stable for the external short circuit and must trip safely for the internal short circuit due to potentially high short-circuit currents.

IEC Class	At Least	Internal Fault	External Fault
	Required ALF'		
5P, 10P[201] (up to 80 % remanence)	25	$\geq 0.5 \cdot \frac{I_{SC\,Int}}{I_{pr}}$	$\geq 2 \cdot \frac{I_{SC\,Ext}}{I_{pr}}$
5PR, 10PR[202]	12.5	$\geq 0.4 \cdot \frac{I_{SC\,Int}}{I_{pr}}$	$\geq 1.5 \cdot \frac{I_{SC\,Ext}}{I_{pr}}$
	Required product $K_{td} \cdot K_{SSC}$		
TPX (up to 80 % remanence)	25	$\geq 0.5 \cdot \frac{I_{SC\,Int}}{I_{pr}}$	$\geq 2 \cdot \frac{I_{SC\,Ext}}{I_{pr}}$
TPY, TPZ	12.5 (Burden: $R_b \geq R_{bc}$)	$\geq 0.4 \cdot \frac{I_{SC\,Int}}{I_{pr}}$	$\geq 1.5 \cdot \frac{I_{SC\,Ext}}{I_{pr}}$
	Required knee-point voltage E_k		
PX (up to 80 % remanence)	$20 \cdot I_{sr} \cdot (R_{ct} + R_{bc})$	$\geq 0.4 \cdot \frac{I_{SC\,Int}}{I_{pr}} \cdot I_{sr} \cdot (R_{ct} + R_{bc})$	$\geq 1.6 \cdot \frac{I_{SC\,Ext}}{I_{pr}} \cdot I_{sr} \cdot (R_{ct} + R_{bc})$
PXR	$10 \cdot I_{sr} \cdot (R_{ct} + R_{bc})$	$\geq 0.3 \cdot \frac{I_{SC\,Int}}{I_{pr}} \cdot I_{sr} \cdot (R_{ct} + R_{bc})$	$\geq 1.3 \cdot \frac{I_{SC\,Ext}}{I_{pr}} \cdot I_{sr} \cdot (R_{ct} + R_{bc})$

ANSI Class	At Least	Internal Fault	External Fault
	Required transformer terminal voltage V_{tc}		
C (I_{sr} = 5 A) (up to 80 % remanence)	$25 \cdot I_{sr} \cdot R_{bc}$	$\geq 0.5 \cdot \frac{I_{SC\,Int}}{I_{pr}} \cdot I_{sr} \cdot R_{bc}$	$\geq 2 \cdot \frac{I_{SC\,Ext}}{I_{pr}} \cdot I_{sr} \cdot R_{bc}$

Remanence may lead to a premature saturation, which is critical for the differential protection. For new plants, Siemens recommends anti-remanence cores in classes 5PR, PXR, and TPY. For expected high direct current components, Siemens recommends class TPZ, which avoids overfunctions if there are external faults.

201 Phase displacement (displacement angle) is not specified in IEC 61869-2. Class 10P is not recommended for differential protection for this reason.

202 Phase displacement (displacement angle) is not specified in IEC 61869-2: Class 10PR is not recommended for differential protection.

Avoid using different classes of current transformer at measuring points. This is particularly the case when combining current transformers of 5P class with current transformers of TPY or TPZ class. In contrast with class 5P current transformers, class TPY and TPZ current transformers heavily suppress a direct current component in the short-circuit current. Additional differential currents will occur when current transformer classes are mixed.

The request of at least ALF' = 25 for class P, PX, TPX, and C current transformers ensures stability if external low-current faults occur with high direct current components or high current transformer remanence at the default settings of the differential protection characteristic. If these current transformers only have a minimum ALF' of 20, Siemens recommends using a Diff> threshold value of 0.25 for the transformer differential protection characteristic and increasing **`Slope 1`** to 0.35. With a minimum ALF' of 15, Siemens recommends using an I-Diff> threshold value of at least 0.3 and adjusting **`Slope 1`** to 0.4.

NOTE

To avoid current transformer remanence, Siemens recommends the use of anti-remanence cores in classes 5PR, PXR, and TPY for differential protection systems. When using closed-iron transformers for low-impedance differential protection, ensure that the remanence factor[203] K_R, according to IEC 61869-2, is less than 80 %. Otherwise, Siemens recommends applying an additional dimensioning factor K_{hr}.

If you use current transformers with a remanence factor $K_R > 80$ % for differential protection, you need to take into account an additional dimensioning factor K_{hr} for the above equations resulting from the following table:

IEC class	Internal fault	External fault
PX	$E_k \geq 0.4 \cdot K_{hr} \cdot \frac{I_{SC,Int}}{I_{pr}} \cdot I_{sr} \cdot (R_{ct} + R_{bc})$	$E_k \geq 1.6 \cdot K_{hr} \cdot \frac{I_{SC,ext}}{I_{pr}} \cdot I_{sr} \cdot (R_{ct} + R_{bc})$
The 5P, 10P[204]	$ALF' \geq 0.5 \cdot K_{hr} \cdot \frac{I_{SC,Int}}{I_{pr}}$	$ALF' \geq 2 \cdot K_{hr} \cdot \frac{I_{SC,ext}}{I_{pr}}$

If current transformers of classes 5P, 10P, PX, and TPX have a remanence factor[203] $K_R > 80$ %, Siemens recommends a dimensioning factor $K_{hr} = 2$.

NOTE

When using distance or line differential protection functions in transformer differential protection, the current transformer requirements of the line protection must be taken into account. You can find these in the *Line protection manual* (C53000-G5040-C010).

NOTE

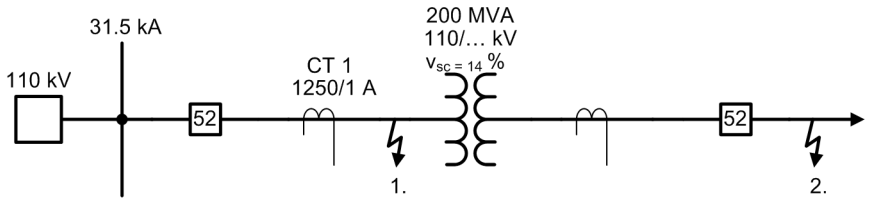
When using restricted ground-fault protection, the neutral point transformer can be designed lower by a factor of 0.5 to 1.0, depending on the required accuracy limit factor (ALF) of the phase current transformer. When using the zero-sequence current correction of the transformer differential protection, Siemens recommends designing the neutral point transformer according to the required accuracy limit factor (ALF) of the phase current transformer.

Example

The transformer for a power-plant unit that feeds into a 110-kV electrical power system is protected. Current transformer 1 (CT 1) is taken into account in the following plant as an example for current transformer design.

203 Remanence factor K_R = manufacturer specification or data from measuring logs

204 Phase displacement (displacement angle) is not specified in IEC 61869-2. Class 10P is not recommended for differential protection for this reason.



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Application of Current Transformers Class IEC 5P

For this example, it is checked whether an existing 5P15 10 VA current transformer meets the requirements.

Parameter	Value	Description
I_{pr}	1250 A	Rated primary current of the current transformer
I_{sr}	1 A	Rated secondary current of the current transformer
S_r	10 VA	Rated power
ALF	15	Accuracy limit factor
R_{ct}	5 Ω	Secondary winding resistance at 75 °C
l_{Cable}	50 m	Length of the secondary current transformer supply lines
A_{Cable}	4 mm²	Core cross section of the current transformer supply lines
ρ_{cu}	0.0213 Ω mm²/m	Specific copper cable resistivity at 75 °C (the value is 0.0179 Ω mm²/m at 20 °C)
S_{Device}	0.1 VA	Protection device burden at rated current

Calculation of the Connected Burden:

The burden R_{bc} connected to the terminals of the current transformer is derived from the double supply-line resistance (supply and return line) and the device burden as indicated below.

$$R_{Cable} = \frac{2 \cdot \rho_{Cu} \cdot l_{Cable}}{A_{Cable}} = \frac{2 \cdot 0.0213 \frac{\Omega \cdot mm^2}{m} \cdot 50}{4\ mm^2} = 0.5325\ \Omega$$

$$R_{Device} = \frac{S_{Device}}{I_{sr}^2} = \frac{0.1\ VA}{(1\ A)^2} = 0.1\ \Omega$$

$$R_b = \frac{S_r}{I_{sr}^2} = \frac{10\ VA}{(1\ A)^2} = 10\ \Omega$$

$$R_{bc} = R_{Cable} + R_{Device} = 0{,}5325\ \Omega + 0{,}1\ \Omega \approx 0{,}6325\ \Omega$$

$$ALF' \approx ALF \cdot \frac{R_{ct} + R_b}{R_{ct} + R_{bc}} = 15 \cdot \frac{5\ \Omega + 10\ \Omega}{5\ \Omega + 0{,}6325\ \Omega} \approx 39{,}9$$

Internal Short Circuit

Maximum short-circuit current: $I_{SC\ Int} = 31.5$ kA

Requirement:

$$ALF' \geq 0.5 \cdot \frac{I_{SC\ Int}}{I_{pr}} = 0.5 \cdot \frac{31.5\ kA}{1250\ A} = 12.6 \text{ at least } 25$$

External Short Circuit

Rated transformer current:

$$I_{rTr} = \frac{S_{rTr}}{\sqrt{3} \cdot V_{rTr}} = \frac{200\,\text{MVA}}{\sqrt{3} \cdot 110\,\text{kV}} = 1050\,\text{A}$$

$$I_{SC\,Ext} \approx \frac{I_{rTr}}{v_{SC}} \cdot 100\,\% = \frac{1050\,\text{A}}{14\,\%} \cdot 100\,\% = 7500\,\text{A}$$

Requirement:

$$ALF' \geq 2 \cdot \frac{I_{SC\,Ext}}{I_{pr}} = 2 \cdot \frac{7500\,\text{A}}{1250\,\text{A}} = 12 \text{ at least } 25$$

Comparison: ALF' current transformer > ALF' requirement
Result: 40 > 25
The current transformer meets the requirement.

Application of Current Transformers Class IEC 5PR

This current transformer should be replaced by a 5PR class current transformer.

Internal Short Circuit

Requirement:

$$ALF' \geq 0.4 \cdot \frac{I_{SC\,Int}}{I_{pr}} = 0.4 \cdot \frac{31.5\,\text{kA}}{1250\,\text{A}} = 10.1 \text{ at least } 12.5$$

External Short Circuit

Requirement:

$$ALF' \geq 1.5 \cdot \frac{I_{SC\,Ext}}{I_{pr}} = 1.5 \cdot \frac{7500\,\text{A}}{1250\,\text{A}} = 9 \text{ at least } 12.5$$

The 5PR15, 5 VA current transformer is selected in the example.
5 VA power was selected as current transformer internal burdens R_{ct} must be taken into account for a smaller rated power system. This makes them more flexible with the connected burden R_{bc} (longer current transformer supply lines are possible).

Application of Current Transformer Class IEC TPZ

The current transformers are specified by K_{SSC}, K_{td}, and R_b.

Internal Short Circuit

Symmetrical rated short-circuit current factor:

$$K_{SSC} = \frac{I_{psc}}{I_{pr}} = \frac{I_{sc\,Int}}{I_{pr}} = \frac{31.5\,\text{kA}}{1250\,\text{A}} = 25.2$$

Required product:

$$K_{td} \cdot K_{SSC} \geq 0.4 \cdot \frac{I_{SC\,Int}}{I_{pr}} = 0{,}4 \cdot \frac{31.5\,\text{k A}}{1250\,\text{A}} = 10.1 \text{ at least } 12.5$$

External Short Circuit

Symmetrical rated short-circuit current factor:

$$K_{SSC} = \frac{I_{psc}}{I_{pr}} = \frac{I_{sc\ Ext}}{I_{pr}} = \frac{7500\ A}{1250\ A} = 6$$

Required product:

$$K_{td} \cdot K_{SSC} \geq 1.5 \cdot \frac{I_{SC\ Ext}}{I_{pr}} = 1.5 \cdot \frac{7500\ A}{1250\ A} = 9 \text{ at least } 12.5$$

The required resistive dimensioning burden R_b of the current transformer must be greater than the connected resistive burden R_{bc} previously calculated. The burden connected in the example is $R_{bc} = 0.633\ \Omega$.

The resistive dimensioning burden is selected with $R_b = 1\ \Omega$.



NOTE

The K_{SSC} factor is determined by the maximum symmetrical short-circuit current. The minimum requirement in the example is $K_{SSC} = 25$ and $K_{td} = 0.4$. As the product is critical for the current transformer design, the standard permits K_{SSC} and K_{td} values can be freely selected, subject to certain limits (see DIN IEC TR 61869-100, *Section 11.5.3.3.5* and *Section 9.2*).
Specification $K_{SSC} = 12.5$ and $K_{td} = 1.0$ is permitted.

The current transformer is specified with $K_{SSC} = 15$, $K_{td} = 1$ and $R_b = 1\ \Omega$ in order to have a reserve. You must increase the burden to $R_b = 2.0\ \Omega$ for longer current transformer supply lines.

The current transformer is designated as follows: 1250 A/1 A, $R_b = 1\ \Omega$, cl. TPZ 15x1.

Application of Current Transformer Class IEC PX

The following values are incorporated into the calculation for the burdens in the example.

$R_{bc} = 0.633\ \Omega$

$R_{ct} = 4.5\ \Omega$

Internal Short circuit

Required knee-point voltage:

$$E_k \geq 0.4 \cdot \frac{I_{SC\ Int}}{I_{pr}} \cdot I_{sr} \cdot (R_{ct} + R_{bc}) = 0.4 \cdot \frac{31.5\ kA}{1250\ A} \cdot 1\ A \cdot (4.5\ \Omega + 0.633\ \Omega) = 51.85\ V$$

At least:

$$E_k \geq 20 \cdot I_{sr} \cdot (R_{ct} + R_{bc}) = 20 \cdot 1\ A \cdot (4.5\ \Omega + 0.633\ \Omega) = 102.7\ V$$

External Short circuit

Required knee-point voltage:

$$E_k \geq 1.6 \cdot \frac{I_{SC\ Ext}}{I_{pr}} \cdot I_{sr} \cdot (R_{ct} + R_{bc}) = 1.6 \cdot \frac{7500\ A}{1250\ A} \cdot 1\ A \cdot (4.5\ \Omega + 0.633\ \Omega) = 49.28\ V$$

The minimum requirement determines the knee-point voltage and must be ≥ 102.7 V.
The rated knee-point EMF is selected with $E_k = 150$ V.

Application of Current Transformer Class ANSI C

The rated secondary current of I_{sr} = 5 A causes the connected burden to change.

$$R_{Device} = \frac{S_{Device}}{I_{sr}^2} = \frac{0.1\ VA}{(5\ A)^2} = 0.004\ \Omega$$

$$R_{bc} = R_{Cable} + R_{Device} = 0.5325\ \Omega + 0.004\ \Omega \approx 0.537\ \Omega$$

Internal Short Circuit

The required transformer terminal voltage for the current transformer:

$$V_{tc} \geq 0.5 \cdot \frac{I_{SC\ Int}}{I_{pr}} \cdot I_{sr} \cdot R_{bc} = 0.5 \cdot \frac{31.5\ kA}{1250\ A} \cdot 5\ A \cdot 0.537\ \Omega = 33.83\ V$$

At least:

$$V_{tc} \geq 25 \cdot I_{sr} \cdot R_{bc} = 25 \cdot 5\ A \cdot 0.537\ \Omega = 67.1\ V$$

External Short Circuit

The required transformer terminal voltage for the current transformer:

$$V_{tc} \geq 2 \cdot \frac{I_{SC\ Ext}}{I_{pr}} \cdot I_{sr} \cdot R_{bc} = 2 \cdot \frac{7500\ A}{1250\ A} \cdot 5\ A \cdot 0.537\ \Omega = 32.22\ V$$

The class C current transformer must have a terminal voltage of ≥ 67.1 V. The C100 current transformer meets the conditions. The rated burden Z_b is 1 Ω.

The current transformer terminal voltage is:

$$V_t = 20 \cdot I_{sr} \cdot Z_b = 20 \cdot 5\ A \cdot 1\ \Omega = 100\ V$$

Requirements for the Generator Differential Protection to Dimension the Phase Current Transformers

In comparison to transformer applications, the current transformer setup is sufficient for observing the external short circuit.

IEC Class	At Least	Requirement
	Required ALF'	
5P, 10P[205] (up to 80 % remanence)	30	$\geq 4 \cdot \frac{I_{SC\ Ext}}{I_{pr}}$
5PR, 10PR[206]	25	$\geq 3 \cdot \frac{I_{SC\ Ext}}{I_{pr}}$
	Required product $K_{td} \cdot K_{SSC}$	
TPY, TPZ	25 (Burden $R_b \geq R_{bc}$)	$\geq 3 \cdot \frac{I_{SC\ Ext}}{I_{pr}}$
	Required knee-point voltage E_k	
PX (up to 80 % remanence)	$25 \cdot I_{sr} \cdot (R_{ct} + R_{bc})$	$\geq 3 \cdot \frac{I_{SC\ Ext}}{I_{pr}} \cdot I_{sr} \cdot (R_{ct} + R_{bc})$

205 Phase displacement (displacement angle) is not specified in IEC 61869-2. Class 10P is not recommended for differential protection.

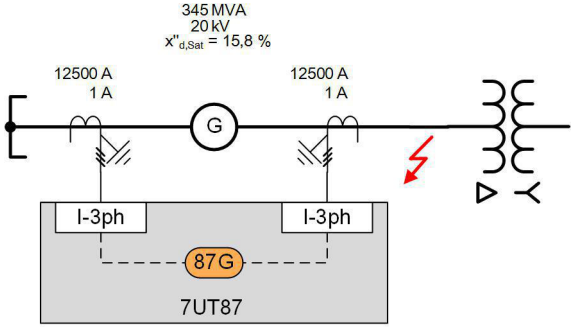
206 Phase displacement (displacement angle) is not specified in IEC 61869-2. Class 10PR is not recommended for differential protection.

ANSI Class	At Least	Requirement
	Required transformer terminal voltage V_{tc}	
C (I_{sr} = 5 A) (up to 80 % remanence)	$25 \cdot I_{sr} \cdot R_{bc}$	$\geq 3 \cdot \frac{I_{SC\ Ext}}{I_{pr}} \cdot I_{sr} \cdot R_{bc}$

Remanence may lead to a premature saturation which is critical for differential protection. For new plants, Siemens recommends anti-remanence cores in classes 5PR and TPY. For expected high direct current components, Siemens recommends class TPZ, which avoids overfunctions if there are external faults. Siemens recommends TPZ for larger generators (i.e > 500 MVA). Avoid using different classes of current transformer at the measuring points. This is the case when combining 5P class and TPY class systems, especially TPZ.
In contrast with class 5P current transformers, class TPY and TPZ current transformers heavily suppress a direct current component in the short-circuit current. Additional differential currents will occur when current transformer classes are mixed.

Example

The following example is used for checking the current transformer:



[dw_l gendiff exam-UT-200121, 1, en_US]

Application of Current Transformers Class IEC 5P

For this example, it is checked whether an existing 5P20 30 VA current transformer meets the requirements.

Parameter	Value	Description
I_{pr}	12500 A	Rated primary current of the current transformer
I_{sr}	1 A	Rated secondary current of the current transformer
S_r	30 VA	Rated power
ALF	20	Accuracy limit factor
R_{ct}	30 Ω	Secondary winding resistance at 75 °C
l_{Cable}	100 m	Length of the secondary current transformer supply lines
A_{Cable}	4 mm²	Core cross section of the current transformer supply lines
ρ_{cu}	0.0213 Ω mm²/m	Copper cable resistivity at 75 °C (the value is 0.0179 Ω mm²/m at 20 °C)
S_{Device}	0.1 VA	Protection device burden at rated current

Calculation of the Connected Burden:

The burden R_{bc} connected to the terminals of the current transformer is derived from the double supply-line resistance (supply and return line) and the device burden as indicated below.

$$R_{Cable} = \frac{2 \cdot \rho_{Cu} \cdot l_{Cable}}{A_{Cable}} = \frac{2 \cdot 0.0213 \frac{\Omega \cdot mm^2}{m} \cdot 100}{4\,mm^2} = 1.065\ \Omega$$

$$R_{Device} = \frac{S_{Device}}{I_{sr}^2} = \frac{0.1\ VA}{(1\ A)^2} = 0.1\ \Omega$$

$$R_b = \frac{S_r}{I_{sr}^2} = \frac{30\ VA}{(1\ A)^2} = 30\ \Omega$$

$$R_{bc} = R_{Cable} + R_{Device} = 1.065\ \Omega + 0.1\ \Omega \approx 1.165\ \Omega$$

$$ALF' \approx ALF \cdot \frac{R_{ct} + R_b}{R_{ct} + R_{bc}} = 20 \cdot \frac{30\ \Omega + 30\ \Omega}{30\ \Omega + 1{,}165\ \Omega} \approx 38{,}5$$

Generator rated current:

$$I_{rG} = \frac{S_{rG}}{\sqrt{3} \cdot V_{rG}} = \frac{345\ MVA}{\sqrt{3} \cdot 20\ kV} = 9959\ A$$

Maximum short-circuit current:

$$I_{SC\ Ext} \approx \frac{I_{rG}}{x''_{d,Sat}} \cdot 100\ \% = \frac{9959\ A}{15.8\ \%} \cdot 100\ \% \approx 63\,032\ A$$

Requirement:

$$ALF' \geq 4 \cdot \frac{I_{SC\ Ext}}{I_{pr}} = 4 \cdot \frac{63032\ A}{12500\ A} = 21.2\ \text{at least } 30$$

Comparison: ALF' current transformer > ALF' requirement
Result: 38.5 > 30
The current transformer meets the requirement.

Application of Current Transformers Class IEC 5PR

This current transformer should be replaced by a 5PR class current transformer.

Requirement:

$$ALF' \geq 3 \cdot \frac{I_{SC\ Ext}}{I_{pr}} = 3 \cdot \frac{63032\ A}{12500\ A} = 15.13\ \text{at least } 25$$

The 5PR30, 5 VA current transformer is selected in the example.
5 VA power was selected as current transformer internal burdens R_{ct} must be taken into account for a smaller rated power system. This makes them more flexible with the connected burden R_{bc} (longer current transformer supply lines are possible).

Application of Current Transformers Class IEC TPZ

The current transformers are specified by K_{SSC}, K_{td}, and R_b.

Symmetrical rated short-circuit current factor:

$$K_{SSC} = \frac{I_{psc}}{I_{pr}} = \frac{I_{sc\ Ext}}{I_{pr}} = \frac{63\ 032\ A}{12\ 500\ A} = 5.04$$

Required product:

$$K_{td} \cdot K_{SSC} \geq 3 \cdot \frac{I_{SC\ Ext}}{I_{pr}} = 3 \cdot \frac{63032\ A}{12500\ A} = 15.13\ \text{at least}\ 25$$

The required resistive dimensioning burden R_b of the current transformer must be greater than the connected resistive burden R_{bc} previously calculated. The burden connected in the example is R_{bc} = 1.165 Ω.

The resistive rated burden is selected with t R_b = 2 Ω.

A current transformer with K_{SSC} = 10, K_{td} = 3 and R_b = 2 Ω meets the requirements. Increase the burden to R_b = 5 Ω for longer current transformer supply lines, if required.

The current transformer is designated as follows: 12500 A/1 A, R_b = 2 Ω, cl. TPZ 10x3.

Application of Current Transformers Class ANSI C

The rated secondary current of I_{sr} = 5 A causes the connected burden to change.

$$R_{Device} = \frac{S_{Device}}{I_{sr}^2} = \frac{0.1\ VA}{(5\ A)^2} = 0.004\ \Omega$$

$$R_{bc} = R_{Cable} + R_{Device} = 1.065\ \Omega + 0.004\ \Omega \approx 1.07\ \Omega$$

Required current transformer terminal voltage:

$$V_{tc} \geq 4 \cdot \frac{I_{SC\ Ext}}{I_{pr}} \cdot I_{sr} \cdot R_{bc} = 4 \cdot \frac{63\ 032\ A}{12\ 500\ A} \cdot 5\ A \cdot 1.07\ \Omega = 107.9\ V$$

At least:

$$V_{tc} \geq 30 \cdot I_{sr} \cdot R_{bc} = 30 \cdot 5\ A \cdot 1.07\ \Omega = 160.5\ V$$

The class C current transformer must have a terminal voltage of ≥ 160.5 V. The C200 current transformer meets the conditions. The rated burden Z_b is 2 Ω.

The terminal voltage is:

$$V_t = 20 \cdot I_{sr} \cdot Z_b = 20 \cdot 5\ A \cdot 2\ \Omega = 200\ V$$

Requirements for Motor Differential Protection for Dimensioning the Phase Current Transformers

In comparison to transformer and generator applications, the current transformer setup must observe the maximum starting current. This affects asynchronous motors during direct startup. The motors temporarily feed the current back into the electrical power system in the event of a short circuit. This fault current doesn't exceed the starting current.

IEC Class	At Least	Requirement
	Required ALF'	
5P, 10P[207] (up to 80 % remanence)	30	$\geq 4 \cdot \frac{I_{AM\ trans}}{I_{pr}}$
5PR, 10PR[208]	25	$\geq 3 \cdot \frac{I_{AM\ trans}}{I_{pr}}$

207 Phase displacement is not specified in IEC 61869-2. Class 10P is not recommended for differential protection.

208 Phase displacement is not specified in IEC 61869-2. Class 10PR is not recommended for differential protection.

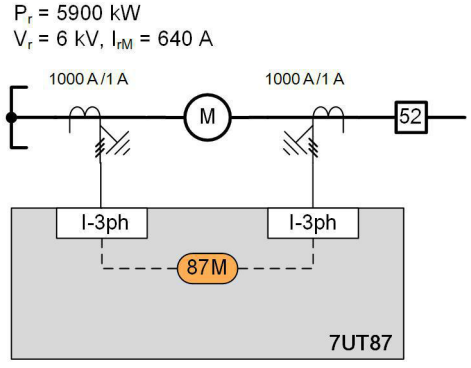
	Required product $K_{td} \cdot K_{SSC}$	
TPY, TPZ	25 (Burden $R_b \geq R_{bc}$)	$\geq 3 \cdot \frac{I_{AM\,trans}}{I_{pr}}$
	Required knee-point voltage E_k	
PX (up to 80 % remanence)	$25 \cdot I_{sr} \cdot (R_{ct} + R_{bc})$	$\geq 3 \cdot \frac{I_{AM\,trans}}{I_{pr}} \cdot I_{sr} \cdot (R_{ct} + R_{bc})$

ANSI Class	At Least	Requirement
	Required transformer terminal voltage V_{tc}	
C (I_{sr} = 5 A) (up to 80 % remanence)	$25 \cdot I_{sr} \cdot R_{bc}$	$\geq 3 \cdot \frac{I_{AM\,trans}}{I_{pr}} \cdot I_{sr} \cdot R_{bc}$

Avoid using different classes of current transformer at the measuring points. This is the case when combining class 5P and class TPY, especially TPZ. In contrast with class 5P current transformers, class TPY and TPZ current transformers heavily suppress a direct current component in the short-circuit current. Additional differential currents will occur when current transformer classes are mixed.

EXAMPLE:

A motor is protected with a starting current in the event of rated voltage $I_{AM} = 5.6 \cdot I_{rM}$. The motor starts up in 4.5 s under rated conditions. You can find the remaining data in the figure below.



[dw_app-example_for_current-transf_connect-requirements_UT, 1, en_US]

$$I_{AM\,trans} \approx 2 \cdot I_{AM} = 2 \cdot 5.6 \cdot I_{rM} = 2 \cdot 5.6 \cdot 640\,A = 7168\,A$$

The current transformer data is specified below.

Application of Current Transformers Class IEC 5P

Requirement:

$$ALF' \geq 4 \cdot \frac{I_{AM\,trans}}{I_{pr}} = 4 \cdot \frac{7168\,A}{1000\,A} = 28.7 \text{ at least } 30$$

A 1000 A/1 A, 5P30 current transformer with S_r = 2.5 VA meets the requirements. The connected burden is required to be $R_{bc} < 2.5\ \Omega$. Increase the power to S_r = 5 VA for longer current transformer supply lines.

Application of Current Transformers Class IEC TPY

The current transformers are specified by K_{SSC}, K_{td}, and R_b.

Symmetrical rated short-circuit current factor:

$$K_{SSC} = \frac{I_{psc}}{I_{pr}} = \frac{I_{AM\,trans}}{I_{pr}} = \frac{7168\,A}{1000\,A} = 7.17$$

Required product:

$$K_{td} \cdot K_{SSC} \geq 3 \cdot \frac{I_{AM\,trans}}{I_{pr}} = 3 \cdot \frac{7168\,A}{1000\,A} = 21.5 \text{ at least } 25$$

The required resistive dimensioning burden R_b of the current transformer must be greater than the connected resistive burden R_{bc}. The connected burden that has been adopted is $R_{bc} < 2\ \Omega$.

The ohmic dimensioning burden is selected with $R_b = 2\ \Omega$.

A current transformer with $K_{SSC} = 10$, $K_{td} = 3$, and $R_b = 2\ \Omega$ meets the requirements. Increase the burden to $R_b = 5\ \Omega$ for longer current transformer supply lines.

The current transformer is designated as follows: 1000 A/1 A, $R_b = 2\ \Omega$, cl. TPY 10x3.

Application of Current Transformers Class IEC PX

The following values are incorporated into the calculation for the burden in the following example.

$R_{bc} = 1.5\ \Omega$

$R_{ct} = 4.5\ \Omega$

Required knee-point voltage:

$$E_k \geq 3 \cdot \frac{I_{AM\,trans}}{I_{pr}} \cdot I_{sr} \cdot (R_{ct} + R_{bc}) = 3 \cdot \frac{7168\,A}{1000\,A} \cdot 1\,A \cdot (4.5\,\Omega + 1.5\,\Omega) = 129\,V$$

At least:

$$E_k \geq 25 \cdot I_{sr} \cdot (R_{ct} + R_{bc}) = 25 \cdot 1\,A \cdot (4.5\,\Omega + 1.5\,\Omega) = 150\,V$$

The PX current transformer must have a knee-point voltage of ≥ 150 V.

The rated knee-point EMF is selected with $E_k = 150$ V. If the connected burdens change, you must adjust E_k, if required.

Application of Current Transformers Class ANSI C

The rated secondary current is I_{sr} for this class = 5 A. A 50 m/4 mm² supply line is adopted for the 2 current transformers. This results in the following for the connected burden:

$$R_{Cable} = \frac{2 \cdot \rho_{Cu} \cdot l_{Cable}}{A_{Cable}} = \frac{2 \cdot 0.0213 \frac{\Omega \cdot mm^2}{m} \cdot 50}{4\ mm^2} = 0.5325\,\Omega$$

$$R_{Device} = \frac{S_{Device}}{I_{sr}^2} = \frac{0.1\ VA}{(5\ A)^2} = 0.004\,\Omega$$

$$R_{bc} = R_{Cable} + R_{Device} = 0.5325\,\Omega + 0.004\,\Omega \approx 0.537\,\Omega$$

Required current transformer terminal voltage:

$$V_{tc} \geq 3 \cdot \frac{I_{AM\,trans}}{I_{pr}} \cdot I_{sr} \cdot R_{bc} = 3 \cdot \frac{7168\,A}{1000\,A} \cdot 5\,A \cdot 0.537\,\Omega = 57.7\,V$$

At least:

$$V_{tc} \geq 25 \cdot I_{sr} \cdot R_{bc} = 25 \cdot 5\,A \cdot 0.537\,\Omega = 67.1\,V$$

The class C current transformer must have a current transformer terminal voltage of ≥ 67.1 V. The C100 current transformer meets the conditions. The rated burden Z_b is 1 Ω.

The current transformer terminal voltage is:

$$V_t = 20 \cdot I_{sr} \cdot Z_b = 20 \cdot 5\ A \cdot 1\ \Omega = 100\ V$$

Requirements for the Core Balance Current Transformer for Sensitive Ground-Fault Detection

The requirements for the core balance current transformer are determined by the **sensitive ground-fault detection** function. A directional sensitive ground-fault protection system is used for selective sensitive ground-fault detection in the busbar connection for motors and generators. The protection function trips with a delay.

The electrical power systems are predominantly isolated. A grounding transformer with load equipment is available that feeds in a maximum active current of 10 A to enable the stator ground-fault protection system to be 80 % to 90 % effective. The cosφ method is used here. The capacitive current of the electrical power system is superimposed on the active current.

The following table shows the requirements and recommendations for the instrument transformer.

Parameter	Value	Note
I_{pr}	60 A	60 A is a recommended value for motor and generator protection applications.
I_{sr}	1 A	Preferred value
Class	1	This is the recommended class. If small currents need to be measured accurately, for example, up to 1 % I_{pr}, Siemens recommends the 0.5S class. Class 3 is sufficient for just measuring the ground current without being influenced by the angle accuracy. The measurement deviation for the transfer ratio of 3 % is defined in the range of (50 % to 120 %) I_{pr}.
S_r	1 VA	The accuracy specifications for the ratio error of measurement and the phase displacement in IEC 61869-2, *Section 5.6.201.3* refer to this rated power. The rated power is sufficient for a connected burden $R_{bc} < 1\ \Omega$. If there are larger burdens, you must increase the power, where the value of 15 VA may not be exceeded in accordance with IEC 61869-2, *Section 5.6.201.4*.
R_{bc}	< 1 Ω	The standard values of the accuracy classes apply for a burdening of 25 % to 100 % of the rated power. The connected burden must be R_{bc} in this range. In the event of deviations, you must adjust the rated power S_r. For small burdens, for example, during use in medium voltage cubicles, you must reduce the rated power to 0.5 VA.
FS	10	Required overcurrent limiting factor (FS 10). The number 10 expresses that the current is reduced to 10 · I_{pr} and **not** transmitted by the current transformer. The standard does not dictate what current the current transformer may be saturated from.

The recommended current transformer has the following specification: 60 A/1 A; 1 VA, cl.1 FS 10



NOTE

The neutral point on the transformer is partially grounded via a resistor in industry networks to minimize transient overvoltages in the event of a ground fault, and this leads to larger ground currents. Adjust the primary rated current I_{pr} of the core balance current transformer if required. The sensitive ground-current measurement function meets the requirements for selectivity, as a sufficient zero-sequence current flows in the faulty motor in the event of a ground fault.

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Table A-2 Limiting Values for the Recommended Instrument Transformers in accordance with IEC 61869-2, Section 5.6.201.3

Class	**Ratio Error of Measurement (± %)**					**Phase Displacement (± Minutes)**				
	for current (% of rated current)					for current (% of rated current)				
	1	5	20	100	120	1	5	20	100	120
0.5S	1.5	0.75	0.5	0.5	0.5	90	45	30	30	30
1	–	3.0	1.5	1.0	1.0	–	180	90	60	60

A.9 Connection Examples for Current Transformers



Current transformer 3-phase: connection = **3-phase**

[ti_3-phase_1, 4, en_US]

Figure A-9 Connection to 3 Phase Current Transformers (Zero-Sequence Current to be Calculated)



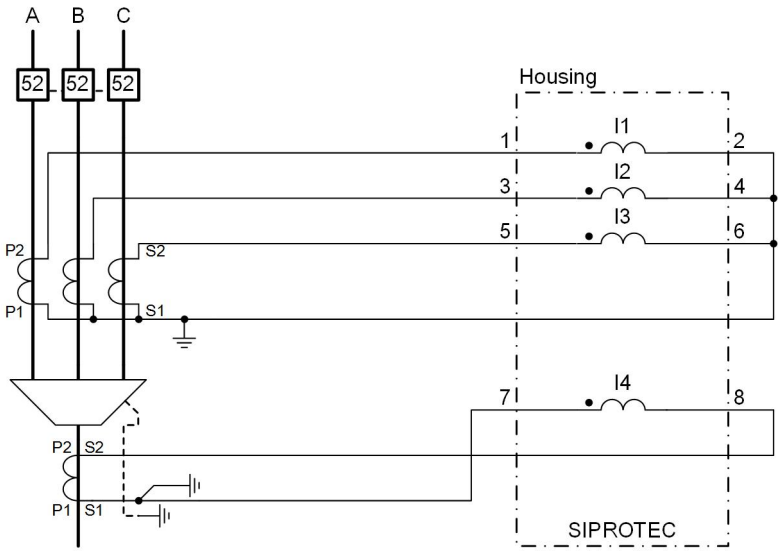
Current transformer 3-phase: connection = **3-phase + IN**

[ti_phase_2, 4, en_US]

Figure A-10 Connection to 3 Phase Current Transformers and a Measured Zero-Sequence Current (Current in Common Return Conductor)

NOTE

The switchover of the current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 (I_N)!



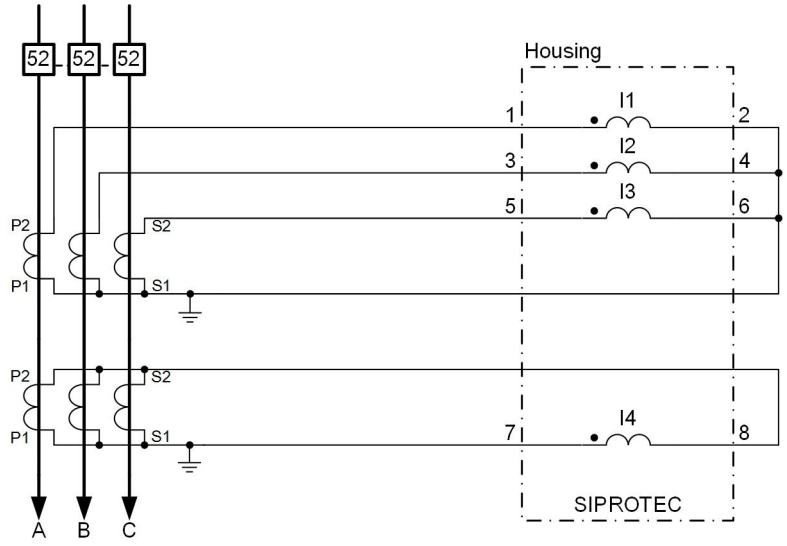
Current transformer 3-phase: connection = **3-phase + IN-separate**

[ti_phase_3, 4, en_US]

Figure A-11 Connection to 3 Phase Current Transformers and a Cable Type Current Transformer for Sensitive Ground-Fault Detection

NOTE

The switchover of the current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N\text{-}sep}$)!



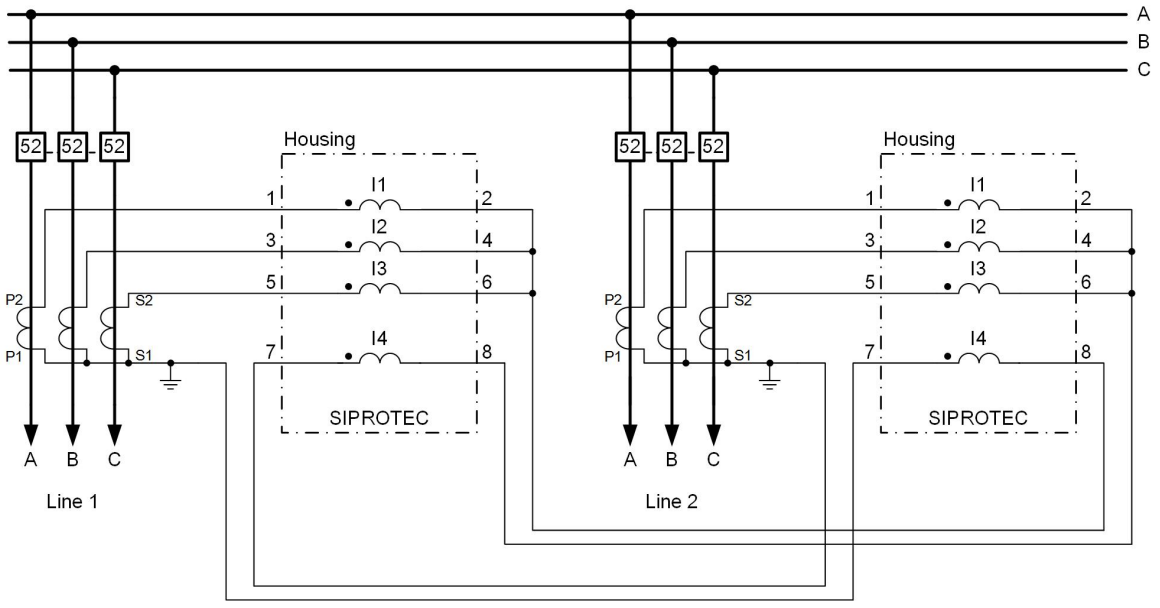
Current transformer 3-phase: connection = **3-phase + IN-separate**

[tileite4-260313-01.tif, 4, en_US]

Figure A-12 Connection to 3 Phase Current Transformers and a Measured Ground Current from a Complete Holmgreen Connection

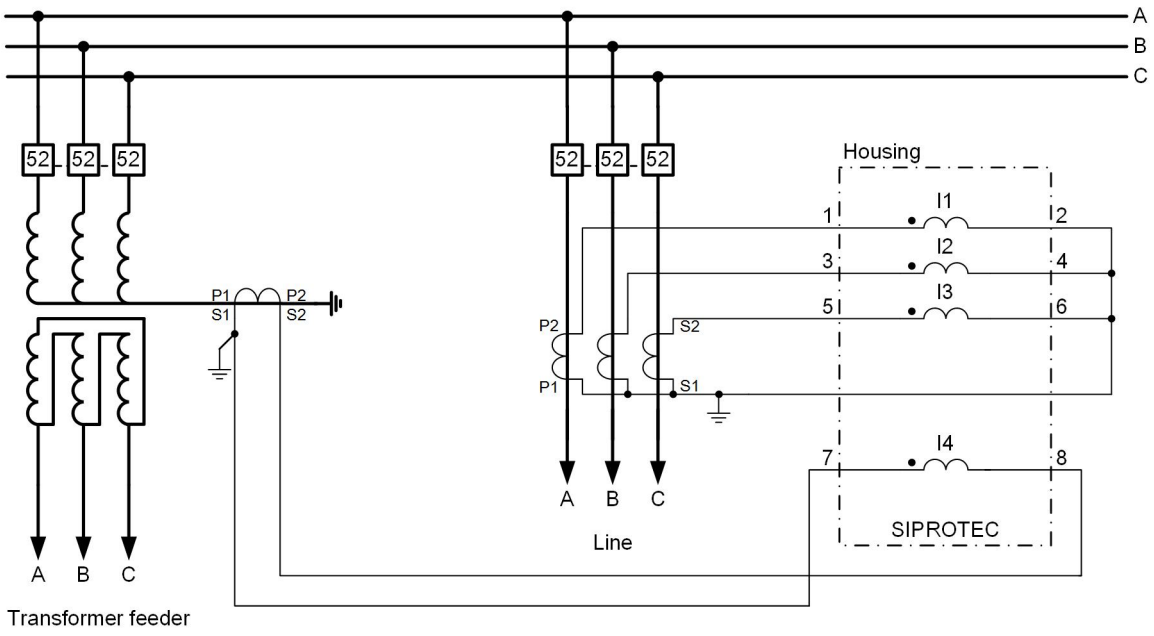
NOTE

The switchover of the current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N\text{-}sep}$)!



[tileite5-060313-01.tif, 4, en_US]

Figure A-13 Connection to 3 Phase Current Transformers and a Measured Residual Current from the Current-Transformer Neutral Point of the Respective Parallel Line (for Parallel-Line Compensation)



Current transformer 3-phase: connection = **3-phase**
Current transformer 1-phase: connection = **Ix**

[tileite6-060313-01.tif, 4, en_US]

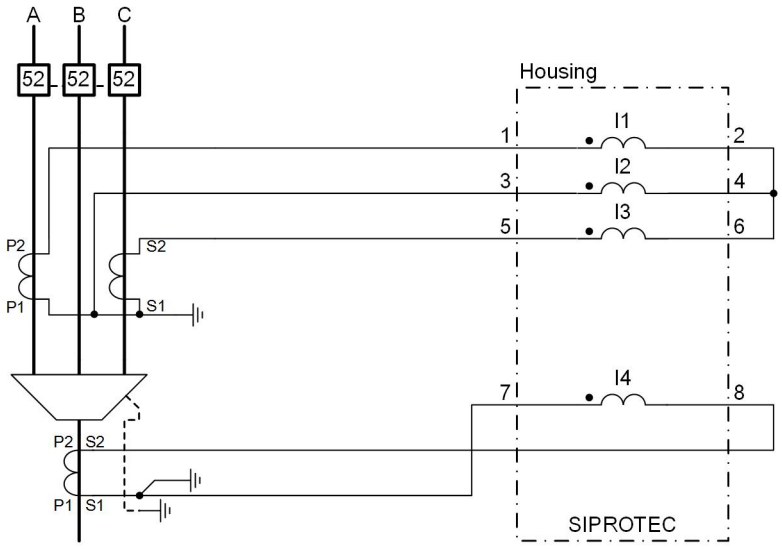
Figure A-14 Connection to 3 Phase Current Transformers and a Measured Ground Current via the Neutral-Point Current Transformer of a Grounded Power Transformer



Current transformer 3-phase: connection = **3-phase, 2 primary CT**

[tileite7-070211-01.tif, 4, en_US]

Figure A-15 Connection to a 2 Phase Current Transformers – for Isolated or Resonant-Grounded Systems Only



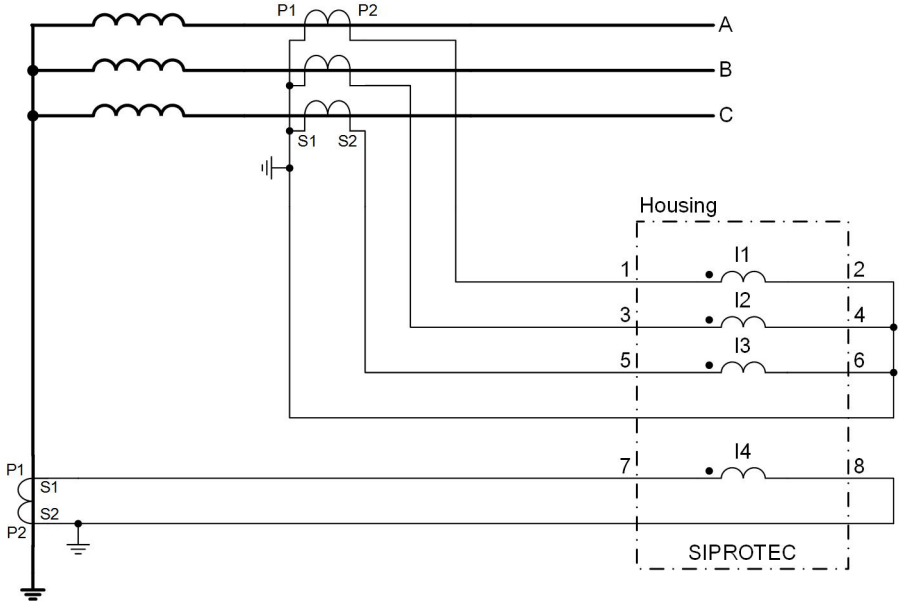
Current transformer 3-phase: connection = **3ph,2prim.CT + IN-sep**

[tileite8-260313-01.tif, 4, en_US]

Figure A-16 Connection to 2 Phase Current Transformers and a Cable Type Current Transformer for Sensitive Ground-Fault Detection – for Isolated or Resonant-Grounded Systems Only

NOTE

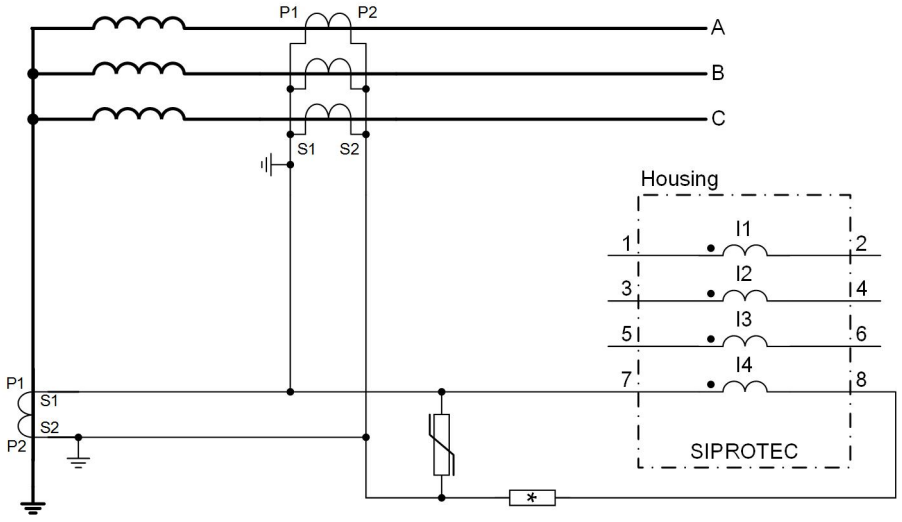
The switchover of the current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N\text{-}sep}$)!



Current transformer 3-phase: connection = **3-phase**
Current transformer 1-phase: connection = **Ix**

[tileite9-260313-01.tif, 5, en_US]

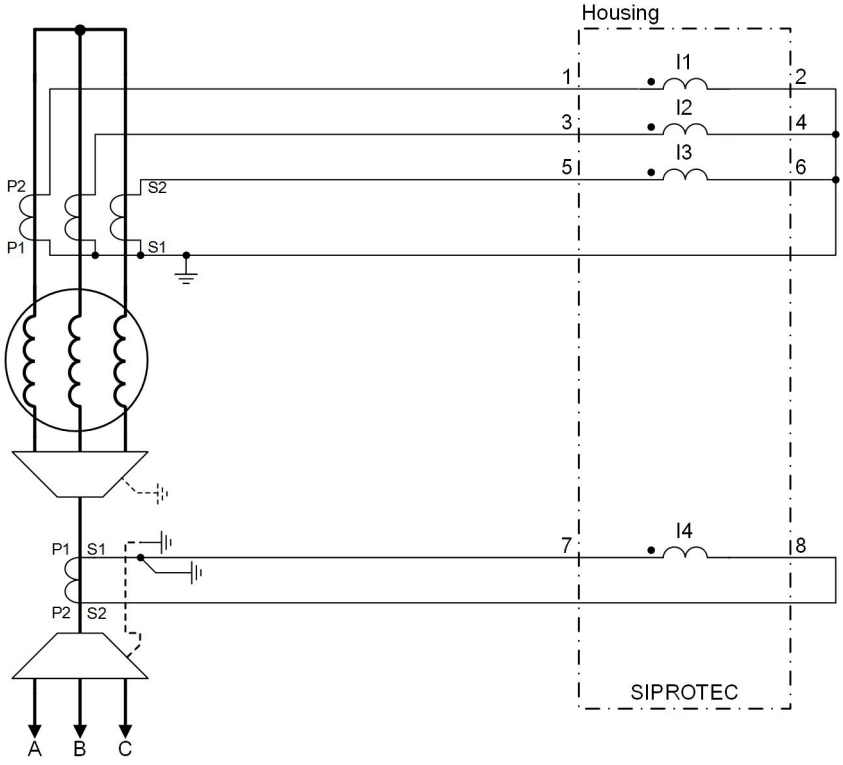
Figure A-17 Connection to 3 Phase Current Transformers and an Additional Current Transformer in the Neutral Point of a Grounded Power Transformer



Current transformer 1-phase: connection = Ix

[ti_phase_10, 5, en_US]

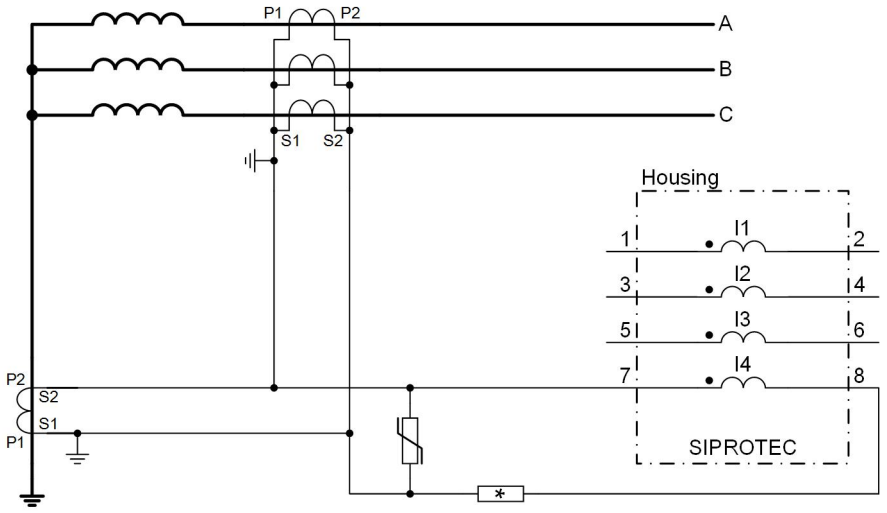
Figure A-18 Current Transformer Connection for High-Impedance Differential Protection (for Example, a Power Transformer, in Preparation)



Current transformer 3-phase: connection = 3-phase
Current transformer 1-phase: connection = Ix

[ti_phase_11, 4, en_US]

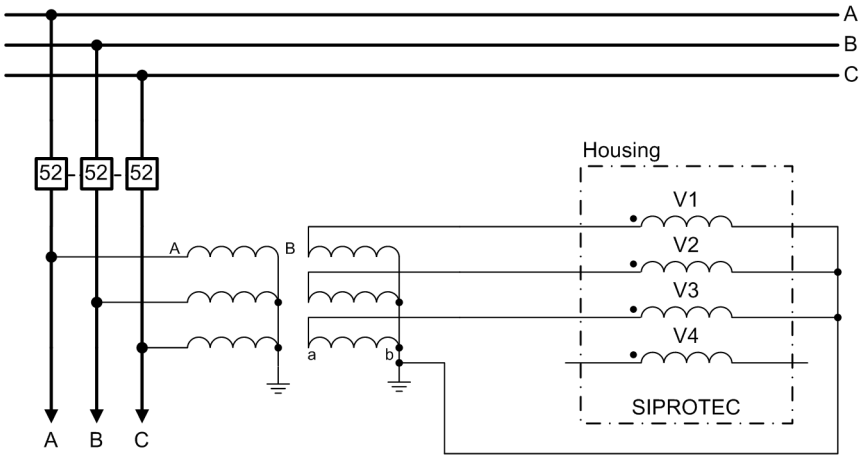
Figure A-19 Connection to 3 Phase Current Transformers in the Neutral Point of a Generator and a Cable Type Current Transformer for Sensitive Ground-Fault Detection of the Line



[ti_phase_12, 5, en_US]

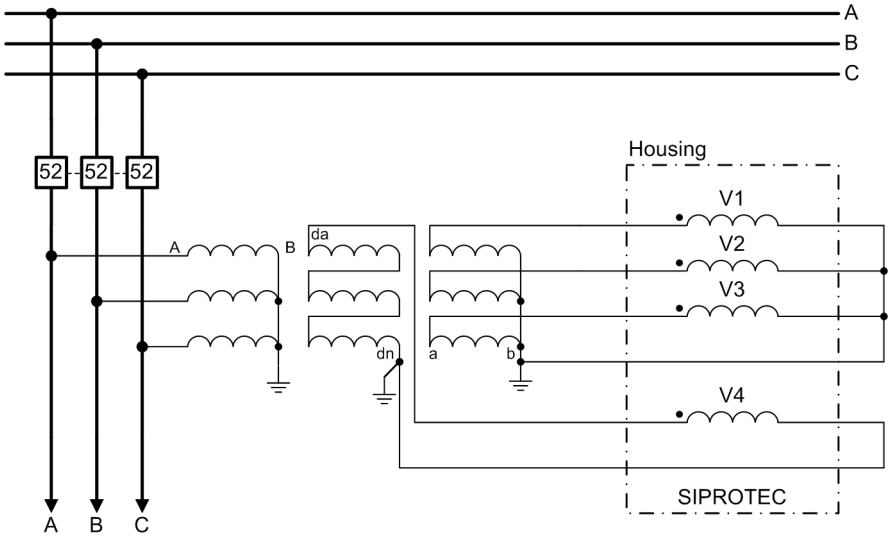
Figure A-20 Current-Transformer Connection for High-Impedance Differential Protection (Example: Power Transformer)

A.10 Connection Examples of Voltage Transformers for Modular Devices



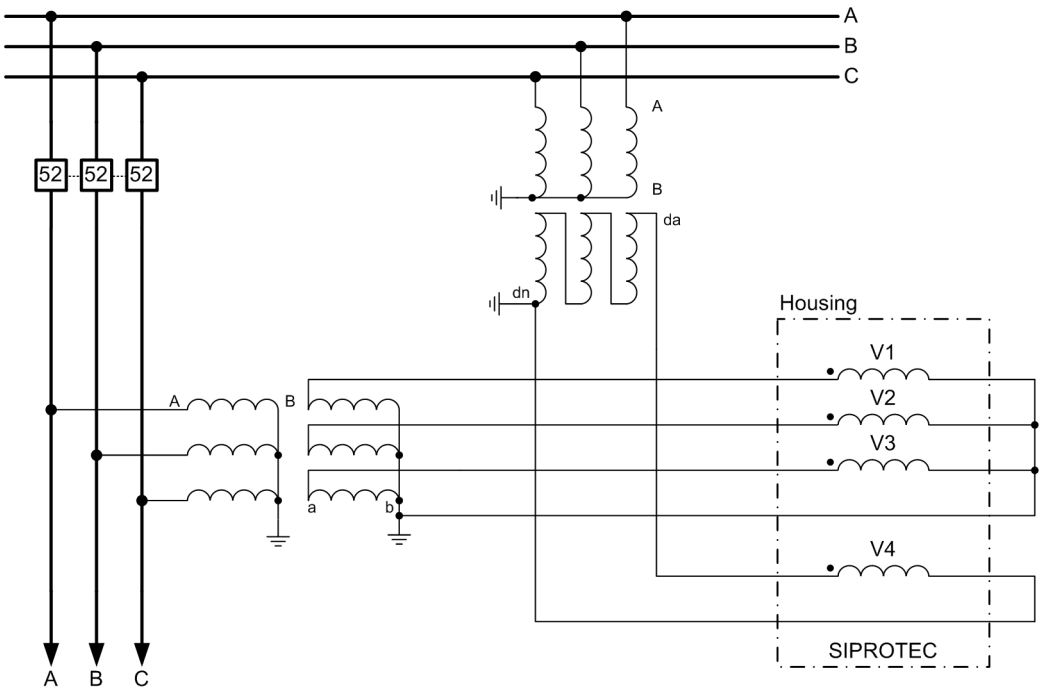
[tvvolta1-260313-01.tif, 1, en_US]

Figure A-21 Connection to 3 Star-Connected Voltage Transformers



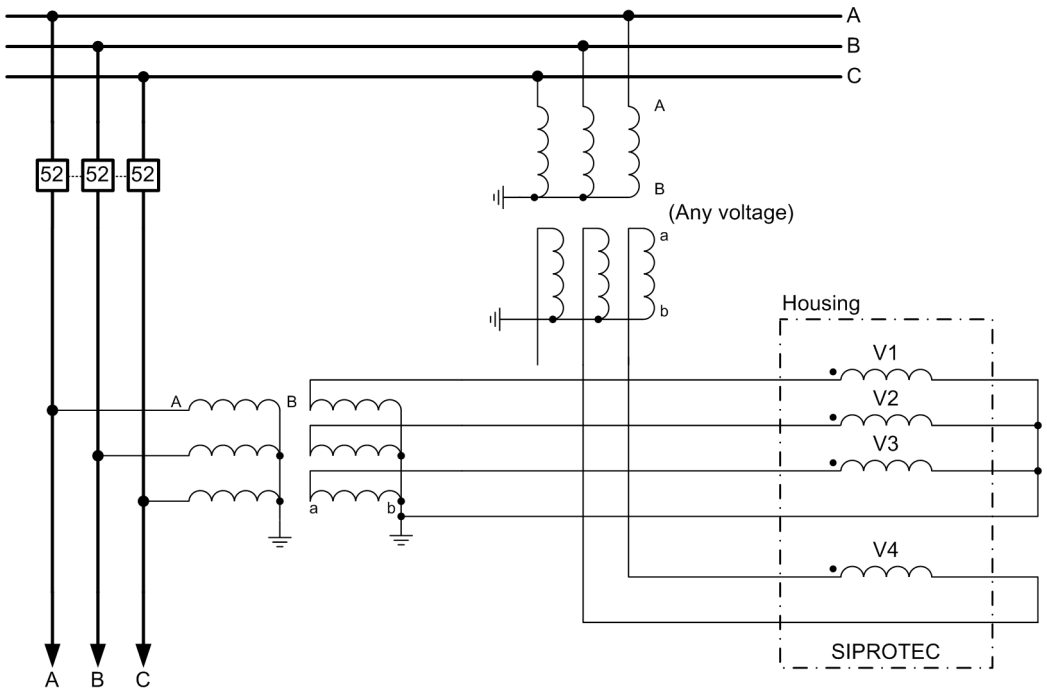
[tvvolta2-260313-01.tif, 1, en_US]

Figure A-22 Connection to 3 Star-Connected Voltage Transformers and to the Broken-Delta Winding



[tvvolta3-260313-01.tif, 1, en_US]

Figure A-23 Connection to 3 Star-Connected Voltage Transformers and to the Broken-Delta Winding of a Separate Voltage Transformer (for Example Busbar)

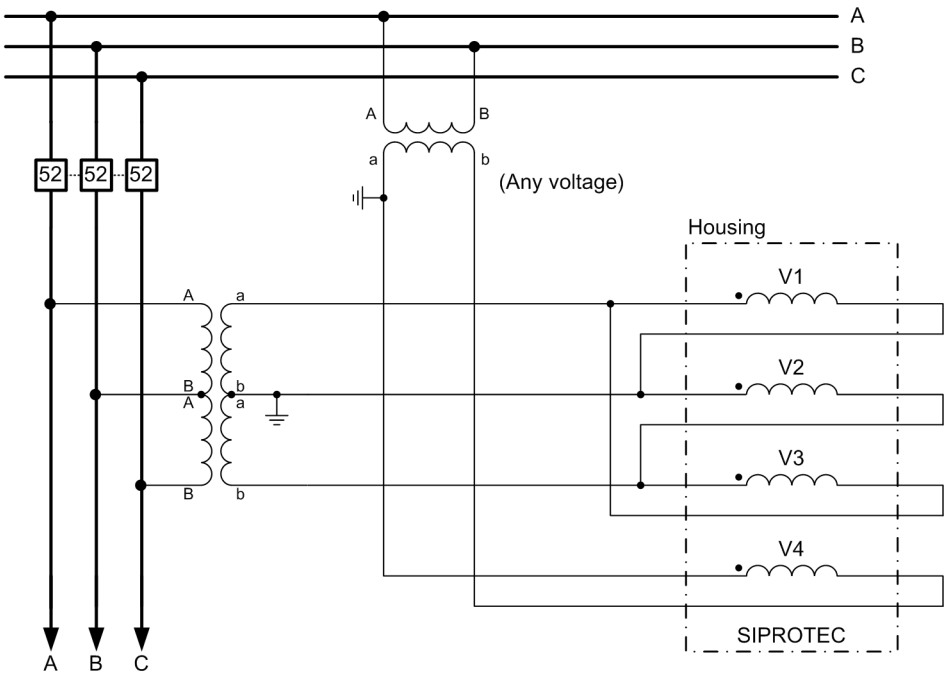


Voltage transformer 3-phase: connection = 3 ph-to-gnd voltages

Voltage transformer 1-phase: connection = VAB

[tvvolta4-260313-01.tif, 2, en_US]

Figure A-24 Connection to 3 Star-Connected Voltage Transformers and to the Phase-to-Phase Voltage of a Busbar Voltage Transformer (for Example for Synchrocheck Applications)



Voltage transformer 3-phase: connection = **3 ph-to-ph voltages**

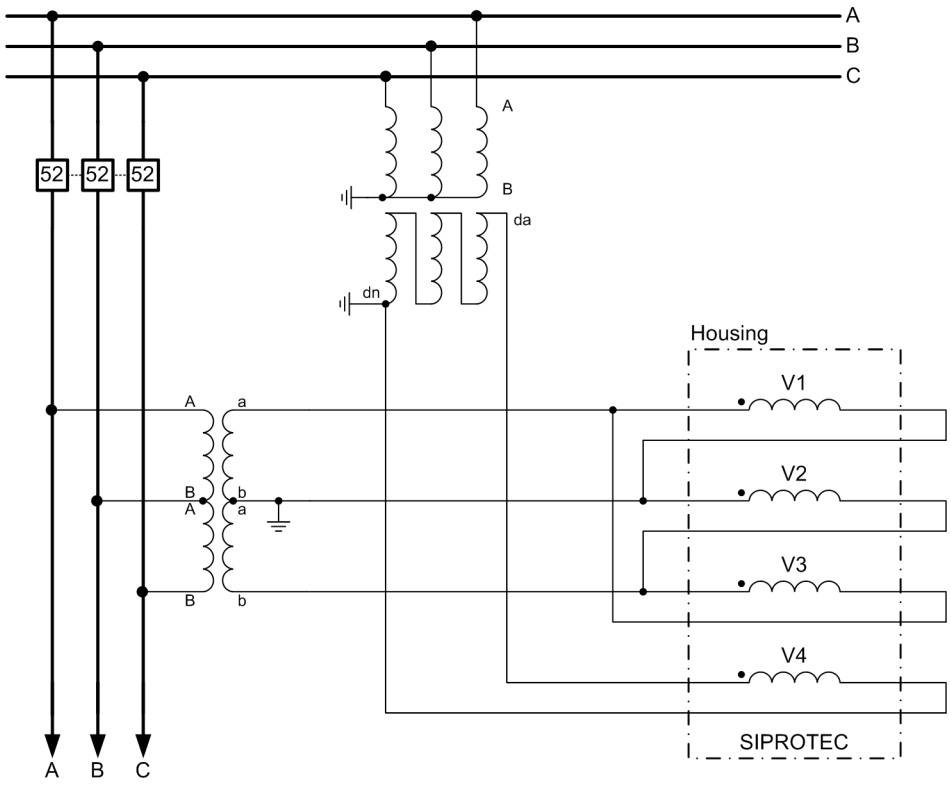
Voltage transformer 1-phase: connection = **VAB**

[tvvolta5-260313-01.tif, 1, en_US]

Figure A-25 Connection to V-Connected Voltage Transformer (Delta-Connected Device Input Transformer) and Connection to the Phase-to-Phase Voltage of a Busbar Voltage Transformer

NOTE

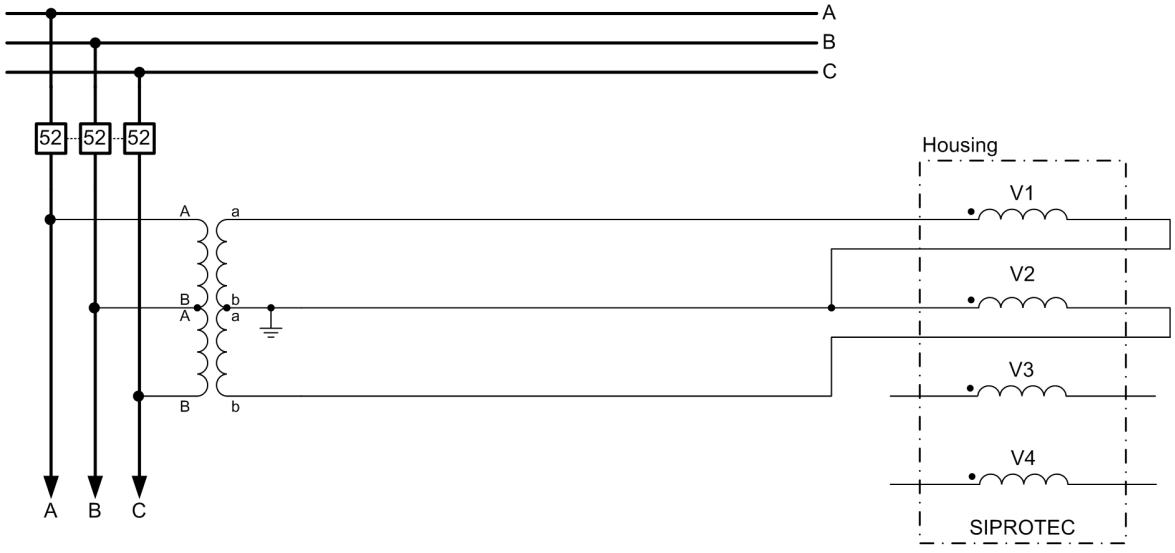
When using the connection type 3-phase-to-phase voltages, the zero-sequence voltage cannot be detected.



Voltage transformer 3-phase: connection = 3 ph-to-ph volt. + VN

[tvvolta6-260313-01.tif, 1, en_US]

Figure A-26 Connection to V-Connected Voltage Transformer (Delta-Connected Device Input Transformer) and Connection to the Broken-Delta Winding of a Busbar Voltage Transformer



Voltage transformer 3-phase: connection = 2 ph-to-ph voltages

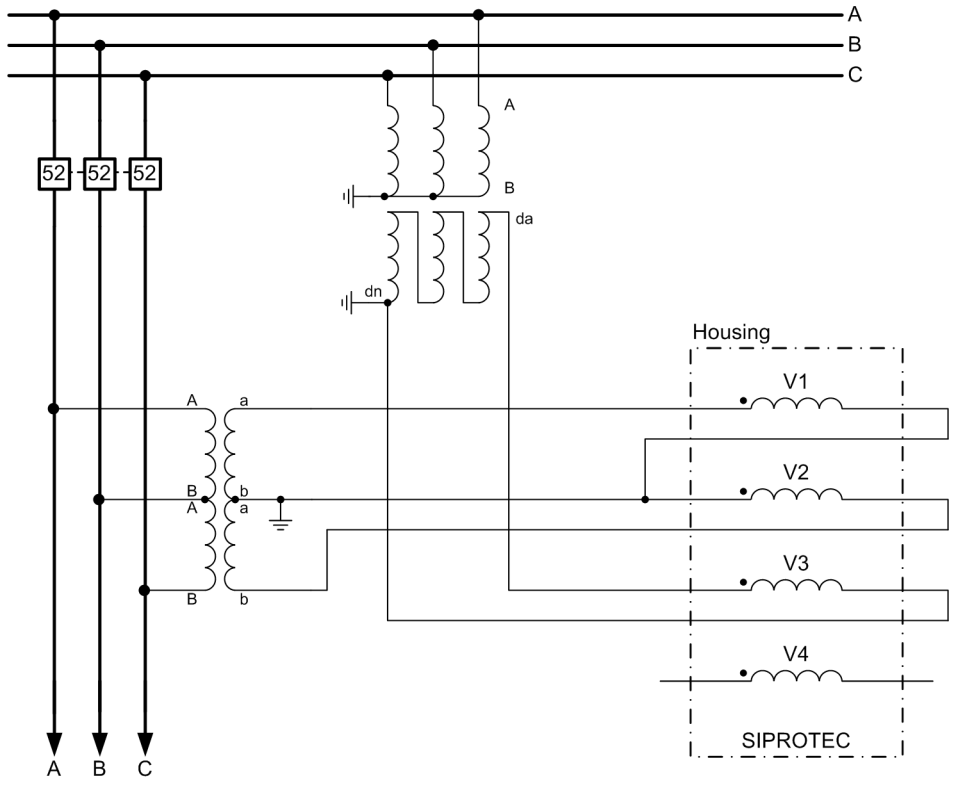
Phase voltages = VAB, VBC

[tvvol2ll-260313-01.tif, 2, en_US]

Figure A-27 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages)

NOTE

When using the connection type 2-phase-to-phase voltages, the zero-sequence voltage cannot be detected.



Voltage transformer 3-phase: connection = **2 ph-to-ph volt. + VN**

Phase voltages = VAB, VBC

[tvl2lluu-260313-01.tif, 2, en_US]

Figure A-28 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages) and Connection to the Broken-Delta Winding of a Busbar Voltage Transformer

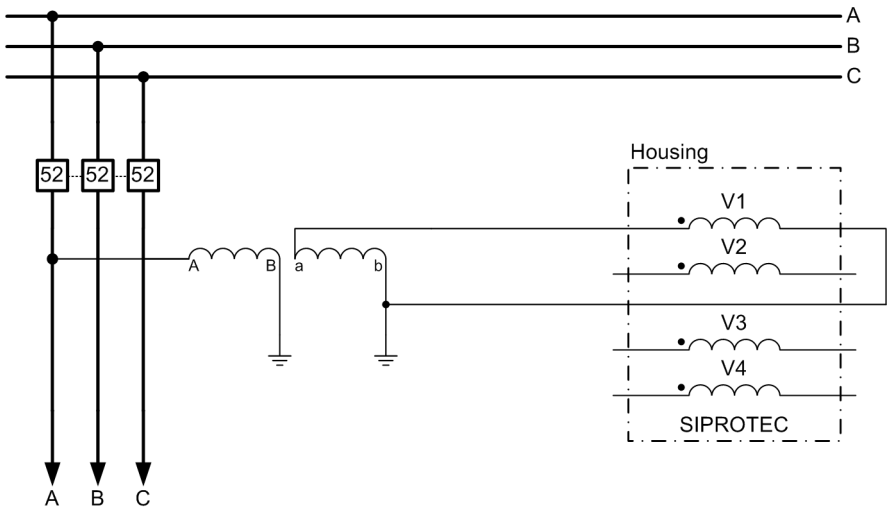
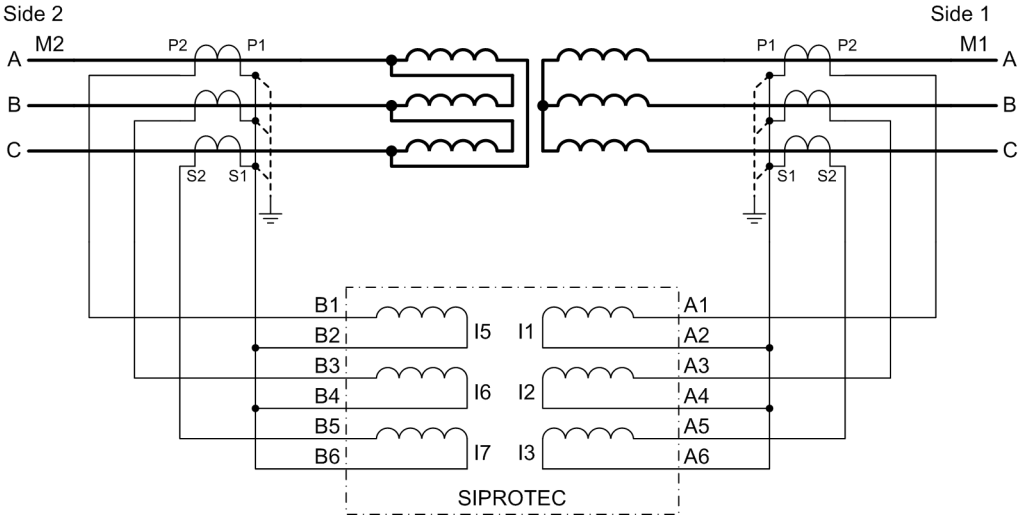


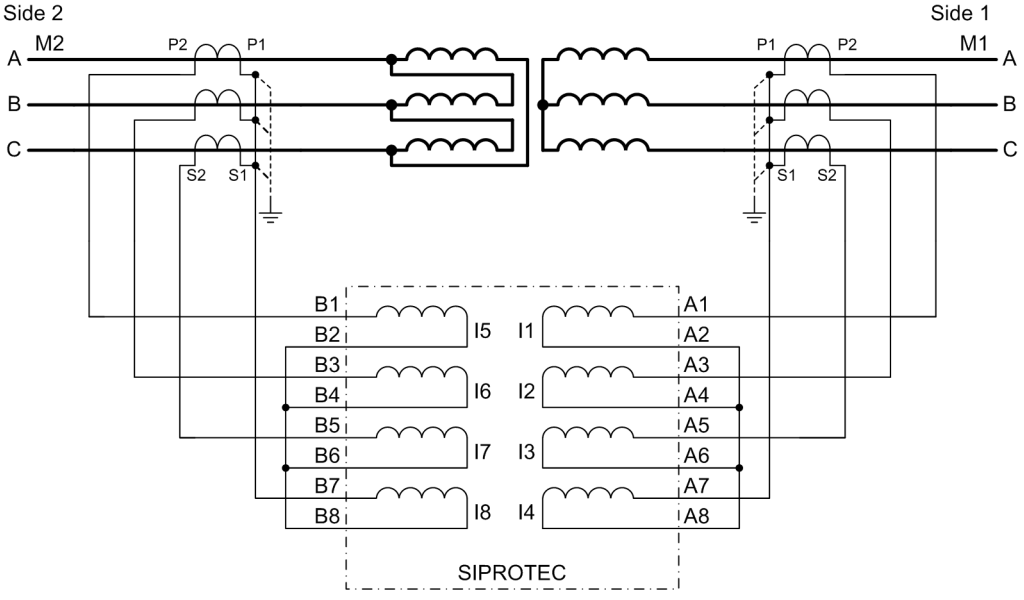
Figure A-29 Connection to a 1-Pole Insulated Voltage Transformer (Phase-to-Ground Voltage)

A.11 Selected Connection Examples for Transformers



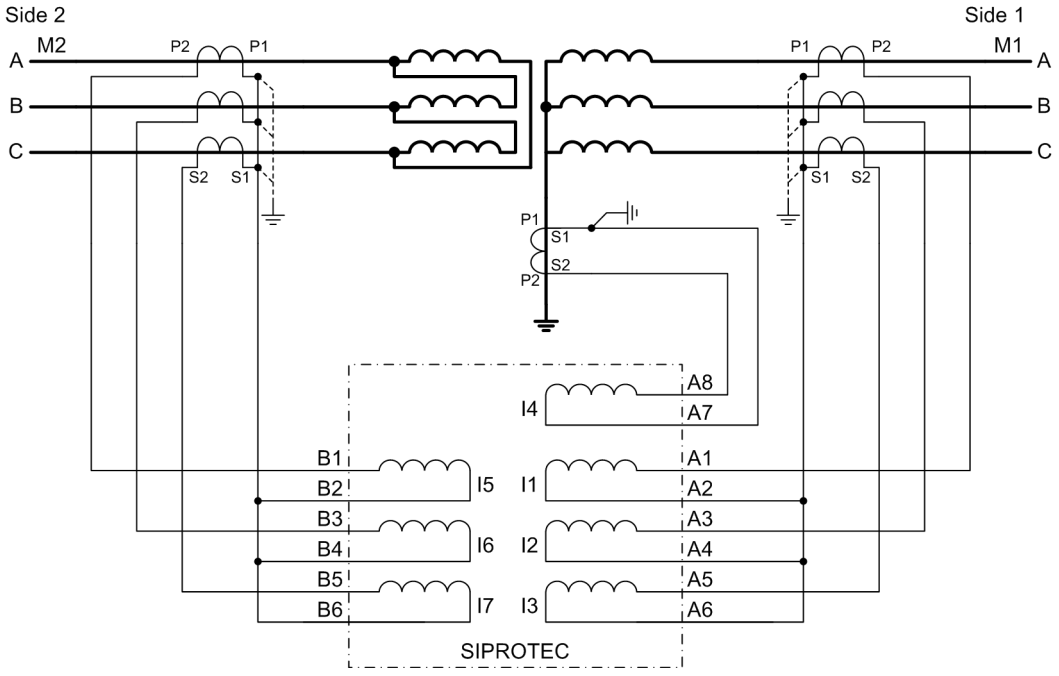
[dw3phtr1-301012-01.tif, 1, en_US]

Figure A-30 Connection Example 3-Phase Transformer Without Grounded Neutral Point



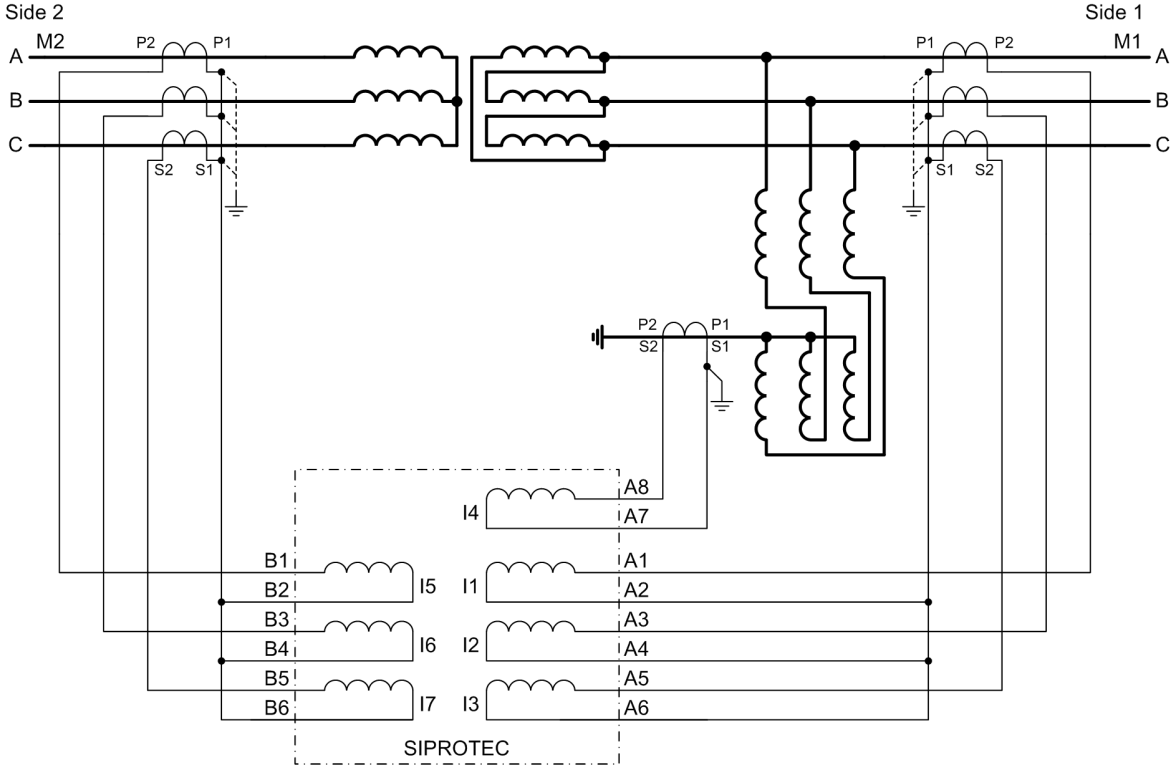
[dw3phtr2-301012-01.tif, 2, en_US]

Figure A-31 Connection Example 3-phase Transformer Without Grounded Neutral Point (Additional Measured-Value Acquisition on Sampling Level through Connection of 4 Current Inputs)



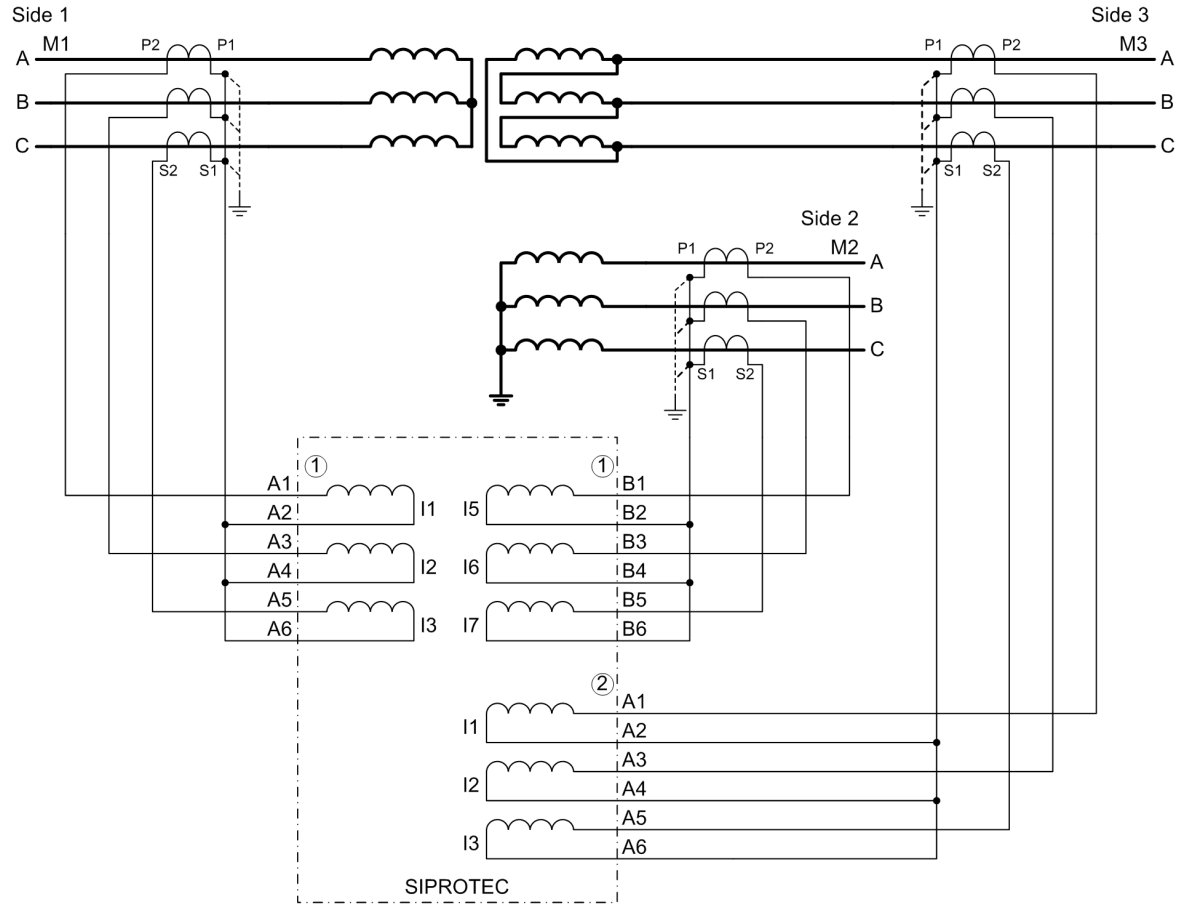
[dw3phtr3-301012-01.tif, 1, en_US]

Figure A-32 Connection Example 3-Phase Transformer with Grounded Neutral Point and Current Transformer in the Neutral Point Feeder



[dw3phtr4-291112-01.tif, 1, en_US]

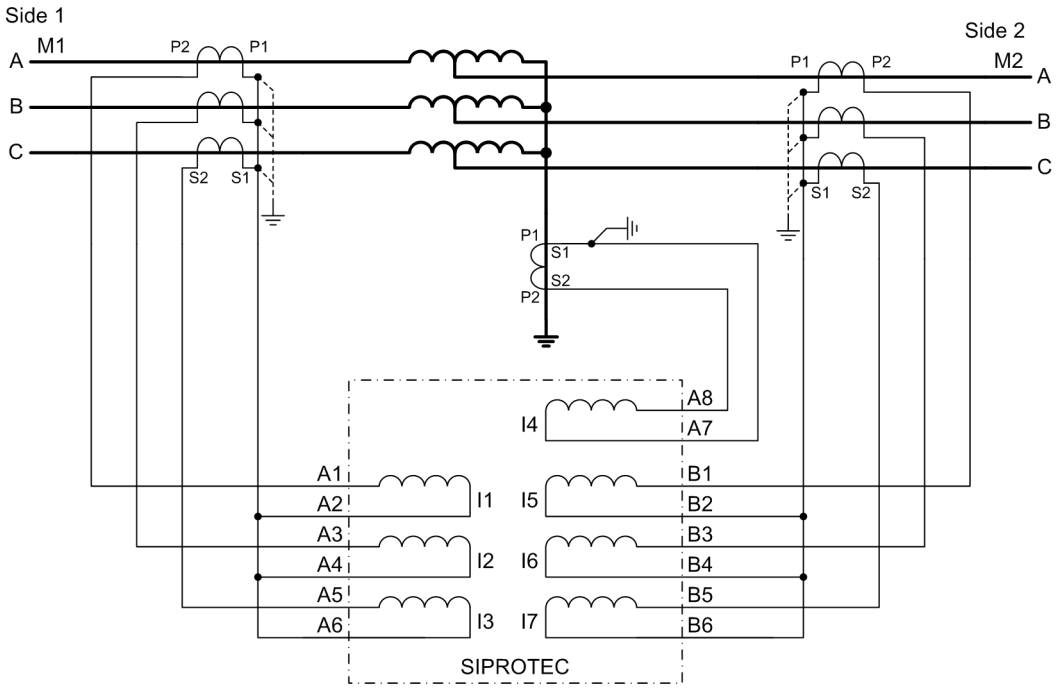
Figure A-33 Connection Example 3-Phase Transformer with Grounded Neutral Point Former and Current Transformer in the Neutral Point Feeder



① Base module
② Expansion module

[dw3phtr5-291112-01.tif, 2, en_US]

Figure A-34 Connection Example 3-Phase Transformer (7UT86, 7UT87)



[dw3phtr6-301012-01.tif, 1, en_US]

Figure A-35 Connection Example for a Grounded Auto Transformer with Current Transformer in the Neutral Point Feeder

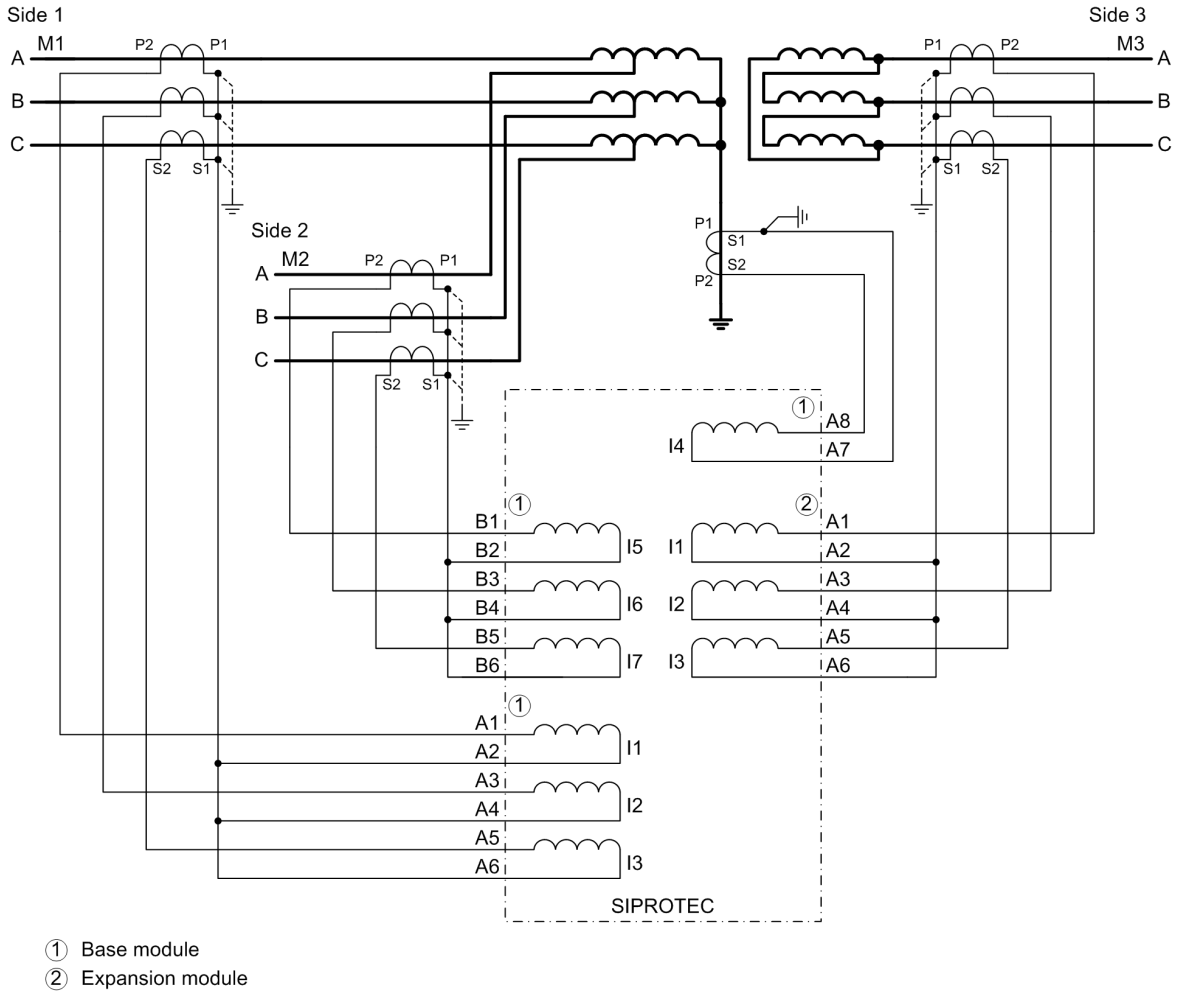
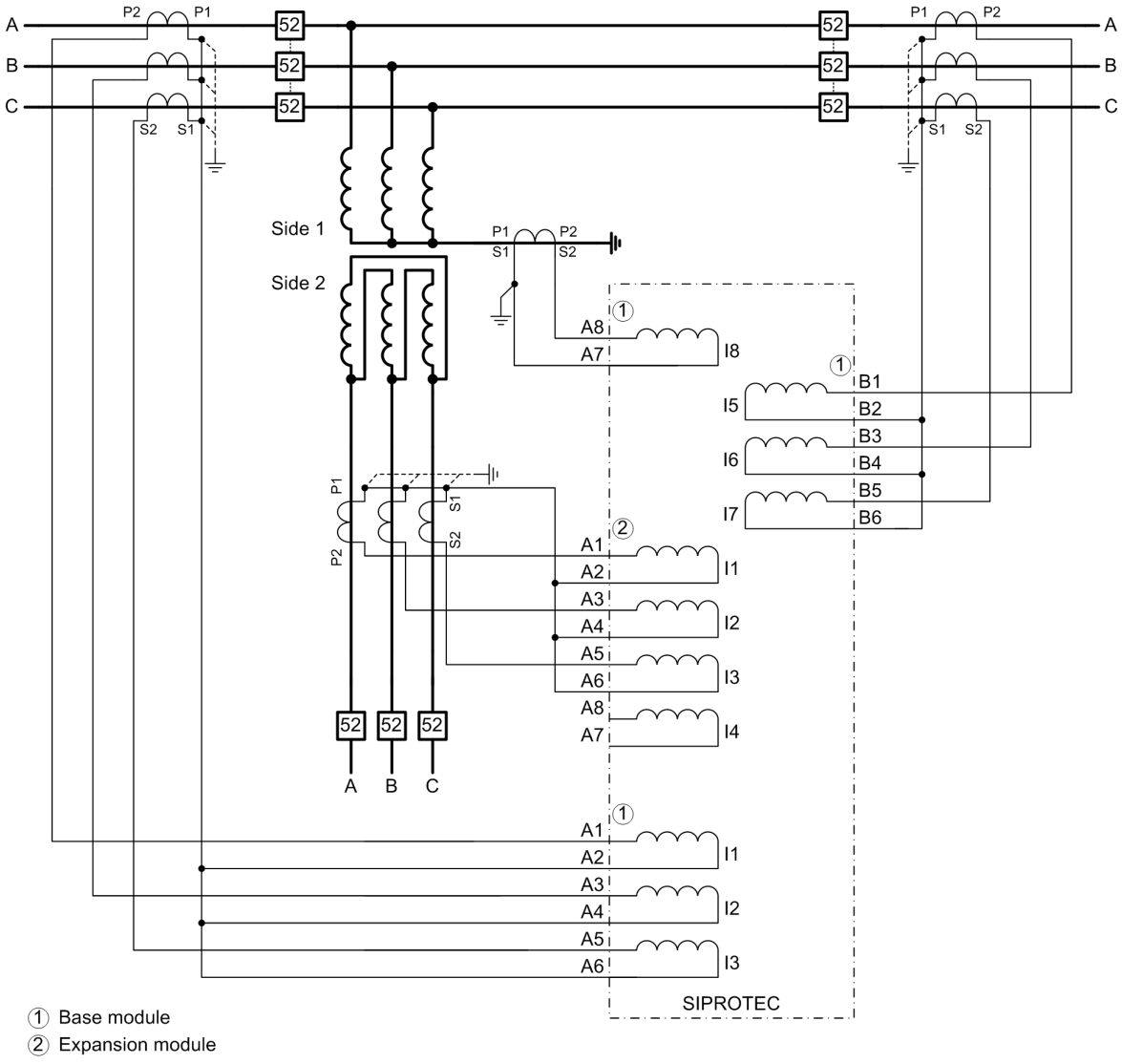


Figure A-36 Connection Example for a Grounded Auto Transformer with Stabilizing Winding (tertiary winding) and Current Transformer the Neutral Point Feeder



[dw3phtr8-291112-01.tif, 1, en_US]

Figure A-37 Connection Example for a 3-Phase Transformer with Grounded Neutral Point and Current Transformer in the Neutral Point Feeder in a 1.5 CB Design

A.12 Prerouting Two-Winding Transf. Basic, Two-Winding Transf.

Meaning of the abbreviations in DIGSI 5, see *Table 7-9*.

Binary Inputs

Table A-3 Default Binary Inputs for Two-Winding Transf. Basic, Two-Winding Transf.

Binary Input	Signal	Number	Signal Type	Configu-ration	Remarks
BI1	Circuit breaker 1:Circuit break.:Posi-tion	201.4261.58	DPC	OH	
BI2	Circuit breaker 1:Circuit break.:Posi-tion	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker:>Ready	201.4261.500	SPS	H	
BI5	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	OH	
BI6	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	CH	
BI7	Circuit breaker 2: Circuit Breaker:>Ready	202.4261.500	SPS	H	

Binary Outputs

Table A-4 Default Binary Outputs for Two-Winding Transf. Basic, Two-Winding Transf.

Binary Input	Signal	Number	Signal Type	Configu-ration	Remarks
BO1	Circuit breaker 1:Circuit break.:Trip/ open cmd.	201.4261.300	SPS	V	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	V	
BO3	Transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	V	

Function Keys

Table A-5 Default Function Keys for Two-Winding Transf. Basic, Two-Winding Transf.

Binary Input	Signal	Number	Signal Type	Configu-ration	Remarks
F-key1	General:Operational log			X	
F-key2	Main menu: Measurements Trans-former side 1: Fund./sym.comp.			X	
F-key3	General:Fault log			X	
F-key4	Main menu: Measurements Trans-former side 2: Fund./sym.comp.			X	

Light-Emitting Diodes

Table A-6 Default LED Displays for Two-Winding Transf. Basic, Two-Winding Transf.

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED1	Transformer side 1: Group indication: Pickup: phase A	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: phase A	912.4501.55			
	Transformer 1:Group indication: Pickup: phase A	901.4501.55			
LED2	Transformer side 1: Group indication: Pickup: phase B	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: phase B	912.4501.55			
	Transformer 1:Group indication: Pickup: phase B	901.4501.55			
LED3	Transformer side 1: Group indication: Pickup: phase C	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: phase C	912.4501.55			
	Transformer 1:Group indication: Pickup: phase C	901.4501.55			
LED4	Transformer side 1: Group indication: Pickup: gnd	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: gnd	912.4501.55			
LED5	Transformer side 1: Group indication: Operate: general	911.4501.57	SPS	L	
	Transformer side 2: Group indication: Operate: general	912.4501.57			
	Transformer 1:Group indication: Operate: general	901.4501.57			
LED8	Transformer side 1: 49 Th.overl. 1: Thermal warning	911.601.302	SPS	V	
LED15	Alarm handling: Group warning	5971.301	SPS	V	
LED16	Device: Process mode inactive		SPS	V	
	General: Functions in Test mode	91 329	SPS	V	

A.13 Prerouting Two-Winding Transf. 1.5 CB

Meaning of the abbreviations in DIGSI 5, see *Table 7-9*.

Binary Inputs

Table A-7 Default Binary Inputs for Two-Winding Transf. 1.5 CB

Binary Input	Signal	Number	Signal Type	Configu-ration	Remarks
BI1	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	OH	
BI2	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker:>Ready	201.4261.500	SPS	H	
BI5	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	OH	
BI6	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	CH	
BI7	Circuit breaker 2: Circuit Breaker:>Ready	202.4261.500	SPS	H	
BI8	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	OH	
BI9	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	CH	
BI10	Circuit breaker 3: Circuit Breaker:>Ready	203.4261.500	SPS	H	

Binary Outputs

Table A-8 Default Binary Outputs for Two-Winding Transf. 1.5 CB

Binary Output	Signal	Number	Signal Type	Configu-ration	Remarks
BO1	Circuit breaker 1: Circuit Breaker:Trip/open cmd.	201.4261.300	SPS	V	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	V	
BO3	Circuit breaker 3: Circuit Breaker:Trip/open cmd.	203.4261.300	SPS	V	
BO4	Transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	V	

Function Keys

Table A-9 Default Function Keys for Two-Winding Transf. 1.5 CB

Function Key	Signal	Number	Signal Type	Configu-ration	Remarks
F-key1	General:Operational log			X	
F-key2	Main menu: Measurements Trans-former side 1: Fund./sym.comp.			X	

Function Key	Signal	Number	Signal Type	Configu-ration	Remarks
F-key3	General:Fault log			X	
F-key4	Main menu: Measurements Trans-former side 2: Fund./sym.comp.			X	

Light-Emitting Diodes

Table A-10 Default LED Displays for Two-Winding Transf. 1.5 CB

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED1	Transformer side 1: Group indica-tion: Pickup: phase A	911.4501.55	SPS	L	
	Transformer side 2: Group indica-tion: Pickup: phase A	912.4501.55			
	Transformer 1:Group indication: Pickup: phase A	901.4501.55			
LED2	Transformer side 1: Group indica-tion: Pickup: phase B	911.4501.55	SPS	L	
	Transformer side 2: Group indica-tion: Pickup: phase B	912.4501.55			
	Transformer 1:Group indication: Pickup: phase B	901.4501.55			
LED3	Transformer side 1: Group indica-tion: Pickup: phase C	911.4501.55	SPS	L	
	Transformer side 2: Group indica-tion: Pickup: phase C	912.4501.55			
	Transformer 1:Group indication: Pickup: phase C	901.4501.55			
LED4	Transformer side 1: Group indica-tion: Pickup: gnd	911.4501.55	SPS	L	
	Transformer side 2: Group indica-tion: Pickup: gnd	912.4501.55			
LED5	Transformer side 1: Group indica-tion: Operate: general	911.4501.57	SPS	L	
	Transformer side 2: Group indica-tion: Operate: general	912.4501.57			
	Transformer 1:Group indication: Operate: general	901.4501.57			
LED8	Transformer side 1: 49 Th.overl. 1: Thermal warning	911.601.302	SPS	V	
LED15	Alarm handling: Group warning	5971.301	SPS	V	
LED16	Device: Process mode inactive		SPS	V	
	General: Functions in Test mode	91 329	SPS	V	

A.14 Prerouting Two-Winding Transf. Diff, Voltage Controller

Meaning of the abbreviations in DIGSI 5, see *Table 7-9*.

Binary Inputs

Table A-11 Default Binary Inputs for Two-Winding Transf. Diff, Voltage Controller

Binary Input	Signal	Number	Signal Type	Configu-ration	Remarks
BI1	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	OH	
BI2	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker:>Ready	201.4261.500	SPS	H	
BI4	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	OH	
BI5	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	CH	
BI6	Circuit breaker 2: Circuit Breaker:>Ready	202.4261.500	SPS	H	
BI7	Tap Changer:Position	162.13981.308	BSC	X	
BI8	Tap Changer:Position	162.13981.308	BSC	X	
BI9	Tap Changer:Position	162.13981.308	BSC	X	
BI10	Tap Changer:Position	162.13981.308	BSC	X	
BI11	Tap Changer:Position	162.13981.308	BSC	X	
BI11	Motor active		SPS	H	user defined

Binary Outputs

Table A-12 Default Binary Outputs for Two-Winding Transf. Diff, Voltage Controller

Binary Output	Signal	Number	Signal Type	Configu-ration	Remarks
BO1	Circuit breaker 1: Circuit Breaker:Trip/open cmd.	201.4261.300	SPS	V	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	V	
BO3	Transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	V	
BO4	Transformer 1: 87T diff. prot 1: Operate: Higher cmd.	162.139:1.305	ACT	X	
BO5	Transformer 1: 87T diff. prot 1: Operate: Lower cmd.	162.139:1.306	ACT	X	

Function Keys

Table A-13 Default Function Keys for Two-Winding Transf. Diff, Voltage Controller

Function Key	Signal	Number	Signal Type	Configu-ration	Remarks
F-key1	General:Operational log			X	
F-key2	Main menu: Measurements Trans-former side 1: Fund./sym.comp.			X	
F-key3	General:Fault log			X	
F-key4	Main menu: Measurements Trans-former side 2: Fund./sym.comp.			X	

Light-Emitting Diodes

Table A-14 Default LED Displays for Two-Winding Transf. Diff, Voltage Controller

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED1	Transformer side 1: Group indica-tion: Pickup: phase A	911.4501.55	SPS	L	
	Transformer side 2: Group indica-tion: Pickup: phase A	912.4501.55			
	Transformer 1:Group indication: Pickup: phase A	901.4501.55			
LED2	Transformer side 1: Group indica-tion: Pickup: phase B	911.4501.55	SPS	L	
	Transformer side 2: Group indica-tion: Pickup: phase B	912.4501.55			
	Transformer 1:Group indication: Pickup: phase B	901.4501.55			
LED3	Transformer side 1: Group indica-tion: Pickup: phase C	911.4501.55	SPS	L	
	Transformer side 2: Group indica-tion: Pickup: phase C	912.4501.55			
	Transformer 1:Group indication: Pickup: phase C	901.4501.55			
LED4	Transformer side 1: Group indica-tion: Pickup: gnd	911.4501.55	SPS	L	
	Transformer side 2: Group indica-tion: Pickup: gnd	912.4501.55			
LED5	Transformer side 1: Group indica-tion: Operate: general	911.4501.57	SPS	L	
	Transformer side 2: Group indica-tion: Operate: general	912.4501.57			
	Transformer 1:Group indication: Operate: general	901.4501.57			
LED8	Transformer side 1: 49 Th.overl. 1: Thermal warning	911.601.302	SPS	V	
LED14	Motor active		SPS	V	user defined
LED15	Alarm handling: Group warning	5971.301	SPS	V	
LED16	Device: Process mode inactive		SPS	V	
	General: Functions in Test mode	91 329	SPS	V	

A.15 Prerouting Motor

Meaning of the abbreviations in DIGSI 5, see *Table 7-9*.

Binary Inputs

Table A-15 Default Binary Inputs for Motor

Binary Input	Signal	Number	Signal Type	Configu-ration	Remarks
BI1	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	OH	
BI2	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker:>Ready	201.4261.500	SPS	H	

Binary Outputs

Table A-16 Default Binary Outputs for Motor

Binary Output	Signal	Number	Signal Type	Configu-ration	Remarks
BO1	Circuit breaker 1: Circuit Breaker:Trip/open cmd.	201.4261.300	SPS	V	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	V	
BO3	Circuit breaker 3: Circuit Breaker:Trip/open cmd.	203.4261.300	SPS	V	
BO4	Transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	V	

Function Keys

Table A-17 Default Function Keys for Motor

Function Key	Signal	Number	Signal Type	Configu-ration	Remarks
F-key1	General:Operational log			X	
F-key2	Main menu: Measurements Trans-former side 1: Fund./sym.comp.			X	
F-key3	General:Fault log			X	
F-key4	Main menu: Measurements Trans-former side 2: Fund./sym.comp.			X	

Light-Emitting Diodes

Table A-18 Default LED Display for Motor

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED1	Transformer side 1: Group indication: Pickup: phase A	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: phase A	912.4501.55			
	Transformer 1:Group indication: Pickup: phase A	901.4501.55			
LED2	Transformer side 1: Group indication: Pickup: phase B	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: phase B	912.4501.55			
	Transformer 1:Group indication: Pickup: phase B	901.4501.55			
LED3	Transformer side 1: Group indication: Pickup: phase C	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: phase C	912.4501.55			
	Transformer 1:Group indication: Pickup: phase C	901.4501.55			
LED4	Transformer side 1: Group indication: Pickup: gnd	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: gnd	912.4501.55			
LED5	Transformer side 1: Group indication: Operate: general	911.4501.57	SPS	L	
	Transformer side 2: Group indication: Operate: general	912.4501.57			
	Transformer 1:Group indication: Operate: general	901.4501.57			
LED8	Transformer side 1: 49 Th.overl. 1: Thermal warning	911.601.302	SPS	V	
LED15	Alarm handling: Group warning	5971.301	SPS	V	
LED16	Device: Process mode inactive		SPS	V	
	General: Functions in Test mode	91 329	SPS	V	

A.16 Prerouting Three-Winding Transf.

Meaning of the abbreviations in DIGSI 5, see *Table 7-9*.

Binary Inputs

Table A-19 Default Binary Inputs for Three-Winding Transf.

Binary Input	Signal	Number	Signal Type	Configu-ration	Remarks
BI1	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	OH	
BI2	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker:>Ready	201.4261.500	SPS	H	
BI5	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	OH	
BI6	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	CH	
BI7	Circuit breaker 2: Circuit Breaker:>Ready	202.4261.500	SPS	H	
BI8	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	OH	
BI9	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	CH	
BI10	Circuit breaker 3: Circuit Breaker:>Ready	203.4261.500	SPS	H	

Binary Outputs

Table A-20 Default Binary Outputs for Three-Winding Transf.

Binary Output	Signal	Number	Signal Type	Configu-ration	Remarks
BO1	Circuit breaker 1: Circuit Breaker:Trip/open cmd.	201.4261.300	SPS	V	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	V	
BO3	Circuit breaker 3: Circuit Breaker:Trip/open cmd.	203.4261.300	SPS	V	
BO4	Transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	V	

Function Keys

Table A-21 Default Function Keys for Three-Winding Transf.

Function Key	Signal	Number	Signal Type	Configu-ration	Remarks
F-key1	General:Operational log			X	
F-key2	Main menu: Measurements Trans-former side 1: Fund./sym.comp.			X	

Function Key	Signal	Number	Signal Type	Configu-ration	Remarks
F-key3	General:Fault log			X	
F-key4	Main menu: Measurements Trans-former side 2: Fund./sym.comp.			X	

Light-Emitting Diodes

Table A-22 Default LED Displays for Three-Winding Transf.

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED1	Transformer 1:Group indication: Pickup: phase A	901.4501.55	SPS	L	
LED2	Transformer 1:Group indication: Pickup: phase B	901.4501.55	SPS	L	
LED3	Transformer 1:Group indication: Pickup: phase C	901.4501.55	SPS	L	
LED5	Transformer 1:Group indication: Operate: general	901.4501.57	SPS	L	
LED15	Alarm handling: Group warning	5971.301	SPS	V	
LED16	Device: Process mode inactive		SPS	V	
	General: Functions in Test mode	91 329	SPS	V	

A.17 Prerouting Three-Winding Transf. 1.5 CB

Meaning of the abbreviations in DIGSI 5, see *Table 7-9*.

Binary Inputs

Table A-23 Default Binary Inputs for Three-Winding Transf. 1.5 CB

Binary Input	Signal	Number	Signal Type	Configu-ration	Remarks
BI1	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	OH	
BI2	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker:>Ready	201.4261.500	SPS	H	
BI5	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	OH	
BI6	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	CH	
BI7	Circuit breaker 2: Circuit Breaker:>Ready	202.4261.500	SPS	H	
BI8	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	OH	
BI9	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	CH	
BI10	Circuit breaker 3: Circuit Breaker:>Ready	203.4261.500	SPS	H	
BI11	Circuit breaker 4: Circuit Breaker:Position	204.4261.58	DPC	OH	
BI12	Circuit breaker 4: Circuit Breaker:Position	204.4261.58	DPC	CH	
BI13	Circuit breaker 4: Circuit Breaker:>Ready	204.4261.500	SPS	H	

Binary Outputs

Table A-24 Default Binary Outputs for Three-Winding Transf. 1.5 CB

Binary Output	Signal	Number	Signal Type	Configu-ration	Remarks
BO1	Circuit breaker 1: Circuit Breaker:Trip/open cmd.	201.4261.300	SPS	V	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	V	
BO3	Circuit breaker 3: Circuit Breaker:Trip/open cmd.	203.4261.300	SPS	V	
BO4	Circuit breaker 4: Circuit Breaker:Trip/open cmd.	204.4261.300	SPS	V	
BO5	Transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	V	

Function Keys

Table A-25 Default Function Keys for Three-Winding Transf. 1.5 CB

Function Key	Signal	Number	Signal Type	Configu-ration	Remarks
F-key1	General:Operational log			X	
F-key2	Main menu: Measurements Trans-former side 1: Fund./sym.comp.			X	
F-key3	General:Fault log			X	
F-key4	Main menu: Measurements Trans-former side 2: Fund./sym.comp.			X	
F-key5	Main menu: Measurements Trans-former side 3: Fund./sym.comp.			X	

Light-Emitting Diodes

Table A-26 Default LED Displays for Three-Winding Transf. 1.5 CB

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED1	Transformer side 1: Group indica-tion: Pickup: phase A	911.4501.55	SPS	L	
	Transformer 1:Group indication: Pickup: phase A	901.4501.55			
LED2	Transformer side 1: Group indica-tion: Pickup: phase B	911.4501.55	SPS	L	
	Transformer 1:Group indication: Pickup: phase B	901.4501.55			
LED3	Transformer side 1: Group indica-tion: Pickup: phase C	911.4501.55	SPS	L	
	Transformer 1:Group indication: Pickup: phase C	901.4501.55			
LED4	Transformer side 1: Group indica-tion: Pickup: gnd	911.4501.55	SPS	L	
	Transformer starp. 1: Group indica-tion: Pickup: general	912.4501.55			
LED5	Transformer side 1: Group indica-tion: Operate: general	911.4501.57	SPS	L	
	Transformer starp. 1: Group indica-tion: Operate: general	912.4501.57			
	Transformer 1:Group indication: Operate: general	901.4501.57			
LED8	Transformer side 1: 49 Th.overl. 1: Thermal warning	911.601.302	SPS	V	
LED15	Alarm handling: Group warning	5971.301	SPS	V	
LED16	Device: Process mode inactive		SPS	V	
	General: Functions in Test mode	91 329	SPS	V	

A.18 Prerouting Three-Winding Transf. DIFF, EDS, DIS

Meaning of the abbreviations in DIGSI 5, see *Table 7-9*.

Binary Inputs

Table A-27 Default Binary Inputs for Three-Winding Transf. DIFF, EDS, DIS

Binary Input	Signal	Number	Signal Type	Configu-ration	Remarks
BI1	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	OH	
BI2	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker:>Ready	201.4261.500	SPS	H	
BI5	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	OH	
BI6	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	CH	
BI7	Circuit breaker 2: Circuit Breaker:>Ready	202.4261.500	SPS	H	
BI8	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	OH	
BI9	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	CH	
BI10	Circuit breaker 3: Circuit Breaker:>Ready	203.4261.500	SPS	H	

Binary Outputs

Table A-28 Default Binary Outputs for Three-Winding Transf. DIFF, EDS, DIS

Binary Output	Signal	Number	Signal Type	Configu-ration	Remarks
BO1	Circuit breaker 1: Circuit Breaker:Trip/open cmd.	201.4261.300	SPS	V	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	V	
BO3	Circuit breaker 3: Circuit Breaker:Trip/open cmd.	203.4261.300	SPS	V	
BO4	Transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	V	

Function Keys

Table A-29 Default Function Keys for Three-Winding Transf. DIFF, EDS, DIS

Function Key	Signal	Number	Signal Type	Configu-ration	Remarks
F-key1	General:Operational log			X	
F-key2	Main menu: Measurements Trans-former side 1: Fund./sym.comp.			X	

Function Key	Signal	Number	Signal Type	Configu-ration	Remarks
F-key3	General:Fault log			X	
F-key4	Main menu: Measurements Trans-former side 2: Fund./sym.comp.			X	

Light-Emitting Diodes

Table A-30 Default LED Displays for Three-Winding Transf. DIFF, EDS, DIS

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED1	Transformer 1:Group indication: Pickup: phase A	901.4501.55	SPS	L	
LED2	Transformer 1:Group indication: Pickup: phase B	901.4501.55	SPS	L	
LED3	Transformer 1:Group indication: Pickup: phase C	901.4501.55	SPS	L	
LED5	Transformer 1:Group indication: Operate: general	901.4501.57	SPS	L	
LED15	Alarm handling: Group warning	5971.301	SPS	V	
LED16	Device: Process mode inactive		SPS	V	
	General: Functions in Test mode	91 329	SPS	V	

A.19 Prerouting Auto Transformer

Meaning of the abbreviations in DIGSI 5, see *Table 7-9*.

Binary Inputs

Table A-31 Default Binary Inputs for Auto Transformer

Binary Input	Signal	Number	Signal Type	Configu-ration	Remarks
BI1	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	OH	
BI2	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker:>Ready	201.4261.500	SPS	H	
BI5	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	OH	
BI6	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	CH	
BI7	Circuit breaker 2: Circuit Breaker:>Ready	202.4261.500	SPS	H	
BI8	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	OH	
BI9	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	CH	
BI10	Circuit breaker 3: Circuit Breaker:>Ready	203.4261.500	SPS	H	

Binary Outputs

Table A-32 Default Binary Outputs for Auto Transformer

Binary Output	Signal	Number	Signal Type	Configu-ration	Remarks
BO1	Circuit breaker 1: Circuit Breaker:Trip/open cmd.	201.4261.300	SPS	V	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	V	
BO3	Circuit breaker 3: Circuit Breaker:Trip/open cmd.	203.4261.300	SPS	V	
BO5	Auto transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	V	

Function Keys

Table A-33 Default Function Keys for Auto Transformer

Function Key	Signal	Number	Signal Type	Configu-ration	Remarks
F-key1	General:Operational log			X	
F-key2	Main menu: Measurements Auto transf. autoside 1: Fund./sym.comp.			X	
F-key3	General:Fault log			X	

Function Key	Signal	Number	Signal Type	Configu-ration	Remarks
F-key4	Main menu: Measurements Auto transf. autoside 2: Fund./sym.comp.			X	
F-key5	Main menu: Measurements Auto transf. Comp.side: Fund./sym.comp.			X	

Light-Emitting Diodes

Table A-34 Default LED Displays for Auto Transformer

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED1	Auto transf. autoside 1: Group indication: Pickup: phase A	941.4501.55	SPS	L	
	Auto transf. autoside 2: Group indication: Pickup: phase A	942.4501.55			
	Auto transf. Comp.side: Group indication: Pickup: phase A	951.4501.55			
	Auto transformer 1: Group indication: Pickup: phase A	931.4501.55			
LED2	Auto transf. autoside 1: Group indication: Pickup: phase B	941.4501.55	SPS	L	
	Auto transf. autoside 2: Group indication: Pickup: phase B	942.4501.55			
	Auto transf. Comp.side: Group indication: Pickup: phase B	951.4501.55			
	Auto Transformer 1:Group indication: Pickup: phase B	931.4501.55			
LED3	Auto transf. autoside 1: Group indication: Pickup: phase C	941.4501.55	SPS	L	
	Auto transf. autoside 2: Group indication: Pickup: phase C	942.4501.55			
	Auto transf. Comp.side: Group indication: Pickup: phase C	951.4501.55			
	Auto Transformer 1:Group indication: Pickup: phase C	931.4501.55			
LED4	Auto transf. autoside 1: Group indication: Pickup: gnd	941.4501.55	SPS	L	
	Auto transf. autoside 2: Group indication: Pickup: gnd	942.4501.55			
	Auto transf. Comp.side: Group indication: Pickup: gnd	951.4501.55			
	Auto transf. Neutral point 1: Group indication: Pickup: general	971.4501.57			

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED5	Auto transf. autoside 1: Group indication: Operate: general	941.4501.57	SPS	L	
	Auto transf. autoside 2: Group indication: Operate: general	942.4501.57			
	Auto transf. Comp.side: Group indication: Pickup: gnd	951.4501.57			
	Auto Transformer 1:Group indication: Operate: general	931.4501.57			
	Auto transf. Neutral point 1: Group indication: Operate: general	971.4501.57			
LED8	Auto transf. autoside 1: 49 Th.overl. 1: Thermal warning	941.601.302	SPS	V	
LED15	Alarm handling: Group warning	5971.301	SPS	V	
LED16	Device: Process mode inactive		SPS	V	
	General: Functions in Test mode	91 329	SPS	V	

A.20 Prerouting Auto Transformer 1.5 CB

Meaning of the abbreviations in DIGSI 5, see *Table 7-9*.

Binary Inputs

Table A-35 Default Binary Inputs for Auto Transformer 1.5 CB

Binary Input	Signal	Number	Signal Type	Configu-ration	Remarks
BI1	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	OH	
BI2	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker:>Ready	201.4261.500	SPS	H	
BI5	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	OH	
BI6	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	CH	
BI7	Circuit breaker 2: Circuit Breaker:>Ready	202.4261.500	SPS	H	
BI8	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	OH	
BI9	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	CH	
BI10	Circuit breaker 3: Circuit Breaker:>Ready	203.4261.500	SPS	H	
BI11	Circuit breaker 4: Circuit Breaker:Position	204.4261.58	DPC	OH	
BI12	Circuit breaker 4: Circuit Breaker:Position	204.4261.58	DPC	CH	
BI13	Circuit breaker 4: Circuit Breaker:>Ready	204.4261.500	SPS	H	

Binary Outputs

Table A-36 Default Binary Outputs for Auto Transformer 1.5 CB

Binary Output	Signal	Number	Signal Type	Configu-ration	Remarks
BO1	Circuit breaker 1: Circuit Breaker:Trip/open cmd.	201.4261.300	SPS	V	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	V	
BO3	Circuit breaker 3: Circuit Breaker:Trip/open cmd.	203.4261.300	SPS	V	
BO4	Circuit breaker 4: Circuit Breaker:Trip/open cmd.	204.4261.300	SPS	V	
BO5	Auto transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	V	
	Auto transformer 1: 87T diff. prot 2: Operate: general	901.1692.4501.57	ACT	V	

Function Keys

Table A-37 Default Function Keys for Auto Transformer 1.5 CB

Function Key	Signal	Number	Signal Type	Configu-ration	Remarks
F-key1	General:Operational log			X	
F-key2	Main menu: Measurements Auto transf. autoside 1: Fund./sym.comp.			X	
F-key3	General:Fault log			X	
F-key4	Main menu: Measurements Auto transf. autoside 2: Fund./sym.comp.			X	
F-key5	Main menu: Measurements Auto transf. Comp.side: Fund./sym.comp.			X	

Light-Emitting Diodes

Table A-38 Default LED Displays for Auto Transformer 1.5 CB

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED1	Auto transf. autoside 1: Group indication: Pickup: phase A	941.4501.55	SPS	L	
	Auto transf. autoside 2: Group indication: Pickup: phase A	942.4501.55			
	Auto transf. Comp.side: Group indication: Pickup: phase A	951.4501.55			
	Auto transformer 1: Group indication: Pickup: phase A	931.4501.55			
LED2	Auto transf. autoside 1: Group indication: Pickup: phase B	941.4501.55	SPS	L	
	Auto transf. autoside 2: Group indication: Pickup: phase B	942.4501.55			
	Auto transf. Comp.side: Group indication: Pickup: phase B	951.4501.55			
	Auto Transformer 1:Group indication: Pickup: phase B	931.4501.55			
LED3	Auto transf. autoside 1: Group indication: Pickup: phase C	941.4501.55	SPS	L	
	Auto transf. autoside 2: Group indication: Pickup: phase C	942.4501.55			
	Auto transf. Comp.side: Group indication: Pickup: phase C	951.4501.55			
	Auto Transformer 1:Group indication: Pickup: phase C	931.4501.55			
LED4	Auto transf. autoside 1: Group indication: Pickup: gnd	941.4501.55	SPS	L	
	Auto transf. autoside 2: Group indication: Pickup: gnd	942.4501.55			
	Auto transf. Comp.side: Group indication: Pickup: gnd	951.4501.55			

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED5	Auto transf. autoside 1: Group indication: Operate: general	941.4501.57	SPS	L	
	Auto transf. autoside 2: Group indication: Operate: general	942.4501.57			
	Auto transf. Comp.side: Group indication: Operate: general	951.4501.57			
	Auto Transformer 1:Group indication: Operate: general	931.4501.57			
LED8	Auto transf. autoside 1: 49 Th.overl. 1: Thermal warning	941.601.302	SPS	V	
LED15	Alarm handling: Group warning	5971.301	SPS	V	
LED16	Device: Process mode inactive		SPS	V	
	General: Functions in Test mode	91 329	SPS	V	

Literature

/1/ Distance Protection, Line Differential Protection, and Overcurrent Protection for 3-Pole Tripping – 7SA82, 7SD82, 7SL82, 7SA84, 7SD84, 7SA86, 7SD86, 7SL86, 7SJ86
C53000-G5040-C010

/2/ Distance and Line Differential Protection, Breaker Management for 1-Pole and 3-Pole Tripping – 7SA87, 7SD87, 7SL87, 7VK87
C53000-G5040-C011

/3/ Overcurrent Protection – 7SJ82/7SJ85
C53000-G5040-C017

/4/ Overcurrent Protection – 7SJ81
C53000-G5040-C079

/5/ Motor Protection – 7SK82/85
C53000-G5040-C024

/6/ Transformer Differential Protection – 7UT82, 7UT85, 7UT86, 7UT87
C53000-G5040-C016

/7/ Generator Protection – 7UM85
C53000-G5040-C027

/8/ Busbar Protection – 7SS85
C53000-G5040-C019

/9/ High-Voltage Bay Controller – 6MD85/86
C53000-G5040-C015

/10/ Paralleling Device – 7VE85
C53000-G5040-C071

/11/ Universal Protection – 7SX82/7SX85
C53000-G5040-C607

/12/ Merging Unit 6MU85
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/13/ Fault Recorder – 7KE85
C53000-G5040-C018

/14/ Compact Class – 7SX800
C53000-G5040-C003

/15/ Hardware Description
C53000-G5040-C002

/16/ Communication Protocols
C53000-L1840-C055

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/18/ DIGSI 5 – Software Description
C53000-D5040-C001

/19/ SIPROTEC 5 – Security
C53000-H5040-C081

/20/ PIXIT, PICS, TICS, IEC 61850
C53000-G5040-C013

/21/ Operation
C53000-G5040-C003

/22/ Engineering Guide
C53000-G5040-C004

/23/ High-Speed Busbar Transfer– 7VU85
C53000-G5040-C090

Glossary

ACD

IEC 61850 data type: Directional protection activation information

ACK

Data transfer acknowledgment

ACT

IEC 61850 data type: Protection-activation information

APC

Controllable analog set point information – information regarding a controllable analog value

ASDU

ASDU stands for **A**pplication **S**ervice **D**ata **U**nit. An ASDU can consist of one or more identical information objects. A sequence of the same information elements, for example measured values, is identified by the address of the information object. The address of the information object defines the associated address of the 1st information element of the sequence. A consecutive number identifies the subsequent information elements. The number builds on this address in integral increments (+1).

BAC

Binary controlled analog process value

Back-up battery

The back-up battery ensures that specified data areas, flags, timers, and counters are held as retentive.

Bay controller

Bay controllers are devices with control and supervision functions without protection functions.

BCR

IEC 61850 data type: **B**inary **C**ounter **R**eading

Best Master Clock Algorithm

A PTP network consists of communicating clocks. The best master clock algorithm (BMCA) is used to determine the device that indicates the most precise time. This device serves as a reference clock and is called the grandmaster. In case of changes to the network topology, the BMC algorithm is performed again for network segments which might be cut off from the grandmaster. If a participating device assumes the role of master and slave at the same time, it is also referred to as a boundary clock.

Big-endian

The terms big-endian and little-endian are used to describe the arrangement of the bytes when saving. In case of big-endian, the upper limiting value byte is saved at the lowest address. Little-endian saves the upper limiting value byte at the highest address.

Binary Controlled Analog Process Value

The data type BAC models a command with or without feedback. The BAC is used to control an arc-suppression coil, for example. The commands **Higher**, **Lower**, and **Stop** can be issued. The process delivers an analog value as feedback.

Binary Controlled Step Position

The data type BSC can, for example, be used to control a transformer tap changer. The commands **up**, **down** can be given.

Bit pattern indication

Bit pattern indication is a processing function with which items of digital process information applicable across several inputs can be detected together in parallel and further processed. The bit pattern length can be selected as 1, 2, 3, or 4 bytes.

BMCA

Best **M**aster **C**lock **A**lgorithm

Boundary clock

The PTP protocol recognizes different types of clock: An Ordinary Clock (OC), Boundary Clock (BC), and Transparent Clock (TC). The boundary clock transmits time information beyond a network limit. For example in a router which connects different switched networks. As a slave, the clock of the router receives time information and passes it on as a master.

BRCB

Buffered **R**eport **C**ontrol **B**lock

BSC

Binary Controlled Step Position

Buffered Report Control Block

Buffered Report Control Block (BRCB) is a form of report controlling. Internal events trigger the immediate sending of reports or saving of events for the transfer. Data values cannot therefore be lost on account of transport flow control conditions or connection interruptions. BRCB provides the functionality **SOE** (see sequence of events).

CB

Circuit breaker

CDC

Common **D**ata **C**lass

CFC

Continuous **F**unction **C**hart

Chatter blocking

A rapidly intermittent input (for example, due to a relay contact fault) is disconnected after a configurable supervision time and can thus not generate any further signal changes. The function prevents overloading of the system when a fault occurs.

CID

Configured **I**ED **D**escription

CIT

Conventional **I**nstrument **T**ransformer

CMV

Complex **m**easured **v**alue

Combination Device

Combination devices are bay units with protection functions and with feeder mimic diagram.

Common Data Class

Generic term for a data class according the IEC 61850 model.

Communication branch

A communication branch corresponds to the configuration of 1 to n participants that communicate via a common bus.

Configured IED Description

A Configured IED Description (CID) is a file for data exchange between the IED Configuration Tool and the IED itself.

Continuous Function Chart

The Continuous Function Chart (CFC) is a programming language. It is used for programmable logic controllers. The programming language Continuous Function Chart is not defined in the standard IEC 61131-3, but represents a common extension of IEC programming environments. CFC is a graphic programming language. Function blocks are linked to one another. This represents an essential difference from conventional programming languages, where sequences of commands are entered.

Control display

The control display becomes visible for devices with a large display after pressing the CTRL key. The diagram contains the switching devices to be controlled in the feeder, with status representation. The control display serves for the bushing of the switching operations. Defining this display is part of the project engineering.

Controllable Integer Status

The data type INC can be used to issue a command (to one or more relays, selectable in information routing) which is then monitored via a whole number as feedback.

Controller

The controller initiates the IO data communication.

COT

Cause **o**f **T**ransmission

CRC

Cyclic **r**edundancy **c**heck

DAN

Double **A**ttached **N**ode

DANP

Double **A**ttached **N**ode **P**RP

DataSet

Defines the current-transformer and/or voltage-transformer signals contained in a sampled value data stream

Data Type

The data type is a value set of a data object, together with the operations allowed on this value set. A data type contains a classification of a data element, such as the determination whether it consists of integers, letters, or suchlike.

Data unit

Information item with a joint transmission source. Abbreviation: DU – **D**ata **U**nit

Data window

The right section of the project window visualizes the content of the section selected in the navigation window. The data window contains for example, indications or measured values of the information lists or the function selection for parameterization of the device.

DCF

Device **C**onfiguration **F**ile

DCF77

The high-precision official time is determined in Germany by the Physikalisch-Technische Bundesanstalt PTB in Brunswick. The atomic clock unit of the PTB transmits this time via the long-wave time signal transmitter in Mainflingen near Frankfurt/Main. The emitted time signal can be received within a radius of approx. 1500 km from Frankfurt/Main.

DCP

Discovery and Basic **C**onfiguration **P**rotocol

DDD

DIGSI 5 **D**evice **D**river – SIPROTEC 5 device driver which must be loaded in DIGSI.

DEL

Phase-to-phase related measurements of a 3-phase system

Device 5 Export Format

DEX5

DEX5

Device 5 **Ex**port Format

You can archive the data from an individual SIPROTEC 5 device in DEX5 format.

DHCP

Dynamic **H**ost **C**onfiguration **P**rotocol

DIGDNP

DIGSI 5 protocol settings for DNP3

File extension for a file which is generated from DIGSI when the protocol configuration is exported from DIGSI 5.

DIGMOD

DIGSI 5 protocol settings for Modbus TCP

File extension for a file which is generated from DIGSI when the protocol configuration is exported from DIGSI 5.

DIGSI

Configuration software for SIPROTEC

DIGSI 5 Display Pages

You can archive individual or all display pages from a SIPROTEC 5 device in DSP5 format. You can also use this format to exchange display pages between SIPROTEC 5 devices. The DSP5 format is based on XML.

DIGSI 5 protocol settings for DNP3

If the protocol DNP3 is configured for a system interface, you can export the protocol settings in DIGDNP format. The DIGDNP format is specially designed to transfer interface data from DIGSI 5 into the substation automation system SICAM PAS.

DIGSI 5 protocol settings for IEC 60870-5-103

If the protocol IEC 60870-5-103 is configured for a system interface, you can export the protocol settings in DIGT103 format. The DIGT103 format is specially designed to transfer interface data from DIGSI 5 into the substation automation system SICAM PAS.

DIGSI 5 protocol settings for IEC 60870-5-104

If the protocol IEC 60870-5-104 is configured for a system interface, you can export the protocol settings in DIGT104 format. The DIGT104 format is specially designed to transfer interface data from DIGSI 5 into the substation automation system SICAM PAS.

DIGSI 5 protocol settings for Modbus TCP

If the protocol Modbus TCP is configured for a system interface, you can export the protocol settings in DIGMOD format. The DIGMOD format is specially designed to transfer interface data from DIGSI 5 into the substation automation system SICAM PAS.

DIGSI 5 Test Sequences

You can archive individual or all test sequences from a SIPROTEC 5 device in SEQ5 format. You can also use this format to exchange test sequences between SIPROTEC 5 devices. The SEQ5 format is based on XML.

DIGT103

DIGSI 5 protocol settings for IEC 60870-5-103

File extension for a file which is generated from DIGSI when the protocol configuration is exported from DIGSI 5.

DIGT104

DIGSI 5 protocol settings for IEC 60870-5-104

File extension for a file which is generated from DIGSI when the protocol configuration is exported from DIGSI 5.

Discovery and Basic Configuration Protocol

The DCP protocol is used to detect devices without an IP address and to assign addresses to these devices.

DNP3

DNP3 is a communication standard for telecontrol engineering. DNP3 is used as a general transmission protocol between control systems and substations, as well as between bay devices and the systems controls.

Double command

Double commands (DPC – **D**ouble **P**oint **C**ontrol) are process outputs which represent 4 process states at 2 outputs: 2 defined states (for example ON/OFF) and 2 undefined states (for example disturbed positions).

Double-point indication

A double-point indication (DPS – **D**ouble **P**oint **S**tatus) ia a process information that represents 4 process states at 2 inputs: 3 defined states (for example, On/Off and disturbed position) and 1 undefined state (00).

DPC

IEC 61850 data type: **D**ouble **P**oint **C**ontrol - double command

DPS

IEC 61850 data type: **D**ouble **P**oint **S**tatus - double-point indication

Drag and drop

Copying, moving, and linkin function, used in graphic user interfaces. Objects are selected with the mouse, held and moved from one data area to another.

DSP5

DIGSI 5 Display Pages

DU

Data **U**nit

Dynamic Host Configuration Protocol

In order to configure PCs automatically, centralized and uniformly in a TCP/IP network, a dynamic assignment of IP addresses is used. DHCP is utilized. The system administrator determines how the IP addresses are to be assigned and specifies the time lapse over which they are assigned. DHCP is defined in the Internet standards RFC 2131 (03/97) and RFC 2241 (11/97).

In the case of SIPROTEC 5, the device can also be assigned an IP address via DIGSI and DHCP.

ELCAD

Electrical CAD

Electrical CAD

You can import the topology information contained in an ELCAD file into a project and use it as the basis for a single-line configuration. The other information contained in the ELCAD file is not included in this process.

Electromagnetic compatibility

Electromagnetic compatibility (EMC) means that an item of electric equipment functions without error in a specified environment. The environment is not influenced in any impermissible way here.

ENC

Enumerated Status **C**ontrollable

ENS

Enumerated **S**tatus

ESD protection

The ESD protection is the entirety of all means and measures for the protection of electrostatic-sensitive devices.

Far End Fault Indication

Far End Fault Indication (FEFI) is a special setting of switches. It is always only possible to log a line interruption on the receive line. If a line interruption is detected, the link status of the line is changed. The status change leads to deletion of the MAC address assigned to the port in the switch. However, outage of the receive line from the aspect of the switch can only be detected in the receiver, that is, by the switch. The receiver then immediately blocks the transmit line and signals the connection failure to the other device. The FEFI setting in the switch triggers detection of the error on the receive line of the switch.

FC

Ferrule **C**onnector

FEFI

Far **E**nd **F**ault **I**ndication

FG

Function group

Fleeting indication

Fleeting indications are single-point indications present for a very short time, in which only the coming of the process signal is logged and further processed time-correctly.

Floating

Floating means that a free potential of the output voltage that is not connected to ground is generated. Therefore, no current flows through the body to ground in the event of touching.

Function group

Functions are brought together into function groups (FG). The assignment of functions to current and/or voltage transformers (assignment of functions to measuring points), the information exchange between the function groups via interfaces as well as the generation of group indications are important for this bringing together.

GaAs

Gallium arsenide

General Interrogation

The state of all process inputs, of the status, and of the fault image are scanned on system startup. This information is used to update the system-side process image. Likewise, the current process state can be interrogated after data loss with a general interrogation (GI).

General Station Description Mark-up Language

GSDML is an XML-based data description language for the creation of a GSD file.

Generic Object-Oriented Substation Event

GOOSE. Protocol of IEC 61850 for communication between bay units.

GI

General Interrogation

GIN

Generic Identification Number

Global Navigation Satellite System

A global navigation satellite system or GNSS is a system for determining position and for navigation on the ground and in the air. Position is determined by the receipt of signals from navigation satellites and pseudolites.

GNSS

Global **N**avigation **S**atellite **S**ystem

GOOSE

Generic **O**bject-**O**riented **S**ubstation **E**vent

Ground

The conductive ground whose electric potential can be set equal to 0 at every point. In the area of grounding conductors, the ground can have a potential diverging from 0. The term **reference ground** is also used for this situation.

Grounding

The grounding is the entirety of all means and measures for grounding.

GSDML

General **S**tation **D**escription **M**ark-up **L**anguage

Hierarchy level

Within a structure with higher-level and lower-level objects a hierarchy level is a level of equivalent objects.

High-Availability Seamless Redundancy Protocol

Like PRP (Parallel Redundancy Protocol), HSR (High-Availability Seamless Redundancy Protocol) is specified in IEC 62439-3. Both protocols offer redundancy without switching time.

The principal function can be found in the definition of PRP. With PRP, the same indication is sent via 2 separated networks. In contrast to this, in the case of HSR the indication is sent twice in the 2 directions of the ring. The recipient receives it correspondingly via 2 paths in the ring, takes the 1st indication and discards the 2nd indication (see PRP protocol).

Whereas NO indications are forwarded in the end device in the case of PRP, a switch function is installed in the HSR node. Thus, the HSR node forwards indications in the ring that are not directed at it.

In order to avoid circular indications in the ring, corresponding mechanisms are defined in the case of HSR.

SAN (Single Attached Node) end devices can only be connected with the aid of a RedBox in the case of HSR. PRP systems and HSR systems can be coupled redundantly with 2 RedBoxes.

HMI

Human-**M**achine **I**nterface (HMI)

HSR

High Availability **S**eamless **R**edundancy Protocol

HV bay description

The HV project description file contains details of bays which exist in a ModPara project. The actual bay information of each bay is stored in a HV field description file. Within the HV project description file, each bay receives an HV field description file through a reference to the file name.

HV project description

If the configuring and parameterization of PCUs and submodules is completed with ModPara, all the data will be exported. This data is distributed to several files. One file contains details about the fundamental project structure. This also includes, for example, information detailing which bays exist in this project. This file is called a HV project description file.

ICD

IED **C**apability **D**escription

IEC

International **E**lectrotechnical **C**ommission - International Electrotechnical Standardization Body

IEC 60870-5-103

International standard protocol for communication with IEDs (especially protection devices) Many protection devices, bay units, bay controllers, and measured-value acquisition devices use the IEC 60870-5-103 protocol to communicate with SICAM PAS.

IEC 60870-5-104

Standard international telecontrol protocol. Transmission protocol based on IEC 60870-5-101 for connecting the substation control level to the telecontrol center via TCP/IP protocols using a wide area network connection (WAN).

IEC 60870-5-104 is also used for communicating with IEDs.

IEC 61850

IEC 61850 is an international standard for continuous communication in switchgear. It defines the communication between devices in a switchgear and the corresponding system requirements. All automation functions of a switchgear and their engineering are supported this way. IEC 61850 can also be transferred to automation systems in other applications, for example for controlling and monitoring decentralized power generation.

IEC address

A unique IEC address must be assigned to each SIPROTEC device within an IEC bus. A total of 254 IEC addresses per IEC bus are available.

IEC communication branch

Within an IEC communication branch, the participants communicate on the basis of the protocol IEC 60870-5-103 via an IEC bus.

IED

Intelligent **E**lectronic **D**evice

IED stands for a physical part of a device (hardware, etc.)

IED Capability Description

Data exchange from the IED configuration software (DIGSI) to the system configurator. This file describes the performance properties of an IED.

IEEE

Institute of **E**lectrical and **E**lectronic **E**ngineers

IEEE 1588

Time-synchronization protocol according to the standard IEEE 1588-2008. Precision Clock Synchronization Protocol for Networked Measurement and Control Systems (IEEE 1588 v2) and the standard IEEE C37.238-2011: IEEE Standard Profile for Use of IEEE 1588 PTP protocol in Power System Applications (Power Profile).

IEEE 1588v2/PTP

PTP has many optional features and often offers more than one way of doing things. Meaning that it is not mandatory for PTP devices to work together. Provided that they are configured with a compatible set of selection options for IEEE 1588 options and settings. The solution for this is profiles. Profiles are rule sets with restrictions for PTP that are designed to be used to meet the requirements for specific applications or a set of similar applications. The IEEE 1588 standard itself only defines 1 profile, which is designated as the **Default profile**. 2 profiles are used in the power industry: IEC 61850-9-3 (Power Utility Profile) and C37.238-2017 (Power Profile).

IID

Instantiated **I**ED **D**escription

INC

Controllable Integer Status

Input data/input direction

Data is sent from the protocol slave to the protocol master.

INS

Integer **S**tatus

Instantiated IED Description

Files in IID format are ICD files adapted for the specific use case in the project. This format is mainly suitable for exchanging data between DIGSI 5 and an external system configurator or a substation automation system such as SICAM PAS. The ICD format uses SCL as the description language for this.

International Electrotechnical Commission

IEC

Internet Protocol

An Internet protocol (IP) enables the connection of participants which are positioned in different networks.

IO

Input-**O**utput

IO Provider Status

The transmitter (provider) of an IO data element uses this to indicate the state (good/bad, including fault location).

IOPS

IO Provider **S**tatus

IP

Internet **P**rotocol

IPv4

Internet-**P**rotocol **V**ersion 4

ISC

Integer **S**tep **C**ontrolled Position Information

LAN

Local **A**rea **N**etwork

Link address

The link address indicates the address of a SIPROTEC device.

Link Layer Discovery Protocol

The Link Layer Discovery Protocol (LLDP) serves as the basis for topology detection and configuration determination.

List view

The right area of the project window displays the names and icons of the objects which are within a container selected in the tree view. As the visualization is in the form of a list, this area is also referred to as list view.

LLDP

Link **L**ayer **D**iscovery **P**rotocol

Local Area Network

A Local Area Network (LAN) is a regional, local PC network. The PCs are all equipped with a network interface card and work with one another via data exchange. The LAN requires an operating system on each PC and standardized data transport software. The operating systems can be different, as can the data transport software, but both must support a common transmission protocol (= TCP/IP protocols), so that all PCs can exchange data with one another.

LPIT

Low-**P**ower **I**nstrument **T**ransformer –

AKA **NCIT** – **N**on **C**onventional **I**nstrument **T**ransformer. Examples: Low-power current transformer, C dividers, R dividers, RC dividers, optical sensors

LPVT

Low-**P**ower **V**oltage **T**ransformer–

LSB

Least **S**ignificant **B**it

LSVS

Logical node **S**ampled **V**alue **S**ubscription supervision

MAC address

The MAC address (Media Access Control) is the hardware address of each individual network adaptor. It serves to identify the devices in the network unambiguously.

Management Information Base

A Management Information Base (MIB) is a database which continuously saves information and statistics concerning each device in a network. The performance of each device can be monitored with this information and statistics. In this way, it can also be ensured that all devices in the network function properly. MIBs are used with SNMP.

Manufacturing Message Specification

The standard Manufacturing Message Specification (MMS) serves for data exchange. The standard is used for the transmission protocols IEC 61850 and IEC 60870-6 TASE.2.

Master Clock

The **M**aster **C**lock (MC) contains a mechanical or electric mechanism and a contact device, which periodically transmits drive pulses to the slave clocks.

MC

Master **C**lock

Measured Value

This data type provides a measured value that can be used as a CFC result, for instance.

Merging Unit

The **M**erging **U**nit (MU) is used (also for IEC 61850 plant) for the field-signal bus interface. The publisher/server of the sampled measured values is designated as the merging unit.

Metered value

Metered values are a processing function, used to determine the total number of discrete similar events (counter pulses), for example, as integral over a time span. In the power utility field, electrical energy is often recorded as a metered value (energy import/delivery, energy transport).

MIB

Management **I**nformation **B**ase

MICS

Model **I**mplementation **C**onformance **S**tatement

MMS

Manufacturing **M**essage **S**pecification

Modbus

The Modbus protocol is a communication protocol. It is based on a master/slave or client/server architecture.

Model Implementation Conformance Statement

MICS

The Model Implementation Conformance Statement describes in detail the standard data object models that are supported by the system or by the device.

Module

Unit of a device. This can either be a physical module or a functional unit of a device.

MSB

Most **S**ignificant **B**it

MU

Merging **U**nit

MV

Data type **M**easured **V**alue

NACK

Negative **ack**nowledgment

Navigation window

The left area of the project window displays the names and icons of all containers of a project in the form of a folder tree structure.

Network Time Protocol

The **N**etwork **T**ime **P**rotocol is an international standard for time synchronization.

NTP

Network **T**ime **P**rotocol

Object

Each element of a project structure is designated as an object in DIGSI 5.

Object property

Each object has properties. These might be general properties that are common to several objects. Otherwise, an object can also have object-specific properties.

Offline

If there is no communication connection between a PC program (for example, configuration program) and a runtime application (for example, a PC application), the PC program is **offline**. The PC program executes in Offline mode.

Online

If there is a communication connection between a PC program (for example configuration program) and a runtime application (for example a PC application), the PC program is **online**. The PC program executes in Online mode.

Optical Switch Module

An Optical Switch Module (OSM) is a process for switching over switches in Ethernet networks that are ring-shaped in structure. OSM is a proprietary process from Siemens, which later became standard under the term MRP. OSM is integrated in the optical Ethernet module EN100-O. OSM is hardly used in IEC 61850 networks. RSTP is used there, this having become established as an international standard.

OSM

Optical **S**witch **M**odule

Output data/output direction

Data is sent from the protocol master to the protocol slave.

Parallel Redundancy Protocol

Parallel Redundancy Protocol (PRP) is a redundancy protocol for Ethernet networks that is specified in IEC 62439-3. Unlike conventional redundancy procedures, such as RSTP (Rapid Spanning Tree Protocol, IEEE 802.1D-2004), PRP offers uninterruptible switchover, which avoids any downtime in the event of a fault, and thus the highest availability.

PRP is based on the following approach: The redundancy procedure is generated in the end device itself. The principle is simple: The redundant end device has 2 Ethernet interfaces with the same address (DAN, Double Attached Node). Now the same indication is sent twice, in the case of PRP (**parallel**) over 2 separate networks, and unambiguously marks both with a sequence number. The receiver takes the information that it receives first, stores its ID based on the source address and the sequence number in a duplicate filter and thus recognizes the 2nd, redundant information. This redundant information is then discarded. If the 1st indication is missing, the 2nd indication with the same content comes via the other network. This redundancy avoids a switching procedure in the network and is thus interruption-free. The end device relays no indications to the other network. Since the process is realized in the Ethernet layer (same MAC address), it is transparent and usable for all Ethernet user data protocols (IEC 61850, DNP, other TCP/IP based protocols). In addition, it is possible to use one of the 2 networks for the transmission of non-redundant indications.

There are 2 versions of PRP: PRP-0 and its successor PRP-1. Siemens implements PRP-1.

Parameterization

Comprehensive term for all setting work on the device. You can set parameters for the protection functions with DIGSI 5 or sometimes also directly on the device.

Parameter set

The parameter set is the entirety of all parameters that can be set for a SIPROTEC device.

Participant address

A participant address comprises the name of the participant, the national code, the area index and the participant-specific phone number.

PB Client

Process-**B**us client. The sampled measured values subscriber is designated as a process-bus client.

PICS

Protocol **I**mplementation **C**onformance **S**tatement

Precision Time Protocol

The PTP protocol causes the time settings of several devices in a network to synchronize. PTP is defined in IEEE 1588. The focus of PTP is on higher accuracy and networks that are locally restricted. PTP can achieve an accuracy in the range of nanoseconds in a hardware variant, and in the range of a few milliseconds in a software variant.

PROFIBUS

PROcess **FI**eld **BUS**, German process and fieldbus standard (EN 50170). The standard specifies the functional, electrical, and mechanical characteristics for a bit-serial fieldbus.

PROFIBUS address

An unambiguous PROFIBUS address must be assigned to each SIPROTEC device within a PROFIBUS network. A total of 254 PROFIBUS addresses per PROFIBUS network are available.

Profile_ID

Together with an API, the Profile_ID unambiguously defines the access and behavior of an application.

PROFINET IO

PROFINET is the open Industrial Ethernet Standard of PROFIBUS for automation.

Programmable Logic

The programmable logic is a function in Siemens devices or station controllers, enabling user-specific functionality in the form of a program. This logic component can be programmed by various methods: CFC (Continuous Function Chart) is one of these. SFC (Sequential Function Chart) and ST (Structured Text) are others.

Programmable Logic Block

Building blocks are parts of the user program delimited by their function, structure, and intended use.

Programmable Logic Controller

Programmable logic controllers (PLC) are electronic controllers whose function is saved as a program in the control unit. The construction and wiring of the device do not therefore depend on the function of the control. The programmable logic controller has the structure of a computer; it consists of CPU with memory, input/output modules (for example, DI, AI, CO, CR), power supply (PS) and rack (with bus system). The peripherals and programming language are oriented towards the circumstances of the control engineering.

Project

Content-wise, a project is the image of a real energy supply system. Graphically, a project is represented as a number of objects which are integrated in a hierarchical structure. Physically, a project consists of a number of directories and files containing project data.

Project tree

The project tree contains a representation of the data structure. This data structure represents the content of the project and is created with a generic browser.

Protection communication

Protection communication includes all functionalities necessary for data exchange via the protection interface. Protection communication is created automatically during configuration of communication channels.

Protection device

A protection device detects erroneous states in distribution networks, taking into consideration various criteria, such as fault distance, fault direction, or fault duration, triggering a disconnection of the defective network section.

Protocol Implementation Conformance Statement

The performance properties of the system to be tested are summarized in the report on the conformity of implementation of a protocol (PICS = protocol implementation conformance statement).

PRP

Parallel **R**edundancy **P**rotocol

PTP

Precision-**T**ime **P**rotocol

Rapid Spanning Tree Protocol

The Rapid Spanning Tree Protocol (RSTP) is a standardized redundancy process with a short response time. In the Spanning Tree Protocol (STP protocol), structuring times in the multidigit second range apply in the case of a reorganization of the network structure. These times are reduced to several 100 milliseconds for RSTP.

Real Time

Real time

RedBox

Redundancy box

The RedBox is used to connect a device with only one interface redundantly to both PRP networks LAN A and LAN B. The RedBox is a DAN (Double Attached Node) and functions as a proxy server for the devices (VDANs) connected to it. The RedBox has its own IP address for configuration, administration, and monitoring.

Relay Information by OMICRON

You can use files in RIO format to exchange data between test systems from the company OMICRON and any other desired project-protection planning system. With DIGSI 5, you can export different settings from protection functions in RIO format, which the OMICRON test equipment 7VP15 can then continue to process. The relevant settings are described in the test equipment manual.

RIO

Data format **R**elay **I**nformation by **O**MICRON

RSTP

Rapid-**S**panning **T**ree **P**rotocol

Sampled Measured Value

IEC 61850 is a communication protocol for electrical substation automation systems. The abstract data models defined in IEC 61850 can be mapped with various protocols. At present, there are mappings in the standard for the following protocols:

MMS (Manufacturing Message Specification)

GOOSE (Generic Object Oriented Substation Event)

SMV (Sampled Measured Value)

Web services (coming soon)

These protocols can run with fast-switching Ethernet via TCP/IP networks or substation LANs to achieve the required response times for protection functions of under 4 ms.

Sampled value

Sampling is the registration of measured values for discrete, mostly equidistant periods of time. This can be used to extract a discrete time signal from a continuous time signal.

Sampling rate

In signal processing, sampling is reducing a continuous time signal (for example current and voltages) to a discrete time signal. A common example is converting soundwave (a continuous signal) into a sampling sequence (a discrete time signal).

SAN

Single **A**ttached **N**ode

An SAN is a non-redundant node in a PRP network. It is connected with a single port to a single network (LAN A or LAN B). It can only communicate in the connected network via nodes. Devices with only one connection can be connected to both networks, LAN A and LAN B, redundantly via a RedBox. In order to keep LAN A and LAN B symmetrical, Siemens recommends avoiding SANs and to connect the devices either via a RedBox or in a separate network without PRP support.

SBO

Select **b**efore **o**perate

SC

Single **c**ommand

SCD

Substation **C**onfiguration **D**escription

SCL

Substation **C**onfiguration Description **L**anguage

SED

System **E**xchange **D**escription

SEQ

Data type sequence

SEQ5

DIGSI 5 Test Sequences

Sequence of Events

Acronym: SOE. An ordered, time-stamped log of status changes at binary inputs (also referred to as state inputs). SOE is used to restore or analyze the behavior, or an electrical power system itself, over a certain period of time.

Service interface

Device interface for interfacing DIGSI 5 (for example, through a modem)

SFP

Small **F**orm-Factor **P**luggable

SICAM SAS

Substation **A**utomation **S**ystem – Modular substation automation system based on the SICAM SC substation controller and the HMI system SICAM WinCC.

SICAM WinCC

The operator control and monitoring system SICAM WinCC graphically displays the state of your network. SICAM WinCC visualizes alarms and indications, archives the network data, provides the option of intervening manually in the process and manages the system rights of the individual employees.

SIM

Simulation data format for single/multiple devices

Simple Network Management Protocol

The Simple Network Management Protocol (SNMP) is an Internet standard protocol and serves for the administration of nodes in an IP network.

Simple Network Time Protocol

The Simple Network Time Protocol (SNTP) is a protocol for the synchronization of clocks via the Internet. With SNTP, client computers can synchronize their clocks via the Internet with a time server.

Simulation data format for single/multiple devices

You can export simulation-related files of a SIPROTEC 5 device in SIM format. This new functionality in DIGSI 5 makes it possible to export the simulation data and to create a simulation of all devices in the DIGSI 5 project for testing and commissioning purposes. The simulation is achieved by importing the simulation file into a signal processing and automation system, which then simulates the device/devices using the process data like in a real-time system. This feature allows a device to be tested for various real-time conditions.

Single command

Single commands (SPC – **S**ingle **P**oint **C**ontrol) are process outputs which represent 2 process states (for instance on/off) at one output.

Single-line diagram

A single-line diagram (SLD) is a simplified electrical overview diagram of the switchgear. Instead of all 3 phases, only a single line is shown, hence the name single-line.

Single-Line Editor

The Single-Line Editor (SLE) contains the catalog with the topological elements of a single-line diagram. Using the single-line components, the customer can configure the topological part of the plant.

Single-point indication

Single-point indications (**SPS**) are a type of process information which represents 2 process states (for instance on/off) at one output.

SIPROTEC

The registered trademark SIPROTEC designates the product family of Siemens protection devices and fault recorders.

SIPROTEC 5 device

This object type represents a real SIPROTEC device with all the contained setting values and process data.

Slave device

A slave may only exchange data with a master after being prompted to do so by the master. SIPROTEC devices work as slaves. A master computer controls a slave computer. A master computer can also control a peripheral device.

SLD

Single-**L**ine **D**iagram

SLE

Single-**L**ine **E**ditor

SMV

Sampled **M**easured **V**alue

SNMP

Single **N**etwork **M**anagement **P**rotocol

SNTP

Single **N**etwork**T**ime **P**rotocol

SOE

Sequence **o**f **E**vents

SP

Single-point status

SP

Single-**P**oint Indication

SPC

IEC 61850 data type: **S**ingle **P**oint **C**ontrol

SPS

IEC 61850 data type: **S**ingle **P**oint **S**tatus

SPS

Programmable **L**ogic **C**ontroller

SSD

System **S**pecification **D**escription

ST

Structured **T**ext file

Structured Text file

You can import function charts (CFC) from DIGSI 4 in ST format. Before doing so, export your function charts from DIGSI 4.83 or higher.

Substation Configuration Description

A substation configuration description is an IEC 61850-compliant file for data exchange between the system configurator and the IED configurator. The substation configuration description contains information on the network structure of a substation. The substation configuration description contains for example, information on the assignment of the devices to the primary equipment, as well as on the station-internal communication.

Substation Configuration Description Language

Substation Configuration Description Language (SCL) is a description language standardized in IEC 61850 and based on XML. This description language allows all information relevant to an IEC 61850 substation to be documented consistently. This format is therefore suitable for exchanging IEC 61850-specific data between different applications, even if these come from different manufacturers. The described import checks are generally carried out for all SCL formats, not only for SCD imports.

SV Stream

Sampled **V**alue Stream

The SV stream is a set of current and voltage values that are transmitted in a fast and cyclical fashion. Information exchange is based on a publisher/subscriber mechanism. SV transmission is a continuous stream of layer-2 Ethernet telegrams in one direction. The content of an SV stream can be configured in anyway you wish in accordance with IEC 61869-9. IEC 61850-9-2 LE defines a fixed set of 4 voltage and 4 current values for each SV stream.

System Exchange Description

With files in SED format, you can exchange interface information between DIGSI 5 projects and thus between substations. To do this, the project extracts the data for the other projects from the file during import and writes its own data in the same file during export. The contents of an SED file are formulated in SCL.

System Specification Description

Files in SSD format contain the complete specification of a substation automation system including a single-line configuration of the substation. The assignment of logical nodes from IEC 61850 to primary equipment can also be described in SSD files. This allows device requirements to be defined in the SSD file so that the devices can be used in the substation. The contents of an SED file are formulated in SCL.

TAI

Temps **A**tomique **I**nternational - International atomic time

TC

Tap-position **c**ommand

TCP

Transmission **C**ontrol **P**rotocol

TEA-X

You can archive the data from individual SIPROTEC 5 devices or whole projects in TEA-X format. This format is also suitable for data exchange between different applications, such as DIGSI 5 and Engineering Base (EB). The TEA-X format is based on XML.

Time stamp

A time stamp is a value in a defined format. The time stamp assigns a point in time to an event, for example, in a log file. Time stamps ensure that events can be found again.

TOCT

Trench **O**ptical **C**urrent **T**ransformer – Optical current transformer manufactures by Trench

Topological view

The Topological View is oriented to the objects of a system (for example, switchgear) and their relationship to one another. The topological view describes the structured layout of the system in hierarchical form. The Topological View does not assign the objects to the devices.

Transmission Control Protocol

The Transmission Control Protocol (TCP) is a transmission protocol for transport services in the Internet. TCP is based on IP and ensures connection of the participants during the data transmission. TCP ensures the correctness of the data and the correct sequence of the data packets.

Transparent clock

The Precision Time Protocol (PTP) recognizes different types of clocks: a standard clock (referred to as Ordinary Clock, OC for short), a Boundary Clock (BC) and a Transparent Clock (TC). The transparent clock was integrated in the specification retrospectively in 2008 and serves to improve the transmission of time information within a network by receiving PTP messages and modifying (correcting) them before passing them on.

Tree view

The left area of the project window displays the names and icons of all containers of a project in the form of a folder tree structure. This area is called the tree view.

Tunneling

Technology for connecting two networks via a third network, whereby the through traffic is completely isolated from the traffic of the third network.

UDP

User **D**atagram **P**rotocol

Unbuffered Report Control Block

Unbuffered Report Control Block (URCB) is a form of report controlling. Internal events trigger the immediate sending of reports based on **best effort**. If no association exists or if the transport data flow is not fast enough, events can be lost.

URCB

Unbuffered **R**eport **C**ontrol **B**lock

USART

Universal **S**ynchronous/**A**synchronous **R**eceiver/**T**ransmitter

User Datagram Protocol

UDP is a protocol. The protocol is based on IP as TCP. In contrast to this, however, UDP works without a connection and does not have any safety mechanisms. The advantage of UDP in comparison to IP is the higher transmission rate.

UTC

Universal **T**ime **C**oordinated

Vendor ID

Manufacturer-specific part of the device labeling for PROFINET.

Virtual device

A virtual device (VD) comprises all communication objects, as well as their properties and states, which a communication user can utilize in the form of services. A VD can be a physical device, a module of a device or a software module.

VLAN

Virtual **L**ocal **A**rea **N**etwork

WYE

Phase-to-ground related measurements of a 3-phase system

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SIEMENS

SIPROTEC 5
Overcurrent Protection
7SJ82/7SJ85

V7.30 and higher

Manual

Preface

Open Source Software

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Appendix A

Glossary

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C53000-G5040-C017-7

NOTE

For your own safety, observe the warnings and safety instructions contained in this document, if available.

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Preface

Purpose of the Manual

This manual describes the protection, automation, control, and supervision functions of the SIPROTEC 5 device functions for distance protection and line differential protection.

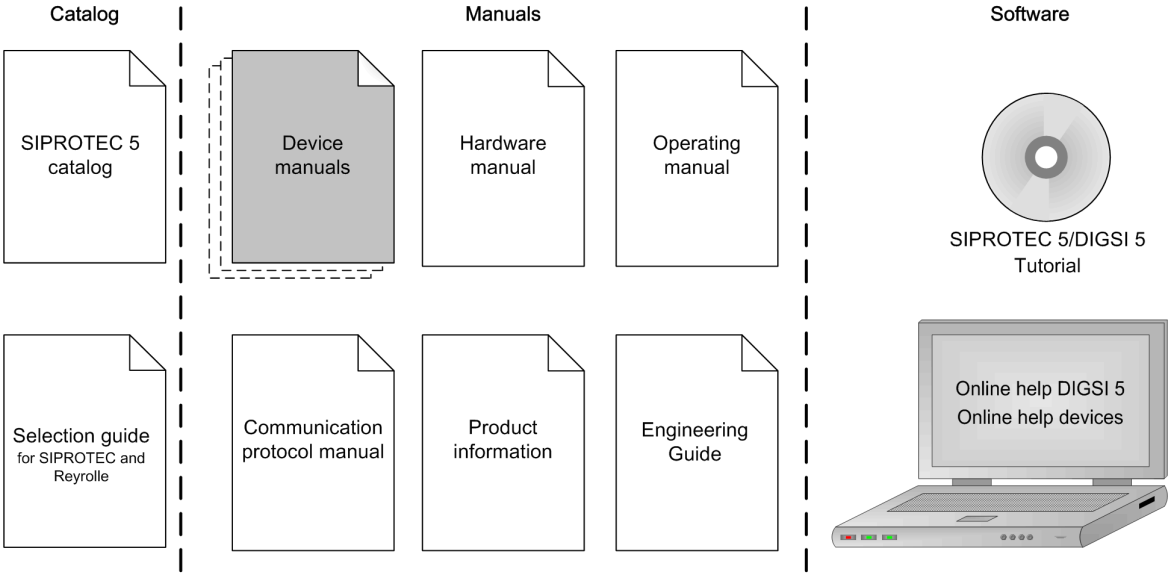
Target Audience

Protection system engineers, commissioning engineers, persons entrusted with the setting, testing and maintenance of automation, selective protection and control equipment, and operational crew in electrical installations and power plants.

Scope

This manual applies to the SIPROTEC 5 device family.

Further Documentation



[dwprefdm-221012-01.tif, 3, en_US]

- Device manuals

  Each Device manual describes the functions and applications of a specific SIPROTEC 5 device. The printed manual and the online help for the device have the same informational structure.

- Hardware manual

  The Hardware manual describes the hardware building blocks and device combinations of the SIPROTEC 5 device family.

- Operating manual

  The Operating manual describes the basic principles and procedures for operating and assembling the devices of the SIPROTEC 5 range.

- Communication protocol manual

  The Communication protocol manual contains a description of the protocols for communication within the SIPROTEC 5 device family and to higher-level network control centers.

- Product information

  The Product information includes general information about device installation, technical data, limiting values for input and output modules, and conditions when preparing for operation. This document is provided with each SIPROTEC 5 device.

- Engineering Guide

  The Engineering Guide describes the essential steps when engineering with DIGSI 5. In addition, the Engineering Guide shows you how to load a planned configuration to a SIPROTEC 5 device and update the functionality of the SIPROTEC 5 device.

- DIGSI 5 online help

  The DIGSI 5 online help contains a help package for DIGSI 5 and CFC.

  The help package for DIGSI 5 includes a description of the basic operation of software, the DIGSI principles and editors. The help package for CFC includes an introduction to CFC programming, basic examples of working with CFC, and a reference chapter with all the CFC blocks available for the SIPROTEC 5 range.

- SIPROTEC 5/DIGSI 5 Tutorial

  The tutorial on the DVD contains brief information about important product features, more detailed information about the individual technical areas, as well as operating sequences with tasks based on practical operation and a brief explanation.

- SIPROTEC 5 catalog

  The SIPROTEC 5 catalog describes the system features and the devices of SIPROTEC 5.

- Selection guide for SIPROTEC and Reyrolle

  The selection guide offers an overview of the device series of the Siemens protection devices, and a device selection table.

Indication of Conformity

CE

This product complies with the directive of the Council of the European Communities on harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2014/30/EU) and concerning electrical equipment for use within specified voltage limits (Low Voltage Directive 2014/35/EU).

This conformity has been proved by tests performed according to the Council Directive in accordance with the product standard EN 60255-26 (for EMC directive) and with the product standard EN 60255-27 (for Low Voltage Directive) by Siemens AG.

The device is designed and manufactured for application in an industrial environment.

The product conforms with the international standards of IEC 60255 and the German standard VDE 0435.

Other Standards

IEEE Std C 37.90

The technical data of the product is approved in accordance with UL.

For more information about the UL database, see *www.ul.com*

Select **Online Certifications Directory** and enter **E194016** as **UL File Number**.

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Additional Support

For questions about the system, please contact your Siemens sales partner.

Support

Our Customer Support Center provides a 24-hour service.

Phone:	+49 (180) 524-7000
Fax:	+49 (180) 524-2471
E-Mail:	*support.energy@siemens.com*

Training Courses

Inquiries regarding individual training courses should be addressed to our Training Center:

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90459 Nürnberg
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Phone:	+49 (911) 433-7415
Fax:	+49 (911) 433-7929
E-Mail:	*poweracademy@siemens.com*
Internet:	*www.siemens.com/poweracademy*

Notes on Safety

This document is not a complete index of all safety measures required for operation of the equipment (module or device). However, it comprises important information that must be followed for personal safety, as well as to avoid material damage. Information is highlighted and illustrated as follows according to the degree of danger:



DANGER

DANGER means that death or severe injury **will** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid death or severe injuries.



WARNING

WARNING means that death or severe injury **may** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid death or severe injuries.



CAUTION

CAUTION means that medium-severe or slight injuries **can** occur if the specified measures are not taken.

✧ Comply with all instructions, in order to avoid moderate or minor injuries.

NOTICE

NOTICE means that property damage **can** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid property damage.



NOTE

Important information about the product, product handling or a certain section of the documentation which must be given particular attention.

Qualified Electrical Engineering Personnel

Only qualified electrical engineering personnel may commission and operate the equipment (module, device) described in this document. Qualified electrical engineering personnel in the sense of this manual are people who can demonstrate technical qualifications as electrical technicians. These persons may commission, isolate, ground and label devices, systems and circuits according to the standards of safety engineering.

Proper Use

The equipment (device, module) may be used only for such applications as set out in the catalogs and the technical description, and only in combination with third-party equipment recommended and approved by Siemens.

Problem-free and safe operation of the product depends on the following:

- Proper transport
- Proper storage, setup and installation
- Proper operation and maintenance

When electrical equipment is operated, hazardous voltages are inevitably present in certain parts. If proper action is not taken, death, severe injury or property damage can result:

- The equipment must be grounded at the grounding terminal before any connections are made.
- All circuit components connected to the power supply may be subject to dangerous voltage.
- Hazardous voltages may be present in equipment even after the supply voltage has been disconnected (capacitors can still be charged).
- Operation of equipment with exposed current-transformer circuits is prohibited. Before disconnecting the equipment, ensure that the current-transformer circuits are short-circuited.
- The limiting values stated in the document must not be exceeded. This must also be considered during testing and commissioning.

Open Source Software

The product contains, among other things, Open Source Software developed by third parties. The Open Source Software used in the product and the license agreements concerning this software can be found in the Readme_OSS. These Open Source Software files are protected by copyright. Your compliance with those license conditions will entitle you to use the Open Source Software as foreseen in the relevant license. In the event of conflicts between Siemens license conditions and the Open Source Software license conditions, the Open Source Software conditions shall prevail with respect to the Open Source Software portions of the software. The Open Source Software is licensed royalty-free. Insofar as the applicable Open Source Software License Conditions provide for it you can order the source code of the Open Source Software from your Siemens sales contact - against payment of the shipping and handling charges - for a period of at least 3 years since purchase of the Product. We are liable for the Product including the Open Source Software contained in it pursuant to the license conditions applicable to the Product. Any liability for the Open Source Software beyond the program flow intended for the Product is explicitly excluded. Furthermore any liability for defects resulting from modifications to the Open Source Software by you or third parties is excluded. We do not provide any technical support for the Product if it has been modified.

When using DIGSI 5 in online mode, you are provided with the option to go to the main menu **Show Open source information** and read and display the Readme_OSS file containing the original license text and copyright information.

To do this, the following steps are necessary:

- Switch to online mode.
- Select the device.
- Select **online** in the menu bar.
- Click **Show Open source information**.



NOTE

To read the Readme_OSS file, a PDF viewer must be installed on the computer.

In order to operate SIPROTEC 5 devices, a valid DIGSI 5 license is required.

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1 Introduction

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1.1 General

The digital multifunctional protection and bay controllers of the SIPROTEC 5 device series are equipped with a powerful microprocessor. As a result, all tasks, from acquiring measurands to entering commands in the circuit breaker, are processed digitally.

Analog Inputs

The measuring inputs transform the currents and voltages sent by the instrument transformers and adapt them to the internal processing level of the device. A SIPROTEC 5 device has a current transformer and, depending on the device type, a voltage transformer. The current inputs are therefore intended for the detection of phase currents and ground current. The ground current can be detected sensitively using a core balance current transformer. In addition, phase currents can be detected very sensitively for a particularly precise measurement. The voltage inputs detect the measuring voltage of device functions requiring current and voltage measured values.

The analog values are digitized in the internal microcomputer for data processing.

Microcomputer System

All device functions are processed in the microcomputer system.

This includes, for example:

- Filtering and preparation of the measurands
- Constant monitoring of the measurands
- Monitoring of the pickup conditions for the individual protection functions
- Querying of limiting values and time-outs
- Controlling of signals for the logic functions
- Decision about the trip and close commands
- Storage of indications, fault data, and fault values for fault analysis
- Administration of the operating system and its functions, such as data storage, real-time clock, communication, interfaces, etc.
- External distribution of information

Binary Inputs and Outputs

Using the binary inputs and outputs, the device receives information from the system or from other devices (such as locking commands). The most important outputs include the commands to the switching devices and the indications for remote signaling of important events and states.

Front Elements

For devices with an integrated or offset operation panel, LEDs and an LC display on the front provide information on the device function and report events, states, and measured values. In conjunction with the LC display, the integrated keypad enables on-site operation of the device. All device information such as setting parameters, operating and fault indications or measured values can be displayed, and setting parameters changed. In addition, system equipment can be controlled via the user interface of the device.

Serial Interfaces

The serial interface in the front cover enables communication with a personal computer when using the DIGSI operating program. As a result, the operation of all device functions is possible. Additional interfaces on the back are used to realize various communication protocols.

Power Supply

The individual functional units of the device are powered by an internal power supply. Brief interruptions in the supply voltage, which can occur during short circuits in the system auxiliary voltage supply are generally bridged by capacitor storage (see also the Technical Data).

1.2 Properties of SIPROTEC 5

The SIPROTEC 5 devices at the bay level are compact and can be installed directly in medium and high-voltage switchgear. They are characterized by comprehensive integration of protection and control functions.

General Properties

- Powerful multiprocessor
- Fully digital measured-value processing and control, from sampling and digitizing of measurands to closing and tripping decisions for the circuit breaker
- Complete galvanic and interference-free isolation of the internal processing switches from the system measuring, control, and supply circuits through instrument transformers, binary input and output modules, and DC and AC voltage converters
- Easy operation using an integrated operator and display panel, or using a connected personal computer with user interface
- Continuous display of measured and metered values at the front
- Storage of min/max measured values (slave pointer function) and storage of long-term average values
- Storage of fault indications for system incidents (faults in system) with real-time assignment and instantaneous values for fault recording
- Continuous monitoring of the measurands as well as the device hardware and software
- Communication with central control and storage devices possible via the device interface
- Battery-buffered, synchronizable clock

Modular Concept

The SIPROTEC 5 modular concept ensures the consistency and integrity of all functionalities across the entire device series. Significant features here include:

- Modular system design in hardware, software, and communication
- Functional integration of various applications, such as protection, control, and fault recorder
- The same expansion and communication modules for all devices in the family
- Innovative terminal technology with easy assembly and interchangeability and the highest possible degree of safety
- The same functions can be configured individually across the entire family of devices
- Ability to upgrade with innovations possible at all times through libraries
- Open, scalable architecture for IT integration and new functions
- Multi-layered security mechanisms in all links of the security chain
- Self-monitoring routines for reliable localization and indication of device faults
- Automatic logging of access attempts and safety-critical operations on the devices and systems

Redundant Communication

SIPROTEC 5 devices maintain complete communication redundancy:

- Multiple redundant communication interfaces
- Redundant and independent protocols to control centers possible (such as IEC 60870-5-103 and IEC 61850, either single or redundant)
- Redundant time synchronization (such as IRIG-B, SNTP, or IEEE 1588)

2 Basic Structure of the Function

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2.1 Function Embedding in the Device

General

SIPROTEC 5 devices offer great flexibility in the handling of functions. Functions can be individually loaded into the device. Additionally, it is possible to copy functions within a device or between devices. The necessary integration of functions in the device is illustrated by the following example.



NOTE

The availability of certain settings and setting options depends on the device type and the functions available on the device!

EXAMPLE

A 1 1/2 circuit-breaker layout of the 7SA86 distance protection device serves as an example. The following protection functions are required for implementation (simplified and reduced):

- Distance protection (21)
- Overcurrent protection, phases (51)
- Circuit-breaker failure protection (50BF), for circuit breakers 1 and 2
- Basic functionality (handling of tripping, etc.)

Several predefined function packages that are tailored to specific applications exist for each device family. A predefined functional scope is called an **application template**. The existing application templates are offered for selection automatically when you create a new device in DIGSI 5.

EXAMPLE

When creating the device in DIGSI 5, you must select the appropriate application template. In the example, select the application template **DIS overhead line, grounded systems, 1 1/2 circuit-breaker layout**. This application template covers the required functional scope. Selecting this application template determines the preconfigured functional scope. This can be changed as necessary (see chapter *2.2 Adjustment of Application Templates/Functional Scope*).

Function Groups (FG)

Functions are arranged in function groups. This simplifies handling of functions (adding and copying). The function groups are assigned to primary objects, such as a line, transformer, or circuit breaker.

The function groups bundle functions with regard to the following basic tasks:

- Assignment of functions to current and/or voltage transformers (assignment of functions to the measuring points and thus to the protected object)
- Exchange of information between function groups

When a function is copied into a function group, it automatically works with the measuring points assigned to the function group. Their output signals are also automatically included in the configured interfaces of the function group.

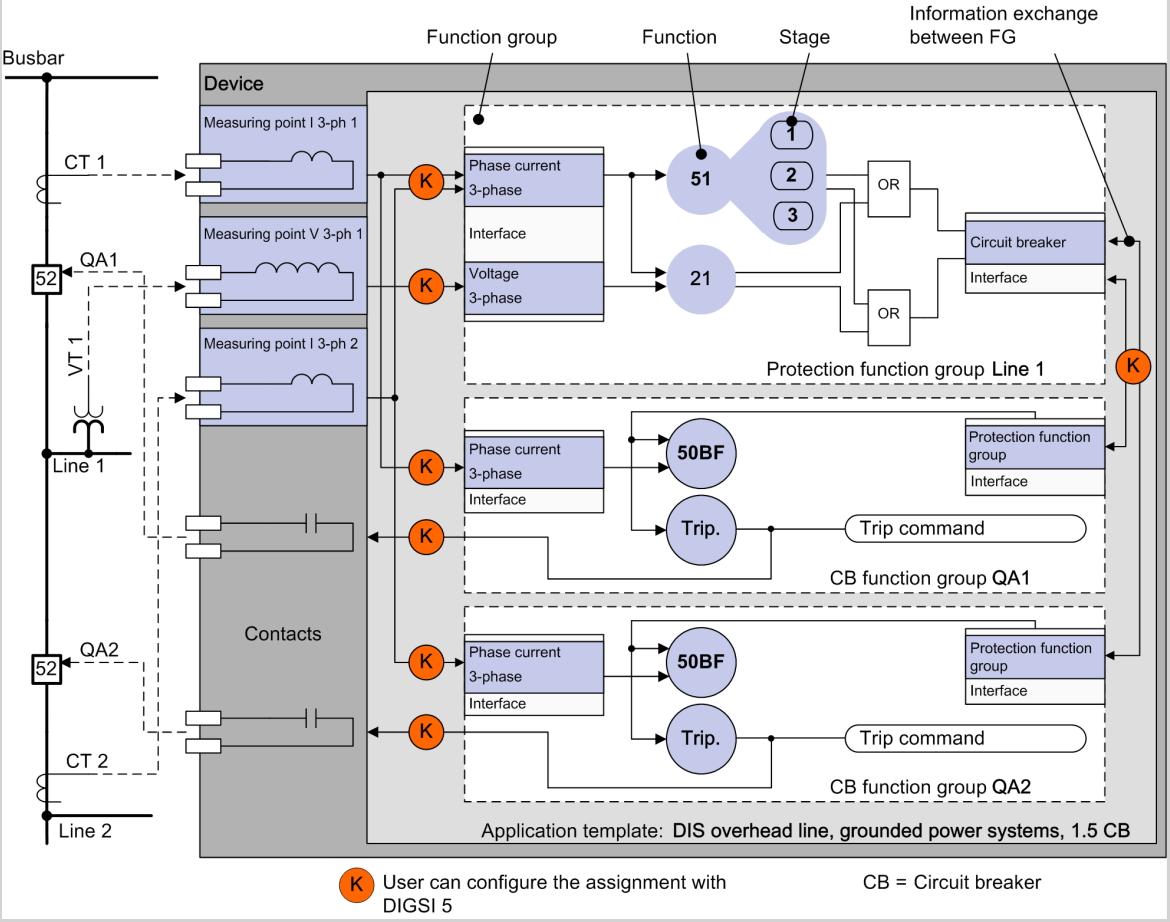
The number and type of function groups differ in the respective application templates, depending on the type of the device and application. You can add, copy, or even delete function groups for a specific application. You can also adapt the functional scope within a function group according to the use case. You can find detailed information on this in the DIGSI 5 Online help.

EXAMPLE

The selected application template **DIS overhead line, grounded systems, 1 1/2 circuit-breaker layout** comprises 3 function groups:

- Protection function group **Line 1**
- Circuit-breaker function group **QA 1**
- Circuit-breaker function group **QA 2**

The following figure shows the embedding of functions via function groups.



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Figure 2-1 Embedding the Functions via Function Groups

Depending on the type of device, there are different types of function groups:

- Protection function groups
- Circuit-breaker function groups

Protection function groups bundle functions that are assigned to one protected object – for example, to the linethe transformer. Depending on the device type and nature of the protected object, there are different types of protection function groups (line, voltage/current 3-phase, transformer, motor, generator, etc.).

Circuit-breaker function groups bundle functions assigned to the local switches – for example, circuit breakers and disconnectors (such as processing of tripping, circuit-breaker failure protection, automatic reclosing).

The number and type of function groups differ in the respective application templates, depending on the type of the device and application. You can add, copy, or even delete function groups for a specific application. You can also adapt the functional scope within a function group according to the use case. Detailed information on this can be found in the DIGSI 5 Online help.

Interface Between Function Group and Measuring Point

The function groups receive the measurands of the current and voltage transformers from measuring points. For this, the function groups are connected to one or more measuring points.

The number of measuring points and the assignment of function groups to the measuring points are preset by the selected application template in accordance with the specific application. Therefore, this specifies which measuring point(s) and the corresponding measurands have to be used by which function within the function group.

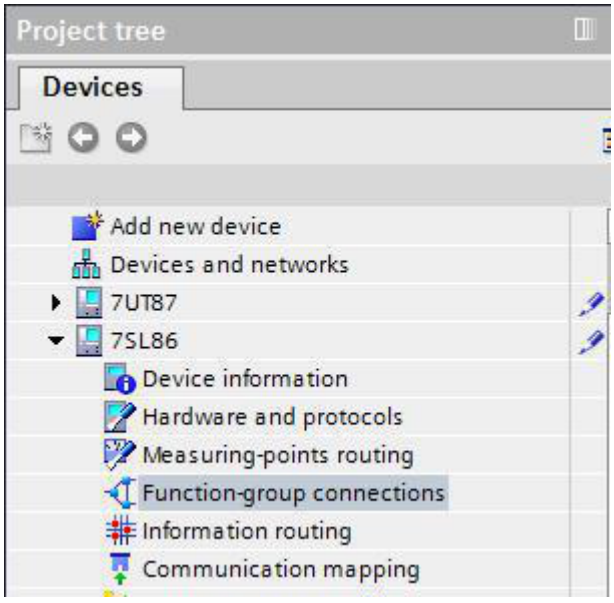
EXAMPLE

The measuring points are assigned to the function groups in the application template in *Figure 2-1* as follows:

- The protection function group **Line** is assigned to the measuring points **I-3ph 1**, **I-3ph 2** and **V-3ph 1**. The function group therefore receives the measured values from current transformers 1 and 2 and from voltage transformer 1. The currents of measuring points **I-3ph 1** and **I-3ph 2** are added geometrically for feeder-related processing.
- The circuit-breaker function group **QA1** is assigned to the measuring point **I-3ph 1** and receives the measured values from current transformer 1.
- The circuit-breaker function group **QA2** is assigned to the measuring point **I-3ph 2** and receives the measured values from current transformer 2.

The user can change the assignment as needed, that is, function groups can be assigned to any available measuring points of the device.

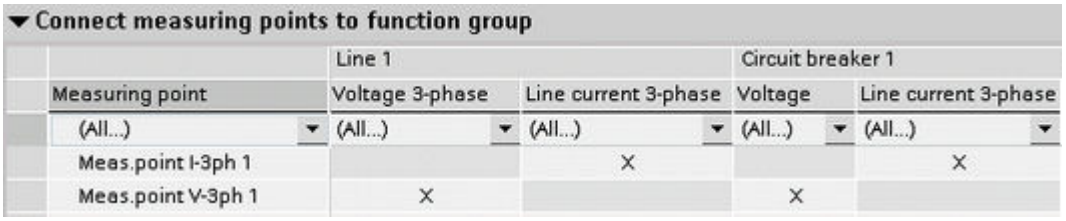
To check or change the assignment of measuring points to the function groups, double-click **Function-group connections** in the DIGSI 5 project tree.



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Figure 2-2 Project Tree in DIGSI 5 (Detail)

The window for routing of the measuring points opens in the working area (see the following Figure, does not correspond to the example).



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Figure 2-3 Connecting Measuring Points and Function Groups

Interface Between Protection and Circuit-Breaker Function Groups

The protection function group(s) is/are connected to one or several circuit-breaker function groups. This connection generally determines:

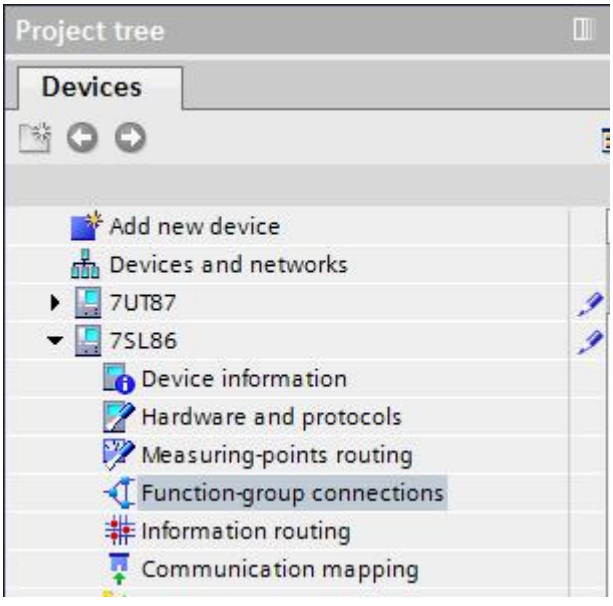
- Which circuit breaker(s) is/are started by the protection functions of the protection FG.
- Starting the **Circuit-breaker failure protection** function (if available in the Circuit-breaker function group) through the protection functions of the connected protection function group
- Starting the **Automatic reclosing** function (AREC, if available in the Circuit-breaker function group) through the protection functions of the connected Protection function group

Besides the general assignment of the protection function group(s) to the circuit-breaker function groups, you can also configure the interface for specific functionalities in detail. Further information on this is included later in the section. *Figure 2-6* shows how to reach the detail configuration. *Figure 2-7* shows the possible assignments in detail.

These definitions are also set appropriately for the specific application by the selected application template.

The user can change this linkage as needed, that is, protection function groups can be freely assigned to any Circuit-breaker function groups.

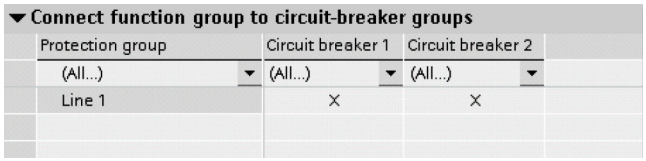
To check or change the allocation of the protection function groups to the circuit-breaker function groups, double-click **Function group connections** in the DIGSI 5 project tree → **Name of device** (see following figure).



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Figure 2-4 Project Tree in DIGSI 5 (Detail)

The window for general routing of the function groups opens in the working area (see following figure).

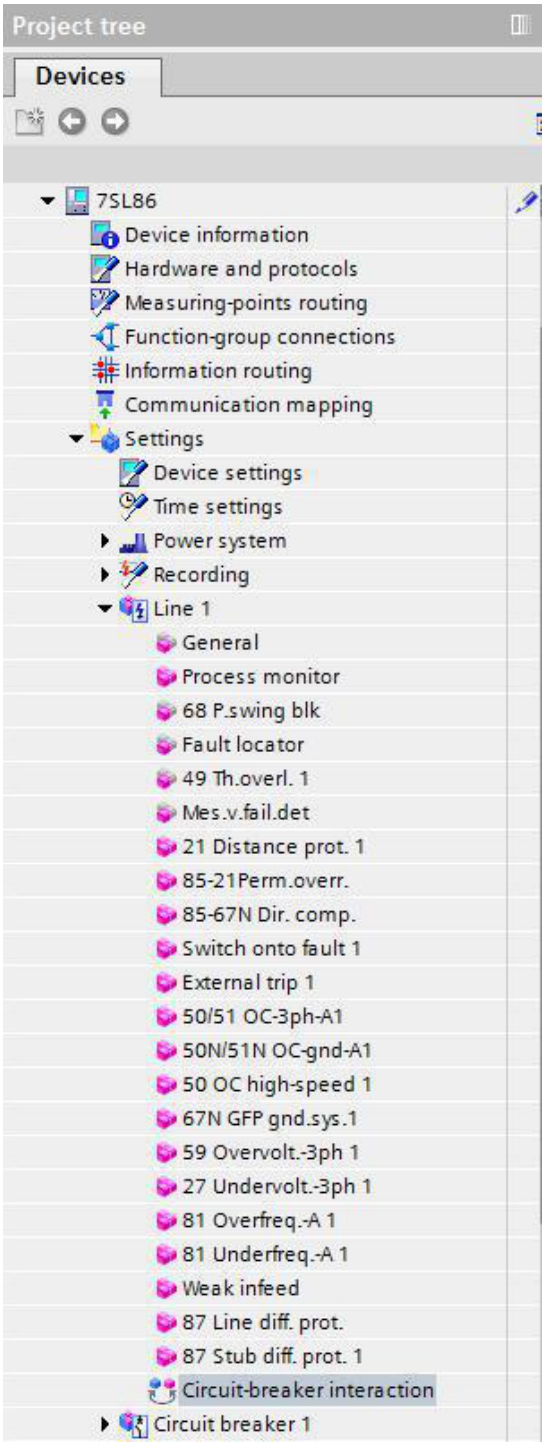


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Figure 2-5 Connection of Protection Function Group with Circuit-Breaker Function Group

Besides the general assignment of the protection function group(s) to the circuit-breaker function groups, you can also configure the interface for specific functionalities in detail. Proceed as follows:

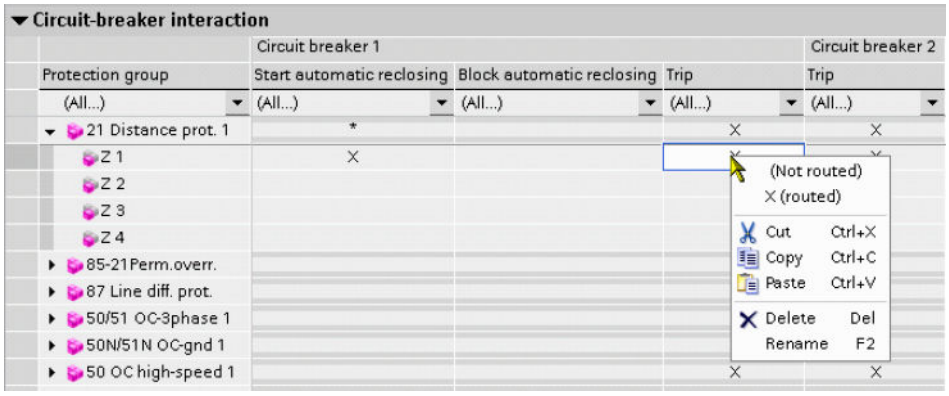
- Open the SIPROTEC 5 device folder in the DIGSI 5 project tree.
- Open the function settings folder in the DIGSI 5 project tree.
- Open the respective protection function group in the DIGSI 5 project tree, for example, **Line 1** (see the following figure)



[sclsinta-190214-01, 1, en_US]

Figure 2-6 Project Tree in DIGSI 5 (Detail)

- Double-click Circuit-breaker interaction (see *Figure 2-6*)
- The window for detailed configuration of the interface between the protection function group and the circuit-breaker function group(s) opens in the working area.
- In this view, configure the interface via the context menu (right mouse button), see *Figure 2-7*.



[scdetail-220211-01.tif, 1, en_US]

Figure 2-7 Detail Configuration of the Interface Between the Protection Function Group and the Circuit-Breaker Function Group(s)

In the detail configuration of the interface, you define:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the automatic reclosing function
- Which protection functions block the automatic reclosing function
- Which protection functions start the Circuit-breaker failure protection function

Functions (FN), Tripping Stages/Function Blocks (FB)

As already illustrated in *Figure 2-1*, functions are assigned to the protected objects or other primary objects via function groups.

Functions can be further subdivided. For example, protection functions often consist of multiple protection stages (for example, the Overcurrent-protection function). Other functions can contain one or more function blocks.

Each stage, each function block, and each function (without stages/function blocks) can be individually switched into specific operating modes (for example, switch on/off). This is termed function control and is explained in chapter *2.3 Function Control*.

To adjust the functionality to the specific application, functions, tripping stages, and function blocks can be added, copied, and deleted (see chapter *2.2 Adjustment of Application Templates/Functional Scope*).

2.2 Adjustment of Application Templates/Functional Scope

Application Template

The application template defines the preconfigured functional scope of the device for a specific use case. A certain number of application templates is predefined for each device type. DIGSI 5 automatically offers the application templates for selection when a new device is installed. The available application templates with the respective functional scope are described in more detail in *4 Applications*.

The selection of the application template first predefines which function groups and functions are present in the device (see also *Figure 2-1* in chapter *2.1 Function Embedding in the Device*).

You can adjust the functional scope to your specific application.

Adjusting the Functional Scope

Adjust the functional scope based on the selected application template. You can add, copy or delete functions, tripping stages, function blocks, or complete function groups.

In the DIGSI 5 project tree, this can be done via the following Editors:

- Single-line configuration
- Information routing
- Function settings

Siemens recommends the **Single-line configuration** Editor to adjust the functional scope.

Complete missing functionalities from the Global DIGSI 5 Library. Then, the default settings of the added functionality are active. You can copy within a device and between devices as well. Settings and routings are also copied when you copy functionalities.



NOTE

If you delete a parameterized function group, function, or level from the device, all settings and routings will be lost. The function group, function, or tripping stage can be added again, but then the default settings are active.

In most cases, the adjustment of the functional scope consists of adding and deleting functions, tripping stages, and function blocks. As previously described, the functions, tripping stages, and function blocks automatically connect themselves to the measuring points assigned to the function group.

In few cases, it may be necessary to add a protection or circuit-breaker function group. These newly added function groups do not contain (protection) functions. You must individually load the (protection) functions for your specific application. You must also connect the protection or circuit-breaker function group to one or more measuring points (see chapter *2.1 Function Embedding in the Device*). You must connect newly added protection function groups to a circuit-breaker function group (see chapter *2.1 Function Embedding in the Device*).

Functions, tripping stages, function blocks, and function groups can be added up to a certain maximum number. The maximum number can be found in the respective function and function-group descriptions.

Function Points

Function points (FP) are assigned to specific functions, but not to other functions. Further information can be found in the description of application templates, in the chapter *4 Applications*.

The device is supplied with the acquired function-point credit. Functions with function points can be loaded into the device only within the available function-point credit. The functional scope cannot be loaded into the device if the required number of points of the functional scope is higher than the function-point credit. You must either delete functions or upgrade the function-point credit of the device.

No function points are required to add additional stages in functions.

Extending the Function-Point Credit

You can reorder function points if the function-point credit for the device is not enough.

Proceed as follows:

- Determine the function point requirement of certain functions, for example, with DIGSI 5 or the SIPROTEC 5 Configurator.
- Order the additional function points from your local distributor or at *http://www.energy.siemens.com*.
- Siemens will provide you with a signed license file for your device, either via e-mail or for downloading.
- Use DIGSI 5 to load the signed license file into your device. The procedure is described in the Online Help of DIGSI 5.

2.3 Function Control

Function control is used for:

- Functions that do not contain stages or function blocks
- Stages within functions
- Function blocks within functions

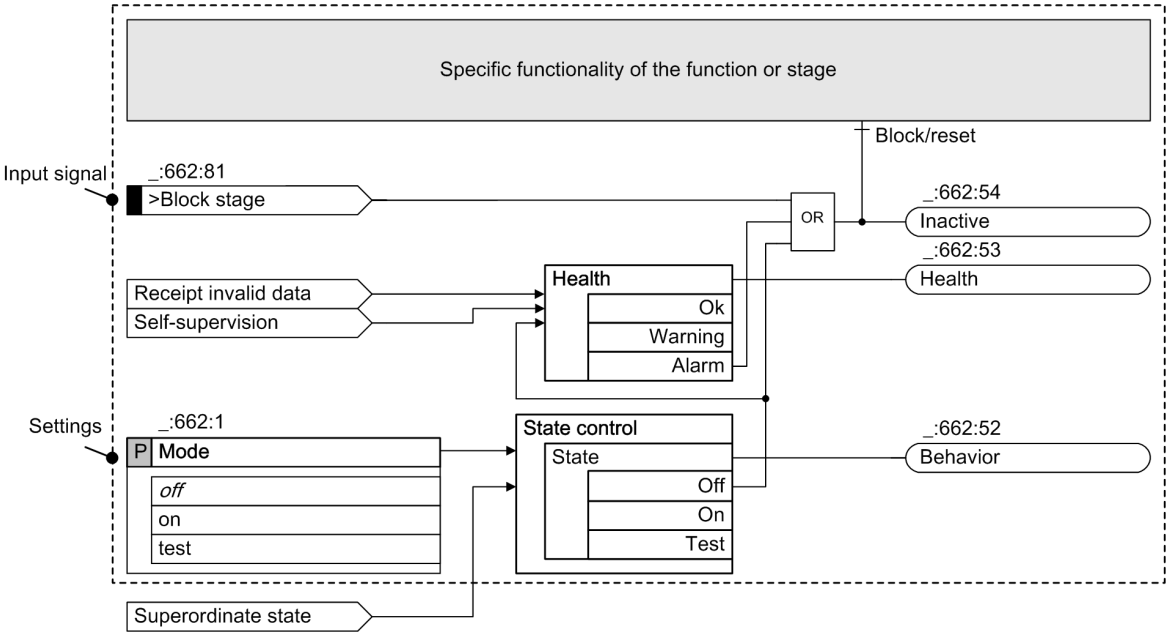
NOTE

Simplifying **Functions** and **Function control** will be discussed in the following. The description also applies to tripping stage control and function block control.

Functions can be switched to different operating modes. You use the parameter **Mode** to define whether you want a function to run (***On***) or not (***Off***). In addition, you can temporarily block a function or switch it into test mode for the purpose of commissioning (parameter **Mode** = ***Test***).

The function shows the current status – such as an *Alarm* – via the *Health* signal.

The following explains the different operating modes and mechanisms and how you set the functions into these modes. The function control is shown in *Figure 2-8*. It is standardized for all functions. Therefore, this control is not discussed further in the individual function descriptions.



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Figure 2-8 General Control of a Function

State Control

You can control the state of a function via the parameter **Mode** and the input **Superordinate state**.

You set the specified operating state of the function via the parameter **Mode**. The function mode can be set to ***On***, ***Off***, and ***Test***. The operating principle is described in *Table 2-2*. You can set the parameter **Mode** via:

- DIGSI 5
- On-site operation at the device
- Certain systems control protocols (IEC 61850, IEC 60870-5-103)

The possibility to adjust the **superordinate state** is limited. For test purposes, the complete device can set into test mode.

The state of the function resulting from the parameter **Mode** and the superordinate state is shown in the following table.

Table 2-1 Resulting State of the Function (from Linkage of Parameter Mode and Superordinate State)

Inputs		**Function State**
Mode Parameter (of the function)	**Superordinate State**	
Off	(any)	Off
(any)	Off	Off
On	On	On
On	Test	Test
Test	On	Test
Test	Test	Test

The following table shows the possible function states:

Table 2-2 Possible Function States

Function State	**Explanation**
On	The function is activated and operating as defined. The prerequisite is that the health of the function is ***OK***.
Off	The function is turned off. It does not create any information. The health of a disabled function always has the value ***OK***.

<table>
<tr><th>Function State</th><th colspan="2">Explanation</th></tr>
<tr><td>Test</td><td colspan="2">The function is set to test mode. This state supports the commissioning. All outgoing information from the function (indications and, if present, measured values) is provided with a test bit. This test bit significantly influences the further processing of the information, depending on the target.
For instance, among other things, it is possible to implement the functionality Blocking of the command relay known from SIPROTEC 4.</td></tr>
<tr><td></td><td>Target of the Information</td><td>Processing</td></tr>
<tr><td></td><td>Log</td><td>The indications are provided with the identification Test in the log.</td></tr>
<tr><td></td><td>Contact</td><td>An indication routed to contact is not triggering the contact.</td></tr>
<tr><td></td><td>Light-emitting diode (LED)</td><td>An indication routed to the LED triggers the LED (normal processing)</td></tr>
<tr><td></td><td>CFC</td><td>Here, the behavior depends on the state of the CFC chart.
• CFC chart itself is not in test state:
The CFC chart is not triggered by a status change of information with a set test bit. The initial state of the information (state before test bit was set) is not processed during execution of the CFC chart.
• CFC chart itself is in test state:
The CFC chart continues to process the information (indication or measured value) normally. The CFC outgoing information is provided with a test bit. The definitions in this table apply to its continued processing.
A CFC chart can be set to the test state only by switching the entire device to test mode.</td></tr>
<tr><td></td><td>Protocol</td><td>Indication and measured value are transmitted with set test bit, provided that the protocol supports this functionality.
If an object is transmitted as a GOOSE message, the test bit is set spontaneously and the GOOSE message is transmitted immediately. The receiver of the GOOSE message is automatically notified of transmitter test mode.
If an object is transmitted via the protection interface, the test bit is not transmitted. The Test state must also be transmitted as information for this state to be taken into account in the application on the receiver end. You must route the Test signal in the DIGSI 5 project tree → Device → Communication routing.
The test mode of the differential protection will be dealt with separately in the application.</td></tr>
</table>

Health

Health signals if a selected function can perform its designated functionality. If so, the health is *OK*. In case the functionality is only possible in a limited way or not at all, due to state or problems within the device, the health will signal *Warning* (limited functionality) or *Alarm* (no functionality).

Internal self-supervision can cause the functions to assume the health *Alarm* (see chapter *9 Supervision Functions*). If a function assumes the health state *Alarm*, it is no longer active (indication *not active* is generated).

Only a few functions can signal the health state *Warning*. The health state *Warning* results from function-specific supervision and - where it occurs - it is explained in the function description. If a function assumes the *Warning* status, it will remain active, that is, the function can continue to work in a conditional manner and trip in the case of a protection function.

Not Active

The indication *Not active* signals that a function is currently not working. The indication *Not active* is active in the following cases:

- Function is switched off
- The function is in the health state *Alarm*
- Function is blocked by an input signal (see *Figure 2-8*)

Blocking of the Operate Indication, No Fault Recording at Pickup

You use the parameter **Blk. Op. Ind. & Fault Rec.** to define whether a function works as a protection or supervision function. Further, you use this to determine the type and scope of the logging (see following table)

Parameter Value	Description
No	The function works as a protection function. It generates an operate indication and starts fault recording with pickup. During fault recording, a fault is created and logged as a fault record in the fault log.
Yes	The function works as a supervision function. The logic runs normally, but without creating the operate indication. The time-out indication is still generated and can be processed further if necessary. No fault recording starts with pickup.

2.4 Text Structure and Reference Number for Settings and Indications

Each parameter and each indication has a unique reference number within every SIPROTEC 5 device. The reference number gives you a clear reference, for example, between an indication entry in the buffer of the device and the corresponding description in the manual. You can find the reference numbers in this document, for example, in the application and setting notes, in the logic diagrams, and in the parameter and information lists.

In order to form explicit texts and reference numbers, each function group, function, function block/stage, and indication or parameter has a text and a number. This means that structured overall texts and numbers are created.

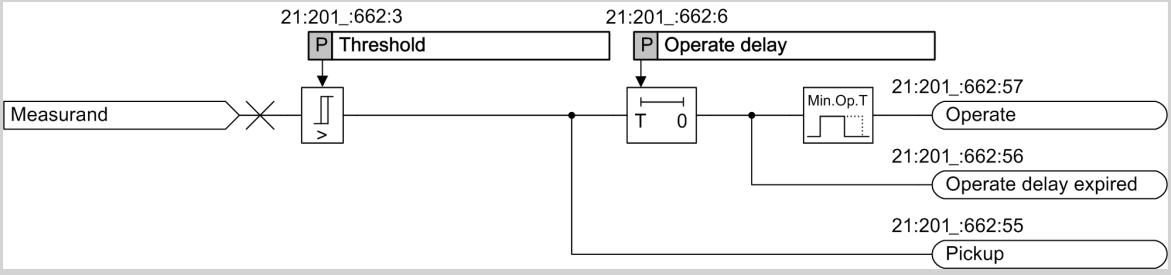
The structure of the texts and the reference numbers follow the hierarchy already shown in *Figure 2-1* :

- Function group:Function:Stage/Function Block:Indication
- Function group:Function:Stage/Function Block:Parameter

The colon serves as a structure element to separate the hierarchy levels. Depending on the functionality, not all hierarchy levels are always available. Function Group and Stage/Function block are optional. Since the function groups, functions as well as tripping stages/function blocks of the same type can be created multiple times, a so-called instance number is added to these elements.

EXAMPLE

The structure of the text and reference number is shown in the protection-function group **Line** as an example of the parameter **`Threshold value`** and the indication **`Pickup`** of the 2nd definite time-overcurrent protection stage of the function **Overcurrent protection, phases** (see *Figure 2-9*). Only one function and one function group exist in the device. The representation of the stage is simplified.



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Figure 2-9 Stage of the Overcurrent Protection Function, Phases (without Representation of Stage Control)

The following table shows the texts and numbers of the hierarchy elements concerned:

	Name	Number of the Type	Instance Number
Protection function group	Line	2	1
Function	Overcurrent 3ph	20	1
Stage	Definite time-overcurrent protection	66	2
Settings	Threshold value	3	–
Indication	Pickup	55	–

Die Instanznummern ergeben sich wie folgt:

- Function group: Line **1**
  1 instance, because only one **Line** function group exists in the device
- Function: Overcurrent 3ph **1**
  1 instance, because only one **Overcurrent 3ph** function exists in the **Line** function group

- Stage: Definite time-overcurrent protection **2**

  2 instances, because 2 definite time-overcurrent protection stages exist in the **Overcurrent 3ph** function (here the 2nd instance as an example)

This results in the following texts and numbers (including the instance numbers):

Parameter:	**Number**
Line 1:Overcurrent 3-ph 1:Definite time-overcurrent protection 2:Threshold value	21:201:662:3
Indication:	**Number**
Line 1:Overcurrent 3-ph 1:Definite time-overcurrent protection 2:Pickup	21:201:662:55

The structure is simplified accordingly for parameters and indications with fewer hierarchy levels.

2.5 Information Lists

For the function groups, functions, and function blocks, settings and miscellaneous signals are defined that are shown in the settings and information lists.

The information lists summarize the signals. The data type of the information may differ. Possible data types are ENS, ACD, ACT, SPS and MV, etc.

A type is assigned to the individual data types. The following table shows the possible types:

Type	Meaning
I	**I**nput – input signal
O	**O**utput – output signal
C	**C**ontrollable – control signal

EXAMPLE:

The following table shows the types for some data types as examples:

Data Type	Type
ENS	O
ACD	O
ACT	O
SPS	I or O
SPC	C
MV	O

3 System Functions

3.1	Indications	60
3.2	Measured-Value Acquisition	87
3.3	Processing Quality Attributes	89
3.4	Fault Recording	101
3.5	Protection Communication	107
3.6	Date and Time Synchronization	148
3.7	User-Defined Objects	156
3.8	Other Functions	161
3.9	General Notes for Setting the Threshold Value of Protection Functions	170
3.10	Device Settings	178

3.1 Indications

3.1.1 General

During operation, indications deliver information about operational states. These include:

- Measured data
- Power-system data
- Device supervisions
- Device functions
- Function procedures during testing and commissioning of the device

In addition, indications give an overview of important fault events after a failure in the system. All indications are furnished with a time stamp at the time of their occurrence.

Indications are saved in logs inside the device and are available for later analyses. The following number of indications are saved at least in the respective buffer (depending on the scope of the indications):

- Ground-fault log 100 indications
- Fault log 1000 indications
- User-defined log 200 indications
- Operational log 2000 indications

If the maximum capacity of the user-defined log or of the operational is exhausted, the oldest entries disappear before the newest entries. If the maximum capacity of the fault log or of the ground-fault log is reached, the number of the last fault is issued via the signal **Fault log is full**. During a supply-voltage failure, recorded data are securely held by means of battery buffering or storage in the flash memory. You can read and analyze the log from the device with DIGSI 5. The device display and navigation using keys allow you to read and analyze the logs on site.

Indications can be output spontaneously via the communication interfaces of the device and through external demand via general interrogation. In DIGSI 5 indications can be tracked spontaneously in online operation in a special indication window. Indications can be made accessible to higher-level control systems through mapping on various communication protocols.



NOTE

All indications are assigned to certain device functions. The text of each indication contains the corresponding function designation. You will find explanations of the meaning of indications in the corresponding device functions. However, you can also define indications yourself and group them into your own function blocks. These can be set by binary inputs or CFC logic.

Reading Indications

To read the indications of your SIPROTEC 5 device you can use the on-site operation panel of the device or a PC on which you have installed DIGSI 5. The subsequent section describes the general procedure.

3.1.2 Reading Indications on the On-Site Operation Panel

Procedure

The menus of the logs begin with a header and 2 numbers at the top right corner of the display. The number after the slash signifies the number of indications that are available. The number before the slash indicates how many indications have just been selected or shown. The end of the indication list is closed with the entry ***END***.

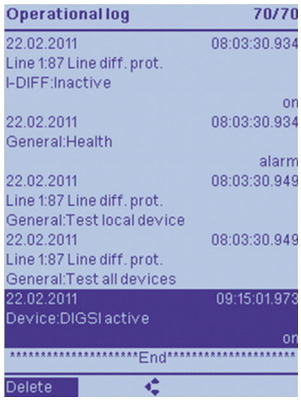


Figure 3-1
On-Site Display of an Indication List (Example: Operational Indications)

Menu Path	Log
Main menu → Indications →	Operational log Fault log Ground-fault log Setting changes User indications 1 User indications 2
Main menu → Test & Diagnosis → Indications →	Security indications Device diagnosis Communication indications

- ✧ To reach the desired log from the main menu, use the navigation keys of the on-site operation panel.
- ✧ Navigate inside the log using the navigation keys (top/bottom). You will find the most current indication at the top of the list. The selected indication is shown with a dark background.
- ✧ Which indications can be shown in the selected log depends on the assignments in the DIGSI 5 information routing matrix or is pre-defined. You will find information about this in chapter *3.1.5.1 General*.
- ✧ Every indication contains date, time and its state as additional information.
- ✧ In some logs you are given the option of deleting the entire indication list by softkey in the footer of the display. To know more about this, read chapter *3.1.6 Saving and Deleting the Logs*.

NOTE

No password entry is necessary to read indications from the device.

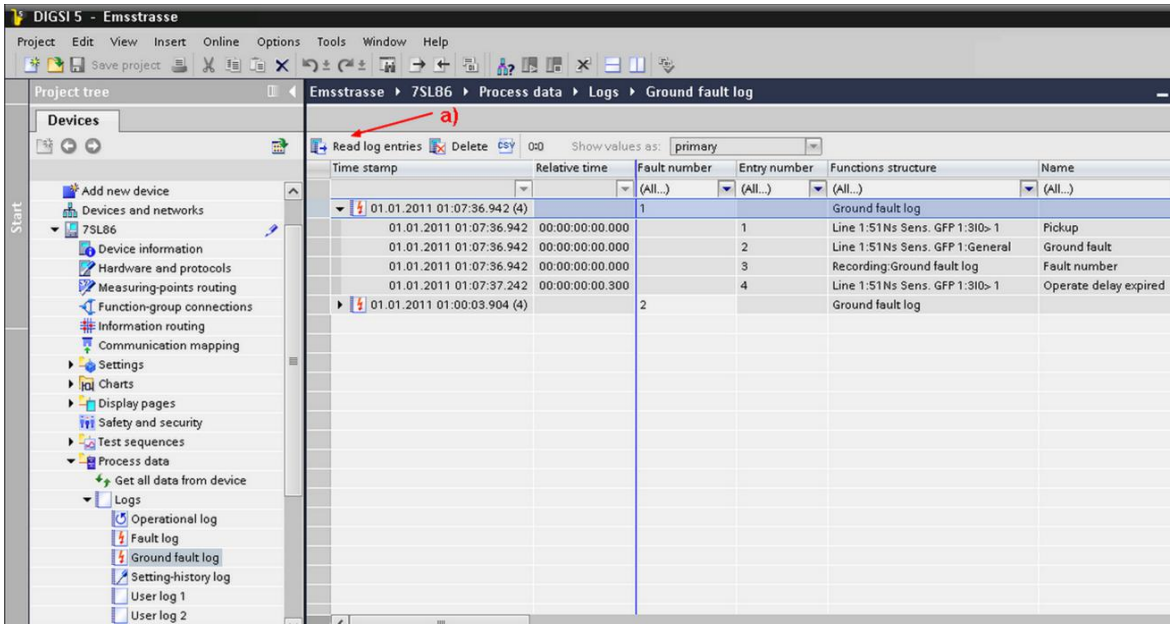
3.1.3 Reading Indications from the PC with DIGSI 5

Procedure

Menu Path (Project)	Log
Project → Device → Process data → Log →	Operational log Fault log Ground-fault log Setting changes User indications 1 User indications 2

Menu Path (Project)	Log
Project → Device → Device information → Log →	Security indication Device diagnosis Communication indications

- ✧ To read the indications with DIGSI 5 your PC must be connected via the **USB user interface** of the on-site operation panel or via an **Ethernet interface** of the device. A direct connection to your PC can be established via the Ethernet interfaces. It is also possible to access all connected SIPROTEC 5 devices via a data network from your DIGSI 5 PC.
- ✧ To reach the desired logs of the SIPROTEC 5 device, use the project-tree window. If you have not set up the device within a project, you can also attain this via **Online access**.
- ✧ After selecting the desired log, you are shown the last state of the log loaded from the device. To update, it is necessary to synchronize with the log in the device.
- ✧ To execute a synchronization with the logs, click the respective button in the headline of the log (see example of ground-fault log in *Figure 3-2* a)).



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Figure 3-2 DIGSI 5 Display of an Indication List (Example of Ground-Fault Log)

- ✧ You will find additional information about the deletion and saving of logs in chapter *3.1.6 Saving and Deleting the Logs*.
- ✧ To determine a relative time for all other indications, you can reference the display of log entries, if needed, to the real time of a certain entry. The real-time stamps of events remain unaffected.
- ✧ For this purpose click the respective button in the headline of the log (see example of ground-fault log in *Figure 3-2* a)).

Setting Relative Time Reference

- ✧ Which indications in the selected log can be displayed depends on the assignments in the DIGSI 5 information routing matrix or is predefined. You will find information about this in chapter *3.1.5.1 General*.

3.1.4 Displaying Indications

Displayed indications in DIGSI 5 and on the on-site operation panel are supplemented with the following information:

Table 3-1 Overview of Additional Information

Indications in	DIGSI 5 Information	Device Display Information
Log for operational indications and log for user-defined indications	Time stamp (date and time), Relative time, Increasing entry number, Value, Indication number, Quality, Cause	Time stamp (date and time), Value
log for fault indications	Time stamp (date and time), Relative time, Error number, Increasing entry number, Value, Indication number, Quality, Cause	Time stamp (date and time), Error number, Value
Log for ground-fault indications	Time stamp (date and time), Relative time, Error number, Increasing entry number, Value, Indication number, Quality, Cause	Time stamp (date and time), Error number, Value
Spontaneous indication window (DIGSI 5)	Time stamp (date and time), Error number, Increasing entry number, Value, Indication number, Quality, Cause	Time stamp (date and time), Error number, Value

DIGSI 5: Quality Indication Column

Quality	Meaning
Good	Indication is valid
Invalid	Indication is invalid

DIGSI 5: Additional Information Indication Column

The entries in the column for additional information are in the format Cause/Originator/Additional Cause:

- Cause → What was the cause?
- Originator → Who was the originator?
- Additional cause → Supplementary notes

Cause	Meaning
Data change	Value change in an indication
Data update	Update of notification value
General interrogation	General interrogation

Cause	Meaning
Cyclic	Cyclical general inquiry
Quality change	Change of the notification quality

Initiator	Meaning
Bay	Control local
Substation	Control via the substation
Remote control	Control via the network control center
Field (auto)	Control local via automatic function
Station (auto)	Control via the station via automatic function
Distance (auto)	Control via the network control center via automatic function
Maintenance	Maintenance
Process	Device operation (normal)

Additional Cause	Meaning
Switching authority test failed	Switching authority check failed
Selection failed	Selection failed
invalid position	invalid position
Position attained	Position attained
Settings change running	Settings change running
Final position attained	Final position attained
Impermissible mode	Impermissible mode
Blocking through process	Blocking by the process
Interlocked	Interlocked
Synchrocheck failed	Synchrocheck failed
Command already running	Command already running
Not ready	Not ready
1 out of N control failed	1 out of N control failed
Command cancellation	Command cancellation
Monitoring time expired	Monitoring time expired
Cancellation due to trip command	Cancellation due to trip command
Object not selected	Object not selected
No access right.	No access right
Final position exceeded	Final position exceeded
Target value not attained	Target value not attained
Loss of connection	Loss of connection
Unknown	Unknown
Blocking through command	Blocking through command
Object already selected	Object already selected
Inconsistent parameter(s)	Inconsistent parameter(s)
Blocked by foreign access	Blocked by foreign access
Select time-out	Select time-out
CB not open	Circuit breaker not open
Communication is interrupted	Communication is interrupted
Topology not stable	Topology not stable
FLO in process	Fault locator in processing
Trigger command active	Trigger command active
Close command active	Close command active

Additional Cause	Meaning
Blocked through protection	Blocked through protection
Fault occurred	Fault occurred
CB not closed	Circuit breaker not closed
CB not ready	Circuit breaker not ready
CB not open	Circuit breaker not open
Close command active	Close command active
CB check running	Circuit breaker check running

3.1.5 Logs

3.1.5.1 General

Indications are saved in logs inside the device and are available for later analyses. Different logs allow categorization of indication logging based on operating states (for example, operational and fault logs) and based on fields of application.

Table 3-2 Log Overview

Log	Logging
Operational log	Operational indications
Fault log	Fault indications
Ground-fault log	Ground-fault indications
Setting-history log	Setting changes
User-defined log	User-defined indication scope
Security log	Access with safety relevance
Device-diagnosis log	Error of the device (software, hardware) and the connection circuits
Communication log	Status of communication interfaces
Motor-startup log	Information on the motor startup

Managing Logs

Logs have a ring structure and are automatically managed. If the maximum capacity of a log is exhausted, the oldest entries disappear before the newest entries. If the maximum capacity of the fault or ground-fault log is reached, the number of the last fault is generated via the signal **Fault log is full**. You can route this signal in the information routing. If indications in the information routing of DIGSI 5 are routed to a log, then they are also saved. During a supply-voltage failure, recorded data are securely held by means of battery buffering or storage in the flash memory. You can read and analyze the log from the device with DIGSI 5. The device display and the navigation allow you to read and evaluate the logs on site using keys.

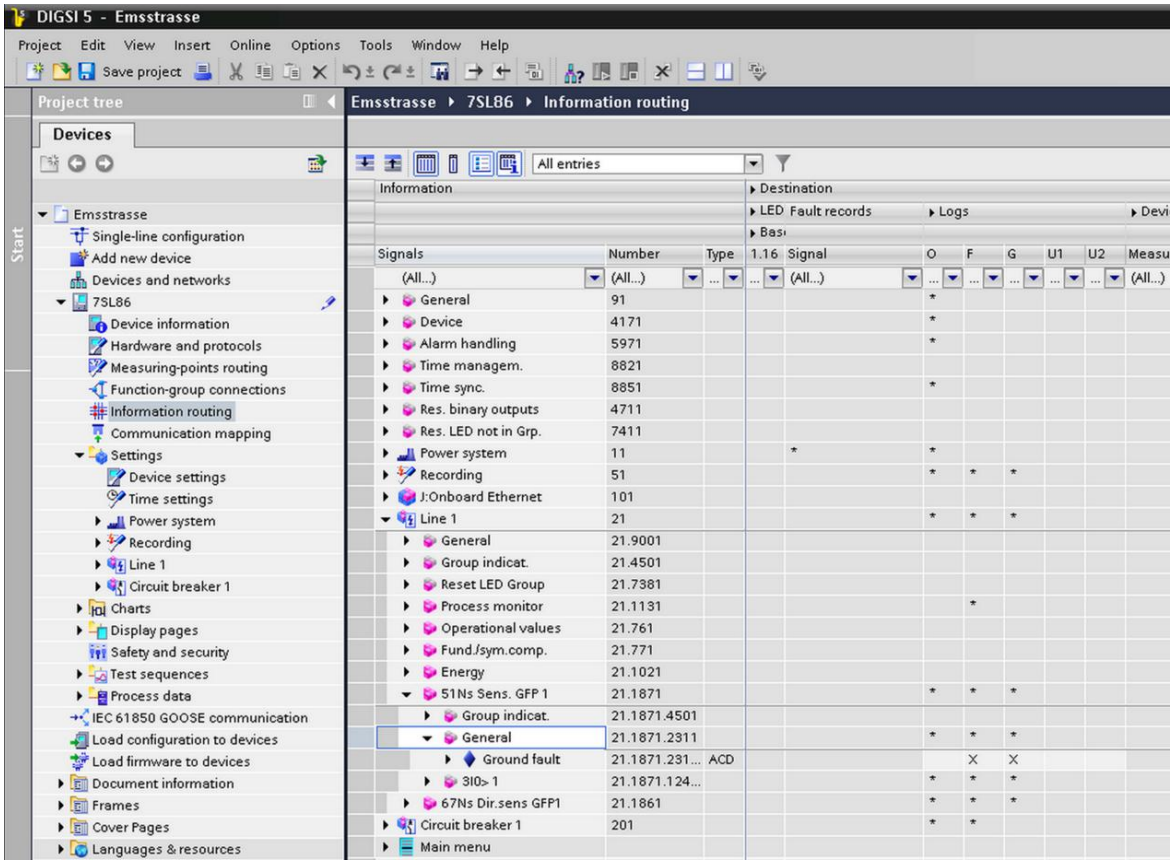
Configurability of Logs

The indication capacity to be recorded in configurable logs (for example, ground-fault log) is laid down in columns of the information routing (matrix) of DIGSI 5 specifically defined for this purpose.

Procedure

- To reach the information routing of your SIPROTEC 5 device, use the project-tree window. Access is only through the project:
  Project → Device → **Information routing**
- Select the associated routing column in the matrix from:
  Target → Log → **Column ground-fault log**

- The routing of the selected indication is done via right click. Select one of the options in the list box shown:
  - Routed (X)
  - Unrouted



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Figure 3-3 Indication Configuration in DIGSI 5 (Example: Ground-Fault Log)

For non-configurable logs (for example, setting-history logs) scope and type of logged indications are described separately (see following chapter about logs).

3.1.5.2 Operational Log

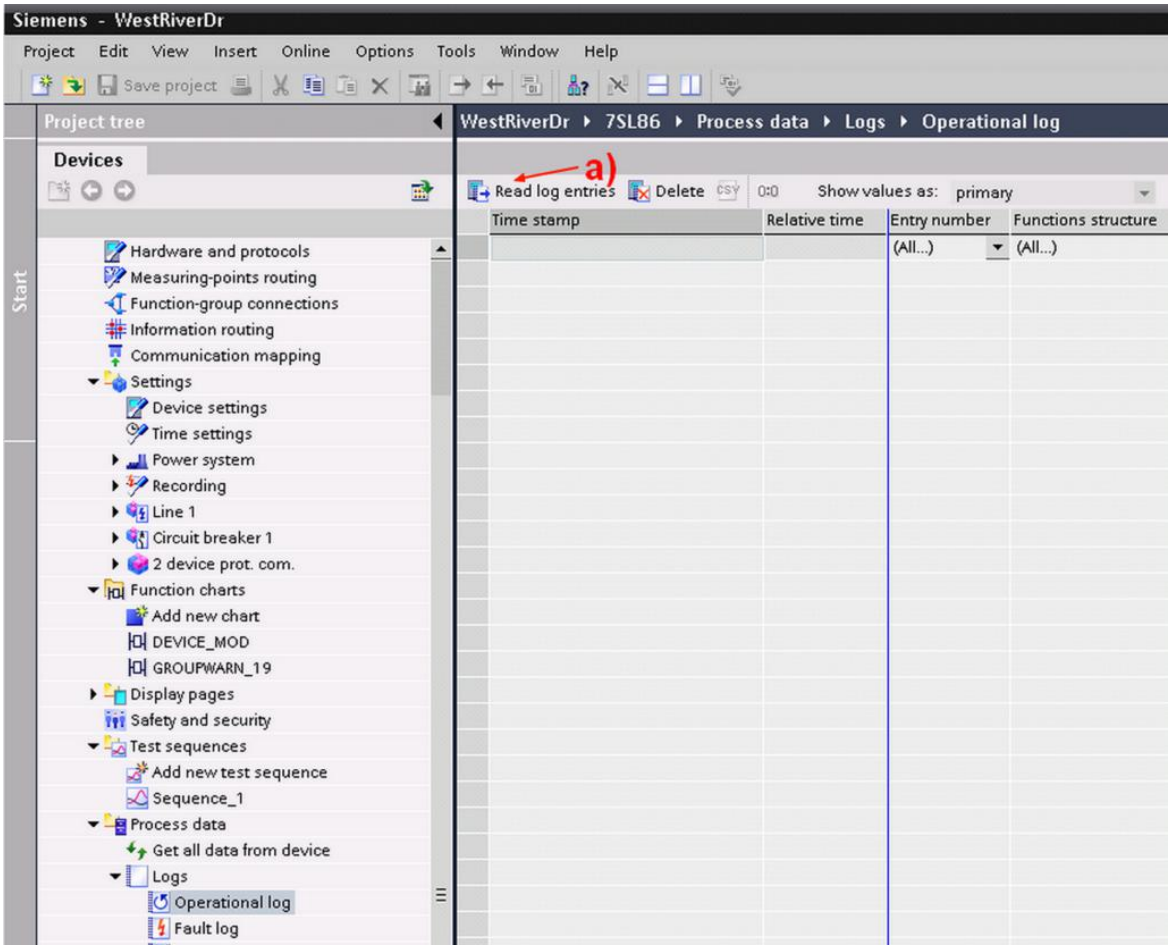
Operational indications are information that the device generates during operation. This includes information about:

- State of device functions
- Measured data
- Power-system data

Exceeding or dropping below limiting values is output as an operational indication. Short circuits in the network are indicated as an operational indication **Fault** with sequential fault number. For detailed information about the recording of system incidents, please refer to the description of the fault log (chapter *3.1.5.3 Fault Log*). Up to 2000 indications can be stored in the log.

Reading from the PC with DIGSI 5

- To reach the operational log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process Data → Log → **Operational log**
- The status of the operational log last loaded from the device is shown to you. To update (synchronization with the device) click the button **Read log entries** in the headline of the indication list (*Figure 3-4* a)).



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Figure 3-4 Reading the Operational Log with DIGSI 5

Reading on the Device Through the On-Site Operation Panel

- To reach the operational log via the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Indications → **Operational log**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

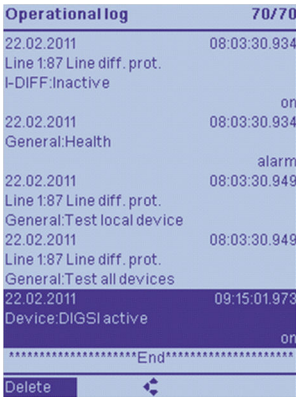


Figure 3-5
On-Site Display of an Indication List (Example: Operational Indications)

Deletability

The operational log of your SIPROTEC 5 device can be deleted. This is done usually after testing or commissioning the device. To know more about this, read chapter *3.1.6 Saving and Deleting the Logs* .

Configurability

The indication scope of the operational log is configured in a specifically defined column of the information routing (matrix) of DIGSI 5:

Target → Log → **Operational log** column

Selected application templates and functions from the library bring with them a predefined set of operational indications which you can adjust individually at any time.

3.1.5.3 Fault Log

Fault indications are events which arise during a fault. They are logged in the fault log with real-time stamp and relative-time stamp (reference point: fault occurrence) . Faults are numbered consecutively in rising order. With fault recording engaged, a corresponding fault record with the same number exists for every fault logged in the fault log. A maximum of 128 fault logs can be stored. A maximum of 1000 indications can be recorded in each fault log.

Fault Definition

In general, a fault is started by the raising pickup of a protection function and ends with the cleared pickup after the trip command.

When using an automatic reclosing function, the complete reclosing cycle (successful or unsuccessful) is preferably integrated into the fault. If evolving faults appear within reclosing cycles, the entire clearing process is logged under one fault number even in multiple pickup cycles. Without automatic reclosing function every pickup is also recorded as its own fault.

User-defined configuration of a fault is also possible.

NOTE

The definition of the fault is done through settings of the fault recording (see Device manual). Events are logged in the fault log even when fault recording is switched off.

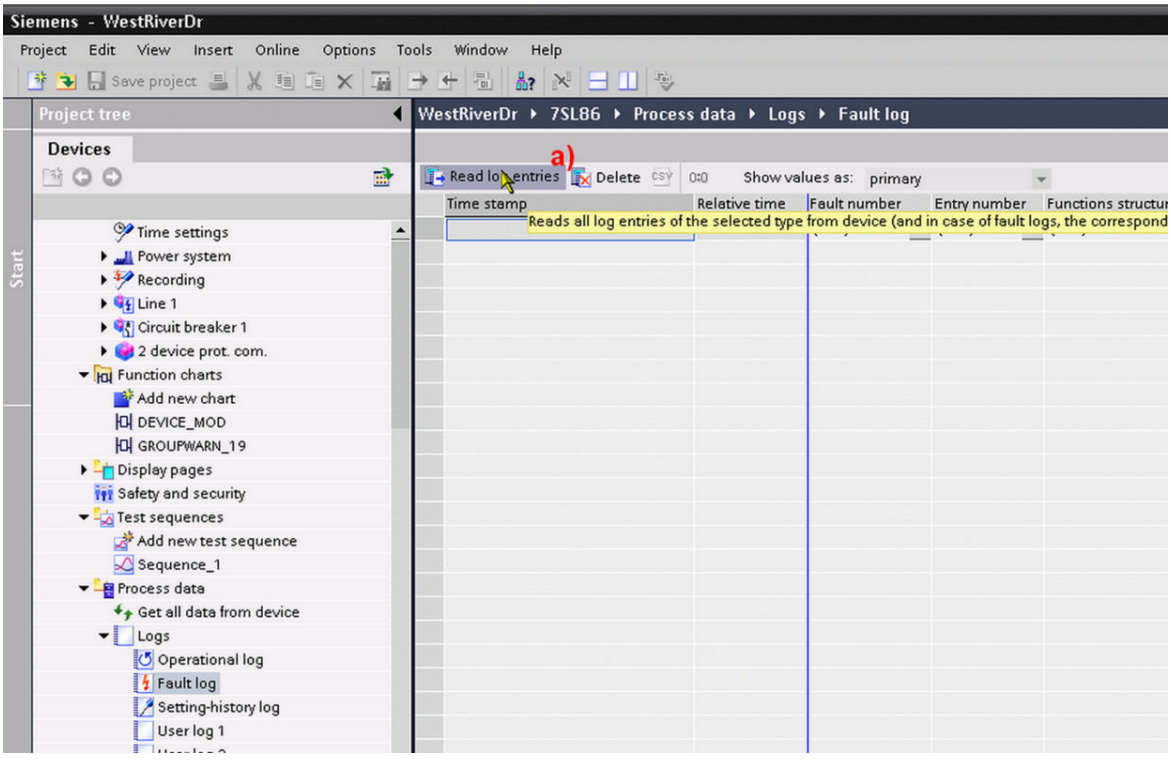
Apart from the recording of fault indications in the fault log, spontaneous display of fault indications of the last fault on the device display is also done. You will find details about this in chapter *3.1.8 Spontaneous Fault Display on the On-Site Operation Panel*.

Reading from the PC with DIGSI 5

- To reach the fault log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process Data → Log → **Fault logs**

The status of the fault log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button **Read log entries** in the headline of the indication list.



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Figure 3-6 Reading the Fault Log with DIGSI 5

Deletability

The fault log of your SIPROTEC 5 device can be deleted. Read about it in chapter *3.1.6 Saving and Deleting the Logs*.

Reading on the Device through the On-Site Operation Panel

- To reach the fault log from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Indications → **Fault logs**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

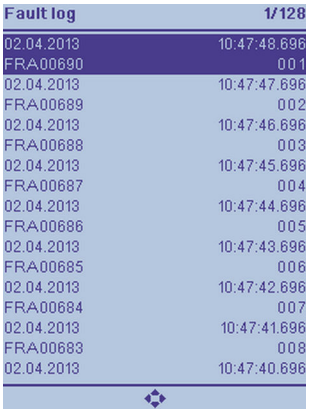


Figure 3-7
Reading the Fault Log on the On-Site Operation Panel of the Device

Configurability

The indication scope of the fault log is configured in a specifically defined column of the information routing (matrix) of DIGSI 5:

Target → Log → **Fault log** column

Selected application templates and functions from the library already bring a predefined set of operational indications with them which you can adjust individually at any time.

The operational measured values and the measured values of the fundamental components and symmetrical components (see Equipment Manual) are calculated every 9 cycles (at 50 Hz, this is every 180 ms). However, this can mean that the data are not synchronized with the sampled values of the analog channels. The recording of these measured values can be used to analyze the slowly changing processes.

3.1.5.4 Ground-Fault Log

Ground-fault indications are events which arise during a ground fault. They are logged in the ground-fault log with real-time stamp and relative-time stamp (reference point: ground-fault occurrence) . Ground faults are numbered consecutively in rising order. A maximum of 10 ground-fault logs are stored and for each ground-fault log, it is guaranteed that at least 100 indications are recorded.

The following functions can start the logging of a ground fault with the raising ground-fault indication:

- **Directional sensitive ground-fault protection for deleted and isolated systems** (67Ns)
- **Sensitive ground current protection with I0** (50Ns/51Ns)
- **Intermittent ground-fault protection**

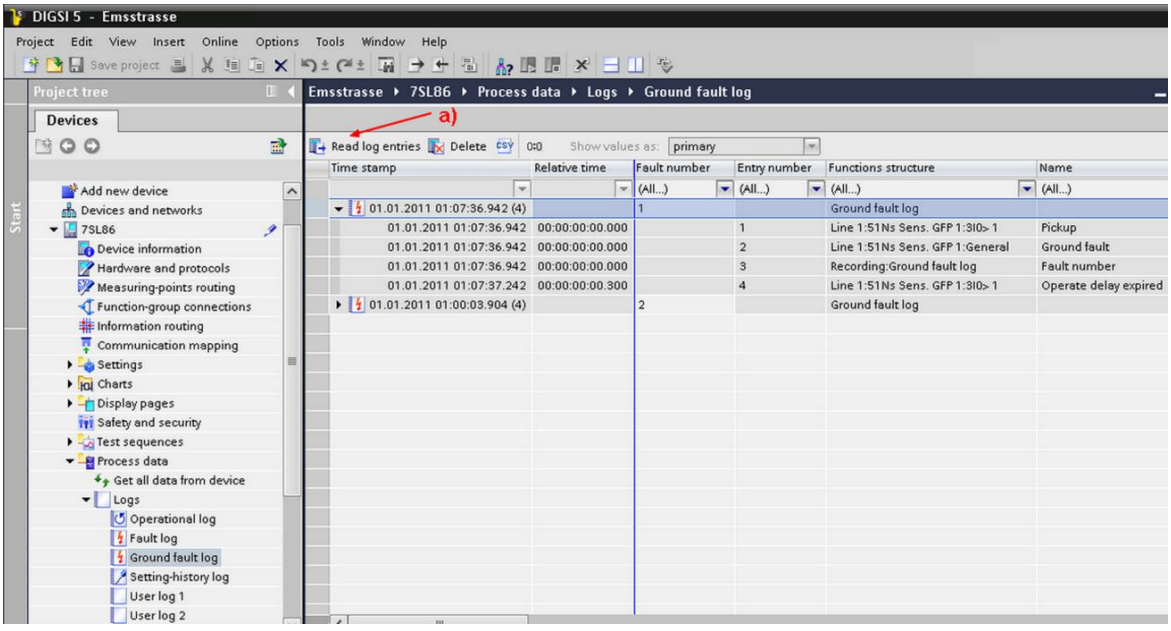
The logging ends with the going ground-fault indication.

Reading from the PC with DIGSI 5

- To reach the ground-fault log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process data → Logs → **Ground-fault log**

The status of the device-diagnosis log last loaded from the ground-fault log is shown to you.

- To update (synchronization with the device) click the button **Read log entries** in the headline of the indication list (*Figure 3-8* a)).



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Figure 3-8 Reading the Ground-Fault Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the ground-fault log from the main menu, use the navigation keys of the on-site operation panel.

  Main Menu → Indications → **Ground-fault indication**

- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

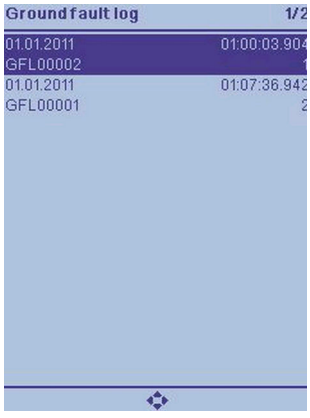


Figure 3-9
Reading the Ground-Fault Log on the On-Site Operation Panel of the Device

Deletability

The ground-fault log of your SIPROTEC 5 device can be deleted. Read about it in chapter *3.1.6 Saving and Deleting the Logs*.

Configurability

The indication scope of the ground-fault log is configured in a specifically defined column of the information routing (matrix) of DIGSI 5:

Target → Log → Column **Ground-fault log**

Selected application templates and functions from the library already bring a predefined set of operational indications with them which you can adjust individually at any time.

3.1.5.5 User Log

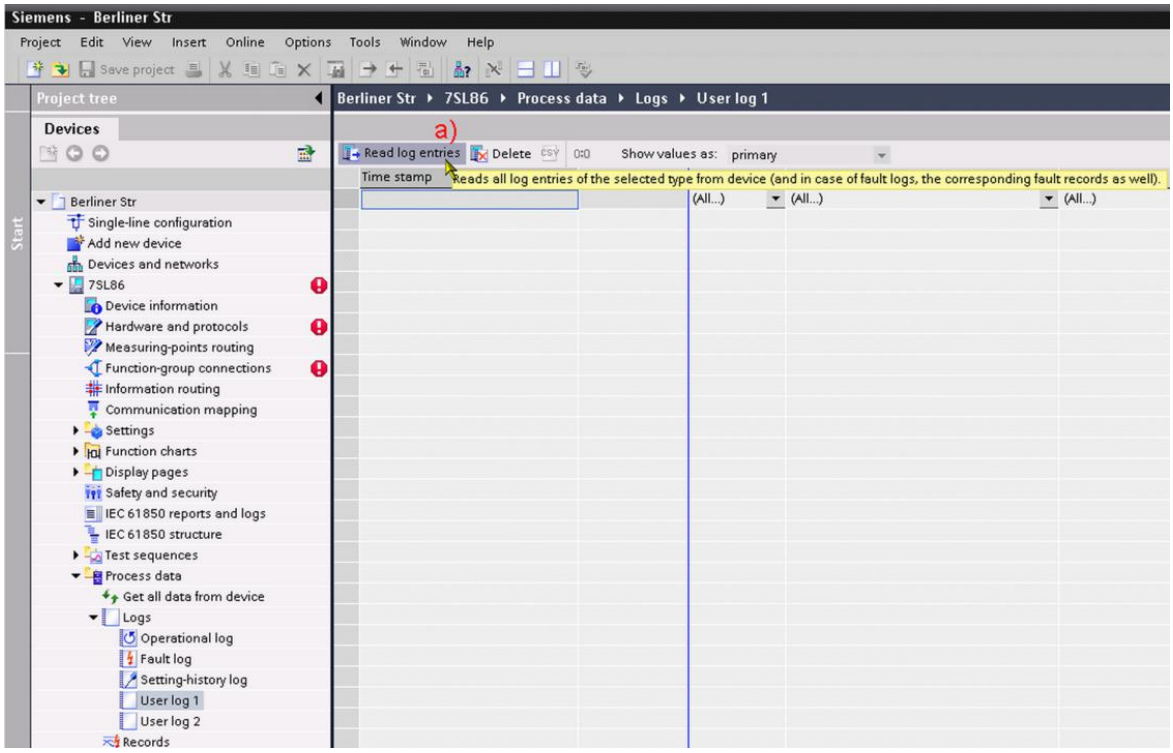
With the user-defined log (up to 2), you have the possibility of individual indication logging parallel to the operational log. This is helpful, for example, in special monitoring tasks but also in the classification into different areas of responsibility of the logs. Up to 200 indications can be stored in the user-defined log.

Reading from the PC with DIGSI 5

- To reach the user-defined log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process Data → Log → **User log 1/2**

The status of the user-defined log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button **Read log entries** in the headline of the indication list (*Figure 3-10* a)).



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Figure 3-10 Reading the User-Defined Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach user-specific logs from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Indications → **User-defined log 1/2**

You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

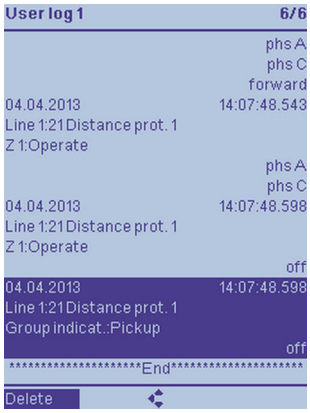


Figure 3-11
Reading the User-Defined Log on the On-Site Operation Panel of the Device

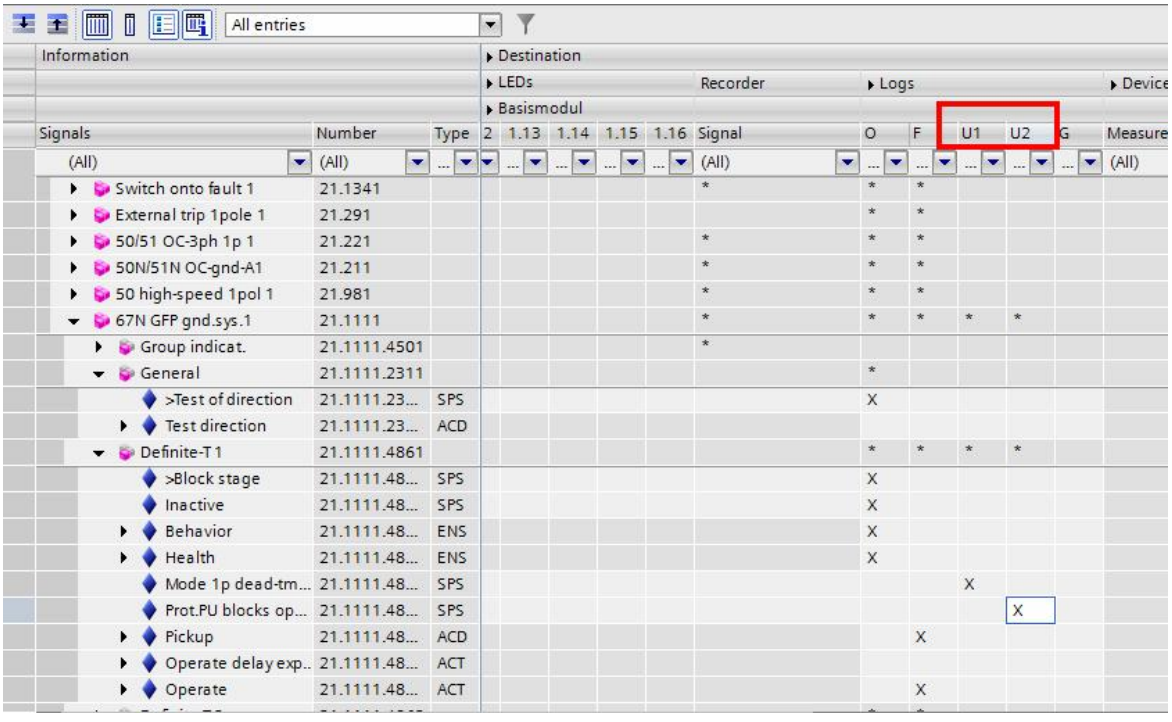
Deletability

The user-defined log of your SIPROTEC 5 device can be deleted. Read about it in chapter *3.1.6 Saving and Deleting the Logs*.

Configuration of a User-Defined Log

The indication capacity of a created user-defined log can be configured freely in the associated column of the information routing (matrix) of DIGSI 5:

Target → Log → U1 or U2



[scdiu1u2-280415-01, 1, en_US]

Figure 3-12 Indication Configuration in DIGSI 5 (Example: User-Defined Log U1/2)

3.1.5.6 Setting-History Log

All individual setting changes and the downloaded files of entire parameter sets are recorded in the log for setting changes. This enables you to determine setting changes made are associated with events logged (for

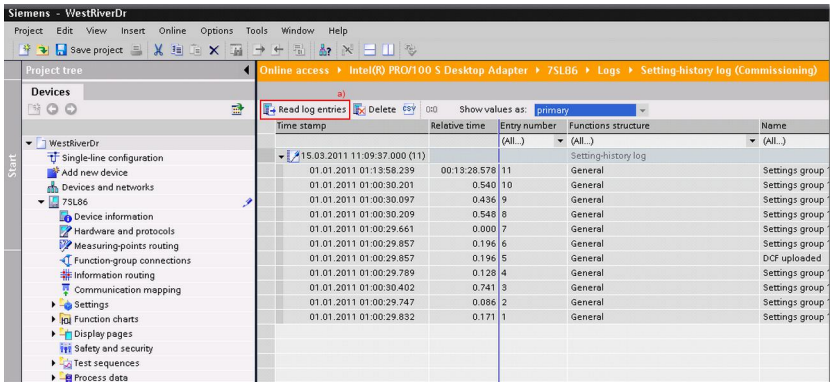
example, faults). On the other hand, it is possible to prove with fault analyses, for example, that the current status of all settings truly corresponds to their status at the time of the fault. Up to 200 indications can be stored in the setting-history log.

Reading from the PC with DIGSI 5

- To reach the log for setting changes of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process Data → Log → **Setting changes**

The status of the setting-history log last loaded from the device is shown to you.

- To update (synchronization with the device), click the **Read log entries** button in the headline of the indication list (*Figure 3-13*).



[scparamd-030211-01, 1, en_US]

Figure 3-13 Reading the Setting-History Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the setting-history log from the main menu, use the navigation keys of the on-site operation panel.
  Menu → Indications → **Setting changes**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

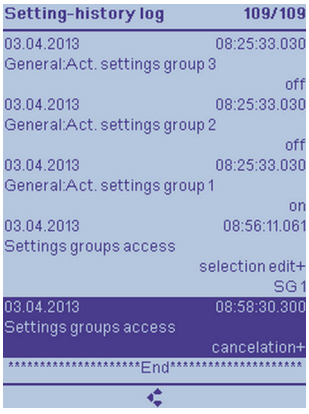


Figure 3-14
Reading the Setting-History Log on the On-Site Operation Panel of the Device

Indication Categories in the Setting-History Log

For this log, there is selected information that is stored in case of successful as well as unsuccessful setting changes. The following list gives you an overview of this information.

Table 3-3 Overview of Indication Types

Displayed Information	Explanation
Selection editing+	Selection of settings group to be edited
Reject+	Rejection of all changes successful
PG activation+	PG activation via command successful
PG activation-	PG activation via command failed
set+	Parameter value was changed
Acceptance+	Acceptance of change successful
Acceptance-	Acceptance of change failed
DCF loaded	DCF loaded into device
SG 1	Settings group 1
SG 2	Settings group 2
SG 3	Settings group 3
SG 4	Settings group 4
SG 5	Settings group 5
SG 6	Settings group 6
SG 7	Settings group 7
SG 8	Settings group 8

Example of Logging in Setting-History Log

For this log, there is selected information that is stored in case of successful as well as unsuccessful setting changes. The following list gives you an overview of this information.



From top downward:

- In the example at the left, a device has started with the active settings group 1.
- Then the settings group 1 is selected for changes.
- The individual parameter for phase-rotation reversal was changed.
- The changes were successfully accepted.

NOTE

- The logged indications are preconfigured and cannot be changed!
- This log, which is organized as a ring buffer. cannot be deleted by the user!
- If you want to archive security-relevant information without loss of information, you must regularly read this log.
- You cannot route additional indication objects to the setting-history log.

3.1.5.7 Communication Log

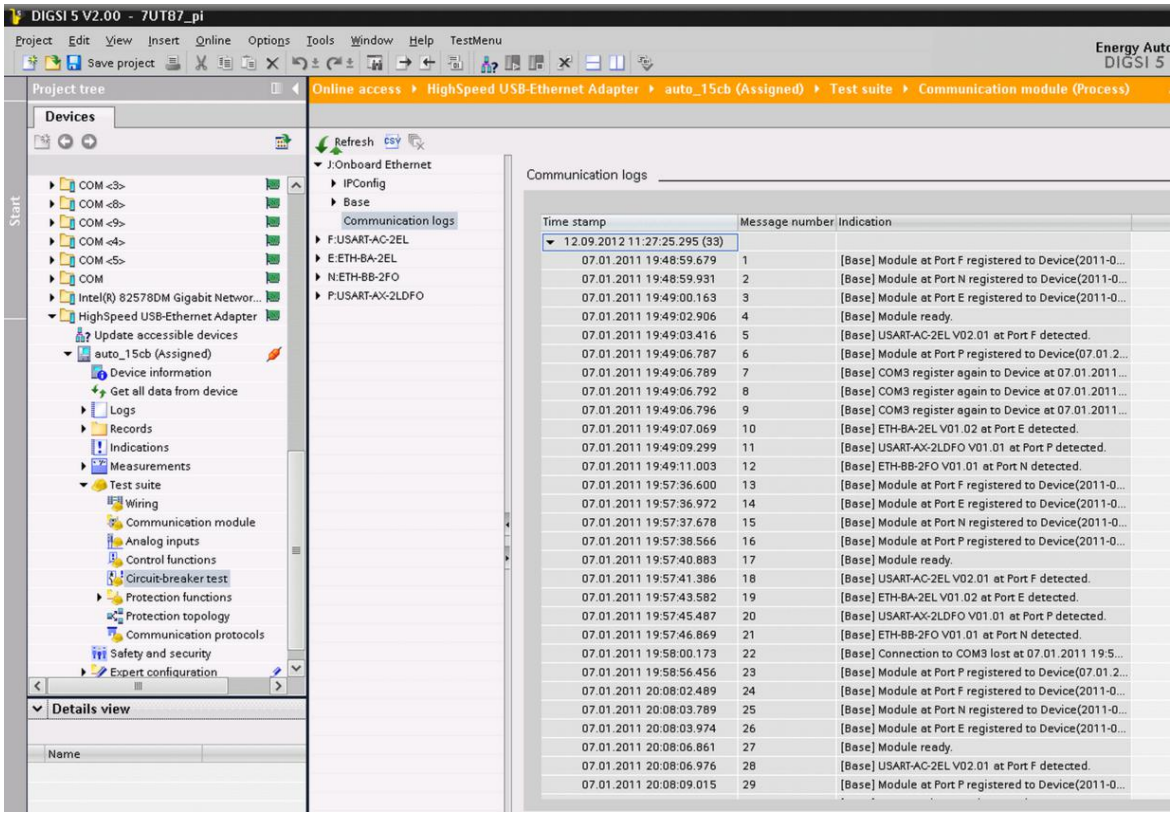
The logging of the respective status such as ensuing faults, test and diagnosis operation, and communication capacity utilizations is done for all hardware-based configured communication interfaces. Up to 500 indications can be stored in the communication log. Logging occurs separately for each communication port of the configured communication modules.

Reading from the PC with DIGSI 5

- Use the project-tree window to reach the communication logs of your SIPROTEC 5 device.
  Online access → USB → Project → Test suite → Communication module
- Then select:
  J:Onboard Ethernet → **Communication log**

The status of the communication log last loaded from the device is shown to you under the Time stamp item.

- To update (synchronization with the device) click the button **Update** in the headline of the indication list.



[sccompuf-140912-01, 1, en_US]

Figure 3-15 Reading the Communication Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the communication log from the main menu, use the navigation keys on the on-site operation panel.
  Main Menu → Test & Diagnosis → Indications → **Communication log**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

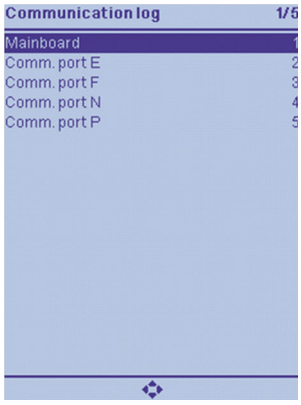


Figure 3-16
Reading the Communication Log on the On-Site Operation Panel of the Device

Deletability

The communication logs of your SIPROTEC 5 device can be deleted. Read details about this in chapter *3.1.6 Saving and Deleting the Logs*.

Configurability

The communication logs are not freely configurable. The entries are preconfigured.

3.1.5.8 Security Log

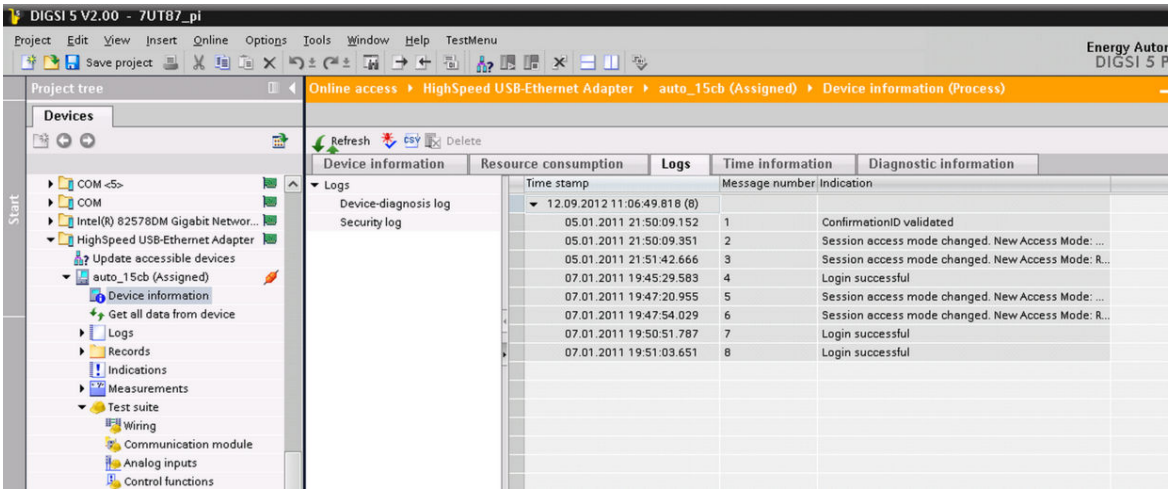
Access to areas of the device with restricted access right is recorded in the security log. Unsuccessful and unauthorized access attempts are also recorded. Up to 500 indications can be stored in the security log.

Reading from the PC with DIGSI 5

- To reach the security log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Device Information → Log → **Security log**

The status of the security log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button **Update** in the headline of the indication list.



[scsecmld-140912-01, 1, en_US]

Figure 3-17 Reading the Communication Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the security log from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Test & Diagnosis → Indications → **Security log**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

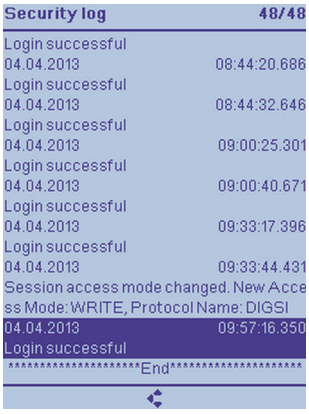


Figure 3-18
Reading the Security Log on the On-Site Operation Panel of the Device

NOTE

- The logged indications are preconfigured and cannot be changed!
- This log, which is organized as a ring buffer. cannot be deleted by the user!
- If you want to archive security-relevant information without loss of information, you must regularly read this log.

3.1.5.9 Device-Diagnosis Log

The logging and the display of concrete instructions are done in the device-diagnosis log during

- Required maintenance (for example, battery supervision)
- Identified hardware defects
- Compatibility problems

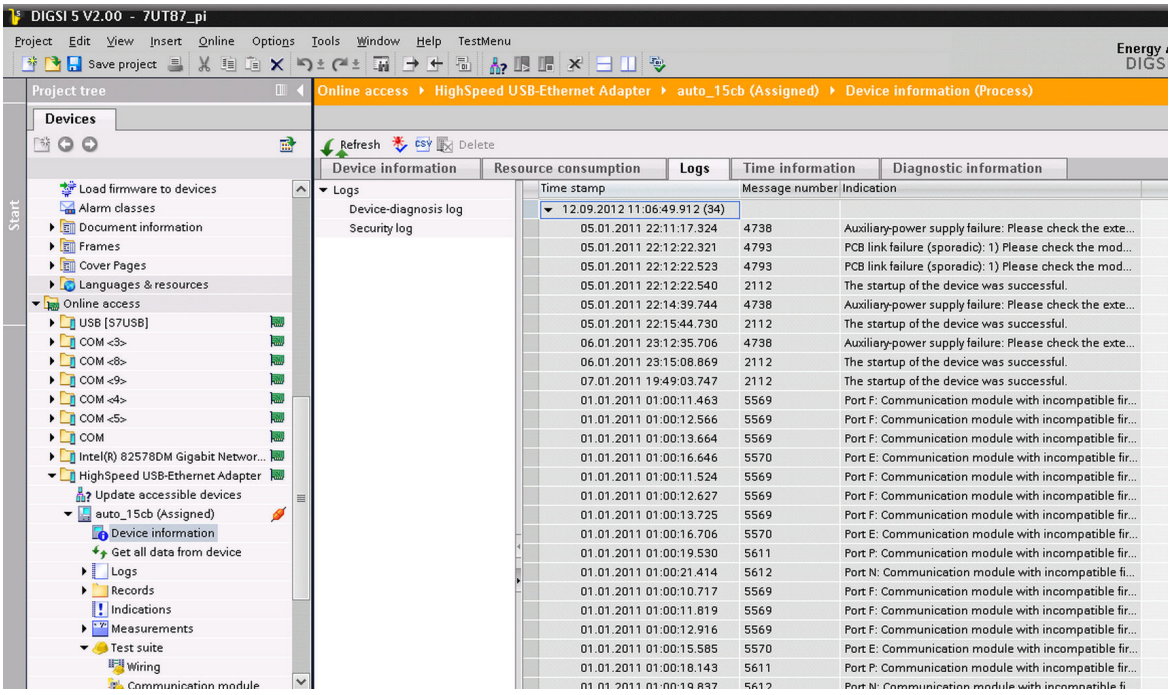
Up to 500 indications can be stored in the device-diagnosis log. In normal operation of the device, it is sufficient for diagnostic purposes to follow the entries of the operational log. This specific significance is assumed by the device-diagnosis log when the device is no longer ready for operation due to hardware defect or compatibility problems and the fallback system is active.

Reading from the PC with DIGSI 5 in Normal Operation

- To reach the device-diagnosis log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Device Information → Log → **Device-diagnosis log**

The status of the device-diagnosis log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button **Update** in the headline of the indication list.



[scdevdia-140912-01, 1, en_US]

Figure 3-19 Reading the Device-Diagnosis Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel in Normal Operation

- To reach the diagnosis log from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Test & Diagnosis → Indications → **Device diagnosis**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.



Figure 3-20
Reading the Device-Diagnosis Log on the On-Site Operation Panel of the Device

NOTE

- The device-diagnosis log cannot be deleted!
- The logged indications are preconfigured and cannot be changed!

3.1.6 Saving and Deleting the Logs

Deleting the logs of the device in the operating state is unnecessary. If storage capacity is no longer sufficient for new indications, the oldest indications are automatically overwritten with new incoming events. In order for the memory to contain information about the new faults in the future, for example, after an inspection of the system, a deletion of the log makes sense. Resetting the logs is done separately for the various logs.

NOTE

Before you delete the content of a log on your SIPROTEC 5 device, save the log with DIGSI 5 on the hard disk drive of your PC.

NOTE

Not all logs of your SIPROTEC 5 device can be deleted. These limitations apply especially to logs with relevance for security and after-sales (security log, device-diagnosis log, setting-history log).

NOTE

Upon deletion of the fault log, the associated fault records are also deleted. In addition, the meters for fault number and fault-record number are reset to 0. In contrast, if you delete fault records, the content of the fault log, including the allocated fault numbers, remains.

NOTE

If the device executes an initial start, for example, after an update of the device software, the following logs are automatically deleted:

- Operational log
- Fault log
- Ground-fault log
- Setting-history log
- User log
- Motor-startup log

Back up the deletable logs using DIGSI 5.

NOTE

If a ground fault is currently active, the ground-fault log cannot be deleted.

Deleting Logs on the On-Site Operation Panel

- To reach the selected log from the main menu, use the navigation keys of the on-site operation panel (example operational log):
  Main Menu → Indications → **Operational log**

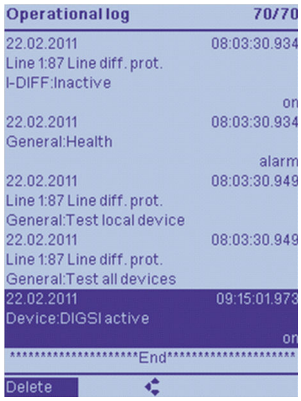


Figure 3-21
Deleting the Operational Log on the On-Site Operation Panel

- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.
- The option to delete the entire log is offered to you in the footer of the display at the bottom left. Use the softkeys below under the display to activate the command prompts. Confirm the request to **Delete**.
- After being prompted, enter the password and confirm with **Enter**.
- After being prompted, confirm the **Deletion of all entries** with **Ok**.

Deleting Logs from the PC with DIGSI 5

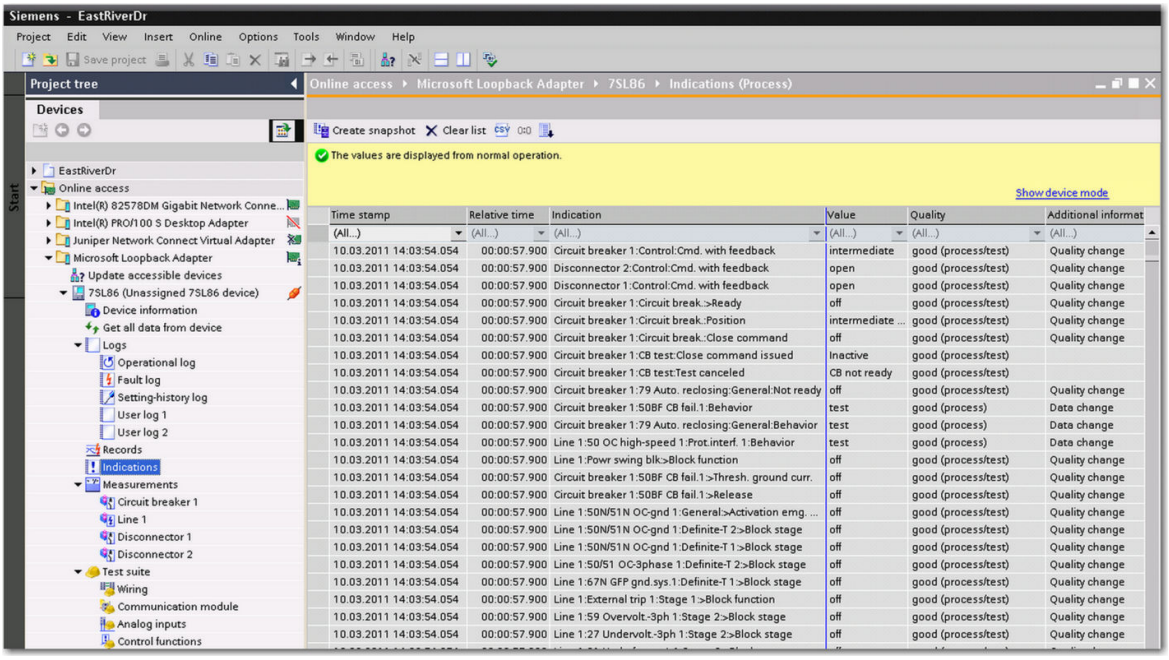
- To reach the selected log of your SIPROTEC 5 device, use the project-tree window (for example, operational log).
  Project → Device → Process data → Logs → **Operational log**

3.1.7 Spontaneous Indication Display in DIGSI 5

With DIGSI 5 you have the possibility of displaying all currently transmitted indications of the selected device in a special indication window.

Procedure

- Call up the spontaneous indications of your selected device in the navigation window under Online access.
- Click **Indications** in the path:
  Online access → Interface → Device → **Indications**
- The raising indications appear immediately without you having to wait for a cyclical update or initiate the manual update.



[scspnmld-230211-01, 1, en_US]

Figure 3-22 Displaying Spontaneous Device Indications in DIGSI 5

3.1.8 Spontaneous Fault Display on the On-Site Operation Panel

After a fault, the most important data of the last fault can be displayed automatically on the device display without further operational measures. In SIPROTEC 5 devices, protected objects and even circuit breakers can be freely created and configured depending on the application (even several instances). In DIGSI 5, several spontaneous fault displays can be configured, depending on the application, with each individual one being assigned a particular circuit breaker. These displays remain stored in the device until they are manually confirmed or reset by LED reset.

Configuration of a Spontaneous Fault Display with DIGSI 5

- To reach the **Fault-display configuration** of your SIPROTEC 5 device, use the project-tree window. Project → Device → Display pages → **Fault-display configuration**
- In the main window, all configured circuit breakers are displayed. A list of a maximum of 6 configurable display lines is offered for each circuit breaker. The activation of a spontaneous fault display occurs for each circuit breaker by selection via checkmark in the column **Display**.
- With the parameter **`(_:139) Fault-display`** (under Device → Parameter → Device settings) you determine whether spontaneous fault displays should be displayed for each pickup or only pickups with the off command.

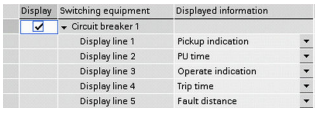


Figure 3-23 Configuration of the Spontaneous Fault Display on the Device

For every display line the following display options can be selected:

Table 3-4 Overview of Display Options

Displayed Information	Explanation
Pickup indication	Display of the first function stage picked up in a fault, as needed with additional information (phases, ground, direction).
PU time	Display of the entire pickup duration of the fault.
Operate indication	Display of the first function stage triggered in a fault, as needed with additional information (phases).
Trip time	Display of the operate time related to the beginning of the fault (pickup start).
Fault distance	Display of the measured fault-location distance.

Acknowledgement of the Spontaneous Fault Display on the Device

After faults, the last occurred fault is always displayed to you. In cases where more than one circuit breaker is configured, several stored fault displays can be present after faults, with the latest being displayed. These displays remain stored in the device until they are manually acknowledged or reset by LED reset.

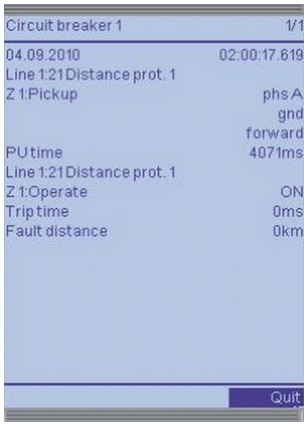


Figure 3-24
Spontaneous Fault Display on the Device

Method 1: Manual acknowledgement

- Press the softkey button **Quit** in the base bar of the display. The display is irretrievably closed. Repeat this step until no spontaneous fault display appears anymore.
- After completion of all confirmations the last display view is showed before the faults.

Method 2: Acknowledgement via LED reset

- An LED reset (device) causes the reset of all stored LEDs and binary output contacts of the device and also to the confirmation of all fault displays stored in the display.

You can find more details on the topic of LED reset in chapter *3.1.9 Stored Indications in the SIPROTEC 5 Device*.

3.1.9 Stored Indications in the SIPROTEC 5 Device

In your SIPROTEC 5 device, you can also configure indications as **stored**. This type of configuration can be used for LEDs as well as for output contacts. The configured output (LED or contact) is activated until it is acknowledged. Acknowledgment occurs via:

- On-site operation panel
- DIGSI 5

- Binary input
- Protocol of substation automation technology

Configuration of Stored Indications with DIGSI 5

- In the **Information Routing** of each device set up in DIGSI 5, you can route binary signals, among others, to LEDs and output contacts. For this, go to the project tree.
  Project → Device → **Information routing**
- Right-click the routing field of your binary indication in the desired LED or binary output column in the routing range of the targets.

You are offered the following options:

Table 3-5 Overview of Routing Options

Routing Options		LEDs	BOs	BIs	Description
H	(active)			X	The signal is routed as active with voltage.
L	(active)			X	The signal is routed as active without voltage.
V	(unlatched)	X	X		The signal is routed as unlatched. Activation and reset of the output (LED, BA) occurs automatically via the binary-signal value.
L	(latched)	X	X		The binary signal is latched when the output (LED) is activated. To reset, a targeted confirmation must occur.
NT	(stored only with tripping)	X			Fault indications are stored when the output (LED) is activated. If the fault is ended via a trip command from the device, the stored state is maintained. In case of dropout of the pickup without trip command from the device (for example, external fault), the state displayed before the fault is restored. **Note**: Observe here the parameter **(_:91:139) Fault-display** with the setting options ***with trip*** or ***with pickup***. For this routing option, select the setting ***with trip***.
TL	(stored only with tripping)		X		Routing option TL (tripping stored) is only possible for the switching object circuit breaker. The output is saved with protection tripping. The contact remains activated until acknowledged. Control commands are not affected. A control command is pending above the parameterized command period until feedback has been successfully received. **Note**: You can realize the functionality of the **Lockout** (ANSI 86) by storing the output relay with the routing option TL.

Acknowledgment of Stored Indications on the On-Site Operation Panel

Acknowledgment via **LED Reset**

Operating the button first causes the activation of all LEDs (LED test) when pressed, and when released the resetting of all stored indications. Stored LEDs, output contacts and spontaneous fault displays are reset.

Acknowledgment via the operating menu

Use the navigation buttons of the on-site operation panel, in order to reach the reset functions from the main menu.

- Select: Main menu → Device functions → **Reset functions**
  You are offered different reset options.
- Open the corresponding submenu.



Figure 3-25 Reset Functions on the On-Site Operation Panel

- Use **Res. binary outputs** to reset stored output contacts.
- Actuate the softkey **Start** in the base bar.
- As needed, enter the confirmation ID when requested and then confirm with the softkey **Enter**.
- Use **Reset LEDs not in FG** to reset stored LEDs that are not assigned to a special function group.
- Actuate the softkey **Start** in the base bar.
- As needed, enter the confirmation ID when requested and then confirm with the softkey **Enter**.

Depending on device configuration, the protection function group(s) are displayed to you as submenus for which separately corresponding, stored LEDs can be reset.

- Go to the submenu of the selected function group (example **Line 1**).
- Use **Reset LEDs** to reset stored LEDs in the selected function group.
- Actuate the softkey **Start** in the base bar.
- As needed, enter the confirmation ID when requested and then confirm with the softkey **Enter**.

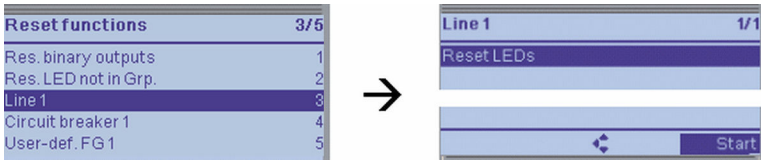


Figure 3-26 Reset Functions on the On-Site Operation Panel (for Example, Line FG)

Acknowledgment of Stored Indications via Binary Inputs

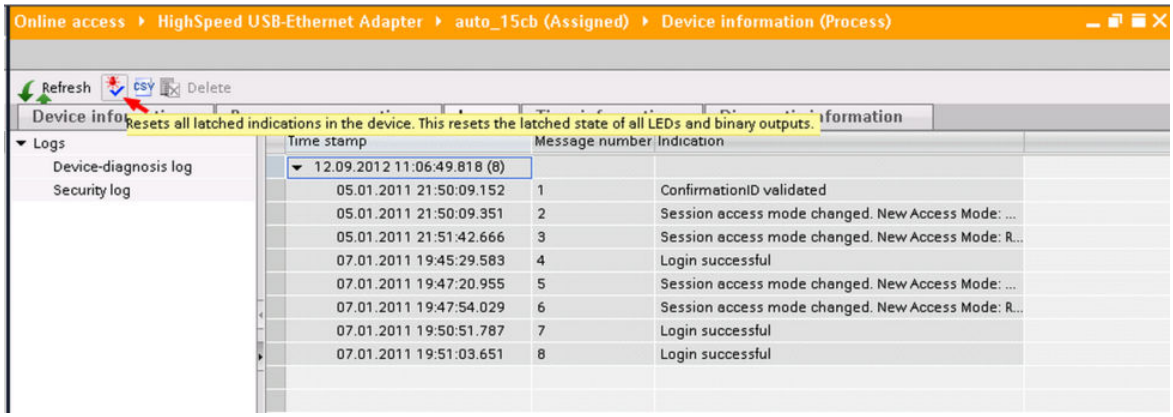
Acknowledgment via entry **>LED Reset**

Acknowledgment via binary input **>LED-Reset** brings about the activation of all LEDs (LED test) and, in case of dropout of signal, the resetting of all stored indications. Stored LEDs, output contacts and spontaneous fault displays are reset.

Acknowledgment of Stored Indications with DIGSI 5

You can acknowledge stored indications via DIGSI 5 in online mode. For this, go to the project tree.

- Select Online access → Interface → Device → **Device information**



[scquiled-140912-01, 1, en_US]

Figure 3-27 LED Reset via DIGSI 5

- Click the LED reset button.
- Enter the confirmation ID.
- Confirm the process with OK.

Stored LEDs, output contacts and spontaneous fault displays are reset on the assigned device.

Acknowledgment of Stored Indications via Log

Initiation of acknowledgment of stored indications can also occur through communication via a connected substation automation technology. This can occur in conformance to standards (IEC 61850, IEC 60870-5-103) or via configuration (mapping) of the LED reset input signal for any protocol. Stored LEDs, output contacts, and spontaneous fault displays are reset.

NOTE

The acknowledgment of **stored** indications then leads to the resetting of configured LEDs and output contacts, as long as these active unstored indications are not present in parallel. That is, indications configured as **unstored** are not affected by the acknowledgment process.

3.1.10 Resetting Stored Indications of the Function Group

You can configure indications of individual functions as "stored" in a function group. This type of configuration can be used for LEDs as well as for output contacts. The configured output (LED or contact) is activated until it is acknowledged.

The protection and the circuit-breaker function groups contain the block **Reset LED FG**. The block **Reset LED FG** is visible only in the Information routing under the corresponding function group in DIGSI 5. You use the binary input signal *>Reset LED* to reset the stored LEDs in the respective function group. The configured outputs (contacts) are not reset.

3.1.11 Test Mode and Influence of Indications on Substation Automation Technology

If the test mode of the device or of individual functions is switched on, the SIPROTEC 5 device marks indications sent to substation automation technology station control system with an additional test bit. This test bit makes it possible to determine that an indication was set during a test. Necessary reactions in normal operation on the basis of an indication can thus be suppressed.

3.2 Measured-Value Acquisition

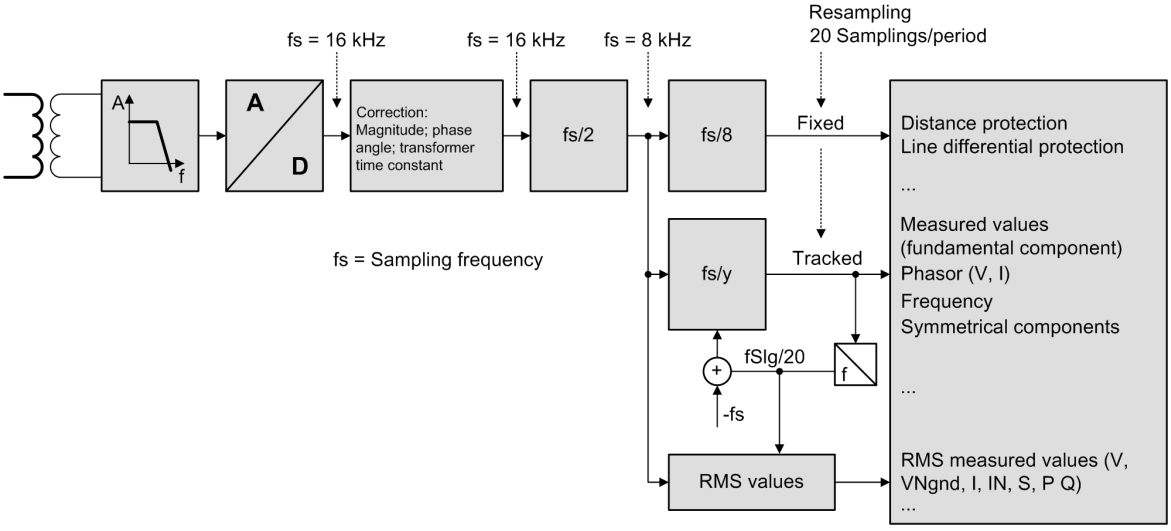
Basic Principle

SIPROTEC 5 devices are equipped with a powerful measured-value acquisition function. In addition to a high sampling frequency, they have a high measurand resolution. This ensures a high degree of measuring accuracy across a wide dynamic range. The 24-bit sigma/delta analog-digital converter represents the core of measured-value acquisition. In addition, the oversampling function supports the high measurand resolution. Depending on the requirements of the individual method of measurement, the sampling frequency is reduced (**Downsampling**).

In digital systems, deviations from the rated frequency lead to additional errors. In order to avoid this, 2 algorithm-dependent processes are used in all SIPROTEC 5 devices:

- Sampling-frequency tracking:
  The analog input channels are scanned for valid signals in cycles. The current power frequency is determined and the required sampling frequency is defined by using a **resampling algorithm**. The tracking is effective in the frequency range between 10 Hz and 80 Hz.
- Fixed sampling frequency – correction of the filter coefficients:
  This method operates in a limited frequency range (f_{rated} +/- 5 Hz). The power frequency is determined and, depending on the degree of the frequency deviation, the filter coefficients are corrected.

The following figure shows the basics of dealing with sampled values (SAV) in the measured-value acquisition chain. *Figure 3-28* shows to whom the various sampling frequencies are made available. In order to limit the bandwidth of the input signals, a low-pass filter (anti-aliasing filter to maintain the sampling theorem) is installed downstream. After sampling, the current input channels are adjusted. This means the magnitude, phase, as well as the transformer time constant are corrected. The compensation is designed to ensure that the current transformer terminal blocks can be exchanged randomly between the devices.



[dwmeserf-250211-01.tif, 1, en_US]

Figure 3-28 Measured-Value Acquisition Chain

The internal sampling frequency of the SIPROTEC 5 devices is fixed at 16 kHz (sampling rate: 320 samplings per 50-Hz cycle). All current and voltage inputs are sampled. If the magnitude, phase, and transformer time constant are corrected, the sampling frequency is reduced to 8 kHz (160 samplings per 50-Hz cycle). This is the basic sampling frequency to which various processes, such as fault recording, RMS measured values, refer. For the RMS measurement, the measured-value window is adjusted on the basis of the power frequency. For numerous measurement and protection applications , 20 samplings per cycle are sufficient (if f_{rated} = 50 Hz: sampling every 1 ms, at f_{rated} = 60 Hz: sampling every 0.833 ms). This sampling rate is an adequate compromise between accuracy and the parallel processing of the functions (multi-functionality).

The 20 samplings per cycle will be made available to the algorithms processed in the function groups, in 2 variants:

- Fixed (not resampled)
- Resampled (frequency range from 10 Hz to 80 Hz)

Depending on the algorithms (see function descriptions), the respective data flow is considered. A higher sampling frequency is used for selected methods of measurement. Detailed information can be found in the corresponding function description.



NOTE

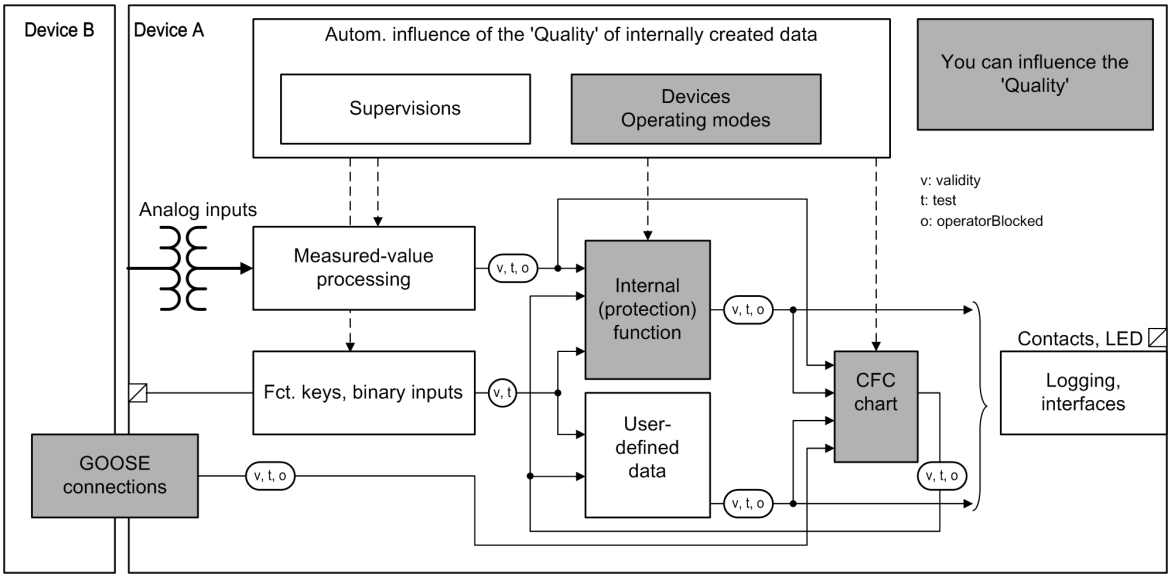
The measuring points for current and voltage are in the **Power-system data** (starting in chapter *6.1 Power-System Data*). Each measuring point has its own parameters.

3.3 Processing Quality Attributes

3.3.1 Overview

The IEC 61850 standard defines certain quality attributes for data objects (DO), the so-called Quality. The SIPROTEC 5 system automatically processes some of these quality attributes. In order to handle different applications, you can influence certain quality attributes and also the values of the data objects on the basis of these quality attributes. This is how you can ensure the necessary functionality.

The following figure describes roughly the general data flow within a SIPROTEC 5 device. The following figure also shows at which points the quality can be influenced. The building blocks presented in the figure are described in more detail in the following.



[loquali1-090212-02.tif, 2, en_US]

Figure 3-29 Data Flow within a SIPROTEC 5 Device

Supported Quality Attributes

The following quality attributes are automatically processed within the SIPROTEC 5 system.

- **Validity** using the values *good* or *invalid*

  The **Validity** quality attribute shows if an object transferred via a GOOSE message is received (valid, invalid) or not received (invalid). The *invalid* state can be suppressed in the receiver device by also setting a substitute value for the object that is not received (see *Figure 3-30*). The substitute value is forwarded to the functions.

  If the device receives one of these values, it is replaced by the *invalid* value and thus processed further as *invalid*.

  If one of the detailed quality attributes (detailQual) has the value *TRUE*, then **Validity** is set to the *invalid* value, unless this was already done at the transmitter end.

- **Test** using the values *TRUE*, *FALSE*

  The **Test** quality attribute indicates to the receiver device that the object received via a GOOSE message was created under test conditions and not operating conditions.

- **OperatorBlocked** using the values *TRUE*, *FALSE*

  The **OperatorBlocked** quality attribute indicates whether an object transferred via GOOSE message originates from a device that is in a *functional logoff* state. When the sending device is switched off, the object is no longer being received and assumes the *invalid* state. However, since the **OperatorBlocked** quality was previously identified on the receiver device, the object can be treated differently at the receiving end (see chapter *3.3.2 Quality Processing/Affected by the User for Received GOOSE Values*). At the receiving end, the object may be treated like a dropped signal.

- **Source** using the values *process*, *substituted*

  The **Source** quality attribute indicates whether the object was updated in the sending device.

  You can find more detailed information in chapter *3.8.2 Acquisition Blocking and Manual Updating*.

Influencing Quality by the Operating Modes

In addition to the normal operation, the device also supports further operating modes that influence quality:

- **Test mode of the device**

  You can switch the entire device to test mode. In this case, all data objects generated in the device (state values and measured values) receive the quality attribute **Test** = *TRUE*.

  The CFC charts are also in test mode and all output data receive the quality attribute **Test** = *TRUE*.

- **Test mode for individual functions, stages, or function blocks**

  You can switch individual functions, stages, or function blocks into test mode. In this case, all data objects generated by the function, stage, or function block (state values and measured values) receive the quality attribute **Test** = *True*.

- **Functional logoff of the device**

  If you take the device out of operation and want to isolate it from the supply voltage, you can functionally log off the device ahead of time. Once you functionally log off the device, all data objects generated in the device (state values and measured values) receive the quality attribute **OperatorBlocked** = *TRUE*. This also applies to the output from CFC charts.

  If objects are transferred via a GOOSE message, the receiver devices can assess the quality. The receiver device detects a functional logoff of the transmitting device. After shutting down the sending device, the receiver device identifies that the sending device has been logged off operationally and did not fail. Now the receiving objects can automatically be set to defined states (see chapter *3.3.2 Quality Processing/Affected by the User for Received GOOSE Values*).

- **Switching off individual functions, stages, or function blocks**

  You can switch off individual functions, stages, or function blocks. In this case, all data objects generated by the function, stage, or function block (state values and measured values) receive the quality attribute **Validity** = *invalid*.

Influencing the Quality through Hardware Supervision

Supervision functions monitor the device hardware (see chapter *9.4 Supervision of the Device Hardware*). If the supervision functions identify failures in the data acquisition of the device, all recorded data will receive the quality attribute **Validity** = *invalid*.

Influencing the Quality through Voltage-Transformer Circuit Breakers

If tripping of the voltage-transformer circuit breaker is detected (see chapter *9.3.4 Voltage-Transformer Circuit Breaker*), all recorded data will receive the quality attribute **Validity** = *invalid*.

Influencing the Quality by the User

You can influence the processing of data and their quality differently. In DIGSI 5, this is possible at the following 3 locations:

- In the **Information routing** editor for external signals of GOOSE connections
- In the CFC chart
- In the **Information routing** editor for binary input signals of device-internal functions

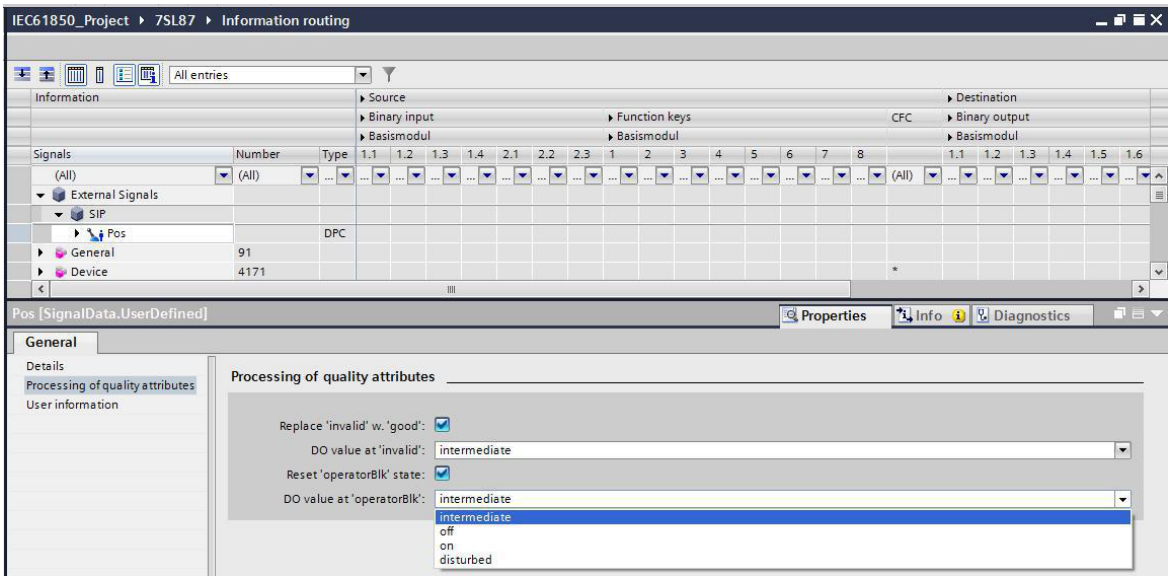
The following chapters describe in more detail the options regarding this influence as well as the automatic quality processing.

If a GOOSE connection is the data source of a binary input signal of a device-internal function, you can influence processing of the quality at 2 locations: at the GOOSE connection and at the input signal of the function. This is based on the following: A GOOSE date can be distributed within the receiving device to several functions. The GOOSE connection setting (influence) affects all functions. However, if different functions require customized settings, these are then set directly at the binary input signal of the function.

3.3.2 Quality Processing/Affected by the User for Received GOOSE Values

In the **Information Routing** editor, you can influence the data value and quality of all data types. The following figure shows the possible influence using the example of an DPC data type.

- In the DIGSI 5 project tree, double-click **Information Routing**.
- Select the desired signal in the **External Signals** group.
- Open the **Properties** window and select the **Processing Quality Attributes** sheet.



[sc_GOOSE values, 1, en_US]

Figure 3-30 Influence Option When Linking an DPC Type Data Object

The setting options work for the device receiving the data.

Quality Attribute: Validity	
The validity values *reserved* and *questionable* are replaced at the receiving end by the *invalid* value.	
• Check box is not set. • Check box is set and receipt of **Validity** = *good*	The validity attribute and data value are forwarded without change.
Check box is set and receipt of **Validity** = *invalid* is set (also applies to values *reserved* and *questionable*).	• The validity attribute is set to *good* and processed further using this value. • The data value is set to the defined substitute value and processed further using this substitute value.

Quality Attribute: OperatorBlocked (opBlk)	
• Check box is not set. • Check box is set and received **OperatorBlocked** = *FALSE*	The OperatorBlocked attribute and data value are forwarded without change.

Quality Attribute: OperatorBlocked (opBlk)	
Check box is set and received **OperatorBlocked** = *TRUE*	• The OperatorBlocked attribute is set to *FALSE* and processed further using this value. • The data value is set to the defined substitute value and processed further using this substitute value.

Interaction of the Quality Attribute Validity and OperatorBlocked	
OperatorBlocked check box is set and receipt of **OperatorBlocked** = *TRUE*	Regardless of whether the validity check box is set or not, and regardless of the current validity, the validity attribute is set to *good* and the substitute value of the OperatorBlocked data object is set. That is, the OperatorBlocked settings overwrite the Validity settings.
OperatorBlocked check box is not set and receipt of **OperatorBlocked** = *TRUE*	The OperatorBlocked attribute remains set and is forwarded. If the Validity check box is set and the receipt of validity = *invalid* is set, the respective data object substitute value is used. For continued signal processing and influence, it must be taken into account that in this configuration the data object substitute value for validity = *invalid* is set, but the quality attribute OperatorBlocked is not yet set.

Data Substitute Values

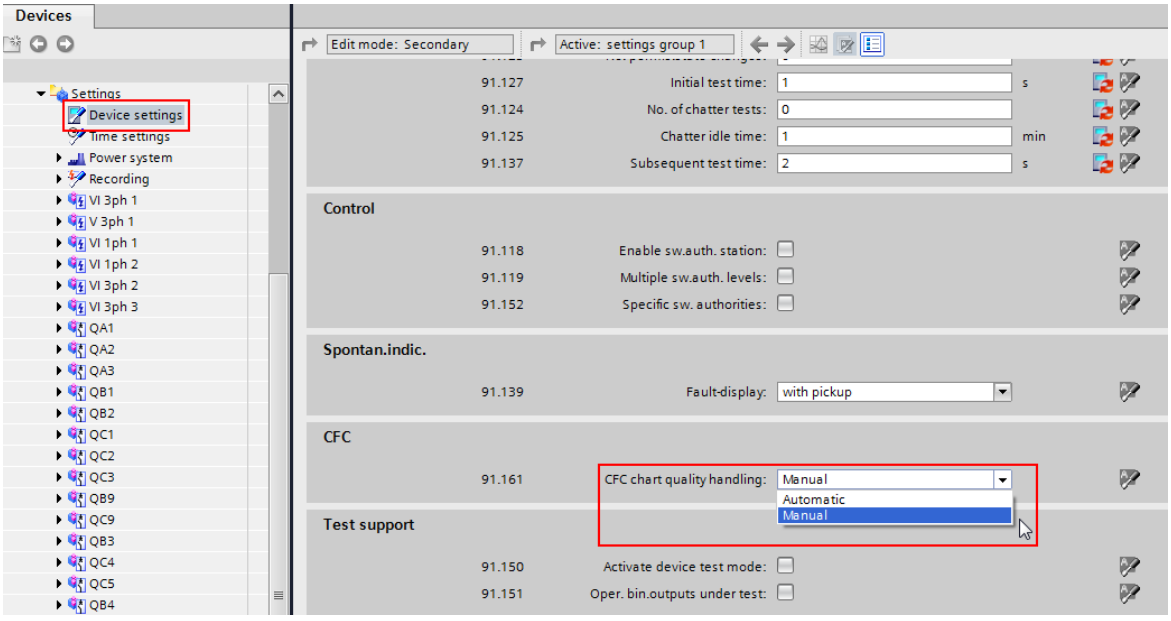
Depending on the data type, different data substitute values must be used.

Data Type	Possible Data Substitute Values	
ACD, ACT	general, phsA, phsB, pshC, neut	0 (False), 1 (True)
only ACD	dirGen	0, 1, 2, 3 (Unknown, Forward, Backward, Both)
	dirPhsA, dirPhsB, dirPhsC, dirNeut	0, 1, 2 (Forward, Backward, Both)
BAC, APC	mxVal	$1.401298 \cdot 10^{-45}$ to $7.922 \cdot 10^{28}$
	stSeld	0 (False), 1 (True)
	ctlNum	1 to 255
BCR	actVal, frVal, frTm	0 to 1 073 741 824
CMV	mag, ang	$1.401298 \cdot 10^{-45}$ to $7.922 \cdot 10^{28}$
DPC, DPS	stVal	0, 1, 2, 3 (intermediate-state, off, on, bad-state)
ENUM types (for example, ENS, EN, ENC)	SPS output	0 (False), 1 (True)
	INS output	The qualities of the object of the sending device are taken on.
INC	stVal	0 to 1 073 741 824
	stSeld	0 (False), 1 (True)
ING	setVal	0 to 1 073 741 824
INS	stVal	0 to 1 073 741 824
ISC, BSC	vWTpos	-64 to 64
	vWTInd	0 (False), 1 (True)
SEC	cnt	0 to 1 073 741 824
SPC, SPS	stVal	0 (False), 1 (True)
SPG	setVal	0 (False), 1 (True)

Data Type	Possible Data Substitute Values	
MV	mag	$1.401298 \cdot 10^{-45}$ to $7.922 \cdot 10^{28}$

3.3.3 Quality Processing/Affected by the User in CFC Charts

In DIGSI 5, you can control the quality processing of CFC charts. In the project tree, you can find the **CFC** block (see the following figure) under **Device name** → **Settings** → **Device settings** in the editor:



[sc quali cfc, 1, en_US]

Figure 3-31 Influencing CFC Quality Handling in DIGSI 5

With the **`CFC chart quality handling`** parameter, you control whether you want to influence the quality of CFC charts in a ***`Manual`*** or ***`Automatic`*** (default setting) manner.

If you select ***`Manual`***, the quality attribute of the CFC chart is always valid regardless of the quality of individual signals (**Validity** = ***good***)!

Only the **Test** quality attribute of the CFC chart is processed. If the device is in test mode or the input TEST of the CHART_STATE CFC block is set, the quality attribute of the CFC chart is set to ***`Test`***.

If you select ***`Automatic`***, the quality processing of the CFC charts is influenced as follows:

In the case of CFC charts, a distinction has to be made between the general quality processing and certain CFC blocks that are specifically designed for quality processing.

General Processing

Most of the CFC blocks do not have an explicit quality processing. For these blocks, the following general mechanisms shall apply.

Quality Attribute: Validity
If one *invalid* signal is received in the case of CFC input data, then **all** CFC output data will also be set to *invalid* if they originate from building blocks without explicit quality processing. In other words, the quality is not processed sequentially from building block to building block but the output data are set globally. This does not apply to CFC output data that originate from building blocks with explicit quality processing (see next section).

Quality Attribute: Test	
CFC chart is in **normal** state.	CFC input data with the **Test** = *TRUE* attribute are ignored. When the CFC chart is executed, then the data value that was used before the **Test** = *TRUE* attribute is used. The quality of this **old** value is also processed. This means that on the output side, the attribute **Test** = *FALSE*.
CFC chart is in **Test**[1)] state.	If the CFC chart is executed, then the attribute **Test** = *TRUE* is set for all data leaving the CFC chart. This does not depend on whether the data are formed via CFC blocks with or without quality processing.

[1)]A CFC chart can be switched to the test state by switching the entire device to test mode or the input TEST of the CFC block CHART_STATE is set.

Quality Attribute: OperatorBlocked	
CFC chart is in **normal** state.	In CFC charts for incoming data, the **OperatorBlocked** attribute is ignored.
CFC chart is in **functionally logged off**[1)] state .	In CFC charts for incoming data, the **OperatorBlocked** attribute is ignored. All CFC output data are labeled as functionally logged off.

[1)] This state only occurs if the device is functionally logged off. In this case, the quality attributes of all CFC outputs are labeled as **functionally logged off**.

Quality Processing Building Blocks (Condition Processing)

The first 3 blocks (x_SPS) process the quality automatically according to the stated logic. The other blocks are used to isolate the quality from a data object and add them back after separate logical processing.

<table>
<tr><th>Building Blocks</th><th>Description</th></tr>
<tr><td rowspan="20">OR_SPS
AND_SPS
NEG_SPS</td><td colspan="3">The blocks also process the supported quality attributes according to their logic. The following tables describe the logic using input values in connection with the quality attribute Validity. The input values are 0 or 1, the quality attribute Validity can have the value good (=g) or invalid (=i).
x = placeholder for the input value and quality attribute Validity</td></tr>
<tr><td colspan="3">OR_SPS</td></tr>
<tr><td>A (Value, Attribute)</td><td>B (Value, Attribute)</td><td>Q (Value, Attribute)</td></tr>
<tr><td>0, i</td><td>0, x</td><td>0, i</td></tr>
<tr><td>0, g</td><td>0, g</td><td>0, g</td></tr>
<tr><td>1, g</td><td>x, x</td><td>1, g</td></tr>
<tr><td>1, i</td><td>0, x</td><td>1, i</td></tr>
<tr><td>1, i</td><td>1, i</td><td>1, i</td></tr>
<tr><td colspan="3">The output thus has the logical value 1 with Validity = good as soon as at least 1 input has the logical value 1 with Validity = good. Otherwise, the inputs are treated according to the OR operation and the INVALID bit is OR-gated for the quality.</td></tr>
<tr><td colspan="3">AND_SPS</td></tr>
<tr><td>A (Value, Attribute)</td><td>B (Value, Attribute)</td><td>Q (Value, Attribute)</td></tr>
<tr><td>0, g</td><td>x, x</td><td>0, g</td></tr>
<tr><td>0, i</td><td>1, x</td><td>0, i</td></tr>
<tr><td>1, i</td><td>1, x</td><td>1, i</td></tr>
<tr><td>1, g</td><td>1, g</td><td>1, g</td></tr>
<tr><td colspan="3">The output thus has the logical value 0 with Validity = good as soon as at least 1 input has the logical value 0 with Validity = good. Otherwise, the inputs are treated according to the AND operation and the INVALID bit is OR-gated for the quality.</td></tr>
<tr><td colspan="3">NEG_SPS</td></tr>
<tr><td>A (Value, Attribute)</td><td>Q (Value, Attribute)</td><td></td></tr>
<tr><td>0, i</td><td>1, i</td><td></td></tr>
<tr><td>0, g</td><td>1, g</td><td></td></tr>
<tr><td>1, i</td><td>0, i</td><td></td></tr>
<tr><td>1, g</td><td>0, g</td><td></td></tr>
<tr><td>SPLIT_SPS
SPLIT_DPS
SPLI_XMV</td><td colspan="3">The blocks isolate the data value and quality of a data object.
The requirement is that the quality is available from the input end. This is the case if the block is interconnected with CFC input data, or is connected downstream with a quality processing building block (x_SPS). In other cases, the CFC editor does not allow a connection.</td></tr>
<tr><td>SPLIT_Q</td><td colspan="3">The block performs binary separation of the quality into good, bad (= invalid), test, off and OperatorBlocked.
These 5 attributes can then be processed individually in a binary operation. The block must be connected downstream to a SPLIT_(DO) block.</td></tr>
<tr><td>BUILD_Q</td><td colspan="3">The building block enters a binary value for good and bad (= invalid) in each quality structure. Thus, with this building block the quality attributes good and bad (=invalid) can be set explicitly, for example, as the result of a monitoring logic.
All other quality attributes are set to the default state, for instance, Test = FALSE. If, for example, the entire CFC chart is in the test state (see Quality Attribute: Test Under General Processing), this default status can again be overwritten on the CFC output side.
The building block is normally connected downstream to a BUILD_(DO) building block.</td></tr>
</table>

Building Blocks	Description
BUILD_ACD **BUILD_ACT** **BUILD_BSC** **BUILD_DPS** **BUILD_ENS** **BUILD_SPS** **BUILD_XMV**	These blocks merge data value and quality. The block output is generally used as a CFC output. Generally, the BUILD_Q block is connected upstream from these building blocks.

CFC charts have a standard behavior in the processing of signals. If an input signal of the CFC chart has the quality *invalid*, all output signals of the CFC chart also get the quality *invalid*. This standard behavior is not desirable in some applications. If you use the building blocks for quality processing, the quality attributes of the input signals in the CFC chart are processed.

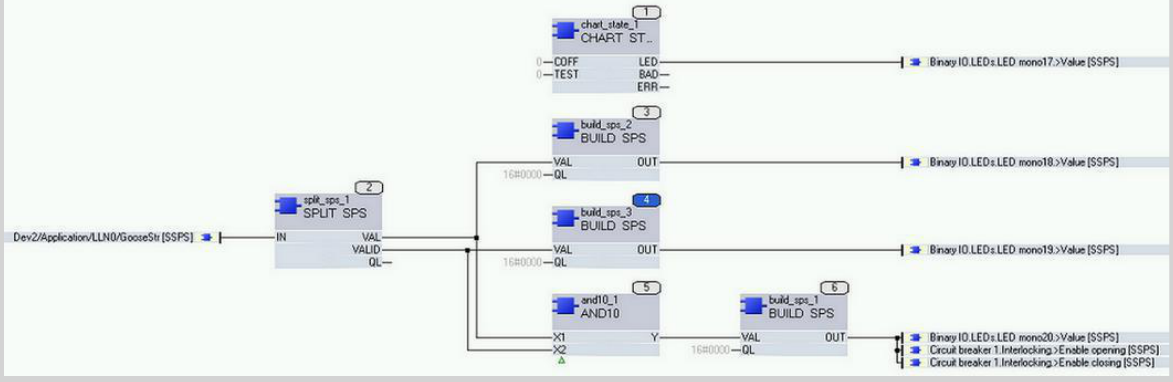
EXAMPLE: Switchgear Interlocking via GOOSE

The following conditions apply to the example:

- The interlocking condition for switchgear interlocking protection is stored in the device as a CFC chart.
- The removed device sends the release signal for the interlocking condition via a GOOSE telegram.

If the communication connection has been interrupted, the release signal (**GOOSEStr**) incoming via the GOOSE telegram gets the quality *invalid*. If the CFC chart obtains an invalid input signal, there are the following possibilities: The last signal valid before the communication interruption is used (quality = *good*) or a substitute data value with the quality *good* is used (True, False).

To do this, you have to create a separate CFC chart in addition to the interlocking plan of the switchgear interlocking. Use the building blocks for quality processing in a separate CFC chart. With the SPLIT_SPS building block, split the input signal (data type = SPS) into data value and quality information. You can then continue to process these signals separately in the CFC chart. Use the quality information as an input signal for a BUILD_SPS building block and assign the quality *good* to the signal. You obtain an SPS signal as a result, with the quality *good*. You can use this to process release messages correctly. You can process the release messages with the quality *good* in the CFC chart of the actual interlocking. Therefore, the release signal for a switch illustrated in the interlocking logic is available as a valid result with the quality *good*. The following figure shows an example of the CFC chart with the building blocks for quality processing:



[sccfcran-220415-01, 1, en_US]

Figure 3-32 CFC Chart with Building Blocks for Quality Processing (Switchgear Interlocking via GOOSE)

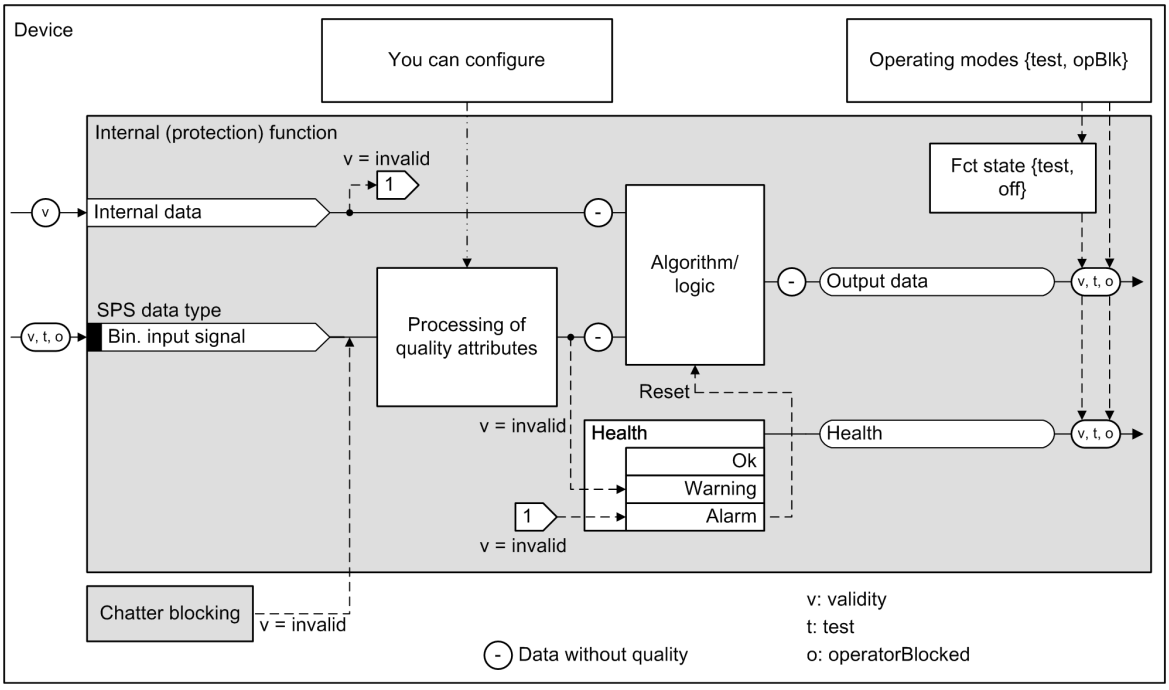
If you do not want to convert the invalid release signal to a valid signal, as described, during the communication interruption, you can also assign a defined data value to the release signal. Proceed as follows: With the SPLIT_SPS building block, split the input signal (data type = SPS) into data value and quality information. Link the VALID output of the SPLIT_SPS building block with the data value of the input signal (AND gate). This way, you can set the value to a non-risk state with the valid input signals. In the example, the output of the CFC chart is set to the value *FALSE* when the input signal is invalid.

3.3.4 Quality Processing/Affected by the User in Internal Device Functions

Figure 3-33 provides an overview for processing the quality of data objects within a device-internal function.
A function can receive internal data or input data that is routable by the user (binary input signal or double commands). The respective quality attributes supported are evaluated by the function on the input side. The attributes are not passed through the specific algorithm/the specific logic of the function. The output data are supplied with a quality that is specified by the function state and device-operating mode.

NOTE

Take into account that pickup of chatter blocking (see chapter *3.8.1 Signal Filtering and Chatter Blocking for Input Signals*) sets the corresponding **Validity** attribute to *invalid*.



[loquali3-100611-01.tif, 2, en_US]

Figure 3-33 Overview for Processing Quality within an Internal Function

Internal Input Data

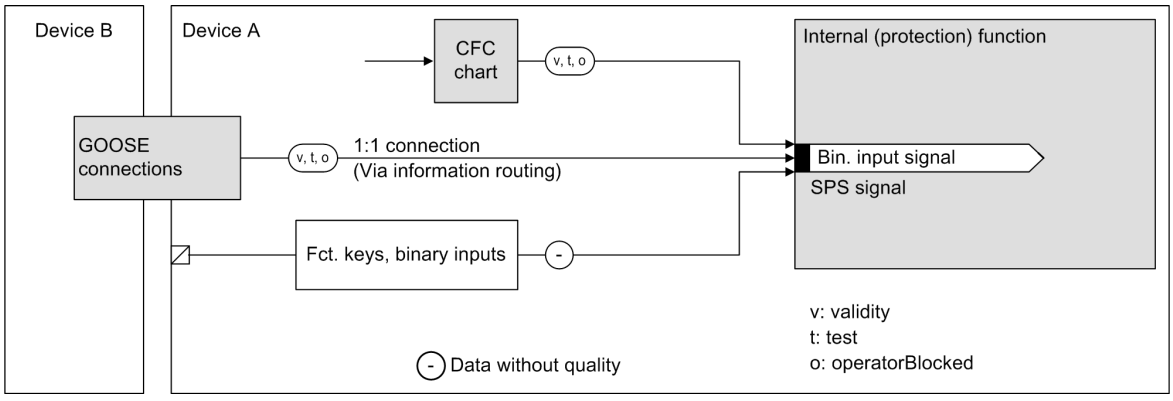
The quality processing is automatic for internal input data.

Supported Quality Attributes	Description
Validity	• At the receiving end, internal values can only be *invalid* or *good*. • If *invalid*, the function health is set to **Alarm** and the function is reset. Causes for invalid internal data are, for example: • The frequency operating range of the device was left. • The device is not calibrated. • The A/D converter monitoring identified an error.

Routable Binary Input Signals (SPS Data Type)

Figure 3-34 shows the possible sources for connecting a binary input signal. Depending on the source, different quality attributes can be set:

- CFC chart: See description in chapter *3.3.3 Quality Processing/Affected by the User in CFC Charts*
- GOOSE connection: See description in chapter *3.3.2 Quality Processing/Affected by the User for Received GOOSE Values*
- Device hardware: No quality attributes are set and supported.



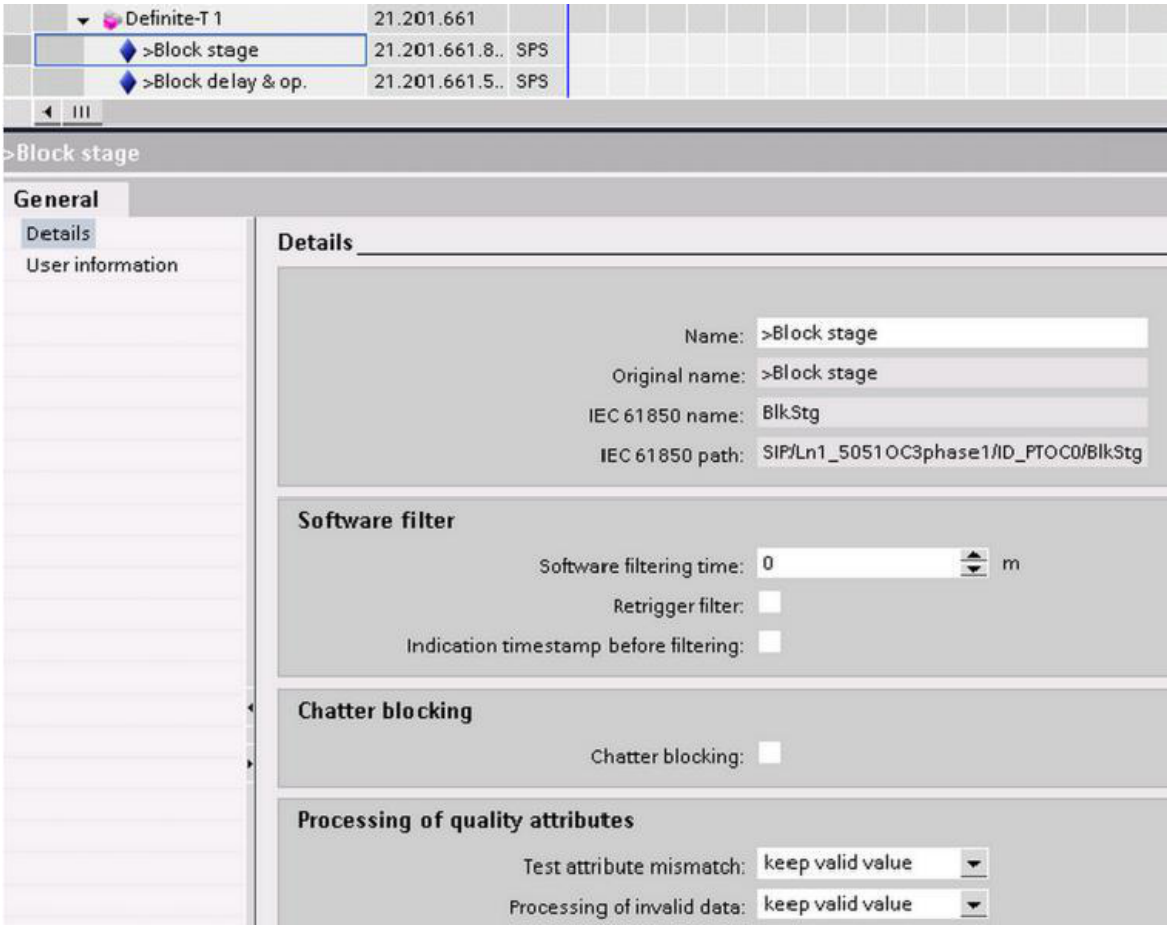
[loquali2-230212-01.tif, 2, en_US]

Figure 3-34 Sources for Connecting a Binary Input Signal

For this signal type (SPS), you can influence the processing of the quality, see overview in *Figure 3-33* .

The following figure shows the possible influence on a binary input signal of a protection stage.

- In the DIGSI 5 project tree, double-click **Information routing**.
- In the operating range, select the desired binary input signal.
- In the **Properties** window, select the **Details** entry. There, you will find the item **Processing quality attributes**.



[sceinflu de, 1, en_US]

Figure 3-35 Influence Options for a Binary Input Signal (SPS Input Signal)

Quality Attribute: Validity	
The **Validity** attribute can have the values *good* or *invalid (reserved* and *questionable* were already replaced at the input end of the device by the value *invalid*).	
The input signal source is *invalid*.	The current data value of the source signal is ignored. You can select between the following options: • Further process last valid data value of the source signal (this is the default setting with only a few exceptions) • Set the binary value to be processed further to **0**. • Set the binary value to be processed further to **1**. This configuration option is necessary to satisfy different applications. The function health switches to Warning.
The input signal source is *good*.	The source signal data value is processed further.

Quality Attribute: Test	
• The input signal source and processed function are in test state. • The input signal source is not in test state and the function to be processed is in test state.	The source signal data value is processed further.

Quality Attribute: Test	
The input signal source is in a test state and the function to be processed is in normal state.	The data value of the source signal is ignored. You can select between the following options: • Further processing of the last valid source signal data value, before the source switches to the test state (that is the default setting) • The binary value to be processed further is set to **0**. • The binary value to be processed further is set to **1**. This configuration option is necessary to satisfy different applications.

Quality Attribute OperatorBlocked
The quality cannot be influenced at this position and does not lead to a response within the logic

Output Data

The quality is not processed through the actual algorithm/logic of the function. The following table displays the conditions required to set the quality of output signals of a function.

Cause	D0 Value	Quality Attribute	
		After **internal** (to the SIPROTEC 5 system, for example, in the direction of a CFC chart)	To the IEC 61850 interface, in buffer
Functional state = **Test** (thus, result of device operating mode = **Test** or function mode = **Test**)	Unchanged	**Test** = *TRUE*	**Test** = *TRUE*
Functional state = **Off** (thus, result of device operating mode = **Off**)	Function-specific, corresponding to the definition for switched off	**Validity** = *good*	**Validity** = *invalid*
Function health = **Alarm** (for example, result of invalid receive data)	Function-specific, corresponding to the definition for reset	**Validity** = *good*	**Validity** = *invalid*
Device operating mode = **functionally logged off**	Unchanged	**Validity** = *good* **OperatorBlocked** = *TRUE*	**Validity** = *good* **detailQual** = *oldData* **OperatorBlocked** = *TRUE*

3.4 Fault Recording

3.4.1 Overview of Functions

All SIPROTEC 5 devices have a fault memory in which fault recordings are kept securely. Fault recording documents operations within the power system and the way in which protection devices respond to them. You can read out fault recordings from the device and analyze them afterwards using evaluation tools such as SIGRA.

A fault record contains the following information:

- Sample values of the analog input channels
- Measured values calculated internally
- Any binary signals (for example, pickup signals and trip signals of protection functions)

You can individually configure the signals to be recorded. Furthermore, you can define the starting condition, the record duration, and the saving criterion of a recording. Fault records saved in the device are also available after a loss of auxiliary voltage.

3.4.2 Structure of the Function

The **Fault recorder** function is a central device function. Both the recording criterion and the measured-value and binary channels to be recorded are functionally preconfigured through the application templates. You are able to individually adapt the configuration in DIGSI 5. The fault recording and the fault log are subject to the same control. This ensures that real time, relative time, and numbering of the fault data are synchronized.

This means that all fault recordings function on the same real-time and relative-time basis.

The data read out via the DIGSI-PC are saved in COMTRADE format. Fault recording data can be transferred to the substation automation technology by request in accordance with the standards via existing communication connections (such as IEC 61850, IEC 60870-5-103). The central device analyzes the data using appropriate programs.

3.4.3 Function Description

The **Fault recorder** function records the sampled values, specific to each device, of all analog inputs, the internally calculated measured values and the binary signals. The configuration, which is predefined for each device via an application template, can be adapted individually.



NOTE

You can find detailed information about selecting and deleting fault records in the Operating Manual (C53000-G5000-C003).

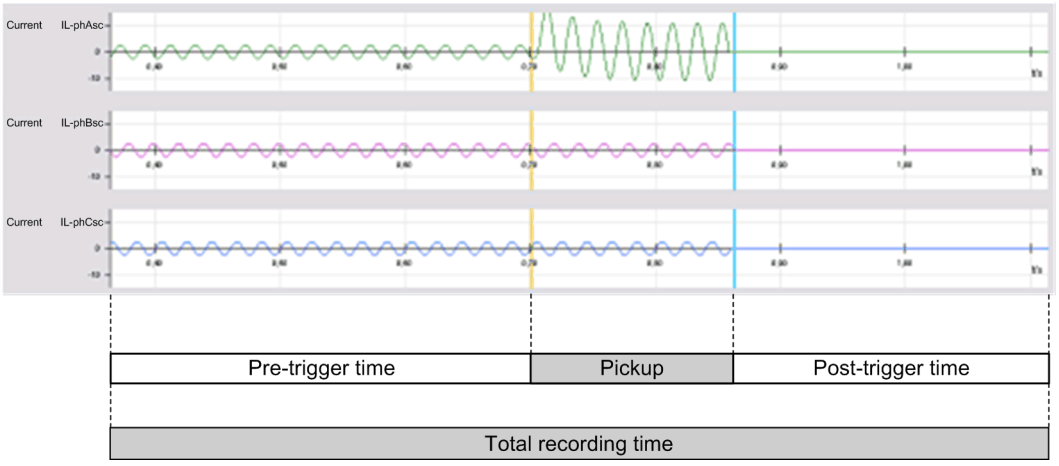
The fault memory of the device is automatically updated with every recording. When the fault memory is filled completely, the oldest records are overwritten automatically. Thus, the most recent recordings are always stored safely. The maximum number of recordings is 128.

Sampling Frequency

The analog measuring channels are sampled at a different sampling rate for fault recording. The **`Sampling frequency`** parameter is used to set the desired sampling frequency. Possible setting values are 1 kHz, 2 kHz, 4 kHz, and 8 kHz. This setting value applies only to fault recording and does not affect protection functions or calculated measured values.

Record Duration

The overall duration of a single fault recording comprises the total duration of the configurable recording criterion, the **`Pre-trigger time`** and the **`Post-trigger time`**. You can set the parameters for these components individually.



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Figure 3-36 Example of a Fault Recording

With the **Fault recording** parameter, you specify the start criterion of the recording.

You can set the following values:

- ***with pickup***:
  The fault recording records the complete fault until dropout. The resulting pickup signals of all function groups are taken into account.
- ***with pickup & AR cyc.***:
  In connection with an active automatic reclosing function (internal/external), the fault recordings record the fault including the short and long interruptions (automatic reclosing cycles).
- ***user-defined***:
  With this setting value, you can individually specify the recording criterion for the fault recording in DIGSI 5. Function-specific recording criteria can be realized in this way.

If a recording criterion reoccurs during the pickup time and post-trigger time, the recording which is currently active is extended to include a new post-trigger time.

For a sampling frequency of 8 kHz and 24 analog channels to be recorded, the duration of one individual fault recording can be up to 20 s.

The maximum record duration can be limited by the **Maximum record time** parameter.

In addition to starting the fault recording via the pickup, the following alternatives are possible:

- Externally via binary input signal *>External start* (for example, from an external protection device without fault recording by an object transferred via a GOOSE message)
- By way of a configurable input signal *>Manual start*, you can start fault records with a configurable length (parameter **Manual record time**).
- With DIGSI 5, you can start test fault records with a fixed length of 1 s.
- With a command from a central device via an existing communication connection (IEC 61850, IEC 60870-5-103)



NOTE

If a pickup signal is present continuously, the fault recording is closed after the **Maximum record time** expires and the fault record cannot be restarted!

Saving the Recording

Not every fault recording that is started actually needs to be saved. With the **Storage** parameter, you specify whether or not you want to save the fault recording that has started. You can also save only fault data for

which the pickup of a protection function also caused a tripping. With this setting, faults beyond the self-protection range will not lead to replacing fault recordings that have already been saved.

Configuration of Signals to Be Recorded

All analog inputs of the device that have been configured (currents and voltages) are recorded as sampled channels. Function-specific binary signals (for example, pickup and trip signals) and measured value channels can be configured individually for recording in the DIGSI information-routing matrix. For this purpose, a separate **Content** column is available.

The operational measured values and the measured values of the fundamental components and symmetrical components (see the Device Manual, chapters *10.3 Operational Measured Values* and *10.4 Fundamental and Symmetrical Components*) are calculated every 9 cycles (at 50 Hz, this is every 180 ms). However, this can mean that the data are not synchronized with the sampled values of the analog channels. The recording of these measured values can be used to analyze the slowly changing processes.

Numbering and Time Stamping

All fault recordings saved are automatically numbered in ascending order and assigned a real-time stamp for the start time. The fault recording logs the fault with a relative time. The reference-time point is the start of the recording. Every fault record has a corresponding fault log with the same number. This ensures that the fault recording can be uniquely assigned to the event log.

Fault Memory

The device manages its available fault memory dynamically, so that the maximum recording capacity is always available. When exceeding the limits of the fault memory, the oldest recordings are automatically overwritten. This means that the most recent records are always available. The sampling rate, type, and number of measured value trends to be recorded are the crucial variables when it comes to restricting the length and number of records possible. Parallel to the sampled tracks, up to 50 tracks with function-specific measured values and up to 100 binary tracks can be recorded. The following table provides an overview of the maximum storage capacities, in seconds, for different connection variations of the protection devices.

Table 3-6 Maximum Length of all Stored Records

Connection Examples	Sampling 1 kHz	Sampling 2 kHz	Sampling 4 kHz	Sampling 8 kHz
Feeder: 4I, 6 measured values, 20 binary tracks	1365 s	819 s	455 s	241 s
Feeder: 4I, 4V, 20 binary tracks	1125 s	566 s	284 s	142 s
Feeder: 4I, 4V, 6 measured values, 20 binary tracks	890 s	500 s	266 s	137 s
Feeder 1.5 CB: 8I, 8V, 6 measured values, 20 binary tracks	525 s	281 s	145 s	74 s

Input and Output Signals

The **Fault recorder** function provides several input signals that allow the precise starting , deleting of records. The output signals provide information about the function status.

In the following table, you can find input signals of the **Fault recorder** function:

Name	Type	Description
Control: Start recording	SPC	Start recording via the function key
Control: Reset memory	SPC	Delete all recording via the function key. The error numbers are reset.
Control: Delete memory	SPC	Delete all recording via the function key. The error numbers remain as is.

Name	Type	Description
Control: >External start	SPS	Start recording by an external binary signal, for example, by the trip command of an external protection device without separate recording. The set pre and post-trigger time are taken into account.
Control: >Manual start	SPS	Start a recording of fixed duration (parameter **Manual record time**) by way of an external binary signal, for example, manually via the function key or by an external binary signal.

In the following table, you can find output signals of the **Fault recorder** function:

Name	Type	Description
General: Mode	ENC	Status feedback of the fault recording according to chapter *2.3 Function Control*
General: State	ENS	
General: Standby	ENS	
Control: Error number	INS	The indication of the current error number allows a unique allocation of entries in the message buffers for the recorded fault records.
Control: Recording started	SPS	Fault recording running

3.4.4 Application and Setting Notes

Parameter: Fault recording

- Recommended setting value **(_:2761:130) Fault recording** = ***with pickup***

With the **Fault recording** parameter, you define the time interval at which faults are recorded. The total record duration is defined as the duration of the fault plus the total of the parameters **Pre-trigger time**, **Post-trigger time** and is limited by the maximum record duration.

Parameter Value	Description
with pickup	The fault recording time is determined by the total number of all protection pickups. The resulting pickup signals of all function groups are taken into account. Note: When the post-trigger time has expired, the indications of an automatic reclosing function are not recorded. Evolving faults after expiry of the post-trigger time can result in the opening of a new fault with its own recording.
with pickup & AR cyc.	The fault recording time is determined by the total number of all protection pickups including short and long interruptions (automatic reclosing cycles). It includes the resulting pickup signals of all function groups and the runtimes of initiated automatic reclosing cycles for all active automatic reclosing functions.
user-defined	The fault recording time is defined user-specific. Note: You must specify all signals for individual definition of the fault recording time in the DIGSI 5 information-routing matrix. In the information routing matrix in the **Fault record** column, the fault recording has for this purpose a separate column **Trigger**. The record duration is calculated from the logical OR operation of all initiated, configured signals.

Parameter: Storage

- Recommended setting value **(_:2761:131) Storage** = ***always***

With the **Storage** parameter, you define the storage criterion for a fault recording that has already started.

Parameter Value	Description
always	Each fault recording that has been started is saved.
with trip	If at least one protection function issues an operate indication during the record time, any fault recording that has been started will be saved.

Parameter: Maximum record time

- Default setting **(_:2761:111) Maximum record time** = ***5.00 s***

With the **Maximum record time** parameter, you configure the maximum record duration for an individual fault recording. When the time configured expires, an ongoing fault recording is canceled. This parameter merely limits the duration of the fault recording. It does not affect the logging of faults in the fault log.

Parameter: Pre-trigger time

- Recommended setting value **(_:2761:112) Pre-trigger time** = ***0.50 s***

With the **Pre-trigger time** parameter, you configure the pre-trigger time for an individual fault recording. The set pre-trigger time is prepended to the actual recording criterion for the fault recording.

Parameter: Post-trigger time

- Recommended setting value **(_:2761:113) Post-trigger time** = ***0.50 s***

With the **Post-trigger time** parameter, you configure the post-trigger time for an individual fault recording. The post-trigger time that has been configured is added to the actual recording criterion for the fault recording after the dropout.

Parameter: Sampling frequency

- Recommended setting value **(_:2761:140) Sampling frequency** = ***8 kHz***

With the **Sampling frequency** parameter, you define the sampling frequency of the fault recording. Possible setting values are 8 kHz, 4 kHz, 2 kHz, and 1 kHz.

Parameter: Manual record time

- Recommended setting value **(_:2761:116) Manual record time** = ***0.50 s***

With the parameter **Manual record time**, you set the duration of a recording if the fault record is activated dynamically (edge-triggered) via a separately configured input signal *>Manual start*.

In this case, pre-trigger and post-trigger times do not take effect.

3.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2731:1	General:Mode		• on • test	on
Control				
_:2761:130	Control:Fault recording		• with pickup • with pickup & AR cyc. • user-defined	with pickup
_:2761:131	Control:Storage		• always • with trip	always
_:2761:111	Control:Maximum record time		0.20 s to 20.00 s	5.00 s
_:2761:112	Control:Pre-trigger time		0.05 sto 4.00 s	0.50 s
_:2761:113	Control:Post-trigger time		0.05 sto 0.50 s	0.50 s

Addr.	Parameter	C	Setting Options	Default Setting
_:2761:116	Control:Manual record time		0.20 s to 20.00 s	0.50 s
_:2761:140	Control:Sampling frequency		• 8 kHz • 4 kHz • 2 kHz • 1 kHz	2 kHz

3.4.6 Information List

No.	Information	Data Class (Type)	Type
Binary IO			
_:2731:51	General:Mode (controllable)	ENC	C
_:2731:52	General:Behavior	ENS	O
_:2731:53	General:Health	ENS	O
Binary IO			
_:2761:300	Control:Start record	SPC	C
_:2761:305	Control:Reset memory	SPC	C
_:2761:306	Control:Clear memory	SPC	C
_:2761:502	Control:>External start	SPS	I
_:2761:503	Control:>Manual start	SPS	I
_:2761:310	Control:Fault number	INS	O
_:2761:311	Control:Recording started	SPS	O
_:2761:314	Control:Record made	SPS	O
_:2761:327	Control:Tmax reduced	SPS	O

3.5 Protection Communication

3.5.1 Overview

Protection communication includes all functionalities required to exchange data via the protection interface (PI). It manages one or a maximum of 2 protection interfaces. The **Protection communication** is generated with the configuration of the channels as a protocol.

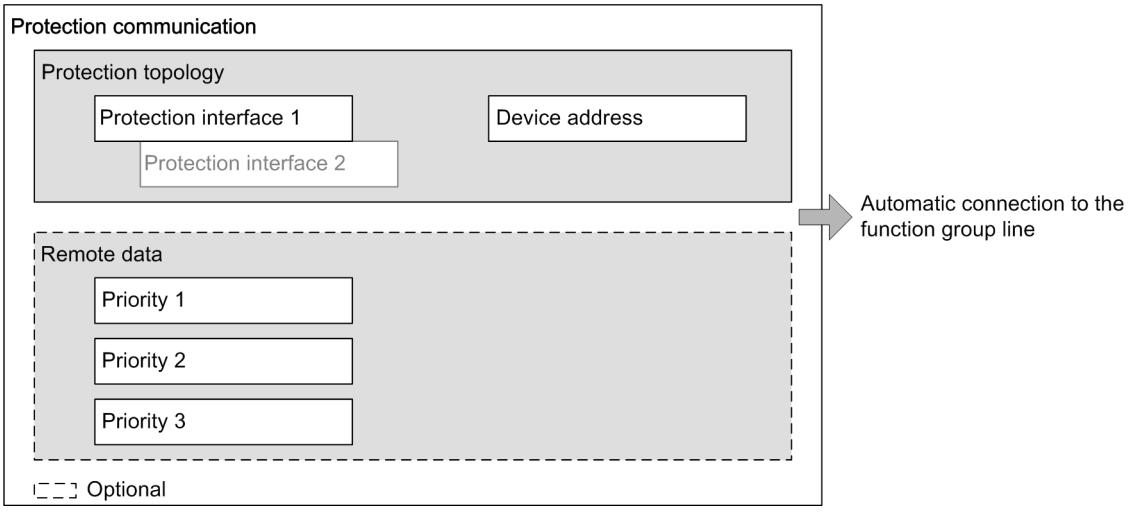
You can find detailed information in the section **Protection interface** in chapter *3.5.3.1 Overview of Functions*.

3.5.2 Protection-Communication Structure

The following **Protection communication** functions are visible:

- Topology recognition
- Remote data

The following figure shows the structure of **Protection communication**:



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Figure 3-37 Protection-Data Communication Structure

Interface to VI 3-Phase Function Group

Binary signals, measured values, and other data are automatically exchanged between the **Protection-data communication** and the **VI 3-phase** protection function group.

Interface to Motor Function Group

Binary signals, measured values, and other data are automatically exchanged between the **Protection-data communication** and the **Motor** protection function group.

Remote Data

The **Remote data** functionality is applied if you route a specific signal or a measured value to the protection interfaces. The protection interface then attends to the transmitting and receiving of such signals. The maximum amount of remote data is defined by the available bandwidth.

3.5.3 Protection Interface and Protection Topology

3.5.3.1 Overview of Functions

The **Protection topology and protection interface**function enables data exchange between the devices via synchronous serial point-to-point connections from 64 Kbits/s to 2 Mbits/s. These connections can be established directly via optical fibers or via other communication media, for example, via dedicated lines or via communication networks.

A protection topology consists of 2 to 6 devices which communicate via protection interfaces. It can be set up either as a redundant ring or as a chain structure. Within a topology, the protection interfaces can have a different bandwidth. Depending on the bandwidth, a certain amount of binary information and measured values can be transmitted bi-directionally between the devices. The connection with the lowest bandwidth defines this amount (of binary information and measured values).

The following information that is significant for the function of the protection interface is also transferred. You cannot change this information:

- Topology data and values are exchanged for monitoring and testing the connection.
  The results are displayed on the device or with DIGSI 5.
- Protection data, for example, differential protection data or teleprotection scheme binary data, are transferred for distance protection and ground-fault protection.
- The devices can be synchronized in time via the connection, whereby a device of the protection topology assumes the role of the timing master.

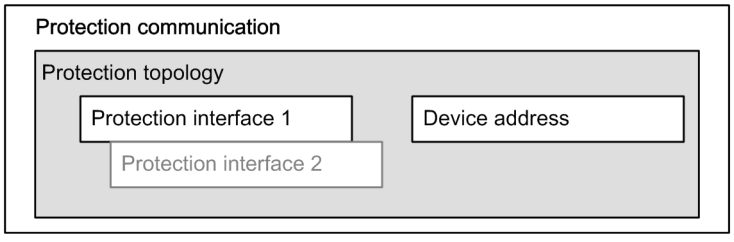
The connection is continuously monitored for data faults and outage, and the time delay of the data is measured.

The protection interfaces are typically used for differential protection and with the teleprotection scheme for distance protection and ground-fault protection. In SIPROTEC 5, you can configure protection interfaces in all devices and then use them for further protection applications. At the same time, any binary information and measured values can be transferred between the devices.

3.5.3.2 Structure of the Function

The protection interfaces of a device are located in the Protection communication function group. A device has 1 or 2 specifically parameterizable protection interfaces.

The **protection topology** is used for administration of that topology data relevant to the respective interfaces and containing data from other devices in the protection topology.



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Figure 3-38 Structure of the Protection Interface in a Device

The protection communication runs physically via a serial optical communication module. This module can have 1 or 2 channels. The protection communication can take place via various modules. This depends on the type of interface and the application. DIGSI 5 is used to configure 1 or 2 channels of a serial optical module as a protection interface. This enables communication with the values set at the **protection interface** via this channel.

3.5.3.3 Function Description

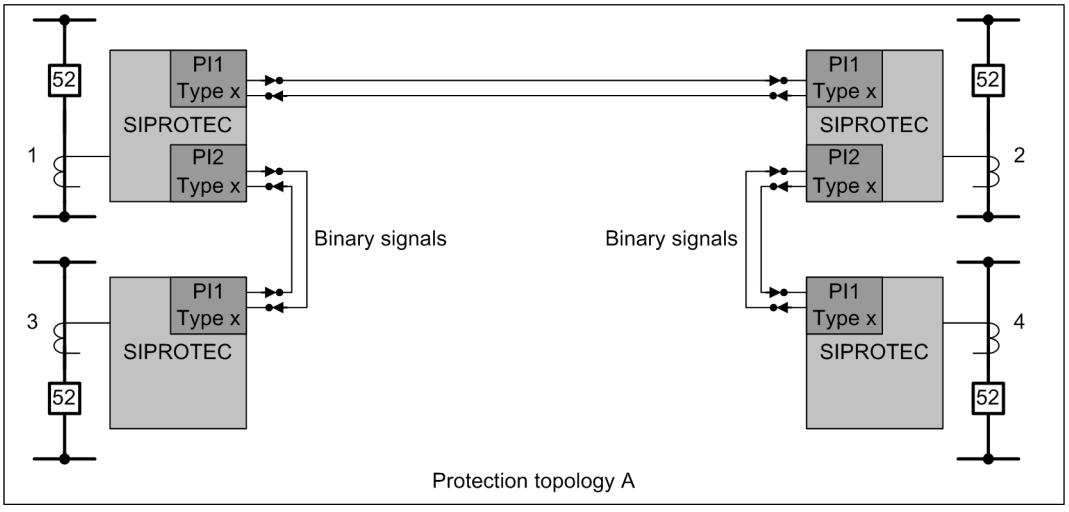
Topology and Type of Protection Communication

The protection interfaces (PI) establish a direct point-to-point connection between devices via different communication media. Data can be transferred within the switchgear or between switchgears.

Devices connected to one another with protection communication form a protection topology. Refer to *Figure 3-39*.

The protection communication in a device can be either type 1 or type 2. In the case of devices with differential protection function (7SD and 7SL), a protection communication of type 1 is automatically created. Type 2 is created for other devices, and is used for other data transmission. A device can contain only the same types of protection communication. Type 1 and type 2 protection communication do not work together in pairs via a protection function.

Types	Description
Type 1 Application using differential protection	With type 1, the differential protection function is the primary application. This application requires the greatest portion of the bandwidth, so that with type 1 the number of signals additionally available is lower. This becomes noticeable with a 64-kbps protection connection via a G703.1 or X21 interface. If a multiple-end differential-protection application is realized, all protection communications must be of type 1. A maximum of 6 line ends is possible. If the **Differential protection** und **Teleprotection scheme** functions are to operate in parallel in the device, the bit rate must not be less than 512 kbps!
Type 2 Application without using differential protection	Type 2 has a significantly higher amount of information that can be transferred as the differential-protection application is not used here. The transmission of protection data and other data, for example, measured values, is predominant here. Using type 2 protection communication, a maximum of 6 devices can be connected to one another and different device types (for example, 6MD, 7VK, 7SA, and 7SJ) can exchange data.



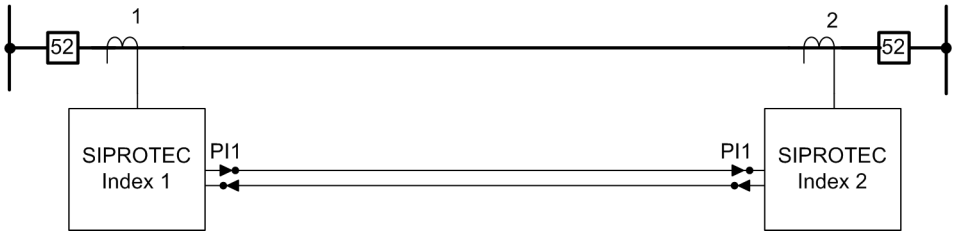
[dwintert-030211-02.tif, 1, en_US]

Figure 3-39 Data Exchange between 4 Devices with Protection Communications of Type 1 or Type 2 in a Protection Topology

2-Device Topology: Simple or Redundant Transfer

In the case of a simple 2-device topology, one protection communication per device is required (see next figure).

The most frequent application is the point-to-point exchange of data between 2 devices (the protection communication is of type 2), as performed by protection transmission devices.



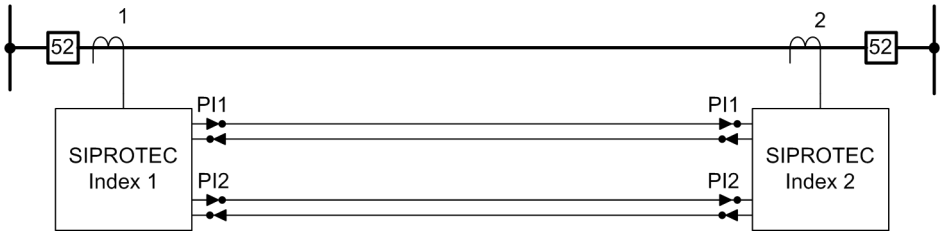
[dwinterf-030211-01.tif, 1, en_US]

Figure 3-40 Data Exchange for 2 Devices, Each Having Protection Communication

NOTE

The index describes the consecutive numbering of the devices in a protection topology (see parameter **`Local device is device`**).

A maximum of 2 protection communications can be integrated in one device (see next figure). If 2 protection communications of the same type are connected to one another, this results in 100 % redundancy regarding the transmission route. The devices then search for the communication connection with the highest bandwidth (for example, optical fiber). If this connection fails, the system switches over automatically to the 2nd connection until the 1st connection is available again. As the connection with lower bandwidth defines the maximum amount of transferable information, the same information is exchanged via both connections. Both protection communications in the device are then of type 1.



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Figure 3-41 Data Exchange for 2 Devices, Each Having 2 Protection Communications/Redundant Transmission Route

Protection-Interface Information Transfer

With the protection-interface information transfer, customer-specific indications and measured values can be communicated via the protection interface with settable update cycles (priorities).

There are 3 different priorities when transferring protection-interface information:

- **Priority 1**: Use **Priority 1** for the transmission of fast protection signals that are transferred and updated at a maximum of every 20 ms in a telegram.
- **Priority 2**: Use **Priority 2** for the transmission of fast single-point or double-point indications that are transferred and updated at a maximum of every 40 ms.
- **Priority 3**: Use **Priority 3** for all indications, measured, and metered values that are transferred and updated a maximum of every 100 ms.

The number of customer-specific signals, indications, and measured values conform with the remaining bandwidth. The remaining bandwidth is lower than with all other protection functions (type 2) when using a differential protection (type 1). Customer-specific measured values consume more bandwidth than single-point indications.

Communication Media

The communication takes place via direct fiber-optic connections, via communication networks or via 2-wire copper conductors. Siemens recommends a direct fiber-optic connection, as this offers the highest transmission rate of 2 Mbps and is immune to failures in the communication route while offering the shortest trans-

mission time. This also enables the transmission of a large amount of additional information on differential protection routes and the remote control of devices at the remote end with DIGSI 5.

The distance to be bridged and the transmission paths available determine the settings of the protection interface. External communication converters are used for the connection to communication networks via G703.1-, X21-, or G703.6 interfaces. The connection to 2-wire copper cores also takes place via a communication converter. The C37.94 interface, for example, with 2 Mbps, offers a direct fiber-optic connection to a multiplexer with the corresponding interface.

Table 3-7 to *Table 3-8* show examples of communication connections.

In the case of a direct connection, the transmission distance depends on the fiber type of the optical fiber. This distance can also be extended via external repeaters.

The modules in the device can be replaced from outside, so that adaptation to a transmission route is possible. In the case of the 820-nm double module USART-AE-2FO with 2 channels, 2 protection interfaces can be operated on one module.

The modules can be located at slots E and F in the base device, and at slots N and P in the plug-in module assembly with integrated power supply.

When using communication converters, the connection from the device to the communication converter by a module is established via optical fibers.

Table 3-7 Plug-In Modules for Applications with the Protection Interface

Plug-In Modules	**Module Type: USART-AF-1LDFO**	**Module Type: USART-AW-2LDFO**	**Module Type: USART-AG-1LDFO**	**Module Type: USART-AU-2LDFO**	**Module Type: USART-AK-1LDFO**	**Module Type: USART-AV-2LDFO**	**Module Type: USART-AH-1LDFO[1]**	**Module Type: USART-AJ-1LDFO[2]**	**Module Type: USART-AX-2LDFO[3]**	**Module Type: USART-AY-2LDFO[4]**
Physical Connection										
1 x optical serial, 1300 nm, duplex LC plug, 24 km via 9/125 µm singlemode optical fibers, 4 km via 62.5/125 µm multimode optical fibers	●									
2 x optical serial, 1300 nm, duplex LC plug, 24 km via 9/125 µm singlemode optical fibers, 4 km via 62.5/125 µm multimode optical fibers		●								
1 x optical serial, 1300 nm, duplex LC plug, 60 km via 9/125 µm singlemode optical fibers			●							
2 x optical serial, 1300 nm, duplex LC plug, 60 km via 9/125 µm singlemode optical fibers				●						
1 x optical serial, 1550 nm, duplex LC plug, 100 km over 9/125 µm singlemode optical fibers					●					
2 x optical serial, 1550 nm, duplex LC plug, 100 km via 9/125 µm singlemode optical fibers						●				
1 x optical serial, bi-directional via 1 optical fiber, 1300/1550 nm (Tx/Rx), simplex plug LC, 40 km via 9/125 µm singlemode optical fiber							●			

[1] USART-AH-1LDFO only pairs with USART-AJ-1LDFO or USART-AY-2LDFO on the opposite side
[2] USART-AJ-1LDFO only pairs with USART-AH-1LDFO or USART-AX-2LDFO on the opposite side
[3] USART-AX-2LDFO only pairs with USART-AJ-1LDFO or USART-AY-2LDFO on the opposite side
[4] USART-AY-2LDFO only pairs with USART-AH-1LDFO or USART-AX-2LDFO on the opposite side

Plug-In Modules	Module Type: USART-AF-1LDFO	Module Type: USART-AW-2LDFO	Module Type: USART-AG-1LDFO	Module Type: USART-AU-2LDFO	Module Type: USART-AK-1LDFO	Module Type: USART-AV-2LDFO	Module Type: USART-AH-1LDFO[1]	Module Type: USART-AJ-1LDFO[2]	Module Type: USART-AX-2LDFO[3]	Module Type: USART-AY-2LDFO[4]
Physical Connection										
1 x optical serial, bi-directional via 1 optical fiber, 1550/1300 nm (Tx/Rx), simplex plug LC, 40 km via 9/125 µm singlemode optical fiber								●		
2 x optical serial, bi-directional via 1 optical fiber, 1300/1550 nm (Tx/Rx), 2 x simplex LC plug, 40 km via 9/125 µm singlemode optical fiber									●	
2 x optical serial, bi-directional via 1 optical fiber, 1550/1300 nm (Tx/Rx), 2 x simplex LC plug, 40 km via 9/125 µm singlemode optical fiber										●

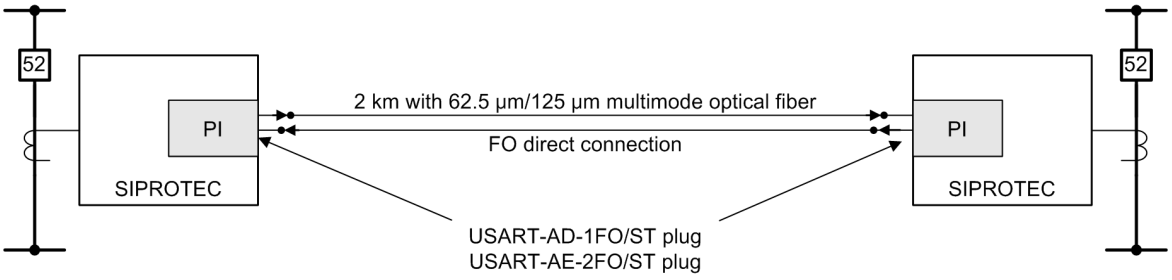
Table 3-8 Plug-In Modules USART-AD-1FO and USART-AE-2FO

Plug-In module	Plug-In Module USART-AD-1FO	USART-AE-2FO
Physical Connection		
1 x optical serial, 820 nm, ST connector, 1.5 km via 62.5/125 µm multimode optical fibers	●	
2 x optical serial, 820 nm, ST connector, 1.5 km via 62.5/125 µm multimode optical fibers		●
Application		
Protection interface (Sync. HDLC, IEEE C37.94)	X	X

NOTE

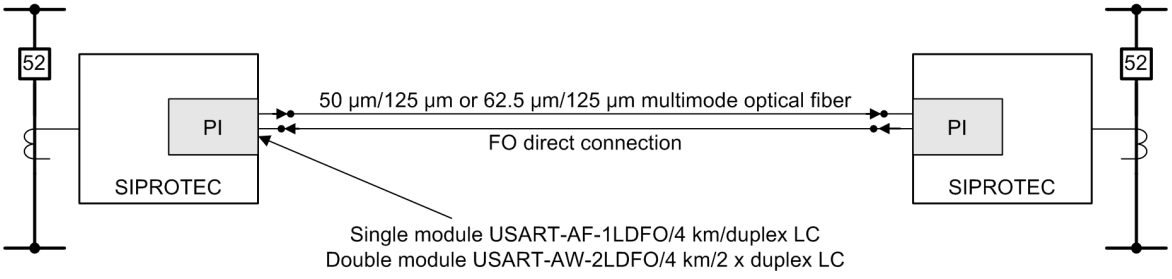
The **USART** plug-in module types can be used in slots **E** and **F** in the base module as well as in slots **N** and **P** in the CB202 expansion module. They are not suitable for use in port **M** in the **CB202** expansion module.

[1] USART-AH-1LDFO only pairs with USART-AJ-1LDFO or USART-AY-2LDFO on the opposite side
[2] USART-AJ-1LDFO only pairs with USART-AH-1LDFO or USART-AX-2LDFO on the opposite side
[3] USART-AX-2LDFO only pairs with USART-AJ-1LDFO or USART-AY-2LDFO on the opposite side
[4] USART-AY-2LDFO only pairs with USART-AH-1LDFO or USART-AX-2LDFO on the opposite side



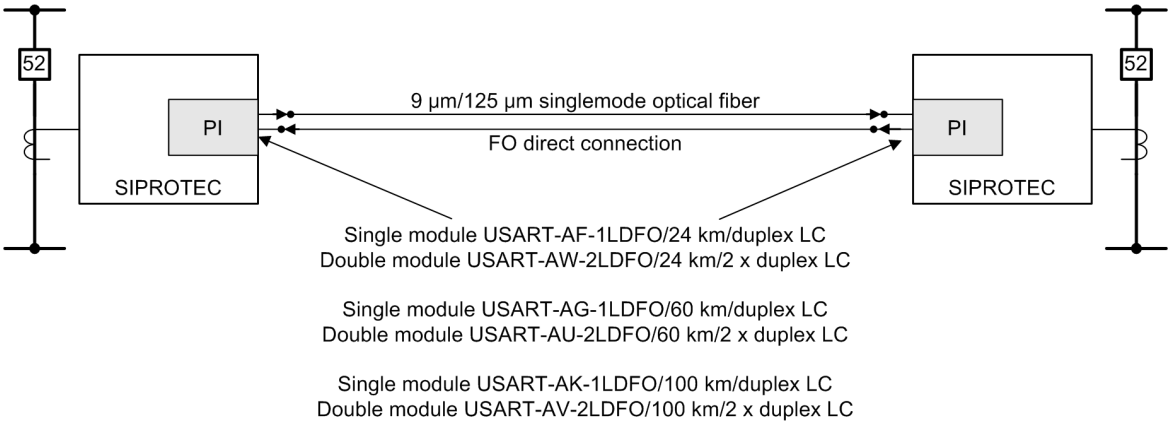
[dwmultim-070611-01.tif, 1, en_US]

Figure 3-42 Connection over Short Distances, 1.5 km to 2 km via Multimode Optical Fiber



[dwmultim-070611-02.tif, 1, en_US]

Figure 3-43 Connection over Maximum 4 km via Multimode Optical Fiber

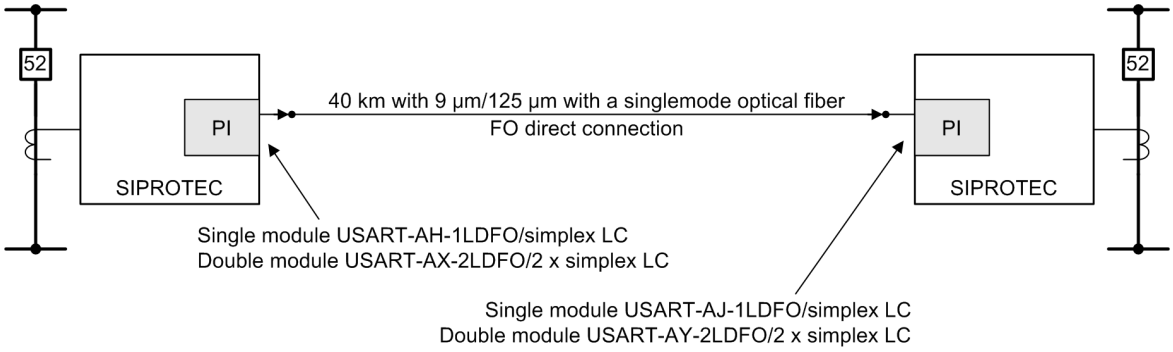


[dwsingle-070611-03.tif, 1, en_US]

Figure 3-44 Connection via Different Distances via Singlemode Optical Fiber

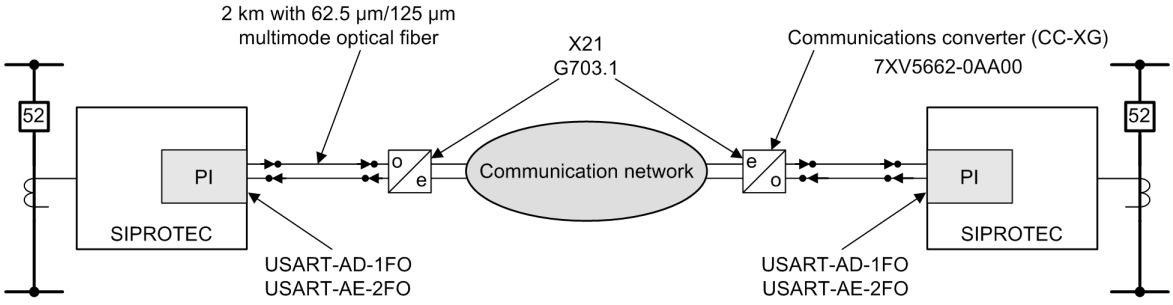
NOTE

In order to prevent optical overload of the receiver, a 7XV5107-0AA00 attenuator must be used on one side in the fiber-optic modules USART-AF, USART-AG, USART-AU, USART-AK, and USART-AV for distances of less than 25 km/50 km.



[dwsingle-020513-04.tif, 1, en_US]

Figure 3-45 Connection via Singlemode Optical Fiber

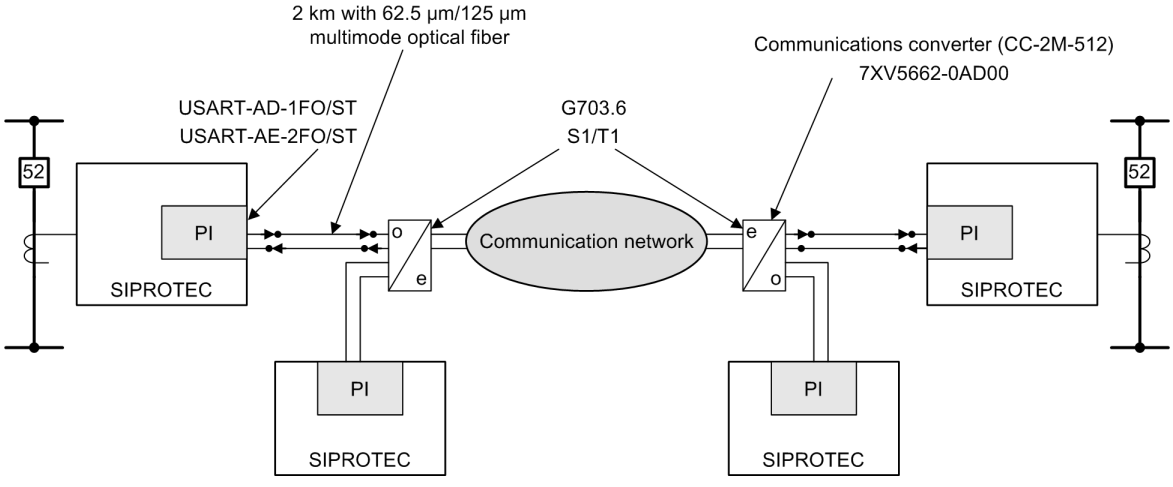


[dwmultim-070611-05.tif, 1, en_US]

Figure 3-46 Connection via Communication Network with a G703.1 Interface

The connection to the multiplexer is established via a communication converter with a G703.1 interface (64 kbps) or X21 interface (64 kbps to 512 kbps). You can set the bit rate for the KU-XG-512 (for X21), KU-XG-256 (for X21), KU-XG-128 (for X21), and KU-XG-64 (for X21 or G703.1) with the parameter **Connection via**.

You can find more detailed information in *Table 3-9*.

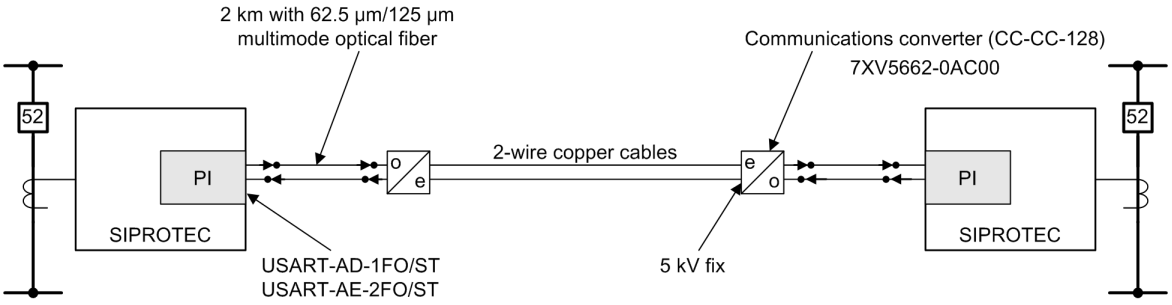


[dwmultim-070611-06.tif, 1, en_US]

Figure 3-47 Connection via Communication Network with a G703.6 Interface

The connection to the multiplexer is established with 512 kbps via a communication converter with a G703.6 interface (E1 with 2 Mbps or T1 with 1.44 Mbps). The communication converter offers a 2nd interface for connecting an additional protection interface.

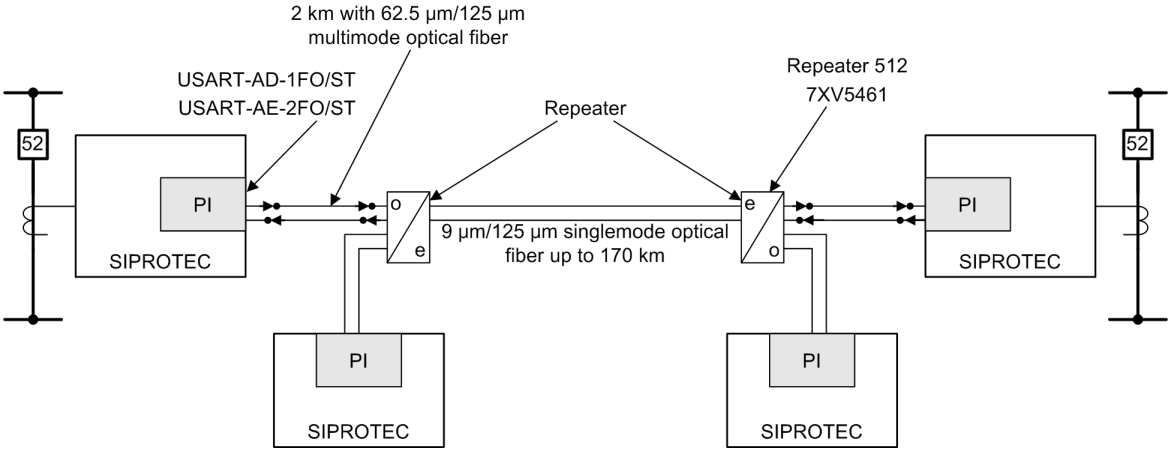
Make the setting for the bit rate with KU-2M-512 with 512 kbps in accordance with *Table 3-9* with the parameter **Connection via**.



[dwmulti7-070611-01.tif, 1, en_US]

Figure 3-48 Connection via 2-Wire Copper Cables

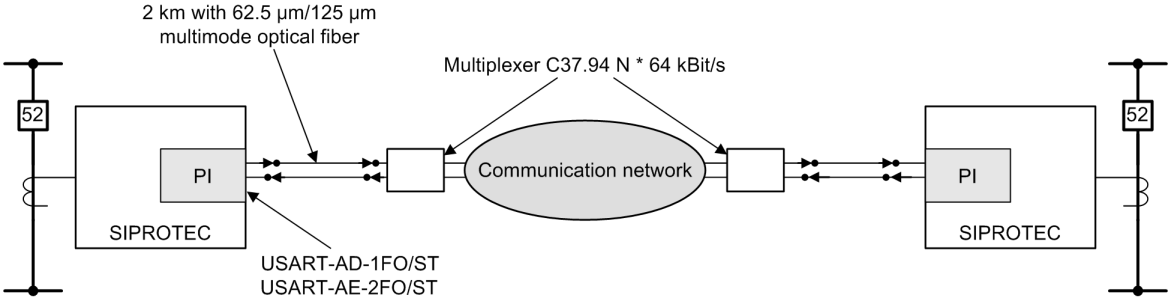
The connection to a communication converter with an integrated 5-kV isolation voltage is established with 128 kbps (KU-KU-128 setting in accordance with *Table 3-9*). A 20 kV isolation of the 2-wire connection is possible via an external 7XR9516 isolating transformer.



[dwrepeat-070611-10.tif, 1, en_US]

Figure 3-49 Direct Fiber-Optic Connection via an External Repeater

The repeater offers an interface for connecting an additional protection interface. The connection to a repeater is established with 512 kbps (repeater 512 setting in accordance with *Table 3-9*).



[dwmutip8-070611-01.tif, 1, en_US]

Figure 3-50 Direct Optical Connection to a Multiplexer with a C37.94 N * 64 kbps Interface (Time Slot N = 1; 2 or 8)

NOTE

The redundancy of different communication connections (for the ring topology) requires rigorous separation of all devices involved in the communication. Therefore, avoid different communication routes via the same multiplexer board, as no more substitute paths are possible if the board fails.

Supervision of the Communication

The communication is continuously monitored by the devices.

If a number of defective data telegrams, or no data telegrams at all, are received, this is regarded as a **failure** in the communication as soon as a failure time of 100 ms (default setting can be changed) is exceeded. A list of the measured values is shown in a window in DIGSI 5 (defective telegrams per minute/hour; transmitted and received telegrams per minute/hour, percentage fault rate per minute/hour). A corresponding failure indication is always available. If no alternative communication route exists (as in the ring topology), the protection function operating with the protection interface is not operating and the remote signals are not updated on the receiver side.

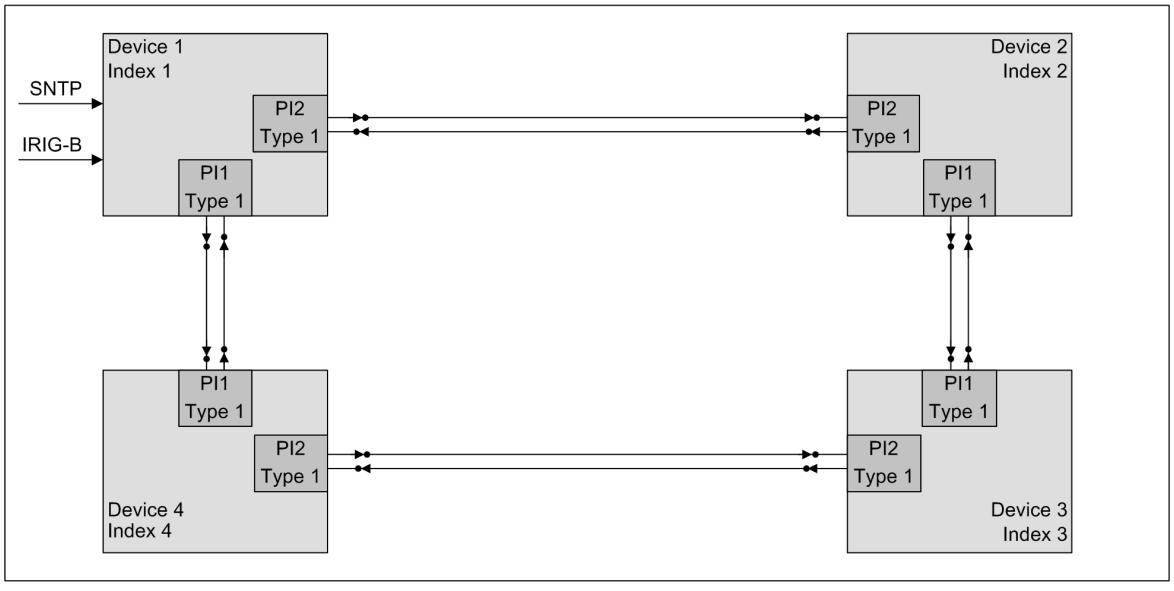
If the communication is interrupted for longer than an adjustable time **Data-connection failure**, this is regarded as a communication failure. A corresponding failure indication is always available.

Time Synchronization via the Protection Interface

All devices of a topology can be time-synchronized with one another. Synchronization is carried out with millisecond accuracy. The synchronization works independently of the protection function and is exclusively for simultaneous time keeping in the devices of a protection topology.

The device you set in the parameter **`Address of device 1`** is the device with index 1. This device functions as the timing master in a protection topology. If the timing master is logged off and switched off, the device with the next highest device index takes on the function of the timing master. The timing master synchronizes the clocks of the other devices of this topology via the protection interfaces. The time of the timing master is typically synchronized via a substation automation protocol (for example, Ethernet or SNTP) or via IRIG-B. For this, these time sources must be set as the 1st time source and optionally as the 2nd time source in the timing master. If available, the system switches over to the 2nd source upon outage of the 1st source in the timing master. This time is communicated with millisecond accuracy to the other devices of the topology.

Set the protection interface as the 1st time source in the other devices of the topology. In this way, all events in the devices of the protection topology are recorded with the same time and are time-synchronized even across different substations. This simplifies fault analysis and the fault records are recorded with the same time in all devices.



[dwtimesy-130212-01.tif, 1, en_US]

Figure 3-51 Time Synchronization in a Protection Topology

Figure 3-51 shows how device 1 with index 1 is synchronized with the devices 2, 3, and 4 via the protection interface. Device 1 is synchronized externally from 2 sources (IRIG-B and SNTP via Ethernet).

Time Synchronization of the Line Differential Protection Measured Values with Millisecond Accuracy

The measured values of the line differential protection for the various line ends are synchronized with each other with microsecond accuracy via the mechanisms of the protection interface. The protection interface displays this state with the RAISING indication *Protection interface synchronized*.

If communications problems occur, it is possible that the measured values may not be properly synchronized. In this case, the protection interface generates the CLEARED indication *Protection interface synchronized*. The line differential protection is blocked. This state can be corrected only by manual intervention.



NOTE

You can reset the synchronization of the protection interface directly in the device. Proceed as follows: **Device functions > x Device protection comm. > Protection interface y > Reset synchron**.

Synchronization via GPS Second Pulse

Millisecond-accurate synchronization of the devices (1*10E-06 s), connected via protection interfaces, can take place via a high-precision GPS second pulse at the time-synchronous port G for special differential protection applications or synchrophasor measuring devices. As a result, the transmission time of the communication route can be measured and displayed separately in the forward and reverse directions. This ensures that the maximum responsivity can be obtained during differential protection, even if transmission times are unbalanced in the communication networks. Different transmission times are insignificant for the transmission of protection data with a protection communication of type 2.

Log Off the Device

A device can be logged off for protection-function tests, system inspections, or disconnection of a feeder for operational reasons. The device that is logged off no longer participates in the distributed functionality and is therefore no longer a component of the topology. The protection functions are still in operation for the other end or ends.

The following conditions are necessary for a successful logoff of the device from the point of view of protection communication:

- The protection topology is not in a transient state and is stable in operation without switchovers.
- The local device is one of the 2 token masters if there is a chain topology. The token masters are the devices at the ends of the chain.
- The circuit breaker must be open and current must not be flowing.



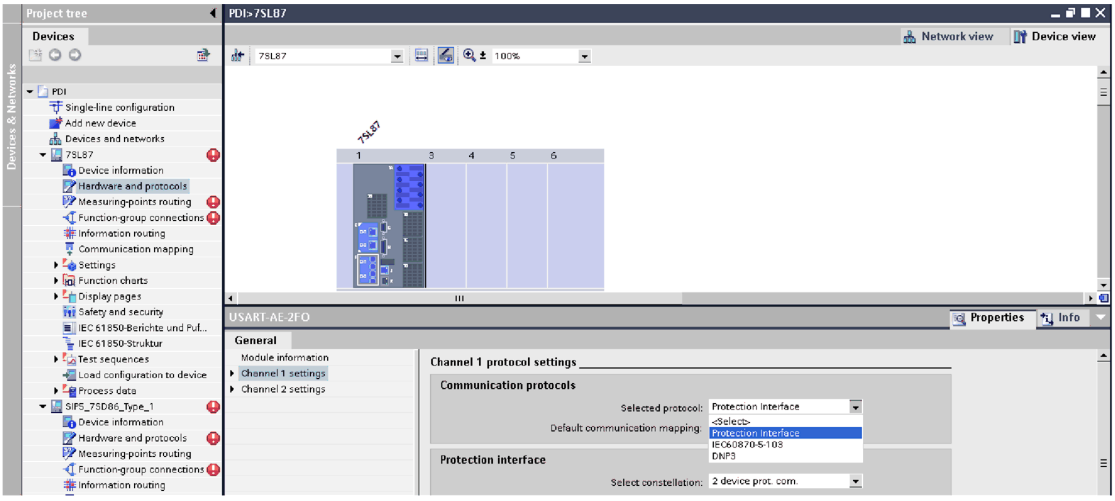
NOTE

If one of these conditions is not fulfilled, the device cannot be logged off.

3.5.3.4 Initialization and Configuration of the Protection Interface in DIGSI 5

If the device is provided with modules, proceed as follows:

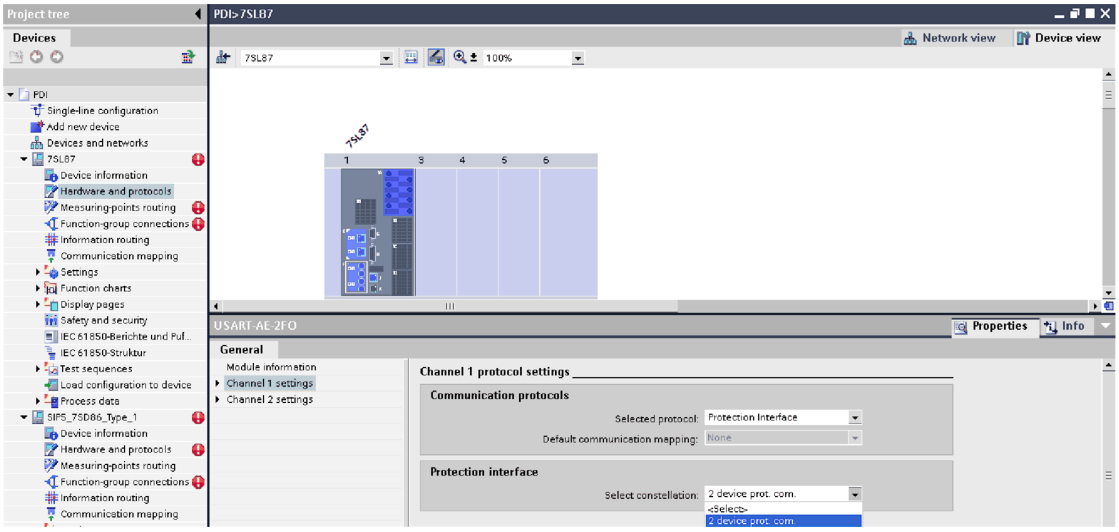
- Select the desired communication module in the rear view of the device.
- Use the **Communication protocols** text box to select the protection interface. A text box entitled **Protection interface** will then appear.



[scconfcp-241110-01.tif, 1, en_US]

Figure 3-52 Selection of the Communication Protocol

- Then select the **Select constellation** text box to select the number of devices (see next figure).



[scconfws-241110-01.tif, 1, en_US]

Figure 3-53 Selecting the Constellation

NOTE

You have the option of changing the number of devices (for example **2 protection communication devices**) depending on the product code any way you like via the **Select constellation** text box.

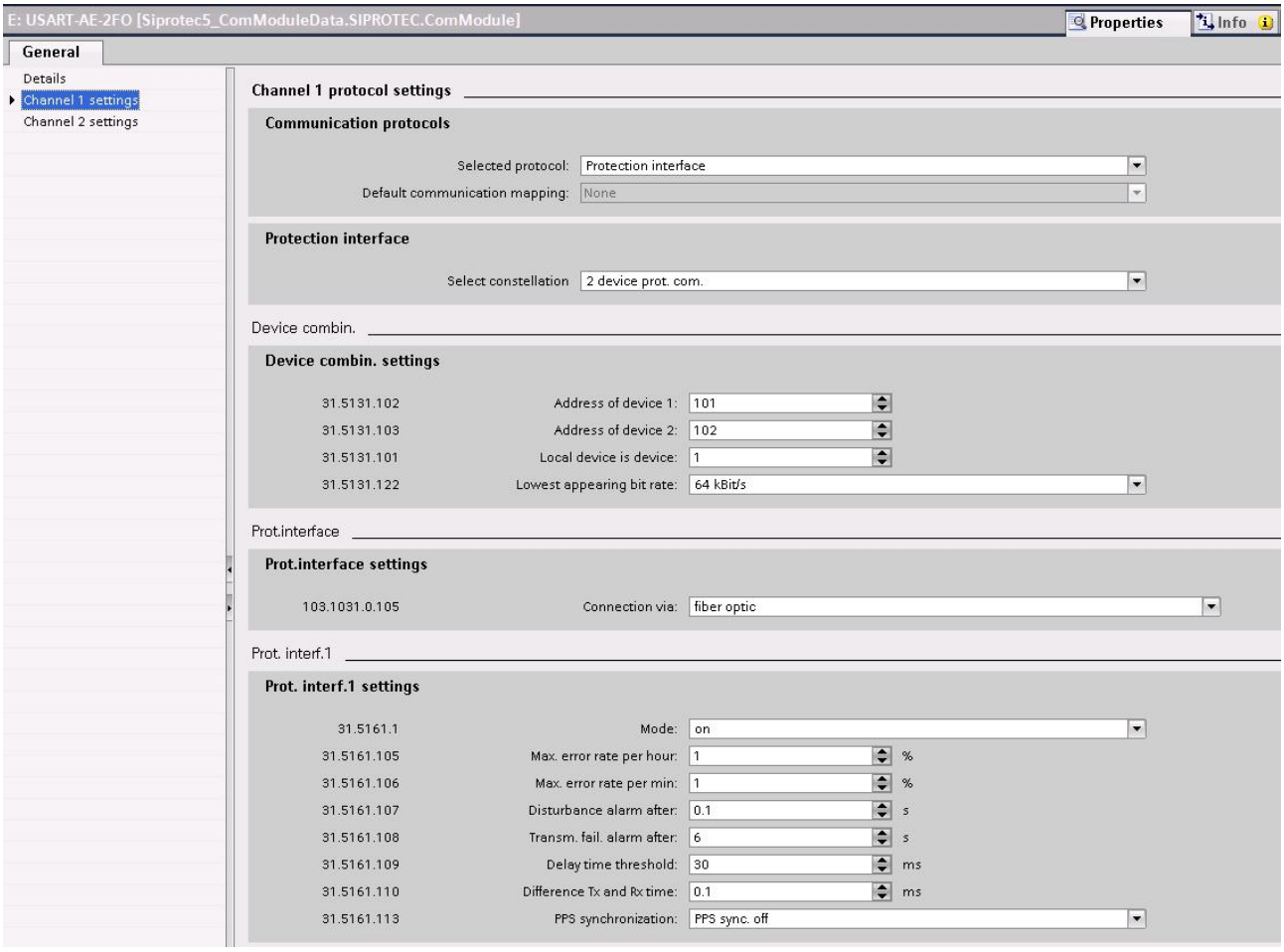
If you change the number of devices via the **Select constellation** text box, all activated constellation settings are lost.

If the module slot is not yet provided with modules, proceed as follows:

- Select the desired communication module in the rear view of the device.
- Select the module from the catalog and drag it to a channel. Thus is the channel configured with a module. DIGSI 5 indicates whether the module can be used for protection communication under **Device Information**.
- Use the **Communication protocols** text box to select the protection interface. A text box entitled **Protection interface** will then appear (see *Figure 3-52*).
- Then use the **Select constellation** text box to select the number of devices (for example **2 devices protection com.**) (see *Figure 3-53*).

3.5.3.5 Device-Combination Settings

Make the device-combination settings and the settings for protection communication (see next figure).



[scconfig-181013-01, 1, en_US]

Figure 3-54 Protection Interface Initialization and Configuration

Changes in a channel are always visible on the other channel as well. All further parameters can be set separately for individual channels.

Setting Device-Combination Settings

- Default setting **(_:5131:102) Address of device 1** = ***101***
- Default setting **(_:5131:103) Address of device 2** = ***102***
- Default setting **(_:5131:104) Address of device 3** = ***103***

- Default setting **(_:5131:105) Address of device 4** = ***104***
- Default setting **(_:5131:106) Address of device 5** = ***105***
- Default setting **(_:5131:107) Address of device 6** = ***106***

The parameters **Address of device 1** to **Address of device 6** can be used to give an address to each device. Set a unique and unambiguous address for each device.

- Default setting **(_:5131:101) Local device is device** = ***1***

With the **Local device is device** parameter, you set the index (number) of your device in the topology. A maximum of 6 devices can be present in one topology.

APPLICATION EXAMPLE

You have a topology with 2 devices.

For example, in DIGSI 5, select the parameter setting **Address of device 1** with the parameter value ***101*** for device 1 and the parameter setting **Address of device 2** with the parameter value ***102*** for device 2.

Then, use the **Local device is device** parameter to set the index of the local device.

The addresses must be configured identically for all devices involved in the constellation. A functional protection communication requires that you also assign the same index in all devices of a constellation for a device with a unique address.

- Default setting **(_:5131:122) Lowest appearing bit rate** = ***64 kBit/s***

The **Lowest appearing bit rate** parameter is used to set the smallest occurring bit rate in the device group. Set the smallest value in each device with a three-end constellation with 2 fiber-optic connections (2 MBit/s) and a 64-kBit/s connection with the lowest value (64 kBit/s). This value determines the maximum signals and measured values within a constellation.

Apart from the default value, you can also set the following bit rates:

- ***128 kBit/s***
- ***512 kBit/s***
- ***2048 kBit/s***

NOTE

If you use fiber-optic cables for the connection between the devices, set the value to ***2048 kBit/s*** .

3.5.3.6 Selecting the Connection

- Default setting **(_:105) Connection via** = ***fiber optic***

The **Connection via** parameter is used to set the bit rate required for the protection interface. Different discrete values can be entered depending on the means of communication (see following table).

Table 3-9 Means of Communication

Means of Communication	See	Setting Value	Bit Rate
Fiber-optic direct connection	*Figure 3-42* to *Figure 3-45*	***fiber optic***	2 MBit/s
CC-XG-512 communication converter	*Figure 3-46*	***CCXG 512 kBit/s***	512 kBit/s
CC-XG-128 communication converter	*Figure 3-46*	***CCXG 128 kBit/s***	128 kBit/s
CC-XG-64 communication converter	*Figure 3-46*	***CCXG 64 kBit/s***	64 kBit/s

Means of Communication	See	Setting Value	Bit Rate
Repeater 512 communication converter	*Figure 3-49*	***repeater 512 kBit/s***	512 kBit/s
CC-CC-128 Communication converter	*Figure 3-48*	***CCPW 128 kBit/s***	128 kBit/s
CC-2M-512 Communication converter	*Figure 3-47*	***CC2M 512 kBit/s***	512 kBit/s
Multiplexer with C37.94 interface	*Figure 3-50*	***C37.94 1 * 64 kBit/s*** ***C37.94 2 * 64 kBit/s*** ***C37.94 8 * 64 kBit/s***	64 kBit/s 128 kBit/s 512 kBit/s
Other (freely adjustable bit rates for a direct connection for special applications)		***64 kBit/s*** ***128 kBit/s*** ***512 kBit/s*** ***2048 kBit/s***	64 kBit/s 128 kBit/s 512 kBit/s 2048 kBit/s

NOTE

Keep in mind that the **Teleprotection schemes** require a minimum bandwidth for communication via a protection interface.

If the **Line differential protection** function is available in the device, the bit rate must not be less than 512 kBit/s!

The minimum bit rate of 512 kBit/s is important for the **Teleprotection with distance protection** and **Teleprotection with ground-fault protection** functions.

3.5.3.7 Setting Notes for the Protection Interface

Parameter: Max. Error Rate/h

- Default setting **(_:5161:105) Max. error rate per hour** = ***1.0 %***

The **Max. error rate per hour** parameter allows you to receive an error message on the number of faults per hour. An indication is then generated.

Parameter: Max. Error Rate/min

- Default setting **(_:5161:106) Max. error rate per min** = ***1.0 %***

The **Max. error rate per min** parameter allows you to receive an error message on the number of faults per minute. An indication is then generated.

Parameter: Disturbance Alarm After

- Default setting **(_:5161:107) Disturbance alarm after** = ***100 ms***

The **Disturbance alarm after** parameter determines the time delay after which defective or missing telegrams are signaled as faulty.

Parameter: Transm. Fail. Alarm After

- Default setting **(_:5161:108) Transm. fail. alarm after** = ***6.0 s***

The **Transm. fail. alarm after** parameter is used to set the time after which a failure of the communication is signaled.

NOTE

If the setting values of the parameters **Disturbance alarm after** and **Transm. fail. alarm after** are exceeded, then an indication is generated.

Parameter: Delay time threshold

- Default setting **(_:5161:109) Delay time threshold** = ***30.0 ms***

For the **Delay time threshold**, the default setting is selected such that it is not exceeded by normal communication networks. If this time delay is exceeded during operation (for example, upon switchover to another transmission route), the indication **Time delay exceeded** is issued.

Parameter: Difference Tx and Rx time

- Default setting **(_:5161:110) Difference Tx and Rx time** = ***0.1 ms***

The **Difference Tx and Rx time** parameter can be used to set a maximum time-delay difference between the send and receive paths.

Set this value to ***0*** for a direct fiber-optic connection. A higher value is necessary for transmission via communication networks. Reference value: ***0.1 ms*** (recommended setting value).

NOTE

Only if the **Line differential protection** function is instantiated, the **Difference Tx and Rx time** parameter is displayed.

NOTE

If the user employs a multiplexer with a C37.94 interface as a communication medium, Siemens recommends a setting value of ***0.25 ms*** to ***0.6 ms***.

Parameter: PPS Synchronization

- Default setting **(_:5161:113) PPS synchronization**=***PPS sync. off***

If the SIPROTEC device operates with PPS synchronization (PPS: pulse per second), use the **PPS synchronization** parameter to define how the protection is activated after restoration of the communication connection (basic state or after transmission fault).

Refer to *Figure 3-55*.

NOTE

The PPS measurement is used to consider the time delay in the send and receive directions. If PPS fails due to a reception fault or due to a short-term unfavorable satellite position, synchronization via conventional communication media remains active.

The **PPS synchronization** parameter offers 3 different setting options:

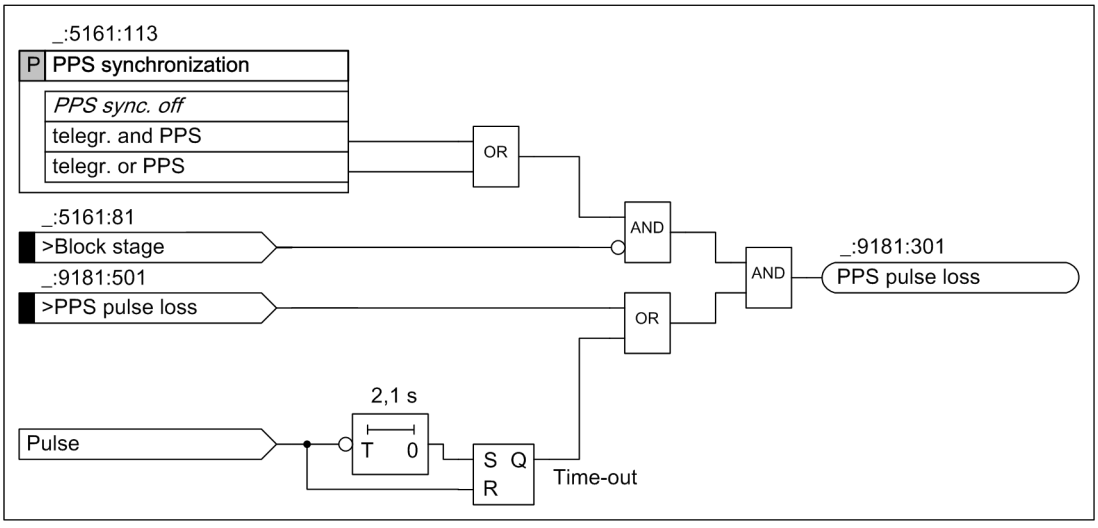
Parameter Value	Description
telegr. and PPS	With this setting, the differential protection is only enabled upon renewed establishment of the connection, if the communication section is synchronized via PPS or if symmetrical time delays are signaled by an external operation (binary input). This results in synchronization with the telegram measurement supported by the PPS measurement.
telegr. or PPS	In this setting, the differential protection is enabled immediately upon renewed establishment of connection (data telegrams are received). The conventional method is used up to synchronization. This results in synchronization with the telegram measurement supported by the PPS measurement.

Parameter Value	Description
PPS sync. off	This setting means that no synchronization is performed via PPS at the protection interface. This is typically the case if no time-delay differences are expected. The synchronization only takes place with the telegram measurement.

NOTE

The synchronization mode can be set separately for both protection interfaces.

If no further PPS pulse is received within 2.1 s, the time-out supervision responds. If no new 2nd pulse occurs after the expiry of the supervision time, the indication **PPS pulse loss** is issued.



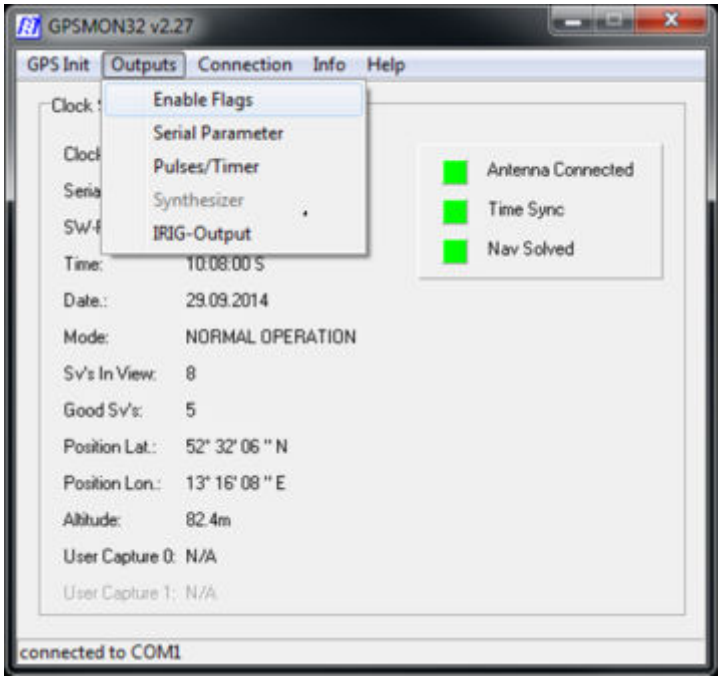
[loppssyn-100113-01.tif, 1, en_US]

Figure 3-55 Setting the PPS Synchronization

The binary input **>PPS pulse loss** can be used to signal an externally detected failure in the PPS signal (for example, error message from the receiver). Setting this binary input also leads to the indication **PPS pulse loss**.

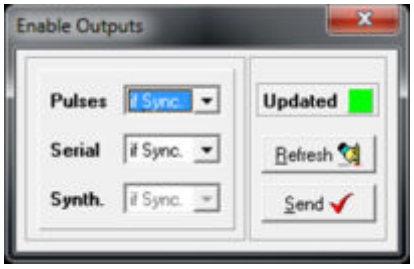
If you are using a second pulse from a GPS receiver, you must ensure that a loss of reception or reception disturbances do not generate a second pulse. The GPS receivers recommended by Siemens are set by default so that a loss of reception or reception disturbances do not generate a second pulse. In the event of problems, check the setting value for the second pulse.

Siemens recommends the **Meinberg 164** GPS receiver. Check the default setting for the second pulse using the **GPSMON32** program. The program is available in the SIPROTEC *download area*. You can find the setting value under **Outputs** →**Enable Flags**. The second pulse must be set to the value ***if Sync.***



[scGPS_1, 2, --_--]

Figure 3-56 Checking the Setting Value for the 2nd Pulse Using the GPSMON32 Program, Step 1



[scGPS_2, 2, --_--]

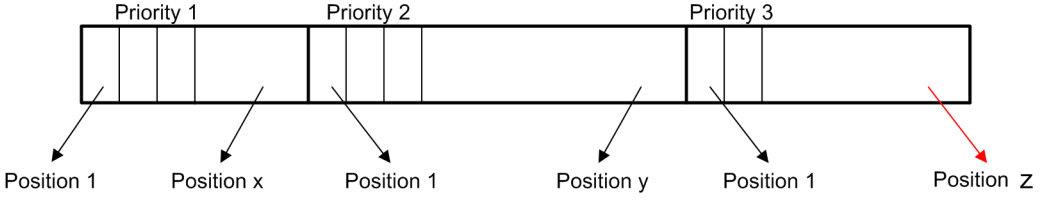
Figure 3-57 Checking the Setting Value for the 2nd Pulse Using the GPSMON32 Program, Step 2

3.5.3.8 Routing Information in DIGSI 5

Protection communications of the same type form a topology.

For more information on this, see chapter *3.5.3.3 Function Description* .

A data bar is exchanged between the devices of a topology connected via protection communication. This can be written into or read from by the devices. This can be used for exchanging various signals between the devices. In this case, each signal demands a certain number of data fields.



[dwdatenl-100113-01.tif, 1, en_US]

Figure 3-58 Data Bar Exchanged Between Devices

The data bar is divided into 3 priorities, which also have different transmission rates and data volumes.

The following basic principle applies for all messages: Only pure data contents are transmitted. The quality (for example, *valid*) is not automatically transmitted as well. If you want to transmit the quality as well (for

example, for further processing of GOOSE messages), the quality must be transmitted separately (for example, by using CFC). If a signal that has a test flag is transmitted (because its function is in test mode, for example), all signals are provided with a test flag on the receiving side. If the connection is broken, all received signals are flagged with the quality *Invalid*. If desired, the value can also be set to a secure state after a selectable dropout time, or the last value received can be retained (**Hold** setting). This can be configured separately for each received signal (see *Table 3-13*).

NOTE

For **ACT** type signals, only the phase information is transmitted.

Indications that are transferred data fields of priority 1 are sent with every telegram. They are preferably used for the transmission of rapid signals, for example, release for circuit-breaker intertripping. A strictly deterministic, rapid transmission is required there.

Signals of priority 2 are transmitted with at least every 2nd telegram. For bit rates >256 kBit/s, there are no differences between priority 1 and priority 2.

Priority 3 information is transmitted at least every 100 ms. This priority is used for transmission of measured and metered values. Complex values must be routed separately as the real and the imaginary part for transmission. Measured-value thresholds that lead to an updating of a measured value are set centrally as a property of the measured value. These measured-value thresholds apply with the corresponding reporting, for example, also for the transfer via IEC 61850 to a substation automation technology.

Indications which are written to a data area x under a priority on the data bar must be routed to an indication of the same type in the device reading this information. Otherwise, they are processed incorrectly on the receiving side. The data bar is organized in terms of bits. For information on the bit requirement of each signal type, refer to *Table 3-12* .

Table 3-10 and *Table 3-11* show the number of data areas in the data bar in relation to the available baud rate.

NOTE

The **Lowest appearing bit rate** parameter, which has to be set in each device for the protection interfaces of a topology, defines the number of data areas as well as the topology type.

If, for example, in a three-end constellation with a type 2 chain topology two devices are connected via direct optical fibers and 2 devices via the 64-kBit/s weakest line, the 64-kBit/s section is the limiting factor for the entire constellation.

Table 3-10 Available Bits - Minimum Constellation Baud Rate 64/128 kBit/s

	Priority 1	Priority 2	Priority 3
Type 1	8 Bits	24 Bits	128 Bits
Type 2	32 Bits	64 Bits	256 Bits

Table 3-11 Available Bits - Minimum Constellation Baud Rate 512/2048 kBit/s

	Priority 1	Priority 2	Priority 3
Type 1	48 Bits	128 Bits	384 Bits
Type 2	96 Bits	200 Bits	1024 Bits

Table 3-12 Requirement in Bits

Signal Type	Size in Bits
SP (single-point indication)	1 Bit
DP (double-point indication)	2 Bits
IN (metered values)	32 Bits

Signal Type	Size in Bits
MW (measured values)[5]	32 Bits
ACT	4 Bits

Table 3-13 Possible Dropout Values

Signal Type	Dropout Values
SP (single-point indication)	Outgoing, Incoming, Hold
DP (double-point indication)	On, Off, Intermediate Position, Disturbed Position, Hold
IN (metered values)	0, Hold
MW (measured values)	0, Hold
ACT	Hold

NOTE

If the protection link fails, these values can be set on the receiver side.

EXAMPLE

2 devices are connected via a 64-kBits channel. This is a type 1 topology. 8 bits are freely available for priority 1. Now, for example, 4 SPS and 2 DPS can be routed:

4 x 1 Bit + 2 x 2 Bits = 8 Bits

NOTE

Measured values are transmitted as primary values.

EXAMPLE

For the rated current display in the receiving device

When I_{rated} = 1000 A in the transmitting device and I_{Load} = 200 A, the number 200 is displayed in the receiving device.

Remote Data Transmission: Routing of the Indications and Measured Values to the Protection Interface

The transmission is organized in the form of a data bar which is continuously exchanged between the devices.

For this, see *Figure 3-58* .

A device indication or measured value is allocated to a definite data area of the bar.

Figure 3-59 to *Figure 3-62* show the routing for a communication topology of protection interface type 1.

To transmit signals to other devices, these signals must be routed in the communication matrix under **Transmit**. Binary inputs 1 and 2 are single-point indications (SPS) and are routed to position 1 and position 2 of the transmission with the highest priority (priority 1). For 64 kBit/s, for example, only 8 of these data areas are available for type 1; they are exchanged between the transmission routes with each telegram. Signals 3 and 4 are double-point indications (DPS), for example, a switch position that is transmitted by a device 1. A double-point indication occupies 2 positions on the data bar. In addition, a measured and metered value are communicated via priority 3.

As a measured or metered value uses 32 bits, value 2 starts at position 33. DIGSI 5 indicates the next available position.

[5] The complex vectors of a measuring point are pre-routed

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.							
			Fault records	Receive					Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value		T	Priority level	Bit position
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)		..	(All...)	(All...)
General	91										
Device	4171										
Alarm handling	5971										
Time managem.	8821										
Time sync.	8851										
Power system	11										
Recording	51										
Binary IO	61								*		
Binary inputs	61.1051								*		
Binary input1	61.1051.3151								*		
Value	61.1051.315...	SPS							X	1	1
Binary input2	61.1051.3152								*		
Value	61.1051.315...	SPS							X	1	2

[scransps-021210-01.tif, 1, en_US]

Figure 3-59 Routing of Single-Point Indications to the Protection Interface in Device 1

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.							
			Fault records	Receive					Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value		T	Priority level	Bit position
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)		..	(All...)	(All...)
General	91										
Device	4171										
Alarm handling	5971										
Time managem.	8821										
Time sync.	8851										
Power system	11										
Recording	51										
Binary IO	61								*		
F:USART-AE-2FO	101										
J:Integrated Ethernet interface	102										
Circuit breaker 1	201										
Line 1	21								*		
General	21.9001										
Group indicat.	21.4501										
Process monitor	21.1131										
Operational values	21.761								*		
Behavior	21.761.1147...	ENS									
Health	21.761.1147...	ENS									
f	21.761.1021...	MV							X	3	1

[scrangmw-021210-01.tif, 1, en_US]

Figure 3-60 Routing of Measured Values to the Protection Interface in Device 1

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.						
			Fault records	Receive					Transmit	
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)
General	91									
Device	4171									
Alarm handling	5971									
Time managem.	8821									
Time sync.	8851									
Power system	11									
Recording	51									
Binary IO	61							*		
F:USART-AE-2FO	101									
J:Integrated Ethernet interface	102									
Circuit breaker 1	201									
Line 1	21							*		
2 device prot. com.	31							*		
Device combin.	31.5131							*		
Behavior	31.5131.52	ENS								
Health	31.5131.53	ENS								
Status of topo. recog.	31.5131.301	ENS								
Topology is	31.5131.302	ENS								
Devices form	31.5131.303	ENS								
Number of detect. dev.	31.5131.304	INS						X	3	33

[scrangzw-021210-01.tif, 1, en_US]

Figure 3-61 Routing of Metered Values to the Protection Interface in Device 1

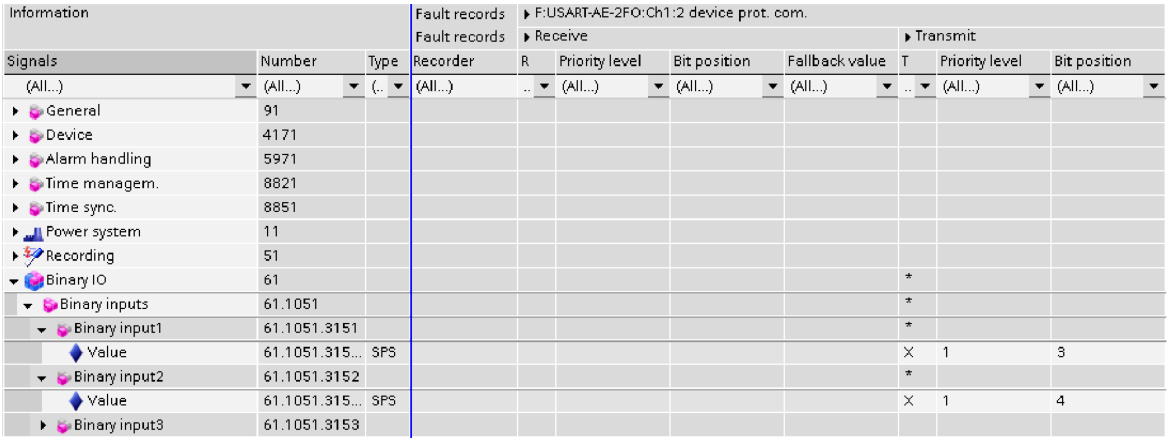
This device also receives information (in the matrix under **Receive**). This must have been routed as a target for other devices (see next figure). The binary outputs 1 and 2 in device 1 receive their information via the protection interface. This is priority 1 information, which has been routed in another device to position 3 and 4 of the data bar. The secure state is defined in the **Fallback value** column. If the data connection fails, the single-point indication is reset to ***coming*** or **going** or its value is retained (***hold***). For data of the various priorities, you can also set a dropout time after which the resetting (see *Figure 3-61*) to the fallback value occurs, in order to retain the original state for a short time in the event of brief interruptions. These 3 dropout times apply for all data of one transmission priority and are set as parameters.

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.						
			Fault records	Receive					Transmit	
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)
General	91									
Device	4171									
Alarm handling	5971									
Time managem.	8821									
Time sync.	8851									
Power system	11									
Recording	51									
Binary IO	61			*						
Binary inputs	61.1051									
Binary outputs	61.1061			*						
Binary output1	61.1061.3181			*						
Value	61.1061.318...	SPS		X	1	3	Hold			
Binary output2	61.1061.3182			*						
Value	61.1061.318...	SPS		X	1	4	Hold			

[scspsemp-021210-01.tif, 1, en_US]

Figure 3-62 Routing of Single-Point Indications (Receive) to the Protection Interface in Device 1

The following figure shows the routing in the 2nd device. Binary inputs 1 and 2 are routed with priority 1 to positions 3 and 4 there. In device 1, positions 1 and 2 are already occupied (see *Figure 3-59*). If you also route the signals to positions 1 and 2, the signals of the devices are then connected to the corresponding position with a logical **OR** operation. If measured and metered values are routed in the same data areas, this results in implausible values for the receivers that read the data. As a user, you are therefore responsible for the correct routing.



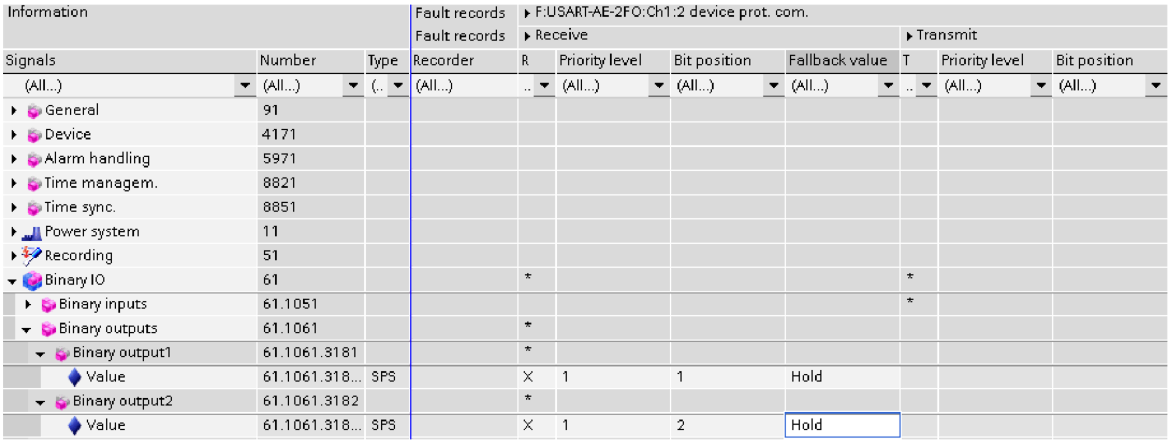
Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.						
			Fault records	Receive				Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)
General	91									
Device	4171									
Alarm handling	5971									
Time managem.	8821									
Time sync.	8851									
Power system	11									
Recording	51									
Binary IO	61							*		
Binary inputs	61.1051							*		
Binary input1	61.1051.3151							*		
Value	61.1051.315...	SPS						X	1	3
Binary input2	61.1051.3152							*		
Value	61.1051.315...	SPS						X	1	4
Binary input3	61.1051.3153									

[scbaspsr-021210-01.tif, 1, en_US]

Figure 3-63 Routing of Single-Point Indications to be Sent to the Protection Interface in Device 2

The binary outputs 1 and 2 (**Receive**) in the 2nd device are connected to priority 1 signals 1 and 2 from the 1st device. This takes place via the data areas at positions 1 and 2 of the data bar, which transfer the state of the indications. Other devices can also read this information and link it to their internal signals. Here, too, the secure state, which is assumed when the protection connection is interrupted, is entered. This state depends on the information. In the case of single-point indications, the state is 0 or 1. In the case of double-point indications, the bit combinations 00, 01, 10, or 11 are possible, in order to directly signal a disturbed position upon failure of the data connection, for example.

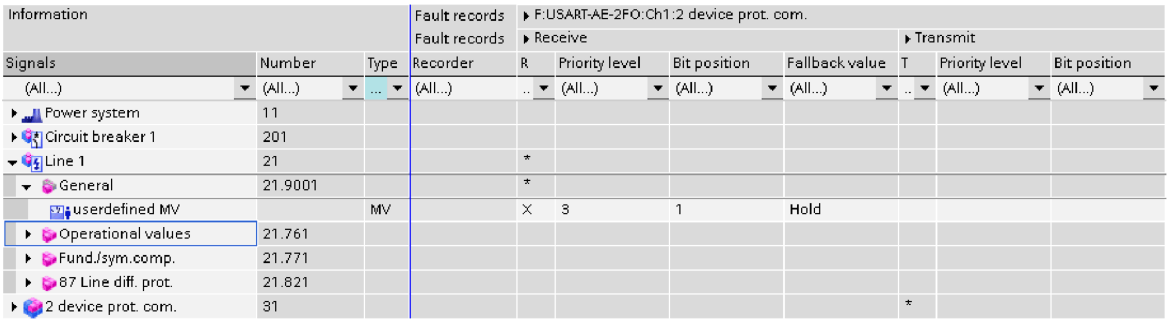
Hold is used to retain the state.



Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.						
			Fault records	Receive				Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position
(All...)	(All...)	(..	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)
General	91									
Device	4171									
Alarm handling	5971									
Time managem.	8821									
Time sync.	8851									
Power system	11									
Recording	51									
Binary IO	61			*				*		
Binary inputs	61.1051							*		
Binary outputs	61.1061			*						
Binary output1	61.1061.3181			*						
Value	61.1061.318...	SPS		X	1	1	Hold			
Binary output2	61.1061.3182			*						
Value	61.1061.318...	SPS		X	1	2	Hold			

[scbausps-021210-01.tif, 1, en_US]

Figure 3-64 Routing of Received Single-Point Indications to the Protection Interface in Device 2



Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.						
			Fault records	Receive				Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position
(All...)	(All...)	...	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)
Power system	11									
Circuit breaker 1	201									
Line 1	21			*						
General	21.9001			*						
userdefined MV		MV		X	3	1	Hold			
Operational values	21.761									
Fund./sym.comp.	21.771									
87 Line diff. prot.	21.821									
2 device prot. com.	31							*		

[scbausmw-021210-01.tif, 1, en_US]

Figure 3-65 Routing of Received Measured Values to the Protection Interface in Device 2

Information			Fault records	F:USART-AE-2FO:Ch1:2 device prot. com.						
			Fault records	Receive				Transmit		
Signals	Number	Type	Recorder	R	Priority level	Bit position	Fallback value	T	Priority level	Bit position
(All...)	(All...)	I...	(All...)	..	(All...)	(All...)	(All...)	..	(All...)	(All...)
Recording	51									
Circuit breaker 1	201									
Line 1	21			*						
General	21.9001			*						
userdefined INS		INS		X	3	33	Hold			
2 device prot. com.	31									
Device combin.	31.5131									
Number of detect. dev.	31.5131.304	INS								

[scbauszw-021210-01.tif, 1, en_US]

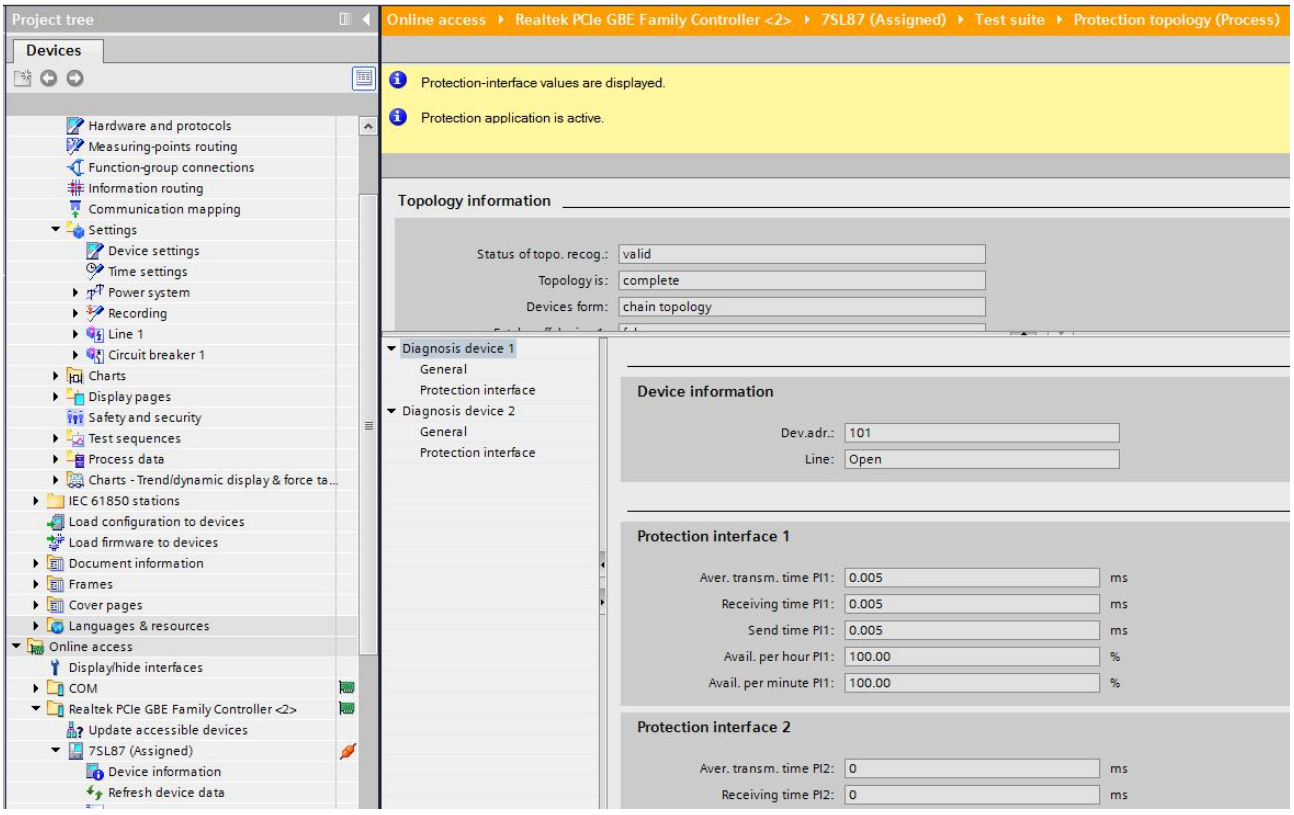
Figure 3-66 Routing of Metered Values to the Protection Interface in Device 2

3.5.3.9 Diagnostic Measured Values of the Protection Interface

The following diagnostic data is provided via the protection interfaces by the devices in the constellation:

- Address of the device in the constellation
- Circuit-breaker switch position (open/closed/undefined) (only for protection interfaces of type 1)
- Availability of protection-interface communication within the last minute, as percentage
  Availability of protection-interface communication within the last hour, as percentage
- Time delay in the send and receive direction of the telegrams between local and neighboring device

You can find this diagnostic data in DIGSI under the following menu structure (see *Figure 3-67*):



[sc_diagnose_wskanäle_geräteadresse, 2, en_US]

Figure 3-67 Protection-Interface Channel Diagnostic Data – Device Address

NOTE

You can use the following procedure to reset the measured values for the protection interface directly in the device:

Device functions > x Device protection comm. > Protection interface y > Reset measured values.

Output Signals of the Protection Interface

Each individual protection interface provides the following indications for commissioning and diagnosing communication:

Indication	Description
(_:5161:301) Status of lay. 1 and 2	The output signal gives you information about the state of communication layers 1 and 2 (1: Physical Layer, 2: Data Link Layer). The following indications values are possible: • *Initialized*: The protection interface is not connected and is in the Initial state. • *Protection interface connected*: The protection interface is connected to the protection interface of a device. • *Protection interface disturbance*: The protection interface has not received any valid telegrams for the time set in parameter **(_:5161:107) Disturbance alarm after**. • *Protection interface failure*: The protection interface has not received any valid telegrams for the time set in parameter **(_:5161:108) Transm. fail. alarm after**. • *not present*: The protection interface has not been assigned to a communication channel.

Indication	Description
(_:5161:302) Status of lay. 3 and 4	The output signal gives you information about the state of communication layers 3 and 4 (3: Network Layer, 4: Transport Layer). The following indications values are possible: • *no error*: The protection interface is operating correctly. • *Software version incompatible*: The firmware versions of the connected devices are incompatible. Update the firmware. • *System mirroring*: The protection interface is receiving its own data. Check the wiring. • *Dev. add. incorrect*: The device address of the partner device is incorrect. Check the settings for parameters **Address of device 1** to **address of device n** (_:5131:102 and following). • *Constell. incorrect*: The constellation settings of the devices are different. Check that the setting for the parameter **Select constellation** is identical in all devices. • *Const. param. incorrect*: Check that the same setting has been made for parameter **(_:5131:122) Lowest appearing bit rate** in all devices. • *Diff. Param. Error*: The line differential protection settings for the connected devices are incompatible. Check whether both devices are set to operate with or without line differential protection. The rated value of the line (parameter **(_:9001:101) Rated current** and **(_:9001:102) Rated voltage**) must have the identical setting at both ends of the line. If a transformer is installed in the line, both parameters must be set such that the rated apparent power is the same at both ends of the line (parameter **(_:9001:103) Rated apparent power**).

In order to clarify faults, each individual protection interface provides the following binary signals:

Binary Output Signal	Description
(_:5161:303) Connection broken	Signal *Connection broken* indicates that during a parameterized time (parameter **(_:5161:107) Disturbance alarm after**) faulty or missing telegrams were continuously received. If the 'Connection interrupted' indication occurs, the affected protection interface link will be terminated. This can cause the blocking of an active differential protection or a ring topology can change to a chain topology.
(_:5161:316) Error rate / min exc.	Signal *Error rate / min exc.* indicates that the set maximum error rate per minute (Parameter **(_:5161:106) Max. error rate per min**) has been exceeded.
(_:5161:317) Error rate / hour exc.	Signal *Error rate / hour exc.* indicates that the set maximum error rate per hour (Parameter **(_:5161:105) Max. error rate per hour**) has been exceeded.
(_:5161:318) Time delay exceeded	Signal *Time delay exceeded* indicates that the threshold value for the set signal-transit time (Parameter **(_:5161:109) Delay time threshold**) has been exceeded.
(_:5161:319) Time delay different	Signal *Time delay different* indicates that the threshold value for asymmetrical transit times has been exceeded. The setting value results from the setting value of the parameter **(_:5161:110) Difference Tx and Rx time**.
(_:5161:320) Time delay jump	Signal *Time delay jump* indicates that the data transit times changed abruptly. This is caused by switching the communication path in the communication network.

Binary Output Signal	Description
(_:5161:321) PI synchronized	Signal *PI synchronized* indicates that the protection-interface connection is synchronized with the opposite end.
(_:5161:340) Telegram lost	Signal *Telegram lost* indicates that an expected telegram has failed to arrive or a faulty telegram has been received. If you would like to allocate the communication failures or faults to other events, move the signal *Telegram lost* temporarily into the operational log. Such events can be switching operations in the primary system or operations on the components of the communication network. **Note:** If the signal is constantly routed, the operational log can overflow. Siemens recommends routing the signal only for clarification of faults.

Measured Values of the Protection Interface

The protection interface provides the following measured value to diagnose the protection interface communication:

Measured Value	Description
(_:5161:308) Tx tel/h	Telegrams sent during the last hour
(_:5161:309) Rx tel/h	Telegrams received during the last hour
(_:5161:310) Tx tel/min	Telegrams sent during the last minute
(_:5161:311) Rx tel/min	Telegrams received during the last minute
(_:5161:312) Tx err/h	Transmission failure rate during the last hour
(_:5161:313) Rx err/h	Reception failure rate during the last hour
(_:5161:314) Tx err/min	Transmission failure rate during the last minute
(_:5161:315) Rx err/min	Reception failure rate during the last minute
(_:5161:325) Aver.Δt	Mean signal-transit time (average value of the transit time in transmission and reception direction divided by 2, without GPS synchronization)
(_:5161:326) Rec. Δt	Signal-transit time in reception direction (with GPS synchronization)
(_:5161:327) Sen. Δt	Signal-transit time in transmission direction (with GPS synchronization)
(_:5161:334) Miss.tel/min	Number of telegram failures within the last minute
(_:5161:335) Miss.tel/h	Number of telegram failures within the last hour
(_:5161:336) Miss.tel/d	Number of telegram failures within the last day
(_:5161:337) Miss.tel/w	Number of telegram failures within the last week
(_:5161:338) M. loss/d	Longest lasting telegram failure within the last day
(_:5161:339) M. loss/w	Longest lasting telegram failures within the last week

NOTE

You can reset the measured values of the protection interface directly in the device. Proceed as follows: **Device functions > x Device protection comm. > Protection interface y > Reset measured values**.

3.5.3.10 Tunneling with DIGSI 5 via Protection Interface

Configuration of the Subnetworks

You can use a PC to access other devices within the constellation via the protection links. DIGSI 5 communication then operates exclusively via the connections and the protection-data communication is turned off. In this way, you operate the remote devices from the local device via DIGSI 5.

Remote control with DIGSI 5 is only possible if you are online with the local device and connected there with the integrated Ethernet interface RJ45

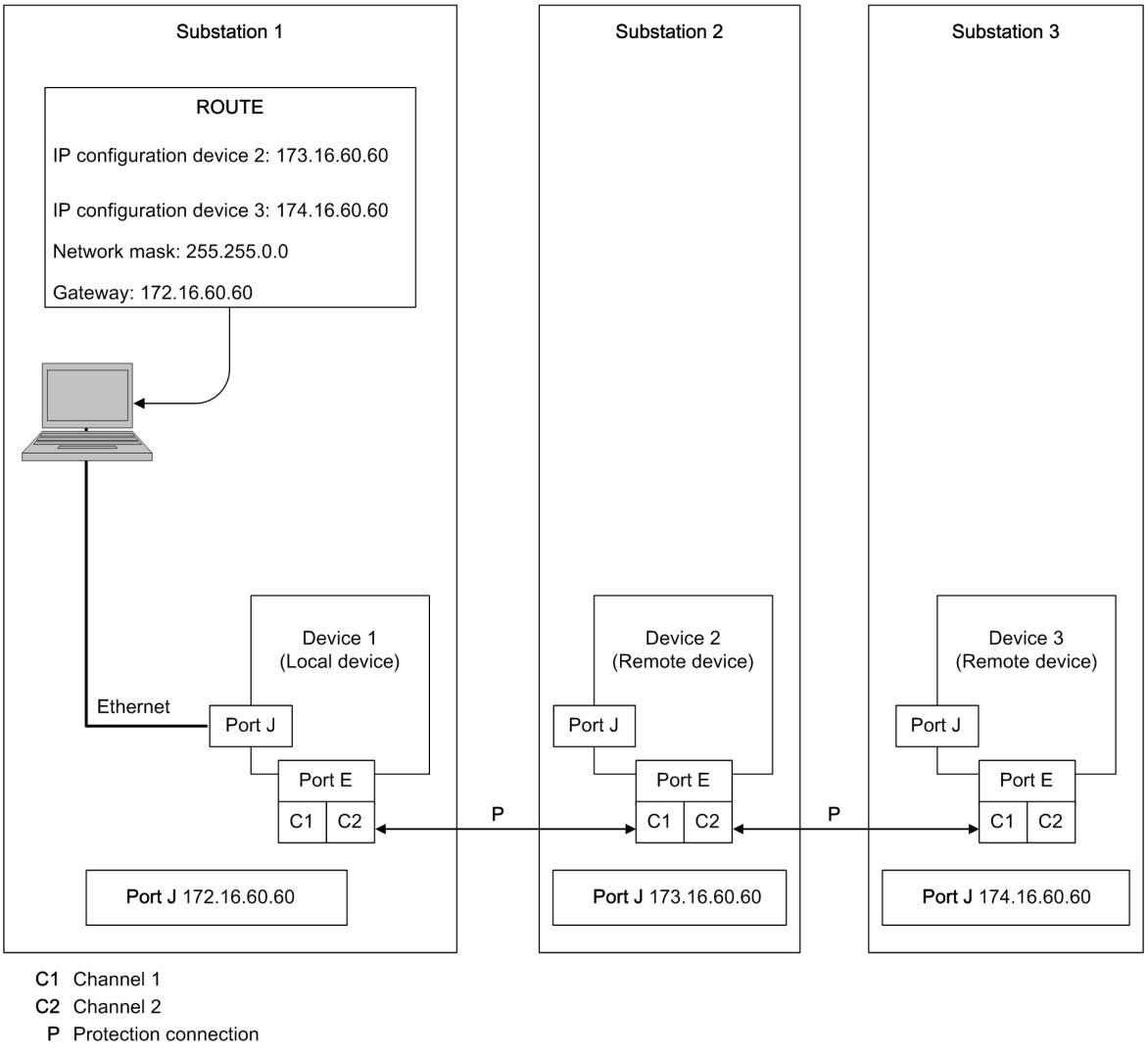
NOTE

All remote devices need an IP configuration for port J (integrated Ethernet interface) in all cases. The IP addresses of slots J of a protection topology must be in different subnetworks.

NOTE

If reparameterization requires a restart of the remote device, then the corresponding route is not available until after approx. 2 min. following a complete restart.

The following figure shows a configuration with 3 devices as an example.



[dwremote-030211-01.tif, 1, en_US]

Figure 3-68 Sample Configuration of a Remote Control with 3 Devices

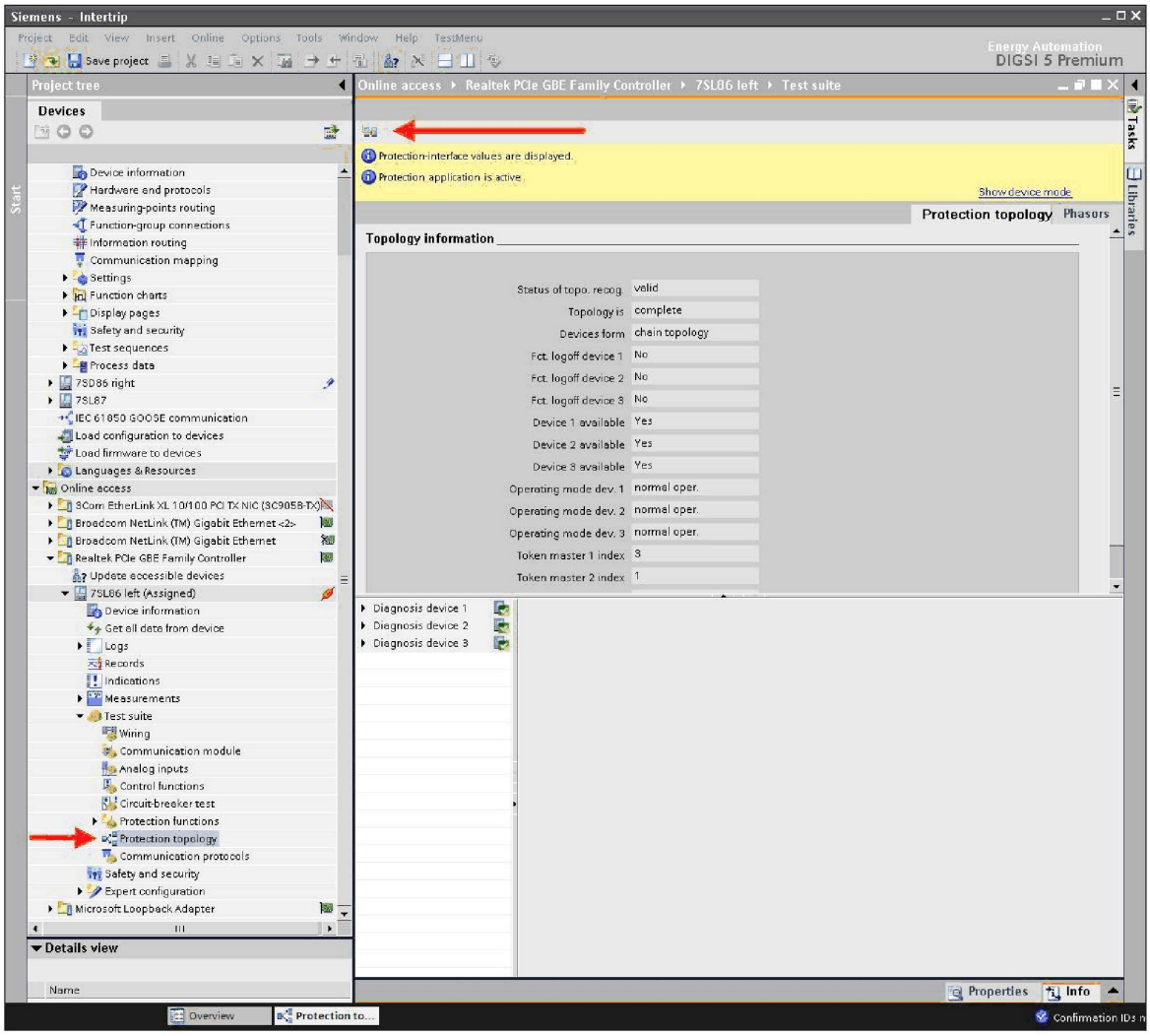
Tunneling with DIGSI 5 via Protection Interface: Procedure

If you want to perform tunneling (remote control)[6] via DIGSI 5, proceed as follows:

- You make a connection between DIGSI 5 and the device through the Ethernet RJ45.
- Open the device concerned in **Online access**.
- Go to **Test suite**/**Protection topology**.
- Open **Protection topology**. In the next window, press the button at top left (see arrow in the following figure). The dialog for deactivating the protection communication then opens.

  If you confirm the query, protection communication is interrupted and the communication channels are used exclusively for DIGSI 5. Note that the protection functions that use protection data communications (e.g. differential protection) are deactivated and no remote data can be updated in the constellation. Then, the remote signals fall back to the secure state the user has defined earlier.

[6] This function is not yet implemented and will first be activated with a later firmware version.



[sctunnel-200213-01.tif, 1, en_US]

Figure 3-69 Tunneling with DIGSI 5

NOTE

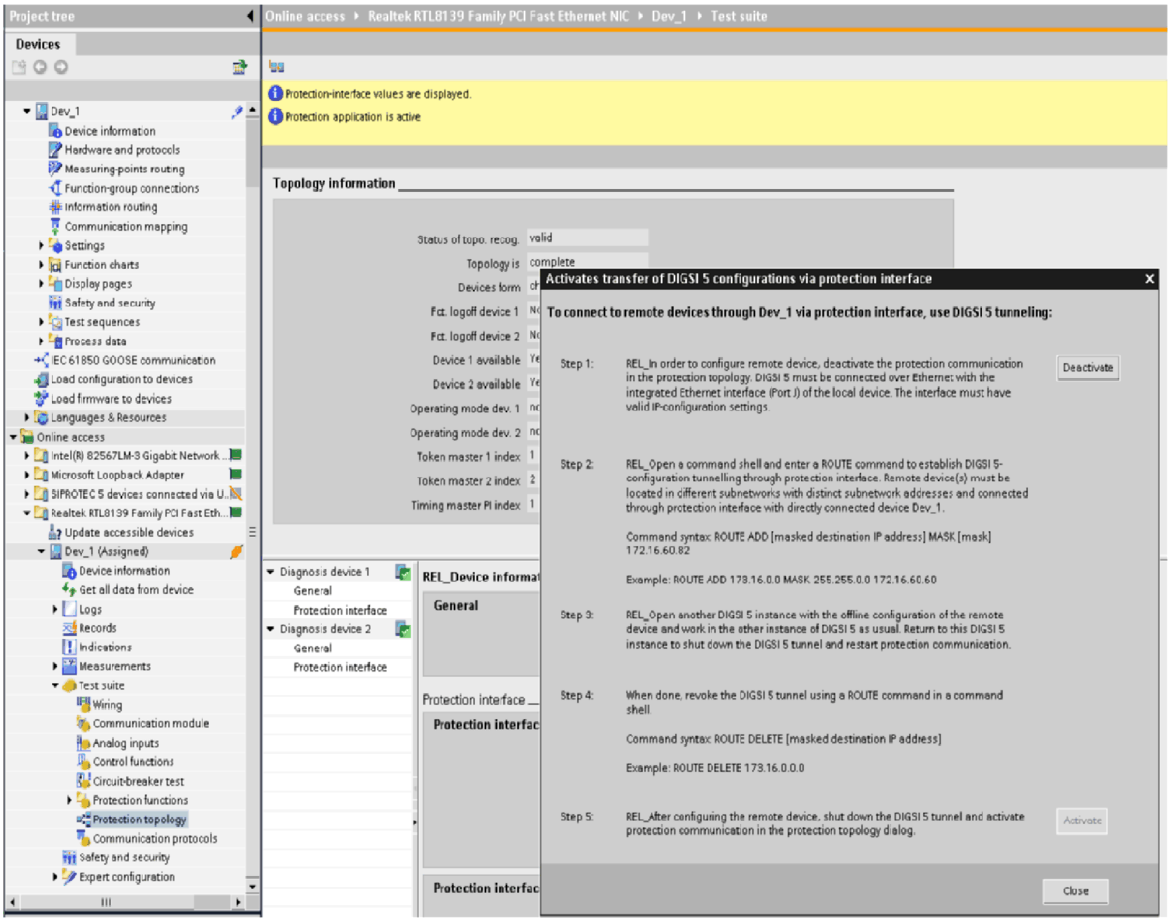
The protection communication remains interrupted until either the user reactivates it manually, or a maximum deactivation duration of 12 hours has been exceeded. After this, the connection reactivates itself. This ensures that the protection communication and protection function working with it are reactivated.

NOTE

Ensure that DIGSI 5 is connected via Ethernet to RJ45 of the local device. The local device must be configured with valid IP addresses.

Figure 3-70 to *Figure 3-71* show the steps for the deactivation of protection communication.

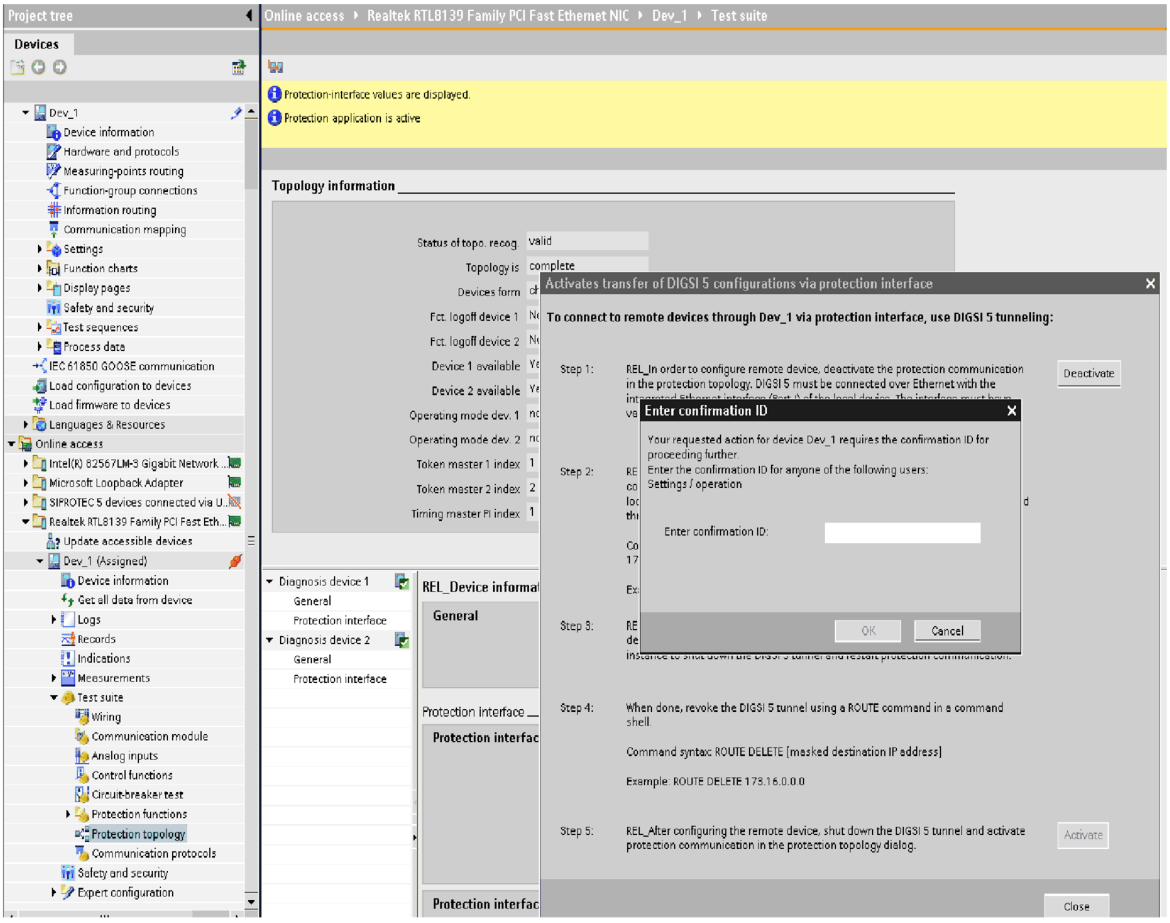
In the next step, a window appears in DIGSI 5 containing the instructions for deactivating the protection data communication (see next figure).



[scdeadig-061210-01.tif, 1, en_US]

Figure 3-70 Steps for the Deactivation of Protection Communication

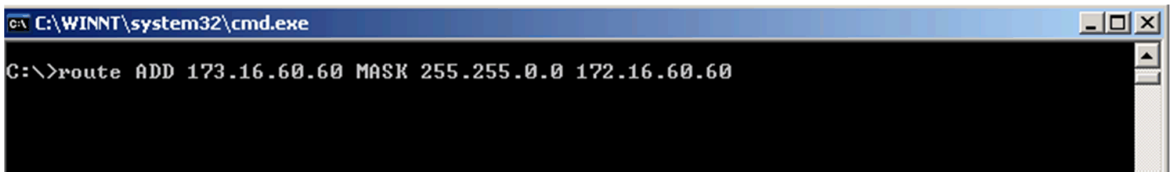
In order to be able to deactivate the protection-data communication, you must enter your confirmation ID if a security query is activated (see next figure). The default confirmation ID is **222222**.



[scdecode-061210-01.tif, 1, en_US]

Figure 3-71 Entering the Confirmation ID for the Deactivation of Protection Communication

- Under **Start ---> Run in Windows**, open an input window by entering **CMD**.
  Use the DOS box to enter a command line to set a route (see next figure). This is the prerequisite that DIGSI 5 can be routed further via the protection interface.



[scdosbox-310311-01.tif, 1, en_US]

Figure 3-72 Setting of the Route in the DOS Box

NOTE

To set the route, you must have administrator rights for the DIGSI PC.

- The following routing command is necessary to connect from device 1 to device 2 in the example shown (see *Figure 3-68*):
  - Route add 173.16.60.60 Mask 255.255.0.0 172.16.60.60
  - Route <Command> Destination (= Device 2) Mask (Routing Device) Local Device

  Remote devices must be available in different subnetworks and provided with unique IP addresses. For this, RJ45 of the relevant devices must already be configured so that these devices can now be accessed remotely.
- Now, select your DIGSI 5 project for substation 2 and connect this to the device. Although you are physically connected to the local device, this device now establishes a connection with the remote device. You can now fully operate the remote device with DIGSI 5.

  After completing the process, the protection communication must be reactivated. For this, end the connection with the remote device in DIGSI 5 at the local device for the protection interface.

  If this communication is not terminated properly, the protection-data communication then switches on again automatically after about 12 hours.
- Delete the route again by entering the following in the DOS box:
  - Route Delete 173.16.60.60
- If you wish to access device 3 via the protection interface, proceed in the same way. In this case, the DIGSI 5 communication is routed to device 3 via device 2 and you are connected from device 1 to device 3.
- To establish a connection with device 3, the following route is necessary:
  - Route add 174.16.60.60 Mask 255.255.0.0 172.16.60.60



NOTE

If there is no connection between the local device and DIGSI 5 for longer than an hour, the connection automatically resets to protection communication.

3.5.3.11 Diagnostic Data for the Protection Interface

Diagnostic Data of the Channel in DIGSI 5

Different diagnostic data can be read with DIGSI 5.

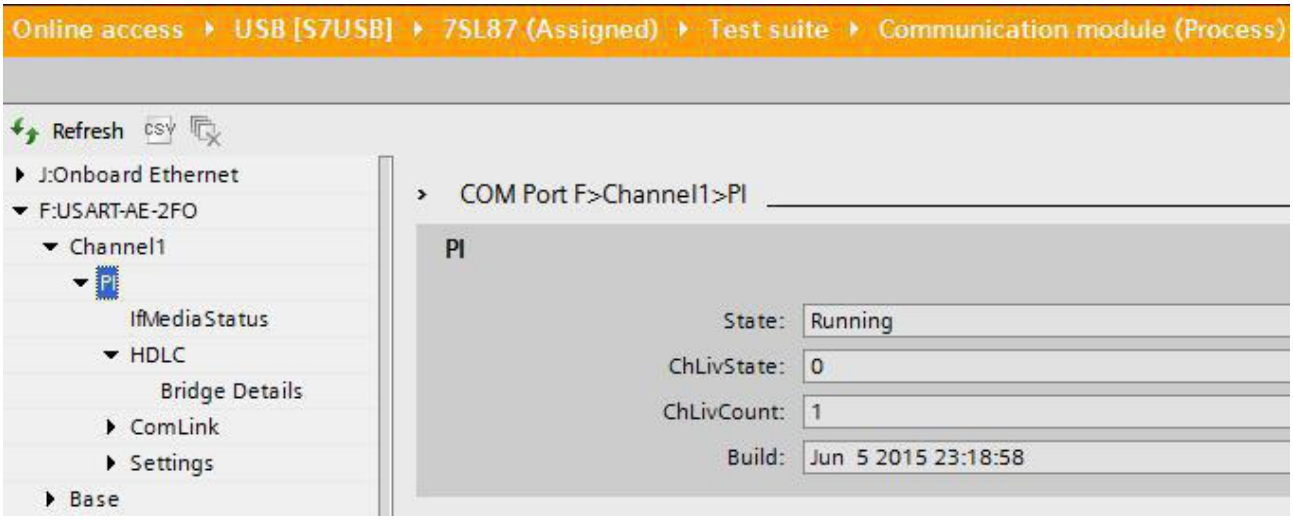
For this, connect with the device via DIGSI 5 and query the device information. Diagnostic data for a module whose channel is configured with the protection interface can be received by selecting the module slots (for example, F) and the corresponding channel (1 or 2). The following figures show the extensive diagnostic data for the protection interface. It is particularly helpful if data failures occur or other irregularities in a communication connection (for example, transmission time fluctuations).



NOTE

The diagnostic data can also be read via the device control on the display of the device. The overview of DIGSI 5 does not offer this option, however.

The following table describes the displays.



[scdiapin-140912-01, 1, en_US]

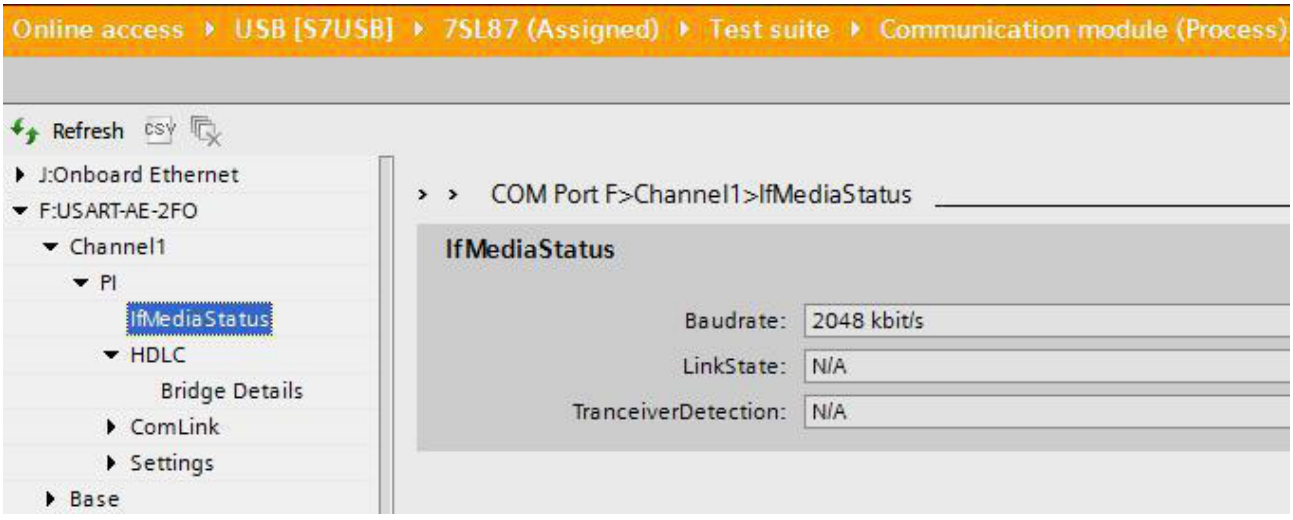
Figure 3-73 Diagnostic Data of a Channel Configured with the Protection Interface

Table 3-14 Description of the Diagnostic Data under Protection Interface

Channel Type	Name	Values	Description - Diagnostic Information for Log PI
Protection interfaces - log	Status	Initial, Running, Error	Runtime status of the log
Protection interfaces - log	Build	Date/time	Date and time of the log version

Diagnostic Data of the Protection-Interface Log in DIGSI 5

The following figures and tables describe the displays of the protection-interface log.

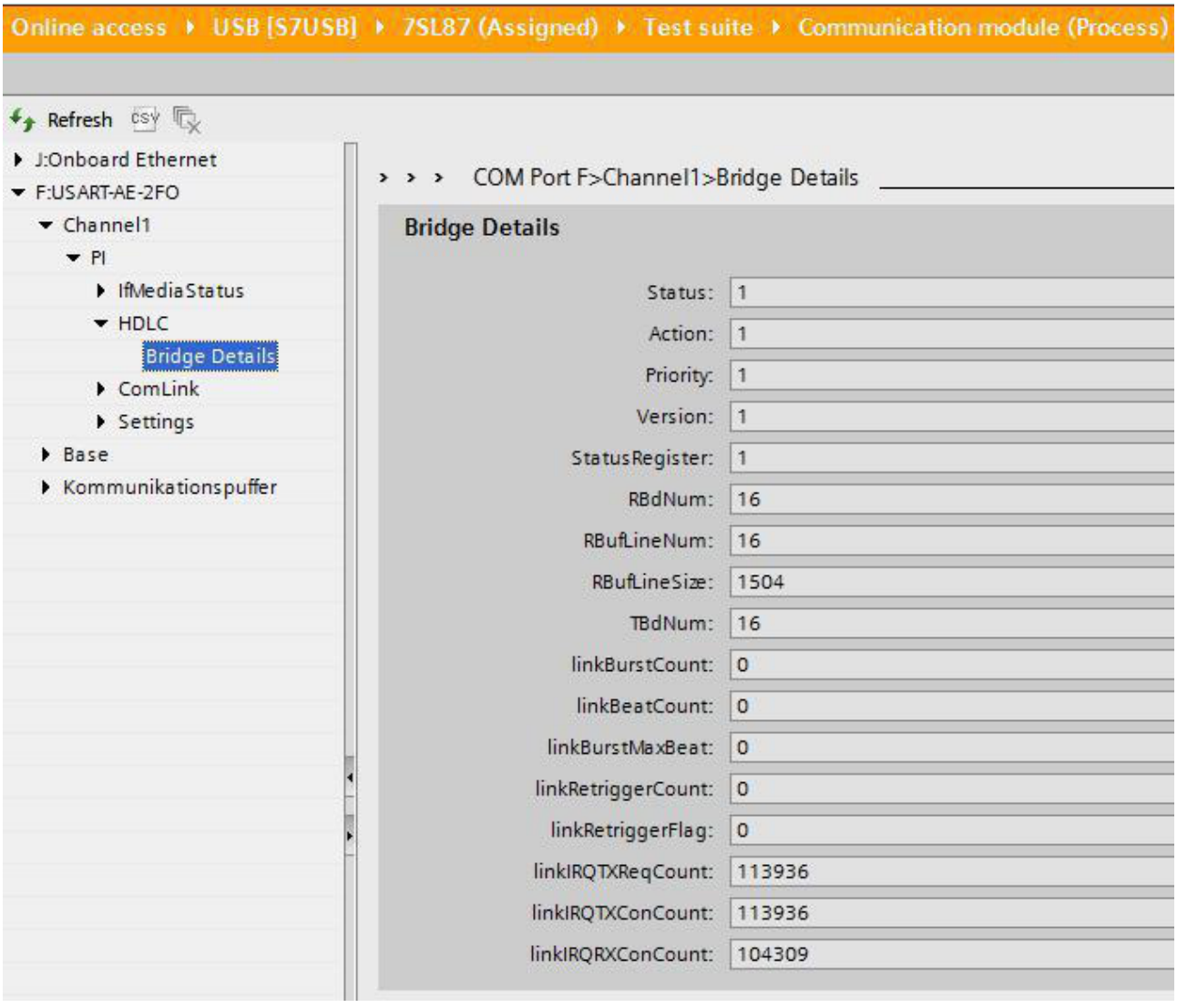


[scdiamed-140912-01, 1, en_US]

Figure 3-74 Diagnostic Data of the Protection-Interface Log - Media Status

Table 3-15 Description of Diagnostic Data under Media Status

Protection Interfaces - Log Type	Name	Values	Description - Media Status Interface (in Direction of Outside Interface)
Media Status	Baud rate	64 kBit/s; 128 kBit/s; 512 kBit/s; 2048 kBit/s; 30 MBit/s; <unknown>	HDLC baud rate: FO: 64 kBit/s to 2048 kBit/s for 820-Nm USART modules LDFO: 30 MBit/s for 1300/1500-Nm long-distance modules Error case: <unknown>
Media Status	LinkState	N/A, UP, DOWN	FO: N/A (always display N/A)
Media Status	TransceiverDetection	N/A, NO Transceiver detected, Transceiver detected	FO: N/A (always N/A) (NO Transceiver detected, Transceiver detected), Error case: N/A

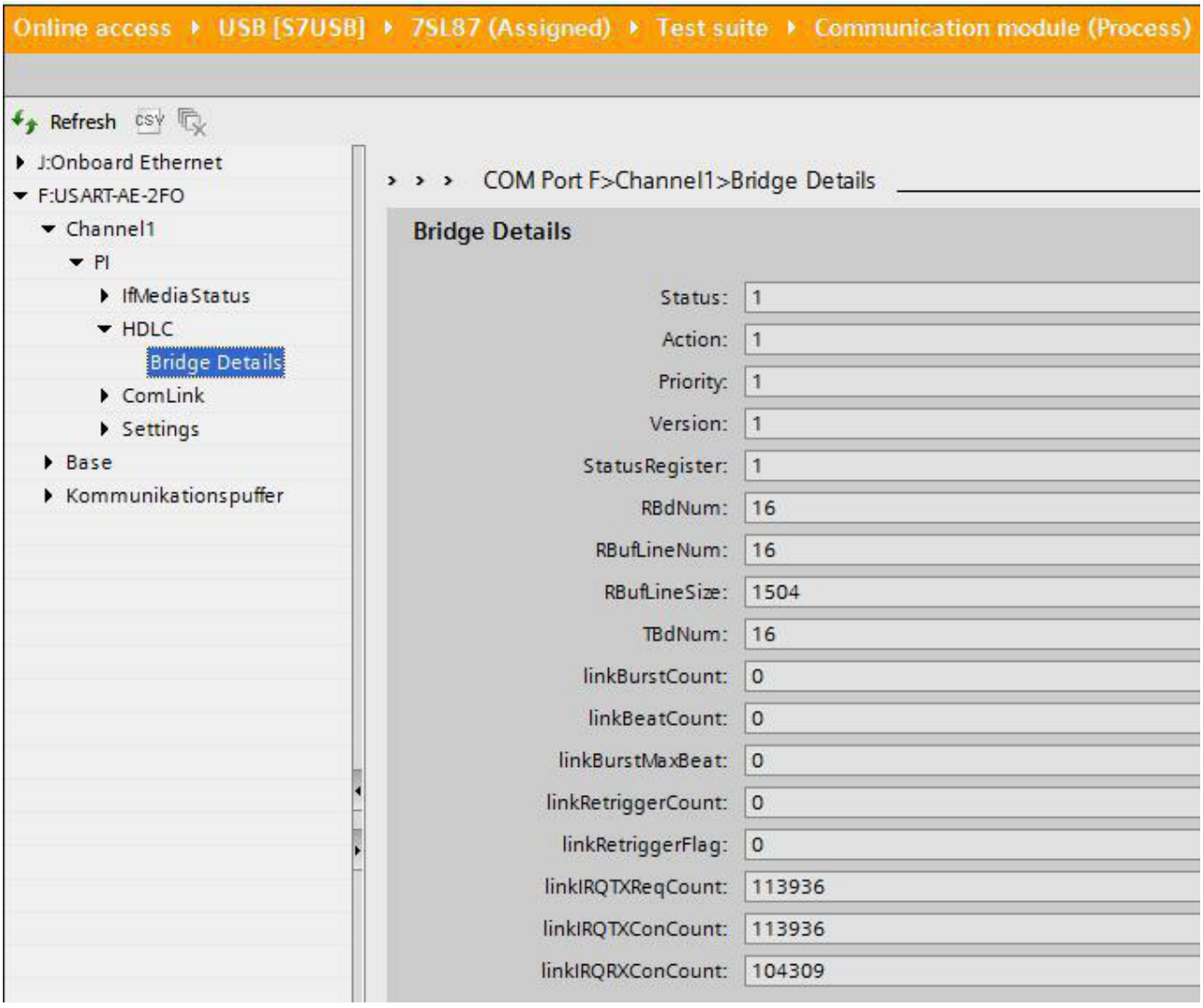


[scdiacom-140912-01, 1, en_US]

Figure 3-75 Diagnostic Data of the Protection-Interface Log - HDLC (Log - Layer)

Table 3-16 Description of Diagnostic Data of the Protection-Interface Log - HDLC (Log - Layer)

Protection Interfaces - Log Type	Name	Values	Description - HDLC Link Layer Diagnostic Information (in Direction of Outside Interface)
HDLC	RXHPFramesOK	Number of corresponding frames (16 bit counter)	Incoming telegrams, high priority, OK
HDLC	RXLPFramesOK	Number of corresponding frames (16 bit counter)	Incoming telegrams, low priority, OK
HDLC	RXHPFramesERR	Number of corresponding frames (16 bit counter)	Incoming telegrams, high priority, faulty
HDLC	RXLPFramesERR	Number of corresponding frames (16 bit counter)	Incoming telegrams, low priority, faulty
HDLC	TXHPFramesOK	Number of corresponding frames (16 bit counter)	Sending telegrams, high priority, OK
HDLC	TXLPFramesOK	Number of corresponding frames (16 bit counter)	Sending telegrams, low priority, OK
HDLC	TXHPFramesERR	Number of corresponding frames (16 bit counter)	Sending telegrams, high priority, faulty
HDLC	TXLPFramesERR	Number of corresponding frames (16 bit counter)	Sending telegrams, low priority, faulty
HDLC	Bridge Details Sub-nodes	Sub-nodes	Siemens-internal special diagnostic for fault search



[scdiahdl-140912-01, 1, en_US]

Figure 3-76 Diagnostic Data of the Protection-Interface Log - COM Interface (Internal COM Link Interface Between Module and Mainboard)

Table 3-17 Description of Diagnostic Data of the COM Interface (Internal COM Link Interface Between Module and Mainboard)

Protection Interfaces - Log Type	**Name**	**Values**	**Description - COM Interface Layer Diagnostic Information (Internal COM Link Interface in Mainboard Direction)**
COM interface	RXHPFramesOK	Number of corresponding frames (16 bit counter)	Incoming telegrams, high priority, OK
COM interface	RXLPFramesOK	Number of corresponding frames (16 bit counter)	Incoming telegrams, low priority, OK
COM interface	RXHPFramesERR	Number of corresponding frames (16 bit counter)	Incoming telegrams, high priority, faulty
COM interface	RXLPFramesERR	Number of corresponding frames (16 bit counter)	Incoming telegrams, low priority, faulty

Protection Interfaces - Log Type	Name	Values	Description - COM Interface Layer Diagnostic Information (Internal COM Link Interface in Mainboard Direction)
COM interface	TXHPFramesOK	Number of corresponding frames (16 bit counter)	Sending telegrams, high priority, OK
COM interface	TXLPFramesOK	Number of corresponding frames (16 bit counter)	Sending telegrams, low priority, OK
COM interface	TXHPFramesERR	Number of corresponding frames (16 bit counter)	Sending telegrams, high priority, faulty
COM interface	TXLPFramesERR	Number of corresponding frames (16 bit counter)	Sending telegrams, low priority, faulty
COM interface	Bridge Details Sub-nodes	Sub-nodes	Siemens-internal special diagnostic for fault search

Table 3-18 Description of Diagnostic Data of some Setting Values of the Protection Interface

Protection Interfaces - Log Type	Name	Values	Description - Protection Interface Setting Values
Settings	**Connection via**	Integer number - display of the internal coding of the settings variant	Protection interface is **Connection via**
Settings	**PDI bandwidth**	Bit-rate display	Bit rate (bit/s) for protection telegrams based on the parameter **Connection via**
Settings	**PDI Telegram.Overhead**	Display of bits	Overhead for every protection telegram in bit.

3.5.3.12 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Device combin.				
_:5131:102	Device combin.:Address of device 1		1 to 65534	101
_:5131:103	Device combin.:Address of device 2		1 to 65534	102
_:5131:104	Device combin.:Address of device 3		1 to 65534	103
_:5131:105	Device combin.:Address of device 4		1 to 65534	104
_:5131:106	Device combin.:Address of device 5		1 to 65534	105
_:5131:107	Device combin.:Address of device 6		1 to 65534	106
_:5131:101	Device combin.:Local device is device		1 to 6	1
_:5131:122	Device combin.:Lowest appearing bit rate		• 64 kBit/s • 128 kBit/s • 512 kBit/s • 2048 kBit/s	64 kBit/s

Addr.	Parameter	C	Setting Options	Default Setting
Prot.interface				
_:105	Prot.interface:Connection via		• fiber optic • CCXG 512 kBit/s • CCXG 128 kBit/s • CCXG 64 kBit/s • repeater 512 kBit/s • CCPW 128 kBit/s • CC2M 512 kBit/s • C37.94 1 * 64 kBit/s • C37.94 2 * 64 kBit/s • C37.94 8 * 64 kBit/s • 64 kBit/s • 128 kBit/s • 512 kBit/s • 2048 kBit/s	fiber optic
Prot. interf.1				
_:5161:1	Prot. interf.1:Mode		• off • on	on
_:5161:105	Prot. interf.1:Max. error rate per hour		0.000 % to 100.000 %	1.000 %
_:5161:106	Prot. interf.1:Max. error rate per min		0.000 % to 100.000 %	1.000 %
_:5161:107	Prot. interf.1:Disturbance alarm after		0.05 s to 2.00 s	0.10 s
_:5161:108	Prot. interf.1:Transm. fail. alarm after		0.0 s to 6.0 s	6.0 s
_:5161:109	Prot. interf.1:Delay time threshold		0.1 ms to 30.0 ms	30.0 ms
_:5161:110	Prot. interf.1:Difference Tx and Rx time		0.000 ms to 3.000 ms	0.100 ms
_:5161:113	Prot. interf.1:PPS synchronization		• telegr. and PPS • telegr. or PPS • PPS sync. off	PPS sync. off

3.5.3.13 Information List

No.	Information	Data Class (Type)	Type
Channel 1			
_:307	Prot.interface:Health	ENS	O
_:304	Prot.interface:Channel Live	SPS	O
Device combin.			
_:5131:52	Device combin.:Behavior	ENS	O
_:5131:53	Device combin.:Health	ENS	O
_:5131:301	Device combin.:Status of topo. recog.	ENS	O
_:5131:302	Device combin.:Topology is	ENS	O
_:5131:303	Device combin.:Devices form	ENS	O
_:5131:304	Device combin.:Number of detect. dev.	INS	O
_:5131:305	Device combin.:Fct. logoff device 1	SPS	O
_:5131:306	Device combin.:Fct. logoff device 2	SPS	O
_:5131:307	Device combin.:Fct. logoff device 3	SPS	O
_:5131:309	Device combin.:Fct. logoff device 4	SPS	O

No.	Information	Data Class (Type)	Type
_:5131:310	Device combin.:Fct. logoff device 5	SPS	O
_:5131:311	Device combin.:Fct. logoff device 6	SPS	O
_:5131:312	Device combin.:Device 1 available	SPS	O
_:5131:313	Device combin.:Device 2 available	SPS	O
_:5131:314	Device combin.:Device 3 available	SPS	O
_:5131:315	Device combin.:Device 4 available	SPS	O
_:5131:316	Device combin.:Device 5 available	SPS	O
_:5131:317	Device combin.:Device 6 available	SPS	O
Prot. interf.1			
_:5161:81	Prot. interf.1:>Block stage	SPS	I
_:5161:500	Prot. interf.1:>Sync reset	SPS	I
_:5161:341	Prot. interf.1:Reset synchronization	SPC	C
_:5161:342	Prot. interf.1:Reset measurements	SPC	C
_:5161:52	Prot. interf.1:Behavior	ENS	O
_:5161:53	Prot. interf.1:Health	ENS	O
_:5161:301	Prot. interf.1:Status of lay. 1 and 2	ENS	O
_:5161:302	Prot. interf.1:Status of lay. 3 and 4	ENS	O
_:5161:303	Prot. interf.1:Connection broken	SPS	O
_:5161:316	Prot. interf.1:Error rate / min exc.	SPS	O
_:5161:317	Prot. interf.1:Error rate / hour exc.	SPS	O
_:5161:318	Prot. interf.1:Time delay exceeded	SPS	O
_:5161:319	Prot. interf.1:Time delay different	SPS	O
_:5161:320	Prot. interf.1:Time delay jump	SPS	O
_:5161:321	Prot. interf.1:PI synchronized	SPS	O
_:5161:340	Prot. interf.1:Telegram lost	SPS	O
_:5161:308	Prot. interf.1:Tx tel/h	MV	O
_:5161:309	Prot. interf.1:Rx tel/h	MV	O
_:5161:310	Prot. interf.1:Tx tel/min	MV	O
_:5161:311	Prot. interf.1:Rx tel/min	MV	O
_:5161:312	Prot. interf.1:Tx err/h	MV	O
_:5161:313	Prot. interf.1:Rx err/h	MV	O
_:5161:314	Prot. interf.1:Tx err/min	MV	O
_:5161:315	Prot. interf.1:Rx err/min	MV	O
_:5161:334	Prot. interf.1:Miss.tel/min	MV	O
_:5161:335	Prot. interf.1:Miss.tel/h	MV	O
_:5161:336	Prot. interf.1:Miss.tel/d	MV	O
_:5161:337	Prot. interf.1:Miss.tel/w	MV	O
_:5161:338	Prot. interf.1:M. loss/d	MV	O
_:5161:339	Prot. interf.1:M. loss/w	MV	O
_:5161:331	Prot. interf.1:Recept.	MV	O
_:5161:323	Prot. interf.1:PPS: time del. unsym.	SPS	O
_:5161:324	Prot. interf.1:PI with PPS synchron.	SPS	O
_:5161:325	Prot. interf.1:Aver.Δt	MV	O
_:5161:326	Prot. interf.1:Rec. Δt	MV	O
_:5161:327	Prot. interf.1:Sen. Δt	MV	O

No.	Information	Data Class (Type)	Type
Ext. Synchron.			
_:9181:500	Ext. Synchron.:>Block stage	SPS	I
_:9181:501	Ext. Synchron.:>PPS pulse loss	SPS	I
_:9181:301	Ext. Synchron.:PPS pulse loss	SPS	O
_:9181:302	Ext. Synchron.:PPS pulse	SPS	O
Meas.val.dev.1			
_:1351:6811:300	Meas.val.dev.1:Dev.adr.	INS	O
_:1351:6811:301	Meas.val.dev.1:Line	ENS	O
_:1351:6811:302	Meas.val.dev.1:Vph	WYE	O
_:1351:6811:303	Meas.val.dev.1:Iph	WYE	O
Meas.val.dev.2			
_:1351:6841:300	Meas.val.dev.2:Dev.adr.	INS	O
_:1351:6841:301	Meas.val.dev.2:Line	ENS	O
_:1351:6841:302	Meas.val.dev.2:Vph	WYE	O
_:1351:6841:303	Meas.val.dev.2:Iph	WYE	O
Meas.val.dev.3			
_:1351:6871:300	Meas.val.dev.3:Dev.adr.	INS	O
_:1351:6871:301	Meas.val.dev.3:Line	ENS	O
_:1351:6871:302	Meas.val.dev.3:Vph	WYE	O
_:1351:6871:303	Meas.val.dev.3:Iph	WYE	O
Meas.val.dev.4			
_:1351:6901:300	Meas.val.dev.4:Dev.adr.	INS	O
_:1351:6901:301	Meas.val.dev.4:Line	ENS	O
_:1351:6901:302	Meas.val.dev.4:Vph	WYE	O
_:1351:6901:303	Meas.val.dev.4:Iph	WYE	O
Meas.val.dev.5			
_:1351:6931:300	Meas val.dev.5:Dev.adr.	INS	O
_:1351:6931:301	Meas val.dev.5:Line	ENS	O
_:1351:6931:302	Meas val.dev.5:Vph	WYE	O
_:1351:6931:303	Meas val.dev.5:Iph	WYE	O
Meas.val.dev.6			
_:1351:6961:300	Meas.val.dev.6:Dev.adr.	INS	O
_:1351:6961:301	Meas.val.dev.6:Line	ENS	O
_:1351:6961:302	Meas.val.dev.6:Vph	WYE	O
_:1351:6961:303	Meas.val.dev.6:Iph	WYE	O

3.6 Date and Time Synchronization

3.6.1 Overview of Functions

Timely recording of process data requires precise time synchronization of the devices. The integrated date/time synchronization allows the exact chronological assignment of events to an internally managed device time that is used to time stamp events in logs, which are then transmitted to a substation automation technology or transferred via the protection interface. A clock module internal to the device and having battery backup is synchronized cyclically with the current device time so that the right device time is available and used even in case of auxiliary-voltage failure. At the same time, this permits hardware-supported monitoring of the device time.

3.6.2 Structure of the Function

The integrated date/time synchronization is a supervisory device function. Setting parameters and indications can be found in the following menus for the DIGSI and the device:

Set date and time:

- DIGSI: Online access -> Interface -> Device -> Device Information -> **Time Information**
- Device: Main menu → Device functions → **Date & Time**

Parameter:

- DIGSI: Project -> Device -> Parameter -> **Time Settings**

Indications:

- DIGSI: Project -> Device -> Information routing ->**Time keeping** or **Time Sync.**

3.6.3 Function Description

Every SIPROTEC 5 device maintains an internal device time with date. The date and time can also be set on the device via the on-site operation panel or via DIGSI 5. Within a system, or even beyond, it is usually necessary to record the time of process data accurately and to have exact time synchronization of all devices. For SIPROTEC 5 devices, the sources of time and synchronization options can be configured.

Configurable Synchronization Options:

- **None** (default setting)
  The device functions without any external time synchronization. The internal time synchronization continues to work with the help of the back-up battery even when the auxiliary voltage is shut down temporarily. The time can be adjusted manually.
- **Telegram**
  The time is synchronized via a telegram with an appropriately configured communication interface in accordance with the IEC 60870-5-103 or DNP3 protocol.
- **Connection to a radio clock**
  The time synchronization takes place with the set time telegram from an external IRIG-B or DCF77 receiver via the time synchronization interface of the device.
- **Ethernet**
  The time synchronization is done via Ethernet-based SNTP protocol (Simple Network Time Protocol), for example with IEC 61850 stations or via IEEE 1588. If you enable both services during configuration of Ethernet interfaces, these protocols are available as an option for the time synchronization.
- **Protection interface**
  The time synchronization takes place via the protection interfaces configured for your SIPROTEC 5 device. Here, the timing master takes over the time management.

Configurable Time Sources:

- 2 time sources can be taken into consideration with the SIPROTEC 5 devices. For each time source, the synchronization type may be selected based on the options provided.
- **Time source 1** takes precedence over **Time source 2**, that is, **Time source 2** will be effective for the synchronization of the device time only if **Time source 1** fails. If only one time source is available and it fails, then only the internal clock continues unsynchronized. The status of the time sources is indicated.
- For every time source it is possible to define via the **Time zone time source 1** parameter (or **Time zone time source 2**) if this source transmits its time by UTC (universal time) or if the settings correspond to the local time zone of the device.



NOTE

Make sure that the settings for the time sources coincide with the actual hardware configuration of your SIPROTEC 5 device. In any event, incorrect settings cause the status indications of time sources to pick up.

Configurable Date Format

Regardless of a feed time-synchronization source, a uniform format is maintained internally within the device. The following options are available for the customary local representation of the date format:

- Day.Month.Year: 24.12.2009
- Month/Day/Year: 12/24/2009
- Year-Month-Day: 2009-12-24

Taking Local Time Zones into Account

The internal device time is maintained in universal time (UTC). To display time stamps in DIGSI and on the device display, you can define the local time zone of the device (parameter Offset time zone for GMT), including the applicable daylight saving times (start, end, and offset of daylight saving time) using parameters. This allows the display of the local time.



NOTE

- For time sources that transmit the status of the switch to daylight saving time, this will be taken into account automatically when creating the internal device time in the UTC format. The differential time of the daylight saving time set in the device (parameter Offset daylight saving time) is taken into consideration. However, in contrast, the settings of the start of daylight saving time and end of the daylight saving times are ignored when converting into the device internal UTC format.
- For active time sources, it is not possible to set the time via the device display or DIGSI 5. An exception is setting the calendar year for active time protocol IRIG-B.

Status, Supervision, and Indications of Time Management

Your SIPROTEC 5 device generates status and monitoring indications that provide important information regarding the correct configuration of the time source and the status of the internal time management during start-up and device operation.

Internal time synchronization is monitored cyclically. Important synchronization processes, the status of the time sources and errors detected are reported. A device time that has become invalid will be marked accordingly so that affected functions can go to a safe state.

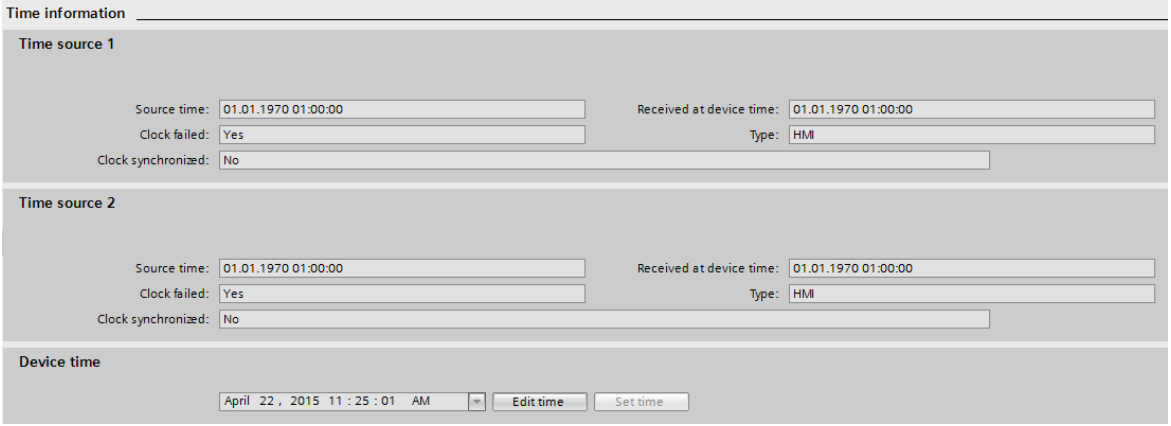
Indication	Description
Device: *Clock fail*	This indication signals a high difference between the internally managed time and the time of the clock module that is not permissible. The triggering of the indication can point to a defect in the clock module or to an unacceptable high drift of the system quartz crystal. The time maintained internally is marked as invalid.
Time management: *Daylight saving time*	This indication signals whether daylight saving time has been enabled.
Time management: *Clock set manually*	This indication signals that the device time has been set manually via the on-site operation panel or via DIGSI 5.
Time synchronization: *Status time source 1* *Status time source 2*	These 2 indications signal whether the active time sources are recognized as valid and active from the device point of view. When the indications get triggered, it can also be an indication that an incorrect configuration of the port or channel numbers was done at the on-site operation panel.
Time synchronization: *Time sync. error*	This indication signals after the parameterized time **Fault indication after** that synchronization using an external time source has failed.
Time synchronization: *High accuracy*	This indication signals that the device is synchronized with an accuracy better than 1 µs. The indication is only of significance when the PMU function is used.

NOTE

In case of a missing or discharged battery, the device starts without active external time synchronization with the device time 2011-01-01 00:00:00 (UTC).

For the device, DIGSI 5 provides a compact overview of the status of the time synchronization of your SIPROTEC 5 device in online mode. All displays are updated continuously. You can access the overview in the project-tree window via Online access.

DIGSI: Online access -> Interface -> Device -> Device Information -> **Time Information**



[sctimedg-220415, 1, en_US]

Figure 3-77 Time Information in DIGSI

For every time source, you see the following:

- Last received time (with date)
- Receipt time of the last received time telegram

- Configured type of timer
- Indication of timer outage or failure
- Whether the device time is currently synchronized from the time source

The lower section displays the device time, which is continuously updated. If the internal device time and the infeed time source were synchronous at the time of telegram receipt, both displayed times are identical.



NOTE

All times displayed (also the time source) take into consideration the local time settings (zone and daylight saving time of the device) in the form of a numerical offset for UTC (universal time).

3.6.4 Application and Setting Notes

Parameter: Date Format

- Default setting **Date format** = ***YYYY-MM-DD***

With the **Date format** parameter, you define the local customary format of the date display.

Parameter Value	Description
YYYY-MM-DD	Day.Month.Year: Typical European display Example: 24.12.2010
YYYY-MM-DD	Month/Day/Year: Typical US representation Example: 12/24/2010
YYYY-MM-DD	Year-Month-Day: Typical Chinese display Example: 2010-12-24

Parameter: Time zone time source 1,Time zone time source 2

- Default setting **Time zone time source 1** = ***local***, **Time zone time source 2** = ***local***

With the **Time zone time source 1** and **Time zone time source 2** parameters, you define the handling of time zones of the external timer.

Parameter Value	Description
local	Local time zone and daylight saving time are considered as time zone offsets to GMT.
UTC	Time format according to UTC (universal time)

Parameter: Time source 1,Time source 2

- Default setting **Time source 1** = ***none***, **Time source 2** = ***none***

With the **Time source 1** and **Time source 2** parameters, you can configure an external timer. The prerequisite is to have the corresponding hardware configuration of the communication interfaces of your SIPROTEC 5 device. This is listed as a prefix when making a selection in DIGSI 5.

Parameter Value	Description
none	The time source is not configured.

Parameter Value	Description
IRIG-B	Time synchronization by an external GPS receiver: SIPROTEC 5 devices support several protocol variants of the IRIG-B standards: • **IRIG-B 002(003)** The control function bits of the signal are not occupied. The missing year is formed from the current device time. In this case, it is possible to set the year via the online access in DIGSI 5. • **IRIG-B 006(007)** The bits for the calendar year are not equal to 00. The calendar year is set automatically by the time protocol. • **IRIG-B 005(004) with extension according to IEEE C37.118-2005** If, in the time signal, other control function bits are occupied in addition to the calendar year, then the device takes the additional information into consideration for leap seconds, daylight saving time, time offset (zone, daylight saving time) and time accuracy. **Time zone time source 1** or **Time zone time source 2**: The value of this setting is not evaluated by the device, since this protocol either transmits or in the case of local time, specifies the appropriate offset to UTC in each set time telegram.
DCF77	Time synchronization by an external DCF 77 receiver **Time zone time source 1** or **Time zone time source 2** = ***local*** Please note: There are also clocks that generate a DCF 77 signal representing UTC. In this case, UTC must be set.
PI	The time synchronization takes place via the protection interfaces configured for your SIPROTEC 5 device. Here, the timing master takes over the time management. Signal-transit times of the protection interface communication are calculated automatically. **Time zone time source 1** or **Time zone time source 2** = ***UTC*** A slave that receives a time or a SIPROTEC 5 master, receives its system time kept in UTC.
SNTP	The time synchronization is done via the Ethernet service SNTP (SNTP server or via IEC 61850). SIPROTEC 5 devices support both Edition1 and Edition2 in accordance with IEC 61850-7-2. In Edition2, the logical attributes LeapSecondsKnown, ClockFailure, ClockNotSynchronized, and the value TimeAccuracy are maintained in each time stamp. For Edition1, these signals contain default settings. Thus, the inter-operability for substation automation technology is ensured for both editions! The SNTP service must be enabled during configuration of Ethernet interfaces so that it is available as an option for the time synchronization. **Time zone time source 1** or **Time zone time source 2** = ***UTC***
IEC 60870-5-103	The time is synchronized via telegram with an appropriately configured communication interface in accordance with the IEC 60870-5-103 protocol. **Time zone time source 1** or **Time zone time source 2** = ***local*** However, there are also T103 systems that send the UTC.

Parameter Value	Description
DNP3	The time is synchronized via telegram with the appropriately configured communication interface in accordance with the DNP3 protocol. Two characteristics are supported in the process: • **Time synchronization via UTC** • **Time synchronization with local time** The daylight saving time status is not transmitted. The device assumes that the DNP3 master follows the same rules for the start and end of the daylight saving time as those that were set for the device. **Time zone time source 1** or **Time zone time source 2** = ***UTC*** is the current implementation ***local*** concerns older implementations.
IEEE 1588	Time is synchronized via an IEEE 1588 timing master. In this case, SIPROTEC 5 devices operate as slave-only clocks. IEEE 1588 v2 is supported with P2P and Ethernet Transport. The IEEE 1588 service must be enabled during configuration of Ethernet interfaces so that it is available as an option for the time synchronization. **Time zone time source 1** or **Time zone time source 2** = ***UTC***.

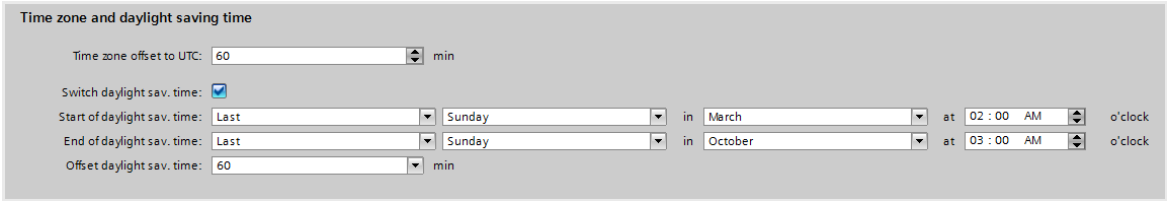
Parameter: Fault indication after

- Default setting **Fault indication after** = ***600 s***

With the **Fault indication after** parameter you set the time delay after which the unsuccessful attempts of time synchronization with external time sources configured are indicated.

Parameter: Time Zone and Daylight Saving Time

This parameter block contains all the settings for the local time zone and daylight saving time of your SIPROTEC 5 device. In addition to the individual parameters, configure the basic settings by preselecting via the radio buttons or check box.



[sctimezo-210415, 1, en_US]

Figure 3-78 Settings for Time Zone and Daylight Saving Time in DIGSI

Selection Button	Description
Manual settings (local time zone and daylight saving time regulation)	This setting must be selected if you want to select the local time zone and daylight saving time zone regulations of your SIPROTEC 5 device regardless of the PC settings. Input: **Offset time zone for GMT** [min] Selection: **Switchover to daylight saving time** [yes/no] via check box  • Input: **Start of daylight saving time** [Day and time] • Input: **End of daylight saving time** [Day and time] • Input: **Offset daylight saving time** [min] • Default settings as in the picture above

3.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Time sync.				
_:102	Time sync.:Time source 1		• none • PPM • IRIG-B • DCF77 • Syncbox • PI • SNTP • IEC 60870-5-103 • PROFIBUS DP • Modbus • DNP3 • IEEE 1588 • IEC 60870-5-104	none
_:103	Time sync.:Time source 1 port		• port J • port F • port E • port P • port N • port G	
_:104	Time sync.:Time source 1 channel		• Ch1 • Ch2	

Addr.	Parameter	C	Setting Options	Default Setting
_:105	Time sync.:Time source 2		• none • PPM • IRIG-B • DCF77 • Syncbox • PI • SNTP • IEC 60870-5-103 • PROFIBUS DP • Modbus • DNP3 • IEEE 1588 • IEC 60870-5-104	none
_:106	Time sync.:Time source 2 port		• port J • port F • port E • port P • port N • port G	
_:107	Time sync.:Time source 2 channel		• Ch1 • Ch2	
_:108	Time sync.:Time zone time source 1		• UTC • local	local
_:109	Time sync.:Time zone time source 2		• UTC • local	local
_:101	Time sync.:Fault indication after		0 s to 3600 s	600 s

3.6.6 Information List

No.	Information	Data Class (Type)	Type
Time managem.			
_:300	Time managem.:Daylight saving time	SPS	O
_:301	Time managem.:Clock set manually	SPS	O

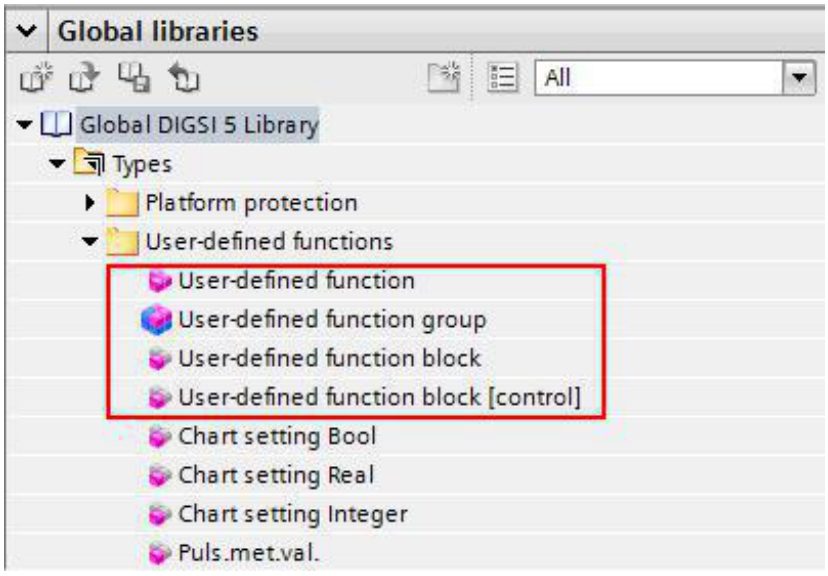
No.	Information	Data Class (Type)	Type
Time sync.			
_:303	Time sync.:Status time source 1	SPS	O
_:304	Time sync.:Status time source 2	SPS	O
_:305	Time sync.:Time sync. error	SPS	O
_:306	Time sync.:Leap second	SPS	O
_:307	Time sync.:High accuracy	SPS	O

3.7 User-Defined Objects

3.7.1 Overview

Within a **User-defined function group**, you can use the **User-defined function block** and the **User-defined function block [Control]** to group user-defined objects that you find in the DIGSI 5 library under **User-defined functions**.

With user-defined function groups and user-defined functions, a grouping of user-defined objects, for example, user-defined function blocks, can be performed. 2 user-defined function blocks are available (see following figure).



[scudef_lib, 1, en_US]

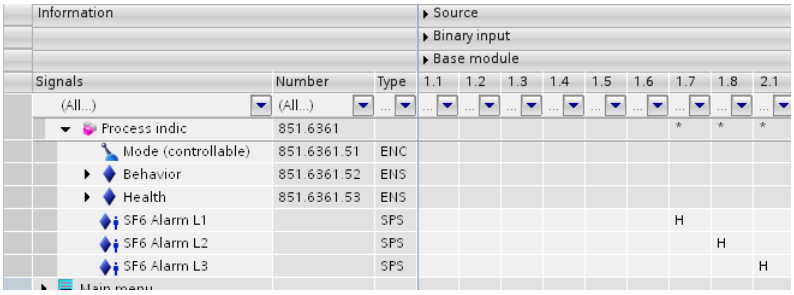
Figure 3-79 User-Defined Objects in the DIGSI 5 Library

You can insert single-point indications, pickup and operate indications (ACD, ACT), single or double commands, commands with a controllable whole number as well as measured values in the **User-defined function block** (see following figure). You can assign a superordinate name to the grouping (for example, **Process indications**, for a group of single-point indications that are read in via binary inputs). This function can be deactivated via the mode. Readiness is also evaluated and represented.

The user-defined function can be instantiated both at the highest level (in parallel to other function groups) and within the function groups and functions.

A **User-defined function block [control]** is also available. In addition to the mentioned option of a general **User-defined function block**, this block offers additional tests for user-defined control signals, for example, SPC or DP.

You can find more information in chapter *8.6.1 Overview of Functions*.



[scbenutz-260912-01.tif, 1, en_US]

Figure 3-80 Information Routing Through Use of Added User-Defined Function Block: Process Indications and Single-Point Indications

3.7.2 Basic Data Types

The following data types are available for user-defined objects in the DIGSI 5 library under the heading **User-defined signals**.

Single-Point Indication (Type SPS: Single-Point Status)

The status of a binary input can be registered in the form of a single-point indication or forwarded as the binary result from a CFC chart.

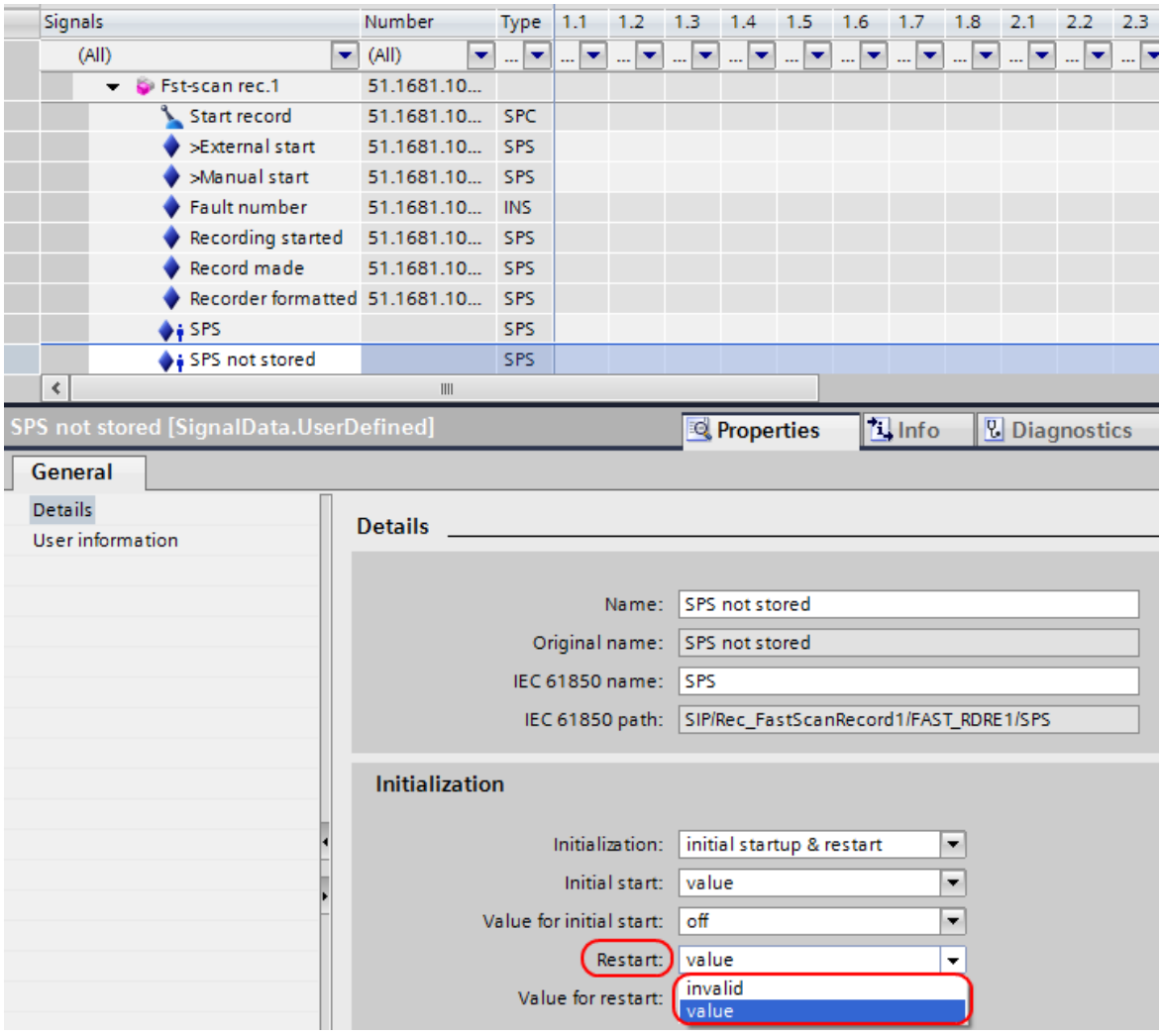
EXAMPLE

Acquisition using binary input, further processing in a CFC and/or signaling using an LED.

Single-Point Indication (Type SPS unsaved: Single-Point Status Unsaved)

In contrast to **SPS** single-point indications, the state of the **SPS unsaved** indication is not maintained after the device restarts.

For this purpose, go to **Properties > Details > Initialization > Restart** and set the ***Value***.



[scspsfas-140613-01.tif, 1, en_US]

Figure 3-81 Single-Point Indication SPS Unsaved (Example: 7KE85 Fault Recorder)

Double-Point Indication (Type DPS: Double-Point Status)

When using a double-point indication, the status of 2 binary inputs can be captured simultaneously and mapped in an indication with 4 possible conditions (***ON***, ***Intermediate position***, ***OFF***, ***Disturbed position***).

EXAMPLE

Acquisition of a disconnector or circuit-breaker switch position.

Marker Command (Type SPC, Single-Point Controllable)

This data type can be used as a command without feedback for simple signaling or as an internal variable (marker).

State of a Whole Number (Type INS)

The data type **INS** is used to create a whole number that represents a CFC result.

EXAMPLE

The output of the CFC block **ADD_D** can, for example, be connected with the data type **INS**. The result can be shown on the display of the device.

State of an Enumeration Value (Type ENS)

The data type **ENS** is used to create an enumerated value that represents a CFC result.

Controllable Single-Point Indication (SPC, Single-Point Controllable)

This can be used to issue a command (to one or several relays, selectable under information routing) that is monitored via a single feedback.

Command with Double-Point Feedback (DPC, Double Point Controllable)

This can be used to issue a command (to one or several relays, selectable under information routing) that is monitored via double-point indication as feedback.

Command with a Whole Number (INC, Controllable Integer Status)

This can be used to issue a command (to one or more relays, selectable under information routing) that is monitored via a whole number as feedback.

Complex Measured Values (CMV)

This data type provides a complex measured value that can be used as a CFC result, for example.

Measured Values (MV)

This data type provides a measured value that can be used as a CFC result, for instance.

NOTE

Additional data types can be found under other headings in the DIGSI 5 library as well as in the corresponding function blocks. This applies to the following data types:

- Pulse-metered values (see **User-defined functions** in the DIGSI 5 library)
- Transformer taps
- Metered values

Phase-to-Ground Measured Values (WYE)

This data type represents the phase-to-ground measured values of a 3-phase system.

Phase-to-Phase Measured Values (DEL, Delta)

This data type represents the phase-to-phase measured values of a 3-phase system.

Protection Activation Information (ACT)

This object type is used by the protection functions for **Tripping**. It is available in the library for receiving protection information via the protection interface, which could also indicate **Tripping**.

Protection Activation Information with Direction (ACD)

This object type is used by the protection functions for **Pickup**. It is available in the library for receiving protection information via the protection interface, which could also indicate **Pickup**. In addition, both ACD and ACT can be generated and processed by CFC charts.

3.7.3 Pulse- and Energy- Metered Values , Transformer Taps

Pulse-Metered Values

Pulse-metered values are available as data types **BCR** (Binary Counter Reading) in the DIGSI library under **User-defined Functions**.

The functionality and the settings of the pulse-metered values can be found in chapter *10.8.1 Pulse-Metered Values Function Description* .

Transformer Taps

Transformer taps are contained in the **Transformer tap changers** switching element. When the **Transformer tap changer** switching element is created in the device, the transformer tap position is available as a data object of type **BSC** (binary controlled tap changer with tap-position information).

You can find detailed information in *8.8.1 Function Description* .

Energy-Metered Values

Energy-metered values no longer need to be created by the user separately. They are available as active and reactive power in each **Line** function group for reference and output direction. The calculation is based on the current and voltage transformers associated with the protected object.

You can find more detailed information in chapter *10.7.1 Function Description of Energy Values* .

3.7.4 Additional Data Types

The following data types are also used in the system but are not available for general use as user-defined signals in the library:

- **ENC** (Enumerated Setting Controllable)
  The data type **ENC** models a command with which the user can set predefined values.
- **SEQ** (Sequence)
- **BSC** (Binary Controlled Step Position)
  The data type **BSC** can, for example, be used to control a transformer tap changer. The commands **up**, **down** can be given.



NOTE

Transformer taps are included in the **Transformer tap changer** switching element. If this switching element is created in the device, the transformer tap position is available as a data object of type **BSC** (binary controlled tap changer with tap-position information).

3.8 Other Functions

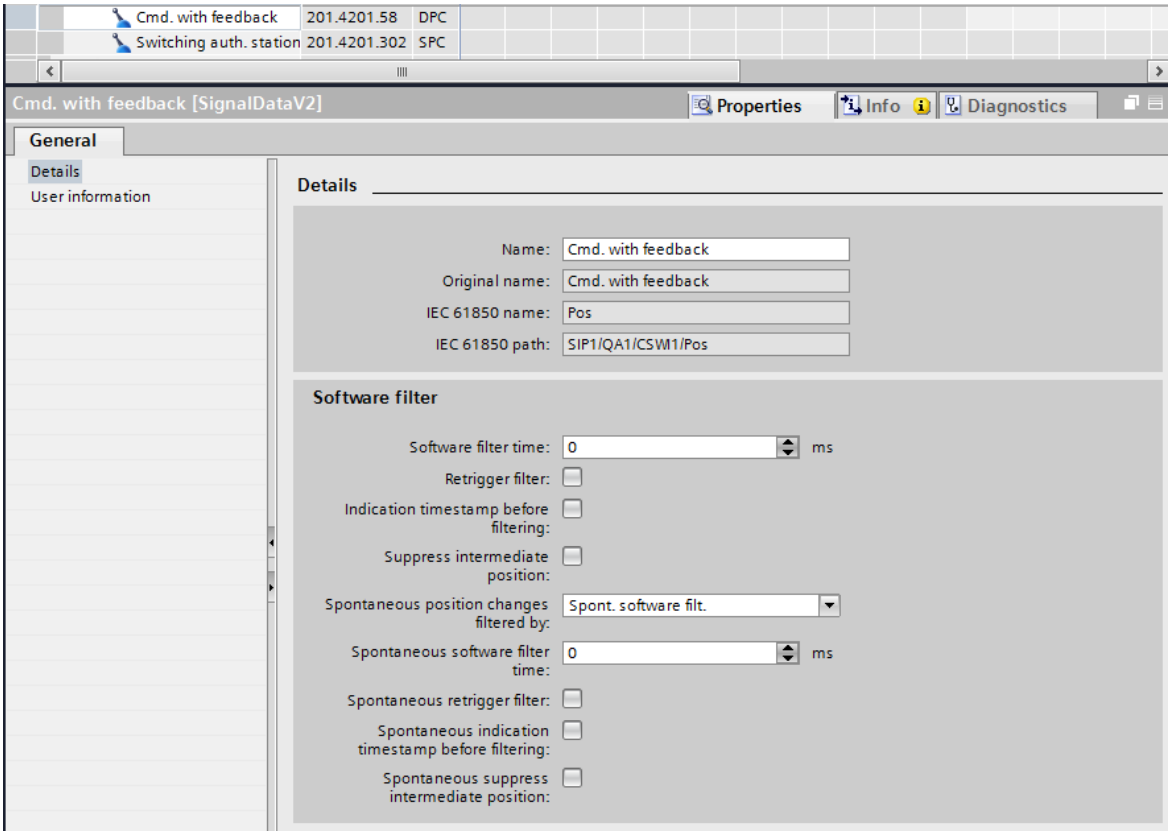
3.8.1 Signal Filtering and Chatter Blocking for Input Signals

Input signals can be filtered to suppress brief changes at the binary input. Chatter blocking can be used to prevent continuously changing indications from clogging the event list. After an adjustable number of changes, the indication is blocked for a certain period.

The settings for indication filtering can be found at the individual signals. The next figure shows the settings using the example of a controllable (circuit-breaker switch position).

NOTE

For the circuit breaker or the disconnector, the settings of the software filter for spontaneous position changes are available only in the **Control/Command with feedback** function block. These settings are not available in the **Circuit breaker** or **Disconnector** function blocks since these function blocks contain the actual unfiltered position of the switch in the bay.



[sclposi-260116, 1, en_US]

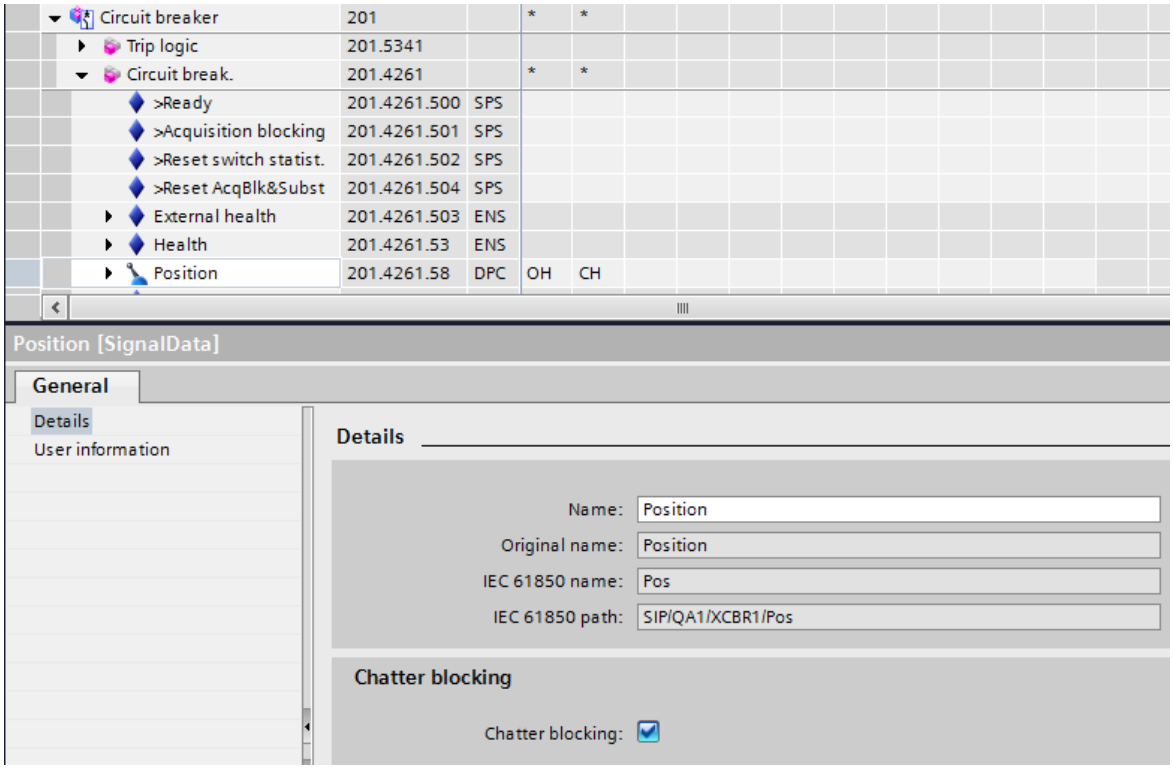
Figure 3-82 Settings for Circuit-Breaker Switch Position

The setting range for the **Software filtering time** parameter ranges from 0 ms to 86 400 000 ms (1 day) in ms increments. The **Retrigger filter** check box can be used to select whether the software filter should be restarted by a change from 1 to 0 and back. When activated, the **Indication timestamp before filtering** check box back dates the time stamp by the set software filtering time and the fixed hardware filtering time. In this case, the time stamp corresponds to the actual status change of the signal. If you activate the **Suppress intermediate position** check box, the intermediate position is suppressed for the duration of this software filter time.

With the parameter **Spontaneous position changes filtered by**, you set how such position changes are to be filtered. Spontaneous position changes are caused by external switching commands, for

example. If the ***General software filter*** setting is selected, the general settings for software filtering of spontaneous position changes and for position changes caused by a switching command apply. The settings for spontaneous position changes can then not be edited. A separate filtering for spontaneous position changes is activated with the ***Spontaneous software filter*** setting and you can edit the settings for this.

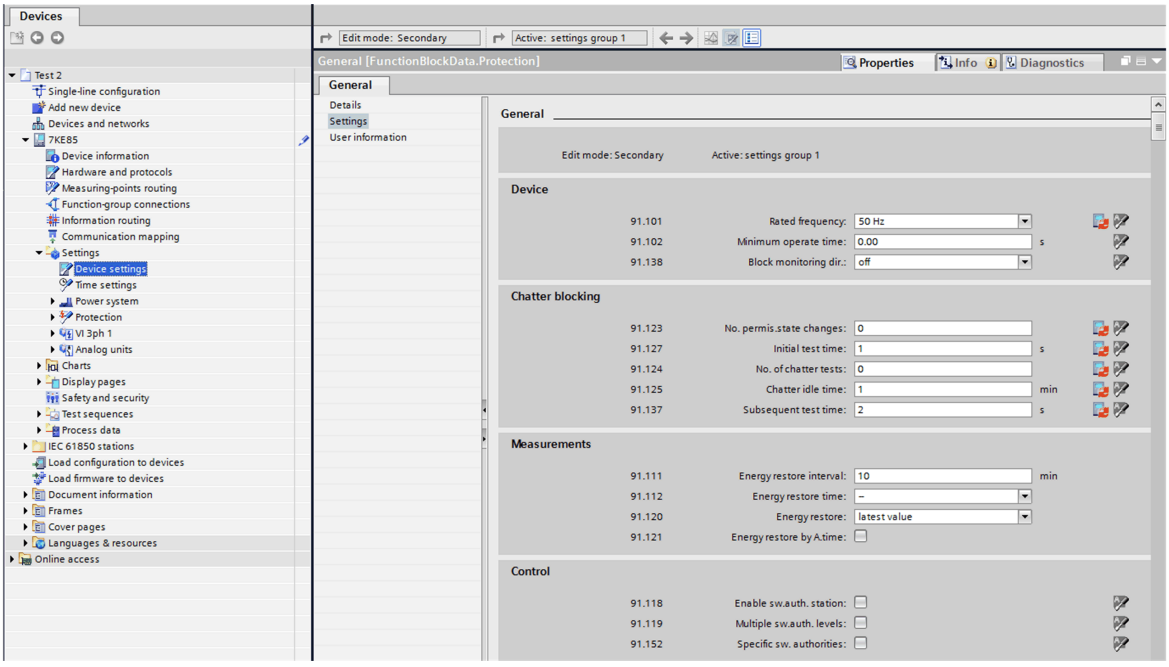
Chatter blocking can be activated or deactivated as a parameter of the position in the **Circuit breaker** or **Disconnector** function block.



[scflatte-180315, 1, en_US]

Figure 3-83 Setting Chatter Blocking

The settings for the chatter blocking function are set centrally for the entire device in DIGSI. They are accessible as settings in the **General** function group (see the following figure).



[scparafl-291110-01.tif, 2, en_US]

Figure 3-84 Chatter-Blocking Settings

The chatter-blocking settings have the following meaning (see also *Figure 3-85* and *Figure 3-86* in the examples shown in the following):

- **`No. permis.state changes`**

  This number specifies how often the state of a signal may toggle within the chatter-test time and the chatter-checking time. If this number is exceeded, the signal will be or remains blocked.

  Enter a number from 0 to 65535 in this field. If the entry is 0, chatter blocking is essentially inactive.

- **`Initial test time`**

  During this time, the number of times a signal changes its status is checked. This time is started if chatter blocking is configured for at least one signal and this signal changes its status. If the configured number of permissible state changes is exceeded during the initial test time, the signal is temporarily blocked and the indication *`Chatter blocking`* is set.

  Enter a number between 1 and 65535 in this field. The number entered corresponds to the time in seconds. When the set time has expired, the timer restarts automatically (cycle time).

- **`No. of chatter tests`**

  This number specifies the maximum number of test cycles to be run. If the number of permissible state changes stays exceeded during the initial test time of the last test cycle, the signal is finally blocked. In this case, the indication *`Group warning`* (**Alarm handling** group) and (**Device** group) are set additionally to the *`Chatter blocking`* indication after expiry of the set number. Restarting the devices removes this block again.

  Enter a number from 0 to 32767 in this field. The value Infinite (∞) is also permissible here.

  Enter this value as character string oo.

- **`Chatter idle time`**

  If the number of permissible status changes for a signal is exceeded during the initial test time or the subsequent test time, the **`Chatter idle time`** starts. Within this time, this signal is blocked temporarily and the *`Chatter blocking`* indication is set. The blocked input signal is assigned the **oscillatory** quality.

  Enter a number between 1 and 65535 in this field. The number entered corresponds to the time in minutes. An entry here is only considered if the number of chatter tests does not equal 0.

- **Subsequent test time**

  During this second test time, the number of times a signal changes its status is checked once again. The time begins when the **Chatter idle time** expires. If the number of status changes is within the permissible limits, the signal is released. Otherwise, an additional dead time begins, unless the maximum number of chatter tests has been reached.

  Enter a number between 2 and 65535 in this field. The number entered corresponds to the time in seconds. An entry here is only considered if the number of chatter tests does not equal 0.

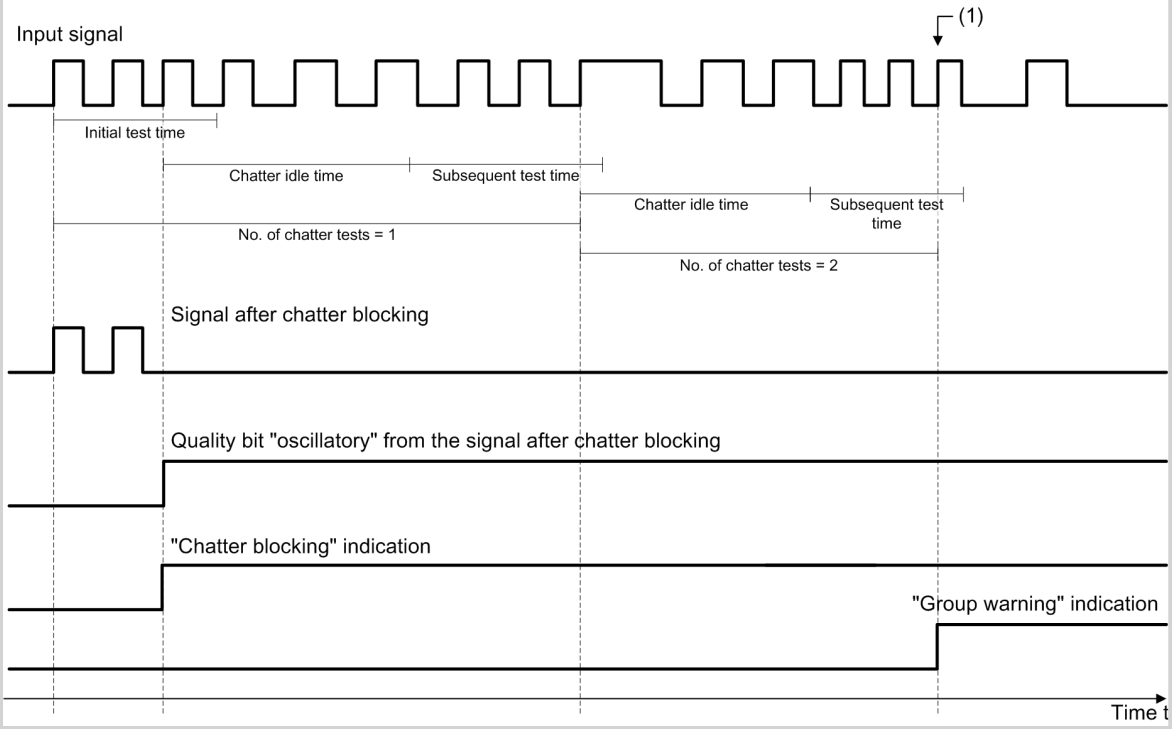
Example 1: Permanent Blocking

The chatter-blocking settings are set as follows:

- **No. permis.state changes** = 4
- **No. of chatter tests** = 2

After more than 4 state changes within the **Initial test time**, the input signal is set to the original state by the chatter blocking and the **oscillatory** quality is assigned. Additionally, a corresponding indication is added to the operational log. At the same time, the *Chatter blocking* indication is set . After expiry of the settable **Chatter idle time**, during the following **Subsequent test time**, it is checked whether the input signal is still chattering. This check is repeated, as the **No. of chatter tests** is set to 2 in this example.

If, during the 2nd **Subsequent test time**, it has been detected that the number of state changes of the input signal exceeds the set **No. permis.state changes**, the chatter blocking detects a persistent violation of the signal stability and sets the *Group warning* indication. The original state of the signal is permanently frozen. Only a device restart removes the chatter blocking again.



[dw_chatter-block-01, 1, en_US]

Figure 3-85 Signal Change during Chatter Blocking with too Important Number of Signal State Changes During 2nd Subsequent Test Time

(1) The input signal is permanently blocked starting from this point in time.

Example 2: Temporary Blocking

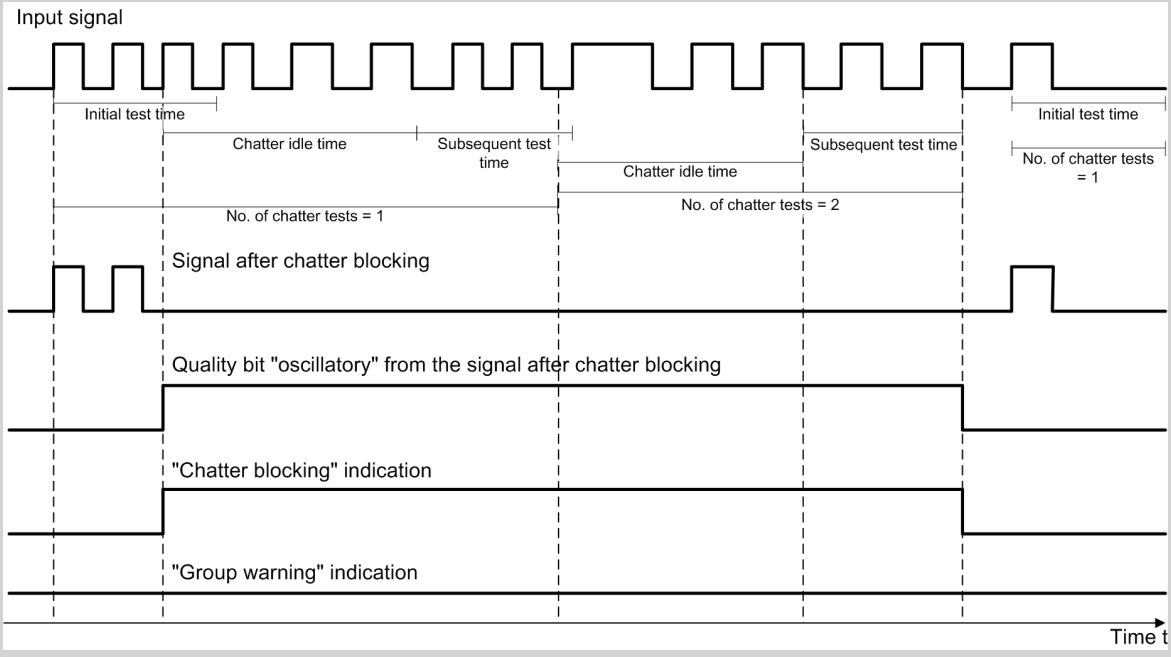
The chatter-blocking settings are set as follows:

- **No. permis.state changes** = 4
- **No. of chatter tests** = 2

After more than 4 state changes within the **Initial test time**, the input signal is set to the original state by the chatter blocking and the **oscillatory** quality is assigned. Additionally, a corresponding indication is added to the operational log. At the same time, the *Chatter blocking* indication is set. After expiry of the settable **Chatter idle time**, during the following **Subsequent test time**, it is checked whether the input signal is still chattering. This check is repeated, as the **No. of chatter tests** is set to 2 in this example.

If, during the 2nd **Subsequent test time**, it has been detected that the number of state changes of the input signal is within the set **No. permis.state changes**, the temporary blocking of state changes of the signal is removed and the actual signal state is released.

The quality bit **oscillatory** is removed and the *Chatter blocking* indication is reset. As the temporary blocking of the signal is removed, the *Group warning* indication is not set. The chatter test starts again.



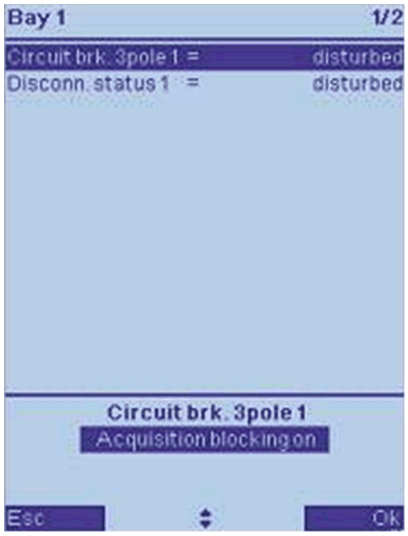
[dw_chatter-block-02, 1, en_US]

Figure 3-86 Signal Change during Chatter Blocking with Permissible Number of Signal State Changes During 2nd Subsequent Test Time

3.8.2 Acquisition Blocking and Manual Updating

During commissioning, maintenance, or testing, a brief interruption of the connection between the logical signals and binary inputs may be useful. It allows you to manually update the status of a switching device that is not providing feedback correctly. Before this can take place, you must first set acquisition blocking.

Set the Acquisition blocking function in the menu of the device display **Commands > Equipment >Aq.blk man. update**. If several switching devices are available, select the appropriate switching device. When pressing the **Change** key, the confirmation ID will be queried. After entering the confirmation ID, the acquisition blocking function is switched on when **OK** is pressed.



[scerfass-280513-01.tif, 1, en_US]

Figure 3-87 Activating the Acquisition Blocking

Manual updating of the switching device is possible from within the same menu. Use the menu item **Change** to select the **Manual updating** function. Subsequently, select the updating setting of the switching device manually and acknowledge the selection by pressing **OK**. The manually updated position of the switching device will be displayed.



[scstatus-280513-01.tif, 1, en_US]

Figure 3-88 Activate Manual Updating



[scstatu2-280513-01.tif, 1, en_US]

Figure 3-89 Selecting Position

NOTE

For safety reasons, manual updating is possible only directly through the on-site operation panel of the device and not through DIGSI 5.

NOTE

Setting acquisition blocking and the subsequent manual updating are also possible via the IEC 61850 system interface.

Acquisition blocking can also be set via a binary input. This way, acquisition blocking can be set for an individual or several switching devices in a feeder simultaneously with an external toggle switch in order to disable the feeder. For this purpose, every switching device in the **Switch** function block (circuit breaker or disconnector switch) has the input signal **`>Acquisition blocking`**. This signal can also be set from the CFC.

Information			Source											Destination		
			Binary input										CFC	Binary output		
			Basismodul											Basismodul		
Signals	Number	Type	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.1	2.2	2.3		1.1	1.2	1.3
(All)	(All)													(All)			
Trip logic	201.5341																
Circuit break.	201.4261		*	*											*	*	
>Ready	201.4261.500	SPS															
>Acquisition blocking	201.4261.501	SPS															
>Reset switch statist.	201.4261.502	SPS															
>Reset AcqBlk&Subst	201.4261.504	SPS															
External health	201.4261.503	ENS															

[scbeerfa-190215, 1, en_US]

Figure 3-90 Input signals *`>Acquisition Block`* and *`>Release Acquisition Block & Manual Updating`* on the Switching Device

NOTE

Interlockings are carried out with the status changes of the switching device. Remove acquisition blocking again manually. Otherwise, position changes of the switching device are not detected and interlockings are ineffective.

If the acquisition blocking and the manually updated position are set using the operation panel of the device or the system interface IEC 61850, these are retained until the acquisition blocking is manually deactivated. When you initially start the device, the acquisition blocking is deactivated.

Except for a restart, the acquisition blocking and the manually updated position are retained.

If the acquisition blocking is activated via the input signal **>Acquisition blocking**, it is retained as long as the binary input is active.

To set the acquisition blocking of a switching device, the following sources are possible:

- Operation panel of the device
- System interface IEC 61850
- Input signal **>Acquisition blocking**

All sources undergo OR operations, that is, the acquisition blocking remains set until all the sources are deactivated.

After deactivation of the acquisition blocking, the actual position of the switching device is adopted and displayed in the operation panel of the device.



NOTE

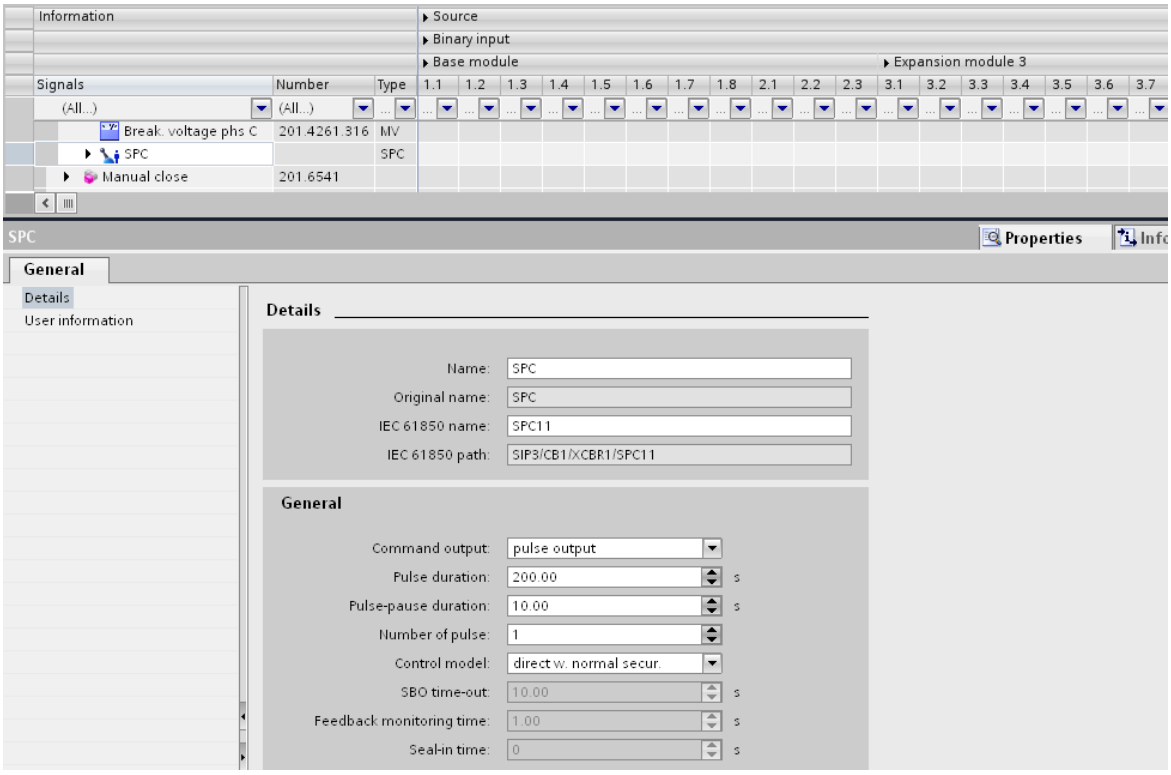
When the acquisition blocking is activated or the switching device updated manually while the entire device or the switching device is in test mode, these states are not saved. The acquisition blocking and the manual updating are not retained after a restart.

Acquisition blocking and manual update for the circuit breaker, the disconnector and the tap changer are reset by way of the **>Reset AcqBlk&Subst** binary input. Setting acquisition blocking and manual update is blocked with the input activated.

3.8.3 Persistent Commands

In addition to the switching commands, which are issued as pulse commands, and stored for the standard switching devices (circuit breaker, disconnector switch), persistent commands are also possible. In this case, a distinction must be drawn between controllables with the **Continuous output** operating mode and a stored signal output that is immune to reset.

You can change a controllable from pulse to persistent command with the **Command output** parameter.



[scbefehl-260912-01.tif, 1, en_US]

Figure 3-91 Setting the Command Type in DIGSI 5

Select ***Pulse output*** or ***Continuous output*** for the command output type. If a persistent command is selected, the Pulse parameter is irrelevant.

3.9 General Notes for Setting the Threshold Value of Protection Functions

3.9.1 Overview

You can set the threshold values of protection functions directly on the device or by using DIGSI 5.

An innovative design was implemented for the protection settings.

You can switchover the edit mode between the following setting views:

- Primary
- Secondary
- Percent

If you change settings in a setting view, DIGSI 5 calculates the settings of the 2 inactive views in the background. If you wish to save, for example, conversion to secondary values, then select the primary view. Configure all the settings and switchover to the secondary view.

Edit Mode: Primary

The parameters are set as primary values and thus refer directly to the primary system. The manual conversion on the secondary circuit omitted.

Edit Mode: Secondary

The settings refer to the secondary circuit of the transformer. This means that the settings must be converted. The secondary setting is the customary setting view. For secondary tests, the pickup values can be read directly.

Edit Mode: Percent

This setting type is beneficial for electric machines (generators, transformers, motors, and busbars). The setting values can be standardized regardless of the machine size. The reference values for the percentage settings are the rated values of the function groups, for example, rated voltage and rated current or rated apparent power . The setting values are, thus, related exclusively to the primary settings. If other reference values are used, then this is documented for the respective protection function in the application and setting notes.

If parameters are selected it may happen that they are set only in percent in all 3 setting views.

Recommendation for Setting Sequence

When setting the protection function, Siemens recommends the following procedure:

- First set the transformation ratios of the transformers. You can find these under **Power-system data**.
- In addition, set the reference parameters for the percent setting. You will find these parameters in function group .
- Next, set the parameter of the protection functions.

  If the transformer data have changed after completing the protection setting, remain in the setting sheet (for example, primary setting) and change the transformer data. In the background, DIGSI 5 obtains the new settings in the inactive setting views (for example, new secondary values).

The following section explains, by way of an example, how to modify the transformer ratios in DIGSI 5 using the corresponding alternatives.

3.9.2 Modifying the Transformer Ratios in DIGSI 5

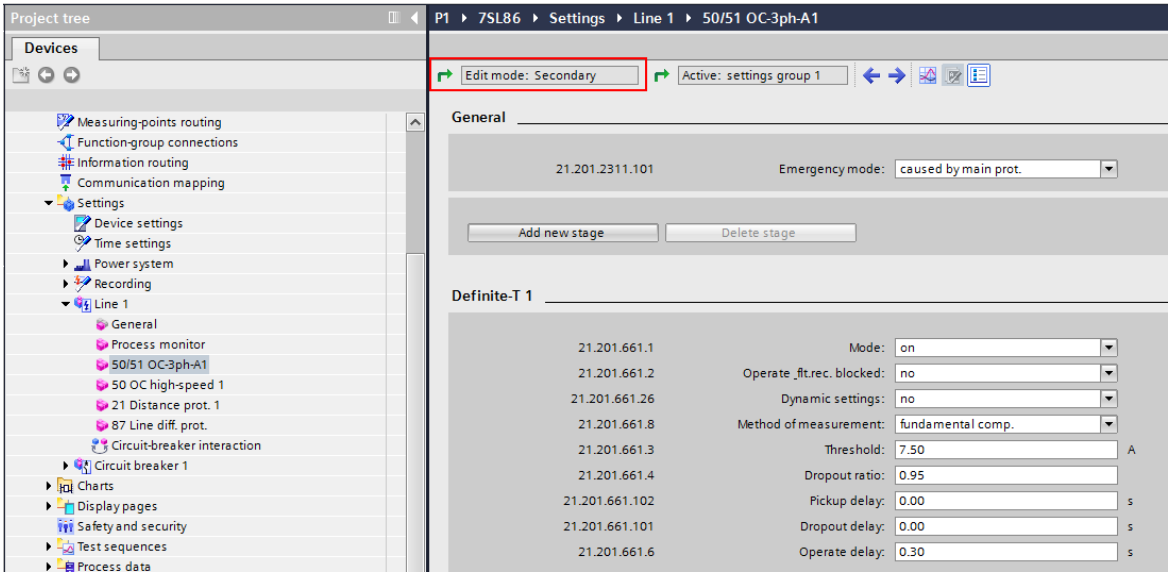
In the delivery setting, DIGSI 5 is set to the **Secondary** edit mode.

The following setting example shows how you can change the transformer ratio in DIGSI 5, and what impact this has on the settings in the setting views **Primary** and **Secondary**. The protection setting is observed in the example of the **Overcurrent protection** function.

The following output data are assumed:

Current transformer:	1000 A/1 A
Protection pickup value:	1.5 A

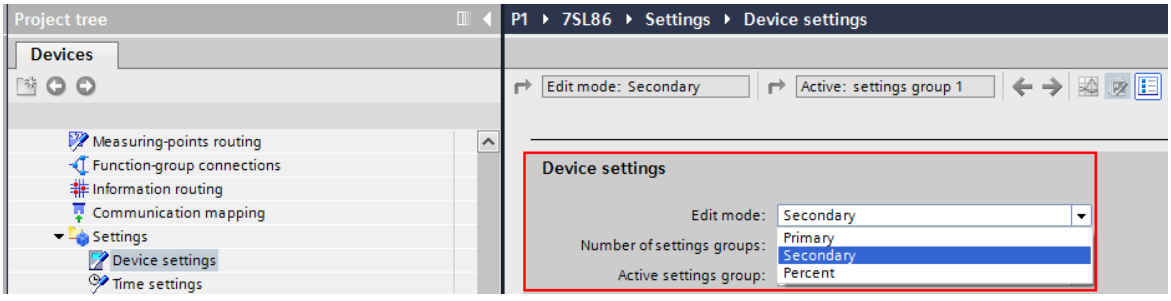
The following figure shows the protection setting of the **Overcurrent protection** function in the secondary view. The threshold value of the stage is set to 1.5 A.



[scmodsek_1, 1, en_US]

Figure 3-92 Protection Setting, Display of the Active Setting Sheet

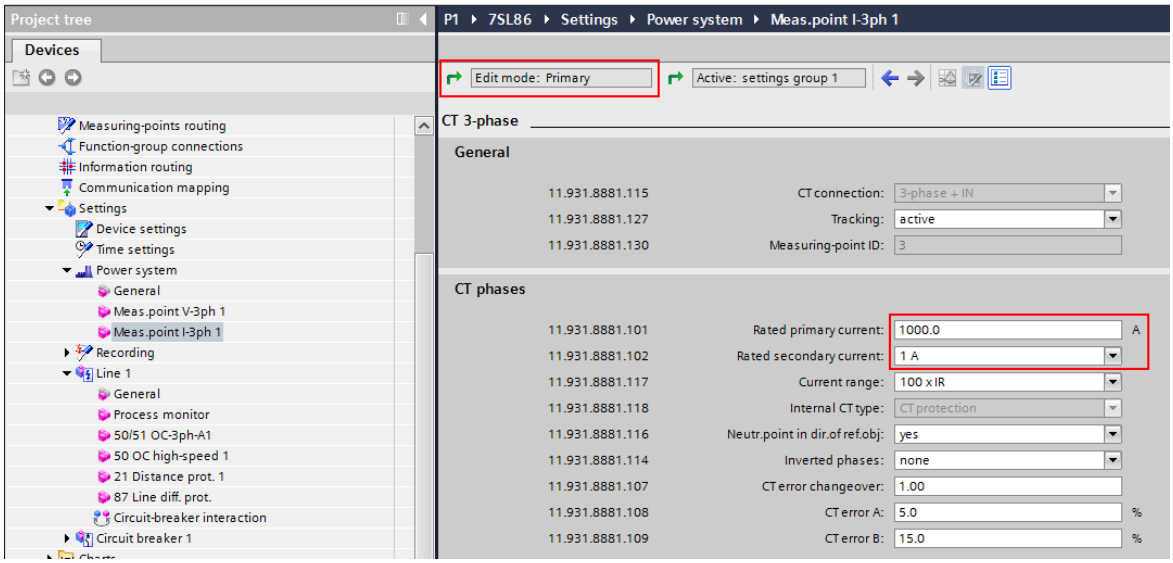
When you click the green arrow in the setting sheet at the upper left, you get to the window for switching over to the setting view (see the following figure). Select the setting view you prefer.



[scmodums_2, 1, en_US]

Figure 3-93 Switchover to the Desired Setting View

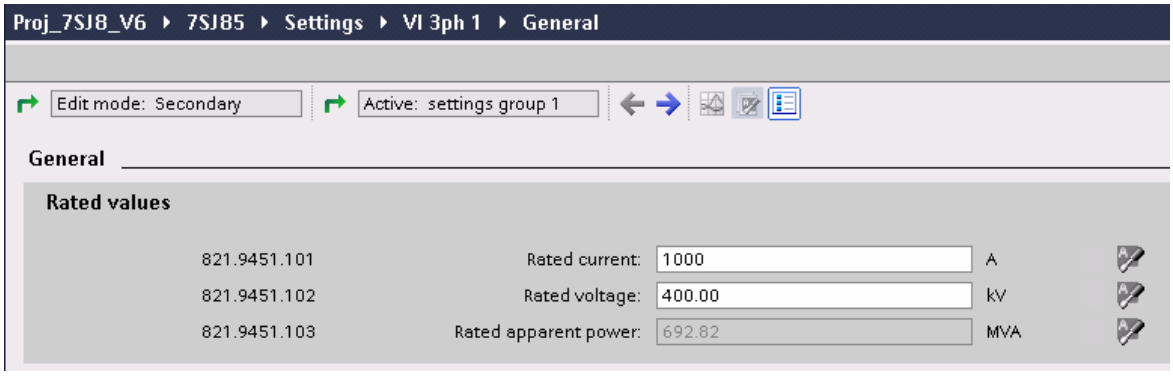
The following figures show the setting sequence in the **Primary** edit mode. Set the transformer data. In the example, the current transformer has a transformation ratio of 1000 A/1 A.



[scpwandl_3, 1, en_US]

Figure 3-94 Setting Sheet:Transformer Data

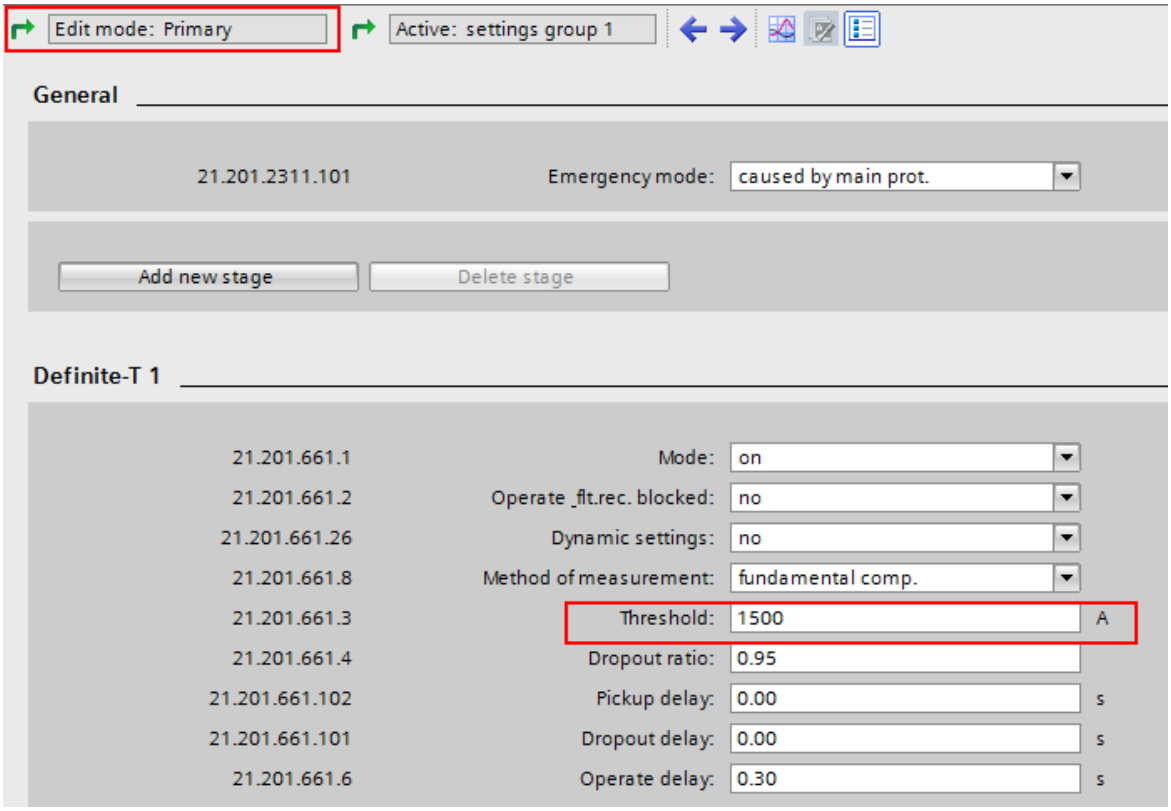
In the **Voltage/current 3-phase** function group, you set the rated current and rated voltage (see the following figure). Rated current, rated voltage are the reference variables for the percent setting.



[scui3phd, 1, en_US]

Figure 3-95 Reference Data for Percentage Settings

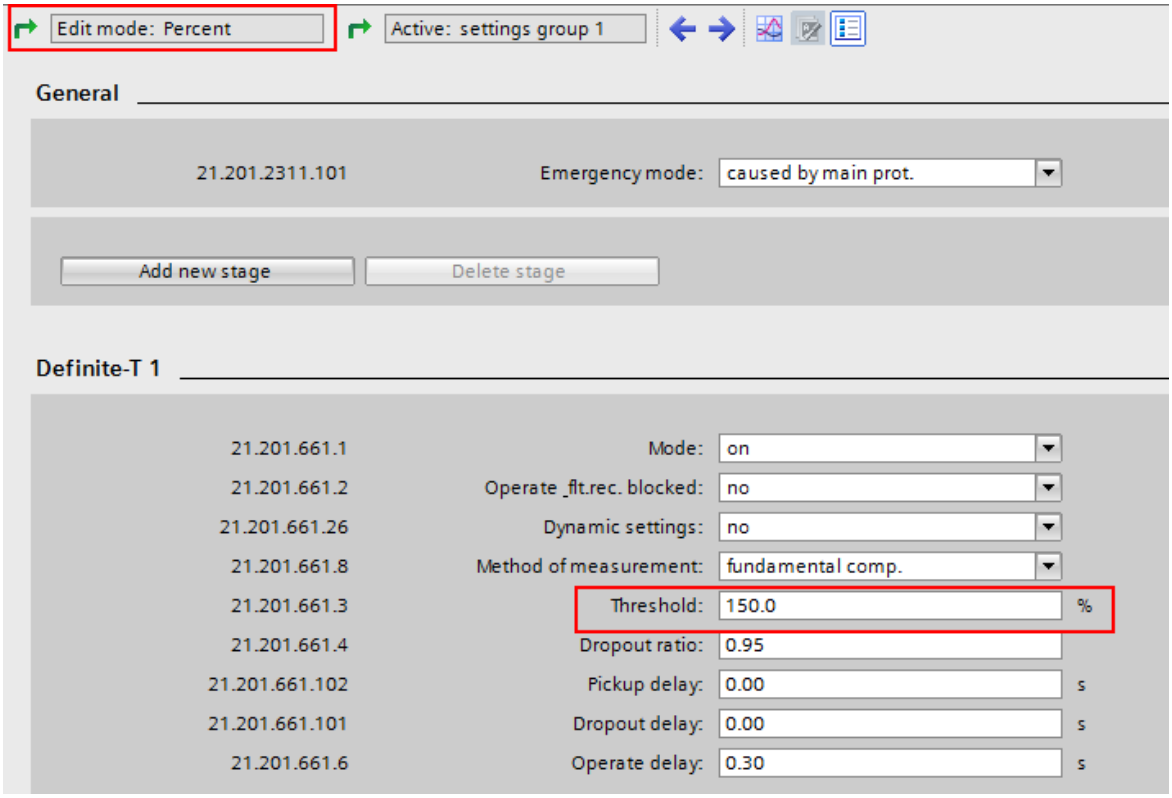
The following figure shows the threshold value of the **Overcurrent protection** function in the primary view at 1500 A.



[scumzpri_5, 1, en_US]

Figure 3-96 Example of the Threshold Value of the Definite Time-Overcurrent Protection (Edit Mode: Primary)

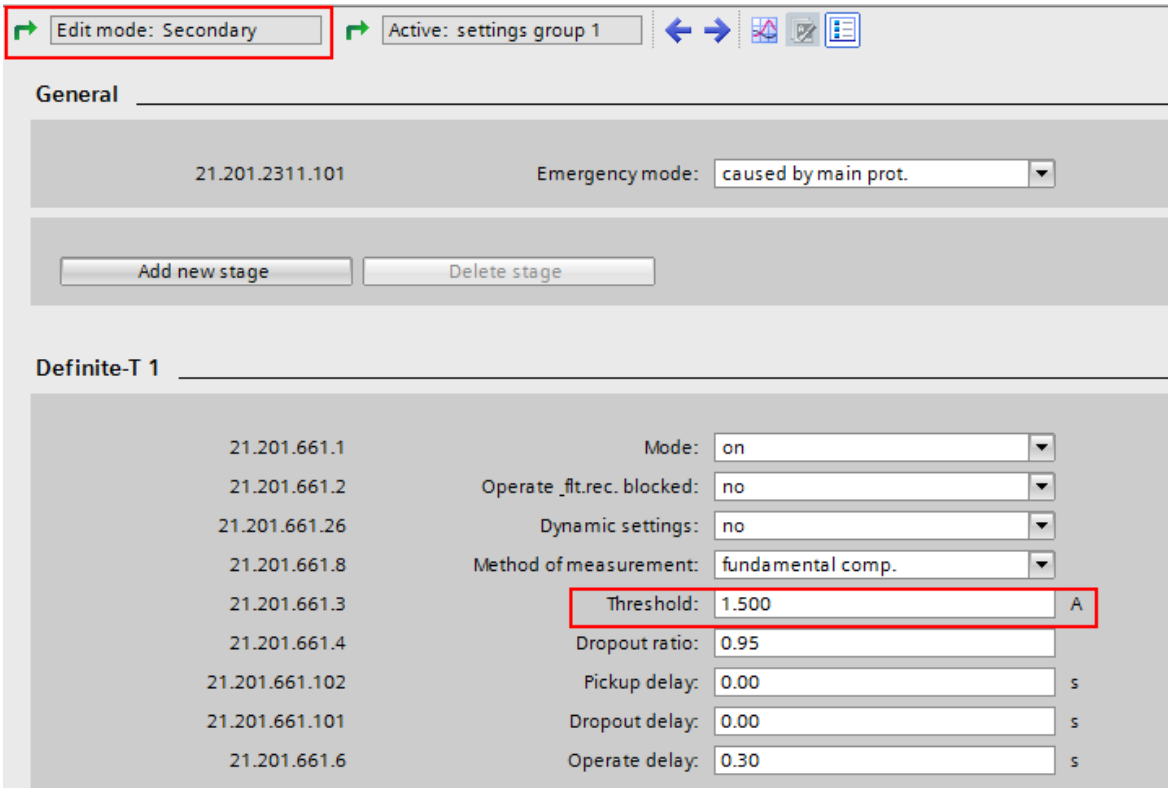
When switching over to the percent view, the result should be the following value:
1500 A/1000 A · 100 % = 150 %



[scumzpro_6, 1, en_US]

Figure 3-97 Example of the Threshold Value of the Definite Time-Overcurrent Protection (Edit Mode: Percent)

When switching over to the secondary view, the result should be the following value:
1500 A/(1000 A/1 A) = 1.5 A

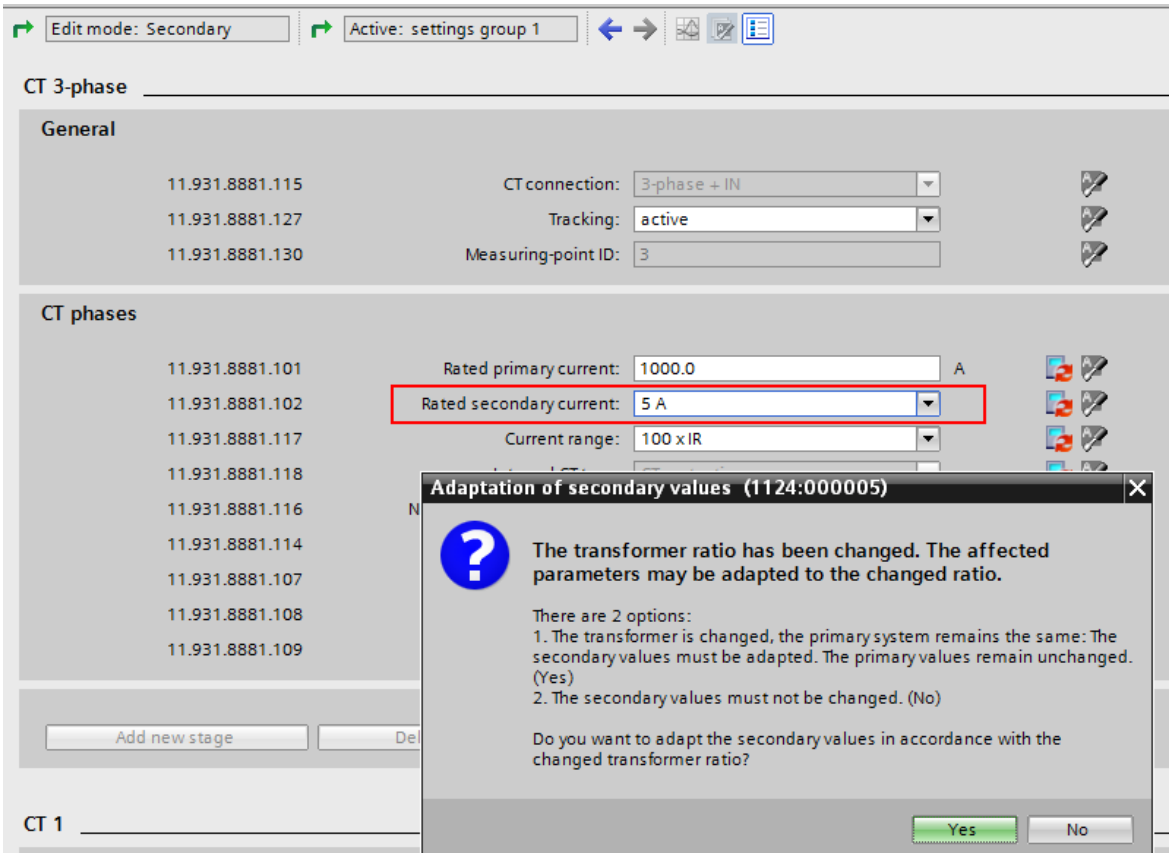


[scumzsek_7, 1, en_US]

Figure 3-98 Example of the Threshold Value of the Definite Time-Overcurrent Protection (Edit Mode: Secondary)

If you only want to work in the secondary view, DIGSI 5 supports you if the transformer ratio changes during the project phase.

In the example, the current-transformer ratio changes from 1000 A/**1 A** to 1000 A/**5 A**. Change the secondary rated current of the current transformer in the setting sheet of the transformer data from 1 A to 5 A (Edit mode: Secondary). If you change the transformer data, a window will appear (see the following figure) that will ask you for the action desired.

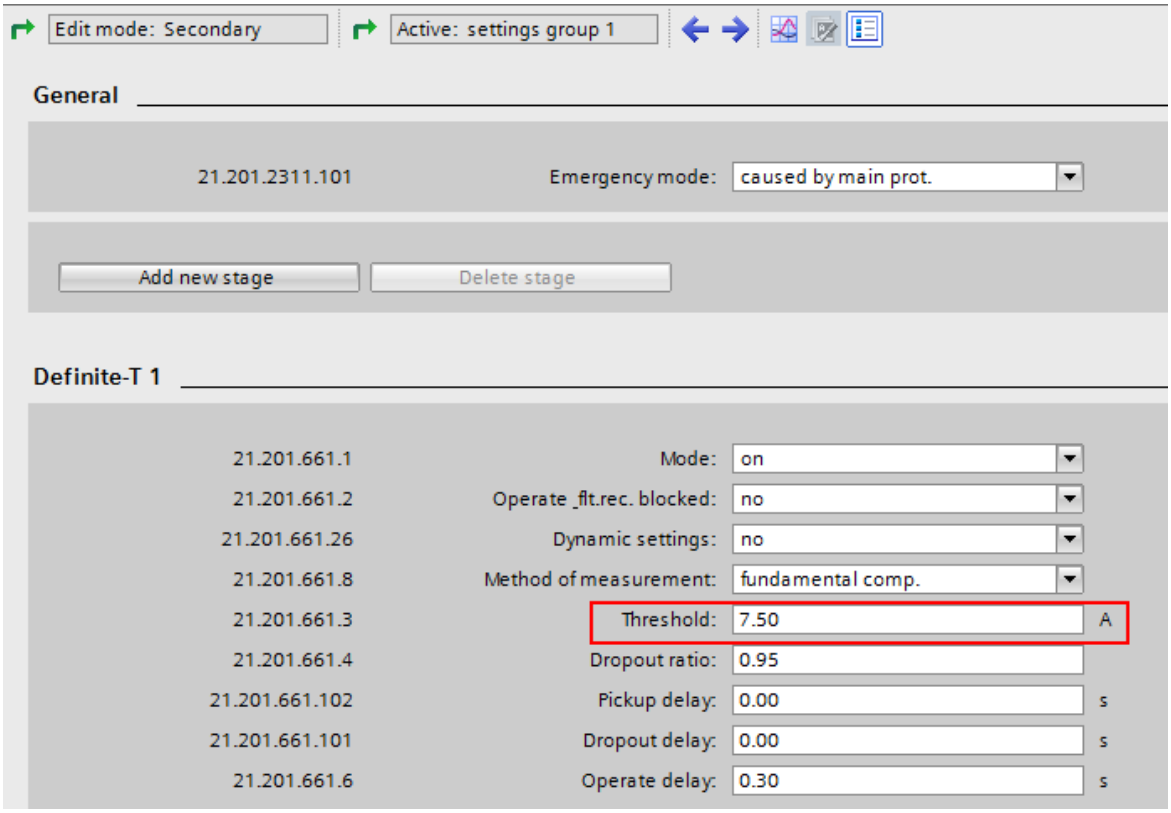


[scfragew_8, 1, en_US]

Figure 3-99 Query after Changing the Transformer Data (Setting View: Secondary)

If you answer the question with **Yes,** then DIGSI 5 will recalculate the pickup values (threshold values) in the active secondary view. For the new secondary transformer current 5 A, the new secondary threshold value obtained is 7.5 A (1.5 A * 5 = 7.5 A). The primary and percent values remain unchanged.

The following figure shows the newly calculated threshold value in the secondary view.



[scsekneu_9, 1, en_US]

Figure 3-100 Automatically Recalculated Secondary Values After Changes in the Transformer Data

If you have already set the settings in the secondary view by including the new transformation ratio of the transformer in the calculation, then you answer the question with **No**. In this case, the protection settings in the secondary view remain unchanged. DIGSI 5 recalculates the settings (threshold values) of the primary view. In the example, the primary threshold value is then 300 A (1.5 A * 1000 A/5 A = 300 A).

In the example, the current-transformer ratio changes from 1000 A/1 A to 1000 A/5 A. The following table summarizes the pickup values that DIGSI 5 will recalculate in the setting view. The new values (in bold) depend on the answer of your inquiry (see *Figure 3-99*).

	Reply to the Question	
	Yes	**No**
Threshold value secondary (active setting view)	**7.5** A	1.5 A
Threshold value primary (covered setting view)	1500 A	**300** A

3.9.3 Changing the Transformation Ratios of the Transformer on the Device

The device is preset to the secondary value at the time of delivery. Only secondary values can be set directly on the device.

If you change transformer data directly on the device, it is not followed by a query, like in DIGSI 5 (see *Figure 3-99*). Instead, the device assumes that all settings remain unchanged in the secondary view.

NOTE

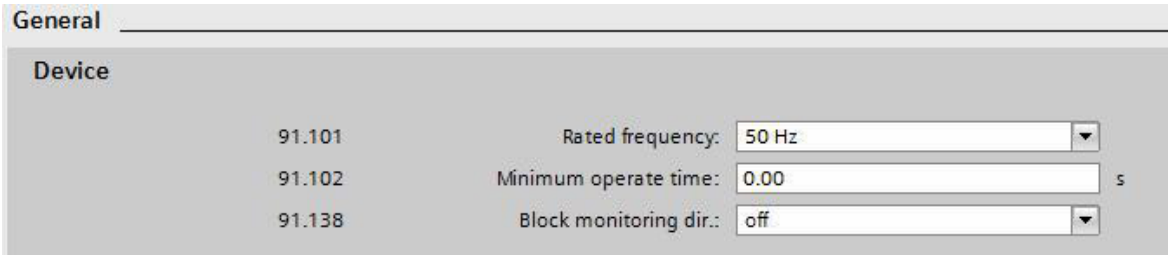
If the device works with IEC 61850 protocol, you change the transformer data only via DIGSI 5 and not directly on the device. If you change the transformer data directly on the device, the IEC 61850 configuration of the measurement and metered values can be faulty.

3.10 Device Settings

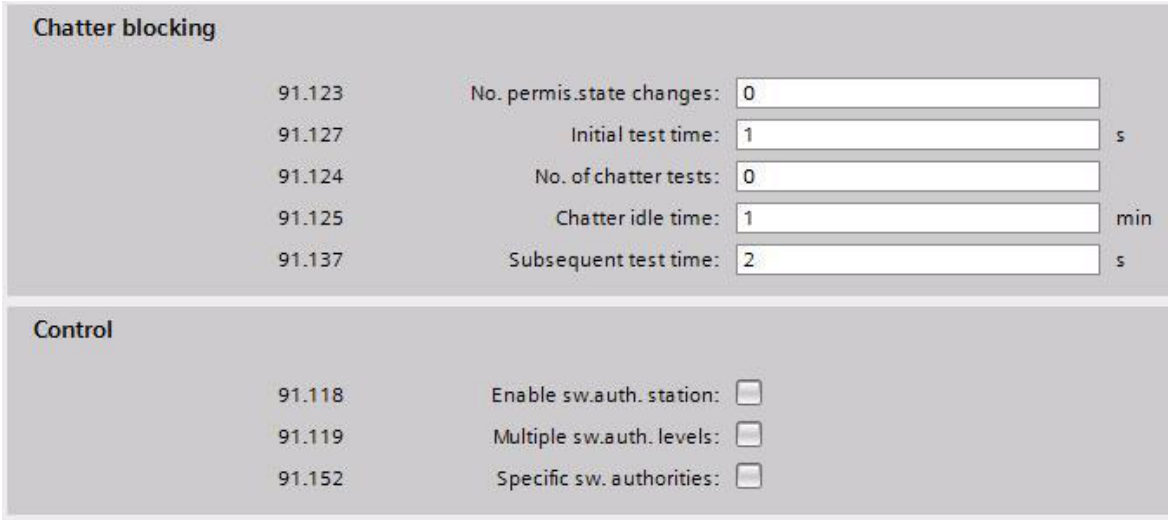
3.10.1 General Device Settings

3.10.1.1 Overview

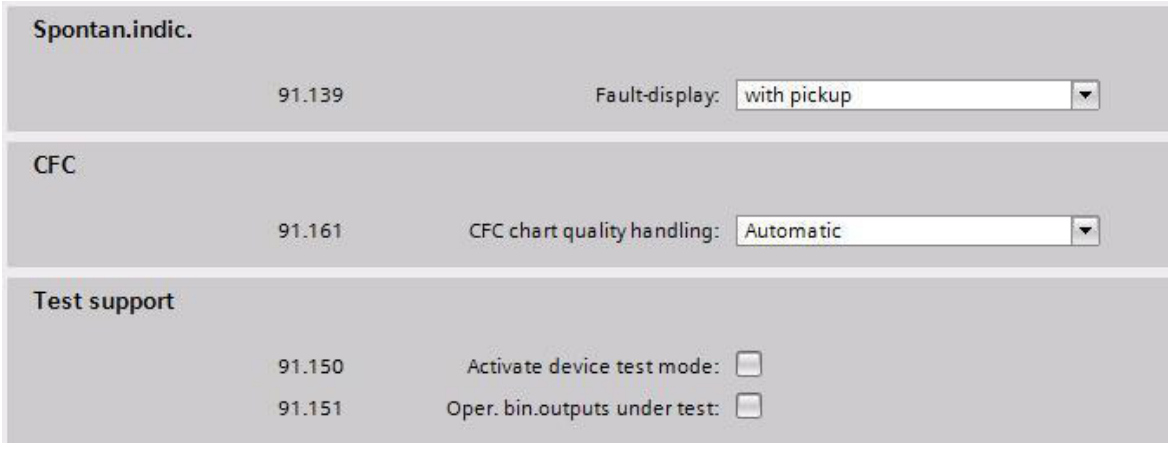
In **Device settings** in DIGSI 5, you find the following general settings.



[scDeSeDe1-310715-01, 1, en_US]



[scDeSeAl-310715-01, 1, en_US]



[scDeSeall-260815-01, 1, en_US]

Figure 3-101 General Device Settings

The following list shows you the chapters containing the desired information.

You can find more about:

- **Chatter blocking** in chapter *3.8.1 Signal Filtering and Chatter Blocking for Input Signals* .
- **Control** in chapter *8.3 Control Functionality* .
- **Spontaneous indications** in chapter *3.1.7 Spontaneous Indication Display in DIGSI 5* .
- **CFC Quality Processing** in Chapter *3.3.3 Quality Processing/Affected by the User in CFC Charts* .

Under **Device**, you set the parameters for the device that are valid across functions.

With the **Test support**, indications issued via communication interfaces are labeled with an additional test bit, if this is supported by the protocol. With this test bit, you can determine that an indication is generated as a test and that all or individual functions of the device are in test mode. In this way, the reactions that are necessary in normal operation due to an indication can be suppressed in other devices that receive these indications. You can also permit, for example, a trip command to close an energized binary output for test purposes. Siemens recommends deactivating the **Test support** again after the test phase.

3.10.1.2 Application and Setting Notes

The major part of the settings is described in the chapters cited above. In the following sections, you can find a description of the parameters of the sections **Device**, **Spontaneous indication**, and **Test support**.

Parameter: Rated frequency

- Default setting **(_:101) Rated frequency** = ***50 Hz***

With the **Rated frequency** parameter, you set the rated frequency of the electrical power system.

Parameter: Minimum operate time

- Default setting **(_:102) Minimum operate time** = **–**

With the **Minimum operate time** parameter, you set the minimum duration for the trip command of the functions. The trip command is maintained for the set duration.

Parameter: Block monitoring dir.

- Default setting **(_:138) Block monitoring dir.** = ***off***

With the **Block monitoring dir.** parameter, you set whether indications are issued via the system interface(s) of the SIPROTEC 5 device or not.

If transmission blocking is switched on, no indications are issued via the system interface(s) of a SIPROTEC 5 device.

Parameter: Fault-display

- Default setting **(_:139) Fault-display** = ***with pickup***

With the **Fault-display** parameter, you set whether spontaneous indications are issued for a pickup or for a tripping. Keep the DIGSI 5 routing options in chapters *3.1.7 Spontaneous Indication Display in DIGSI 5* and *Table 3-5* in mind.

Parameter: Activate device test mode

- Default setting **(_:150) Activate device test mode** = inactive

With the **Activate device test mode** parameter, you activate the test mode that adds a test bit to the issued indications.

Parameter: Oper.bin.outp. under test

- Default setting **(_:151) Oper.bin.outp. under test** = inactive

If you activate the parameter **Oper.bin.outp. under test** , you can allow the closing of a binary output for test purposes. In this way, indications are issued during a device-wide test mode and the relays are either

activated or not. If an individual function is in test mode, only indications are issued and the relays are not activated.



NOTE

The device remains in test mode during every startup until you set the device back into process mode intentionally. You switch to the process mode by switching the parameterActivate device test mode to inactive again (removing the check mark).

3.10.1.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Device				
_:101	General:Rated frequency		• 50 Hz • 60 Hz	50 Hz
_:102	General:Minimum operate time		0.00 s to 60.00 s	0.00 s
_:138	General:Block monitoring dir.		• off • on	off
Spontan.indic.				
_:139	General:Fault-display		• with pickup • with trip	with pickup
Test support				
_:150	General:Activate device test mode		• 0 • 1	false
_:151	General:Oper.bin.outp. under test		• 0 • 1	false

3.10.1.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:510	General:>Test mode on	SPS	I
_:511	General:>Test mode off	SPS	I
_:507	General:>Device funct.logoff on	SPS	I
_:508	General:>Dev. funct.logoff off	SPS	I
_:512	General:>LED reset	SPS	I
_:52	General:Behavior	ENS	O
_:53	General:Health	ENS	O
_:51	General:Test mode	ENC	C
_:321	General:Protection on	SPC	C
_:54	General:Protection inactive	SPS	O
_:323	General:LED reset	SPC	C
_:320	General:LED have been reset	SPS	O

3.10.2 Settings-Group Switching

3.10.2.1 Overview of Functions

For different applications you can save the respective function settings in so-called **Settings groups**, and if necessary enable them quickly.

You can save up to 8 different settings groups in the device. In the process, only one settings group is active at any given time. During operation, you can switch between settings groups. The source of the switchover can be selected via a parameter.

You can switchover the settings groups via the following alternatives:

- Via the on-site operation panel directly on the device
- Via an online DIGSI connection to the device
- Via binary inputs
- Via a communication connection to the substation automation technology.
  The communication protocols IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP or Modbus TCP can be used for switching the settings groups.

A settings group includes all switchable settings of the device. Except for a few exceptions (for example, general device settings such as rated frequency), all device settings can be switched.

Detailed information about the settings groups can be found in the Operating Manual and DIGSI 5 Online Help.

3.10.2.2 Structure of the Function

The function of the **Settings group switching** is a supervisory device function. Accordingly, the settings and indications of the settings group switching can be found in DIGSI 5 and at the on-site operation panel of the device, below the general device settings respectively.

If you want to switchover a settings group, navigate to DIGSI 5 or proceed on the on-site operation panel of the device, as follows:

- Via the project tree in DIGSI 5:
  Project -> Device -> Settings -> Device settings
- Via the on-site operation panel of the device:
  Main menu → Settings → General → Group switchover

The indications for the settings group switching can be found in the DIGSI 5 project tree under:
Project → Device → Information routing → General

3.10.2.3 Function Description

Activation

If you want to use the **Settings group switching** function, you must first set at least 2 settings groups in DIGSI 5 (parameter **Number of settings groups** > 1). You can set up a maximum of 8 settings groups. The settings groups set in DIGSI 5 are subsequently loaded into the device.

Mechanism of the Switchover

When switching over from one settings group to another, the device operation is not interrupted. With the **`Active settings group`** parameter, you are either specifying a certain settings group or you allow switching ***`via control`*** (IEC 60870-5-103, IEC 61850) or ***`via binary input`***.

Switching via Control

When using the ***`Control`*** function for switching, the settings groups can be switched via a communication connection from the substation automation technology or via a CFC chart.

The communication protocols IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP or Modbus TCP can be used for switching the settings groups via a communication connection.

In order to use a CFC chart for switching, you must create a new CFC chart in DIGSI 5. Create the CFC chart in the DIGSI 5 project tree under **Name of the device → Charts → Add new chart**. Link the signals that control settings group switching in the CFC chart.

Switching via Binary Input

There are 3 appropriate input signals available for switching via binary inputs. These input signals allow selection of the settings group via a binary code. If one of the 3 signals changes, the signal image present will, after 100 ms (stabilization time), result in switching over to the appropriate settings group. If only 2 settings groups must be switched over, only 1 binary input is required. The following table shows the possible binary codes (BCD) and applicable settings groups (PG).

Table 3-19 Binary Codes of the Input Signals and Applicable Settings Groups

BCD Code via Binary Inputs	PG 1	PG 2	PG 3	PG 4	PG 5	PG 6	PG 7	PG 8
>PG selection bit 3	0	0	0	0	1	1	1	1
>PG selection bit 2	0	0	1	1	0	0	1	1
>PG selection bit 1	0	1	0	1	0	1	0	1

Copying and Comparing Settings Groups

In DIGSI 5, you can copy or compare settings groups with each other.

If you want to copy settings groups, select a source and target parameter group in DIGSI 5 in the device settings, and then start the copy process. The device settings can be found in the DIGSI 5 project tree under Project → Device → Settings → Device settings.

If you want to compare settings groups, it is possible to do so in all setting sheets for settings. You will then select in addition to the active settings group, a 2nd settings group for comparison. Active setting values and the comparable values are displayed next to each other. For settings that cannot be switched over, no comparable values are displayed.

Indication of Settings Group Switchings

Every settings group shows an applicable binary indication as well as its activation and deactivation. The process of settings group switching is also logged in the log for settings changes.

3.10.2.4 Application and Setting Notes

Parameter: Number settings groups

- Default setting **(_:113) Number settings groups** = ***1***

With the **Number settings groups** parameter, you can set the number of available settings groups; you can switch between these.

Parameter: Activat. of settings group

- Default setting **(_:114) Activat. of settings group** = ***settings group 1***

With the **Activat. of settings group** parameter, you specify the settings groups that you want to activate, or the mechanisms via which the switchover is allowed. You can switchover only between the settings groups specified with the **Number settings groups** parameter. Parameter Value

Parameter Value	Description
via control	The switchover between the settings groups can only be initiated via a communication connection from a substation automation technology or via a CFC chart. The communication protocols IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP or Modbus TCP can be used for switching the settings groups via a communication connection.
via binary input	The switchover between the settings groups functions exclusively via the binary input signals routed to the settings group switching.
settings group 1 ... ***settings group 8***	They define the active settings groups. You can define the active settings groups in DIGSI 5, or directly on the device via the on-site operation.

3.10.2.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Change group				
_:113	General:Number settings groups		1 to 8	1
_:114	General:Activat. of settings group		• via control • via binary input • settings group 1 • settings group 2 • settings group 3 • settings group 4 • settings group 5 • settings group 6 • settings group 7 • settings group 8	settings group 1

3.10.2.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:500	General:>SG choice bit 1	SPS	I
_:501	General:>SG choice bit 2	SPS	I
_:502	General:>SG choice bit 3	SPS	I
_:300	General:Act. settings group 1	SPC	C
_:301	General:Act. settings group 2	SPC	C
_:302	General:Act. settings group 3	SPC	C
_:303	General:Act. settings group 4	SPC	C
_:304	General:Act. settings group 5	SPC	C
_:305	General:Act. settings group 6	SPC	C
_:306	General:Act. settings group 7	SPC	C
_:307	General:Act. settings group 8	SPC	C

4 Applications

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4.2	Application Templates and Functional Scope for the Devices 7SJ82/7SJ85	187

4.1 Overview

The Global DIGSI 5 library provides application templates for the applications of the devices. The application template

- Supports the fast realization of complete protection solutions for applications
- Contains the basic configuration for the use case
- Contains functions and default settings for the use case

When using an application template, please note the following:

- Adapt the application template to your specific use (check/adapt default settings, delete/add functions). You can find more detailed information in the *2.1 Function Embedding in the Device*.
- Check the routing of binary outputs with respect to fast and normal relays.
- Check the CFC charts for the group-warning indications and group-fault indications.

The following describes the application templates and maximum functional scope for the devices shown in this manual.



NOTE

The availability of certain settings and setting options depends on the device type and the functions available on the device!

4.2 Application Templates and Functional Scope for the Devices 7SJ82/7SJ85

Application templates are available in **DIGSI 5** for the applications of the device 7SJ82/7SJ85. The application templates contain the basic configurations, required functions, and default settings.

The following application templates are available for the device 7SJ82 and 7SJ85 in the **DIGSI 5** function library:

- Non-directional OC (4*I)
- Non-directional OC (4*I, 4*V)
- Directional OC, grounded system
- Directional OC, resonant-grounded/isol. system
- Capacitor bank H-bridge + 1*RLC, **7SJ85 only**
- Capacitor bank MSCDN, **7SJ85 only**
- Capacitor bank H-bridge, **7SJ82 only**

To load the application templates to the device, the following minimum hardware configuration requirements must be met:

Application Template		**Hardware Configuration Minimum Requirement**
Template 1	Non-directional OC (4*I)	9 BI, 8 BO, 4 I
Template 2	Non-directional OC (4*I, 4*V)	9 BI, 8 BO, 4 I, 4 V
Template 3	Directional OC, grounded system	
Template 4	Directional OC, resonant-grounded / isol. system	
Template 5	Capacitor bank: H-bridge + 1*RLC	2 BI, 2 BO, 12 I
Template 6	Capacitor bank: MSCDN	2 BI, 2 BO, 28 I, 4 V
Template 7	Capacitor bank: H-bridge	2 BI, 2 BO, 8 I

The following table shows the functional scope and the required function points of the application templates for the device 7SJ82/7SJ85:

Table 4-1 Functional Scope of the Application Template for the Device 7SJ82/7SJ85

ANSI	**Function**	**Abbr.**	**Available in 7SJ82**	**Available in 7SJ85**	**Template 1**	**Template 2**	**Template 3**	**Template 4**	**Template 5**	**Template 6**	**Template 7**
	Protection functions for 3-pole tripping	3-pole	x	x	x	x	x	x	x	x	x
	Hardware quantity structure expandable	I/O	x	x	x	x	x	x	x	x	x
24	Overexcitation protection	V/f	x	x							
25	Synchrocheck, synchronizing function	Sync	x	x							
27	Undervoltage protection, 3-phase	V<	x	x							

ANSI	Function	Abbr.	Available in 7SJ82	Available in 7SJ85	Template 1	Template 2	Template 3	Template 4	Template 5	Template 6	Template 7
27	Undervoltage protection, positive-sequence system	V1<	x	x							
27	Undervoltage protection, 3-phase, universal, Vx	Vx<	x	x							
27	Undervoltage protection, 1-phase, universal, Vx	Vx<	x	x							
27/Q	Undervoltage-controlled reactive-power protection	QU	x	x							
32R	Reverse power protection	-P<	x	x							
32, 37	Power protection active/reactive power	P<>, Q<>	x	x							
37	Undercurrent protection x	I<	x	x					x	x	x
38	Temperature Supervision	TmpUb	x	x							
46	Negative sequence overcurrent protection	I2>	x	x					x	x	x
46	Unbalanced-load protection (thermal)	$I2^2t$>	x	x							
46	Negative sequence overcurrent protection with direction	I2>, ∠ (V2, I2)	x	x							
49	Thermal overload protection	Θ, I^2t	x	x					x	3	x
49	Thermal overload protection with user-def. charac. curve	Θ, I^2t	x	x						3	x
49	Thermal overload protection for RLC element	Θ, I^2t	x	x					x		
50TD/ 51	Overcurrent protection, phases - advanced	I>	x	x					x		
50TD/ 51	Overcurrent protection, phases - basic	I>	x	x	x	x	x	x		3	x
50NTD/ 51N	Overcurrent protection, ground - advanced	IN>	x	x					x		
50NTD/ 51N	Overcurrent protection, ground - basic	IN>	x	x	x	x	x			x	x

ANSI	Function	Abbr.	Available in 7SJ82	Available in 7SJ85	Template 1	Template 2	Template 3	Template 4	Template 5	Template 6	Template 7
50N/ 51N	Overcurrent protection, 1-phase - advanced	I>1pA	x	x							
50N/ 51N	Overcurrent protection, 1-phase - basic	I>1pB	x	x							
50HS	High speed instantaneous overcurrent protection	I>>>	x	x							
50Ns/ 51Ns	Sensitive ground-current protection for systems with resonant or isolated neutral	INs>	x	x							
50BF	Circuit-breaker failure protection		x	x						x	
RBRF	Restrike protection		x	x							
51-R	OC-3ph protection for RLC elements		x	x							
51V	OC-3phase voltage-dependent		x	x							
59	Overvoltage protection, 3-phase	V>	x	x						x	
59	Overvoltage protection, positive-sequence system	V1>	x	x							
47	Overvoltage protection, negative-sequence system	V2>	x	x							
47	Overvoltage protection with negative-sequence voltage/positive-sequence voltage	V2/V1>	x	x							
59N	Overvoltage protection, zero-sequence system	V0>	x	x							
59	Overvoltage protection, 3-phase or 1-phase, universal, Vx	Vx>	x	x							
59C	Peak overvoltage protection for capacitors		x	x					x	2	x
60C	Current unbalance protection for capacitors, 3-phase	Iunbal>	x	x					x	2	x
60C	Current Unbalance Protection for Capacitors, 1-phase	Iunbal>	x	x							

ANSI	Function	Abbr.	Available in 7SJ82	Available in 7SJ85	Template 1	Template 2	Template 3	Template 4	Template 5	Template 6	Template 7
67	Directional overcurrent protection 1-pole			x							
67	Directional time-overcurrent protection, phases – advanced	I>, ∠(V,I)	x	x							
67	Directional time-overcurrent protection, phases – basic	I>, ∠(V,I)	x	x			x	x			
67N	Directional overcurrent protection, ground - advanced	IN>, ∠ (V,I)	x	x							
67N	Directional time-overcurrent protection, ground - basic	IN>, ∠ (V,I)	x	x			x				
67Ns	Directional sensitive ground-fault detection for systems with resonant or isolated neutral	INs>, ∠ (V,I)	x	x				x			
67Ns	Transient ground-fault function, for transient and permanent ground faults in resonant-grounded or isolated networks	W0p,tr>	x	x							
74TC	Trip circuit supervision	TCS	x	x							
79	Automatic reclosing	AREC	x	x							
81O	Overfrequency protection	f>	x	x							
81U	Underfrequency protection	f<	x	x							
81R	Rate of frequency change protection	df/dt	x	x							
86	Lockout		x	x	4	4	4	4	x	x	x
87C	Capacitor bank differential protection		x	x						x	
87V	Voltage-differential protection	ΔV		x							
87N	Restricted ground-fault protection	ΔIN	x	x							
90V	Voltage controller		x	x							
Arc Prot	Arc protection		x	x							
DIGFP	Directional intermittent ground-fault protection		x	x							
IGFP	Intermittent ground-fault protection		x	x							

ANSI	Function	Abbr.	Available in 7SJ82	Available in 7SJ85	Template 1	Template 2	Template 3	Template 4	Template 5	Template 6	Template 7
FL	Fault locator, single-ended measurement	FL-one	x	x							
PMU	Synchrophasor measurement	PMU	x	x							
SOTF	Instantaneous tripping at switch onto fault	SOTF	x	x	x	x	x	x			
Monit	Circuit-breaker wear monitoring		x	x							
VSEL	Voltage measuring-point selection		x	x							
20mA MT	20-mA unit Ethernet		x	x							
20mA MS	20-mA unit serial		x	x							
RTDMT	RTD unit Ethernet		x	x							
RTDMS	RTD unit Serial		x	x							
	Signaling-Voltage Supervision		x	x							
	Measuring-voltage failure detection		x	x							
	Switch onto fault		x	x	x	x	x	x			
	CB Test		x	x	x	x	x	x	x	x	x
	Interlocking		x	x	4	4	4	4	x	x	x
	I-jump detection		x	x							
	V- jump detection		x	x							
	Pulse metered value		x	x							
	Measured values, standard		x	x	x	x	x	x	x	2	x
	User-defined function block		x	x							
	Measured values, extended: Min, Max, Avg		x	x							
	Switching statistic counters		x	x							
	CFC standard and control		x	x	x	x	x	x	x	x	x
	CFC arithmetic		x	x							
	Switching sequences function		x	x							
	Inrush current detection		x	x	x	x	x	x			
	External trip initiation		x	x							
	Control		x	x	4	4	4	4	x	x	x

ANSI	Function	Abbr.	Available in 7SJ82	Available in 7SJ85	Template 1	Template 2	Template 3	Template 4	Template 5	Template 6	Template 7
	Fault recording of analog and binary signals		x	x	x	x	x	x	x	x	x
	Monitoring and supervision		x	x	x	x	x	x	x	x	x
	Protection interface, serial		x	x							
	Capacitor bank		x	x					x	2	x
	Circuit Breaker		x	x	x	x	x	x	x	x	x
	Circuit Breaker [control]		x	x							
	Circuit Breaker [status only]		x	x							
	Disconnector		x	x	3	3	3	3			
	Disconnector [status only]		x	x							
	Tap changer		x	x							
	Analog unit		x	x							
	Communication modules		x	x	x	x	x	x	x	x	x
	Function-points class:				0	0	30	45	90	295	80

5 Function-Group Types

5.1	Function-Group Type Voltage-Current 3-Phase	194
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5.1 Function-Group Type Voltage-Current 3-Phase

5.1.1 Overview

All functions for protection and supervision of a protected object or equipment allowing 3-phase current and voltage measurement can be used in the function group **Voltage-current 3-phase**. The function group also contains the operational measurement for the protected object or equipment (on this topic, see chapter *10 Measured Values, Energy Values, and Supervision of the Primary System*).

You will find the **Voltage-current 3-phase** function group under each device type in the Global DIGSI 5 library. You will find all protection and supervision functions that you can use for this function-group type in the function group **Voltage-current 3-phase**. These functions are described in chapter *6 Protection and Automation Functions* .

You can find additional information on the embedding of the functions in the device in chapter *2 Basic Structure of the Function* . You can find the function scope of the application templates for the various device types in the chapter *4 Applications* .

5.1.2 Structure of the Function Group

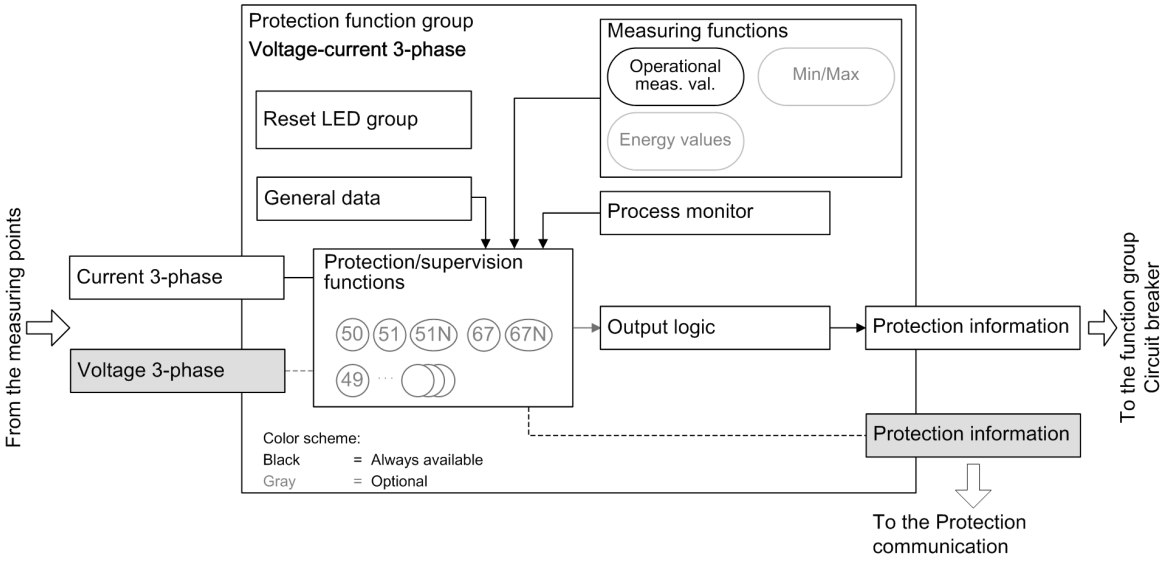
The function group always contains the following blocks:

- Protected object/equipment data (FB General)
- Operational measured values
- Process monitor
- Output logic of the function group
- Reset LED group

These blocks are essential for the function group under all circumstances, so they cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.

The following figure shows the structure of the function group **Voltage-current 3-phase**.



[dwfgui3p-301112-01.tif, 4, en_US]

Figure 5-1 Structure of the Voltage-Current 3-Phase Function Group

The function group has interfaces with

- **Measuring points**
- **Circuit-breaker** function group

Interface with Measuring Points

The function group receives the required measured values via its interfaces with the measuring points. If you are using an application template, the function group is already connected to the necessary measuring points. If you add functions to the function group, they will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the **Function group connections** editor. You can find more detailed information in chapter *2 Basic Structure of the Function*.

The function group has the following interfaces with the measuring points:

- **3-phase current**

  The measurands from the 3-phase power system are supplied via this interface. Depending on the connection type of the transformers, these are, for example, I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The function group must always be connected to the **I-3ph** measuring point.

  You can connect the **3-phase current** interface to a maximum of **four** 3-phase current measuring points (for example, for 1 1/2 circuit-breaker layouts). If 2 current measuring points have been connected with the **3-phase current** interface, the total current is also determined from measured values from both measuring points in the function group. All functions in the function group have access to these values.

- **3-phase voltage (optional)**

  The measurands from the 3-phase voltage system are supplied via this interface. There are various types of transformer connections possible. All values that can be calculated from the measurands are also provided via this interface. Connecting the function group to the **V 3ph** measuring point is optional.

  You can connect multiple measuring points with this interface. You can find more information in chapter *6.48 Voltage Measuring-Point Selection*.

  If you want to test or change the connection between the voltages and the V-3ph measuring point, double-click in the DIGSI 5 project tree → **(Name of the device)** on **Measuring point routing** (Connection type = 3 phase-to-ground voltage). For more information, refer to the description of the power-system data starting in chapter *6.1 Power-System Data*.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and **Circuit-breaker** function groups via the interface with the Circuit-breaker function group. This data includes, for example, the pickup and operate indications of the protection functions sent in the direction of the Circuit-breaker function group and, for example, the circuit-breaker condition information in the direction of the protection function groups.

The **Voltage-current 3-phase** function group is connected to one or more Circuit-breaker function groups. This connection generally determines:

- Which circuit breaker(s) is/are activated by the protection functions of the protection function group
- Starting the Circuit-breaker failure protection function (if available in the Circuit-breaker function group) through the protection functions of the connected protection function group
- Starting the Automatic reclosing function (AREC, if available in the Circuit-breaker function group) through the protection functions of the connected Protection function group

Besides the general allocation of the protection function group to the Circuit-breaker function groups, you can also configure the interface for certain functionalities in detail. Configure the details in DIGSI 5 using the **Circuit-breaker interaction** editor in the protection function group.

In the detail configuration of the interface, you define:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the automatic reclosing function
- Which protection functions start the Circuit-breaker failure protection function

If you are using an application template, the function groups are already connected to each other, because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor.

You can find more detailed information in chapter *2.1 Function Embedding in the Device*.

If the connection is missing, DIGSI 5 reports an inconsistency.

Protected Object/Equipment Data (FB General)

The rated voltage and rated current as well as the neutral-point treatment of the protected object or the equipment are defined here. These data apply to all functions in the **Voltage-current 3-phase** function group.

Resetting the LED Group

Using the **Reset the LED group** function, you can reset the stored LEDs of the functions in one specific function group while the activated, stored LEDs of other functions in other function groups remain activated.

You can find more detailed information in chapter *3.1.10 Resetting Stored Indications of the Function Group* .

Process Monitor

The process monitor is always present in the **Voltage-current 3-phase** function group and cannot be removed.

The process monitor provides the following information in the **Voltage-current 3-phase** function group:

- Current-flow criterion:
  Detection of an open/activated protected object/equipment based on the flow of leakage current
- Closure detection:
  Detection of the switching on of the protected object/equipment
- Cold-load pickup detection (optional, only for protection devices):

These data apply to all functions in the **Voltage-current 3-phase** function group.

The description of the process monitor begins in chapter *5.8 Process Monitor*.

Operational Measured Values

The operational measured values are always present in the **Voltage-current 3-phase** function group and cannot be removed.

The following table shows the operational measured values of the **Voltage-current 3-phase** function group:

Table 5-1 Operational Measured Values of the Voltage-Current 3-Phase Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary values
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary values
I_N	Neutral-point phase current	A	A	Rated operating current of the primary values
I_{NS}	Sensitive ground current	A	mA	Rated operating current of the primary values
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Operating rated voltage of primary values/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary values
V_0	Zero-sequence voltage	kV	V	Operating rated voltage of primary values/√3
V_{NG}	Neutral-point displacement voltage	kV	V	Operating rated voltage of primary values/√3
f	Frequency	Hz	Hz	Rated frequency
P_{total}	Active power (total power)	MW	W	Active power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$

Measured Values		Primary	Secon-dary	% Referenced to
Q_{total}	Reactive power (total power)	Mvar	var	Reactive power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S_{total}	Apparent power (total power)	MVA	VA	Apparent power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active power factor	(abs)	(abs)	100 % corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	W	Active power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	var	Reactive power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$
S_A, S_B, S_C	Phase-related apparent power	MVA	VA	Apparent power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$

The operational measured values are explained in more detail in chapter *10.3 Operational Measured Values* .

Inversion of Power-Related Measured and Statistical Values (FB General)

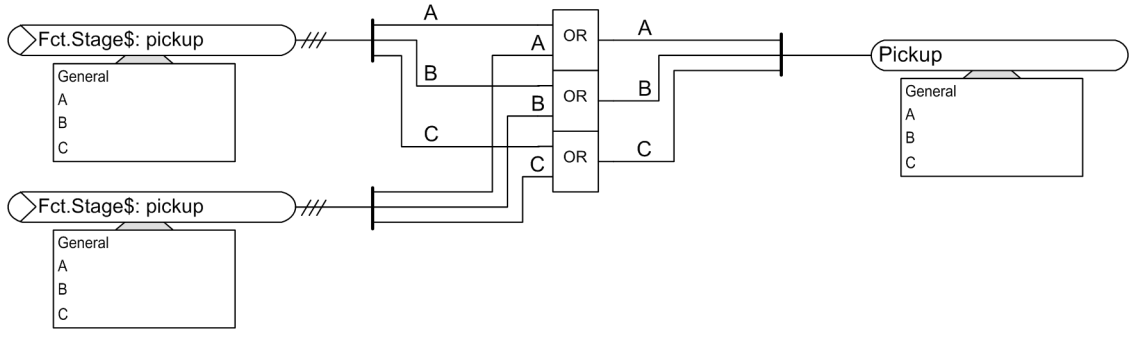
The following directional values calculated in operational measured values are defined positively in the direction of the protected object.

- Power
- Active power factor
- Energy
- Minimum, maximum values
- Average values

With the **`P, Q sign`** parameter, you can invert the sign of these operational measured values such that a power flow from the line to the busbar is displayed positively.
More information can be found in chapter *10.1 Overview of Functions*.

Output Logic

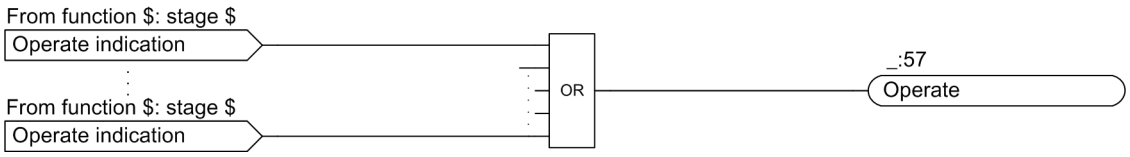
The output logic treats the pickup and trip signals of the protection and supervision functions that are available in the function group separately, in a pickup logic and a trip logic, respectively. The pickup and trip logic generate the overreaching indications (group indications) of the function group. These group indications are transferred via the **Protection information** interface to the **Circuit-breaker** function group and are processed further there.
The pickup signals of the protection and supervision functions in the **Voltage-current 3-phase** function group are combined in a phase-selective manner and output as a group indication.



[loanrlin-150211-01.tif, 3, en_US]

Figure 5-2 Creation of the Pickup Indication of the Voltage-Current 3-Phase Function Group

The trip signals from the protection and supervision functions of the **Voltage-current 3-phase** function group always result in 3-pole tripping of the device.



[loauslin-150211-01.tif, 3, en_US]

Figure 5-3 Creation of the Operate Indication of the Voltage-Current 3-Phase Function Group

5.1.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

With this, you define which circuit-breaker(s) is/are affected by the protection functions of the Protection function group. A feasible default setting has already been provided in the application templates. You can find more information in chapter 2.

Protected Object/Equipment Data (FB General)

The set data applies to all functions in the function group.

Set the protected object/equipment data for your specific application.

Parameter: Rated current

- Default setting **(_:9451:101) Rated current** = ***1000 A***

With the **Rated current** parameter, you can set the primary rated current of the protected object or equipment. The **Rated current** parameter is significant for protection functions, as long as the current values are set in percentages. In this case it is the reference value. In addition it is the reference value for the measured values in percent.

If the device works with the IEC 61850 protocol, then you change only the setting value of the parameter via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated voltage

- Default setting **(_:9451:102) Rated voltage** = ***400.00 kV***

With the **Rated voltage** parameter, you can set the primary rated voltage of the protected object or equipment. The **Rated voltage** parameter is significant for protection functions, as long as the current values are set in percentages. In this case it is the reference value. In addition it is the reference value for the measured values in percent.

If the device works with the IEC 61850 protocol, then you change only the setting value of the parameter via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Power-sys. neutral point

- Default setting **(_:9451:149) Power-sys. neutral point** = ***grounded***

With the **Power-sys. neutral point** setting, you specify whether the system neutral is ***grounded*** , ***isolated*** , or ***suppress. coil grounded*** (grounded via arc-suppression coil). Currently, the parameter does not affect any protection function; only if the **Automatic reclosing function** uses the voltage measurement.

You can find more information in Chapter *6.43.1 Overview of Functions* .

Parameter: `P, Q sign`

- Default setting **`(_:9451:158) P, Q sign`** = ***`not reversed`***

The power and energy values are defined by the manufacturer such that power in the direction of the protected object is considered positive. You can also define the power output by the protected object (for example, as seen by the consumer) as positive. With the **`P, Q sign`** setting, you can invert the sign for these components. This inversion does not influence any protection function.

5.1.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameters	C	Range of Values	Default Setting
`Network data`				
_:103	General:rated apparent power		0.20 MVA to 5 000.00 MVA	692.82 MVA

NOTE

You can find more detailed information on the Process monitor in chapter *5.8 Process Monitor*.

5.1.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Rated values`				
_:9451:101	General:Rated current		1 A to 100000 A	1000 A
_:9451:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
`Power-system data`				
_:9451:149	General:Power-sys. neutral point		• grounded • suppress. coil grounded • isolated	grounded
`Measurements`				
_:9451:158	General:P, Q sign		• not reversed • reversed	not reversed

5.1.6 Information List

No.	Information	Data Class (Type)	Type
`General`			
_:9451:52	General:Behavior	ENS	O
_:9451:53	General:Health	ENS	O
`Group indicat.`			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
`Reset LED Group`			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O

No.	Information	Data Class (Type)	Type
Closure detec.			
_:1131:4681:500	Closure detec.:>Disconnector open	SPS	I
_:1131:4681:300	Closure detec.:Closure	SPS	O

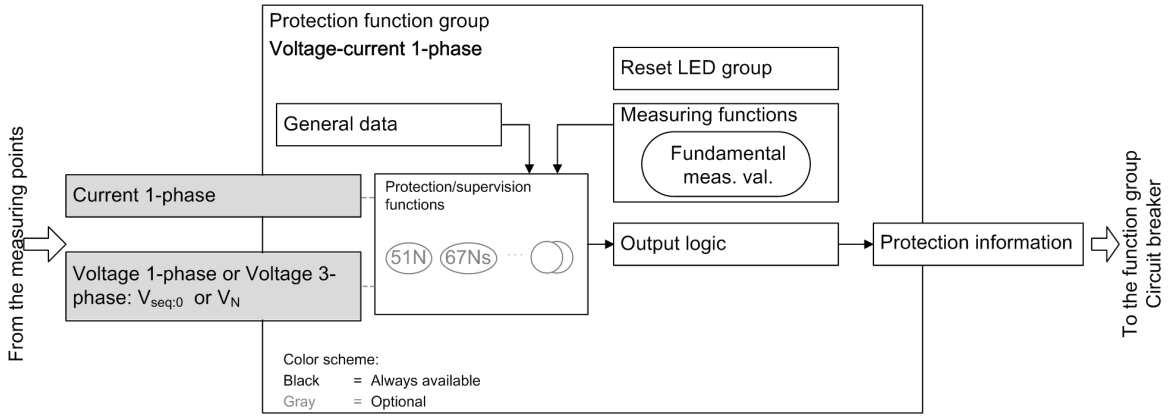
5.2 Function-Group Type Voltage-Current 1-Phase

5.2.1 Overview

In the **Voltage-current 1-phase** function group, all functions can be used for protecting and for monitoring a protected object or equipment which allow a 1-phase current and voltage measurement or a zero-sequence voltage measurement via a 3-phase voltage measuring point. The function group also contains the operational measurement for the protected object or equipment (on this topic, see chapter *10 Measured Values, Energy Values, and Supervision of the Primary System*).

5.2.2 Structure of the Function Group

The **Voltage-current 1-phase** function group has interfaces to the measuring points and the **Circuit-breaker** function group.



[dw1spstr-301112-01.tif, 3, en_US]

Figure 5-4 Structure of the Voltage-current 1-Phase Function Group

Interface with Measuring Points

You connect the **Voltage-current 1-phase** function group to the current and voltage measuring points via the interfaces to the measuring points. At least one measuring point has to be connected. The other is optional. This assignment can only be made in DIGSI via **Project tree** → **Function group connections**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.

The function group has the following interfaces to the measuring points:

- **1-phase current**

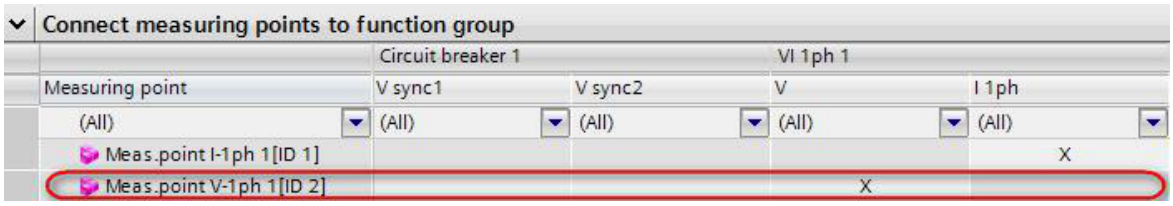
  The 1-phase current measured values are supplied via this interface.

  You can connect multiple measuring points with the **1-phase current** interface.

- 1-phase voltage or 3-phase voltage

  You can connect the voltage interface of the function group with a 1-phase or a 3-phase measuring point. The calculated zero-sequence voltage or the measured residual voltage are available for connection with a 3-phase measuring point. The phase-to-ground voltages are not available in the function group **Voltage-current 1-phase**. You can use both connection types at the same time.

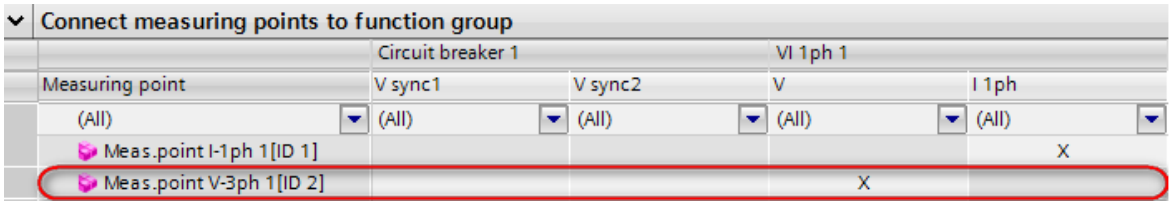
  You configure the 1-phase voltage measuring points via the voltage interface (see the following figure).



[scVI1ph_V1ph, 1, en_US]

Figure 5-5 Connecting Measuring Points to the Voltage-current 1-Phase Function Group

The converted, calculated zero-sequence voltage or measured residual voltage from the 3-phase voltage system is available via the voltage interface (see following figure).



[scVI1ph_V3ph, 1, en_US]

Figure 5-6 Connecting Measuring Points 3-Phase Voltage and 1-Phase Current to the 1-Phase Voltage-Current Function Group

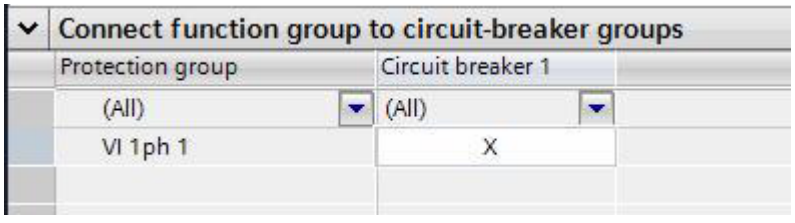
You can connect the voltage interface with precisely one 3-phase voltage measuring point. 3 types of 3-phase voltage measuring-point connections are supported. With the differenct connection types, the type of voltage input also changes in line with the functions. The following table shows the characteristics of the voltage input depending on the types of connection.

Connection Type of the 3-Phase Voltage Measuring Point	**Voltage Input**
3 ph-to-gnd voltages	The zero-sequence voltage is calculated from the phase-to-ground voltages and used as a voltage input for all funtions.
3 ph-to-gnd volt. + VN	The residual voltage VN is converted to the voltage equivalent of the zero-sequence voltage. The converted voltage is used as a voltage input for functions.
3 ph-to-ph volt. + VN	

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and circuit-breaker function groups via the interface with the **Circuit-breaker** function group. In this example, the pickup and operate indications of the protection functions are exchanged in the direction of the Circuit-breaker function group.

You must connect the **Voltage-current 1-phase** function group with the **Circuit-breaker** function group. This assignment can only be made in DIGSI via **Project tree** → **Function group connections**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix. If the interface is not connected, the functions operate as supervision functions in the **Voltage-current 1-phase function group**.



[sc1stspc-190214-01, 1, en_US]

Figure 5-7 Connecting Voltage-current 1-Phase Function Group with Circuit-Breaker Function Group

Fundamental Components

The fundamental components are always present in the **Voltage-current 1-phase** function group and cannot be deleted.

The following table shows the fundamental components of the **Voltage-current 1-phase** function group:

Table 5-2 Fundamental Components of the Voltage-current 1-Phase Function Group

Measured Values		Primary	Secondary	% Referring to
I	1-phase current	A	A	**Rated operating current**
V[7]	1-phase voltage	kV	V	**Rated operating voltage**
V_0 [8]	Zero-sequence voltage	kV	V	**Rated operating voltage**/√3
V_N [9]	Residual voltage	kV	V	**Rated operating voltage**/√3

5.2.3 Application and Setting Notes



NOTE

Prior to creation of the protection functions in the function group, these functions should first be connected to the appropriate **Circuit-breaker** function group.

Parameter: Rated current

- Default setting **(_:9451:101) Rated current** = ***1000 A***

The **Rated current** parameter is used to set the primary rated current. The **Rated current** specified here is the reference value for the percentage-measured values and setting values made in percentages.

Parameter: Rated voltage

- Default setting **(_:9421:102) Rated voltage** = ***400.00 kV***

With the **Rated voltage** parameter, you set the primary voltage, which serves as a reference for all voltage-related % values within the **Circuit-breaker** function group.

5.2.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_:9421:104	General:rated apparent power		0.20 MVA to 5000.00 MVA	400.00 MVA
Network data				
_:91:214	General:M I-1ph uses measuring point ID		0 to 100	0
_:91:223	General: Scale factor M I-1ph		0.01 to 100.00	1.00

[7] The 1-phase voltage V is only visible if it is connected to a 1-phase voltage measuring point
[8] The zero-sequence voltage V0 is only visible if it is connected to a 3-phase voltage measuring point with the 3-phase phase-to-ground voltage connection type
[9] The residual voltage VN is only visible if it is connected to a 3-phase voltage measuring point with the 3-phase phase-to-ground voltage connection type + VN or 3-phase phase-to-phase voltage + VN

5.2.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9421:101	General:Rated current		1 A to 100000 A	1000 A
_:9421:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Power-system data				
_:9421:214	General:M I-1ph uses MeasP with ID		0 to 100	0
_:9421:127	General:Number of Meas.point. 1ph		0 to 11	0

5.2.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:9421:52	General:Behavior	ENS	O
_:9421:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED FG			
_:4741:500	Reset LED Group:>LED reset	SPS	I
_:4741:320	Reset LED Group:LED have been reset	SPS	O

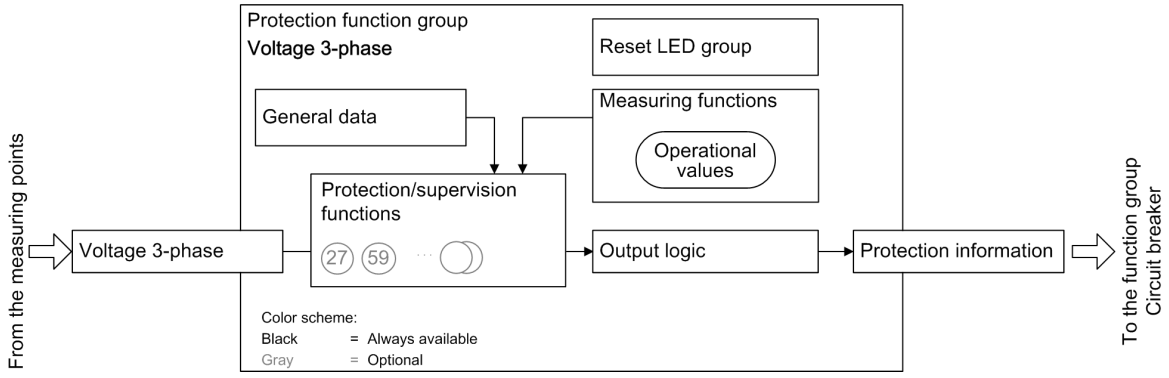
5.3 Function-Group Type Voltage 3-Phase

5.3.1 Overview

In the **Voltage 3-phase** function group, all functions can be used for protecting and for monitoring a protected object or equipment which allows a 3-phase voltage measurement. The function group also contains the operational measurement for the protected object or equipment (on this topic, see chapter *10 Measured Values, Energy Values, and Supervision of the Primary System*). Applicable functions are, for example, Voltage protection or Frequency protection.

5.3.2 Structure of the Function Group

The **Voltage 3-phase** function group has interfaces to the measuring points and the **Circuit-breaker** function group.

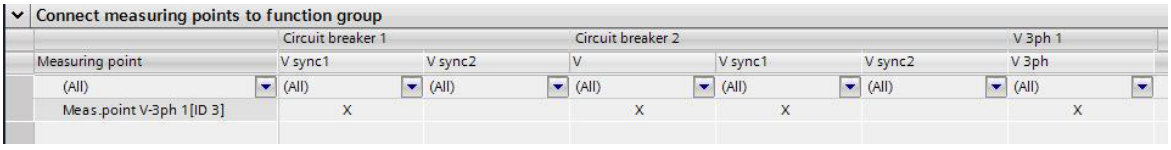


[dw3spann-300913, 1, en_US]

Figure 5-8 Structure of the Voltage 3-Phase Function Group

Interface with Measuring Points

You connect the **Voltage 3-phase** function group to the voltage measuring points via the interface to the measuring points. This assignment can only be made in DIGSI via **Project tree** → **Function group connections**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.



[sc3span1-190214-01, 1, en_US]

Figure 5-9 Connecting Measuring Points to the Voltage 3-Phase Function Group

If you add functions to the **Voltage 3-phase** function group, these are connected to the measuring point automatically.

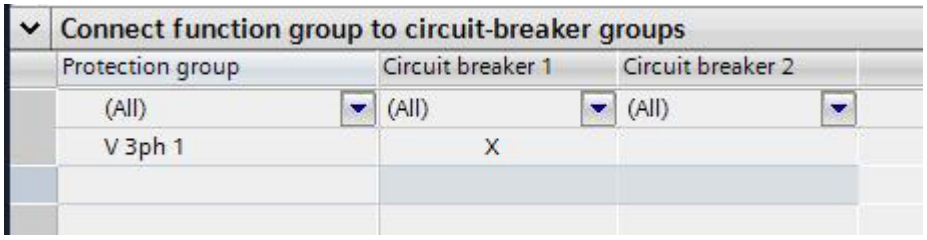
You can connect multiple measuring points with this interface. You can find more information in chapter *6.48 Voltage Measuring-Point Selection*.

The measurands from the 3-phase voltage system are supplied via the **V 3-ph** interface. Depending on the type of transformer connections, these are, for example, V_A, V_B, V_C, V_{gnd}. All values that can be calculated from the measurands are also provided via this interface.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and circuit-breaker function groups via the interface with the **Circuit-breaker** function group. In this example, the pickup and operate indications of the protection functions are exchanged in the direction of the Circuit-breaker function group.

You must connect the **Voltage 3-phase** function group with the **Circuit-breaker** function group. This assignment can be made in DIGSI only via **Project tree** → **Connect function group**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.



[sc3span2-190214-01, 1, en_US]

Figure 5-10 Connecting Voltage 3-Phase Function Group with Circuit-Breaker Function Group

Operational Measured Values

The operational measured values are always present in the **Voltage 3-phase** function group and cannot be deleted.

The following table shows the operational measured values of the **Voltage 3-phase** function group:

Table 5-3 Operational Measured Values of the Voltage 3-Phase Function Group

Measured Values		Primary	Secondary	% Referenced to
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Operating rated voltage of primary values/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltage	kV	V	Rated operating voltage of the primary values
V_0	Zero-sequence voltage	kV	V	Operating rated voltage of primary values/√3
V_{NG}	Neutral-point displacement voltage	kV	V	Operating rated voltage of primary values/√3
f	Frequency	Hz	Hz	Rated frequency

5.3.3 Application and Setting Notes

NOTE

Before creating the protection functions in the function group, you should first connect hese functions to the appropriate **Circuit-breaker** function group.

Parameter: Rated voltage

- Default setting **(_:9421:102) Rated voltage** = ***400.00 kV***

With the **Rated voltage** parameter, you set the primary rated voltage. The **Rated voltage** set here is the reference value for the percentage-measured values and setting values made in percentages.

5.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9421:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV

5.3.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:9421:52	General:Behavior	ENS	O
_:9421:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED FG			
_:4741:500	Reset LED Group:>LED reset	SPS	I
_:4741:320	Reset LED Group:LED have been reset	SPS	O

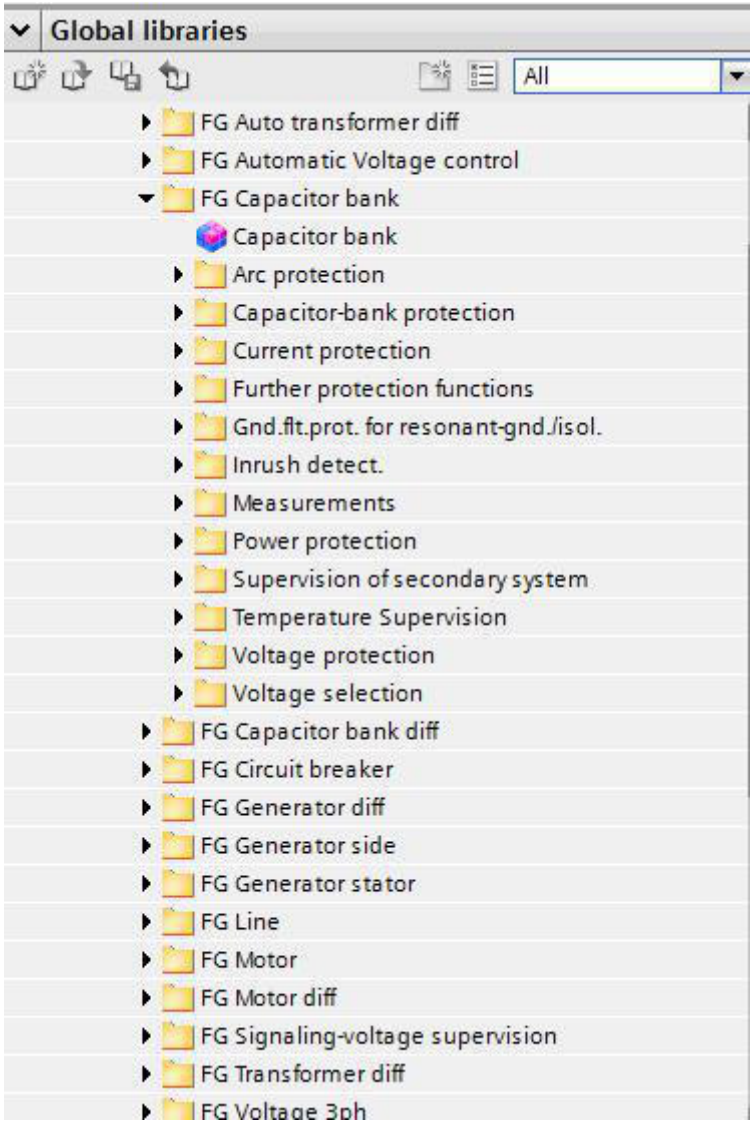
5.4 Function-Group Type Capacitor Bank

5.4.1 Overview

In the **Capacitor bank** function group, all the functions that are necessary for protecting and monitoring a capacitor bank can be used.

You can find the **Capacitor bank** function group under 7SJ82/7SJ85 device types in the Global DIGSI 5 Library. The **Capacitor bank** function group contains all of the protection and supervision functions that you can use for this device type.

Some of these functions are exclusively used for protecting capacitor banks, and others are universal standard functions which can be used for other protected objects as well. You find the exclusive protection functions in the directory **Capacitor-bank protection**.



[scfgcapb-250314-01, 2, en_US]

Figure 5-11 Capacitor Bank Function Group - Functional Scope for Device Type 7SJ85

For more information about the embedding of the functions in the device, refer to chapter 2. For information about the overall functional scope of the application templates for the various device types, refer to chapter 4.

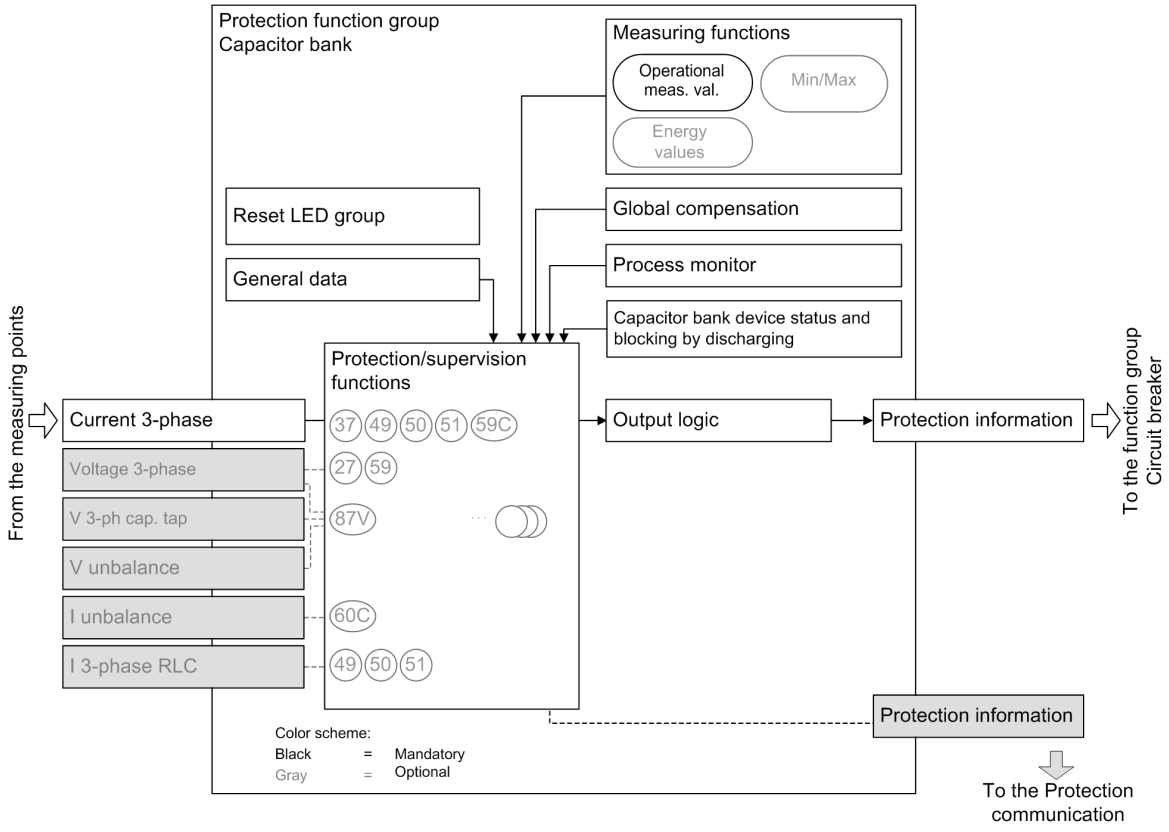
5.4.2 Structure of the Function Group

The **Capacitor bank** function group always contains the following functionality:

- Protected object/equipment data (function block **General**)
- Operational measured values
- Capacitor bank device status and blocking by discharging (function block **General**)
- Process monitor
- Global compensation (function block **General**)
- Output logic of the function group
- Reset LED group

This functionality is essential for the **Capacitor bank** function group, so it cannot be loaded or deleted.

You can load the protection functions and supervision functions required for your application in the **Capacitor bank** function group. The functions are available from the Global DIGSI 5 Library. Functions that are not needed can be deleted from the function group.



[Dwstrcap-20140619-01.vsd, 2, en_US]

Figure 5-12 Structure of the Capacitor Bank Function Group

The **Capacitor bank** function group has interfaces with the following parts:

- **Measuring points**
- **Circuit-breaker** function group

Interfaces with the Measuring Points

The **Capacitor bank** function group receives the required measured values via the interfaces with the measuring points. If you are using an application template, the **Capacitor bank** function group is already connected to the specific measuring points.

You can find more detailed information in Chapter 2.

The **Capacitor bank** function group has the following 6 interfaces with the measuring points. The universal standard functions only work with the standard interfaces **3-phase current** and/or **3-phase voltage**; the other 4 interfaces are provided for the functions which are exclusively used for the capacitor banks. Please also refer to the example given below.

The **Capacitor bank** function group has the following interfaces with the measuring points:

- **3-phase current:**

  The measurands from the 3-phase current system are supplied via this interface. Depending on the connection type of the current transformers, the measurands can be for example I_A, I_B, I_C, I_N, or $3I_0$. All values that can be calculated from the measurands are also provided via this interface.

  The **Capacitor bank** function group must always be connected to the **3-phase current measuring point**. You can connect the **3-phase current measuring point** interface to the maximum of two **3-phase current measuring points**. If 2 current measuring points have been connected to the 3-phase current interface, the total current is determined by adding the measured values from both measuring points in the function group. The functions in the **Capacitor bank** function group evaluate the total current.

- **3-phase voltage** (optional):

  The measurands from the 3-phase voltage system are supplied via this interface. Depending on the connection type of the voltage transformers, these can be for example V_A, V_B, V_C, V_N, or $3V_0$. All values that can be calculated from the measurands are also provided via this interface.

  The connection of the **3-phase voltage** interface is optional. This connection is only required if protection functions or supervision functions are applied, which require voltage measurements.

- **3-phase voltage CB tap** (optional):

  The measurands of a 3-phase tap voltage within a capacitor bank are supplied via this interface.

  The connection of the **3-phase voltage CB tap** interface is optional. You can connect the 3-phase voltage CB tap interface to a maximum of one **3-phase voltage measuring point**.

- **Voltage unbalance** (optional):

  The unbalanced-voltage measurands (for example, an isolated neutral point of the capacitor bank) are supplied via this interface.

  The connection of the **voltage unbalance** interface is optional. You can connect the **voltage unbalance** interface to a maximum of one **1-phase voltage measuring points**.

- **Current unbalance** (optional):

  The unbalanced-current measurands are supplied via this interface.

  The connection of the **current unbalance** interface is optional. You can connect the **current unbalance** interface to a maximum of two **3-phase current measuring points** and six **1-phase current measuring points**.The interface allows mixed connections to 3-phase current measuring point and 1-phase current measuring point; however the sum of the connections is no more than 6.

  For an overview which function are applicable on this interface, please refer to Figure 1-5.

- **3-phase current RLC** (optional)

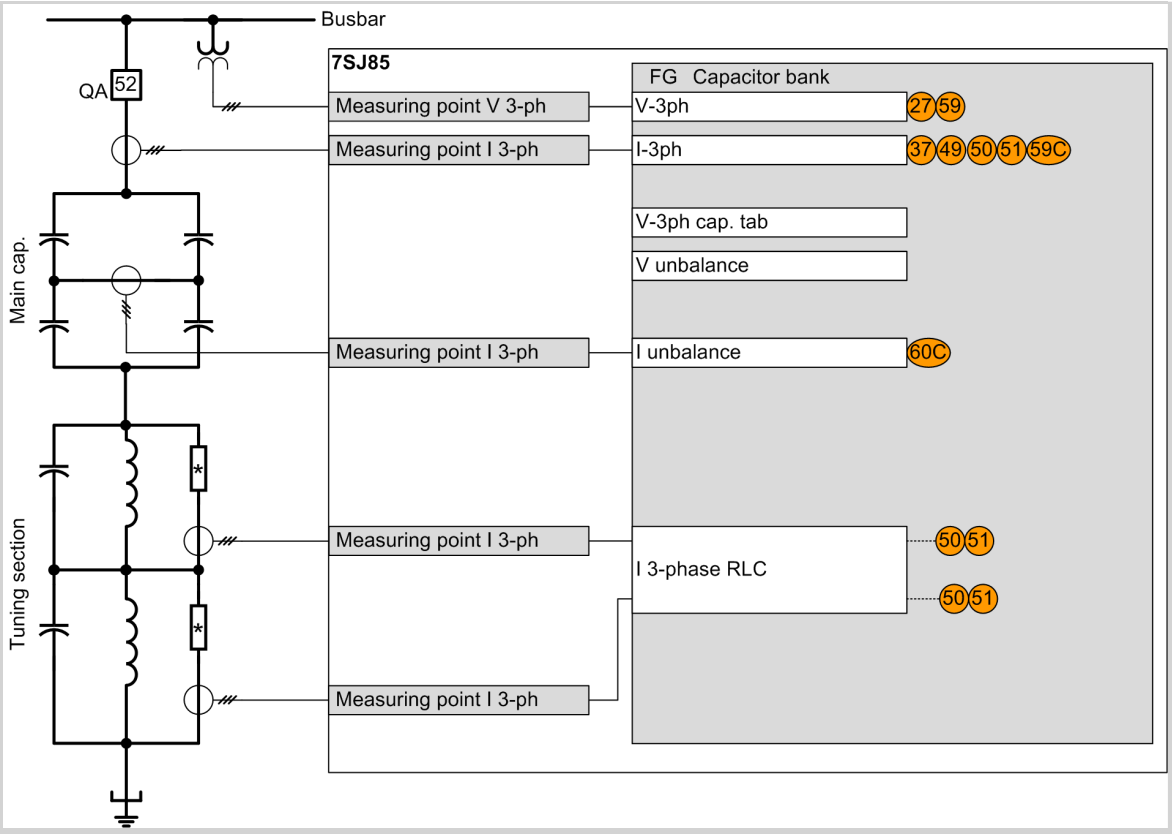
  The measurands from a tuning or filtering section (R, L, or C) of a capacitor bank are supplied via this interface.

  The connection of the **3-phase current RLC** interface is optional. You can connect the **3-phase current RLC** interface to a maximum of nine **3-phase current measuring points**.

  For an overview which function are applicable on this interface, please refer to *Figure 5-13*.

Example

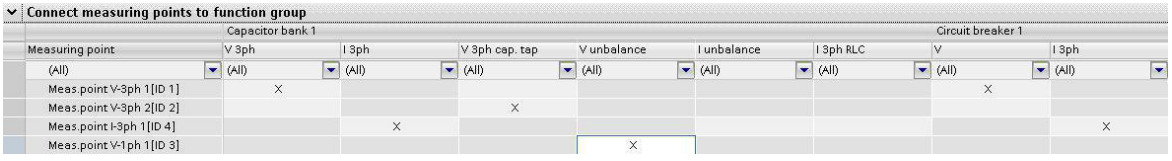
The following figure shows an example of a capacitor in H-configuration and tuning section. In the single line, the primary current and voltage measurement are shown. The required device measuring points and their connections to the function group interfaces are shown as well. In addition, it is indicated which protection function receives its measuring value from which measuring point.



[dwasscap-180713-01.tif, 2, en_US]

Figure 5-13 An Example of Assignment of Measuring Points to the Capacitor-Bank Functions

You can connect the **Capacitor bank** function group to the current and voltage measuring points via interfaces. You make this assignment in DIGSI via **Project tree → Function group connections**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.



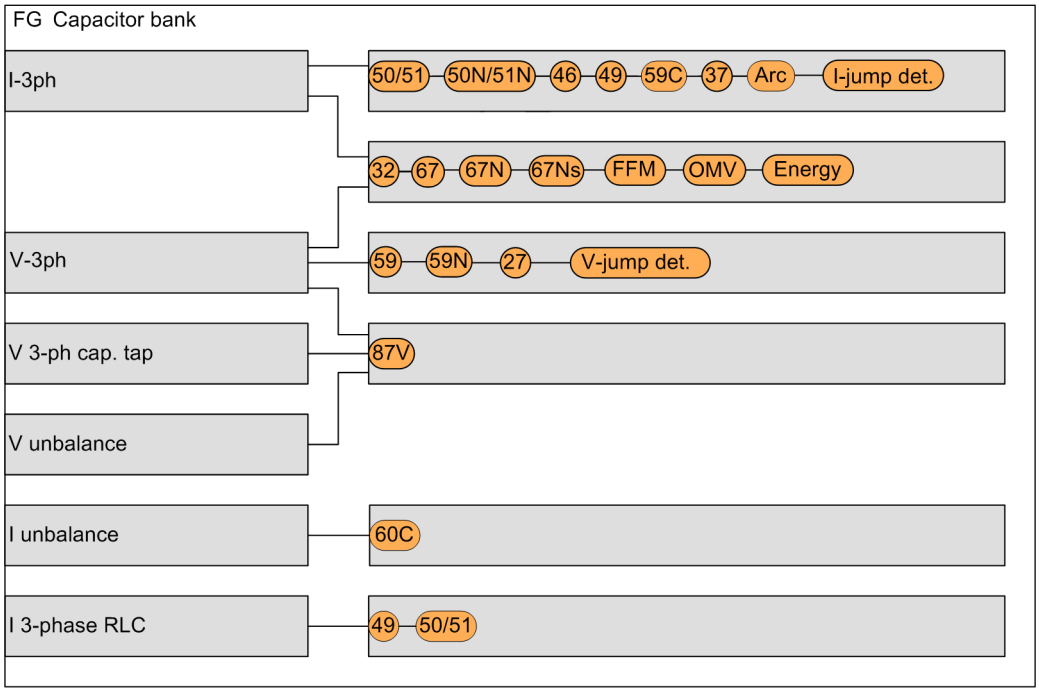
[scrconba-110314-03, 2, en_US]

Figure 5-14 Connecting Measuring Points to the Capacitor Bank Function Group

For the protection functions applied on the interfaces **3-phase current** and **3-phase voltage**, if you add these functions to the **Capacitor bank** function group, these functions will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary interface is not connected to any measuring point, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 using the **Function group connections** editor.

For the protection functions applied on the interfaces **Current unbalance** and **3-phase current**, you have to select the desired measuring points via a setting **`MP selection`**, which offers a list of all measuring points connected to the specific interface. The setting **`MP selection`** is located on the setting page of the protection function.

The following figure shows an overview of the protection functions and the interface assignment in the **Capacitor bank** function group.



27	Undervoltage protection
32	General power protection
37	Undercurrent protection
46	Negative-sequence protection
49	Overload protection
50/51	Overcurrent protection, phases
50N/51N	Overcurrent protection, ground
59	Overvoltage protection
59C	Peak overvoltage protection
59N	Overvoltage protection with zero-sequence voltage/residual voltage
60C	Current-unbalance protection
67/67N	Directional overcurrent protection for ground faults
67Ns	Directional sensitive ground-fault detection
87V	Voltage-differential protection
OMV	Operational values
FFM	Fuse-failure monitor

[DwCapBank-180713-01, 4, en_US]

Figure 5-15 Overview of the Protection Functions and Interface Assignment in the Capacitor Bank Function Group

Interfaces with Circuit-Breaker Function Group

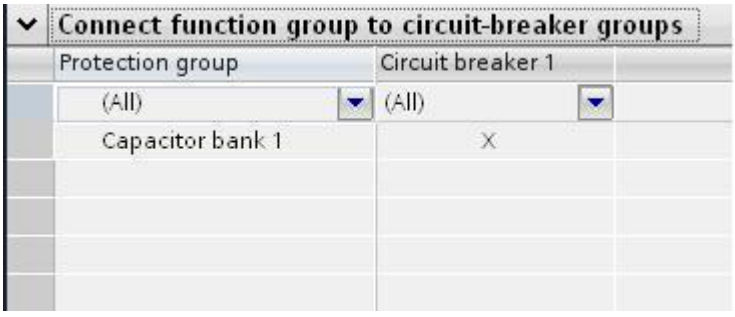
All required data are exchanged between the protection function group and the **Circuit-breaker** function group via the interface with the **Circuit-breaker** function group. These data include, for example, the pickup and operate indications of the protection functions sent in the direction of the **Circuit-breaker** function group and, for another example, the information about the circuit-breaker condition sent in the direction of the protection function group.

The **Capacitor bank** function group is connectable to a **Circuit-breaker** function group. This connection generally determines:

- Which circuit breaker is activated by the protection functions of the **Capacitor bank** function group
- Starting of the **Circuit-breaker failure protection** function (if available in the **Circuit-breaker** function group) through the protection functions of the connected **Capacitor bank** function group
- Starting of the **Automatic reclosing** function (if available in the **Circuit-breaker** function group) through the protection functions of the connected **Capacitor bank** function group

NOTE

For capacitor bank protection, the **Automatic reclosing** function is not applied in most cases. However, due to flexibility and standardization, the respective interface is offered.



[scrconb1-180713-01.tif, 1, en_US]

Figure 5-16 Connecting Capacitor Bank Function Group with Circuit-Breaker Function Group

Besides the general assignment of the **Capacitor bank** function group to the **Circuit-breaker** function group, you can also configure the interface for certain functionalities in detail. Configure the details in DIGSI 5 using the **Circuit breaker interaction** editor in the Capacitor bank function group.

In the detailed configuration of the interface, define:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the **Circuit-breaker failure protection** function
- Which protection functions start the **Automatic reclosing** function

	Circuit breaker 1	
	Trip logic	50BF CB fail.1
Protection group	Trip	Start CB failure
(All)	(All)	(All)
50/51 OC-3ph-A1	X	X
Definite-T 1	X	X
Definite-T 2	X	X
Inverse-T 1	X	X

[scconcap-150713-01.tif, 2, en_US]

Figure 5-17 Connecting Protection Functions and Stage Using the Circuit-Breaker Interaction Editor

If an application template is used, the function groups have already been connected to each other because this link is essential to ensure proper operation. You can modify the link in DIGSI 5 using the **Function-group connections** editor.

You can find more information in chapter *2.1 Function Embedding in the Device*. If this link is missing, DIGSI 5 reports an inconsistency.

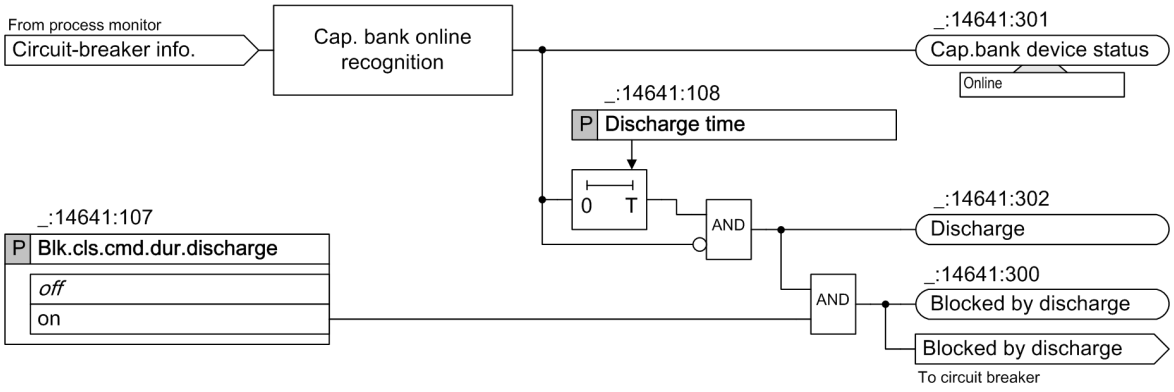
Protected Object/Equipment Data (FB General)

Capacitor-bank rated and reference data are defined as well as further protected object/equipment data. The data applies for all functions in the **Capacitor bank** function group.

For further information, refer to chapter *5.4.3 Application and Setting Notes*.

Capacitor Bank Device Status and Blocking by Discharging (FB General)

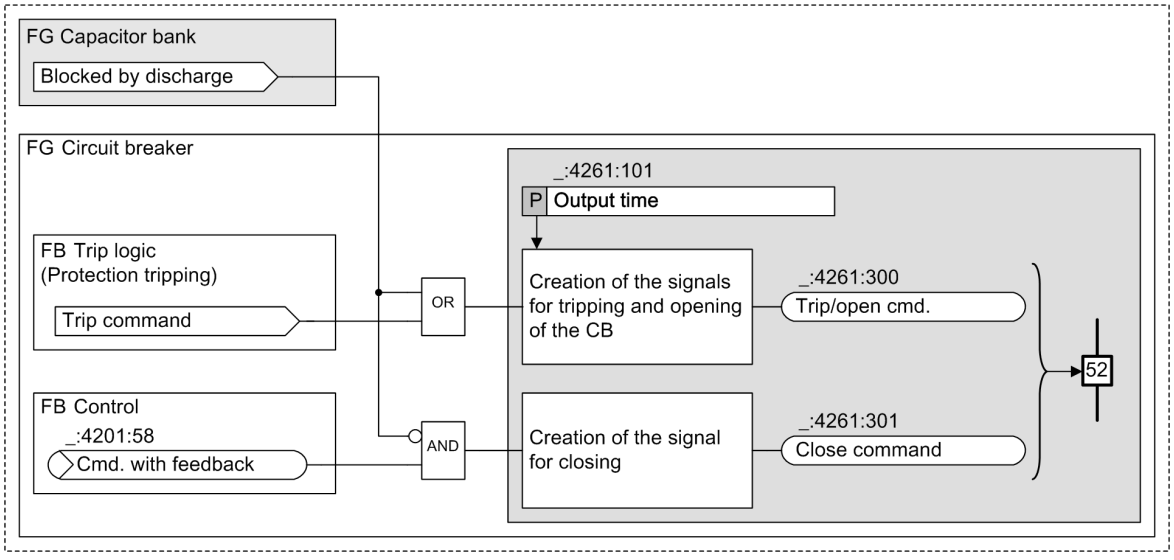
The functionality detects whether a capacitor bank is **online** or **offline**. When the status of the capacitor bank changes from **online** to **offline**, the signal *Discharge* is issued during the capacitor-bank discharging time.



[Lo-CapZap-20140617-01, 1, en_US]

Figure 5-18 Logic Diagram of Capacitor Bank Device Status and Blocking by Discharging

The device can block the closing of the circuit breaker automatically when a capacitor bank discharges. The configuration is made with the parameter **Blk.cls.cmd.dur.discharge**. If the parameter **Blk.cls.cmd.dur.discharge** is set to ***on***, the device generates a trip/open command during the discharge time and blocks closing commands additionally, see the following figure. This blocking condition is signaled via the message *Blocked by discharge*.



[Lo-discharge-20140617-01, 1, en_US]

Figure 5-19 Logic Diagram of Processing the Blocked by Discharge Signal

Global Compensation (FB General)

The **Global compensation** function block provides the binary input signal *>Compensate* to carry out the manual compensation for all functions in the FG using compensated measuring values.

In addition, the binary input signal *>Reset comp. val.* is provided to reset all compensation values for the functions using compensated measuring values.

Process Monitor

The **Process monitor** detects the current state of the protected object. It is always present in the function group and cannot be removed.

For detailed description of the **Process monitor**, refer to *5.8.1 Overview of Functions*.

Reset LED Group

The **Reset LED group** function block allows you to reset only the stored LEDs of the functions contained in the respective function group, while stored LEDs activated from functions in other function groups remain active.

For more information refer to chapter *3.1.10 Resetting Stored Indications of the Function Group* .

Operational, Fundamental, Symmetrical Components Measurements

The operational fundamental, symmetrical components and functional measurements are always available in the **Capacitor bank** function group and cannot be deleted.

Table 5-4 Operational Measured Values (True RMS) of the Function Group Capacitor Bank

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
I_N	Neutral-point phase current	A	A	Rated operating current of the primary system
$3I_0$	Residual current	A	A	Rated operating current of the primary system
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltage	kV	V	Rated operating voltage of the primary system
V_0	Zero-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
V_{NG}	Neutral-point displacement voltage	kV	V	Rated operating voltage of the primary system/√3
f	Frequency	Hz	Hz	Rated frequency
P_{tot}	Active power (total power)	MW	–	Rated operating voltage and rated operating current of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q_{tot}	Reactive power (total power)	MVAr	–	Rated operating voltage and rated operating current of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S_{tot}	Apparent power (total power)	MVA	–	Rated operating voltage and rated operating current of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active factor	(abs)	(abs)	100 % corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	–	Apparent power of the phase $V_{rated\ Lx} \cdot I_{rated\ Lx}$
Q_A, Q_B, Q_C	Phase-related reactive power	MVAr	–	Apparent power of the phase $V_{rated\ Lx} \cdot I_{rated\ Lx}$
S_A, S_B, S_C	Phase-related apparent power	MVA	–	Apparent power of the phase $V_{rated\ Lx} \cdot I_{rated\ Lx}$

Table 5-5 Fundamental and Symmetrical Components Measurement Values of the Function Group Capacitor Bank

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system

Measured Values		Primary	Secondary	% Referenced to
I_N	Neutral-point phase current	A	A	Rated operating current of the primary system
$I_{seq:0}$	Zero-sequence current	A	A	Rated operating current of the primary system
$I_{seq:1}$	Positive-sequence current	A	A	Rated operating current of the primary system
$I_{seq:2}$	Negative-sequence current	A	A	Rated operating voltage of the primary system
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltage	kV	V	Rated operating voltage of the primary system
V_N	Neutral-point phase voltage	kV	V	Rated operating voltage of the primary system/√3
$V_{seq:0}$	Zero-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
$V_{seq:1}$	Positive-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
$V_{seq:2}$	Negative-sequence voltage	kV	V	Rated operating voltage of the primary system/√3

Voltage and power measurements are only available if **V-3ph measuring point** connected to the **Capacitor bank** function group.

The energy measurements are not predefined. If required, they must be loaded from the Global DIGSI 5 Library.

Inversion of Power-Related Measured and Statistical Values (FB General)

The following values calculated in operational measured values are defined positively in the direction of the protected object.

- Power
- Power factor
- Energy
- Minimum, maximum values of the power
- Average values of the power

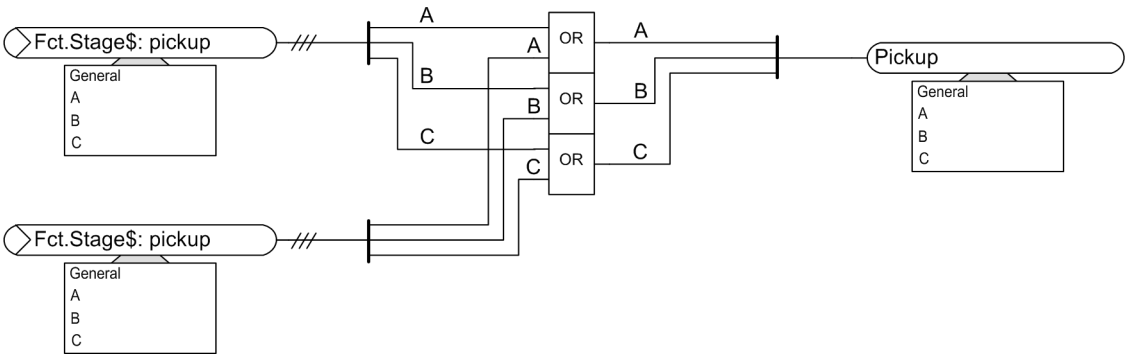
With the **P, Q sign** setting, you can invert the sign of these operational measured values such that a power flow from the line to the busbar is displayed positively.

More information can be found in Chapter *10.1 Overview of Functions*.

Output Logic

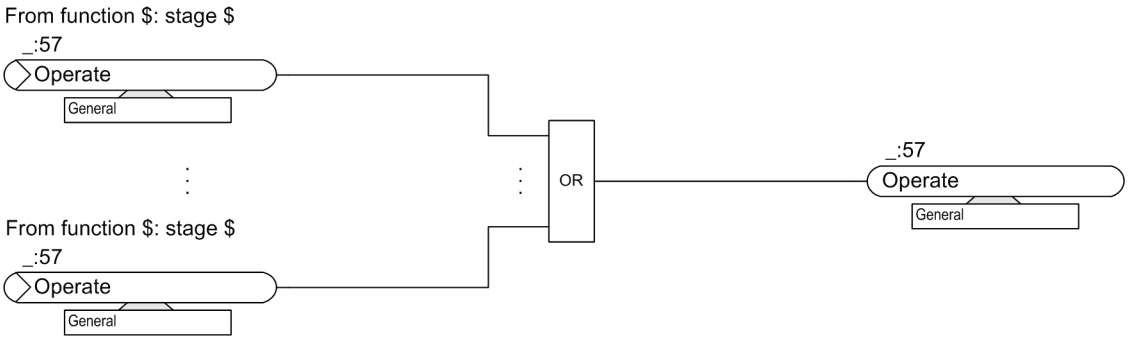
The output logic treats the pickup and operate indications of the protection functions and supervision functions in the **Capacitor bank** function group separately, in a pickup logic and an output logic respectively. The pickup and output logics generate the group indications of the function group. These group indications are transferred to the **Circuit-breaker** function group via the **protection-information** interface and are processed further there.

The pickup and operate indications of the protection functions and the supervision functions in the **Capacitor bank** function group are combined according to the following figures of group indications.



[logepiin-230812-02.tif, 1, en_US]

Figure 5-20 Generation of the Pickup Indication of the Capacitor Bank Function Group



[logeopin-230812-02.tif, 1, en_US]

Figure 5-21 Generation of the Operate Indication of the Capacitor Bank Function Group

5.4.3 Application and Setting Notes

Interface to Circuit-Breaker Function Group

The **Capacitor bank** protection function group is linked to one **Circuit-breaker** function group. This **Circuit-breaker** function group is assigned to the circuit breaker of the capacitor bank.

Protected Object/Equipment Data (FB General)

The following application and setting notes apply for the general data. The data are configured in the function block **General** of the **Capacitor bank** function group and apply for all functions in the function group.

Parameter: `Capacitor reference curr.`

- Default setting **`(_:14641:101) Capacitor reference curr. = 1000 A`**

With the **`Capacitor reference curr.`** parameter, you set the reference current for the capacitor bank to be protected. This **`Capacitor reference curr.`** specified here is the reference value for the percentage-measured values and setting values made in percentages.

Depending on the user philosophy, the reference value could be the capacitor-bank rated current, which includes harmonics, or the capacitor-bank fundamental current.

Parameter: `Capacitor reference volt.`

- Default setting **`(_:14641:102) Capacitor reference volt. = 400.00 kV`**

With the parameter **`Capacitor reference volt.`**, you set the reference voltage of the capacitor bank to be protected. This **`Capacitor reference volt.`** specified here is the reference value for the percentage-measured values and setting values made in percentages.

Depending on the user philosophy, the reference value could be the system rated voltage (bus voltage), or the capacitor rated voltage

Parameter: `Capacitor element type`

- Default setting **`(_:14641:106) Capacitor element type`** = ***`fused`***

With the parameter **`Capacitor element type`**, you set if the capacitor elements contain internal fuses or not. This information is required in the current-unbalance protection for the fault position annunciation.

Parameter: `Blk.cls.cmd.dur.discharge`

- Default setting **`(_:14641:107) Blk.cls.cmd.dur.discharge`** = ***`off`***

With the parameter **`Blk.cls.cmd.dur.discharge`**, you set whether closing of the circuit breaker is blocked automatically or not when a capacitor bank discharges.



NOTE

If the parameter **`Blk.cls.cmd.dur.discharge`** is set to ***`on`***, the device generates a trip/open command during the discharge time.

Parameter: `Discharge time`

- Default setting **`(_:14641:108) Discharge time`** = ***`300 s`***

With the parameter **`Discharge time`**, you define capacitor-bank discharging duration. You get the value from the capacitor manufacturer.

Parameter: `Cap.-bank neutral point`

- Default setting **`(_:14641:109) Cap.-bank neutral point`** =***`isolated`***

With the parameter **`Cap.-bank neutral point`**, you can specify whether the neutral point of capacitor bank is ***`isolated`*** or ***`grounded`***. This information is required when applying the function **87V voltage differential protection**.

Parameter: `P, Q sign`

- Default setting **`(_:14611:158) P, Q sign`** =***`not reversed`***

The power and energy values are defined by the manufacturer such that power in the direction of the protected object is considered positive. You can also define the power output by the protected object as positive. With the **`P, Q sign`** parameter, you can invert the sign for these components. This inversion does not influence any protection function.

5.4.4 Write-Protected Settings

The settings listed here are primarily to aid understanding when configuring the function groups. They are calculated as a function of other settings and cannot be changed directly.

Addr.	Parameter	C	Setting Options	Default Setting
`Rated values`				
_:14641:103	General:Rated apparent power		-1.00 MVA to -1.00 MVA	0.00 MVA



NOTE

You can find more detailed information on the Process monitor in Chapter *5.7.1 Overview* .

5.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:14641:101	General:Capacitor reference curr.		1 A to 100000 A	1000 A
_:14641:102	General:Capacitor reference volt.		0.20 kV to 1200.00 kV	400.00 kV
Cap.bank data				
_:14641:106	General:Capacitor element type		• fused • unfused	fused
_:14641:107	General:Blk.cls.cmd.dur. discharge		• off • on	off
_:14641:108	General:Discharge time		1 s to 1200 s	300 s
_:14641:109	General:Cap.-bank neutral point		• grounded • isolated	isolated
Measurements				
_:14611:158	Further settings:P, Q sign		• not reversed • reversed	not reversed

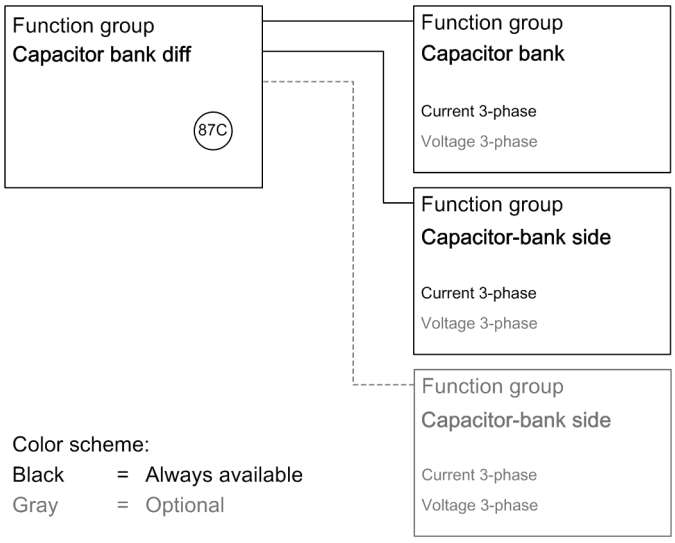
5.4.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
General			
_:14641:500	General:>Compensate	SPS	I
_:14641:501	General:>Reset comp. val.	SPS	I
_:14641:300	General:Blocked by discharge	SPS	O
_:14641:302	General:Discharge	SPS	O
_:14641:301	General:Cap.bank device status	SPC	C

5.5 Function-Group Type Capacitor Bank Differential Protection

5.5.1 Function-Group Types

In the following graphic, you can see the structural association of the function-group types to the **Capacitor bank differential protection**.



[dwfgueca-120214-01, 2, en_US]

Figure 5-22 Function-Group Types Capacitor Bank Diff

The following function-group types are summarized in the Global DIGSI 5 library: Motor diff

- **Capacitor bank diff**
- **Capacitor bank side**

You can find the description of the function group**Capacitor bank** in chapter *5.4.1 Overview*.

The individual function-group types are stored in the **Capacitor bank diff function group** folder and can be selected. In the protection function folders, you find all protection functions which are operational in each function group. A **Capacitor bank diff** function group always includes the **Capacitor bank** and **Capacitor bank side** function groups. In total, you can assign a maximum of 3 function groups **Capacitor bank** or **Capacitor bank side** to the **Capacitor bank diff** function group.

The following table shows you the number of function-group types that can be instantiated for device 7SJ85.

Table 5-6 Function-Group Types in the Device

Device	Function-Group Type		
	Capacitor Bank Diff	Capacitor Bank	Capacitor Bank Side
7SJ85	Max. 2	Max. 9	Max. 9

Interconnection of the function groups is necessary so that the capacitor bank differential protection functions properly. The **Circuit-breaker** function group is not listed.

Table 5-7 Assignment of Protection Function Groups to Protection Function Groups

	Capacitor Bank Diff 1
	Side (2 to 3)
Capacitor bank	X
Capacitor bank side 1	X

	Capacitor Bank Diff 1
	Side (2 to 3)
Capacitor bank side 2	X

The individual function-group types are described in the following.

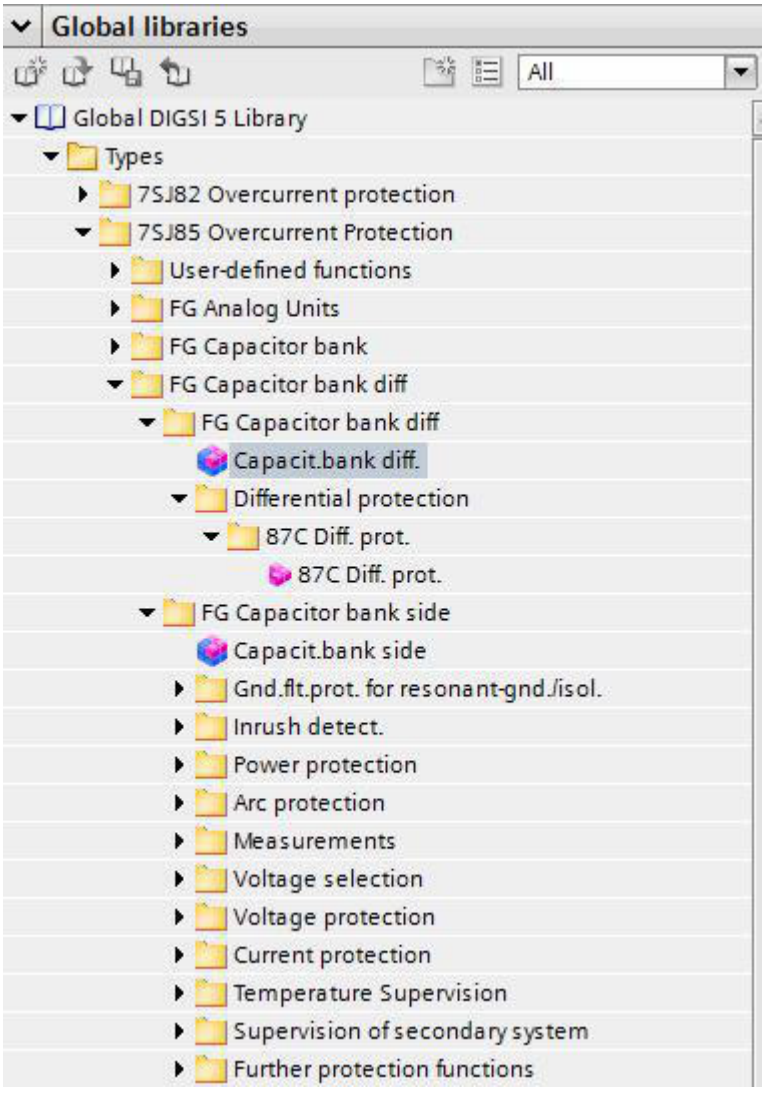
5.5.2 Function-Group Type Capacitor Bank Diff

5.5.2.1 Overview

The **Capacitor bank diff.** function group contains the differential protection function and protection-function-relevant measured values.

You can find more information in the chapter *10 Measured Values, Energy Values, and Supervision of the Primary System* .

You will find the corresponding function groups and the folders with the usable protection functions in the Global DIGSI library under each device type. In the **Capacitor bank diff.** function group, you can load only the differential protection functions.



[scfgcadf-300414-01, 2, en_US]

Figure 5-23 Function Group Capacitor Bank Diff. - Functional Scope

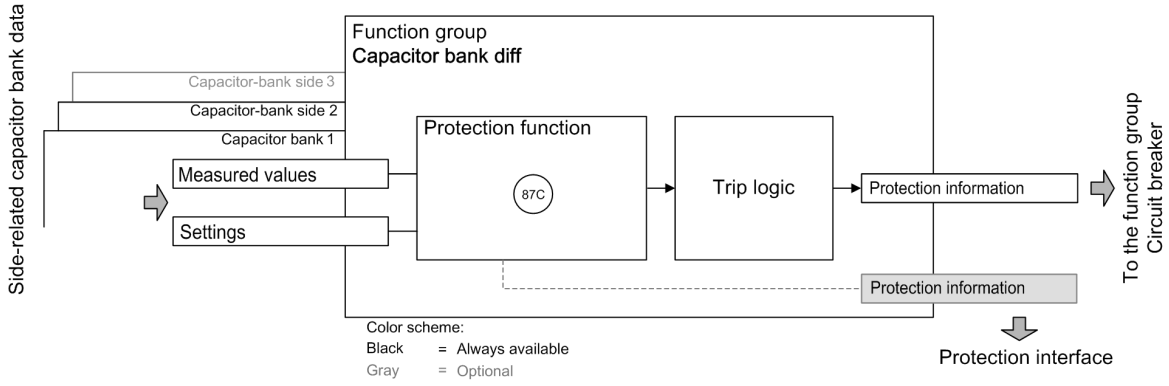
For more information about the embedding of the functions in the device, refer to chapter *2 Basic Structure of the Function* . For application templates of the various device types, refer to chapter *4 Applications* .

5.5.2.2 Structure of the Function Group

The **Capacitor bank diff.** function group, according to *5.5.2.1 Overview* , has interfaces with the **Capacitor bank**, the **Capacitor bank side**, and the **Circuit-breaker** function groups. The **Capacitor bank diff.** function group contains the function blocks:

- Protection function (execution of the differential protection function)
- Trip logic (generation of forwarding of the operate indication)

In the **Capacitor bank diff.** function group, the differential protection function must always be available so that the protection functionality can be ensured. If you do not use an application template, load the differential protection function from the Global DIGSI library.



[dwfgcadf-030314-01, 3, en_US]

Figure 5-24 Structure of the Capacitor Bank Diff. Function Group

The **Capacitor bank diff.** function group has interfaces to the following components:

- Function group **Capacitor bank**
- Function group **Capacitor bank side**
- **Circuit-breaker** function group

Interfaces with the Circuit-Breaker Function Group

The interface with the **Circuit-breaker** function group is used to exchange all required data between the protection function group and the **Circuit-breaker** function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the Protection function groups

You can connect the **Capacitor bank diff.** function group to one or more **Circuit-breaker** function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the **Capacitor bank diff.** function group
- Start of the **Circuit-breaker failure protection** function, if available in the **Circuit-breaker** function group, through the protection functions of the connected **Capacitor bank diff.** function group

Besides the general assignment of the **Capacitor bank diff.** function group to the **Circuit-breaker** function group, you can also configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 via the **Circuit-breaker interaction** Editor in the **Capacitor bank side diff.** function group.

For the detail configuration of the interface, define the following:

- Which operate indications of the protection functions are included when the trip command is generated
- Which protection functions activate the **Circuit-breaker failure protection** function

If an application template is used, the function groups are connected to each other because this link is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter *2.1 Function Embedding in the Device* .

Resetting the LED Group

Using the **Reset the LED group** function, you can reset the stored LEDs of the functions in one specific function group while the activated, stored LEDs of other functions in other function groups remain activated.

Interface with Protection Communication (optional)

All required data is exchanged between the protection function group and the protection communication via the interface with **Protection communication**. These are for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter *3.5 Protection Communication* .

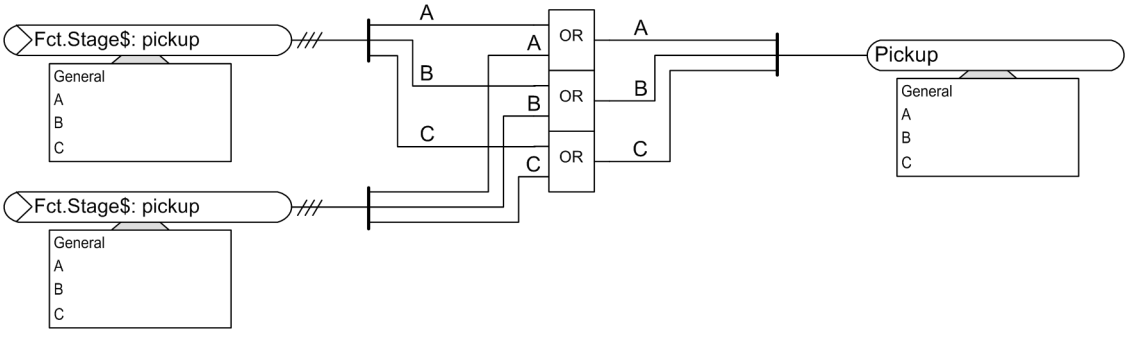
Capacitor-Bank Data (General)

The capacitor-bank data characterizes the data of the capacitor bank to be protected. The data relevant for the differential protection is shown. The **Capacitor bank diff.** function group takes the data from the coupled function groups **Capacitor bank** and **Capacitor bank side**.

Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overarching indications (group indications) of the function group. These group indications are transferred via the **Protection-information** interface to the **Circuit-breaker** function group and are processed further there.

The pickup and operate indications of the protection and supervision functions in the **Capacitor bank diff.** function group are combined into one group indication using the following numbers and outputs.



[loanrlin-150211-01.tif, 3, en_US]

Figure 5-25 Generation of Pickup Indication of the Capacitor Bank Diff. Function Group

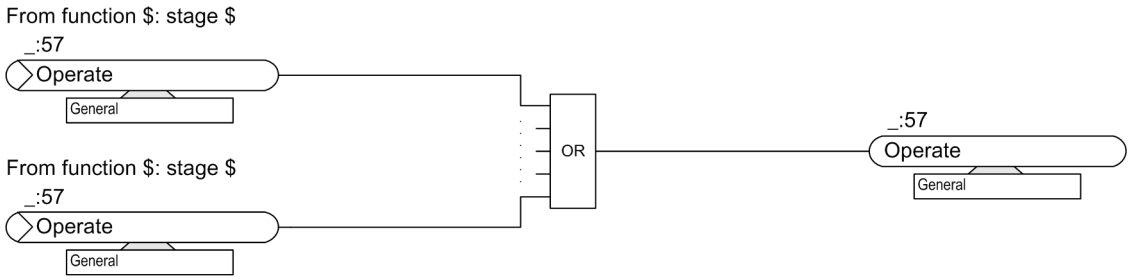


Figure 5-26 Generation of Operate Indication of the Capacitor Bank Diff. Function Group

5.5.2.3 Information List

No.	Information	Data Class (Type)	Type
General			
_:91:52	General:Behavior	ENS	O
_:91:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O

5.5.3 Function-Group Type Capacitor Bank Side

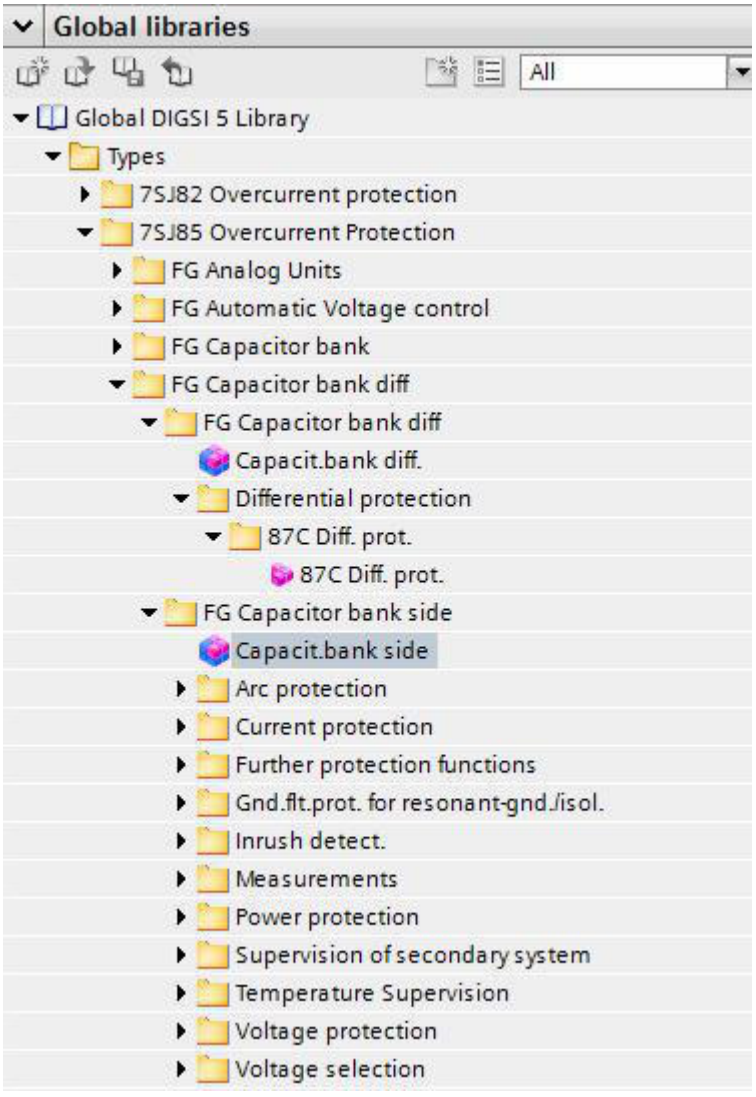
5.5.3.1 Overview

In the **Capacitor bank side** function group, all of the functions that are necessary for protecting and supervising a capacitor bank side can be used. The **Capacitor bank side** function group also contains the measuring functions.

You can find more information in chapter *10 Measured Values, Energy Values, and Supervision of the Primary System*.

The **Capacitor bank side** function group must always have interfacing to the **Capacitor bank diff.** function group.

You will find the corresponding function groups and the folders with the usable protection functions in the Global DIGSI library under each device type. Depending on the connected measuring points, you can load the respective protection and supervision functions in the **Capacitor bank side** function group. The functions are described in chapter *6 Protection and Automation Functions* .



[scfgcasd-300414-01, 2, en_US]

Figure 5-27 Capacitor Bank Side Function Group - Functional Scope

For more information about the embedding of the functions in the device, refer to chapter *2 Basic Structure of the Function* . For application templates for the various device types, refer to chapter *4 Applications* .

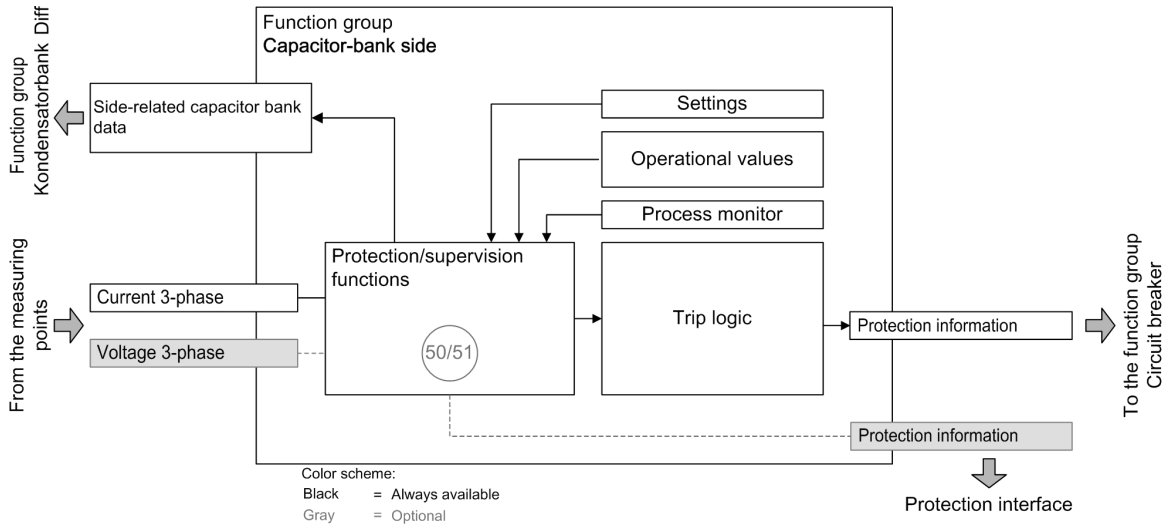
5.5.3.2 Structure of the Function Group

The **Capacitor bank side** function group always contains the following function blocks:

- Side-dependent capacitor-bank data
- Operational measured values
- Process monitor
- Output logic of the function group

These blocks are required for the **Capacitor bank side** function group and therefore cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the **Capacitor bank side** function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.



[dw_fgcabsi-201114-01, 2, en_US]

Figure 5-28 Structure of the Capacitor Bank Side Function Group

The **Capacitor bank side** function group has interfaces to the following components:

- **Measuring points**
- **Capacitor bank diff.** function group
- **Circuit-breaker** function group

Interfaces with Measuring Points

The **Capacitor bank side** function group receives the required measured values via its interfaces with the measuring points. If you are using an application template, the **Capacitor bank side** function group is connected to the necessary measuring points.

If you add functions to the **Capacitor bank side** function group, they will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the **Function group connections** Editor.

You can find more detailed information in chapter *2 Basic Structure of the Function* .

The **Capacitor bank side** function group has the following interfaces with the measuring points:

- **3-phase current**

  The measurands from the 3-phase power system are supplied via this interface. Depending on the transformer connection type, these are for example: I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The **Capacitor bank side** function group must always be linked to the **I-3ph measuring point**.

  You can connect the **3-phase current** interface with a maximum of **two** 3-phase current measuring points. If 2 current measuring points have been connected to the **3-phase current** interface, the total current is also determined from measured values from both measuring points in the **Capacitor bank side** function group. All functions in the **Capacitor bank side** function group have access to these values.

- **3-phase voltage** (optional):

  The measurands from the 3-phase voltage system are supplied via this interface. Different transformer connection types are possible. All values that can be calculated from the measurands are also provided via this interface.

  The connection of the **3-phase voltage** is optional. This connection is necessary only if protection or supervision functions that require voltage measurements are used.

Interfaces to the Circuit-Breaker Function Group

The interface with the **Circuit-breaker** function group is used to exchange all required data between the protection function group and the **Circuit-breaker** function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the Protection function groups

You can connect the **Capacitor bank side** function group to one or more **Circuit-breaker** function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the **Capacitor bank side** function group
- Start of the **Circuit-breaker failure protection** function, if available in the **Circuit-breaker** function group, through the protection functions of the connected **Capacitor bank side** function group

Besides the general assignment of the **Capacitor bank side** function group to the **Circuit-breaker** function group, you can also configure the interface for certain functionalities in detail. Configure the details in DIGSI 5 using the **Circuit-breaker interaction** Editor in the **Capacitor bank side** function group.

For the detail configuration of the interface, define the following:

- Which operate indications of the protection functions are included when the trip command is generated
- Which protection functions activate the **Circuit-breaker failure protection** function

If an application template is used, the function groups are connected to each other because this link is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections** Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter *2.1 Function Embedding in the Device* .

Interface with Protection Communication (optional)

All required data is exchanged between the protection function group and the protection communication via the interface with **Protection communication**, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter *3.5 Protection Communication* .

Resetting the LED Group

Using the **Reset the LED group** function, you can reset the stored LEDs of the functions in one specific function group while the activated, stored LEDs of other functions in other function groups remain activated.

Process Monitor

The process monitor is always present in the **Capacitor bank side** function group and cannot be removed. The process monitor provides the following information in the **Capacitor bank side** function group:

- Current-flow criterion:
  Detection of an open/activated capacitor bank side based on the flow of leakage current
- Closure detection:
  Detection of closure of the capacitor bank side
- Cold-load pickup detection (optional):

This information is in the **Capacitor bank side** function group and is available to all the functions in the function group.

Operational Measured Values

The operational measured values are always present in the **Capacitor bank side** function group and cannot be deleted. If a 3-phase voltage measuring point is connected, the following table shows the total scope. If only current is connected, only the first 3 lines apply.

Table 5-8 Possible Operational Measured Values of the Capacitor Bank Side Function Group

Measured Values		Primary	Secon-dary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
3I0	Calculated residual current	A	A	Rated operating current of the primary system
I_N	Measured residual current	A	A	Rated operating current of the primary system
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating current of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary system
V_0	Calculated zero-sequence voltage	kV	V	Rated operating current of the primary system/√3
V_r	Measured neutral-point displace-ment voltage	kV	V	Rated operating current of the primary system/√3
f	Frequency	Hz	Hz	Rated frequency
P	Active power (total power)	MW	–	Rated operating voltage and rated operating current of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q	Reactive power (total power)	MVAr	–	Rated operating voltage and rated operating current of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S	Apparent power (total power)	MVA	–	Rated operating voltage and rated operating current of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active factor	(abs)	(abs)	100 % corresponds to c os φ = 1
P_A, P_B, P_C	Phase-related active power	MW	–	Active power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$
Q_A, Q_B, Q_C	Phase-related reactive power	MVAr	–	Reactive power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$
S_A, S_B, S_C	Phase-related apparent power	MVA	–	Apparent power of the phase $V_{rated\ phsx} \cdot I_{rated\ phsx}$

If a **V-3ph measuring point** was connected to the **Capacitor bank side** function group, voltage and phase measurements are available.

The energy measurements are not predefined. If necessary, you must load them from the Global DIGSI 5 library.

Depending on the protection and supervision functions used, additional function measurements may be available. The function values are listed in the **information list** of the appropriate protection or supervision function (see chapter *6 Protection and Automation Functions*).

NOTE

With the **`P, Q sign`** parameter in the function block **General**, the sign of the following measured values of the respective function group can be inverted (see chapter *10.2 Structure of the Function* Structure of the Function, section Inversion of Power-Related Measured and Statistical Values):

- Active power (total): P total
- Active power (phase-related): P_A, P_B, P_C
- Reactive power (total): Q total
- Reactive power (phase-related): Q_A, Q_B, Q_C

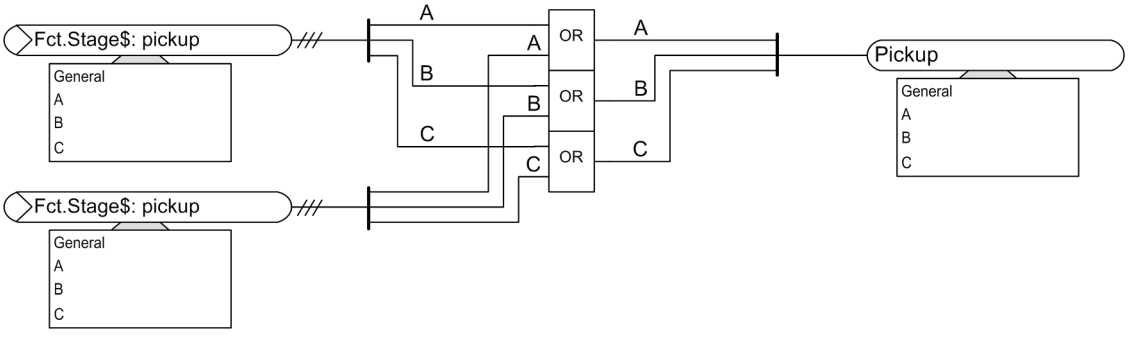
Capacitor-Bank Data (Side-Dependent)

The capacitor-bank data characterizes the data of the capacitor bank to be protected. The side-dependent capacitor-bank data applies to all of the functions in the **Capacitor bank side** function group.

Output Logic

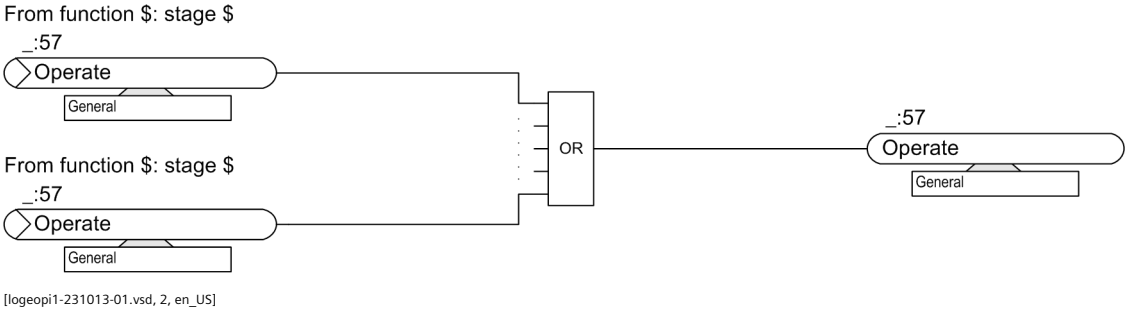
The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overarching indications (group indications) of the function group. These group indications are transferred via the **Protection information** interface to the **Circuit-breaker** function group and are processed further there.

The pickup and operate indications of the protection and supervision functions in the **Capacitor bank side** function group are combined into one group indication using the following numbers and outputs.



[loanrlin-150211-01.tif, 3, en_US]

Figure 5-29 Generation of Pickup Indication of the Capacitor Bank Side Function Group



[logeopi1-231013-01.vsd, 2, en_US]

Figure 5-30 Generation of Operate Indication of the Capacitor Bank Side Function Group

5.5.3.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

The **Capacitor bank side** function group is usually connected to 1 **Circuit-breaker** function group. The **Circuit-breaker** function group is assigned to the circuit breaker of the capacitor bank.

Parameter: `Rated apparent power`

- Default setting **`(_:1781:15571:103) Rated apparent power`** = ***`692.82 MVA`***.

  The **`Rated apparent power`** parameter shows the primary rated apparent power of the capacitor bank to be protected. The setting value is determined of the **`Capacitor reference volt.`** and the **`Capacitor reference curr.`** parameters.

Parameter: `Capacitor reference volt.`

- Default setting **`(_:1781:15571:102) Capacitor reference volt.`** = ***`400.00 kV`***

You can use the **`Capacitor reference volt.`** parameter to set the reference voltage of the capacitor bank to be protected. The reference voltage set here is the reference value for the percentage measured values and setting values made in percent.

Depending on user philosophy you can use the system rated voltage (busbar voltage) or the capacitor rated voltage as a reference value.

Parameter: `Capacitor reference curr.`

- Default setting **`(_:1781:15571:101) Capacitor reference curr.`** = ***`1000 A`***

You can use the **`Capacitor reference curr.`** parameter to set the reference current for the capacitor bank to be protected. The capacitor reference current set here is the reference value for the percentage measured values and setting values in percent.

For Differential protection, these values are used for absolute-value correction (rated current of the protected object).

If the capacitor bank is part of a delta connection, the value to be set here can differ from the capacitor reference current set in the **Capacitor bank** function group (by factor √3). Otherwise, set always the same values.

Depending on user philosophy, you can use the capacitor-bank rated current including the harmonics or the capacitor-bank fundamental-component current as a reference value.

Parameter: `Neutral point`

- Default setting **`(_:1781:15571:149) Neutral point`** = ***`isolated`***

With the **`Neutral point`** parameter, you specify whether the neutral point in the protection range of the differential protection is ***`grounded`*** or ***`isolated`***. If there is no neutral point in the protection zone, use the parameter ***`isolated`***. The neutral point of a capacitor bank is usually not in the protection zone. Therefore, even if the neutral point is grounded, set ***`isolated`*** here.

You can find further information in the Device manual 7UT8 Chapter 6.2.3 function description neutral point-current handling.

Parameter: `Winding configuration`

- Default setting **`(_:1781:15571:104) Winding configuration`** = ***`Y (Wye)`***

You can use the **`Winding configuration`** parameter to set ***`D (Delta)`*** for a delta connection. Another setting option is ***`Y (Wye)`*** for a star connection. The **`Winding configuration`** parameter is relevant for the Differential protection function.

Parameter: `Vector group numeral`

- Default setting **`(_:1781:15571:100) Vector group numeral`** = ***`0`***

This parameter is used to account for phase-angle rotation, which is expressed by a numeral.

Phase-angle rotation	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
Vector group numeral	0	1	2	3	4	5	6	7	8	9	10	11

In the function group, the following information is displayed additionally in the setting sheet:

- Side number
- Identification of the measuring points used
- Adaptation factor for the 3-phase measuring point (with reference to the side)

Each **Vector group numeral** can be set from 0 to 11 to the extent possible. Thus, for example, only even numbers are possible for the vector group Yy and Dd and only odd numbers are possible for Yd and Dy.

Parameter: Side number

- Default setting **(_:1781:14611:130) Side number** = ***not assigned***

The **Side number** parameter shows you which capacitor bank side is currently valid for the following parameters. The side number (***Side 1*** to ***Side 3***) is automatically assigned with the connection to a capacitor bank side.

Parameter: MI3ph1 usesMeasP with ID

- Default setting **(_:1781:14611:210) MI3ph1 usesMeasP with ID** = ***0***

The **MI3ph1 usesMeasP with ID** parameter shows you which 3-phase measuring point is connected to the capacitor bank side. Every measuring point is assigned a unique ID.

Parameter: MI3ph2 usesMeasP with ID

- Default setting **(_:1781:14611:211) MI3ph2 usesMeasP with ID** = ***0***

The **MI3ph2 usesMeasP with ID** parameter shows you which 3-phase measuring point is connected to the capacitor bank side. Every measuring point is assigned a unique ID.

Parameter: CT mismatch M I-3ph 1

- Default setting **(_:1781:14611:215) CT mismatch M I-3ph 1** = ***0.000***

The **CT mismatch M I-3ph 1** parameter shows you the magnitude adaptation of the phase currents of the 1st assigned measuring point. The numerical value results from the ratio of the primary rated current of the current transformer to the rated current of the side.

Parameter: CT mismatch M I-3ph 2

- Default setting **(_:1781:14611:217) CT mismatch M I-3ph 2** = ***0.000***

The **CT mismatch M I-3ph 2** parameter shows you the magnitude adaptation of the phase currents of the 2nd assigned measuring point.

5.5.3.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_:1781:15571:103	Rated apparent power		0.20 MVA to 5000.00 MVA	692.82 MVA

Addr.	Parameter	C	Range of Values	Default Setting
Side data				
_:1781:14611:130	Side number		• not assigned • Side 1 • Side 2 • Side 3	Side 2
_:1781:14611:210	MI3ph1 usesMeasP with ID		0 to 100	8
_:1781:14611:215	CT mismatch M I-3ph 1		0.010 to 100.000	1.000

5.5.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:1781:15571:101	General:Capacitor reference curr.		1 A to 100 000 A	1000A
_:1781:15571:102	General:Capacitor reference volt.		0.20 kV to1200.00 kV	400.00 kV
Side data				
_:1781:15571:149	General:Neutral point		• grounded • isolated	isolated
_:1781:15571:104	General:Winding configuration		• Y (Wye) • D (Delta)	Y (Wye)
_:1781:15571:100	General:Vector group numeral		0 to 11	0
Measurements				
_:1781:14611:158	Further settings:P, Q sign		• not reversed • reversed	not reversed

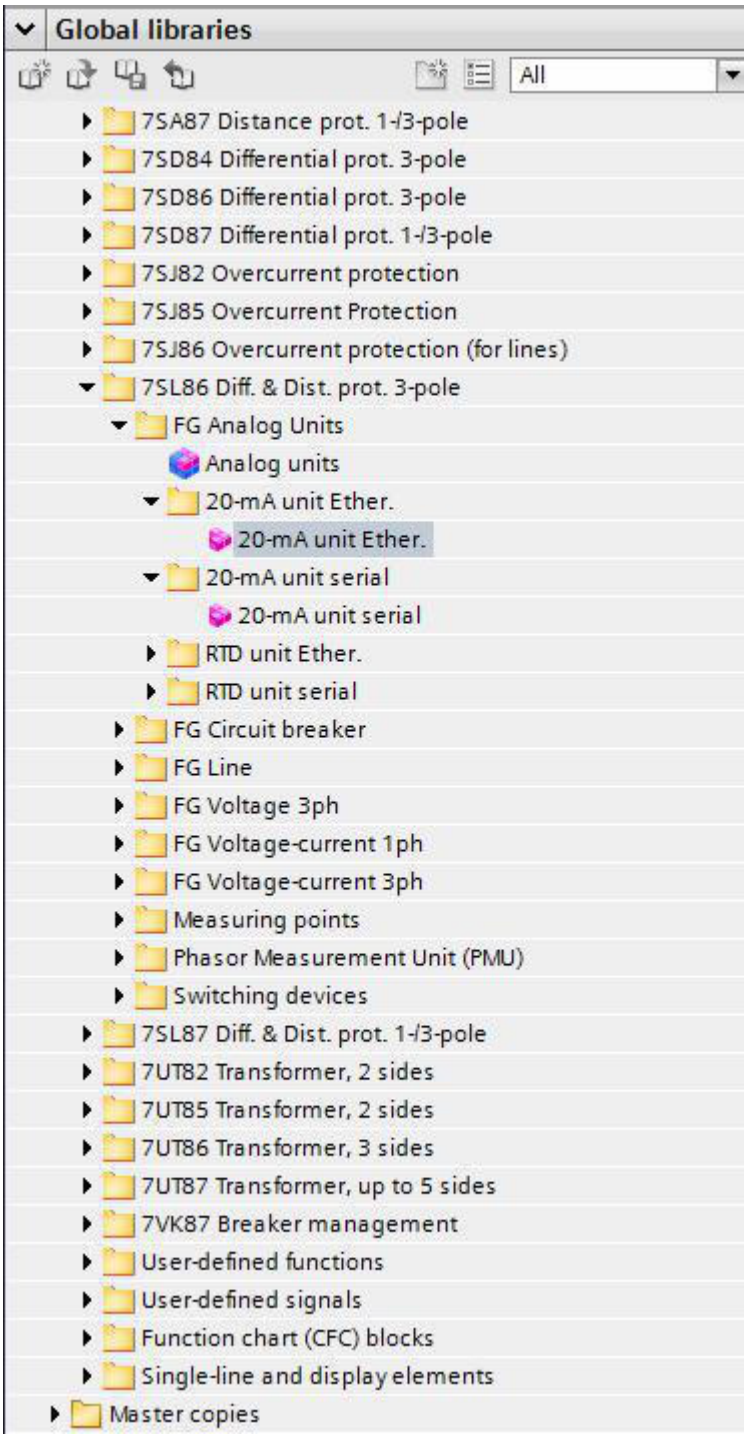
5.5.3.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O

5.6 Function-Group Type Analog Units

5.6.1 Overview

The **Analog units** function group is used to map analog units and communicate with them. Analog units are external devices, such as RTD units, or analog plug-in modules, such as measuring-transducer modules.
You will find the **Analog units** function group for many device types in the Global DIGSI 5 library.



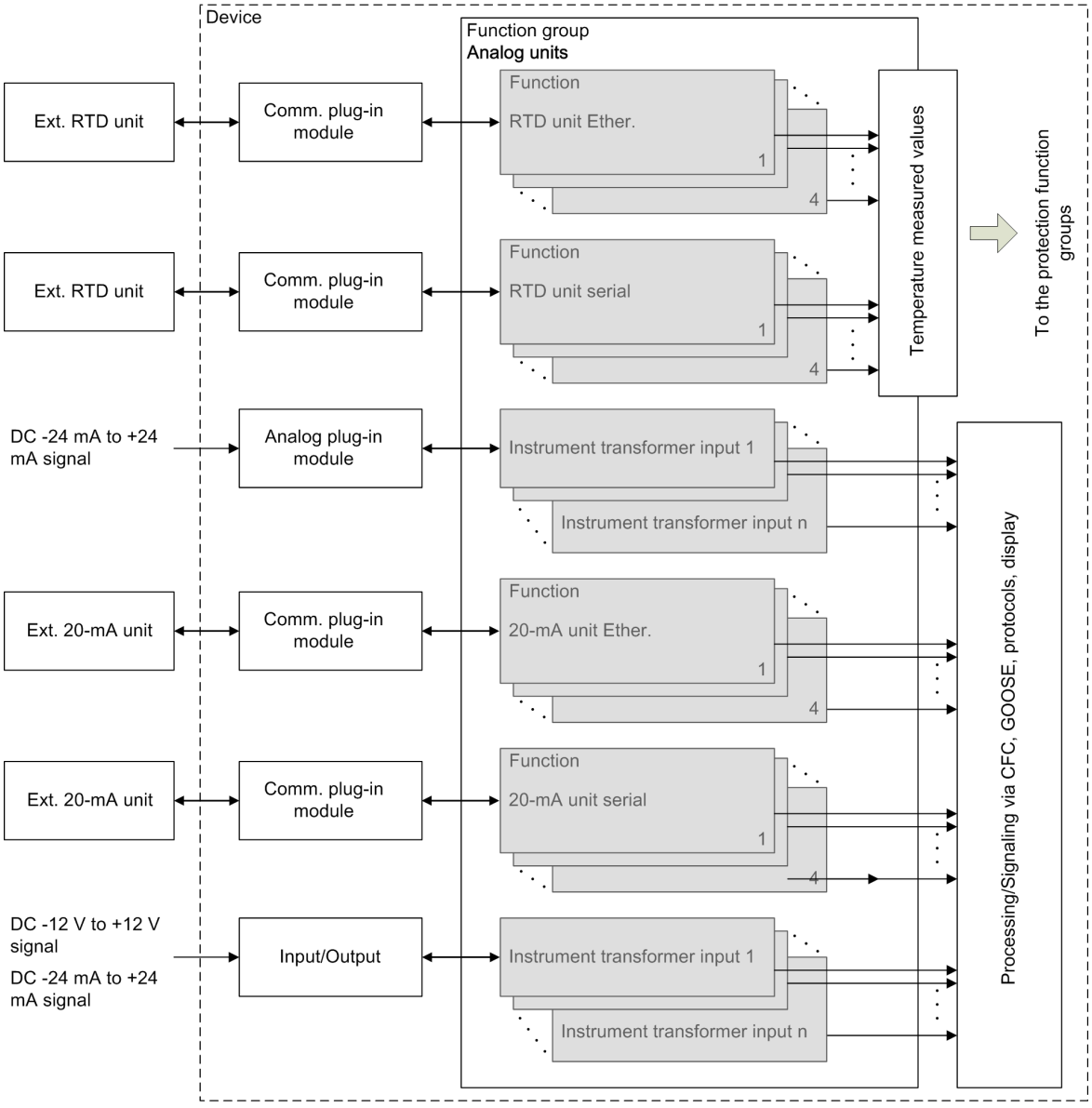
[sc20maee-190214-01, 1, en_US]

Figure 5-31 Analog Unit Function Group in DIGSI

5.6.2 Structure of the Function Group

If the device has a measuring transducer, it is automatically mapped in the **Analog units** function group. If one or more RTD units are connected to the device, you have to load one or more **RTD unit Ether.** or **RTD unit serial** functions from the Global DIGSI library in order to map the RTD units.

The following figure shows the structure of the function group.



[dwstrthe-030615-01.vsd, 1, en_US]

Figure 5-32 Structure of the Analog Unit Function Group

The **Analog units** function group has interfaces to protection function groups. The **Analog units** function group provides measured temperature values that come from an external RTD unit. These measured temperature values are available for all protection function groups in which a temperature monitoring function works.

The **RTD unit Ether.** function is not preconfigured by the manufacturer. A maximum of 20 function instances can work simultaneously.

The **RTD unit serial** function is set up structurally exactly in the same manner as the **RTD unit Ether.** function.

5.6.3 20-mA Unit Ethernet

5.6.3.1 Overview

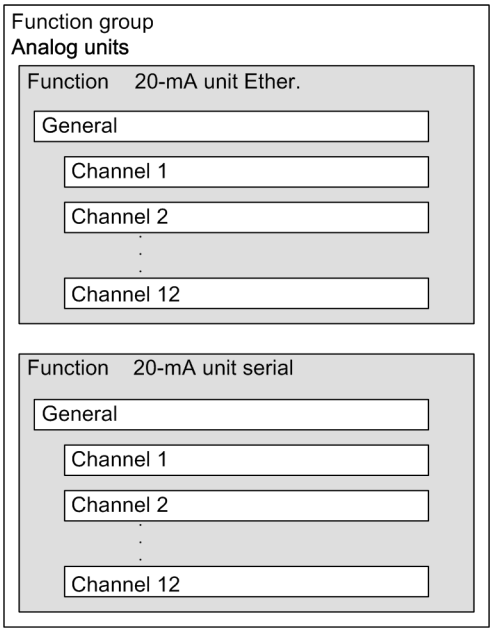
The function **20-mA unit Ether.**:

- Communicates in series with a 20-mA unit via the Slave Unit Protocol (SUP) and records the values measured by the 20-mA unit
- Transforms the measured 20-mA values into slowly changing process tags such as temperature or gas pressure
- Makes the recorded process tags available to CFC, GOOSE, protocols and the device display
- Monitors communication with the 20-mA unit

5.6.3.2 Structure of the Function

The function **20-mA unit Ether.** can work only in the function group **Analog units**. A maximum of 4 function instances can work simultaneously. Each instance contains 12 preconfigured channel function blocks.

The function **20-mA unit Ether.** contains input and output channels which can be configured independently of one another.

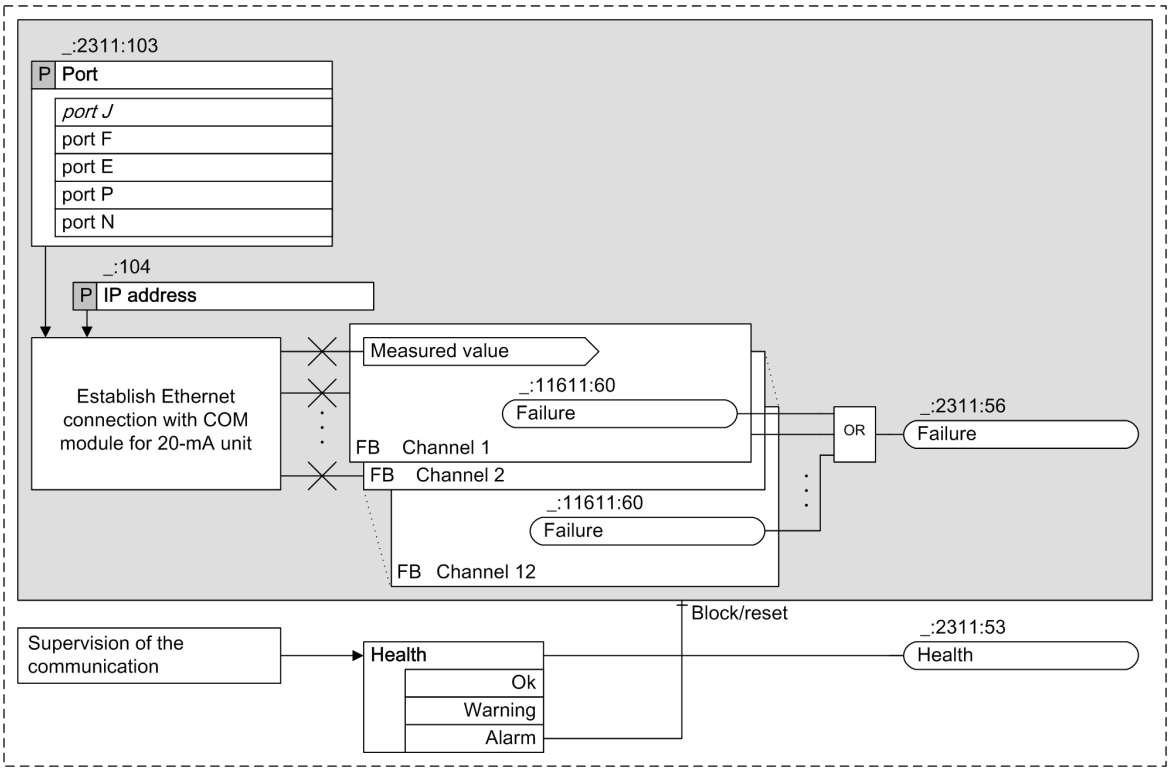


[dwstrfn2-150113-01.tif, 2, en_US]

Figure 5-33 Structure/Embedding of the Function

5.6.3.3 Communication with 20-mA Unit Ethernet

Logic



[lo20mtcp-150113-01.tif, 1, en_US]

Figure 5-34 Logic of the Function 20-mA Unit Ethernet

Communication with 20-mA Unit

The function is used to communicate with a 20-mA unit connected via an Ethernet connection. When a connection of the function to an external 20-mA unit via an Ethernet interface has successfully been established, the 20-mA unit sends the measured values of all connected channels to the function **20-mA unit. Ether.**. For the connection to be established successfully, specific communication settings must be specified.

You can find more detailed information in Chapter *5.6.3.4 Application and Setting Notes* .

The 20-mA measurement unit **7XV5674** is supported.

Error Responses

The following table lists the conditions under which the *Health* status transitions to the Alarm or Warning state.

Table 5-9 Error Responses

Error Description	Status Health
The function **20-mA unit Ether.** cannot establish a connection with a communication module.	Alarm
The function **20-mA unit Ether.** sends TCP settings to the communication module, which evidently would like to connect to the 20-mA unit via a serial protocol. This communication module does not establish a connection to the 20-mA unit.	Alarm
The connection between the communication module and the 20-mA unit causes a time-out indication.	Warning

Error Description	Status Health
A communication module has not received any more data from the 20-mA unit for 9 sec.	Warning

The *Failure* signal is set as soon as one of the channel function blocks reports a failure.

5.6.3.4 Application and Setting Notes

Parameter: Port

- Default setting **(_:2311:103) Port** = ***port J***

Use the **Port** setting to define the port connecting the 20-mA unit to the SIPROTEC 5 device.

Parameter: IP address

- Default setting **(_:2311:104) IP address** = ***10.16.60.1***

With the **IP address** settings, you set the IP address of the 20-mA unit connected to the communication module via the TCP protocol. You must assign each 20-mA unit an unambiguous IP address. The IP address to be set depends on your network configuration. You can set any valid IPv4 address that does not cause conflicts with other IP addresses in the network. First set an IP address for the **7XV5674 20-mA unit**. Then specify the **IP address** settings for the communication module to the same address.

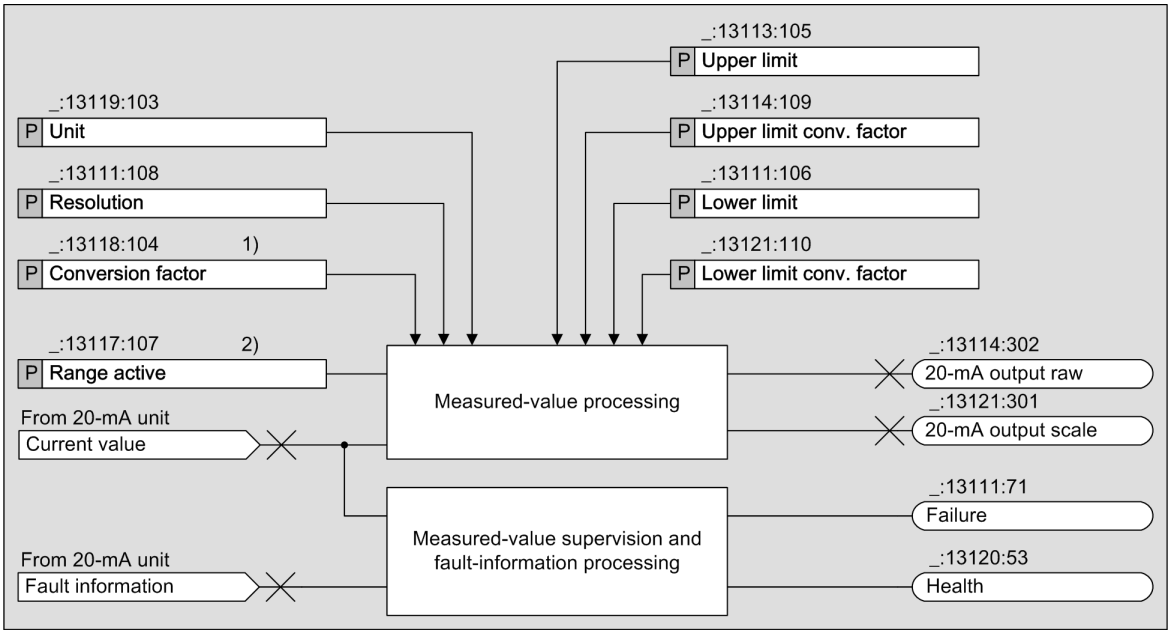
Settings on the 20-mA Unit

The **7XV5674 20-mA unit**is set with a web browser on the laptop computer via the latter's Ethernet interface. Set ***Modbus TCP*** as bus protocol/operating mode.

You can find detailed notes on the settings in the 7XV5674 manual that accompanies the 20-mA unit. The documents are also available in the SIPROTEC download area *http://www.energy.siemens.com*.

5.6.3.5 20-mA Channel

Logic



[lo20mcha-160113-01.tif, 1, en_US]

Figure 5-35 Logic Diagram of the Function 20-mA Channel

(1) If the setting **Range active** is set to ***test***, the setting **Transformation ratio** is not displayed.

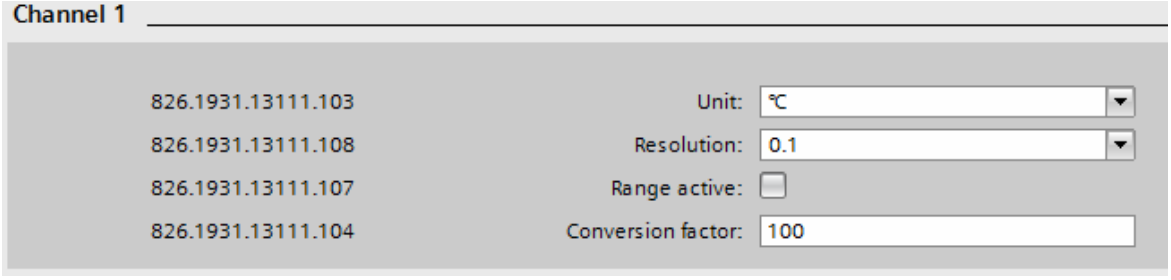
(2) If the setting **Range active** is set to ***false***, the settings **Upper limit**, **Transformation ratio upper limit**, **Lower limit** and **Transformation ratio** are not displayed.

Measured-Value Calculation

The function **20-mA channel** processes a single 20-mA current signal supplied by the 20-mA unit of the corresponding channel. The 20-mA current measured value is converted into the correct physical quantities such as temperature or pressure. In each 20-mA functional unit (Ether. and serial) there are always 12 of the 20-mA channel function blocks, even if fewer channels are connected with the 20-mA unit. The calculated values are available for further processing via CFC, GOOSE, protocols, and the display image.

Measured-Value Processing

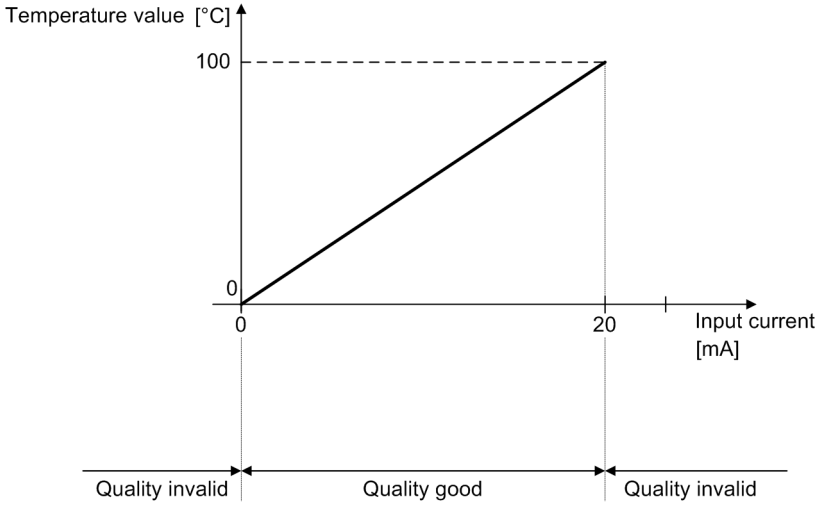
The 20-mA unit typically transmits a value which represents a physical quantity, such as a temperature or a pressure. Therefore, the device must contain a characteristic curve that maps the physical quantity to the 20-mA value. If you do not activate the **Range active** setting (no x in the check box), the function operates over the range 0 mA to 20 mA. If a value smaller than 0 mA or greater than 20 mA is active at the input of the 20-mA unit, the measured value is identified as invalid. The setting of the range for the scaled value goes from a usable range of 0 mA to 20 mA. The following figure shows an example.



[sckanumw-190214-01, 1, en_US]

Figure 5-36 Settings for Example 1

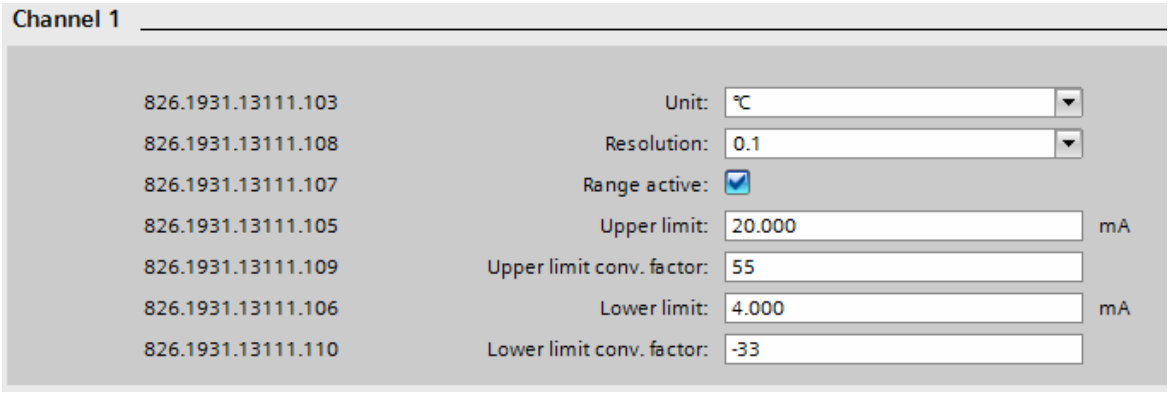
In this example, the measured value 0 mA means a temperature of 0 °C and the measured value 20 mA means a temperature of 100 °C. So enter as **Unit** = ***°C*** and **Conversion factor** = ***100***. The resolution (decimal place) of the temperature value can be chosen; for a decimal place, select **Resolution** = ***0.1***.



[dwknges3-020513-01.tif, 1, en_US]

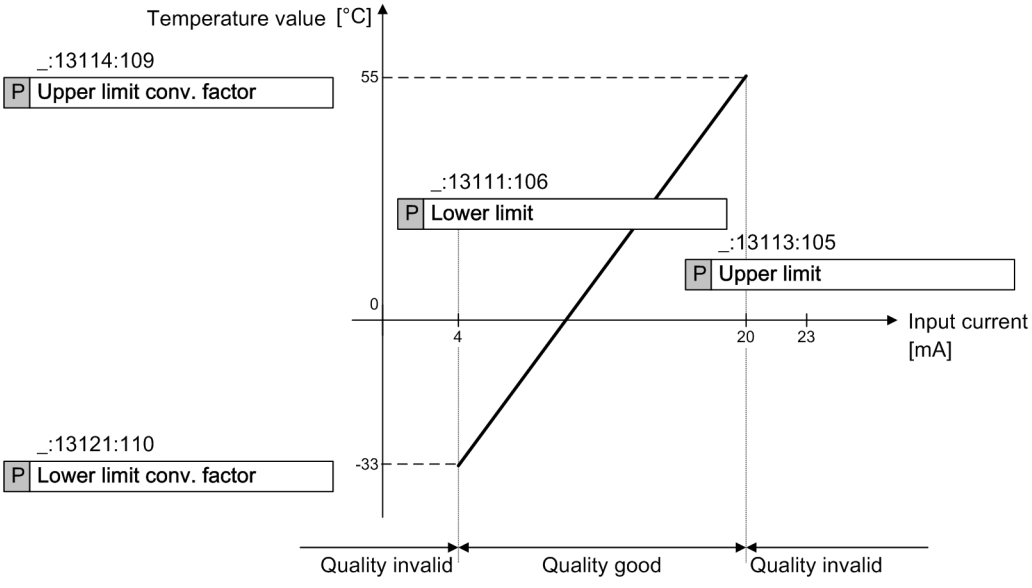
Figure 5-37 Characteristic Curve of a 20-mA Input (Example 1)

If you activate the **Range active** setting, then 4 additional parameters **Upper limit**, **Lower limit**, **Upper limit - Sensor**, and **Lower limit - Sensor** appear. The parameters **Upper limit** and **Lower limit** indicate the range of the input current in mA. The setting **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The setting **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting. The setting of the range for the scaled value corresponds to the useable range between **Lower limit** and **Upper limit** (see following figure).



[sckanumf-190214-01, 1, en_US]

Figure 5-38 Settings for Example 2



[dwknges2-020513-01.tif, 1, en_US]

Figure 5-39 Characteristic Curve of a 20-mA Unit (Example 2)

In this example, the **Range active** setting is selected. The setting **Upper limit** is at 20 mA, the setting **Lower limit** is at 4 mA. The setting **Upper limit - Sensor** is at 55 and the setting **Lower limit - Sensor** is at -33. If the input current is smaller than 4 mA or greater than 20 mA, the quality of the scaled measured value in this example is invalid.

Each 20-mA channel makes available the scaled measured value in the information routing (these are the temperature values in the examples) and the original current measured value in mA for further processing.

The 20-mA values can be displayed in the display page and processed with CFC charts.

Error Responses

If the current input value is determined to be incorrect, the quality attribute of the output value is set to *invalid* That status for *Health* and the defect status assume the states displayed in the table.

Table 5-10 Error Responses

Error Description	Status *Health*	Error Status
The input value lies outside the given limits	OK	Yes
Channel not connected	OK	No

5.6.3.6 Application and Setting Notes

Parameter: Unit

- Default setting **(_:13111:103) Unit** = ***°C***

You use the setting **Unit** to specify which physical unit of measurement the measured values represent. The possible setting values are listed in the settings table.

Parameter: Conversion factor

- Default setting **(_:13111:104) Conversion factor** = ***100***

The **Conversion factor** setting allows you to set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting **(_:13111:108) Resolution** = ***0.1***

The **Resolution** setting is used to specify the measured value resolution.

Parameter: Range active

- Default setting **(_:13111:107) Range active** = ***false***

If you do not activate the **Range active** setting (no x in the check box), the function operates over the range -24 mA to +24 mA. The setting of the range for the scaled value goes from a usable range of -20 mA to +20 mA.

If you activate the **Range active** setting, then 4 additional settings **Upper limit**, **Upper limit - Sensor**, **Lower limit**, and **Lower limit - Sensor** appear.

Parameter: Upper limit, Lower limit, Upper limit - Sensor and Lower limit - Sensor

- Default setting **(_:13111:105) Upper limit** = ***20000 mA***
- Default setting **(_:13111:109) Upper limit - Sensor** = ***100***
- Default setting **(_:13111:106) Lower limit** = ***4000 mA***
- Default setting **(_:13111:110) Lower limit - Sensor** = ***100***

If you activate the **Range active** setting, then 4 additional settings **Upper limit**, **Lower limit**, **Upper limit - Sensor**, and **Lower limit - Sensor** appear. The setting **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The setting **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting.

The following settings and information table shows only 1 of the 12 channels, as the setting possibilities of the 12 channels do not differ.

5.6.3.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port E • port F • port J • port N • port P	port J
Channel 1				
_:13111:103	Channel 1:Unit		• % • ° • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • in • J • J/Wh • K • l/s • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • W/s • Wh	m
_:13111:108	Channel 1:Resolution		• 1 • 0.1 • 0.01 • 0.001	0.1

Addr.	Parameter	C	Setting Options	Default Setting
_:13111:107	Channel 1:Range active		• 0 • 1	false
_:13111:104	Channel 1:Conversion factor		1 to 10000	100
_:13111:105	Channel 1:Upper limit		0.00 mA to 20.00 mA	20.00 mA
_:13111:109	Channel 1:Upper limit - Sensor		-10000 to 10000	100
_:13111:106	Channel 1:Lower limit		0.00 mA to 20.00 mA	4.00 mA
_:13111:110	Channel 1:Lower limit - Sensor		-10000 to 10000	100

5.6.3.8 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Channel 1			
_:13111:53	Channel 1:Health	ENS	O
_:13111:71	Channel 1:Failure	SPS	O
_:13111:301	Channel 1:20-mA output scale	MV	O
_:13111:302	Channel 1:20-mA output raw	MV	O

5.6.4 20-mA Unit Serial

5.6.4.1 Overview

The function **20-mA unit Serial**:

- Provides serial communications with a 20-mA unit via the Modbus protocol and records the values measured by the 20-mA unit
- Transforms the measured 20-mA values into slowly changing process variables such as temperature or gas pressure
- Makes the recorded process tags available to CFC, GOOSE, protocols and the device display
- Monitors communication with the 20-mA unit

The function **20-mA unit Serial** is structured in the same way as the function **20-mA Unit Ether.**. The mode of operation is also identical. The only difference is that the measured values are transferred to the communication module via a serial connection instead of an Ethernet connection.

You can find more information in Chapter *5.6.3.2 Structure of the Function*.

5.6.4.2 Application and Setting Notes

Parameter: Port

- Default setting **(_:2311:103) Port** = ***Port J***

With the **Port** setting, you specify the slot for the communication module that will be used for the connection with an external 20-mA unit.

Parameter: Channel number

- Default setting **(_:2311:105) Channel number** = ***1***

A serial communication module optionally uses 2 channels. With the **Channel number** setting, you specify the channel number (1 or 2) used to connect the 20-mA unit to the device. The communication module inputs are labeled with the channel numbers.

Parameter: Slave address

- Default setting **(_:2311:106) Slave address** = *1*

Use the**Slave address** setting to define the device address of the 20-mA unit. If only one 20-mA unit is connected to the serial bus, the default value *1* can be used. Set the same device address as used with the 20-mA unit. The device address is important for distinguishing several 20-mA units that are connected to a serial bus. Set an unambiguous device address on every 20-mA unit, for example, 1, 2 and 3 when connecting 3 of the 20-mA units. On every 20-mA unit, set for the **Slave address** setting in the 3 functions **20-mA Unit Serial** the same device address for each.

Parameter: Unit

- Default setting **(_:13111:103) Unit** = *°C*

You use the setting **Unit** to specify which physical unit of measurement the measured values represent. The possible setting values are listed in the settings table.

Parameter: Conversion factor

- Default setting **(_:13111:104) Conversion factor** = *100*

The **Conversion factor** setting allows you to set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting **(_:13111:108) Resolution** = *0.1*

The **Resolution** setting is used to specify the measured value resolution.

Parameter: Range active

- Default setting **(_:13111:107) Range active** = *false*

If you do not activate the **Range active** setting (no x in the check box), the function operates over the range 0 mA to 20 mA. The setting of the range for the scaled value goes from a usable range of 0 mA to 20 mA.

If you activate the **Range active** setting, then 4 additional settings **Upper limit**, **Upper limit - Sensor**, **Lower limit** and **Lower limit - Sensor** appear.

Parameter: Upper limit, Lower limit, Upper limit - Sensor and Lower limit - Sensor

- Default setting **(_:13111:105) Upper limit** = *20 mA*
- Default setting **(_:13111:109) Upper limit - Sensor** = *100*
- Default setting **(_:13111:106) Lower limit** = *4 mA*
- Default setting **(_:13111:110) Lower limit - Sensor** = *100*

If you activate the **Range active** setting, then 4 additional settings **Upper limit**, **Lower limit**, **Upper limit - Sensor** and **Lower limit - Sensor** appear. The setting **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The setting **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting.

The following settings and information table shows only 1 of the 12 channels, as the setting possibilities of the 12 channels do not differ.

5.6.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port E • port F • port J • port N • port P	port J
_:2311:105	General:Channel number		1 to 2	1
_:2311:106	General:Slave address		1 to 247	1
Channel 1				
_:13111:103	Channel 1:Unit		• % • ° • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • in • J • J/Wh • K • l/s • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • W/s • Wh	m

Addr.	Parameter	C	Setting Options	Default Setting
_:13111:108	Channel 1:Resolution		• 1 • 0.1 • 0.01 • 0.001	0.1
_:13111:107	Channel 1:Range active		• 0 • 1	false
_:13111:104	Channel 1:Conversion factor		1 to 10000	100
_:13111:105	Channel 1:Upper limit		0.00 mA to 20.00 mA	20.00 mA
_:13111:109	Channel 1:Upper limit - Sensor		-10000 to 10000	100
_:13111:106	Channel 1:Lower limit		0.00 mA to 20.00 mA	4.00 mA
_:13111:110	Channel 1:Lower limit - Sensor		-10000 to 10000	100

5.6.4.4 Information List

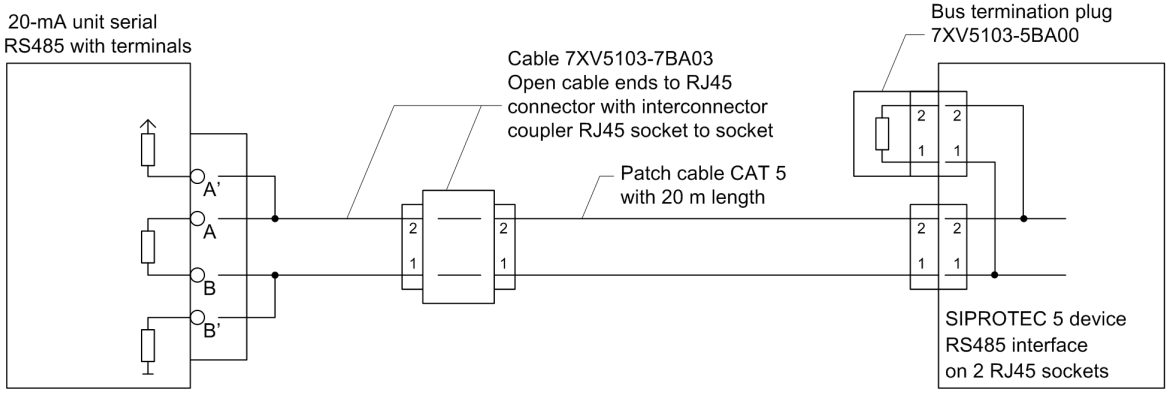
No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Channel 1			
_:13111:53	Channel 1:Health	ENS	O
_:13111:71	Channel 1:Failure	SPS	O
_:13111:301	Channel 1:20-mA output scale	MV	O
_:13111:302	Channel 1:20-mA output raw	MV	O

5.6.5 Communication with 20-mA Unit

5.6.5.1 Integration of a Serial 20-mA Unit

Connection of the Communication Lines

Figure 5-40 shows how to connect the 20-mA unit to the SIPROTEC 5 device. Note that Pin 1 of the RJ45 plug is connected to RTD-B and Pin 2 is connected to RTD-A.

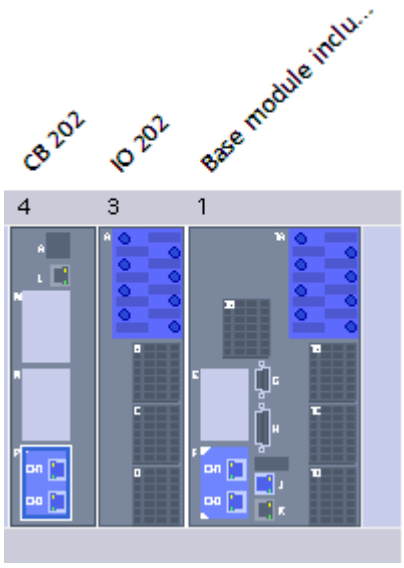


[dwve20au-150213-01.tif, 1, en_US]

Figure 5-40 Connection of the 20-mA Unit to the SIPROTEC 5 Device

Adding a USART Module

Add a USART-AB-1EL or a USART-AC-2EL USART module in DIGSI to the device. The USART module must be inserted at one of the plug-in positions for communication modules in the base module or in the CB202 expansion module (refer to the following figure).

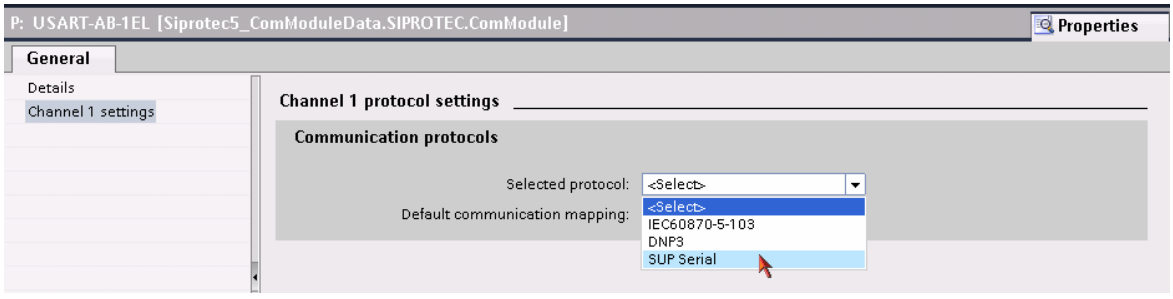


[sc20ser3-220114-01-DE, 1, en_US]

Figure 5-41 Insertion Position for a USART Module

Selecting the SUP Protocol

Select the Slave Unit Protocol (SUP). This protocol is responsible for the communication between the SIPROTEC 5 device and the 20-mA unit.



[scauser4-220114-01-DE, 1, en_US]

Figure 5-42 Selecting the SUP Protocol

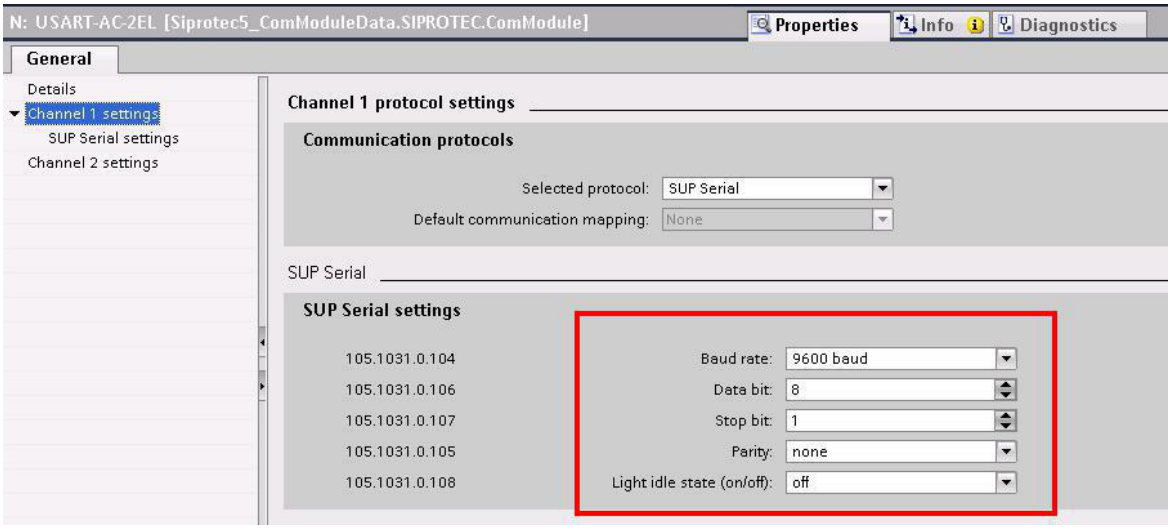
Communication Settings

Make the communications settings for the relevant serial channels. For this, use the default settings specified by the 20-mA unit. Normally, you must adapt only the parameterization of the SIPROTEC 5 device to the settings of the 20-mA unit. Make sure that the setting values in both devices are the same. The settings of the **`Non-flickering light (on/off)`:** is not relevant for the RS485 interface.



NOTE

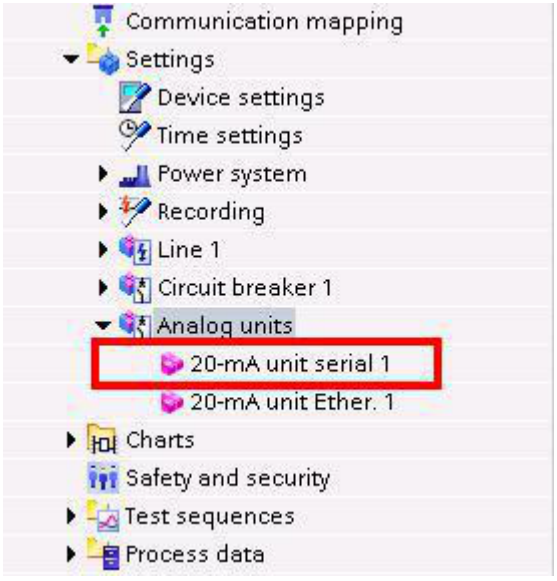
The driver for the USART module for the SUP protocol is not preinstalled as standard for the initial use of this interface (following the firmware update).



[scauser5-220114-01-DE, 1, en_US]

Figure 5-43 Making the Communication Settings

With the selection of the SUP protocol for the 20-mA unit DIGSI automatically adds the function group **Analog units** to your device configuration. You can now instantiate the function **20-mA unit serial 1** (see following figure).



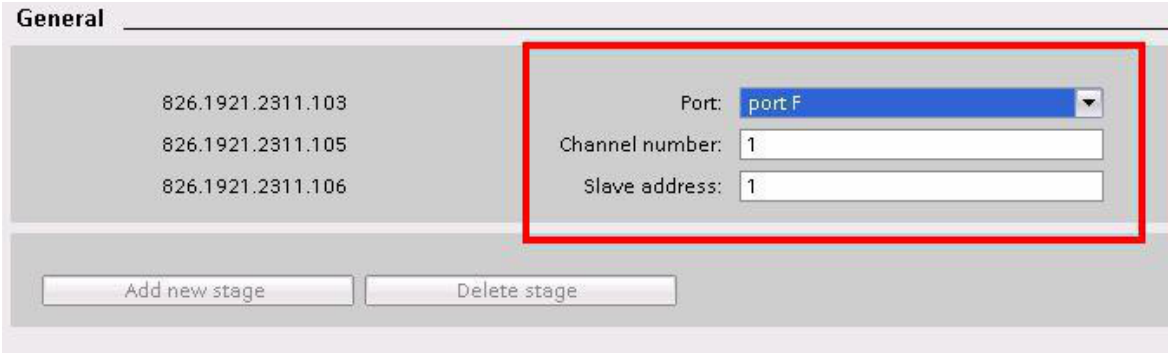
[sc20ser6-220114-01-DE, 1, en_US]

Figure 5-44 Insertion of the Function 20-mA Unit Serial 1

Now, set the channel number over which the SUP protocol runs. In addition, set the slave address of the 20-mA unit. This address must be set with the same value in the 20-mA unit (refer to the following figure).

For the first use of the 20-mA unit, the following device configuration must be set on the 20-mA unit:

- Bus protocol: mod
- Device address: 1
- Baud rate: 9600
- Parity: no



[scauser7-220114-01-DE, 1, en_US]

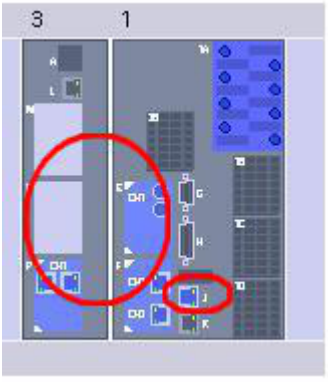
Figure 5-45 Setting the Port, Channel Number, and Device Address

Finally, load the configuration in the device.

5.6.5.2 Integration of a 20-mA Unit Ethernet

Device Configuration

In DIGSI, insert an Ethernet module into the provided slot, thus, adding the module to the device configuration. *Figure 5-46* displays the available slots in the base module or on the expansion module CB 202. Alternatively, you can also use the integrated Ethernet interface Port J.

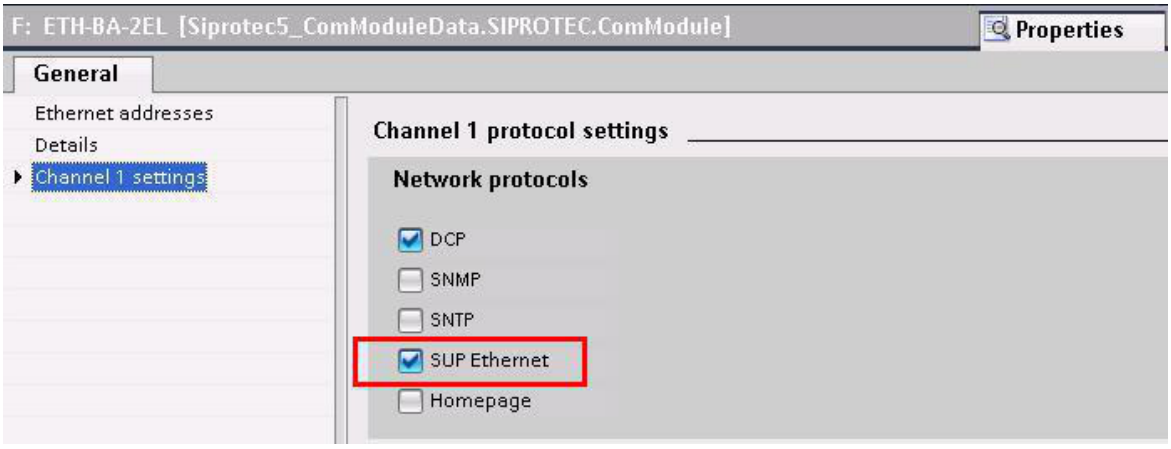


[scautcp1-220114-01-DE, 1, en_US]

Figure 5-46 Inserting an Ethernet Module

Communication Settings

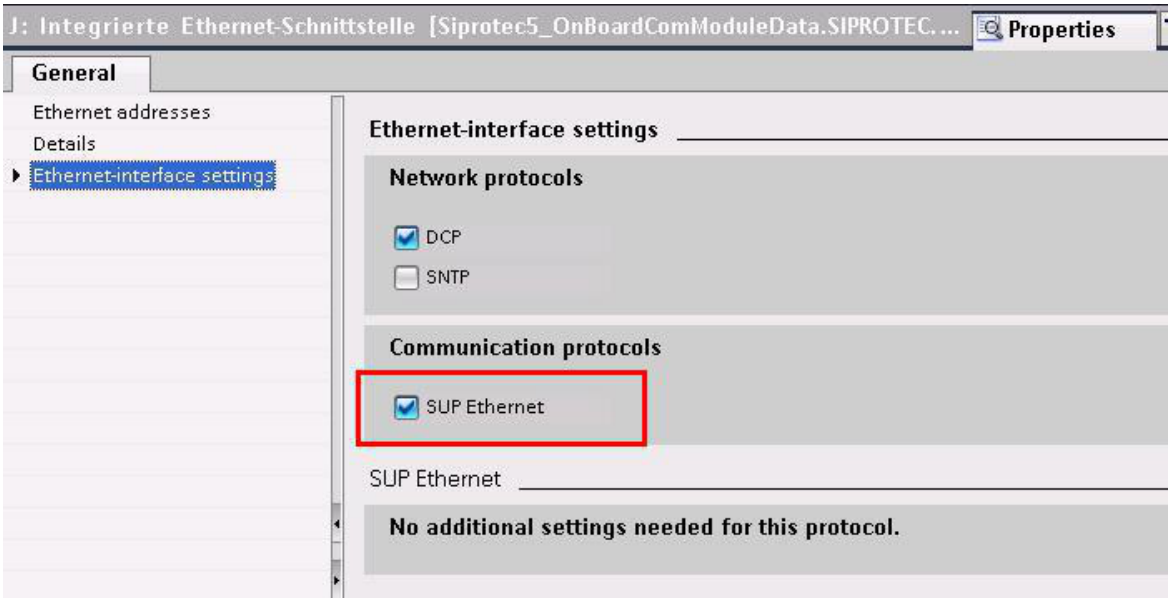
Activate the SUP Ethernet protocol for the Ethernet module.



[scautcp2-220114-01-DE, 1, en_US]

Figure 5-47 Activation of the protocol

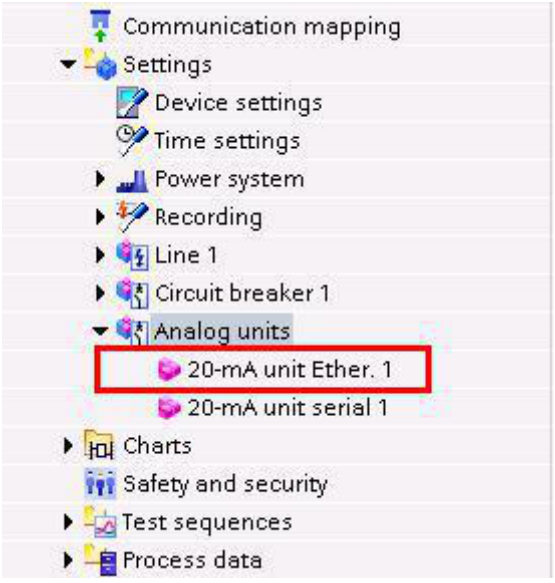
This protocol is also available for Port J of the integrated Ethernet interface of the base module (refer to following figure).



[scautcp3-220114-01-DE, 1, en_US]

Figure 5-48 Selection of the Protocol

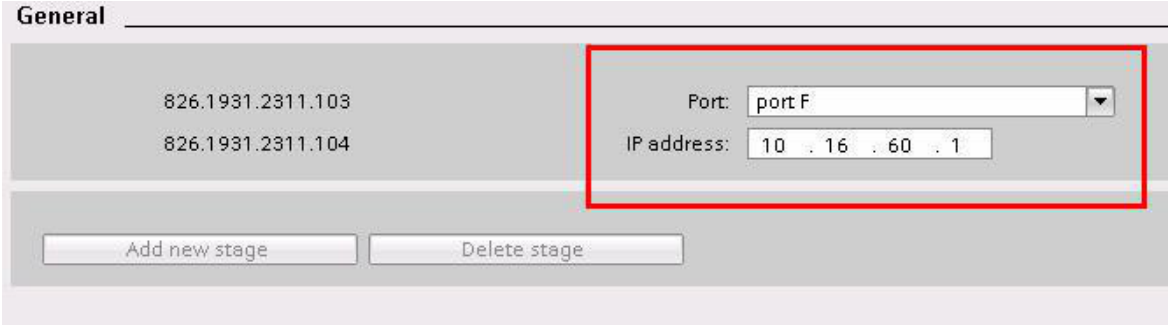
With the selection of the SUP protocol for the 20-mA unit, DIGSI automatically adds the **Analog units** function group and the **20-mA unit Ether.** function to your device configuration (refer to the following figure).



[sc20tcp4-220114-01-DE, 1, en_US]

Figure 5-49 Insertion of the Function 20-mA Unit Ether. 1

Now, set the port over which the SUP protocol runs. In addition, set the IP address of the 20-mA unit (refer to the following figure). This address must be set with the same value in the 20-mA unit.



[scautcp5-220114-01-DE, 1, en_US]

Figure 5-50 Setting the Port and IP Address

Finally, load the configuration in the device.

5.6.6 V/I-Measuring-Transducer Unit with Fast Inputs

5.6.6.1 Overview

The fast analog measuring-transducer inputs process voltage values (DC -10 V to +10 V) as well as current values (DC -20 mA to 20 mA).

The function **MT fast input**:

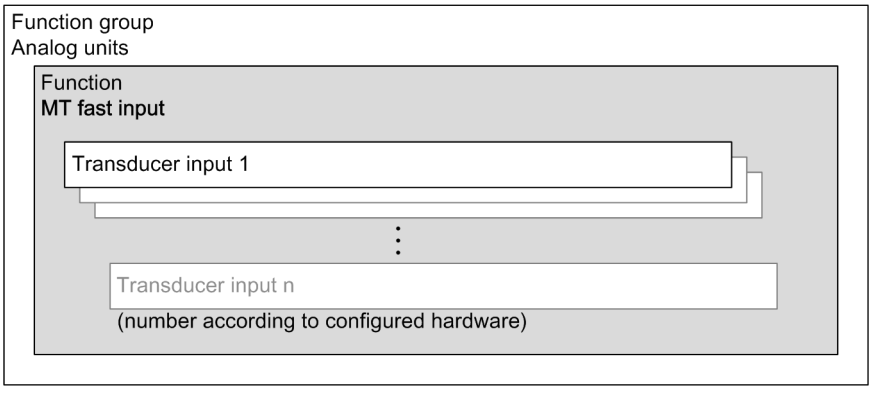
- Provides sampled values for recording in the fault record (the maximum sampling frequency is 8 kHz for all other SIPROTEC 5 devices). The recorded sampling frequency results from the setting of the fault-recorder function.
- Calculated measured values from the sampled values. These measured values have been deduced from the arithmetic mean values. The measuring range for the mean-value calculation is adjustable in the interval from 10 ms to 100 ms.

- Converts the measured current or voltage values into process values, for example, temperature, gas pressure, etc.
- Provides the recorded process variables for further processing by the fault recorder, the CFC, and in GOOSE-applications for transmission via communication protocols, and for visualization

The fast measuring-transducer inputs are located on the IO212 module with 8 inputs (optionally current or voltage inputs), and the IO210 module with 4 inputs (optionally current or voltage inputs).

5.6.6.2 Structure of the Function

The function **MT fast input** works in the function group **Analog units** and contains the number of available measuring-transducer inputs, depending on the hardware configuration. You can configure these channels independently from one another either as current or voltage inputs.



[dw_mu-structure, 1, en_US]

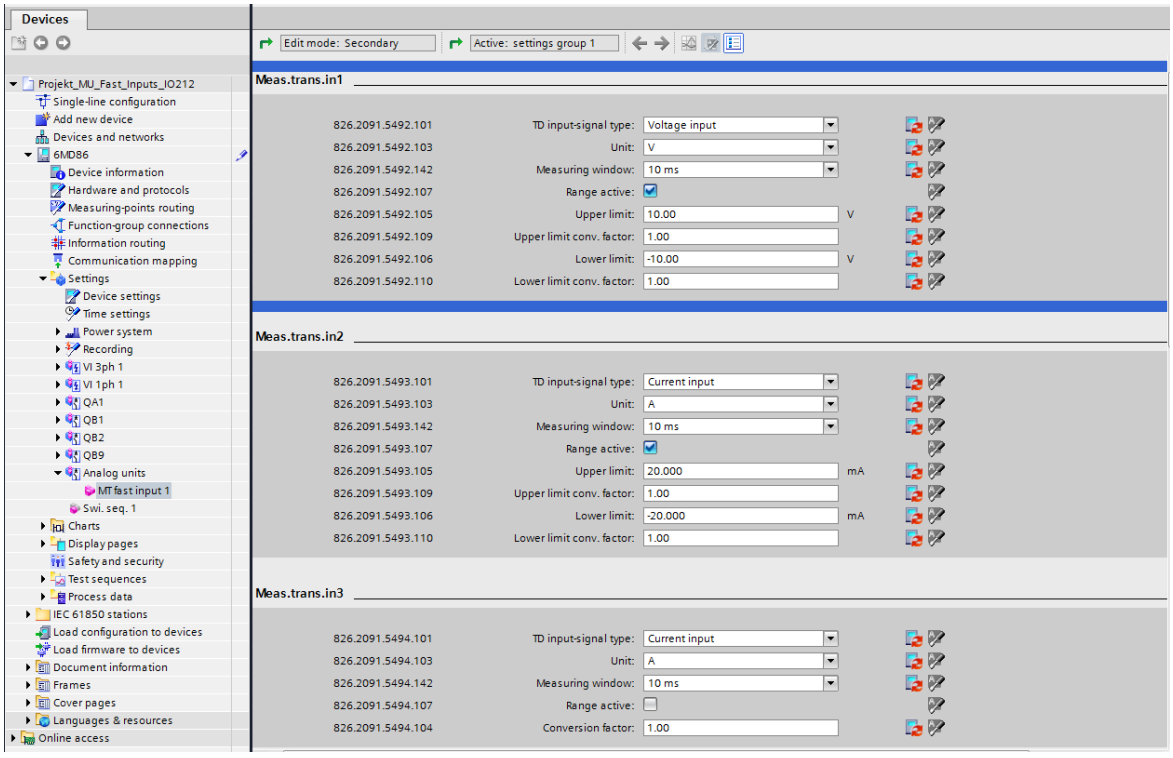
Figure 5-51 Structure/Embedding of the Function

5.6.6.3 Function Description

Once you have instantiated the **MT fast input** function, it will be visible in the project tree in the function group **Analog units**. You can find the function group **Analog units** in DIGSI in the **Settings** folder.

If you open the subdirectory **MT fast input**, you reach the setting sheet for the respective input (for more details, see Application and Setting Notes).

The hardware is designed in such a way that either a current or a voltage can be processed at each input. Use the corresponding terminals (see Hardware manual). Configure the input in accordance with the selected connection (Parameter **`TD input-signal type`**). With the parameter **`Measuring window`**, you set the measuring range with which the arithmetic mean value is determined. With the parameter **`Measuring window`**, you also determine measurement speed for the input. For example, a setting of 100 ms means that the measured value is updated every 100 ms.



[scmuio212, 1, en_US]

Figure 5-52 Parameters of the Measuring-Transducer Channels.

The fast measuring-transducer channels can be configured either as current or as voltage inputs. Apart from this, their function corresponds to the basic function of the 20-mA-channels (see chapter *5.6.3.5 20-mA Channel*).

5.6.6.4 Application and Setting Notes

Parameter: `TD input-signal type`

- Default setting **`(_:101) TD input-signal type`** = ***`Current input`***

With the parameter **`TD input-signal type`**, you determine whether the measuring-transducer input channel works as a ***`Current input`*** or as a ***`Voltage input`***.

Make sure that the selected channel has also been wired correctly (see Hardware manual, Input and Output Module IO212).

Parameter: `Unit`

- Default setting **`(_:103) Unit`** = ***`A`***

With the parameter **`Unit`**, you set the physical unit of measurement of the measured values. The possible setting values are listed in the settings table.

Parameter: `Measuring window`

- Default setting **`(_:142) Measuring window`** = ***`10 ms`***

With the parameter **`Measuring window`**, you set the measuring window that is used to determine the arithmetic mean value from the sampled values. In case of slowly varying signals, Siemens recommends setting the top value to 100 ms. With this value, a new, current measured value is provided every 100 ms for further processing.

Parameter: `Range active`

- Default setting **`(_:107) Range active`** = ***`false`***

If you do not activate the **`Range active`** parameter, the function assumes a range of -20 mA to +20 mA or -10 V to +10 V. The setting of the range for the scaled value then assumes a usable range of -20 mA to +20 mA or -10 V to +10 V.

If you activate the **`Range active`** parameter, then 4 additional parameters **`Upper limit`**, **`Upper limit - Sensor`**,**`Lower limit`**, and **`Lower limit - Sensor`** appear.

Note that this setting is activated by either placing, or not placing the relevant check mark in DIGSI (see *Figure 5-52*).

Parameter: Conversion factor

- Default setting **`(_:104) Conversion factor`** = ***`1.00`***

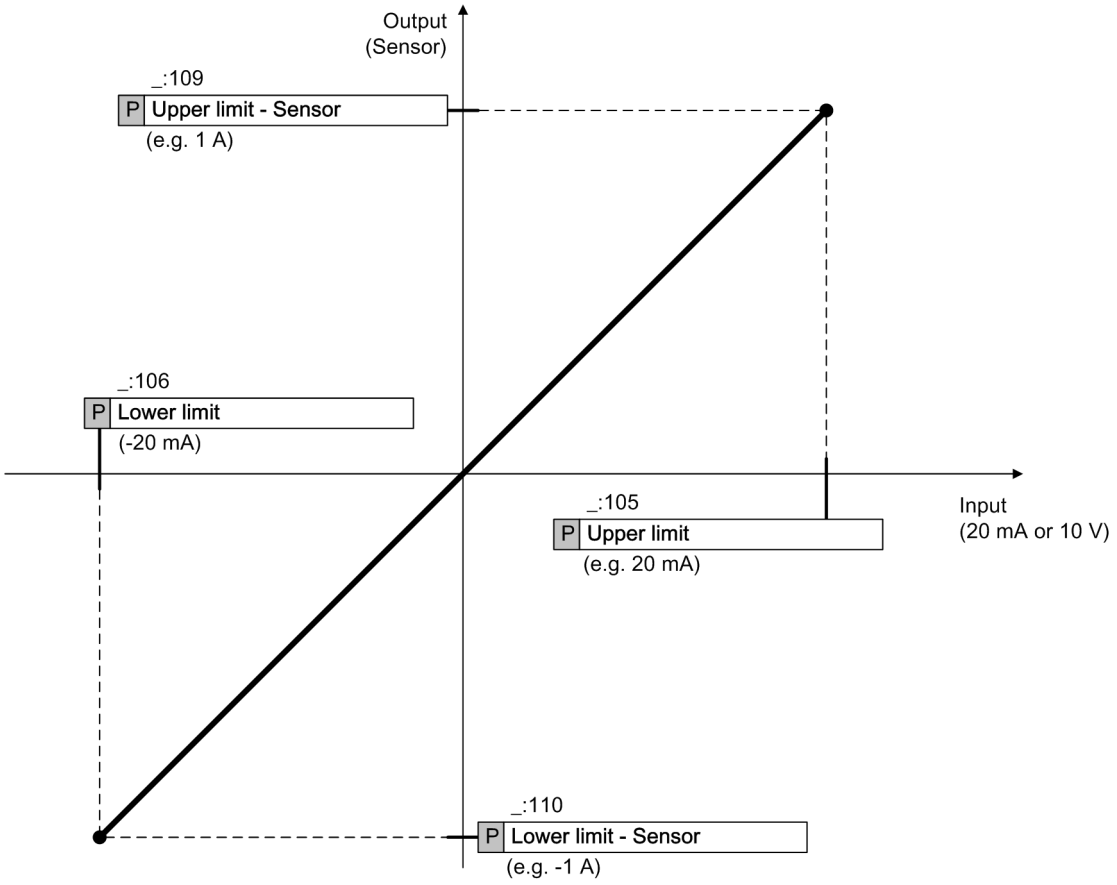
With the parameter **`Conversion factor`**, you set the conversion factor for the measuring transducer.

Parameter: Upper limit, Lower limit, Upper limit - Sensor, and Lower limit - Sensor

With the following parameters, you set the scaling of the measuring variables. By that, you can scale in an application-specific way:

- Default setting **`Upper limit`** = ***`20.00 mA`***
- Default setting **`Upper limit - Sensor`** = ***`1.00`***
- Default setting **`Lower limit`** = ***`-20.00 mA`***
- Default setting **`Lower limit - Sensor`** = ***`1.00`***

With these setting parameters, you set the operating range of the measuring transducer as well as the conversion of the values transmitted to the sensor values. Harmonize the operating range of the measuring transducer with the transmitter of the sensor. Using the free scalability of the system, you can meet different requirements. The following figure shows the setting parameters in general terms.

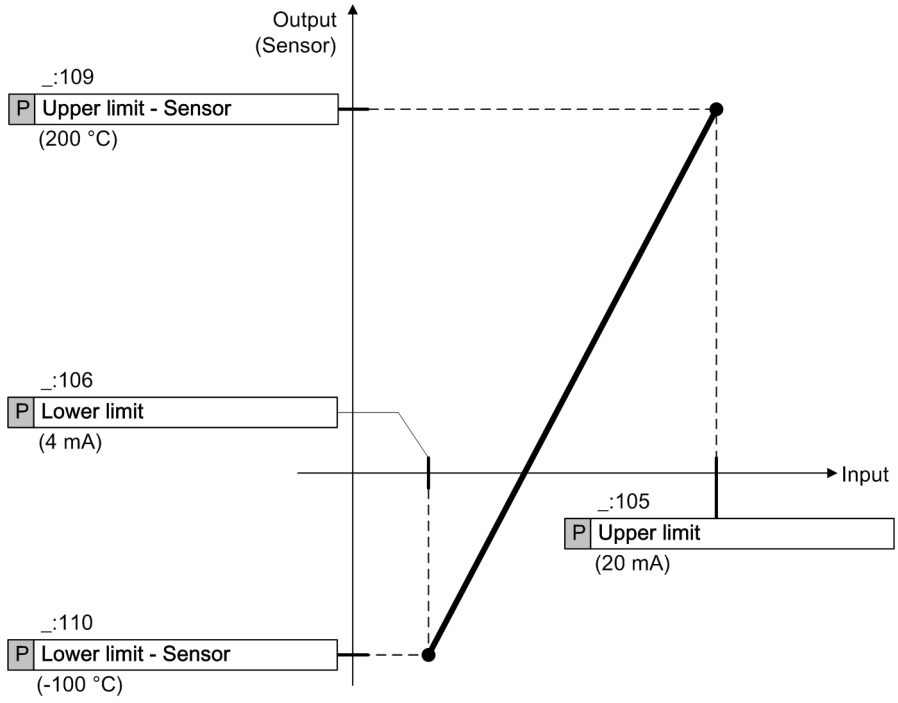


[dw_measured-value-scaling, 1, en_US]

Figure 5-53 Scaling Principle

Setting Example 1:

A measuring transducer transmitting a current signal of 4 mA to 20 mA is used as a transmitter. Currents well below 4 mA indicate a transmitter failure; currents around 0 mA indicate a broken wire. A sensor detecting a temperature is attached to the transmitter. The upper value corresponds to 200 °C and the lower value to -100 °C. This results in the following characteristic. In accordance with the set characteristic curve, the function calculates the sensor value from the measured current. The coefficients of the linear equation (gradient and foot point) are calculated from the set threshold and the sensor values are determined. A supplied current of 9.333 mA corresponds to a temperature of 0 °C.



[dw_measuring-transducer-characteristic, 1, en_US]

Figure 5-54 Characteristic Curve of Setting Example 1

NOTE

The hardware of the measuring transducer has been designed in such a way that measured values are transmitted and analyzed using the setting range (**`Upper limit`** or **`Lower limit`**). Therefore, special applications are possible, if necessary. The limits lie at approximately +20 mA and -20 mA or +10 V and -10 V. If the measured values are supplied above or below these limits, the quality ***`invalid`*** is assigned.

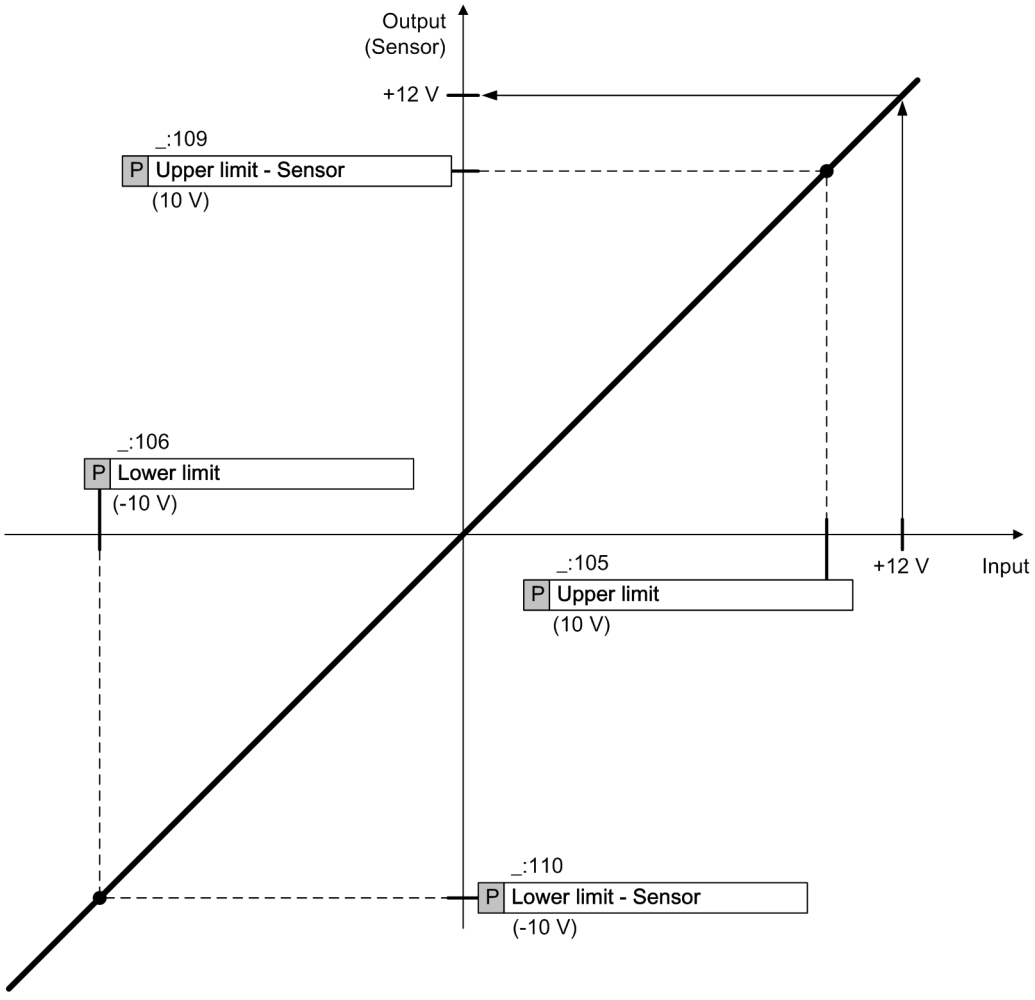
Setting Example 2:

For special applications, the transmitter sends a maximum of ±12 V. This voltage shall be issued accordingly as sensor voltage.

Set the parameters as follows:

- **`Upper limit`** = ***`10.00 V`***
- **`Upper limit - Sensor`** = ***`10.00 V`***
- **`Lower limit`** = ***`-10.00 V`***
- **`Lower limit - Sensor`** = ***`-10.00 V`***

With this setting, a signal of 12 V is issued as a 12-V measured value (see following figure).



[dw_measuring-transducer-setting, 1, en_US]

Figure 5-55 Parameter Settings and Representation of an Input Signal Greater than 10 V

5.6.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MT fast #				
_:101	MT in #:TD input-signal type		• Voltage input • Current input	Current input

Addr.	Parameter	C	Setting Options	Default Setting
_:103	MT in #:Unit		• • % • ° • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • in • J • J/Wh • K • l/s • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • W/s • Wh	A
_:142	MT in #:Measuring window		• 10 ms • 20 ms • 40 ms • 60 ms • 80 ms • 100 ms	10 ms
_:107	MT in #:Range active		• 0 • 1	false
_:104	MT in #:Conversion factor		-10000.00 to 10000.00	1.00
_:105	MT in #:Upper limit		-20.00 mA to 20.00 mA	5.00 mA
_:109	MT in #:Upper limit - Sensor		-10000.00 to 10000.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
_:106	MT in #:Lower limit		-20.00 mA to 20.00 mA	4.00 mA
_:110	MT in #:Lower limit - Sensor		-10000.00 to 10000.00	1.00

5.6.6.6 Information List

No.	Information	Data Class (Type)	Type
MT in #			
_:302	MT in #:TD scale MV	MV	O
_:306	MT in #:TD scale SAV	SAV	O

5.6.7 RTD Unit Ethernet

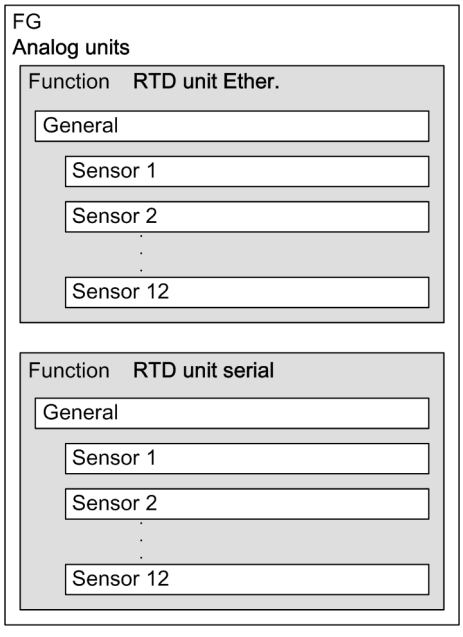
5.6.7.1 Overview

The **RTD unit Ether.** function:

- Communicates with an external RTD unit via the Slave Unit Protocol (SUP) and records the measured temperatures from the RTD unit
- Provides the captured temperatures to the temperature monitoring function
- Monitors communication with the RTD unit

5.6.7.2 Structure of the Function

The **RTD unit Ether.** function can only work in the **Analog units** function group. A maximum of 20 function instances can work simultaneously. Each instance contains 12 preconfigured sensor function blocks.

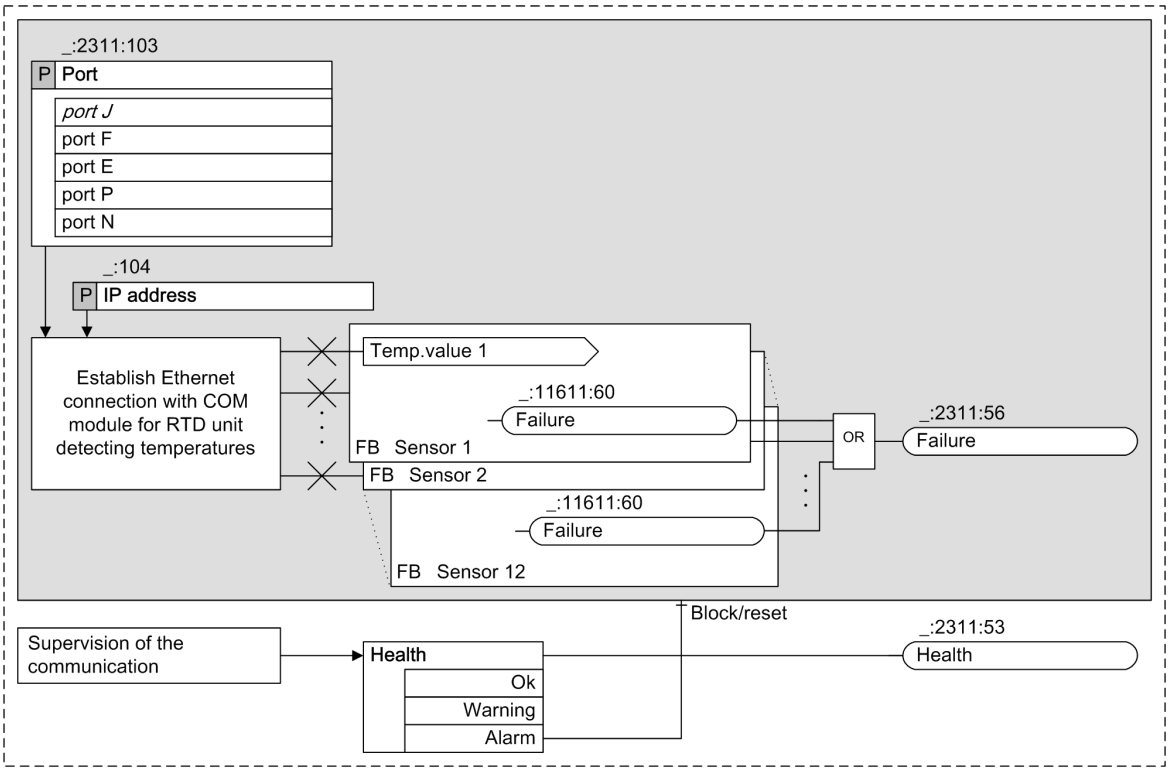


[dwstrfnc-291112-01.tif, 2, en_US]

Figure 5-56 Structure/Embedding of the Function

5.6.7.3 Communication with an RTD Unit

Logic



[lortdtcp-311012-01.tif, 1, en_US]

Figure 5-57 Logic of the RTD Unit Ether. Function

Communication with an RTD Unit

The function is used to communicate with an RTD box connected via an Ethernet connection. If the connection of the function is successfully established to the external RTD box via the Ethernet interface, the RTD box transmits the temperatures of all connected sensors to the **RTD box Ether.** function. For the connection to be established successfully, specific communication settings must be set, see chapter *5.6.7.4 Application and Setting Notes*.

The RTD box **Ziehl TR1200 IP** supports only an Ethernet connection of 10 MBit/s. A direct connection to a 100-Mbit communication module is therefore not possible. For this reason, you must connect the RTD box to the communication module via a 10/100 MBit/s autosensing switch which automatically recognizes the transmission rates and adapts them accordingly. Further information can be found in the Application and setting notes, see chapter *5.6.7.4 Application and Setting Notes*.

Error Responses

The following table lists the conditions under which the *Health* status transitions to the Alarm or Warning state.

Table 5-11 Error Responses

Error Description	Status Health
The **RTD unit Ether.** function cannot establish a connection with a communication module.	Alarm
The connection between the communication module and the RTD unit causes a time-out.	Warning

Error Description	Status Health
A communication module has not received any more data from the RTD unit for 9 sec.	Warning

The *Failure* signal is set as soon as one of the sensor function blocks reports a failure.

5.6.7.4 Application and Setting Notes

Parameter: Port

- Default setting **(_:2311:103) Port** = ***port J***

Use the **Port** parameter to define over which port the external RTD unit is connected to the SIPROTEC 5 device.

If you want to connect the external RTD unit to the integrated Ethernet interface, set the parameter **Port** = ***Port J***. If you want to connect the external RTD unit to an Ethernet plug-in module, set the parameter **Port** = ***Port F***, ***Port E***, ***Port P***, or ***Port N***.

You can connect directly the RTD unit to the device via the internal 10-Mbit Ethernet port J. If you operate the RTD unit on another port via a 100-Mbit communication module, you need an interconnected 10/100-Mbit autosensing switch, which adapts transmission rates accordingly.

Parameter: IP address

- Default setting **(_:2311:104) IP address** = ***10.16.60.1***

With the **IP address** parameter, you set the IP address of the RTD unit connected to the communication module via the SUP protocol. Every RTD unit has to be assigned a unique IP address. The IP address to be set depends on your network configuration. You can set any valid IPv4 address that does not cause conflicts with other IP addresses in the network. Set an appropriate IP address first at the **Ziehl TR1200 IP** RTD unit. Then specify the **IP address** parameter for the communication module to the same address.

Settings on the RTD Unit

The **Ziehl TR1200 IP** RTD unit is set with the front keys or in a Web browser on a laptop computer via its Ethernet interface. Set the connection type of the sensors (3-wire connection or resistance value for 2-wire connection), the idle state of the fault-indication relay, as well as the IP interface setting.

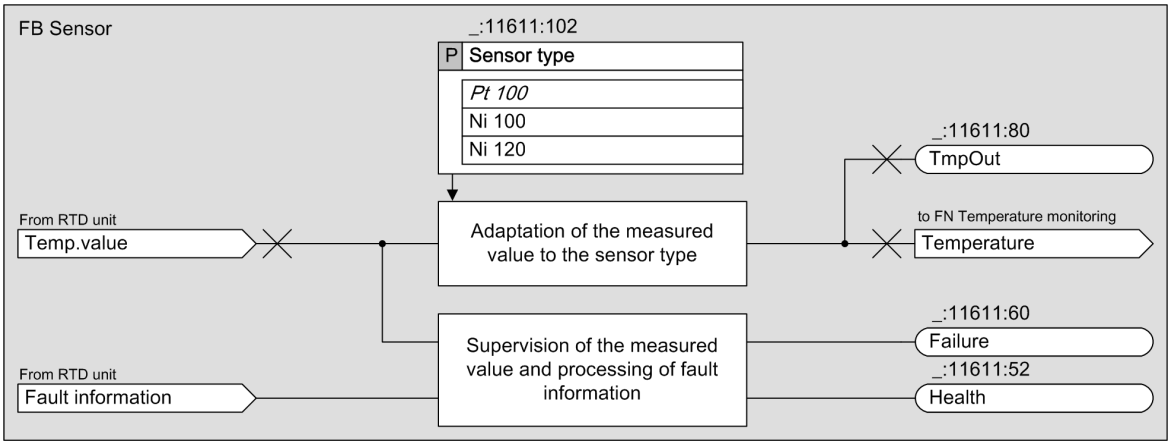
The code lock has to be switched off for parameterization. This is only possible using the front keys of the RTD unit. The code lock is **off** (switched off) in as-delivered condition and has pin **504**.

For detailed information on the settings, refer to the TR1200 IP manual that comes with the RTD unit. The documents are also available in the SIPROTEC download area (http://www.siprotec.de) under **Accessories -> 7XV5662-xAD**.

For an Ethernet connection to a SIPROTEC 5 device communicating with the RTD unit TR1200 IP via the **SUP protocol** (Slave Unit Protocol), the **Modbus TCP** setting must be activated in the RTD unit. You can activate the Modbus TCP protocol using the function keys under the **TcP - mod** menu item or with the Web browser in the **TCP/UDP Config** tab. The **RTD** (RTD protocol) and **UDP Port** settings have no effect here. The Modbus TCP port is permanently set to 502 and cannot be changed.

5.6.7.5 Temperature Sensor

Logic



[lotmpval-311012-01.tif, 1, en_US]

Figure 5-58 Logic Diagram of the Temperature Sensor Function Block

Measured Temperature Value

The **Temperature sensor** function block processes one single measured temperature value delivered from the RTD box for the assigned sensor. 12 temperature sensor function blocks are always available in each RTD box function (both via Ethernet and serial), even if fewer sensors are connected to the RTD box.

Various temperature sensor types are supported: Pt100, Ni100, and Ni120 sensors. The function block is notified regarding the selection of connected type via the **`Sensor type`** parameter.

The function block delivers a measured temperature value in °C or °F as an output variable. The measured temperature value is available as an operational measured value and can be monitored by the **Temperature supervision** function.

Error Responses

If the measured input value is determined to be incorrect, the quality attribute of the output measured temperature value is set to *`invalid`*. The statuses for Health and Error take the statuses in accordance with the following table:

Table 5-12 Error response

Error Description	Health Status	Error Status
Sensor or line short circuited	Alarm	Yes
Sensor or line interrupted	Alarm	Yes
Measured temperature value outside the valid measuring range specified in the technical data. The valid measuring range depends on the sensor type.	Alarm	Yes
Sensor not connected	OK	No

5.6.7.6 Application and Setting Notes

Parameter: Sensor type

- Default setting **`(_:11611:102) Sensor type`** = ***`Pt 100`***

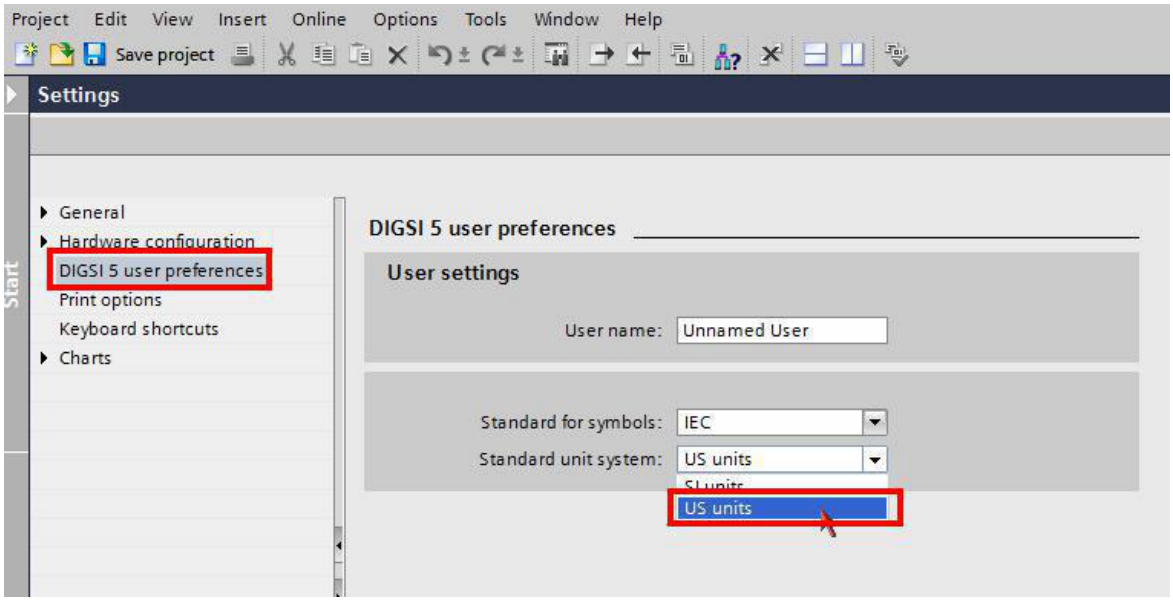
The **`Sensor type`** parameter is used to set the sensor element used. You can select between ***`Pt 100`***, ***`Ni 100`*** and ***`Ni 120`***.

Parameter: Temperature unit

To change the display and evaluation of measured temperature values from °C to °F, adapt the DIGSI user default settings accordingly.

Proceed as follows:

- In DIGSI select the menu item **Extras** --> **Settings**.
- In the **Settings** view select the menu item **DIGSI 5 User preferences**.
- Under **Standard unit system** change the setting value of the unit system used from *SI units* to *US units*.



[scfahrht-190214-01, 1, en_US]

Figure 5-59 Change of the Display Between °C and °F

The following settings and information table shows only 1 of the 12 sensors, as the setting possibilities of the 12 sensors do not differ.

5.6.7.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port E • port F • port J • port N • port P	port J
Sensor 1				
_:11611:102	Sensor 1:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100

5.6.7.8 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O

No.	Information	Data Class (Type)	Type
Sensor 1			
_:11611:52	Sensor 1:Health	ENS	O
_:11611:60	Sensor 1:Failure	SPS	O
_:11611:80	Sensor 1:TmpOut	MV	O

5.6.8 RTD Unit, Serial

5.6.8.1 Overview

The **RTD unit serial** function:

- Communicates with an external RTD unit serial via the Slave Unit Protocol (SUP) and records the measured temperatures from the RTD unit
- Provides the captured temperatures to the temperature supervision function
- Monitors communication with the RTD unit

The **RTD unit Serial** function is set up structurally in the same manner as the **RTD unit Ether.** function. The mode of operation is also identical (see *5.6.7.3 Communication with an RTD Unit*).

5.6.8.2 Application and Setting Notes

Parameter: Port

- Default setting **(_:2311:103) Port** = ***F***

With the **Port** parameter, you set the slot for the communication module that will be used for the connection with an external RTD unit.

If you want to connect the external RTD box to an Ethernet plug-in module, set the parameter **Port** = ***Port F***, ***Port E***, ***Port P***, or ***plug-in module position***.

Parameter: Channel number

- Default setting **(_:2311:105) Channel number** = ***1***

A serial communication module optionally uses 2 channels. With the **Channel number** settings, you set the channel number (1 or 2) through which the RTD unit is connected to the device. The communication module inputs are labeled with the channel numbers.

Parameter: Slave address

- Default setting **(_:2311:106) Slave address** = ***1***

Use the **Slave address** parameter to define the device address of the RTD unit. If only one RTD unit is connected to the serial bus, the default value *1* can be used. The same device address has to be set on the RTD unit. The device address is important for distinguishing among several RTD units connected to a serial bus. Set a unique device address (for example 1, 2 and 3 when connecting 3 RTD units) for each RTD unit and the same device address for the parameter **Slave address** in the 3 **RTD unit serial** functions.

The following settings and information table shows only 1 of the 12 sensors, as the setting possibilities of the 12 sensors do not differ.

5.6.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port F • port E • port P • port N • port J	port J
_:2311:105	General:Channel number		1 to 2	1
_:2311:106	General:Slave address		1 to 254	1
Sensor 1				
_:11611:102	Sensor 1:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 2				
_:11612:102	Sensor 2:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 3				
_:11613:102	Sensor 3:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 4				
_:11614:102	Sensor 4:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 5				
_:11615:102	Sensor 5:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 6				
_:11616:102	Sensor 6:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 7				
_:11617:102	Sensor 7:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 8				
_:11618:102	Sensor 8:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 9				
_:11619:102	Sensor 9:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 10				
_:11611:102	Sensor 10:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100

Addr.	Parameter	C	Setting Options	Default Setting
Sensor 11				
_:11611:102	Sensor 11:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 12				
_:11611:102	Sensor 12:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100

5.6.8.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Sensor 1			
_:11611:52	Sensor 1:Health	ENS	O
_:11611:60	Sensor 1:Failure	SPS	O
_:11611:80	Sensor 1:TmpOut	MV	O
Sensor 2			
_:11612:52	Sensor 2:Health	ENS	O
_:11612:60	Sensor 2:Failure	SPS	O
_:11612:80	Sensor 2:TmpOut	MV	O
Sensor 3			
_:11613:52	Sensor 3:Health	ENS	O
_:11613:60	Sensor 3:Failure	SPS	O
_:11613:80	Sensor 3:TmpOut	MV	O
Sensor 4			
_:11614:52	Sensor 4:Health	ENS	O
_:11614:60	Sensor 4:Failure	SPS	O
_:11614:80	Sensor 4:TmpOut	MV	O
Sensor 5			
_:11615:52	Sensor 5:Health	ENS	O
_:11615:60	Sensor 5:Failure	SPS	O
_:11615:80	Sensor 5:TmpOut	MV	O
Sensor 6			
_:11616:52	Sensor 6:Health	ENS	O
_:11616:60	Sensor 6:Failure	SPS	O
_:11616:80	Sensor 6:TmpOut	MV	O
Sensor 7			
_:11617:52	Sensor 7:Health	ENS	O
_:11617:60	Sensor 7:Failure	SPS	O
_:11617:80	Sensor 7:TmpOut	MV	O
Sensor 8			
_:11618:52	Sensor 8:Health	ENS	O
_:11618:60	Sensor 8:Failure	SPS	O
_:11618:80	Sensor 8:TmpOut	MV	O

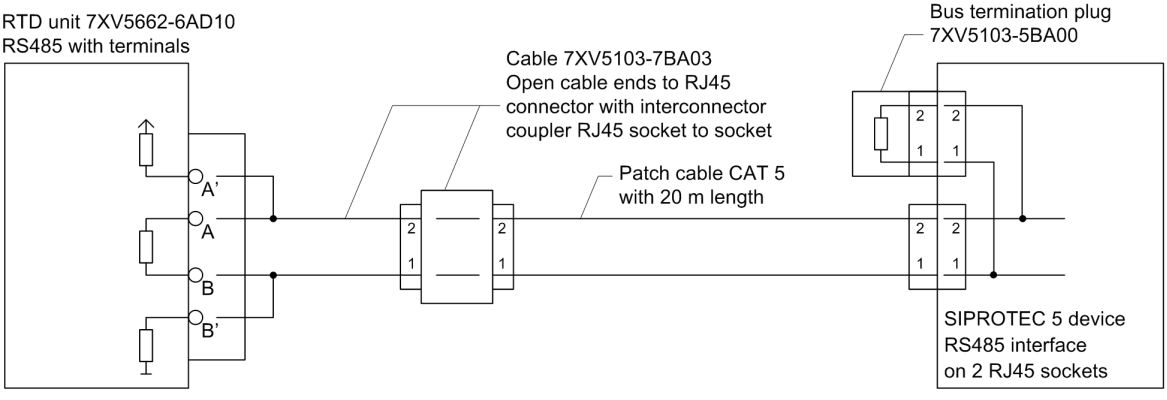
No.	Information	Data Class (Type)	Type
Sensor 9			
_:11619:52	Sensor 9:Health	ENS	O
_:11619:60	Sensor 9:Failure	SPS	O
_:11619:80	Sensor 9:TmpOut	MV	O
Sensor 10			
_:11611:52	Sensor 10:Health	ENS	O
_:11611:60	Sensor 10:Failure	SPS	O
_:11611:80	Sensor 10:TmpOut	MV	O
Sensor 11			
_:11611:52	Sensor 11:Health	ENS	O
_:11611:60	Sensor 11:Failure	SPS	O
_:11611:80	Sensor 11:TmpOut	MV	O
Sensor 12			
_:11611:52	Sensor 12:Health	ENS	O
_:11611:60	Sensor 12:Failure	SPS	O
_:11611:80	Sensor 12:TmpOut	MV	O

5.6.9 Communication with RTD Unit

5.6.9.1 Integration of a Serial RTD Unit (Ziehl TR1200)

Connection of the Communication Lines

Figure 5-60 shows how you connect the RTD box to the SIPROTEC 5 device. Note that Pin 1 of the RJ45 plug is connected to RTD-B and Pin 2 is connected to RTD-A.



[dwverbau-201112-01.tif, 1, en_US]

Figure 5-60 Connection of the RTD Unit to the SIPROTEC 5 Device

Adding a USART Module

Add a USART-AB-1EL or a USART-AC-2EL USART module in DIGSI to the device. The USART module must be inserted at one of the plug-in positions for communication modules in the base module or in the CB202 expansion module (refer to the following figure).

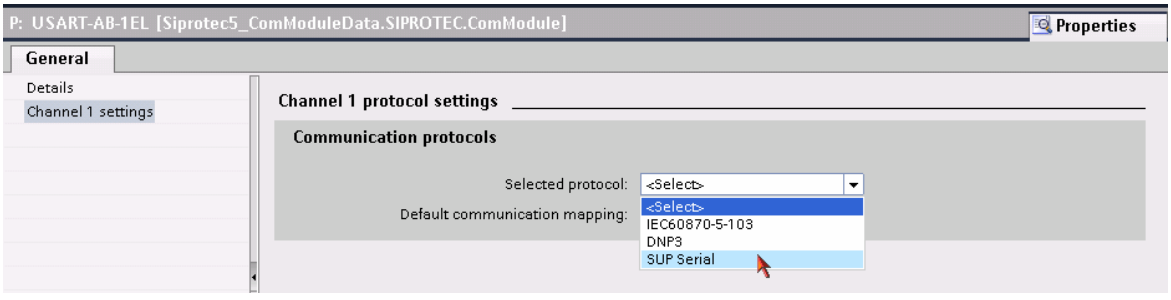


[scauser3-190214-01, 1, en_US]

Figure 5-61 Insertion Position for a USART Module

Selecting the SUP Protocol

Select the Slave Unit Protocol (SUP). This protocol is responsible for the communication between the SIPROTEC 5 device and the RTD Unit.



[scauser4-220114-01-DE, 1, en_US]

Figure 5-62 Selecting the SUP Protocol

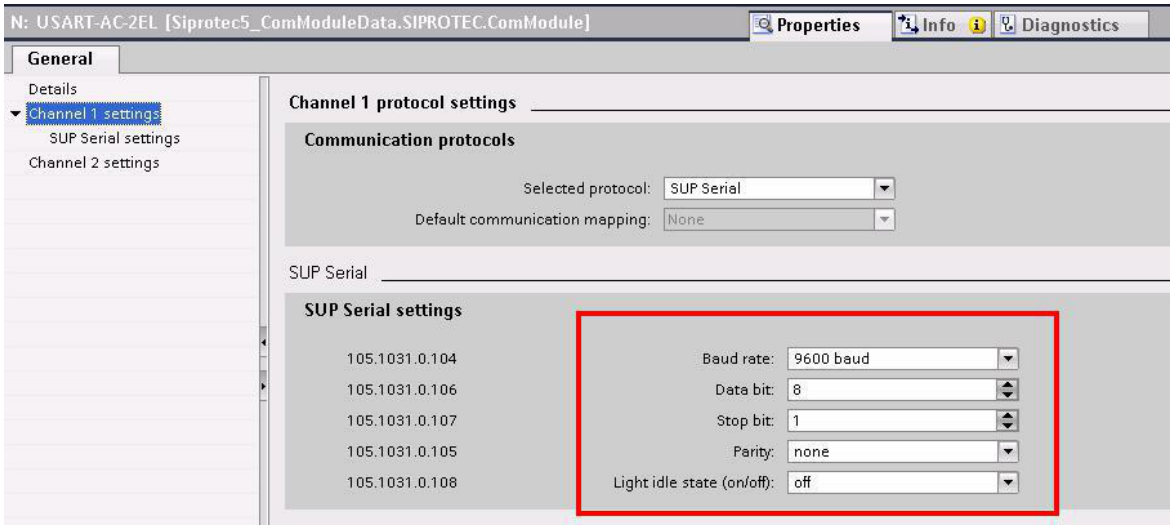
Communication Settings

Make the communications settings for the relevant serial channels. For this, use the default settings specified by the RTD box. Normally, you must adapt only the parameterization of the SIPROTEC 5 device to the settings of the RTD box. Make sure that the setting values in both devices are the same. The settings of the **`Non-flickering light (on/off)`:** is not relevant for the RS485 interface.



NOTE

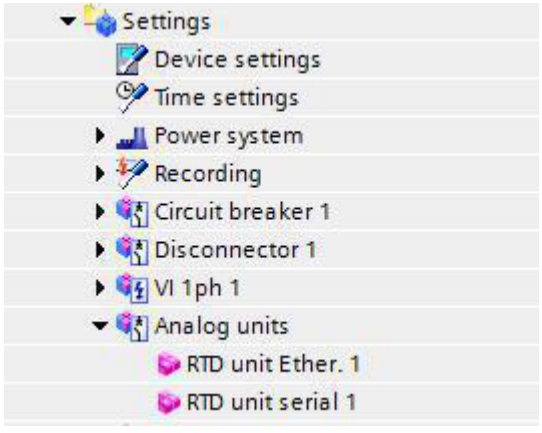
The driver for the USART module for the SUP protocol is not preinstalled as standard for the initial use of this interface (following the firmware update).



[scauser5-220114-01-DE, 1, en_US]

Figure 5-63 Making the Communication Settings

With the selection of the SUP protocol for the RTD box DIGSI automatically adds the function group **Analog units** to your device configuration. You can now instantiate the function **RTD box serial 1** (refer to the following figure).



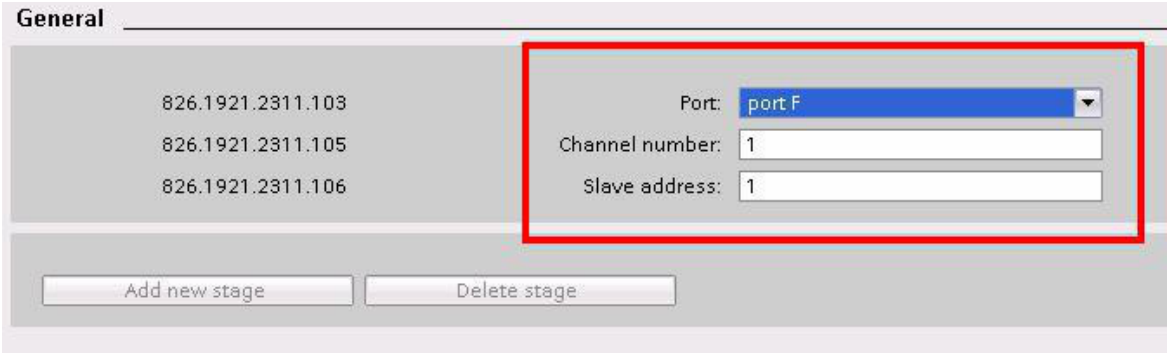
[scauser6-190214-01, 1, en_US]

Figure 5-64 Analog-Unit Instance

Now, set the channel number over which the SUP protocol runs. In addition, set the slave address of the RTD box. This address must be set with the same value in the RTD box (refer to the following figure).

The following device configuration must be set on the TR1200 RTD unit when the RTD unit is used for the first time:

- Bus protocol: mod
- Device address: 1
- Baud rate: 9600
- Parity: no



[scauser7-220114-01-DE, 1, en_US]

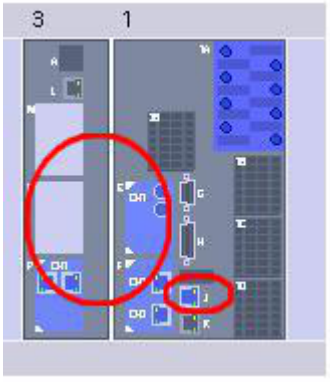
Figure 5-65 Setting the Port, Channel Number, and Slave Address

Finally, load the configuration in the device.

5.6.9.2 Integration of an RTD-Unit Ethernet (TR1200 IP)

Device Configuration

In the DIGSI, insert an Ethernet module into the provided slot, thus, adding the module to the device configuration. *Figure 5-66* displays the available slots in the base module or on the expansion module CB 202. Alternatively, you can also use the integrated Ethernet interface Port J.

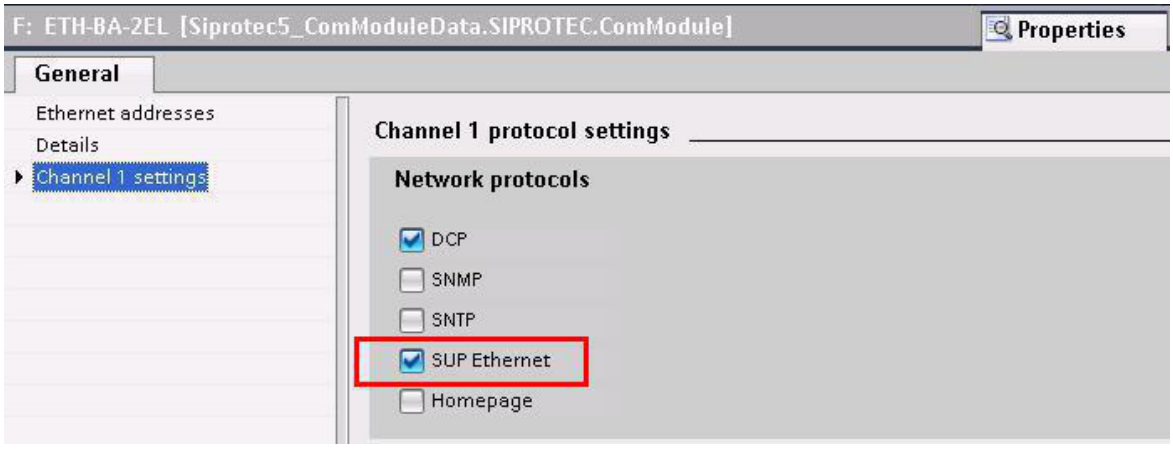


[scautcp1-220114-01-DE, 1, en_US]

Figure 5-66 Inserting an Ethernet Module

Communication Settings

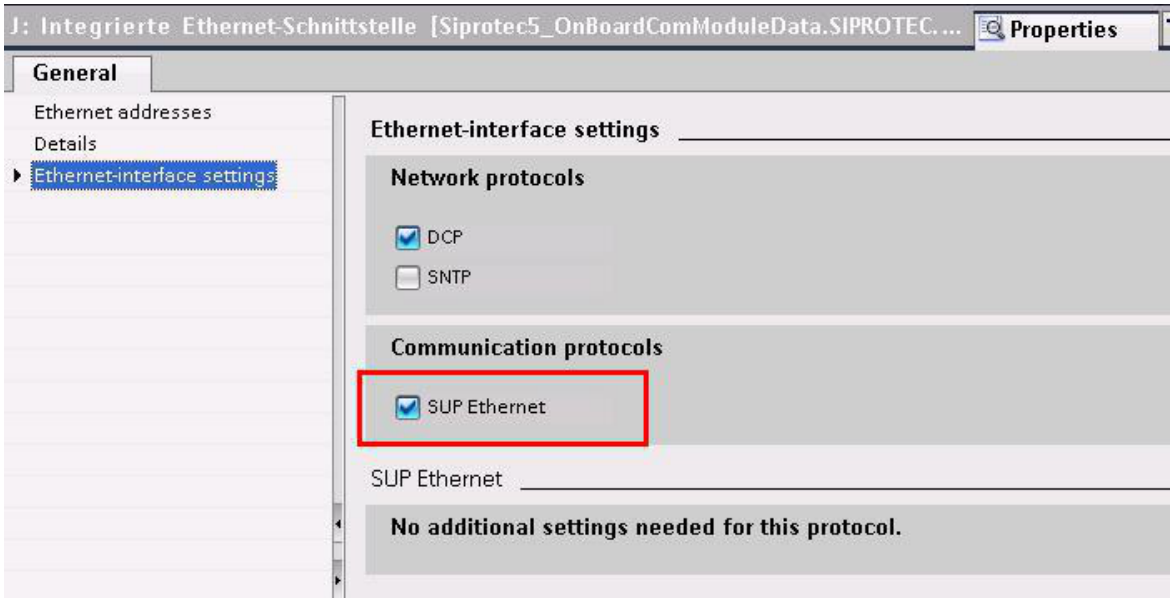
Activate the SUP Ethernet protocol for the Ethernet module.



[scautcp2-220114-01-DE, 1, en_US]

Figure 5-67 SUP Ethernet Protocol Activation

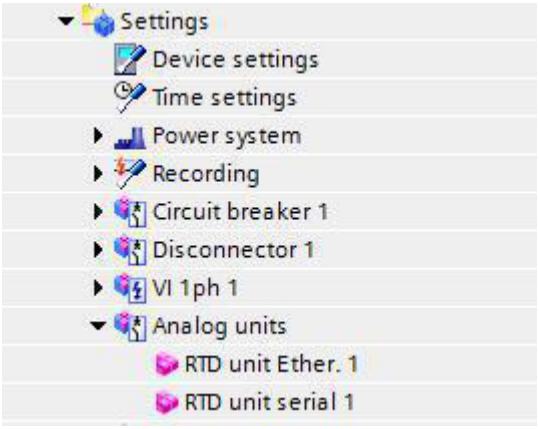
This protocol is also available for Port J of the integrated Ethernet interface of the base module (refer to following figure).



[scautcp3-220114-01-DE, 1, en_US]

Figure 5-68 SUP Ethernet Protocol Activation (base module)

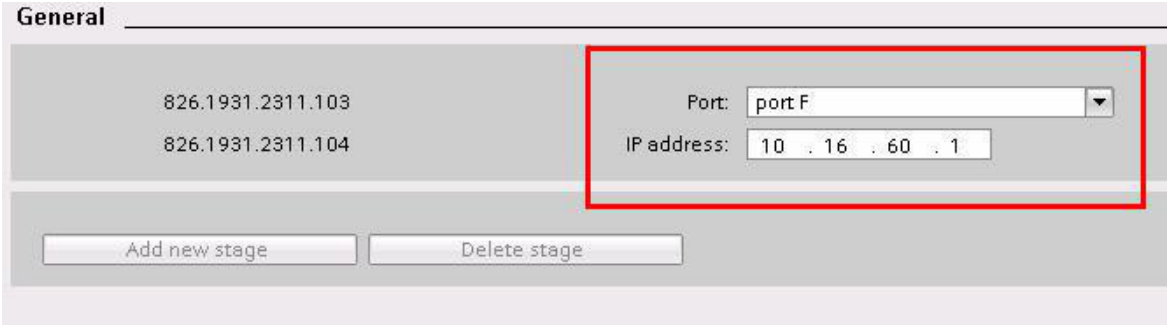
With the selection of the SUP protocol for the RTD unit, DIGSI automatically adds the **Analog units** function group and the **RTD unit Ether.** function to your device configuration (refer to the following figure).



[scauser6-190214-01, 1, en_US]

Figure 5-69 Analog Unit Instance

Now, set the port over which the SUP protocol runs. In addition, set the IP address of the RTD box (refer to the following figure). This address must be set with the same value in the RTD box.



[scautcp5-220114-01-DE, 1, en_US]

Figure 5-70 Setting the Port and IP Address

Finally, load the configuration in the device.

5.6.9.3 Temperature Simulation without Sensors

Connect a resistor on the sensor terminals of the RTD unit. Using this resistor, simulate a constant temperature. The resistance value should be around 50 Ω to 200 Ω.

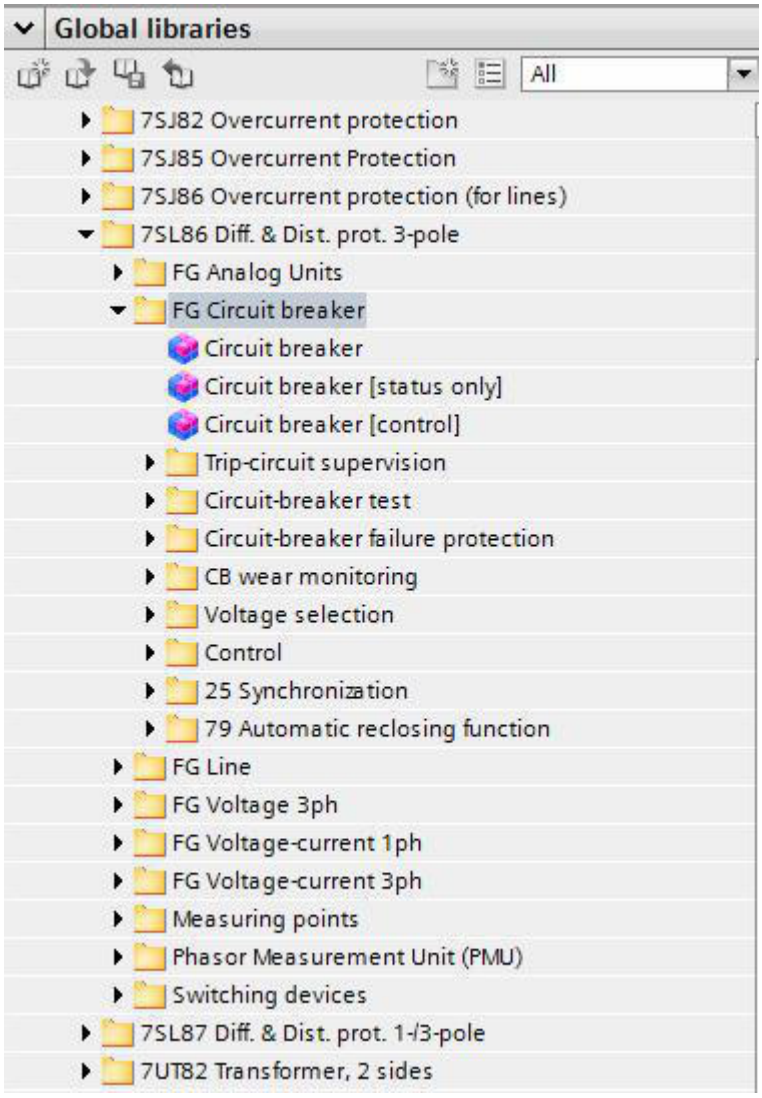
If you want to simulate a changeable temperature, connect an adjustable resistor of maximum 470 Ω instead of a fixed resistor.

5.7 Function-Group Type Circuit Breaker

5.7.1 Overview

The **Circuit-breaker** function group combines all the user functions that relate to a circuit breaker.

You will find the **Circuit-breaker** function group under each device type in the function library in DIGSI 5. The **Circuit-breaker** function group contains all of the protection, control, and supervision functions that you can use for this device type. The following figure shows, for example, the functional scope of the **Circuit-breaker** function group.



[scfgleis-200214-01, 1, en_US]

Figure 5-71 Circuit-Breaker Function Group - Example of the Functional Scope

The Circuit-breaker function group includes 3 different types of circuit breakers:

- Circuit breaker
- Circuit-breaker control
- Circuit breaker [status only]

The circuit-breaker type can accept additional basic function blocks for protection functions along with the actual circuit breaker control.

The circuit breaker [status only] is used only for acquiring the circuit-breaker switch position. This type can be used to model switches that can only be read but not controlled by the SIPROTEC 5 device.

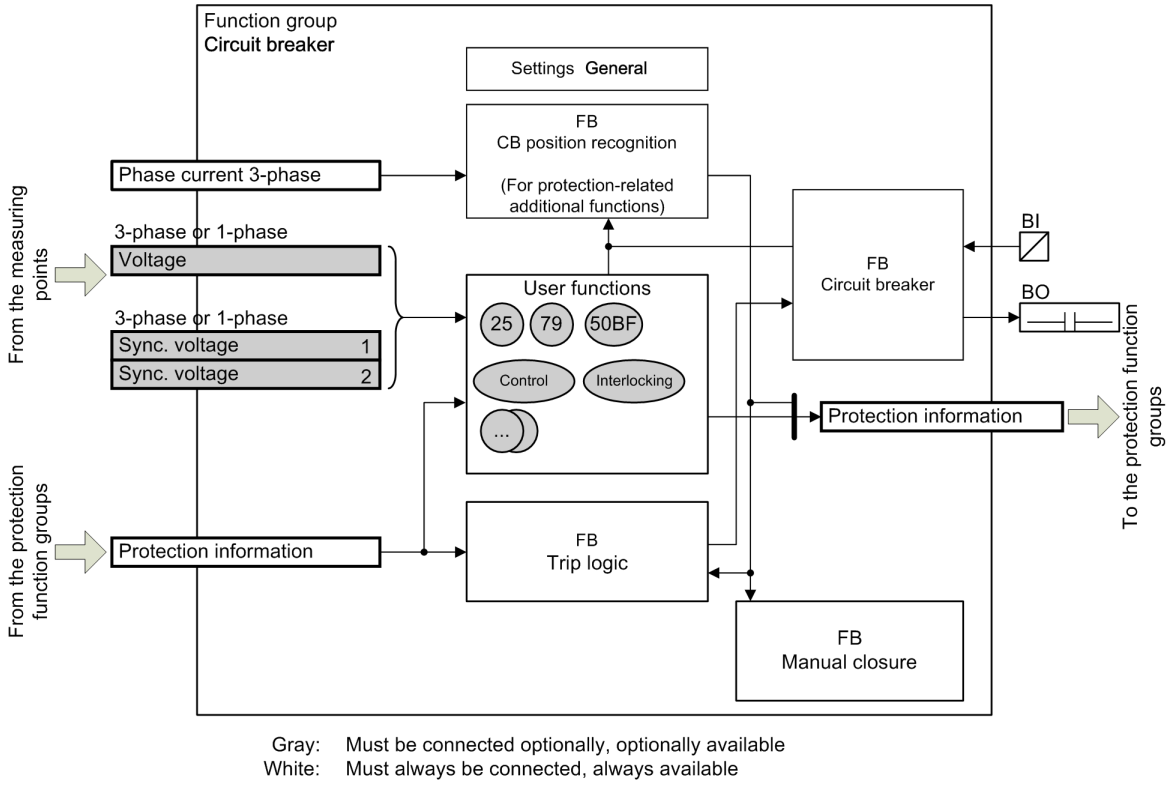
The available functions are described in the chapters *6 Protection and Automation Functions* and *8 Control Functions*.

5.7.2 Structure of the Function Group

Besides the user functions, the **Circuit-breaker** function group contains certain functionalities that are essential for general purposes and therefore cannot be loaded or deleted:

- Trip logic
- Mapping the physical circuit breaker
- Circuit-breaker position recognition for protection functions
- Detection of manual closure
- General settings

The following figure shows the structure of the **Circuit-breaker** function group. The individual function blocks in the image are described in the following chapters.



[dwfgstru-080812-01.tif, 1, en_US]

Figure 5-72 Structure of the Circuit-Breaker Function Group

The **Circuit-breaker** function group has interfaces with:

- **Measuring points**
- Protection function groups

Interfaces with Measuring Points

The function group contains the measured values needed from the measuring points associated with this function group.

If an application template is used, the function group is connected to the measuring point of the 3-phase current because this connection is essential. It can be necessary to connect additional measuring points to the function group, depending on the nature of the user functions used. Configuration is carried out using the **Function-group connections** editor in DIGSI 5. You can find more detailed information on this in chapter *2.1 Function Embedding in the Device*.

If a user function, for example, synchronization, is used in the function group but the required measuring point has not linked to it, DIGSI 5 reports an inconsistency. This inconsistency provides an indication of the missing measuring-point connection.

The **Circuit-breaker** function group has interfaces with the following measuring points:

- **`3-phase line current`**

  The measurands from the 3-phase power system are supplied via this interface. The function group must always be connected to this measuring point.

- **`Voltage`**

  The measurands of the 3-phase voltage system or 1-phase voltage are supplied via this interface. Depending on the connection type of the transformers, in the 3-phase voltage system these are, for example, V_A, V_B, V_C of the line or feeder.

  The connection to the corresponding measuring point is necessary only if a user function that needs the measurand of the 3-phase voltage system is used, for example, to make use of the **Synchronization** or **Automatic reclosing** function.

- **`Sync. Voltage1, Sync. Voltage2`**

  A 1-phase synchronization voltage (for example, voltage of the busbar with a 1-phase connection) or a 3-phase synchronization voltage (for example, voltage of the busbar with a 3-phase connection) is supplied via this interface.

  The connection to the corresponding measuring point is necessary only if synchronization is used.

Interface with Protection-Function Groups

All required data is exchanged between the Protection and Circuit-breaker function groups via the interface with the Protection function group. This data includes, for example, the pickup and operate indications of the protection functions sent in the direction of the Circuit-breaker function group and, for example, the circuit-breaker condition information in the direction of the protection function groups.

If an application template is used, the function groups are connected to each other because this connection is essential to ensure proper operation. You can modify the connection using the **Function-group connections** editor in DIGSI 5.

You can find more detailed information in chapter *2.1 Function Embedding in the Device*.

If the connection is missing, DIGSI 5 reports an inconsistency.

Besides the general assignments of the Protection function group or groups to the Circuit-breaker function groups, you can also configure the interface for certain functionalities in detail:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the **Automatic reclosing** function?
- Which protection functions activate the **Circuit-breaker failure protection** function?

You can find more detailed information in chapter *2.1 Function Embedding in the Device*.

5.7.3 Application and Setting Notes

Interface with Measuring Points

The interface with the 3-phase power system must have been configured. Otherwise, DIGSI 5 supplies an inconsistency message.

If the **Synchronization** function is used, the measuring points that represent voltages V1 and V2 of the parts of the electrical power system to be synchronized must be connected.

You can find more detailed information in the chapter *8.4 Synchronization Function* .

The **Automatic reclosing** function provides the auxiliary functions **Dead-line check** and **Reduced dead time**. For these auxiliary functions, the 3-phase voltage system has to be measured. If you want to use these auxiliary functions, the measuring point of the 3-phase voltage system must be connected to the **Voltage** function group interface. This connection is also necessary if the **Automatic reclosing function with adaptive dead time** function type is used.

Interface with Protection-Function Groups

The protection-function group is connected to 2 circuit breakers (2 **Circuit-breaker** function groups) for 1 1/2 circuit-breaker layouts.

Parameter: Rated Normal Current for % Values

- Default setting **(_:2311:101) Rated normal current** = ***1000 A***

With the **Rated normal current** parameter, you set the primary current which serves as a reference for all current-related % values within the Circuit-breaker function group. This applies both for operational measured values and for setting values in %.

Enter the primary rated current of the protected object here.

If the device works with the IEC 61850 protocol, then you change only the setting value of the parameter via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated Voltage for % Values

- Default setting **(_:2311:102) Rated voltage** = ***400 kV***

With the **Rated voltage** parameter, you set the primary voltage, which serves as a reference for all voltage-related % values within the Circuit-breaker function group. This applies both for operational measured values and for setting values in %.

Enter the primary rated voltage of the protected object (for example, the line) here.

If the device works with the IEC 61850 protocol, then you change only the setting value of the parameter via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Current Threshold Circuit Breaker Open

- Default setting **(_:2311:112) Current thresh. CB open** = ***0.10 A***

With the **Current thresh. CB open** parameter, you specify the threshold value below which the circuit-breaker pole or the circuit breaker is recognized as open.

Set the **Current thresh. CB open** parameter so that the current measured when the circuit-breaker pole is open will certainly fall below the parameterized value. If parasitic currents (for example, due to induction) are excluded with the line deactivated, you can make a secondary setting of the value with a high degree of sensitivity, to ***0.05 A*** for example.

If no special requirements exist, Siemens recommends retaining the setting value of ***0.10 A*** for secondary purposes.

5.7.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Ref. for %-values				
_:2311:101	General:Rated normal current		0.20 A to 100000.00 A	1000.00 A
_:2311:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV

Addr.	Parameter	C	Setting Options	Default Setting
Breaker settings				
_:2311:112	General:Current thresh. CB open	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2311:136	General:Op. mode BFP		• unbalancing • I> query	unbalancing
Trip logic				
_:5341:103	Trip logic:Reset of trip command		• with I< • with I<< & aux.contact • with dropout	with I<<
Circuit break.				
_:4261:101	Circuit break.:Output time		0.02 s to 1800.00 s	0.10 s
Manual close				
_:6541:101	Manual close:Action time		0.01 s to 60.00 s	0.30 s
Control				
_:4201:101	Control:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:4201:102	Control:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:4201:103	Control:Feedback monitoring time		0.01 s to 1800.00 s	1.00 s
_:4201:104	Control:Check switching authority		• no • yes • advanced	yes
_:4201:105	Control:Check if pos. is reached		• no • yes	yes
_:4201:106	Control:Check double activat. blk.		• no • yes	yes
_:4201:107	Control:Check blk. by protection		• no • yes	yes
Switching authority				
_:4201:151	Control:Swi.dev. related sw.auth.		• 0 • 1	false
_:4201:152	Control:Specific sw. authorities		• 0 • 1	true
_:4201:115	Control:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:4201:153	Control:Num. of specific sw.auth.		2 to 5	2
_:4201:155	Control:Ident. sw.auth. 1		Freely editable text	
_:4201:156	Control:Ident. sw.auth. 2		Freely editable text	
_:4201:157	Control:Ident. sw.auth. 3		Freely editable text	

Addr.	Parameter	C	Setting Options	Default Setting
_:4201:158	Control:Ident. sw.auth. 4		Freely editable text	
_:4201:159	Control:Ident. sw.auth. 5		Freely editable text	
_:4201:154	Control:Multiple specific sw.auth.		• 0 • 1	false
CB test				
_:6151:101	CB test:Dead time		0.00 s to 60.00 s	0.10 s

5.7.5 Information List

No.	Information	Data Class (Type)	Type
Trip logic			
_:5341:300	Trip logic:Trip indication	ACT	O
Circuit break.			
_:4261:500	Circuit break.:>Ready	SPS	I
_:4261:501	Circuit break.:>Acquisition blocking	SPS	I
_:4261:502	Circuit break.:>Reset switch statist.	SPS	I
_:4261:504	Circuit break.:>Reset AcqBlk&Subst	SPS	I
_:4261:503	Circuit break.:External health	ENS	I
_:4261:53	Circuit break.:Health	ENS	O
_:4261:58	Circuit break.:Position	DPC	C
_:4261:300	Circuit break.:Trip/open cmd.	SPS	O
_:4261:301	Circuit break.:Close command	SPS	O
_:4261:302	Circuit break.:Command active	SPS	O
_:4261:303	Circuit break.:Definitive trip	SPS	O
_:4261:304	Circuit break.:Alarm suppression	SPS	O
_:4261:306	Circuit break.:Op.ct.	INS	O
_:4261:307	Circuit break.:ΣI Brk.	BCR	O
_:4261:308	Circuit break.:ΣIA Brk.	BCR	O
_:4261:309	Circuit break.:ΣIB Brk.	BCR	O
_:4261:310	Circuit break.:ΣIC Brk.	BCR	O
_:4261:311	Circuit break.:Break.-current phs A	MV	O
_:4261:312	Circuit break.:Break.-current phs B	MV	O
_:4261:313	Circuit break.:Break.-current phs C	MV	O
_:4261:314	Circuit break.:Break. voltage phs A	MV	O
_:4261:315	Circuit break.:Break. voltage phs B	MV	O
_:4261:316	Circuit break.:Break. voltage phs C	MV	O
_:4261:322	Circuit break.:CB open hours	INS	O
_:4261:323	Circuit break.:Operating hours	INS	O
Manual close			
_:6541:501	Manual close:>Block manual close	SPS	I
_:6541:500	Manual close:>Input	SPS	I
_:6541:300	Manual close:Detected	SPS	O
Reset LED Group			
_:13381:500	Reset LED Group:>LED reset	SPS	I
_:13381:320	Reset LED Group:LED have been reset	SPS	O

No.	Information	Data Class (Type)	Type
Control			
_:4201:503	Control:>Sw. authority local	SPS	I
_:4201:504	Control:>Sw. authority remote	SPS	I
_:4201:505	Control:>Sw. mode interlocked	SPS	I
_:4201:506	Control:>Sw. mode non-interl.	SPS	I
_:4201:53	Control:Health	ENS	O
_:4201:58	Control:Cmd. with feedback	DPC	C
_:4201:302	Control:Switching auth. station	SPC	C
_:4201:308	Control:Enable sw. auth. 1	SPC	C
_:4201:309	Control:Enable sw. auth. 2	SPC	C
_:4201:310	Control:Enable sw. auth. 3	SPC	C
_:4201:311	Control:Enable sw. auth. 4	SPC	C
_:4201:312	Control:Enable sw. auth. 5	SPC	C
_:4201:313	Control:Switching authority	ENS	O
_:4201:314	Control:Switching mode	ENS	O
Interlocking			
_:4231:500	Interlocking:>Enable opening	SPS	I
_:4231:501	Interlocking:>Enable closing	SPS	I
_:4231:502	Interlocking:>Enable opening(fixed)	SPS	I
_:4231:503	Interlocking:>Enable closing (fixed)	SPS	I
_:4231:53	Interlocking:Health	ENS	O
CB test			
_:6151:53	CB test:Health	ENS	O
_:6151:301	CB test:Test execution	ENS	O
_:6151:302	CB test:Trip command issued	ENS	O
_:6151:303	CB test:Close command issued	ENS	O
_:6151:304	CB test:Test canceled	ENS	O
_:6151:311	CB test:3-pole open-close	SPC	C

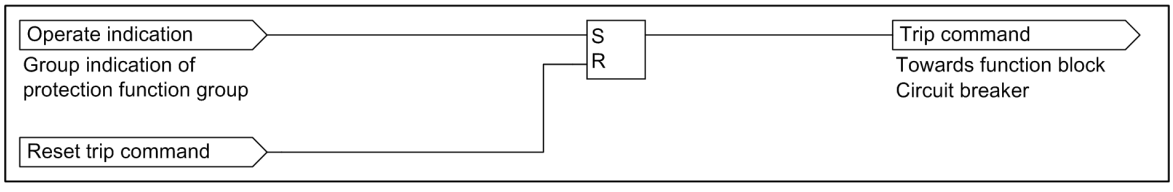
5.7.6 Trip Logic

5.7.6.1 Function Description

The **Trip logic** function block receives the group operate indication from the Protection function group or Protection function groups and forms the protection trip command that is transmitted to the **Circuit-breaker** function block.

The **Circuit-breaker** function block activates the device contact and thus causes the circuit breaker to open (see *5.7.7 Circuit Breaker*). The command output time is also effective here.

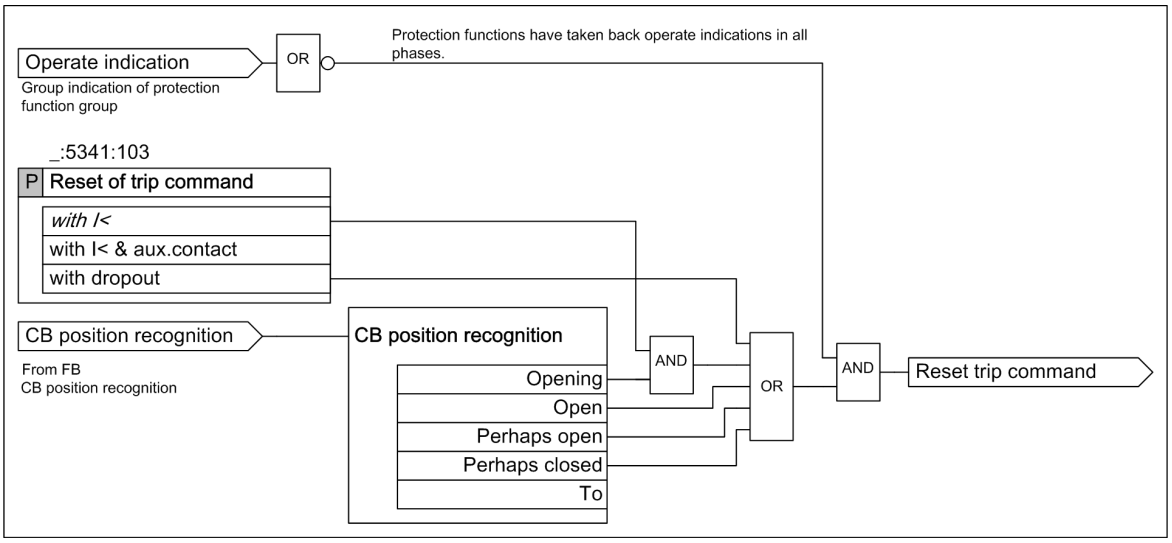
The trip logic also decides when the protection trip command is reset (see *Figure 5-74*).



[loausbef-140113-01.tif, 1, en_US]

Figure 5-73 Trip Command

Trip-Command Reset



[lobefe3p-140113-01.tif, 1, en_US]

Figure 5-74 Trip-Command Reset

Once a trip command is issued, it is stored (see *Figure 5-73*).

You determine the criteria for resetting a trip command that has been issued with the parameter **`Reset of trip command`**.

- **`with dropout`**

  The trip command is reset if the function that initiated tripping resets its operate indication. This occurs typically with dropout. Command reset of the trip command takes place regardless of verification of the circuit-breaker condition.

- **`with I<`**

- **`with I< & aux.contact`**

  For these criteria, the state of the circuit breaker is also taken into account as a further criterion in addition to the dropout of the tripping function (operate indication is reset by command). You can select whether the state is determined by means of the current (**`with I<`**) or by means of the current in conjunction with the circuit-breaker auxiliary contacts (**`with I< & aux.contact`**). The behavior of these setting options only differs in one situation of the circuit-breaker state. If the circuit breaker is in the **opening** state, the trip command is reset in the case of the option **`with I<`**, whereas it is not reset yet in the case of the option with **`with I< & aux.contact`**. The **opening** state is detected if the auxiliary contacts still detect the circuit breaker as being closed and opening is detected via the decreasing current flow.

  As long as the circuit breaker is detected unambiguously as closed (**fully closed**), the trip command will not be reset with these setting options.

  The information about the condition of the circuit breaker is supplied by the **Circuit-breaker position recognition** function block (see *5.7.8 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions*). The determination of the various conditions is also described in this chapter.

5.7.6.2 Application and Setting Notes

Parameter: Reset of trip command

- Recommended setting value **`(_:5341:103) Reset of trip command`** = ***`with I<`***

Parameter Value	Description
with I<	With this setting, the trip command is reset as soon as the current is removed, provided the tripping function has dropped out. The most important factor for recognition of the open circuit breaker is the current falling short of the value set in the parameter **(_:2311:112) Current thresh. CB open**.
with I< & aux.contact	For this setting not only the current has to be removed, but also the circuit-breaker auxiliary contact has to report that the circuit breaker is open. This setting assumes that the setting of the auxiliary contact has been routed via a binary input (for more information, see *5.7.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information*).
with dropout	The setting can be selected for special applications in which the trip command does not result in complete interruption of the current in every case. In this case, the trip command is reset if the pickup of the tripping protection function drops out. The setting is useful if the load current in the system cannot be interrupted during the protection device test and the test current is fed in parallel with the load current.

5.7.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Trip logic				
_:103	Trip logic:Reset of trip command		• with I< • with I< & aux.contact • with dropout	with I<

5.7.6.4 Information List

No.	Information	Data Class (Type)	Type
Trip logic			
_:300	Trip logic:Trip indication	ACT	O

5.7.7 Circuit Breaker

5.7.7.1 Overview

The **Circuit-breaker** function block represents the physical switch in the SIPROTEC 5 device.
The basic tasks of this function block are the operation of the circuit breaker and the acquisition of the circuit-breaker auxiliary contacts and other circuit-breaker information.
The **Circuit-breaker** function block provides information about:

- Number of switching cycles
- Breaking current, breaking voltage, and breaking frequency
- Summation breaking current

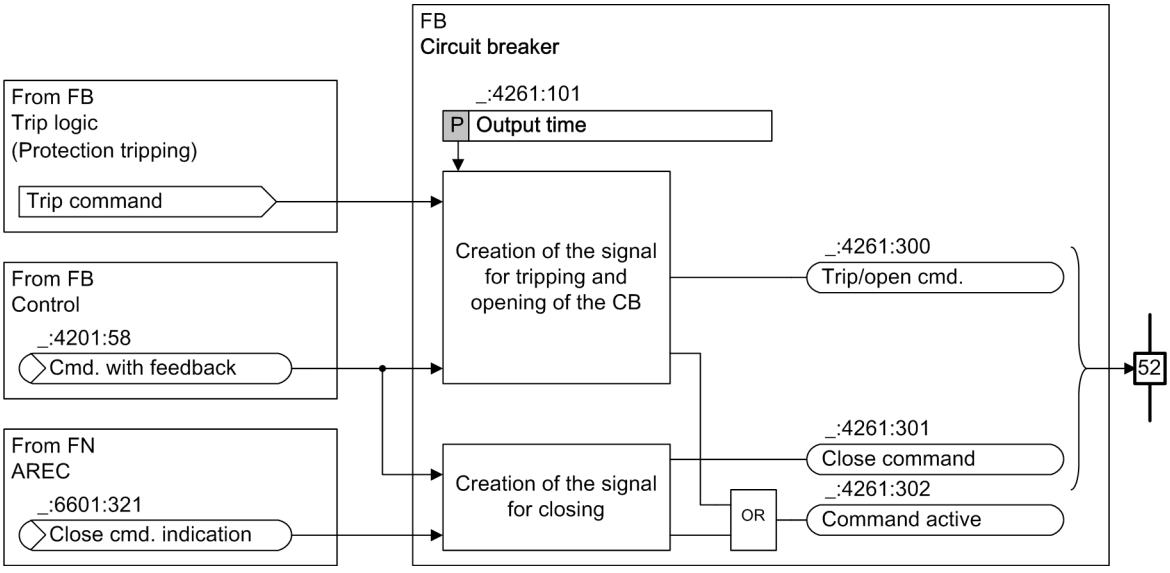
5.7.7.2 Tripping, Opening, and Closing the Circuit Breaker

The circuit breaker is operated in the following situations:

- Tripping of the circuit breaker as a result of a protection trip command
- Opening of the circuit breaker as a result of control operations
- Closing of the circuit breaker as a result of automatic reclosing or control operations

Tripping is always the result of a protection function. The operate indications of the individual protection functions are summarized in the **Trip logic** function block. The trip command that causes the tripping in the **Circuit breaker** function block is generated there.

To operate the circuit breaker, the **Circuit-breaker** function block provides the output signals that must be routed to the corresponding binary outputs of the device (see *Table 5-13*).



[loausssc-090211-01.tif, 1, en_US]

Figure 5-75 Tripping, Opening, and Closing the Circuit Breaker

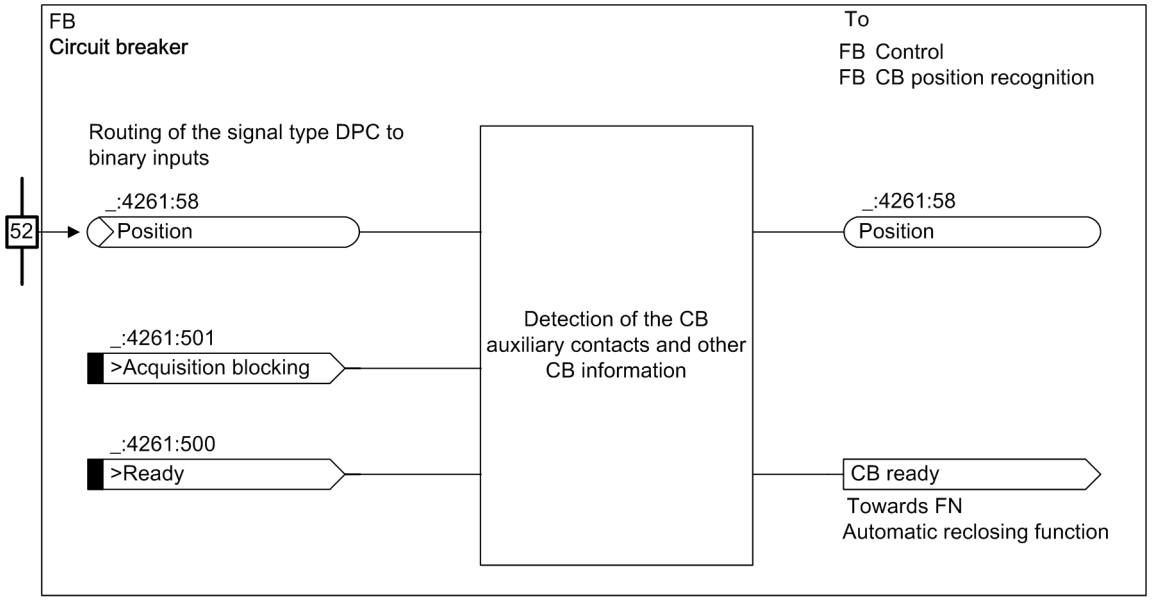
Table 5-13 Description of the Output Signals

Signal	Description	Routing Options
Trip/open cmd.	This signal executes all tripping and opening operations. The **Output time** parameter affects the signal. The signal is pending for the duration of this period, with the following exceptions: • Only when switched off by the control: The signal is canceled before expiration of the period if the auxiliary contacts report that the circuit breaker is open before expiration of the period. • Only in the event of protection tripping: The signal remains active as long as the trip command is still active after expiration of the period (see also *5.7.6.1 Function Description*). • Only in the event of protection tripping: With the routing option **Only saved in the event of tripping**, the signal remains pending until it is acknowledged manually. This only applies for protection tripping.	• Unlatched • Only saved in the event of protection tripping (not when opened)
Close command	This signal executes all closing operations. The **Output time** parameter affects the signal. The signal is pending for the duration of this period, with the following exception: The signal is canceled before expiration of the period if the auxiliary contacts report that the circuit breaker is closed before expiration of the period.	Normal routing
Command active	This signal is active as long as one of the binary outputs assigned to the signals **Trip/open cmd.** and **Close command** is active because a switching command is being executed by the control.	Normal routing

5.7.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information

To determine the circuit breaker position, the **Circuit-breaker** function block provides position signals (see next figure).

These signals are of the **Double-point indication** (DPC) type. A double-point indication can be routed to 2 binary inputs so that the open and closed circuit-breaker positions can be reliably acquired.



[loerfass-101210-01.tif, 1, en_US]

Figure 5-76 Acquisition of the Circuit-Breaker Information

Signal	Type	Description
Position	DPC	Acquisition of the circuit-breaker position The position **3-pole circuit breaker open** and/or the position **3-pole circuit breaker closed** can be acquired by routing to 1 or 2 binary inputs.

The signals must be routed to the binary input that is connected with the CB auxiliary contacts. The **open** and **closed** signals do not necessarily have to be routed in parallel. The advantage of parallel routing is that it can be used to determine an intermediate or disturbed position. On the other hand, this is not possible if only one signal is routed.

In the monitoring direction, the position signals generate the following information when the **open** and **closed** positions are acquired (see following table). This information is further processed by the **Circuit-breaker position recognition** and **Control** function blocks.

Information	Type	Description
Off	SPS	Circuit-breaker position is **opened**.
On	SPS	Circuit-breaker position is **closed**.
Intermediate position	SPS	Circuit-breaker position is in **intermediate position**.
Disturbed position	SPS	Circuit-breaker position is in **disturbed position**.
Not selected	SPS	The circuit breaker is **not selected** for a control operation.

Other input signals are:

Signal	Type	Description
>Acquisition blocking	SPS	This is used to activate acquisition blocking of the circuit-breaker auxiliary contacts (see Other Functions *3.8.3 Persistent Commands* for a description of acquisition blocking).

Signal	Type	Description
>Reset AcqBlk&Subst	SPS	This is used to reset acquisition blocking and manual update of the circuit breaker. Setting acquisition blocking and tracking is blocked with the input activated.
>Ready	SPS	The active signal indicates that the circuit breaker is ready for an **OFF-ON-OFF cycle**. The signal remains active as long as the circuit breaker is unable to trip. The signal is used in the **Automatic reclosing** and **Circuit-breaker test** functions.

Another output signal is:

External health	SPS	This can be used to indicate the health of the physical circuit breaker. For this, you must acquire any failure information for the circuit breaker via a binary input. This failure information can set the appropriate state of the **External health** signal with a CFC chart (using the **BUILD_ENS** block). The signal has no effect on the health of the function block.

5.7.7.4 Definitive Tripping, Circuit-Breaker Tripping Alarm Suppression

Definitive Tripping

Definitive tripping is always pending whenever the **Automatic reclosing (AREC)** function does not carry out any reclosing after tripping. It follows that this is the case whenever an automatic reclosing is not present or the AREC has been switched off.

Circuit-Breaker Tripping Alarm Suppression

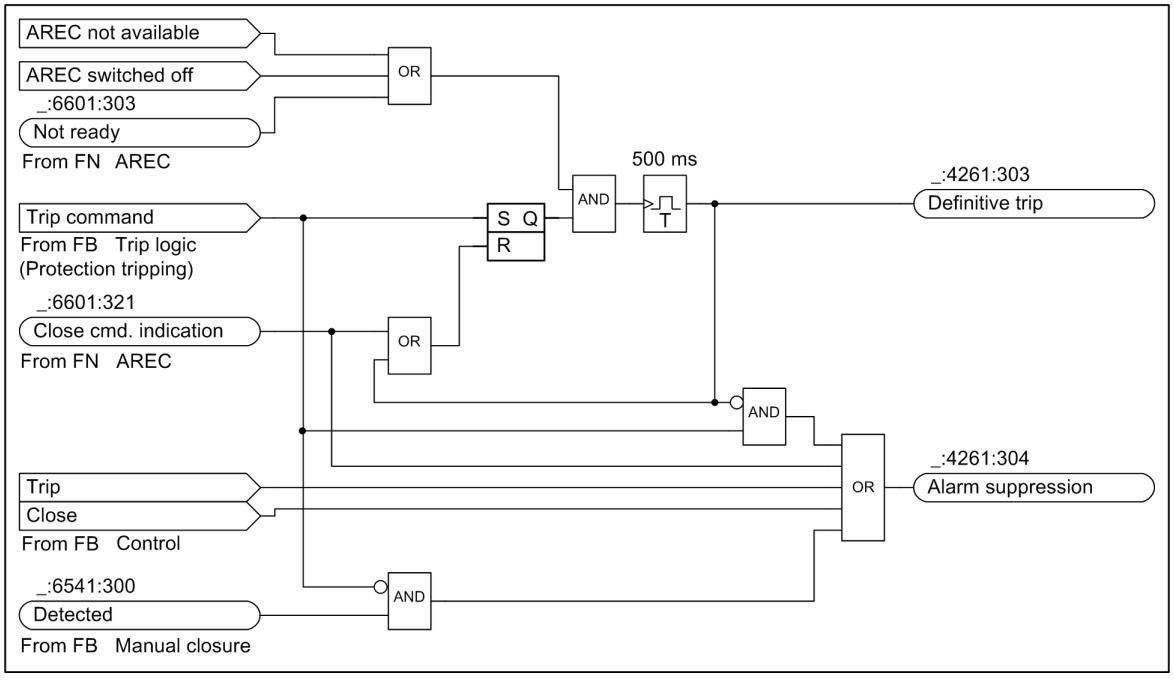
In certain systems, the user may wish to actuate an alarm (for example, a horn) when tripping (circuit-breaker tripping) occurs. This alarm should not to be issued if the circuit breaker is to be reclosed automatically after tripping or if it is to be closed or opened via the control. The alarm is only to be issued in the event of final tripping.

Depending on how the alarm is generated (for example, triggered by a fleeting contact of the circuit breaker), the **Alarm suppression** signal can be used to suppress the alarm.

The signal is generated if:

- A definitive protection tripping is not present
- The automatic reclosing function executes a closure
- The integrated control executes a closure or opening action
- External closing is detected via the **Manual close** function

For further information about its use, please refer to *5.7.9.2 Application and Setting Notes* .

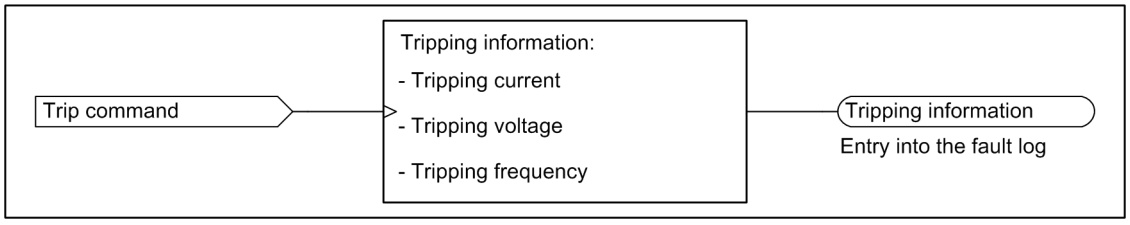


[lounterd-100611-01.tif, 1, en_US]

Figure 5-77 Definitive Tripping, Circuit-Breaker Tripping Alarm Suppression

5.7.7.5 Tripping and Opening Information

When a trip command is issued, the tripping information shown in the next figure is saved in the fault log.



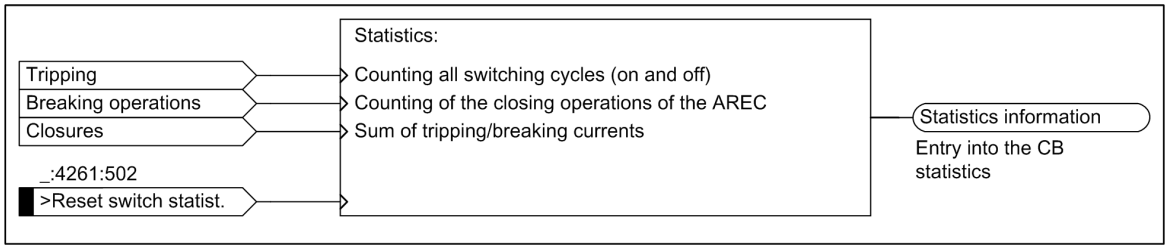
[loausloe-081210-01.tif, 1, en_US]

Figure 5-78 Tripping Information

The following statistics information is saved for the circuit breaker:

- Number of switching cycles:
  All tripping, opening, and closing operations are counted.
- Number of closing operations by the automatic reclosing function
- Total of tripping and breaking currents

The statistics information can be individually set and reset via the device control. It is also possible to reset all values via the binary input signal **>Reset switch statist.**.



[lostatis-140113-01.tif, 1, en_US]

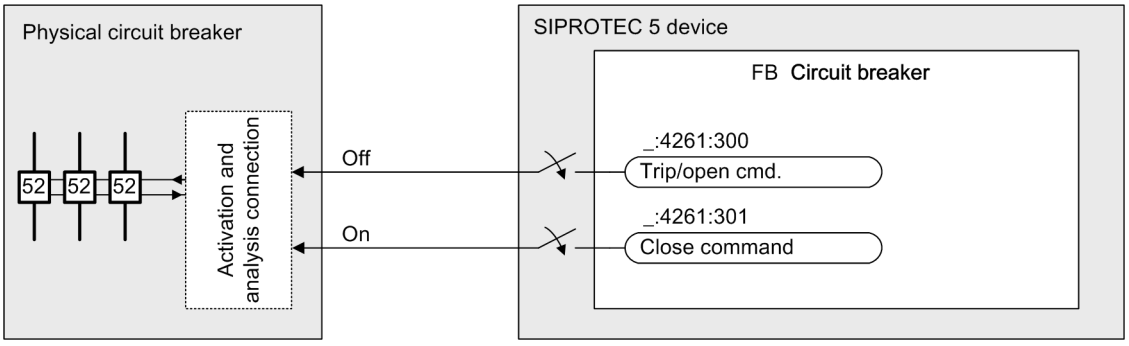
Figure 5-79 Statistics Information About the Circuit Breaker

5.7.7.6 Application and Setting Notes

Routings for Activation of the Circuit Breaker

Figure 5-80 shows the necessary routings:

- The device can execute 3-pole tripping (via the protection device).
- The device can execute 3-pole opening (via the control).
- The device can execute 3-pole closing (via AREC or via the control).



[loansteu-230311-01.tif, 1, en_US]

Figure 5-80 Activation of the Circuit Breaker

By routing the **`Trip/open cmd.`** signals to 1 or 2 binary outputs, you can carry out 1, 1.5, and 2-pole activations of the circuit breaker. You will find a detailed description of this in *8.2.2.3 Connection Variants of the Circuit Breaker*.

NOTE

Do not confuse these 1-pole, 1.5-pole, and 2-pole activations of the circuit breaker with 1-pole or 3-pole tripping of the circuit breaker.

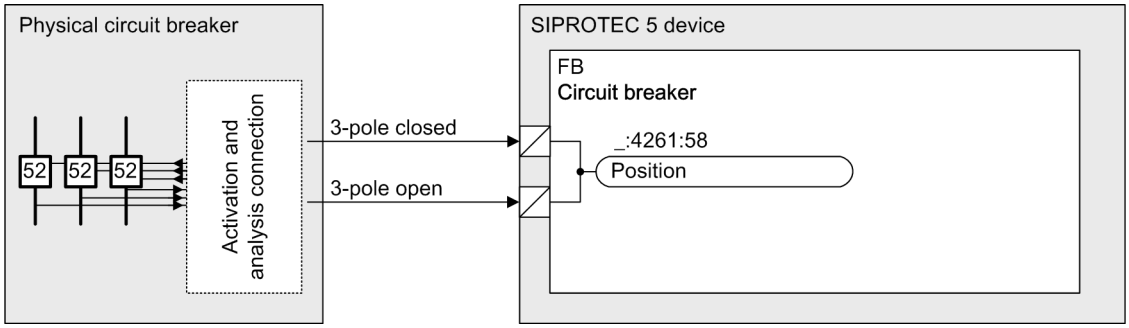
Routing for Analysis of the Circuit-Breaker Switch Position

For certain functions of the device, it is useful to detect the circuit-breaker switch position via its auxiliary contacts. These are for example:

- **Circuit-breaker position recognition** function block
- **Circuit-breaker failure protection** function
- **Control** function block

The operating principle of the auxiliary contacts is described in the individual functions.

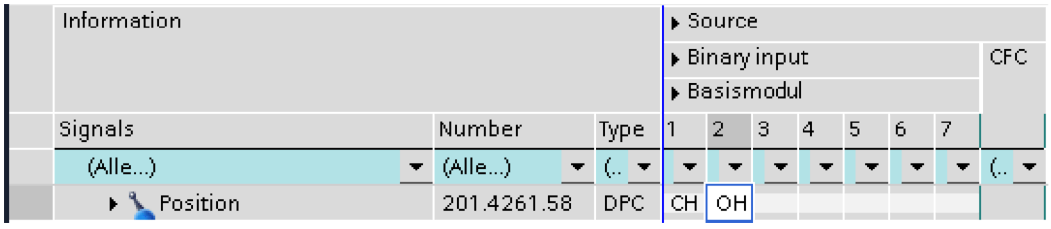
Siemens recommends capturing the *`Circuit breaker is open in 3 poles`* and *`Circuit breaker is closed in 3 poles`* information via auxiliary contacts. This is the optimal configuration for the control functionality. For purely protection applications, it is also enough to capture just one of the 2 circuit-breaker positions.



[loauswer-230311-01.tif, 1, en_US]

Figure 5-81 Recommended Analysis of the Circuit-Breaker Switch Position when Used as a Protection and Control Device

The following diagram shows the recommended routing, in which **H** stands for **active with voltage**.



[scpolg3p-230311-01.tif, 1, en_US]

Figure 5-82 Routing for Acquisition of the Circuit-Breaker Switch Position via 2 Auxiliary Contacts

The device can also function without the analysis from the circuit-breaker auxiliary contacts, that is, routing of the auxiliary contacts is not absolutely necessary. However, this is a requirement for control functions.

Parameter: Output time

- Default setting **(_:101) Output time** = ***0.10 s***

The **Output time** parameter acts on the signals for tripping, opening, and closing of the circuit breaker.

CAUTION

Do not set a time that is too short.

If you set a time that is too short, there is a danger that the device contacts will interrupt the control circuit. If this happens, the device contacts will burn out.

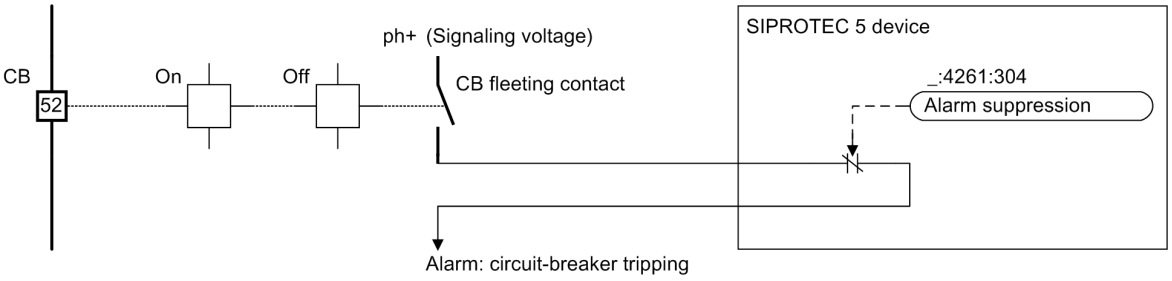
✧ Set a time that is long enough to ensure that the circuit breaker reliably reaches its final position (**open** or **closed**) after a control operation.

Output Signal: Indication Suppression

Whereas in the case of feeders without an automatic reclosing function every trip command is final due to a protection function, the use of an automatic reclosing function should only cause the motion detector of the circuit breaker (fleeting contact on the circuit breaker) to trigger an alarm if tripping of the circuit breaker is definitive (see next figure for more details). Likewise, a tripping alarm should not be triggered for switching operations by the control.

For this, the alarm activation circuit should be looped via a suitably routed output contact of the device (output signal **Alarm suppression**). In the idle state and when the device is switched off, this contact is permanently closed. For this, an output contact with a break contact must be routed. The contact opens whenever the output signal **Alarm suppression** becomes active, so that tripping or a switching operation

does not cause an alarm (see the logic in *5.7.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information* for more details).



[loschalt-081210-01.tif, 1, en_US]

Figure 5-83 Circuit-Breaker Tripping Alarm Suppression

5.7.7.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Circuit break.				
_:101	Circuit break.:Output time		0.02 s to 1800.00 s	0.10 s

5.7.7.8 Information List

No.	Information	Data Class (Type)	Type
Circuit break.			
_:500	Circuit break.:>Ready	SPS	I
_:501	Circuit break.:>Acquisition blocking	SPS	I
_:502	Circuit break.:>Reset switch statist.	SPS	I
_:504	Circuit break.:>Reset AcqBlk&Subst	SPS	I
_:503	Circuit break.:External health	ENS	I
_:53	Circuit break.:Health	ENS	O
_:58	Circuit break.:Position	DPC	C
_:300	Circuit break.:Trip/open cmd.	SPS	O
_:301	Circuit break.:Close command	SPS	O
_:302	Circuit break.:Command active	SPS	O
_:303	Circuit break.:Definitive trip	SPS	O
_:304	Circuit break.:Alarm suppression	SPS	O
_:306	Circuit break.:Op.ct.	INS	O
_:307	Circuit break.:ΣI Brk.	BCR	O
_:308	Circuit break.:ΣIA Brk.	BCR	O
_:309	Circuit break.:ΣIB Brk.	BCR	O
_:310	Circuit break.:ΣIC Brk.	BCR	O
_:311	Circuit break.:Break.-current phs A	MV	O
_:312	Circuit break.:Break.-current phs B	MV	O
_:313	Circuit break.:Break.-current phs C	MV	O
_:314	Circuit break.:Break. voltage phs A	MV	O
_:315	Circuit break.:Break. voltage phs B	MV	O
_:316	Circuit break.:Break. voltage phs C	MV	O
_:322	Circuit break.:CB open hours	INS	O
_:323	Circuit break.:Operating hours	INS	O

5.7.8 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions

5.7.8.1 Overview

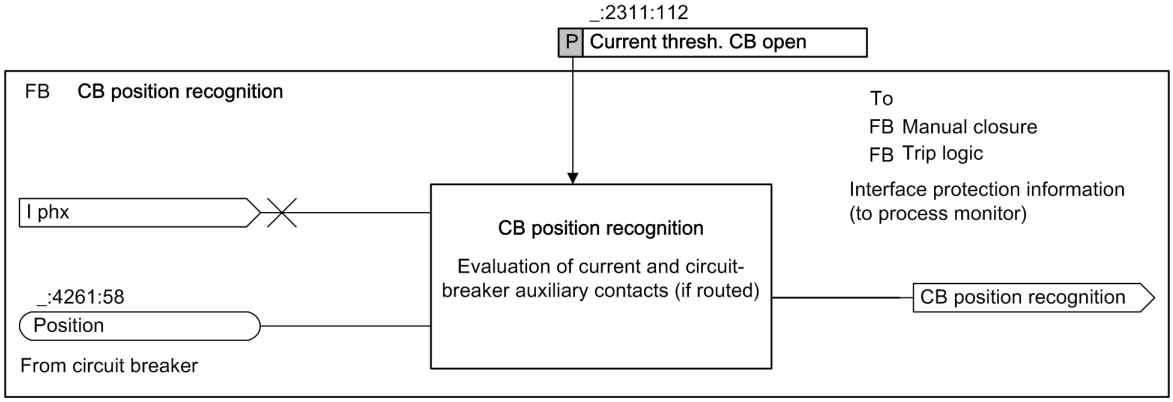
This function block calculates the position of the circuit breaker from the evaluation of the auxiliary contacts and the current flow.

This information is needed in the following protection-related additional functions:

- Trip logic (see *5.7.6.1 Function Description*)
- Detection of manual closing (see *5.7.9.1 Function Description*)
- Process monitor (Standard V/I) *5.8 Process Monitor*)

Its use is described in the respective chapters.

The control does not use this information. The control evaluates the circuit-breaker auxiliary contacts.



[lozust3p-070611-01.tif, 1, en_US]

Figure 5-84 Overview of the Circuit-Breaker Condition Position Function

Based on the link between the information from the auxiliary contacts and the current flow, the circuit breaker can assume the following positions:

Circuit-Breaker Condition	Description
Open	The circuit-breaker pole is detected unambiguously as **open** according to both criteria.
Closed	The circuit-breaker pole is detected unambiguously as **closed** according to both criteria.
Possibly open, possibly closed	These conditions can occur if the information is incomplete due to the routing of the auxiliary contacts and the condition can no longer be determined reliably. These **uncertain conditions** are evaluated differently by certain functions.
Opening	This is a dynamically occurring condition that results when, while a trip command is active and the auxiliary contact is still closed, the current is detected to have fallen below the threshold value because the current-flow criterion takes effect faster than the auxiliary contact can open.

5.7.9 Detection Manual Closure (for AREC and Process Monitor)

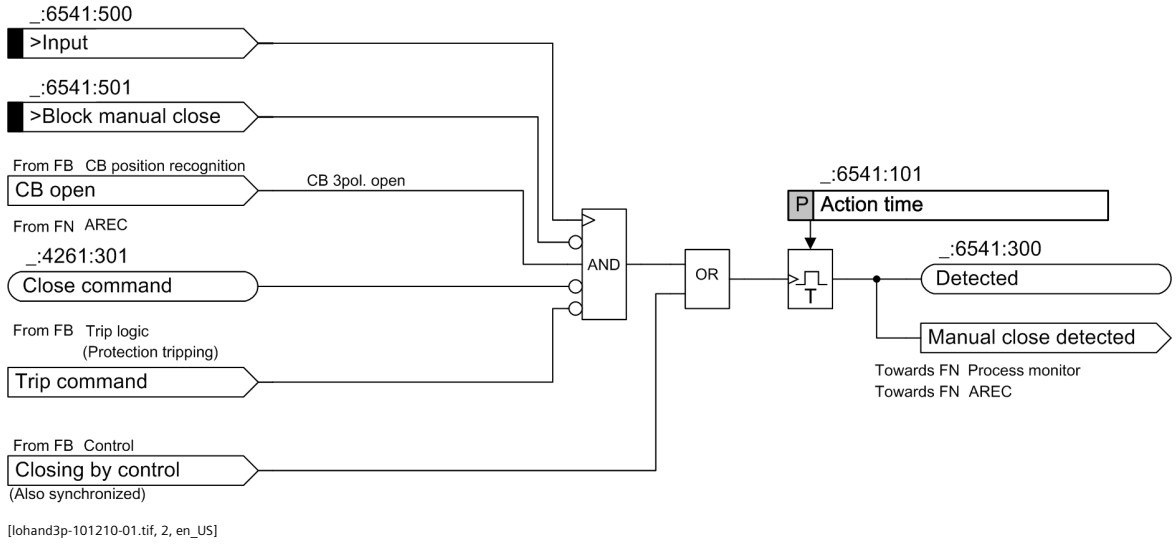
5.7.9.1 Function Description

Detection of Manual Closure (for AREC and Process Monitor)

The **Manual closure** function block detects any closure carried out by hand. This information is used in function, the **automatic reclosing (AREC)** and **Process monitor** (functions (within protection function groups).

You will find detailed information in the chapters Automatic reclosing function and Process monitor.

The following figure shows the logic for manual closure detection.



[lohand3p-101210-01.tif, 2, en_US]

Figure 5-85 Logic for Manual Closure Detection

External Manual Closure

An external manual closure is communicated to the device via the input signal **>Input**. The input signal can also be connected directly to the control circuit of the circuit-breaker closing coil. For this reason, detection is suppressed in the event of a close command by the AREC function. Detection via the input signal **>Input** is also blocked if the circuit breaker is closed or if a protection trip is active.

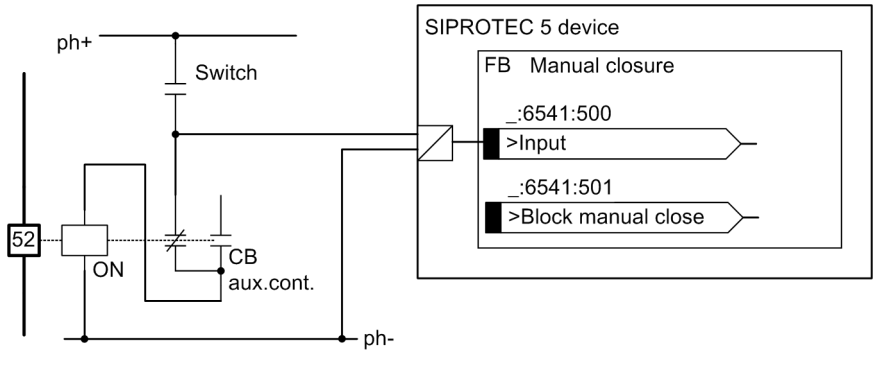
Internal Manual Closure

Manual closure is detected in all cases if a close command is transmitted by the internal control function of the device. This is possible because the control carries out plausibility checks itself and is also subject to interlocking.

5.7.9.2 Application and Setting Notes

Input Signals: >Input, >Blocking of Manual Closure

In practice, the input signal **>Input** is connected directly to the control circuit of the circuit-breaker closing coil (see following figure).



[losteuer-150113-01.tif, 1, en_US]

Figure 5-86 Connection of the Input Signal to the Control Circuit of the Circuit-Breaker Closing Coil

Every closure of the circuit breaker is recorded in the process. Therefore, detection is suppressed in the event of a close command by the internal AREC function of the device.

If external close commands are possible (actuation of the circuit breaker by other devices), which are not intended to prompt detection of a manual closure (for example, with an external reclosing device), this can be ensured in 2 ways:

- The input signal is connected in such a way that it is not activated in the event of external close commands.
- The external close command is connected to the blocking input **>Block manual close** for manual closure detection.

Parameter: Action time

- Recommended setting value **(_:101) Action time** = ***300 ms***

In order to ensure independence from manual activation of the input signal, the detection function is extended for a defined length of time using the parameter **Action time**.

Siemens recommends an action time of ***300 ms***.

5.7.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Manual close				
_:101	Manual close:Action time		0.01 s to 60.00 s	0.30 s

5.7.9.4 Information List

No.	Information	Data Class (Type)	Type
Manual close			
_:501	Manual close:>Block manual close	SPS	I
_:500	Manual close:>Input	SPS	I
_:300	Manual close:Detected	SPS	O

5.8 Process Monitor

5.8.1 Overview of Functions

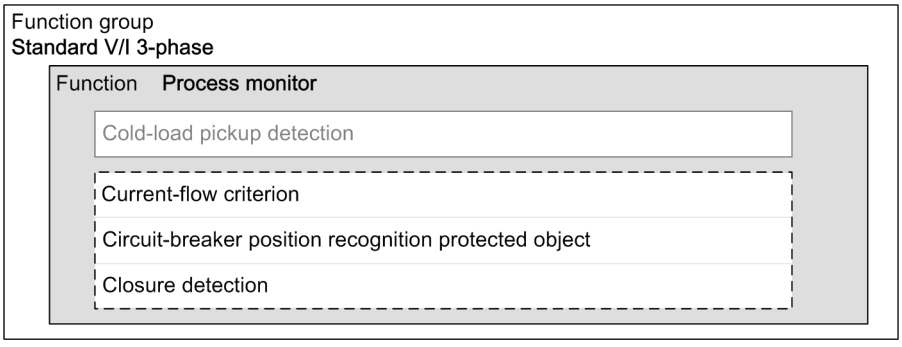
All function groups that have functions with dependencies on the state of the protected object contain a process monitor. The process monitor detects the current state of the protected object.

5.8.2 Structure of the Function

The **Process monitor** function is used in the **Standard V/I 3-phase** protection function group.

The **Process monitor** function is provided by the manufacturer with the following function blocks:

- Cold-load pickup detection (optional)
- Current-flow criterion
- Circuit-breaker condition
- Closure detection

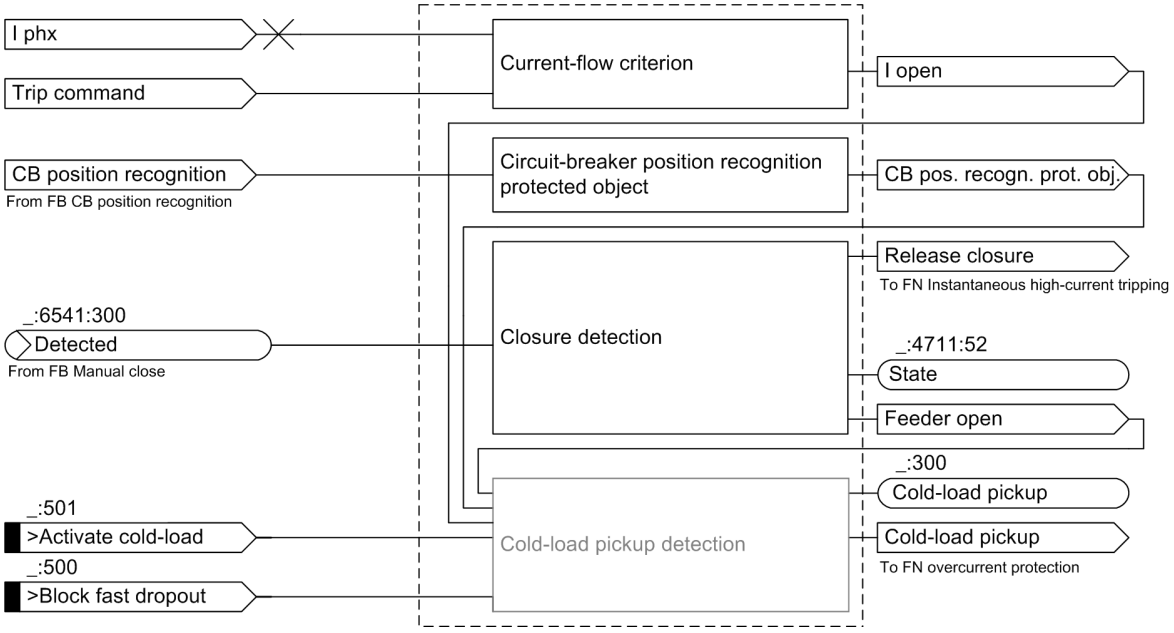


[dwpro3pt-061212-01.tif, 2, en_US]

Figure 5-87 Structure/Embedding of the Function

You can activate the cold-load pickup detection as needed. All other stages of the process monitor run permanently in the background and are not displayed in DIGSI.

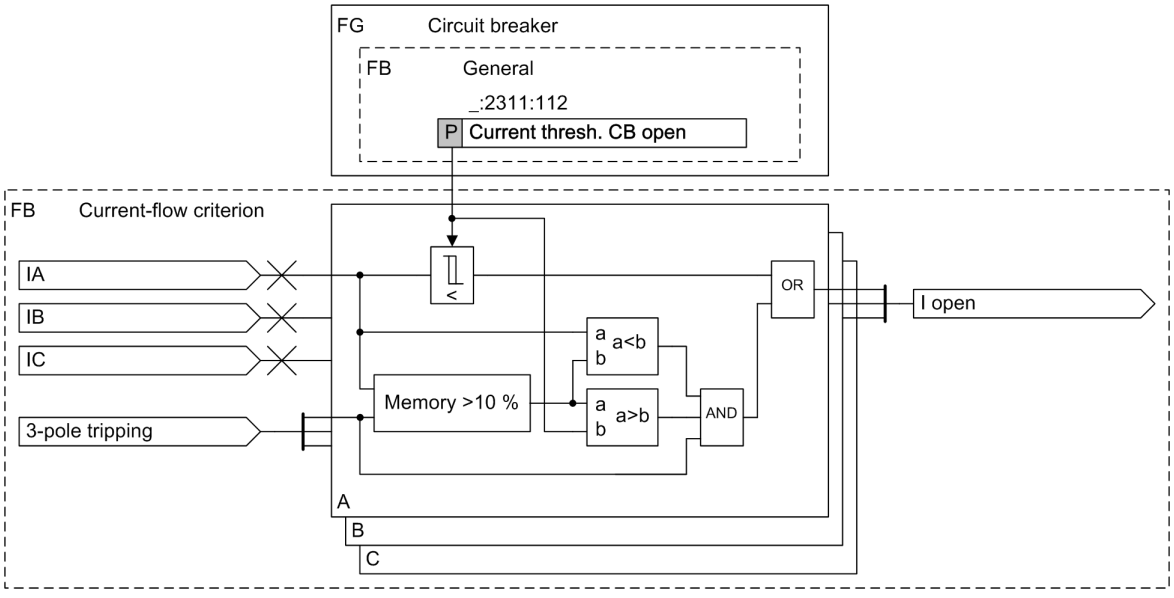
The following figure shows the relationships of the individual function blocks.



[lopro3pt-171012-01.tif, 2, en_US]

Figure 5-88 Logic Diagram of the Overall Function Process Monitor

5.8.3 Current-Flow Criterion



[loproikr-011112-01.tif, 1, en_US]

Figure 5-89 Logic Diagram of the Current-Flow Criterion Function Block

The **I open** signal of one phase is generated if one of the following conditions is met:

- A phase current falls below the set threshold of the **Current thresh. CB open** parameter. The hysteresis stabilizes the signal.
- The corresponding phase current, for example, **I A**, falls below 10 % of the phase current when the trip command arrives. If the current does not drop until after a delay due to current transformer influences, an open pole can therefore be detected quickly even after a high-current fault on the line.

With the **Current thresh. CB open** parameter, you define the minimum current as the criterion for a deactivated line. The parameter lies in the **Circuit-breaker** function group. It acts both in the **Circuit-breaker** function group, for example circuit-breaker position recognition, and also for the process monitor in the Protection-function group.

5.8.4 Application and Setting Notes (Current-Flow Criterion)

Parameter: Current thresh. CB open

- Recommended setting value **(_:2311:112) Current thresh. CB open** = ***0.100 A***

The **Current thresh. CB open** parameter is used to define the threshold for the leakage current as the criterion for a deactivated line.

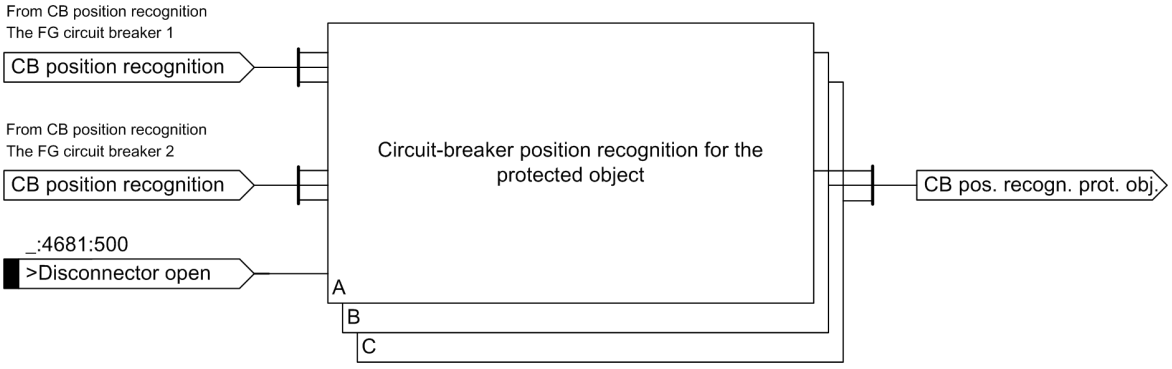
Set the **Current thresh. CB open** parameter so that the current measured when the feeder is deactivated falls below the value of the **Current thresh. CB open** parameter with certainty. The hysteresis is additionally active if the threshold is exceeded.

If parasitic currents, for example, due to induction, are ruled out when the feeder is deactivated, set the **Current thresh. CB open** parameter sensitively.

Siemens recommends a setting value of ***0.100 A***.

5.8.5 Circuit-Breaker Condition for the Protected Object

Logic



[loprolsz-140611-01.tif, 2, en_US]

Figure 5-90 Logic Diagram of the Circuit-Breaker Condition for the Protected-Object Function Block

The circuit-breaker position recognition in the **Circuit breaker** (CB) function group provides the circuit-breaker condition by way of the internal signal *CB pos. recogn. prot. obj.*.

If a protected object is supplied via 2 circuit breakers (CBs), for example with the 1 1/2 circuit-breaker layout, then the circuit-breaker switch position of the protected object must be determined with the aid of both circuit breakers. In this case, the **Circuit-breaker position recognition for the protected object** function block connects the individual CB states. The connection provides the internal *CB pos. recogn. prot. obj.* signal to the other function blocks of the process monitor and to other functions, for example, **Trip in the event of weak infeed** and **Echo function for teleprotection method**, within the same function group.

If one of the following 2 conditions is met, the *CB pos. recogn. prot. obj.* signal is in the ***Open*** state:

- All connected circuit breakers signal the ***Open*** state internally.
- The **>Disconnector open** input is active.

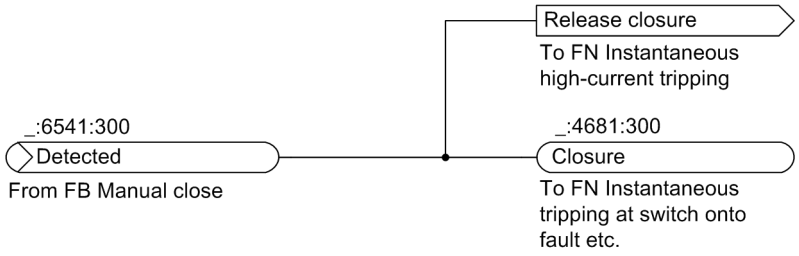
If the following 2 conditions are met, the *CB pos. recogn. prot. obj.* signal is in the ***Closed*** state:

- At least one of the connected circuit breakers signals the ***Closed*** state internally.
- The **>Disconnector open** input is not active.

5.8.6 Closure Detection

The closure detection enables the immediate tripping of selected protection functions or protection stages when switching to short circuit or the reduction of the responsivity. The closure detection determines whether the protected object is switched on.

Logic



[loein6md-171012-01.tif, 1, en_US]

Figure 5-91 Logic Diagram of Closure Detection

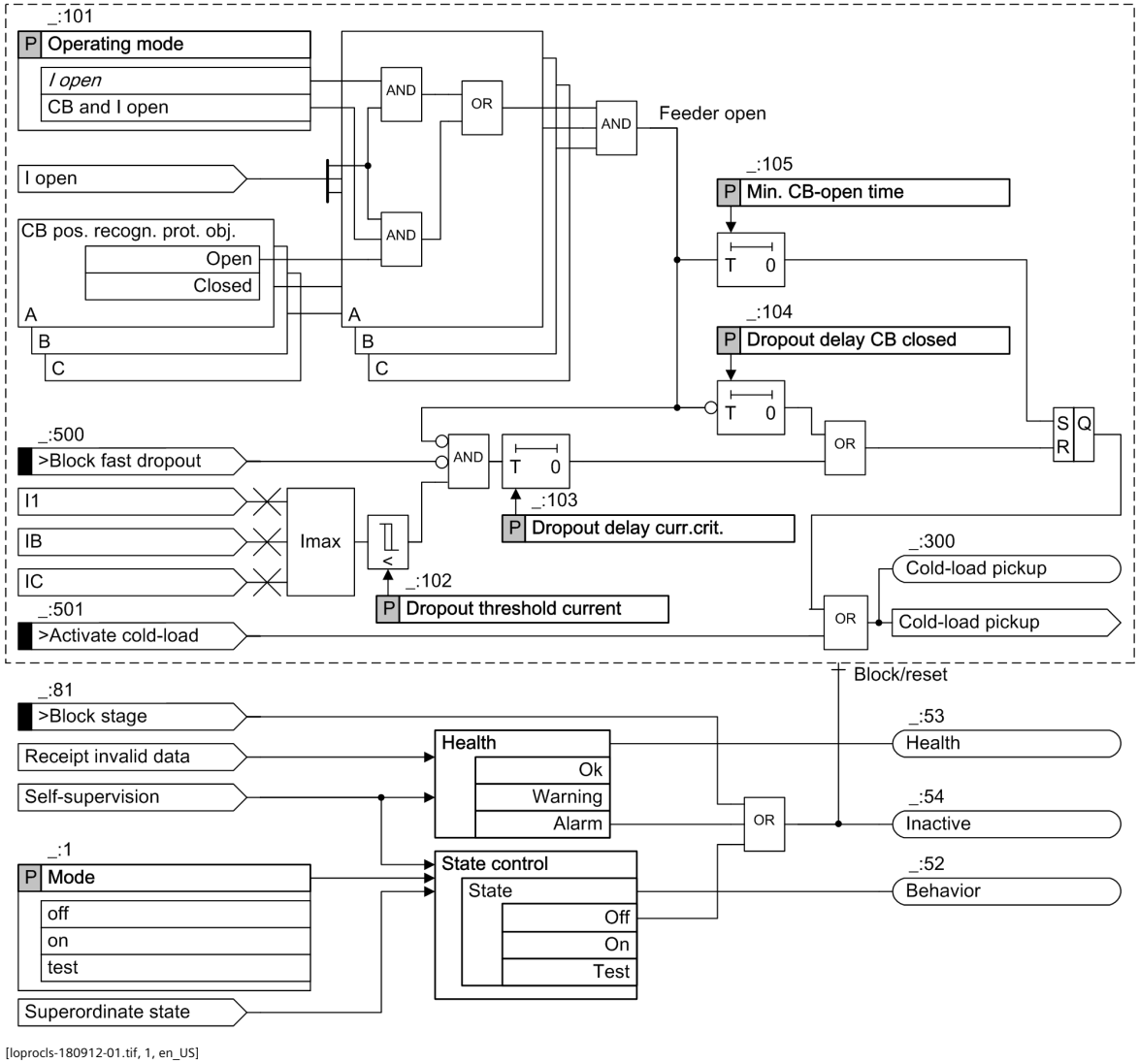
For an applied binary input signal **`Detected`** (from Manual close function block), the indication **`Closure`** is active.

5.8.7 Information List

No.	Information	Data Class (Type)	Type
`Closure detec.`			
_:4681:500	Closure detec.:>Disconnector open	SPS	I
_:4681:300	Closure detec.:Closure	SPS	O

5.8.8 Cold-Load Pickup Detection (Optional)

Logic



[loprocls-180912-01.tif, 1, en_US]

Figure 5-92 Logic Diagram of the Cold-Load Pickup Detection Function Block

The **Cold-load pickup detection** function block detects that a specific time has been exceeded after deactivation of the line or protected object. If you want to connect the protected object again, you must note that an increased load-current requirement exists for a limited time after connection. This results from the nature of the load.

The **Cold-load pickup detection** function block ensures that different parameters are used for an adjustable time after connection. For example, for the time of the **`Min. CB-open time`** parameter, you can increase the threshold value of a protection function or you can select a special characteristic curve.

If the **Cold-load pickup detection** function block detects an open feeder and the set time of the **`Min. CB-open time`** parameter has expired, the indication **`>Activate cold-load`** is generated.

With the **`>Activate cold-load`** indication, you can activate a parameter set of the **Cold-load pickup** function. Via the binary input signal **`>Activate cold-load`**, you can also activate the **`>Activate cold-load`** indication directly.

If the **Cold-load pickup detection** function block detects closure and the corresponding load current, it starts the time set in the **`Dropout delay CB closed`** parameter. The **`>Activate cold-load`** indication and the activated parameter set are deactivated after this time has elapsed.

If, for the time set in the **Dropout delay curr.crit.** parameter, the maximum phase current falls below the threshold value **Dropout threshold current**, the parameter set for the **Cold-load pickup detection** function block is also deactivated. As a result, if the load current is very low, the action time **Dropout delay curr.crit.** of the **>Activate cold-load** indication can be shortened.

5.8.9 Application and Setting Notes (Cold-Load Pickup Detection)



NOTE

The settings and indications described in this chapter are only available when using the optional **Cold-load pickup detection** function block.

Parameter: Operating mode

- Default setting **(_:101) Operating mode** = ***I open***

With the **Operating mode** parameter, you set the criteria with which the Closure-detection function block operates.

Parameter Value	Description
I open	When the Current-flow criterion function block detects a clearing open condition, the decision is made for pickup. For this setting, make sure that the **Current thresh. CB open** parameter is set lower than the possible load current. If this is not the case, open is detected continuously and each fault current that exceeds the **Current thresh. CB open** parameter is interpreted as closure.
CB and I open	Closure is detected if one of the following conditions is met: • Analysis of the circuit-breaker auxiliary contact detects a clearing open condition in at least one phase. • The current-flow criterion detects a clearing open condition.

Parameter: Dropout threshold current

- Default setting **(_:102) Dropout threshold current** = ***1.00 A***

With the **Dropout threshold current** parameter, you set the threshold at which the output signal **Cold-load pickup** is deactivated when the current in at least one phase falls below this threshold.

Parameter: Dropout delay current criterion

- Default setting **(_:103) Dropout delay curr.crit.** = ***600 s***

With the **Dropout delay curr.crit.** parameter, you set the time for which the actual value must be below the **Dropout threshold current** threshold so that the output signal **Cold-load pickup** can be deactivated prematurely.

Parameter: Dropout delay CB closed

- Default setting **(_:104) Dropout delay CB closed** = ***3600 s***

With the **Dropout delay CB closed** parameter, you set the action time for the dynamic parameter set switching in the event of cold-load pickup detection.

Parameter: Min. CB open time

- Default setting **(_:105) Min. CB-open time** = ***3600 s***

With the **Min. CB-open time** parameter, you set the time after which the dynamic parameter set is activated in the event of **cold-load pickup** when the line is opened.

5.8.10 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Cold-load PU				
_:1	Cold-load PU:Mode		• off • on • test	off
_:101	Cold-load PU:Operating mode		• I open • CB and I open	I open
_:102	Cold-load PU:Dropout threshold current	1 A @ 100 Irated	0.030 A to 10.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 50.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 10.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 50.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:103	Cold-load PU:Dropout delay curr.crit.		1 s to 600 s	600 s
_:104	Cold-load PU:Dropout delay CB closed		1 s to 21600 s	3600 s
_:105	Cold-load PU:Min. CB-open time		0 s to 21600 s	3600 s

5.8.11 Information List

No.	Information	Data Class (Type)	Type
Cold-load PU			
_:81	Cold-load PU:>Block stage	SPS	I
_:500	Cold-load PU:>Block fast dropout	SPS	I
_:501	Cold-load PU:>Activate cold-load	SPS	I
_:54	Cold-load PU:Inactive	SPS	O
_:52	Cold-load PU:Behavior	ENS	O
_:53	Cold-load PU:Health	ENS	O
_:300	Cold-load PU:Cold-load pickup	SPS	O

6 Protection and Automation Functions

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6.28	Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage	703
6.29	Undervoltage Protection with 3-Phase Voltage	710
6.30	Undervoltage Protection with Positive-Sequence Voltage	726
6.31	Undervoltage Protection with Any Voltage	733
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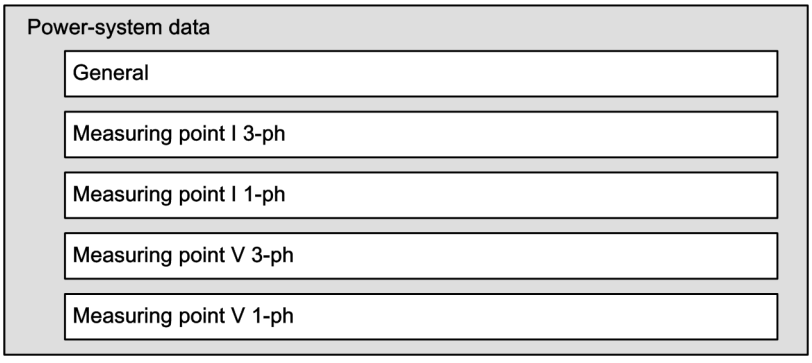
6.1 Power-System Data

6.1.1 Overview

The **Power-system data** are provided with each SIPROTEC 5 device and cannot be deleted. You will find them in DIGSI under **Settings** → **Power-system data**.

6.1.2 Structure of the Power-System Data

The **Power-system data** contain the block **General** and the **Measuring points** of the device. The following figure shows the structure of the **Power-system data**:



[dwandata-180912-01.tif, 2, en_US]

Figure 6-1 Structure of the Power-System Data

In order to adjust its functions to the application, the device requires some data about the power system. The necessary settings can be found in the Power-system data under **General** as well as in the **Measuring points**.

NOTE

You can find information on the supervision-function parameters in chapter *9.3 Supervision of the Secondary System*.

Type and scope of the required measuring points depend on the application. Possible measuring points are:

- Voltage 3-phase (measuring point V 3-ph)
- Current 3-phase (measuring point I 3-ph)
- Voltage 1-phase (measuring point V 1-ph)
- Current 1-phase (measuring point I 1-ph)

The measuring points have interfaces to the function groups requiring voltage and/or current measured values of the power system.

6.1.3 Application and Setting Notes – General Settings

Parameter: Phase sequence

- Recommended setting value **(_:2311:101) Phase sequence**= ***ABC***

The parameter **Phase sequence** is used to set the phase sequence (***ABC***) or (***ACB***). The setting value applies to the entire SIPROTEC 5 device.

Use the **General** function to set the settings in the power-system data.

6.1.4 Application and Setting Notes for Measuring-Point Voltage 3-Phase (V-3ph)

The following example describes the settings of the voltage measuring point **Measuring point V-3ph** (voltage 3-phase). Settings for the supervision functions are also located in the voltage measuring point. The description of these settings can be found in chapter Supervision Functions .

Parameter: Rated primary voltage

- Default setting **(_:8911:101) Rated primary voltage** = ***400.000 kV***

The **Rated primary voltage** parameter is used to set the primary rated voltage of the voltage transformer.

Parameter: Rated secondary voltage

- Default setting **(_:8911:102) Rated secondary voltage** = ***100 V***

The **Rated secondary voltage** parameter is used to set the secondary rated voltage of the voltage transformer.

Parameter: Matching ratio Vph / VN

- Default setting **(_:8911:103) Matching ratio Vph / VN** = ***1.73***

With the parameter **Matching ratio Vph / VN**, you set the deviation between the calculated zero-sequence voltage and the residual voltage measured directly via a measuring input. The different transmission ratio of the voltage transformers is the cause for the deviation (see *Figure 6-2*).

The **Matching ratio Vph / VN** is equal to the ratio $3V_{0\,sec}/V_{N\,sec}$

with

$V_{0\,sec}$	Calculated zero-sequence voltage
$V_{N\,sec}$	Measured residual voltage

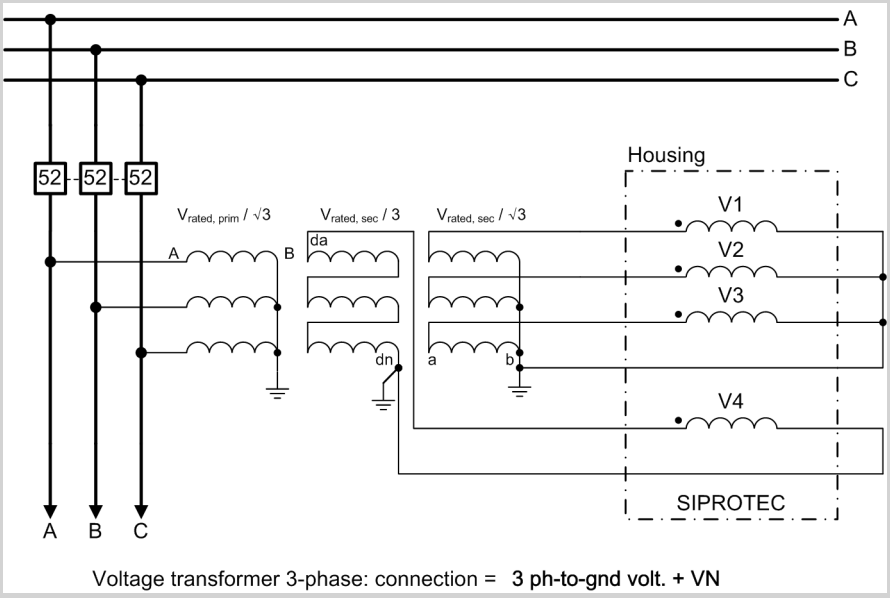
The zero voltage is calculated as phase-to-ground voltages. The residual voltage is measured on the open delta winding of the voltage transformer. For 1-phase voltage transformers, the residual voltage is measured in the generator or the transformer neutral point.

NOTE

The measurement residual voltage $V_{N\,sec}$ is converted to a zero-sequence voltage in the device as follows:

$$V_{0\,sec} = V_{N\,sec} \cdot \frac{\text{Matching ratio Vph/VN}}{3}$$

EXAMPLE 1:



[dw_bsp1uwdl_anpassfaktor, 2, en_US]

Figure 6-2 3-Phase Voltage Transformer: Connection = 3 Phase-to-Ground Voltage + VN

If the connection type of the voltage transformer is ***3 ph-to-gnd volt. + VN*** (parameter: **VT connection**) and the voltage input V4 is connected to the broken-delta winding of the voltage transformer (da/dn), the **Matching ratio Vph / VN** is as follows:

When changing the neutral point according to *Figure 6-2* , this results in the following values:

- The calculated secondary zero-sequence voltage $V_{0\ sec}$ is equal to the secondary phase-to-ground voltage. Expressed as secondary transformer rated voltage, then $V_{rated\ sec}/\sqrt{3}$.
- The measured residual voltage on the open delta winding is the sum of the voltage drops on the 3 sides. Expressed with the side ratio, the result is $V_{N,\ sec} = 3\ V_{rated,sec}/3$.

Calculate the **Matching ratio Vph / VN** parameter as follows:

$$\text{Matching ratio } \frac{\text{Vph}}{\text{VN}} = \frac{3 \cdot V_{0\ sec}}{V_{N\ sec}} = \frac{3 \cdot \frac{V_{nom\ sec}}{\sqrt{3}}}{3 \cdot \frac{V_{nom\ sec}}{3}} = \frac{3}{\sqrt{3}} = \sqrt{3} = 1.73$$

[fo_bsp1, 1, en_US]

Set **Matching ratio Vph / VN** = ***1.73***.

In **example 1** $V_{rated\ sec}$, the phase-to-ground voltage and the secondary voltage on the open delta winding were identical. If these voltages are different, use the actual numerical values in the calculation.

EXAMPLE 2:

Phase-to-ground voltage	$V_{rated\ sec}$ = 100 V
Broken-delta winding (for example, grounding transformer in generator protection)	$V_{rated\ sec}$ = 500 V The voltage input of the device is designed for a continuous operation using 230 V max. Therefore, the voltage on the open delta winding (500 V) is reduced to a 5:2 ratio, using an Ohmic divider. In order to calculate the matching factor, the secondary voltage of 200 V will be applied.

Calculate the **Matching ratio Vph / VN** parameter as follows:

$$\text{Matching ratio}\ \frac{\text{Vph}}{\text{VN}} = \frac{3 \cdot V_{0\ \text{sec}}}{V_{\text{N sec}}} = \frac{3 \cdot \frac{V_{\text{nom sec}}}{\sqrt{3}}}{3 \cdot \frac{V_{\text{nom sec}}}{3}} = \frac{3 \cdot \frac{100\ \text{V}}{\sqrt{3}}}{3 \cdot \frac{200\ \text{V}}{3}} = \frac{3}{2 \cdot \sqrt{3}} = \frac{\sqrt{3}}{2} = 0.866$$

[fo_bsp2, 1, en_US]

Set **Matching ratio Vph / VN** = ***0.866***.

Interpretation of the result:

The zero-sequence voltage calculated from the phase-to-ground voltage is 57.73 V (= 100V/√3). The measured residual voltage is 200 V. The calculated adaptation factor is 0.866. The measured residual voltage is converted to a zero-sequence voltage inside the device:

$$V_{0\ \text{sec}} = V_{\text{N sec}} \cdot \frac{\text{Matching ratio Vph/VN}}{3} = 200\ \text{V} \cdot \frac{0.866}{3} = 57.73\ \text{V}$$

[fo_umrechnung2, 2, en_US]

NOTE

During the ground-fault test, the set adaptation factor can be checked by comparing the operational measured values. The operational measured values contain the calculated zero-sequence voltage $V_{0\ \text{sec}}$ and the measured residual voltage $V_{\text{N sec}}$. Proceed with the compilation as follows:

$$\text{Matching ratio.}\frac{\text{Vph}}{\text{VN}} = \frac{3 \cdot V_{0\ \text{sec}}}{V_{\text{N sec}}}$$

The **Matching ratio Vph / VN** parameter is significant for the following functions:

- Overvoltage protection with zero-sequence voltage/residual voltage
- Measured-value supervision
- Scaling of the faulty and measured values

Parameter: VT connection

- Default setting **(_:8911:104) VT connection** = ***3 ph-to-gnd volt. + VN***

The parameter **VT connection** shows the connection type of the voltage transformer for the 3-phase voltage measuring point. The parameter can be found in the DIGSI 5 project tree under **Name of the device** → **Settings** → **Power-system data** → **Measuring point V 3-phase**. You cannot change the connection type of the voltage transformer in the power-system data.

You can change the connection type of the voltage transformer only under measuring point routing in DIGSI 5. Under **Name of the device** → **Measuring-points routing** → **Voltage measuring points**, select the desired connection type under **Connection type**. The following types of connections are possible:

- ***3 ph-to-gnd volt. + VN***
- ***3 ph-to-gnd voltages***
- ***3 ph-to-ph volt. + VN***
- ***3 ph-to-ph voltages***
- ***2 ph-to-ph volt. + VN***
- ***2 ph-to-ph voltages***
- ***2 ph-to-gnd volt. + VN***
- ***2 ph-to-gnd voltages***

Depending on the connection type selected, you must route the measured values to the terminals of the voltage measuring point in DIGSI 5. You can find connection examples for voltage transformers in the chapters

A.8 Connection Examples for Voltage Transformers for 7SJ85 and *A.9 Connection Examples for Voltage Transformers for 7SJ82*. The connection examples provide assistance when selecting the type of connection.

Parameter: Inverted phases

- Default setting **(_:8911:106) Inverted phases** = ***none***

The **Inverted phases** parameter is intended for special applications, for example, pumped-storage hydropower plants (see chapter Phase-rotation reversal). This default setting may be retained for power-system protection applications.

Parameter: Tracking

- Default setting **(_:8911:111) Tracking** = ***active***

The **Tracking** parameter is used to determine whether the measuring channels of this measuring point shall be used to determine the sampling frequency.

The sampling frequency of the device is adjusted to the power frequency. The device selects a measuring channel, through which the sampling frequency is determined. Preferably, this should be a voltage metering channel. This validity of the signal is monitored (minimum level, frequency range). If these values are invalid, the device switches to another channel (etc.). Once switched to a current channel, the system automatically switches back to this channel if a voltage channel is valid again.

Parameter Value	Description
active	If the parameter **Tracking** = ***active*** has been set, the measuring point will be included when determining the sampling frequency. If possible, only the 3-phase measuring points shall be considered. Siemens recommends using the default setting. **Note:** If the parameter **Tracking** = ***active*** , the determined sampling frequency applies to all functions in the device that do not use fixed sampling rates.
inactive	If the channels of the measuring point are not to be considered for determining the sampling frequency, please select the setting value ***inactive***.

Parameter: Magnitude correction

- Default setting **(_:3811:103) Magnitude correction** = ***1.000***

When using the **Magnitude correction** parameter, the magnitude (magnitude correction) is adjusted for the voltage input. This allows you to correct the tolerances of the primary current transformer phase-selectively. The magnitude correction may be required for highly precise measurements. Use a comparison measurement to determine the setting value (for example, a high-precision measuring-voltage transformer). If a primary correction is not necessary, retain the default setting.



NOTE

The **Magnitude correction** parameter has nothing to do with the internal adjustment of the input circuit.

6.1.5 Application and Setting Notes for Measuring Point Current 3-Phase (I-3ph)

The following example describes the settings for the current **Measuring point I 3-ph** (Current 3-phase). The supervision function settings are also located in the current measuring point. The description of these settings can be found in chapter *9 Supervision Functions*.

Parameter: CT connection

- Default setting **(_:8881:115) CT connection** = ***3-phase + IN-separate***

The parameter **CT connection** shows the connection type of the current transformer for the 3-phase current measuring point. The parameter can be found in the DIGSI 5 project tree under **Name of the device → Settings → Power-system data → Measuring point I 3-phase**. You cannot change the connection type of the current transformer in the **Power-system data**.

You can change the connection type of the current transformer only under measuring point routing in DIGSI 5. Under **Name of the device → Measuring point routing → Current measuring points**, select the desired connection type under Connection type. The following types of connections are possible:

- ***3-phase + IN-separate***
- ***3-phase + IN***
- ***3-phase***
- ***3-phase, 2 primary CT***
- ***3ph,2prim.CT + IN-sep***
- ***2ph, 2p. CT + IN-sep***

Depending on the connection type selected, you must route the measured values to the terminals of the current measuring point in DIGSI 5. You can find connection examples for current transformers in chapter *A.7 Connection Examples for Current Transformers* . The connection examples provide assistance when selecting the type of connection.

Parameter: Tracking

- Default setting **(_:8881:127) Tracking** = ***active***

With the parameter**Tracking**, you specify whether you would like to work with the sampling-frequency tracking function.

Parameter Value	Description
active	If the parameter **Tracking** = ***active*** has been set, the measuring point will be included when determining the sampling frequency. If possible, only the 3-phase measuring points shall be considered. Siemens recommends using the default setting. **Note:** If the parameter **Tracking** = ***active***, the determined sampling frequency applies to all functions in the device not using fixed sampling rates.
inactive	If the channels of the measuring point are not to be considered for determining the sampling frequency, please select the setting value ***inactive***.

Parameter: Rated primary current

- Default setting **(_:8881:101) Rated primary current** = ***1000 A***

With the **Rated primary current** parameter, the active rated primary current of the current transformer is set.

Parameter: Rated secondary current

- Default setting **(_:8881:102) Rated secondary current** = ***1 A***

With the **Rated secondary current** parameter, you set the current rated secondary current of the current transformer.

Parameter: Current range

- Default setting 7SJ82 **(_:8881:117) Current range** = ***50 x IR***
- Default setting 7SJ85 **(_:8881:117) Current range** = ***100 x IR***

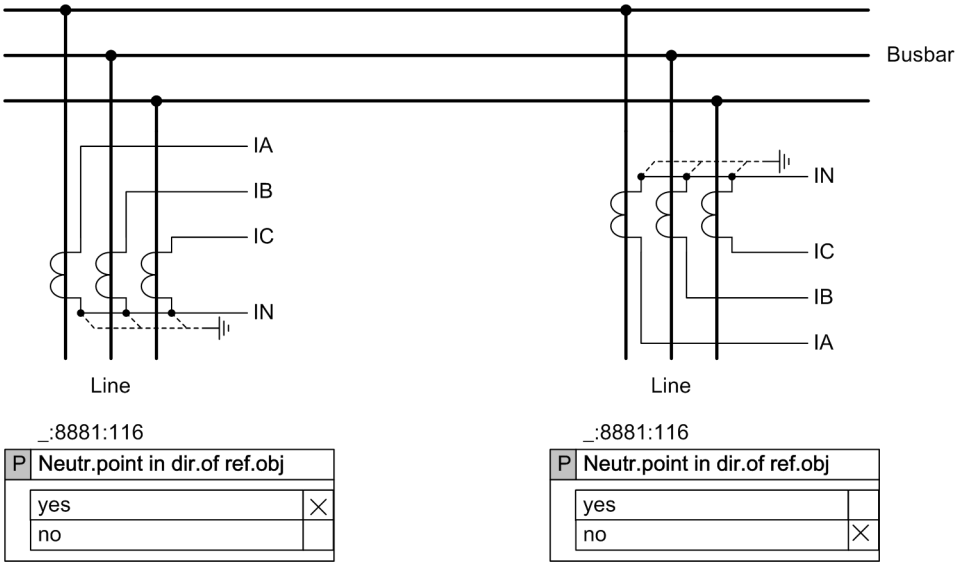
The **Current range** parameter allows you to set the dynamic range for the current input. Please retain the default setting for power-system protection applications. The current measuring range 1.6 x Irated applies for the connection type ***3-phase + IN-separate*** and the sensitive current input or for the measuring inputs.

Parameter: Neutr.point in dir.of ref.obj

- Default setting **(_:8881:116) Neutr.point in dir.of ref.obj** = ***yes***

The **Neutr.point in dir.of ref.obj** parameter is used to set the direction of the neutral point of the current transformer (see following figure). Often, the neutral point of the current transformer is determined by the direction of the protected object (for example, in the direction of the line, cable, transformer). For this reason, the default setting of the parameter was defined as ***yes***.

When switching the parameter, the direction of the phase currents and of the ground current IN or IN-separate is rotated device-internally.



[dwpolstromwdl-251013, 1, en_US]

Figure 6-3 Polarity of Current Transformers

Parameter: Inverted phases

- Default setting **(_:8881:114) Inverted phases** = ***none***

The **Inverted phases** parameter is intended for special applications, for example, pumped-reservoir plants (see Chapter Phase-rotation reversal). This default setting may be retained for power-system protection applications.

Parameter: Magnitude correction

- Default setting **(_:3841:103) Magnitude correction** = ***1.000***

When using the **Magnitude correction** parameter, you adjust the amplitude (amplitude correction) for the current input. This allows you to correct the tolerances of the primary current transformer phase-selectively. The magnitude correction may be required for highly precise measurements. Use a comparison measurement to determine the setting value (for example, a high-precision measuring-voltage transformer). If a primary correction is not necessary, retain the default setting.

NOTE

The **Magnitude correction** parameter has nothing to do with the internal adjustment of the input circuit.

Note Regarding Routable Data

Indications for the current rotating field and the information pertaining to the sampling-frequency tracking can be found in **Information routing** under **Power-system data** → **General** in DIGSI 5. The indication *Freq.out of oper.range* means that the frequency operating range has been exceeded. Either the

frequency is out of range (10 Hz to 80 Hz) or the input signals are too small for a manual update. Should this condition occur, the system switches the update frequency to a sampling rate that corresponds to the rated frequency.

Furthermore, there are 2 additional measured frequency values available. The measured value *f sys* displays the current system frequency, and the measured value *f track* displays the sampling frequency currently set. Siemens recommends routing both measured values as fault-recording channel.

6.1.6 Settings

General Information

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Phase sequence		• ABC • ACB	ABC

Measuring Point I-1ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Rated primary current		1.0 A to 100000.0 A	1000.0 A
_:2311:102	General:Rated secondary current		• 1 A • 5 A	1 A
_:2311:103	General:Current range		• 1.6 x IR • 100 x IR • 50 x IR	100 x IR
_:2311:104	General:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
_:2311:116	General:Term. 1,3,5,7 in dir. of obj.		• no • yes	yes
_:2311:105	General:Tracking		• inactive • active	inactive
_:2311:130	General:Measuring-point ID		0 to 100	0
CT 1				
_:3841:103	CT 1:Magnitude correction		0.010 to 10.000	1.000
_:3841:117	CT 1:Phase		• I A • I B • I C • IN • INsens • Ix	

Measuring Point I-3ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:8881:115	CT 3-phase:CT connection		• not assigned • 3-phase + IN • 3-phase • 3-phase + IN-separate • 3-phase, 2 primary CT • 3ph,2prim.CT + IN-sep • 2ph, 2p. CT + IN-sep	3-phase + IN
_:8881:127	CT 3-phase:Tracking		• inactive • active	active
_:8881:130	CT 3-phase:Measuring-point ID		0 to 100	0
CT phases				
_:8881:101	CT 3-phase:Rated primary current		1.0 A to 100000.0 A	1000.0 A
_:8881:102	CT 3-phase:Rated secondary current		• 1 A • 5 A	1 A
_:8881:117	CT 3-phase:Current range		• 1.6 x IR • 100 x IR • 50 x IR	100 x IR
_:8881:118	CT 3-phase:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
_:8881:116	CT 3-phase:Neutr.point in dir.of ref.obj		• no • yes	yes
_:8881:114	CT 3-phase:Inverted phases		• none • AC • BC • AB	none
_:8881:107	CT 3-phase:CT error changeover		1.00 to 10.00	1.00
_:8881:108	CT 3-phase:CT error A		0.5 % to 50.0 %	5.0 %
_:8881:109	CT 3-phase:CT error B		0.5 % to 50.0 %	15.0 %
CT IN				
_:8881:104	CT 3-phase:Rated primary current		1.0 A to 100000.0 A	1000.0 A
_:8881:105	CT 3-phase:Rated secondary current		• 1 A • 5 A	1 A
_:8881:119	CT 3-phase:Current range		• 1.6 x IR • 100 x IR • 50 x IR	100 x IR
_:8881:120	CT 3-phase:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
CT IN2				
_:8881:106	CT 3-phase:Rated primary current		1.0 A to 100000.0 A	1000.0 A
_:8881:113	CT 3-phase:Rated secondary current		1 A to 5 A	1 A

Addr.	Parameter	C	Setting Options	Default Setting
_:8881:121	CT 3-phase:Current range		• 1.6 x IR • 100 x IR • 50 x IR	1.6 x IR
_:8881:122	CT 3-phase:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
CT 1				
_:3841:103	CT 1:Magnitude correction		0.010 to 10.000	1.000
_:3841:117	CT 1:Phase		• I A • I B • I C • IN • INsens • Ix	
CT 2				
_:3842:103	CT 2:Magnitude correction		0.010 to 10.000	1.000
_:3842:117	CT 2:Phase		• I A • I B • I C • IN • INsens • Ix	
CT 3				
_:3843:103	CT 3:Magnitude correction		0.010 to 10.000	1.000
_:3843:117	CT 3:Phase		• I A • I B • I C • IN • INsens • Ix	
CT 4				
_:3844:103	CT 4:Magnitude correction		0.010 to 10.000	1.000
_:3844:117	CT 4:Phase		• I A • I B • I C • IN • INsens • Ix	
Brk.wire det.				
_:5581:1	Brk.wire det.:Mode		• off • on • test	off
Supv. balan. I				
_:2491:1	Supv. balan. I:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:2491:101	Supv. balan. I:Release threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	2.500 A
_:2491:102	Supv. balan. I:Threshold min/max		0.10 to 0.95	0.50
_:2491:6	Supv. balan. I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv. ph.seq.I				
_:2551:1	Supv. ph.seq.I:Mode		• off • on • test	off
_:2551:6	Supv. ph.seq.I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv. sum I				
_:2431:1	Supv. sum I:Mode		• off • on • test	off
_:2431:102	Supv. sum I:Threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2431:101	Supv. sum I:Slope factor		0.00 to 0.95	0.10
_:2431:6	Supv. sum I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv.ADC sum I				
_:2401:1	Supv.ADC sum I:Mode		• off • on • test	off

Measuring Point V-1ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Rated primary voltage		0.200 kV to 1200.000 kV	400.000 kV
_:2311:102	General:Rated secondary voltage		80 V to 340 V	100 V
_:2311:103	General:Tracking		• inactive • active	inactive
_:2311:130	General:Measuring-point ID		0 to 100	0
VT 1				
_:3811:103	VT 1:Magnitude correction		0.010 to 10.000	1.000

Addr.	Parameter	C	Setting Options	Default Setting
_:3811:108	VT 1:Phase		• V A • V B • V C • V AB • V BC • V CA • VN • Vx • VCB •	
_:3811:107	VT 1:Sequence number device		1 to 2147483647	2147483647
VT miniatureCB				
_:2641:101	VT miniatureCB:Response time		0.00 s to 0.03 s	0.00 s

Measuring Point V-3ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:8911:101	VT 3-phase:Rated primary voltage		0.200 kV to 1200.000 kV	400.000 kV
_:8911:102	VT 3-phase:Rated secondary voltage		80 V to 230 V	100 V
_:8911:103	VT 3-phase:Matching ratio Vph / VN		0.10 to 9.99	1.73
_:8911:104	VT 3-phase:VT connection		• not assigned • 3 ph-to-gnd volt. + VN • 3 ph-to-gnd voltages • 3 ph-to-ph volt. + VN • 3 ph-to-ph voltages • 2 ph-to-ph volt. + VN • 2 ph-to-ph voltages	3 ph-to-gnd volt. + VN
_:8911:106	VT 3-phase:Inverted phases		• none • AC • BC • AB	none
_:8911:111	VT 3-phase:Tracking		• inactive • active	active
_:8911:130	VT 3-phase:Measuring-point ID		0 to 100	0
VT 1				
_:3811:103	VT 1:Magnitude correction		0.010 to 10.000	1.000
_:3811:108	VT 1:Phase		• V A • V B • V C • V AB • V BC • V CA • VN • Vx • VCB	

Addr.	Parameter	C	Setting Options	Default Setting
_:3811:107	VT 1:Sequence number device		1 to 2147483647	2147483647
VT 2				
_:3812:103	VT 2:Magnitude correction		0.010 to 10.000	1.000
_:3812:108	VT 2:Phase		• V A • V B • V C • V AB • V BC • V CA • VN • Vx • VCB	
_:3812:107	VT 2:Sequence number device		1 to 2147483647	2147483647
VT 3				
_:3813:103	VT 3:Magnitude correction		0.010 to 10.000	1.000
_:3813:108	VT 3:Phase		• V A • V B • V C • V AB • V BC • V CA • VN • Vx • VCB •	
_:3813:107	VT 3:Sequence number device		1 to 2147483647	2147483647
VT 4				
_:3814:103	VT 4:Magnitude correction		0.010 to 10.000	1.000
_:3814:108	VT 4:Phase		• V A • V B • V C • V AB • V BC • V CA • VN • Vx • VCB •	
_:3814:107	VT 4:Sequence number device		1 to 2147483647	2147483647
Supv. balan. V				
_:2521:1	Supv. balan. V:Mode		• off • on • test	off
_:2521:101	Supv. balan. V:Release threshold		0.300 V to 170.000 V	50.000 V
_:2521:102	Supv. balan. V:Threshold min/max		0.58 to 0.95	0.75

Addr.	Parameter	C	Setting Options	Default Setting
_:2521:6	Supv. balan. V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv. ph.seq.V				
_:2581:1	Supv. ph.seq.V:Mode		• off • on • test	off
_:2581:6	Supv. ph.seq.V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv. sum V				
_:2461:1	Supv. sum V:Mode		• off • on • test	off
_:2461:3	Supv. sum V:Threshold		0.300 V to 170.000 V	25.000 V
_:2461:6	Supv. sum V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
VT miniatureCB				
_:2641:101	VT miniatureCB:Response time		0.00 s to 0.03 s	0.00 s

6.1.7 Information List

General

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Phs-rotation reversal	SPS	I
_:2311:501	General:>Invert Phases	SPS	I
General			
_:2311:319	General:Phase sequence ABC	SPS	O
_:2311:320	General:Phase sequence ACB	SPS	O
_:2311:321	General:Freq.out of oper.range	SPS	O
_:2311:322	General:f sys	MV	O
_:2311:323	General:f track	MV	O

Measuring Point I-1ph

No.	Information	Data Class (Type)	Type
CT 1			
_:3841:300	CT 1:Sampled val. current	SAV	O

Measuring Point I-3ph

No.	Information	Data Class (Type)	Type
General			
_:8881:319	CT 3-phase:Phases AB inverted	SPS	O
_:8881:320	CT 3-phase:Phases BC inverted	SPS	O
_:8881:321	CT 3-phase:Phases AC inverted	SPS	O

No.	Information	Data Class (Type)	Type
CT 1			
_:3841:300	CT 1:Sampled val. current	SAV	O
CT 2			
_:3842:300	CT 2:Sampled val. current	SAV	O
CT 3			
_:3843:300	CT 3:Sampled val. current	SAV	O
CT 4			
_:3844:300	CT 4:Sampled val. current	SAV	O
Brk.wire det.			
_:5581:82	Brk.wire det.:>Block function	SPS	I
_:5581:54	Brk.wire det.:Inactive	SPS	O
_:5581:52	Brk.wire det.:Behavior	ENS	O
_:5581:53	Brk.wire det.:Health	ENS	O
_:5581:301	Brk.wire det.:Phs A BW suspected	SPS	O
_:5581:302	Brk.wire det.:Phs B BW suspected	SPS	O
_:5581:303	Brk.wire det.:Phs C BW suspected	SPS	O
_:5581:304	Brk.wire det.:Phase A broken wire	SPS	O
_:5581:305	Brk.wire det.:Phase B broken wire	SPS	O
_:5581:306	Brk.wire det.:Phase C broken wire	SPS	O
_:5581:307	Brk.wire det.:Broken wire suspected	SPS	O
_:5581:308	Brk.wire det.:Broken wire confirmed	SPS	O
Supv. balan. I			
_:2491:82	Supv. balan. I:>Block function	SPS	I
_:2491:54	Supv. balan. I:Inactive	SPS	O
_:2491:52	Supv. balan. I:Behavior	ENS	O
_:2491:53	Supv. balan. I:Health	ENS	O
_:2491:71	Supv. balan. I:Failure	SPS	O
Supv. ph.seq.I			
_:2551:82	Supv. ph.seq.I:>Block function	SPS	I
_:2551:54	Supv. ph.seq.I:Inactive	SPS	O
_:2551:52	Supv. ph.seq.I:Behavior	ENS	O
_:2551:53	Supv. ph.seq.I:Health	ENS	O
_:2551:71	Supv. ph.seq.I:Failure	SPS	O
Supv. sum I			
_:2431:82	Supv. sum I:>Block function	SPS	I
_:2431:54	Supv. sum I:Inactive	SPS	O
_:2431:52	Supv. sum I:Behavior	ENS	O
_:2431:53	Supv. sum I:Health	ENS	O
_:2431:71	Supv. sum I:Failure	SPS	O
Supv.ADC sum I			
_:2401:82	Supv.ADC sum I:>Block function	SPS	I
_:2401:54	Supv.ADC sum I:Inactive	SPS	O
_:2401:52	Supv.ADC sum I:Behavior	ENS	O
_:2401:53	Supv.ADC sum I:Health	ENS	O
_:2401:71	Supv.ADC sum I:Failure	SPS	O

Measuring Point V-1ph

No.	Information	Data Class (Type)	Type
VT 1			
_:3811:300	VT 1:Sampled val. voltage	SAV	O
Definite-T 1			
_:2641:500	VT miniatureCB:>Open	SPS	I

Measuring Point V-3ph

No.	Information	Data Class (Type)	Type
General			
_:8911:315	VT 3-phase:Phases AB inverted	SPS	O
_:8911:316	VT 3-phase:Phases BC inverted	SPS	O
_:8911:317	VT 3-phase:Phases AC inverted	SPS	O
VT 1			
_:3811:300	VT 1:Sampled val. voltage	SAV	O
VT 2			
_:3812:300	VT 2:Sampled val. voltage	SAV	O
VT 3			
_:3813:300	VT 3:Sampled val. voltage	SAV	O
VT 4			
_:3814:300	VT 4:Sampled val. voltage	SAV	O
Supv. balan. V			
_:2521:82	Supv. balan. V:>Block function	SPS	I
_:2521:54	Supv. balan. V:Inactive	SPS	O
_:2521:52	Supv. balan. V:Behavior	ENS	O
_:2521:53	Supv. balan. V:Health	ENS	O
_:2521:71	Supv. balan. V:Failure	SPS	O
Supv. ph.seq.V			
_:2581:82	Supv. ph.seq.V:>Block function	SPS	I
_:2581:54	Supv. ph.seq.V:Inactive	SPS	O
_:2581:52	Supv. ph.seq.V:Behavior	ENS	O
_:2581:53	Supv. ph.seq.V:Health	ENS	O
_:2581:71	Supv. ph.seq.V:Failure	SPS	O
Supv. sum V			
_:2461:82	Supv. sum V:>Block function	SPS	I
_:2461:54	Supv. sum V:Inactive	SPS	O
_:2461:52	Supv. sum V:Behavior	ENS	O
_:2461:53	Supv. sum V:Health	ENS	O
_:2461:71	Supv. sum V:Failure	SPS	O
Definite-T 1			
_:2641:500	VT miniatureCB:>Open	SPS	I

6.2 Group Indications of Overcurrent Protection Functions

6.2.1 Description

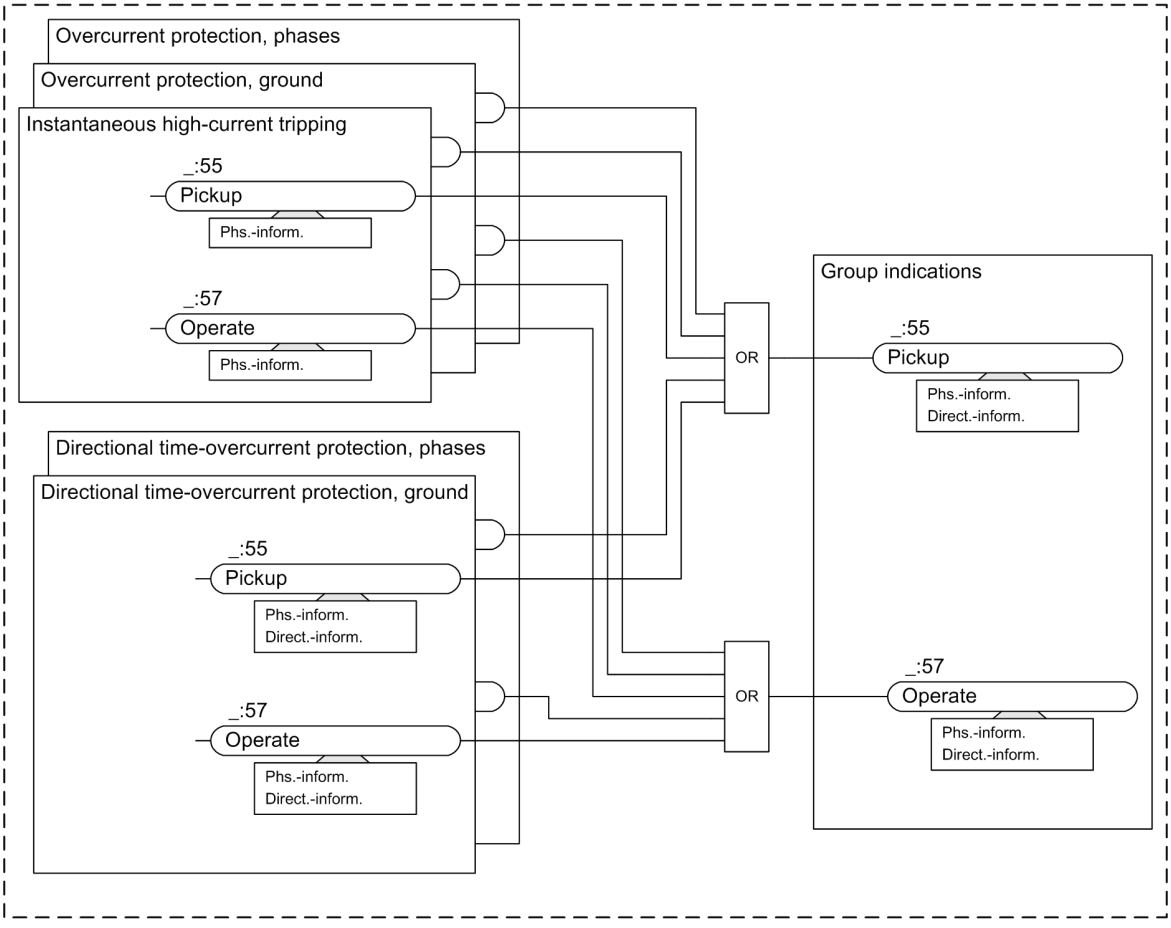
The function block **Group indications of the overcurrent protection functions** uses the pickup and operate indications of the following functions:

- Overcurrent Protection, Phases
- Overcurrent Protection, Ground
- Directional time-overcurrent protection, phases
- Directional Overcurrent Protection, Ground
- Instantaneous High-Current Tripping

The group indications of the overcurrent protection are generated by a logical OR of the stage-selective pickup and operate indications of the functions listed above (see also *Figure 6-4*):

- **`Pickup`**
- **`Operate`**

The pickup and operate indications are output, where present, with direction information.



[loocgri2-271112-01.tif, 2, en_US]

Figure 6-4 Logic Diagram of the Overcurrent Protection Group Indications

6.3 Overcurrent Protection, Phases

6.3.1 Overview of Functions

The **Overcurrent protection, phases** function (ANSI 50/51):

- Detects short circuits in electrical equipment
- Can be used as backup overcurrent protection in addition to the main protection

6.3.2 Structure of the Function

The **Overcurrent protection, phases** function is used in protection function groups. 2 kinds of functions are available for the 3-phase overcurrent protection:

- **Overcurrent protection, phases – advanced** (50/51 OC-3ph-A)
- **Overcurrent protection, phases – basic** (50/51 OC-3ph-B)

The Basic function type is provided for standard applications. The Advanced function type offers more functionality and is provided for more complex applications.

Both function types are preconfigured by the manufacturer with 2 **Definite time-overcurrent protection** stages and with 1 **Inverse time-overcurrent protection** stage.

In the **Overcurrent protection, phase– advanced** function type, the following stages can be operated simultaneously:

- Maximum of 4 stages **Definite time-overcurrent protection – advanced**
- 2 stages **Inverse time-overcurrent protection – advanced**
- 2 stages **User-defined overcurrent protection characteristic curve**

In the **Overcurrent protection, phases – basic** function type, the following stages can be operated simultaneously:

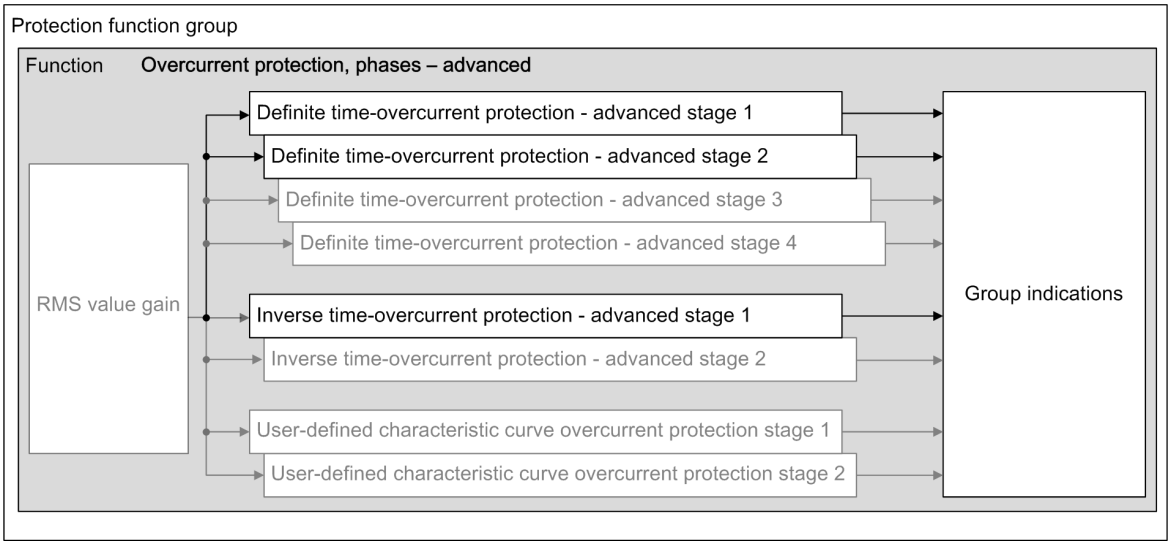
- Maximum of 4 stages **Definite time-overcurrent protection – basic**
- 1 stage **Inverse time-overcurrent protection – basic**

Stages that are not preconfigured are shown in gray in the following figures. Apart from the tripping delay characteristic, the stages are identical in structure.

The optional function block **Filter** offered in the advanced function allows to gain harmonics or to compensate the amplitude attenuation for the RMS value.

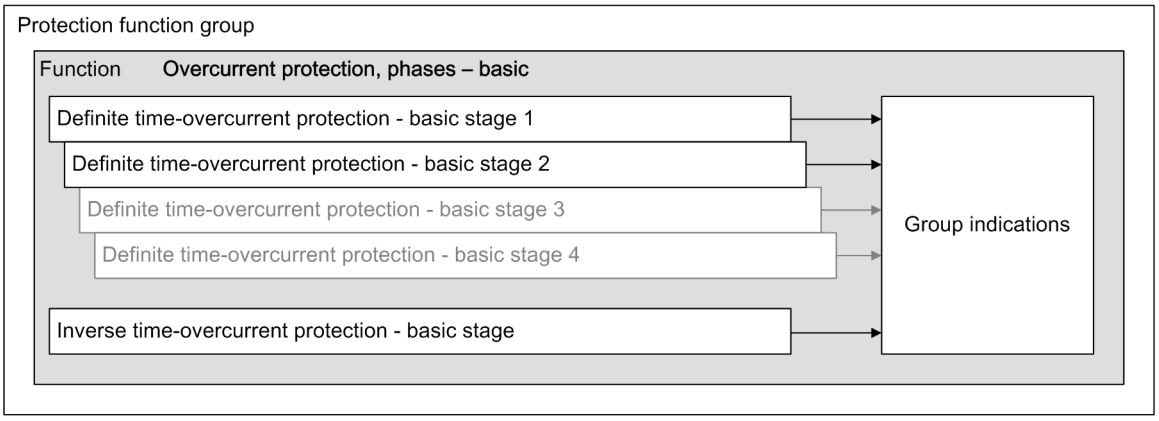
The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- **`Pickup`**
- **`Operate`**



[dw_ocp_ad with Filter.tif, 1, en_US]

Figure 6-5 Structure/Embedding of the Function Overcurrent Protection, Phases – Advanced



[dwocpbp1-210113-01.tif, 2, en_US]

Figure 6-6 Structure/Embedding the Function Overcurrent Protection, Phases – Basic

If the device-internal functions listed in the following are present in the device, these functions can influence the pickup values and tripping delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Automatic reclosing (AREC)
- Cold-load pickup detection
- Binary input signal

If the device is equipped with an **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer-inrush currents (available in both function types).

6.3.3 Filter for RMS Value Gain

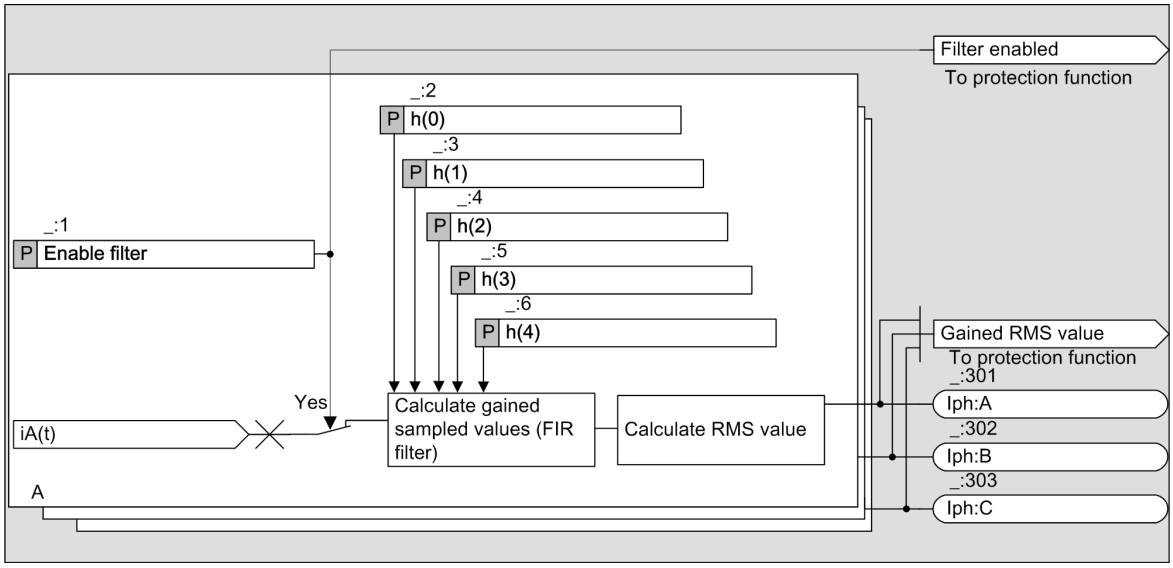
6.3.3.1 Description

The function block **Filter** can be used to adapt the RMS value for 2 means:

- To gain harmonics in a defined way. Higher harmonics can stress the protected object thermally more than lower harmonics. This is the case for reactors applied in AC filters. In addition, the amplitude attenuation of higher frequencies due to the anti-aliasing filter of the device is automatically compensated by the filter
- To only compensate the amplitude attenuation of higher frequencies due to the anti-aliasing filter

The filter gain (amplitude response) is realized by a 9-order FIR filter.

Logic



[lo_TOLP_FilterStage, 1, en_US]

Figure 6-7 Logic Diagram of the Function Block Filter

The FIR filter gains the 8-kHz sampled values according to the set filter coefficients. Afterwards, the RMS value is calculated. The symmetrical 9-order filter coefficients are set via the values of the respective parameters **`h(0)`**, **`h(1)`**, **`h(2)`**, **`h(3)`**, and **`h(4)`**.

NOTE

A FIR-filter configuration tool is provided as an auxiliary PC tool. With this PC tool, the coefficients h(0), h(1), h(2), h(3), h(4) of the FIR filter are generated according to the required gain factors (amplitude response). The tool can be obtained from the SIPROTEC download area. For more information about the tool, refer to the tool help function.

The gained RMS value is delivered to the protection stages only when the function block **Filter** is instantiated and the parameter **`Enable filter`** is set as ***`yes`***. Otherwise, the normal RMS value is used.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
Iph:A	Gained RMS measured value of current A	kA	A	Parameter **`Rated current`**
Iph:B	Gained RMS measured value of current B	kA	A	Parameter **`Rated current`**

Values	Description	Primary	Secondary	% Referenced to
Iph:C	Gained RMS measured value of current C	kA	A	Parameter **Rated current**

You can find the parameter **Rated current** in the **FB General** of function groups where the **Overcurrent protection, phases – advanced** function is used.

If the parameter **Enable filter** is set to ***no***, the functional measured values are shown as ---.

6.3.3.2 Application and Setting Notes

Parameter: Enable filter

- Default setting **(_:1) Enable filter** = ***no***.

With the parameter **Enable filter**, you set whether the **Filter** is enabled.

Parameter Value	Description
yes	If gained RMS values should be used in one of the protection stages, set parameter **Enable filter** = ***yes***.
no	If no gained RMS values are needed, set the parameter **Enable filter** = ***no***.

Parameter: h(0),h(1),h(2),h(3),h(4)

- Default setting **(_:2) h(0)** = ***0.000***
- Default setting **(_:3) h(1)** = ***0.000***
- Default setting **(_:4) h(2)** = ***0.000***
- Default setting **(_:5) h(3)** = ***0.000***
- Default setting **(_:6) h(4)** = ***1.000***

With the default value of the coefficients, the filter has no effect and no gain is applied.

If the filter shall be applied to adapt the RMS value calculation to a specific protection object such as a reactor, the reactor manufacturer has to provide the required amplitude response (gain factors) for the reactor. To determine the coefficients h(0) to h(4) for the FIR filter, you must enter the gain factors into the auxiliary PC tool which is available in the SIPROTEC download area. The 5 required coefficients are generated by the tool. They have to be entered manually as settings to configure the filter. The amplitude attenuation of higher frequencies due to the anti aliasing filter of the device is automatically taken into account and compensated by the filter.

To only compensate the attenuation of higher frequencies by the device, set the following coefficients in the filter.

Rated Frequency	Filter Coefficients for Only Compensating the Device Amplitude Attenuation
50 Hz	h(0) = -0.002 h(1) = -0.012 h(2) = 0.045 h(3) = -0.110 h(4) = 1.151
60 Hz	h(0) = -0.005 h(1) = -0.020 h(2) = 0.058 h(3) = -0.128 h(4) = 1.170

6.3.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Filter				
_:1	Filter:Enable filter		• no • yes	no
_:2	Filter:h(0)		-100.000 to 100.000	0.000
_:3	Filter:h(1)		-100.000 to 100.000	0.000
_:4	Filter:h(2)		-100.000 to 100.000	0.000
_:5	Filter:h(3)		-100.000 to 100.000	0.000
_:6	Filter:h(4)		-100.000 to 100.000	1.000

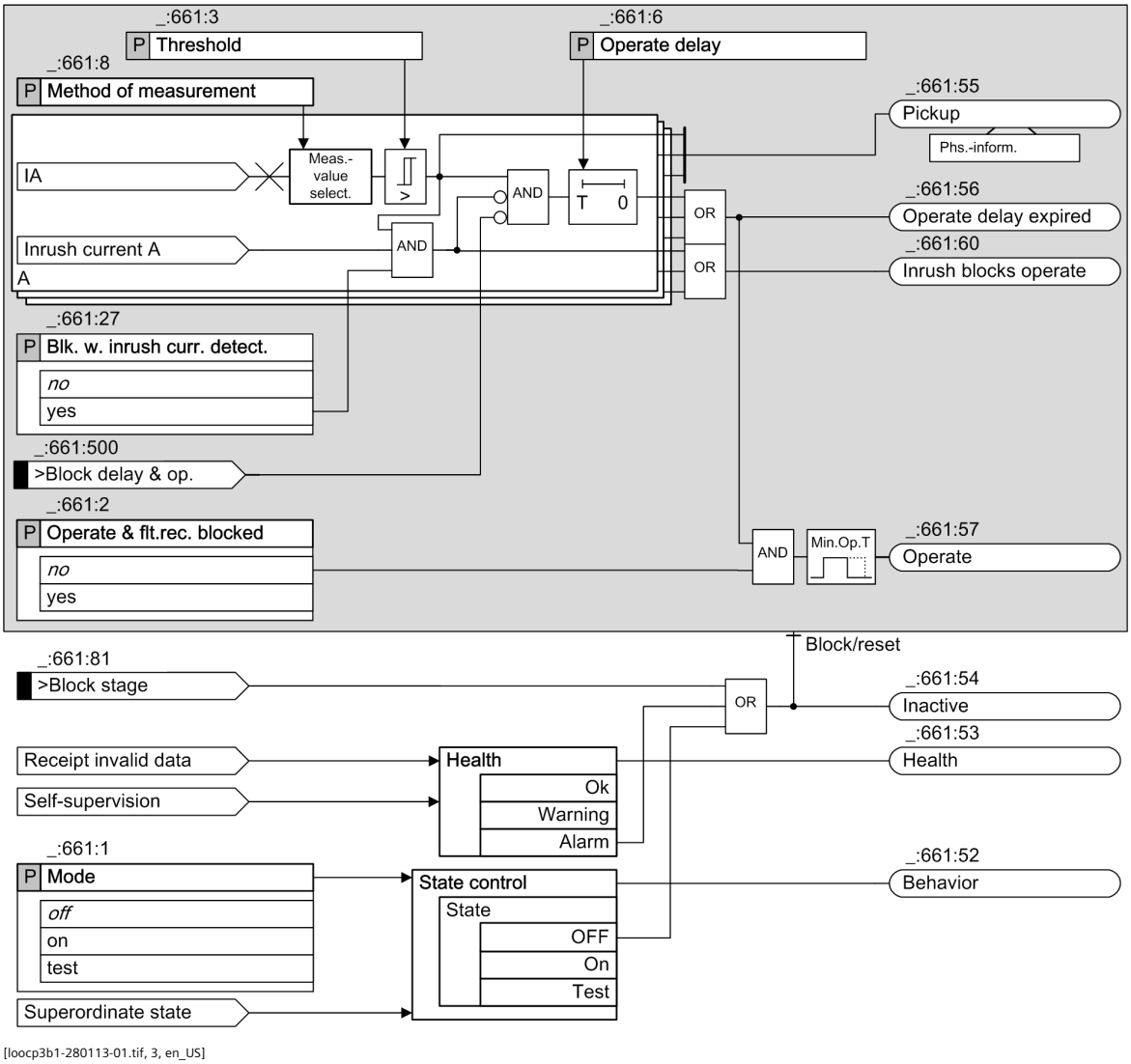
6.3.3.4 Information List

No.	Information	Data Class (Type)	Type
Filter			
_:301	Filter:Iph:A	MV	O
_:302	Filter:Iph:B	MV	O
_:303	Filter:Iph:C	MV	O

6.3.4 Stage with Definite-Time Characteristic Curve

6.3.4.1 Description

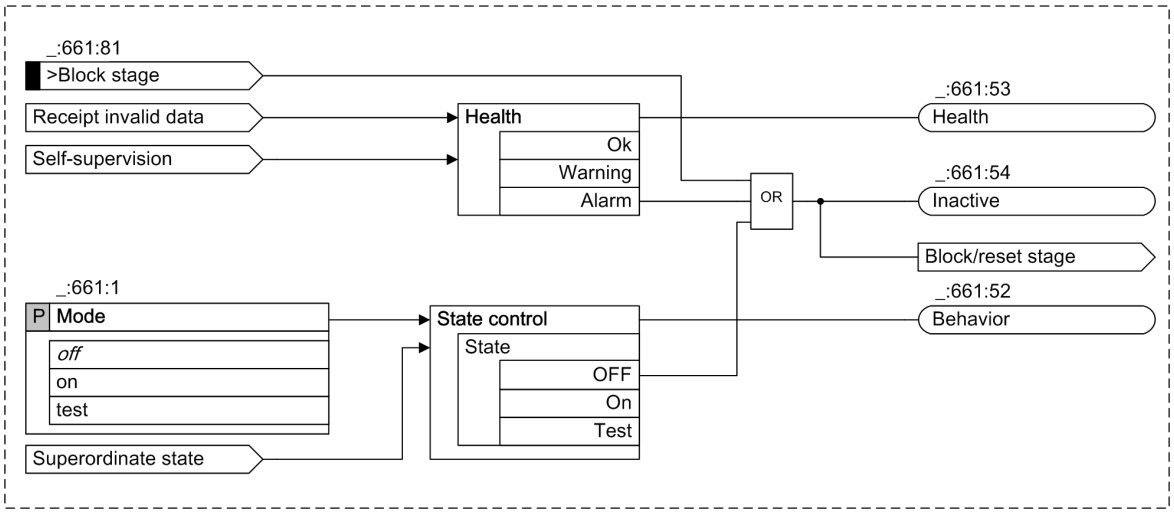
Logic of the Basic Stage



[loocp3b1-280113-01.tif, 3, en_US]

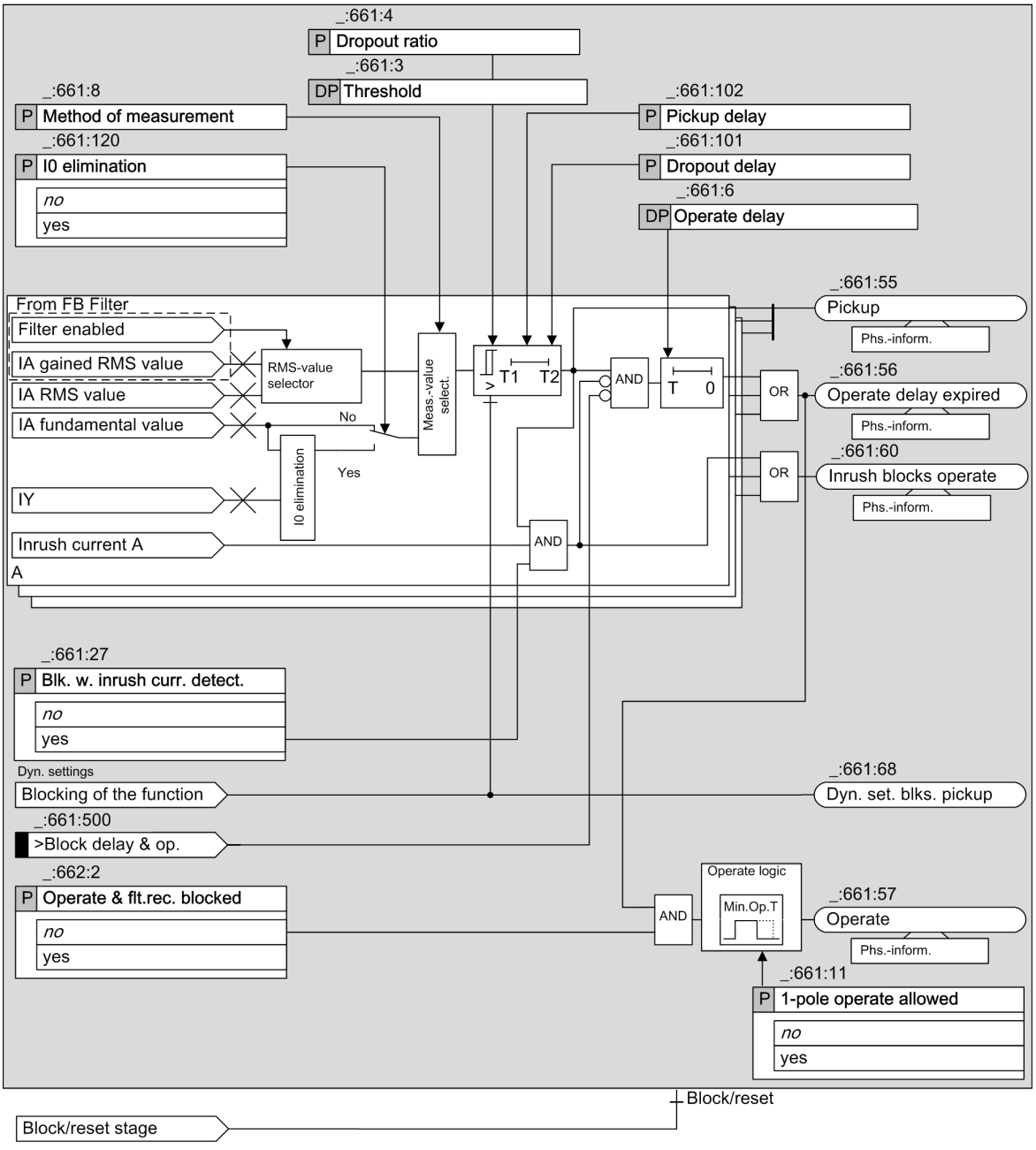
Figure 6-8 Logic Diagram of the Definite Time-Overcurrent Protection (Phases) – Basic

Logic of the Advanced Stage



[lo_OCP_Adv_UMZ_StageControl, 1, en_US]

Figure 6-9 Logic Diagram of the Stage Control



[loocp3p1-310511-01.tif, 3, en_US]

Figure 6-10 Logic Diagram of the Definite Time-Overcurrent Protection (Phases) – Advanced

Method of measurement (Basic and Advanced Stage)

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

RMS-Value Selection (Advanced Stage)

If ***RMS value*** is selected as the method of measurement, the protection function supports 2 kinds of RMS measurement.

- Normal RMS value
- Gained RMS value from the function block **Filter**

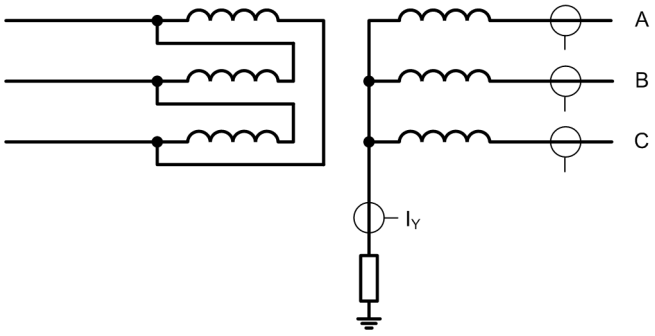
If the function block **Filter** is configured and if you have enabled the filter, the gained RMS value is automatically used.

NOTE

When the function block **Filter** is applied, only one 3-phase current measuring point is allowed to be connected to the 3-phase current interface of the function group.

I0 Elimination (Advanced Stage)

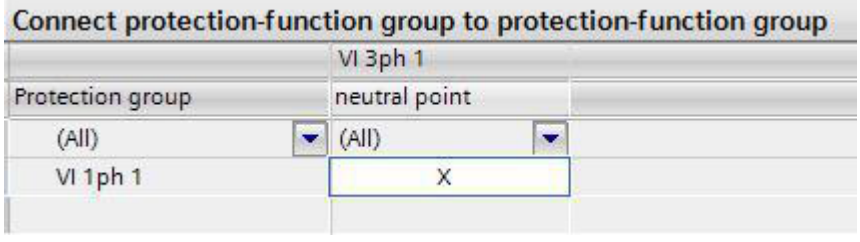
In order to increase the sensitivity for the phase-to-phase faults on the transformer low-voltage side, use the I0 elimination of the phase currents for the overcurrent-protection application on one transformer.
In order to determine the I0 elimination of the phase currents, the transformer neutral point current I_Y must be measured.



[dwsgaocp-230414-01, 1, en_US]

Figure 6-11 I0 Elimination Principle

The transformer neutral point current I_Y is measured via a 1-phase current measuring point that is connected to the **Voltage/current 1-phase**. The function group **Voltage/current 1-phase** must be connected to the function group **Voltage/current 3-phase** in which the function **Overcurrent protection, phases** is being used.



[sccpfoint-230414-01, 1, en_US]

Figure 6-12 Connection of the Voltage/Current 1-Phase Function Group with the Neutral Point Input of the Voltage/Current 3-Phase Function Group

In case of an I0 elimination, the following calculations result:

$\underline{I}_{A\text{-elim.}} = \underline{I}_A - 1/3\ \underline{I}_Y$

$\underline{I}_{B\text{-elim.}} = \underline{I}_B - 1/3\ \underline{I}_Y$

$\underline{I}_{C\text{-elim.}} = \underline{I}_C - 1/3\ \underline{I}_Y$

The phase current $\underline{I}_{phx\text{-elim.}}$ is necessary for the following protection process.

If the **Method of measurement** parameter is set to ***fundamental comp.***, the I0 elimination is applied.

The currents $I_{phx\text{-}elim.}$ are available as functional values.

Pickup delay (Advanced Stage)

If the current exceeds the threshold value, the pickup delay is generated. If the threshold remains exceeded during the pickup delay time, the pickup signal is generated.

Dropout Delay (Advanced Stage)

If the value falls below the dropout threshold, the pickup dropout can be delayed. The pickup is maintained for the specified time. The tripping delay continues to run. If the time delay expires while the pickup is still maintained, the stage operates.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal **>Block stage** from an external or internal source
- Via the functionality of the **dynamic settings** (only available in the Advanced function type, see subtitle **Influence of other functions via dynamic settings** and chapter *6.3.8.1 Description*).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.3.7.1 Description* .

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic Reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.3.8.1 Description* .

6.3.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:661:8) Method of measurement** = ***fundamental comp.***

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value*** parameter Value

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: `Threshold` , `Operate delay`

- Default setting **`(_:661:3) Threshold`** = ***`1.500 A`*** (for the 1st stage)
- Default setting **`(_:661:6) Operate delay`** = ***`0.30 s`*** (for the 1st stage)

Set the **`Threshold`** and **`Operate delay`** parameters for the specific application.

The following details apply to a 2-stage characteristic curve (1st stage = definite time-overcurrent protection stage and 2nd stage = high-current stage).

1st stage (overcurrent stage):

The setting depends on the maximum occurring operating current. Pickup by overload must be excluded since overcurrent protection operates with short tripping times as short-circuit protection and not as overload protection. Therefore, set the **`Threshold`** parameter for lines to approx. 10 %, for transformers and motors to approx. 20% above the maximum load that is expected.

EXAMPLE

Overcurrent-protection stage: 110-kV overhead line, 150 mm² cross-section

Maximum transmittable power	
P_{max}	= 120 MVA
Correspondingly	
I_{max}	= 630 A
Current transformer	= 600 A/5 A
Safety factor	= 1.1

Settings in primary and secondary values result in the setting values:

Threshold value 1st stage (primary)	$= 1.1 \cdot 630\ A = 693\ A$
Threshold value 1st stage (secondary)	$= 1.1 \cdot \frac{630\ A}{600\ A} \cdot 5\ A = 5.8\ A$

[foocpph1-030311-01.tif, 2, en_US]

The **`Operate delay`** to be set is derived from the time-grading schedule that has been prepared for the system.

2nd stage (high-current stage):

This tripping stage can also be used for current grading. This applies in the case of very long lines with low source impedance or ahead of high reactances (for example, transformers, shunt reactors). Set the **`Threshold`** parameter to ensure that the stage does not pick up in case of a short circuit at the end of the line.

Set the **`Operate delay`** parameter to ***`0`*** or to a low value.

Siemens recommends that the threshold values be determined with a system analysis. The following example illustrates the principle of grading with a current threshold on a long line.

EXAMPLE

High-current stage: 110-kV overhead line, 150 mm² cross-section

s (length)	= 60 km
Z_L/s	= 0.46 Ω/km

Ratio of zero-sequence impedance and positive-sequence impedance of the line: $Z_{L0}/Z_{L1} = 4$

Short-circuit power at the beginning of the line:

S_{sc}'	= 2.5 GVA

Ratio of zero-sequence impedance and positive-sequence impedance of the source impedance at the beginning of the line: $Z_{P0}/Z_{P1} = 2$

Current transformer = 600 A/5 A

Resulting in the following values for the line impedance Z_L and the source impedance Z_P:

$$Z_L = 0.46\ \Omega/\mathrm{km} \cdot 60\mathrm{km} = 27.6\ \Omega$$

[fo_OCP002_030311, 1, en_US]

$$Z_P = \frac{110\ \mathrm{kV}^2}{2500\ \mathrm{MVA}} = 4.84\ \Omega$$

[fo_OCP003_030311, 1, en_US]

The 3-phase short-circuit current at the end of the line is $I_{sc\ end}$:

$$I_{sc\ end} = \frac{1.1 \cdot V_{rated}}{\sqrt{3} \cdot (Z_P + Z_L)} = \frac{1.1 \cdot 110\ kV}{\sqrt{3} \cdot (4.84\ \Omega + 27.6\ \Omega)} = 2150\ A$$

[fo_ocpph4_030311, 1, en_US]

The settings in primary and secondary values result in the following setting values which include a safety margin of 10 %:

Threshold value 2nd stage (primary) = $1.1 \cdot 2150\ \mathrm{A} = 2365\ \mathrm{A}$

Threshold value 2nd stage (secondary) = $1.1 \cdot \frac{2150\ \mathrm{A}}{600\ \mathrm{A}} \cdot 5\ \mathrm{A} = 19.7\ \mathrm{A}$

[foocp004-030311-01.tif, 2, en_US]

If short-circuit currents exceed 2365 A (primary) or 19.7 A (secondary), there is a short circuit on the line to be protected. The overcurrent protection can cut off this short circuit immediately.

Note: The amounts in the calculation example are accurate enough for overhead lines. If the source impedance and line impedance have different angles, you have to use complex numbers to calculate the **Threshold** .

Parameter: I0 elimination

- Default setting **(_:661:120) I0 elimination** = ***no***

This parameter is not visible in the basic stage.

The I0 elimination in phase currents for overcurrent-protection applications can be used in a transformer. This increases the sensitivity for the phase-to-phase fault on the transformer low-voltage side. The following conditions must be fulfilled:

- The transformer neutral point current I_Y is measured and is available for the protection function group.
- The parameter **Method of measurement** is set to ***fundamental comp.*** .

With the **I0 elimination** parameter, you can switch the I0 elimination function on or off.

Parameter: Pickup delay

- Default setting **(_:661:102) Pickup delay** = ***0.00 s***

This parameter is not visible in the basic stage.

For special applications, it is desirable that a short exceeding of the current threshold does not lead to the pickup of the stage and start fault logging and recording. If this stage is used as a thermal overload function, that is considered a special application.

When using the **Pickup delay** parameter, a time interval is defined during which a pickup is not triggered if the current threshold is exceeded.

For all short-circuit protection applications, this value is 0.00 s as a default.

Parameter: `Dropout delay`

- Recommended setting value **`(_:661:101) Dropout delay`** = ***`0.00 s`***

This parameter is not visible in the basic stage.

Siemens recommends to use the default setting ***`0`*** since the dropout of a protection stage must be done as fast as possible.

You can use the **`Dropout delay`** parameter ≠ ***`0`*** to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical Data) and set the result.

Parameter: `Dropout ratio`

- Recommended setting value **`(_:661:4) Dropout ratio`** = ***`0.95`***

This parameter is not visible in the basic stage.

The recommended set value of ***`0.95`*** is appropriate for most applications.

To achieve high-precision measurements, the setting value of the parameter **`Dropout ratio`** can be reduced, for example, to ***`0.98`***. If you expect highly fluctuating measurands at the response threshold, you can increase the setting value of the parameter **`Dropout ratio`**. This avoids chattering of the tripping stage.

Parameter: `1-pole operate allowed`

- Default setting **`(_:661:11) 1-pole operate allowed`** = ***`no`***

The parameter must be set for the specific application.

Parameter Value	Description
`no`	The stage always operates 3-pole.
`yes`	The stage operates phase-selectively. However, tripping by the device (generated in the tripping logic of the function group **Circuit-breaker**) is always 3-pole because the device does not support phase-selective tripping.

6.3.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:661:1	Definite-T 1:Mode		• off • on • test	off
_:661:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:661:11	Definite-T 1:1-pole operate allowed		• no • yes	no
_:661:26	Definite-T 1:Dynamic settings		• no • yes	no
_:661:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:661:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:661:120	Definite-T 1:I0 elimination		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:661:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:661:102	Definite-T 1:Pickup delay		0.00 s to 60.00 s	0.00 s
_:661:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:661:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n.rdy				
_:661:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:661:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:661:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:661:36	Definite-T 1:Stage blocked		• no • yes	no
_:661:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:661:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:661:37	Definite-T 1:Stage blocked		• no • yes	no
_:661:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:661:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no
_:661:38	Definite-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:661:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:661:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:661:39	Definite-T 1:Stage blocked		• no • yes	no
_:661:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: Cold load PU				
_:661:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:661:40	Definite-T 1:Stage blocked		• no • yes	no
_:661:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:661:34	Definite-T 1:Effected by binary input		• no • yes	no
_:661:41	Definite-T 1:Stage blocked		• no • yes	no
_:661:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

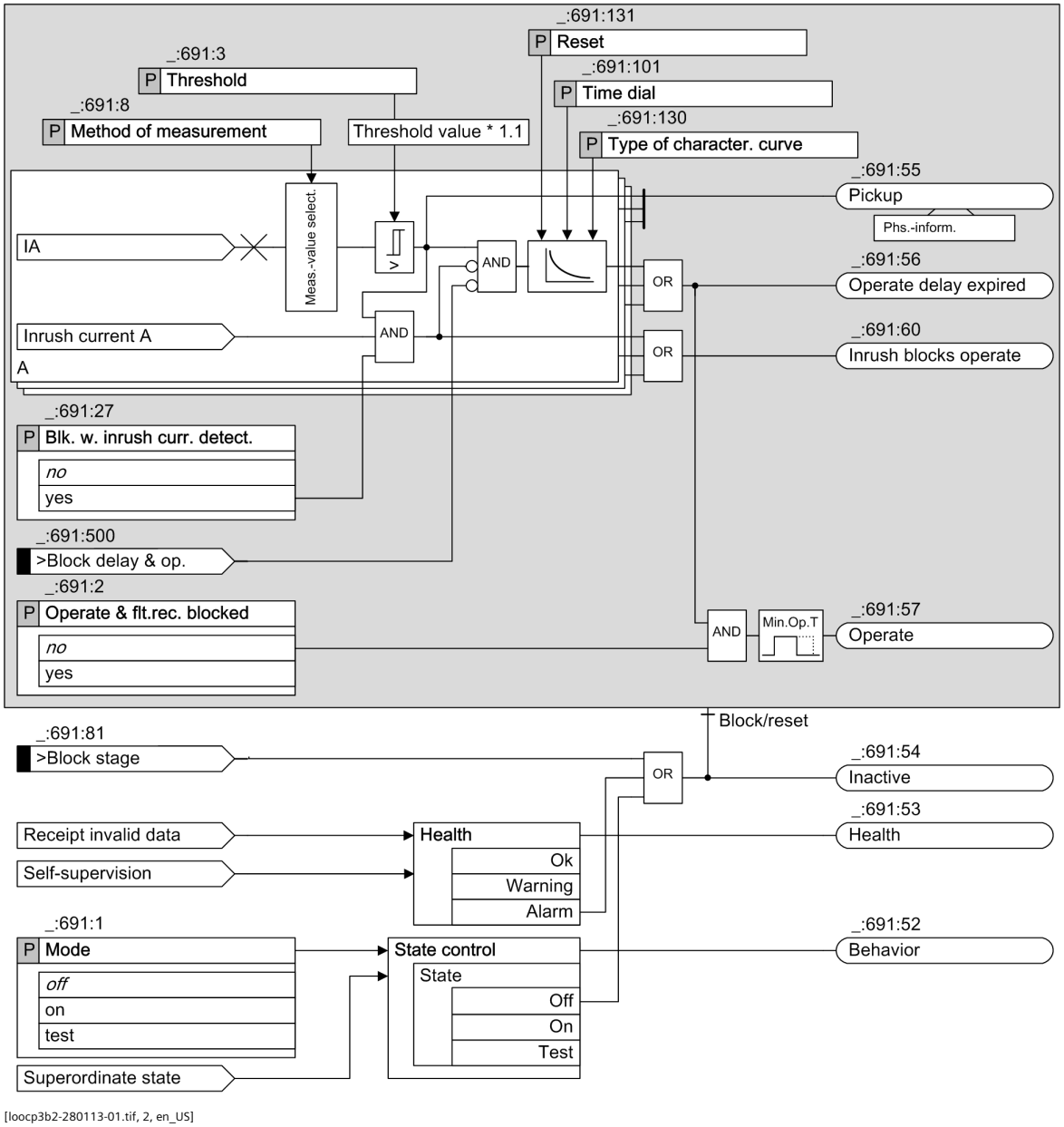
6.3.4.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:661:81	Definite-T 1:>Block stage	SPS	I
_:661:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:661:500	Definite-T 1:>Block delay & op.	SPS	I
_:661:54	Definite-T 1:Inactive	SPS	O
_:661:52	Definite-T 1:Behavior	ENS	O
_:661:53	Definite-T 1:Health	ENS	O
_:661:60	Definite-T 1:Inrush blocks operate	ACT	O
_:661:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:661:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:661:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O
_:661:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:661:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:661:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:661:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O
_:661:55	Definite-T 1:Pickup	ACD	O
_:661:56	Definite-T 1:Operate delay expired	ACT	O
_:661:57	Definite-T 1:Operate	ACT	O
_:661:302	Definite-T 1:I0el.Iph	WYE	O

6.3.5 Stage with Inverse-Time Characteristic Curve

6.3.5.1 Description

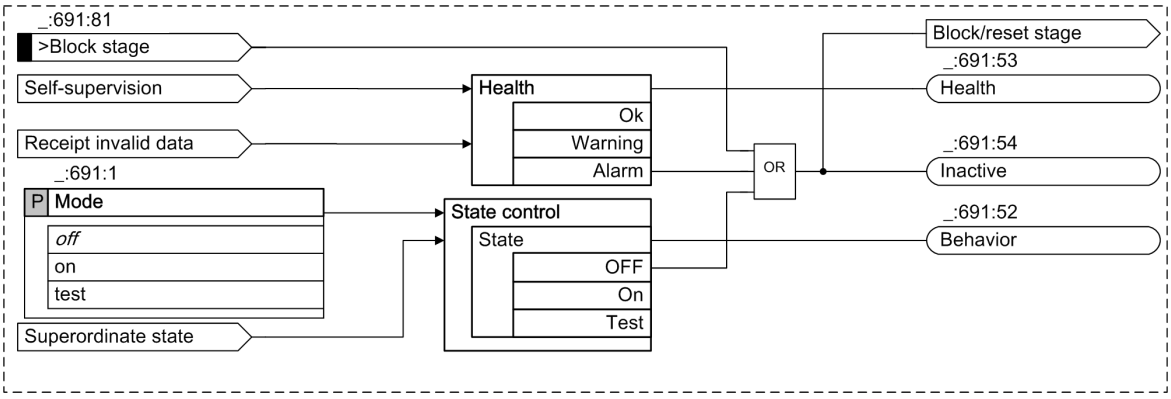
Logic of the Basic Stage



[loocp3b2-280113-01.tif, 2, en_US]

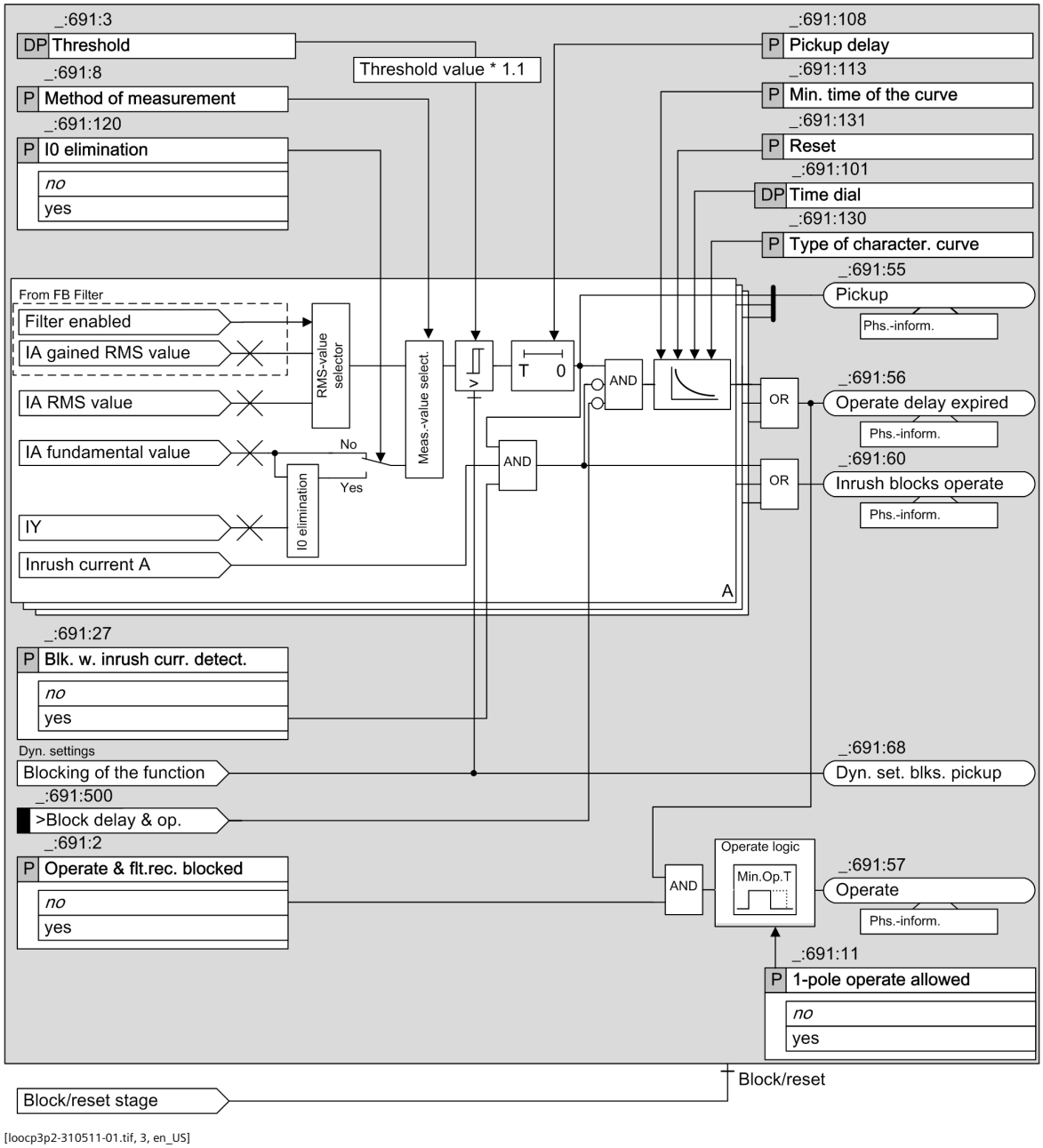
Figure 6-13 Logic Diagram of the Inverse Time-Overcurrent Protection (Phases) – Basic

Logic of the Advanced Stage



[lo_Stage Control, 1, en_US]

Figure 6-14 Logic Diagram of the Stage Control



[loocp3p2-310511-01.tif, 3, en_US]

Figure 6-15 Logic Diagram of the Inverse Time-Overcurrent Protection (Phases) – Advanced

RMS-Value Selection (Advanced Stage)

If ***RMS value*** is selected as the method of measurement, the protection function supports 2 kinds of RMS measurement.

- Normal RMS value
- Gained RMS value from the function block **Filter**

If the function block **Filter** is configured and if youSelf practise_LG_OCP_Inverse time_Advanced, 1, en_US have enabled the filter, the gained RMS value is automatically used.

NOTE

When the function blcok **Filter** is applied, only one 3-phase current measuring point is allowed to be connected to the 3-phase current interface of the function group.

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI (Basic and Advanced Stage)

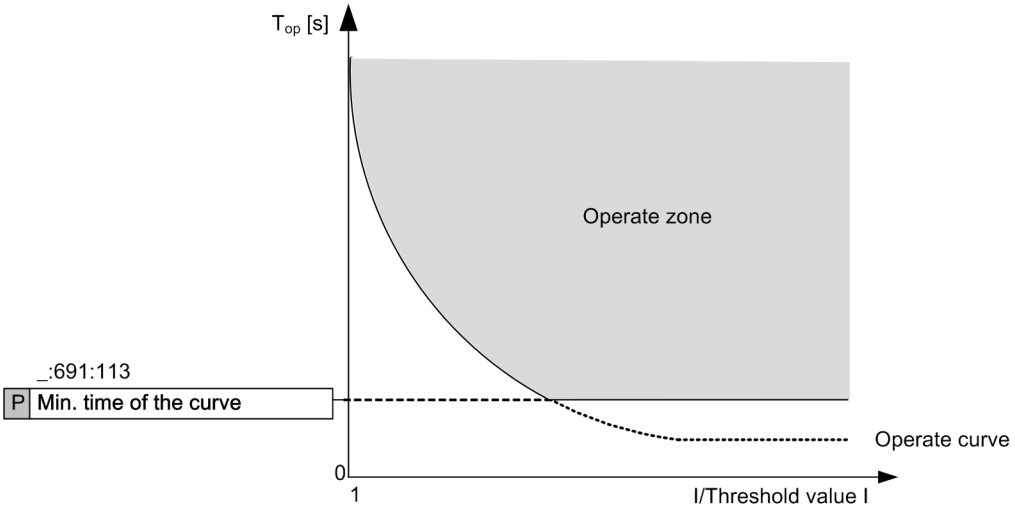
When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Minimum Time of the Curve (Advanced Stage)

With the parameter **`Min. time of the curve`**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.



[DwOcp3Mi_20140715-01, 1, en_US]

Figure 6-16 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter **`Additional time delay`**, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

Method of Measurement (Basic and Advanced Stage)

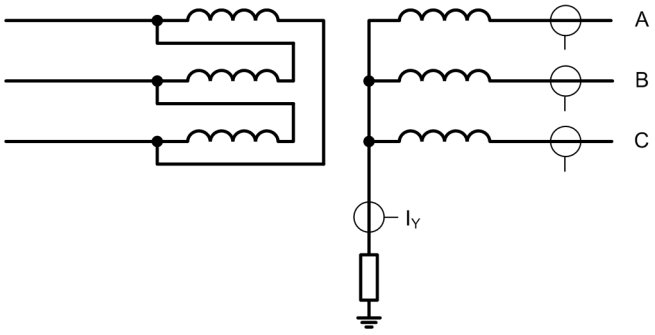
You use the **`Method of measurement`** parameter to define whether the stage uses the ***`fundamental comp.`*** or the calculated ***`RMS value`***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

I0 Elimination (Advanced Stage)

In order to increase the sensitivity for the phase-to-phase fault on the transformer low-voltage side, use the I0 elimination of the phase currents for the overcurrent-protection applications on one transformer.

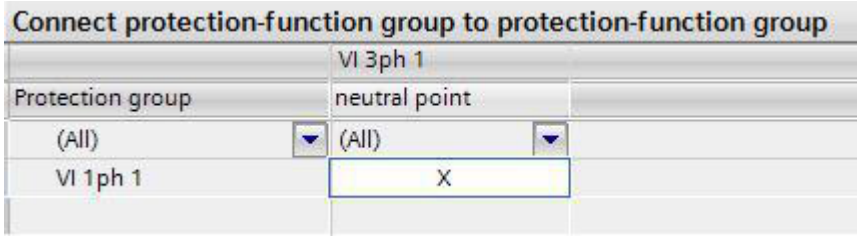
In order to determine the I0 elimination of the phase currents, the transformer neutral point current I_Y must be measured.



[dwsgaocp-230414-01, 1, en_US]

Figure 6-17 I0 Elimination Principle

The transformer neutral point current I_Y is measured via a 1-phase current measuring point that is connected to the **Voltage/current 1-phase**. The function group **Voltage/current 1-phase** must be connected to the function group **Voltage/current 3-phase** in which the function **Overcurrent protection, phases** is used.



[sccpfoint-230414-01, 1, en_US]

Figure 6-18 Connection of the Function Group Voltage/Current 1-Phase with the Neutral Point Input of the Voltage/Current 3-Phase Function Group

In case of an I0 elimination, the following calculations must be considered:

$\underline{I}_{A\text{-elim.}} = \underline{I}_A - 1/3\ \underline{I}_Y$

$\underline{I}_{B\text{-elim.}} = \underline{I}_B - 1/3\ \underline{I}_Y$

$\underline{I}_{C\text{-elim.}} = \underline{I}_C - 1/3\ \underline{I}_Y$

The phase current $\underline{I}_{phx\text{-elim.}}$ is necessary for the following protection process.

If the **`Method of measurement`** parameter is set to ***`fundamental comp.`***, the I0 elimination is operating.

The currents $\underline{I}_{phx\text{-elim.}}$ are available as functional values.

Pickup Delay (Advanced Stage)

If the current exceeds the threshold value, the pickup delay starts. If the threshold is exceeded during the pickup delay time, the pickup signal is generated.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal **`>Block stage`** from an external or internal source
- Via the functionality of the **`dynamic settings`** (only available in the Advanced function type, see subtitle **Influence of other functions via dynamic settings** and chapter *6.3.8.1 Description*).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.3.7.1 Description* .

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic Reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.3.8.1 Description* .

6.3.5.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:691:8) Method of measurement** = ***fundamental comp.***

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value*** Parameter Value

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: Type of character. curve

- Default setting **(_:691:130) Type of character. curve** = ***IEC normal inverse***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **Type of character. curve** required for your specific application. For more information about the parameter **Type of character. curve**, refer to chapter *12.5.2 Stage with Inverse-Time Characteristic Curve*.

Parameter: Min. time of the curve

- Default setting **(_:691:113) Min. time of the curve** = ***0.00 s***

This parameter is only available in the advanced stage.

With the parameter **Min. time of the curve**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: Additional time delay

- Default setting **(_:691:115) Additional time delay** = ***0.00 s***

With the parameter **Additional time delay**, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic time.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

Parameter: Threshold

- Default setting **(_:691:3) Threshold** = ***1.500 A***

Set the **Threshold** and **Type of character. curve** parameters for the specific application.

The setting depends on the maximum occurring operating current. Pickup by overload must be excluded since overcurrent protection operates with short tripping times as short-circuit protection and not as overload protection. Set the **Threshold** parameter for lines to approx. 10 %, for transformers and motors to approx. 20 % above the maximum expected load.

Note that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the **Threshold**.

EXAMPLE

Overcurrent-protection stage: 110-kV overhead line, 150 mm² cross-section

Maximum transmittable power	
P_{max}	= 120 MVA
Correspondingly	
I_{max}	= 630 A
Current transformer	= 600 A/5 A

Settings in primary and secondary values result in the setting values:

Threshold value I> (primary) = 630 A

$$\text{Threshold value I> (secondary)} = \frac{630\ \text{A}}{600\ \text{A}} \cdot 5\ \text{A} = 5.25\ \text{A}$$

[foocp005-030311-01.tif, 2, en_US]

Parameter: I0 elimination

- Default setting **(_:661:120) I0 elimination** = ***no***

This parameter is not visible in the basic stage.

The I0 elimination in phase currents for overcurrent-protection applications can be used in a transformer. This increases the sensitivity for the phase-to-phase faults on the low-voltage side of the transformer. The following conditions must be fulfilled:

- The transformer neutral point current I_Y is measured and is available for the protection function group.
- The parameter **Method of measurement** is set to ***fundamental comp.***.

With the **I0 elimination** setting, you can switch the I0 elimination function on or off.

Parameter: `Pickup delay`

- Default setting **`(_:661:102) Pickup delay`** = ***`0.00 s`***

This parameter is not visible in the basic stage.

For special applications it is desirable if the current threshold is briefly exceeded, that this will not lead to the pickup of the stage and starts fault logging or recording. If this stage is used as a thermal overload function, that is considered a special application.

When using the **`Pickup delay`** parameter, a time interval is defined during which a pickup is not trigger if the current threshold is exceeded.

For all short-circuit protection applications, this value is 0.00 s and is considered as a default.

Parameter: `Time dial`

- Default setting **`(_:691:101) Time dial`** = ***`1.00`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The set value for the **`Time dial`** parameter is derived from the time-grading chart that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter **`Time dial`** at ***`1`*** (default setting).

Parameter: `Reset`

- Default setting **`(_:691:131) Reset`** = ***`disk emulation`***

You use the **`Reset`** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: `1-pole operate allowed`

- Default setting **`(_:691:11) 1-pole operate allowed`** = ***`no`***

The parameter must be set for the specific application.

Parameter Value	Description
`no`	The stage always operates 3-pole.
`yes`	The stage operates phase-selectively. However, tripping by the device (generated in the tripping logic of the function group **Circuit-breaker**) is always 3-pole because the device does not support phase-selective tripping.

6.3.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:691:1	Inverse-T 1:Mode		• off • on • test	off
_:691:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:691:11	Inverse-T 1:1-pole operate allowed		• no • yes	no
_:691:26	Inverse-T 1:Dynamic settings		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:691:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:691:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:691:120	Inverse-T 1:I0 elimination		• no • yes	no
_:691:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:108	Inverse-T 1:Pickup delay		0.00 s to 60.00 s	0.00 s
_:691:130	Inverse-T 1:Type of character. curve			
_:691:113	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:691:131	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:691:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:691:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:691:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:691:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:691:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:691:36	Inverse-T 1:Stage blocked		• no • yes	no
_:691:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 2				
_:691:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:691:37	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:691:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 3				
_:691:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no
_:691:38	Inverse-T 1:Stage blocked		• no • yes	no
_:691:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: AR cycle>3				
_:691:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:691:39	Inverse-T 1:Stage blocked		• no • yes	no
_:691:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:691:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:691:40	Inverse-T 1:Stage blocked		• no • yes	no
_:691:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: bin.input				
_:691:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:691:41	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:691:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

6.3.5.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:691:81	Inverse-T 1:>Block stage	SPS	I
_:691:500	Inverse-T 1:>Block delay & op.	SPS	I
_:691:54	Inverse-T 1:Inactive	SPS	O
_:691:52	Inverse-T 1:Behavior	ENS	O
_:691:53	Inverse-T 1:Health	ENS	O
_:691:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:691:59	Inverse-T 1:Disk emulation running	SPS	O
_:691:55	Inverse-T 1:Pickup	ACD	O
_:691:56	Inverse-T 1:Operate delay expired	ACT	O
_:691:57	Inverse-T 1:Operate	ACT	O

6.3.6 Stage with User-Defined Characteristic Curve

6.3.6.1 Description

This stage is only available in the advanced function type.

This stage is structured the same way as the **Inverse time-overcurrent protection – advanced** stage (see chapter *6.3.5.1 Description*). The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

With the user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

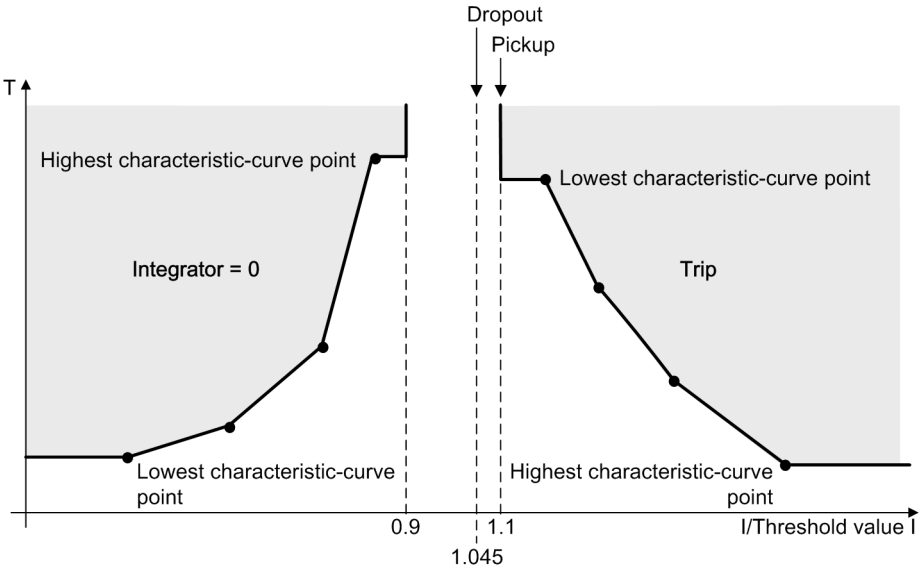
Pickup and Dropout Behavior with the User-Defined Characteristic Curve

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The

dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.



[dwocpken-140611-02.tif, 1, en_US]

Figure 6-19 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

The currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

6.3.6.2 Application and Setting Notes

This stage is structured the same way as the **Inverse time-overcurrent protection – advanced** stage. The only difference is that you can define the characteristic curve as desired. This chapter provides only application and setting notes for setting characteristic curves.

Parameter: `Current/time value pairs` (from the operate curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to shift the characteristic curve.

Set the time value in seconds. The characteristic curve is shifted via the **`Time dial`** parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: `Time dial`

- Default setting **`(_:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The set value for the **Time dial** parameter is derived from the time-grading chart that has been prepared for the electrical power system. Where no time grading and therefore no displacement of the characteristic curve is required, leave the **Time dial** parameter at ***1***.

Parameter: Reset

- Default setting **(_:110) Reset** = ***disk emulation***

You use the **Reset** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation but an instantaneous dropout is desired.

Parameter: Current/time value pairs (of the dropout characteristic curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **Threshold** parameter to ***1.00*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to shift the characteristic curve.

Set the time value in seconds. The characteristic curve is shifted via the **Time dial** parameter.



NOTE

The value pairs must be entered in continuous order.

Parameter: 1-pole operate allowed

- Default setting **(_:11) 1-pole operate allowed** = ***no***

The parameter must be set for the specific application.

Parameter Value	Description
no	The stage always operates 3-pole.
yes	The stage operates phase-selectively. However, tripping by the device (generated in the tripping logic of the function group **Circuit breaker**) is always 3-pole because the device does not support phase-selective tripping.

6.3.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:11	User curve #:1-pole operate allowed		• no • yes	no
_:26	User curve #:Dynamic settings		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:120	User curve #:I0 elimination		• no • yes	no
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:111	User curve #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

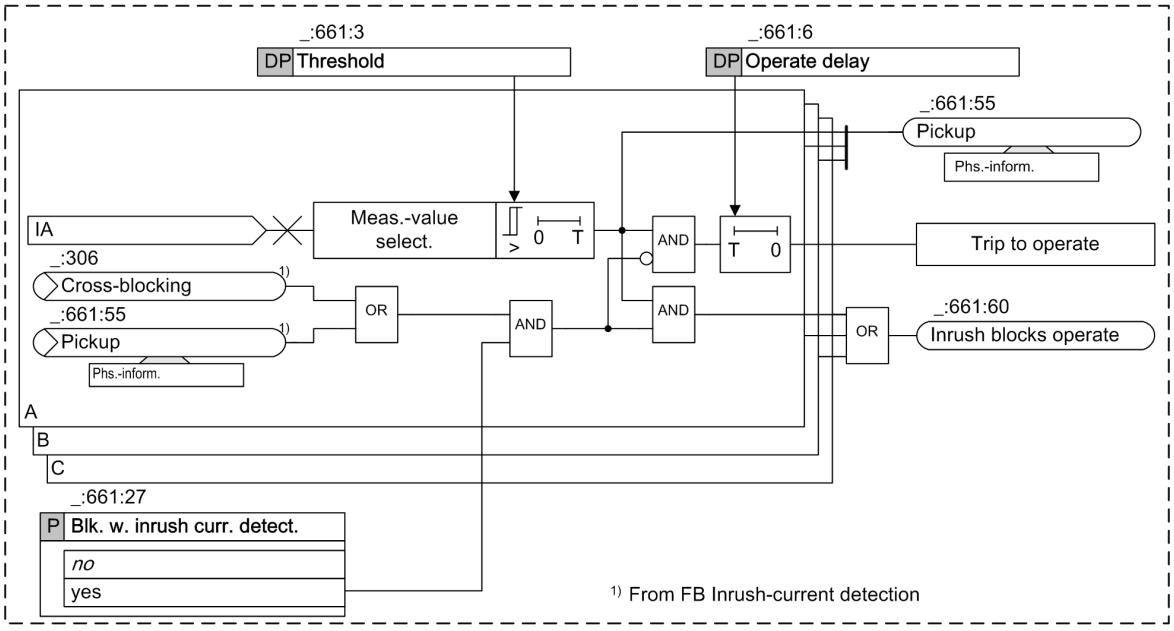
6.3.6.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:84	User curve #:>Activ. dyn. settings	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:62	User curve #:Dyn.set. AR cycle1act.	SPS	O
_:63	User curve #:Dyn.set. AR cycle2act.	SPS	O
_:64	User curve #:Dyn.set. AR cycle3act.	SPS	O
_:65	User curve #:Dyn.set. ARcycl.>3act	SPS	O
_:66	User curve #:Dyn.set. CLP active	SPS	O
_:67	User curve #:Dyn.set. BI active	SPS	O
_:68	User curve #:Dyn. set. blks. pickup	SPS	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.3.7 Blocking of the Tripping by Device-Internal Inrush-Current Detection

6.3.7.1 Description

With the **`Blk. w. inrush curr. detect.`** parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the tripping delay and the trip signal are blocked. The function signals this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. After that time, the stage operates. The following figure only shows the part of the stage (exemplified by definite time-overcurrent protection stage 1) that illustrates the influence of the blocking. Only if the central function **Inrush-current detection** (see chapter *12.10 Inrush-Current Detection*) is in effect can the blocking be set.



[loocp3pha-210812-01.vsd, 1, en_US]

Figure 6-20 Part-Logic Diagram on the Influence of Inrush-Current Detection Exemplified by the 1st Definite Time-Overcurrent Protection Stage

6.3.7.2 Application and Setting Notes

Parameter: **`Blk. w. inrush curr. detect.`**

- Default setting **`(_:661:27) Blk. w. inrush curr. detect.`** = ***`no`***

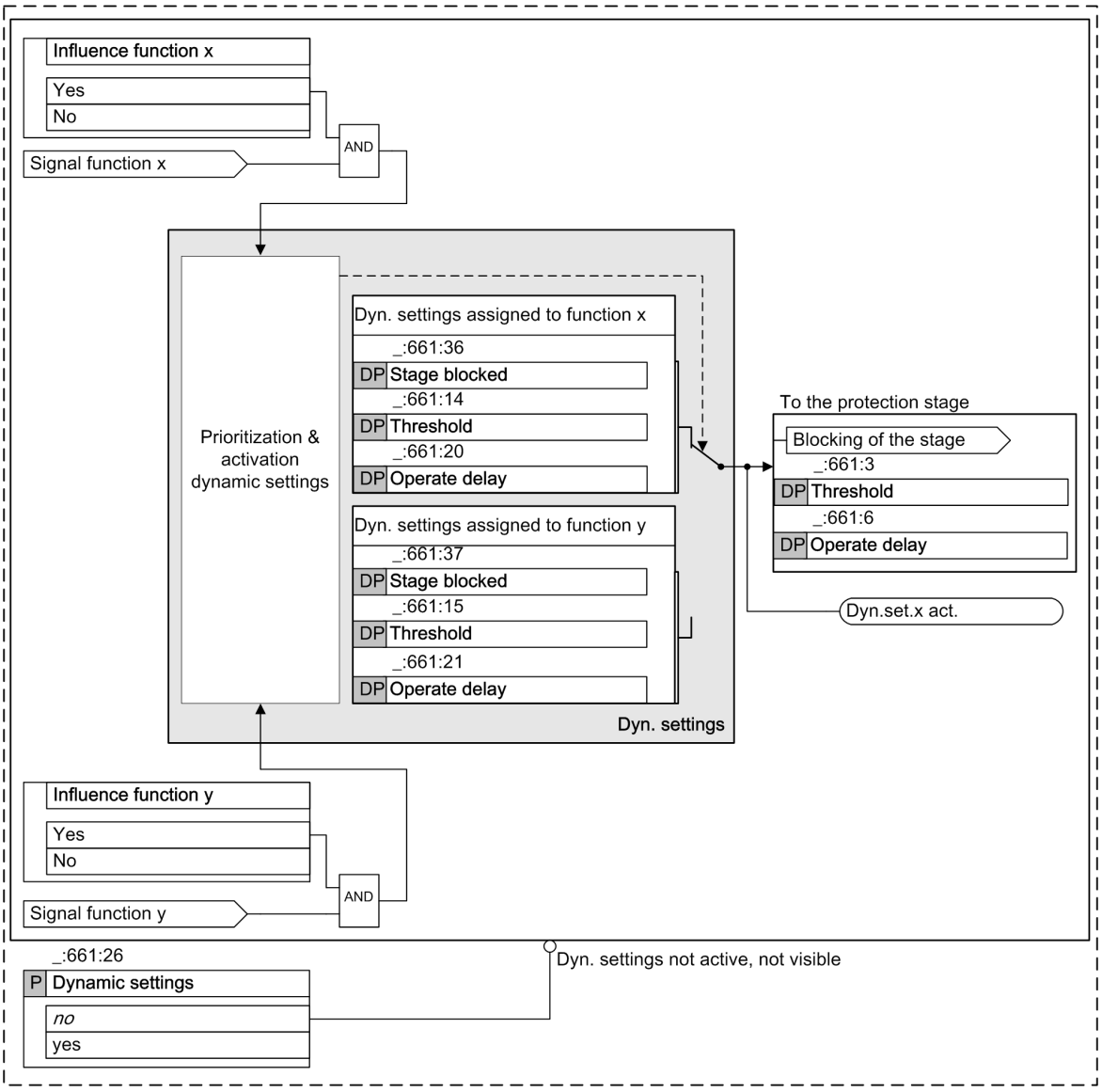
Parameter Value	Description
`no`	The transformer inrush current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This, for example, applies to the high-current stage that is set such according to the short-circuit voltage V_{sc} of the transformer that it only picks up on faults from the high-voltage side. The transformer-inrush current cannot become larger than the maximum transmittable short-circuit current.
`yes`	When the transformer inrush current detection detects an inrush current that would lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

6.3.8 Influence of Other Functions via Dynamic Settings

6.3.8.1 Description

The parameters **`Threshold`** and **`Operate delay`** used for tripping are so-called **`dynamic settings`**. Depending on other functions, the settings of these parameters can be changed dynamically (see

Figure 6-21). Depending on other functions, the stage can also be blocked dynamically. This functionality is only available in function type Advanced.



[loocp3dpa-030311-01.vsd, 1, en_US]

Figure 6-21 Principle of the Dynamic Settings Exemplified by 1st Definite Time-Overcurrent Protection Stage

If available in the device, the following functionalities can affect the overcurrent-protection stages:

Functionalities	Priority
Automatic reclosing (AREC)	Priority 1
Cold-load pickup detection	Priority 2
Binary input signal	Priority 3

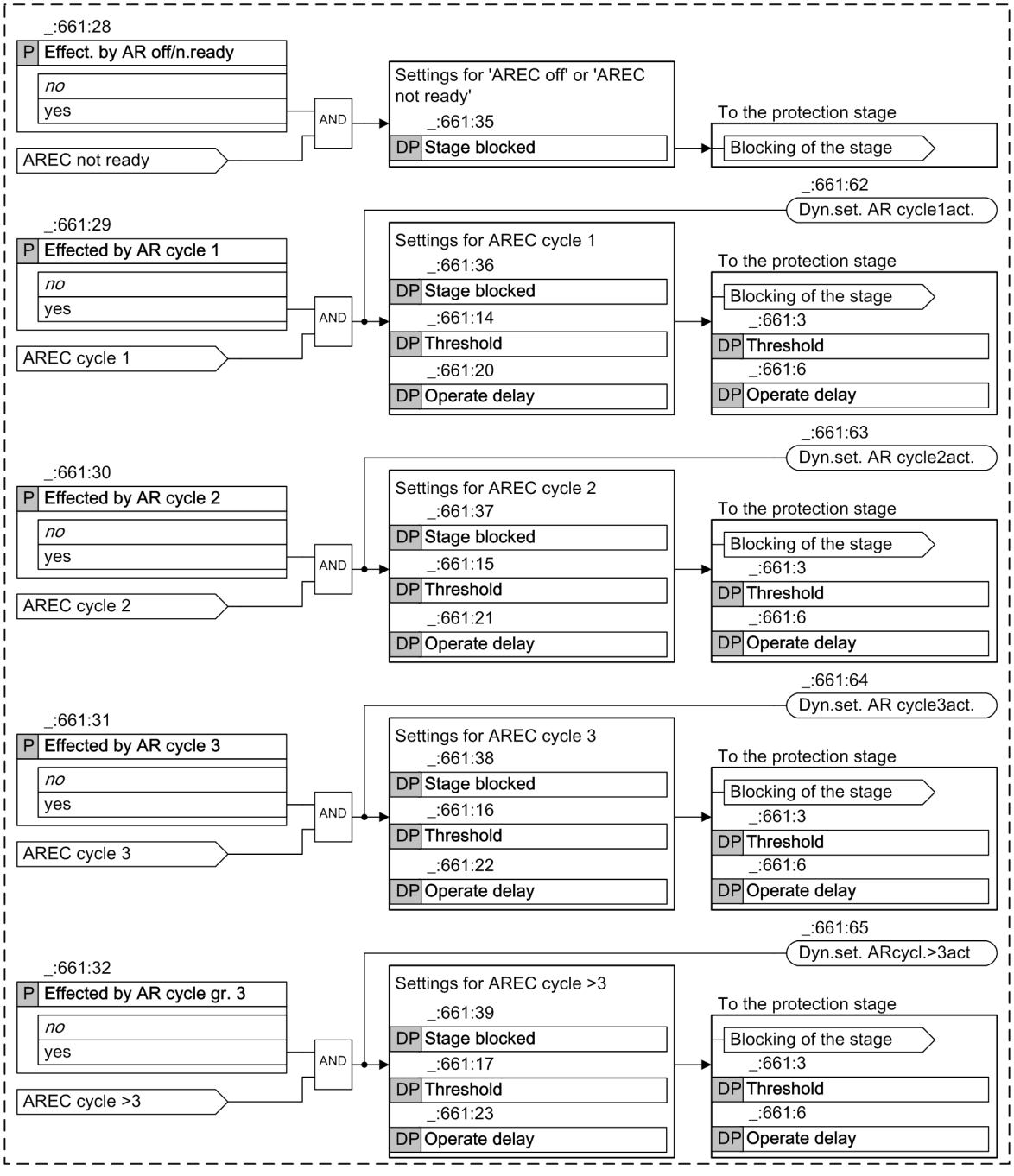
These functionalities generate signals that change the settings of the dynamic settings of the overcurrent-protection stage or block it, if required. In the latter case, the settings of the **Threshold** and **Operate delay** parameters are of no relevance. Within the overcurrent-protection stage, each of these signals is provided with a configuration parameter **Influence of function ...** and its own dynamic settings (**Operate delay** and **Threshold**). The configuration settings are used to set whether the signal shall be active or not, this means whether the dynamic settings shall be activated or not. If one of these signals (for

example, signal function x) becomes active and is to take effect, these settings become dynamic, that is, instantly active. This means that the setting assigned to the signal replaces the standard setting. If the signal becomes inactive, the standard settings apply again. The activation of the dynamic settings is reported.

Where several signals are active in parallel, the priority specified above shall apply. This means that a signal with priority 2 precedes that of priority 3. The settings assigned to signal 2 become active.

The functionality of the dynamic settings can be disabled. In this case, the settings assigned to the signals are not visible and are without effect.

Link to the Device-Internal Function *Automatic Reclosing (Advanced Stage)*



[loocp3awe-040311-01, 1, en_US]

Figure 6-22 Influence of the AREC Signals on the Overcurrent-Protection Stage

Several AREC signals can affect the setting for the **Threshold** and **Operate delay** parameters of the protection stage and its blocking.

- AREC is ready for reclosing 1 (= Automatic reclosing cycle 1)
- AREC is ready for reclosing 2 (= Automatic reclosing cycle 2)
- AREC is ready for reclosing 3 (= Automatic reclosing cycle 3)
- AREC is ready for reclosing 4 (= Automatic reclosing cycle >3)

The following signal can only block the protection stage:

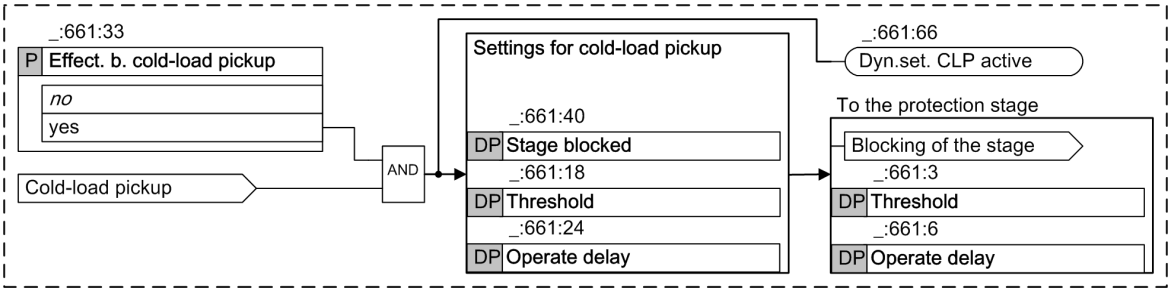
- AREC is not ready or switched off (= Automatic reclosing off / not ready)

This means that if the AREC is ready and the protection stage is in the idle state, the settings for **AREC cycle 1** are active and not the standard settings. The standard settings are active in the case of **AREC off/not ready**.

The influence can be activated for each signal individually. You also have to set the **Threshold** and **Operate delay** or **Stage blocked** parameters, which take effect when the signal is active.

The way AREC signals are generated is described in chapter *6.43.1 Overview of Functions*.

Link to the Device-Internal Function *Cold-Load Pickup Detection (Advanced Stage)*



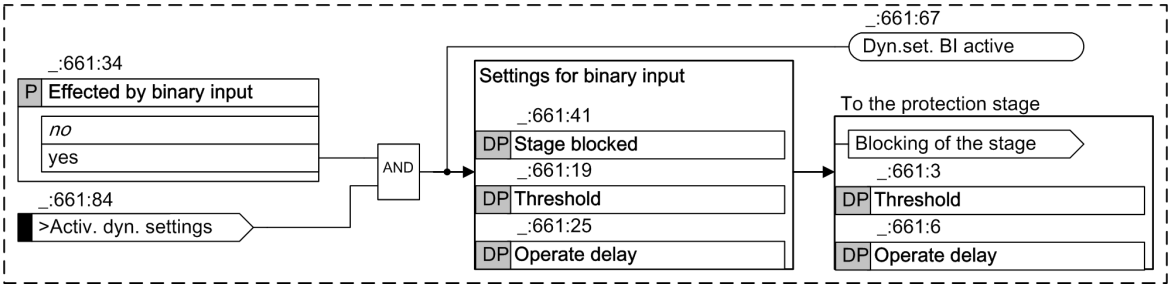
[loocp3kal-030311-01.vsd, 1, en_US]

Figure 6-23 Influence of the Cold-Load Pickup Detection on the Overcurrent-Protection Stage

In the case of cold-load pickup, you have the option to change the settings for the **Threshold** and **Operate delay** parameters of the protection level. You can also block the level. To do so, you must activate the influence of the cold-load pickup. You also have to set the **Threshold** and **Operate delay** or assign settings to **Stage blocked**, which take effect when the signal is active.

The way signals are generated **Cold-load pickup** is described in chapter *5.8.1 Overview of Functions*.

Link to an External *Function via a Binary Input Signal (Advanced Stage)*



[loocp3bin-030311-01.vsd, 1, en_US]

Figure 6-24 Influence of the Binary Input on the Overcurrent-Protection Stage

You can use the binary input signal **>Activ. dyn. settings** to change the settings for the **Threshold** and the **Operate delay** parameters of the protection stage. You can also block the level. To do so, you must activate the influence of the binary input. You also have to set the **Threshold** and **Operate delay** or assign settings to **Stage blocked**, which take effect when the signal is active.

6.3.8.2 Application and Setting Notes (Advanced Stage)

Parameter: `Dynamic settings`

- Default setting **`(_:661:26) Dynamic settings`** = ***no***

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (automatic reclosing function or cold-load pickup detection) or an external function should affect the overcurrent-protection stage (such as change the setting of the threshold value or time delay, blocking of the stage), the setting must be changed to ***yes***. This makes the configuration parameters **`Influence of function...`** as well as the dynamic settings **`Threshold`**, **`Operate delay`** and **`Stage blocked`** of the stage visible and enables the settings to be set for the specific influence.

Influence of AREC

The example of how the overcurrent stage (1st stage) can be used as a fast stage before automatic reclosing describes the influence exerted by AREC.

The setting of the overcurrent stage (1st stage) results from the time-grading schedule. Additionally, it is to be used as fast stage before an automatic reclosing. Because a fast disconnection of the short-circuit current takes priority over the selectivity prior to reclosing, the tripping delay can be set to ***0*** or a very small value. To achieve the selectivity, the final disconnection must be done with the grading time.

AREC is set to 2 reclosings. A secondary **`Threshold`** of ***1.5 A*** and a **`Operate delay`** of ***600 ms*** are assumed (according to the time-grading schedule) for the overcurrent-protection stage. The standard settings of the stage are set to these values.

To realize the application, the configuration settings **`Effected by AR cycle 1`** and **`Effected by AR cycle 2`** are changed in the example to ***yes*** (= influenced). This activates the **`AR cycle 1`** and **`AR cycle 2`** input signals within the stage. When they become active, they switch to the assigned dynamic settings.

The two dynamic settings **`Operate delay`** assigned to these input signals (sources of influence) are set to the time delay ***0*** (instantaneous tripping). The two dynamic settings **`Threshold`** assigned to these input signals are set to the normal threshold value of ***1.5 A***.

If the threshold value (***1.5 A***) is exceeded before AREC 1 and AREC 2, the overcurrent-protection stage trips instantaneously. If the fault still exists after AREC 2 (unsuccessful AREC), the stage trips with the time delay of ***600 ms*** according to the time-grading schedule.

Influence of External Devices

The influence of an external device can also be configured. The above is an example of how the overcurrent-protection stage (1st stage) can be used as a fast stage before automatic reclosing, in which case the AREC function is performed by an external device.

To realize the application, the configuration setting **`Effected by binary input`** must be changed to ***yes*** (= influenced). This activates the **`>Activ. dyn. settings`** input signal within the stage. When the input signal becomes active, it switches to the assigned dynamic settings. The external device must provide the **`Cycle 1`** and **`Cycle 2`** signals or, alternatively, the **`AR ready`** signal. The signals must be connected with the binary input signal **`>Activ. dyn. settings`**.

The dynamic setting **`Operate delay`**, which is assigned to the input signal (source of influence) **`>Activ. dyn. settings`**, is set to the time delay ***0*** (instantaneous tripping). The dynamic setting **`Threshold`** assigned to this input signal is set to the normal threshold value of ***1.5 A***.

If the threshold value (***1.5 A***) is exceeded before AREC 1 and AREC 2, the overcurrent-protection stage trips instantaneously. If the fault still exists after AREC 2 (unsuccessful AREC), the stage trips with the time delay of ***600 ms*** according to the time-grading schedule.

6.4 Voltage-Dependent Overcurrent Protection, Phases

6.4.1 Overview of Functions

The **Voltage-dependent overcurrent protection** (ANSI 51V) function:

- Detects short circuits affecting electric equipment
- Can be used for special network conditions where the overcurrent pickup level should be decreased depending on the fault voltage
- Can be used for generators where the excitation voltage is derived from the machine terminals and the overcurrent pickup should be kept depending on the fault voltages

6.4.2 Structure of the Function

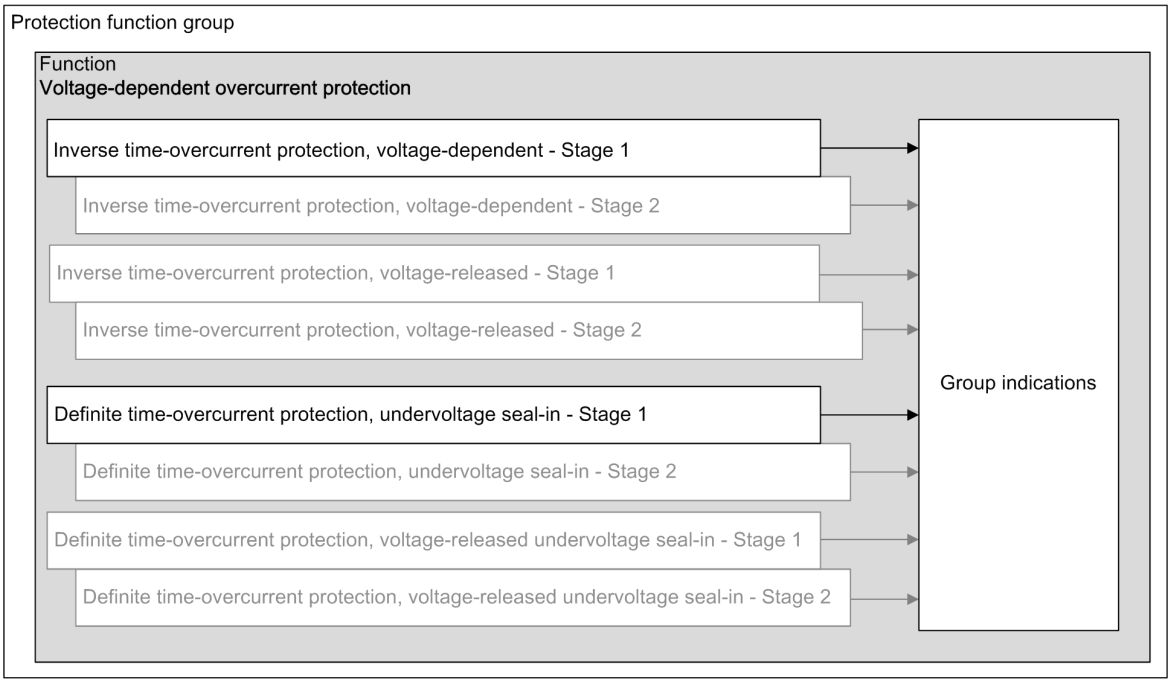
The **Voltage-dependent overcurrent protection** function is used in protection function groups with 3-phase current and voltage measurement.

The function **Voltage-dependent overcurrent protection** comes with the following factory-set stages:

- Inverse time-overcurrent protection, voltage-dependent stage
- Definite time-overcurrent protection, undervoltage seal-in stage

In this function, the following stages can operate simultaneously:

- A maximum of 2 inverse time-overcurrent protection, voltage-dependent stages
- A maximum of 2 inverse time-overcurrent protection, voltage-released stages
- A maximum of 2 definite time-overcurrent protection, undervoltage seal-in stages
- A maximum of 2 definite time-overcurrent protection, voltage-released undervoltage seal-in stages



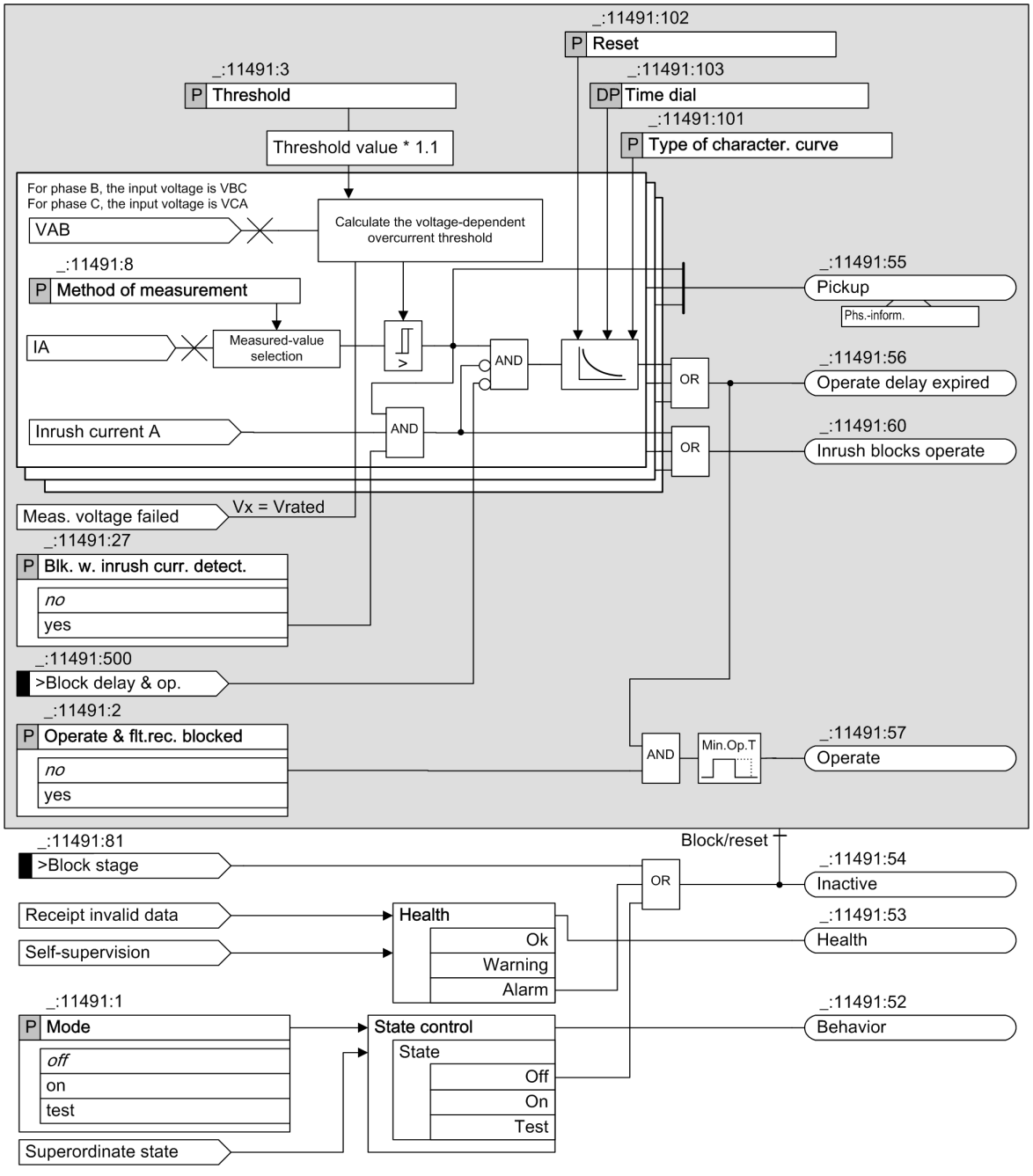
[dwstuvol-210713-03_Release.vsd, 2, en_US]

Figure 6-25 Structure/Embedding of the Function

6.4.3 Stage with Inverse Time-Overcurrent Protection, Voltage-Dependent

6.4.3.1 Description

Logic of the Stage



[lovoldep-210713-01.tif, 1, en_US]

Figure 6-26 Logic Diagram of the Inverse Time-Overcurrent Protection, Voltage-Dependent

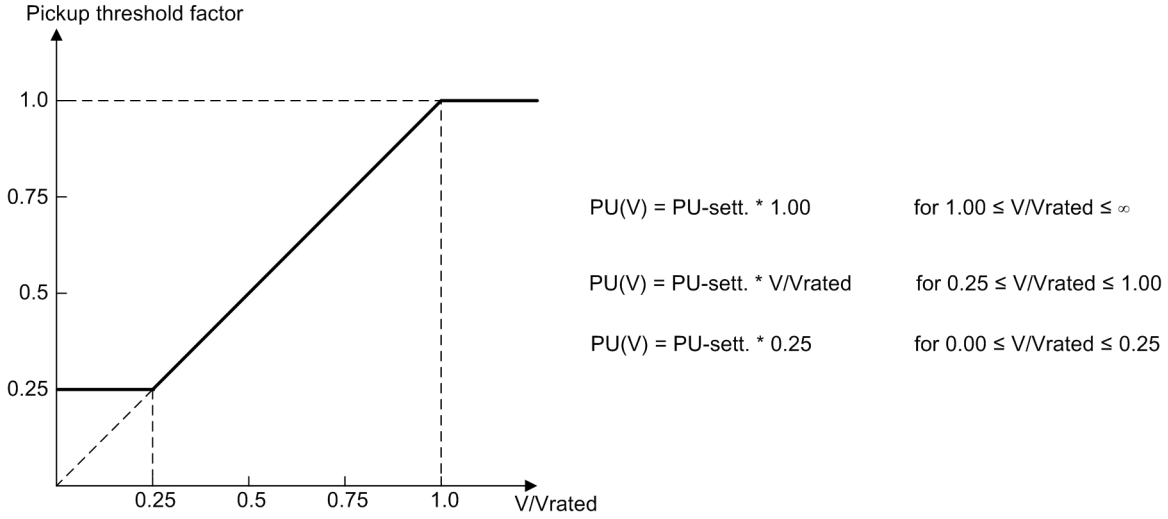
Method of Measurement

You use the **`Method of measurement`** parameter to define whether the stage uses the *`fundamental comp.`* (standard method) or the calculated *`RMS value`*.

- Measurement of the fundamental comp.:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Voltage-Dependent Pickup Threshold

The pickup threshold of the overcurrent stage depends on the voltage magnitude. A lower voltage decreases the current pickup value (see *Figure 6-27*). In the range between V/V_{rated} = 1.00 to 0.25 a linear, directly proportional dependence is realized.



[dwvolpic-220713-01.tif, 1, en_US]

Figure 6-27 Voltage Influence of the Pickup Threshold

With:

V	=	Measured phase-to-phase voltage
V_{rated}	=	Rated voltage (parameter Rated voltage in the function block General of the protection function group)
PU sett.	=	Pickup threshold setting (parameter address: _11491:3)
PU(V)	=	Applied pickup threshold according to the voltage influence

The minimum current pickup threshold value is 0.03 * Irated. This value cannot be decreased any further even not by voltage-dependent pickup threshold factor.

Decreasing the pickup threshold is carried out phase-selectively. The assignment of voltages to current-carrying phases is shown in *Table 6-1*.

Table 6-1 Controlling Voltages in Relation to the Fault Current

Current	Controlling Voltage
I_A	V_{AB}
I_B	V_{BC}
I_C	V_{CA}

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve According to IEC and ANSI

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by 1.045 times (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to the characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is started from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical data.

Influence On the Operate Curve

The current pickup threshold is decreased proportional to the voltage decrease. Consequently, for a constant current I the I/Threshold-value ratio is increased and the operate time is reduced. Compared with the standard curves represented in the **Technical Data**, the operate curve shifts to the left side as the voltage decreases.

Measuring-Voltage Failure Detection

In case of a measuring-voltage failure detection the input voltage value is automatically set to V_{rated}, so that the pickup threshold factor will be 1.

Blocking of the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.3.7.1 Description* .

6.4.3.2 Application and Setting Notes

Parameter: **Blk. w. inrush curr. detect.**

- Default setting **(_:11491:27) Blk. w. inrush curr. detect.** = ***no***

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This applies, for example, to the high-current stage that is set according to the short-circuit voltage Vsc of the transformer in such a way that the stage only picks up on faults from the high-voltage side. The transformer-inrush current cannot become larger than the maximum transmittable short-circuit current.
yes	When the transformer inrush-current detection detects an inrush current that would lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: Method of measurement

- Recommended setting value **(_:11491:8) Method of measurement** = ***fundamental comp.***

You use the **Method of measurement** parameter to define whether the stage uses the *fundamental comp.* (standard method) or the calculated *RMS value*.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard process.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks).

Parameter: Threshold

- Default setting **(_:11491:3) Threshold** = ***1.500 A***

The recommended setting value of 1.500 A is suitable for most applications.

Set the **Threshold** and **Type of character. curve** parameters for the specific application.

The setting depends on the maximum occurring operating current. Pickup by overload must be excluded since overcurrent protection operates with short tripping times as short-circuit protection and not as overload protection.

Set the **Threshold** parameter for lines to approx.10 %, for transformers and motors to approx. 20 % above the maximum expected load.

Note that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the **Threshold**.

Parameter Type of character. curve

- Default setting **(_:11491:101) Type of character. curve** = ***IEC normal inverse***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **Type of character. curve** required for your specific application.

Parameter: Reset

- Default setting **(_:11491:102) Reset** = ***disk emulation***

The **Reset** parameter allows you to define whether the stage decreases according to the dropout characteristic curve (behavior of a disk emulation = rotor disc) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Select this setting if the dropout does not have to be performed after a disk emulation and an instantaneous dropout is desired instead.

Parameter: Time dial

- Default setting **(_:11491:103) Time dial** = ***1***

You can use the **Time dial** parameter to displace the characteristic curve in the time direction.

The setting value for the **Time dial** parameter is derived from the time-grading chart that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter **Time dial** at 1 (default setting).

6.4.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-dependent 1				
_:11491:1	V-dependent 1:Mode		• off • on • test	off
_:11491:2	V-dependent 1:Operate & flt.rec. blocked		• no • yes	no
_:11491:27	V-dependent 1:Blk. w. inrush curr. detect.		• no • yes	no
_:11491:8	V-dependent 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:11491:3	V-dependent 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:11491:101	V-dependent 1:Type of character. curve			
_:11491:102	V-dependent 1:Reset		• instantaneous • disk emulation	disk emulation
_:11491:103	V-dependent 1:Time dial		0.05 to 15.00	1.00

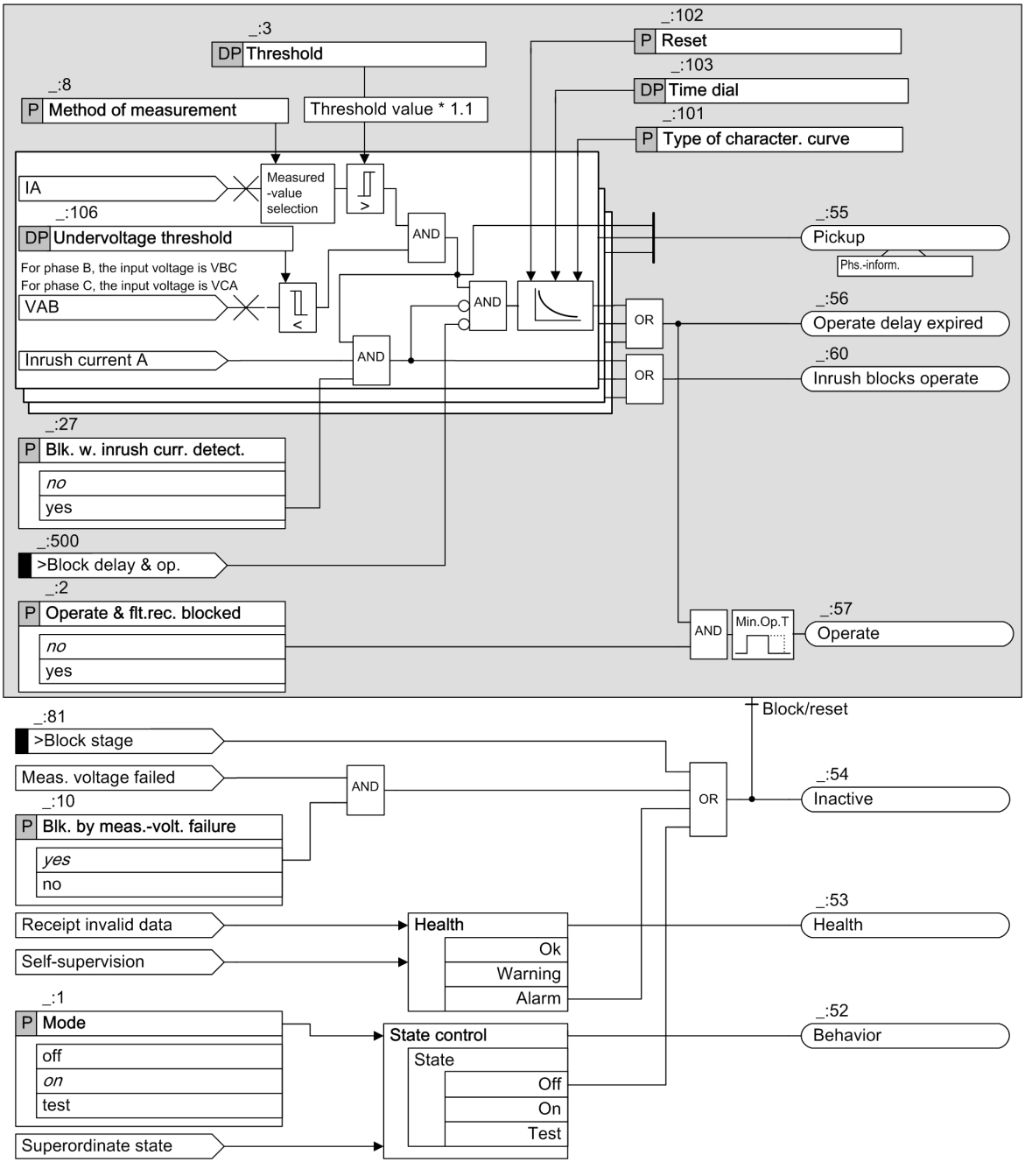
6.4.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
V-dependent 1			
_:11491:81	V-dependent 1:>Block stage	SPS	I
_:11491:500	V-dependent 1:>Block delay & op.	SPS	I
_:11491:54	V-dependent 1:Inactive	SPS	O
_:11491:52	V-dependent 1:Behavior	ENS	O
_:11491:53	V-dependent 1:Health	ENS	O
_:11491:60	V-dependent 1:Inrush blocks operate	ACT	O
_:11491:59	V-dependent 1:Disk emulation running	SPS	O
_:11491:55	V-dependent 1:Pickup	ACD	O
_:11491:56	V-dependent 1:Operate delay expired	ACT	O
_:11491:57	V-dependent 1:Operate	ACT	O

6.4.4 Stage with Inverse Time-Overcurrent Protection, Voltage-Released

6.4.4.1 Description

Logic of the Stage



[lovolrel-210713-01.tif, 1, en_US]

Figure 6-28 Logic Diagram of the Inverse Time-Overcurrent Protection, Voltage-Released

This stage is structured in the same way as the Inverse time-overcurrent, voltage-dependent stage (see chapter *6.4.3.1 Description*). The only differences are the conditions for the pickup and the influence on the operate curve.

Measuring-Element Release

When the controlling voltage drops below the setting **Undervoltage threshold**, the respective measuring element is released.

The release of the measuring elements is carried out phase-selectively. The assignment of voltages to current-carrying phases is shown in *Figure 6-27*.

Blocking of the Stage with Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In case of a blocking, the picked up stage is reset. The following blocking options are available for the stage:

- From an internal source upon pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker

The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.4.4.2 Application and Setting Notes

This stage is structured in the same way as the **Inverse time-overcurrent, voltage-dependent** stage. The only differences are the conditions for the pickup and the influence on the operate curve. This chapter only provides the application and setting notes for the setting **Blk. by meas.-volt. failure** and **Undervoltage threshold**. For guidance on the other parameters of this stage, refer to chapter *6.4.3.2 Application and Setting Notes*.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You can use the **Blk. by meas.-volt. failure** parameter to control the response of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal **Measuring-voltage failure detection** function is configured and switched on.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
no	The overcurrent-protection stage is not blocked when a measuring-voltage failure is detected.
yes	The overcurrent-protection stage is blocked when a measuring-voltage failure is detected. Siemens recommends using the default setting, as correct operation of the stage cannot be guaranteed if a measuring-voltage failure occurs.

Parameter: Undervoltage threshold

- Default setting **(_:104) Undervoltage threshold** = ***75.0 V***

When the controlling voltage is below the set value, the inverse time-overcurrent stage is released.

The parameter is set to a value just below the lowest phase-to-phase voltage admissible during operation, for example, from 75 % to 80 % of V_{rated}.

6.4.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-release #				
_:1	V-release #:Mode		• off • on • test	off
_:2	V-release #:Operate & flt.rec. blocked		• no • yes	no
_:10	V-release #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	V-release #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	V-release #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	V-release #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:101	V-release #:Type of character. curve		• ANSI long-time inv. • ANSI short-time inv. • ANSI extremely inv. • ANSI very inverse • ANSI normal inverse • ANSI moderately inv. • ANSI definite inverse • IEC normal inverse • IEC very inverse • IEC extremely inv. • IEC long-time inverse	IEC normal inverse
_:102	V-release #:Reset		• instantaneous • disk emulation	disk emulation
_:103	V-release #:Time dial		0.05 to 15.00	1.00
_:104	V-release #:Undervoltage threshold		0.300 V to 175.000 V	75.000 V

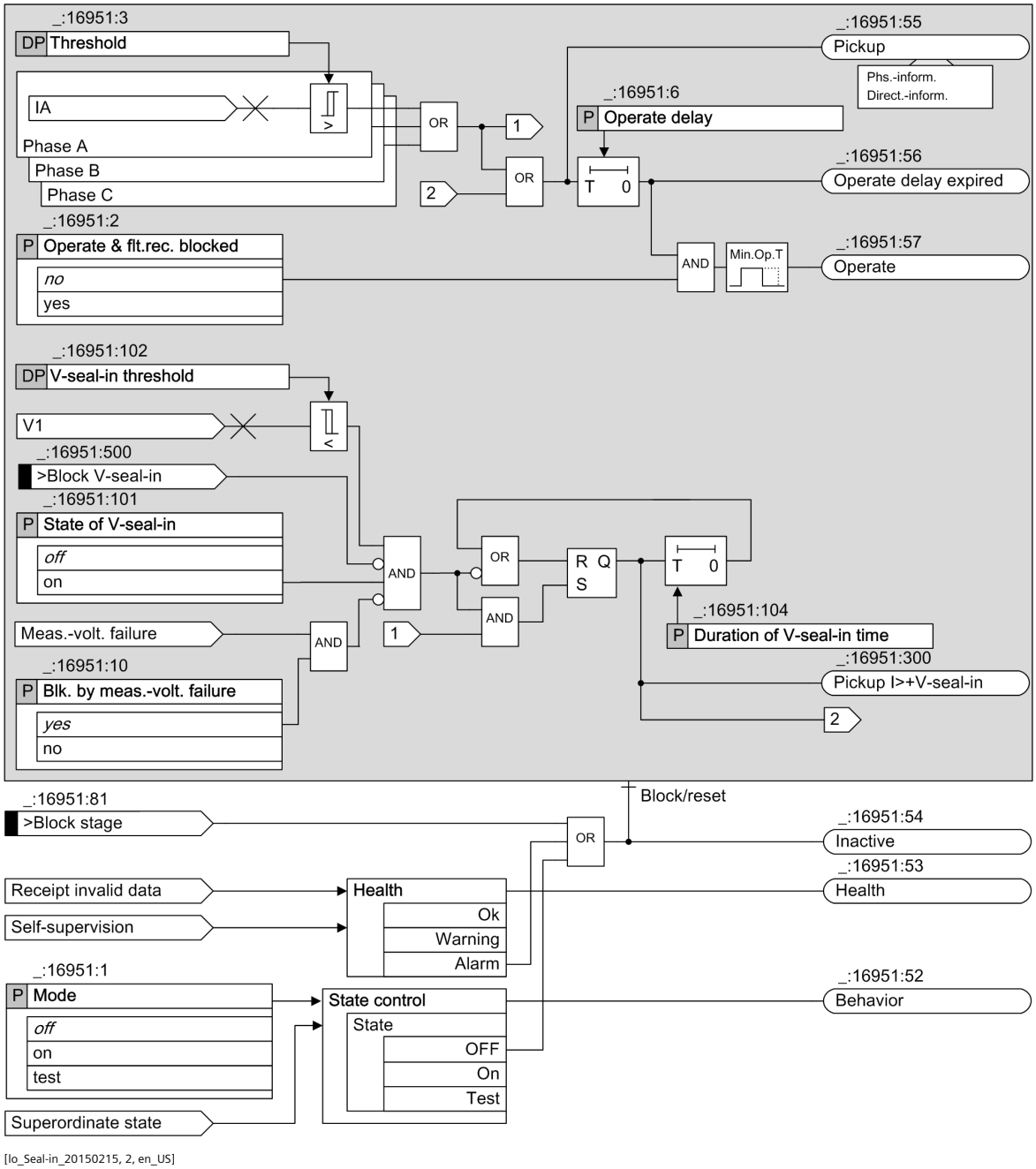
6.4.4.4 Information List

No.	Information	Data Class (Type)	Type
V-release #			
_:81	V-release #:>Block stage	SPS	I
_:500	V-release #:>Block delay & op.	SPS	I
_:54	V-release #:Inactive	SPS	O
_:52	V-release #:Behavior	ENS	O
_:53	V-release #:Health	ENS	O
_:60	V-release #:Inrush blocks operate	ACT	O
_:59	V-release #:Disk emulation running	SPS	O
_:55	V-release #:Pickup	ACD	O
_:56	V-release #:Operate delay expired	ACT	O
_:57	V-release #:Operate	ACT	O

6.4.5 Stage with Definite Time-Overcurrent Protection, Undervoltage Seal-In

6.4.5.1 Description

Logic of the Stage



[lo_Seal-in_20150215, 2, en_US]

Figure 6-29 Logic Diagram of the Definite Time-Overcurrent Protection, Undervoltage Seal-in

Undervoltage Seal-In

In generators where the excitation voltage is derived from the machine terminals, the short-circuit current decreases quickly in the event of close-in faults (for example, in a generator or a generator-transformer range). The current decreases to a value below the current threshold within a few seconds because of the absence of the excitation voltage. To avoid a dropout of the relay, the positive-sequence voltages are used as an additional criterion for detecting a short-circuit fault.

The pickup signal is maintained for a settable seal-in time **Duration of V-seal-in time**, if the positive-sequence voltage falls below a settable threshold **V-seal-in threshold** after an overcurrent pickup, even if the current falls below the threshold again. If the voltage recovers before the seal-in time has elapsed, or if the undervoltage seal-in is blocked via a binary input *>Block V-seal-in*, the signal *Pickup I>+V-seal-in* drops out immediately.

You can switch off the undervoltage seal-in via the parameter **State of V-seal-in**.

Blocking of the Undervoltage Seal-in with Measuring-Voltage Failure

The **Undervoltage seal-in** can be blocked if a measuring-voltage failure occurs. In case of a blocking, the pickup signal *Pickup I>+V-seal-in* drops out immediately. The following blocking options are available for the **Undervoltage seal-in**:

- From an internal source upon pickup of the **Measuring-voltage failure detection** function.
- From an external source via the binary input signal *>Open* of the function block **VT miniature CB**, which links in the tripping of the voltage-transformer circuit breaker.

The parameter **Blk. by meas.-volt. failure** can be used to control the measuring-voltage failure detection. The **Undervoltage seal-in** remains unaffected if the parameter **Blk. by meas.-volt. failure** is switched off.

6.4.5.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting **(_:16951:2) Operate & flt.rec. blocked** = ***no***

With the parameter **Operate & flt.rec. blocked**, you can block the operate indication, the fault recording, and the fault log.

Parameter: Threshold

- Default setting **(_:16951:3) Threshold** = ***1.350 A***

The setting is mainly determined by the maximum operating current.

Pickup by overload must be excluded since the protection may trip if a short operate delay time is set. Set the **Threshold** parameter for generators to a value between 20 % and 30 %, for transformers and motors approx. 40 % above the expected peak load.

Parameter: Operate delay

- Default setting **(_:16951:6) Operate delay** = ***3.00 s***

The parameter **Operate delay** must be coordinated with the time grading of the network protection to guarantee the selectivity. Practical time delays are between 1 s to 2 s.

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:16951:10) Blk. by meas.-volt. failure** = ***yes***

With the parameter **Blk. by meas.-volt. failure**, you can activate (***yes***) or deactivate (***no***) the blocking by the **Measuring voltage failure detection** function. The recommended setting is the default setting.

Parameter: State of V-seal-in

- Default setting **(_:16951:101) State of V-seal-in** = ***off***

With the parameter **State of V-seal-in**, the seal-in functionality can be activated (switched ***on***). Siemens recommends this setting if the excitation transformer is connected to the main lead of the generator.

Parameter: V-seal-in threshold

- Default setting **(_:16951:102) V-seal-in threshold** = ***46.2 V***

The **V-seal-in threshold** (positive-sequence voltage) is set to a value below the lowest phase-to-phase voltage admissible during an operation, for example 80 % of the rated voltage of a generator. The positive-sequence voltage is evaluated. The practicable value for a voltage transformer with a rated secondary voltage of 100 V is 46.2 V.

The following table shows an example of a specification:

Threshold	1.4 * $I_{rated, Gen}$		
Operate delay	3.00 s		
Undervoltage seal-in	0.8 * $V_{rated, Gen}$		
Duration of V-seal-in time	4.00 s		
Dropout ratio	0.95		
Rated current $I_{rated, Gen}$	483 A	Rated voltage $V_{rated, Gen}$	6.3 kV
Rated current $I_{rated, VT, prim}$	500 A	Rated voltage $V_{rated, VT, prim}$	6.3 kV
Rated current $I_{rated, VT, sec}$	1 A	Rated voltage $V_{rated, VT, sec}$	100 V

The following secondary setting values result from this specification:

$$\text{Threshold} = \frac{1.4 \times I_{\text{rated ,Gen}}}{I_{\text{rated ,CT,prim}}} \times I_{\text{rated ,VT,sec}} = \frac{1.4 \times 483\ \text{A}}{500\ \text{A}} \times 1\ \text{A} = 1.35\ \text{A}$$

[fo_OCP_UVSI_threshold, 1, en_US]

$$\text{Undervoltage seal} - \text{in} = \frac{0.8 \times V_{\text{rated ,Gen}}}{V_{\text{rated ,VT,prim}}} \times \frac{V_{\text{reated ,VT,sec}}}{\sqrt{3}} = \frac{0.8 \times 6.3\ \text{kV}}{6.3\ \text{kV}} \times \frac{100\ \text{V}}{\sqrt{3}} = 46.200\ \text{V}$$

[fo_OCP_UVSI_Seal-in, 1, en_US]

Parameter: Duration of V-seal-in time

- Default setting **(_:16951:104) Duration of V-seal-in time** = ***4.00 s***

The parameter **Duration of V-seal-in time** limits the pickup seal-in induced by an overcurrent or undervoltage. The value must be set higher than the value of the parameter **Operate delay**. The difference shall be greater than 0.5 s. In the default setting, a difference of 1 s is used.

6.4.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-seal-in 1				
_:16951:1	V-seal-in 1:Mode		• off • on • test	off
_:16951:2	V-seal-in 1:Operate & flt.rec. blocked		• no • yes	no
_:16951:3	V-seal-in 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.75 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.75 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.350 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.750 A
_:16951:6	V-seal-in 1:Operate delay		0.00 s to 60.00 s	3.00 s
_:16951:10	V-seal-in 1:Blk. by meas.-volt. failure		• no • yes	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:16951:101	V-seal-in 1:State of V-seal-in		• off • on	off
_:16951:102	V-seal-in 1:V-seal-in threshold		0.300 V to 175.000 V	80.019 V
_:16951:104	V-seal-in 1:Duration of V-seal-in time		0.10 s to 60.00 s	4.00 s

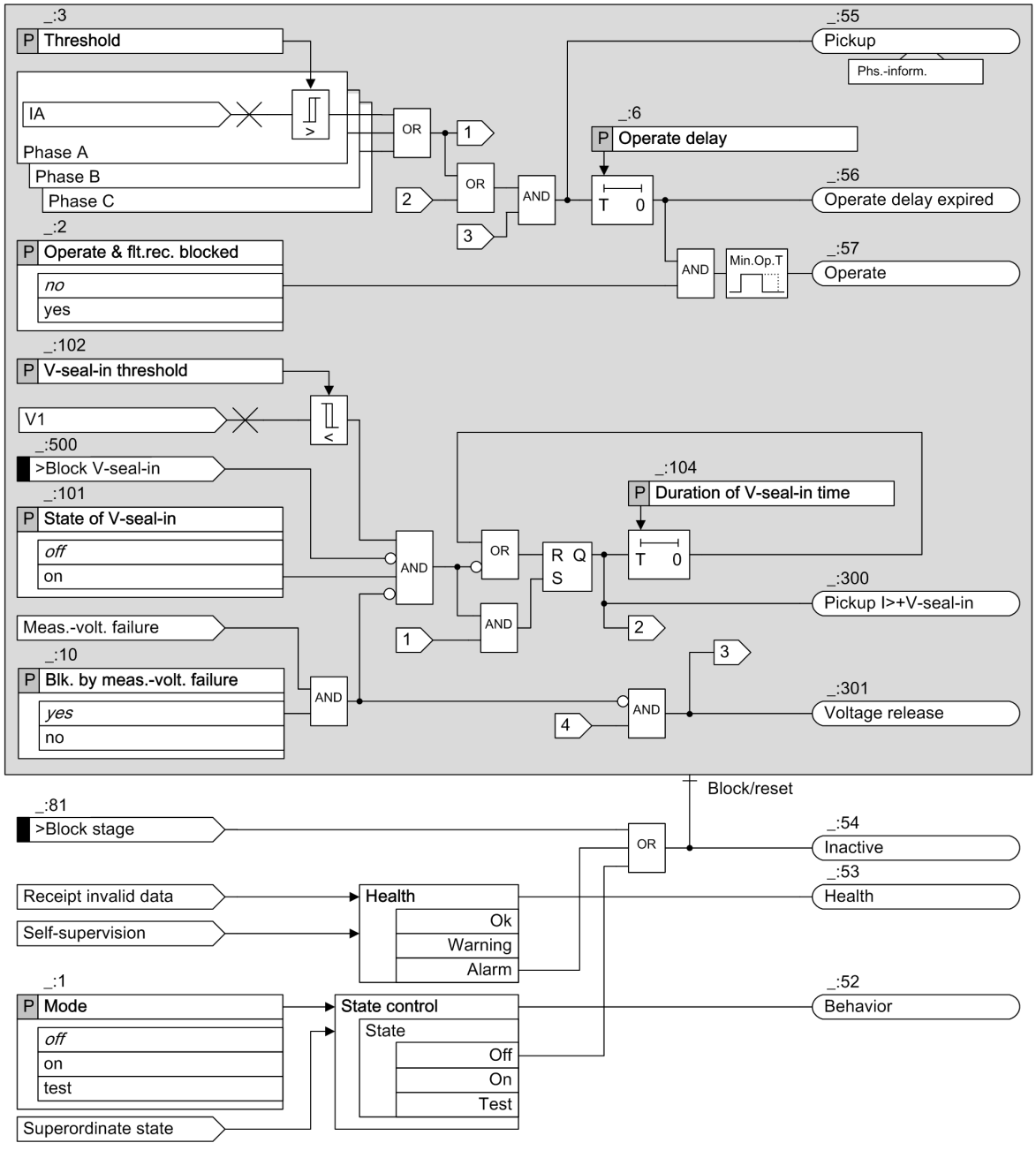
6.4.5.4 Information List

No.	Information	Data Class (Type)	Type
V-seal-in 1			
_:16951:81	V-seal-in 1:>Block stage	SPS	I
_:16951:500	V-seal-in 1:>Block V-seal-in	SPS	I
_:16951:52	V-seal-in 1:Behavior	ENS	O
_:16951:53	V-seal-in 1:Health	ENS	O
_:16951:54	V-seal-in 1:Inactive	SPS	O
_:16951:55	V-seal-in 1:Pickup	ACD	O
_:16951:300	V-seal-in 1:Pickup I>+V-seal-in	SPS	O
_:16951:56	V-seal-in 1:Operate delay expired	ACT	O
_:16951:57	V-seal-in 1:Operate	ACT	O

6.4.6 Stage with Definite Time-Overcurrent Protection, Voltage-Released Undervoltage Seal-In

6.4.6.1 Description

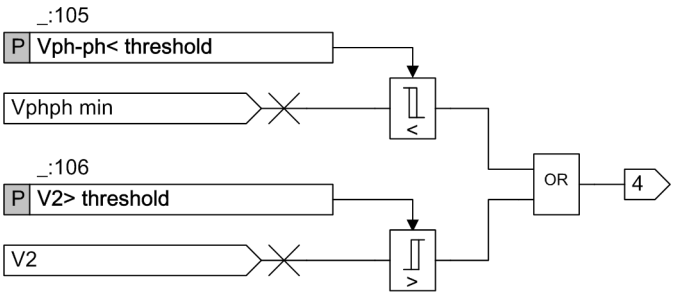
Logic of the Stage



[lo_Seal-in_Rel20150215, 2, en_US]

Figure 6-30 Logic Diagram of the Definite Time-Overcurrent Protection, Voltage-Released Undervoltage Seal-in, Part 1

Signal 4 in the following figure refers to *Figure 6-30*.



[lo_Seal-in_Rel2, 1, en_US]

Figure 6-31 Logic Diagram of the Definite Time-Overcurrent Protection, Voltage-Released Undervoltage Seal-in, Part 2

Voltage Release

In addition to the current criterion with undervoltage seal-in, a voltage-released logic must be present to issue the indication *Pickup*. The voltage-released logic monitors the negative-sequence voltage and phase-to-phase voltages respectively for detecting unsymmetrical faults and symmetrical faults. With the voltage-released logic, the setting value of the parameter **Threshold** can be reduced in a certain range and the reliability and sensibility of this function can be improved correspondingly.

Undervoltage Seal-In

In generators where the excitation voltage is derived from the machine terminals, the short-circuit current decreases quickly in the event of close-in faults (for example, in a generator or a generator-transformer range). The current decreases to a value below the current threshold within a few seconds because of the absence of the excitation voltage. To avoid a dropout of the relay, the positive-sequence voltages are used as an additional criterion for detecting a short-circuit fault.

The pickup signal is maintained for a settable seal-in time **Duration of V-seal-in time**, if the positive-sequence voltage falls below a settable threshold **V-seal-in threshold** after an overcurrent pickup, even if the current falls below the threshold again. If the voltage recovers before the seal-in time has elapsed, or if the undervoltage seal-in is blocked via a binary input *>Block V-seal-in*, the signal *Pickup I>+V-seal-in* drops out immediately.

You can switch off the undervoltage seal-in via the parameter **State of V-seal-in**.

Blocking of the Undervoltage Seal-in with Measuring-Voltage Failure

The **Undervoltage seal-in** can be blocked if a measuring-voltage failure occurs. In case of a blocking, the pickup signal *Pickup I>+V-seal-in* drops out immediately. The following blocking options are available for the **Undervoltage seal-in**:

- From an internal source upon pickup of the **Measuring-voltage failure detection** function.
- From an external source via the binary input signal *>Open* of the function block **VT miniature CB**, which links in the tripping of the voltage-transformer circuit breaker.

The parameter **Blk. by meas.-volt. failure** can be used to control the measuring-voltage failure detection. The **Undervoltage seal-in** ramains unaffectecd if the parameter **Blk. by meas.-volt. failure** is switched off.

6.4.6.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting **(_:2) Operate & flt.rec. blocked** = *no*

With the parameter **Operate & flt.rec. blocked**, you can block the operate indication, the fault recording, and the fault log.

Parameter: Threshold

- Default setting **(_:3) Threshold** = ***1.350 A***

The setting is mainly determined by the maximum operating current.

Pickup by overload must be excluded since the protection may trip if a short operate delay time is set. Set the **Threshold** parameter for generators to a value between 20 % and 30 %, for transformers and motors approx. 40 % above the expected peak load.

Parameter: Operate delay

- Default setting **(_:6) Operate delay** = ***3.00 s***

The parameter **Operate delay** must be coordinated with the time grading of the network protection to guarantee the selectivity. Practical time delays are between 1 s to 2 s.

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:10) Blk. by meas.-volt. failure** = ***yes***

With the parameter **Blk. by meas.-volt. failure**, you can activate (***yes***) or deactivate (***no***) the blocking by the **Measuring voltage failure detection** function. The recommended setting is the default setting.

Parameter: State of V-seal-in

- Default setting **(_:101) State of V-seal-in** = ***off***

With the parameter **State of V-seal-in**, the seal-in functionality can be activated (switched ***on***). Siemens recommends this setting if the excitation transformer is connected to the main lead of the generator.

Parameter: V-seal-in threshold

- Default setting **(_:102) V-seal-in threshold** = ***46.2 V***

The **V-seal-in threshold** (positive-sequence voltage) is set to a value below the lowest phase-to-phase voltage admissible during an operation, for example 80 % of the rated voltage of a generator. The positive-sequence voltage is evaluated. The practicable value for a voltage transformer with a rated secondary voltage of 100 V is 46.2 V.

The following table shows an example of a specification:

Threshold	1.4 * $I_{rated, Gen}$		
Operate delay	3.00 s		
Undervoltage seal-in	0.8 * $V_{rated, Gen}$		
Duration of V-seal-in time	4.00 s		
Dropout ratio	0.95		
Rated current $I_{rated, Gen}$	483 A	Rated voltage $V_{rated, Gen}$	6.3 kV
Rated current $I_{rated, VT, prim}$	500 A	Rated voltage $V_{rated, VT, prim}$	6.3 kV
Rated current $I_{rated, VT, sec}$	1 A	Rated voltage $V_{rated, VT, sec}$	100 V

The following secondary setting values result from this specification:

$$\text{Threshold} = \frac{1.4 \times I_{rated\ ,Gen}}{I_{rated\ ,CT,prim}} \times I_{rated\ ,VT,sec} = \frac{1.4 \times 483\ \text{A}}{500\ \text{A}} \times 1\ \text{A} = 1.35\ \text{A}$$

[fo_OCP_UVSI_threshold, 1, en_US]

$$\text{Undervoltage seal} - \text{in} = \frac{0.8 \times V_{rated\ ,Gen}}{V_{rated\ ,VT,prim}} \times \frac{V_{reated\ ,VT,sec}}{\sqrt{3}} = \frac{0.8 \times 6.3\ \text{kV}}{6.3\ \text{kV}} \times \frac{100\ \text{V}}{\sqrt{3}} = 46.200\ \text{V}$$

[fo_OCP_UVSI_Seal-in, 1, en_US]

Parameter: Duration of V-seal-in time

- Default setting **(_:104) Duration of V-seal-in time** = ***4.00 s***

The parameter **Duration of V-seal-in time** limits the pickup seal-in induced by an overcurrent or undervoltage. The value must be set higher than the value of the parameter **Operate delay**. The difference shall be greater than 0.5 s. In the default setting, a difference of 1 s is used.

Parameter: Vph-ph< threshold

- Default setting **(_:105) Vph-ph< threshold** = ***60.000 V***

With the parameter **Vph-ph< threshold**, you can set the threshold at which the output signal *Voltage release* is activated when the minimum phase-to-phase voltage falls below this threshold.

Parameter: V2> threshold

- Default setting **(_:106) V2> threshold** = ***4.600 V***

With the parameter **V2> threshold**, you can set the threshold at which the output signal *Voltage release* is issued when V2 exceeds the threshold.

6.4.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Vseal-in+Vrel#				
_:1	Vseal-in+Vrel#:Mode		• off • on • test	off
_:2	Vseal-in+Vrel#:Operate & flt.rec. blocked		• no • yes	no
_:3	Vseal-in+Vrel#:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 100 Irated	0.150 A to 175.000 A	6.750 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 50 Irated	0.150 A to 175.000 A	6.750 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.350 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.750 A
_:6	Vseal-in+Vrel#:Operate delay		0.00 s to 60.00 s	3.00 s
_:10	Vseal-in+Vrel#:Blk. by meas.-volt. failure		• no • yes	yes
_:101	Vseal-in+Vrel#:State of V-seal-in		• off • on	off
_:102	Vseal-in+Vrel#:V-seal-in threshold		0.300 V to 175.000 V	46.200 V
_:104	Vseal-in+Vrel#:Duration of V-seal-in time		0.10 s to 60.00 s	4.00 s
_:105	Vseal-in+Vrel#:Vph-ph< threshold		0.300 V to 175.000 V	60.000 V
_:106	Vseal-in+Vrel#:V2> threshold		0.300 V to 200.000 V	4.600 V

6.4.6.4 Information List

No.	Information	Data Class (Type)	Type
Vseal-in+Vrel#			
_:81	Vseal-in+Vrel#:>Block stage	SPS	I
_:500	Vseal-in+Vrel#:>Block V-seal-in	SPS	I
_:52	Vseal-in+Vrel#:Behavior	ENS	O
_:53	Vseal-in+Vrel#:Health	ENS	O
_:54	Vseal-in+Vrel#:Inactive	SPS	O
_:55	Vseal-in+Vrel#:Pickup	ACD	O
_:300	Vseal-in+Vrel#:Pickup I>+V-seal-in	SPS	O
_:301	Vseal-in+Vrel#:Voltage release	SPS	O
_:56	Vseal-in+Vrel#:Operate delay expired	ACT	O
_:57	Vseal-in+Vrel#:Operate	ACT	O

6.5 Overcurrent Protection, Ground

6.5.1 Overview of Functions

The **Overcurrent protection, ground** function (ANSI 50N/51N):

- Detects short circuits in electrical equipment
- Can be used as backup overcurrent protection in addition to the main protection

6.5.2 Structure of the Function

The **Overcurrent protection, ground** function is used in protection function groups. 2 kinds of functions are available for the 3-phase overcurrent protection:

- **Overcurrent protection, ground – advanced** (50N/51N OC-gnd-A)
- **Overcurrent protection, ground – basic** (50N/51N OC-gnd-B)

The function type Basic is provided for standard applications. The function type Advanced offers more functionality and is provided for more complex applications.

Both function types are pre-configured by the manufacturer with 2 **Definite time-overcurrent protection** stages and with 1 **Inverse time-overcurrent protection** stage.

In the function type **Overcurrent protection, ground – advanced** the following stages can be operated simultaneously:

- Maximum of 3 stages **Definite time-overcurrent protection – advanced**
- 1 stage **Inverse time-overcurrent protection – advanced**
- 1 stage **User-defined characteristic curve overcurrent protection**

In the function type **Overcurrent protection, ground – basic** the following stages can be operated simultaneously:

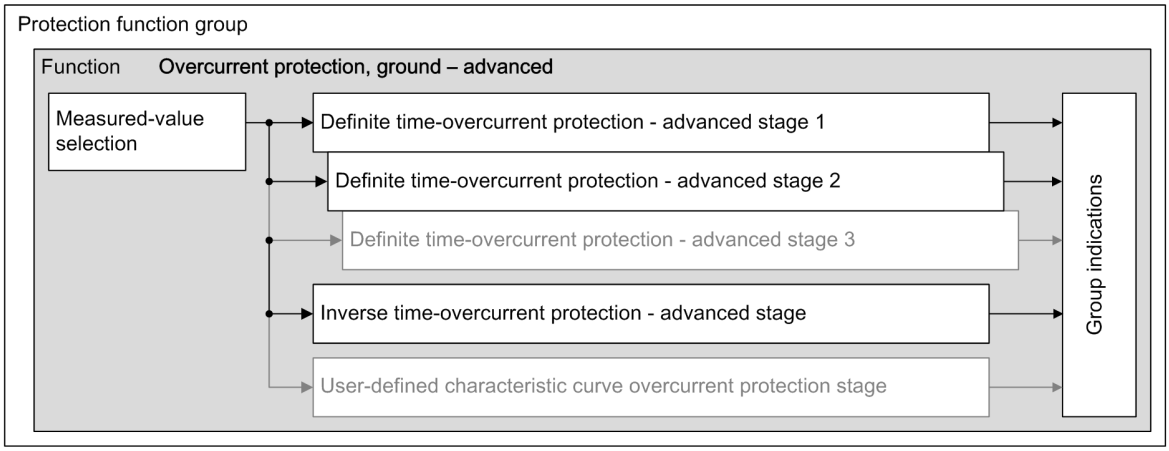
- Maximum of 3 stages **Definite time-overcurrent protection – basic**
- 1 stage **Inverse time-overcurrent protection – basic**

The non-preconfigured stages are shown in gray in the following figures. Apart from the tripping delay characteristic, the stages are identical in structure.

The measured-value selection (only advanced stage) is general functionality and has a uniform effect on the stages (see *Figure 6-32* and chapter *6.5.3.1 Description*). This ensures that all stages of the function receive the same measured current value.

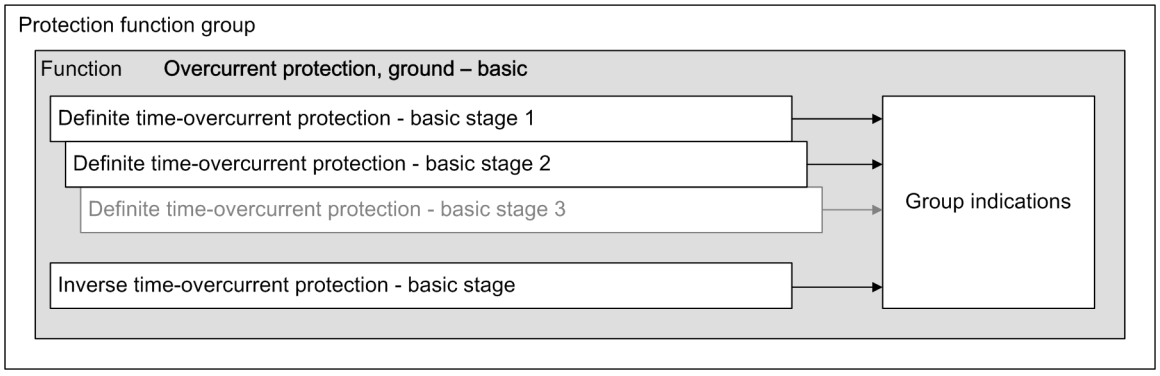
The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- **`Pickup`**
- **`Operate`**



[dwocpga2-060213-01.tif, 4, en_US]

Figure 6-32 Structure/Embedding the Function Overcurrent Protection, Ground – Advanced



[dwocpgb1-060213-01.tif, 3, en_US]

Figure 6-33 Structure/Embedding the Function Overcurrent Protection, Ground – Basic

If the following listed, device-internal functions are present in the device, these functions can influence the pickup values and tripping delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Automatic reclosing (AREC)
- Cold-load pickup detection
- Binary input signal

If the device is equipped with an **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer-inrush currents (available in both function types).

6.5.3 General Functionality

6.5.3.1 Description

Measured-Value Selection

The function provides the option to select between the values ***IN measured*** or ***3I0 calculated***.

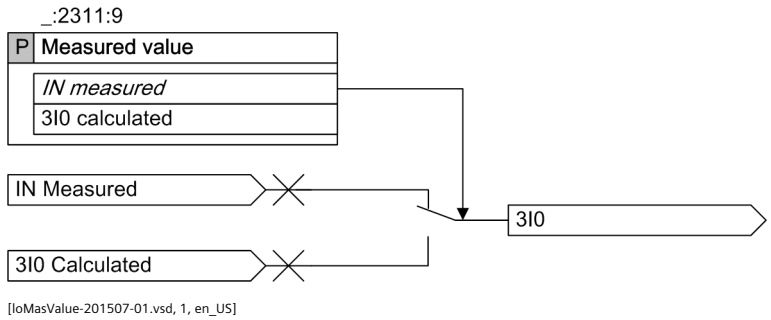


Figure 6-34 Logic Diagram of Measured-Value Selection

Both options are only available for the current-transformer connection types ***3-phase + IN*** and ***3-phase + IN-separate***. For other connection types respectively, only one option is possible. If you select an option that is not allowed, an inconsistency message is given.

Depending on the CT secondary rated current, the CT connection type, and the selected setting, the secondary threshold setting range varies according to the following table.

Table 6-2 Threshold Setting Range

Connection Type	Measured Value	CT Terminal Type	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 5 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 5 A)
3ph + IN	3I0 calculated	4 * Protection	0.030 A to 35.000 A	N/A	N/A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.030 A to 35.000 A	N/A	N/A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
3ph + IN-separate	3I0 calculated	4 * Protection	0.030 A to 35.000 A	0.030 A to 35.000 A	0.15 A to 175.00 A	0.15 A to 175.00 A
		3 * Protection, 1 * sen.	0.030 A to 35.000 A	0.030 A to 35.000 A	0.15 A to 175.00 A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	0.001 A to 1.600 A	0.005 A to 8.000 A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.030 A to 35.000 A	0.15 A to 175.00 A	0.030 A to 35.000 A	0.15 A to 175.00 A
		3 * Protection, 1 * sen.	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A
		4 * Measurement	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A

6.5.3.2 Application and Setting Notes

Parameter: `Measured value`

- Recommended setting value **`Measured value`** = ***`IN Measured`***

This parameter is not available in the basic function.

Parameter Value	Description

IN Measured	The function operates with the measured ground current IN. This is the recommended setting unless there is a specific reason to use the calculated zero-sequence current 3I0.
3I0 Calculated	The function operates with the calculated zero sequence current 3I0. This setting option can be used when applying a redundant 50N/51N function for safety reasons.

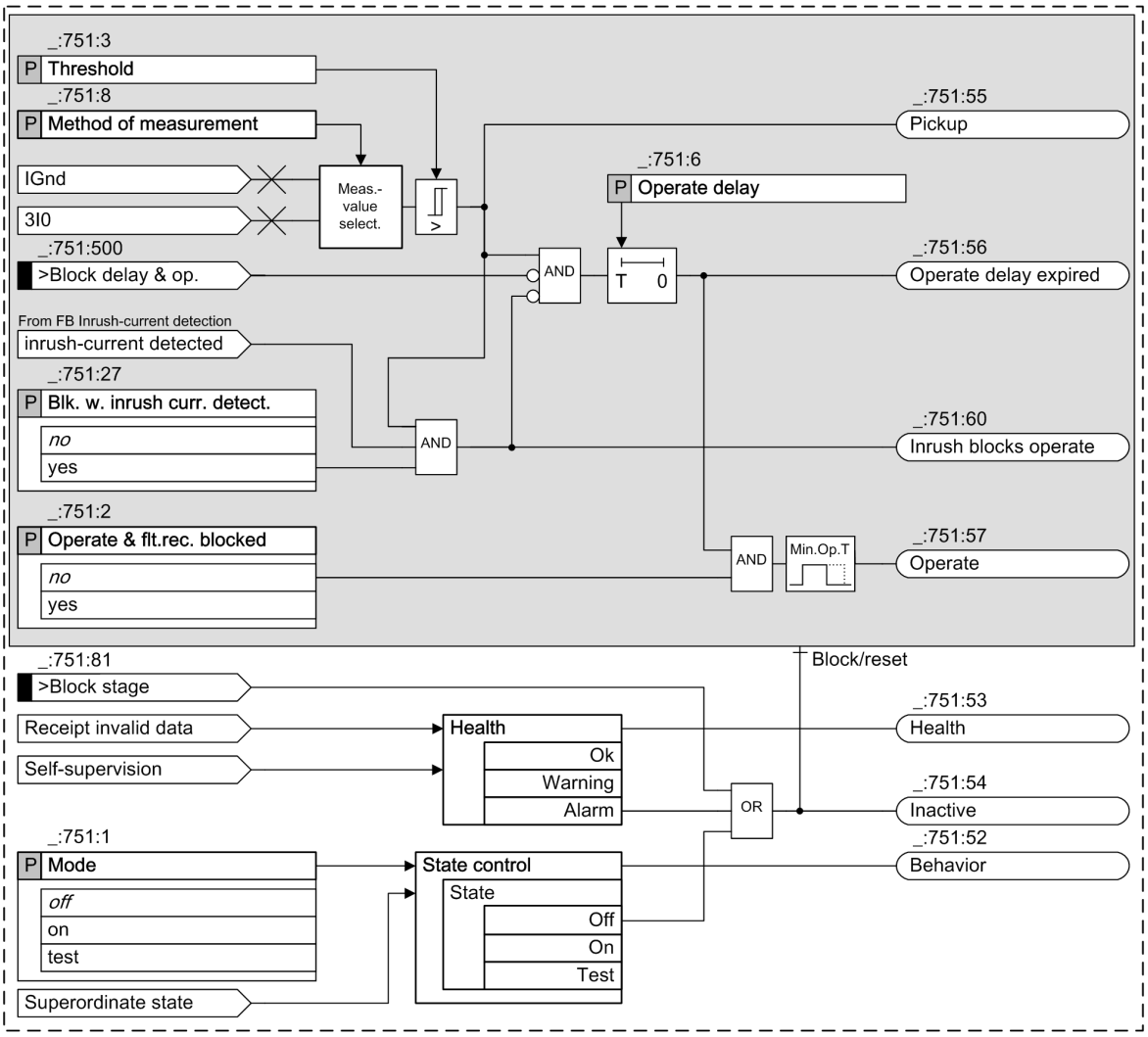
6.5.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:9	General:Measured value		• 3I0 calculated • IN measured	IN measured

6.5.4 Stage with Definite-Time Characteristic Curve

6.5.4.1 Description

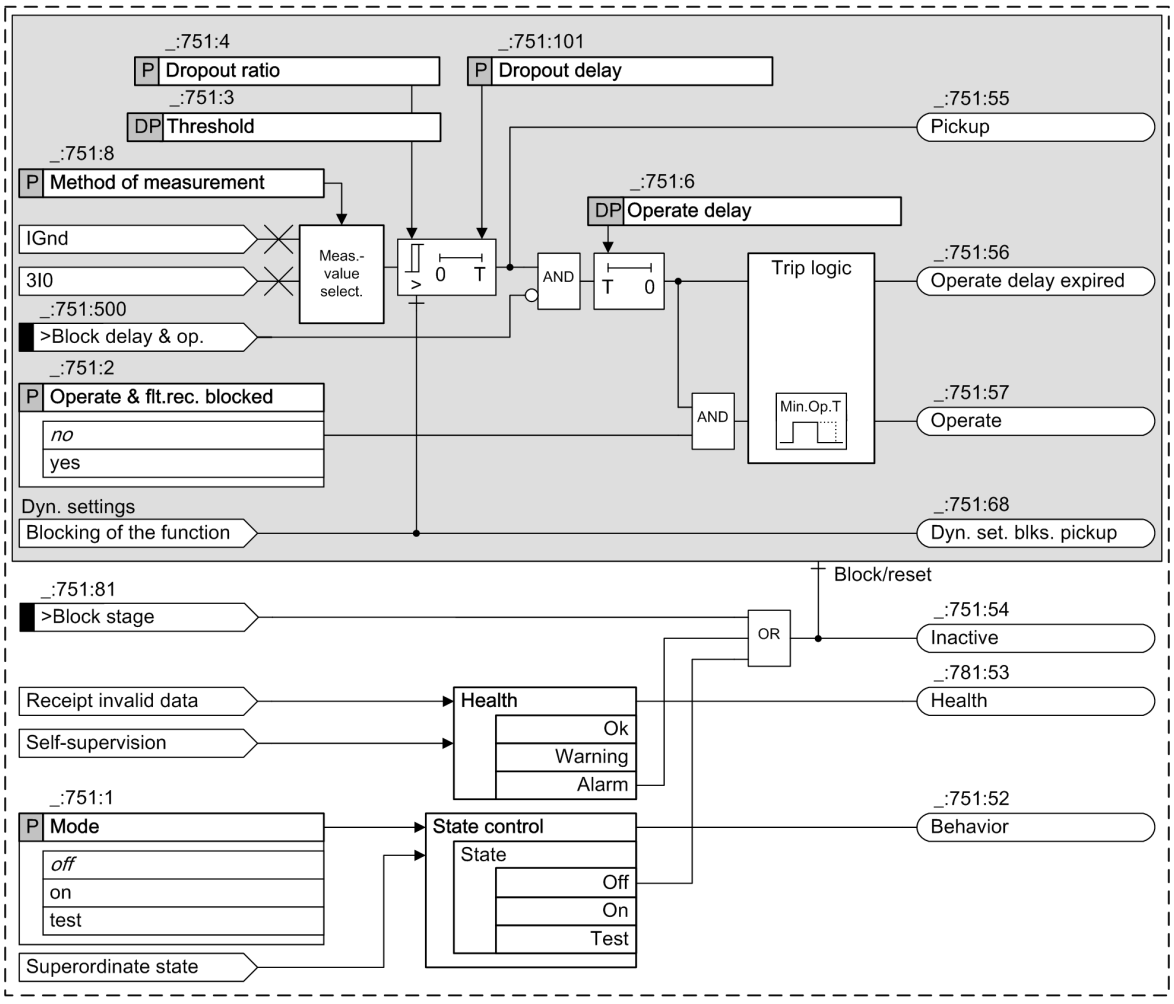
Logic of the Basic Stage



[loocpgb1-060213-01.tif, 2, en_US]

Figure 6-35 Logic Diagram of the Definite Time-Overcurrent Protection (Ground) – Basic

Logic of the Advanced Stage



[loocpgn1-291112-01.tif, 1, en_US]

Figure 6-36 Logic Diagram of the Definite Time-Overcurrent Protection (Ground) – Advanced

Method of Measurement (Basic and Advanced Stage)

You use the **`Method of measurement`** parameter to define whether the stage uses the ***`fundamental comp.`*** or the calculated ***`RMS value`***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Dropout Delay (Advanced Stage)

If the value falls below the dropout threshold, the pickup dropout can be delayed. The pickup is maintained for the specified time. The tripping delay continues to run. If the time delay expires while the pickup is still maintained, the stage operates.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal **>Block stage** from an external or internal source
- Via the functionality of the **dynamic settings** (see chapter **Influence of other functions via dynamic settings** and section *6.5.8.1 Description*).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.5.7.1 Description*.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.5.8.1 Description* .

6.5.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:751:8) Method of measurement** = ***fundamental comp.***

The **Method of measurement** parameter allows you to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: Threshold, Operate delay

- Default setting **(_:751:3) Threshold** = ***1.20 A*** (for the first stage)
- Default setting **(_:751:6) Operate delay** = ***0.300 s*** (for the first stage)

Set the **Threshold** and **Operate delay** parameters for the specific application.

The following details apply to a 2-stage characteristic curve (1st stage = definite time-overcurrent protection stage and 2nd stage = high-current stage).

1st stage (overcurrent stage):

The setting depends on the minimal occurring ground-fault current. This must be determined.

The **Operate delay** to be set is derived from the time-grading schedule that has been prepared for the system.

2nd stage (high-current stage):

This tripping stage can also be used for current grading. This applies in the case of very long lines with low source impedance or ahead of high reactances (for example, transformers, shunt reactors). Set the **Threshold** parameter to ensure that the stage does not pick up in case of a short-circuit at the end of the line.

Set the **Operate delay** parameter to ***0*** or to a low value.

Siemens recommends that the threshold values be determined with a system analysis. The following example illustrates the principle of grading with a current threshold on a long line.

EXAMPLE

High-current stage: 110-kV overhead line, 150 mm² cross-section

s (length)	= 60 km
Z_L/s	= 0.46 Ω/km

Ratio of zero-sequence impedance and positive-sequence impedance of the line: $Z_{L0}/Z_{L1} = 4$

Short-circuit power at the beginning of the line:

S_{sc}'	= 2.5 GVA

Ratio of zero-sequence impedance and positive-sequence impedance of the source impedance at the beginning of the line: $Z_{P0}/Z_{P1} = 2$

Current transformer	= 600 A/5 A

Resulting in the following values for the line impedance Z_L and the source impedance Z_P:

$$Z_L = 0.46\ \Omega/\mathrm{km} \cdot 60\mathrm{km} = 27.6\ \Omega$$

[fo_OCP002_030311, 1, en_US]

$$Z_P = \frac{110\ \mathrm{kV}^2}{2500\ \mathrm{MVA}} = 4.84\ \Omega$$

[fo_OCP003_030311, 1, en_US]

The 1-pole short-circuit current at the end of the line is $I_{scG\ end}$:

$$I_{sc\ gnd\ end} = \frac{1.1 \cdot V_N \cdot 3}{\sqrt{3} \cdot \left[Z_P \cdot \left(2 + \frac{Z_{P0}}{Z_{P1}}\right) + Z_L \cdot (2 + \frac{Z_{L0}}{Z_{L1}})\right]} = \frac{1.1 \cdot 110\mathrm{kV} \cdot 3}{\sqrt{3} \cdot [4.84\ \Omega \cdot (2+2) + 27.6\ \Omega \cdot (2+4)]} = 1133\ \mathrm{A}$$

[fo_ocp005_030311, 1, en_US]

The settings in primary and secondary values result in the following setting values which include a safety margin of 10 %:

$$\text{Threshold value 2nd stage (primary)} = 1.1 \cdot 1133\ \mathrm{A} = 1246.3\ \mathrm{A}$$

$$\text{Threshold value 2nd stage (secondary)} = 1.1 \cdot \frac{1133\ \mathrm{A}}{600\ \mathrm{A}} \cdot 5\ \mathrm{A} = 10.39\ \mathrm{A}$$

[foocpgr4-030311-01.tif, 3, en_US]

In case of short-circuit currents exceeding 1246 A (primary) or 10.39 A (secondary) there is a short-circuit on the line to be protected. The overcurrent protection can cut off this short circuit immediately.

Note: The amounts in the calculation example are accurate enough for overhead lines. If the source impedance, line impedance and zero-sequence impedance have very different angles, you have use complex numbers to calculate the **Threshold**.

Parameter: `Dropout delay`

- Recommended setting value **`(_:751:101) Dropout delay`** = ***0***

This parameter is not visible in the basic stage.

Siemens recommends to use the default setting ***0*** since the dropout of a protection stage must be done as fast as possible.

You can use the **`Dropout delay`** parameter ≠ ***0*** to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical Data) and set the result.

Parameter: `Dropout ratio`

- Recommended setting value **`(_:751:4) Dropout ratio`** = ***0.95***

This parameter is not visible in the basic stage.

The recommended set value of ***0.95*** is appropriate for most applications.

To achieve high-precision measurements, the setting value of the parameter **`Dropout ratio`** can be reduced, for example, to ***0.98***. If you expect highly fluctuating measurands at the response threshold, you can increase the setting value of the parameter **`Dropout ratio`**. This avoids chattering of the tripping stage.

6.5.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:751:1	Definite-T 1:Mode		• off • on • test	off
_:751:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:751:26	Definite-T 1:Dynamic settings		• no • yes	no
_:751:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:751:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:751:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:751:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:751:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n.rdy				
_:751:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:751:35	Definite-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 1				
_:751:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:751:36	Definite-T 1:Stage blocked		• no • yes	no
_:751:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:751:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:751:37	Definite-T 1:Stage blocked		• no • yes	no
_:751:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:751:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no
_:751:38	Definite-T 1:Stage blocked		• no • yes	no
_:751:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:751:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:751:39	Definite-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:751:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: Cold load PU				
_:751:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:751:40	Definite-T 1:Stage blocked		• no • yes	no
_:751:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:751:34	Definite-T 1:Effected by binary input		• no • yes	no
_:751:41	Definite-T 1:Stage blocked		• no • yes	no
_:751:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

6.5.4.4 Information List

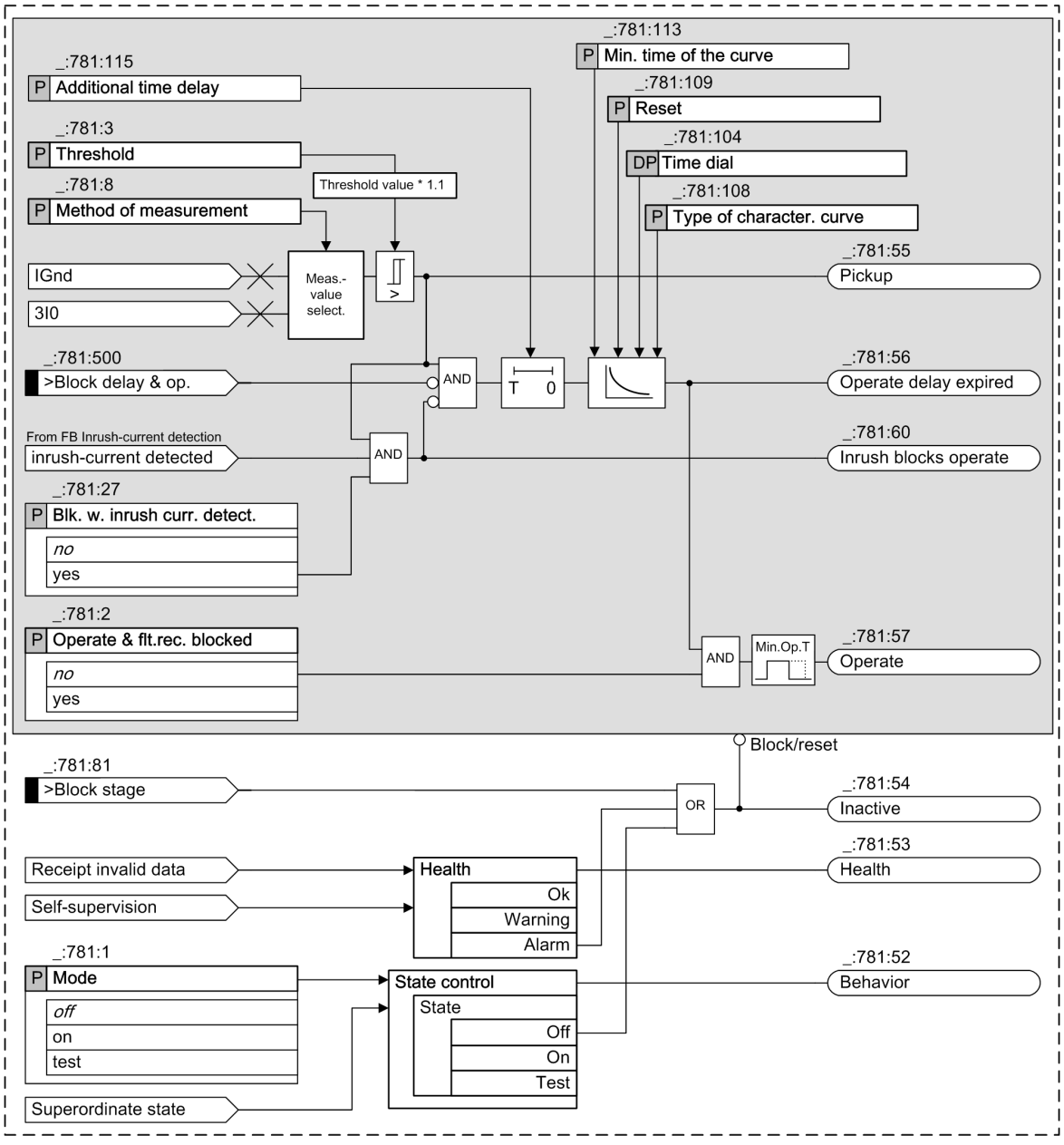
No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:751:81	Definite-T 1:>Block stage	SPS	I
_:751:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:751:500	Definite-T 1:>Block delay & op.	SPS	I
_:751:54	Definite-T 1:Inactive	SPS	O
_:751:52	Definite-T 1:Behavior	ENS	O
_:751:53	Definite-T 1:Health	ENS	O

No.	Information	Data Class (Type)	Type
_:751:60	Definite-T 1:Inrush blocks operate	ACT	O
_:751:55	Definite-T 1:Pickup	ACD	O
_:751:56	Definite-T 1:Operate delay expired	ACT	O
_:751:57	Definite-T 1:Operate	ACT	O

6.5.5 Stage with Inverse-Time Characteristic Curve

6.5.5.1 Description

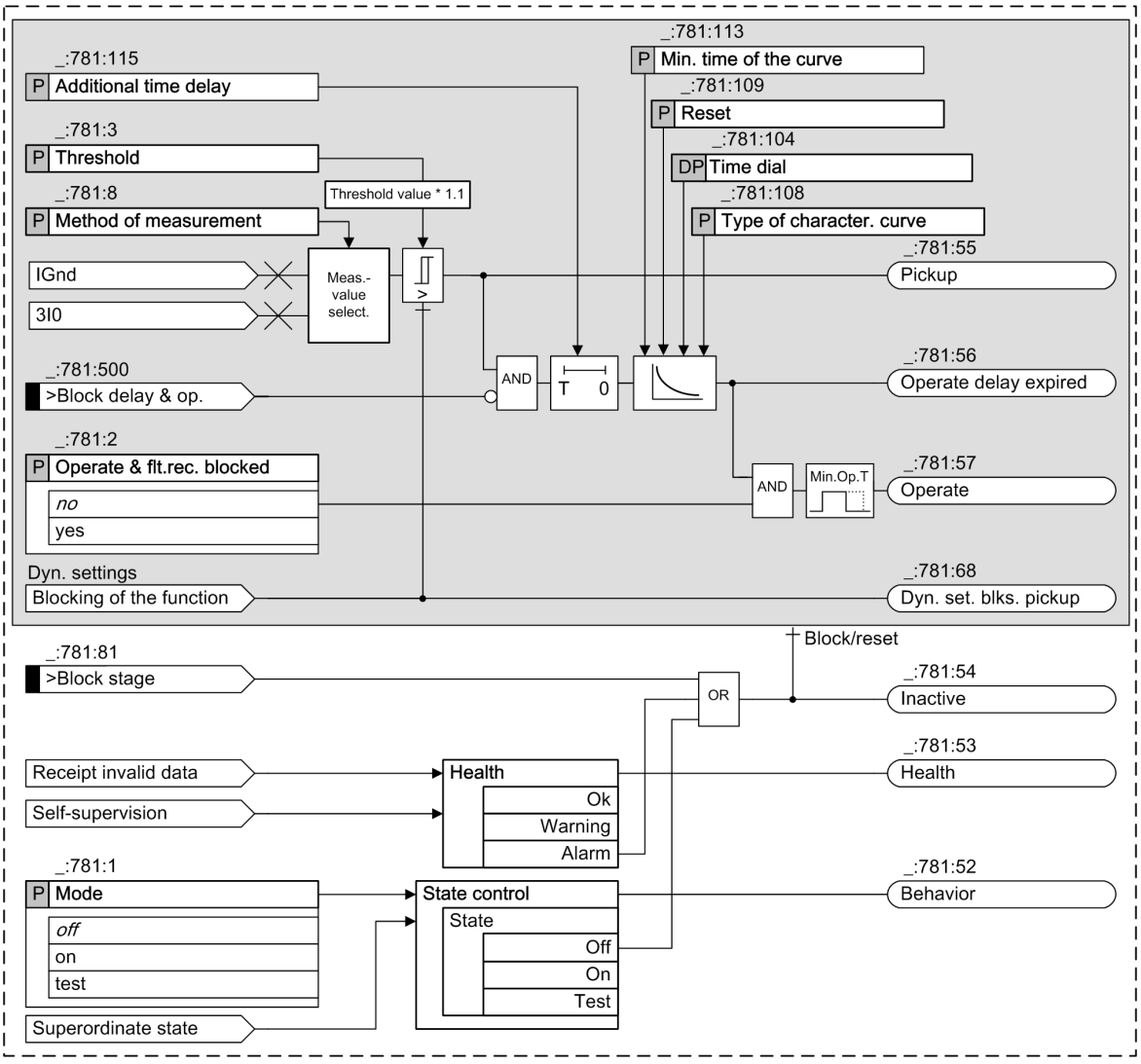
Logic of the Basic Stage



[loocpgr2-070213-01.tif, 3, en_US]

Figure 6-37 Logic Diagram of the Inverse Time-Overcurrent Protection (Ground) – Basic

Logic of the Advanced Stage



[loocpgn2-291112-01.tif, 2, en_US]

Figure 6-38 Logic Diagram of the Inverse Time-Overcurrent Protection (Ground) – Advanced

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI (Basic and Advanced Stage)

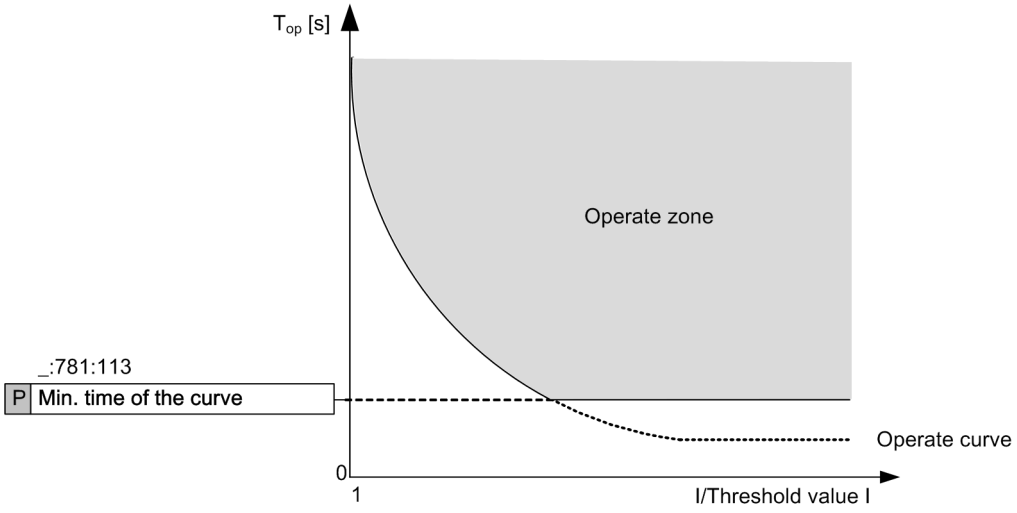
When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Minimum Time of the Curve (Advanced Stage)

With the parameter **Min. time of the curve**, you define the minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.



[Dwocpgr3Mi_20140716-01, 1, en_US]

Figure 6-39 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter **Additional time delay**, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

Method of Measurement (Basic and Advanced Stage)

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal **>Block stage** from an external or internal source
- Via the functionality of the **dynamic settings** (see subtitle **Influence of other functions via dynamic settings** and chapter *6.5.8.1 Description*).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.5.7.1 Description*.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.5.8.1 Description* .

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic reclosing
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.5.8.1 Description* .

6.5.5.2 Application and Setting Notes

Parameter: `Method of measurement`

- Recommended setting value **`(_:781:8) Method of measurement`** = ***`fundamental comp.`***

You use the **`Method of measurement`** parameter to define whether the stage uses the ***`fundamental comp.`*** (standard method) or the calculated ***`RMS value`***.

Parameter Value	Description
`fundamental comp.`	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
`RMS value`	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **`threshold value`** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: Type of character. curve

- Default setting **`(_:781:108) Type of character. curve`** = ***`IEC normal inverse`***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **`Type of character. curve`** required for your specific application. For more information about the parameter **`Type of character. curve`**, refer to chapter*12.7.2 Stage with Inverse-Time Characteristic Curve*.

Parameter: `Min. time of the curve`

- Default setting **`(_:781:113) Min. time of the curve`** = ***`0.00 s`***

This parameter is only available in the advanced stage.

With the parameter **`Min. time of the curve`**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: `Additional time delay`

- Recommended setting value **`(_:781:115) Additional time delay`** = ***`0.00 s`***

With the parameter **`Additional time delay`**, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommend keeping the default setting of 0 s.

Parameter: `Threshold`

- Default setting **`(_:781:3) Threshold`** = ***`1.20 A`***

The setting depends on the minimal occurring ground-fault current. This must be determined.

Parameter: `Time dial`

- Default setting **`(_:781:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The set value for the **`Time dial`** parameter is derived from the time-grading chart that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the **`Time dial`** parameter at ***`1`***.

Parameter: `Reset`

- Default setting **`(_:781:109) Reset`** = ***`disk emulation`***

You use the **`Reset`** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

6.5.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:781:1	Inverse-T 1:Mode		• off • on • test	off
_:781:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:781:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:781:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:781:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:781:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:108	Inverse-T 1:Type of character. curve			
_:781:113	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:781:109	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:781:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:781:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:781:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:781:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:781:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:781:36	Inverse-T 1:Stage blocked		• no • yes	no
_:781:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 2				
_:781:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:781:37	Inverse-T 1:Stage blocked		• no • yes	no
_:781:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 3				
_:781:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:781:38	Inverse-T 1:Stage blocked		• no • yes	no
_:781:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: AR cycle>3				
_:781:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:781:39	Inverse-T 1:Stage blocked		• no • yes	no
_:781:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:781:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:781:40	Inverse-T 1:Stage blocked		• no • yes	no
_:781:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: bin.input				
_:781:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:781:41	Inverse-T 1:Stage blocked		• no • yes	no
_:781:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

6.5.5.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:781:81	Inverse-T 1:>Block stage	SPS	I
_:781:500	Inverse-T 1:>Block delay & op.	SPS	I
_:781:54	Inverse-T 1:Inactive	SPS	O
_:781:52	Inverse-T 1:Behavior	ENS	O
_:781:53	Inverse-T 1:Health	ENS	O
_:781:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:781:59	Inverse-T 1:Disk emulation running	SPS	O
_:781:55	Inverse-T 1:Pickup	ACD	O
_:781:56	Inverse-T 1:Operate delay expired	ACT	O
_:781:57	Inverse-T 1:Operate	ACT	O

6.5.6 Stage with User-Defined Characteristic Curve

6.5.6.1 Description

This stage is only available in the advanced function type.

This stage is structured the same way as the **Inverse time-overcurrent protection – advanced** stage (see chapter *6.5.5.1 Description*). The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

With the user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

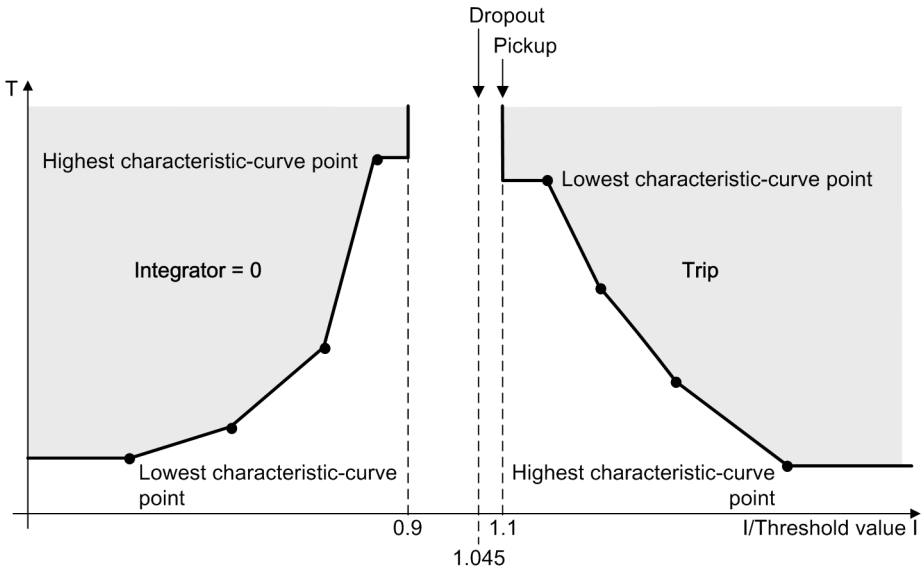
Pickup and Dropout Behavior with the User-Defined Characteristic Curve

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The following figure shows the pickup and dropout behavior when a user-defined characteristic curve is used.



[dwocpken-140611-02.tif, 1, en_US]

Figure 6-40 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

Note that the currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

6.5.6.2 Application and Setting Notes

This stage is structured the same way as the **Inverse time-overcurrent protection – advanced** stage. The only difference is that the user can define the characteristic curve as desired. This chapter only provides application and setting notes for setting characteristic curves. For guidance on the other parameters of the stage, see chapter *6.5.5.2 Application and Setting Notes* .

Parameter: `Current/time value pairs` (from the operate curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: `Time dial`

- Default setting **`(_:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The set value for the **Time dial** parameter is derived from the time-grading chart that has been prepared for the electrical power system. Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter **Time dial** at ***1*** (default setting).

Parameter: Reset

- Default setting **(_:110) Reset** = ***disk emulation***

You use the **Reset** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: Current/time value pairs (of the dropout characteristic curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **Threshold** parameter to ***1.00*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the **Time dial** parameter.



NOTE

The value pairs must be entered in continuous order.

6.5.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation

Addr.	Parameter	C	Setting Options	Default Setting
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

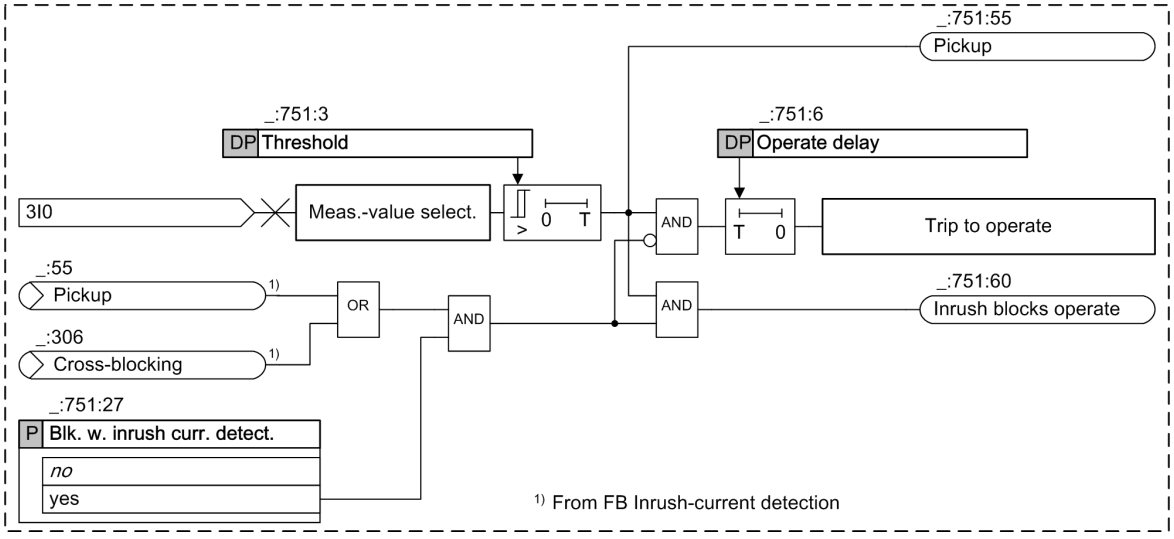
6.5.6.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.5.7 Blocking of the Tripping by Device-Internal Inrush-Current Detection

6.5.7.1 Description

With the **Blk. w. inrush curr. detect.** parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the tripping delay and the trip signal are blocked. The function signals this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. After that time, the stage operates. The following figure only shows the part of the stage (exemplified by definite time-overcurrent protection stage 1) that illustrates the influence of the inrush-current detection. Only if the central function **Inrush-current detection** (see section *12.10 Inrush-Current Detection*) is in effect can the blocking be set.



[loocpgrd-210812-01.tif, 1, en_US]

Figure 6-41 Part-Logic Diagram on the Influence of Inrush-Current Detection Exemplified by the 1st Definite Time-Overcurrent Protection Stage

6.5.7.2 Application and Setting Notes

Parameter: Blk. w. inrush curr. detect.

- Default setting **(_:751:27) Blk. w. inrush curr. detect.** = ***no***

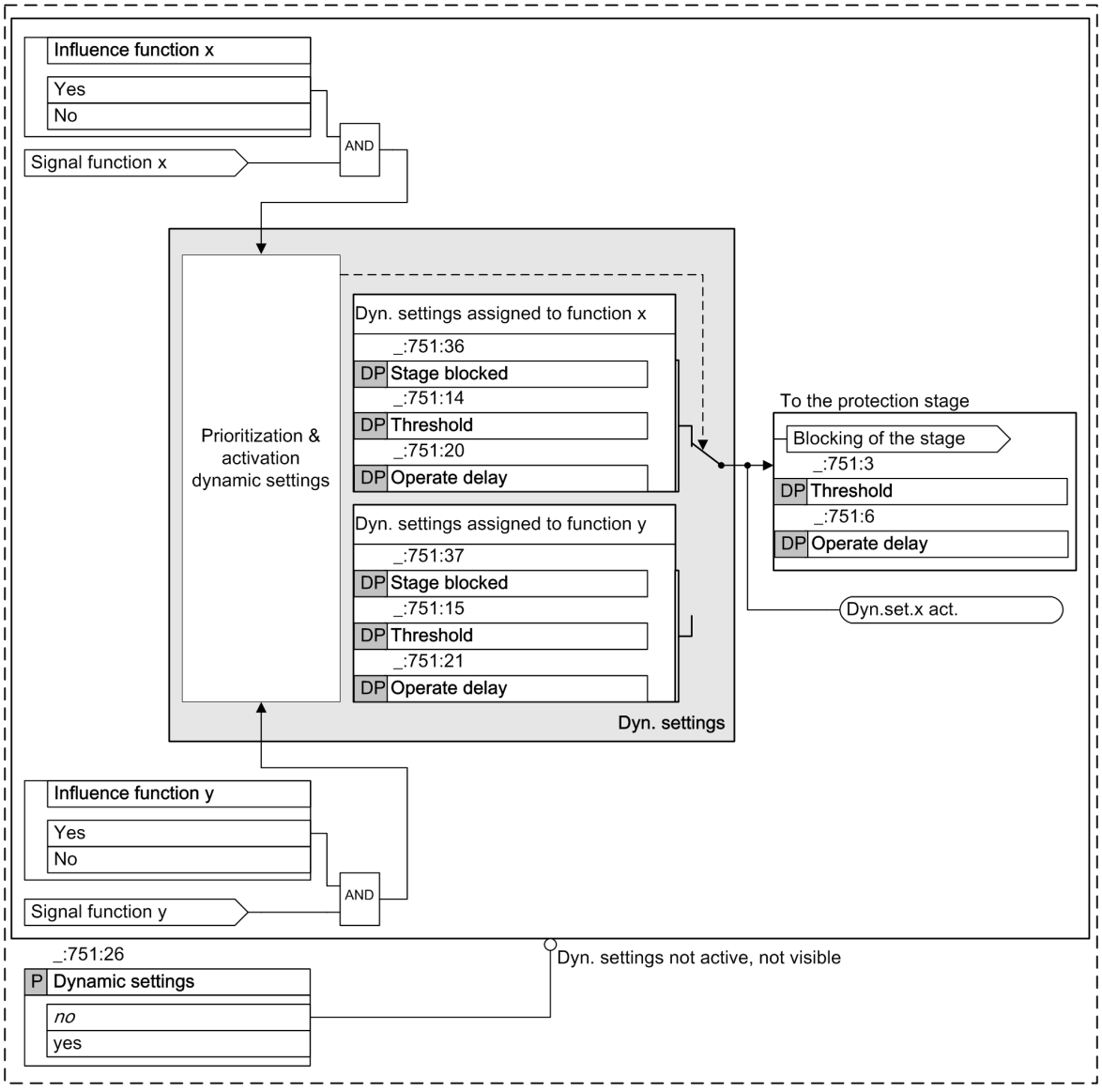
Parameter Value	Description
no	The transformer inrush current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This, for example, applies to the high-current stage that is set such according to the short-circuit voltage V_{sc} of the transformer that it only picks up on faults from the high-voltage side. The transformer-inrush current cannot become larger than the maximum transmittable short-circuit current.

Parameter Value	Description
yes	When the transformer inrush current detection detects an inrush current that would lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

6.5.8 Influence of Other Functions via Dynamic Settings

6.5.8.1 Description

The **Threshold** and **Operate delay** settings used for tripping are so-called **dynamic settings**. Depending on other functions, the settings of these parameters can be changed dynamically. Depending on other functions, the stage can also be blocked dynamically. This functionality is only available in function type Advanced.



[loocpgnd-030311-01.vsd, 1, en_US]

Figure 6-42 Principle of the Dynamic Settings in the Example of 1st Definite Time-Overcurrent Protection Stage

If available in the device, the following functionalities can affect the overcurrent-protection stages:

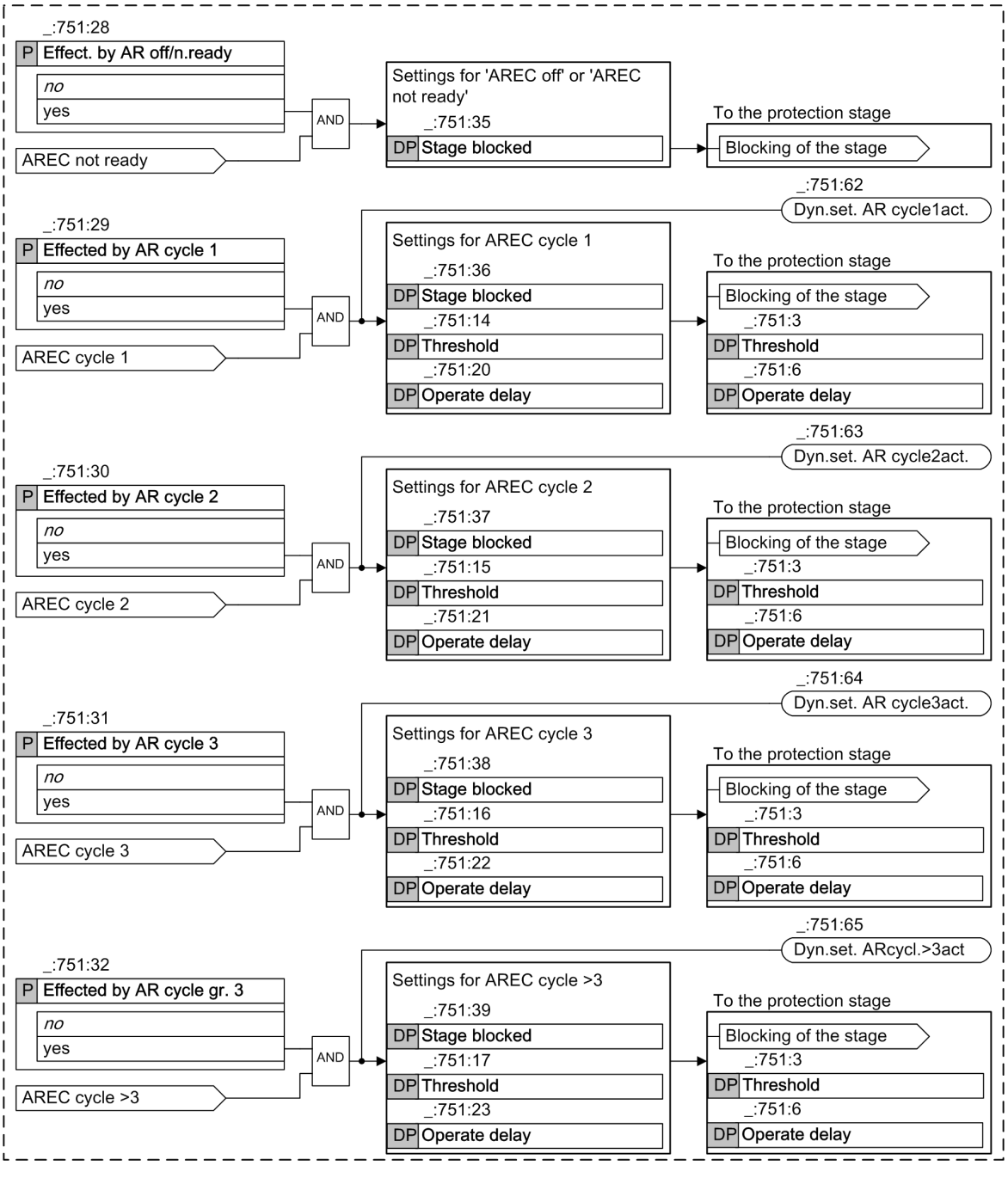
Functionalities	Priority
Automatic reclosing (AREC)	Priority 1
Cold-load pickup detection	Priority 2
Binary input signal	Priority 3

These functionalities generate signals that change the settings of the dynamic settings of the overcurrent-protection stage or block it, if required. In the latter case, the settings for the **Threshold** and the **Operate delay** are of no relevance. Within the overcurrent-protection stage, each of these signals is provided with a configuration parameter **Influence of function ...** and its own dynamic settings (**Operate delay** and **Threshold**). The configuration settings are used to set whether the signal shall be active or not, this means whether the dynamic settings shall be activated or not. If one of these signals (for example, signal function x) becomes active and is to take effect, these parameter settings become dynamic, that is, instantly active. This means that the setting assigned to the signal replaces the standard setting. If the signal becomes inactive, the standard settings apply again. The activation of the dynamic settings is reported.

Where several signals are active in parallel, the priority specified above shall apply. This means that a signal with priority 2 precedes that of priority 3. The settings assigned to signal 2 become active.

The functionality of the dynamic settings can be disabled. In this case, the settings assigned to the signals are not visible and are without effect.

Link to the Device-Internal Function *Automatic Reclosing (Advanced Stage)*



[loocpgrnd-040311-01.vsd, 1, en_US]

Figure 6-43 Influence of the AREC Signals on the Overcurrent-Protection Stage

Several AREC signals can affect the setting for the **Threshold** and the **Operate delay** of the protection stage and its blocking.

- AREC is ready for reclosing 1 (= Automatic reclosing cycle 1)
- AREC is ready for reclosing 2 (= Automatic reclosing cycle 2)
- AREC is ready for reclosing 3 (= Automatic reclosing cycle 3)
- AREC is ready for reclosing 4 (= Automatic reclosing cycle >3)

The following signal can only block the protection stage:

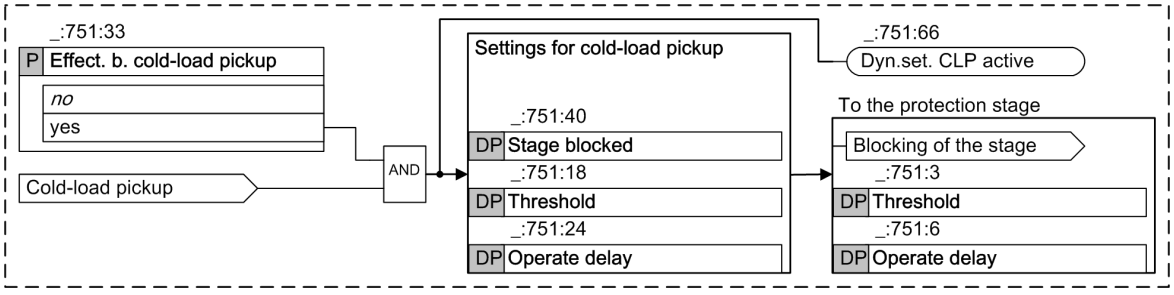
- AREC is not ready or switched off (= Automatic reclosing off / not ready)

This means that if the AREC is ready and the protection stage is in the idle state, the settings for **AREC cycle 1** are active and not the standard settings. The standard settings are active in the case of **AREC off/not ready**.

The influence can be activated for each signal individually. You also have to set the **Threshold** and **Operate delay** or **Stage blocked** parameters, which take effect when the signal is active.

The way AREC signals are generated is described in chapter *6.43.1 Overview of Functions*.

Link to the Device-Internal Function *Cold-Load Pickup Detection (Advanced Stage)*



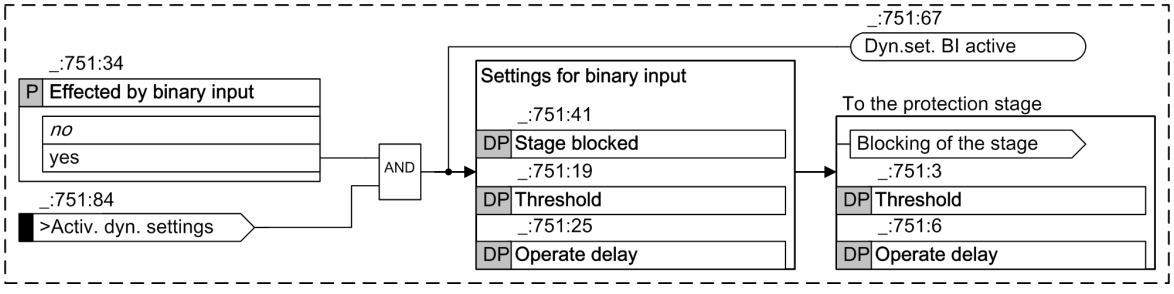
[loocpkalgnd-030311-01.vsd, 1, en_US]

Figure 6-44 Influence of the Cold-Load Pickup Detection on the Overcurrent-Protection Stage

You have the option of changing the settings for the **Threshold** and the **Operate delay** of the protection stage for a cold-load pick-up. You can also block the stage. To do so, you must activate the influence of the cold-load pickup. You also have to set the **Threshold** and **Operate delay** or assign settings to **Stage blocked**, which take effect when the signal is active.

The way signals are generated **Cold-load pickup** is described in chapter *5.8.8 Cold-Load Pickup Detection (Optional)* .

Link to an External *Function via a Binary Input Signal (Advanced Stage)*



[loocpbingnd-030311-01.vsd, 1, en_US]

Figure 6-45 Influence of the Binary Input on the Overcurrent-Protection Stage

You can use the binary input signal **>Activ. dyn. settings** to change the settings for the **Threshold** and the **Operate delay** of the protection stage. You can also block the stage. To do so, you must activate the influence of the binary input. You also have to set the **Threshold** and **Operate delay** or assign settings to **Stage blocked**, which take effect when the signal is active.

6.5.8.2 Application and Setting Notes (Advanced Stage)

Binary Input Signal: `Dynamic settings`

- Default setting **`(_:751:26) Dynamic settings`** = ***`no`***

Parameter Value	Description
`no`	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
`yes`	If a device-internal function (automatic reclosing function or cold-load pickup detection) or an external function should affect the overcurrent-protection stage (such as change the setting of the threshold value or time delay, blocking of the stage), the setting must be changed to ***`yes`***. This makes the configuration parameters **`Influence of function...`** as well as the dynamic settings **`Threshold`**, **`Operate delay`** and **`Stage blocked`** of the stage visible and enables the settings to be set for the specific influence.

Influence of AREC

The example of how the overcurrent-protection stage (1st stage) can be used as a fast stage before automatic reclosing describes the influence exerted by AREC.

The setting of the overcurrent level (1st level) results from the time-grading schedule. It is to be used as fast stage before an automatic reclosing. Because fast disconnection of the short-circuit current takes priority over the selectivity prior to reclosing, the **`Operate delay`** parameter can be set to ***`0`*** or to a very low value. To achieve the selectivity, the final disconnection must be done with the grading time.

AREC is set to 2 reclosings. A secondary **`Threshold`** of ***`1.5 A`*** and a **`Operate delay`** of ***`600 ms`*** are assumed (according to the time-grading schedule) for the overcurrent-protection stage. The standard settings of the stage are set to these values.

To realize the application, the configuration settings **`Effected by AR cycle 1`** and **`Effected by AR cycle 2`** are changed in the example to ***`yes`*** (= influenced). This activates the **`AR cycle 1`** and **`AR cycle 2`** input signals within the stage. When they become active, they switch to the assigned dynamic settings.

The two dynamic settings **`Operate delay`** assigned to these input signals (sources of influence) are set to the time delay ***`0`*** (instantaneous tripping). The two dynamic settings **`Threshold`** assigned to these input signals are set to the normal threshold value of ***`1.5 A`***.

If the threshold value (***`1.5 A`***) is exceeded before AREC 1 and AREC 2, the overcurrent-protection stage trips instantaneously. If the fault still exists after AREC 2 (unsuccessful AREC), the stage trips with the time delay of ***`600 ms`*** according to the time-grading schedule.

Influence of External Devices

The influence of an external device can also be configured. The above is an example of how the overcurrent-protection stage (1st stage) can be used as a fast stage before automatic reclosing, in which case the AREC function is performed by an external device.

To realize the application, the configuration setting **`Effected by binary input`** must be changed to ***`yes`*** (= influenced). This activates the **`>Activ. dyn. settings`** input signal within the stage. When the input signal becomes active, it switches to the assigned dynamic settings. The external device must provide the **`Cycle 1`** and **`Cycle 2`** signals or, alternatively, an AREC ready signal. The signals must be connected with the binary input signal **`>Activ. dyn. settings`**.

The dynamic setting **`Operate delay`**, which is assigned to the input signal (source of influence) **`>Activ. dyn. settings`**, is set to the time delay ***`0`*** (instantaneous tripping). The dynamic setting **`Threshold`** assigned to this input signal is set to the normal threshold value of ***`1.5 A`***.

If the threshold value (***`1.5 A`***) is exceeded before AREC 1 and AREC 2, the overcurrent-protection stage trips instantaneously. If the fault still exists after AREC 2 (unsuccessful AREC), the stage trips with the time delay of ***`600 ms`*** according to the time-grading schedule.

6.6 Directional Overcurrent Protection, Phases

6.6.1 Overview of Functions

The **Directional time-overcurrent protection, phases** (ANSI 67):

- Detects short circuits at electrical equipment
- Can be used as backup overcurrent protection in addition to the main protection
- Ensures selective fault detection for parallel lines or transformers with infeed at one end
- Ensures selective fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies

6.6.2 Structure of the Function

The **Directional time-overcurrent protection, phases** function is used in protection function groups. 2 function types are offered:

- **Directional time-overcurrent protection, phases - advanced** (67 Dir.OC-3ph-A)
- **Directional time-overcurrent protection, phases - basic** (67 Dir.OC-3ph-B)

The Basic function type is provided for standard applications. The Advanced function type offers more functionality and is provided for more complex applications.

Both function types are preconfigured by the manufacturer with 2 **directional, definite time-overcurrent protection** stages and with 1 **directional inverse time-overcurrent protection** stage.

In the advanced function type **Directional time-overcurrent protection, phases – advanced** the following stages can be operated simultaneously:

- Maximum of 4 stages **Definite time-overcurrent protection – advanced**
- 1 stage **Inverse time-overcurrent protection – advanced**
- 1 stage **User-defined overcurrent protection characteristic curve**

In the Basic function type **Directional time-overcurrent protection, phases – basic** the following stages can be operated simultaneously:

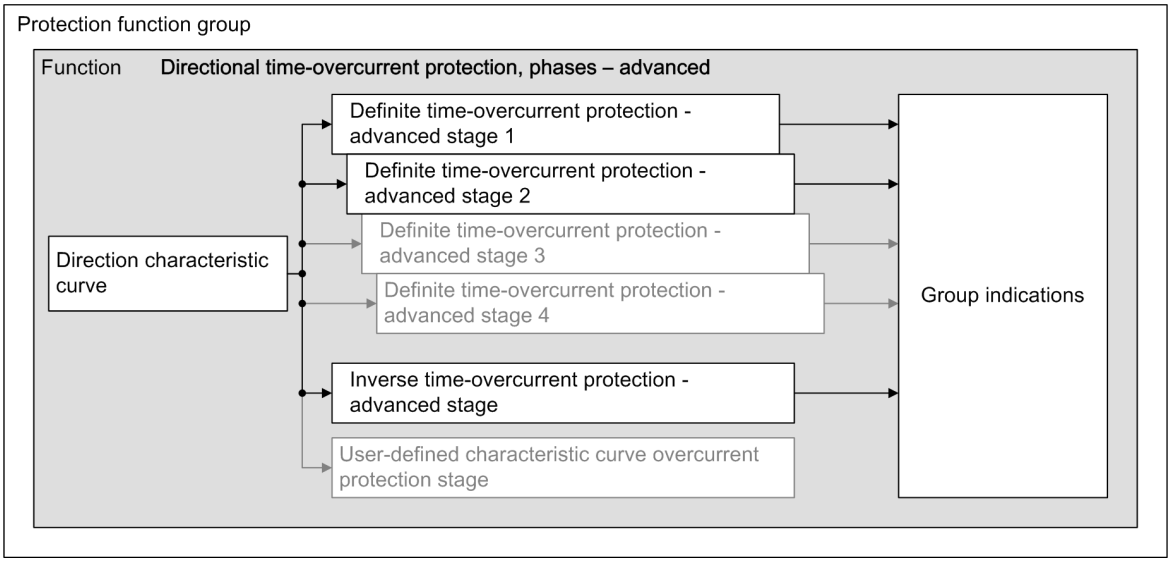
- Maximum of 4 stages **Definite time-overcurrent protection – basic**
- 1 stage **Inverse time-overcurrent protection – basic**

Stages that are not preconfigured are shown in gray in the following figures. Apart from the tripping delay characteristic, the stages are identical in structure.

The direction determination occurs on function level and has the same effects in all stages (see following figure and chapter *6.6.7.1 Description*). In this way, it is ensured that all stages of a function receive the same direction result. Every stage can be set to the forward or reverse direction.

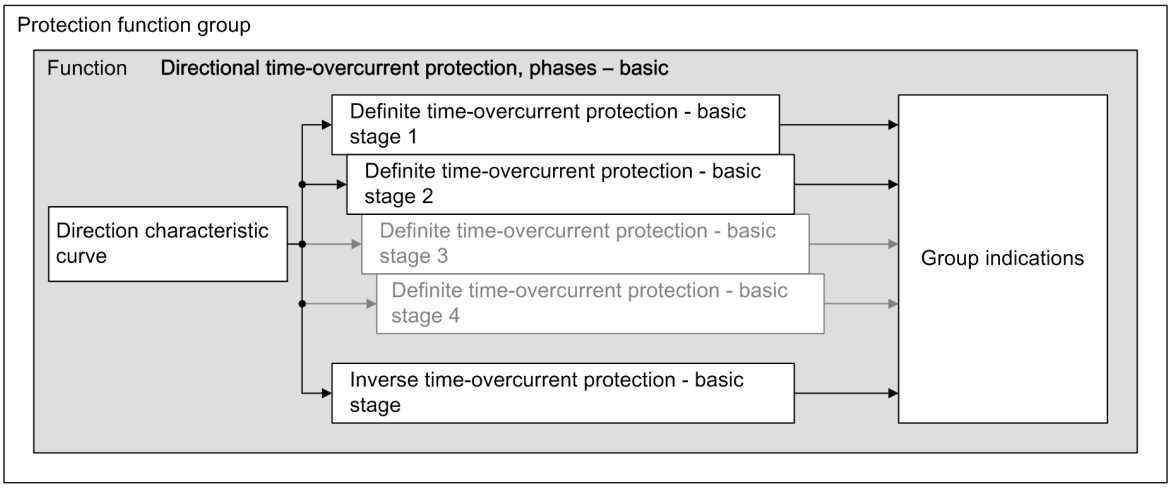
The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- **`Pickup`**
- **`Operate`**



[dwdiocan-050213-01.tif, 3, en_US]

Figure 6-46 Structure/Embedding the Function Directional Time-Overcurrent Protection, Phases – Advanced



[dwdiocba-050213-01.tif, 4, en_US]

Figure 6-47 Structure/Embedding the Function Directional Time-Overcurrent Protection, Phases – Basic

If the device-internal functions listed in the following are present in the device, these functions can influence the pickup values and tripping delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Automatic reclosing (AREC)
- Cold-load pickup detection
- Binary input signal

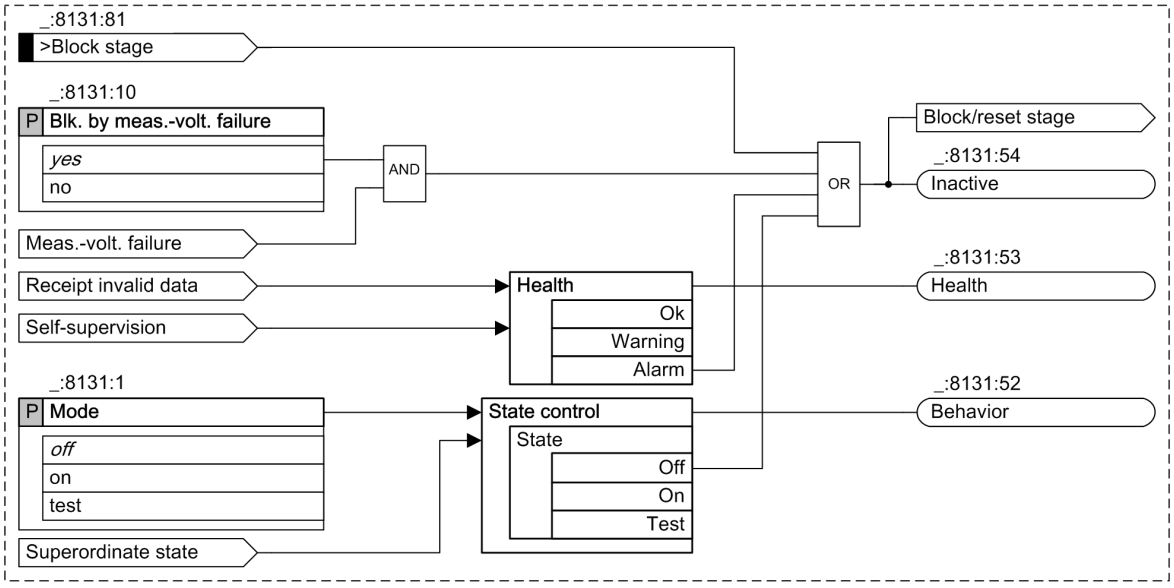
If the device is equipped with the **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer-inrush currents.

6.6.3 Stage Control

6.6.3.1 Description

Logic

The following figure represents the stage control. It applies to all types of stages.



[lodocpn2-291112-01.tif, 1, en_US]

Figure 6-48 Stage-Control Logic Diagram

Blocking of the Stage with Measuring-Voltage Failure (Basic and Advanced Stage)

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function (see chapter *9.3.2.1 Overview of Functions*)
- From an external source via the binary input signal **>Open** of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker

The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.6.3.2 Application and Setting Notes

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:8131:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following two conditions is met:

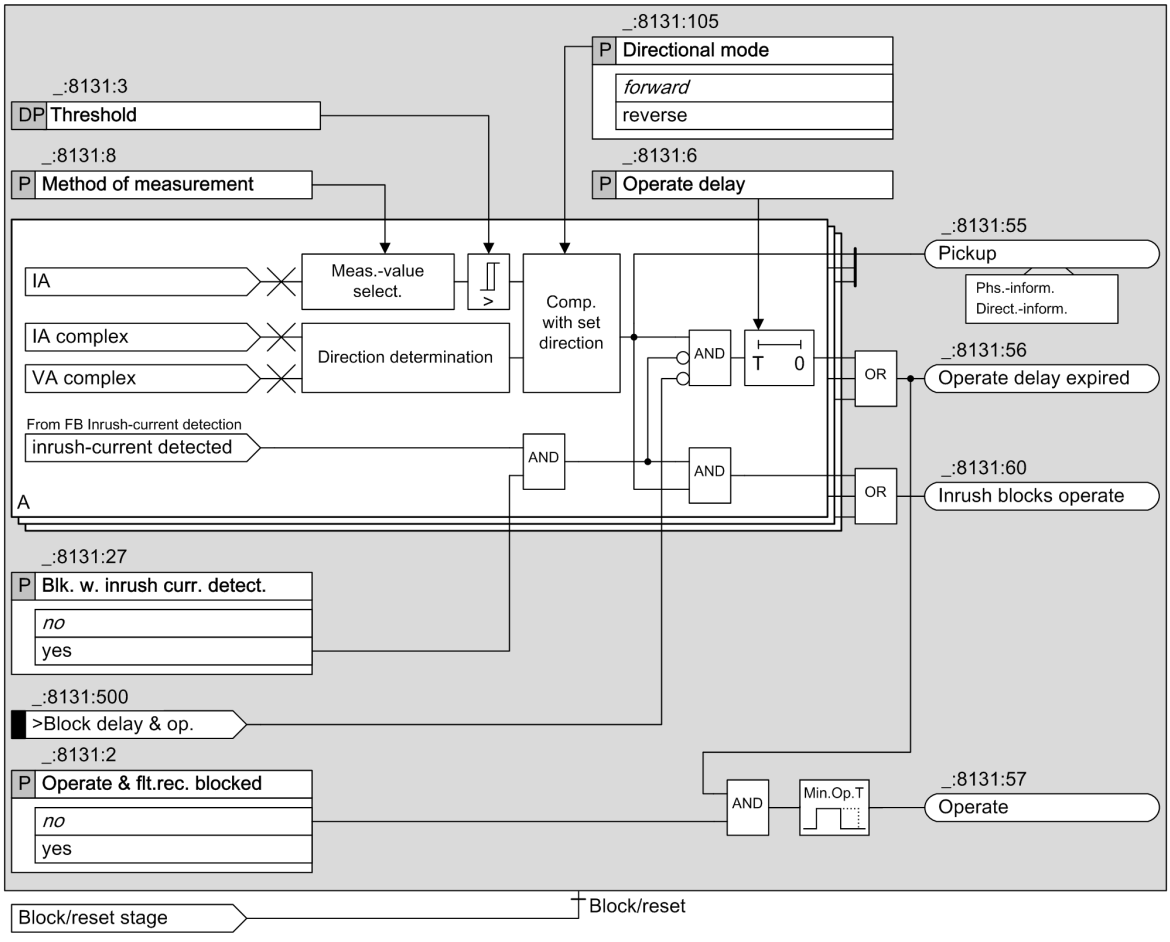
- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see chapter *9.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The directional overcurrent-protection stage is blocked. Siemens recommends that you retain the default setting, as correct direction determination cannot be guaranteed if a measuring-voltage failure occurs.
no	The directional overcurrent-protection stage is not blocked.

6.6.4 Stage with Definite-Time Characteristic Curve

6.6.4.1 Description

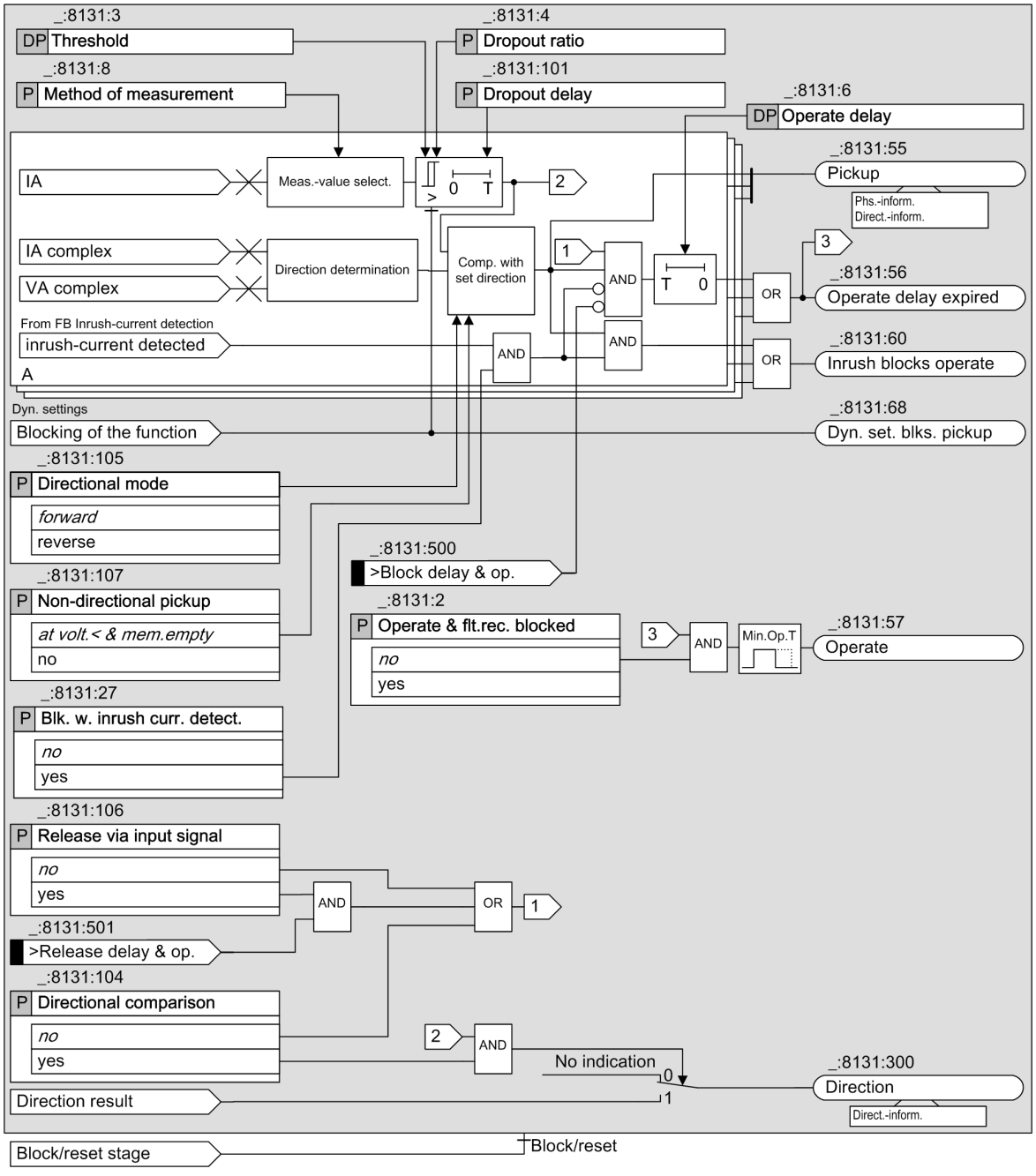
Logic of the Basic Stage



[lodocg6b-060213-01.tif, 2, en_US]

Figure 6-49 Logic Diagram of the Directional, Definite Time-Overcurrent Protection, Phases - Basic

Logic of the Advanced Stage



[lodocp31-141013, 1, en_US]

Figure 6-50 Logic Diagram of the Directional, Definite Time-Overcurrent Protection, Phases - Advanced

Directional mode (Basic and Advanced Stage)

You use the **`Directional mode`** parameter to define whether the stage works in a forward or reverse direction.

Direction determination itself works across stages (see section *6.6.7.1 Description*).

Non-Directional Pickup, Voltage Memory (Basic and Advanced Stage)

If a 3-phase close-up fault occurs, all 3 phase-to-ground voltages drop to almost 0. If this happens, direction determination can fall back on a voltage memory (see chapter l *6.6.7.1 Description*). If no voltage measure-

ments which can be used to determine the direction are available in the voltage memory, the basic stage generally picks up without direction determination, that is non-directionally. For the advanced stage, the response can be defined via the **Non-directional pickup** parameter. With the ***at volt.< & mem.empty*** setting, the function picks up in such a situation without direction determination. With the ***no*** setting, the function does not pick up.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the **Directional comparison** parameter. With the ***yes*** setting, the function uses the threshold value violation to determine the direction (forward or reverse) and reports the indication **Direction** . The direction indicated is independent of the directional mode set for the stage.

The **Release via input signal** setting and the **>Release delay & op.** input signal are available with directional comparison protection. If the **Release via input signal** parameter is set to ***yes*** , the start of the time delay, and therefore the tripping of the stage, are only enabled if the **>Release delay & op.** input signal is active.

Method of measurement (Basic and Advanced Stage)

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the calculated ***RMS value*** .

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Dropout delay (Advanced Stage)

If the value falls below the dropout threshold, the pickup dropout can be delayed. The pickup is maintained for the specified time. The tripping delay continues to run. If the time delay expires while the pickup is still maintained, the stage operates.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal **>Block stage** (see chapter *6.6.3.1 Description*)
- Measuring-voltage failure (see chapter *6.6.3.1 Description*)
- Via the dynamic settings function (only provided in the Advanced function type, see chapter **Influence of other functions via dynamic settings** and chapter *6.3.8.1 Description*)

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.3.7.1 Description* .

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.3.8.1 Description* .

6.6.4.2 Application and Setting Notes

Parameter: **Directional mode**

- Default setting **(_:8131:105) Directional mode** = ***forward***

You use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in a forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in a reverse direction (in the direction of the busbar).

Parameter: **Method of measurement**

- Recommended setting value **(_:8131:8) Method of measurement** = ***fundamental comp.***

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: **Directional comparison**, **Release via input signal**

- Default setting **(_:8131:104) Directional comparison** = ***no***
- Default setting **(_:8131:106) Release via input signal** = ***no***

These 2 parameters are not visible in the basic stage.

You use these parameters to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the **Direction** and **>Release delay & op.** signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.

Parameter Value	Description
yes	If the **Directional comparison** parameter is set to ***yes***, the **Release via input signal** parameter, the **Direction** output signal, and the **>Release delay & op.** input signal become available. If the **Release via input signal** parameter is set to ***yes***, the start of the time delay, and therefore also the operate signal of the stage, are only enabled if the **>Release delay & op.** input signal is active. The **>Release delay & op.** input signal must be connected to the release information from the opposite end (forward information from the **Direction** output signal); see also the application example in chapter *6.6.10 Application Notes for Directional Comparison Protection* .

Parameter: Non-directional pickup

- Recommended setting value **(_:8131:107) Non-directional pickup** = ***at volt.< & mem.empty***

This parameter is not visible in the basic stage.

Parameter Value	Description
at volt.< & mem.empty	Select this setting if the stage is to pick up in a non-directional manner if the voltage memory is empty and determining of direction has to be performed at low voltages (3-phase close-up fault). An empty voltage memory may exist, for example, if there is a voltage transformer at the line end and the circuit breaker (CB) trips. Siemens recommends using the default setting.
no	Select this setting if determining of direction is required under all circumstances, that is, even in the event of pickup on a 3-phase close-up fault.

Parameter: Threshold

- Default setting **(_:8131:3) Threshold** = ***1.50 A*** (for the first stage)

The same considerations apply to setting the threshold value as for non-directional overcurrent protection. For further information, refer to section *6.3.4.2 Application and Setting Notes* .

Parameter: Operate delay

- Default setting **(_:8131:6) Operate delay** = ***0.300 s*** (for the 1st stage)

The Operate delay to be set is derived from the time-grading schedule that has been prepared for the system.

Typical examples of grading times are provided in the chapters *6.6.9 Application Notes for Parallel Lines and Cable Runs with Infeed at Both Ends* and *6.6.10 Application Notes for Directional Comparison Protection* .

Parameter: Dropout ratio

- Recommended setting value **(_:8131:4) Dropout ratio** = ***0.95***

This parameter is not visible in the basic stage.

The recommended set value of 0.95 is appropriate for most applications.

For high-precision measurements, the setting value of the **Dropout ratio** parameter can be reduced, for example to 0.98. If you expect heavily fluctuating measurands at the response threshold, you can increase the setting value of the **Dropout ratio** parameter. This avoids chattering of the tripping stage.

Parameter: Dropout delay

- Recommended setting value **(_:8131:101) Dropout delay** = ***0 s***

This parameter is not visible in the basic stage.

Siemens recommends using this setting value, since the dropout of a protection stage must be performed as fast as possible.

You can use the **Dropout delay** parameter ≠ ***0 s*** to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical Data) and set the result.

6.6.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:102	General:Rotation angle of ref. volt.		-180 ° to 180 °	45 °
Definite 1				
_:8131:1	Definite-T 1:Mode		• off • on • test	off
_:8131:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:8131:105	Definite-T 1:Directional mode		• forward • reverse	forward
_:8131:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:8131:107	Definite-T 1:Non-directional pickup		• no • at volt.< & mem.empty	at volt.< & mem.empty
_:8131:104	Definite-T 1:Directional comparison		• no • yes	no
_:8131:106	Definite-T 1:Release via input signal		• no • yes	no
_:8131:10	Definite-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:8131:26	Definite-T 1:Dynamic settings		• no • yes	no
_:8131:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:8131:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:8131:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:8131:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n.rdy				
_:8131:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:8131:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:8131:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:8131:36	Definite-T 1:Stage blocked		• no • yes	no
_:8131:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:8131:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:8131:37	Definite-T 1:Stage blocked		• no • yes	no
_:8131:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:8131:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no
_:8131:38	Definite-T 1:Stage blocked		• no • yes	no
_:8131:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:8131:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:8131:39	Definite-T 1:Stage blocked		• no • yes	no
_:8131:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.s: Cold load PU				
_:8131:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:8131:40	Definite-T 1:Stage blocked		• no • yes	no
_:8131:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:8131:34	Definite-T 1:Effected by binary input		• no • yes	no
_:8131:41	Definite-T 1:Stage blocked		• no • yes	no
_:8131:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

6.6.4.4 Information List

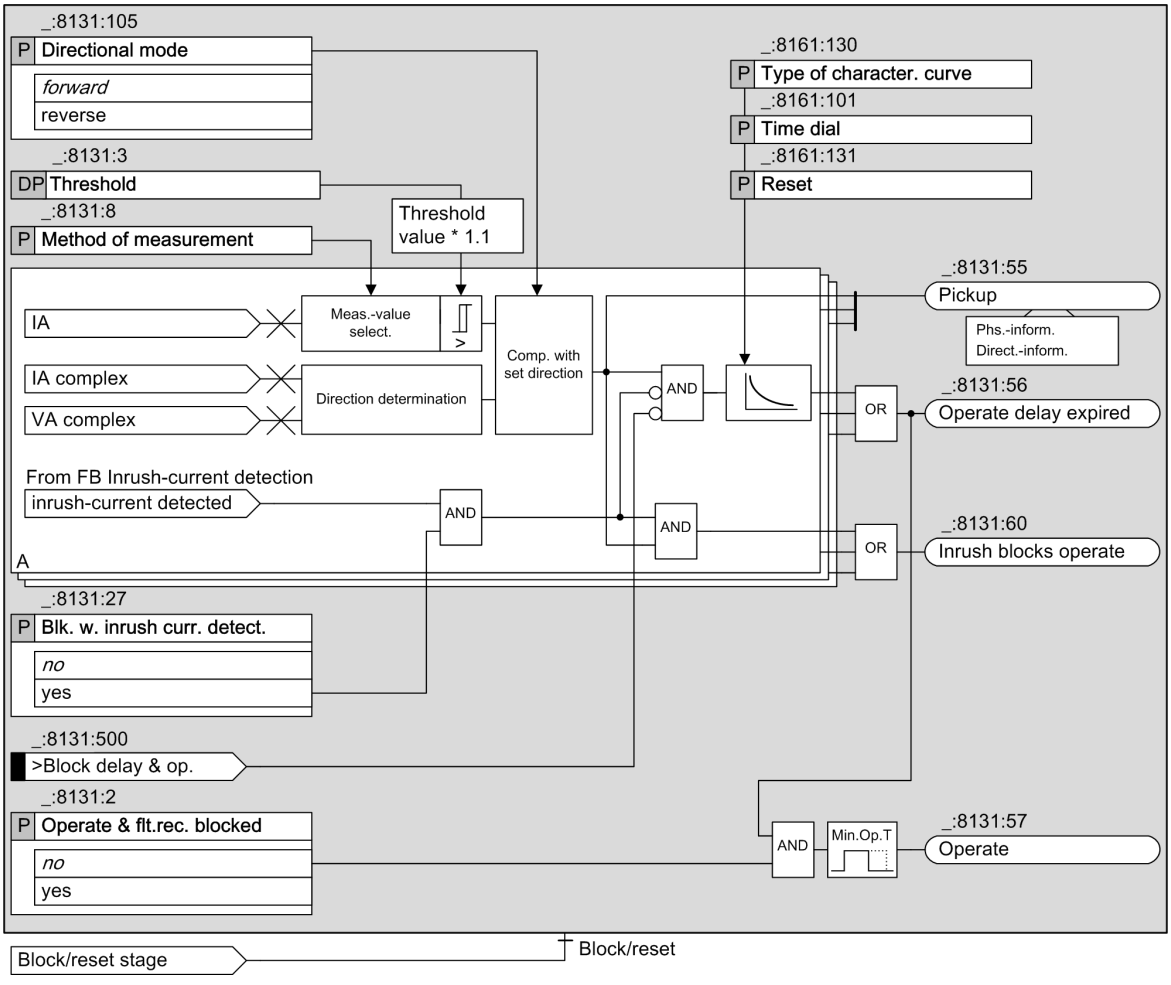
No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Test of direction	SPS	I
_:2311:301	General:Test direction	ACD	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:8131:81	Definite-T 1:>Block stage	SPS	I
_:8131:501	Definite-T 1:>Release delay & op.	SPS	I
_:8131:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:8131:500	Definite-T 1:>Block delay & op.	SPS	I
_:8131:54	Definite-T 1:Inactive	SPS	O
_:8131:52	Definite-T 1:Behavior	ENS	O
_:8131:53	Definite-T 1:Health	ENS	O
_:8131:60	Definite-T 1:Inrush blocks operate	ACT	O
_:8131:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:8131:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:8131:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O

No.	Information	Data Class (Type)	Type
_:8131:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:8131:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:8131:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:8131:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O
_:8131:55	Definite-T 1:Pickup	ACD	O
_:8131:300	Definite-T 1:Direction	ACD	O
_:8131:56	Definite-T 1:Operate delay expired	ACT	O
_:8131:57	Definite-T 1:Operate	ACT	O

6.6.5 Stage with Inverse-Time Characteristic Curve

6.6.5.1 Description

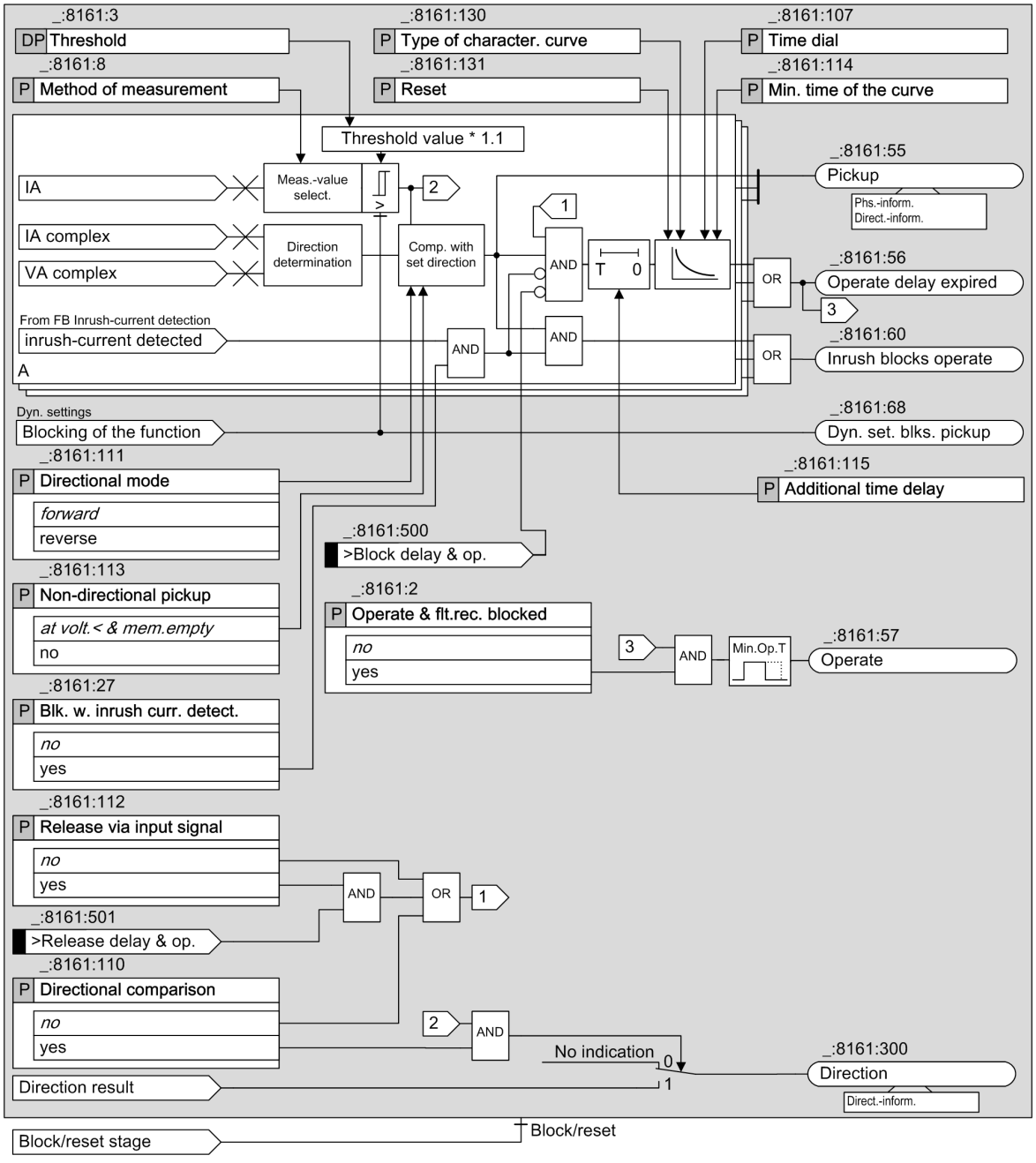
Logic of the Basic Stage



[lodoci6b-060213-01.tif, 2, en_US]

Figure 6-51 Logic Diagram of the Directional, Inverse Time-Overcurrent Protection, Phases - Basic

Logic of the Advanced Stage



[lodocp33-121013, 2, en_US]

Figure 6-52 Logic Diagram of the Directional, Inverse Time-Overcurrent Protection, Phases - Advanced

Directional mode (Basic and Advanced Stage)

You use the **`Directional mode`** parameter to define whether the stage works in a forward or reverse direction.

The direction determination works across stages (see chapter *6.6.7.1 Description*).

`Non-directional pickup`, Voltage Memory (Basic and Advanced Stage)

If a 3-phase close-up fault occurs, all 3 phase-to-ground voltages drop to almost 0. If this happens, direction determination can fall back on a voltage memory (see chapter *6.6.7.1 Description*). If no voltage measurements which can be used to determine the direction are available in the voltage memory, the basic stage

generally picks up without direction determination, that is non-directionally. For the advanced stage, the response can be defined via the **Non-directional pickup** parameter. With the ***at volt.< & mem.empty*** setting, the function picks up in such a situation without direction determination. With the ***no*** setting, the function does not pick up.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the **Directional comparison** parameter. With the ***yes*** setting, the function uses the threshold value violation to determine the direction (forward or reverse) and reports the indication **Direction**. The direction indicated is independent of the directional mode set for the stage.

The **Release via input signal** setting and the **>Release delay & op.** input signal are available with directional comparison protection. If the **Release via input signal** parameter is set to ***yes***, the start of the time delay, and therefore the tripping of the stage, are only enabled if the **>Release delay & op.** input signal is active.

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI (Basic and Advanced Stage)

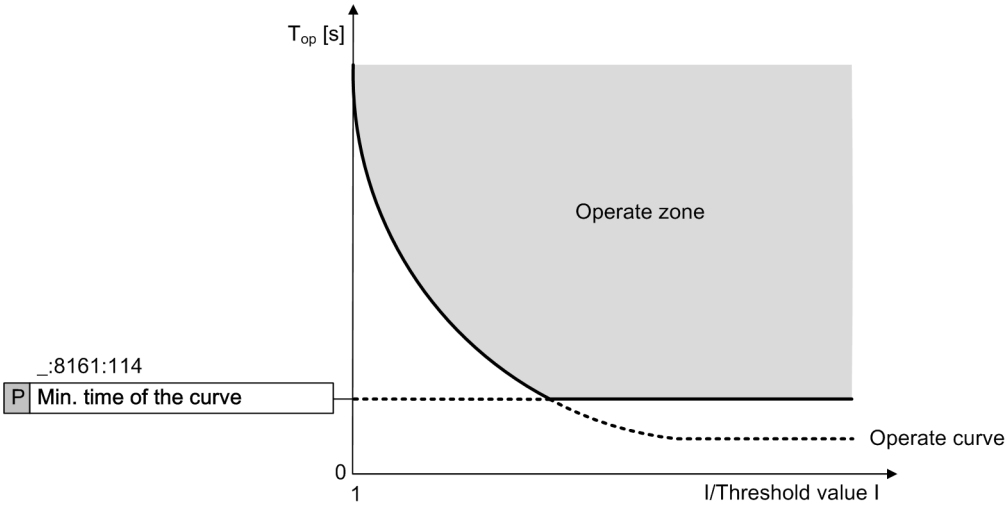
When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Minimum Time of the Curve (Advanced Stage)

With the parameter **Min. time of the curve**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.



[DwDocp01_040715-01.vsd, 1, en_US]

Figure 6-53 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter **Additional time delay**, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal **>Block stage** (see chapter *6.6.3.1 Description*)
- Measuring-voltage failure (see chapter *6.6.3.1 Description*)
- Via the functionality of the **dynamic settings** (only in the advanced function type, see subtitle **Influence of other functions via dynamic settings** and chapter *6.3.8.1 Description*).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.3.7.1 Description* .

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.3.8.1 Description* .

6.6.5.2 Application and Setting Notes

Parameter: Directional mode

- Default setting **(_:8161:111) Directional mode** = ***forward***

You use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in a forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in a reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value **(_:8161:8) Method of measurement** = ***fundamental comp.***

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.

Parameter Value	Description
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: Directional comparison, Release via input signal

- Default setting **(_:8161:110) Directional comparison** = ***no***
- Default setting **(_:8161:112) Release via input signal** = ***no***

These 2 parameters are not visible in the basic stage.

You use these parameters to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the **Direction** and **>Release delay & op.** signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.
yes	If the **Directional comparison** parameter is set to ***yes***, the **Release via input signal** parameter, the **Direction** output signal, and the **>Release delay & op.** input signal become available. If the **Release via input signal** parameter is set to ***yes***, the start of the time delay, and therefore also the operate signal of the stage, are only enabled if the **>Release delay & op.** input signal is active. The **>Release delay & op.** input signal must be connected to the release information from the opposite end (forward information from the **Direction** output signal); see also the application example in chapter *6.6.10 Application Notes for Directional Comparison Protection* .

Parameter: Non-directional pickup

- Recommended setting value **(_:8161:113) Non-directional pickup** = ***at volt.< & mem.empty***

This parameter is not visible in the basic stage.

Parameter Value	Description
at volt.< & mem.empty	Select this setting if the stage is to pick up in a non-directional manner if the voltage memory is empty and determining of direction has to be performed at low voltages (3-phase close-up fault). An empty voltage memory may exist, for example, if there is a voltage transformer at the line end and the CB trips. Siemens recommends using the default setting.
no	Select this setting if determining of direction is required under all circumstances, that is, even in the event of pickup on a 3-phase close-up fault.

Parameter: Type of character. curve

- Default setting **(_:8161:130) Type of character. curve** = ***IEC normal inverse***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **Type of character. curve** required for your specific application.

Parameter: Min. time of the curve

- Default setting **(_:8161:114) Min. time of the curve** = ***0.00 s***

This parameter is only available in the advanced stage.

With the parameter **Min. time of the curve**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: Additional time delay

- Default setting **(_:8161:115) Additional time delay** = ***0.00 s***

With the parameter **Additional time delay**, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

Parameter: Threshold

- Default setting **(_:8161:3) Threshold** = ***1.50 A***

The same considerations apply to setting the threshold value as for non-directional overcurrent protection. Therefore, refer to chapter *6.3.5.2 Application and Setting Notes* for further information.

Parameter: Time dial

- Default setting **(_:8161:101) Time dial** = ***1***

Use the **Time dial** parameter to displace the characteristic curve in the time direction.

The set value for the **Time dial** parameter is derived from the time-grading chart that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the **Time dial** parameter at ***1*** (default setting).

Parameter: Reset

- Default setting **(_:8161:131) Reset** = ***disk emulation***

You use the **Reset** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

6.6.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:102	General:Rotation angle of ref. volt.		-180 ° to 180 °	45 °
Inverse-T 1				
_:8161:1	Inverse-T 1:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:8161:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:8161:111	Inverse-T 1:Directional mode		• forward • reverse	forward
_:8161:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:8161:113	Inverse-T 1:Non-directional pickup		• no • at volt.< & mem.empty	at volt.< & mem.empty
_:8161:110	Inverse-T 1:Directional comparison		• no • yes	no
_:8161:112	Inverse-T 1:Release via input signal		• no • yes	no
_:8161:10	Inverse-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:8161:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:8161:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:8161:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:130	Inverse-T 1:Type of character. curve			
_:8161:114	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:8161:131	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:8161:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:8161:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:8161:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:8161:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:8161:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:8161:36	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 2				
_:8161:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:8161:37	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 3				
_:8161:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no
_:8161:38	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: AR cycle>3				
_:8161:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:8161:39	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:8161:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:8161:40	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: bin.input				
_:8161:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:8161:41	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

6.6.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Test of direction	SPS	I
_:2311:301	General:Test direction	ACD	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:8161:81	Inverse-T 1:>Block stage	SPS	I
_:8161:501	Inverse-T 1:>Release delay & op.	SPS	I
_:8161:84	Inverse-T 1:>Activ. dyn. settings	SPS	I
_:8161:500	Inverse-T 1:>Block delay & op.	SPS	I
_:8161:54	Inverse-T 1:Inactive	SPS	O
_:8161:52	Inverse-T 1:Behavior	ENS	O
_:8161:53	Inverse-T 1:Health	ENS	O
_:8161:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:8161:62	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:8161:63	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:8161:64	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:8161:65	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:8161:66	Inverse-T 1:Dyn.set. CLP active	SPS	O
_:8161:67	Inverse-T 1:Dyn.set. BI active	SPS	O
_:8161:68	Inverse-T 1:Dyn. set. blks. pickup	SPS	O
_:8161:59	Inverse-T 1:Disk emulation running	SPS	O
_:8161:55	Inverse-T 1:Pickup	ACD	O
_:8161:300	Inverse-T 1:Direction	ACD	O
_:8161:56	Inverse-T 1:Operate delay expired	ACT	O
_:8161:57	Inverse-T 1:Operate	ACT	O

6.6.6 Stage with User-Defined Characteristic Curve

6.6.6.1 Description

The structure of this stage is identical to that of the advanced stage with directional inverse-time characteristic curve (*6.6.4.1 Description*). The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

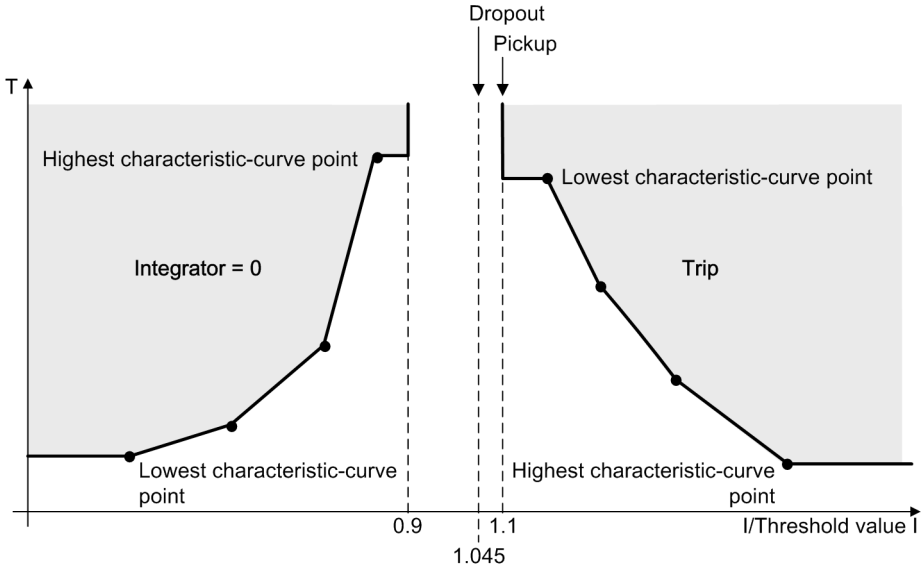
With the directional, user-defined characteristic curve, you can define the tripping curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

Pickup and Dropout Behavior with User-Defined Characteristic Curve

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.



[dwocpken-140611-02.tif, 1, en_US]

Figure 6-54 Pickup and Dropout Behavior when Using a Directional User-Defined Characteristic Curve

NOTE

Note that the currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

6.6.6.2 Application and Setting Notes

This stage is structured in the same way as the stage with a directional inverse-time characteristic curve. The only difference is that you can define the characteristic curve as desired. This chapter only provides application and setting notes for setting characteristic curves.

Parameter: `Current/time value pairs` (from the operate curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.



NOTE

The value pairs must be entered in continuous order.

Parameter: `Time dial`

- Default setting **`(_:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The set value for the **`Time dial`** parameter is derived from the time-grading chart that has been prepared for the electrical power system. Where no time grading and therefore no displacement of the characteristic curve is required, leave the **`Time dial`** parameter set to ***`1`***.

Parameter: `Reset`

- Default setting **`(_:115) Reset`** = ***`disk emulation`***

You use the **`Reset`** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: `Current/time value pairs` (of the dropout characteristic curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.



NOTE

The value pairs must be entered in continuous order.

6.6.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:110	User curve #:Directional mode		• forward • reverse	forward
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:112	User curve #:Non-directional pickup		• no • at volt.< & mem.empty	at volt.< & mem.empty
_:109	User curve #:Directional comparison		• no • yes	no
_:111	User curve #:Release via input signal		• no • yes	no
_:10	User curve #:Blk. by meas.-volt. failure		• no • yes	yes
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:115	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

6.6.6.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:501	User curve #:>Release delay & op.	SPS	I
_:84	User curve #:>Activ. dyn. settings	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:62	User curve #:Dyn.set. AR cycle1act.	SPS	O
_:63	User curve #:Dyn.set. AR cycle2act.	SPS	O
_:64	User curve #:Dyn.set. AR cycle3act.	SPS	O
_:65	User curve #:Dyn.set. ARcycl.>3act	SPS	O
_:66	User curve #:Dyn.set. CLP active	SPS	O
_:67	User curve #:Dyn.set. BI active	SPS	O
_:68	User curve #:Dyn. set. blks. pickup	SPS	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:309	User curve #:Direction	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.6.7 Direction Determination

6.6.7.1 Description

General

Every phase has a separate direction-measuring element. If the threshold value in a phase is exceeded, the direction determination is started for this phase. If there are multiphase short circuits, all measuring elements involved perform direction determination independently. If one of the determined directions matches the set direction, the stage picks up (see descriptions of the stage logic).

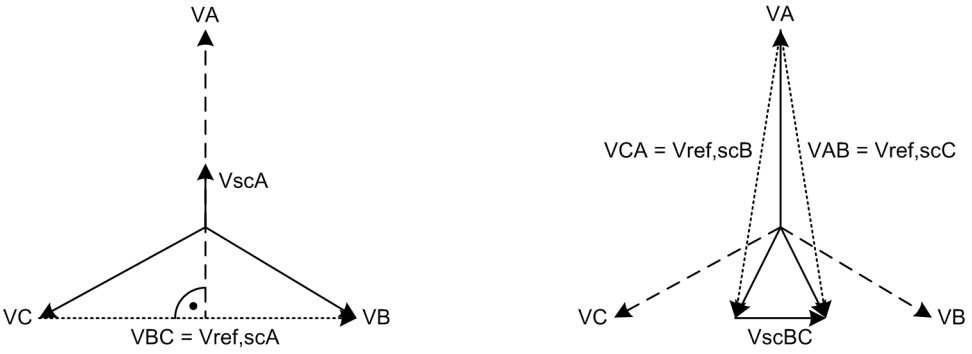
The direction is determined by calculating the phase angle between the short-circuit current and a reference voltage.

Measurands for Direction Determining

The directional measuring element uses the short-circuit current of the phase concerned and the cross-polarized phase-to-phase voltage (as the reference voltage) to determine the direction. This means that the direction can still be determined unambiguously and correctly, even if the short-circuit voltages collapse completely when a 1 or 2-phase fault occurs (close-up fault).

The phase-to-phase voltages are calculated when phase-to-ground voltages are connected.

The cross-polarized voltage (reference voltage) is vertical in relation to the short-circuit voltages for 1-phase-to-ground faults (*Figure 6-55*, left). For 2-phase short circuits, the position of the reference voltages changes up to 30°, depending on the extent to which the short-circuit voltages collapse (*Figure 6-55*, right).



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Figure 6-55 Cross-Polarized Voltages for Direction Determination

The following table shows how measurands are assigned for direction-determination purposes in the event of different types of fault.

Table 6-3 Measurands for Direction Determining

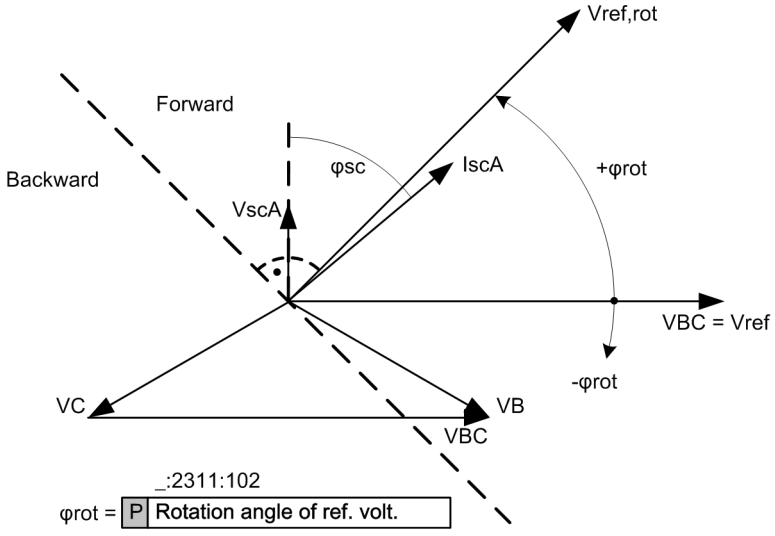
Threshold-Value Exceeding	Measuring Element							
	A		B		C		Ground	
	Current	Voltage	Current	Voltage	Current	Voltage	Current	Voltage
A	I_A	V_{BC}	–	–	–	–	–	–
B	–	–	I_B	V_{CA}	–	–	–	–
C	–	–	–	–	I_C	V_{AB}	–	–
Gnd	–	–	–	–	–	–	I_r	V_0
A, Gnd	–	V_{BC}	–	–	–	–	I_r	V_0
B, Gnd	–	–	I_B	V_{CA}	–	–	I_r	V_0
C, Gnd	–	–	–	–	I_C	V_{AB}	I_r	V_0
A, B	I_A	V_{BC}	I_B	V_{CA}	–	–	–	–
B, C	–	–	I_B	V_{CA}	I_C	V_{AB}	–	–
A, C	I_A	V_{BC}	–	–	I_C	V_{AB}	–	–
A, B, Gnd	I_A	V_{BC}	I_B	V_{CA}	–	–	I_r	V_0
B, C, Gnd	–	–	I_B	V_{CA}	I_C	V_{AB}	I_r	V_0
A, C, Gnd	I_A	V_{BC}	–	–	I_C	V_{AB}	I_r	V_0
A, B, C	I_A	V_{BC}	I_B	V_{CA}	I_C	V_{AB}	–	–
A, B, C, Gnd	I_A	V_{BC}	I_B	V_{CA}	I_C	V_{AB}	I_r	V_0

Voltage Memory

Saved voltages are used if, when a 3-pole close-up fault occurs, the measuring voltages are not sufficient for reliable direction determination. Insofar as and as long as no sufficient measuring voltage is available after the storage time (2 s) has elapsed, the detected direction is retained. If the memory does not contain any voltages (when closing onto a short circuit, for example), the behavior of the stage is defined using the **Non-directional pickup** parameter.

Direction Determination

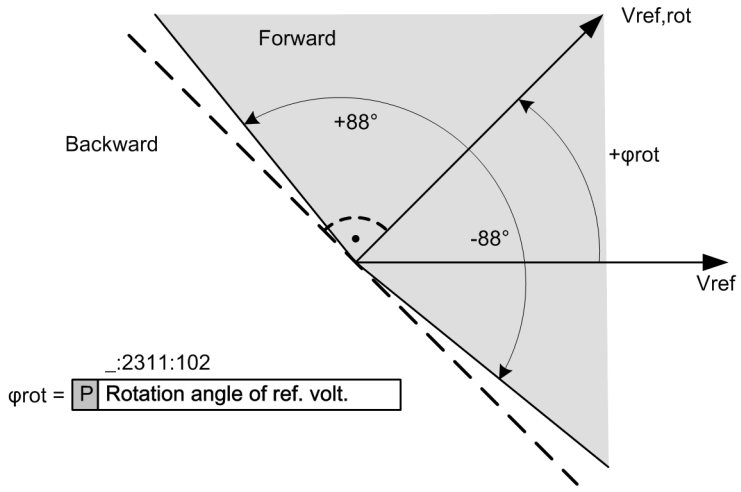
As mentioned in the **General** section, the direction is determined by calculating the phase angle between short-circuit current and reference voltage. To take different system conditions and applications into account, the reference voltage can be rotated through an adjustable angle (**Rotation angle of ref. volt.** parameter). This moves the vector of the rotated reference voltage close to the vector of the short-circuit current. Consequently, the result of direction determination is as reliable as possible. *Figure 6-56* illustrates the relationship based on a 1-phase ground fault in phase A. The short-circuit current I_{kL1} lags the short-circuit voltage by the short-circuit angle φ_k. The reference voltage, in this case V_{BC} for measuring element A, is rotated positively (counterclockwise) by the setting value of the **Rotation angle of ref. volt.** parameter. In the scenario illustrated here, the rotation is +45°.



[dwdocp33-070611-01.tif, 2, en_US]

Figure 6-56 Rotation of the Reference Voltage, Phase-Measuring Element

The rotated reference voltage defines the forward and reverse range; see *Figure 6-57*. The forward range is calculated as ±88° around the rotated reference voltage $V_{ref,rot}$. If the short-circuit current vector is located in this range, the device decides on the forward direction. In the mirrored range, the device decides on the backward direction. In the intermediate range, the direction is undetermined.



[dwdocp34-240611-01.tif, 2, en_US]

Figure 6-57 Forward Characteristic of the Directional Function, Phase-Measuring Element

Direction Determination for Test Purposes

If you activate the binary input signal **>Test of direction**, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. The direction can be determined as soon as current and voltage are greater than approx. 7 % of their secondary rated values.

6.6.7.2 Application and Setting Notes

Parameter: Rotation angle of ref. volt.

- Default setting **(_:2311:102) Rotation angle of ref. volt.** = ***45°***

The directional characteristic, that is, the position of the **forward** and **reverse** ranges, is set with the **Rotation angle of ref. volt.** parameter. The short-circuit angle is typically to be found in a range from 30° to 60° inductive. Therefore, in most cases, the default setting of +45° can be retained to position the reference voltage, as it ensures a reliable directional result.

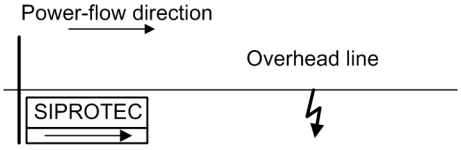
Some example settings for special applications appear in the following (*Table 6-4*). Please note that for phase-to-ground faults (PG faults), the reference voltage (fault-free voltage) is vertical in relation to the short-circuit voltage. This results in the following setting for the rotation angle:

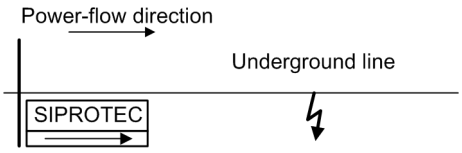
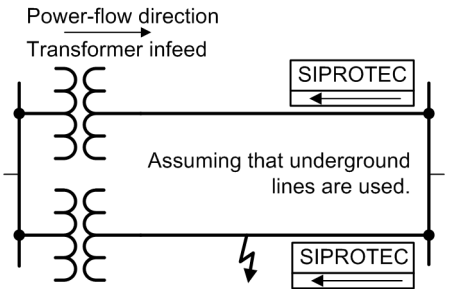
Rotation angle of ref. volt. = 90 - φsh phase-measuring elements (PG faults)

Please also note that for phase-to-phase faults, the reference voltage is rotated between 0° (distant fault) and 30° (close-up fault) dependent upon the collapse of the faulted voltage (see *Figure 6-56*). You can take this into account with an average value of 15°.

Rotation angle of ref. volt. = 90 - φsh - 15° phase-measuring elements (PP faults)

Table 6-4 Example settings

Application	φsh typical	Setting Rotation angle of ref. volt.
	60°	Range 30° to 0° for PP faults Selected: 15°

Application	φsh typical	Setting **Rotation angle of ref. volt.**
	30°	Range 60° to 30° for PP faults Selected: 45°
	30°	Range 60° to 30° for PP faults Selected: 45°

Input signal: >Test of direction

If you activate the binary input signal **>Test of direction**, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. This provides an easy means of checking the direction during commissioning, without changing the threshold values of the stages.

6.6.8 Influence of Other Functions via Dynamic Settings

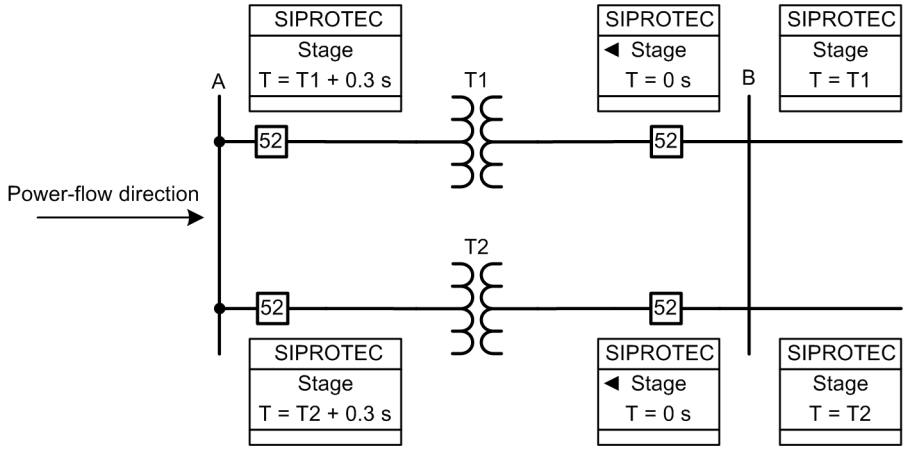
The influence of these functions via dynamic settings is described in chapter *6.3.8.1 Description* and chapter *6.3.8.2 Application and Setting Notes (Advanced Stage)* .

6.6.9 Application Notes for Parallel Lines and Cable Runs with Infeed at Both Ends

Parallel Lines or Transformers

In parallel lines or transformers with infeed at one end (see *Figure 6-58*), if there is no directional measuring element, a fault on feeder T1 will also trip the other feeder T2. In contrast, a directional measuring element in the devices on busbar B prevents the tripping of the circuit-breaker in the parallel feeder. Therefore, in *Figure 6-58*, directional time-overcurrent protection is used in the places marked with direction arrows. Please note that the forward direction of the protection device represents the direction towards the object to be protected. This does not have to be the same as the power direction of normal load flow.

Set time grading in opposition to the load flow with increasing time. As load can only flow in one direction, you can set the directional devices without time delay.



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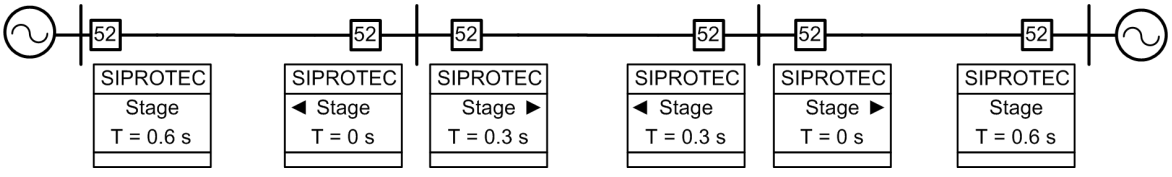
Figure 6-58 Parallel Line with Transformers

Legend for *Figure 6-58*

Stage ►:	Directional stage, **forward** direction set
Stage:	Non-directional stage
T:	Grading time

Cable Runs with Infeed at Both Ends

Cable runs with infeed at both ends and lines connected to form ring topologies also require that you supplement overcurrent protection with the directional criterion. *Figure 6-59* shows a ring system implementation, with the 2 infeeds shown merging in the ring to form a single infeed. For the directional devices whose forward direction matches the power-flow direction, set time grading in opposition to the power flow with increasing time. As power flow from both ends is possible, grading has to be set at both ends.



[dwdocp06-240611-01.tif, 1, en_US]

Figure 6-59 Cable Runs with Infeed at Both Ends

Legend for *Figure 6-59*

Stage ►:	Directional stage, **forward** direction set
Stage:	Non-directional stage
T:	Grading time

6.6.10 Application Notes for Directional Comparison Protection

The direction determination of directional time-overcurrent protection can be used to implement directional comparison protection for cable runs with infeed at both ends. Directional comparison protection is used for the selective isolation of a faulted line section (for example, subsections of closed rings). Sections are isolated in fast time, that is, they do not suffer the disadvantage of long grading times.

This technique requires that directional information can be exchanged between the individual protection stations. You can implement this information exchange using a communication channel (protection interface or IEC 61850 GOOSE) or with pilot wires for signal transmission via an auxiliary voltage loop.

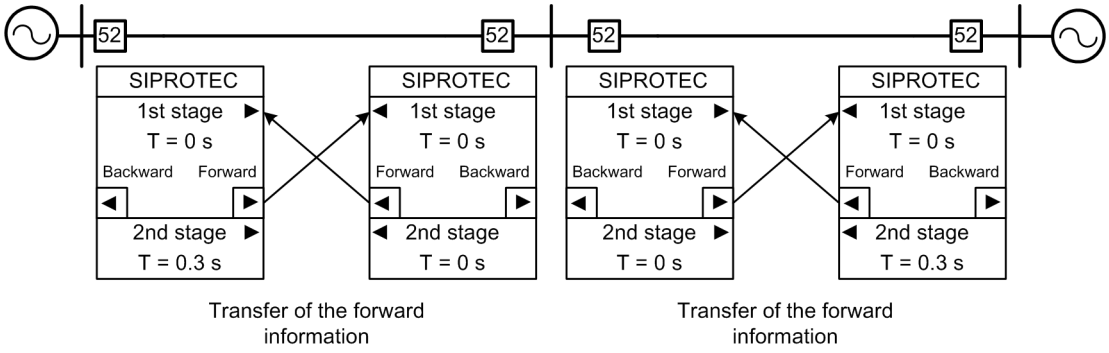
Protection Principle

The protection principle is shown in *Figure 6-60*. 2 devices (one at the start of the line and the other at the end of the line) work together in each line section. The information **fault in forward direction** is transferred between them. A directional definite time-overcurrent protection level is in operation in both devices in the forward direction (1st level). However, this level is not enabled in the idle state. The level is only released when the information **fault in forward direction** is received from the opposite end. If the enabled level also defines the fault in the forward direction, the fault must be on this line section and the level trips immediately. As this protection principle works with an enable procedure (and not with a blocking procedure), there is no need to delay the level.

A second directional definite time-overcurrent protection stage with standard time grading works in parallel with the first stage as a selective backup stage. This ensures full selectivity of protection in the following situations:

- Infeed at one end or weak infeed at one end: In this case, no release signal is generated.
- Failure of the communication route: In this case, the release signal is not transmitted.

To provide selective protection in fast time for busbars between the line sections also, you can combine this protection principle with the principle of reverse interlocking. This principle is not discussed in further detail in this document.



[dwdocp07-240611-01.tif, 1, en_US]

Figure 6-60 Selectivity through Directional Comparison Protection

Legend for *Figure 6-60*

Stage ►:	Stage is set in the **forward** direction; stage 1 is instantaneous, stage 2 is graded
►, ◄:	If a threshold value is exceeded, the stage indicates the direction (forward or reverse)

If you are using a communication channel, the protocol-transmission methods detect if the channel is interrupted. If you are using pilot wires, we recommend operation based on a closed-circuit connection. The device uses a function chart to check and indicate if the binary input is dead for an unexpectedly long period. In contrast with the blocking procedure, overfunction is not possible if communication is lost. Therefore, a loss of communication is not critical where this procedure is concerned, although it must be detected and indicated.

Directional comparison protection can also be implemented as a blocking procedure. This procedure works under all system switching states, i.e. also with infeed at one end (or weak infeed). However, to use it you must delay the stage (typically by 100 ms) so that the blocking signal is received in time under all circumstances. It is also essential that you monitor the communication channel to avoid overfunction in the event of failure followed by a system incident.

Configuration of the Stage, Function Chart

To configure the stage, proceed as follows:

- The **`Directional mode`** parameter of both stages must be set to ***`forward`***
- The **`Directional comparison`** and **`Release via input signal`** parameters of the first stage must be set to ***`yes`***. This is so that the first stage is only released if the **`>Release delay & op.`** input signal is active. Furthermore, the direction is indicated if a threshold value is exceeded.
- The first stage can be set without a time delay. The second stage has to be graded

- The information ***forward*** from the **Direction** signal in the first stage must be transmitted to the opposite end. The routing is determined by the type of transmission
- A function chart has to be implemented at the receive end to link the received (***forward*** information) and release signals, dependent upon the type of transmission.

6.7 Directional Overcurrent Protection, Ground

6.7.1 Overview of Functions

The **Directional time-overcurrent protection, ground** function (ANSI 67N):

- Detects short circuits to ground affecting electric equipment
- Ensures selective ground fault detection for parallel lines or transformers with infeed at one end
- Ensures selective ground fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies

6.7.2 Structure of the Function

The **Directional time-overcurrent protection, ground** function can be used in protection function groups which provide zero-sequence current and zero-sequence voltage measurements. 2 function types are offered:

- **Directional time-overcurrent protection, ground – advanced** (67N Dir.OC-gnd-A)
- **Directional time-overcurrent protection, ground – basic** (67N Dir.OC-gnd-B)

The basic function type shall be used for standard applications. The advanced function type provides more functionalities and is intended for more sophisticated applications.

Both function types are preconfigured by the manufacturer with 2 **Definite time-overcurrent protection** stages and 1 **Inverse time-overcurrent protection** stage.

In the advanced function type **Directional time-overcurrent protection, ground – advanced**, the following stages can operate simultaneously:

- A maximum of 4 **Definite time-overcurrent protection – advanced** stages
- 1 **Inverse time-overcurrent protection – advanced** stage
- 1 **Logarithmic inverse time-overcurrent protection** stage
- 1 **Logarithmic inverse time with knee-point overcurrent protection** stage
- 1 **User-defined characteristic curve overcurrent protection** stage

In the basic function type **Directional time-overcurrent protection, ground – basic**, the following stages can operate simultaneously:

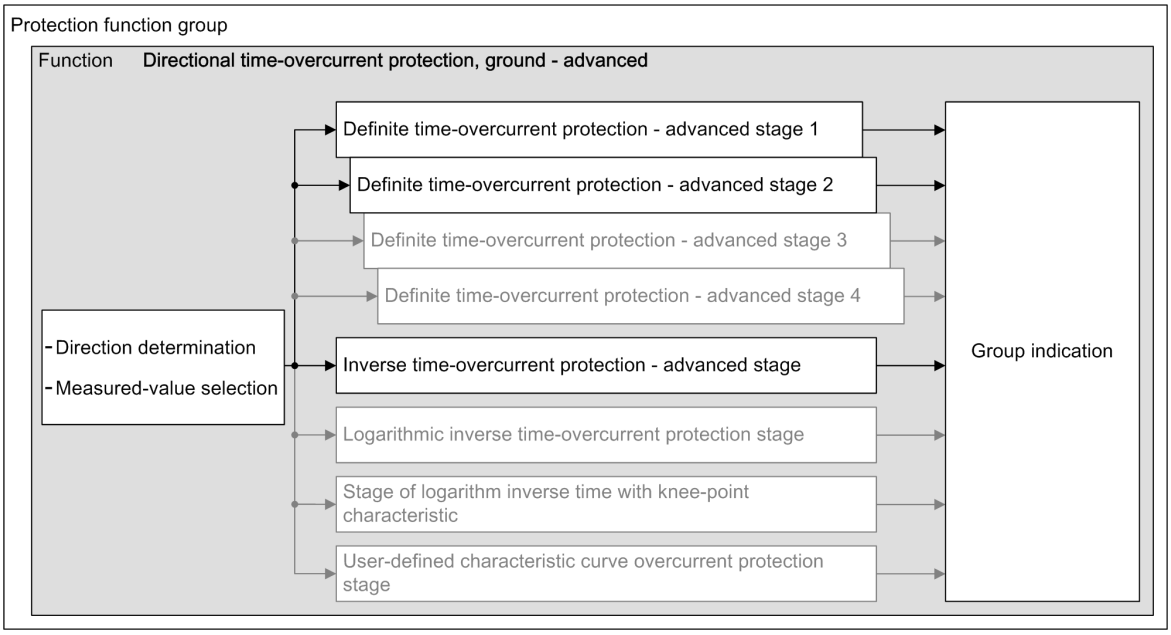
- A maximum of 4 **Definite time-overcurrent protection – basic** stages
- 1 **Inverse time-overcurrent protection – basic** stage

Referring to *Figure 6-61* and *Figure 6-62*, the stages not preconfigured are shown in gray. Apart from the operate-delay characteristic curve, the stages are similar in structure.

The general functionallity includes the direction determination and the measured-value selection (only advanced function). They take place on the functional level and have a uniform effect on the stages (see *Figure 6-61* and chapter General Functionality. This ensures that all stages of the function receive the same measured current value and the same direction result. Each stage can be set to work in forward or reverse direction.

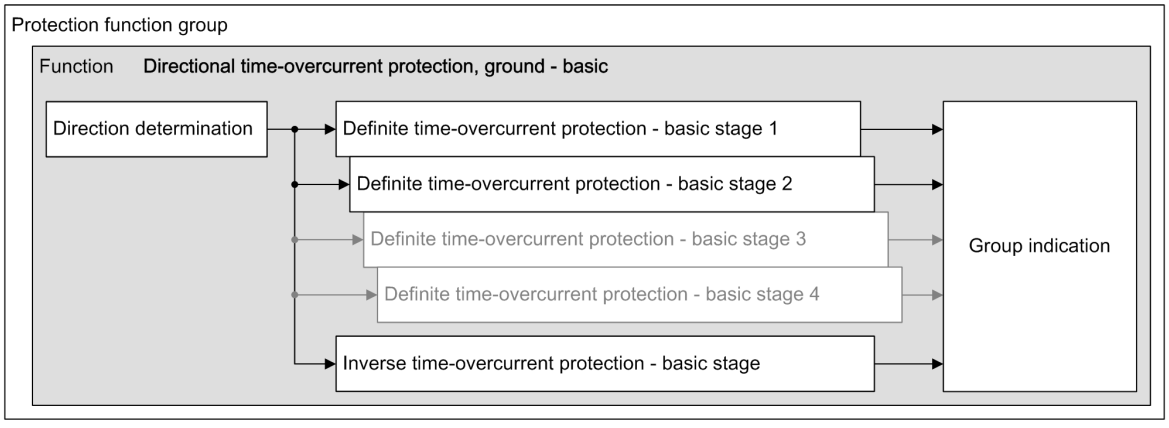
The group indication output logic generates the following group indications for the protection function by the logic OR from the stage-selective indications:

- Pickup
- Operate



[dwrdirad-300913, 2, en_US]

Figure 6-61 Structure/Embedding of the Function Directional Time-Overcurrent Protection, Ground – Advanced



[dwrdirba-300913, 1, en_US]

Figure 6-62 Structure/Embedding of the Function Directional Time-Overcurrent Protection, Ground – Basic

If the following listed device-internal functions are present in the device, these functions can influence the pickup values and operate delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Automatic reclosing (AREC)
- Cold-load pickup detection
- Binary input signal

If the device is equipped with the **Inrush-current detection** function, the stages can be stabilized against operate due to transformer-inrush currents.

6.7.3 General Functionality

6.7.3.1 Measured-Value Selection

Logic

The function provides the option to select between the values ***IN measured*** or ***3I0 calculated***.

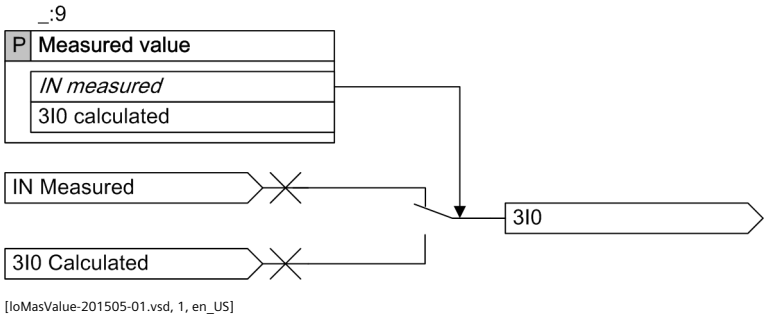


Figure 6-63 Logic Diagram of Measured-Value Selection

Both options are only available for the current-transformer connection types ***3-phase + IN*** and ***3-phase + IN-separate***. For other connection types respectively, only one option is possible. If you select an option that is not allowed, an inconsistency message is given.

Depending on the CT secondary rated current, the CT connection type, and the selected setting, the secondary threshold setting range varies according to the following table.

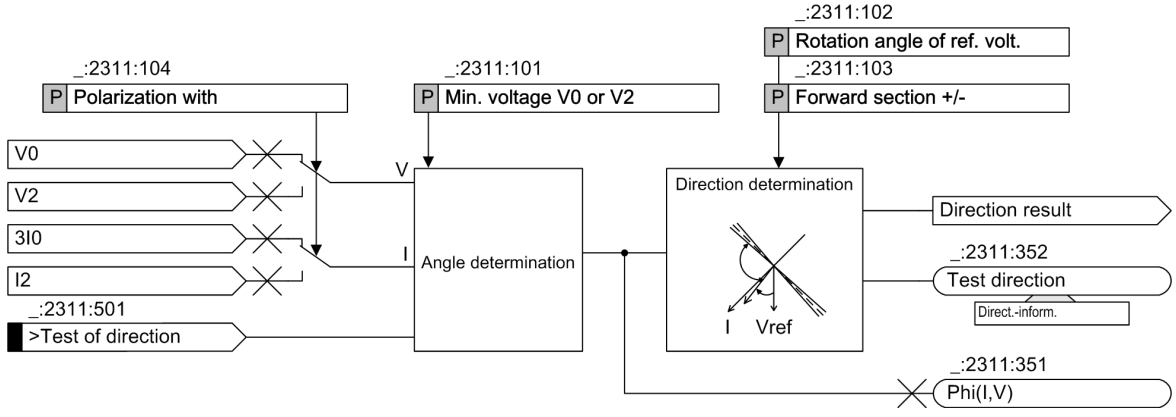
Table 6-5 Threshold Setting Range

Connection Type	Measured Value	CT Terminal Type	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 5 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 5 A)
3ph + IN	3I0 calculated	4 * Protection	0.030 A to 35.000 A	N/A	N/A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.030 A to 35.000 A	N/A	N/A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
3ph + IN-separate	3I0 calculated	4 * Protection	0.030 A to 35.000 A	0.030 A to 35.000 A	0.15 A to 175.00 A	0.15 A to 175.00 A
		3 * Protection, 1 * sen.	0.030 A to 35.000 A	0.030 A to 35.000 A	0.15 A to 175.00 A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	0.001 A to 1.600 A	0.005 A to 8.000 A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.030 A to 35.000 A	0.15 A to 175.00 A	0.030 A to 35.000 A	0.15 A to 175.00 A
		3 * Protection, 1 * sen.	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A
		4 * Measurement	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A

6.7.3.2 Direction Determination

Logic of Direction Determination

The following figure represents the logic of the direction determination. It applies to all types of stages.



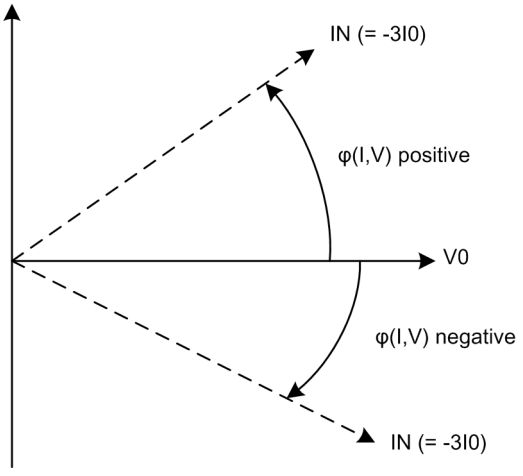
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Figure 6-64 Logic Diagram of Direction Determination

Measurand for the Direction Determination

With the parameter **`Polarization with`** you define whether the direction determination is calculated with the zero-sequence components 3I0 and V0 or with the negative-sequence components I2 and V2, which are present during faults in the network.

The angle between IN (=-3I0) and V0 (respectively -I2 and V2) in case of using the negative-sequence components is available as a functional measured value. This value is only present during faults in the network.



[DwUlkenn-240812-01.vsd, 1, en_US]

Figure 6-65 Measured-Value Definition

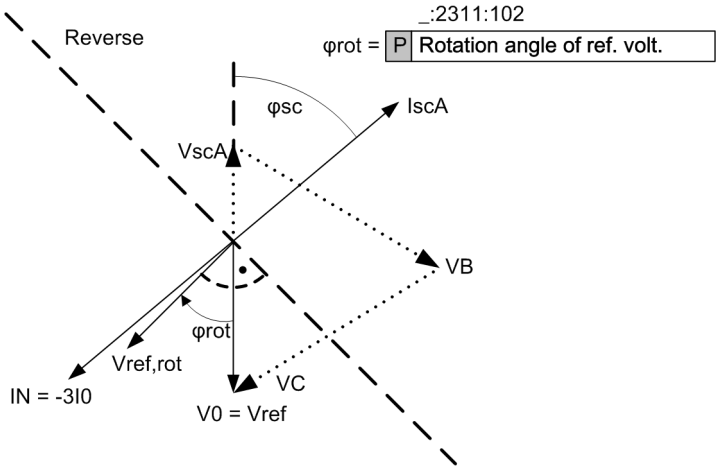
Start of the Direction Determination

If the zero-sequence current 3I0 exceeds the pickup threshold of a stage and the selected voltage (V0 or V2) exceeds the parameter **`Min. voltage V0 or V2`** as well, the direction determination is started.

Direction Determination with Zero-Sequence Values

The direction is determined by calculating the phase angle between the short-circuit current -3I0 and the rotated reference voltage **Vref, rot**. Contrary to the **Directional time-overcurrent protection, phase** function, which works with the healthy voltage as reference voltage, the fault voltage V0 itself is the reference voltage for the **Directional time-overcurrent protection, ground** function. To take different system condi-

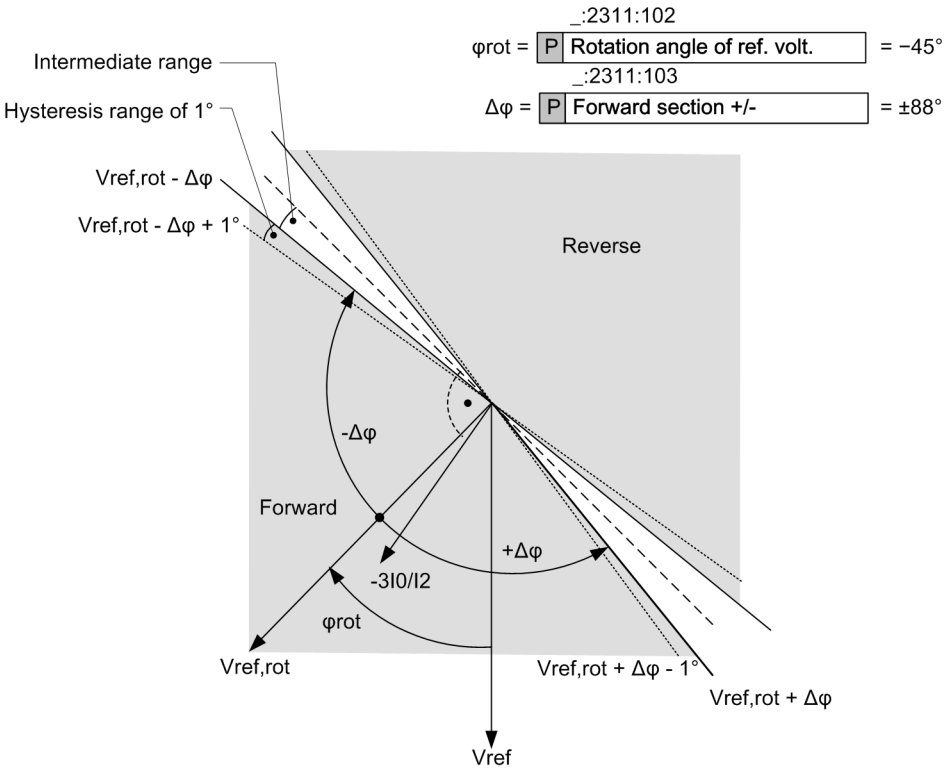
tions and applications into account, the reference voltage V0 can be rotated through an adjustable angle (parameter **Rotation angle of ref. volt.**). This moves the vector of the rotated reference voltage close to the vector of the short-circuit current -3I0. Consequently, the result of direction determination is as reliable as possible. *Figure 6-66* illustrates the relationship based on a 1-phase-to-ground fault in phase A. The fault current has a phase displacement of 180° to the fault current IscA and lags the fault voltage by the fault angle φsc. The reference voltage V0 is rotated by φrot which is -45°.



[dwroreze-300913, 2, en_US]

Figure 6-66 Rotation of the Reference Voltage, Directional Time-Overcurrent Protection, Ground Function with Zero-Sequence Values

The rotated reference voltage **Vref, rot** and the parameter **Forward section +/-** define the forward and reverse ranges, see *Figure 6-67* . The forward range is calculated as ± Δφ° around the rotated reference voltage **Vref, rot**. Δφ is set with the parameter **Forward section +/-** . If the short-circuit current vector -3I0 is located in this range, the device decides on the forward direction. In the mirrored range, the device decides on the reverse direction. In the intermediate range, the direction is undetermined.



[dwforrev-281013, 2, en_US]

Figure 6-67 Forward/Reverse Characteristic of the Directional Time-Overcurrent Protection, Ground Function

Direction Determination with Negative-Sequence Values

The method works in the same way as for zero-sequence values. Instead of 3I0 and V0, the negative-sequence values I2 and V2 are used for determining the direction.

Direction Determination for Test Purposes

If you activate the binary input signal *>Test of direction* , the direction is determined and indicated even without the current threshold being exceeded in one of the stages. The direction can be determined as soon as the zero-sequence current 3I0 and the zero-sequence voltage V0 exceeds approx. 7 % of the secondary rated values of phase current and voltage.

6.7.3.3 Application and Setting Notes

Parameter: `Measured value`

- Recommended setting value **`(_:9) Measured value`** = ***`IN Measured`***

This parameter is not available in the basic function.

Parameter Value	Description
`IN Measured`	The function operates with the measured ground current IN. This is the recommended setting unless there is a specific reason to use the calculated zero-sequence current 3I0.
`3I0 Calculated`	The function operates with the calculated zero-sequence current 3I0. This setting option can be used when applying a redundant 50N/51N function for safety reasons.

Parameter: **Min. voltage V0 or V2**

- Recommended setting value **(_:2311:101) Min. voltage V0 or V2** = ***2 V***

This parameter is not available in the basic function. The basic function uses a fixed value of 2 V.

You use the **Min. voltage V0 or V2** parameter to define the minimum zero-sequence voltage or negative-sequence voltage for the direction determination. The minimum voltage must be set greater than the maximum operational unbalance plus the voltage-transformer measuring errors.

As the measuring error of the individual voltage transformer is not added up, the critical measuring-error influence is the unbalance of the primary system.

Siemens recommends observing the operational zero-sequence voltage V0 of the protected object (for example, the line) via the operational measured values of the device and providing the maximum value with a certainty of 50 %.

EXAMPLE

Maximum operational measured value of zero-sequence voltage V0 = 0.5 Vsec

Min. voltage V0 or V2 = 1.5 * 0.5 V = 0.75Vsec

If you have no information about maximum operational unbalance, Siemens recommends using the default setting.

Parameter: **Rotation angle of ref. volt.** / **Forward section +/-**

- Recommended setting value **(_:2311:102) Rotation angle of ref. volt.** = ***-45°***
- Recommended setting value **(_:2311:103) Forward section +/-** = ***88°***

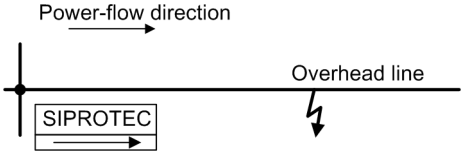
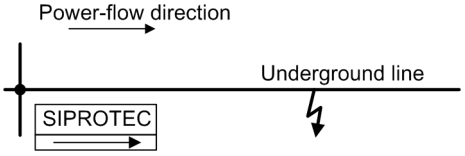
The parameter **Forward section +/-** is not available in the basic function. The basic function uses a fixed value of 88°.

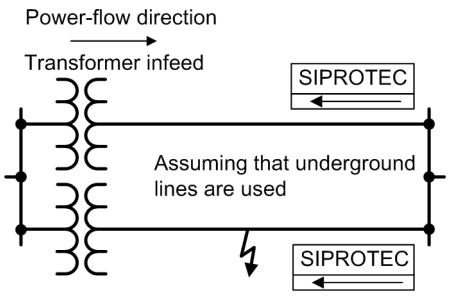
The direction characteristic, that is, the area of the forward and reverse ranges, is set with the **Rotation angle of ref. volt.** and the **Forward section +/-** parameters. The short-circuit angle is typically to be found in a range from -30° to -60° inductively. Therefore, in most cases, the default setting of -45° can be retained to position the reference voltage, as it ensures a reliable directional result.

Some example settings for special applications appear below *Table 6-6*. Note that for 1-phase-to-ground faults (PG faults), the reference voltage is the zero-sequence voltage V0. This results in the following setting for the rotation angle:

Rotation angle of ref. volt. = -φk ground-measuring elements (PG faults)

Table 6-6 Example Settings

Application	φk Typical	Setting **Rotation angle of ref. volt.**
	60°	-60°
	30°	-30°

	30°	-30°

Parameter: `Polarization with`

- Recommended setting value **`(_:2311:104) Polarization with`** = ***`zero sequence`***

This parameter is not available in the basic function. The basic function uses always zero-sequence components for the direction determination.

You use the parameter **`Polarization with`** to select the values for the direction determination.

Parameter Value	Description
`zero sequence`	Select ***`zero sequence`*** to determine the direction via the zero-sequence components V0 and 3I0. Siemens recommends using the zero-sequence components for the direction determination.
`negative sequence`	Select ***`negative sequence`*** to determine the direction via the negative-sequence components V2 and I2. The negative-sequence system can be used in case of danger that the zero-sequence voltage is too small due to unfavorable zero-sequence impedance conditions or that a parallel line influences the zero-sequence system.

Input Signal: *`>Test of direction`*

If you activate the binary input signal *`>Test of direction`*, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. This provides an easy means of checking the direction during commissioning, without changing the threshold values of the stages.

6.7.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:9	General:Measured value		• 3I0 calculated • IN measured	IN measured
_:101	General:Min. voltage V0 or V2		0.150 V to 20.000 V	2.000 V
_:102	General:Rotation angle of ref. volt.		-180 ° to 180 °	-45 °
_:103	General:Forward section +/-		0 ° to 90 °	88 °
_:104	General:Polarization with		• zero sequence • negative sequence	zero sequence

6.7.3.5 Information List

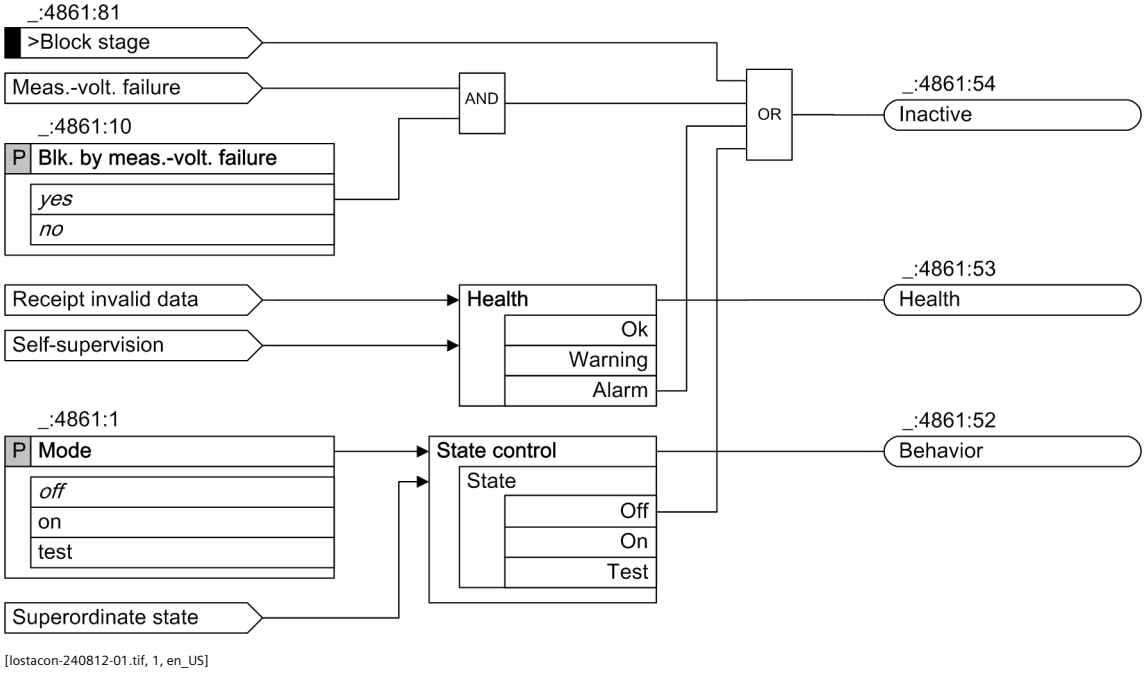
No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Test of direction		I
_:2311:352	General:Test direction		O
_:2311:351	General:Phi(I,V)		O

6.7.4 Stage Control

6.7.4.1 Description

Logic

The following figure represents the stage control. It applies to all types of stages.



[lostacon-240812-01.tif, 1, en_US]

Figure 6-68 Logic Diagram of the Stage Control

Blocking of Stage in Case of Measuring-Voltage Failure

The stages can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From an internal source on the pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **Voltage-transformer circuit breaker**, which links to the trip of the voltage-transformer circuit breaker

The **`Blk. by meas.-volt. failure`** parameter can be set to either block or not block the stage when the **Measuring-voltage failure detection** function picks up.

6.7.4.2 Application and Setting Notes

Parameter: **`Blk. by meas.-volt. failure`**

- Recommended setting value **`(_:4861:10) Blk. by meas.-volt. failure`** = ***`yes`***

You can use the **Blk. by meas.-volt. failure** parameter to control the response of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

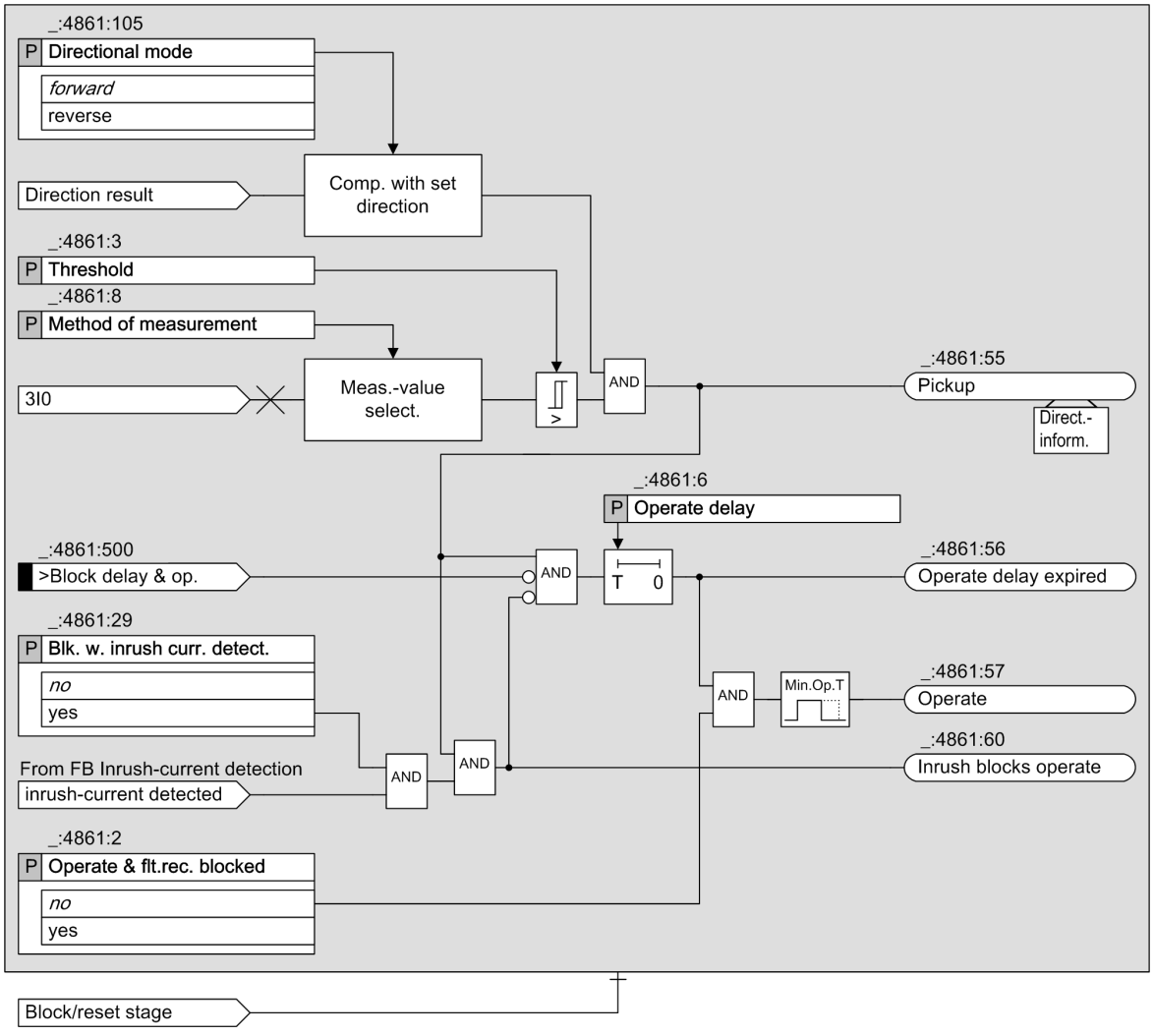
- The device-internal **Measuring-voltage failure detection** function is configured and switched on.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The directional overcurrent-protection stage is blocked when a measuring-voltage failure is detected. Siemens recommends using the default setting, as correct direction determination cannot be guaranteed if a measuring-voltage failure occurs.
no	The directional overcurrent-protection stage is not blocked when a measuring-voltage failure is detected.

6.7.5 Stage with Definite-Time Characteristic Curve

6.7.5.1 Description

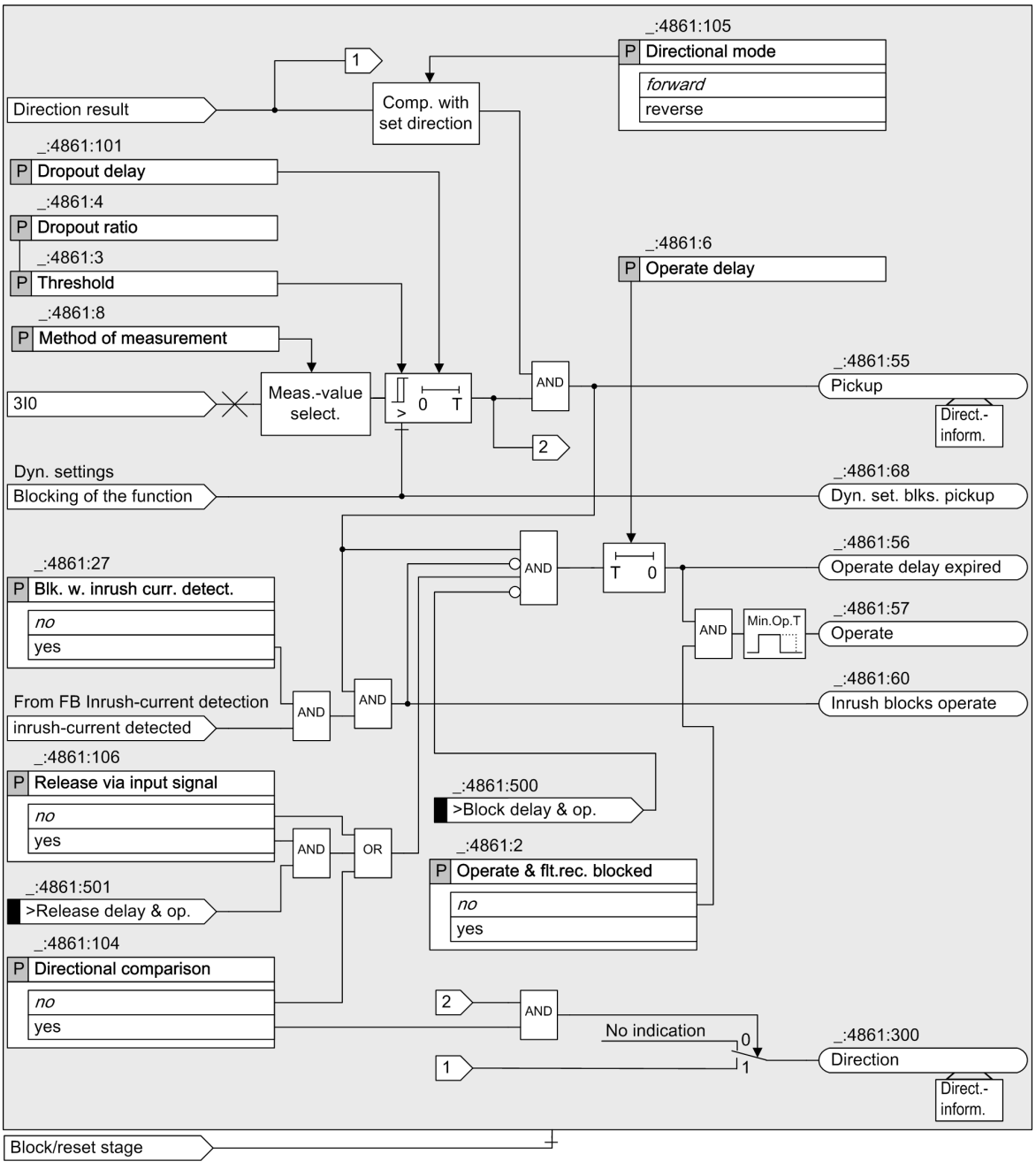
Logic of the Basic Stage



[lodirovb-280812-02.tif, 1, en_US]

Figure 6-69 Logic Diagram of the Directional Definite Time-Overcurrent Protection, Ground – Basic

Logic of the Advanced Stage



[lodirova-280812-02.tif, 1, en_US]

Figure 6-70 Logic Diagram of the Directional Definite Time-Overcurrent Protection, Ground – Advanced

Measurand (Basic and Advanced Stage)

The function uses the zero-sequence current (3I0) as a criterion for the ground fault.

Depending on the parameter setting connection type of the **Measuring point I-3ph**, the zero-sequence current is measured or calculated. Depending on the applied CT terminal type, the 3I0 **`Threshold`** range varies according to the following table.

Table 6-7 Threshold Setting Range

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary)
3-phase	Calculated	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1* sensitive	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
x + IN x + IN-separate	Measured	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1* sensitive	0.001 A to 1.600 A
		4 * Measurement	0.001 A to 1.600 A

Method of Measurement (Basic and Advanced Stage)

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This measuring procedure processes the sampled current values and filters out the fundamental components numerically.
- Measurement of the RMS value:
  This measuring procedure determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Directional Mode (Basic and Advanced Stage)

You can use the **Directional mode** parameter to define whether the stage works in a forward or reverse direction.
The direction determination works across all stages (see chapter *6.7.3.2 Direction Determination*).

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal *>Block stage* (see chapter *6.7.4.1 Description*)
- Measuring-voltage failure (see chapter *6.7.4.1 Description*)
- Via the dynamic settings functionality (only available in the advanced function type, see **Influence of Other Functions via Dynamic Settings** and chapter *6.7.10 Influence of Other Functions via Dynamic Settings*)

Blocking of the Operate Delay (Basic and Advanced Stage)

You can use the binary input signal *>Block delay & op.* to prevent the start of the operate delay and thus also the generation of the operate signal. A running operate delay is reset. The pickup is indicated. Fault logging and fault recording take place.

Blocking of the Operate Delay and Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter *6.5.7.1 Description*

Dropout Delay (Advanced Stage)

In case of undershooting of the dropout threshold, the dropout can be delayed. The pickup is maintained for the specified time. The operate delay continues to run. If the operate delay expires while the pickup is still maintained, the stage operates.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the **Directional comparison** parameter. With the ***yes*** setting, the direction indication *Direction* is released and the direction (forward or reverse) is determined, if the current exceeds the threshold of the stage. The direction indicated is independent of the directional mode set for the stage.

The **Release via input signal** parameter and the *>Release delay & op.* input signal are available with directional comparison protection. If the **Release via input signal** parameter is set to ***yes***, the start of the operate delay, and therefore the operate signal of the stage, are only enabled when the *>Release delay & op.* input signal is active.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can exert an influence on the overcurrent-protection stage:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.7.10 Influence of Other Functions via Dynamic Settings*.

6.7.5.2 Application and Setting Notes

Parameter: Directional mode

- Default setting **(_:4861:105) Directional mode** = ***forward***

You can use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value **(_:4861:8) Method of measurement** = ***fundamental comp.***

You can use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard process.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks).

Parameter: Directional comparison, Release via input signal

- Default setting **(_:4861:104) Directional comparison** = ***no***
- Default setting **(_:4861:106) Release via input signal** = ***no***

The parameters **Directional comparison** and **Release via input signal** are not visible for the basic stage.

You can use these settings to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the *Direction* and *>Release delay & op.* signals.

Parameter Value	Description

no	The stage is not used for directional comparison protection.
yes	If the **Directional comparison** parameter is set to ***yes***, the **Release via input signal** parameter, the *Direction* output signal, and the *>Release delay & op.* input signal become available. If the **Release via input signal** parameter is set to ***yes***, the starts of the operate delay and operate signal are only enabled when the *>Release delay & op.* input signal is active. The *>Release delay & op.* input signal must be connected to the enable information from the opposite end (forward information from the *Direction* output signal). See also the application example in chapter *6.6.10 Application Notes for Directional Comparison Protection*

Parameter: **Dynamic settings**

- Default setting **(_:4861:26) Dynamic settings** = ***no***

This parameter is not visible for the basic stage.

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (**Automatic reclosing** or **Cold-load pickup detection**) or an external function should affect the overcurrent-protection stage (such as change the setting of the threshold value or operate delay, blocking of the stage), the setting must be changed to ***yes***. This makes the configuration parameters effected by **Auto reclosing**/**Cold-load PU**/**Binary input** as well as the dynamic settings **Threshold**, **Operate delay**, and **Stage blocked** of the stage visible and enables the settings to be set for the specific influence.

For further setting notes, refer to chapter *6.5.8.2 Application and Setting Notes (Advanced Stage)* of the function **Overcurrent Protection, Ground**.

Parameter: **Blk. w. inrush curr. detect.**

- Default setting **(_:4861:27) Blk. w. inrush curr. detect.** = ***no***

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This applies, for example, to the high-current stage that is set according to the short-circuit voltage Vsc of the transformer in such a way that the stage only picks up on faults from the high-voltage side. The transformer inrush current cannot become larger than the maximum transmittable short-circuit current.
yes	When the transformer inrush-current detection detects an inrush current that would lead to an operate of the stage, the start of the operate delay and operate of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: Threshold

- Default setting **(_:4861:3) Threshold** = ***1.20 A***

For setting the threshold value, the same considerations apply as for the non-directional time-overcurrent protection function.

For further information, refer to chapter *6.5.4.2 Application and Setting Notes* .

Parameter: Dropout ratio

- Recommended setting value **(_:4861:4) Dropout ratio** = ***0.95***

This parameter is not visible for the basic stage.

The recommended setting value of ***0.95*** is appropriate for most applications.

For high-precision measurements, the setting value of the **Dropout ratio** parameter can be reduced, for example to 0.98. If you expect highly fluctuating measurands at the pickup threshold, you can increase the setting value of the **Dropout ratio** parameter. This avoids chattering of the stage.

Parameter: Dropout delay

- Recommended setting value **(_:4861:101) Dropout delay** = ***0 s***

This parameter is not visible for the basic stage.

Siemens recommends using the dropout delay of 0 s, since the dropout of a protection stage must be performed as fast as possible.

You can use the **Dropout delay** parameter ≠ ***0 s*** to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical data) and set the result.

Parameter: Operate delay

- Default setting **(_:4861:6) Operate delay** = ***0.300 s*** (for the 1st stage)

The **Operate delay** to be set is derived from the time-grading chart that has been prepared for the system.

Typical examples of grading times are provided in sections *6.6.9 Application Notes for Parallel Lines and Cable Runs with Infeed at Both Ends* and *6.6.10 Application Notes for Directional Comparison Protection* .

6.7.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:4861:1	Definite-T 1:Mode		• off • on • test	off
_:4861:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:4861:105	Definite-T 1:Directional mode		• forward • reverse	forward
_:4861:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:4861:104	Definite-T 1:Directional comparison		• no • yes	no
_:4861:106	Definite-T 1:Release via input signal		• no • yes	no
_:4861:10	Definite-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:4861:26	Definite-T 1:Dynamic settings		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4861:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:4861:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:4861:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:4861:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n.rdy				
_:4861:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:4861:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:4861:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:4861:36	Definite-T 1:Stage blocked		• no • yes	no
_:4861:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:4861:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:4861:37	Definite-T 1:Stage blocked		• no • yes	no
_:4861:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:4861:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4861:38	Definite-T 1:Stage blocked		• no • yes	no
_:4861:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:4861:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:4861:39	Definite-T 1:Stage blocked		• no • yes	no
_:4861:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: Cold load PU				
_:4861:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:4861:40	Definite-T 1:Stage blocked		• no • yes	no
_:4861:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:4861:34	Definite-T 1:Effected by binary input		• no • yes	no
_:4861:41	Definite-T 1:Stage blocked		• no • yes	no
_:4861:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

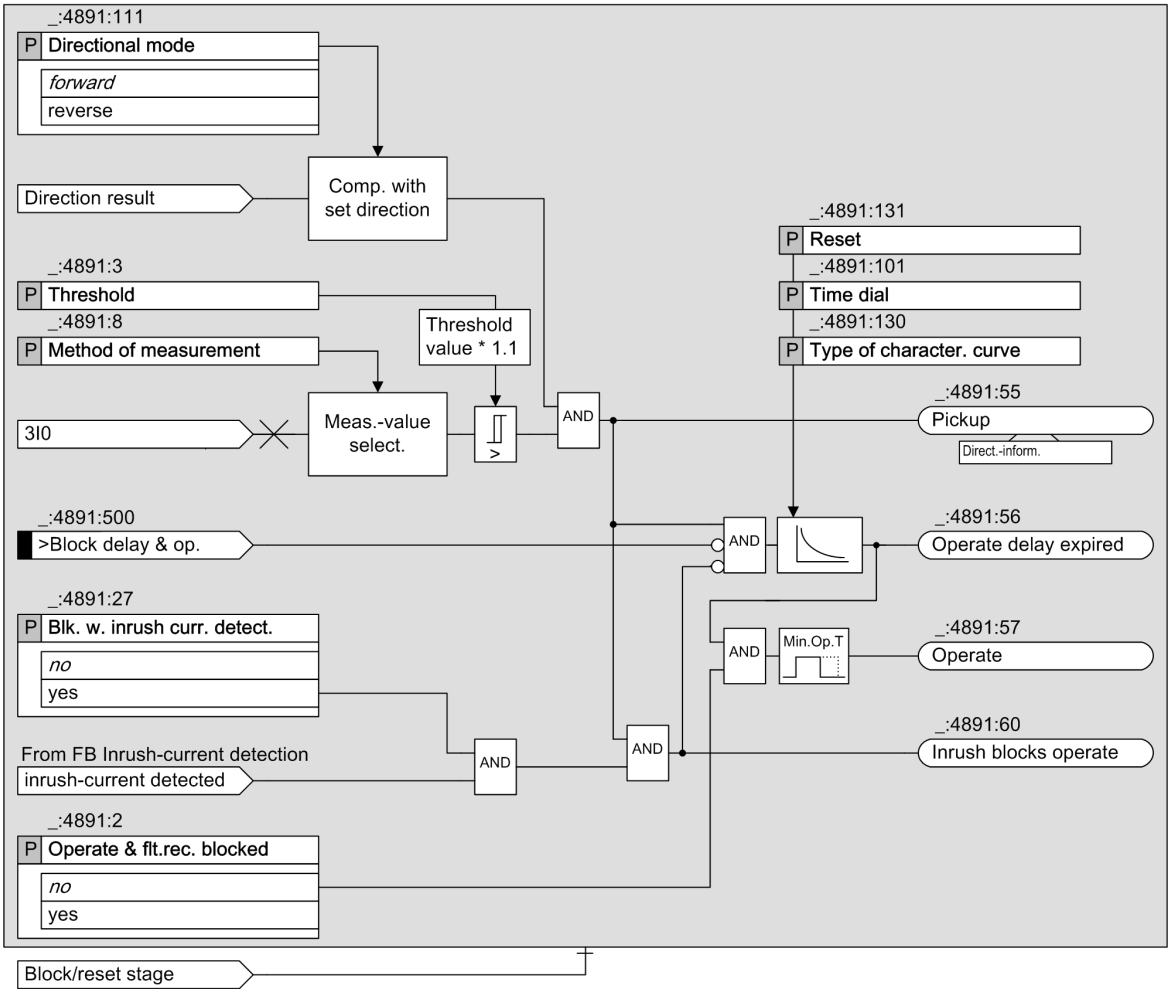
6.7.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Test of direction	SPS	I
_:2311:352	General:Test direction	ACD	O
_:2311:351	General:Phi(I,V)	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:4861:81	Definite-T 1:>Block stage	SPS	I
_:4861:501	Definite-T 1:>Release delay & op.	SPS	I
_:4861:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:4861:500	Definite-T 1:>Block delay & op.	SPS	I
_:4861:54	Definite-T 1:Inactive	SPS	O
_:4861:52	Definite-T 1:Behavior	ENS	O
_:4861:53	Definite-T 1:Health	ENS	O
_:4861:60	Definite-T 1:Inrush blocks operate	SPS	O
_:4861:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:4861:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:4861:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O
_:4861:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:4861:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:4861:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:4861:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O
_:4861:55	Definite-T 1:Pickup	ACD	O
_:4861:300	Definite-T 1:Direction	ACD	O
_:4861:56	Definite-T 1:Operate delay expired	ACT	O
_:4861:57	Definite-T 1:Operate	ACT	O

6.7.6 Stage with Inverse-Time Characteristic Curve

6.7.6.1 Description

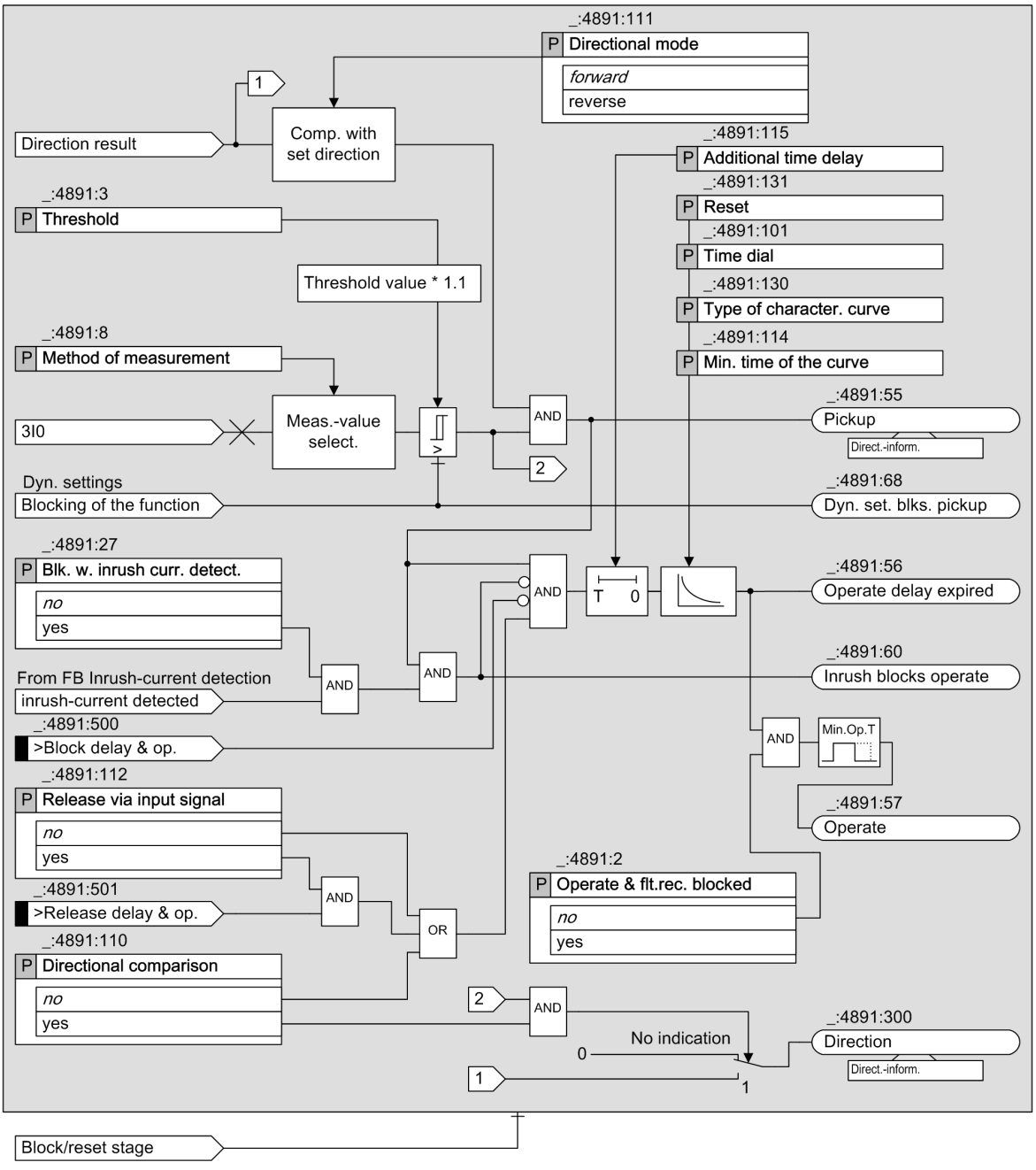
Logic of the Basic Stage



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Figure 6-71 Logic Diagram of the Directional Inverse Time-Overcurrent Protection, Ground – Basic

Logic of the Advanced Stage



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Figure 6-72 Logic Diagram of the Directional Inverse Time-Overcurrent Protection, Ground – Advanced

Measurand (Basic and Advanced Stage)

The function uses the zero-sequence current (3I0) as a criterion for the ground fault.

Depending on the parameter setting connection type of the **Measuring point I-3ph**, the zero-sequence current is measured or calculated. Depending on the applied CT terminal type, the 3I0 **`Threshold`** range varies according to the following table.

Table 6-8 Threshold Setting Range

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary)
3-phase	Calculated	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1* sensitive	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
x + IN x + IN-separate	Measured	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1* sensitive	0.001 A to 1.600 A
		4 * Measurement	0.001 A to 1.600 A

Method of Measurement (Basic and Advanced Stage)

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

- Measurement of the fundamental component:

  This measuring procedure processes the sampled current values and filters out the fundamental components numerically.

- Measurement of the RMS value:

  This measuring procedure determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Directional Mode (Basic and Advanced Stage)

You can use the **Directional mode** parameter to define whether the stage works in a forward or reverse direction.

The direction determination works across all stages (see chapter *6.7.3.2 Direction Determination*).

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve According to IEC and ANSI (Basic and Advanced Stage)

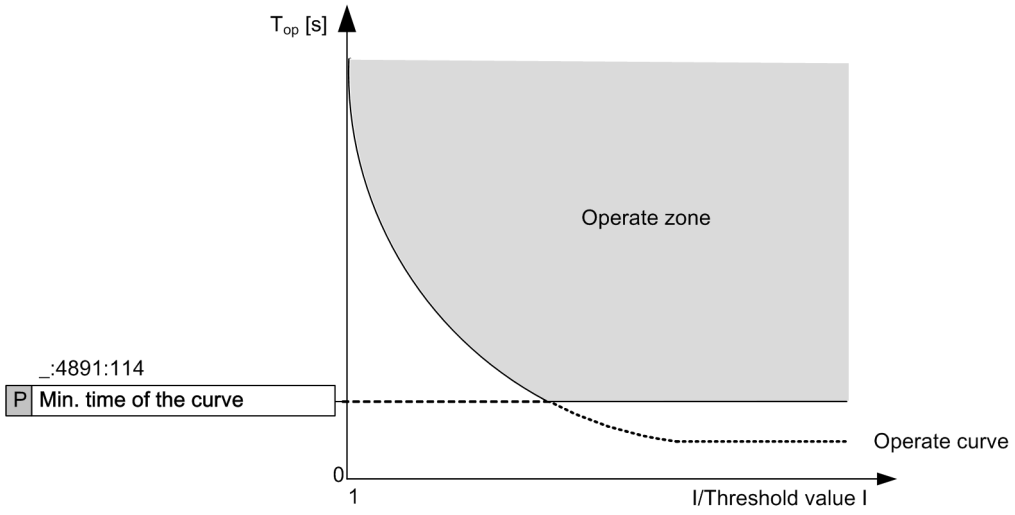
When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrated measuring procedure totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the threshold value by a factor of 1.045 (0.95 × 1.1× threshold value), the dropout starts. The pickup will be indicated as clearing. You can influence the dropout behavior via adjustable parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is started from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical data.

Minimum Time of the Curve (Advanced Stage)

With the parameter **Min. time of the curve**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.



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Figure 6-73 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter **Additional time delay**, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal *>Block stage* (see chapter *6.7.4.1 Description*)
- Measuring-voltage failure (see chapter *6.7.4.1 Description*)
- Via the dynamic settings functionality (only available in the advanced function type, see **Influence of Other Functions via Dynamic Settings** and chapter *6.7.10 Influence of Other Functions via Dynamic Settings*)

Blocking of the Operate Delay (Basic and Advanced Stage)

You can use the binary input signal *>Block delay & op.* to prevent the start of the operate delay and thus also the generation of the operate signal. A running operate delay is reset. The pickup is indicated. Fault logging and fault recording take place.

Blocking of the Operate Delay and Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal **Inrush-current detection** function is described in chapter Blocking of the Tripping by Device-Internal Inrush-Current Detection

For more information, refer to *6.5.7.1 Description*.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the **Directional comparison** parameter. With the ***yes*** setting, the direction indication *Direction* is released and the direction (forward or reverse) is determined, if the current exceeds the threshold of the stage. The direction indicated is independent of the directional mode set for the stage.

The **Release via input signal** parameter and the *>Release delay & op.* input signal are available with directional comparison protection. If the **Release via input signal** parameter is set to ***yes***, the start of the operate delay, and therefore the operate signal of the stage, are only enabled when the *>Release delay & op.* input signal is active.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can exert an influence on the overcurrent-protection stage:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter *6.7.10 Influence of Other Functions via Dynamic Settings*.

6.7.6.2 Application and Setting Notes

Parameter: Directional mode

- Default setting **(_:4891:111) Directional mode** = ***forward***

You can use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value **(_:4891:8) Method of measurement** = ***fundamental comp.***

You can use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard process.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks).

Parameter: Directional comparison, Release via input signal

- Default setting **(_:4891:110) Directional comparison** = ***no***
- Default setting **(_:4891:112) Release via input signal** = ***no***

The parameters **Directional comparison** and **Release via input signal** are not visible for the basic stage.

You can use these settings to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the *Direction* and *>Release delay & op.* signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.

Parameter Value	Description
yes	If the **Directional comparison** parameter is set to ***yes***, the **Release via input signal** parameter, the *Direction* output signal, and the *>Release delay & op.* input signal become available. If the **Release via input signal** parameter is set to ***yes***, the starts of the operate delay and operate signal are only enabled when the *>Release delay & op.* input signal is active. The *>Release delay & op.* input signal must be connected to the release information from the opposite end (forward information from the *Direction* output signal). See also the application example in chapter *6.6.10 Application Notes for Directional Comparison Protection* .

Parameter: **Dynamic settings**

- Default setting **(_:4891:26) Dynamic settings** = ***no***

This parameter is not visible for the basic stage.

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (**Automatic reclosing** or **Cold-load pickup detection**) or an external function should affect the overcurrent-protection stage (such as change the setting of the threshold value or operate delay, blocking of the stage), the setting must be changed to ***yes***. This makes the configuration parameters effected by **Auto reclosing**/**Cold-load PU**/**Binary input** as well as the dynamic settings **Threshold**, **Time dial**, and **Stage blocked** of the stage visible and enables the settings to be set for the specific influence.

For further setting notes, refer to chapter *6.5.8.2 Application and Setting Notes (Advanced Stage)* of the function **Overcurrent Protection, Ground**.

Parameter: **Blk. w. inrush curr. detect.**

- Default setting **(_:4891:27) Blk. w. inrush curr. detect.** = ***no***

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This applies, for example, to the high-current stage that is set according to the short-circuit voltage V_{sc} of the transformer in such a way that the stage only picks up on faults from the high-voltage side. The transformer inrush current cannot become larger than the maximum transmittable shortcircuit current.

Parameter Value	Description
yes	When the transformer inrush-current detection detects an inrush current that would lead to an operate of the stage, the start of the operate delay and operate of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: `Min. time of the curve`

- Default setting **`(_:4891:114) Min. time of the curve`** = ***`0.00 s`***

This parameter is only available in the advanced stage.

With the parameter **`Min. time of the curve`**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.



NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: `Additional time delay`

- Default setting **`(_:4891:115) Additional time delay`** = ***`0.00 s`***

With the parameter **`Additional time delay`**, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommend keeping the default setting of 0 s.

Parameter: `Threshold`

- Default setting **`(_:4891:3) Threshold`** = ***`1.20 A`***

The setting depends on the minimal occurring ground-fault current. This must be detected.

Consider that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the **`Threshold`**.

Parameter: `Type of character. curve`

- Default setting **`(_:4891:130) Type of character. curve`** = ***`IEC normal inverse`***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **`Type of character. curve`** required for your specific application.

Parameter: `Time dial`

- Default setting **`(_:4891:101) Time dial`** = ***`1`***

You can use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The setting value for the **`Time dial`** parameter is derived from the time-grading chart that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the **Time dial** parameter at ***1*** (default setting).

Parameter: Reset

- Default setting **(_:4891:131) Reset** = ***disk emulation***

You can use the **Reset** parameter setting to define whether the stage decreases according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Select this setting if the dropout does not have to be performed after a disk emulation and an instantaneous dropout is desired instead.

6.7.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:4891:1	Inverse-T 1:Mode		• off • on • test	off
_:4891:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:4891:111	Inverse-T 1:Directional mode		• forward • reverse	forward
_:4891:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:4891:110	Inverse-T 1:Directional comparison		• no • yes	no
_:4891:112	Inverse-T 1:Release via input signal		• no • yes	no
_:4891:10	Inverse-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:4891:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:4891:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:4891:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:130	Inverse-T 1:Type of character. curve			
_:4891:114	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:4891:131	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:4891:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:4891:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.s: AR off/n.rdy				
_:4891:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:4891:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:4891:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:4891:36	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 2				
_:4891:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:4891:37	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 3				
_:4891:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no
_:4891:38	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: AR cycle>3				
_:4891:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:4891:39	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4891:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:4891:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:4891:40	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: bin.input				
_:4891:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:4891:41	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

6.7.6.4 Information List

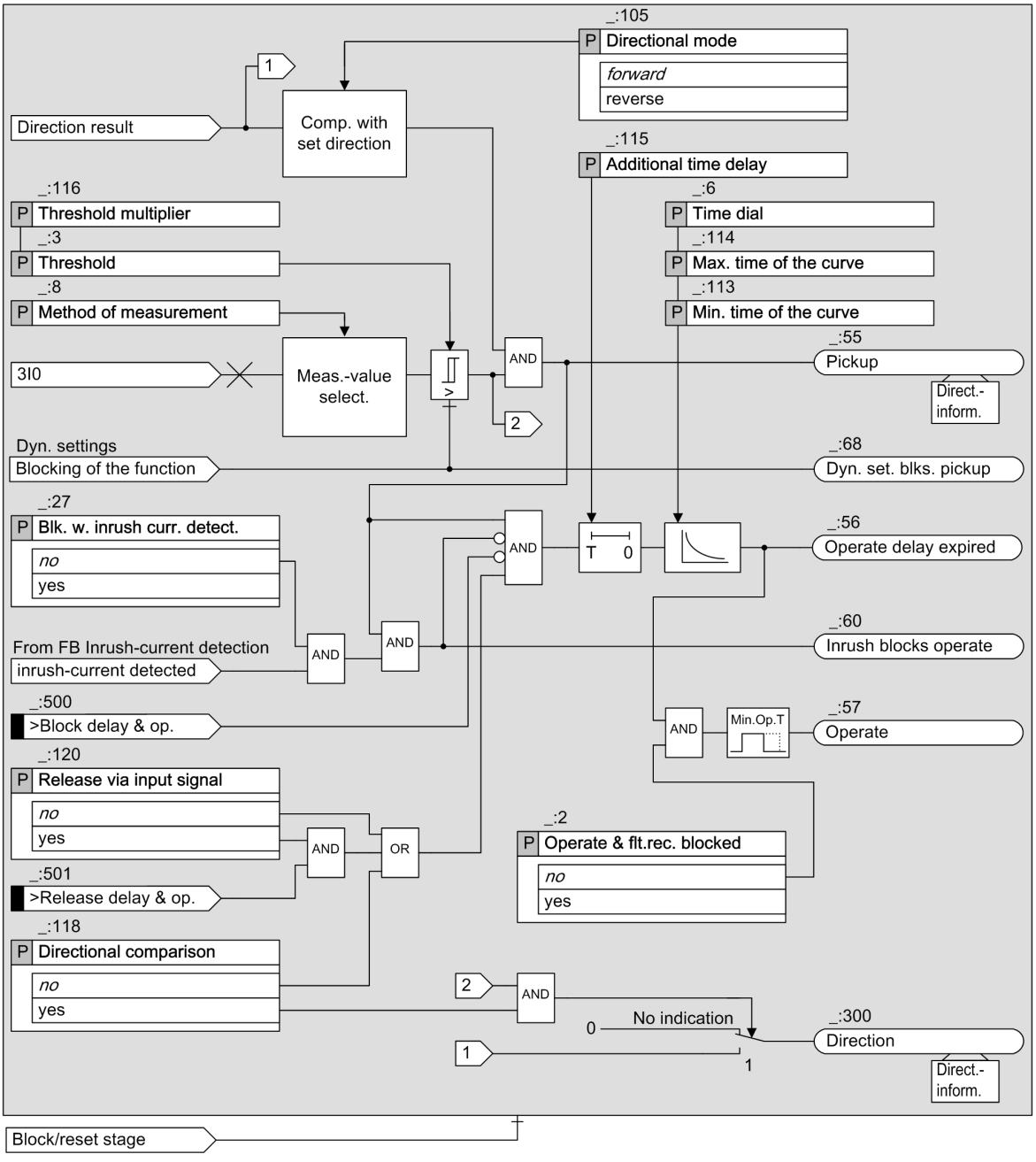
No.	Information	Data Class (Type)	Type
Inverse-T 1			
_:4891:81	Inverse-T 1:>Block stage	SPS	I
_:4891:501	Inverse-T 1:>Release delay & op.	SPS	I
_:4891:84	Inverse-T 1:>Activ. dyn. settings	SPS	I
_:4891:500	Inverse-T 1:>Block delay & op.	SPS	I
_:4891:54	Inverse-T 1:Inactive	SPS	O
_:4891:52	Inverse-T 1:Behavior	ENS	O
_:4891:53	Inverse-T 1:Health	ENS	O
_:4891:60	Inverse-T 1:Inrush blocks operate	SPS	O
_:4891:62	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:4891:63	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:4891:64	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:4891:65	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O

No.	Information	Data Class (Type)	Type
_:4891:66	Inverse-T 1:Dyn.set. CLP active	SPS	O
_:4891:67	Inverse-T 1:Dyn.set. BI active	SPS	O
_:4891:68	Inverse-T 1:Dyn. set. blks. pickup	SPS	O
_:4891:59	Inverse-T 1:Disk emulation running	SPS	O
_:4891:55	Inverse-T 1:Pickup	ACD	O
_:4891:300	Inverse-T 1:Direction	ACD	O
_:4891:56	Inverse-T 1:Operate delay expired	ACT	O
_:4891:57	Inverse-T 1:Operate	ACT	O

6.7.7 Stage with Inverse Time-Overcurrent Protection with Logarithmic-Inverse Characteristic Curve

6.7.7.1 Description

Logic of the Stage



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Figure 6-74 Logic Diagram of the Directional Logarithmic Inverse Time-Overcurrent Protection, Ground

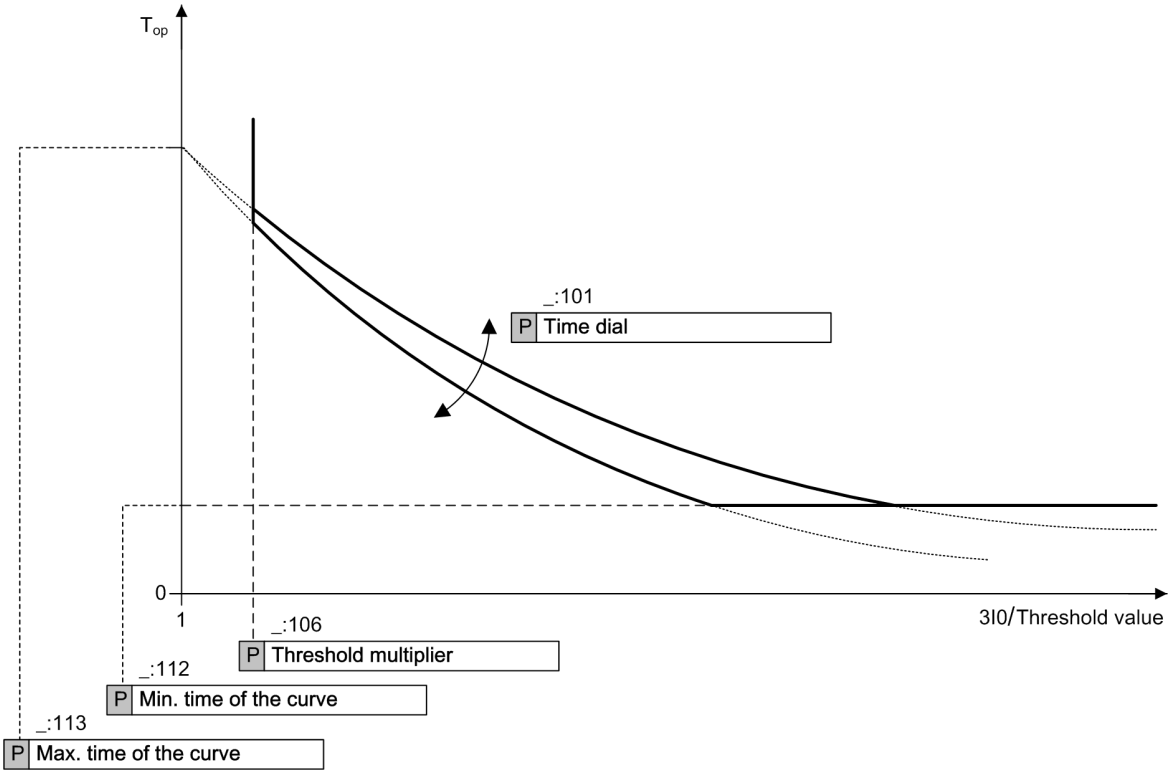
Apart from the operate curve, this type of stage is identical to the **Inverse time-overcurrent protection – advanced** stage (see chapter *6.7.6.1 Description*).

This section will only discuss the nature of the operate curve. For further functionality, refer to chapter *6.7.6.1 Description*.

Operate Curve

If the function picks up, the logarithmic inverse-time characteristic curve is processed. A time value T_{op} is calculated for every input value exceeding 95 % of the pickup value. An integrator accumulates the value 1/ T_{op}. If the accumulated integral reaches the fixed value 1, the stage operates.

The curve used to calculate the time value T_{op} is shown in the following figure. The **Threshold multiplier** parameter defines the beginning of the characteristic curve. The **Max. time of the curve** determines the initial value of the characteristic curve. The **Time dial** parameter changes the slope of the characteristic curve. At high currents, the **Min. time of the curve** parameter indicates the lower time limit.



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Figure 6-75 Operate Curve of Logarithmic Inverse-Time Characteristic

The time to operate is calculated with the following formula:

$$T_{op} = T_{max} - T_d \ln\left(\frac{3I0}{I_{thresh} \times I_{mul}}\right)$$

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Where

T_{max}	Maximum time of the curve (parameter **Max. time of the curve**)
T_d	Time dial (parameter **Time dial**)
T_{op}	Operate time
3I0	Measured zero-sequence current
I_{thresh}	Threshold value (parameter **Threshold**)
I_{mul}	Threshold multiplier (parameter **Threshold multiplier**)

If the calculated time is less than T_{min} (parameter **Min. time of the curve**), T_{min} is used.

6.7.7.2 Application and Setting Notes

Apart from the operate curve, this type of stage is identical to the ground-fault protection type with inverse-time delay according to IEC and ANSI (advanced function type) (see chapter *6.7.6.1 Description*).

This section only discusses the nature of the operate curve. For further functionality, refer to chapter *6.7.6.2 Application and Setting Notes*.

Stage Type Selection

If the operate delay is to be dependent on the current level according to a logarithmic characteristic curve, select this stage type.

Dynamic Settings: `Threshold`

- Default setting **`(_:3) Threshold`** = ***`1.20 A`***

Define the pickup value corresponding to the application. In doing so, for time-graded stages, the settings of the superordinate and of the subordinate stages in the time-grading chart must be taken into consideration.

Parameter: `Threshold multiplier`

- Default setting **`(_:116) Threshold multiplier`** = ***`1.1`***

You can use the **`Threshold multiplier`** parameter to define the beginning of the characteristic curve on the current axis (in relation to the threshold value).

General information cannot be provided. Define the value corresponding to the application.

EXAMPLE

`Threshold` (Secondary current)	I_{thresh} = 1.2 A
`Threshold multiplier`	I_{mul} = 1.1
Pickup value (Secondary current)	I_{PU} = 1.2 A ×1.1 = 1.32 A

Dynamic Settings: `Time dial`

- Default setting **`(_:6) Time dial`** = ***`1.250 s`***

You can use the **`Time dial`** parameter to change the slope of the characteristic curve.

General information cannot be provided. Define the value corresponding to the application.

Parameter: `Max. time of the curve`

- Default setting **`(_:114) Max. time of the curve`** = ***`5.800 s`***

The parameter **`Max. time of the curve`** determines the initial value of the characteristic curve (for 3I0 = **`Threshold`**).

General information cannot be provided. Define the value corresponding to the application.

Parameter: `Min. time of the curve`

- Default setting **`(_:113) Min. time of the curve`** = ***`1.200 s`***

The parameter **`Min. time of the curve`** determines the lower time limit (at high currents).

General information cannot be provided. Define the value corresponding to the application.

Parameter: `Additional time delay`

- Recommended setting value **`(_:115) Additional time delay`** = ***`0 s`***

You can set an additional current-independent time delay. This additional delay is intended for special applications.

Siemens recommends setting this time to ***0 s*** so that it has no effect.

6.7.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Log.-inv.-T #:Mode		• off • on • test	off
_:2	Log.-inv.-T #:Operate & flt.rec. blocked		• no • yes	no
_:119	Log.-inv.-T #:Directional mode		• forward • reverse	forward
_:8	Log.-inv.-T #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:118	Log.-inv.-T #:Directional comparison		• no • yes	no
_:120	Log.-inv.-T #:Release via input signal		• no • yes	no
_:10	Log.-inv.-T #:Blk. by meas.-volt. failure		• no • yes	yes
_:26	Log.-inv.-T #:Dynamic settings		• no • yes	no
_:27	Log.-inv.-T #:Blk. w. inrush curr. detect.		• no • yes	no
_:3	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:6	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
_:113	Log.-inv.-T #:Min. time of the curve		0.000 s to 60.000 s	1.200 s
_:114	Log.-inv.-T #:Max. time of the curve		0.000 s to 60.000 s	5.800 s
_:116	Log.-inv.-T #:Threshold multiplier		1.00 to 4.00	1.10
_:115	Log.-inv.-T #:Additional time delay		0.000 s to 60.000 s	0.000 s
Dyn.s: AR off/n.rdy				
_:28	Log.-inv.-T #:Effect. by AR off/n.ready		• no • yes	no
_:35	Log.-inv.-T #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	Log.-inv.-T #:Effected by AR cycle 1		• no • yes	no
_:36	Log.-inv.-T #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:14	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:107	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.set: AR cycle 2				
_:30	Log.-inv.-T #:Effected by AR cycle 2		• no • yes	no
_:37	Log.-inv.-T #:Stage blocked		• no • yes	no
_:15	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:108	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.set: AR cycle 3				
_:31	Log.-inv.-T #:Effected by AR cycle 3		• no • yes	no
_:38	Log.-inv.-T #:Stage blocked		• no • yes	no
_:16	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:109	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.s: AR cycle>3				
_:32	Log.-inv.-T #:Effected by AR cycle gr. 3		• no • yes	no
_:39	Log.-inv.-T #:Stage blocked		• no • yes	no
_:17	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.s: Cold load PU				
_:33	Log.-inv.-T #:Effect. b. cold-load pickup		• no • yes	no
_:40	Log.-inv.-T #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:18	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:111	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.set: bin.input				
_:34	Log.-inv.-T #:Effected by binary input		• no • yes	no
_:41	Log.-inv.-T #:Stage blocked		• no • yes	no
_:19	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:112	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s

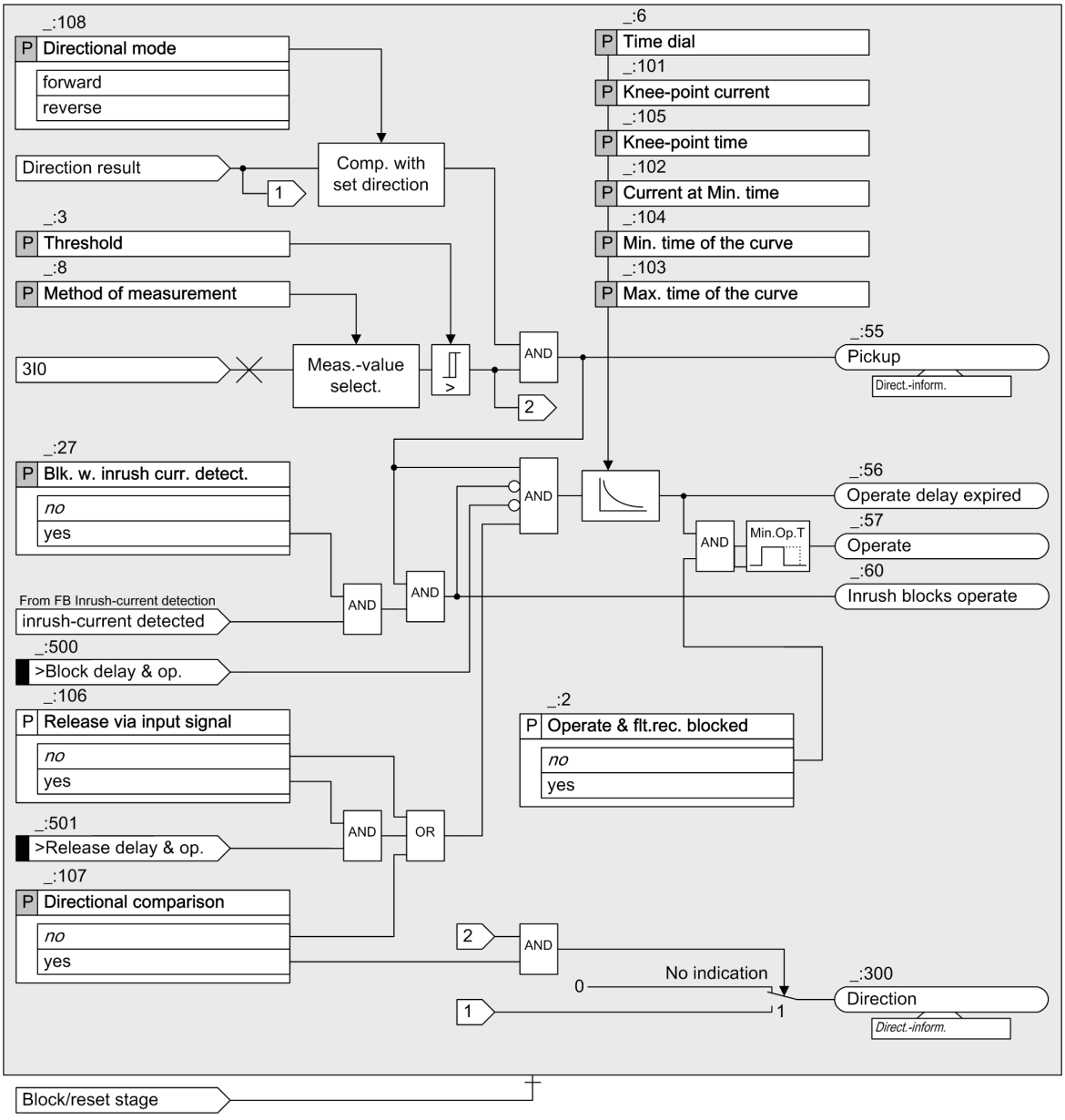
6.7.7.4 Information List

No.	Information	Data Class (Type)	Type
Log.-inv.-T #			
_:81	Log.-inv.-T #:>Block stage		I
_:501	Log.-inv.-T #:>Release delay & op.		I
_:84	Log.-inv.-T #:>Activ. dyn. settings		I
_:500	Log.-inv.-T #:>Block delay & op.		I
_:54	Log.-inv.-T #:Inactive		O
_:52	Log.-inv.-T #:Behavior		O
_:53	Log.-inv.-T #:Health		O
_:60	Log.-inv.-T #:Inrush blocks operate		O
_:62	Log.-inv.-T #:Dyn.set. AR cycle1act.		O
_:63	Log.-inv.-T #:Dyn.set. AR cycle2act.		O
_:64	Log.-inv.-T #:Dyn.set. AR cycle3act.		O
_:65	Log.-inv.-T #:Dyn.set. ARcycl.>3act		O
_:66	Log.-inv.-T #:Dyn.set. CLP active		O
_:67	Log.-inv.-T #:Dyn.set. BI active		O
_:68	Log.-inv.-T #:Dyn. set. blks. pickup		O
_:55	Log.-inv.-T #:Pickup		O
_:300	Log.-inv.-T #:Direction		O
_:56	Log.-inv.-T #:Operate delay expired		O
_:57	Log.-inv.-T #:Operate		O

6.7.8 Stage Description Knee-Point Characteristic Curve

6.7.8.1 Description

Logic of the Stage



[lodilokn-280812-02.tif, 2, en_US]

Figure 6-76 Logic Diagram of the Directional Logarithmic Inverse Time with Knee-Point Overcurrent Protection, Ground

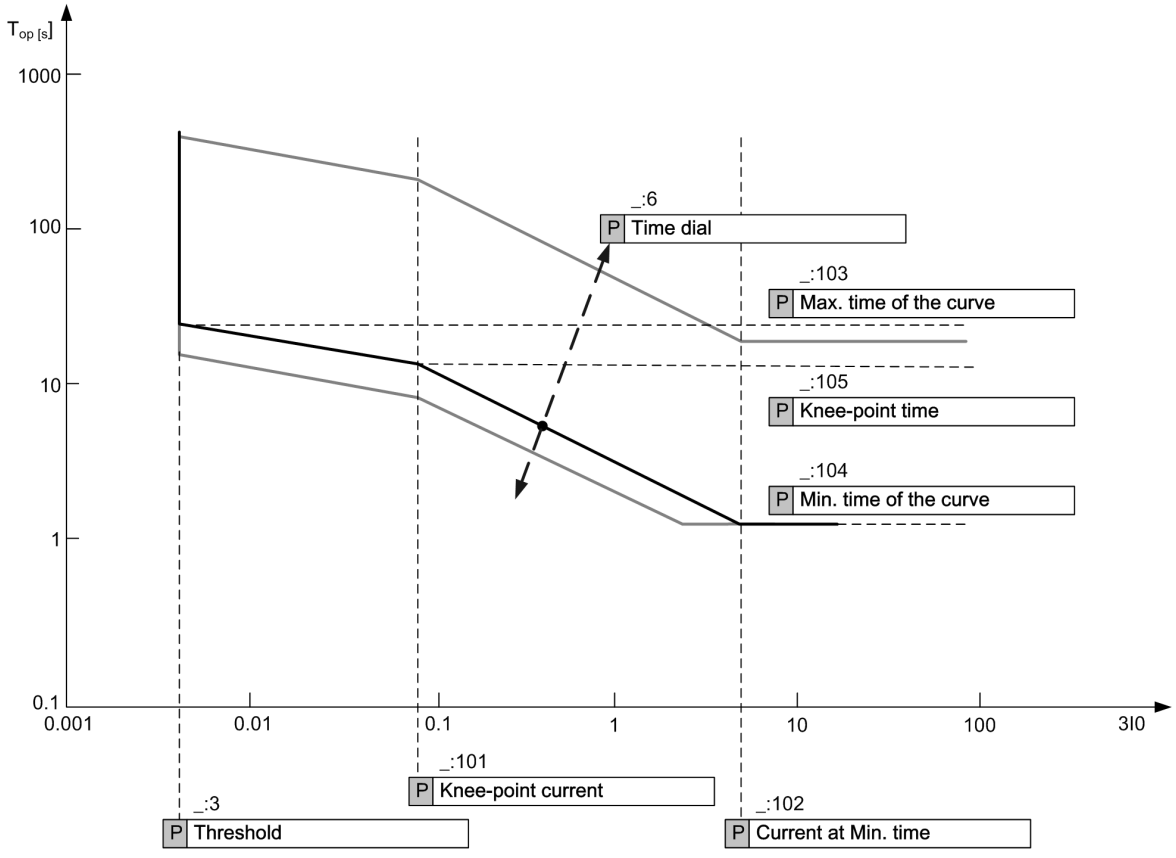
Apart from the operate curve, this type of stage is almost identical to the **Inverse time-overcurrent protection – advanced** stage (see chapter *6.7.6.1 Description*). The only difference is that the dynamic settings change functionality is not available.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter *6.7.6.1 Description*.

Operate Curve

If the function picks up, the logarithmic inverse-time characteristic curve is processed. A time value T_{op} is calculated for every input value exceeding 95 % of the threshold value. An integrator accumulates the value $1/T_{op}$. If the accumulated integral reaches the fixed value 1, the stage operates.

The curve used to calculate the time value T_{op} is shown in the following graphic. The curve is composed of 2 sections with different slops. 7 parameters are used to define the logarithmic inverse time with knee-point characteristic curve. The parameter **Max. time of the curve** determines the initial time value of the characteristic curve, and relates to the 3I0 **Threshold** value. The transition point is defined by parameter **Knee-point current** and parameter **Knee-point time**. The parameter **Min. time of the curve** indicates the lower time limit, and parameter **Current at Min. time** determines the current value at **Min. time of the curve**. The parameter **Time dial** servers as a time factor to the operate time.



[dwloinkn-300913, 2, en_US]

Figure 6-77 Operate Curve of the Logarithmic Inverse Time with Knee-Point Characteristic (In the Example of **Threshold** = ***0.004 A***)

6.7.8.2 Application and Setting Notes

Apart from the operate curve, this type of stage is almost identical to the **Inverse time-overcurrent protection – advanced** stage (see chapter *6.7.6.1 Description*). The only difference is that the dynamic settings change functionality is not available.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter *6.7.6.2 Application and Setting Notes*.

Parameter: Threshold

- Default setting **(_:3) Threshold** = ***1.20 A***

You can use the **Threshold** parameter to define the pickup value of the stage corresponding to the specific application.

Parameter: Time dial

- Default setting **(_:6) Time dial** = *0.2*

You can use the **Time dial** parameter to displace the operate curve in the time direction.

General information cannot be provided. Define the value corresponding to the application.

Parameter: Knee-point

- Default setting **(_:101) Knee-point current** = *1.300 A*
- Default setting **(_:105) Knee-point time** = *23.60 s*

You use the **Knee-point current** parameter and the **Knee-point time** parameter to define the knee-point of the operate curve.

General information cannot be provided. Define the values corresponding to the application.

Parameter: Minimum Time of the Operate Curve

- Default setting **(_:104) Min. time of the curve** = *0.80 s*
- Default setting **(_:102) Current at Min. time** = *1.500 A*

Via the parameters **Min. time of the curve** and **Current at Min. time**, the point of the operate curve is defined where higher currents do no longer cause shorter operate times.

General information cannot be provided. Define the value corresponding to the application.

Parameter: Maximum Time of the Operate Curve

- Default setting **(_:103) Max. time of the curve** = *93.00 s*

You can use the parameter **Max. time of the curve** to determine the initial value of the operate curve (for 3I0 = **Threshold**).

General information cannot be provided. Define the value corresponding to the application.

6.7.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Log.inv.T KP #:Mode		• off • on • test	off
_:2	Log.inv.T KP #:Operate & flt.rec. blocked		• no • yes	no
_:108	Log.inv.T KP #:Direc-tional mode		• forward • reverse	forward
_:8	Log.inv.T KP #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:107	Log.inv.T KP #:Direc-tional comparison		• no • yes	no
_:106	Log.inv.T KP #:Release via input signal		• no • yes	no
_:10	Log.inv.T KP #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	Log.inv.T KP #:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:3	Log.inv.T KP #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:109	Log.inv.T KP #:Time dial		0.05 to 1.50	0.20
_:101	Log.inv.T KP #:Knee-point current	1 A @ 100 Irated	0.030 A to 35.000 A	1.300 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.300 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.300 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.500 A
_:105	Log.inv.T KP #:Knee-point time		0.00 s to 100.00 s	23.60 s
_:102	Log.inv.T KP #:Current at Min. time	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:104	Log.inv.T KP #:Min. time of the curve		0.00 s to 30.00 s	0.80 s
_:103	Log.inv.T KP #:Max. time of the curve		0.00 s to 200.00 s	93.00 s

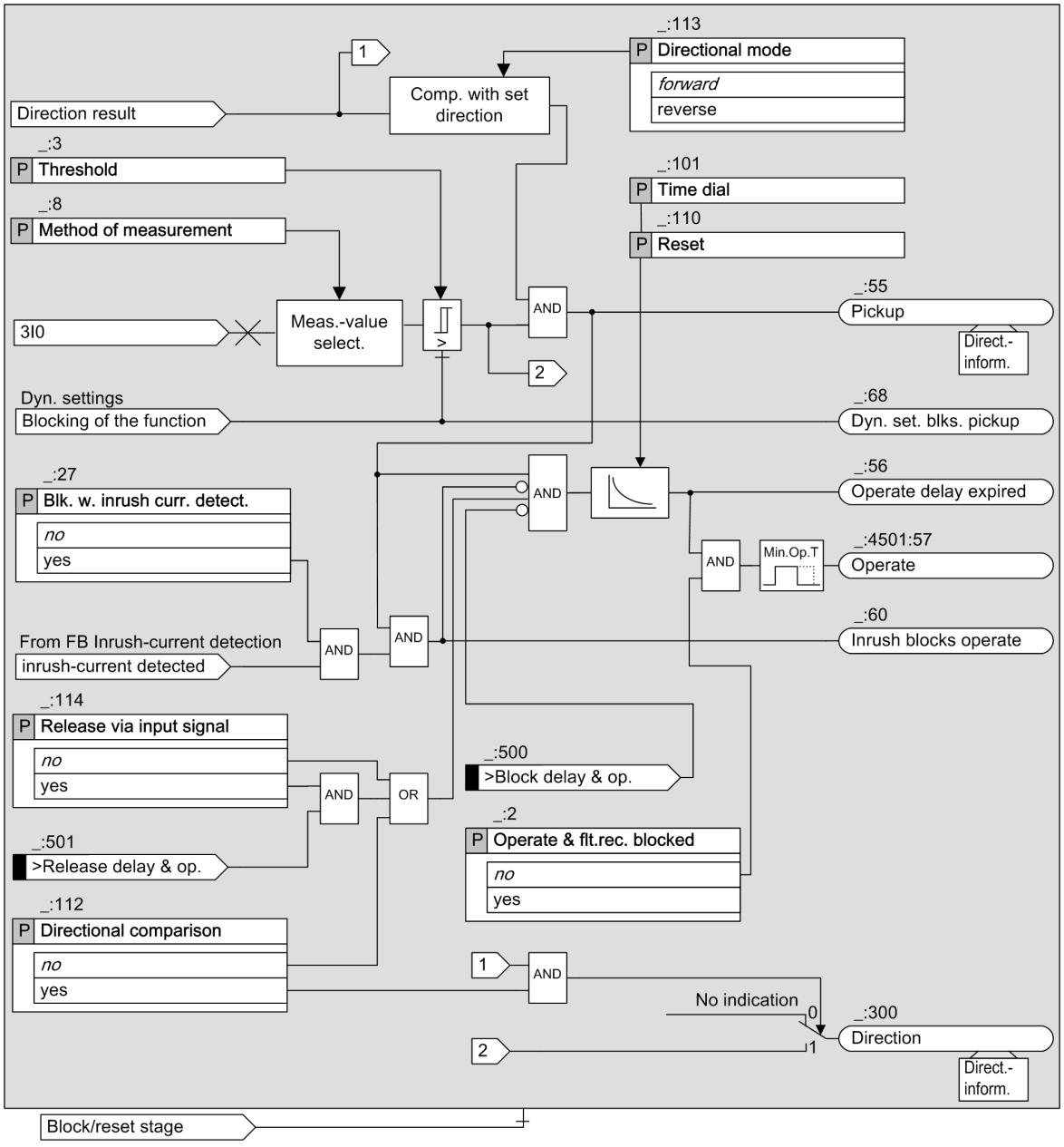
6.7.8.4 Information List

No.	Information	Data Class (Type)	Type
Stage #			
_:81	Log.inv.T KP #:>Block stage	SPS	I
_:501	Log.inv.T KP #:>Release delay & op.	SPS	I
_:500	Log.inv.T KP #:>Block delay & op.	SPS	I
_:54	Log.inv.T KP #:Inactive	SPS	O
_:52	Log.inv.T KP #:Behavior	ENS	O
_:53	Log.inv.T KP #:Health	ENS	O
_:60	Log.inv.T KP #:Inrush blocks operate	SPS	O
_:55	Log.inv.T KP #:Pickup	ACD	O
_:300	Log.inv.T KP #:Direction	ACD	O
_:56	Log.inv.T KP #:Operate delay expired	ACT	O
_:57	Log.inv.T KP #:Operate	ACT	O

6.7.9 Stage with User-Defined Characteristic Curve

6.7.9.1 Description

Logic of the Stage



[lodirusr-280812-02.tif, 1, en_US]

Figure 6-78 Logic Diagram of the Directional User-Defined Characteristic Curve Overcurrent Protection, Ground

This stage is structured in the same way as the **Inverse time-overcurrent protection – advanced** stage (see chapter *6.7.6.1 Description*). The only difference is that you can define the characteristic curve.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter *6.7.6.1 Description*.

User-Defined Characteristic Curve

With the directional, user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

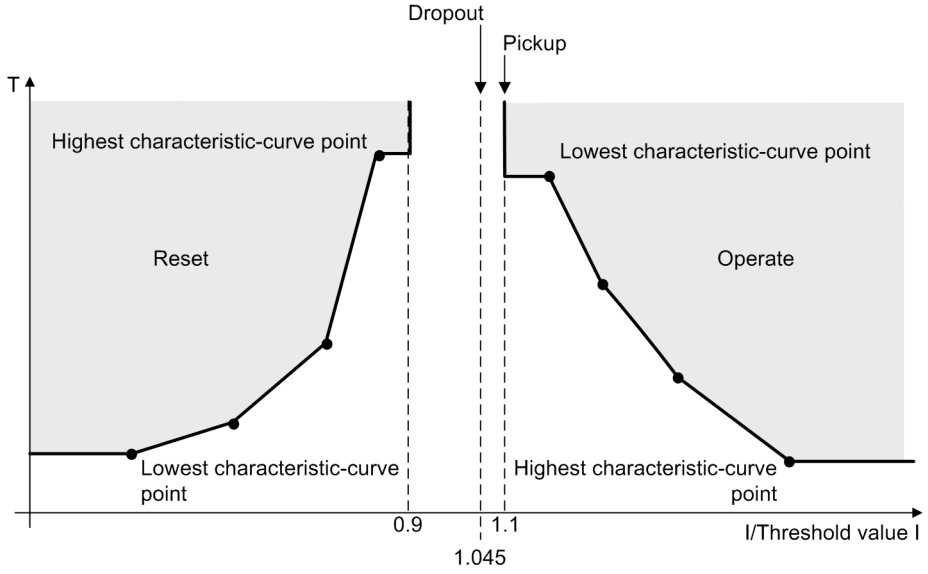
Pickup and Dropout Behavior with User-Defined Characteristic Curves

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the threshold value by a factor of 1.045 (0.95 × 1.1× threshold value), the dropout is started. The pickup will be indicated as outgoing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is started from 0.9 of the set threshold value.

The following figure shows the pickup behavior and dropout behavior when a directional user-defined characteristic curve is used.



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Figure 6-79 Pickup and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

Note that the currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

6.7.9.2 Application and Setting Notes

This stage is structured in the same way as the **Inverse time-overcurrent protection – advanced** stage. The only difference is that you can define the characteristic curve as required. This section only provides application and setting notes for setting the characteristic curves. For guidance on the other parameters of the stage, see chapter *6.7.6.2 Application and Setting Notes*.

Parameter: `Current/time value pairs` (of the Operate Curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting follows the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold setting afterwards if you want to displace the characteristic curve.

Specify the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.



NOTE

The value pairs must be entered in continuous order.

Parameter: `Time dial`

- Default setting **`(_:101) Time dial`** = ***`1`***

You can use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

The setting value for the **`Time dial`**parameter is derived from the time-grading chart that has been prepared for the system. Where no grading and therefore no displacement of the characteristic curve is required, leave the **`Time dial`** set to ***`1`***.

Parameter: `Reset`

- Default setting **`(_:110) Reset`** = ***`disk emulation`***

The **`Reset`** parameter is used to define whether the stage drops out according to the dropout characteristic curve (behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	Both operate curve and a dropout characteristic curve have to be specified with this setting. Use this setting if the device is coordinated with electromechanical devices or other devices performing dropout after disk emulation.
`instantaneous`	Use this setting if the dropout is not to be performed after disk emulation, that is, if instantaneous dropout is required.

Parameter: `Current/time value pairs` (of the Dropout Curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting is determined by the characteristic curve you want to achieve.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold setting afterwards if you want to displace the characteristic curve.

Specify the time value in seconds. The characteristic curve is displaced using the **`Time dial`**parameter.



NOTE

The value pairs must be entered in continuous order.

6.7.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:1	User curve #:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:113	User curve #:Directional mode		• forward • reverse	forward
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:112	User curve #:Directional comparison		• no • yes	no
_:114	User curve #:Release via input signal		• no • yes	no
_:10	User curve #:Blk. by meas.-volt. failure		• no • yes	yes
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

6.7.9.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:501	User curve #:>Release delay & op.	SPS	I
_:84	User curve #:>Activ. dyn. settings	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	SPS	O
_:62	User curve #:Dyn.set. AR cycle1act.	SPS	O
_:63	User curve #:Dyn.set. AR cycle2act.	SPS	O
_:64	User curve #:Dyn.set. AR cycle3act.	SPS	O
_:65	User curve #:Dyn.set. ARcycl.>3act	SPS	O
_:66	User curve #:Dyn.set. CLP active	SPS	O
_:67	User curve #:Dyn.set. BI active	SPS	O
_:68	User curve #:Dyn. set. blks. pickup	SPS	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:300	User curve #:Direction	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.7.10 Influence of Other Functions via Dynamic Settings

6.5.8.1 Description and *6.5.8.2 Application and Setting Notes (Advanced Stage)* describe the influence of other functions on dynamic settings.

6.8 Inrush-Current Detection

6.8.1 Overview of Functions

The function **Inrush-current detection**

- Recognizes an inrush process on transformers
- Generates a blocking signal for protection functions that protect the transformer (protected object) or for protection functions that are affected in undesirable ways when transformers are switched on
- Allows a sensitive setting of the protection functions

The following protection functions evaluate the blocking signal

- Overcurrent protection with a pickup value below the maximum inrush current
- Negative-sequence protection as sensitive backup protection for transformers

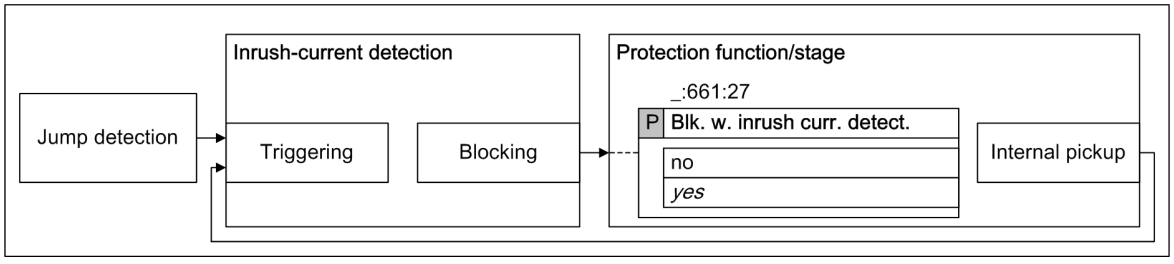
6.8.2 Structure of the Function

The function **Inrush current detection** is not an individual protection function. In the connection process of a transformer, it transmits a blocking signal to other protection functions. For this reason, the inrush-current detection must be in the same function group as the functions that are to be blocked.

The following figure shows the embedding of the function. The setting parameter **`Blk. w. inrush curr. detect.`** establishes the connection between inrush-current detection and the functions that are to be blocked. If the parameter is set to ***`yes`***, the connection is effective.

A jump detection or the threshold value exceeding of the functions to be blocked is used as trigger signal for synchronization of the internal measurement methods.

The jump detection reacts to changes in the current. The threshold value exceeding is recognized due to an internal pickup of the protection function that is to be blocked.



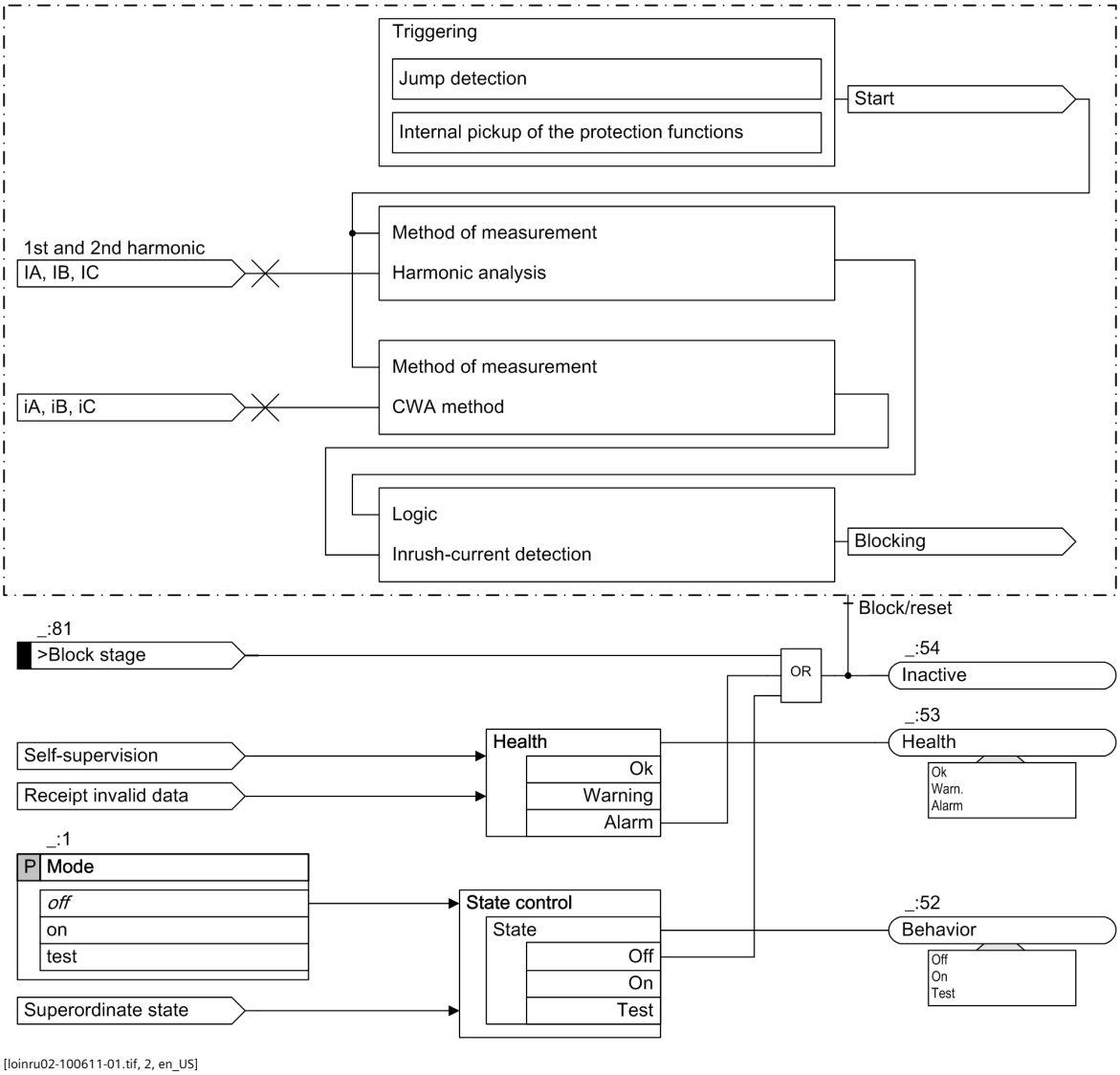
[dwirsh01-070611-01.tif, 1, en_US]

Figure 6-80 Structure/Embedding of the Function

6.8.3 Function Description

The function **Inrush-current detection** analyzes the trigger signal of the jump detection or the threshold-value violation of the function to be blocked in a start logic, and synchronizes the method of measurement. In order to securely record the inrush processes, the function uses the **Harmonic analysis** method of measurement and the **CWA method** (current wave shape analysis). Both methods work in parallel and link the results through a logical OR.

If you wish to work with only one process, deactivate the other method by way of the parameters **`Blocking with 2. harmonic`** or **`Blocking with CWA`** .



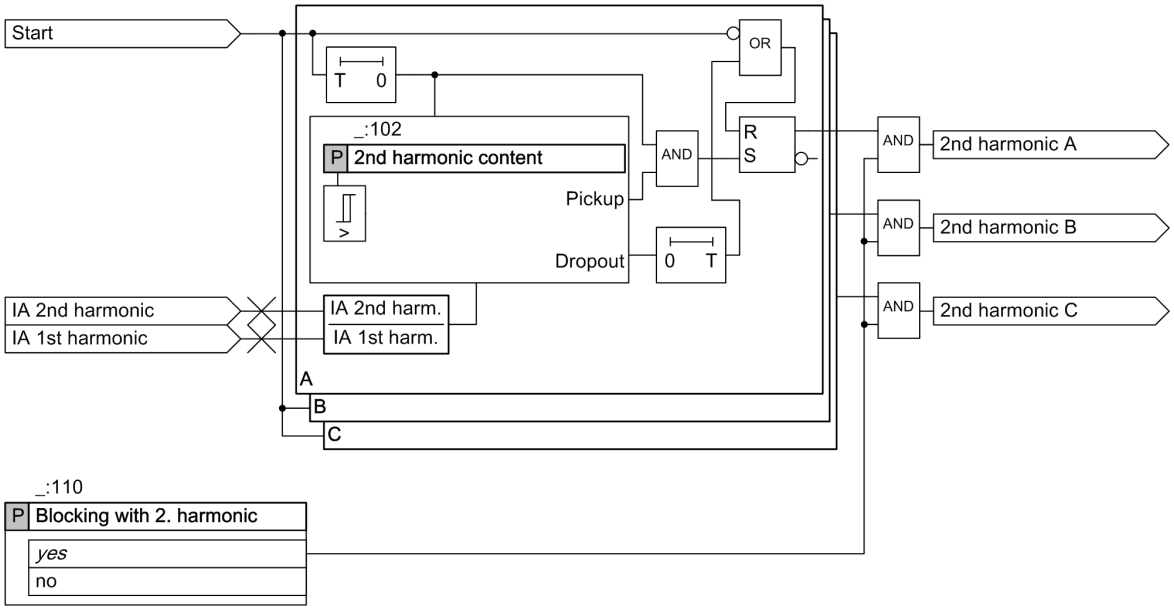
[loinru02-100611-01.tif, 2, en_US]

Figure 6-81 Basic Structure of the Inrush-Current Detection

Harmonic Analysis

For this method of measurement, the content of the 2nd harmonic and the fundamental component (1st harmonic) are determined for each of the phase currents I_A, I_B, and I_C and the quotient $I_{2nd\ harm} / I_{1st\ harm}$ is formed from this. If this quotient exceeds the set threshold value, a phase-selective signal is issued.

If 95 % of the set threshold value is exceeded, this leads to a pickup reset (dropout ratio = 0.95).

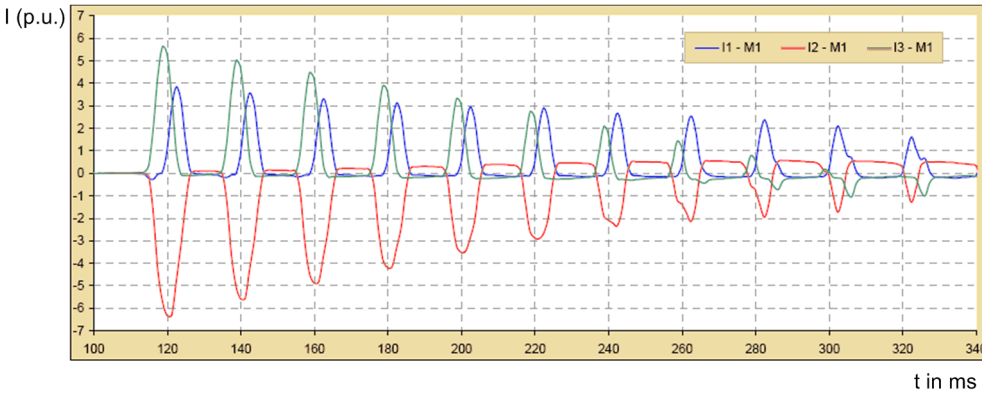


[loinru10-040912-01.tif, 1, en_US]

Figure 6-82 Logic of the Harmonic Analysis Function (T = 1 Period)

CWA Method (Current Wave Shape Analysis)

The CWA method executes a wave shape analysis of the phase currents IA, IB, and IC. If all 3 phase currents show flat areas at the same point in time, the inrush-current detection signal will be issued. This signal applies for all 3 phases simultaneously. The following figure shows a typical inrush-current characteristic, with the simultaneously occurring flat areas clearly recognizable.

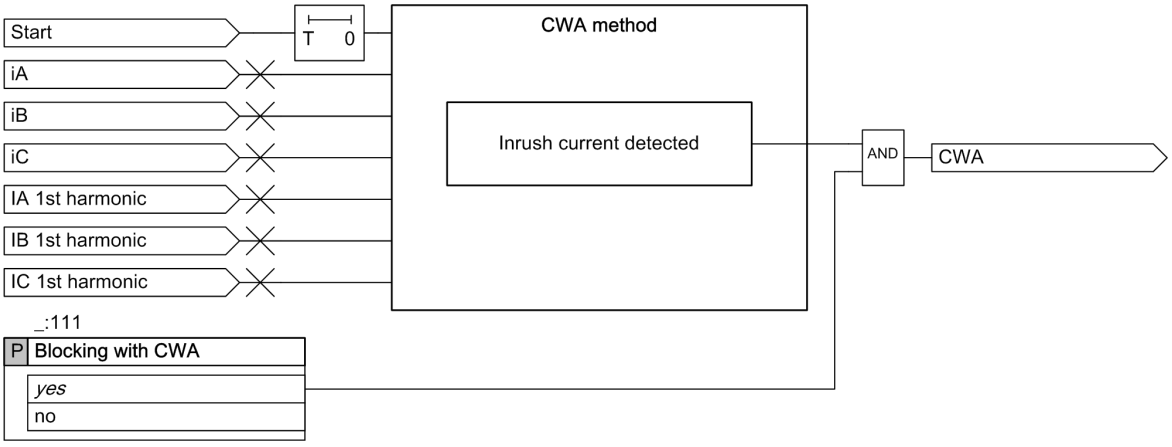


[dwinru03-240211-01.tif, 1, en_US]

Figure 6-83 Inrush-Current Characteristic

The following figure shows the logic diagram of the CWA method.

From the present fundamental-component current (1st harmonic), the threshold value for identification of the flat areas is derived via an internal factor.



[loinru05-240211-01.tif, 1, en_US]

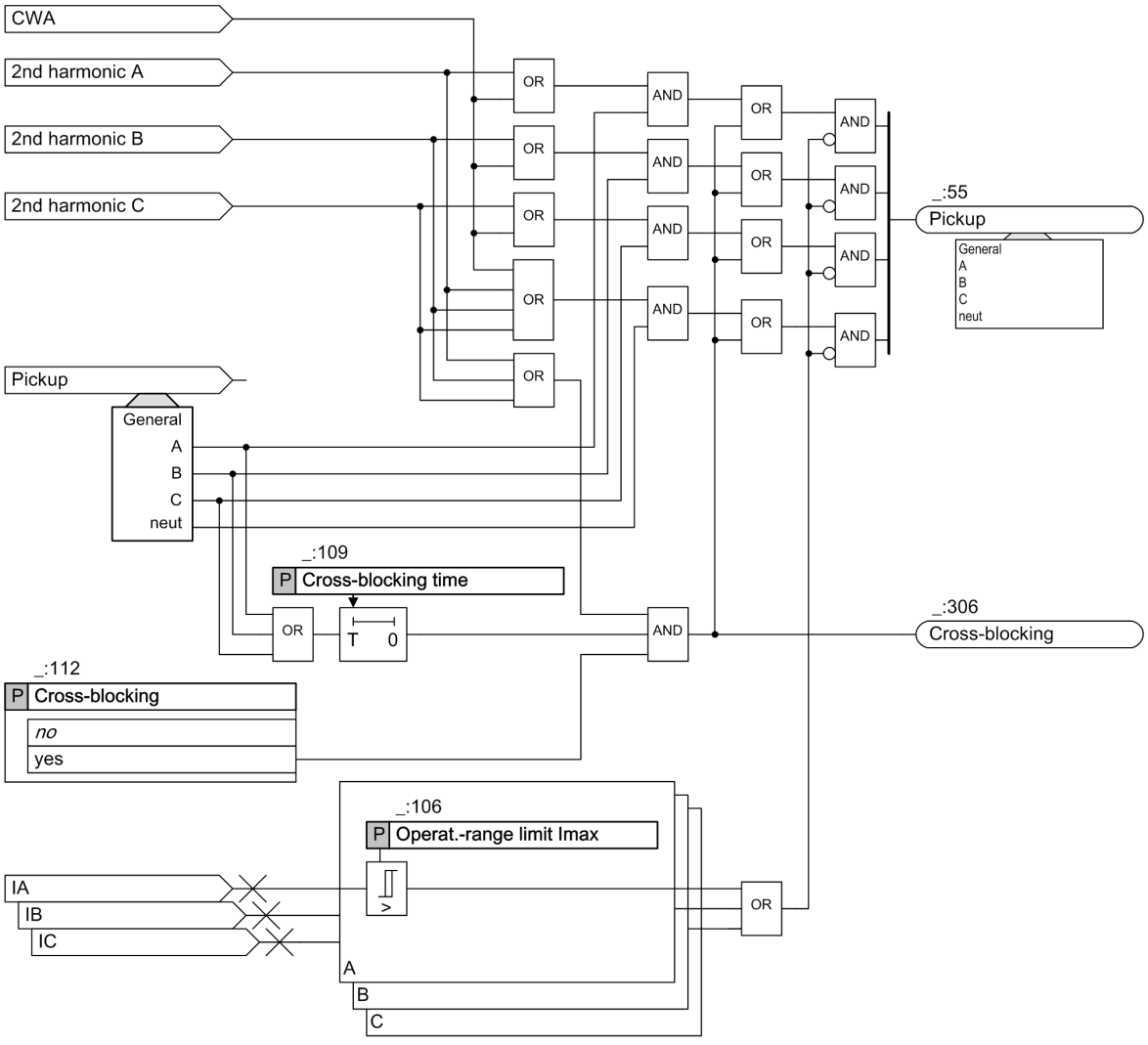
Figure 6-84 Logic of the CWA-Method Function (T = 1 Period)

Logic of the Inrush-Current Detection

The following logic diagram shows the link of the 2 methods of measurement **Harmonic Analysis** and **CWA method**.

The crossblock function influences the **Harmonic Analysis** process. If you have set the parameter **`Cross-blocking`** to ***`yes`***, you will receive in the event of threshold-value violation a blocking indication for all 3 phase currents and the measured or calculated zero-sequence current ($I_{2nd\ harm}$ / $I_{1st\ harm}$). The crossblock function works via a timer. Set parameters for the time depending on the expected duration factor via the parameter **`Cross-blocking time`**.

If the phase current exceeds the maximum permissible current **`Operat.-range limit Imax`**, the inrush-current detection will be blocked.



[loinru12-060912-01.tif, 1, en_US]

Figure 6-85 Logic Diagram of the Inrush-Current Detection

6.8.4 Application and Setting Notes

Parameter: Operat.-range limit Imax

- Recommended setting value **(_:106) Operat.-range limit Imax** = ***7.5 A***

  With the parameter **Operat.-range limit Imax** , you can specify at which current the inrush-current detection is blocked internally. The setting value must be above the maximum inrush current of the transformer. A practicable value is 7.5 times the transformer rated current.

Parameter: Blocking with CWA

- Recommended setting value = **(_:111) Blocking with CWA** = ***yes***

Parameter Value	Description
yes	**CWA process** activated.
no	**CWA process** deactivated.

Parameter: Blocking with 2. harmonic

- Recommended setting value **(_:110) Blocking with 2. harmonic** = ***yes***

Parameter Value	Description
yes	**Harmonic analysis** process activated.
no	**Harmonic analysis** process deactivated.



NOTE

Make sure that at least one process is activated. Siemens recommends retaining the advised setting values.

Parameter: 2nd harmonic content

- Recommended setting value **(_:102) 2nd harmonic content** = ***15 %***
  With the parameter **2nd harmonic content** , you can specify the pickup value of the harmonic analysis function. The setting value of 15 % is practicable for most transformers.

Parameter: Cross-blocking

- Recommended setting value **(_:112) Cross-blocking** = ***no***

Parameter Value	Description
no	Through the CWA process working in parallel in the inrush-current detection, the function is not activated as standard.
yes	If a subfunction of the inrush-current detection is identified in the course of the closure trials during commissioning, set the parameter **Cross-blocking** to ***yes*** .

Parameter: Cross-blocking time

- Default setting **(_:109) Cross-blocking time** = ***0.06 s***
  You define the duration of this blocking with the **Cross-blocking time** parameter. The default setting of ***0.06 s*** (about 3 periods) has proven practicable. Set the time as short as possible and check the value during the closure trials. The parameter **Cross-blocking time** is inactive at **Cross-blocking** = ***no*** .

Parameter: Start flt.rec

- Default setting **(_:114) Start flt.rec** = ***yes***
  With the **Start flt.rec** parameter, you determine whether a fault record should be started upon pickup of the inrush-current detection. The following settings are possible:

Parameter Value	Description
no	No fault recording starts with pickup.
yes	The fault recording starts with pickup. When the protection function is blocked by the inrush-current detection, a fault recording is started nevertheless.

6.8.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inrush detect.				
_:1	Inrush detect.:Mode		• off • on • test	on

Addr.	Parameter	C	Setting Options	Default Setting
_:106	Inrush detect.:Operat.-range limit Imax	1 A @ 100 Irated	0.030 A to 35.000 A	7.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	37.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	7.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	37.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	7.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	37.500 A
_:111	Inrush detect.:Blocking with CWA		• no • yes	yes
_:110	Inrush detect.:Blocking with 2. harmonic		• no • yes	yes
_:102	Inrush detect.:2nd harmonic content		10 % to 45 %	15 %
_:112	Inrush detect.:Cross-blocking		• no • yes	no
_:109	Inrush detect.:Cross-blocking time		0.03 s to 200.00 s	0.06 s
_:114	Inrush detect.:Start flt.rec		• no • yes	yes

6.8.6 Information List

No.	Information	Data Class (Type)	Type
Inrush detect.			
_:81	Inrush detect.:>Block stage	SPS	I
_:54	Inrush detect.:Inactive	SPS	O
_:52	Inrush detect.:Behavior	ENS	O
_:53	Inrush detect.:Health	ENS	O
_:300	Inrush detect.:2.harmonic phase A	SPS	O
_:301	Inrush detect.:2.harmonic phase B	SPS	O
_:302	Inrush detect.:2.harmonic phase C	SPS	O
_:305	Inrush detect.:CWA	SPS	O
_:306	Inrush detect.:Cross-blocking	SPS	O
_:55	Inrush detect.:Pickup	ACD	O

6.9 Instantaneous High-Current Tripping

6.9.1 Overview of Functions

The **Instantaneous high-current tripping** function has the following tasks:

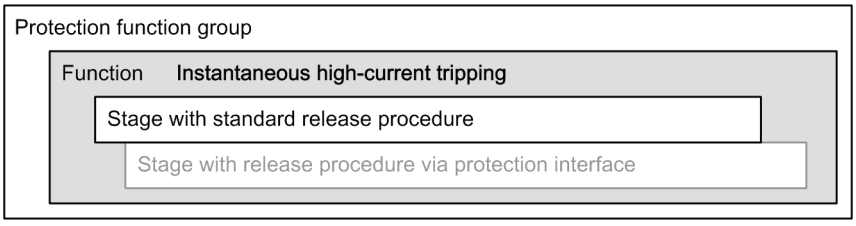
- Instantaneous tripping when switching onto an existing fault, for example, if a grounding switch is closed.
- Instantaneous disconnection of high currents above the highest overcurrent-protection stage.

6.9.2 Structure of the Function

The **Instantaneous high-current tripping** function offers 2 different increment types:

- Stage with standard release method
- Stage with release method via protection interface (only applicable if the device is equipped with a protection interface)

The function with the stage for the standard release procedure is factory-set.

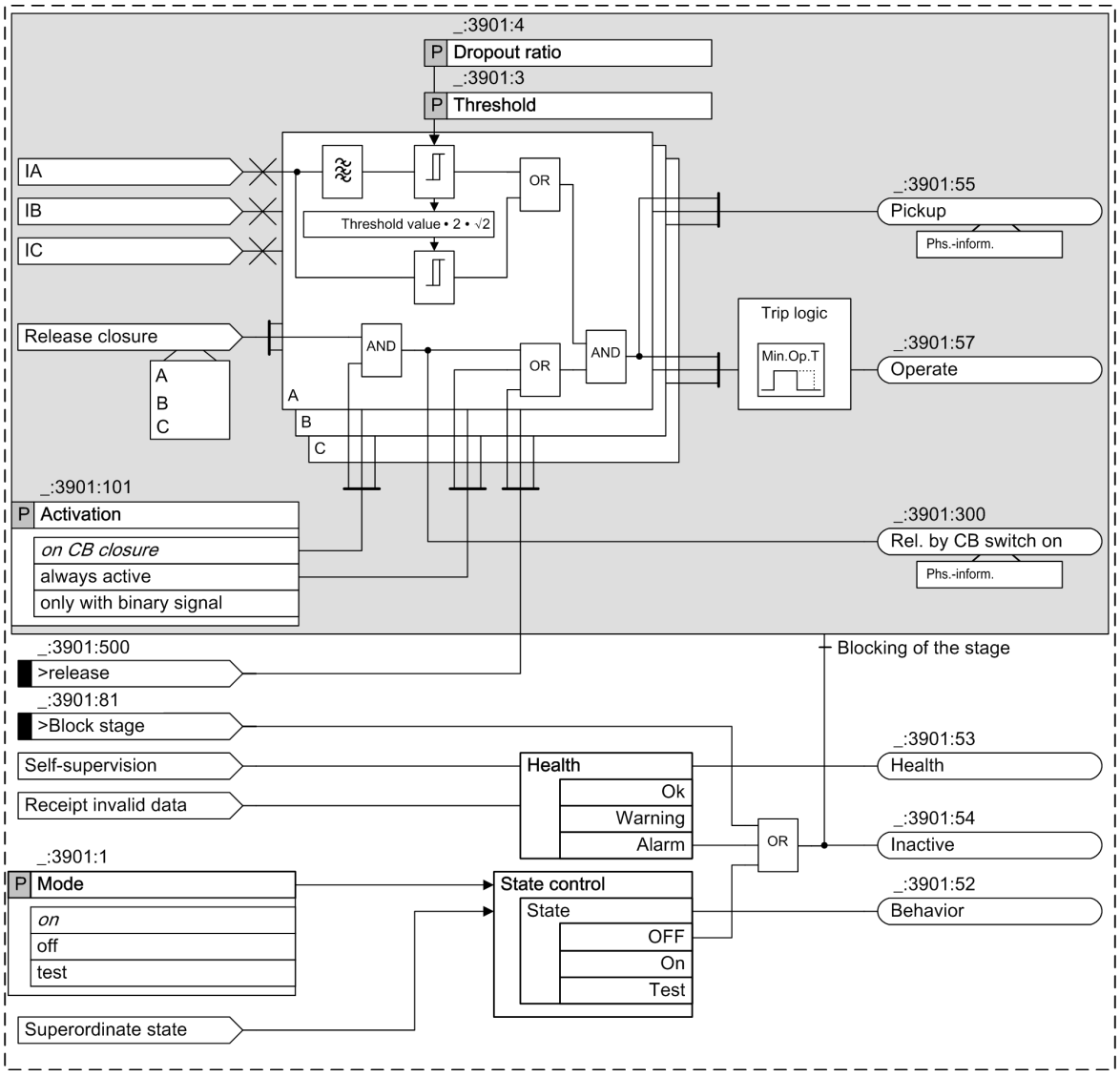


[dwihcstr-230211-01.tif, 1, en_US]

Figure 6-86 Structure/Embedding of the Function

6.9.3 Standard Release Procedure

Logic



[lohlore3-160611-01.tif, 2, en_US]

Figure 6-87 Logic Diagram of Instantaneous High-Current Tripping with Standard Release Method

Activation

Using the **Activation** parameter, you set the conditions under which the stage is released.

- ***on CB closure***

With this procedure, the stage is released only if the circuit breaker is about to be closed (the CB is open) or if the circuit breaker is being closed or if the binary input signal *>release* is active. The way signals are generated *Rel. by CB switch on* is described in section *5.7.8 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions*.

- ***always active***

The stage is always released and is thus independent of closing of the circuit breaker switch and of the binary input signal *>release*.

- ***only with binary signal***

The stage is released only if the binary input signal *>release* is active.

Method of Measurement, Threshold Value

The stage works with 2 different methods of measurement.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically. A DC component is thus eliminated. The RMS value of the fundamental component is compared with the set threshold.
- Evaluation of the unfiltered measurand:
  If the current exceeds a preset threshold value by
  current ≥ 2·√2·threshold value
  this stage will use unfiltered measurands in addition. Thus, very short operate times are possible.

6.9.4 Application and Setting Notes

Parameter: Activation

- Default setting **(_:3901:101) Activation** = ***on CB closure***

Using the parameter **Activation**, you define the conditions under which the stage is released.

Parameter Value	Description
on CB closure	Select this setting to activate the stage only when the circuit breaker is closed.
always active	Select this setting to release the stage statically.
only with binary signal	Select this setting to release the stage via an external signal.

Parameter: Threshold

- Default setting **(_:3901:3) Threshold** = ***10.0 A*** for I_{rated} = 1 A or ***50.0 A*** for I_{rated} = 5 A

The stage works independently of the position of the remote circuit breakers. For this reason, set the **Threshold** so that the fault current flowing through does not trigger the stage. Thus, use this stage only if current grading over the protected object is possible, that is, for transformers, shunt reactors or long lines with low source impedance. In other cases, deactivate the stage.

EXAMPLE

Calculation example for current grading of a 110 kV overhead line measuring 150 mm²

s (length) = 100 km;

R_1/s = 0.21 Ω/km;

X_1/s = 0.43 Ω/km

Since the stage is non-directional, the calculation must consider the maximum short-circuit power at the start of the line or at the opposite end:

Ssc" = 3.5 GVA (subtransient, because the function can respond to the 1st peak value)

Current transformer: 600 A/5 A

The line impedance Z_L and the minimum source impedance Z_S are calculated on this basis:

Line impedance Z_L and Source impedance Z_S:

$$Z_1/s = \sqrt{0.21^2 + 0.43^2}\ \Omega/km = 0.479\ \Omega/km$$

$$Z_L = 0.479\ \Omega/km \cdot 100\ km = 47.9\ \Omega$$

$$Z_S = \frac{110\ kV^2}{3500\ MVA} = 3.46\ \Omega$$

[foglchzv-170309-01.tif, 1, en_US]

The maximum 3-phase short-circuit current I''_{sc} flowing through is (at a source voltage of 1.1 V_N):

$$I''_{sc} = \frac{1.1 \cdot V_{net}}{\sqrt{3} \cdot (Z_S + Z_L)} + \frac{1.1 \cdot 110\,kV}{\sqrt{3} \cdot (3.46\,\Omega + 47.9\,\Omega)} = 1360\,A$$

[foglchik-170309-01.tif, 1, en_US]

With a safety margin of 10 %, the following setting value results:

- **Threshold value** (primary) = 1.1 · 1360 A = 1496 A
- **Threshold value** (secondary) = $1.1 \cdot \frac{1360\,A}{600\,A} \cdot 5\,A = 12.5\,A$

[foglnste-170309-01.tif, 1, en_US]

If short-circuit currents exceed 1496 A (primary) or 12.5 A (secondary), there is a short circuit on the line to be protected. It can be disconnected immediately.

NOTE

The calculation was performed with absolute values, which is accurate enough for overhead lines. A complex calculation is required only if the source impedance and the line impedance have extremely different angles.

Parameter: `Dropout ratio`

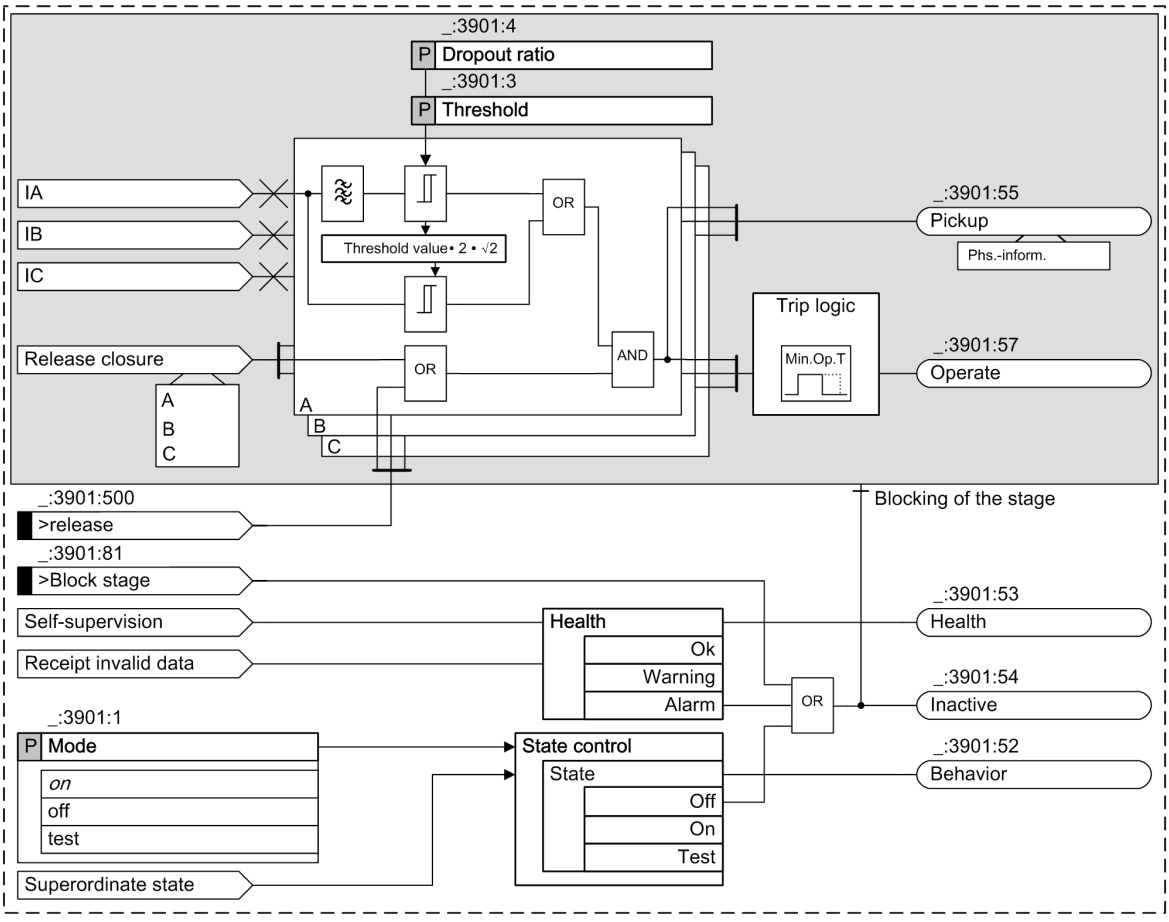
- Recommended setting value **`(_:3901:4) Dropout ratio`** = ***`0.90`***

The recommended setting value of ***`0.90`*** is sufficient for many applications. To obtain high-precision measurements, the **`Dropout ratio`** can be reduced. If you expect highly fluctuating measurands at the pickup threshold, you can increase the setting value of the parameter **`Dropout ratio`**. This avoids chattering of the tripping stage.

6.9.5 Release Procedure via Protection Interface

This stage can be applied only if the device is equipped with a protection interface.

Logic



[lohinre3-160611-01.tif, 1, en_US]

Figure 6-88 Logic Diagram of Instantaneous High-Current Tripping with Release Procedure via Protection Interface

Release

If one of the following conditions is fulfilled, the stage is released (the internal **Release** signal is present) (for further information, see chapter *5.8 Process Monitor*):

- No voltage has yet been applied to the protected object, which means that the remote circuit breakers are open, or
- Switching to the local circuit breaker is immanent.

These conditions are recognized internally if a circuit breaker is open or just closed

Furthermore, the stage can be activated externally via the **`>release`** binary input signal.

NOTE

To enable internal release of the stage, the devices at all ends of the protected object must be informed of the circuit-breaker position (the circuit-breaker auxiliary contacts must be connected to the devices; the respective binary input signals must be jumpered).

Method of Measurement, Threshold Value

The stage works with 2 different methods of measurement.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically. A DC component is thus eliminated. The RMS value of the fundamental component is compared with the set threshold.
- Evaluation of the unfiltered measurand:
  If the current exceeds a preset threshold value by
  current ≥ 2·√2·threshold value
  this stage will use unfiltered measurands in addition. Thus, very short operate times are possible.

6.9.6 Application and Setting Notes

Parameter: `Threshold`

- Default setting **`(_:3901:3) Threshold`** = ***`2.5 A`*** for I_{rated} = 1 A or ***`12.5 A`*** for I_{rated} = 5 A

Select the value high enough for the protection not to pick up on the RMS value of the inrush current that occurs when the local circuit breaker is closed. You do not have to consider short-circuit currents flowing through, because the stage is released only if the circuit breakers are opened at all remote ends of the protected object or the release was caused by the binary input *>release*.

Parameter: `Dropout ratio`

- Recommended setting value **`(_:3901:4) Dropout ratio`** = ***`0.90`***

The recommended setting value of ***`0.90`*** is sufficient for many applications. To obtain extremely accurate measurements, the dropout ratio can be reduced. If you expect highly fluctuating measurands at the pickup threshold, you can increase the dropout ratio. This avoids chattering of the tripping stage.

6.9.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Standard 1`				
_:3901:1	Standard 1:Mode		• off • on • test	on
_:3901:101	Standard 1:Activation		• on CB closure • only with binary signal • always active	on CB closure
_:3901:3	Standard 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	10.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	50.000 A
_:3901:4	Standard 1:Dropout ratio		0.50 to 0.90	0.90

6.9.8 Information List

No.	Information	Data Class (Type)	Type
`Group indicat.`			
_:4501:55	Group indicat.:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:4501:57	Group indicat.:Operate	ACT	O
Standard 1			
_:3901:500	Standard 1:>release	SPS	I
_:3901:81	Standard 1:>Block stage	SPS	I
_:3901:54	Standard 1:Inactive	SPS	O
_:3901:52	Standard 1:Behavior	ENS	O
_:3901:53	Standard 1:Health	ENS	O
_:3901:300	Standard 1:Rel. by CB switch on	ACT	O
_:3901:55	Standard 1:Pickup	ACD	O
_:3901:57	Standard 1:Operate	ACT	O

6.10 Arc Protection

6.10.1 Overview of Function

The function **Arc protection**:

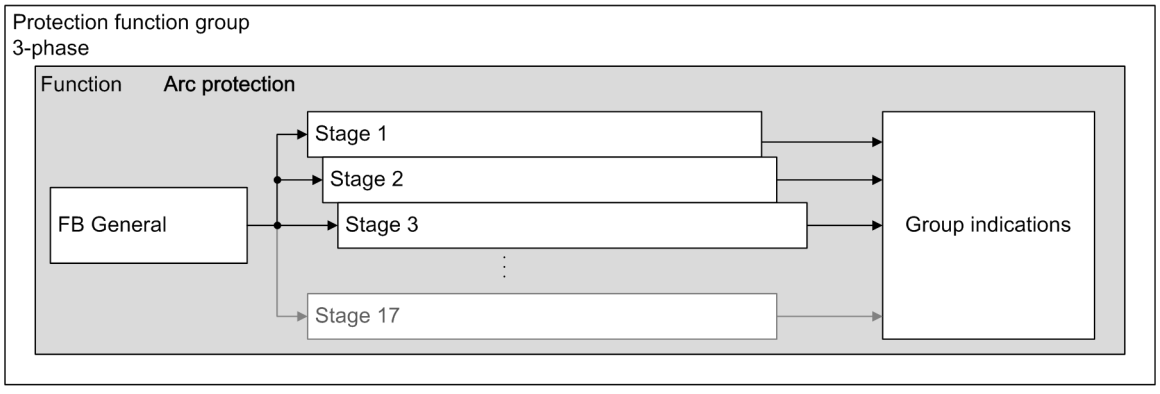
- Detects arcs in air-insulated switchgear parts without delay and in a fail-safe way
- Limits system damage through instantaneous high-speed tripping
- Protect systems from thermal overload
- Increases safety of personnel
- Trips in a 3-pole way
- Is suitable for use in all voltage levels

6.10.2 Structure of the Function

The **Arc protection** function can be added to function groups that provide current measured values.
The **Arc protection** function consists of the following blocks.

- General
- 3 stages
- Output logic 3-phase

The **Arc protection** function is preconfigured with 3 stages. A maximum of 17 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.
The following figure shows the basic structure of the **Arc protection** function.

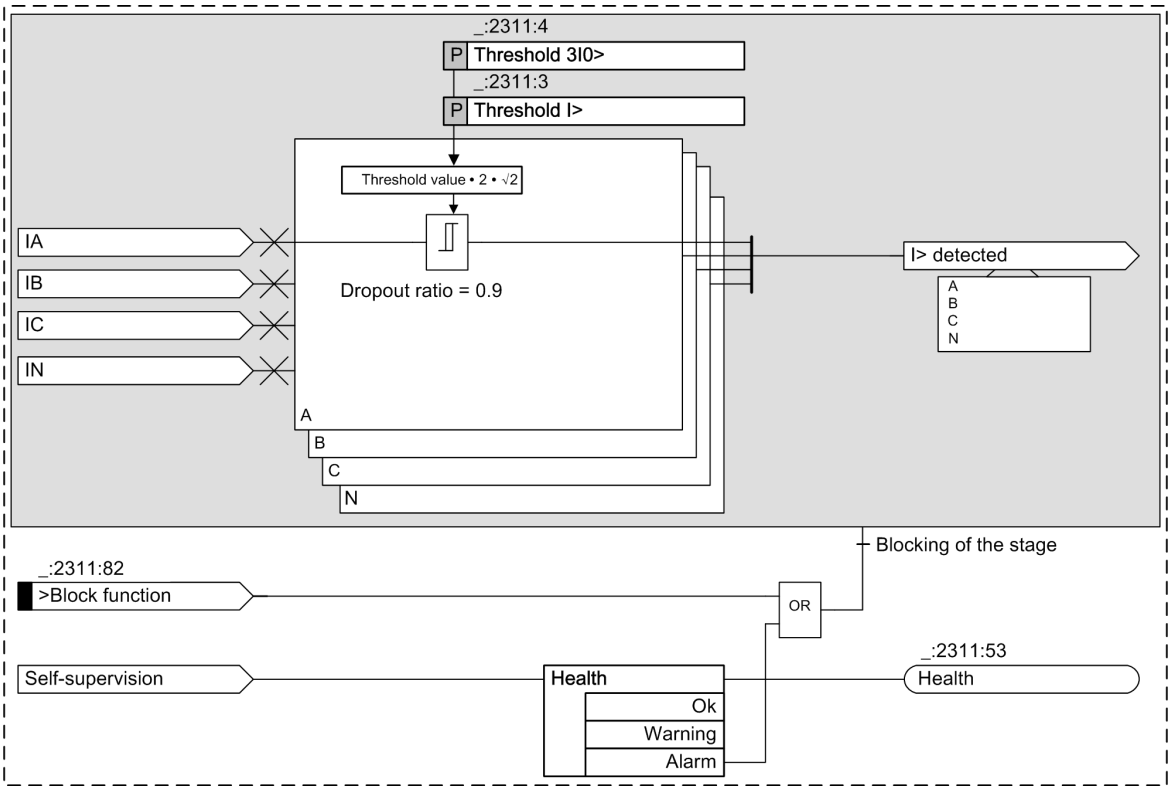


[dw_structure_arcprot, 2, en_US]

Figure 6-89 Structure/Embedding of the Arc Protection Function

6.10.3 Function Description

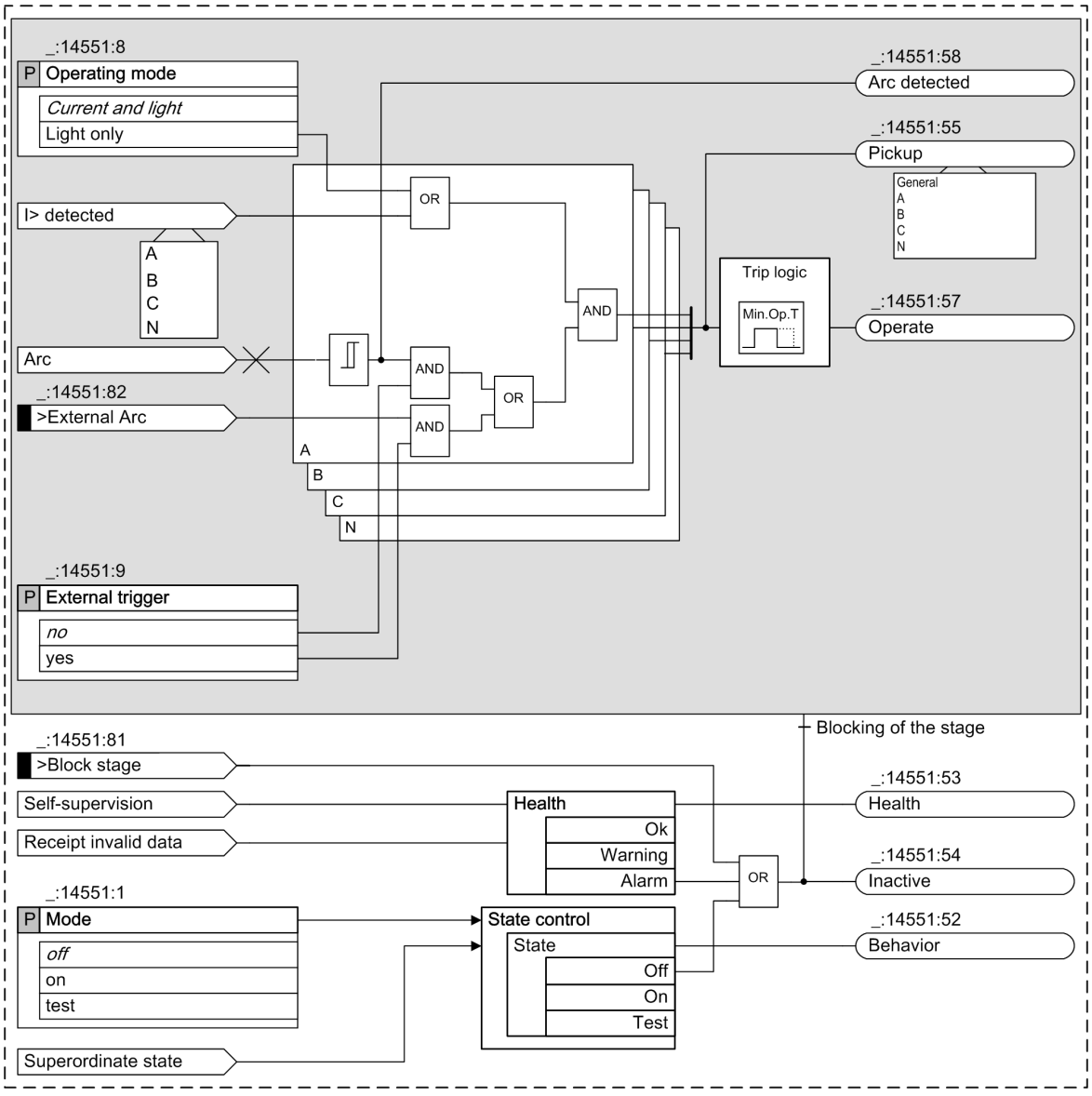
General Logic of the Function Block



[lo_fb0_arcprot, 1, en_US]

Figure 6-90 General Logic Diagram of the Function Block

Logic of the Stage



[lo_stage_arcprot, 1, en_US]

Figure 6-91 Logic Diagram of the Stage

The**Arc protection** function uses a locally connected optical arc sensor or an external trip initiation by other devices in order to detect arcs.

NOTE

Install the arc sensors inside the switchgear in such a way that they are not hidden behind other system components!

Shadowing of the arc sensors must be avoided!

NOTE

Once an optical sensor has detected an arc, you must replace the affected optical sensor!

Within the **Arc protection** function, you can use a fast current-flow criterion as an additional release criterion. The parameters for the current-flow criterion can be found in the **General** block. For each stage, you can select individually whether the current-flow criterion must be evaluated as well.

Method of Measurement, Current-Flow Criterion

The current-flow criterion works with 2 different methods of measurement.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically. A direct-current component is thus eliminated. The RMS value of the fundamental component is compared with the set threshold.
- Evaluation of the unfiltered measurand:
  If the current exceeds the threshold value set by the current amount $\geq 2 \cdot \sqrt{2} \cdot$ threshold value, the stage uses additional unfiltered measurands. Thus, very short operate times are possible.



NOTE

If using the current-flow criterion in addition to the light, prevent a potential overfunction caused by the suddenly occurring light signal.

If you use the current-flow criterion, arcs are typically detected in 4 ms!

Self Monitoring

The **Arc protection** function uses a self-monitoring circuit. This circuit monitors the optical arc sensors and the fiber-optic cables. The arc-protection module uses the fiber-optic cable to send a cyclic test signal (light) to the arc sensors. If the channel is operating properly, the test signal is sent back to the arc protection module. If the test signal is not returned to the arc protection module, the indication *channel # sensor failure* is generated.

If the self-monitoring function detects a fault, the indication *Health* is set to *Alarm* and the stage/function is blocked.

6.10.4 Application and Setting Notes – General Settings

Go to **General** under the function **Arc protection** and set the following parameters. The setting values apply to all stages.

Parameter: Threshold I>

- Default setting **(_:2311:3) Threshold I>** = *2.000 A*

Use the parameter **Threshold I>** to define the trigger threshold of the phase currents. The **Threshold I>** is relevant for the current-flow criterion of the **arc protection** function.

Set the **Threshold I>** of the function **Arc protection** in such a manner that the RMS value of the inrush current does not exceed the **Threshold I>** when activating the local circuit breaker.

For more information about how to calculate the setting value, refer to *6.3.4.2 Application and Setting Notes*

Parameter: Threshold 3I0>

- Default setting **(_:2311:4) Threshold 3I0>** = *1.000 A*

Use the parameter **Threshold 3I0>** to determine the tripping threshold for the zero-sequence current. The **Threshold 3I0>** is relevant for the current-flow criterion of the **Arc protection function**.

Set the **Threshold 3I0>** of the function **Arc protection** in such a manner that the RMS value of the inrush current does not exceed the **Threshold 3I0>** when activating the local circuit breaker.

For more information about how to calculate the setting value, refer to *6.5.4.2 Application and Setting Notes*

NOTE

If you set the parameter **CT connection** = ***3-phase, 2 primary CT*** for the **3-phase current measuring point**, the parameter **Threshold 3I0>** has no effect.

6.10.5 Application and Setting Notes for the Stage

Parameter: External trip initiation

- Default setting **(_:14551:9) External trip initiation** = ***no***

Use parameter **External trip initiation** to set whether an external input signal is used to trigger the stage.

Parameter Value	Description
no	The stage does not operate with an external input signal.
yes	The stage operates with an external input signal. If the stage operates with an external input signal, the binary input signal *>External Arc* must be routed in the DIGSI 5 information routing. In this setting option, the binary input signal *>External Arc* is only visible in the DIGSI 5 information routing **Note**: When working with external trip initiation, do not select a channel. If an additional channel is selected with this setting value, DIGSI 5 will signal an inconsistency.

Parameter: Operating mode

- Default setting **(_:14551:8) Operating mode** = ***Current and light***

Use the parameter **Operating mode** to define the basic functionality of the stage.

Parameter Value	Description
Current and light	The stage operates with the input variables current and light. The current-flow criterion ensures that the light signal originates from an arc. Siemens recommends using this setting.
Light only	This stage operates only with the input signal 'light' and is triggered even if current is not measured. This operating mode can cause a overfunction if light is detected suddenly. Use this setting value only if the effect caused by external light signals is impossible.

Parameter: Sensor

- Default setting **(_:14551:11) Sensor** = ***Point sensor***

Use the parameter **Sensor** to set which sensor type is connected to the device.

Parameter Value	Description
Point sensor	A point sensor is connected to the device.
Line sensor	A line sensor is connected to the device.
Custom	If you select this setting option, the parameter **Threshold Light** is visible. Siemens recommends the default setting values ***Point sensor*** or ***Line sensor***. This allows arcs to be detected reliably regardless of diffused light.

Parameter: Threshold Light

- Default setting **(_:14551:7) Threshold Light** = ***-20.00 dB***

Use the parameter **Threshold Light** to set the light sensitivity. If you set the **Threshold Light** to a smaller value, the sensitivity increases. If you set the **Threshold Light** to a higher value, the sensitivity decreases. If the sensors even pick up in case of a switching arc of the circuit breaker, set the **Threshold Light** parameter to a higher value.

Siemens recommends the default settings for point or line sensors.

Set the parameter **Threshold Light** manually only if you have special default settings for light sensitivity.

Parameter: Channel

- Default setting **(_:14551:10) Channel** = ***No channel is selected***

Use the parameter **Channel** to select which sensor channel the stage uses.

If the **Arc protection** function has several stages, a different channel must be selected for each stage.

For parameter **Channel**, the selection texts are identical to the name of the arc-protection module and its channels.

6.10.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:3	General:Threshold I>	1 A @ 100 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:2311:4	General:Threshold 3I0>	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
Stage 1				
_:14551:1	Stage 1:Mode		• off • on • test	off
_:14551:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:14551:9	Stage 1:External trip initiation		• no • yes	no
_:14551:8	Stage 1:Operating mode		• Light only • Current and light	Current and light
_:14551:11	Stage 1:Sensor		• Point sensor • Line sensor • Custom	Point sensor
_:14551:7	Stage 1:Threshold Light		-34.00 dB to -10.00 dB	-20.00 dB
_:14551:10	Stage 1:Channel		Setting options depend on configuration	

Addr.	Parameter	C	Setting Options	Default Setting
Stage 2				
_:14552:1	Stage 2:Mode		• off • on • test	off
_:14552:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:14552:9	Stage 2:External trip initiation		• no • yes	no
_:14552:8	Stage 2:Operating mode		• Light only • Current and light	Current and light
_:14552:11	Stage 2:Sensor		• Point sensor • Line sensor • Custom	Point sensor
_:14552:7	Stage 2:Threshold Light		-34.00 dB to -10.00 dB	-20.00 dB
_:14552:10	Stage 2:Channel		Setting options depend on configuration	
Stage 3				
_:14553:1	Stage 3:Mode		• off • on • test	off
_:14553:2	Stage 3:Operate & flt.rec. blocked		• no • yes	no
_:14553:9	Stage 3:External trip initiation		• no • yes	no
_:14553:8	Stage 3:Operating mode		• Light only • Current and light	Current and light
_:14553:11	Stage 3:Sensor		• Point sensor • Line sensor • Custom	Point sensor
_:14553:7	Stage 3:Threshold Light		-34.00 dB to -10.00 dB	-20.00 dB
_:14553:10	Stage 3:Channel		Setting options depend on configuration	

6.10.7 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:82	General:>Block function	SPS	I
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:14551:81	Stage 1:>Block stage	SPS	I
_:14551:82	Stage 1:>External Arc	SPS	I
_:14551:54	Stage 1:Inactive	SPS	O
_:14551:52	Stage 1:Behavior	ENS	O
_:14551:53	Stage 1:Health	ENS	O
_:14551:58	Stage 1:Arc detected	SPS	O

No.	Information	Data Class (Type)	Type
_:14551:55	Stage 1:Pickup	ACD	O
_:14551:57	Stage 1:Operate	ACT	O
Stage 2			
_:14552:81	Stage 2:>Block stage	SPS	I
_:14552:82	Stage 2:>External Arc	SPS	I
_:14552:54	Stage 2:Inactive	SPS	O
_:14552:52	Stage 2:Behavior	ENS	O
_:14552:53	Stage 2:Health	ENS	O
_:14552:58	Stage 2:Arc detected	SPS	O
_:14552:55	Stage 2:Pickup	ACD	O
_:14552:57	Stage 2:Operate	ACT	O
Stage 3			
_:14553:81	Stage 3:>Block stage	SPS	I
_:14553:82	Stage 3:>External Arc	SPS	I
_:14553:54	Stage 3:Inactive	SPS	O
_:14553:52	Stage 3:Behavior	ENS	O
_:14553:53	Stage 3:Health	ENS	O
_:14553:58	Stage 3:Arc detected	SPS	O
_:14553:55	Stage 3:Pickup	ACD	O
_:14553:57	Stage 3:Operate	ACT	O

Informationen der Selbstüberwachung vom Lichtbogenschutz-Modul

No.	Information	Data Class (Type)	Type
channel #			
_:307	channel #:Sensor failure	SPS	O

6.10.8 Application Example for Arc Protection with Point Sensors in Operating Mode: Light Only

6.10.8.1 Description

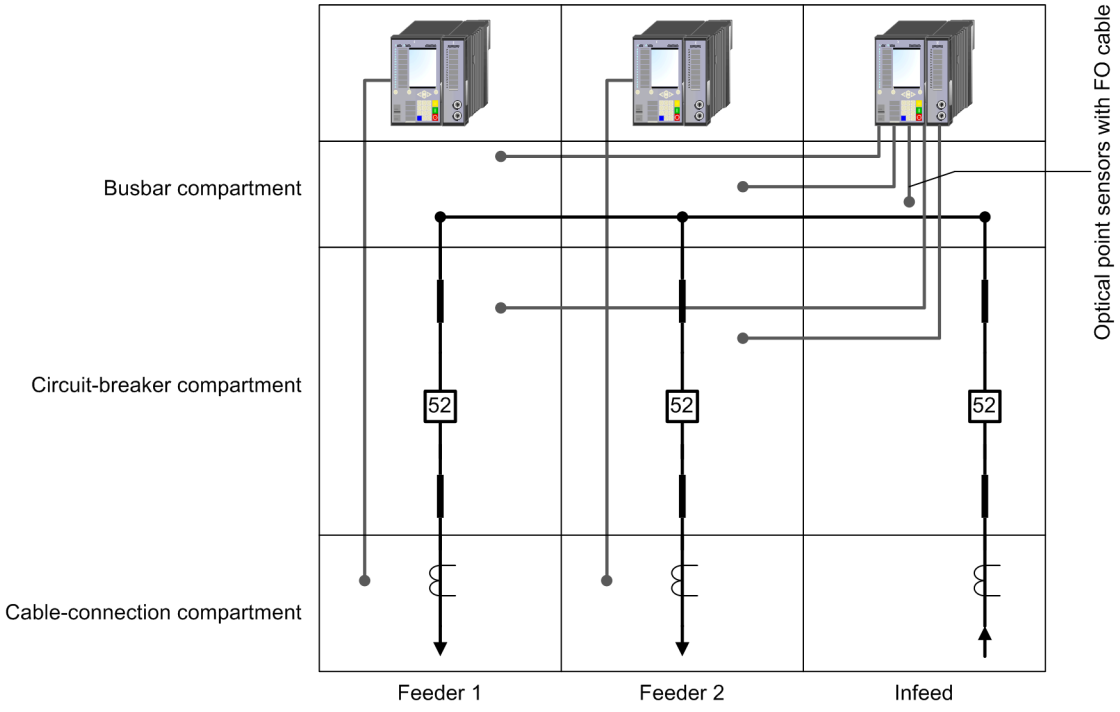
Overview

The example describes the **Arc protection** function in a medium-voltage switchgear with one infeed and 2 feeders. The **Arc protection** function operates with the **Operating mode** = ***Light only***.

The following items are considered in the example below:

- Positioning the optical point sensors in the switchgear
- Connecting the optical point sensors to the protection devices in the feeders and the infeed
- Number of necessary stages of the functions in the protection devices of the feeders and the infeed
- Setting notes about the selected parameters in the stages of the function

The following figure shows the arrangement and the connection of the optical point sensors:



[dw_arcprot-light-only, 2, en_US]

Figure 6-92 Layout and Connection of the Optical Point Sensors (Operating Mode = Light only)

For this example, the following is assumed:

- The circuit breaker of the infeed must be switched off. This ensures that the arcs in the busbar compartments of the infeed and the feeders or in the circuit-breaker compartment of the feeders are off.

  Install the optical point sensors in the busbar compartments (BB compartment) of the infeed and feeders. Install additional optical point sensors in the circuit-breaker compartment (CB compartment) of the feeders. Connect all optical point sensors to the protection device of the infeed.

- The optical point sensors in the cable-connection compartment of the feeders detect arcs in this compartment. Install one optical point sensor in the cable-connection compartment of the feeders and connect it to the protection device of the feeder. This allows for the selective clearing of arcs inside the cable-connection compartment.

  Due to the pressure waves that occur during the formation of an arc, partitions can deform and cause undesirable light influences in adjacent compartments. This can result in a non-selective tripping.

- If there is an arc in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device must switch off.

NOTE

If the **Arc protection** function operates in **`Operating mode`** = ***`Light only`***, the effects of external light can result in non-selective tripping.

NOTE

It must be considered that the number of arc protection modules connected to the device depends on the hardware configuration of the device.

When using modular devices, a maximum of 15 sensors can be connected. If using non-modular devices, a maximum of 6 sensors (3 sensors per module) can be connected.

6.10.8.2 Application and Setting Notes

General Notes

- Connect one optical point sensor from the cable-connection compartment in feeder 1 to the protection device in feeder 1. Arcs in the cable-connection compartment are cleared selectively by the circuit breaker in feeder 1.
- Connect one optical point sensor from the cable-connection compartment in feeder 2 to the protection device in feeder 2. Arcs in the cable-connection are cleared selectively by the circuit breaker in feeder 2.
- Connect optical point sensors from all busbar compartments and all circuit-breaker compartments of feeders 1 and 2 to the protection device in the infeed. Arcs in these compartments are detected and cleared by the device in the infeed.

Setting Notes for the Protection Device in Feeder 1

The **Arc protection** function operates with **one** stage.

Set the parameters of the stage as follows:

- Parameter: **Operating mode** = ***Light only***
- Parameter: **Sensor** = ***Point sensor***
- Parameter: **External trip initiation** = ***no***
- Parameter: **Channel** = ***Arc mod. 1 channel 1***

The parameters in block **General** are not relevant since the **Operating mode** = ***Light only***.

Setting Notes for the Protection Device in Feeder 2

The **Arc protection** function operates with **one** stage.

Set the parameters of the stage as follows:

- Parameter: **Operating mode** = ***Light only***
- Parameter: **Sensor** = ***Point sensor***
- Parameter: **External trip initiation** = ***no***
- Parameter: **Channel** = ***Arc mod. 1 channel 1***

The parameters in block **General** are not relevant since the **Operating mode** = ***Light only***.

Setting Notes for the Protection Device in the Infeed

The **Arc protection** function operates with **5** stages.

Set the parameters of the stages as follows:

- Parameter: **Operating mode** = ***Light only*** (applies to all stages)
- Parameter: **Sensor** = ***Point sensor*** (applies to all stages)
- Parameter: **External trip initiation** = ***no*** (applies to all stages)
- Parameter: **Channel** = ***Arc mod. 1 channel 1*** (Stage 1) → Busbar compartment supervision in feeder 1

  Parameter: **Channel** = ***Arc mod. 1 channel 2*** (Stage 2) → Circuit-breaker compartment supervision in feeder 1

  Parameter: **Channel** = ***Arc mod. 1 channel 3*** (Stage 3) → Busbar compartment supervision in feeder 2

  Parameter: **Channel** = ***Arc mod. 2 channel 1*** (Stage 4) → Circuit-breaker compartment supervision in feeder 2

  Parameter: **Channel** = ***Arc mod. 2 channel 2*** (Stage 5) → Busbar compartment supervision in the infeed

The parameters in block **General** are not relevant since the **Operating mode** = ***Light only***.

6.10.9 Application Example for Arc Protection with Point Sensors in Operating Mode: Light and Current

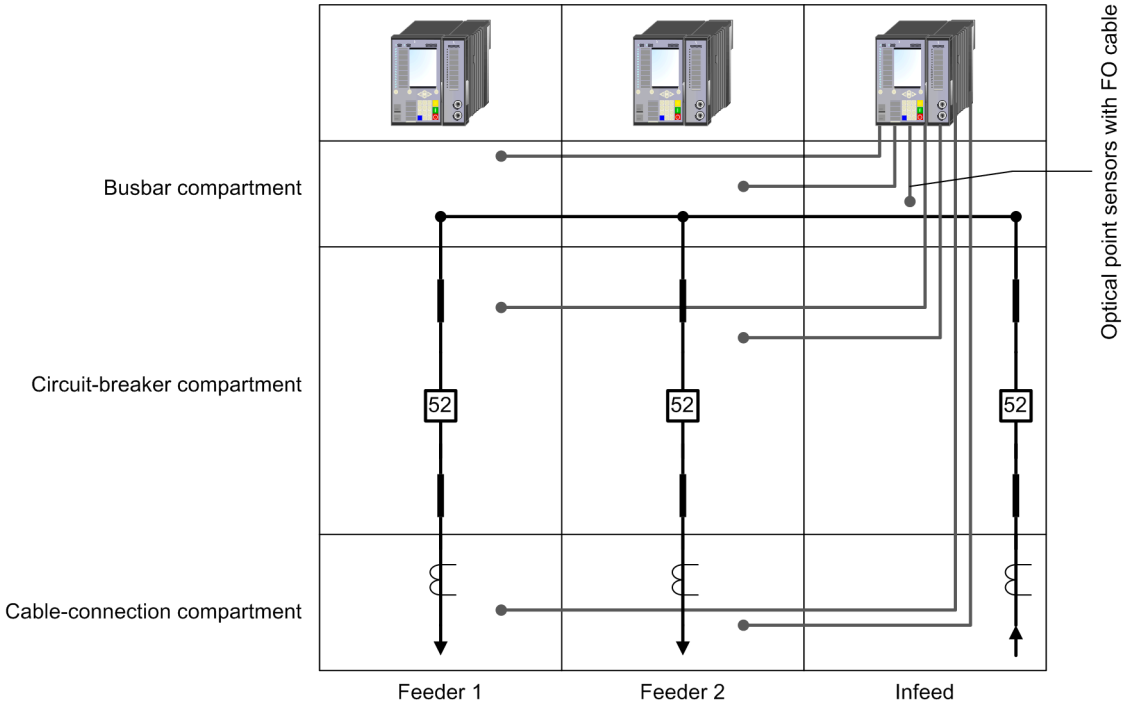
6.10.9.1 Description

Overview

The example describes the **Arc protection** function in a medium-voltage switchgear with one infeed and 2 feeders. The **Arc protection** function operates with the **Operating mode** = ***Current and light***. In the example, all arcs are detected by the protection device in the infeed.

The following items are considered in the example:

- Positioning the optical point sensors in the switchgear
- Connecting the optical point sensors to the protection devices in the feeders and the infeed
- Number of necessary stages of the functions in the protection devices of the feeders and the infeed
- Setting notes about selected parameters in the stages of the function



[dw_light-and-current, 2, en_US]

Figure 6-93 Layout and Connection of the Optical Point Sensors (Operating Mode = Current and Light)

For this example, the following is assumed:

- The current-flow criterion offers additional security to prevent unwanted tripping caused by sudden light influences.

  Depending on the arc location in the cable-connection compartment of the feeder, it is not always possible to measure the current. If an arc is detected in the cable-connection compartment of the feeder, the current will therefore be evaluated in the infeed.
- Install the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders as well as the busbar compartment of the infeed. Connect the optical point sensors to the protection device in the infeed.
- The protection device in the infeed clears all arcs in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of feeder 1 and 2. Furthermore, the protection device clears arcs in the busbar compartment of the infeed.

- If the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders, or in the busbar compartment of the infeed detect an arc, the protection device in the infeed evaluates the current as well.
- If an arc occurs in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device must trip.



NOTE

If the **Arc protection** function operates with the **Operating mode** = ***Current and light***, the additional current-flow criterion prevents unwanted tripping caused by external light influences.



NOTE

This application example requires the connection of several optical point sensors to a single protection device. It must be considered that the number of arc-protection modules that are connected to the device depends on the hardware configuration of the device.

When using modular devices, a maximum of 15 sensors can be connected. If you use non-modular devices, a maximum of 6 sensors (3 sensors per module) can be connected.

6.10.9.2 Application and Setting Notes

General Notes

- Connect the optical point sensors from the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of feeders 1 and 2 to the protection device in the infeed. Arcs in the busbar compartment, the circuit-breaker compartment and the cable-connection compartment of feeders 1 and 2 are detected and cleared by the device in the infeed.
- Connect an optical point sensor from the busbar compartment in the infeed to the protection device in the infeed. Arcs in the busbar compartment of the infeed are cleared selectively by the circuit breaker in the infeed.

Setting Notes for the Protection Device in the Infeed

The **Arc protection** function operates with **7** stages.

Set the parameters of the stages as follows:

- Parameter: **Operating mode** = ***Current and light*** (applies to all stages)
- Parameter: **Sensor** = ***Point sensor*** (applies to all stages)
- Parameter: **External trip initiation** = ***no*** (applies to all stages)
- Parameter: **Channel** = ***Arc mod. 1 channel 1*** (Stage 1) → Busbar compartment supervision in feeder 1

  Parameter: **Channel** = ***Arc mod. 1 channel 2*** (Stage 2) → Circuit-breaker compartment supervision in feeder 1

  Parameter: **Channel** = ***Arc mod. 1 channel 3*** (Stage 3) → Cable-connection compartment supervision in feeder 1

  Parameter: **Channel** = ***Arc mod. 2 channel 1*** (Stage 4) → Busbar compartment supervision in feeder 2

  Parameter: **Channel** = ***Arc mod. 2 channel 2*** (Stage 5) → Circuit-breaker compartment supervision in feeder 2

  Parameter: **Channel** = ***Arc mod. 2 channel 3*** (Stage 6) → Cable-connection compartment supervision in feeder 2

  Parameter: **Channel** = ***Arc mod. 3 channel 1*** (Stage 7) → Busbar compartment supervision in the infeed

You can find more information about the settings of the parameters **Threshold I>** and **Threshold 3I0>** in chapter *6.10.4 Application and Setting Notes – General Settings*.

6.10.10 Application Example for Arc Protection with Point Sensors via External Trip Initiation

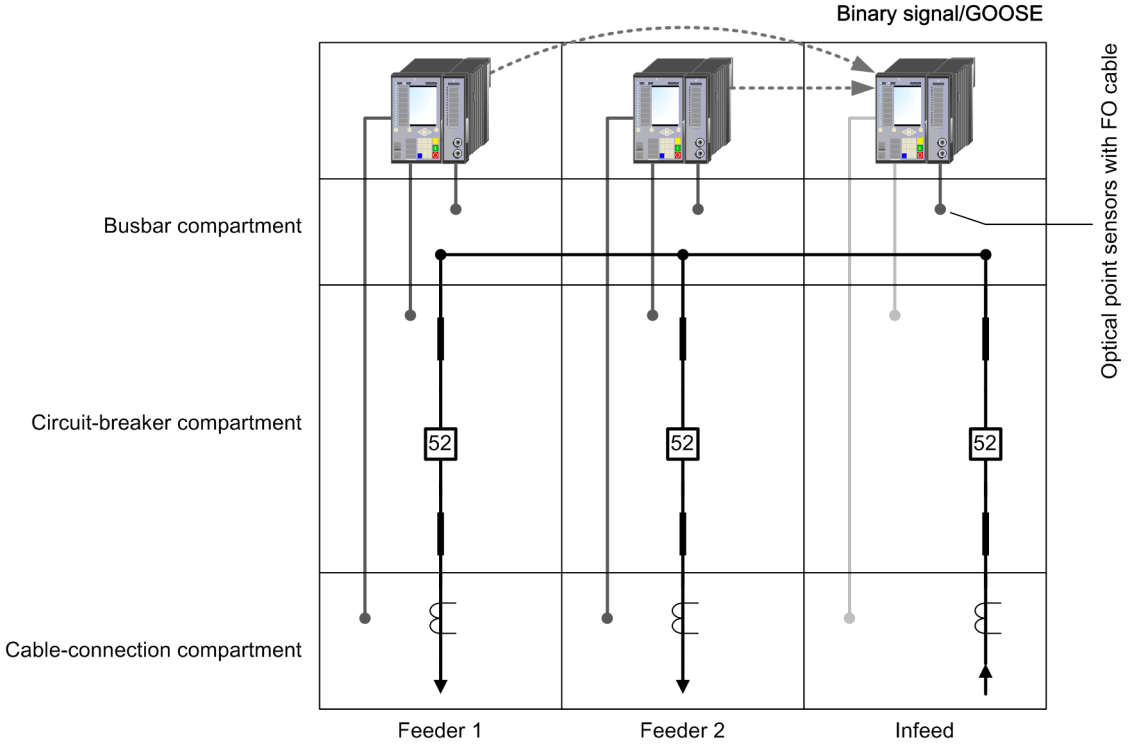
6.10.10.1 Description

Overview

The example describes the **Arc protection** function in a medium-voltage switchgear with one infeed and 2 feeders. The stages of the **Arc protection** function are triggered by **`External trip initiation`**.

The following items are considered in the example below:

- Positioning the optical point sensors in the switchgear
- Connecting the optical point sensors to the protection devices in the feeders and the infeed
- Number of necessary stages of the functions in the protection devices of the feeders and the infeed
- Setting notes about the selected parameters in the stages of the function



[dw_arcprot-extern-input, 2, en_US]

Figure 6-94 Arc Protection with External Trip Initiation

For this example, the following is assumed:

- Install the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeder and the infeed. Connect the optical point sensors to the respective protection device in the feeder and infeed.
- If the optical point sensors detect an arc in the busbar compartment, the circuit-breaker compartment, or the cable-connection compartment of the feeders, the *`Arc detected`* indication is sent via binary inputs/outputs, a protection interface, or IEC 61850 GOOSE to the protection device in the infeed. Then, the protection device in the infeed evaluates the current as well. If the measured current exceeds the thresholds **`Threshold I>`** and/or **`Threshold 3I0>`**, the protection device in the infeed clears the malfunction.

  You can find detailed information in chapter *6.10.10.2 Application and Setting Notes*

- Alternatively, arcs in the cable-connection compartment of the feeders can be cleared selectively by the protection device of the affected feeder. To do this, the pickup indication from the infeed unit must be sent back to the appropriate protection device in the feeder.
- If an arc occurs in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device trips.



NOTE

If the **Arc protection** function operates via the **`External trip initiation`**, only 3 optical point sensors are required per feeder protection device in order to detect the arcs (only one arc-protection module).

The signals from the feeder protection devices are sent via binary inputs/outputs, a protection interface or IEC 61850 GOOSE to the protection device of the infeed and processed.

The number of GOOSE messages is not limited. Therefore, the number of feeders is not limited, and the protection of complex systems is feasible.

Siemens recommends using the **Arc protection** function with external trip initiation.

6.10.10.2 Application and Setting Notes

General Notes:

- Install the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders and the infeed to the respective protection devices.
- Arcs in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders must be cleared by the protection device in the infeed. To do this, the protection devices in the feeder device must send the indication *`Arc detected`* to the infeed device. Use the binary inputs/outputs, a protection interface, or IEC 61850 GOOSE.
- The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds **`Threshold I>`** and/or **`Threshold 3I0>`**, the protection device in the infeed clears the malfunction.

  Connect the signals over 6 stages, using the external trip initiation or a CFC chart.

Setting Notes for the Protection Device in Feeder 1

The **Arc protection** function operates with **3** stages.

Set the parameters of the stages as follows:

- Parameter: **`Operating mode`** = ***`Light only`*** (applies to all stages)
- Parameter: **`Sensor`** = ***`Point sensor`*** (applies to all stages)
- Parameter: **`External trip initiation`** = ***`no`*** (applies to all stages)
- Parameter: **`Operate & flt.rec. blocked`** = ***`yes`*** (applies to all stages)
- Parameter: **`Channel`** = ***`Arc mod. 1 channel 1`*** (Stage 1) → Busbar compartment supervision in feeder 1

  Parameter: **`Channel`** = ***`Arc mod. 1 channel 2`*** (Stage 2) → Circuit-breaker compartment supervision in feeder 1

  Parameter: **`Channel`** = ***`Arc mod. 1 channel 3`*** (Stage 3) → Cable-connection compartment supervision in feeder 1

Setting Notes for the Protection Device in Feeder 2

The **Arc protection** function operates with **3** stages.

Set the parameters of the stages as follows:

- Parameter: **`Operating mode`** = ***`Light only`*** (applies to all stages)
- Parameter: **`Sensor`** = ***`Point sensor`*** (applies to all stages)

- Parameter: **External trip initiation** = ***no*** (applies to all stages)
- Parameter: **Operate & flt.rec. blocked** = ***yes*** (applies to all stages)
- Parameter: **Channel** = ***Arc mod. 1 channel 1*** (Stage 1) → Busbar compartment supervison in feeder 2

  Parameter: **Channel** = ***Arc mod. 1 channel 2*** (Stage 2) → Circuit-breaker compartment supervision in feeder 2

  Parameter: **Channel** = ***Arc mod. 1 channel 3*** (Stage 3) → Cable-connection compartment supervision in feeder 2

Setting Notes for the Protection Device in the Infeed

The **Arc protection** function operates with **9** stages.

Stage 1 (busbar compartment supervision):

- Parameter: **Operate & flt.rec. blocked** = ***no***

  If an arc is detected in the busbar compartment of the infeed and the thresholds **Threshold I>** or **Threshold 3I0>** are exceeded, an operate indication is generated immediately.
- Parameter: **Channel** = ***Arc mod. 1 channel 1***
- Parameter: **Operating mode** = ***Current and light***
- Parameter: **Sensor** = ***Point sensor***
- Parameter: **External trip initiation** = ***no***

Stage 2 (circuit-breaker compartment supervision):

- Parameter: **Operate & flt.rec. blocked** = ***yes***

  If an arc is detected in the circuit-breaker compartment of the infeed (light-gray point sensors in *Figure 6-94*), a pickup indication is generated immediately. The arc is cleared by a superordinate protection device.
- Parameter: **Channel** = ***Arc mod. 1 channel 2***
- Parameter: **Operating mode** = ***Current and light***
- Parameter: **Sensor** = ***Point sensor***
- Parameter: **External trip initiation** = ***no***

Stage 3 (cable-connection compartment supervision):

- Parameter: **Operate & flt.rec. blocked** = ***yes***

  If an arc is detected in the cable-connection compartment of the infeed (light-gray point sensors in *Figure 6-94*), a pickup indication is generated immediately. The arc is cleared by a superordinate protection device.

  Depending where the arc is generated in the cable-connection compartment of the infeed, it is not always possible to measure the current. If an arc is detected in the cable-connection compartment of the infeed, the current must be evaluated by the superordinate protection device.
- Parameter: **Channel** = ***Arc mod. 1 channel 3***
- Parameter: **Operating mode** = ***Light only***
- Parameter: **Sensor** = ***Point sensor***
- Parameter: **External trip initiation** = ***no***

Stage 4 to 9 (External trip initiation):

- Parameter: **Operate & flt.rec. blocked** = ***no***
- Parameter: **Operating mode** = ***Current and light***

- Parameter: **External trip initiation** = ***yes***

  If an arc is detected in the busbar compartment, the circuit-breaker compartment, or the cable-connection compartment of the feeder, the feeder device sends the indication *Arc detected* to the infeed device. Only if the indication in the infeed device *Arc detected* is connected with the signal *>External Arc*, an external trip initiation via these stages is effective.

  The protection device in the infeed evaluates the current. If the measured current exceeds the **Threshold I>** and/or **Threshold 3I0>** threshold values, the protection device in the infeed clears the arc.

6.10.11 Application Example for Arc Protection with a Line Sensor in Operating Mode: Light and Current

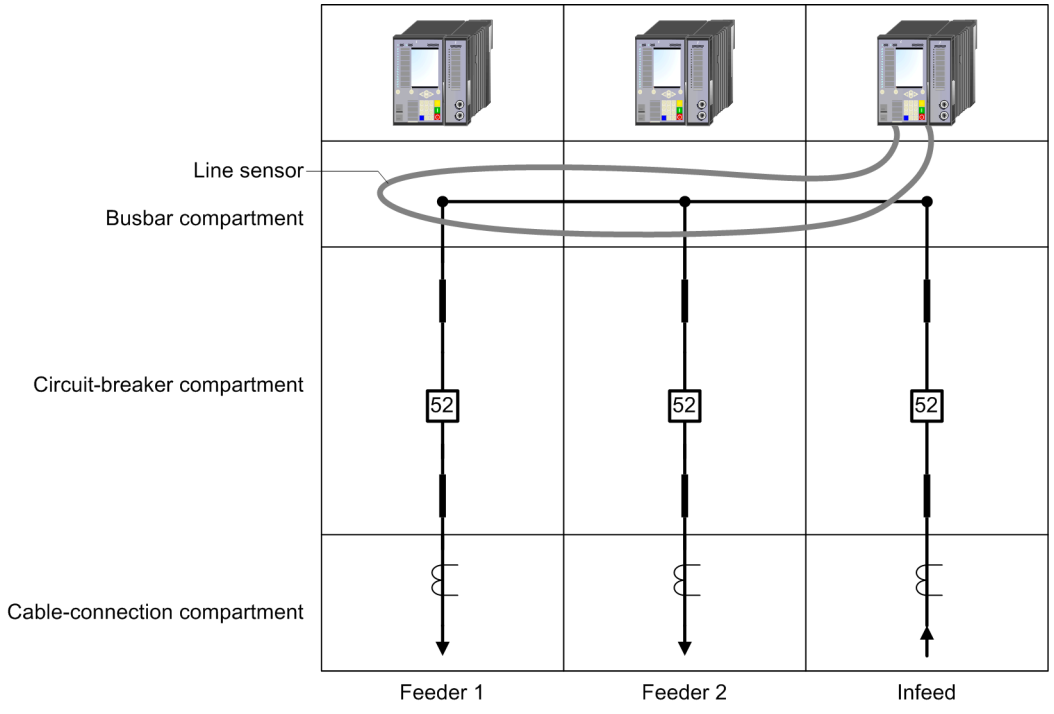
6.10.11.1 Description

Overview

The example describes the **Arc protection** function in a medium-voltage switchgear with 1 infeed and 2 feeders. The **Arc protection** function operates with the **Operating mode** = ***Current and light***. In the example, all arcs are detected by the protection device in the infeed.

The following items are considered in the example below:

- Optical line sensor placement in the switchgear
- Optical line sensor connection to the protection device in the infeed
- Number of necessary stages of the functions in the infeed protection device
- Setting notes about the selected parameters in the stages of the function



[dw_Liniensensor, 1, en_US]

Figure 6-95 Layout and Connection of the Optical Line Sensors (Operating Mode = Current and Light)

For this example, the following is assumed:

- The current-flow criterion offers additional protection to prevent unwanted tripping caused by the sudden effects of light.
- *Figure 6-95* shows how the optical line sensors should be routed. Start in the infeed busbar compartment and route the optical line sensor along the busbar and back again to the protection device in the infeed. Connect the optical line sensor to the protection device in the infeed.
- Depending on the routing options in the control cabinet, you can also route the optical line sensor through the circuit breaker and cable-connection compartments of the feeders.

  If this is not possible, you can detect arcs in these compartments using point sensors. For more detailed information, see chapters *6.10.8 Application Example for Arc Protection with Point Sensors in Operating Mode: Light Only* and *6.10.9 Application Example for Arc Protection with Point Sensors in Operating Mode: Light and Current*.
- If an arc occurs in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device will shut off.

NOTE

If the **Arc protection** function operates with the **Operating mode** = ***Current and light***, the additional current-flow criterion will prevent unwanted tripping caused by external light effects.

NOTE

Note that the number of arc protection modules that are connected to the device depend on the hardware configuration of the equipment.

When using modular equipment, a maximum of 15 sensors can be connected. If using non-modular equipment, a maximum of 6 sensors (3 sensors per module) can be connected.

Depending on the use case, you can combine point and line sensors.

6.10.11.2 Application and Setting Notes

Setting Notes for the Protection Device in the Infeed

The **Arc protection** function operates with **1** stage.

Set the parameters of the stage as follows:

- Parameter: **Operating mode** = ***Current and light***
- Parameter: **Sensor** = ***Line sensor***
- Parameter: **External trip initiation** = ***no***
- Parameter: **Channel** = ***Arc mod. 1 channel 1*** (Stage 1) → Busbar compartment supervision (infeed, feeder 1, feeder 2)

You can find more information about the settings of the parameters **Threshold I>** and **Threshold 3I0>** in chapter *6.10.4 Application and Setting Notes – General Settings*.

6.11 Instantaneous Tripping at Switch onto Fault

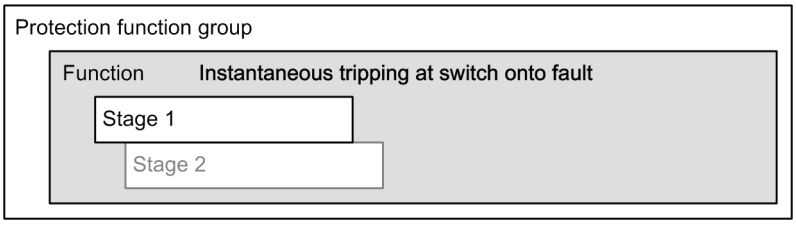
6.11.1 Overview of Functions

The **Instantaneous tripping at switch onto fault** function serves for immediate tripping when switching onto a fault.

The function does not have its own measurement and must be linked to another protection function with the pickup (measurement).

6.11.2 Structure of the Function

The function **Instantaneous tripping at switch onto fault** can be used in all protection function groups.The function is preconfigured with a stage. A maximum of 2 tripping stages can be operated simultaneously in the function. The stages have an identical structure.

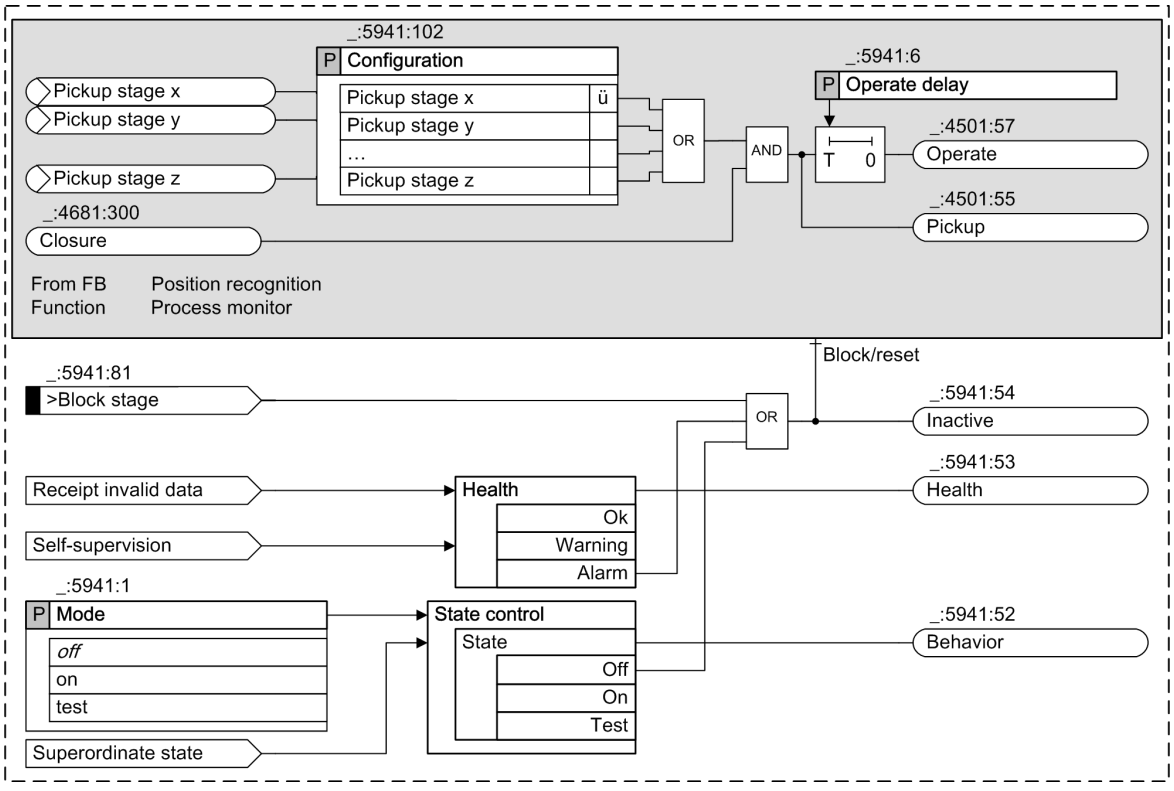


[dwstrsto-030211-01.tif, 1, en_US]

Figure 6-96 Structure/Embedding of the Function

6.11.3 Stage Description

Logic of the Stage



[logisotf-170312-01.tif, 1, en_US]

Figure 6-97 Logic Diagram of the Stage Instantaneous Tripping at Switch onto Fault

Connection of the Stage

The stage is intended to initiate instantaneous tripping when switching onto a fault. To do this, the stage must be connected to one or more pickups from protection functions or protection stages, for example, to pickup of an overcurrent-protection stage . That is, the stage of the **Instantaneous tripping at switch onto fault** function does not have its own measuring function but requires the pickup of another protection function or protection stage to pick up.

The stage is active only if switching is pending or executed (for this, see section *6.3 Overcurrent Protection, Phases*).

NOTE

If the pickup of a protection stage takes place and tripping is blocked by the **Inrush-current detection** function, no pickup of the **Instantaneous tripping at switch onto fault** function takes place. In this case, there is no fault recording neither. Despite this, if a fault recording is necessary, you can activate it with the parameter **(_:114) Start flt.rec** of the **Inrush-current detection** function (see chapter *6.8 Inrush-Current Detection*).

6.11.4 Application and Setting Notes

Parameter: Configuration

- Default setting **(_:5941:102) Configuration** = ***no stage***

The **Configuration** parameter is used to define with which pickup of a protection function or protection stage the **Instantaneous tripping at switch onto fault** function responds.

Normally, the pickups of protection functions and stages with high fault current are selected:

- Distance Protection
- Overcurrent protection (phase and ground)
- Directional time-overcurrent protection (phase and ground)

A specific protection stage is generally used. This can be one of the protection stages provided for the protection application, which itself trips with a delay. An additional protection stage with settings optimized for this use case, for example, increased threshold value and blocking of self-tripping, can also be used.

Parameter: Operate delay

- Recommended setting value **(_:5941:6) Operate delay** = ***0.00 s***

When switching onto a fault, the tripping should usually be instantaneous. The tripping delay is therefore set to 0.

6.11.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:5941:1	Stage 1:Mode		• off • on • test	off
_:5941:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:5941:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.00 s
_:5941:102	Stage 1:Configuration		Setting options depend on configuration	

6.11.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:5941:81	Stage 1:>Block stage	SPS	I
_:5941:54	Stage 1:Inactive	SPS	O
_:5941:52	Stage 1:Behavior	ENS	O
_:5941:53	Stage 1:Health	ENS	O
_:5941:55	Stage 1:Pickup	ACD	O
_:5941:57	Stage 1:Operate	ACT	O

6.12 Overcurrent Protection, 1-Phase

6.12.1 Function Overview

The **Overcurrent protection, 1-phase** function (ANSI 50N/51N):

- Detects and monitors the current measured in a transformer neutral point grounding
- Can operate as sensitive tank leakage protection
- Detects and monitors the circulating current between the neutral points of 2 capacitor banks
- Switches off high-current faults instantaneously

6.12.2 Structure of the Function

The **Overcurrent protection, 1-phase** function is used in protection function groups with 1-phase current measurement. 2 function types are offered:

- **Overcurrent protection, 1-phase – advanced** (50N/51N OC-1ph-A)
- **Overcurrent protection, 1-phase – basic** (50N/51N OC-1ph-B)

The function type Basic is provided for standard applications. The function type Advanced offers more functionality and is provided for more complex applications.

Both function types are pre-configured by the manufacturer with 2 **Definite time-overcurrent protection** stages and with 1 **Inverse time-overcurrent protection** stage.

In the function type **Overcurrent protection, 1-phase – advanced** the following stages can be operated simultaneously:

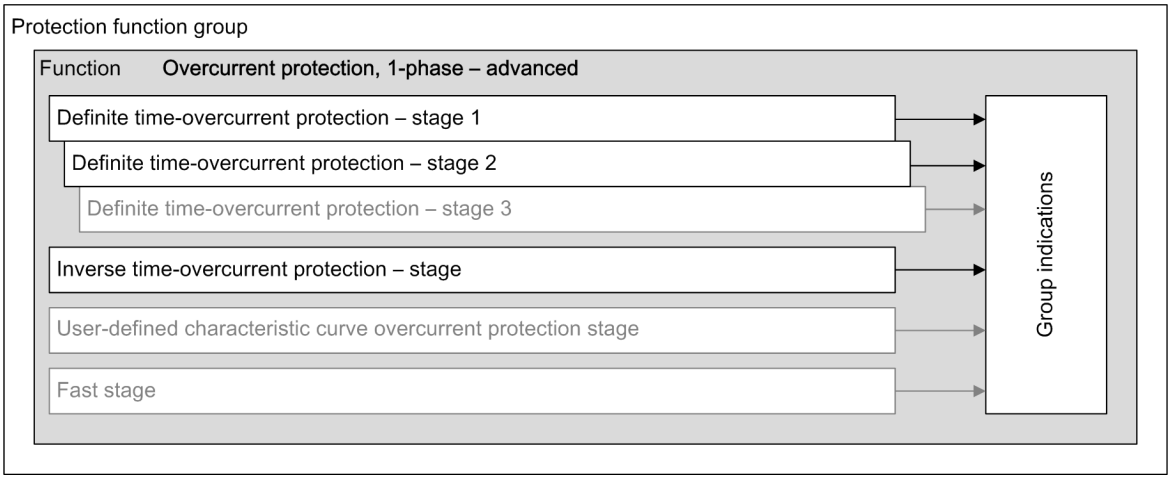
- Maximum of 3 stages **Definite time-overcurrent protection** (UMZ)
- 1 stage **Inverse time-overcurrent protection** (AMZ)
- 1 stage **User-defined characteristic curve overcurrent protection**
- 1 **Fast stage**

In the function type **Time-Overcurrent protection, 1-phase – basic**, the following stages can operate simultaneously:

- Maximum of 3 stages **Definite time-overcurrent protection**
- 1 stage **Inverse time-overcurrent protection**

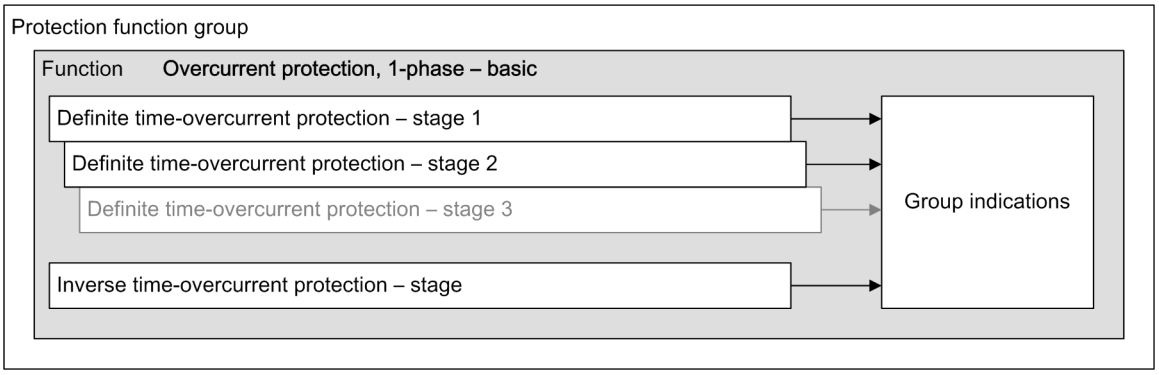
The non-preconfigured stages in *Figure 6-98* and *Figure 6-99* are shown in gray. Apart from the operate-delay characteristic curve, the **Definite time-overcurrent protection** stage, the **Inverse time-overcurrent protection** stage, and the **User-defined characteristic curve time-overcurrent protection** stage are structured identically.

The **Fast stage** uses a fast tripping algorithm. It is therefore suited in particular for sensitive ground-fault detection according to the high-impedance principle.



[dwocp1pa-280113-01.tif, 2, en_US]

Figure 6-98 Structure/Embedding the Function Overcurrent Protection, 1-Phase – Advanced



[dwocp1pb-310113-01.tif, 2, en_US]

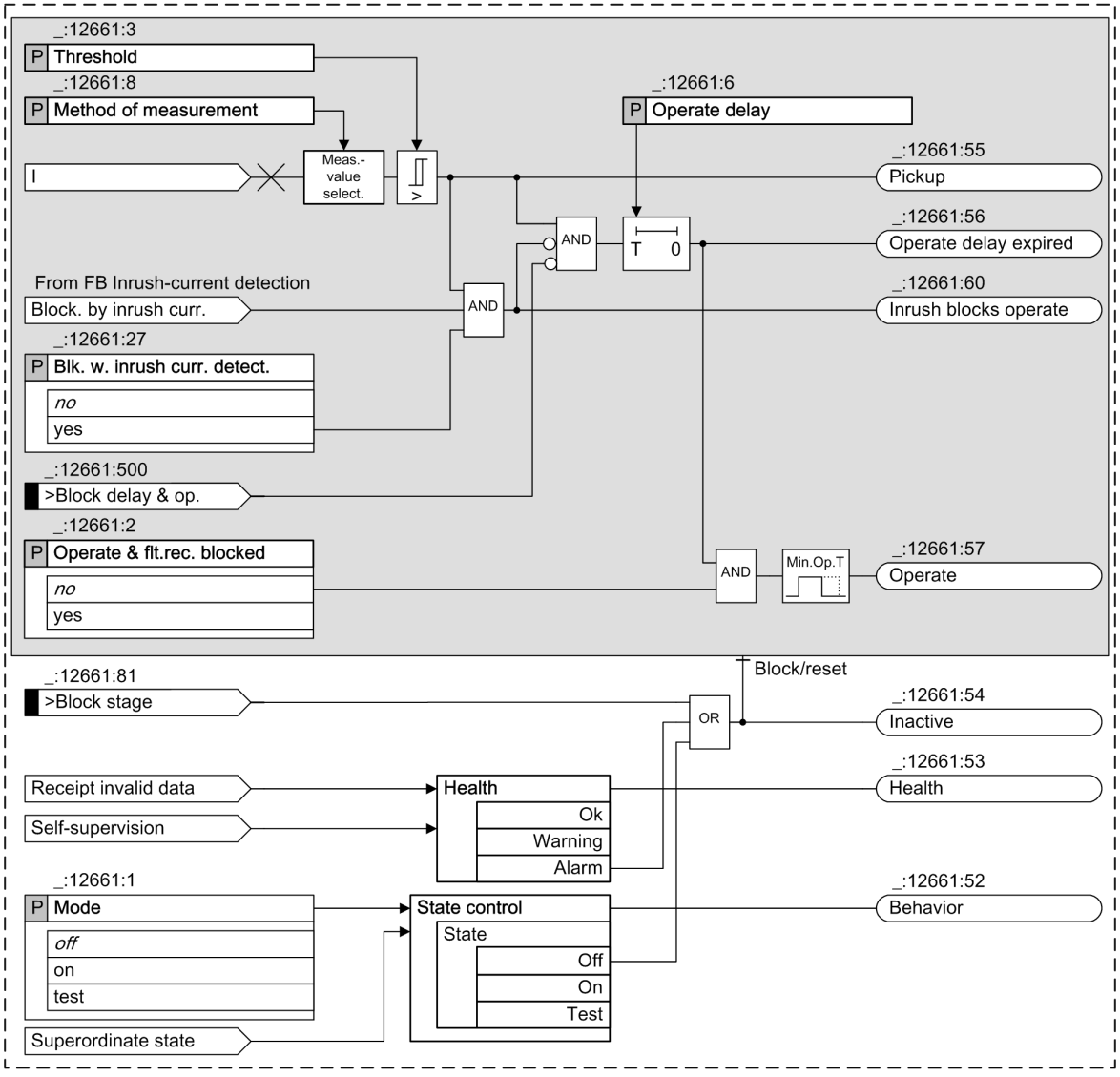
Figure 6-99 Structure/Embedding the Function Overcurrent Protection, 1-Phase – Basic

If the device is equipped with the **Inrush-current detection** function, you can stabilize the stages against issuing of the operate indication due to transformer inrush-currents.

6.12.3 Stage with Definite-Time Characteristic Curve

6.12.3.1 Description

Logic of a Stage



[loinvocp-270612-01.tif, 1, en_US]

Figure 6-100 Logic Diagram of the Definite Time-Overcurrent Protection, 1-Phase

Method of measurement

You use the **`Method of measurement`** parameter to define whether the stage uses the ***`fundamental comp.`*** or the calculated ***`RMS value`***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Blocking of the Stage

The picked up stage can reset completely via the binary input signal *>Block stage*.

Blocking of the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also tripping. A running time delay is reset. The pickup is reported and a fault is opened.

Blocking of Tripping via the Device-Internal Inrush-Current Detection Function

With the **Blk. w. inrush curr. detect.** parameter, you can block the operate indication of the stage for a threshold-value violation due to the inrush current. In case of a blocking, the stage picks up. The start of the time delay and the operate indication are blocked. The function signals this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. When complete, the stage generates an operate indication. The blocking can only be set if the central function **Inrush-current detection** is effective.

Blocking of tripping with the **Inrush-current detection** function is possible only if the following conditions have been met:

- The central **Inrush-current detection** function has to be available in another protection function group with 3-phase current measurement.
- You have to connect the protection function group with 1-phase current measurement to the protection function group with 3-phase current measurement. You connect protection function groups in the DIGSI 5 Project Tree → Name of the device → **Function group connections**.

Related Topics

6.3.7.1 Description

6.12.3.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:12661:8) Method of measurement** = ***fundamental comp.***

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: Threshold, Operate delay

- Default setting **(_:12661:3) Threshold** = ***1.200 A*** (for the first stage)
- Default setting **(_:12661:6) Operate delay** = ***0.300 s*** (for the first stage)

Set the **Threshold** and **Operate delay** parameters for the specific application.

6.12.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Definite-T 1				
_:12661:1	Definite-T 1:Mode		• off • on • test	off
_:12661:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:12661:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:12661:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:12661:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:12661:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

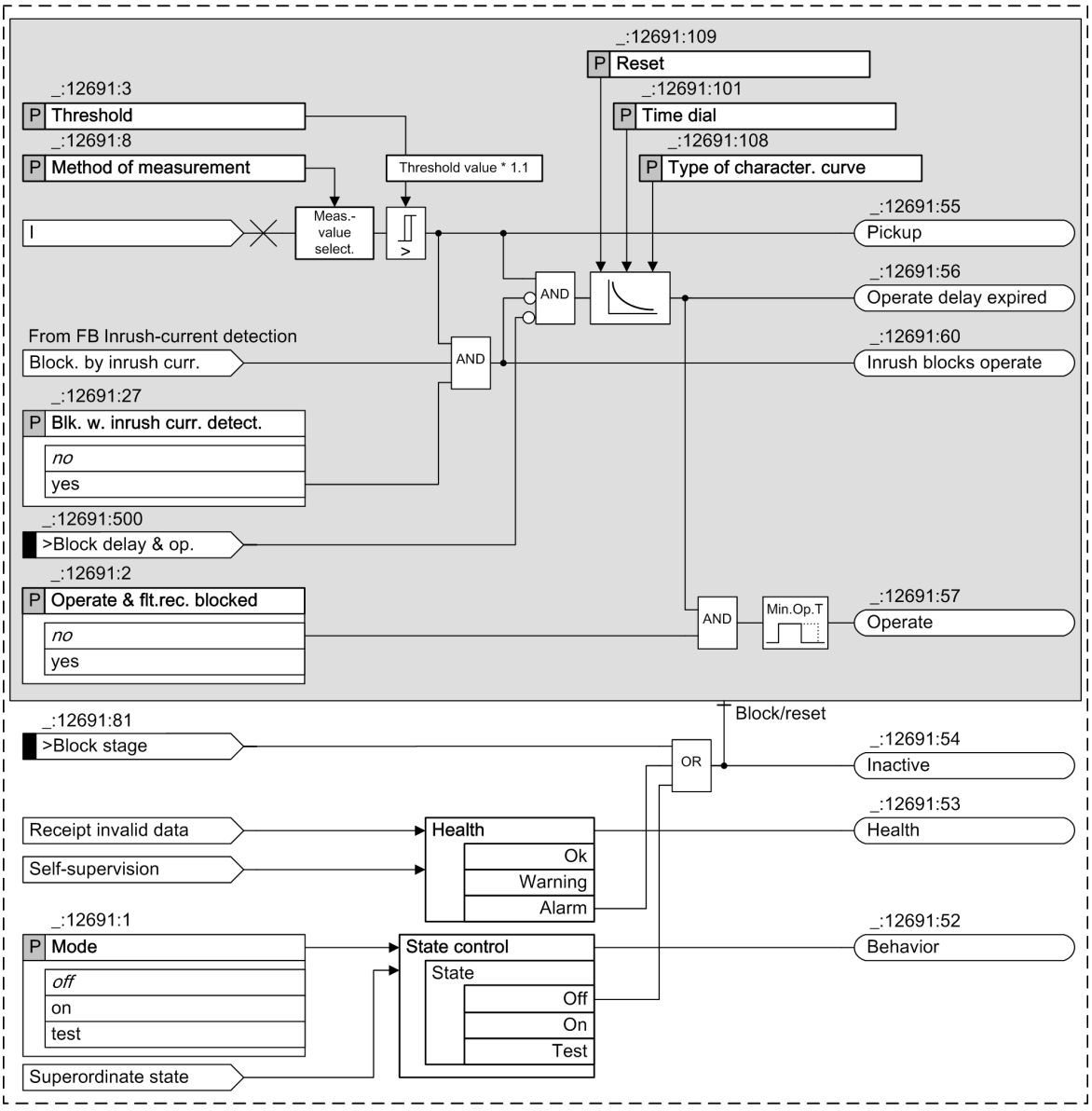
6.12.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:12661:81	Definite-T 1:>Block stage	SPS	I
_:12661:500	Definite-T 1:>Block delay & op.	SPS	I
_:12661:54	Definite-T 1:Inactive	SPS	O
_:12661:52	Definite-T 1:Behavior	ENS	O
_:12661:53	Definite-T 1:Health	ENS	O
_:12661:60	Definite-T 1:Inrush blocks operate	ACT	O
_:12661:55	Definite-T 1:Pickup	ACD	O
_:12661:56	Definite-T 1:Operate delay expired	ACT	O
_:12661:57	Definite-T 1:Operate	ACT	O

6.12.4 Stage with Inverse-Time Characteristic Curve

6.12.4.1 Description

Logic of the Stage



[lodefocp-270612-01.tif, 1, en_US]

Figure 6-101 Logic Diagram of the Inverse Time-Overcurrent Protection (1-Phase)

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The

dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Method of Measurement

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the calculated ***RMS value***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Blocking of the Stage

The picked up stage can reset completely via the binary input signal *>Block stage*.

Blocking of the Time Delay

You can use the binary input signal **>Block delay & op.** to prevent the start of the time delay and thus also tripping. A running time delay is reset. The pickup is reported and a fault is opened.

Blocking of Tripping via the Device-Internal Inrush-Current Detection Function

With the **Blk. w. inrush curr. detect.** parameter, you can block the operate indication of the stage for a threshold-value violation due to the inrush current. In case of a blocking, the stage picks up. The start of the time delay and the operate indication are blocked. The function signals this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. When complete, the stage generates an operate indication.

Blocking of tripping with the **Inrush-current detection** function is possible only if the following conditions have been met:

- The central **Inrush-current detection** function has to be available in another protection function group with 3-phase current measurement.
- You have to connect the protection function group with 1-phase current measurement to the protection function group with 3-phase current measurement. You connect protection function groups in the DIGSI 5 Project Tree → Name of the device → **Function group connections**.

6.12.4.2 Application and Setting Notes

Parameter: **Method of measurement**

- Recommended setting value **(_:12691:8) Method of measurement** = ***fundamental comp.***

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: `Type of character. curve`

- Default setting **`(_:12691:108) Type of character. curve`** = ***`IEC normal inverse`***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **`Type of character. curve`** required for your specific application.

Parameter: `Threshold`

- Default setting **`(_:12691:3) Threshold`** = ***`1.20 A`***

Set the **`Threshold`** and **`Type of character. curve`** parameters for the specific application.

Note that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the **`Threshold`**.

Parameter: `Time dial`

- Default setting **`(_:12691:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter **`Time dial`** at ***`1`*** (default setting).

Parameter: `Reset`

- Default setting **`(_:12691:109) Reset`** = ***`disk emulation`***

You use the **`Reset`** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

6.12.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Inverse-T 1`				
_:12691:1	Inverse-T 1:Mode		• off • on • test	off
_:12691:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:12691:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:12691:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:12691:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:12691:108	Inverse-T 1:Type of character. curve			

Addr.	Parameter	C	Setting Options	Default Setting
_:12691:109	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:12691:101	Inverse-T 1:Time dial		0.05 to 15.00	1.00

6.12.4.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:12691:81	Inverse-T 1:>Block stage	SPS	I
_:12691:500	Inverse-T 1:>Block delay & op.	SPS	I
_:12691:54	Inverse-T 1:Inactive	SPS	O
_:12691:52	Inverse-T 1:Behavior	ENS	O
_:12691:53	Inverse-T 1:Health	ENS	O
_:12691:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:12691:59	Inverse-T 1:Disk emulation running	SPS	O
_:12691:55	Inverse-T 1:Pickup	ACD	O
_:12691:56	Inverse-T 1:Operate delay expired	ACT	O
_:12691:57	Inverse-T 1:Operate	ACT	O

6.12.5 Stage with User-Defined Characteristic Curve

6.12.5.1 Description

The **User-defined characteristic curve time-overcurrent protection** stage is only available in the advanced function type.

This stage is structured the same way as the stage with the inverse-time characteristic curve. The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

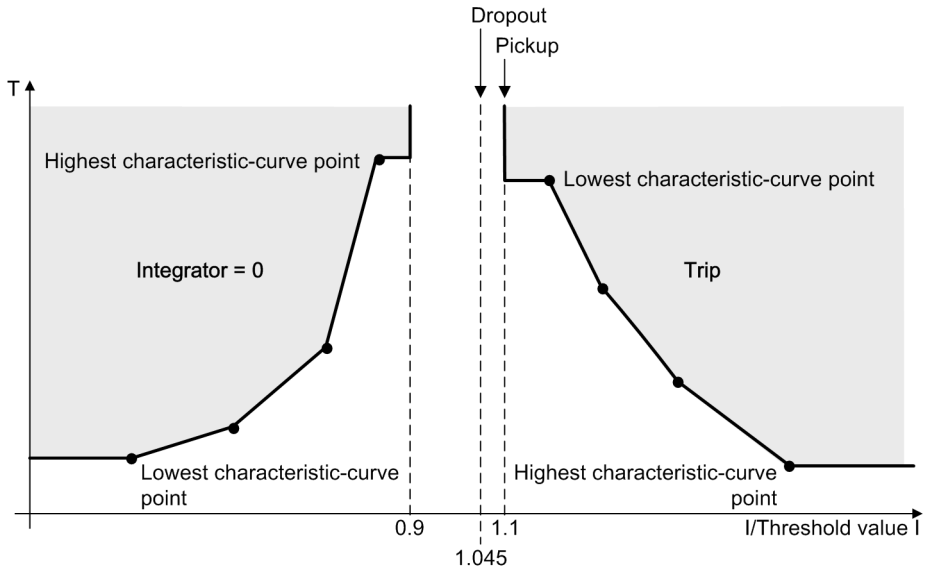
With the user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

Pickup and Dropout Behavior with the User-Defined Characteristic Curve

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.



[dwocpken-140611-02.tif, 1, en_US]

Figure 6-102 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

Note that the currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

6.12.5.2 Application and Setting Notes

This stage is structured the same way as the stage with the inverse-time characteristic curve. The only difference is that you can define the characteristic curve as desired. This chapter only provides application and setting notes for setting characteristic curves.

Parameter: `Current/time value pairs` (from the operate curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: `Time dial`

- Default setting **`(_:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the **`Time dial`** parameter at ***`1`***.

Parameter: `Reset`

- Default setting **`Reset`** = ***`disk emulation`***

You use the **`Reset`** parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
`disk emulation`	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
`instantaneous`	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: `Current/time value pairs` (of the dropout characteristic curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the **`Threshold`** parameter to ***`1.00`*** in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the **`Time dial`** parameter.



NOTE

The value pairs must be entered in continuous order.

6.12.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00

6.12.5.4 Information List

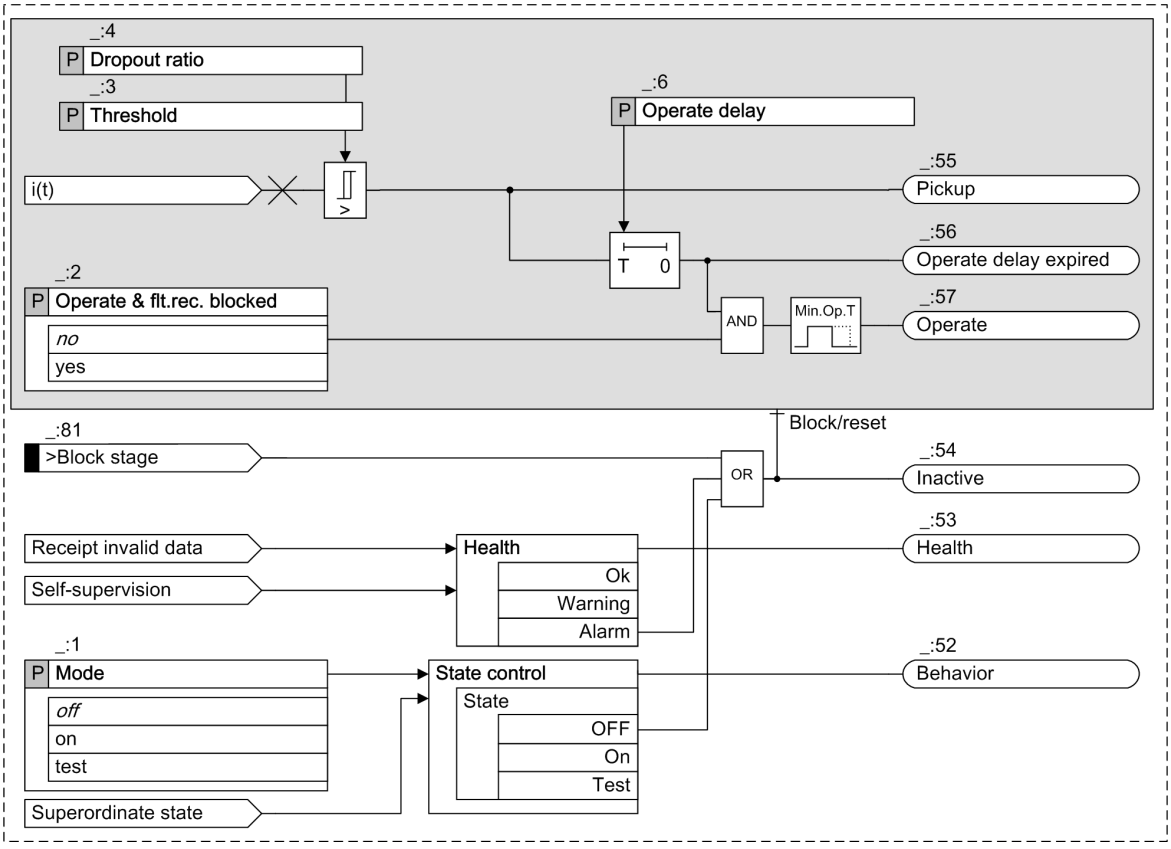
No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.12.6 Fast Stage

6.12.6.1 Description

Logic of a Stage

The fast stage is only available in function type Advanced.



[loocp1hs-280113-01.tif, 2, en_US]

Figure 6-103 Logic Diagram of the Fast Stage, 1-Phase

Method of Measurement, Pickup and Dropout Behavior of the Fast Stage

This stage evaluates the unfiltered measurands. Thus, very short response times are possible. When the absolute values of 2 consecutive sampled values of the last half period exceed the **Threshold**, the stage picks up. When all sampled values of the previous period are less than the dropout threshold, the stage drops out.

Blocking of the Stage

The picked up stage can reset completely via the binary input signal *>Block stage*.

6.12.6.2 Application and Setting Notes

Parameter: Threshold, Operate delay

- Default setting **(_:3) Threshold** = ***10.00 A***
- Default setting **(_:6) Operate delay** = ***0.00 s***

Set the **Threshold** and **Operate delay** parameters for the specific application.

Ensure that the sampled values are compared directly without an additional factor with the set threshold value.

Parameter: Dropout ratio

- Recommended setting value **(_:4) Dropout ratio** = ***0.90***

The recommended setting value of ***0.90*** is sufficient for many applications. To obtain high-precision measurements, the **Dropout ratio** can be reduced. If you expect highly fluctuating measurands at the pickup threshold, you can increase the **Dropout ratio** setting. This avoids chattering of the tripping stage.

6.12.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Fast stage #				
_:1	Fast stage #:Mode		• off • on • test	off
_:2	Fast stage #:Operate & flt.rec. blocked		• no • yes	no
_:3	Fast stage #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	10.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	50.000 A
_:4	Fast stage #:Dropout ratio		0.90 to 0.99	0.90
_:6	Fast stage #:Operate delay		0.00 s to 60.00 s	0.00 s

6.12.6.4 Information List

No.	Information	Data Class (Type)	Type
Fast stage #			
_:81	Fast stage #:>Block stage	SPS	I
_:54	Fast stage #:Inactive	SPS	O
_:52	Fast stage #:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:53	Fast stage #:Health	ENS	O
_:55	Fast stage #:Pickup	ACD	O
_:56	Fast stage #:Operate delay expired	ACT	O
_:57	Fast stage #:Operate	ACT	O

6.12.7 Application Example: High-Impedance Restricted Ground-Fault Protection

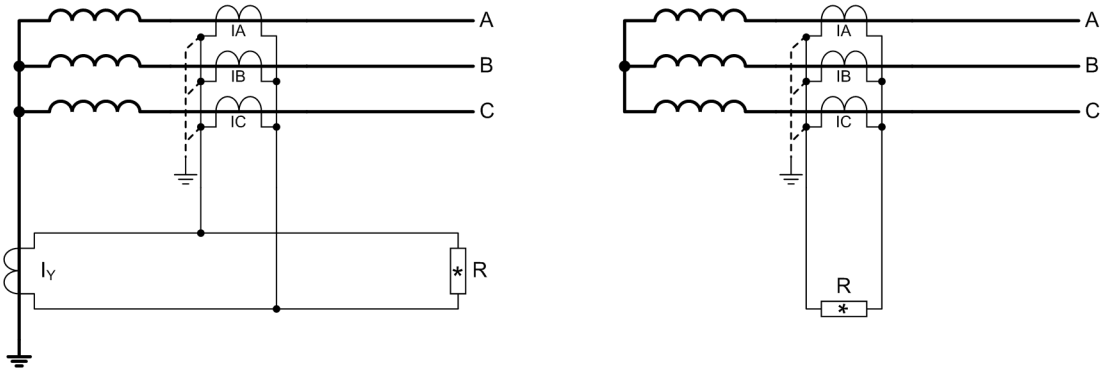
6.12.7.1 Description

With the high-impedance method, all current transformers operate in parallel at the limits of the protection range on a common, relatively high-impedance resistor R, the voltage of which is measured.

The current transformers must be of the same type of construction and have at least one core of their own for the High-impedance restricted ground-fault protection. Furthermore, they must have the same transfer ratio and approximately the same knee-point voltage.

The high-impedance principle is especially suited for ground-fault detection in grounded networks at transformers, generators, motors, and shunt reactors.

The left part of *Figure 6-104* shows an application example for a grounded transformer winding or a grounded motor/generator. The example at the right shows an ungrounded transformer winding or an ungrounded motor/generator. In this example, it is assumed that the network is grounded at a different point.



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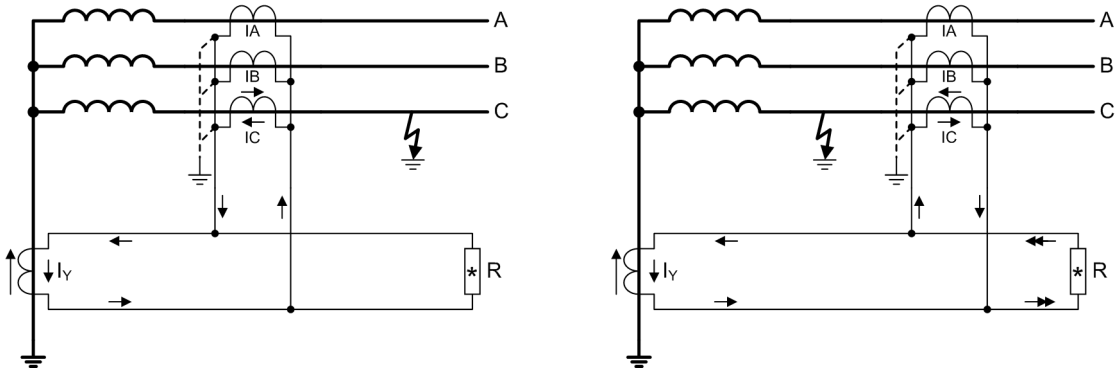
Figure 6-104 Restricted Ground-Fault Protection According to the High-Impedance Principle

Function of the High-Impedance Principle

The high-impedance principle is explained using the example of a grounded transformer winding.

In normal state, no residual currents flow, that is, in the transformer neutral point $I_Y = 0$ and in the phases $3I_0 = I_A + I_B + I_C = 0$.

With an external ground fault (on the left in *Figure 6-105*), the short-circuit current of which is fed via a grounded neutral point, the same current flows in the transformer neutral point and in the phases. The respective secondary currents (with the same transfer ratio of all current transformers) draw each other off. They are connected in series. At the resistor R, only a little voltage arises, which results from the internal resistances of the transformers and those of the transformer connection lines. Even if a current transformer is briefly saturated, it becomes a low-impedance during the time of the saturation and forms a low-impedance shunt to the high-impedance resistor R. The high resistance of the resistor thus has a stabilizing effect (so-called resistor stabilization).



[dwprhimp-310113-01.tif, 2, en_US]

Figure 6-105 Principle of the Restricted Ground-Fault Protection According to the High-Impedance Principle

With a ground-fault in the protection range (on the right in *Figure 6-105*), a neutral-point current I_Y flows in any case. The magnitude of the residual current in the phase currents depends on the grounding conditions in the rest of the network. A secondary current corresponding to the entire short-circuit current attempts to flow via the resistor R. But since this resistor is high-impedance, a high voltage arises there which causes the saturation of the current transformers. The effective voltage at the resistor therefore corresponds approximately to the knee-point voltage of the current transformers.

The resistor R is thus dimensioned in such a way that even the smallest ground-fault current to be detected leads to a secondary voltage that corresponds to half of the knee-point voltage of the current transformers (see chapter 2.5.4).

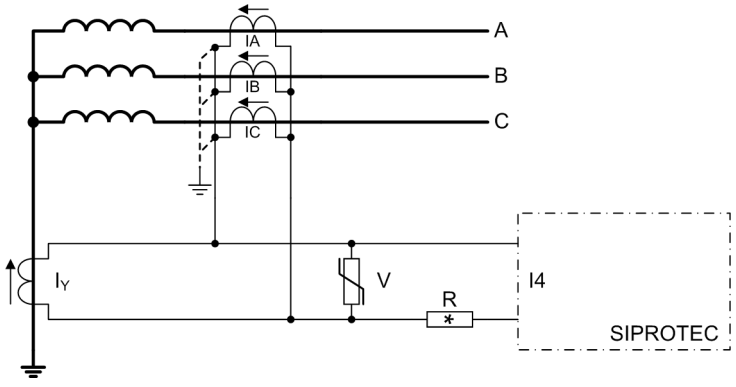
Further information can be found at Sensitivity view for high-impedance ground-fault differential protection in chapter *6.12.7.2 Application and Setting Notes* .

High-Impedance Restricted Ground-Fault Protection with a SIPROTEC 5 Device

Use the I4 measuring input of the SIPROTEC 5 device for the high-impedance restricted ground-fault protection. This input for this application is to be executed as a sensitive measuring input. Since this is a current input, the current is detected by this resistor instead of the voltage at the resistor R.

Figure 6-106 shows the connection diagram. The protection device is connected in series with the resistor R and thus measures its current.

The varistor V limits the voltage in case of an internal fault. The varistor cuts the high instantaneous voltage peaks in the case of transformer saturation. Simultaneously, a smoothing of the voltage arises without any relevant reduction of the average value.



[dwanedif-310113-01.tif, 2, en_US]

Figure 6-106 Connection Diagram of the Restricted Ground-Fault Protection According to the High-Impedance Principle

As a protection against overvoltages, it is important that you connect the device directly at the grounded side of the current transformer. The high voltage at the resistor is thus kept away from the device.

In a similar manner, the high-impedance restricted ground-fault protection for generators, motors, and shunt reactors is used. With auto transformers, you must connect the upper-voltage side and low-voltage side current transformers and neutral-point transformer in parallel.

The method can be realized for each protected object. As busbar protection, the device, for example, is connected via the resistor to the parallel connection of the transformers of all feeders.

6.12.7.2 Application and Setting Notes

A prerequisite for the application of the high-impedance restricted ground-fault protection is that neutral-point current detection is possible on the station side (see example in (*Figure 6-106*). Furthermore, a sensitive input transformer must be available at device input I4. Set the pickup value for current at input I4 with the function **Overcurrent protection, 1-phase**.

Observe the interaction between current-transformer characteristic curve, external resistor R, and the voltage at R for the overall function of the high-impedance restricted ground-fault protection. Notes on this follow.

Current Transformer Data for High-Impedance Restricted Ground-Fault Protection

All affected current transformers must have the same ratio and approximately the same knee-point voltage. This is normally the case when the current transformers are of the same type and have the same rated data. You can calculate the knee-point voltage from the rated data as follows:

$$V_{KP} = \left(R_i + \frac{P_{rated}}{I_{rated}^2} \right) \cdot n \cdot I_{rated}$$

[foukniep-310113-01.tif, 1, en_US]

V_{KP}	Knee-point voltage
Ri	Internal resistance of the current transformer
P_{rated}	Rated power of the current transformer
I_{rated}	Secondary rated current of the current transformer
n	Rated overcurrent factor

Rated current, rated power, and overcurrent factor are found on the name plate of the transformer.

EXAMPLE

Current transformer with the following data on the name plate: 800/5; 5P10; 30 VA

You can read the following transformer data with this data:

I_{rated}	= 5 A (out of 800/**5**)
n	= 10 (out of 5P**10**)
P_{rated}	= **30** VA

The internal resistance is frequently to be found in the test report of the transformer. If it is not known, it can be approximately determined by a direct current measurement at the secondary winding.

EXAMPLE

Calculation of the knee-point voltage

Current transformer 800/5; 5P10; 30 VA with $R_i = 0.3\ \Omega$

$$V_{KP} = \left(R_i + \frac{P_{rated}}{I_{rated}^2} \right) \cdot n \cdot I_{rated} = \left(0.3\ \Omega + \frac{30\ VA}{(5\ A)^2} \right) \cdot 10 \cdot 5\ A = 75\ V$$

[foukp5aw-310113-01.tif, 1, en_US]

Current transformer 800/1; 5P10; 30 VA with $R_i = 5\ \Omega$

$$V_{KP} = \left(R_i + \frac{P_{rated}}{I_{rated}^2} \right) \cdot n \cdot I_{rated} = \left(5\,\Omega + \frac{30\ VA}{(1\,A)^2} \right) \cdot 10 \cdot 1\,A = 350\ V$$

[foukp1aw-310113-01.tif, 1, en_US]

Besides the current-transformer data, the resistance of the longest connection line between transformer and device must be known.

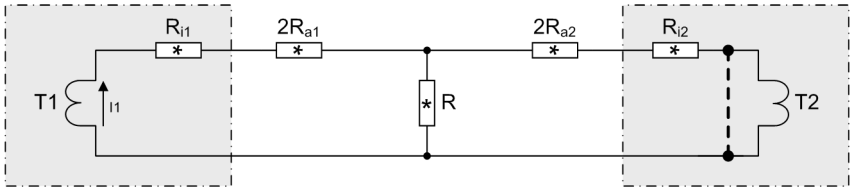
Stability Consideration for High-Impedance Restricted Ground-Fault Protection

The stability condition is based on the simplified assumption that one current transformer is completely saturated and the others transfer their partial currents proportionately in the case of an external fault. This is theoretically the worst case. A safety margin is automatically provided, since, in practice, even the saturated transformer still delivers some current.

Figure 6-107 shows an equivalent circuit of this simplification. CT1 and CT2 are assumed to be ideal transformers with their internal resistances R_{i1} and R_{i2}. R_a are the core resistances of the connection lines between transformer and resistance R; they are used doubled (forward line and return line). R_{a2} is the resistance of the longest connection line.

CT1 transmits the current I1. CT2 is assumed to be saturated. This is indicated by the dotted short-circuit line. The transformer thus represents a low-impedance shunt by its saturation.

A further prerequisite is $R >> (2R_{a2} + R_{i2})$.



[dwvebhdi-310113-01.tif, 2, en_US]

Figure 6-107 Simplified Connection Diagram of a Layout for High-Impedance Restricted Ground-Fault Protection

The voltage at R is, then,

$V_R = I_1 \cdot (2R_{a2} + R_{i2})$

A further assumption is that the pickup value of the SIPROTEC 5 device corresponds to half of the knee-point voltage of the current transformers. In the edge case,

$V_R = V_{KP}/2$

The stability limit I_{SL} results, which means the through-current up to which the arrangement remains stable:

$$I_{SL} = \frac{V_{KP}/2}{2 \cdot R_{a2} + R_{i2}}$$

[foistabl-310113-01.tif, 1, en_US]

EXAMPLE

For the 5 A transformer as above with V_{KP} = 75 V and R_i = 0.3 Ω

Longest connection line = 22 m with 4 mm² cross-section; that corresponds to R_a = 0.1 Ω

$$I_{SL} = \frac{V_{KP}/2}{2 \cdot R_{a2} + R_{i2}} = \frac{37.5\ V}{2 \cdot 0.1\,\Omega + 0.3\,\Omega} = 75\ A$$

[foisl5aw-310113-01.tif, 1, en_US]

In the example, the stability limit is 15 × rated current or 12 kA primary.

For the 1 A transformer as above with V_{KP} = 350 V and R_i = 5 Ω

Longest connection line = 107 m with 2.5 mm^2 cross-section; that corresponds to R_a = 0.75 Ω

$$I_{SL} = \frac{V_{KP}/2}{2 \cdot R_{a2} + R_{i2}} = \frac{175\ V}{2 \cdot 0.75\ \Omega + 5\ \Omega} = 27\ A$$

[foisl1aw-310113-01.tif, 1, en_US]

In the example, the stability limit is 27 × rated current or 21.6 kA primary.

Sensitivity Consideration for High-Impedance Restricted Ground-Fault Protection

The voltage present at the set of current transformers is supplied to the protection device via a series resistor R as proportional current for evaluation. For dimensioning of the resistor, the following must be taken into account:

The high-impedance restricted ground-fault protection should pick up at approximately half of the knee-point voltage of the current transformers. From this, you can calculate the resistor R.

Since the device measures the current through the resistor, the resistor and measuring input of the device must be connected in series. Since the resistor still should be high-impedance (aforementioned condition R >> $2R_{a2} + R_{i2}$), the inherent resistance of the measuring input can be neglected. The resistance results thus from the pickup current I_{pick} and half of the knee-point voltage:

$$R = \frac{V_{KP}/2}{I_{pick.}}$$

[foberecr-310113-01.tif, 1, en_US]

EXAMPLE

For the 5 A transformer as above

Desired pickup value I_{pick} = 0.1 A (corresponds to 16 A primary)

$$R = \frac{V_{KP}/2}{I_{pick.}} = \frac{75\ V/2}{0.1\ A} = 375\ \Omega$$

[fober5aw-310113-01.tif, 1, en_US]

For the 1 A transformer as above

Desired pickup value I_{pick} = 0.05 A (corresponds to 40 A primary)

$$R = \frac{V_{KP}/2}{I_{pick.}} = \frac{350\ V/2}{0.05\ A} = 3500\ \Omega$$

[fober1aw-310113-01.tif, 1, en_US]

The series resistor R must be designed for a minimum continuous load $P_{continuous}$.

$$P_{continuous} \geq \frac{(V_{KP}/2)^2}{R} = \frac{37.5^2}{375} = 3.75\ W \qquad \text{at the 5-A-transformer}$$

[fopdau5a-310113-01.tif, 1, en_US]

$$P_{continuous} \geq \frac{(V_{KP}/2)^2}{R} = \frac{175^2}{3500} = 8.75\ W \qquad \text{at the 1-A-transformer}$$

[fopdau1a-310113-01.tif, 1, en_US]

Further, the series resistor R must be designed for a fault current lasting approximately 0.5 s. This time is usually sufficient for fault clarification through backup protection.

The thermal stress of the series resistor depends on the voltage $V_{RMS,stab}$ that is present during an internal fault. It is calculated according to the following equations:

$$V_{RMS,rest} = 1.3 \cdot \sqrt[4]{V_{KP}^3 \cdot R \cdot I_{K,max,int}} = 1.3 \cdot \sqrt[4]{75^3 \cdot 375 \cdot 250} = 579.7\ V \qquad \text{at the 5-A-transformer}$$

[fousta5a-310113-01.tif, 1, en_US]

$$V_{RMS,rest} = 1.3 \cdot \sqrt[4]{V_{KP}^3 \cdot R \cdot I_{K,max,int}} = 1.3 \cdot \sqrt[4]{350^3 \cdot 3500 \cdot 50} = 2151.6\ V \qquad \text{at the 1-A-transformer}$$

[fousta1a-310113-01.tif, 1, en_US]

$I_{K,max,int}$ corresponds to the maximum fault current here in the case of an internal fault.

5-A current transformer 800/5 with 40 kA primary corresponds to $I_{K,max,int}$ = 250 A secondary.

1-A current transformer 800/1 with 40 kA primary corresponds to $I_{K,max,int}$ = 50 A secondary.

This results in a temporary load for the series resistor over 0.5 s of:

$$P_{0.5\,s} = \frac{V_{RMS,rest}^2}{R} = \frac{579.7^2}{375} = 896\ W \qquad \text{at the 5-A-transformer}$$

[fop05s5a-310113-01.tif, 1, en_US]

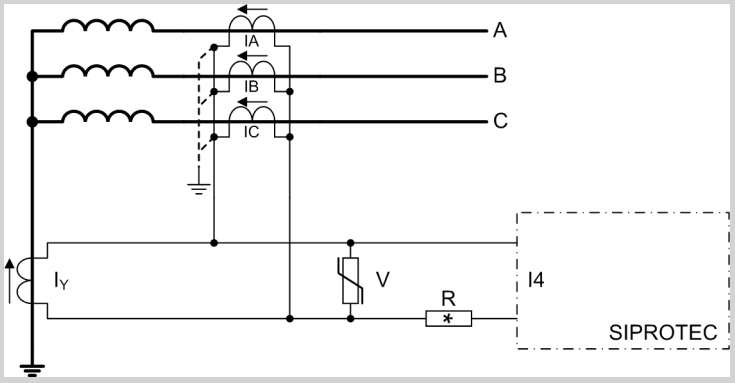
$$P_{0.5\,s} = \frac{V_{RMS,rest}^2}{R} = \frac{2151.6^2}{3500} = 1322.7\ W \qquad \text{at the 1-A-transformer}$$

[fop05s1a-310113-01.tif, 1, en_US]

Observe that with the selection of a higher pickup value I_{pick}, the resistor value must be lowered and therefore the dissipation rises sharply.

The varistor (see following figure) must be sized such that it remains high impedance up to the knee-point voltage, for example:

- Approx. 100 V with 5 A transformer
- Approx. 500 V with 1 A transformer



[dwanedif-310113-01.tif, 2, en_US]

Figure 6-108 Connection Diagram of the Restricted Ground-Fault Protection According to the High-Impedance Principle

Even with unfavorable wiring, the maximum occurring voltage peaks do not exceed 2 kV for safety reasons.

When for performance reasons, several varistors must be connected in parallel, give preference to types with flat characteristic curves, in order to avoid an unbalanced load. Siemens therefore recommends the following types by METROSIL:

600A/S1/S256 (k = 450, β = 0.25)

600A/S1/S1088 (k = 900, β = 0.25)

In the example, set the pickup value of the first Definite time-overcurrent protection stage (setting **`Threshold`**) to 0.1 A for 5-A transformers or 0.05 A for 1-A transformers. No further protection stages are needed. Delete these or switch them off. Set the **`Operate delay`** setting to 0 s.

If several current transformers are connected in series, for example, with use as busbar protection with several feeders, the magnetization currents of the transformers switched in parallel can no longer be neglected. In

this case, add up the magnetization currents at half of the knee-point voltage (corresponds to the set **Threshold**). These magnetization currents reduce the current through the resistor R. Thus, the actual pickup value is correspondingly higher.

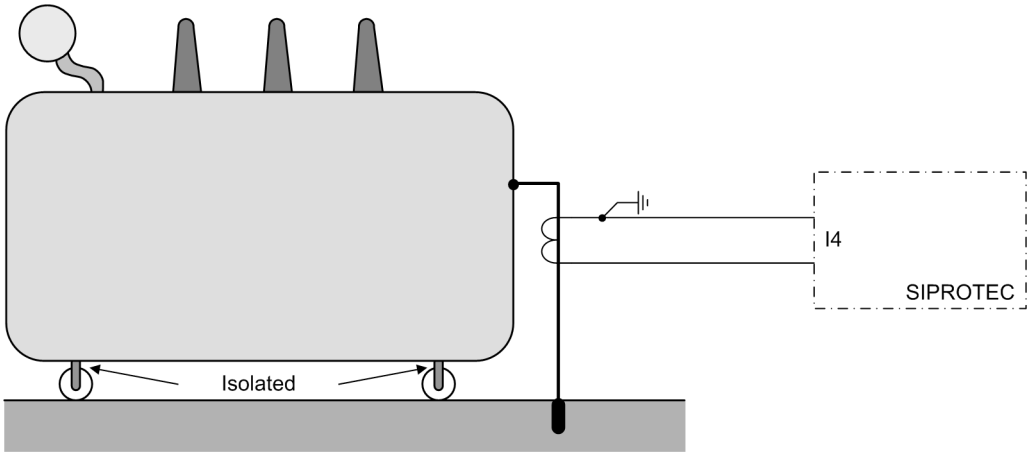
6.12.8 Application Example: Tank Leakage Protection

6.12.8.1 Description

Tank leakage protection records short-circuits to ground – including high-impedance ones – between a phase and the tank of a transformer. The tank is thus insulated, or at least grounded with high impedance. The tank must be connected with a line to ground. The current that flows through this line is fed to the protection device. If a short-circuit to ground occurs in a tank, a fault current (tank current) flows to substation ground via the ground connection.

The function **Overcurrent protection, 1-phase** detects the tank current. If the tank current exceeds the set **Threshold**, the function **Overcurrent protection, 1-phase** generates an operate indication. Depending on the set **Operate delay**, the transformer is tripped immediately or time-delayed on all sides.

For tank protection, a sensitive, 1-phase current measuring input is used.



[dwprkess-310113-01.tif, 2, en_US]

Figure 6-109 Tank-Control Principle

6.12.8.2 Application and Setting Notes

A prerequisite for the application of tank protection is the availability of a sensitive input transformer at device input I4.

If you connect **Measuring point I 1-ph** with the function group **Voltage-current 1-phase**, the function **Overcurrent protection, 1-phase** works with the 1-phase current connected to input I4.

Use only the first definite time-overcurrent protection stage of function **Overcurrent protection, 1-phase**. The **Threshold** setting is used to set the pickup value. No further protection stages are needed. Delete these or switch them off. Set the **Operate delay** setting to 0 s.

6.13 Non-Directional Intermittent Ground-Fault Protection

6.13.1 Overview of Functions

A typical characteristic of intermittent ground faults is that they often extinguish automatically and strike again after some time. The fault duration can last between a few milliseconds and many seconds. Thus, such faults are not detected at all or not selectively by the ordinary overcurrent protection. If pulse durations are extremely short, not all protection devices in a short-circuit path can pick up. Thus, selective tripping is not ensured.

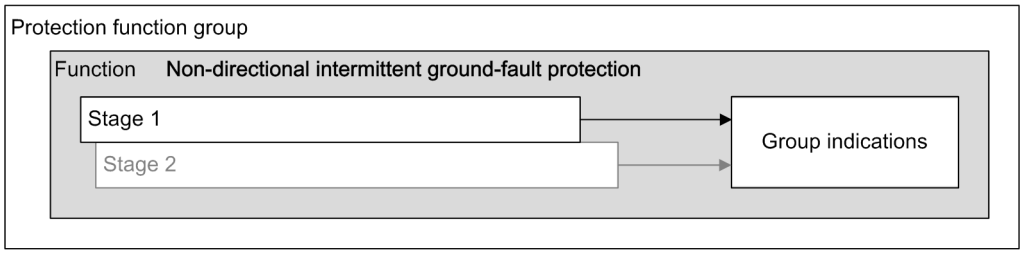
Due to the time delay of the overcurrent protection function, such faults are too short to initiate switching off the faulted cable. The short-circuit protection can clear such ground faults selectively only if the ground faults have become permanent.

But such intermittent ground faults already bear the risk of damaging the equipment thermally. This is why SIPROTEC 5 devices feature a protection function that is able to detect such intermittent ground faults and accumulates their duration. If the sum reaches a configurable value within a certain time, the limit of the thermal rating has been reached. If intermittent ground faults are distributed over a long period or if the ground fault disappears and does not restrike after some time, the equipment under load is expected to cool down. Tripping is not necessary in this case.

The **Non-directional intermittent ground-fault protection** function is used to protect against intermittent ground faults which occur, for example, in cables due to poor insulation or water ingress in cable joints.

6.13.2 Structure of the Function

The **Non-directional intermittent ground-fault protection** function can be used in protection function groups with current measurement. The function is preconfigured by the manufacturer with 1 stage, and a maximum of 2 stages can be operated simultaneously. The non-preconfigured stages are shown in gray in the following figure.



[DwIntGFP, 1, en_US]

Figure 6-110 Structure/Embedding of the Function

6.13.3 Stage Description

Logic

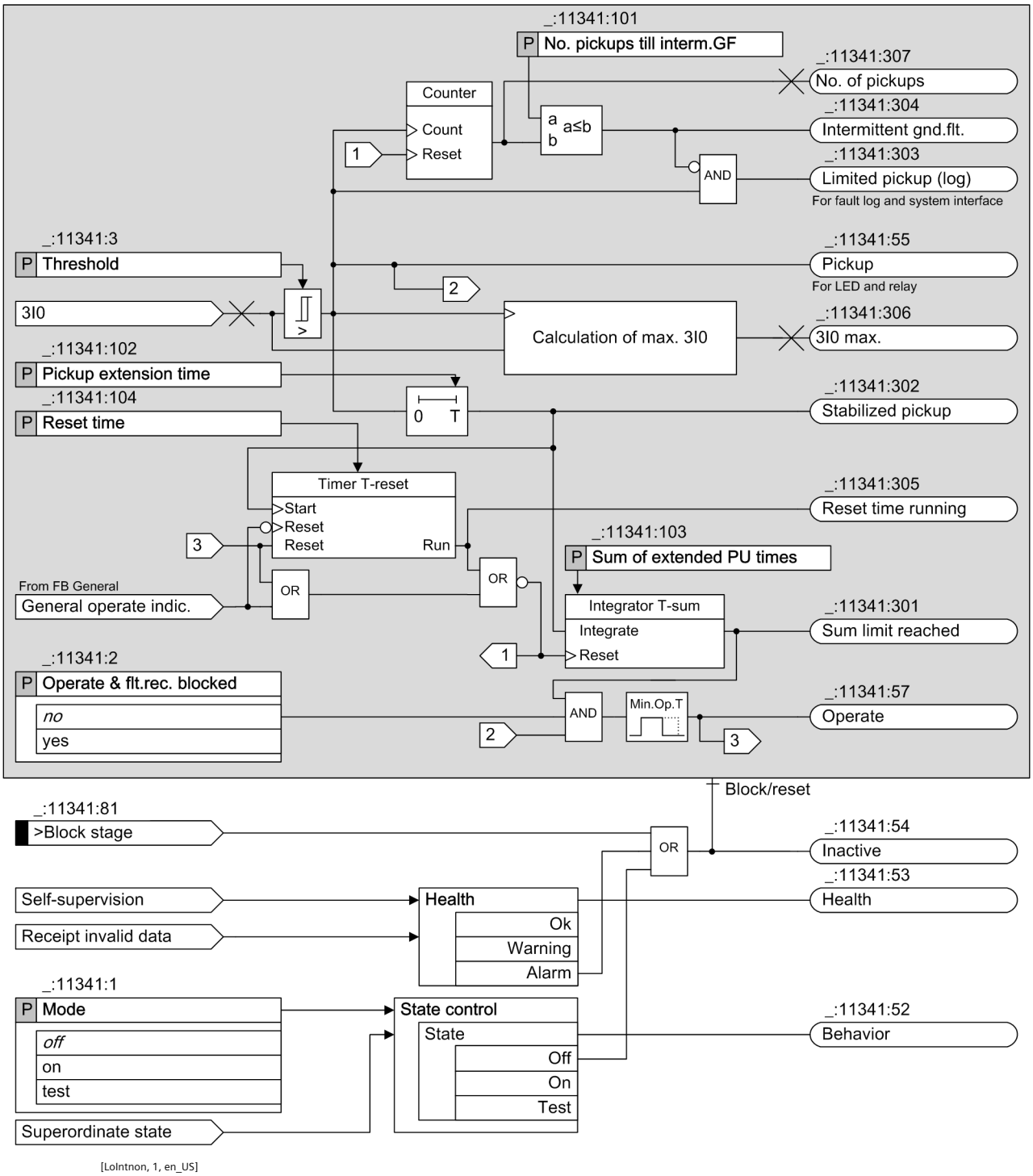


Figure 6-111 Logic of the Non-Directional Intermittent Ground-Fault Protection

Measured Value 3I0

The intermittent ground-fault current 3I0 can either be detected via the standard ground-current input I_N or via the sensitive ground-current input I_{NS}. It can also be calculated from the sum of the 3-phase currents. The measured value depends on the parameter **Connection type** of the measuring point I-3ph.

Table 6-9 Threshold Setting Range with Different Connection Types

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary at Irated = 1 A)
3-phase	Calculated	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1* sensitive	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
x + IN x + IN-separate	Measured	4 * Protection	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
	Measured and calculated when exceeding 1.6 A	3 * Protection, 1 * sensitive	0.001 A to 35.000 A

Method of Measurement

The stage calculates the RMS value of 3I0 since this value takes into account the higher-order harmonics components and the direct component (DC). Both components contribute to the thermal load.

Maximum 3I0 of the Fault

The stage records the maximum RMS value of 3I0 during the intermittent ground fault. The statistic value *3I0 max.* is a percentage value calculated through dividing the primary maximum RMS value by the rated current value of the protected object. With the coming operate signal, this value is logged via the information *3I0 max.*.

Pickup and Intermittent Ground-Fault Indication

When 3I0 exceeds the threshold value, the pickup signals *Pickup* and *Limited pickup (log)* are issued. The stage generates the *Stabilized pickup* signal by extending the *Pickup* for a defined time (parameter **Pickup extension time**).

The stage counts the *Pickup* signals. If the counted number reaches the configured **No. pickups till interm.GF**, the *Intermittent gnd.flt.* signal is issued. The signal *Limited pickup (log)* is not issued anymore after the issue of the *Intermittent gnd.flt.* signal.

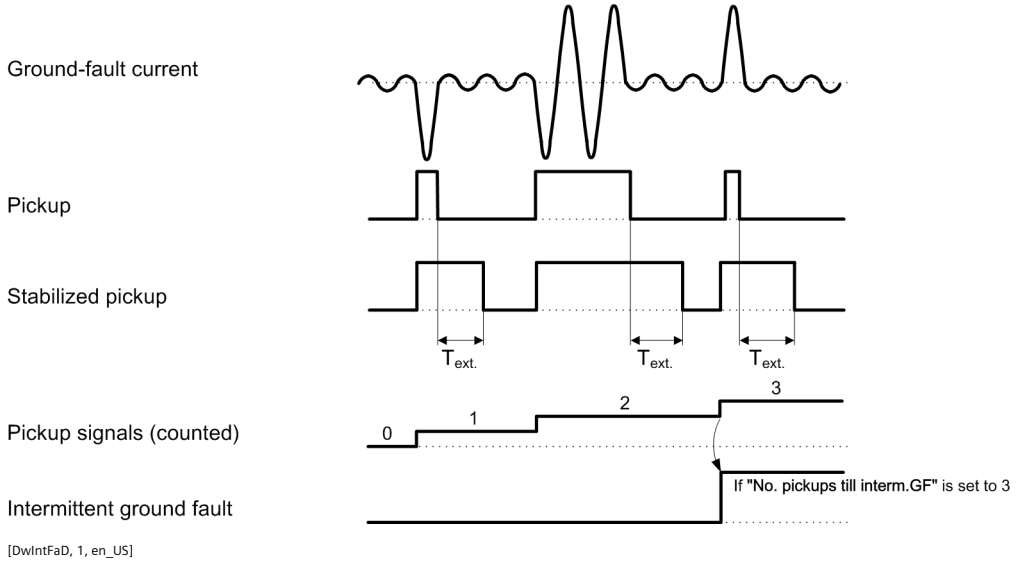


Figure 6-112 Fault Detection of the Intermittent Ground-Fault Protection

$T_{ext.}$ Defined time for extending the *Pickup* signal

Number of Pickups

The stage counts the number of *Pickup* signals during the intermittent ground fault. With the operate of the stage this number is logged via the information *No. of pickups*.

Accumulation of the Intermittent Ground-Fault Current and Issuing the Operate Signal

An intermittent ground fault can result in thermal stress on the protected equipment. The magnitude and the duration of the ground-fault current are decisive for the thermal stress. In order to calculate the thermal stress, the stage sums up the duration of the stabilized pickups with an integrator. If the integration value reaches the predefined **Sum of extended PU times**, the limit of the thermal load is reached. The stage issues the signal *Sum limit reached* and operates when the signal *Pickup* is active.

Reset Timer for the Definition of the Interval between Independent Ground Faults

If there is a large interval between independent ground faults or if ground fault extinguishes and does not restrike again within a larger time, the stressed equipment can cool down. In this case, an operation is not necessary. The interval between ground faults is monitored with the reset timer. If a ground fault occurs, the **Timer T-reset** with its setting **Reset time** is launched simultaneously with **Integrator T-sum**. Unlike the integrator, each new ground fault restarts the reset timer with its initial value. If **Timer T-reset** expires, that is, no new ground fault was detected during that period, all memories and the stage logics are reset. **Timer T-reset** thus determines the time during which the next ground fault must occur to be processed yet as intermittent ground fault in connection with the previous fault. A ground fault that occurs later is considered as a new fault event.

Reset Conditions

Under one of the following 2 conditions, **Timer T-reset** is reset.

- The Intermittent ground-fault protection stage operates.
- The general operate indication is going.

Under one of the following conditions, **Integrator T-sum** and **Counter** are reset and the whole stage is reset and returns to its idle state.

- **Timer T-reset** expires without an operate signal of this stage or another function was issued.
- The operate signal of the intermittent ground-fault protection stage is going.
- The general operate indication is going without the operate signal of the intermittent ground-fault protection stage issued.

Fault Log and Fault Recording

You can select between the ground-fault log without fault recording or the normal fault log with fault recording. If you set the parameter **Operate & flt.rec. blocked** to ***yes***, the operate of the stage and fault recording are blocked and the information automatically appears in the ground-fault log. Otherwise, the operate and fault recording are not blocked and the information appears in the normal fault log.

Start & Stop of Fault Recording, Fault Logging, and General Pickup

The *Stabilized pickup* signal initiates the fault recording, fault logging, and the general pickup of the function group. The fault recording starts according to the pre-trigger time before the *Stabilized pickup* signal rises.

With the reset condition of this stage, the fault recording, fault logging, and the general pickup of the function group are terminated.

Influence on Other Functions to Avoid a Burst of Signals

Intermittent ground faults may cause other functions, based on overcurrent measurement, to pick up, which may result in a burst of signals. In order to avoid an overflow of the fault log, a special mechanism is applied to the signals of these functions after detection of an intermittent ground fault (signal *Intermittent gnd.flt.*).

The special mechanism is applied for the following listed functions and other functions are not influenced:

- Overcurrent protection, phases
- Overcurrent protection, ground
- Directional overcurrent protection, phases
- Directional overcurrent protection, ground
- Overcurrent protection, 1-phase
- Negative-sequence protection with definite-time characteristic curve
- Directional negative-sequence protection with definite-time delay
- Directional overcurrent-protection stage with cos phi or sin phi measurement
- Directional overcurrent-protection stage with 3I0-phi (V,I) measurement
- Sensitive ground-current protection with 3I0

If a function picks up, normally its output signals are sent directly to the information targets, for example, the pickup signal is written to the fault log. To avoid overflow of logs due to intermittent ground faults, a special log buffer mechanism is used. If one of the preceding functions or stages picks up after an intermittent ground fault has been detected (signal *Intermittent gnd.flt.* has been issued), its output signals are processed as shown in the following 2 tables.

Table 6-10 Processing of the Signal Status Changes

Processing of Signal Status Changes	Description
Special buffering mechanism	The status changes of signals are written to a special buffer. This buffer can store a maximum of 2 status changes (the most recent ones) for each signal. With the pickup signal as example, if one of the preceding protection functions or stages picks up during an active *Intermittent gnd.flt.* signal, the pickup signal is not written in the fault log anymore unless one of the preceding functions operates. After the operation, the buffered signals are written to the information target with the original time stamp. This measure ensures that a pickup signal, although delayed, is always signaled in association with each operate command.
Discard	The signal status changes are discarded.
Pass through	The signal is forwarded to the information target without restriction. Special buffering does not apply for specific information targets as protection measure, for example, reverse interlocking, need these signals for proper operation.

Table 6-11 Information Target with Different Processing of Signal Status Changes

Information Target		Processing of Signal Status Changes
Processing of Signal Status Changes	Operational log Fault log Ground-fault log User-defined log	Special buffering mechanism
Communication interface	IEC 61850-8-1 Client/Server IEC 60870-5-103/104 DNP V3.0	Special buffering mechanism
Protection interface	PDI	Pass through
IEC 61850-8-1 GOOSE		Pass through
CFC		Pass through
LEDs		Pass through
Binary output		Pass through
Fault recorder		Pass through
Automatic reclosing function		Discard
Circuit-breaker failure protection		Discard
Group indications		Discard

6.13.4 Application and Setting Notes

No Start of the Automatic Reclosing Function

Automatic reclosing is not an effective measure against intermittent ground faults as the protection function only operates after repeated detection of a fault or after the integration value reaches the predefined **Sum of extended PU times**. Besides this, its basic design is to prevent thermal overload. For these reasons, the intermittent ground-fault protection function is not intended to start the automatic reclosing function.

Rooting of Pickup Signals

The signal *Pickup* is supposed to be routed to LED and relay. The signal *Limited pickup (log)* is only reported to the fault log and communication interface before the signal *Intermittent gnd.flt.* is issued. This scheme prevents a burst of messages.



NOTE

To avoid a burst of messages, do not route the signal *Pickup* to the operational log and fault log.

Parameter: 3I0 Threshold

- Default setting **(_:11341:3) Threshold** = ***1.00 A***

With the **Threshold** parameter, you set the threshold value of the ground current 3I0, measured as RMS value.

A rather sensitive setting is possible to respond also to short ground faults since the pickup time shortens as the ground-fault current increases.

Parameter: No. pickups till interm.GF

- Default setting **(_:11341:101) No. pickups till interm.GF** = ***3***

With the parameter **No. pickups till interm.GF**, you set the number of counted *Pickup* signals after which the ground fault is considered as intermittent.

Parameter: Pickup extension time

- Default setting **(_:11341:102) Pickup extension time** = ***0.10 s***

You can get a stabilized pickup signal with the **Pickup extension time** parameter. This stabilization is especially important for the coordination with existing static or electromechanical overcurrent protections.

Parameter: Sum of extended PU times

- Default setting **(_:11341:103) Sum of extended PU times** = ***20 s***

With the **Sum of extended PU times** parameter, you set the threshold value for the integrator. If the integration reaches **Sum of extended PU times**, the stage operates if the pickup state is present.

This **Sum of extended PU times** represents one of the 4 selectivity criteria (pickup threshold, pickup extension time, reset time, and integrator threshold value) for coordination of the relays on adjacent feeders. It is comparable to the time grading of the overcurrent protection. The protection in the radial system which is closest to the intermittent fault and picks up, has the shortest summation time **Sum of extended PU times**.

Parameter: Reset time

- Default setting **(_:11341:104) Reset time** = ***300 s***

With the parameter **Reset time**, you can define the maximum interval between 2 adjacent ground faults. If the interval is larger than the **Reset time**, the counter and integrator are reset.

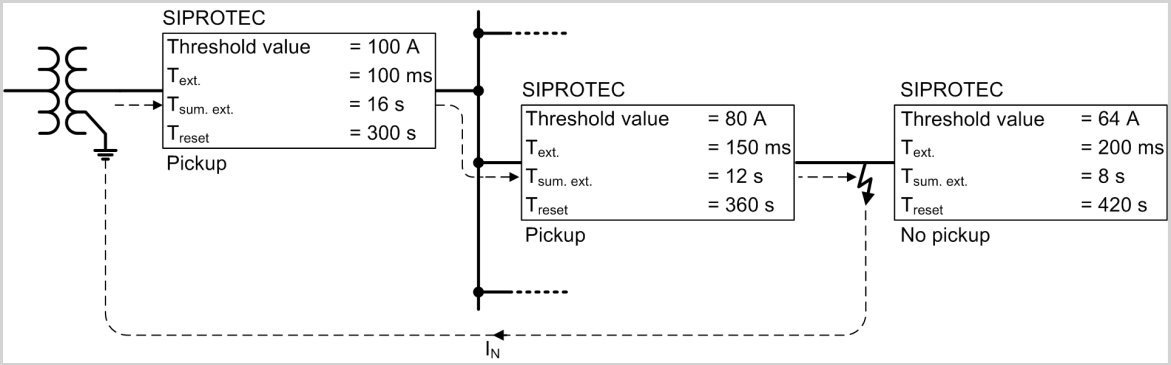
The **Reset time** parameter must be much higher than the operate value of the **Sum of extended PU times**.

Parameter: Operate & flt.rec. blocked

- Default setting **(_:11341:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

EXAMPLE



[TiExaInt, 1, en_US]

Figure 6-113 Example of Selectivity Criteria of the Intermittent Ground-Fault Protection

6.13.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:11341:1	Stage 1:Mode		• off • on • test	off
_:11341:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:11341:3	Stage 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:11341:101	Stage 1:No. pickups till interm.GF		2 to 10	3
_:11341:102	Stage 1:Pickup extension time		0.00 s to 10.00 s	0.10 s
_:11341:103	Stage 1:Sum of extended PU times		0.00 s to 100.00 s	20.00 s
_:11341:104	Stage 1:Reset time		1.00 s to 600.00 s	300.00 s

6.13.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:11341:81	Stage 1:>Block stage	SPS	I
_:11341:54	Stage 1:Inactive	SPS	O
_:11341:52	Stage 1:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:11341:53	Stage 1:Health	ENS	O
_:11341:55	Stage 1:Pickup	ACD	O
_:11341:302	Stage 1:Stabilized pickup	ACD	O
_:11341:303	Stage 1:Limited pickup (log)	ACD	O
_:11341:304	Stage 1:Intermittent gnd.flt.	SPS	O
_:11341:301	Stage 1:Sum limit reached	SPS	O
_:11341:305	Stage 1:Reset time running	SPS	O
_:11341:57	Stage 1:Operate	ACT	O
_:11341:306	Stage 1:3I0 max.	MV	O
_:11341:307	Stage 1:No. of pickups	MV	O

6.14 Directional Intermittent Ground-Fault Protection

6.14.1 Overview of Functions

The function **Directional intermittent ground-fault protection**:

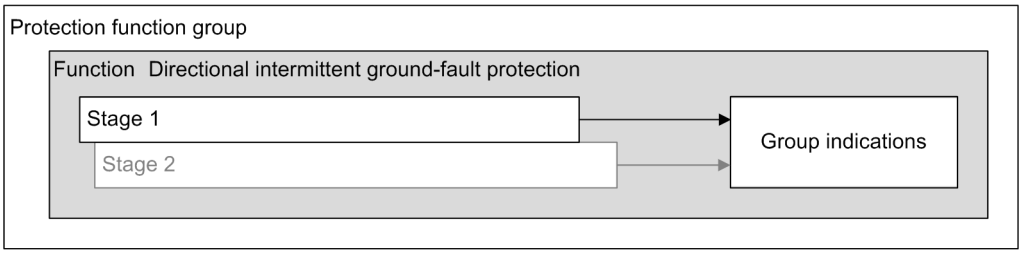
- Detects the intermittent ground faults in grounded, compensated, or isolated cable systems selectively
- Can be operated in 2 different modes:
  - Operate only by counting directional ground-current pulses
  - Operate by integration of the fault current in combination with a directional criterion by counting directional ground-current pulses

The intermittent ground faults in cable systems are frequently caused by weak insulation or water ingress in cable joints. The ground faults are characterized by the following properties:

- Intermittent ground faults show very short high ground-current pulses (up to several hundred amperes) with a duration of less than 1 ms.
- Intermittent ground faults are self-extinguishing and reignite within one half period up to several periods, depending on the power-system conditions and the fault type.
- Intermittent ground faults can persist over longer periods (several seconds to minutes) and develop to static ground faults.

6.14.2 Structure of the Function

The function **Directional intermittent ground-fault protection** can be used in protection function groups with current and voltage measurement. The function is preconfigured by the manufacturer with 1 stage, and a maximum of 2 stages can be operated simultaneously.

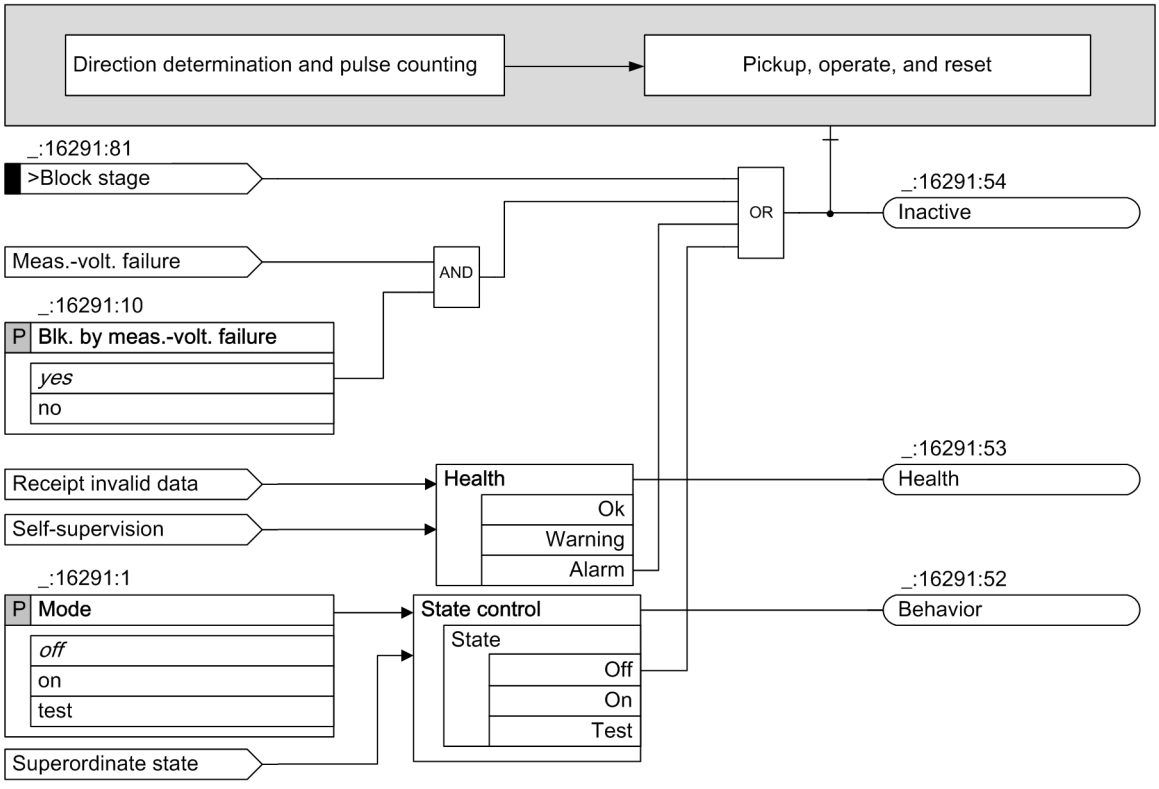


[DwStrDirIGFP_20140618, 1, en_US]

Figure 6-114 Structure/Embedding of the Function

6.14.3 Stage Description

Overview



[LoOverview, 1, en_US]

Figure 6-115 Logic of the Directional Intermittent Ground-Fault Protection

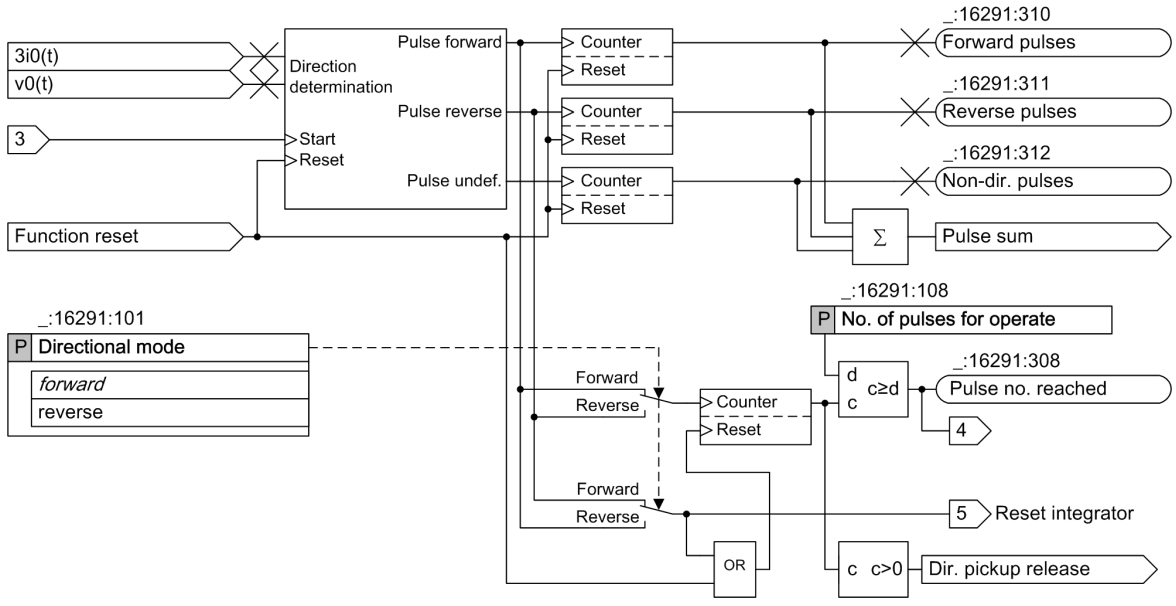
Blocking of the Stage with Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From an internal source upon pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **`Volt.-transf. c. b.`**, which links in the tripping of the voltage-transformer circuit breaker

The **`Blk. by meas.-volt. failure`** parameter can be set so that the measuring-voltage failure detection blocks the stage or does not block it.

Logic for Direction Determination and Pulse Counting



[LoIntdir1, 2, en_US]

Figure 6-116 Logic Diagram of Direction Determination and Pulse Counting

(1) The input signal 3 is from *Figure 6-117*.

Measurement Values for Direction Determination

The function **Directional intermittent ground-fault protection** uses the zero-sequence active energy to determine the direction of the ground-current pulse.

The zero-sequence active energy is calculated from v0(t) and 3i0(t). The zero-sequence voltage v0(t) can either be measured via the voltage input VN or can be calculated from the sum of 3 phase-to-ground voltages. The measured value depends on the parameter **Connection type** of the measuring point V-3ph.

The intermittent ground-fault current 3i0(t) can either be measured via the ground-current input IN or via the sensitive ground-current input INS. It can also be calculated from the sum of the 3 phase currents. The measured value and its setting range depend on the parameter **Connection type** of the measuring point I-3ph.

Table 6-12 Threshold Setting Range with Different Connection Types

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary at Irated = 1 A)
3-phase	Calculated	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1* sensitive	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
x + IN x + IN-separate	Measured	4 * Protection	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
	Measured and calculated when exceeding 1.6 A	3 * Protection, 1 * sensitive	0.001 A to 35.000 A

Direction Determination and Pulse Counting

When the RMS value of 3I0 exceeds the set threshold value (signal no. 3 in *Figure 6-116*), the direction determination process is started and is continuously carried out until the function resets. At first, the current pulse (current peak) detection takes place. If a current pulse is detected, the direction determination for this pulse is carried out.

The direction is determined by calculating the active zero-sequence energy of the current pulse. The active zero-sequence energy of the pulse is compared to internal threshold values resulting in the directional decision ***forward***, ***reverse***, or ***non-directional***. During the ongoing intermittent ground fault, the directional results for all current pulses are counted.

Directional Mode and Directional Pulse Counter Criterion

The parameter **Directional mode** defines whether the function operates in ***forward*** or in ***reverse*** direction. The pulses in the specified direction are counted. If the pulse counter reaches the threshold value set in the parameter **No. of pulses for operate**, the signal *Pulse no. reached* is issued. Depending on the operating mode (***Counter*** or ***Integrator and counter***) of the function, the signal can immediately cause the operate of the function (***Counter*** mode) or it is processed as directional release criteria (***Integrator and counter*** operating mode). Refer to the further description in the following sections.

The directional pulse counter is reset when a different direction than the set **Directional mode** is detected. An undefined direction result does not reset the counter.

Operating Mode

2 different functional operating modes are available: ***Counter*** and ***Integrator and counter***. You can select the different operating modes using the parameter **Operating mode**.

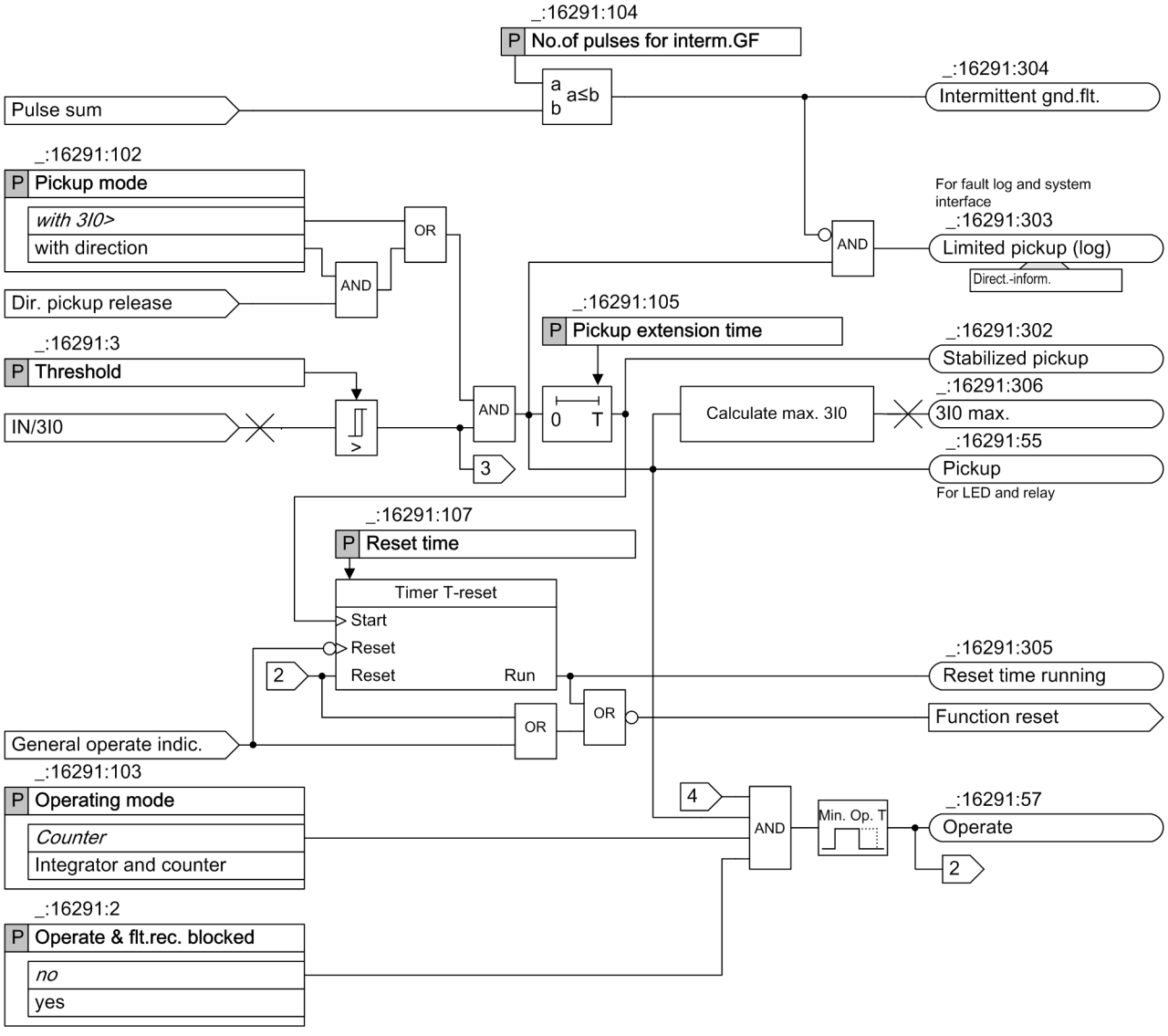
- Operating mode ***Counter***:

  Many ground-current pulses of intermittent ground faults can result in a damage of the protected object. In this mode, the criterion for operate is only the number of directional current pulses. This is similar to the SIPROTEC 4 implementation.

- Operating mode ***Integrator and counter***:

  An intermittent ground fault can result in thermal stress on the protected object. The magnitude and the duration of the ground-current pulses are decisive for the thermal stress. In order to calculate the thermal stress, the stage sums up the duration of the stabilized pickups with an integrator. If the integration value reaches the threshold value, one criterion for the operate is fulfilled. The 2nd criterion for the operate is the ground-fault direction. The ground-fault direction is determined by counting the directional ground-current pulses.

Pickup, Operate, and Reset logic for the Counter Mode

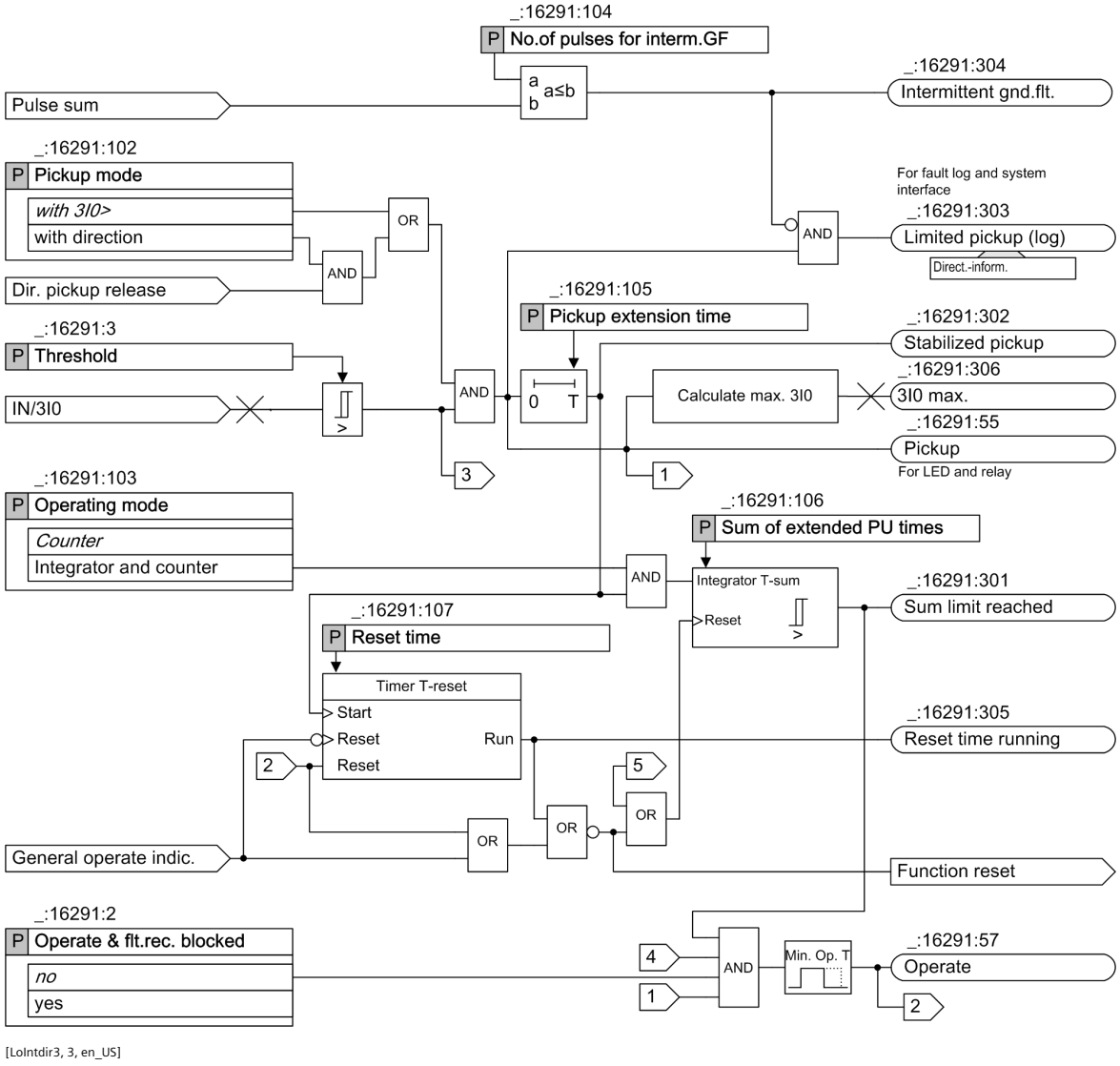


[LoIntdir2, 3, en_US]

Figure 6-117 Pickup, Operate, and Reset Logic in Operating Mode Counter

(1) The internal signal 4 is from *Figure 6-116*.

Pickup, Operate, and Reset logic for the Integrator and Counter Mode



[LoIntdir3, 3, en_US]

Figure 6-118 Pickup, Operate, and Reset Logic in Operating Mode Integrator and Counter

(1) The internal signal 4 and 5 are from *Figure 6-116*.

Measurement Value for Pickup and Integration

The stage calculates the RMS value of 3I0 since this value takes into account the higher-order harmonic components and the direct component (DC). Both components contribute to the thermal load.

Pickup, Limited Pickup, and Stabilized Pickup

Whenever 3I0 exceeds **Threshold**, the stage issues the signal *Pickup*. The signal is intended to be applied for LED and relay output.

Stabilized pickup is formed by prolonging the pickup indication by a settable time **Pickup extension time**. This stabilization is especially important for the coordination with the existing static or electromechanical overcurrent protection.

The *Limited pickup (log)* signal is intend to be applied for logging and communication interface. The *Limited pickup (log)* signal will be entered in the fault log and reported via the system interface unless the *Intermittent gnd.flt.* indication is given. This behavior prevents a burst of indications.

Intermittent Ground-Fault Indication

The stage counts the 3I0 pulses. If the sum of forward pulse counts, reverse counts, and directional undefined counts is equal to or greater than **No.of pulses for interm.GF**, the signal *Intermittent gnd.flt.* is issued.

If the signal *Intermittent gnd.flt.* is issued, the pickup indications of some protection functions will be restraint to avoid an indication burst during an intermittent ground fault.

Operate

The conditions for issuing the signal *Operate* depend on the operating mode.

Operating Mode	Conditions for Issuing the Operate Signal
Counter	• The current-pulse counter reached the **No. of pulses for operate**, which is signaled via the *Pulse no. reached* indication. • The pickup is active, which is signaled via the *Pickup* indication.
Integrator and counter	• The 3I0 current integration value reaches the predefined **Sum of extended PU times**, which is signaled via the *Sum limit reached* indication. • The current-pulse counter reached the **No. of pulses for operate**, which is signaled via the *Pulse no. reached* indication. • The pickup is active, which is signaled via the *Pickup* indication.

When an opposite current pulse against the setting **Directional mode** is detected, the **Integrator T-sum** and the **Counter** are reset.

Reset Time for the Definition of the Interval between Independent Ground Faults

If there is a large interval between independent ground faults or if the ground fault extinguishes and does not restrike again within a larger time, the stressed equipment can cool down. In this case, no operate is necessary. The interval between ground faults is monitored with the reset time. If a ground fault occurs, the **Timer T-reset** with the setting **Reset time** and the **Integrator T-sum** are launched simultaneously. Unlike the integrator, each new ground-current pulse restarts the reset time with its initial value. If the **Timer T-reset** expires, that is, no new ground fault was detected during that period, all memories and the stage logics are reset. The **Timer T-reset** thus determines the time during which the next ground fault must occur to be processed yet as intermittent ground fault in connection with the previous fault. A ground fault that occurs later is considered as a new ground-fault event.

Reset Conditions

Under one of the following 2 conditions, **Timer T-reset** is reset:

- The intermittent ground-fault protection stage operates.
- The general operate indication is going.

Under one of the following conditions, **Integrator T-sum** and **Counter** are reset and the whole stage is reset and returns to its idle state:

- The **Timer T-reset** expires without an operate signal of this stage or another function was issued.
- The operate signal of the intermittent ground-fault protection stage is going.
- The general operate indication is going without the operate signal of the intermittent ground-fault protection stage issued.

Maximum Value 3I0 of the Ground Fault

The stage records the maximum RMS value of 3I0 during the intermittent ground fault.The statistic value *3I0 max.* is a percentage value calculated through dividing the primary maximum RMS value by the rated current value of the protected object. If the function resets or operates, this value is logged via the signal *3I0 max.*.

Fault Log and Fault Recording

You can select between the ground-fault log without fault recording or the normal fault log with fault recording. If you set the parameter **Operate & flt.rec. blocked** to ***yes***, the operate of the stage and fault recording are blocked and the information automatically appears in the ground-fault log. Otherwise, the operate and fault recording are not blocked and the information appears in the normal fault log.

Start and Stop of Fault Recording, Fault Logging, and General Pickup

The *Stabilized pickup* signal initiates fault recording, fault logging, and the general pickup of the function group. The fault recording starts according to the pre-trigger time before the *Stabilized pickup* signal rises.

With the reset condition of this stage, the fault recording, fault logging, and the general pickup of the function group are terminated.

Influence on Other Functions to Avoid a Burst of Indications

In this case, the function uses the same mechanism as the **Non-directional intermittent ground-fault protection**. For more information, refer to chapter *Influence on Other Functions to Avoid a Burst of Signals, Page 538*.

6.14.4 Application and Setting Notes

No Start of the Automatic Reclosing Function

Automatic reclosing is not an effective measure against intermittent ground faults. For this reason, the **Directional intermittent ground-fault protection** function is not intended to start the Automatic reclosing function.

Routing of Pickup Signals

The signal *Pickup* is supposed to be routed to an LED and a relay. The signal *Limited pickup (log)* is only reported to the fault log and communication interface until the signal *Intermittent gnd.flt.* is issued. This scheme prevents a burst of indications.



NOTE

To avoid a burst of indications, do not route the signal *Pickup* to the operational log and to the fault log.

Parameter: Threshold

- Default setting **(_:16291:3) Threshold** = ***1.00 A***

With the parameter **Threshold**, you set the threshold value of the ground current 3I0, measured as RMS value.

A rather sensitive setting is possible to respond also to short ground faults since the pickup time shortens as the ground-fault current increases.

Parameter: Directional mode

- Default setting **(_:16291:101) Directional mode** = ***forward***

With the parameter **Directional mode**, you define if the function operates in *forward* or in *reverse* direction.

Parameter: Pickup mode

- Default setting **(_:16291:102) Pickup mode** = ***with 3I0>***

With the parameter **Pickup mode**, you define under which conditions pickup is detected and fault logging and recording start:

- When the parameter **Pickup mode** is set to ***with 3I0>***, the signal *Pickup* is released without considering the ground fault direction. The signal *Pickup* is issued once the IN/3I0 exceeds the threshold value.
- When the parameter **Pickup mode** is set to ***with direction***, the signal *Pickup* is issued when at least one pulse direction is the same as the direction specified by the set value of parameter **Directional mode**.

Parameter: Operating mode

- Default setting **(_:16291:103) Operating mode** = ***Counter***

With the parameter **Operating mode**, you define if the function operates in ***Counter*** or in ***Integrator and counter*** mode.

Operating Mode	Application and Setting Notes
Counter	The number of directional pulses is the determining operate criterion. This is a simple method which is similar to the implementation in the 7SJ SIPROTEC 4 devices. Siemens recommends using this method if no time grading or only simple time grading between protection devices (time grading of only 2 or 3 devices) is required. Time grading is then carried out by increasing the parameter value **No. of pulses for operate** towards the infeed.
Integrator and counter	The integrator and the counter are the determining operate criteria while the counter criterion is only used for the direction determination. The integrator works in the same way as for the non-directional intermittent ground fault function. This allows the same time-grading principles as for the non-directional intermittent ground fault function. Refer to this function for more description.

Parameter: No.of pulses for interm.GF

- Default setting **(_:16291:104) No.of pulses for interm.GF** = ***3***

With the parameter **No.of pulses for interm.GF**, you set the total number of pulse counts (***forward***, ***reverse*** and ***non-dir. pulses***) at which the ground fault is considered to be intermittent. Siemens recommends using the default setting.

Parameter: Pickup extension time

- Default setting **(_:16291:105) Pickup extension time** = ***0.10 s***

With the parameter **Pickup extension time**, you get a prolonged and thus stabilized pickup signal. This stabilization is especially important for the coordination with existing static or electromechanical overcurrent protections.

Parameter: No. of pulses for operate

- Default setting **(_:16291:108) No. of pulses for operate** = ***5***

The pulses in the specified direction from **Directional mode** are counted. If the pulse counter reaches the set value of the parameter **No. of pulses for operate**, the directional counter criterion is fulfilled.

The setting of parameter **No. of pulses for operate** depends on the **Operating mode**.

Operating Mode	Application and Setting Notes
Counter	The number of directional pulses is the determining operate criterion. Thus do not set the value for parameter **No. of pulses for operate** too small. Consider that a permanent intermittent ground fault will cause many current pulses. If no time-grading considerations are required, Siemens recommends using a value in the range of 10 to 20.
Integrator and counter	The integrator and the counter are the determining operate criteria while the counter criterion is only used for the direction determination. The value for parameter **No. of pulses for operate** to fulfill the directional criterion can be set to a rather small value in the range of 3 to 5.

Parameter: **Sum of extended PU times**

- Default setting **(_:16291:106) Sum of extended PU times** = ***20.00 s***

This parameter is only relevant in the operating mode ***Integrator and counter***.

With the parameter **Sum of extended PU times**, you set the threshold value for the integrator. If the integration reaches **Sum of extended PU times**, the stage operates if the *Pulse no. reached* signal and the pickup state is present.

The parameter **Sum of extended PU times** represents one of the 5 selectivity criteria (ground-fault direction, pickup threshold, pickup extension time, reset time, and integrator threshold value) for coordination of the relays on subordinate devices. It is comparable to the time grading of the overcurrent protection.

The **Sum of extended PU times** has the shortest summation time in the radial system for the device that is closest to the intermittent ground fault and that picks up.

Parameter: **Reset time**

- Default setting **(_:16291:107) Reset time** = ***300 s***

With the parameter **Reset time**, you can define the maximum interval between 2 adjacent ground faults. If the interval is larger than the **Reset time**, the counter and integrator are reset.

The **Reset time** parameter must be much higher than the operate value of the **Sum of extended PU times**.

Parameter: **Operate & flt.rec. blocked**

- Default setting **(_:16291:2) Operate & flt.rec. blocked** = ***no***

With the parameter **Operate & flt.rec. blocked**, you can block the operate indication, the fault recording, and the fault log. In this case, a ground-fault log is created instead of the fault log.

6.14.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:16291:1	Stage 1:Mode		• off • on • test	off
_:16291:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:16291:10	Stage 1:Blk. by meas.-volt. failure		• no • yes	yes
_:16291:101	Stage 1:Directional mode		• forward • reverse	forward

Addr.	Parameter	C	Setting Options	Default Setting
_:16291:102	Stage 1:Pickup mode		• with 3I0> • with direction	with 3I0>
_:16291:103	Stage 1:Operating mode		• Counter • Integrator and counter	Counter
_:16291:3	Stage 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:16291:105	Stage 1:Pickup extension time		0.00 s to 10.00 s	0.10 s
_:16291:104	Stage 1:No.of pulses for interm.GF		2 to 10	3
_:16291:106	Stage 1:Sum of extended PU times		0.00 s to 100.00 s	20.00 s
_:16291:107	Stage 1:Reset time		1.00 s to 600.00 s	300.00 s
_:16291:108	Stage 1:No. of pulses for operate		2 to 100	5

6.14.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:16291:81	Stage 1:>Block stage	SPS	I
_:16291:54	Stage 1:Inactive	SPS	O
_:16291:52	Stage 1:Behavior	ENS	O
_:16291:53	Stage 1:Health	ENS	O
_:16291:55	Stage 1:Pickup	ACD	O
_:16291:302	Stage 1:Stabilized pickup	ACD	O
_:16291:303	Stage 1:Limited pickup (log)	ACD	O
_:16291:304	Stage 1:Intermittent gnd.flt.	SPS	O
_:16291:301	Stage 1:Sum limit reached	SPS	O
_:16291:308	Stage 1:Pulse no. reached	SPS	O
_:16291:305	Stage 1:Reset time running	SPS	O
_:16291:57	Stage 1:Operate	ACT	O
_:16291:306	Stage 1:3I0 max.	MV	O
_:16291:310	Stage 1:Forward pulses	MV	O
_:16291:311	Stage 1:Reverse pulses	MV	O
_:16291:312	Stage 1:Non-dir. pulses	MV	O

6.15 Sensitive Ground-Fault Detection

6.15.1 Overview of Functions

2 functions are available for ground-fault detection: A directional one that is used if, in addition to the zero-sequence current 3I0, the zero-sequence voltage V0 is also available, and a non-directional one that is used if only the zero-sequence current 3I0 is available.

The **Directional sensitive ground-fault detection** (ANSI 67Ns) serves:

- For directional detection of permanent ground faults in isolated or resonant-grounded systems
- For directional detection of fast extinguishing transient ground faults in isolated or resonant-grounded systems
- For determination of the faulty phase
- For detection of high-resistance ground faults in effectively (solidly) or low-resistance (semi-solidly) grounded systems

The **Non-directional sensitive ground-fault detection** (ANSI 51Ns) serves:

- For ground-fault detection in isolated or resonant-grounded systems
- For detection of high-resistance ground faults in effectively (solidly) or low-resistance (semi-solidly) grounded systems

6.15.2 Structure of the Function

Directional Sensitive Ground-Fault Detection

The **Directional sensitive ground-fault detection** function can be used in protection function groups that make current and voltage zero-sequence systems (3I0 and V0) available. The function is preconfigured at the factory with a **V0> stage**, a directional **3I0> stage with cos φ or sin φ measurement**, and a **transient ground-fault stage**.

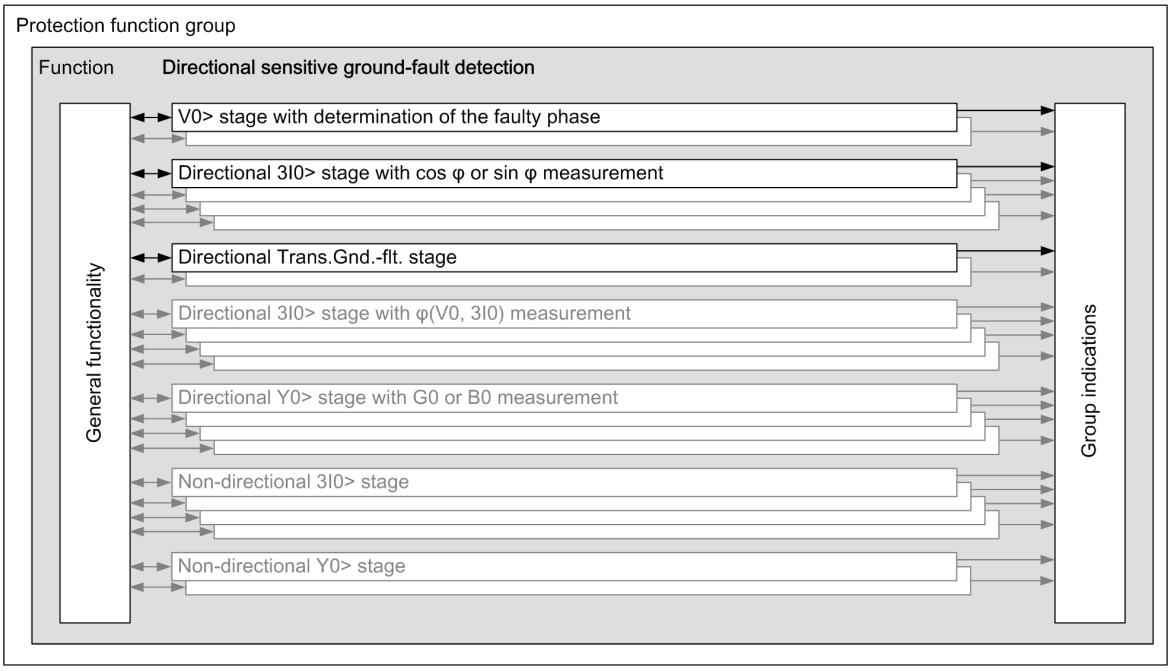
The following stages can be operated simultaneously within the function:

- 2 **V0> stages** with determination of the faulty phase
- 4 directional **3I0> stages with cos φ or sin φ measurement**
- 2 directional **transient ground-fault stages**
- 4 directional **3I0> stages with φ(V0, 3I0) measurement**
- 4 directional **Y0> stages with G0 or B0 measurement** (admittance method)
- 4 non-directional **3I0> stages**
- 2 non-directional **Y0> stages**

The general functionality works across stages on the function level.

The group-indications output logic generates the following group indications of the entire function by the logical OR from the stage-selective indications:

- Pickup
- Operate indication



[DwStrGFP-250113-01, 4, en_US]

Figure 6-119 Structure/Embedding of the Directional Function in Protection Function Groups

Non-Directional Sensitive Ground-Fault Detection

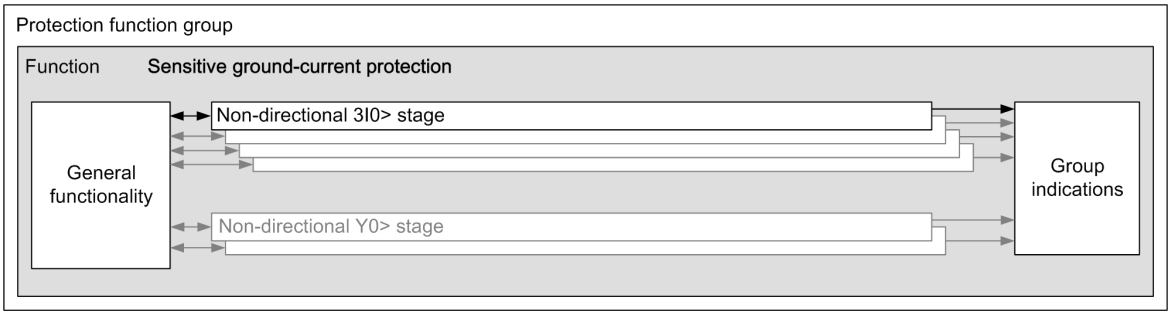
The **Non-directional sensitive ground-fault detection** function can be used in protection function groups that only make the zero-sequence system (3I0) available. The function is preconfigured at the factory with a non-directional **3I0> stage**.

4 non-directional **3I0> stages** and 2 non-directional **Y0> stages** can be operated simultaneously in the function.

The general functionality works across stages on the function level.

The group-indications output logic generates the following group indications of the entire function by the logical OR from the stage-selective indications:

- Pickup
- Operate indication



[DwSGFPu4-230113-01, 3, en_US]

Figure 6-120 Structure/Embedding of the Non-Directional Function in Protection Function Groups

6.15.3 General Functionality

6.15.3.1 Description

Logic

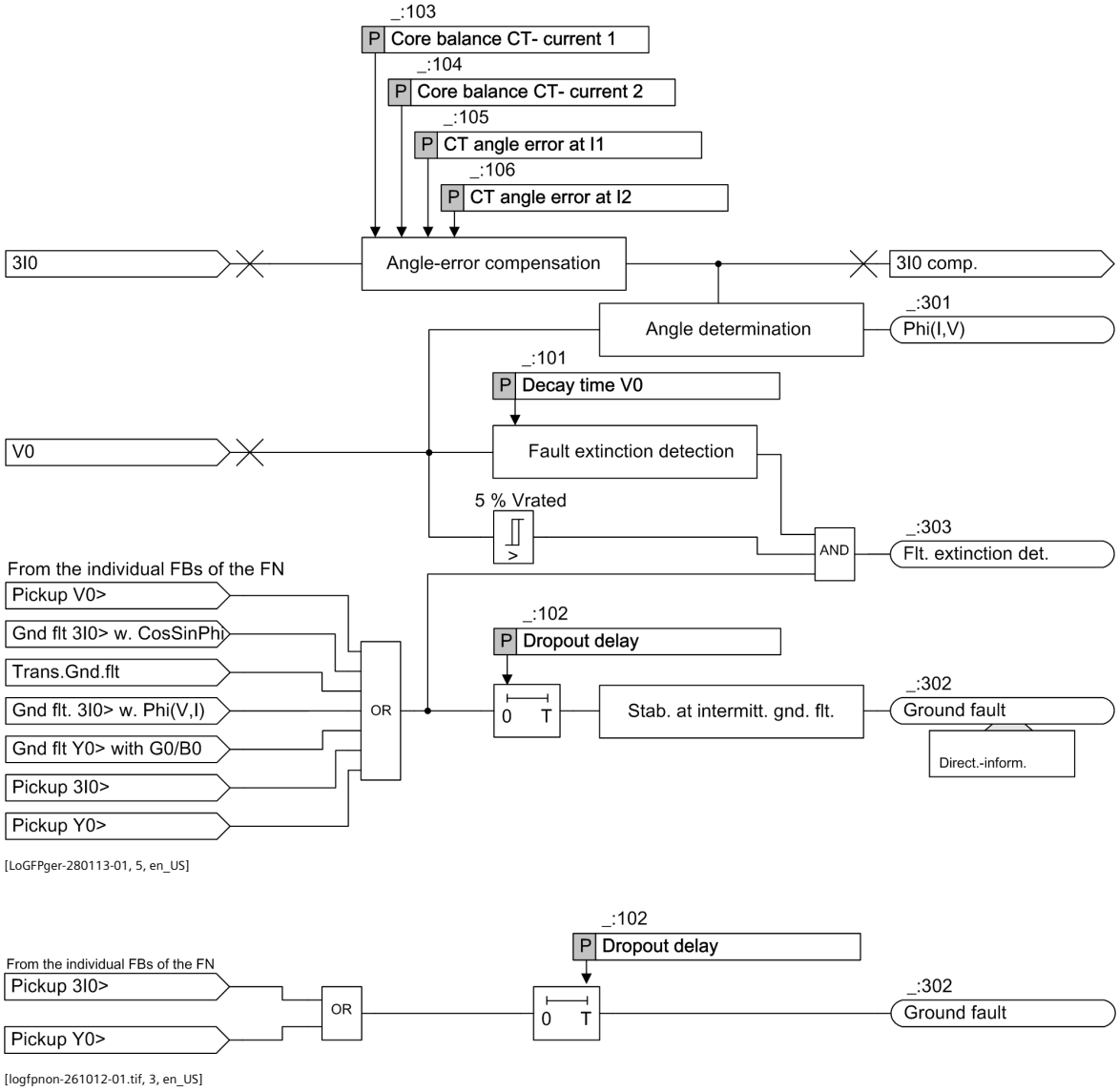
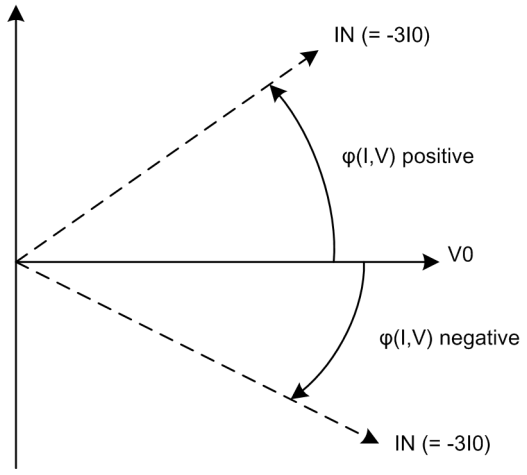


Figure 6-121 Logic Diagram of the Cross-Stage Functionality of the Non-Directional Function

Operational Measured Value φ(I,V)

The function block calculates the angle between IN and V0 and makes the angle available as function measured value *Phi(I,V)* .



[DwPhINU0, 1, en_US]

Figure 6-122 Sign Definition for the Measured Value

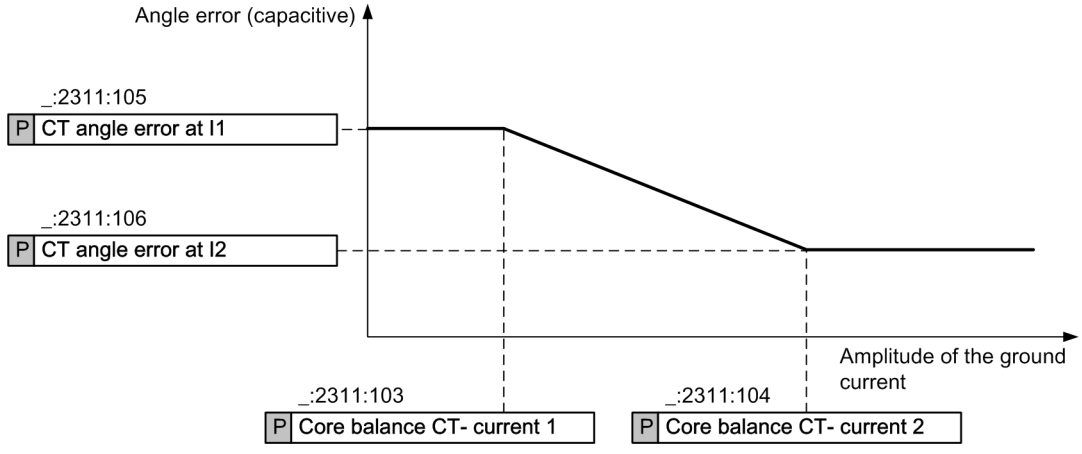
Fault-Extinction Detection

The extinction of the fault is characterized by the fact that the zero-sequence voltage subsides. Depending on the system conditions and fault characteristics, this process can last several 100 ms. If a continuously falling zero-sequence voltage is detected during the set time **`Decay time V0`**, then the fault is considered extinguished. The signal ***`Flt. extinction det.`*** is issued.

Thus, the possibility exists, for example, to block the **3I0> stage with cos φ or sin φ measurement** directly after the fault extinction, in order to avoid an overfunction during the subsiding process with a very sensitive setting of the stage.

Angle-Error Compensation

The high reactive power factor in the arc-suppression-coil-ground system and the unavoidable air-gap of the core balance current transformer often make necessary a compensation of the angle error of the core balance current transformer. Using the characteristic shown in the following figure, the device approaches the angle error of the core balance current transformer with sufficient precision.



[dwerdwdl-110512-01.tif, 1, en_US]

Figure 6-123 Correction of the Transmission Characteristic Curve of a Core Balance Current Transformer

Ground-Fault Indication, Stabilization at Intermittent Ground Fault

The indication ***`(_:302) Ground fault`*** indicates the ground fault and manages the ground-fault log (see *Ground-Fault Log, Page 558*). The corresponding information of the stages used is accessed for the generation of this indication.

The indication *Ground fault* contains the direction information, independent of the parameterized working direction of a stage. The indication is thus suited for transfer to a station.

To avoid a flood of indications in case of an intermittent ground fault, a maximum of 30 status changes of this indication is logged per ground fault. An intermittent ground fault must be treated as a ground fault so that the stabilization can take action. This is ensured with the parameter **Dropout delay**, by the dropout of the indication *Ground fault* being delayed. If the next ignition of the ground fault takes place during the dropout delay, the indication does not dropout and the log remains open.



NOTE

The *Ground fault* indication in the general stage must be routed to the ground-fault log. If not, you can meet an overflow of the ground-fault log when an intermittent ground fault occurs.

Ground-Fault Log

Ground faults can be recorded in a designated buffer, the ground-fault log. As long as the **Operate & flt.rec. blocked** parameter is set to ***yes***, all indications routed into the ground-fault log are written in the ground-fault log.

The criterion for opening the ground-fault log is the raising of any indication which is routed to the ground-fault log, for example, the indication *Ground fault* . The criterion for closing is the clearing of all routed indications.

Related Topics

You can find general notes on the ground-fault login chapter **Indications** under *3.1.5.4 Ground-Fault Log* .

Value Indications

If the following value indications can be calculated, they are written into the log (ground-fault log or fault log) at the time of the 1st raising ground-fault indication and the 1st operate indication of any stage.

- 3I0 (value)
- 3I0 active component
- 3I0 reactive component
- V0
- φ (IN, V0)

6.15.3.2 Application and Setting Notes

Indication: Ground fault

To indicate the ground fault and its direction via the protocol, Siemens recommends using the indication *(_:302) Ground fault*. The indication contains the direction information, independent of the parameterized working direction of a stage. And this indication is also stabilized against a flood of indications in case of an intermittent ground fault.

Parameter: Decay time V0

- Recommended setting value **(_:101) Decay time V0** = ***0.10 s***

With the **Decay time V0** parameter, you specify the time slot for the detection of a fault extinction. If V0 continuously falls within this time, fault extinction is detected and the indication *Flt. extinction det.* is issued.

Siemens recommends using the default setting.

Parameter: Dropout delay

- Recommended setting value **(_:102) Dropout delay** = ***1.00 s***

To avoid chattering of the indication *Ground fault* during an intermittent ground fault and thus a frequent opening and closing of the ground-fault log, the dropout of the indication *Ground fault* (and thus the closing of the log) can be delayed by the **Dropout delay**.

Siemens recommends using the default setting.

Using the default setting ensures that no flood of indications arises in case of an intermittent ground fault for the indication *Ground fault*. The intermittent ground fault is then treated as a ground fault, and the stabilization of the indication *Ground fault* can thus take action.

Angle-Error Compensation of the Core Balance Current Transformer

- Default setting **(_:103) Core balance CT- current 1** = ***0.050 A***
- Default setting **(_:104) Core balance CT- current 2** = ***1.000 A***
- Default setting **(_:105) CT angle error at I1** = ***0.0°***
- Default setting **(_:106) CT angle error at I2** = ***0.0°***

The high reactive-power factor in the arc-suppression-coil-ground system and the unavoidable air gap of the core balance current transformer often make necessary a compensation of the angle error of the core balance current transformer. For the burden actually connected, the maximum angle error **CT angle error at I1** and the corresponding secondary current **Core balance CT- current 1** as well as a further operating point **CT angle error at I2**/**Core balance CT- current 2** are entered, from which point the angle error no longer changes appreciably.

In the isolated or grounded system, angle compensation is not necessary.

6.15.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:101	General:Decay time V0		0.06 s to 0.20 s	0.10 s
_:102	General:Dropout delay		0.00 s to 60.00 s	1.00 s
_:103	General:Core balance CT- current 1	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:104	General:Core balance CT- current 2	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:105	General:CT angle error at I1		0.0 ° to 5.0 °	0.0 °
_:106	General:CT angle error at I2		0.0 ° to 5.0 °	0.0 °

6.15.3.4 Information List

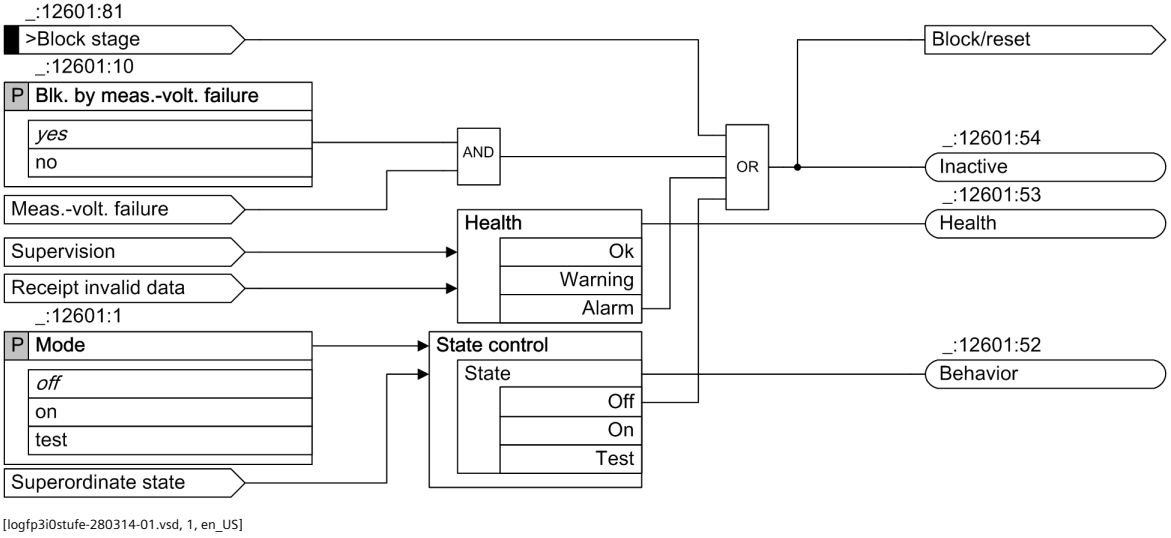
No.	Information	Data Class (Type)	Type
General			
_:302	General:Ground fault	ACD	O
_:303	General:Flt. extinction det.	SPS	O

No.	Information	Data Class (Type)	Type
_:309	General:Pos. measuring window	SPS	O
_:301	General:Phi(I,V)	MV	O

6.15.4 Directional 3I0 Stage with Cos φ or Sin φ Measurement

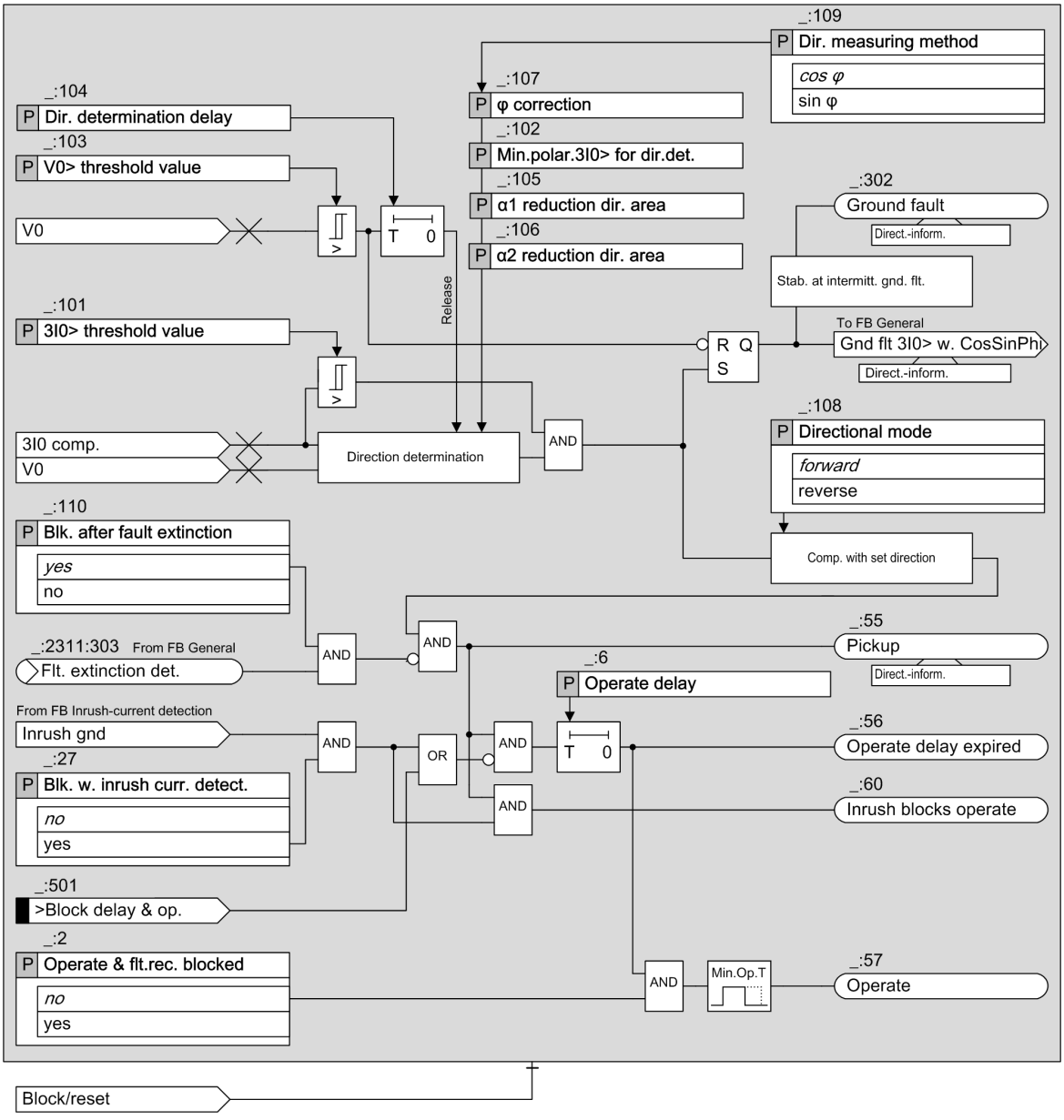
6.15.4.1 Description

Logic



[logfp3i0stufe-280314-01.vsd, 1, en_US]

Figure 6-124 Logic Diagram of the Stage Control



[logfp3i0f-280314-01, 3, en_US]

Figure 6-125 Logic Diagram of the Directional 3I0 Stage with Cos φ or Sin φ Measurement

Measured Value V0, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, Method of Measurement

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

Depending on the setting of the parameter Connection type of the measuring point **I-3ph** as well as the current terminal block used, the following different linearity and settings ranges result in addition to the usual application:

Setting Value Connection Type of the Measuring Point I-3ph	3I0	Current Terminal Block	3I0 Threshold Value Settings Range (Secondary) [10]
3-phase + IN separate [11] 3-phase + IN	Measured	3 x protection, 1 x sensitive	0.001 A to 35.000 A
		4 x protection	0.030 A to 35.000 A
		4 x measurement	0.001 A to 1.600 A
3-phase	Calculates	4 x protection	0.030 A to 35.000 A
		3 x protection, 1 x sensitive	0.030 A to 35.000 A
		4 x measurement	0.001 A to 1.600 A

With the use of the function within a 1-phase function group and therefore at a 1-phase measuring point **I-1ph**, the following different linearity and settings ranges result:

Measuring Point I-1ph	3I0	Current Terminal Block	3I0 Threshold Value Settings Range (Secondary) [12]
	Measured	Sensitive	0.001 A to 1.600 A
		Protection	0.030 A to 35.000 A

The method of measurement processes the sampled current values and filters out the fundamental component numerically.

The methods of measurement are characterized by high accuracy and by insensitivity to harmonics, especially the 3rd and 5th harmonics frequently present in the ground-fault (leakage) current.

Ground-Fault Detection, Pickup

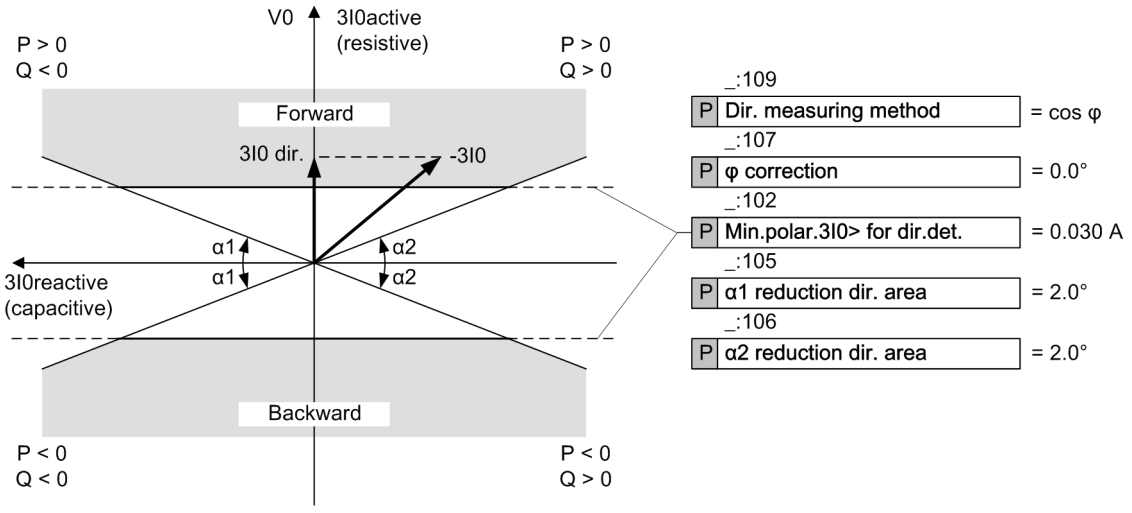
If the absolute value of the ground current 3I0 exceeds the threshold value **3I0> threshold value** and the absolute value of the zero-sequence voltage V0 exceeds the threshold value **V0> threshold value**, the stage recognizes the ground fault. The direction determination (see the next paragraph) is started when the V0 threshold value is exceeded. The direction result is indicated via the *Ground fault* signal (in the general function block). If the direction result equals the parameterized direction (parameter **Directional mode**), the stage picks up.

Direction Determination

Exceeding the threshold values by the zero-sequence voltage V0 is a criterion for the ground fault. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the **Dir. determination delay** parameter to achieve steady-state measurands. The result form the direction determination is only valid if the absolute value of the ground current 3I0 has also exceeded its threshold value.

The following figure shows an example of the direction determination in the complex phasor diagram for the cos-φ direction measurement method with a correction value of the direction straight lines from 0 (parameter **φ correction**). The example is suitable for the determination of the ground-fault direction in an arc-suppression-coil-ground system where the variable 3I0 · cos φ is decisive for the direction determination.

[10] These values apply for a secondary rated current of 1 A. The values need to be multiplied by 5 when the secondary rated current is 5 A.
[11] Usual application
[12] These values apply for a secondary rated current of 1 A. The values need to be multiplied by 5 when the secondary rated current is 5 A.



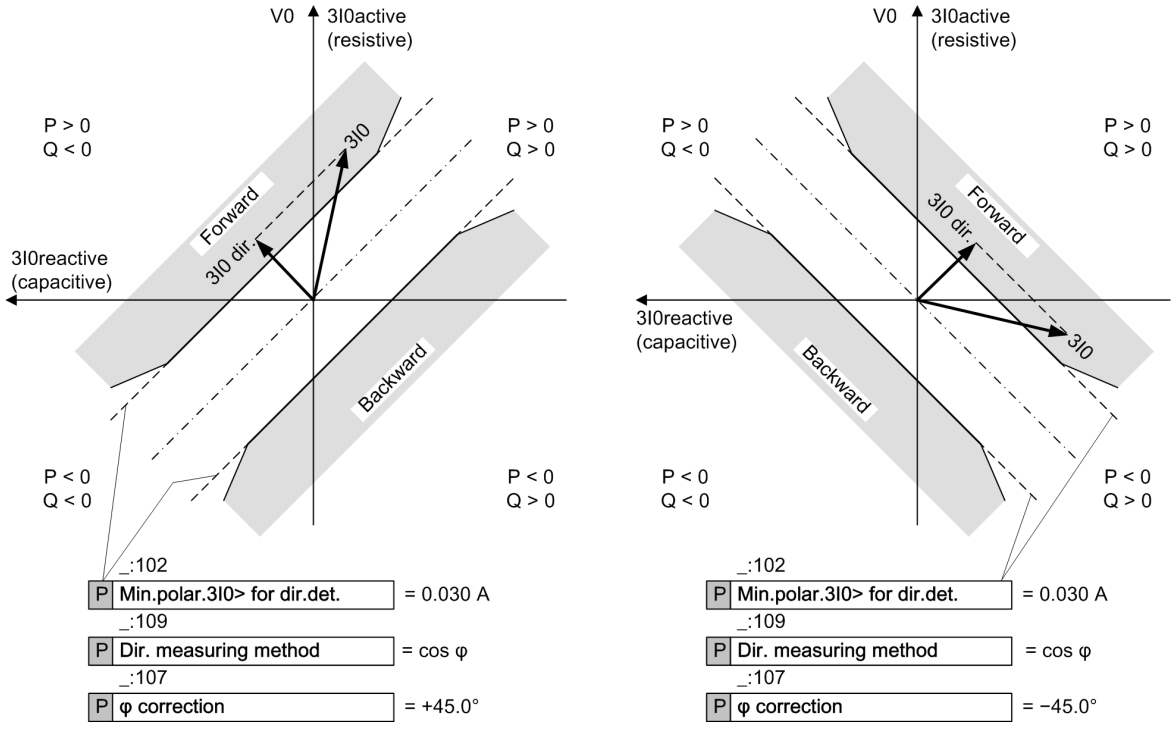
[dwcosphi-171012-01.tif, 2, en_US]

Figure 6-126 Direction-Characteristic Curve with Cos φ Measurement

The zero-sequence voltage V0 is basically the reference value for the real axis. The axis of symmetry of the direction-characteristic curve coincides with the 3I0react axis for this example. For the direction determination, basically the portion of the current vertical to the set direction-characteristic curve (= axis of symmetry) is decisive (3I0 dir.). In this example, this is the active portion 3I0active of the current 3I0. The current 3I0dir. (here = 3I0active) is calculated and compared with the setting value **`Min.polar.3I0> for dir.det.`**. If the current 3I0 dir. exceeds the positive setting value, the direction is forward. If the current 3I0 dir. exceeds the negative setting value, the direction is backward. In the range in between, the direction is undetermined.

With the **`α1 reduction dir. area`** and **`α2 reduction dir. area`** parameters, you can limit the forward and backward ranges as shown in the figure. With this, the direction determination is secured in case of high currents in the direction of the axis of symmetry.

The symmetry axis can be turned via a correction angle **`φ correction`** parameter) in a range of ±45. Through this, it is possible, for example, to attain the greatest sensitivity in grounded systems in the resistive-inductive range with a -45° turn. In the case of electric machines in busbar connection on the isolated system, the greatest sensitivity in the resistive-capacitive range can be attained with a rotation of +45°.

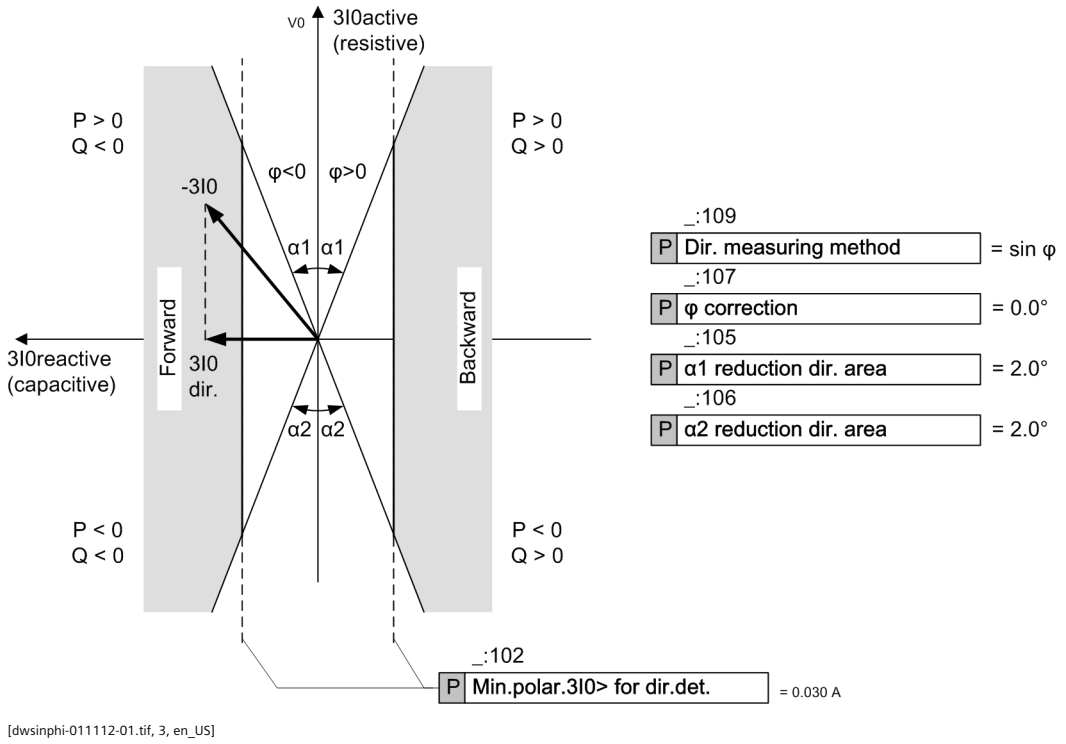


[dwphicor-171012-01.tif, 1, en_US]

Figure 6-127 Turning the Direction-Characteristic Curves with Cos φ Measurement with Angle Correction

If you set the **Dir. measuring method** parameter to ***sin φ*** and the **φ correction** parameter to ***0***, the symmetry axis of the direction-characteristic curve coincides with the 3I0active axis and the V0 axis. Since the portion of the current vertical to the direction-characteristic curve (= axis of symmetry) is decisive (3I0dir.), here, the current 3I0react is included in the direction determination. If the current 3I0dir. (here, =3I0react) exceeds the negative setting value **Min.polar.3I0> for dir.det.**, the direction is forward. If the current 3I0dir. exceeds the positive setting value, the direction is backward. In the range in between, the direction is undetermined.

This direction measurement thus is appropriate for the determination of ground-fault direction in isolated systems.



[dwsinphi-011112-01.tif, 3, en_US]

Figure 6-128 Direction-Characteristic Curve with Sin φ Measurement

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pick up of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **Voltage transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker.

The **Blk. by meas.-volt. failure** parameter can be set so that Measuring-voltage failure detection blocks the stage or does not block it.

Blocking the Pickup with Detection of the Fault Extinction

Using the evaluation of the instantaneous value developing of the zero-sequence voltage, the fault extinction can be recognized faster than via the dropout of the V0 fundamental-component value under the pickup value. The pickup of the stage is blocked with the fast detection of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero-sequence system after the fault extinction. With the **Blk. after fault extinction** parameter, you enable or disable this accelerated detection of the fault extinction.

Blocking the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking the Operate Indication via the Device-Internal Inrush-Current Detection Function

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started.

6.15.4.2 Application and Setting Notes

Parameter: **Operate & flt.rec. blocked**

- Default setting **(_:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: **Blk. by meas.-volt. failure**

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>Open* of the function block **Voltage transformer circuit breaker** is linked with the voltage transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: **Blk. w. inrush curr. detect.**

- Recommended setting value **(_:27) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you specify whether the operate is blocked during detection of an inrush current.

Siemens recommends disabling the blocking. The fundamental component of the zero-sequence voltage is a reliable criterion for the ground fault and remains unaffected by an enabling procedure.

Parameter: **Blk. after fault extinction**

- Recommended setting value **(_:110) Blk. after fault extinction** = ***yes***

If the **Blk. after fault extinction** parameter is set to ***yes***, the pickup is blocked after detection of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero-sequence system after the fault extinction. Siemens recommends using the default setting.

Parameter: **Directional mode**

- Default setting **(_:108) Directional mode** = ***forward***

When a fault is detected, the selection of the parameter **Directional mode** defines whether the pickup of the stage occurs in forward or backward direction.

Parameter: `Dir. measuring method`, `φ correction`, `Min.polar.3I0> for dir.det.`, `3I0> threshold value`

- Default setting **`(_:109) Dir. measuring method`** = ***`cos φ`***
- Default setting **`(_:107) φ correction`** = ***`0.0°`***
- Default setting **`(_:102) Min.polar.3I0> for dir.det.`** = ***`0.030 A`***
- Default setting **`(_:101) 3I0> threshold value`** = ***`0.050 A`***

These parameters are used to define the direction characteristic of the stage. The direction characteristic to use is dependent on the neutral-point treatment of the system.

Note that, for the direction determination, basically only a portion of the current vertical to the set direction-characteristic curve (3I0dir.) is decisive, refer to *6.15.4.1 Description*. This portion of the current is compared to the threshold value **`Min.polar.3I0> for dir.det.`**. In contrast, the absolute value of the current 3I0 is compared with the **`3I0> threshold value`** parameter.

System Type/ Neutral-Point Treatment	Description
Grounded	In the arc-suppression-coil-ground system, the watt leakage current 3I0 · cos φ of the arc-suppression coil is decisive for the direction determination. To evaluate the watt leakage current, set the parameters as follows: • **`Dir. measuring method`** = ***`cos φ`*** • **`φ correction`** = ***`0.0°`*** The direction determination for a ground fault is made more difficult in that a much larger capacitive or inductive reactive current is superimposed on the small watt leakage current. Therefore, depending on the system configuration and the fault evaluation, the total ground current supplied to the device can vary considerably in its values regarding the magnitude and the phase angle. However, the device should only evaluate the active component of the ground-fault current. This requires extremely high accuracy, particularly regarding the phase-angle measurement of all the instrument transformers. Furthermore, the device must not be set to operate too sensitively. A reliable direction measurement can only be expected with connection to a core balance current transformer. For the setting of the **`Min.polar.3I0> for dir.det.`** parameter, the rule of thumb is: Set the pickup value only to half of the expected measuring current as only the watt leakage current can be put into use. The **`3I0> threshold value`** parameter can also be set to half of the expected measuring current, whereby here the entire zero-sequence current can be put to use.
Isolated	In the isolated system, the capacitive ground reactive current 3I0 · sin φ is decisive for the direction determination. To evaluate the capacitive ground reactive current, set the parameters as follows: • **`Dir. measuring method`** = ***`sin φ`*** • **`φ correction`** = ***`0.0°`*** In an isolated system, the capacitive ground-fault currents of the entire electrically connected system flow through the measuring point in case of a ground fault. The ground current of the faulty feeder is compensated in the measuring point. As the pickup value of the **`Min.polar.3I0> for dir.det.`** and **`3I0> threshold value`** parameters, select about half of this capacitive ground-fault current flowing via the measuring point.

System Type/ Neutral-Point Treatment	Description
Resistance-Grounded	In the resistance-grounded system, the ohmic-inductive ground-fault current is decisive for the direction determination. To evaluate this short-circuit current, set the parameters as follows: • **Dir. measuring method** = ***cos φ*** • **φ correction** = ***-45.0°*** Set the **Min.polar.3I0> for dir.det.** and **3I0> threshold value** parameters to a value below the minimum ground-fault current to be expected.

Parameter: α1 reduction dir. area, α2 reduction dir. area

- Recommended setting value **(_:105) α1 reduction dir. area** = ***2°***
- Recommended setting value **(_:106) α2 reduction dir. area** = ***2°***

With the **α1 reduction dir. area** and **α2 reduction dir. area** parameters, you specify the angle for the limitation of the direction range. Siemens recommends using the default setting of 2°.

In an arc-suppression-coil-ground system in feeders with a very large reactive current, it can be practical to set a somewhat larger angle α1 to avoid a false pickup based on transformer and algorithm tolerances.

Parameter: V0> threshold value

- Default setting **(_:103) V0> threshold value** = ***30.000 V***

The **V0> threshold value** parameter allows you to set the zero-sequence voltage sensitivity of the stage. Set the threshold value smaller than the minimum absolute value of the zero-sequence voltage V0 that must still be detected.

Parameter: Dir. determination delay

- Default setting **(_:104) Dir. determination delay** = ***0.00 s***

The start of the ground fault normally shows a significant transient behavior. This can lead to an incorrect direction decision. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the **Dir. determination delay** parameter to achieve steady-state measurands. The duration of the transient cycle is determined from the system conditions and the respective fault characteristics. If you have no knowledge of a suitable time delay, Siemens recommends keeping the default setting.

Parameter: Operate delay

- Default setting **(_:6) Operate delay** = ***2.0 s***

The parameterized time **Operate delay** determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.15.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
3I0> cos/sinφ#				
_:1	3I0> cos/sinφ#:Mode		• off • on • test	off
_:2	3I0> cos/sinφ#:Operate & flt.rec. blocked		• no • yes	no
_:10	3I0> cos/sinφ#:Blk. by meas.-volt. failure		• no • yes	yes
_:27	3I0> cos/sinφ#:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:110	3I0> cos/sinφ#:Blk. after fault extinction		• no • yes	yes
_:108	3I0> cos/sinφ#:Directional mode		• forward • reverse	forward
_:109	3I0> cos/sinφ#:Dir. measuring method		• cos φ • sin φ	cos φ
_:107	3I0> cos/sinφ#:φ correction		-45 ° to 45 °	0 °
_:102	3I0> cos/sinφ#:Min.polar.3I0> for dir.det.	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 35.000 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 35.000 A	0.150 A
_:105	3I0> cos/sinφ#:α1 reduction dir. area		1 ° to 15 °	2 °
_:106	3I0> cos/sinφ#:α2 reduction dir. area		1 ° to 15 °	2 °
_:101	3I0> cos/sinφ#:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:103	3I0> cos/sinφ#:V0> threshold value		0.300 V to 200.000 V	30.000 V
_:104	3I0> cos/sinφ#:Dir. determination delay		0.00 s to 60.00 s	0.10 s
_:6	3I0> cos/sinφ#:Operate delay		0.00 s to 60.00 s	2.00 s

6.15.4.4 Information List

No.	Information	Data Class (Type)	Type
3I0> cos/sinφ#			
_:81	3I0> cos/sinφ#:>Block stage	SPS	I
_:501	3I0> cos/sinφ#:>Block delay & op.	SPS	I
_:54	3I0> cos/sinφ#:Inactive	SPS	O
_:52	3I0> cos/sinφ#:Behavior	ENS	O
_:53	3I0> cos/sinφ#:Health	ENS	O
_:60	3I0> cos/sinφ#:Inrush blocks operate	ACT	O
_:55	3I0> cos/sinφ#:Pickup	ACD	O
_:56	3I0> cos/sinφ#:Operate delay expired	ACT	O
_:57	3I0> cos/sinφ#:Operate	ACT	O
_:302	3I0> cos/sinφ#:Ground fault	ACD	O

6.15.5 Directional Transient Ground-Fault Stage

6.15.5.1 Description

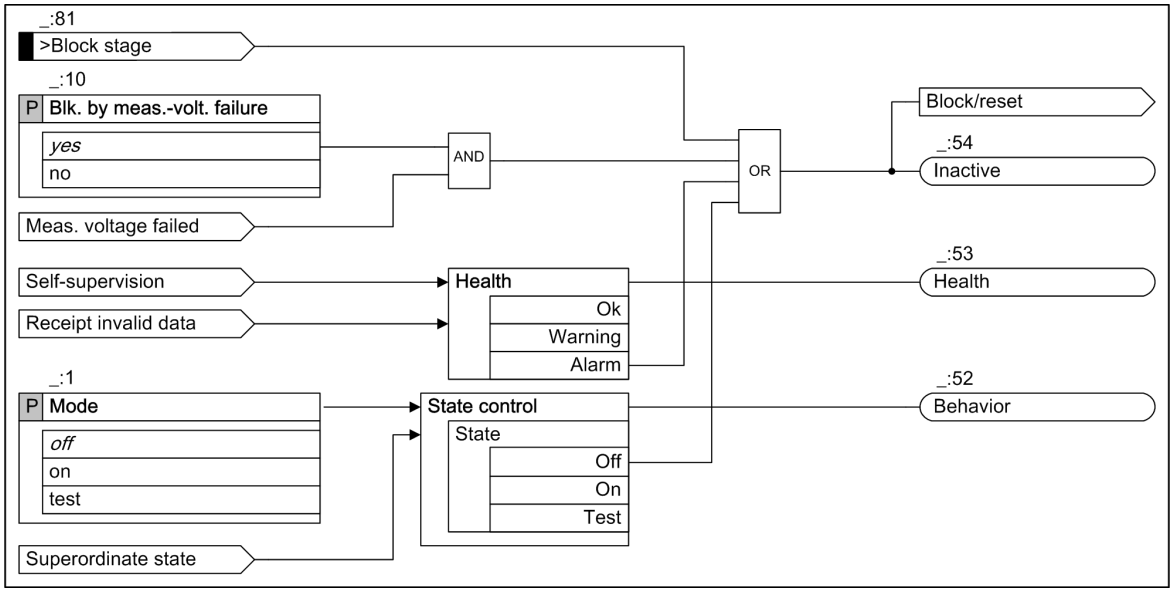
Overview

Ground faults occurring in arc-suppression-coil-ground systems quite often extinguish a short time after the ignition, mostly within a few milliseconds. Such transient occurrences are called transient ground faults. In order to detect the ground-fault direction, based on these transient occurrences, a special method of measurement is required that can also capture high frequencies. Conventional methods based on phasor calculations are not suitable. Even for ground faults lasting for a short time, usually, a high-frequency charging process occurs in healthy phases. The transient charging process is evaluated by the transient ground-fault method of measurement to determine the ground-fault direction. An integrating method of measurement ensures a high degree of sensitivity and a positive stability against parasitic signals in the zero-sequence system.

Since permanent ground faults also start with the transient charging process of flawless wires, those errors will be detected as well.

This process is most suitable for the use in closed loops or meshed systems. Operational, circulating zero-sequence currents are eliminated and therefore, cannot affect the directional result.

Stage-Control Logic



[lostuwis-240113-01.tif, 1, en_US]

Figure 6-129 Logic Diagram of the Stage Control

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage* . In the event of blocking, the picked up stage will be reset.

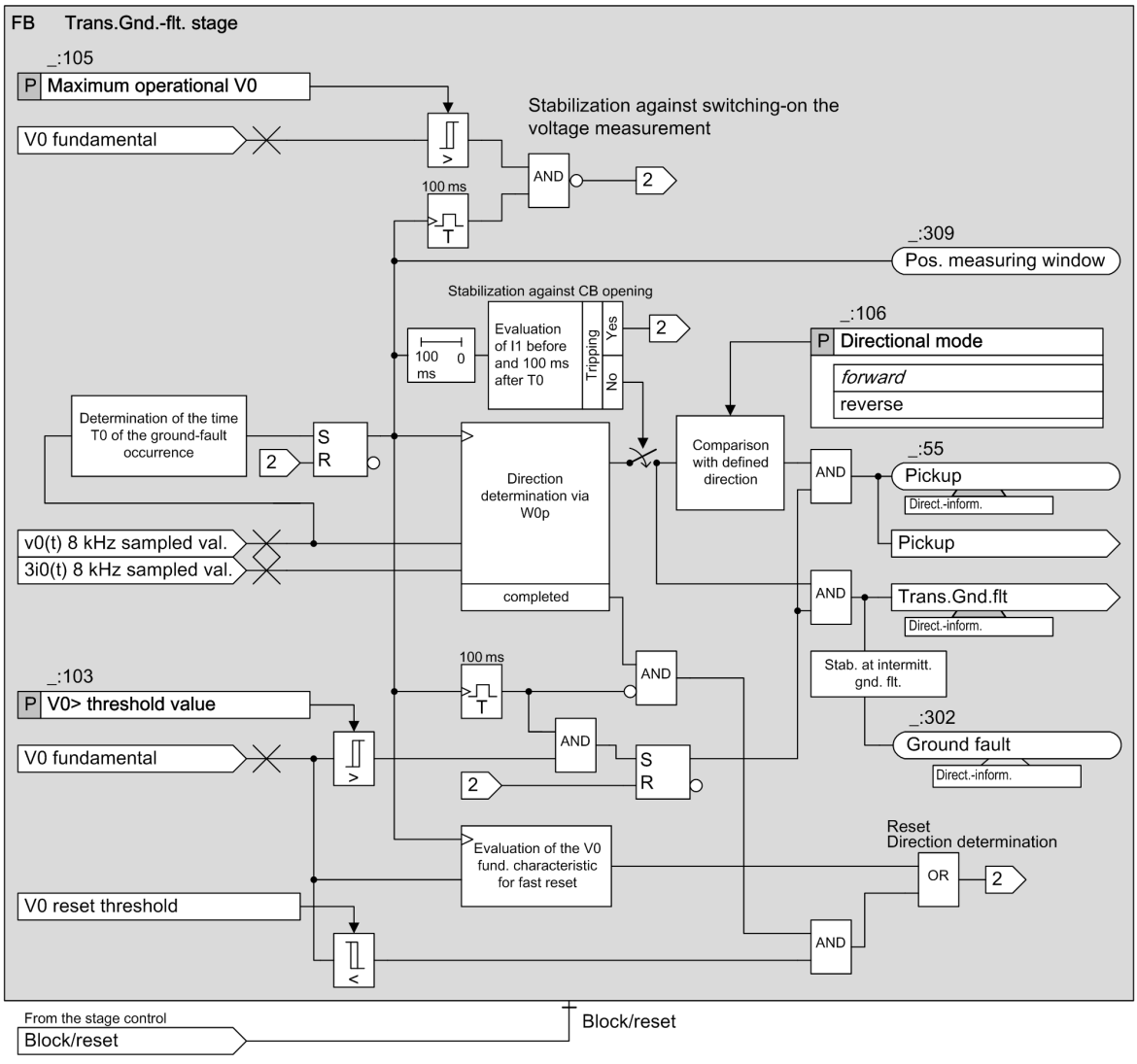
Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker.

The **`Blk. by meas.-volt. failure`** parameter can be set so that **measuring-voltage failure detection** blocks the stage or not.

Logic of the Transient Ground-Fault Functionality



[lowisfut-240113-01.tif, 6, en_US]

Figure 6-130 Logic Diagram of the Directional Transient Ground-Fault Stage

Measured Values, Method of Measurement

The zero-sequence values of zero-sequence voltage and zero-sequence current are measured directly or calculated from the phase variables. When measuring directly, the following is detected:

- Zero-sequence voltage on the broken-delta winding
- Zero-sequence current via Holmgreen connection or via core balance current transformer

The voltage measured on the broken-delta winding will be converted to zero-sequence voltage V_0.

The instantaneous values of the zero-sequence voltage V0(t) that are sampled at a high frequency (8 kHz) serve to determine the point in time of the ground fault occurrence T0.

The instantaneous values of the zero-sequence voltage V0(t) and the ground current 3I0(t), which are sampled at a high frequency (8 kHz), are the basis for direction determination.

The fundamental-component values of the zero-sequence voltage V0 serve to release the directional result and the pickup as well as a criterion for the stabilization against switching operations.

The positive-sequence system (if it exists as a measured value) serves as an additional criterion for the stabilization against switching operations.

The fundamental-component values V0 and 3I0 will be used in the optional trip logic.

Operational, meaning circulating zero-sequence currents, can occur in closed loops or meshed systems. This type of zero-sequence current is also present in case of a failure and can falsify the directional result. Therefore, an operational zero-sequence current is eliminated.

Determining the Time of the Ground-Fault Ignition

The algorithm uses the evaluation of the instantaneous values of the zero-sequence voltage to verify continuously if a ground fault occurred. This takes place regardless of whether the set threshold value for V0 is exceeded. If a ground fault occurred, the measuring window for determining the direction is positioned and the direction determination is performed. The position of the measuring window is logged via the indication *Pos. measuring window* (in FB **General**). The precise identification of the time T0 at which the ground fault occurred is decisive for the correct direction determination.

Determination of Direction, Method of Measurement

The active energy of the zero-sequence system is calculated for the direction determination. Once the ground fault occurrence has been detected, the active energy will be calculated across approximately 1 cycle frequency. If the active energy of the zero-sequence system is negative, a forward fault is present; otherwise it is a backward fault.

Direction Result Message, Pickup

Determining the time of the ground-fault ignition and the direction is always done with maximum sensitivity. With the parameter **V0> threshold value**, you define the sensitivity for the indication of the direction and the pickup of the stage.

If the fundamental-component value of the zero-sequence voltage V0 exceeds the associated threshold value (**V0> threshold value** parameter) within 100 ms after detecting the ground-fault ignition, the direction result will be reported. In this way, high-impedance ground faults are also reported in which the zero-sequence system values rise only slowly, and, for this reason, the occurrence of the ground fault is detected noticeably earlier than the exceedance of the parameterized threshold value.

The direction result will be reported to the function via the *(_:302) Ground fault* of the function block **General information**. This indication is reported irrespective of the parameterized direction of the function.

If the determined direction corresponds with the parameterized direction (parameter **Directional mode**), a pickup occurs.

Reset of the Algorithm

To allow a new directional measurement, the algorithm needs to be reset. The normal reset takes place when the fundamental component of the zero-sequence voltage V0 drops below the V0 reset threshold. This reset threshold is a small device-internal V0 threshold. It is also depending on an operational V0 and is thus a dynamic threshold. The threshold value is 3.0 V secondary without dynamic influence.

Stabilization against Switching Operations

Switching operations in the system to be protected can cause transient signals in the zero-sequence system. The stage is stabilized against possible overfunction due to switching operations.

The following mechanisms are applied:

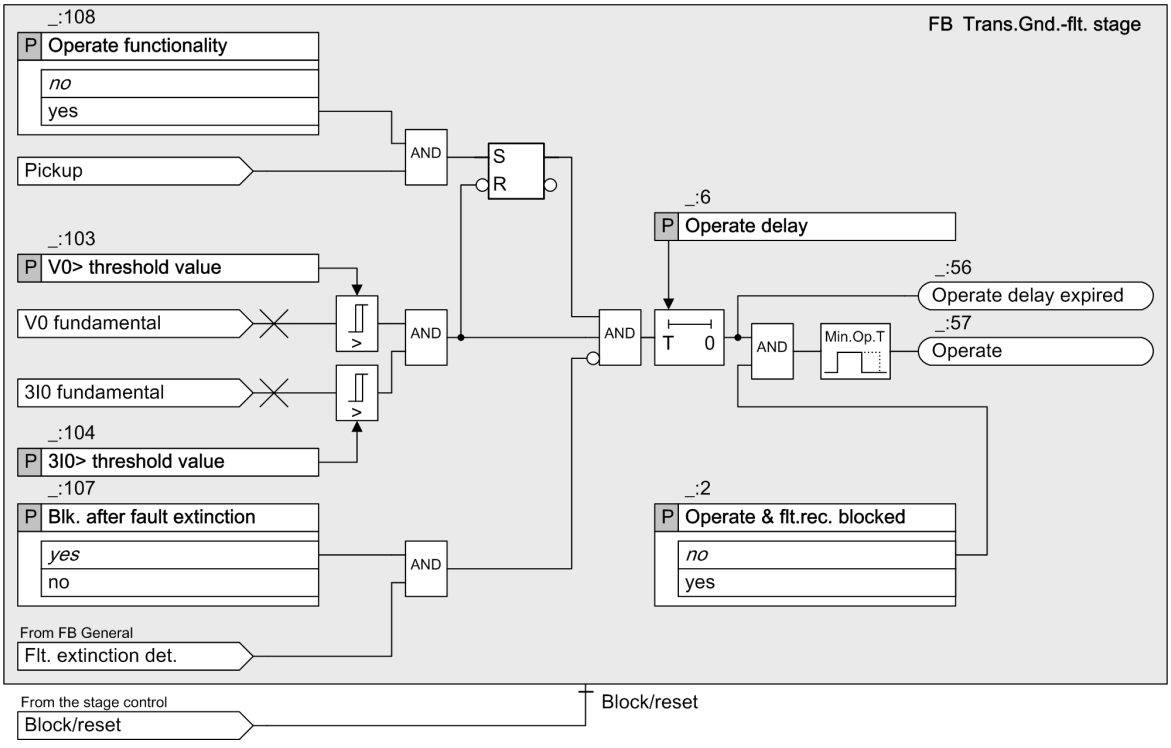
- For reporting the direction result, the fundamental-component value of the zero-sequence voltage must exceed the **V0> threshold value** in a time slot of 100 ms after the ground-fault extinction. This effectively suppresses wrong indications as a result of switching operations.
- The fundamental-component value of the zero-sequence voltage V0 is not influenced by switching operations and is thus a good criterion for distinguishing the ground fault from a switching procedure. The condition that the fundamental-component value must exceed the **V0> threshold value** for reporting the direction result effectively suppresses switching operations.

  For rare cases in which high zero-sequence voltages occur over longer time ranges after switching off the feeder or line, a criterion on the basis of the positive-sequence system current is also effective. This criterion compares the positive-sequence system current before and after the transient event and thus detects a disconnection. In case of disconnection, the direction result is not reported.

  Through stabilization mechanisms, the direction result is reported 100 ms after the ground-fault ignition. Thus a pickup occurs with a 100-ms delay.

  If the stage is used in a 1-phase function group, the additional criterion via the positive-sequence system current is not effective.
- The function detects transient occurrences in the zero-sequence voltage. In systems with operational zero-sequence voltages, if the measuring voltage is switched on, the function can internally be started. If the fundamental-component value of the zero-sequence voltage does not exceed the threshold of the **Maximum operational V0** parameter in a time slot of 100 ms after the function start, the function is reset internally.

Trip Logic



[loauswis-240113-01.tif, 2, en_US]

Figure 6-131 Trip Logic Diagram

In many applications, the transient ground-fault stage is used only to indicate the direction. In this case, the trip logic is not required and remains disabled. However, this stage can also be used to disable a permanent ground fault. For this, you enable the optional trip logic with the **Operate functionality** parameter. If the fundamental-component values V0 and 3I0 exceed the set threshold values, the operate delay (**Operate delay** parameter) starts with the pickup. In order to start the operate delay, the threshold values must be

exceeded during the time delay. The process of the operate delay will be indicated. If the **Operate & flt.rec. blocked** setting is set to ***no***, the pickup indication is sent.

Blocking the Pickup with Detection of the Fault Extinction

Using the evaluation of the instantaneous value cycle of the zero-sequence voltage, the fault extinction of the ground fault can be detected faster than via the dropout of the V0 fundamental-component value under the pickup value. The fast detection of the fault extinction (see function block **General information**) blocks the tripping time delay. When using the parameter **Blk. after fault extinction**, this accelerated blocking mechanism can be enabled or disabled.

6.15.5.2 Application and Setting Notes

Parameter: Operate functionality

- Default setting **(_:108) Operate functionality** = ***no***

If the transient ground-fault stage is used only to indicate the direction, this optional trip logic is not required and remains disabled. If the transient ground-fault stage is used to disable permanent faults as well, this optional trip logic is enabled. Pickup of the stage will initiate the tripping delay.

Parameter: Operate & flt.rec. blocked

- Default setting **(_:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>Open* of the function block **Voltage transformer circuit breaker** is linked with the voltage transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: Blk. after fault extinction

- Recommended setting value **(_:107) Blk. after fault extinction** = ***yes***

If the **Blk. after fault extinction** parameter is set to ***yes***, the tripping delay is reset after the detection of the fault extinction. Therefore, if the tripping delay is set for a short time, the possibility of an overfunction is avoided. The reason for an overfunction is a slower attenuation in the zero-sequence system following the fault extinction. Siemens recommends keeping this default setting if the stage is used for tripping. If you are using the stage only for reporting or for detecting intermittent faults, you have to disable the blocking.

Parameter: Directional mode

- Default setting **(_:106) Directional mode** = ***forward***

When a fault is detected, the selection of the parameter **Directional mode** defines whether the pickup of the stage occurs in forward or backward direction.

Parameter: V0> threshold value

- Default setting **(_:103) V0> threshold value** = ***15.000 V***

With the parameter **V0> threshold value**, you define the sensitivity for the indication of the direction and the pickup of the stage.

Note that the sensitivity of the direction determination itself is not thereby changed. The direction determination always works with maximum sensitivity.

Should high-resistive ground faults be reported as well, very sensitive settings are possible, for example, **V0> threshold value** = ***5 V*** secondary.

Parameter: Maximum operational V0

- Recommended setting value **(_:105) Maximum operational V0** = ***3.000 V***

The setting of the **Maximum operational V0** parameter is in conjunction with the stabilization against switching operations.

The setting is made with reference to the zero-sequence voltage V0 according to its definition.

Network Structure	Description
Radial system	In the primary system, no operational zero-sequence voltages are present. A measured zero-sequence voltage results from tolerances within the voltage measurement, for example, from the voltage transformers. Siemens recommends using the default value of 3.000 V.
Ring network, meshed network	Operational zero-sequence voltages can occur in such networks. The secondary operational zero-sequence voltages can be determined by reading the residual voltage $V_{N\,sec}$ or the zero-sequence voltage $V_{0\,sec}$ under the symmetrical components from the device or via DIGSI. In case you read the secondary residual voltage $V_{N\,sec}$, you convert it to $V_{0\,sec}$ with the **Matching ratio Vph / VN** parameter. You can find more information in chapter *6.1.4 Application and Setting Notes for Measuring-Point Voltage 3-Phase (V-3ph)* . If $V_{0\,sec}$ is greater than 2.5 V, the value of **Maximum operational V0** shall be increased to $V_{0\,sec} \cdot 1.2$. Example: $V_{N\,sec}$ = 5.000 V **Matching ratio Vph / VN** = $\sqrt{3}$ $V_{0\,sec}$ = 5.000 V $\cdot$ $\sqrt{3}$ / 3 = 2.887 V **Maximum operational V0** = 2.887 V $\cdot$ 1.2 = 3.464V In most cases, the operational zero-sequence voltages will be smaller than 2.500 V. Siemens recommends using the default value of 3.000 V.

Parameter: 3I0> threshold value

- Default setting **(_:104) 3I0> threshold value** = ***0.030 A***

The setting is significant only for optional trip logic for switching off permanent ground faults. Select the setting such that the static ground-fault current exceeds the threshold value.

Parameter: Operate delay

- Default setting **(_:6) Operate delay** = ***0.50 s***

The parameterized time **Operate delay** determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

The setting of the **Operate delay** depends on the specific application. Ensure that the pickup is delayed by 100 ms with regard to the time of the ground-fault ignition.

6.15.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Trans.Gnd.flt#				
_:1	Trans.Gnd.flt#:Mode		• off • on • test	off
_:2	Trans.Gnd.flt#:Operate & flt.rec. blocked		• no • yes	no
_:10	Trans.Gnd.flt#:Blk. by meas.-volt. failure		• no • yes	yes
_:107	Trans.Gnd.flt#:Blk. after fault extinction		• no • yes	yes
_:108	Trans.Gnd.flt#:Operate functionality		• no • yes	no
_:106	Trans.Gnd.flt#:Direc-tional mode		• forward • reverse	forward
_:103	Trans.Gnd.flt#:V0> threshold value		0.300 V to 200.000 V	25.981 V
_:104	Trans.Gnd.flt#:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.150 A
_:6	Trans.Gnd.flt#:Operate delay		0.00 s to 60.00 s	0.50 s
_:105	Trans.Gnd.flt#:Maximum operational V0		0.300 V to 340.000 V	3.000 V

6.15.5.4 Information List

No.	Information	Data Class (Type)	Type
Trans.Gnd.flt#			
_:81	Trans.Gnd.flt#:>Block stage	SPS	I
_:54	Trans.Gnd.flt#:Inactive	SPS	O
_:52	Trans.Gnd.flt#:Behavior	ENS	O
_:53	Trans.Gnd.flt#:Health	ENS	O
_:55	Trans.Gnd.flt#:Pickup	ACD	O
_:56	Trans.Gnd.flt#:Operate delay expired	ACT	O
_:57	Trans.Gnd.flt#:Operate	ACT	O
_:302	Trans.Gnd.flt#:Ground fault	ACD	O

6.15.6 Usage Information for Detection of Intermittent Ground Faults

The stage type **3I0> with cos φ or sin φ measurement** is suited for directional detection of intermittent ground faults. Many years of field experience and field tests have shown that the direction determination of this stage type reliably determines the direction of the current peaks. Between the current peaks, the direction is detected as *unknown*. To generate a tripping or an alarm, you can analyze the individual pickups of a stage (each directional pickup corresponds to a current peak) in a time-based way or count them via an additional user logic (CFC chart).

You can also ensure the result in the user logic via a 2nd directional stage that works in the backward direction, as well as a V0 stage.

You can operate a 3rd directional stage in parallel for detection of permanent ground faults.

In the following, certain settings are explained that are necessary for this application (detection of intermittent ground faults):

- Parameter: **(_:102) Dropout delay**

  The function must treat the intermittent process as one ground fault. For this, it is necessary that the indication *Ground fault* does not drop out between 2 consecutive current peaks. This is ensured via the **Dropout delay** parameter (FB **General**). A dropout delay of 1 s is a feasible value.

- Parameter: **(_:104) Dir. determination delay**

  You must set the delay of the direction determination to 0 s so that the direction of the current peaks can be determined.

- Parameter: **(_:105) α1 reduction dir. area** and **(_:106) α2 reduction dir. area**

  The current peaks show a clear ohmic component. With these parameters, you can limit the direction characteristic and ensure a reliable direction result.

  Siemens recommends setting both parameters to 10°.

- Parameter: **(_:110) Blk. after fault extinction**

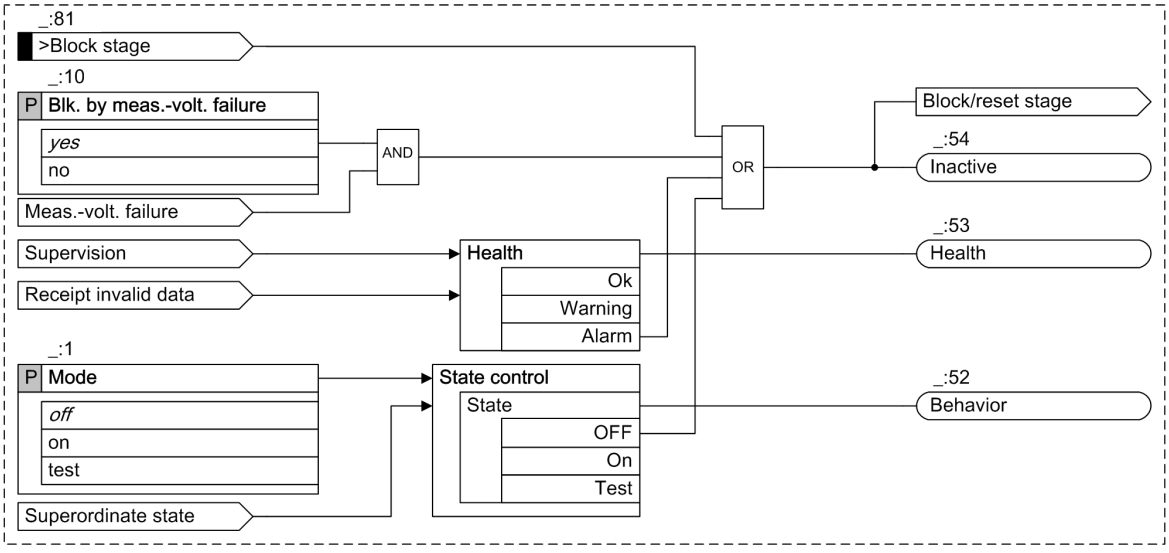
  To make possible a continuous and immediate detection of the current peaks, you must switch off the blocking after fault suppression.

No further parameters need particular consideration with regard to an intermittent ground fault. You can set these as for the detection of permanent ground faults.

6.15.7 Directional 3I0 Stage with φ(V0,3I0) Measurement

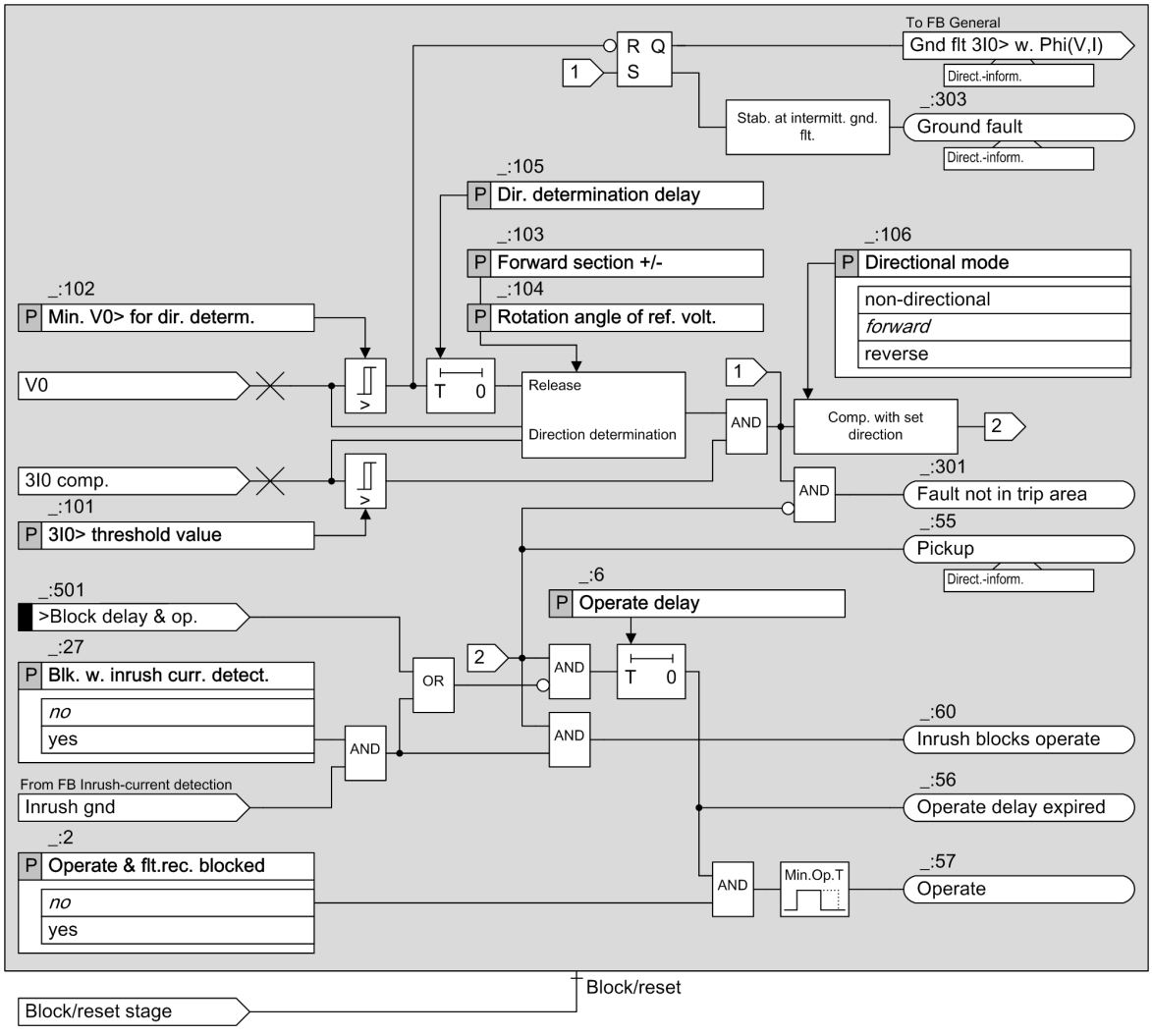
6.15.7.1 Description

Logic



[logfppvi-291112-02.vsd, 1, en_US]

Figure 6-132 Logic Diagram of the Stage Control



[logfppvi-291112-01.tif, 3, en_US]

Figure 6-133 Logic Diagram of the Directional 3I0 Stage with φ(V0,3I0) Measurement

Measured Value V0, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages VA, VB, and VC using the defining equation.

This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, Method of Measurement

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

The method of measurement processes the sampled current values and filters out the fundamental component numerically.

Depending upon the settings of the **`Connection type`** and **`Measuring point I-3ph`** parameters, as well as the current terminal blocks used, different linearity and setting ranges result, refer for this to chapter *6.15.4.1 Description* , Ground-Fault Detection, Pickup.

Ground-Fault Detection, Pickup

If the absolute value of the ground current 3I0 vector exceeds the threshold value **3I0> threshold value** and the absolute value of the zero-sequence voltage V0 vector exceeds the threshold value **Min. V0> for dir. determ.**, the stage detects the ground fault . The direction determination (see in the following paragraph) is started when the zero-sequence voltage exceeds the threshold. The result from the direction determination is only valid if the absolute value of the ground current 3I0 vector has also exceeded its threshold value. The direction result is indicated via the *Ground fault* signal (in the **General** function block).

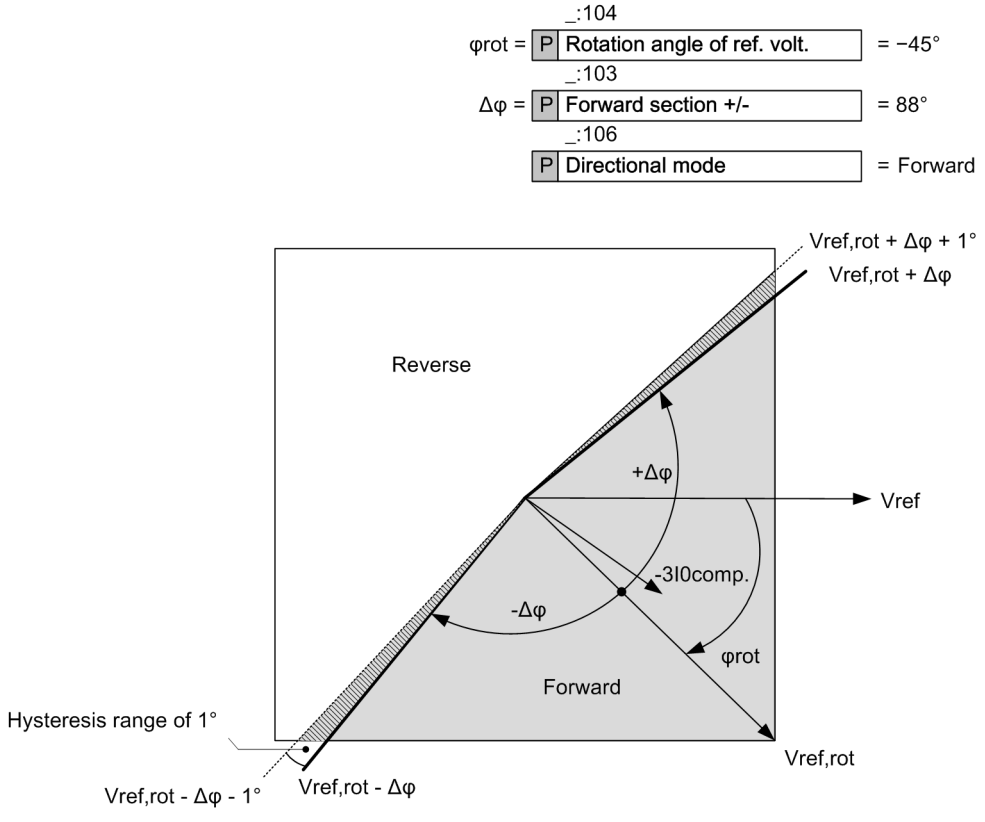
As long as the direction result equals the parameterization direction (parameter **Directional mode**), the stage picks up.

Direction Determination

Exceeding the threshold values by the zero-sequence voltage V0 is a criterion for the ground fault. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the **Dir. determination delay** parameter to achieve steady-state measurands.

The direction is determined via the determination of the phase angle between the angle-error compensated ground current 3I0com. and the rotated zero-sequence voltage V0, indicated in the following as reference voltage $V_{ref,rot}$. To take different system conditions and applications into account, the reference voltage can be rotated through an adjustable angle (**Rotation angle of ref. volt.** parameter). This moves the vector of the rotated reference voltage close to the vector ground current -3I0com. Consequently, the result of direction determination is as reliable as possible.

The rotated reference voltage $V_{ref,rot}$ and the **Forward section +/-** parameter define the forward and reverse area. The forward area results as range ± Δφ around the rotated reference voltage $V_{ref,rot}$. The value ± Δφ is set with the **Forward section +/-** parameter. The remaining area besides the forward area is the reverse area. Between the forward and reverse area, a hysteresis is defined, refer to *Figure 6-134* .



[dwdirrot-011112-02.vsd, 1, en_US]

Figure 6-134 Directional Characteristic in Forward Mode

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>open* of the function block **Voltage transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker.

The **Blk. by meas.-volt. failure** parameter can be set so that **measuring-voltage failure detection** blocks the stage or not.

Blocking the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking the Operate Indication via the Device-Internal Inrush-Current Detection Function

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started.

6.15.7.2 Application and Setting Notes

Parameter: **Operate & flt.rec. blocked**

- Default setting **(_:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: **Blk. by meas.-volt. failure**

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>open* of the function block **Voltage transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: **Blk. w. inrush curr. detect.**

- Recommended setting value **(_:27) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you specify whether the operate is blocked during detection of an inrush current.

Siemens recommends disabling the blocking. The fundamental component of the zero-sequence voltage is a reliable criterion for the ground fault and remains unaffected by an enabling procedure.

Parameter: Directional mode

- Default setting **(_:106) Directional mode** = ***forward***

When a fault is detected, the selection of the parameter **Directional mode** defines whether the pickup of the stage occurs in forward or reverse direction.

When the parameter **Directional mode** is set as ***non-directional***, the direction determination is not considered. The pickup condition depends only on the absolute values 3I0 and V0 and the respective thresholds.

Parameter: Rotation angle of ref. volt.,Forward section +/-

- Default setting **(_:104) Rotation angle of ref. volt.** = ***-45°***
- Default setting **(_:103) Forward section +/-** = ***88°***

With the **Rotation angle of ref. volt.** and **Forward section +/-** parameters, you set the direction characteristic, that is, the areas of forward and reverse. With this, you set the direction characteristic according to the system conditions and the neutral-point treatment.

Typical settings for the **Rotation angle of ref. volt.** parameter are:

- Arc-suppression-coil-ground system: 0°
- Isolated system: +45°
- Grounded system: -45°

The **Forward section +/-** parameter can normally be left at its default setting. A reduction of the forward area by a few degrees is practical, for example in an arc-suppression-coil-ground system with long cable feeders, that generate high capacitive fault currents.

Parameter: Min. V0> for dir. determ.

- Default setting **(_:102) Min. V0> for dir. determ.** = ***2.000 V***

With the **Min. V0> for dir. determ.** parameter, you determine the minimum voltage V0 necessary for the release of the direction determination that must be attained within the time delay **Dir. determination delay**.

Parameter: 3I0> threshold value

- Default setting **(_:101) 3I0> threshold value** = ***0.050 A***

The **3I0> threshold value** parameter allows you to set the ground-current sensitivity of the stage. Set the threshold value lower than the minimum absolute value of the ground-fault current 3I0 that must still be detected.

Parameter: Dir. determination delay

- Default setting **(_:105) Dir. determination delay** = ***0.10 s***

The start of the ground fault normally shows a significant transient behavior. This can lead to an incorrect direction decision. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the **Dir. determination delay** parameter to achieve steady-state measurands. The duration of the transient cycle is determined from the system conditions and the respective fault characteristics. If you have no knowledge of a suitable time delay, Siemens recommends keeping the default setting.

Parameter: Operate delay

- Default setting **(_:6) Operate delay** = ***0.50 s***

The parameterized time **Operate delay** determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.15.7.3 Settings

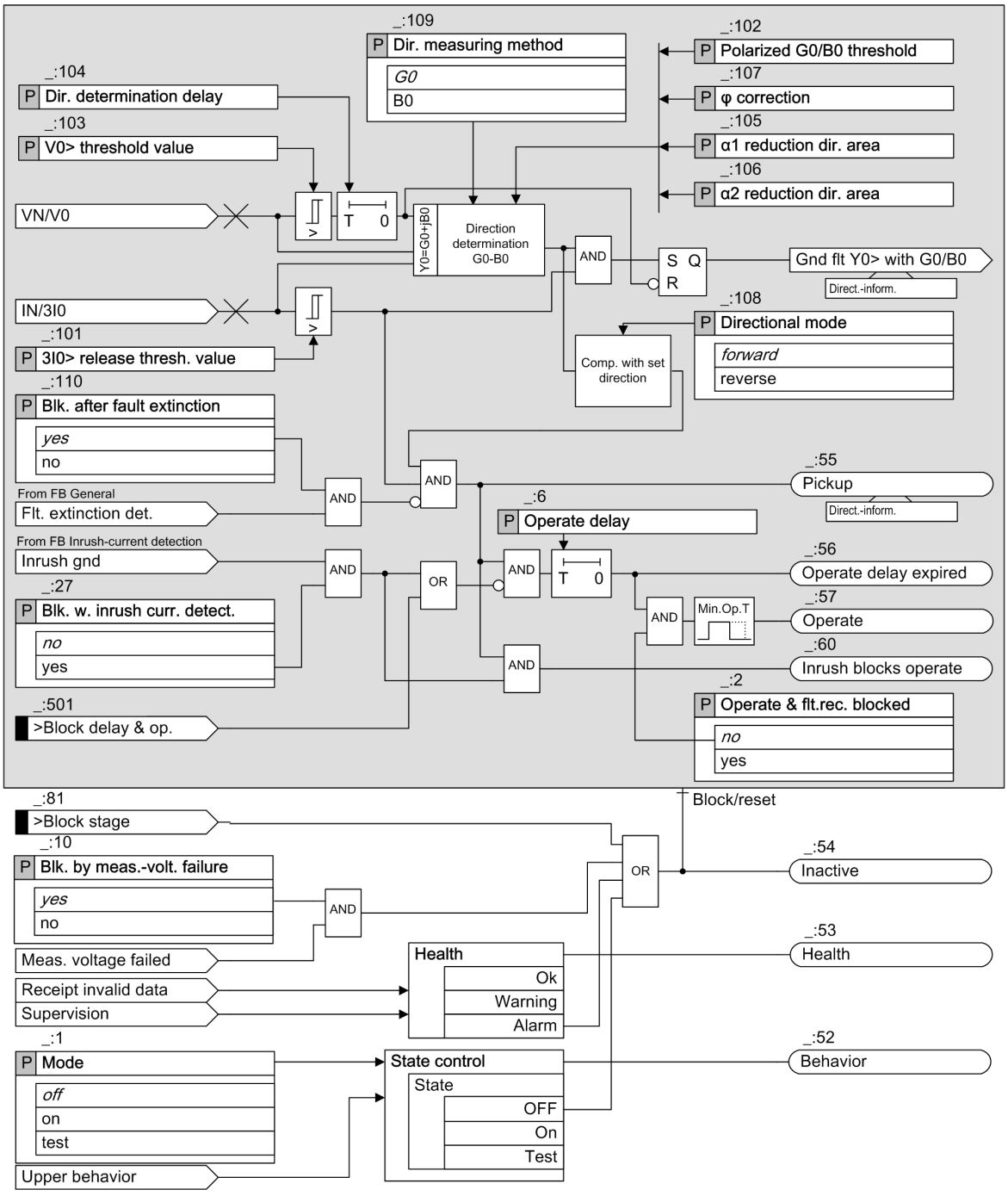
Addr.	Parameter	C	Setting Options	Default Setting
3I0> φ(VI) #				
_:1	3I0> φ(VI) #:Mode		• off • on • test	off
_:2	3I0> φ(VI) #:Operate & flt.rec. blocked		• no • yes	no
_:10	3I0> φ(VI) #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	3I0> φ(VI) #:Blk. w. inrush curr. detect.		• no • yes	no
_:106	3I0> φ(VI) #:Directional mode		• non-directional • forward • reverse	forward
_:104	3I0> φ(VI) #:Rotation angle of ref. volt.		-180 ° to 180 °	-45 °
_:103	3I0> φ(VI) #:Forward section +/-		0 ° to 180 °	88 °
_:102	3I0> φ(VI) #:Min. V0> for dir. determ.		0.300 V to 200.000 V	2.000 V
_:101	3I0> φ(VI) #:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:105	3I0> φ(VI) #:Dir. determination delay		0.00 s to 60.00 s	0.10 s
_:6	3I0> φ(VI) #:Operate delay		0.00 s to 60.00 s	0.50 s

6.15.7.4 Information List

No.	Information	Data Class (Type)	Type
3I0> φ(VI) #			
_:81	3I0> φ(VI) #:>Block stage	SPS	I
_:501	3I0> φ(VI) #:>Block delay & op.	SPS	I
_:54	3I0> φ(VI) #:Inactive	SPS	O
_:52	3I0> φ(VI) #:Behavior	ENS	O
_:53	3I0> φ(VI) #:Health	ENS	O
_:301	3I0> φ(VI) #:Fault not in trip area	SPS	O
_:60	3I0> φ(VI) #:Inrush blocks operate	ACT	O
_:303	3I0> φ(VI) #:Ground fault	ACD	O
_:55	3I0> φ(VI) #:Pickup	ACD	O
_:56	3I0> φ(VI) #:Operate delay expired	ACT	O
_:57	3I0> φ(VI) #:Operate	ACT	O

6.15.8 Directional Y0 Stage with G0 or B0 Measurement

6.15.8.1 Description



[LoY0G0B0-300713-01, 4, en_US]

Figure 6-135 Logic Diagram of the Directional Y0 Stage with G0 or B0 Measurement

Measured Value V0, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages VA, VB, and VC using the definition equation.

This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, G0, B0, Method of Measurement

The function usually evaluates the ground current 3I0 sensitively measured via a core balance current transformer, this current being converted with the voltage V0 into the admittance Y0 = G0 + jB0. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 calculated from the phase currents. This results in a very large linearity and settings range.

The method of measurement processes the sampled current values and filters out the fundamental component numerically. The methods of measurement are characterized by high accuracy and by insensitivity to harmonics, especially the 3rd and 5th harmonics frequently present in the ground-fault (leakage) current.

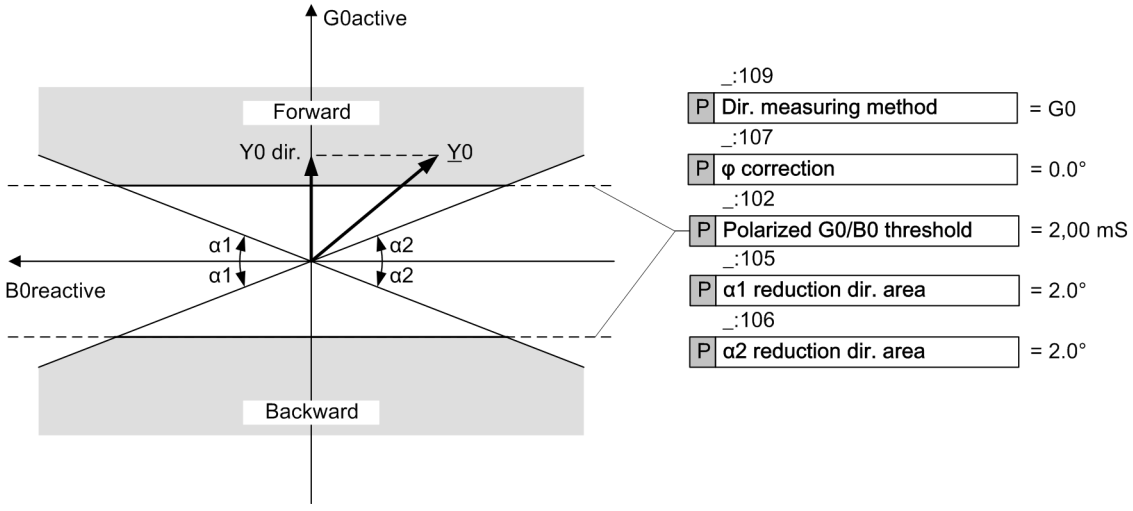
Ground-Fault Detection, Pickup

If the absolute value of the ground current 3I0 exceeds the threshold value **`3I0> release thresh. value`** and the absolute value of the zero-sequence voltage V0 exceeds the threshold value **`V0> threshold value`**, the stage recognizes the ground fault. The calculation of G0 or B0 is started with exceeding the threshold values and then, the direction determination (see the following) is performed. The direction result is indicated via the *`Ground fault`* signal (in the **General** function block). If the direction result equals the parameterized direction (parameter **`Directional mode`**), the stage picks up.

Direction Determination

Exceeding the threshold values by the zero-sequence voltage V0 is a criterion for the ground fault. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the **`Dir. determination delay`** parameter to achieve steady-state measurands. The result from the direction determination is only valid if the absolute value of the ground current 3I0 has also exceeded its release threshold value.

The following figure shows an example of the direction determination in the complex phasor diagram for the G0 direction measurement method with a correction value of the direction straight line from 0 (Parameter **`φ correction`**). The example is suitable for the determination of the ground-fault direction in an arc-suppression-coil-ground system where the value G0 is decisive for the direction determination.



[DwY0Dire-171012-01, 1, en_US]

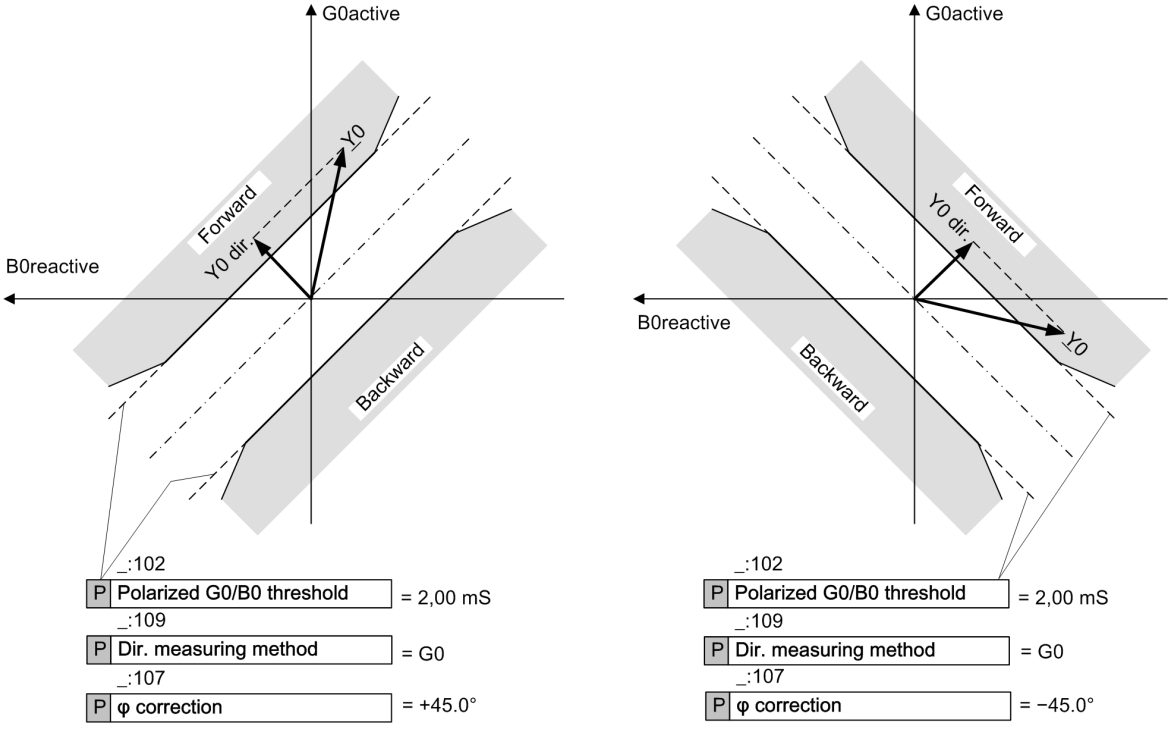
Figure 6-136 Direction-Characteristic Curve for the G0 Measurement

The zero-sequence voltage V0 is generally the reference value for the real axis and is identical to the G0 axis. The axis of symmetry of the direction-characteristic curve coincides with the B0 (reactive) axis for this example. For the direction determination, the component of the admittance perpendicular to the set direction-characteristic curve (= axis of symmetry) is decisive G0dir (=Y0dir). In this example, this is the active component **G0active** of the admittance Y0. The conductance G0dir. (here = G0active) is calculated and

compared with the setting value **Polarized G0/B0 threshold**. If the conductance G0dir. exceeds the positive setting value, the direction is forward. If the conductance G0dir. exceeds the negative setting value, the direction is backward. In the range in between, the direction is undetermined.

With the **α1 reduction dir. area** and **α2 reduction dir. area** parameters, you can limit the forward and backward ranges as shown in *Figure 6-137* . With this, the direction determination is secured in case of high currents in the direction of the axis of symmetry.

The symmetry axis can be turned via a correction angle (**φ correction** parameter) in a range of ±45. Through this, it is possible, for example, to attain the greatest sensitivity in grounded systems in the resistive-inductive range with a -45° turn. In the case of electric machines in busbar connection on the isolated system, the greatest sensitivity in the resistive-capacitive range can be attained with a turn of +45° (see following figure).

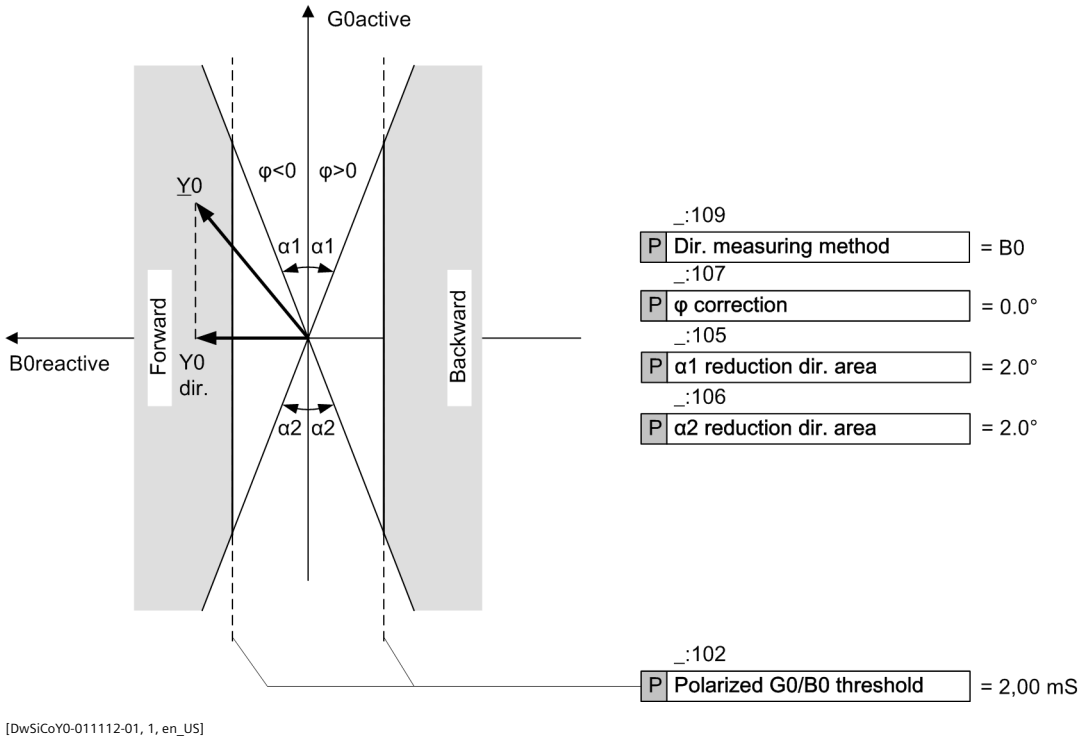


[DwY0meas-171012-01, 1, en_US]

Figure 6-137 Turning the Direction-Characteristic Curves with G0 Measurement with Angle Correction

If you set the **Dir. measuring method** parameter to B0 and the **φ correction** parameter to ***0***, the axis of symmetry of the direction-characteristic curve coincides with the G0 and V0 axes. Since the component of the admittance Y0 perpendicular to the direction-characteristic curve (= axis of symmetry) is decisive (B0dir. (=Y0dir.)), here, the susceptance B0 (reactive) is used in the direction determination. If the susceptance B0dir. (B0reactive) exceeds the negative setting value **Polarized G0/B0 threshold**, the direction is forward. If the susceptance B0dir. exceeds the positive setting value, the direction is backward. In the range in between, the direction is undetermined.

This direction measurement thus is appropriate for the determination of ground-fault direction in isolated systems.



[DwSiCoY0-011112-01, 1, en_US]

Figure 6-138 Direction-Characteristic Curve for the B0 Measurement

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>open* of the function block **Voltage transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker.

The **Blk. by meas.-volt. failure** parameter can be set so that Measuring-voltage failure detection blocks the stage or does not block it.

Blocking the Pickup with Detection of the Fault Extinction

Using the evaluation of the instantaneous value developing of the zero-sequence voltage, the fault extinction can be recognized faster than via the dropout of the V0 fundamental-component value under the pickup value. The pickup of the stage is blocked with the fast detection of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero-sequence system after the fault extinction. With the **Blk. after fault extinction** parameter, you enable or disable this accelerated detection of the fault extinction.

Blocking of the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking the Operate Indication via the Device-Internal Inrush-Current Detection Function

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started.

6.15.8.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting **(_:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>Open* of the function block **Voltage transformer circuit breaker** is linked with the voltage transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: Blk. w. inrush curr. detect.

- Recommended setting value **(_:27) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you specify whether the operate is blocked during detection of an inrush current.

Siemens recommends disabling the blocking. The fundamental component of the zero-sequence voltage is a reliable criterion for the ground fault and remains untouched by an enabling procedure.

Parameter: Blk. after fault extinction

- Recommended setting value **(_:110) Blk. after fault extinction** = ***yes***

If the **Blk. after fault extinction** parameter is set to ***yes***, the pickup is blocked after detection of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero-sequence system after the fault extinction. Siemens recommends using the default setting.

Parameter: Directional mode

- Default setting **(_:108) Directional mode** = ***forward***

When a fault is detected, the selection of the parameter **Directional mode** defines whether the pickup of the stage occurs in forward or backward direction.

Parameter: **Dir. measuring method, φ correction, Polarized G0/B0 threshold, 3I0> release thresh. value**

- Default setting **(_:109) Dir. measuring method** = ***G0***
- Default setting **(_:107) φ correction** = ***0.0°***
- Default setting **(_:102) Polarized G0/B0 threshold** = ***2.00 mS***
- Default setting **(_:101) 3I0> release thresh. value** = ***0.002 A***

These parameters are used to define the direction characteristic of the stage. The direction characteristic to use is dependent on the neutral-point treatment of the system.

Note that, for the direction determination, basically only the component of the admittance perpendicular to the set direction-characteristic curve is decisive, see chapter *6.15.8.1 Description* . This admittance component is compared to the threshold value **Polarized G0/B0 threshold**. In contrast, the absolute value of the current 3I0 is compared with the **3I0> release thresh. value** parameter.

System Type/ Neutral-Point Treatment	Description
Grounded	In the arc-suppression-coil-ground system, the watt leakage current 3I0 · cos φ of the arc-suppression coil is decisive for the direction determination. To evaluate the watt leakage current, set the parameters as follows: • **Dir. measuring method** = *G0* • **φ correction** = *0.0°* The direction determination for a ground fault is made more difficult in that a much larger reactive current of capacitive or inductive character is superimposed on the small watt leakage current. Therefore, depending on the system configuration and the fault evaluation, the total ground current supplied to the device can vary considerably in its values regarding the magnitude and the phase angle. However, the device should only evaluate the active component of the ground-fault current. This requires extremely high accuracy, particularly regarding the phase-angle measurement of all the instrument transformers. Furthermore, the device must not be set to operate too sensitively. A reliable direction measurement can only be expected with connection to a core balance current transformer. For the setting of the **Polarized G0/B0 threshold** parameter, the following formula applies: $G0 > k_s \frac{I_{0active}}{\sqrt{3}V_{rated}} + \frac{I_{0min}}{V0>}$ where: k_s: Safety margin, k_s = 1.2 (cable networks), k_s = 2.0 (overhead lines) $I_{0active}$: Active component of the ground-fault current (watt leakage current) of the protected line V_{rated}: Secondary rated voltage in the healthy case I_{0min}: Min. ground current in the healthy case, 5 mA to 10 mA (core balance current transformer), 50 mA to 100 mA (Holmgreen transformer) V0>: Pickup threshold of the residual voltage $\approx 0.1\sqrt{3}V_{rated}$ If a parallel resistor Rp is used on the arc-suppression coil, the threshold value G0 must also be smaller than: $G0 \leq \frac{1}{k_s} \frac{I_{Rp}}{\sqrt{3}V_{rated}}$ where: k_s: Safety margin ≥ 1.5 I_{Rp}: Secondary rated current of the parallel resistor V_{rated}: Secondary rated voltage in the healthy case The **3I0> release thresh. value** parameter can be set to half of the expected measuring current and here, the entire zero-sequence current can be put to use.

System Type/ Neutral-Point Treatment	Description
Isolated	In the isolated system, the capacitive ground reactive current 3I0 · sin φ is decisive for the direction determination. To evaluate the capacitive ground reactive current, set the parameters as follows: • **Dir. measuring method** = ***B0*** • **φ correction** = ***0.0°*** In isolated systems, a ground fault allows the capacitive ground-fault currents of the entire electrically connected system, except for the ground current in the faulty cable itself, to flow through the measuring point as the latter flows directly away from the fault location (that is, not via the measuring point). The following formula can be used to determine the pickup value of the **Polarized G0/B0 threshold** parameter. $B0 \geq \frac{I_{0min}}{V0>}$ where: I_{0min}: Ground current in the healthy case V0>: Pickup threshold of the residual voltage $\approx 0.02\sqrt{3}V_{rated}$ In healthy operation, B0 ≤ 0. For the **3I0> release thresh. value** parameter, select around half of this capacitive ground-fault current flowing via the measuring point.
Resistance-Grounded	In the resistance-grounded system, the ohmic-inductive ground-fault current is decisive for the direction determination. To evaluate this short-circuit current, set the parameters as follows: • **Dir. measuring method** = ***G0*** • **φ correction**= ***-45.0°*** For the setting of the **Polarized G0/B0 threshold** parameter, the rule of thumb is: Set the pickup value according to the following formula where only the active ground-fault current can be put into use. $G0 > k_s \frac{I_{0active}}{\sqrt{3}V_{rated}} + \frac{I_{0min}}{V0>}$ where: k_s: Safety margin, k_s = 1.2 (cable networks), k_s = 2.0 (overhead lines) $I_{0active}$: Active component of the ground-fault current of the protected line V_{rated}: Secondary rated voltage in the healthy case I_{0min}: Min. ground current in the healthy case, 5 mA to 10 mA (core balance current transformer), 50 mA to 100 mA (Holmgreen transformer) V0>: Pickup threshold of the residual voltage $\approx 0.02\sqrt{3}V_{rated}$ The **3I0> release thresh. value** parameter must be set to a value below the minimum expected ground-fault current.

Parameter: **α1 reduction dir. area, α2 reduction dir. area**

- Recommended setting value **(_:105) α1 reduction dir. area** = ***2°***
- Recommended setting value **(_:106) α2 reduction dir. area** = ***2°***

With the **α1 reduction dir. area** and **α2 reduction dir. area** parameters, you specify the angle for the limitation of the direction range. Siemens recommends using the default setting of 2°.

In an arc-suppression-coil-ground system in feeders with a very large reactive current, it can be practical to set a somewhat larger angle α1 to avoid a false pickup based on transformer and algorithm tolerances.

Parameter: V0> threshold value

- Default setting **(_:103) V0> threshold value** = ***30.000 V***

The **V0> threshold value** parameter allows you to set the zero-sequence voltage sensitivity of the stage. The threshold value must be smaller than the minimum amount of the zero-sequence voltage V0 which must still be detected.

Parameter: Dir. determination delay

- Default setting **(_:104) Dir. determination delay** = ***0.10 s***

The start of the ground fault normally indicates a significant transient behavior. This can lead to an incorrect direction decision. The direction determination can be delayed for this reason from the occurrence of the zero-sequence voltage with the **Dir. determination delay** parameter to achieve steady-state measurands. The duration of the transient cycle is determined from the system conditions and the respective fault characteristics. If you have no knowledge of a suitable time delay, Siemens recommends keeping the default setting.

Parameter: Operate delay

- Default setting **(_:6) Operate delay** = ***2.0 s***

The parameterized time **Operate delay** determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.15.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Y0> G0/B0 #				
_:1	Y0> G0/B0 #:Mode		• off • on • test	off
_:2	Y0> G0/B0 #:Operate & flt.rec. blocked		• no • yes	no
_:10	Y0> G0/B0 #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	Y0> G0/B0 #:Blk. w. inrush curr. detect.		• no • yes	no
_:110	Y0> G0/B0 #:Blk. after fault extinction		• no • yes	yes
_:108	Y0> G0/B0 #:Directional mode		• forward • reverse	forward
_:109	Y0> G0/B0 #:Dir. measuring method		• G0 • B0	G0
_:107	Y0> G0/B0 #:φ correction		-45 ° to 45 °	0 °
_:102	Y0> G0/B0 #:Polarized G0/B0 threshold		0.10 mS to 100.00 mS	2.00 mS
_:105	Y0> G0/B0 #:α1 reduction dir. area		1 ° to 15 °	2 °
_:106	Y0> G0/B0 #:α2 reduction dir. area		1 ° to 15 °	2 °

Addr.	Parameter	C	Setting Options	Default Setting
_:101	Y0> G0/B0 #:3I0> release thresh. value	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.150 A
_:103	Y0> G0/B0 #:V0> threshold value		0.300 V to 200.000 V	30.000 V
_:104	Y0> G0/B0 #:Dir. determination delay		0.00 s to 60.00 s	0.10 s
_:6	Y0> G0/B0 #:Operate delay		0.00 s to 60.00 s	2.00 s

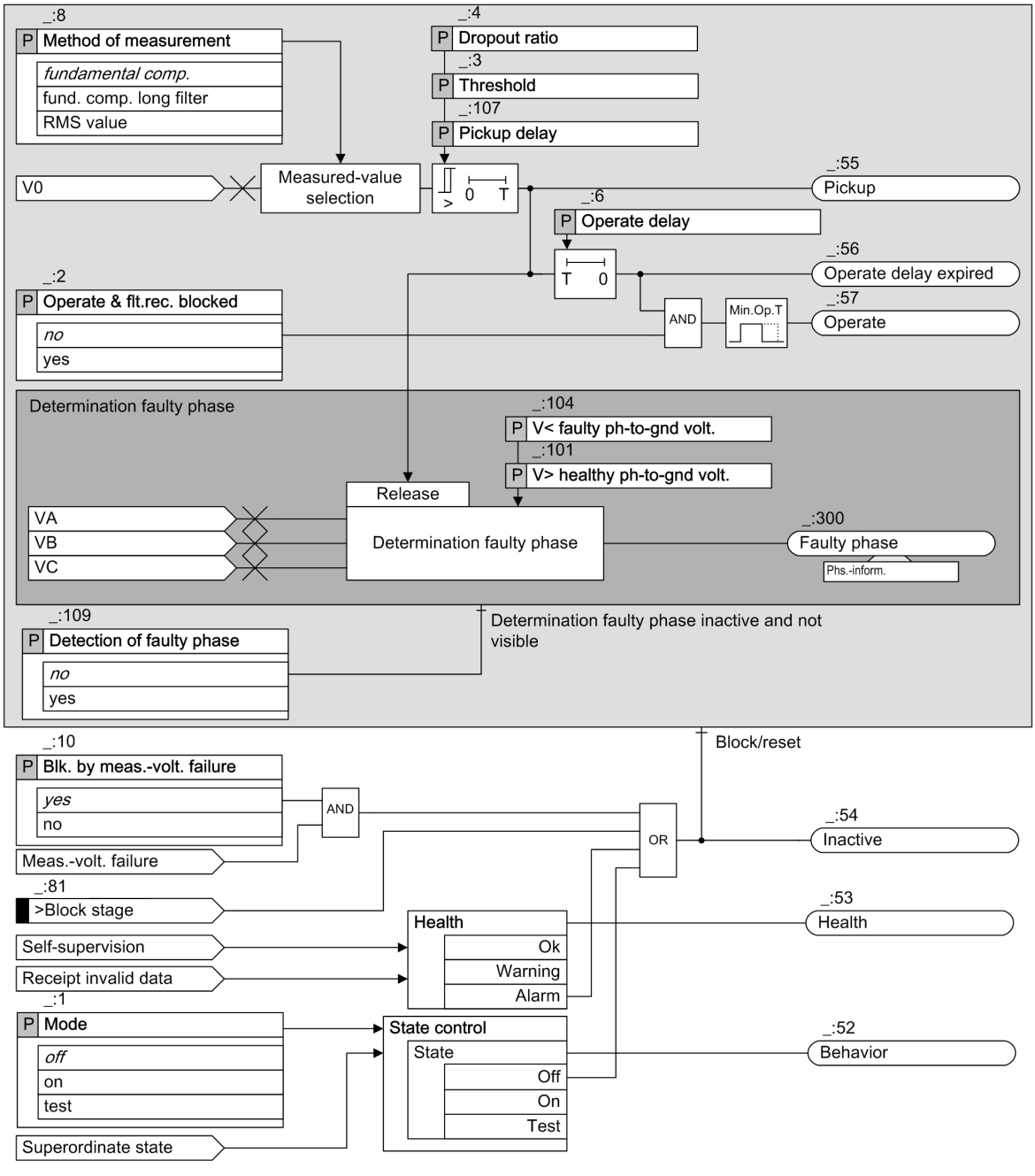
6.15.8.4 Information List

No.	Information	Data Class (Type)	Type
Y0> G0/B0 #			
_:81	Y0> G0/B0 #:>Block stage	SPS	I
_:501	Y0> G0/B0 #:>Block delay & op.	SPS	I
_:54	Y0> G0/B0 #:Inactive	SPS	O
_:52	Y0> G0/B0 #:Behavior	ENS	O
_:53	Y0> G0/B0 #:Health	ENS	O
_:60	Y0> G0/B0 #:Inrush blocks operate	ACT	O
_:55	Y0> G0/B0 #:Pickup	ACD	O
_:56	Y0> G0/B0 #:Operate delay expired	ACT	O
_:57	Y0> G0/B0 #:Operate	ACT	O

6.15.9 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage

6.15.9.1 Description

Logic



[logfpsv0-291112-01.tif, 3, en_US]

Figure 6-139 Logic Diagram of the Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage

Measured Value, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V_0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V_0 is calculated from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

Use the **Method of measurement** parameter to select the relevant method of measurement, depending on the application:

- Measurement of the fundamental component (standard filter):
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement of the RMS value (true RMS):
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value.
- Measurement of the fundamental component over 2 cycle filters with triangular window:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically. The extended filter length compared to the standard filter and the use of the triangular window results in a particularly strong attenuation of harmonics and transient faults. The extended filter length causes the pickup time to increase slightly compared to the standard filter (see *12.18.6 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage*).

Pickup, Dropout

The stage compares the **Threshold** with the zero-sequence voltage V_0. The **Pickup delay** parameter allows you to delay the pickup of the stage depending on the residual voltage.
With the **Dropout ratio** parameter, you can define the ratio of the dropout value to the **Threshold**.

Determination of the Faulty Phase

With the **Detection of faulty phase** parameter, you can enable or disable the determination of the ground-fault phase. Determining is released when the stage picks up. If 2 phases exceed the threshold value **V> healthy ph-to-gnd volt.** and one phase falls below the threshold value **V< faulty ph-to-gnd volt.**, the last phase is determined to be faulty and is signaled as such.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal **>Block stage** from an external or internal source
- From inside on pickup of the **measuring-voltage failure detection** function. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal *>open* of the function block **Voltage transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or not.

6.15.9.2 Application and Setting Notes

Parameter: **Operate & flt.rec. blocked**

- Default setting **(_:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: **Method of measurement**

- Recommended setting value **(_:8) Method of measurement** = ***fundamental comp.***

The **Method of measurement** parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

Parameter Value	Description
fundamental comp.	This method of measurement suppresses the harmonics or transient voltage peaks. Siemens recommends using this setting as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks).
fund. comp. long filter	To implement particularly strong damping of harmonics and transient faults, select this method of measurement. At 2 periods, the length of the filter is longer than that of the standard filter. Note that in this case the pickup time of the stage increases slightly (see *12.18.6 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage*).

Parameter: `Pickup delay`

- Recommended setting value **`(_:107) Pickup delay`** = ***`0 ms`***

The **`Pickup delay`** parameter allows you to delay the analysis of the measurand (to generate the pickup) depending on the occurrence of the residual voltage. A pickup delay can be necessary if high transients are anticipated after fault inception due to high line and ground capacitances.
Siemens recommends using the default setting **`Pickup delay`** = ***`0 ms`***.

Parameter: `Threshold`

- Default setting **`(_:3) Threshold`** = ***`30 V`***

The threshold value of the function is set as the zero-sequence voltage V_0. The device calculates the zero-sequence voltage V_0 either from the residual voltage measured via the broken-delta winding or from the 3 phase-to-ground voltages.
The setting value depends on the system grounding:

- Since virtually the full residual voltage occurs during ground faults in isolated or arc-suppression-coil-grounded systems, the setting value is uncritical there. Siemens recommends setting the value between 20 V and 40 V. A higher sensitivity (= lower threshold value) can be necessary for high fault resistances.
- Siemens recommends setting a more sensitive (smaller) value in grounded systems. This value must be higher than the maximum residual voltage anticipated during operation caused by system unbalances.

EXAMPLE

For an isolated system

The residual voltage is measured via the broken-delta winding:

- If the ground fault is fully unbalanced, a residual voltage of 100 V is present at the device terminals.
- The threshold value should be set so that the stage picks up on 50 % of the full residual voltage.
- At full residual voltage, the zero-sequence voltage is 100 V/√3 = 57.7 V
  Setting value: 0,5 · 57.7 V = 28.9 V ≈ 30 V

Parameter: `Dropout ratio`

- Recommended setting value **`(_:4) Dropout ratio`** = ***`0.95`***

The recommended setting value of ***`0.95`*** is appropriate for most applications. To achieve high measurement precision, the dropout ratio can be reduced to 0.98, for example.

Parameter: `Operate delay`

- Default setting **`(_:6) Operate delay`** = ***`3.00 s`***

The **`Operate delay`** allows you to prevent transient residual voltages from initiating a trip. The setting depends on the specific application.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal *>Open* of the function block **Voltage transformer circuit breaker** is linked with the voltage transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: Detection of faulty phase

- Default setting **(_:109) Detection of faulty phase** = ***no***

The **Detection of faulty phase** parameter controls how the stage responds to determine which phase is affected by the ground fault.

Parameter Value	Description
no	The phase affected by the ground fault is not determined. Select the default setting if you do not want to use the stage to detect ground faults, for example for applications in grounded systems.
yes	After a pickup by the residual voltage, the device tries to determine which phase is affected by the ground fault. Select this setting for applications in isolated or arc-suppression-coil-grounded systems.

Parameter: V< faulty ph-to-gnd volt.

- Default setting **(_:104) V< faulty ph-to-gnd volt.** = ***30 V***

Set the threshold value for determining which phase is affected by the ground fault in the **V< faulty ph-to-gnd volt.** parameter. The setting value is a phase-to-ground quantity.

The set value must be smaller than the minimum phase-to-ground voltage occurring during operation. Siemens recommends using the default setting **V< faulty ph-to-gnd volt.** = ***30 V***.

Parameter: V> healthy ph-to-gnd volt.

- Default setting **(_:101) V> healthy ph-to-gnd volt.** = ***70 V***

Set the threshold value for the 2 healthy phases in the **V> healthy ph-to-gnd volt.** parameter. The setting value is a phase-to-ground measurand.

The set value must be above the maximum phase-to-ground voltage occurring during operation, but below the minimum phase-to-phase voltage present during operation. At V_{rated} = 100 V, the value has to be set to 70 V, for example. Siemens recommends using the default setting **V> healthy ph-to-gnd volt.** = ***70 V***.

Operation as Supervision Function

If you want the stage to have a reporting effect only, the generation of the operate indication and fault logging can be disabled via the **(_:2) Operate & flt.rec. blocked** parameter.

6.15.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V0> #				
_:1	V0> #:Mode		• off • on • test	off
_:2	V0> #:Operate & flt.rec. blocked		• no • yes	no
_:10	V0> #:Blk. by meas.-volt. failure		• no • yes	yes
_:109	V0> #:Detection of faulty phase		• no • yes	no
_:8	V0> #:Method of measure-ment		• fundamental comp. • fund. comp. long filter • RMS value	fundamental comp.
_:3	V0> #:Threshold		0.300 V to 200.000 V	30.000 V
_:4	V0> #:Dropout ratio		0.90 to 0.99	0.95
_:107	V0> #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:6	V0> #:Operate delay		0.00 s to 60.00 s	3.00 s
_:101	V0> #:V> healthy ph-to-gnd volt.		0.300 V to 200.000 V	70.000 V
_:104	V0> #:V< faulty ph-to-gnd volt.		0.300 V to 200.000 V	30.000 V

6.15.9.4 Information List

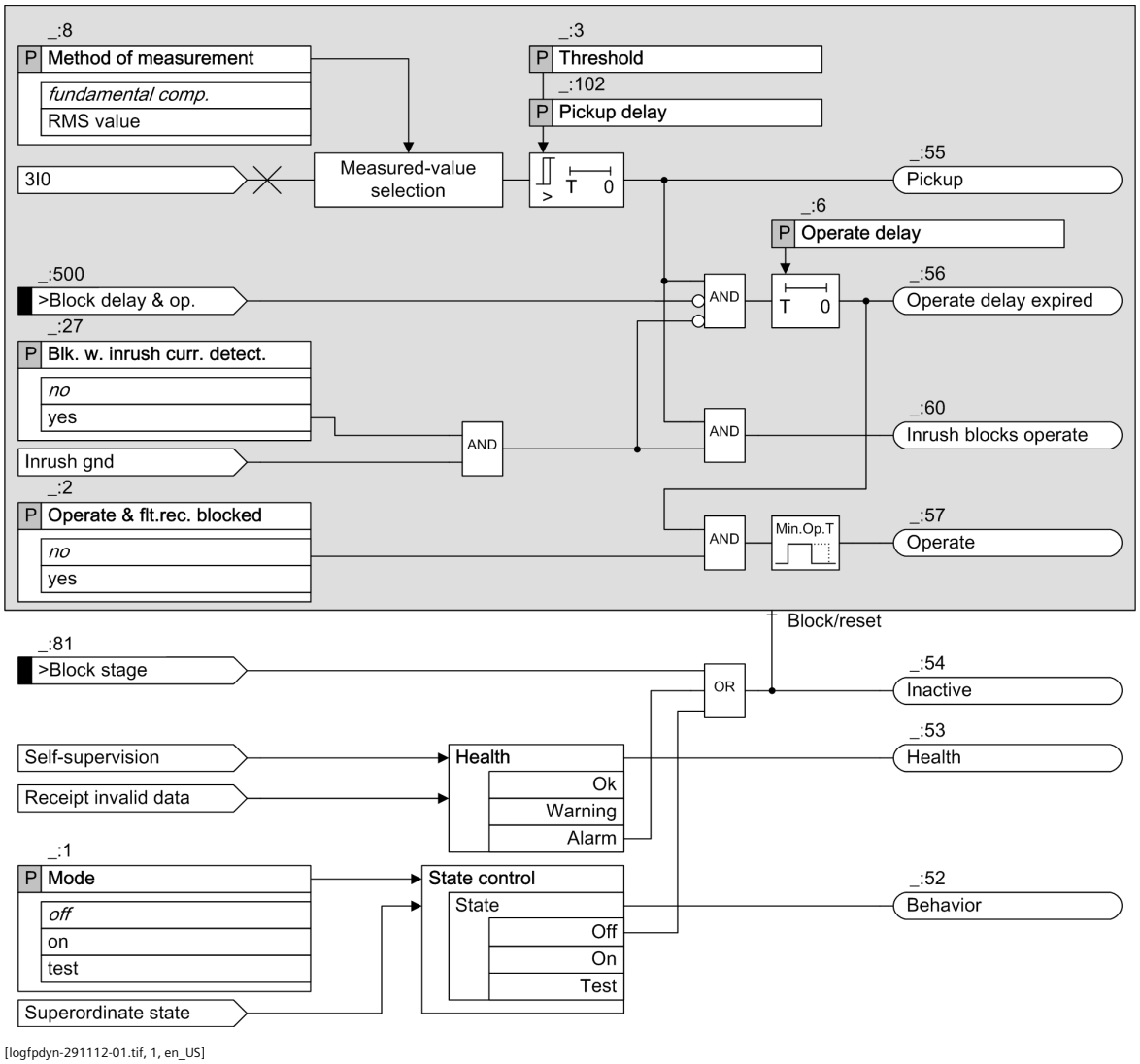
No.	Information	Data Class (Type)	Type
V0> #			
_:81	V0> #:>Block stage	SPS	I
_:54	V0> #:Inactive	SPS	O
_:52	V0> #:Behavior	ENS	O
_:53	V0> #:Health	ENS	O
_:300	V0> #:Faulty phase	ACT	O
_:55	V0> #:Pickup	ACD	O
_:56	V0> #:Operate delay expired	ACT	O
_:57	V0> #:Operate	ACT	O

6.15.10 Non-Directional 3I0 Stage

6.15.10.1 Description

In the **Directional sensitive ground-fault detection** function, the **Non-directional 3I0 stage** also works on demand.

Logic



[logfpdyn-291112-01.tif, 1, en_US]

Figure 6-140 Logic Diagram of the Non-Directional 3I0 Stage

Measured Value 3I0

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

Depending upon the settings of the **`Connection type`** and **Measuring point I-3ph** parameters, as well as the current terminal blocks used, different linearity and setting ranges result, refer for this to chapter *6.15.4.1 Description* , Ground-Fault Detection, Pickup.

Method of Measurement

You use the **`Method of measurement`** parameter to define whether the stage uses the ***`fundamental comp.`*** or the calculated ***`RMS value`***.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.

- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking the Tripping via the Device-Internal Inrush-Current Detection Function

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started.

6.15.10.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting **(_:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording and the fault log with the **Operate & flt.rec. blocked** parameter. In this case a ground-fault log is created instead of the fault log.

Parameter: Blk. w. inrush curr. detect.

- Default setting **(_:27) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you determine whether the tripping is blocked during the detection of an inrush current.

Parameter: Method of measurement

- Recommended setting value **(_:8) Method of measurement** = ***fundamental comp.***

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the **threshold value** of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: Threshold

- Default setting **(_:3) Threshold** = ***0.050 A***

The **Threshold** parameter allows you to set the threshold value of the ground current 3I0.

Parameter: `Pickup delay`

- Default setting **`(_:102) Pickup delay`** = ***`0.00 s`***

With the parameter **`Pickup delay`** you set whether pickup of the stage is to be delayed or not. If the transient cycle of the ground fault occurrence should not be evaluated, set a delay of 100 ms, for example.

Parameter: `Operate delay`

- Default setting **`(_:6) Operate delay`** = ***`0.30 s`***

The parameterized time **`Operate delay`** determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.15.10.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
3I0> #				
_:1	3I0> #:Mode		• off • on • test	off
_:2	3I0> #:Operate & flt.rec. blocked		• no • yes	no
_:27	3I0> #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	3I0> #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	3I0> #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:102	3I0> #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:6	3I0> #:Operate delay		0.00 s to 60.00 s	0.30 s

6.15.10.4 Information List

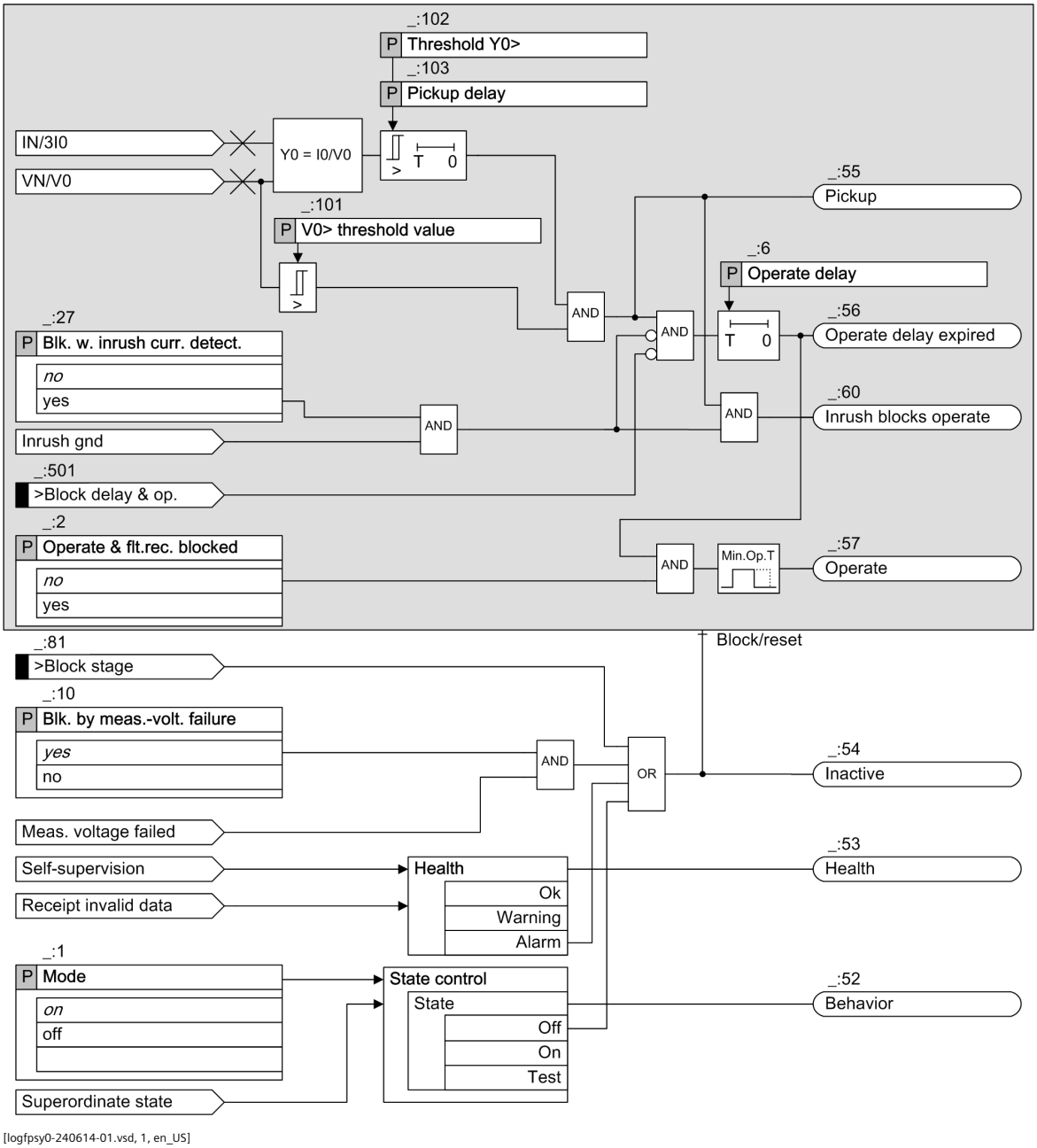
No.	Information	Data Class (Type)	Type
3I0> #			
_:81	3I0> #:>Block stage	SPS	I
_:500	3I0> #:>Block delay & op.	SPS	I
_:54	3I0> #:Inactive	SPS	O
_:52	3I0> #:Behavior	ENS	O
_:53	3I0> #:Health	ENS	O
_:60	3I0> #:Inrush blocks operate	ACT	O
_:55	3I0> #:Pickup	ACD	O
_:56	3I0> #:Operate delay expired	ACT	O
_:57	3I0> #:Operate	ACT	O

6.15.11 Non-Directional Y0 Stage

6.15.11.1 Description

In the **Directional sensitive ground-fault detection** function, the **Non-directional Y0 stage** also works on demand.

Logic



[logfpsy0-240614-01.vsd, 1, en_US]

Figure 6-141 Logic Diagram of the Non-Directional Y0 Stage

Measured Value 3I0, Y0

The function evaluates the sensitively measured ground current 3I0 via a core balance current transformer, this current being converted with the voltage V0 into the admittance Y0=I0/V0. Since the linearity range of the

sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

Depending on the settings of the **Connection type** and **Measuring point I-3ph** parameters, as well as the current terminal block used, different linearity and setting ranges result, refer for this to chapter *6.15.8.1 Description* .

Blocking the Stage via Binary Input Signal

Blocking of the stage is possible externally or internally via the binary input signal *>Block stage*. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pick up of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>open* of the function block **Voltage transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker.

The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

Blocking of the Time Delay

You can use the binary input signal *>Block delay & op.* to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking of the Operate Indication via the Device-Internal Inrush-Current Detection Function

The **Blk. w. inrush curr. detect.** parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started.

6.15.11.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting **(_:2) Operate & flt.rec. blocked** = ***no***

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected. A measuring-voltage failure can only be detected if 1 of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.

Parameter Value	Description
no	The protection stage is not blocked.

Parameter: **Blk. w. inrush curr. detect.**

- Default setting **(_:27) Blk. w. inrush curr. detect.** = ***no***

With the **Blk. w. inrush curr. detect.** parameter, you determine whether the operate is blocked during the detection of an inrush current.

Parameter: **V0> threshold value**

- Default setting **(_:101) V0> threshold value** = ***5.000 V***

The **V0> threshold value** parameter allows you to set the zero-sequence voltage sensitivity of the stage. The threshold value must be smaller than the minimum amount of the zero-sequence voltage V0 which must still be detected.

Parameter: **Threshold Y0>**

- Default setting **(_:102) Threshold Y0>** = ***2.00 mS***

With the parameter **Threshold Y0>**, you set the threshold value of the ground admittance Y0. If the ground admittance for the setting value is unknown, you can assume the following relation:

$$Y0 > k_s \frac{I_{c,line}}{3V_{ph-gnd}} + \frac{3I_{0min}}{V0>}$$

[fo_SeGfY0-270614-01, 2, en_US]

k_s:	Factor, takes into account the ohmic components of the current (1.2 for overhead lines, 1.0-1.05 for cable systems)
$I_{c,line}$	Secondary capacitive ground-fault current for the protected line
V_{ph-gnd}	Secondary phase-to-ground voltage in the healthy case
$3I_{0min}$	Secondary ground current in the healthy case (resulting from transformer error), 5 mA to 10 mA (core balance current transformer), 50 mA to 100 mA (Holmgreen transformer)
V0>	Secondary pickup threshold of the residual voltage

Parameter: **Pickup delay**

- Default setting **(_:103) Pickup delay** = ***0.00 s***

With the parameter **Pickup delay**, you set whether pickup of the stage is to be delayed or not. If the transient cycle of the ground fault occurrence should not be evaluated, set a delay of 100 ms, for example.

Parameter: **Operate delay**

- Default setting **(_:6) Operate delay** = ***0.30 s***

The parameterized time **Operate delay** determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.15.11.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Y0> #				
_:1	Y0> #:Mode		• off • on • test	off
_:2	Y0> #:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:10	Y0> #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	Y0> #:Blk. w. inrush curr. detect.		• no • yes	no
_:101	Y0> #:V0> threshold value		0.300 V to 200.000 V	5.000 V
_:102	Y0> #:Threshold Y0>		0.10 mS to 100.00 mS	2.00 mS
_:103	Y0> #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:6	Y0> #:Operate delay		0.00 s to 60.00 s	0.30 s

6.15.11.4 Information List

No.	Information	Data Class (Type)	Type
Y0> #			
_:81	Y0> #:>Block stage	SPS	I
_:501	Y0> #:>Block delay & op.	SPS	I
_:54	Y0> #:Inactive	SPS	O
_:52	Y0> #:Behavior	ENS	O
_:53	Y0> #:Health	ENS	O
_:60	Y0> #:Inrush blocks operate	ACT	O
_:55	Y0> #:Pickup	ACD	O
_:56	Y0> #:Operate delay expired	ACT	O
_:57	Y0> #:Operate	ACT	O

6.16 Undercurrent Protection

6.16.1 Overview of Functions

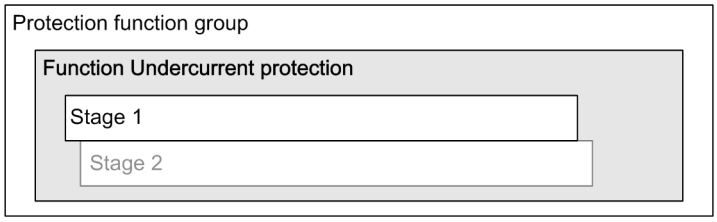
The **Undercurrent protection** function (ANSI 37):

- Detects the going current in a feeder after the opening of the infeed circuit breaker
- Detects the loss of loads
- Detects and protects pumps from running idle

6.16.2 Structure of the Function

The **Undercurrent protection** function is used in protection function groups with current measurement.

The **Undercurrent protection** function comes with 1 protection stage preconfigured at the factory. A maximum of 2 protection stages can be operated simultaneously in this function. The protection stages are structured identically.

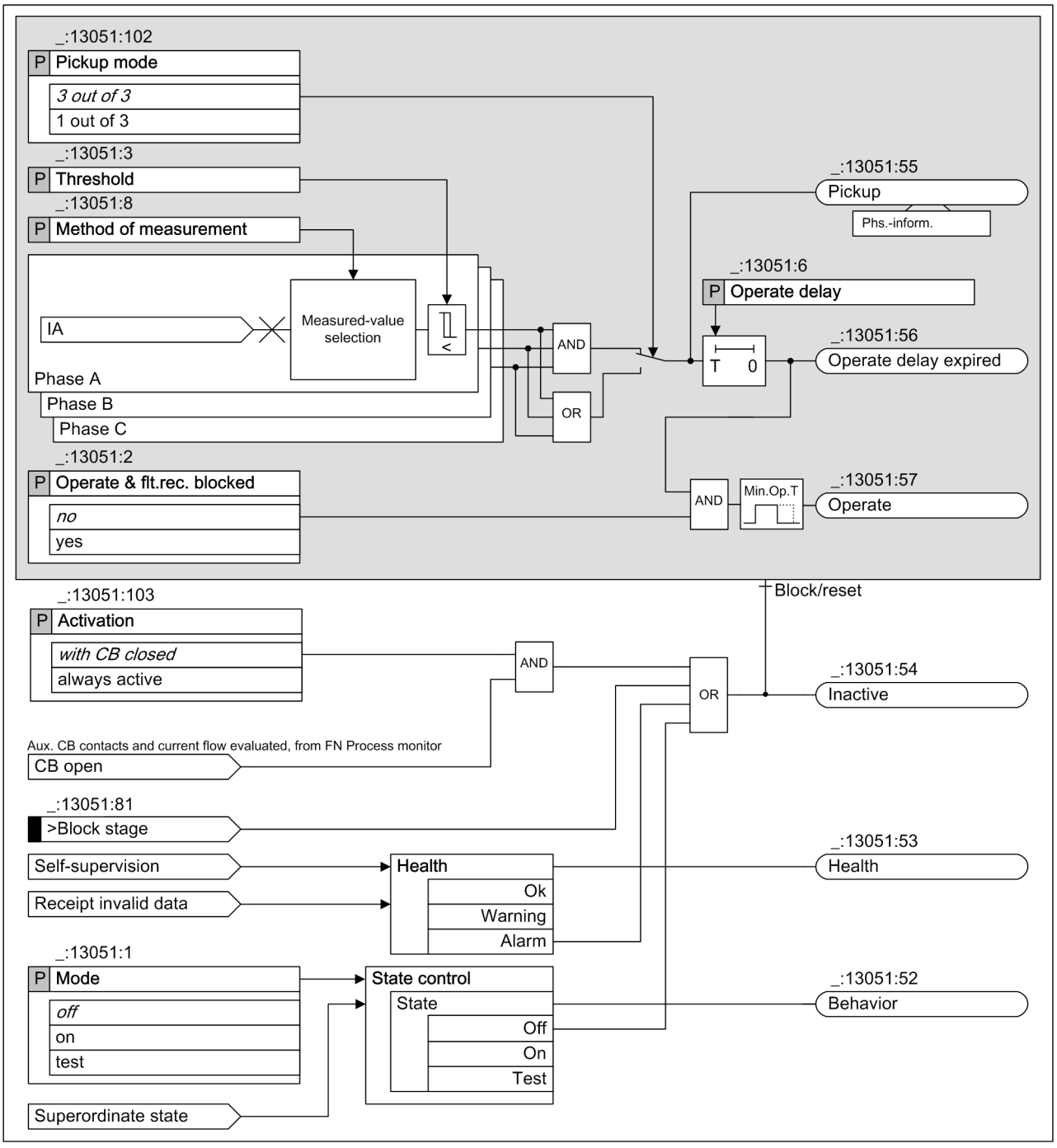


[lostuundcu-150813, 2, en_US]

Figure 6-142 Structure/Embedding of the Function

6.16.3 Stage Description Undercurrent Protection

Logic of the Stage



[loundcur-200713-01.tif, 1, en_US]

Figure 6-143 Logic Diagram of the Undercurrent Protection

Method of Measurement

You use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

- Measurement of the fundamental comp.:
  This measurement method processes the sampled current values and numerically filters out the fundamental component.
- Measurement of the parameter value RMS value:
  This measurement method determines the current amplitude from the sampled values according to the definition equation of the RMS value. Harmonics are included in the analysis.

Pickup Mode

The **Pickup mode** parameter defines whether the protection stage picks up if all 3 measuring elements detect the undercurrent condition (***3 out of 3***) or if only 1 measuring element has to detect the undercurrent condition (***1 out of 3***).

Blocking the Stage

When blocked, the picked-up protection stage will drop out. Blocking the stage is possible externally or internally via the binary input signal *>Block stage*.

Activation and Blocking of the Stage Depending On the Circuit-Breaker Condition

With the parameter **Activation**, you define if the **Undercurrent protection** stage is always active or only active if the circuit breaker is indicating **closed**.

If the parameter **Activation** is set to ***with CB closed*** and the local circuit breaker is not **closed**, the function **Undercurrent protection** is blocked and no pickup is generated.

The circuit-breaker position is detected as **closed** if one of the following condition is met:

- The binary inputs are connected to the auxiliary contacts of the circuit breaker. The circuit-breaker switch position is detected as **closed** via the related binary inputs of the **Position** indication. This is also true under the condition that no phase current is flowing.
- The current-flow criterion indicates that the circuit breaker is **closed**. This is also true under the condition that the auxiliary contacts indicate the circuit breaker as **open**.

6.16.4 Application and Setting Notes

Parameter: Activation

- Default setting **(_:13051:103) Activation** = ***with CB closed***

Parameter Value	Description
with CB closed	The **Undercurrent protection** is active only when the circuit-breaker position is detected as **closed**. A precondition is, that the **Position** indication is routed to binary inputs to obtain the CB position information via the CB auxiliary contacts. If this is not the case, the function will always be inactive.
always active	The **Undercurrent protection** stage is always active independent of the position of the circuit breaker.

Parameter: Method of measurement

- Recommended setting value **(_:13051:8) Method of measurement** = ***fundamental comp.***

Use the **Method of measurement** parameter to define whether the tripping stage uses the ***fundamental comp.*** (standard method) or the calculated ***RMS value***.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient current peaks. Siemens recommends using this method as default setting.

Parameter Value	Description
RMS value	Select this measurement method if you want the stage to take harmonics into account (for example, at capacitor banks).

Parameter: `Pickup mode`

- Default setting **`(_:13051:102) Pickup mode`** = ***`3 out of 3`***

Use the **`Pickup mode`** parameter to define whether the protection stage picks up if all 3 measuring elements detect the undercurrent condition (***`3 out of 3`***) or if only 1 measuring element has to detect the undercurrent condition (***`1 out of 3`***).

Parameter: `Threshold`

- Default setting **`(_:13051:3) Threshold`** = ***`0.050 A`***

Specify the **`Threshold`** (pickup threshold) for the specific application.

Parameter: `Operate delay`

- Default setting **`(_:13051:6) Operate delay`** = ***`0.05 s`***

Operate delay must be set according to the specific application. No general application notes can be given.

6.16.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:13051:1	Stage 1:Mode		• off • on • test	off
_:13051:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:13051:103	Stage 1:Activation		• always active • with CB closed	with CB closed
_:13051:8	Stage 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:13051:102	Stage 1:Pickup mode		• 1 out of 3 • 3 out of 3	3 out of 3
_:13051:3	Stage 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:13051:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.50 s

6.16.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:13051:81	Stage 1:>Block stage	SPS	I

No.	Information	Data Class (Type)	Type
_:13051:54	Stage 1:Inactive	SPS	O
_:13051:52	Stage 1:Behavior	ENS	O
_:13051:53	Stage 1:Health	ENS	O
_:13051:55	Stage 1:Pickup	ACD	O
_:13051:56	Stage 1:Operate delay expired	ACT	O
_:13051:57	Stage 1:Operate	ACT	O

6.17 Negative-Sequence Protection

6.17.1 Overview of Functions

The function **Negative-sequence protection** (ANSI 46):

- Detects 1-phase or 2-phase short circuits in the electrical power system with clearly increased sensitivity compared to the classical overcurrent protection
- Protects electric machines during excessive unbalanced load
- Reports unbalanced load conditions in the electricity supply system
- Detects phase interruptions in the primary system
- Locates short circuits or inversions in the connections to the current transformers

6.17.2 Structure of the Function

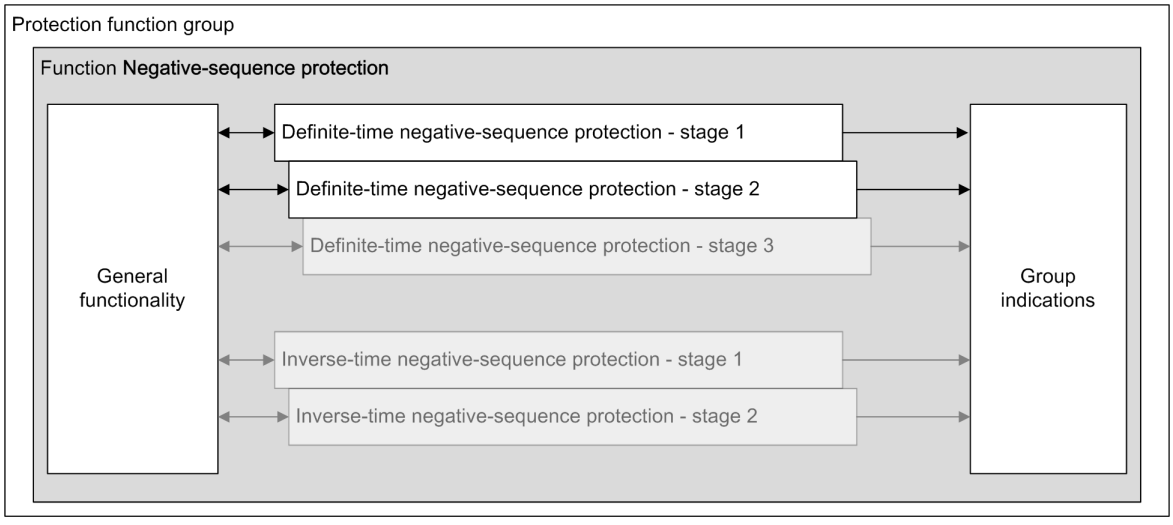
The **Negative-sequence protection** function is used in protection function groups with current measurement.

The function is preconfigured by the manufacturer with 2 **Definite-time negative-sequence protection** stages.

In the function **Negative-sequence protection**, the following stages can be operated simultaneously:

- 3 stages **Definite-time negative-sequence protection**
- 2 stages **Inverse-time negative-sequence protection**

The stages have an identical structure. Stages that are not preconfigured are shown in gray in the following figure.



[dwnspstr-271112-01.tif, 3, en_US]

Figure 6-144 Structure/Embedding of the Function

If the device is equipped with the **Inrush-current detection** function, the stages can be stabilized against operate due to transformer-inrush currents.

6.17.3 General Functionality

6.17.3.1 Description

Logic

The following figure represents the logic of the general functionality which applies across all configured stages. It contains:

- Selection of the reference value
- Current-release criterion

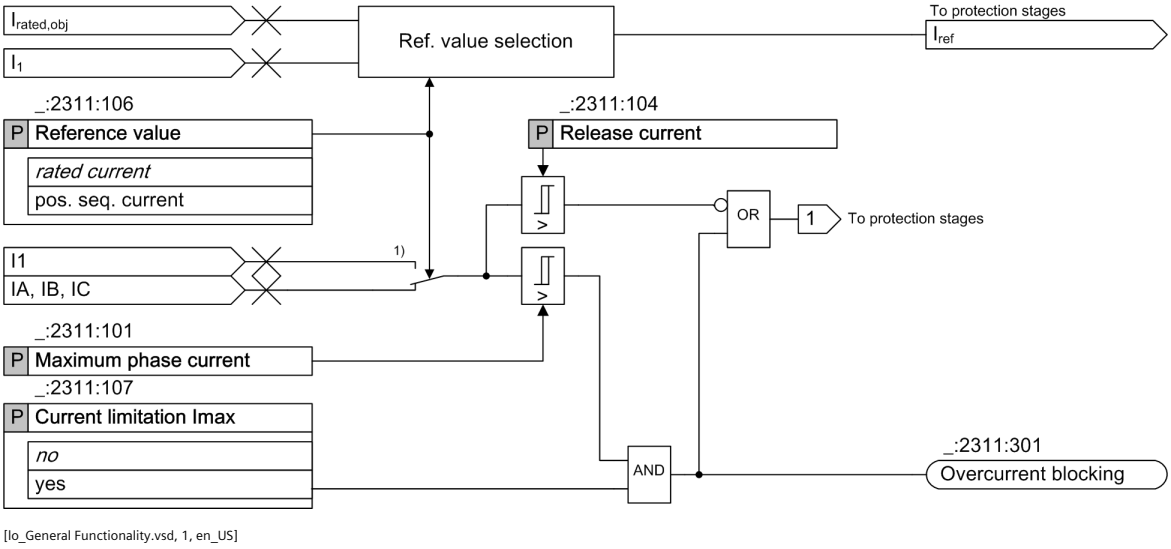


Figure 6-145 Logic Diagram of the General Functionality

(1) Switchover to I_1 with **(_:2311:106) Reference value** = ***pos. seq. current***

Reference Value

With the parameter **Reference value**, the negative-sequence current I_2 is normalized to the rated object current $I_{rated, obj}$ or to the positive-sequence current I_1. When I_2 is normalized to I_1, the sensitivity of the function for low short-circuit currents is increased.

Current Limitation and Maximum Phase Current

With the parameters **Current limitation Imax** and **Maximum phase current**, you restrict the operating range of the function. When the limiting is activated, pickup of the stages is blocked as soon as the maximum phase-current threshold value is exceeded. For more information, refer to the stage description.

Release Current

The threshold value of the **Release current** serves to release the negative-sequence protection.

6.17.3.2 Application and Setting Notes

Parameter: Reference value

- Default setting **(_:2311:106) Reference value** = ***rated current***

With the parameter **Reference value**, you define the normalization of the negative-sequence current I_2 to the rated object current $I_{rated, obj}$ ($I_2/I_{rated, obj}$) or to the positive-sequence current I_1 (I_2/I_1).

Parameter Value	Description
$I_2/I_{rated, obj}$	The negative-sequence current is referred to the rated current of the protected object. This is a preferred normalization for electrical machines, because the permissible limiting values are indicated exclusively referred to the machine rated current. You can also use this normalization for other applications.
I_2/I_1	The normalization of the negative-sequence system to the positive-sequence system yields a higher sensitivity. Use this normalization when detecting interruptions in the primary system.

Set the parameter depending on the application.

Parameter: **Current limitation Imax, Maximum phase current**

- Default setting **(_:2311:107) Current limitation Imax** = ***no***
- Recommended setting value **(_:2311:101) Maximum phase current** = ***10.0 A at 1 A***

If the protection function needs a maximum current limitation, set the value of the **Current limitation Imax** parameter from ***no*** to ***yes***. With the parameter **Maximum phase current**, you set the upper limit of the phase current. CT saturation will cause negative-sequence current in the secondary system. To avoid over-function due to the CT saturation, a suitable phase-current limit value is 10 times of the rated protection-object current.

Parameter: **Release current**

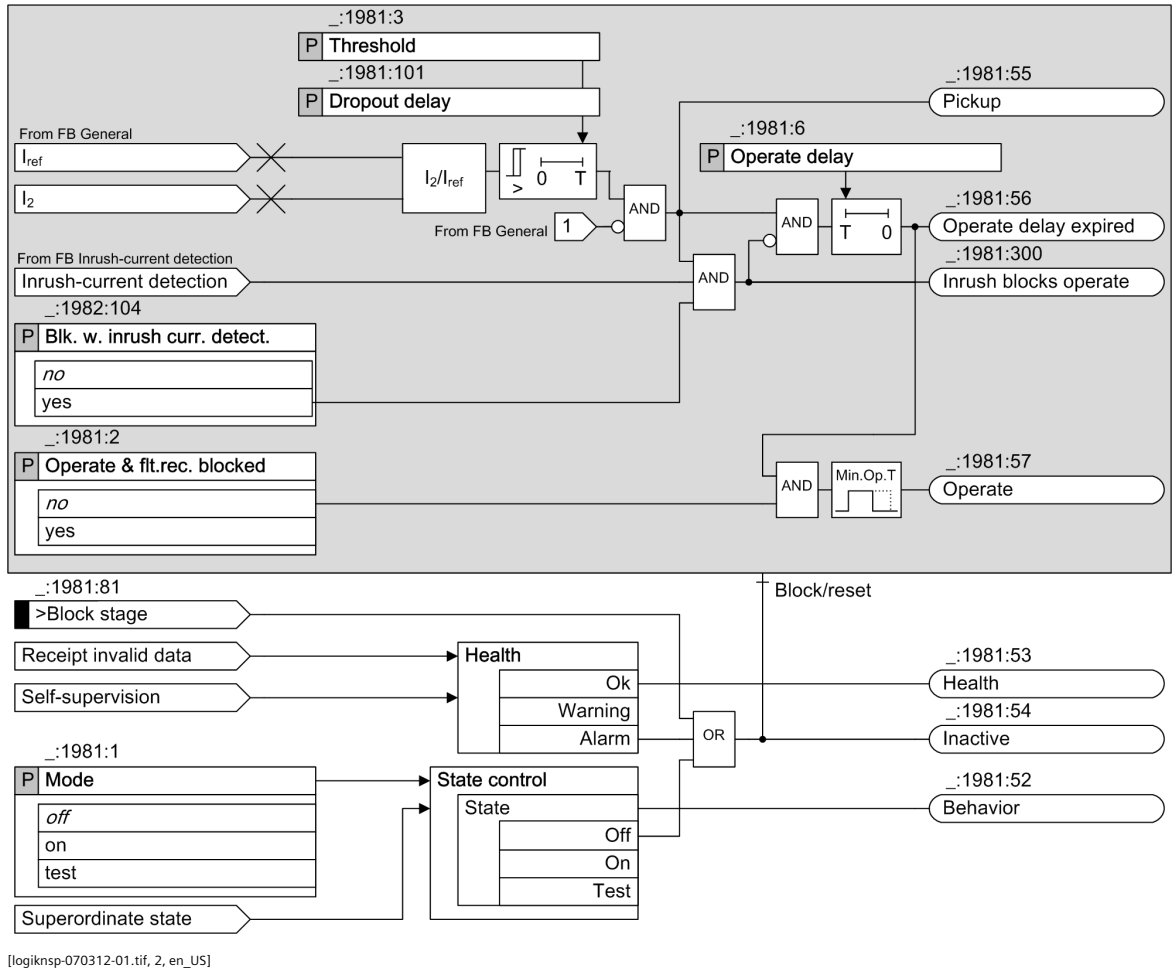
- Recommended setting value **(_:2311:104) Release current** = ***0.05 A at 1 A***

For the safe calculation of negative-sequence currents, the current in at least one phase must be greater than 5 % of the secondary rated device current. For a 1-A device, the value of **Release current** is 0.05 A (0.25 A for a 5-A device).

6.17.4 Stage with Definite-Time Characteristic Curve

6.17.4.1 Stage Description

Logic of a Stage



[logiknsp-070312-01.tif, 2, en_US]

Figure 6-146 Logic Diagram of the Stage Negative-Sequence Protection with Definite-Time Characteristic Curve

Method of Measurement

The fundamental phasors are calculated from the 3-phase phase currents. Based on this, the negative-sequence system and the positive-sequence system are calculated. Following this, the negative-sequence current is normalized to the reference current. The selection of the reference current is made in the **FB General**.

Blocking of the Stage

When blocked, the picked-up protection stage will drop out.

Blocking the stage is possible externally or internally via the binary input signal **`>Block stage`**.

Blocking of Tripping via the Device-Internal Inrush-Current Detection Function

With the **`Blk. w. inrush curr. detect.`** parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and tripping are however blocked. The stage signals this by way of a

corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the tripping delay (time delay) is started. After that time, the stage operates.

6.17.4.2 Application and Setting Notes

Parameter: `Threshold`

- Recommended setting value **`(_:1981:3) Threshold`** = ***`10 %`***

The setting of the parameter **`Threshold`** depends on the respective application. A threshold value of 10 % is a practicable value for fault indications of electrical machines.

Parameter: `Operate delay`

- Recommended setting value **`(_:1981:6) Operate delay`** = ***`1500 ms`***

The setting of the **`Operate delay`** depends on the application. Observe the time grading in the power-system protection and do not set the time for monitoring too short. The default setting is practicable. For motors, the time depends on the permissible time period for the set unbalanced load.

Parameter: `Blk. w. inrush curr. detect.`

- Default setting **`(_:1981:104) Blk. w. inrush curr. detect.`** = ***`no`***

With the parameter **`Blk. w. inrush curr. detect.`**, the stage can be stabilized against tripping on transformer-inrush currents. If transformers are parts of the protection zones, set this parameter to **`yes`**.

6.17.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:106	General:Reference value		• pos. seq. current • rated current	rated current
_:2311:107	General:Current limitation Imax		• no • yes	no
_:2311:101	General:Maximum phase current	1 A @ 100 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	10.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	50.000 A
_:2311:104	General:Release current	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
Definite-T 1				
_:1981:1	Definite-T 1:Mode		• off • on • test	off
_:1981:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:1981:3	Definite-T 1:Threshold		5.0 % to 999.9 %	10.0 %
_:1981:4	Definite-T 1:Dropout ratio		0.40 to 0.99	0.95

Addr.	Parameter	C	Setting Options	Default Setting
_:1981:104	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:1981:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:1981:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	1.50 s
Definite-T 2				
_:1982:1	Definite-T 2:Mode		• off • on • test	off
_:1982:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:1982:3	Definite-T 2:Threshold		5.0 % to 999.9 %	65.0 %
_:1982:4	Definite-T 2:Dropout ratio		0.40 to 0.99	0.95
_:1982:104	Definite-T 2:Blk. w. inrush curr. detect.		• no • yes	no
_:1982:101	Definite-T 2:Dropout delay		0.00 s to 60.00 s	0.00 s
_:1982:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.50 s

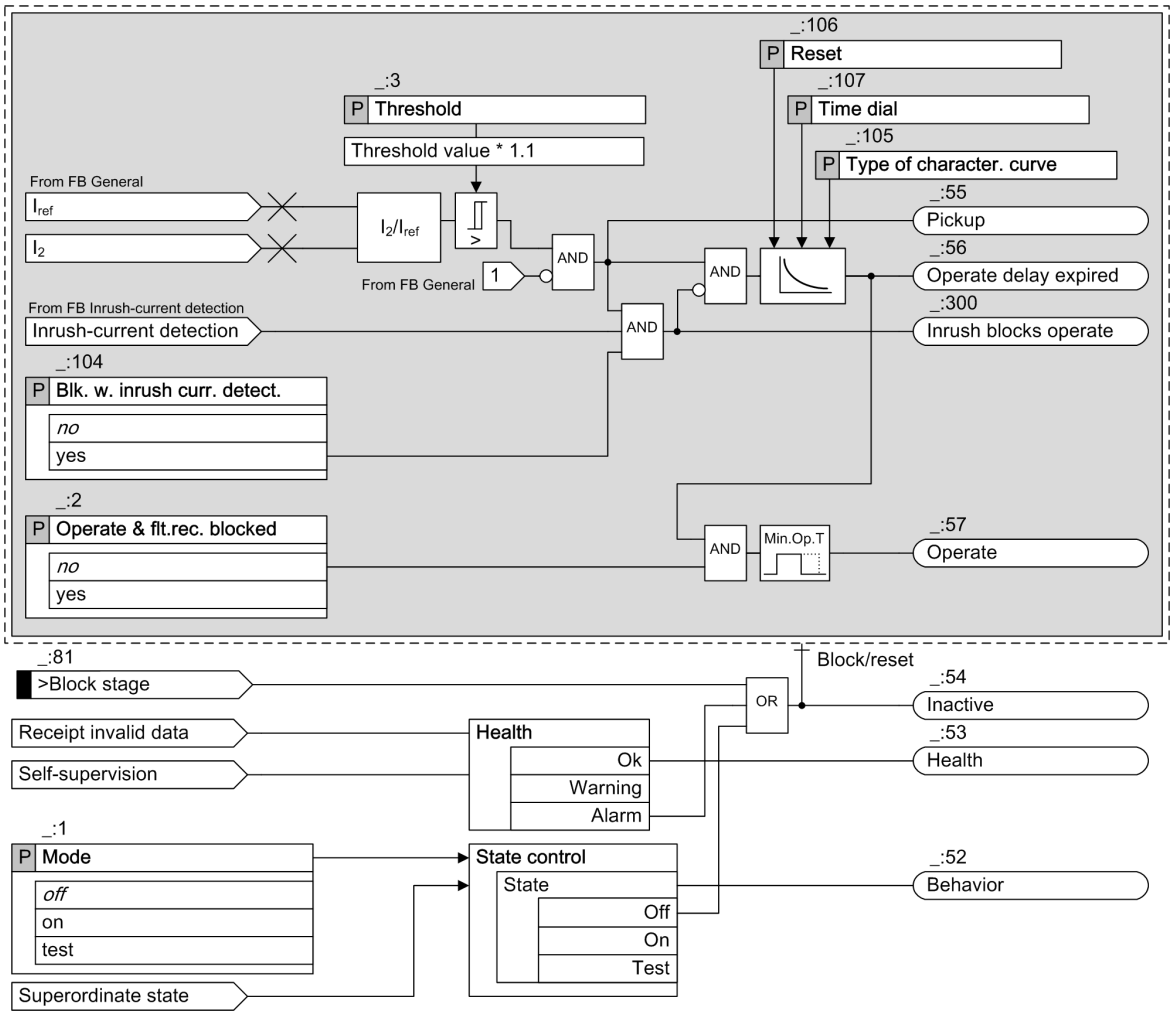
6.17.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:Overcurrent blocking	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:1981:81	Definite-T 1:>Block stage	SPS	I
_:1981:52	Definite-T 1:Behavior	ENS	O
_:1981:53	Definite-T 1:Health	ENS	O
_:1981:54	Definite-T 1:Inactive	SPS	O
_:1981:56	Definite-T 1:Operate delay expired	ACT	O
_:1981:300	Definite-T 1:Inrush blocks operate	ACT	O
_:1981:55	Definite-T 1:Pickup	ACD	O
_:1981:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:1982:81	Definite-T 2:>Block stage	SPS	I
_:1982:52	Definite-T 2:Behavior	ENS	O
_:1982:53	Definite-T 2:Health	ENS	O
_:1982:54	Definite-T 2:Inactive	SPS	O
_:1982:56	Definite-T 2:Operate delay expired	ACT	O
_:1982:300	Definite-T 2:Inrush blocks operate	ACT	O
_:1982:55	Definite-T 2:Pickup	ACD	O
_:1982:57	Definite-T 2:Operate	ACT	O

6.17.5 Stage with Inverse-Time Characteristic Curve

6.17.5.1 Description

Logic of a Stage



[lo_NSP_Inverse, 1, en_US]

Figure 6-147 Logic Diagram of the Negative-Sequence Protection with Inverse-Time Characteristic Curve

Method of Measurement

The fundamental phasors are calculated from the 3-phase phase currents. Based on this, the negative-sequence system and the positive-sequence system are calculated. Following this, the negative-sequence current is normalized to the reference current. The selection of the reference current is made in the **FB General**.

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI

When the input variable exceeds the threshold value by a factor of 1.1, the stage picks up, and the inverse-time characteristic curve is processed. An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by a factor of 0.95 (0.95 · 1.1 · threshold value), the dropout is started. The pickup is indicated as clearing. You can influence the dropout behavior via setting

parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Blocking of the Stage

When blocked, the picked-up protection stage will drop out.

Blocking the stage is possible externally or internally via the binary input signal **>Block stage**.

Blocking of Tripping via the Device-Internal Inrush-Current Detection Function

With the **Blk. w. inrush curr. detect.** parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and tripping are however blocked. The stage signals this by way of a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the tripping delay (time delay) is started. After that time, the stage operates.

6.17.5.2 Application and Settings Notes

Parameter: Type of character. curve

- Default setting **(_:105) Type of character. curve** = ***IEC normal inverse***

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the **Type of character. curve** required for your specific application. For more information about the parameter **Type of character. curve**, refer to chapter *12.20.2 Stage with Inverse-Time Characteristic Curve*.

Parameter: Threshold

- Recommended setting value **(_:3) Threshold** = ***10.0 %***

The setting of the parameter **Threshold** depends on the respective application. A threshold value of 10 % is a practicable value for fault detection for different applications.

Parameter: Time dial

- Recommended setting value **(_:107) Time dial** = ***1.00***

With the parameter **Time dial**, you displace the characteristic curve in the time direction.

The set value for the parameter **Time dial** is derived from the time-grading schedule that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the **Time dial** parameter at 1.00 (default setting).

Parameter: Reset

- Default setting **(_:106) Reset** = ***disk emulation***

With the parameter **Reset**, you define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: Blk. w. inrush curr. detect.

- Default setting **(_:104) Blk. w. inrush curr. detect.** = ***no***

With the parameter **Blk. w. inrush curr. detect.**, the stage can be stabilized against tripping on transformer-inrush currents. If transformers are parts of the protection zones, set this parameter to ***yes***.

6.17.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T #				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:3	Inverse-T #:Threshold		5.0 % to 999.9 %	10.0 %
_:104	Inverse-T #:Blk. w. inrush curr. detect.		• no • yes	no
_:105	Inverse-T #:Type of character. curve			
_:106	Inverse-T #:Reset		• instantaneous • disk emulation	disk emulation
_:107	Inverse-T #:Time dial		0.05 to 15.00	1.00

6.17.5.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	Inverse-T #:>Block stage	SPS	I
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:54	Inverse-T #:Inactive	SPS	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:300	Inverse-T #:Inrush blocks operate	ACT	O
_:59	Inverse-T #:Disk emulation running	SPS	O
_:55	Inverse-T #:Pickup	ACD	O
_:57	Inverse-T #:Operate	ACT	O

6.18 Directional Negative-Sequence Protection

6.18.1 Overview of Functions

The function **Directional negative-sequence protection with current-independent time delay** (ANSI 46) serves as the backup short-circuit protection for unbalanced faults.

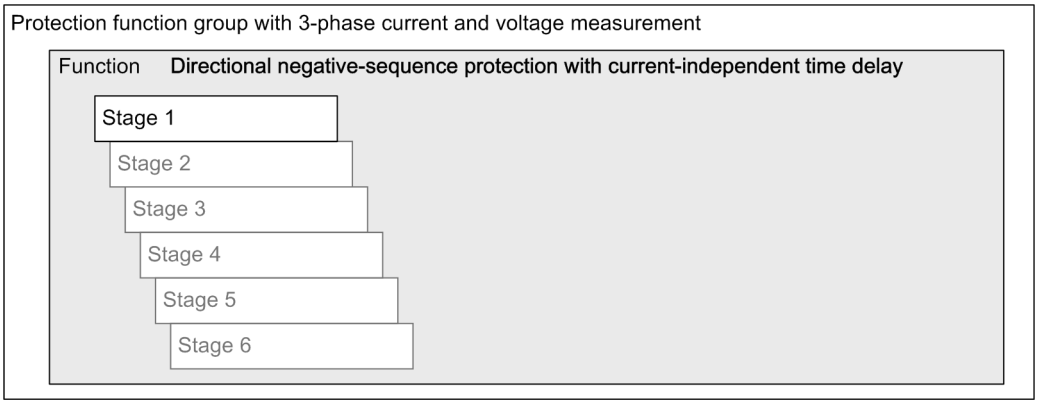
With the negative-sequence system, various supervision and protection tasks can be realized, for example:

- Recording of 1 or 2-phase short circuits in the system with a higher sensitivity than in classic overcurrent protection. The pickup value can be set under the rated object current.
- Recording of phase conductor interruptions in the primary system and in the current-transformer secondary circuits
- Location of short circuits or reversals in the connections to the current transformers
- Indication of unbalanced states in the energy system
- Protection of electrical machines following unbalanced loads that are caused by unbalanced voltages or conductor interruptions (for example, through a defective fuse)

6.18.2 Structure of the Function

The **Directional negative-sequence protection with definite time delay** function can be used in protection function groups with 3-phase current and voltage measurement.

The function comes factory-set with 1 stage. A maximum of 6 tripping stages can be operated simultaneously in the function.



[dwnspdir-271112-01.tif, 1, en_US]

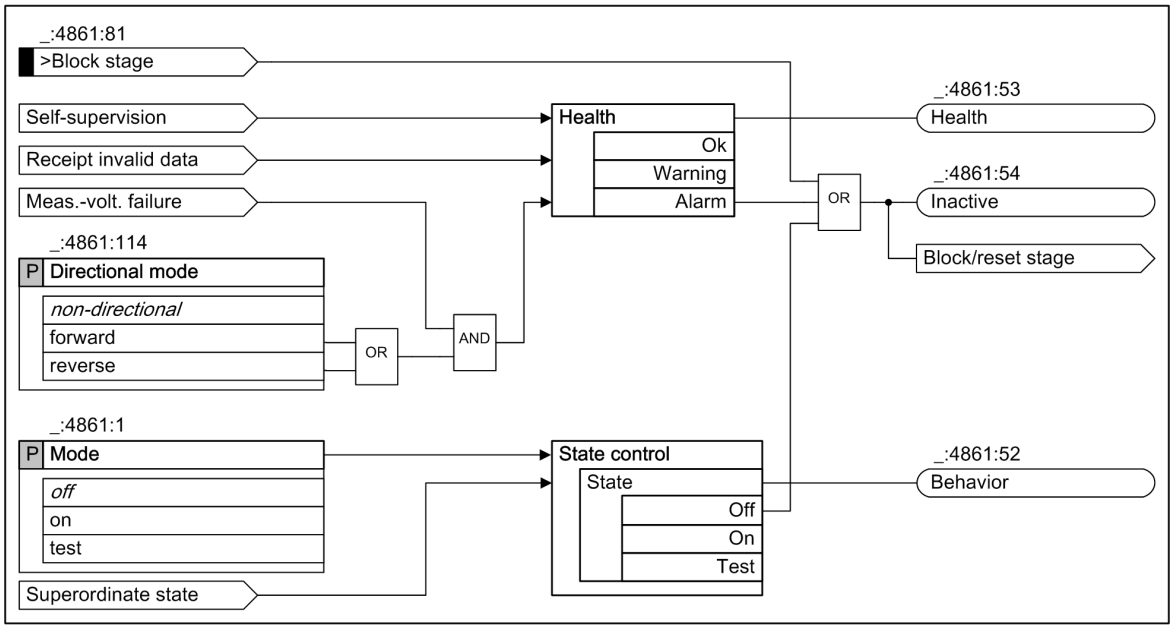
Figure 6-148 Structure/Embedding of the Function

If the device is equipped with the **Inrush-current detection** function, the tripping stages can be stabilized against tripping due to transformer-inrush currents.

6.18.3 Function Description

Stage Control

The following figure shows a stage control. It is available separately for each stage.

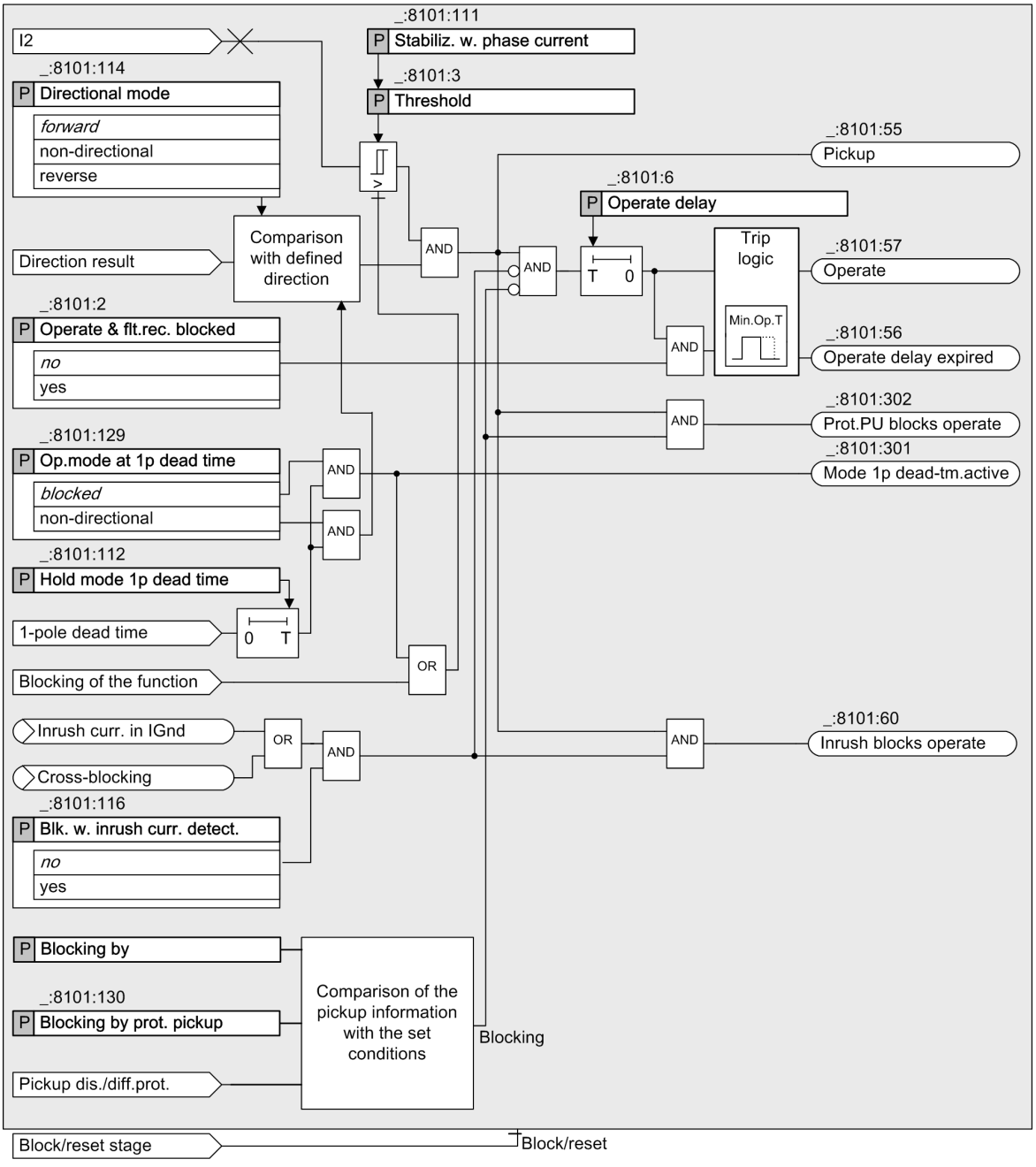


[lostensp-070611-01.tif, 1, en_US]

Figure 6-149 Stage Control of the Directional Negative-Sequence System Protection

In addition to the generally valid stage control, the stage is blocked in the event of a measuring voltage failure, provided the stage is working directionally.

Logic of the Stage



[lonspdir-300112-01.tif, 1, en_US]

Figure 6-150 Logic Diagram of the Function Directional Negative-Sequence System Protection with Current-Independen Time Delay

Measurand

The negative-sequence current I2 is used as a measurand. From the 3-phase currents, the fundamental phasors are determined via a 1-cycle filter and, corresponding with the definition equation of the symmetrical components, the negative-sequence system is calculated from this.

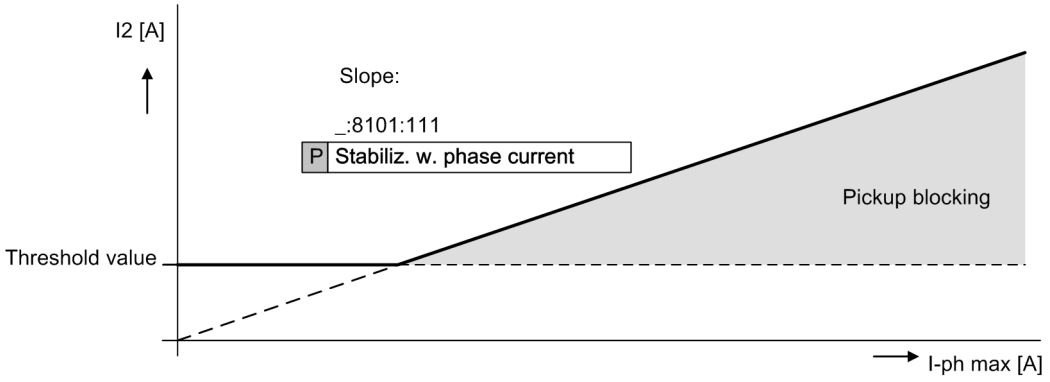
Functioning

The stage picks up if the negative-sequence system current exceeds the set threshold value and the parameterized direction agrees with the measured direction. The pickup drops out if the negative-sequence system current falls below 95 % of the set threshold.

Stabilization with Phase Current

Unbalance in operation and unbalanced transformer ratios can lead to spurious pickups and incorrect tripping. In order to avoid this, the directional negative-sequence system stage is stabilized with the phase currents. The threshold value increases with rising phase currents (see next image).

You can change the stabilization factor (= gradient) via the **Stabiliz. w. phase current** parameter.



[dwstabil-300112-01.tif, 1, en_US]

Figure 6-151 Stabilization with Phase Currents

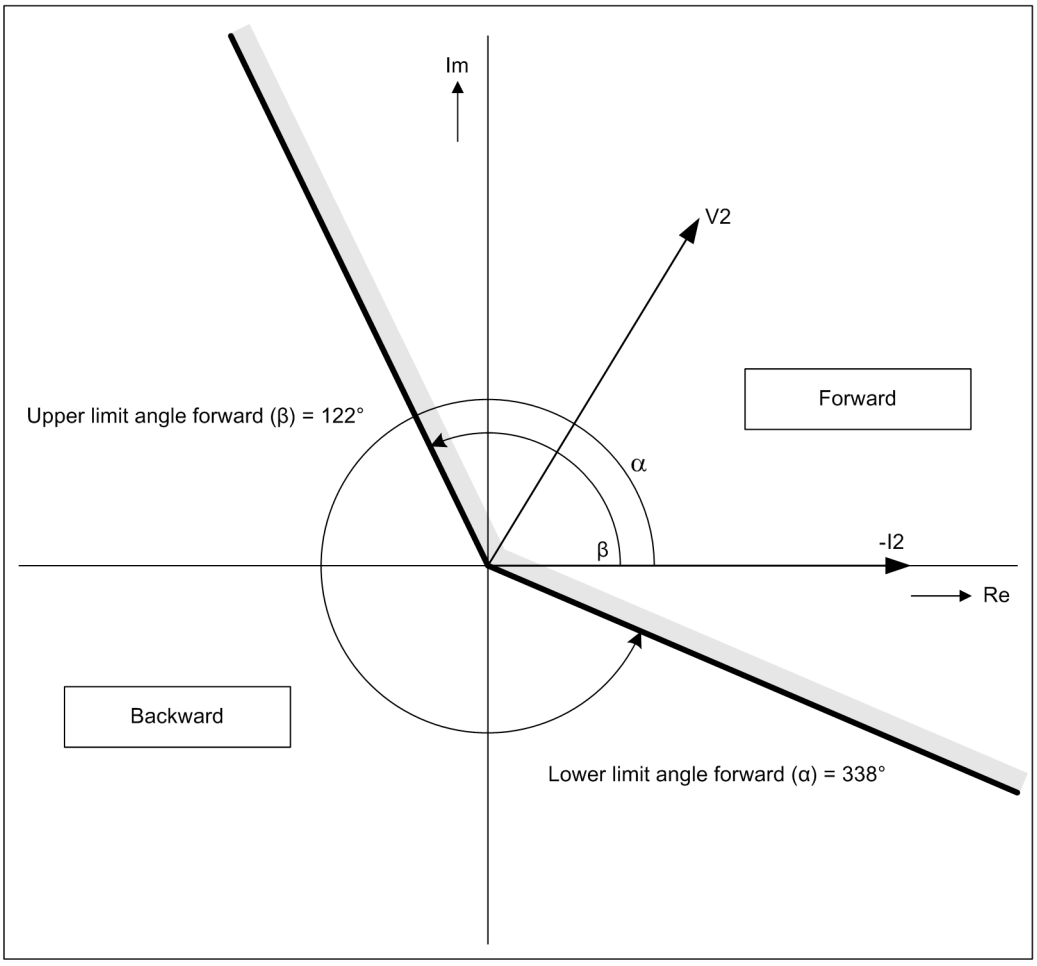
Direction Determination

The direction determination takes place with the negative-sequence system measurements I2 and V2.

The forward and reverse region is defined through the parameters **Angle forward α** and **Angle forward β** (see next figure). The reference for the 2 angles that must be set is the positive real axis. The angles are positively defined in a mathematical sense (counter-clockwise). The region between the limit angle α and the limit angle β - counted from the former in a positive direction - is the forward region. The remaining region is the reverse region.

For determining of the direction, the function places the measuring current I2 on the real axis. If the phasor of the negative-sequence system voltage V2 is located within the defined forward region, the function determines the direction as *forward*. In the other case, the function determines the direction as *reverse*.

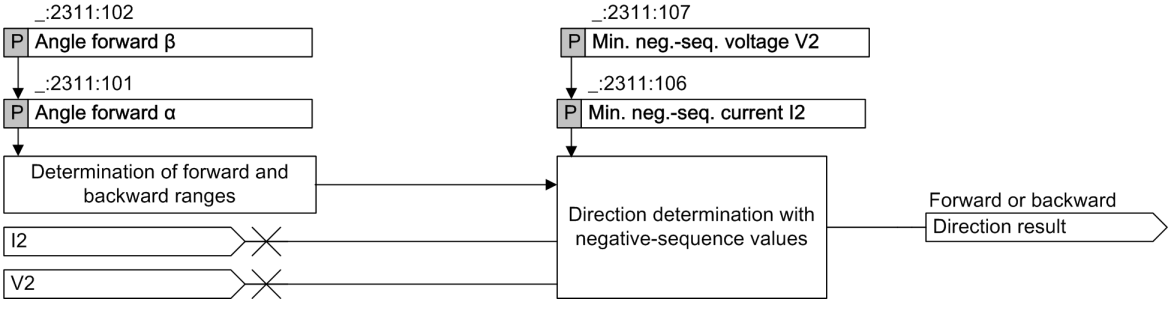
The requirement for determining the direction is that the adjustable minimum variables have been exceeded for the negative-sequence system current and negative-sequence system voltage (parameters **Min. neg.-seq. current I2** and **Min. neg.-seq. voltage V2**).



[dwphasor-140212-01.tif, 1, en_US]

Figure 6-152 Phasor Diagram for Direction Determination with Negative-Sequence System Values

If the device determines a fault in the voltage-transformer secondary circuit (through the binary input *voltage transformer circuit-breaker dropout* or through **measuring-voltage failure detection**), direction determination will be disabled and every directionally set stage will be blocked. Non-directionally set stages become active again if there are faults in the voltage-transformer secondary circuit.



[lorichtu-070611-01.tif, 1, en_US]

Figure 6-153 Logic of Direction Determination

Directional Mode

You use the **`Directional mode`** parameter to define whether the stage works in a forward or reverse direction. Non-directional operation is also possible.

Blocking the Tripping by Pickup of the Main Protection Functions

The pickup and type of pickup for the main protection functions can block the tripping of the stage. You can perform this setting via 2 parameters:

- **Blocking by**

  This setting is used to select the zone or stage at which blocking is to occur in the event of pickup.

- **Blocking by prot. pickup**

  The pickup type at which the blocking is to occur is defined with this parameter. The blocking can occur at any pickup or only at 1-pole or only at multipole pickups.

  This parameter is also used to set that no blocking should occur when the main protection has picked up.

Blocking of Tripping via the Device-Internal Inrush-Current Detection Function

If the device is equipped with the additional **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer inrush currents.

With the **Blk. w. inrush curr. detect.** parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and tripping are however blocked. The stage signals this by way of a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the tripping delay (time delay) is started. After that time, the stage operates.

6.18.4 Application and Setting Notes for Direction Determination

Parameter: Limit Angle Region Forward

- Recommended setting value **(_:2311:101) Angle forward α** = ***338°***
- Recommended setting value **(_:2311:102) Angle forward β** = ***122°***

With the parameters **Angle forward α** and **Angle forward β**, you can change the location of the directional characteristic curve.

Siemens recommends using the defaults, because the function with these settings reliably determines the direction.

Parameter: Minimum Negative-Sequence System Variables V2 and I2

- Default setting **(_:2311:107) Min. neg.-seq. voltage V2** = ***0.7 V***
- Default setting **(_:2311:106) Min. neg.-seq. current I2** = ***0.05 A***

With the parameters **Min. neg.-seq. voltage V2** and **Min. neg.-seq. current I2**, you can specify the minimum negative-sequence system values for direction determination with V2 and I2. The set limiting values must not be exceeded by operational unbalances.

6.18.5 Application and Setting Notes for Stages

Parameter: Directional mode

- Default setting **(_:8101:114) Directional mode** = ***forward***

You use the **Directional mode** parameter to define the directional mode of the stage.

Parameter Value	Description
non-directional	If the stage is to work in the forward and reverse direction (in the direction of the line and busbar), then select this setting. The stage will work with this setting even if no direction measurement is possible, for example due to insufficient polarization voltage (or none at all), or due to failure of the measuring voltage.

Parameter Value	Description
forward	Select these settings if the stage is only to work in a forward direction (in direction of the line).
reverse	Select this setting if the level is only to work in the reverse direction (in the direction of the busbar).

Parameter: Blk. w. inrush curr. detect.

If the device is equipped with the additional **Inrush-current detection** function, the stages can be stabilized against tripping due to transformer inrush currents.

- Default setting **(_:8101:116) Blk. w. inrush curr. detect.** = ***no***

Parameter Value	Description
no	The transformer inrush current detection does not affect the stage. Select this setting in the following cases: 1) In cases where the device is not used on transformers. 2) In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer.
yes	When the transformer inrush current detection detects an inrush current that can lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer.

Parameter: Blocking by the main Protection

- Recommended setting value **(_:8101:140) Blocking by** =

If you wish to give selective fault clarification through the main protection function precedence over tripping through the directional negative-sequence protection, you can define this via the 2 parameters **Blocking by** and **Blocking by prot. pickup**. The **Blocking by** parameter is used to select the zones or tripping stages of the main protection function(s), upon whose pickup the negative-sequence protection is to be blocked.

Parameter: Blocking by prot. pickup

- Default setting **(_:8101:130) Blocking by prot. pickup** = ***every pickup***

The **Blocking by prot. pickup** parameter can be used to define the type of pickup, which leads to the blocking.

Parameter Value	Description
every pickup	Blocking at every pickup
1-phase pickup	Blocking only at 1-pole pickup
multi-phase pickup	Blocking only at multipole pickup
no pickup	If the pickup of the main protection function should not lead to blocking of the negative-sequence protection, select this setting.

Parameter: Hold mode 1-p dead time

- Default setting **(_:8101:112) Hold mode 1p dead time** = ***0.040 s***

The **Hold mode 1p dead time** setting is used to define the time by which the device-internal signal for the 1-pole interruption is extended after the end of the 1-pole interruption.

At all line ends, there is no simultaneous switch-in after a 1-pole dead time. Thus, the parameterized operating mode for a 1-pole dead time must be retained for a certain time after the switch-in (end of the 1-pole dead time) until the other end or ends have securely switched in. The time to be set here corresponds to the maximum time between the switch-in of the 1st circuit breaker and the switch-in of the last circuit breaker at all ends of the feeder after a 1-pole dead time.

NOTE

The **Hold mode 1p dead time** setting is only available in devices with 1-/3-pole tripping. In devices with 3-pole tripping, this setting does not apply.

Parameter: Stabiliz. w. phase current

- Recommended setting value **(_:8101:111) Stabiliz. w. phase current** = ***10 %***

In order to avoid unwanted pickups and tripping, the negative-sequence system current stage is stabilized with the phase currents.

More information can be found in chapter *6.18.3 Function Description*.

The threshold value increases as the phase currents increase.

You can change the stabilization factor (= gradient) via the **Stabiliz. w. phase current** parameter.

Siemens recommends a default setting of 10 % under normal operations.

Parameter: Threshold

- Default setting **(_:8101:3) Threshold** = ***1.5 A***

Define the pickup value corresponding to the application. In doing so, for the time-graded stages, the setting for the superordinate and subordinate stages must be taken into account in the grading chart.

With a very sensitive setting, you must make sure that the negative-sequence system current does not lead to undesired response of the stage due to unbalance (for example non-twisted line).

Parameter: Operate delay

- Default setting **(_:8101:6) Operate delay** = ***0.30 s***

The tripping delay (time delay) to be set is derived from the time-grading schedule that has been prepared for the system.

When selecting the current and time setting, pay attention to whether the stage must work dependent on the direction.

6.18.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Angle forward α		0 ° to 360 °	338 °
_:2311:102	General:Angle forward β		0 ° to 360 °	122 °
_:2311:107	General:Min. neg.-seq. voltage V2		0.150 V to 34.000 V	1.213 V
_:2311:106	General:Min. neg.-seq. current I2	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
Definite-T 1				
_:8101:1	Definite-T 1:Mode		• off • on • test	off
_:8101:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:8101:114	Definite-T 1:Directional mode		• non-directional • forward • reverse	forward
_:8101:111	Definite-T 1:Stabiliz. w. phase current		0 % to 30 %	10 %
_:8101:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8101:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
_:8101:116	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:8101:130	Definite-T 1:Blocking by prot. pickup		• every pickup • 1-phase pickup • multi-phase pickup • no pickup	every pickup
_:8101:129	Definite-T 1:Op.mode at 1p dead time		• blocked • non-directional	blocked
_:8101:112	Definite-T 1:Hold mode 1p dead time		0.000 s to 60.000 s	0.040 s
_:8101:140	Definite-T 1:Blocking by		Setting options depend on configuration	

6.18.7 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Test of direction	SPS	I
_:2311:300	General:Test direction	ACD	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:8101:81	Definite-T 1:>Block stage	SPS	I
_:8101:54	Definite-T 1:Inactive	SPS	O
_:8101:52	Definite-T 1:Behavior	ENS	O
_:8101:53	Definite-T 1:Health	ENS	O
_:8101:60	Definite-T 1:Inrush blocks operate	ACT	O
_:8101:302	Definite-T 1:Prot.PU blocks operate	SPS	O
_:8101:301	Definite-T 1:Mode1p dead-tm.active	SPS	O
_:8101:55	Definite-T 1:Pickup	ACD	O
_:8101:56	Definite-T 1:Operate delay expired	ACT	O
_:8101:57	Definite-T 1:Operate	ACT	O

6.19 Thermal Overload Protection, 3-Phase

6.19.1 Overview of Functions

The **Thermal overload protection** function (ANSI 49) is used to:

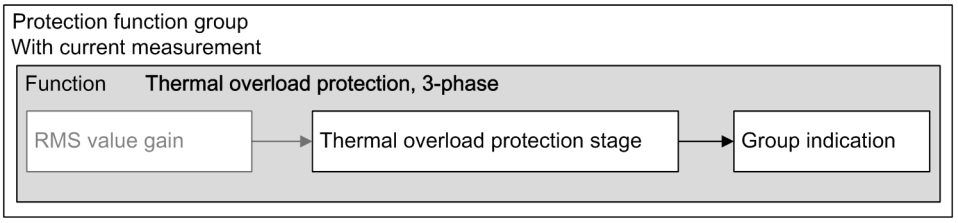
- Protect the equipment (motors, generators, transformers, capacitors, overhead lines, and cables) against thermal overloads
- Monitor the thermal state of motors, generators, transformers, capacitors, overhead lines, and cables

6.19.2 Structure of the Function

The **Thermal overload protection, 3-phase** function is used in protection function groups with current measurement.

The function is preconfigured by the manufacturer with 1 **Thermal overload protection** stage.

The non-preconfigured function block **Filter** can optionally be applied to gain the RMS value used by the **Thermal overload protection** stage.



[dw_TOLP_with Filter stage, 1, en_US]

Figure 6-154 Structure/Embedding of the Function

6.19.3 Filter for RMS Value Gain

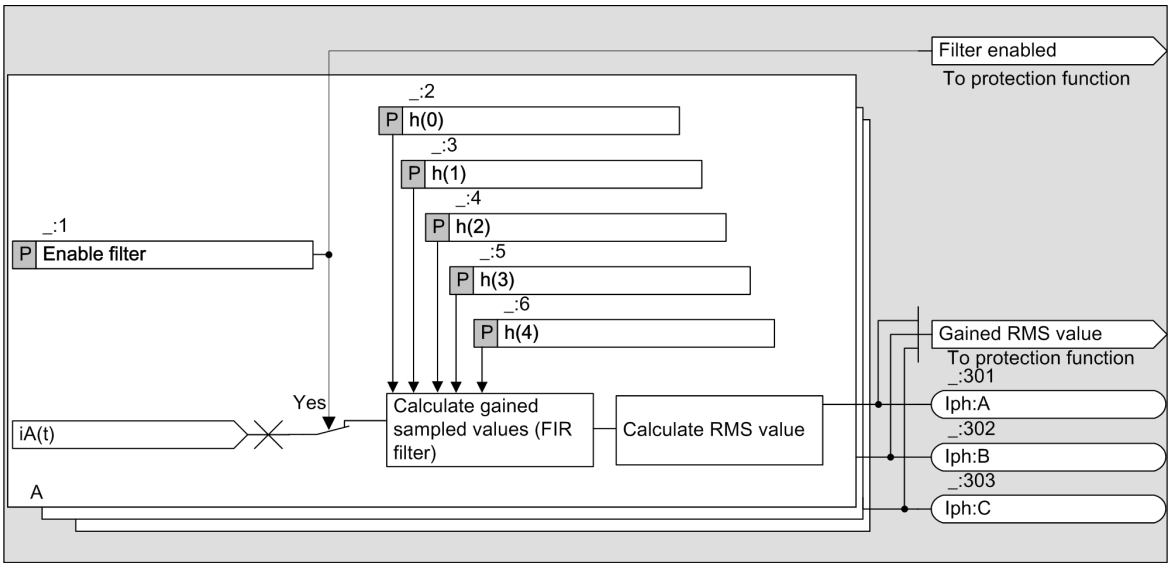
6.19.3.1 Description

The function block **Filter** can be used to adapt the RMS value for 2 means:

- To gain harmonics in a defined way. Higher harmonics can stress the protected object thermally more than lower harmonics. This is the case for reactors applied in AC filters. In addition, the amplitude attenuation of higher frequencies due to the anti-aliasing filter of the device is automatically compensated by the filter
- To only compensate the amplitude attenuation of higher frequencies by the device (due to the anti-aliasing filter)

The filter gain (amplitude response) is realized by a 9-order FIR filter.

Logic



[lo_TOLP_FilterStage, 1, en_US]

Figure 6-155 Logic Diagram of the Function Block Filter

The FIR filter gains the 8-kHz sampled values according to the set filter coefficients. Afterwards the RMS value is calculated. The symmetrical 9-order filter coefficients are set via the respective parameters **h(0)**, **h(1)**, **h(2)**, **h(3)** and **h(4)**.

NOTE

A FIR-filter configuration tool is provided as an auxiliary PC tool. With this PC tool, the coefficients h(0), h(1), h(2), h(3), h(4) of the FIR filter are generated according to the required gain factors (amplitude response). The tool can be obtained from the SIPROTEC download area. For more information about the tool, refer to the tool help function.

The gained RMS value is delivered to the protection stages only when the function block **Filter** is instantiated and the parameter **Enable filter** is set as ***yes*** . Otherwise, the normal RMS value is used.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
Iph:A	Filtered RMS measured value of current A	kA	A	Parameter **Rated current**
Iph:B	Filtered RMS measured value of current B	kA	A	Parameter **Rated current**
Iph:C	Filtered RMS measured value of current C	kA	A	Parameter **Rated current**

You can find the parameter **Rated current** in the **FB General** of function groups where the **Thermal overload protection** function is used.

If the parameter **Enable filter** is set to ***no***, the function values are shown as ---.

6.19.3.2 Application and Setting Notes

Parameter: Enable filter

- Default setting **(_:1) Enable filter** = ***no***.

With the parameter **Enable filter**, you set whether the **Filter** is enabled.

Parameter Value	Description
yes	If gained RMS values should be used in one of the protection stages, set parameter **Enable filter** = ***yes***.
no	If no gained RMS values are needed, set the parameter **Enable filter** = ***no***.

Parameter: **h(0),h(1),h(2),h(3),h(4)**

- Default setting **(_:2) h(0)** = ***0.000***
- Default setting **(_:3) h(1)** = ***0.000***
- Default setting **(_:4) h(2)** = ***0.000***
- Default setting **(_:5) h(3)** = ***0.000***
- Default setting **(_:6) h(4)** = ***1.000***

With the default value of the coefficients, the filter has no effect and no gain is applied.

If the filter shall be applied to adapt the RMS value calculation to a specific protection object such as a reactor, the reactor manufacturer has to provide the required amplitude response (gain factors) for the reactor. To determine the coefficients h(0) to h(4) for the FIR filter, you must enter the gain factors into the auxiliary PC tool which is available in the SIPROTEC download area. The 5 required coefficients are generated by the tool. They have to be entered manually as settings to configure the filter. The amplitude attenuation of higher frequencies due to the anti aliasing filter of the device is automatically taken into account and compensated by the filter.

To only compensate the attenuation of higher frequencies by the device, set the following coefficients in the filter.

Rated Frequency	Filter Coefficients for Only Compensating the Device Amplitude Attenuation
50 Hz	h(0) = -0.002 h(1) = -0.012 h(2) = 0.045 h(3) = -0.110 h(4) = 1.151
60 Hz	h(0) = -0.005 h(1) = -0.020 h(2) = 0.058 h(3) = -0.128 h(4) = 1.170

6.19.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Filter				
_:1	Filter:Enable filter		• no • yes	no
_:2	Filter:h(0)		-100.000 to 100.000	0.000
_:3	Filter:h(1)		-100.000 to 100.000	0.000
_:4	Filter:h(2)		-100.000 to 100.000	0.000
_:5	Filter:h(3)		-100.000 to 100.000	0.000
_:6	Filter:h(4)		-100.000 to 100.000	1.000

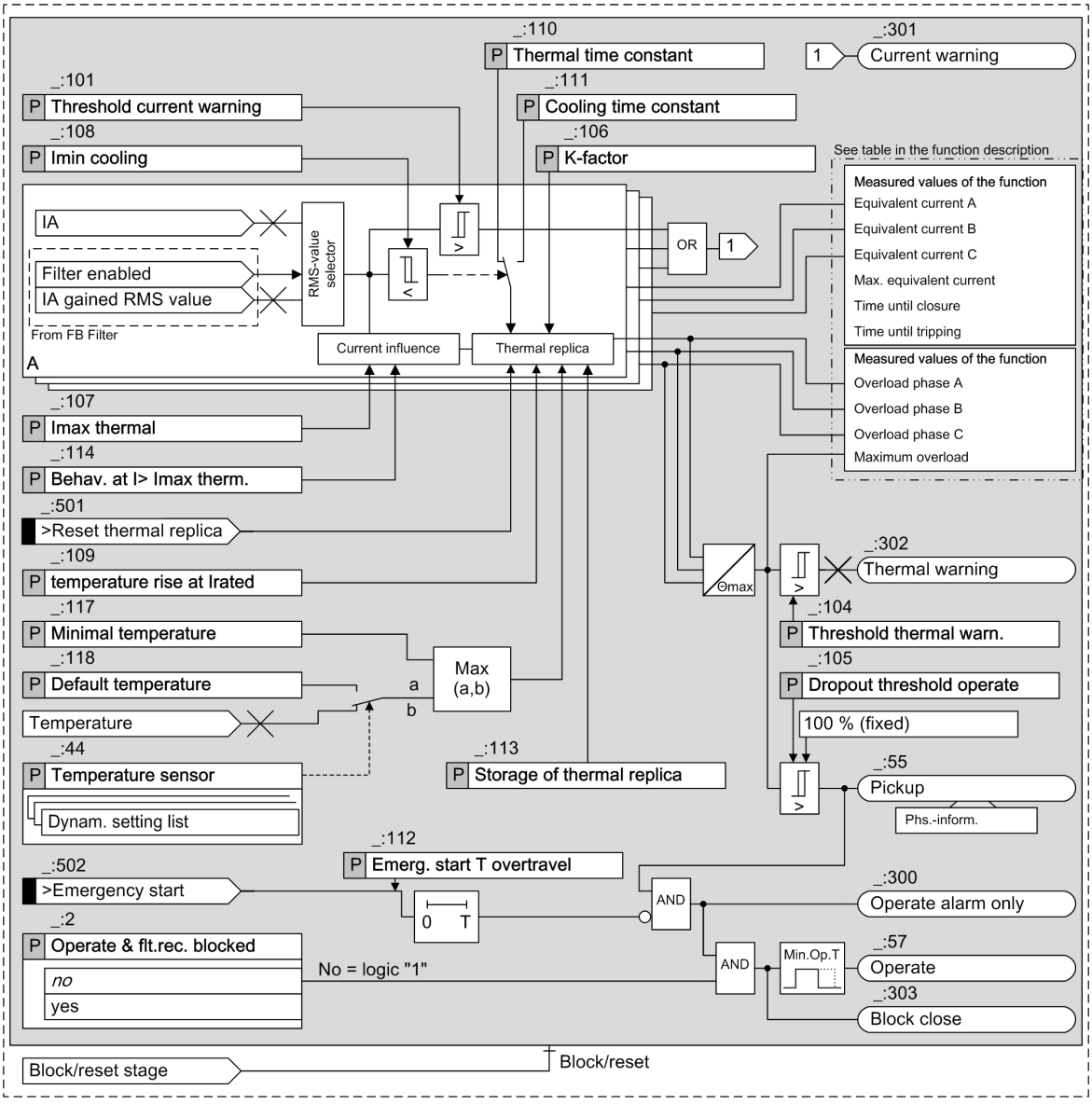
6.19.3.4 Information List

No.	Information	Data Class (Type)	Type
Filter			
_:301	Filter:Iph:A	MV	O
_:302	Filter:Iph:B	MV	O
_:303	Filter:Iph:C	MV	O

6.19.4 Stage with Thermal Overload Protection

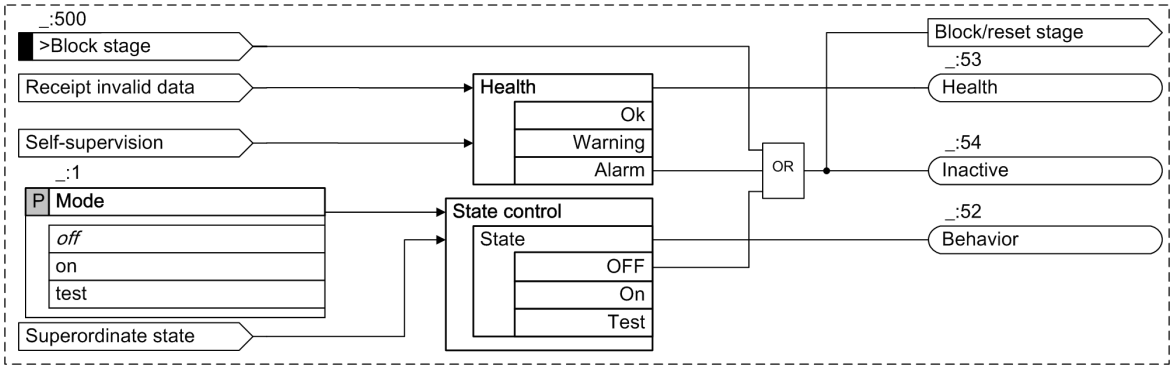
6.19.4.1 Description

Logic



[lo_TOLP_withFilterstage, 1, en_US]

Figure 6-156 Logic Diagram of the Thermal Overload Protection Stage



[lo_Stage Control, 1, en_US]

Figure 6-157 Logic Diagram of the Stage Control

RMS-Value Selection

The protection function supports 2 kinds of RMS measurement:

- Normal RMS value
- Gained RMS value from the function block **Filter**

The gained RMS value is automatically used if the function block **Filter** is configured and the filter has been enabled.

NOTE

When the function block **Filter** is applied, only one current measuring point I-3ph is allowed to be connected to the 3-phase current interface of the function group.

Thermal Replica

The protection function calculates the overtemperature from the phase currents based on a thermal single-body model according to the thermal differential equation with

$$I_{p.u.}^2 = \tau_{th} \frac{d\theta}{dt} + \theta - \theta_{Amb}$$

[fo_diffgl-170914, 2, en_US]

With the following standardization:

$$I_{p.u.} = \frac{I}{I_{max}} = \frac{I}{K \cdot I_{rated\ ,obj.}} \qquad \theta = \frac{\vartheta}{\vartheta_{max}} = \frac{\vartheta}{K^2 \cdot \Delta\vartheta_{rated\ ,obj.}}$$

$$\tau_{th} = R_{th} \cdot C_{th} \qquad \theta_{Amb} = \frac{\vartheta_{Amb} - 40\ °C}{\vartheta_{max}} = \frac{\vartheta_{Amb} - 40\ °C}{K^2 \cdot \Delta\vartheta_{Amb\ ,obj.}}$$

[fo_normie-170914, 2, en_US]

Θ	Current overtemperature, in relation to the final temperature at a maximum permissible phase current k $I_{rated, obj}$
Θ_{Amb}	Standardized ambient temperature, where ϑ_{Amb} describes the coupled ambient temperature. The coupled ambient temperature ϑ_{Amb} can be the measured ambient temperature or the ambient temperature preset using the **`Default temperature`** parameter.
$\Delta\vartheta_{rated\ obj}$	Overtemperature of the protected object set at rated current
τ_{th}	Thermal time constant (temperature rise/cooling) of the protected object

k	This factor indicates the maximum continuous permissible phase current. The factor refers to the rated current of the protected object ($k = I_{max}/I_{rated, obj}$)
$I_{rated, obj}$	Rated current of the protected object

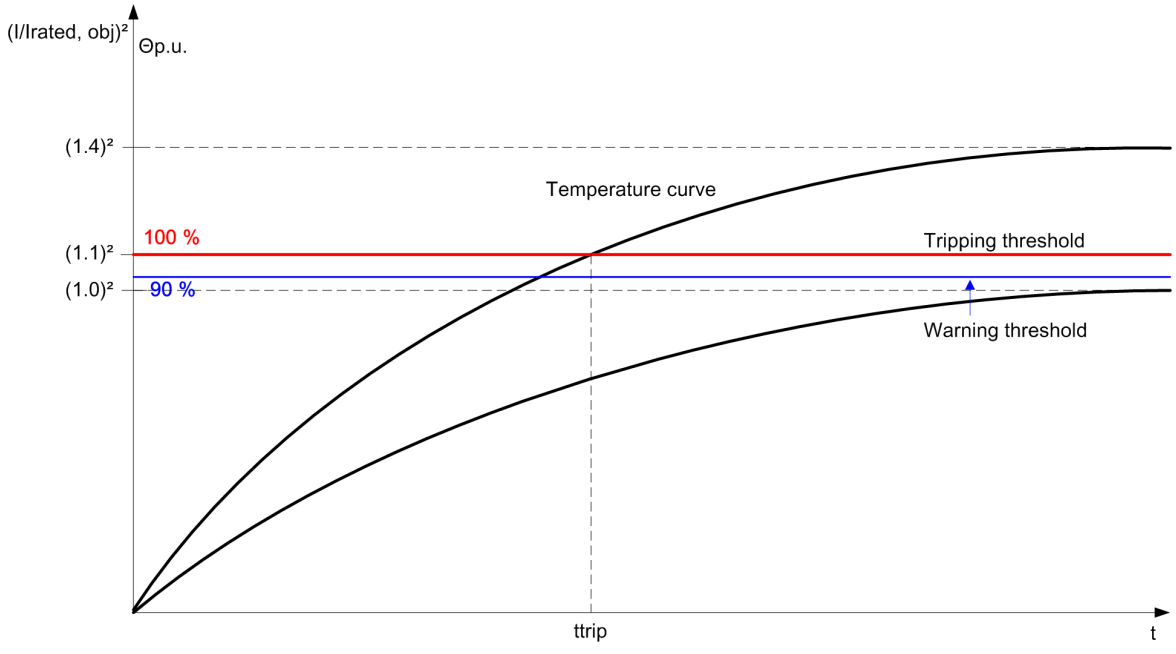
At the same time, $I_{rated, obj}$ is the rated current of the assigned protected object side:

- In the case of transformers, the rated current of the winding to be protected, which the device calculates from the set rated apparent power and rated voltage, is decisive.
- The uncontrolled winding forms the basis in the case of transformers with voltage control
- In the case of generators, motors and reactors, the rated current, which the device calculates from the set rated apparent power and rated voltage, is decisive.
- In the case of lines, nodes and busbars, the rated current of the protected object is set directly

In a steady state, the solution to the thermal differential equation is an e-function whose asymptote represents the final overtemperature Θ_{end}. The time constant τ_{th} determines the rise. After reaching an initial adjustable overtemperature threshold Θ_{warn} (**Threshold thermal warn.**), a warning indication is given.

If the overtemperature limit Θ_{Off} (tripping overtemperature) is exceeded, an operate indication is immediately issued and the equipment disconnected from the power supply. This threshold is specified at 100 % and corresponds to the final temperature set at a flowing permissible continuous current (I_{max}).

Figure 6-158 shows the temperature rise at different overload currents and the supervision thresholds.



[dwtempve-030211-01.tif, 1, en_US]

Figure 6-158 Temperature History for Different Overload Currents (**K-factor** = ***1.1***)

The overtemperature is calculated separately for each phase. The current overtemperature can be obtained from the operational measured values. It is shown in percent. An indication of 100 % means that the thermal threshold has been reached. The maximum overtemperature of the phases is regarded as the tripping temperature. This means that the highest of the 3 phase currents is always assumed.

The analysis of the RMS values of the currents over a broad frequency band also includes the harmonic components. These harmonic components contribute to the temperature rise of the equipment.

If the flowing current falls below an adjustable minimum current **Imin cooling** , the **Cooling time constant** is activated.

Operate Curve

If the ambient temperature is not measured and set to 40°C, you can get the operate curve as following:

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj.}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - 1}$$

[foauslos-211010-01.tif, 1, en_US]

t	Operate time
τ_{th}	Time constant
I	Measured load current
$I_{preload}$	Preload current
k	Setting factor according to VDE 0435 part 3011 or IEC 60255-8 (K factor)
$I_{rated, obj}$	Rated current of the protected object

Ambient Temperature

This function can take the ambient temperature into consideration. The reference temperature of the thermal model is 40°C. If the ambient temperature drops below the reference temperature, the thermal limit increases. The equipment can be stressed more. If the ambient temperature is higher, the conditions change.

The **Default temperature** parameter can be used to fix or measure the ambient temperature. The **Minimal temperature** parameter limits the coupled ambient temperature. If the measured ambient temperature is lower than the minimum temperature, the minimum temperature is processed in the thermal model.

The ambient temperature refers to the overtemperature of the protected object, which sets itself at the rated current (parameter **Temperature rise at Irated**).

The measured ambient temperature is measured by an external RTD unit (RTD = Resistance Temperature Detector) and provided by the functions **RTD unit Ether.** or **RTD unit serial** of the function group **Analog transformer**. When using the **Temperature sensor** parameter, the respective temperature sensor can be selected.

If the temperature measurement is faulty, for example, due to an open circuit between the device and the RTD unit, the device reports this. In this case, the process continues with either the temperature measured last or the value set under the **Default temperature** parameter, depending on which value is the highest.

Current Influence

The thermal replica based on the single-body model applies with limitations to high overcurrent situations (short circuits, motor startup currents). To avoid an overfunction of the overload protection, the thermal replica must be influenced for overcurrents (exceeding **1** $_{threshold}$). You can select between 2 strategies for this:

- Freezing of the thermal memory
- Limitation of the input current for the thermal replica to the set current. The temperature rise is thereby **retarded** at high currents.

Warning Thresholds

The thermal warning threshold issues a warning indication before the tripping threshold (tripping temperature) is reached. In this way, for example, a load can be reduced in sufficient time and a disconnection avoided. At a normal **K-factor** of ***1.1*** , a thermal memory value of 83 % sets in at continuously flowing rated current.

Apart from the thermal warning threshold, the overload protection also has a current-warning threshold. This current-warning threshold can signal an overload current in sufficient time before the overtemperature value has reached the warning or tripping threshold.

Dropout of Tripping

Once the thermal memory has fallen below the setting value of the **Dropout threshold operate** , the trip command is cancelled upon tripping. In contrast, the current-warning threshold and the thermal warning threshold are reduced at a fixed dropout threshold (see Technical Data).

Behavior in the Event of Auxiliary-Voltage Failure

The behavior of the thermal replica can be controlled upon auxiliary-voltage failure via the setting parameter **Storage of thermal replica** . You can save the thermal state for a time of 500 min. Once the supply voltage returns, the thermal replica continues to function with the saved thermal state.

If the thermal replica is not saved, it will be reset to 0 upon failure of the auxiliary voltage.

Resetting the Thermal Map

You can reset the thermal memory via the binary input indication **>Reset thermal replica** . The thermal memory will then have a 0 value. A reparameterization will also lead to resetting the thermal memory.

Emergency Start

Depending on the operating conditions, tripping can be blocked or closure enabled despite the permissible thermal limits being exceeded. Upon activation of the binary input signal **>Emergency start** , tripping is blocked and closure enabled. This does not affect the state of the thermal memory. After the input **>Emergency start** disappears, the blocking remains in effect for the set **Emerg. start T overtravel** .

Blocking the Function

Blocking will cause a picked up function to be reset. The tripping function can be blocked externally or internally by the binary input signal **>Block stage** .

All indications then drop out and the thermal memory is set to the value 0.

Blocking Closure

The signal **Block close** can be used to prevent closure of the protected object at a high thermal load. The signal is set if the tripping overtemperature is exceeded, and cancelled if the temperature falls below the dropout threshold.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:601:305) Time until trip	Expected time until tripping	s	s	s
(_:601:304) Time until close	Time until close release	s	s	s
(_:601:306) Overload phase A	Thermal measured values of the phases	%	%	Tripping temperature
(_:601:307) Overload phase B				
(_:601:308) Overload phase C				
(_:601:309) Overload maximum	Thermal measured value of the overload protection	%	%	Tripping temperature
(_:601:310) Equival. current phs A	Current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values
(_:601:311) Equival. current phs B				
(_:601:312) Equival. current phs C				
(_:601:313) Equival. current max.	Maximum current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values

6.19.4.2 Application and Setting Notes

Parameter: `Threshold current warning`

- Recommended setting value **`(_:101) Threshold current warning`** = ***`1.1 A`*** at I_{rated} = 1 A

Set the threshold to the maximum permissible continuous current ($I_{max, perm}$). This results in the same setting value as for the **`K-factor`** .

Parameter: `Threshold thermal warn.`

- Recommended setting value **`(_:104) Threshold thermal warn.`** = ***`90 %`***

The default setting can be left at a **`K-factor`** , of ***`1.1`***, as the thermal memory results for 83 % at continuously flowing rated current. The calculation uses the rule of three: 100 % corresponds to (**`K-factor`**)^2 and x % corresponds to 1^2.

$$\frac{\Theta}{\Theta_{off}} = \frac{100\ \%}{k^2} = 83\ \%$$

[fowarnsc-100810-01.tif, 2, en_US]

At a **`K-factor`** of 1.05, the thermal memory for rated current is already 91 % filled. Increase the **`Threshold thermal warn.`** to 95 %.

Parameter: `Dropout threshold operate`

- Recommended setting value **`(_:105) Dropout threshold operate`** = ***`90 %`***

The **`Dropout threshold operate`** parameter is used to drop out pickup and tripping when the value drops below this threshold. A setting on the order of magnitude of the warning threshold is recommended. You can select a lower setting value for special applications, desired additional cooling or longer blocking of closing.
Note that the calculation of the operational measured value **`Time until close`** refers to this value.

Parameter: `Emerg. start T overtravel`

- Default setting **`(_:112) Emerg. start T overtravel`** = ***`6300 s`***

This functionality is not required for protection of lines and cables. If the logical binary indication is not routed, the **`Emerg. start T overtravel`** will be ineffective. The **`Emerg. start T overtravel`** presetting can therefore be retained.

Parameter: `K-factor`

- Recommended setting value **`(_:106) K-factor`** = ***`1.1`***

The **`K-factor`** parameter is used to describe the limiting value for the maximum permissible continuous load. The rated current $I_{rated, obj}$ of the protected object (for example, cable) is the basic current for overload sensing.
You can determine the **`K-factor`** on the basis of the thermally permissible continuous current $I_{max, perm.}$:

$$K\text{-factor} = \frac{I_{max,perm.}}{I_{rated,obj.}}$$

[fotolpkf-100810-01.tif, 2, en_US]



NOTE

The thermally permissible continuous current for the protected object is known from relevant tables or from the specifications of the manufacturer!

In the case of cables, the permissible continuous current depends on the cross-section, insulation material, design type, and the manner in which the cables have been laid. In the case of overhead lines, an overload of 10 % is permissible.

EXAMPLE

For the Permissible Continuous Current

Cross-linked polyethylene cables (N2XS2Y): 10 kV 150 mm² (Cu)

Current-carrying capacity (underground laying): $I_{max, perm}$ = 406 A

Selected **`K factor`** of 1.1

This yields a rated current of $I_{rated, obj}$= 369 A

Parameter: `Thermal time constant`

- Recommended setting value **`(_:110) Thermal time constant`** = ***`2777 s (46.29 min)`***

The **`Thermal time constant`** parameter is used to define the tripping characteristics of the stage. If no data on the **`Thermal time constant`** is available, you can determine this from the short-time current-rating capacity of the cable, for example, from the 1-s current. The 1-s current is the maximum current permissible for 1 s application time. The 1-s current can be found in the cable specifications. Calculate the **`Thermal time constant`** according to the following formula:

$$\tau[\text{min}] = \frac{1}{60}\left(\frac{\text{perm. 1–s–current}}{\text{perm. continuous current}}\right)^2$$

[fodauers-170309-07.tif, 2, en_US]

If the short-term current-rating capacity is specified for an application time other than 1 s, use the short-time current instead of the 1-s current. Multiply the result by the specified application time.

For a given short-term current-carrying capacity of 0.5 s, use the following formula:

$$\tau[\text{min}] = \frac{0.5}{60}\left(\frac{\text{perm. 0.5–s–current}}{\text{perm. continuous current}}\right)^2$$

[fodauers-170309-01.tif, 2, en_US]

EXAMPLE for a Cable

For a cable

Permissible continuous current: $I_{max, perm}$ = 406 A

Maximum short-circuit current for 1 s: I_{1s} = 21.4 kA

Therefore, for the **`Thermal time constant`**, it follows

$$\tau\ [\text{min}] = \frac{1}{60}\left(\frac{21400\ \text{A}}{406\ \text{A}}\right)^2 = \frac{1}{60}52.7^2 = 46.29\ \text{min}$$

[fokonsta-310510-01.tif, 2, en_US]

with 46.29 min = 2777 s

Parameter: `Cooling time constant`

- Recommended setting value **`(_:111) Cooling time constant`** = ***`2777 s`***

The **`Cooling time constant`** parameter is used to define the dropout behavior of the stage. Cables and overhead lines have the same time constant for both heating and cooling. Therefore, set the same value for the **`Cooling time constant`** as for the parameter **`Thermal time constant`**.

Parameter: `Imax thermal`

- Recommended setting value **`(_:107) Imax thermal`** = ***`2.5 A`*** at I_{rated} = 1 A

The **`Imax thermal`** parameter allows you to set the threshold current for the **`Behav. at I> Imax therm.`** parameter. The selected threshold current of 2.5 $I_{rated, obj}$ is a practicable value.

Parameter: `Imin cooling`

- Recommended setting value **`(_:108) Imin cooling`** = ***`0 A`***

If only the thermal time constant (parameter **`Thermal time constant`**) must provide protection, set the current parameter **`Imin cooling`** to 0 A.

Parameter: `Temperature rise at Irated`

- Default setting **`(_:109) Temperature rise at Irated`** = ***`70 K`***

As a value, set the overtemperature that is the result if the equipment is continuously operated with the rated current and at an ambient temperature of 40°C. Here, the rated current refers to the protected object. You can find the temperature value in the technical data of the equipment or measure it. If you use a temperature sensor when measuring at the rated current, deduct the actual ambient temperature or the coolant temperature from the measured value.

When selecting the setting value, you can also use the specified temperature class for orientation. Usually, you will find the overtemperature expressed in Kelvin (K), which can be accepted as is. If the absolute temperature is given, the ambient temperature must be deducted. As a rule, this is 40°C.

The overtemperature at maximum permissible current (***`ϑmax`***) and the **`Temperature rise at Irated`** (***`ϑrated,obj.`***) can be converted by using the following formula:

$$k^2 = \left(\frac{\Delta\vartheta_{max}}{\Delta\vartheta_{rated\ ,obj.}} \right)$$

[fo_ueb_for_Irated, 3, en_US]

EXAMPLE:

Temperature class **B** for continuous operation: permissible overtemperature = 80 K
From this, a temperature for I_{rated} of 120°C (80 K + 40°C) can be derived when using a temperature sensor for the measurement.
Temperature class **F** as thermal limiting value: permissible overtemperature = 105 K.
From this, a maximum temperature of 155°C (105 K + 40°C) derives.

From these values, the K factor can be derived:

$$k^2 = \frac{\Delta\vartheta_{max\ ,Obj.}}{\Delta\vartheta_{rated\ ,Obj.}} = \frac{105\ K}{80\ K} = 1.31 \qquad \rightarrow\ k = 1.146$$

[fo_bsp_kfaktor, 3, en_US]

If you select a setting value of 1.1 for the **`K-factor`**, your selection can be considered as conservative.



NOTE

For electrical machines, the limits can vary depending on the type of coolant.
Consult the machine manufacturer to agree on a setting value for the overtemperature.

Parameter: `Storage of thermal replica`

- Recommended setting value **`(_:113) Storage of thermal replica`** = ***`no`***

If a continuous auxiliary voltage for the bay units is ensured, the bay default setting can be retained.

Parameter: `Behav. at I> Imax therm.`

- Recommended setting value **`(_:114) Behav. at I> Imax therm.`** = ***`freeze therm. rep.`***

The **`Behav. at I> Imax therm.`** parameter is used to select the process by which the function reacts to short-circuit currents. To prevent premature tripping of the overload protection at low time constants, high preloading and high short-circuit currents, the thermal replica can be modified.
The default setting has been selected to be compatible with SIPROTEC 4 devices. If you wish to take further temperature rise into consideration, the ***`current limiting`*** procedure is recommended.

Parameter Value	Description
`freeze therm. rep.`	If input currents exceed the **`Imax thermal`** parameter, the thermal replica will be frozen for the time the parameter is exceeded. This parameter value is provided to enable compatibility with older products!
`current limiting`	The input currents are limited to the value set in the **`Imax thermal`** parameter. If the measured current exceeds the set current value, the limited current value is supplied to the thermal replica. An advisable current threshold is approx. 2 to 2.5 $I_{rated, obj}$.

Parameter: `Temperature sensor`

- Default value **`(_:44) Temperature sensor`** = ***`none`***

With the **`Temperature sensor`** parameter, you determine which temperature sensor to use to detect the ambient temperature.
A temperature sensor (RTD = Resistance Temperature Detector) is used to measure the ambient temperature of the protected object and feed it to the device via an RTD unit. The **Thermal overload protection** function receives the measured temperature value via the functions **RTD unit Ether.** or **RTD unit Serial** from the function group **Analog transformer**.

Parameter: `Default temperature`

- Recommended setting value **`(_:118) Default temperature`** = ***`40 °C`***

The **`Default temperature`** is set as ambient temperature under the following conditions:

- No temperature sensor for measuring the ambient temperature is connected.
- The temperature measurement is faulty and the last measured temperature value is less than the **`Default temperature`**.

Siemens recommends using the default setting.

Parameter: `Minimal temperature`

- Default setting **`(_:117) Minimal temperature`** = ***`-20 °C`***

If the measured ambient temperature drops below the set value, the set value is assumed as the ambient temperature. If the overload protection works with a prespecified outside temperature, and this temperature drops below the value set in the **`Minimal temperature`** parameter, the **`Minimal temperature`** is also used.

6.19.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`49 Th.overl. #`				
_:1	49 Th.overl. #:Mode		• off • on • test	off
_:2	49 Th.overl. #:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:101	49 Th.overl. #:Threshold current warning	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:104	49 Th.overl. #:Threshold thermal warn.		50 % to 100 %	90 %
_:105	49 Th.overl. #:Dropout threshold operate		50 % to 99 %	90 %
_:112	49 Th.overl. #:Emerg. start T overtravel		0 s to 15000 s	300 s
_:106	49 Th.overl. #:K-factor		0.10 to 4.00	1.10
_:110	49 Th.overl. #:Thermal time constant		10 s to 60000 s	900 s
_:111	49 Th.overl. #:Cooling time constant		10 s to 60000 s	3600 s
_:107	49 Th.overl. #:Imax thermal	1 A @ 100 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 100 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 50 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	12.500 A
_:108	49 Th.overl. #:Imin cooling	1 A @ 100 Irated	0.000 A to 10.000 A	0.500 A
		5 A @ 100 Irated	0.00 A to 50.00 A	2.50 A
		1 A @ 50 Irated	0.000 A to 10.000 A	0.500 A
		5 A @ 50 Irated	0.00 A to 50.00 A	2.50 A
		1 A @ 1.6 Irated	0.000 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.000 A to 8.000 A	2.500 A
_:109	49 Th.overl. #:Temperature rise at Irated		40 K to 200 K	70 K
_:113	49 Th.overl. #:Storage of thermal replica		• no • yes	no
_:114	49 Th.overl. #:Behav. at I> Imax therm.		• current limiting • freeze therm. rep.	current limiting
_:118	49 Th.overl. #:Default temperature		-55°C to 55°C	40°C
_:117	49 Th.overl. #:Minimal temperature		-55°C to 40°C	-20°C
_:44	49 Th.overl. #:Temperature sensor		Setting options depend on configuration	

6.19.4.4 Information List

No.	Information	Data Class (Type)	Type
49 Th.overl. #			
_:500	49 Th.overl. #:>Block stage	SPS	I
_:501	49 Th.overl. #:>Reset thermal replica	SPS	I
_:502	49 Th.overl. #:>Emergency start	SPS	I

No.	Information	Data Class (Type)	Type
_:54	49 Th.overl. #:Inactive	SPS	O
_:52	49 Th.overl. #:Behavior	ENS	O
_:53	49 Th.overl. #:Health	ENS	O
_:301	49 Th.overl. #:Current warning	SPS	O
_:302	49 Th.overl. #:Thermal warning	SPS	O
_:303	49 Th.overl. #:Block close	SPS	O
_:55	49 Th.overl. #:Pickup	ACD	O
_:300	49 Th.overl. #:Operate alarm only	ACT	O
_:57	49 Th.overl. #:Operate	ACT	O
_:304	49 Th.overl. #:Time until close	MV	O
_:305	49 Th.overl. #:Time until trip	MV	O
_:306	49 Th.overl. #:Overload phase A	MV	O
_:307	49 Th.overl. #:Overload phase B	MV	O
_:308	49 Th.overl. #:Overload phase C	MV	O
_:309	49 Th.overl. #:Overload maximum	MV	O
_:310	49 Th.overl. #:Equival. current phs A	MV	O
_:311	49 Th.overl. #:Equival. current phs B	MV	O
_:312	49 Th.overl. #:Equival. current phs C	MV	O
_:313	49 Th.overl. #:Equival. current max.	MV	O

6.20 Thermal Overload Protection, User-Defined Characteristic Curve

6.20.1 Overview of Functions

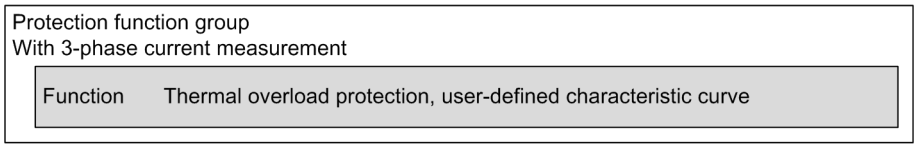
The **Thermal overload protection, user-defined characteristic curve** function (ANSI 49) is used to:

- Protect the equipment (motors, generators, and transformers) against thermal overloads
- Realize a manufacturer specific overload characteristic curve for specific equipment, for example, shunt reactors
- Monitor the thermal state of motors, generators, and transformers

6.20.2 Structure of the Function

The **Thermal overload protection, user-defined characteristic curve** function is used in protection function groups with 3-phase current measurement.

The **Thermal overload protection, user-defined characteristic curve** function is steplessly preconfigured.

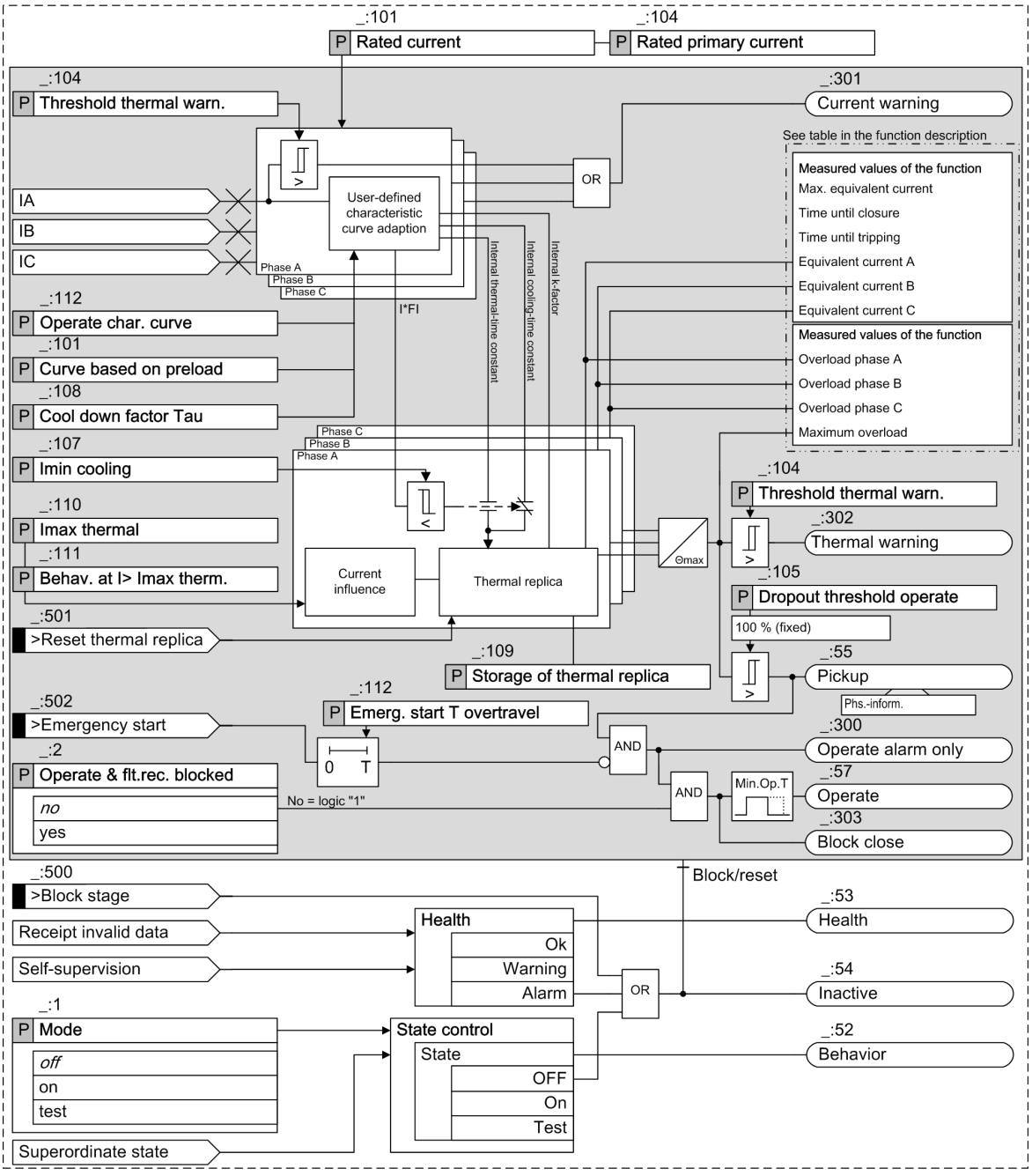


[dw_TOLP_UserCurveStr, 1, en_US]

Figure 6-159 Structure/Embedding of the Function

6.20.3 Function Description

Logic



[lo_TOLP_UserCurve_stage, 1, en_US]

Figure 6-160 Logic Diagram of the Thermal Overload Protection, User-Defined Characteristic Curve Function

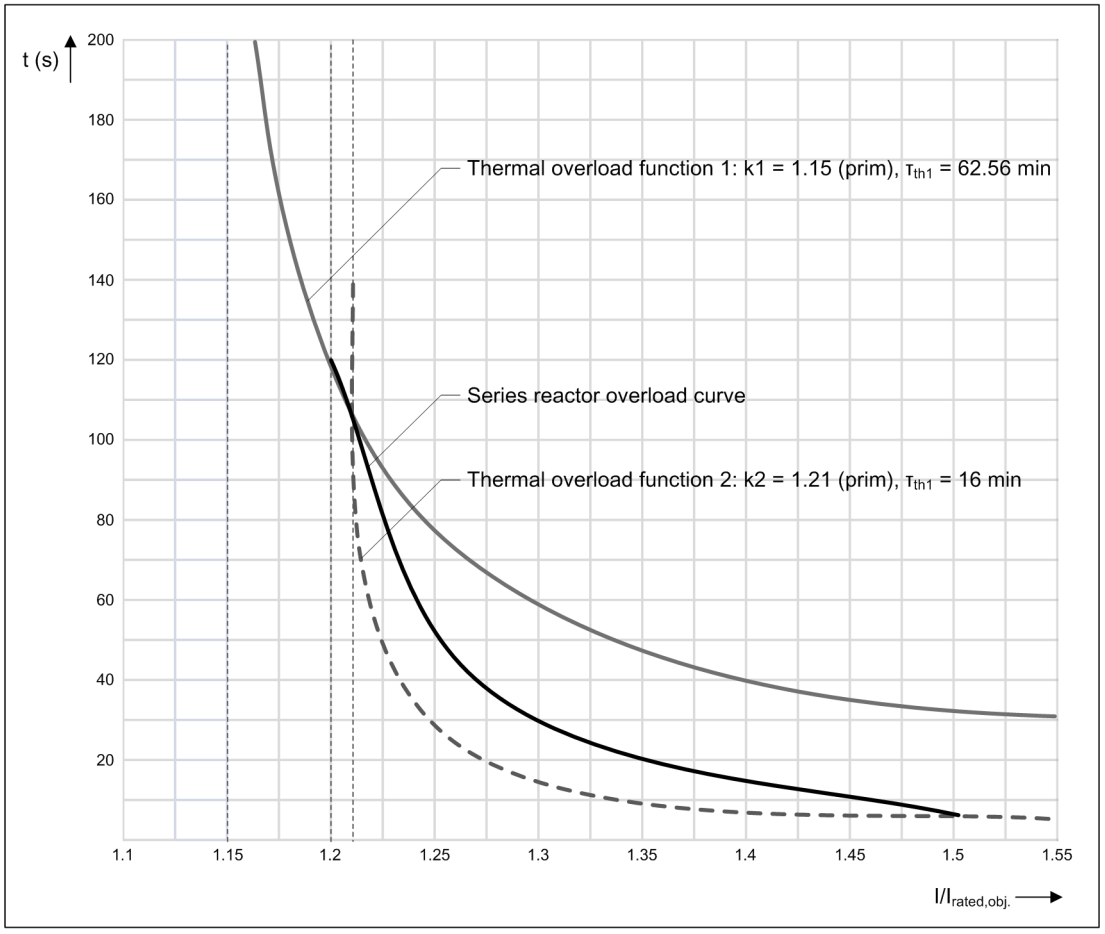
(1) The **(_:101) Rated current** parameter is from the protected object.

(2) The **(_:104) Rated primary current** parameter is from the used current transformer.

User-Defined Characteristic Curve

For specific equipment (for example, shunt reactors and transformers) or for special applications, the manufacturer specifies an overload characteristic curve. This curve cannot be described accurately with a single-

body model so that deviations can occur. The following figure shows an example of a predefined overload characteristic curve and 2 standard characteristic curves based on the single-body model.



[dw_TOLP_UserCurve_characteristic, 1, en_US]

Figure 6-161 User-Defined Characteristic Curve with Replica of Standard Characteristics

The calculation is identical to the realization of the standard **Thermal overload protection, 3-phase** function. You can find more information in the function description **Thermal overload protection, 3-phase** starting from chapter *6.19.1 Overview of Functions* .

The main deviations are as follows:

- The thermal characteristic is set with a flexible characteristic ($t_{trip} = f(I/I_{rated,obj})$).
  - The first point of the characteristic curve is important and is used to calculate the internal k-Factor.
  - The point at $I/I_{rated,obj} = 1.5$ is used to calculate the internal thermal time constant. If there is no point at $I/I_{rated,obj} = 1.5$, the point which is the closest to $I/I_{rated,obj} = 1.5$ from $I/I_{rated,obj} = 1.1$ is used to calculate the internal thermal time.
  - The points are set according to the maximum permissible load current.
- The **`Curve based on preload`** parameter describes for which thermal preload the user-defined characteristic curve is valid. Normally, such a curve is given for protected objects under rated load.
- The **`Cool-down factor Tau`** parameter is used for the determination of the cooling time constant. The set factor is multiplied with the internal calculated time constant.
- The thermal model is based on a constant ambient temperature of 40 °C. It cannot be corrected via the external measurement.

Thermal Replica

The protection function calculates the overtemperature from the phase currents on the basis of a thermal single-body model according to the thermal differential equation with

$$I_{p.u.}^2 = \tau_{th} \frac{d\theta}{dt} + \theta$$

[fo_TOLP_diffgl, 1, en_US]

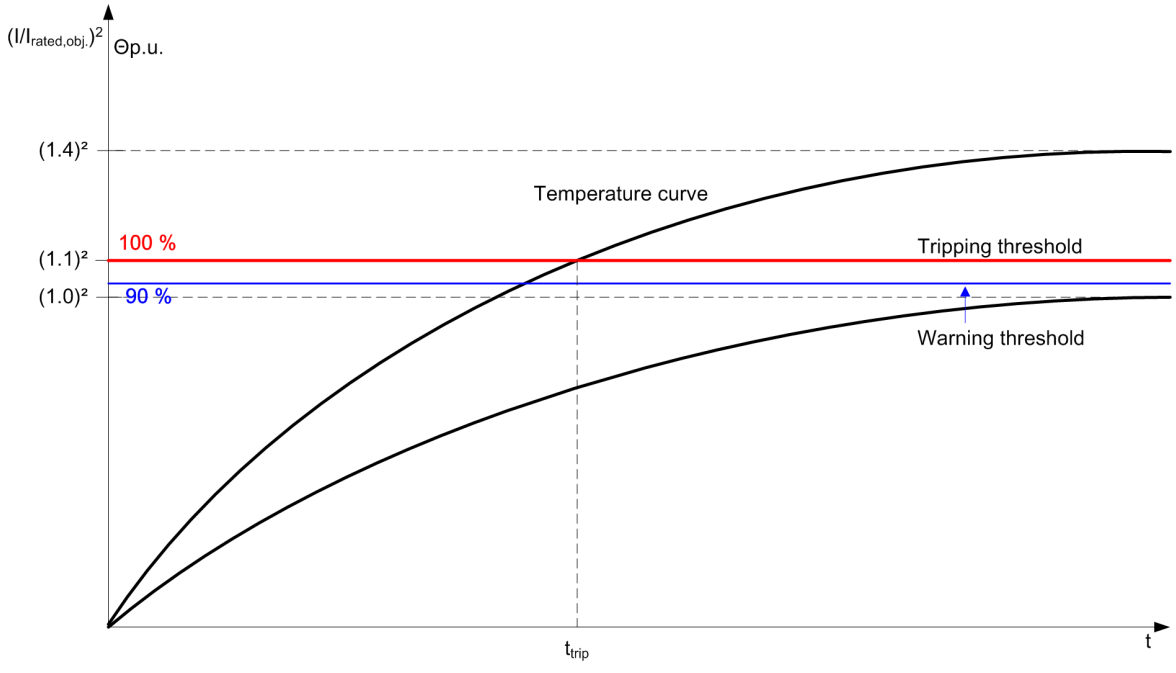
With the following standardization:

$$I_{p.u.} = \frac{I}{I_{max}} = \frac{I}{K \cdot I_{rated\ ,obj.}} \qquad \theta = \frac{\vartheta}{\vartheta_{max}} = \frac{\vartheta}{K^2 \cdot \Delta\vartheta_{rated\ ,obj.}}$$

$$\tau_{th} = R_{th} \cdot C_{th}$$

[fo_TOLP_normie, 1, en_US]

Θ	Current overtemperature, in relation to the final temperature at a maximum permissible phase current k $I_{rated, obj}$
$\Delta\vartheta_{rated\ obj}$	Overtemperature of the protected object set at rated current
τ_{th}	Thermal time constant (temperature rise/cooling) of the protected object. The value is calculated internally.
K	This factor indicates the maximum continuous permissible phase current. The factor refers to the rated current of the protected object ($K = I_{max}/I_{rated, obj}$) and is calculated internally.
$I_{rated, obj}$	Rated current of the protected object



[dw_TOLP_Temperature, 1, en_US]

Figure 6-162 Temperature History for Different Overload Currents (**K-factor** = ***1.1***)

The overtemperature is calculated separately for each phase. The current overtemperature can be obtained from the operational measured values. It is shown in percent. An indication of 100 % means that the thermal threshold has been reached. The maximum overtemperature of the phases is regarded as the tripping temperature. This means that the highest of the 3 phase currents is always assumed.

The analysis of the RMS values of the currents over a broad frequency band also includes the harmonic components. These harmonic components contribute to the temperature rise of the equipment.

Current Influence

The thermal replica based on the single-body model applies only with limitations to high overcurrent situations (short circuits, motor startup currents). To avoid an overfunction of the overload protection, the thermal replica must be influenced in case of overcurrents (exceeding $I_{threshold}$). You can select between 2 strategies for this:

- Freezing of the thermal memory
- Limitation of the input current for the thermal replica to the set current. The temperature rise is thereby **retarded** at high currents.

Warning Thresholds

The thermal warning threshold issues a warning indication before the tripping threshold (tripping temperature) is reached. In this way, for example, a load can be reduced in sufficient time and a disconnection can be avoided. If the first setting value of the user-defined characteristic curve is set to 1.1 of the rated current, a thermal memory value of 83 % is set to the continuously flowing rated current.

Apart from the thermal warning threshold, the overload protection also has a current-warning threshold. This current-warning threshold can signal an overload current in sufficient time before the overtemperature value has reached the warning or tripping threshold.

Dropout of Tripping

Once the thermal memory has fallen below the setting value of the **Dropout threshold operate**, the trip command is cancelled upon tripping. In contrast, the current-warning threshold and the thermal warning threshold are reduced at a fixed dropout threshold (see Technical Data).

Behavior in the Event of Auxiliary-Voltage Failure

The behavior of the thermal replica can be controlled upon auxiliary-voltage failure via the setting parameter **Storage of thermal replica**. You can save the thermal state for a time of 500 min. Once the supply voltage returns, the thermal replica continues to function with the saved thermal state.

If the thermal replica is not saved, it will be reset to 0 upon failure of the auxiliary voltage.

Resetting the Thermal Memory

You can reset the thermal memory via the binary input indication **>Reset thermal replica**. The thermal memory will then have a 0 value.

Emergency Start

Depending on the operating conditions, tripping can be blocked or closure enabled despite the permissible thermal limits being exceeded. Upon activation of the binary input signal **>Emergency start**, tripping is blocked and closure enabled. This does not affect the state of the thermal memory. After the input **>Emergency start** disappears, the blocking remains in effect for the set **Emerg. start T overtravel**.

Blocking the Function

Blocking will cause a picked up function to be reset. The tripping function can be blocked externally or internally by the binary input signal **>Block stage**.

All indications then drop out and the thermal memory is not calculated.

Blocking Closure

The signal **Block close** can be used to prevent closure of the protected object at a high thermal load. The signal is set if the tripping overtemperature is exceeded, and cancelled if the temperature falls below the dropout threshold.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:601:305) Time until trip	Expected time until tripping	s	s	s
(_:601:304) Time until close	Time until close release	s	s	s
(_:601:306) Overload phase A	Thermal measured values of the phases	%	%	Tripping temperature
(_:601:307) Overload phase B				
(_:601:308) Overload phase C				
(_:601:309) Overload maximum	Thermal measured value of the overload protection	%	%	Tripping temperature
(_:601:310) Equival. current phs A	Current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values
(_:601:311) Equival. current phs B				
(_:601:312) Equival. current phs C				
(_:601:313) Equival. current max.	Maximum current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values

6.20.4 Application and Setting Notes

Motors and generators as well as transformers are at risk from long-lasting overloads. You can adapt the given overload characteristic curve to the user-defined characteristic curve with the **Thermal overload protection, user-defined characteristic curve** function. You can find the predefined characteristic curve in the chapter *12.23 Thermal Overload Protection, User-Defined Characteristic Curve*.

When setting the parameters, consider the following:

- The settings for the used current transformer (primary values and secondary values) must be set correctly in the power system.
- The rated values for the protected object must be correct in the used function group.

Parameter: `Threshold current warning`

- Recommended setting value **`(_:101) Threshold current warning`** = ***`1.1 A`*** at I_{rated} = 1 A

Set the threshold to the maximum permissible continuous current ($I_{max, perm}$). This results in the same setting value as for the first value of the user-defined characteristic curve.

Parameter: `Threshold thermal warn.`

- Recommended setting value **`(_:104) Threshold thermal warn.`** = ***`90 %`***

If the first value of the user-defined characteristic curve is 1.1 of the rated current, the default setting can be left. The thermal memory results for 83 % at continuously flowing rated object current.

If the first value of the user-defined characteristic curve is 1.05 of the rated object current, the thermal memory for rated current is already 91 % filled. Increase the **`Threshold thermal warn.`** to 95 %.

Parameter: `Dropout threshold operate`

- Recommended setting value **`(_:105) Dropout threshold operate`** = ***`90 %`***

The **`Dropout threshold operate`** parameter is used to drop out pickup and tripping when the value drops below this threshold. A setting on the order of magnitude of the warning threshold is recommended. You can select a lower setting value for special applications, desired additional cooling or longer blocking of closing.

Note that the calculation of the operational measured value **`Time until close`** refers to this value.

Parameter: Emerg. start T overtravel

- Default setting **(_:112) Emerg. start T overtravel** = ***300 s***

The **Emerg. start T overtravel** parameter is used to set the time for which blocking of the tripping has to remain active after an outgoing binary input signal **>Emergency start**. With an outgoing input signal, the load on the protected object is removed. The emergency start T-overtravel must be set long enough to allow the thermal memory to fall below the dropout threshold after cooling. Select a time on the order of magnitude of the **Cooling time constant**. In the example, 5 min (300 s) have been assumed.

Parameter: Imax thermal

- Recommended setting value **(_:107) Imax thermal** = ***2.5 A*** at I_{rated} = 1 A

The **Imax thermal** parameter allows you to set the threshold current for the **Behav. at I> Imax therm.** parameter. If you calculate with relatively long start times for motors (longer than 25 s), the current limiting must be reduced to 2 $I/I_{rated, obj}$.

Parameter: Imin cooling

- Recommended setting value **(_:108) Imin cooling** = ***0.5 A*** at I_{rated} = 1 A

When defining the minimum current **Imin cooling**, you can use the no-load current for orientation. If no data is available, set 0.5 $I/I_{rated, obj}$. If the current falls below this value, the internal thermal time constant τ automatically switches to the internal cooling time constant with the **Cool-down factor Tau** parameter.

Parameter: Storage of thermal replica

- Recommended setting value **(_:113) Storage of thermal replica** = ***no***

If a continuous auxiliary voltage for the bay units is ensured, the default setting can be retained.

Parameter: Behav. at I> Imax therm.

- Recommended setting value **(_:114) Behav. at I> Imax therm.** = ***current limiting***

The **Behav. at I> Imax therm.** parameter is used to select the process by which the function reacts to short-circuit currents. To prevent premature tripping of the overload protection at low time constants, high preloading and high short-circuit currents, the thermal replica can be modified. As overcurrent due to a starting of the motor also leads to a certain heating of the stator winding, limiting the input current is recommended for machines.

Parameter Value	Description
current limiting	The input currents are limited to the value set in the **Imax thermal** parameter. If the measured current exceeds the set current value, the limited current value is supplied to the thermal replica. An advisable current threshold is approx. 2 to 2.5 $I_{rated, obj}$.
freeze therm. rep.	If input currents exceed the **Imax thermal** parameter, the thermal replica will be frozen for the time the parameter is exceeded.

Parameter: Curve based on preload

- Default value **(_:101) Curve based on preload** = ***100 %***

The **Curve based on preload** parameter is used for a certain load case. In most cases, it applies for an operation under rated conditions. For that, it is assumed that rated current is flowing permanently. This is referred to as warm condition. In this case, the default setting 100 % is applied.

Thus, the thermal behavior is also correct for different preloads.

For cases without preload or cold condition, set the parameter to 0 %.

Parameter: **Cool-down factor Tau**

- Default value **(_:108) Cool-down factor Tau** = ***7.0***

If the current becomes lower than the setting value of the **Imin cooling** parameter, you can set the **Cool-down factor Tau** parameter to calculate the internal cooling time constant.

Parameter: **Operate char. curve**

- Default value **Operate char. curve** = ***1.1 p.u., 600.00 s***

With the **Operate char. curve** parameter, you define the characteristic curve in a tabular form with ordered normalized current values and associated normalized time values.

When setting the parameter, consider the following:

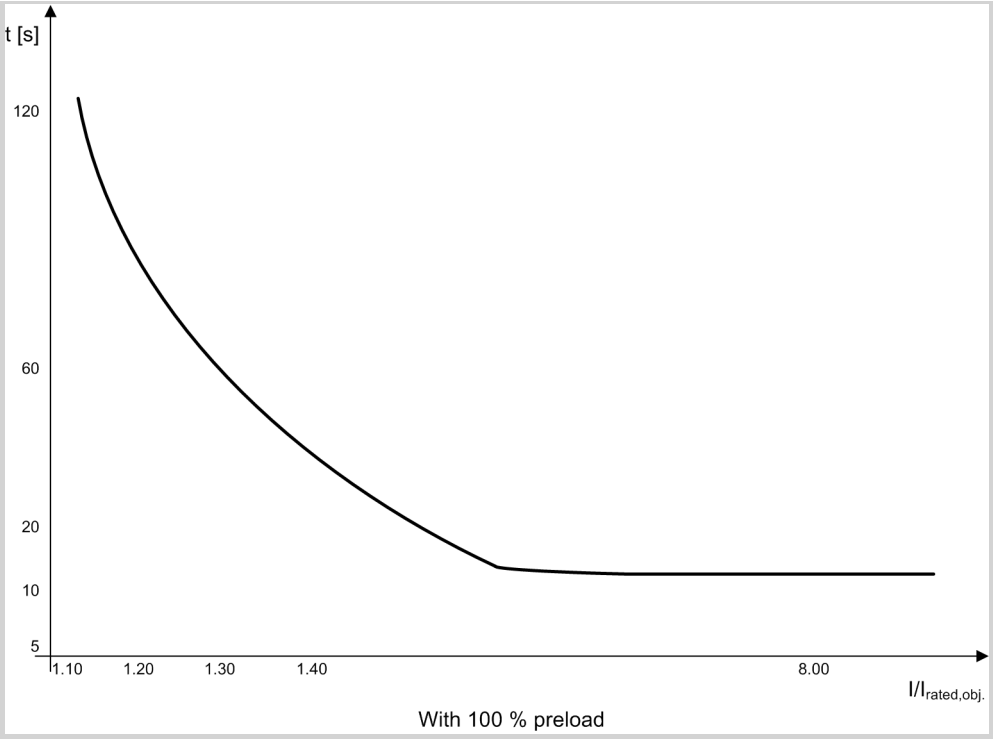
- Set the current value as per-unit value with the rated current of the protected object as reference.
- Set the time value in seconds.
- Enter the values in continuous order.

EXAMPLE

With the following 12 points, you can get a user-defined characteristic curve as shown in the following figure.

Table 6-13 User-Defined Points

I / I_{obj}	t (s)
1.16	120.00
1.21	96.00
1.25	76.00
1.28	62.00
1.35	48.00
1.42	37.50
1.48	33.50
1.58	27.50
1.84	20.50
2.09	14.00
2.25	9.85
8.00	9.85



[dw_TOLP_Predefined curve, 1, en_US]

Figure 6-163 Example of the User-Defined Characteristic Curve

6.20.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User charact.#:Mode		• off • on • test	off
_:2	User charact.#:Operate & flt.rec. blocked		• no • yes	no
_:102	User charact.#:Threshold current warning	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:104	User charact.#:Threshold thermal warn.		50 % to 100 %	90 %
_:105	User charact.#:Dropout threshold operate		50 % to 99 %	90 %
_:106	User charact.#:Emerg. start T overtravel		0 s to 15000 s	300 s

Addr.	Parameter	C	Setting Options	Default Setting
_:107	User charact.#:Imin cooling	1 A @ 100 Irated	0.000 A to 10.000 A	0.500 A
		5 A @ 100 Irated	0.00 A to 50.00 A	2.50 A
		1 A @ 50 Irated	0.000 A to 10.000 A	0.500 A
		5 A @ 50 Irated	0.00 A to 50.00 A	2.50 A
		1 A @ 1.6 Irated	0.000 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.000 A to 8.000 A	2.500 A
_:108	User charact.#:Cool-down factor Tau		0.5 to 20.0	7.0
_:109	User charact.#:Storage of thermal replica		• no • yes	no
_:110	User charact.#:Imax thermal	1 A @ 100 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 100 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 50 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	12.500 A
_:111	User charact.#:Behav. at I> Imax therm.		• current limiting • freeze therm. rep.	current limiting
_:112	User charact.#:Operate char. curve		Setting options depend on configuration	1.1 p.u., 600 s
_:101	User charact.#:Curve based on preload		0 % to 100 %	100 %

6.20.6 Information List

No.	Information	Data Class (Type)	Type
User charact.#			
_:81	User charact.#:>Block stage	SPS	I
_:500	User charact.#:>Reset thermal replica	SPS	I
_:501	User charact.#:>Emergency start	SPS	I
_:54	User charact.#:Inactive	SPS	O
_:52	User charact.#:Behavior	ENS	O
_:53	User charact.#:Health	ENS	O
_:300	User charact.#:Current warning	SPS	O
_:301	User charact.#:Thermal warning	SPS	O
_:302	User charact.#:Block close	SPS	O
_:55	User charact.#:Pickup	ACD	O
_:303	User charact.#:Operate alarm only	ACT	O
_:57	User charact.#:Operate	ACT	O
_:304	User charact.#:Time until close	MV	O
_:305	User charact.#:Time until trip	MV	O
_:306	User charact.#:Overload phase A	MV	O
_:307	User charact.#:Overload phase B	MV	O
_:308	User charact.#:Overload phase C	MV	O
_:309	User charact.#:Overload maximum	MV	O
_:310	User charact.#:Equival. current phs A	MV	O
_:311	User charact.#:Equival. current phs B	MV	O

No.	Information	Data Class (Type)	Type
_:312	User charact.#:Equival. current phs C	MV	O
_:313	User charact.#:Equival. current max.	MV	O

6.21 Thermal Overload Protection, 1-Phase

6.21.1 Overview of Functions

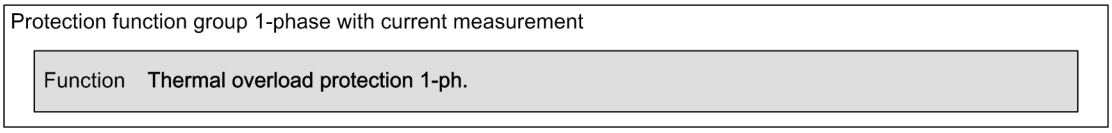
The **Thermal overload protection 1-phase** function (ANSI 49) is used to:

- Protect the equipment (reactors or resistors in the neutral point of a transformer) from thermal overload

6.21.2 Structure of the Function

The **Thermal overload protection 1-phase** function is used in 1-phase protection function groups with current measurement..

The **Thermal overload protection, 1-phase** function is steplessly preconfigured.

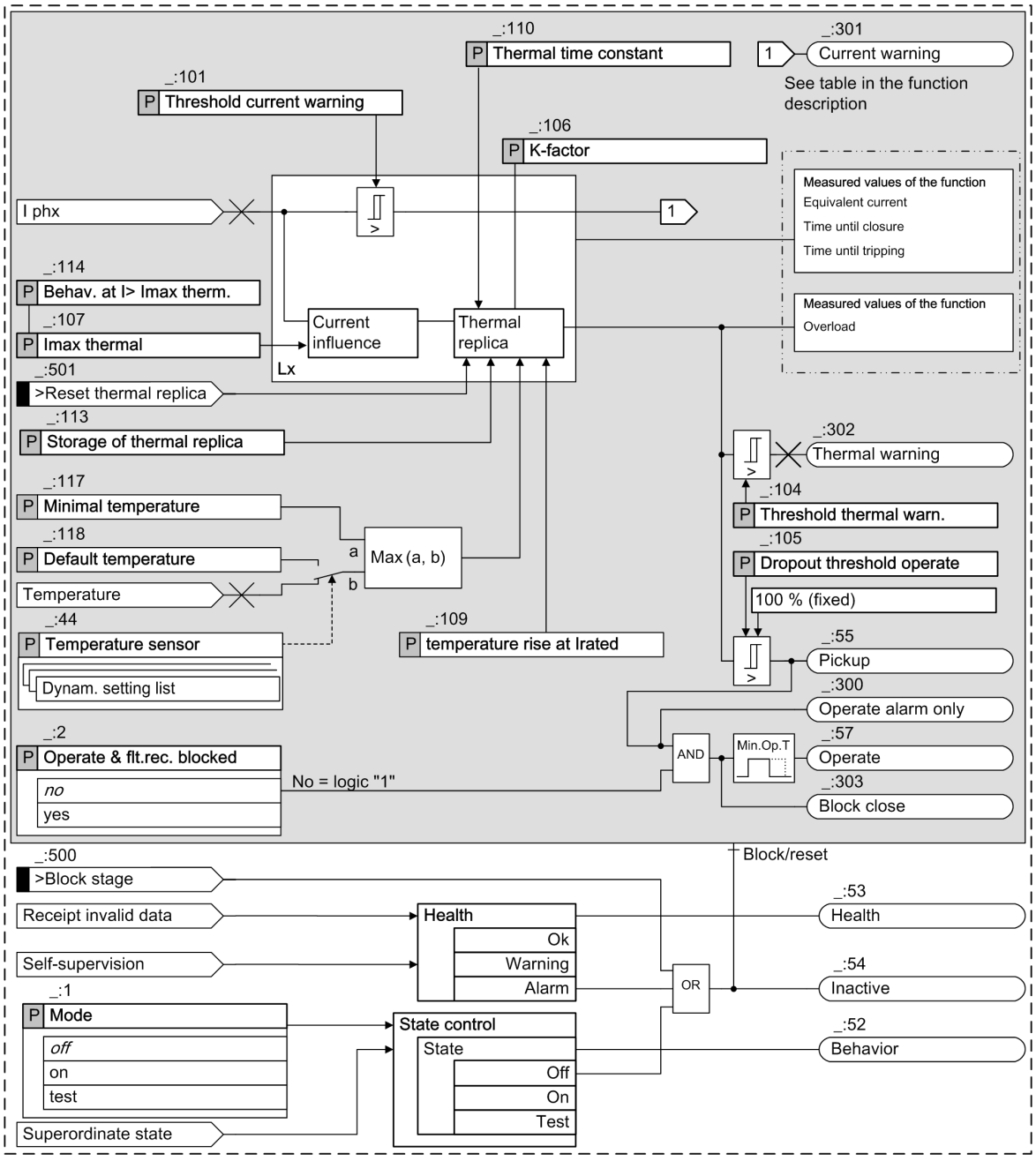


[dwtolp1p-270613-01.tif, 2, en_US]

Figure 6-164 Structure/Embedding of the Function

6.21.3 Function Description

Logic



[lotolp1p-250713-01.tif, 2, en_US]

Figure 6-165 Logic Diagram of the Thermal Overload Protection Function

Thermal Replica

The protection function calculates the overtemperature from the current flowing in the protected object (for example, reactor or resistance in the transformer neutral point) on the basis of a thermal single-body model according to the thermal differential equation with

$$I_{p.u.}^2 = \tau_{th} \frac{d\Theta}{dt} + \Theta - \Theta_V$$

[fodiffgl-310510-01.tif, 2, en_US]

With the following standardization:

$$I_{p.u.} = \frac{I}{I_{max}} = \frac{I}{k \cdot I_{rated,obj.}} \qquad \Theta = \frac{\vartheta}{\vartheta_{max}} = \frac{\vartheta}{k^2 \cdot \Delta\vartheta_{rated,obj.}}$$

$$\tau_{th} = R_{th} \cdot C_{th} \qquad \Theta_V = \frac{\vartheta_{Amb} - 40\,°C}{\vartheta_{max}} = \frac{\vartheta_{Amb} - 40\,°C}{k^2 \cdot \Delta\vartheta_{rated,obj.}}$$

[fonormie-310510-01.tif, 2, en_US]

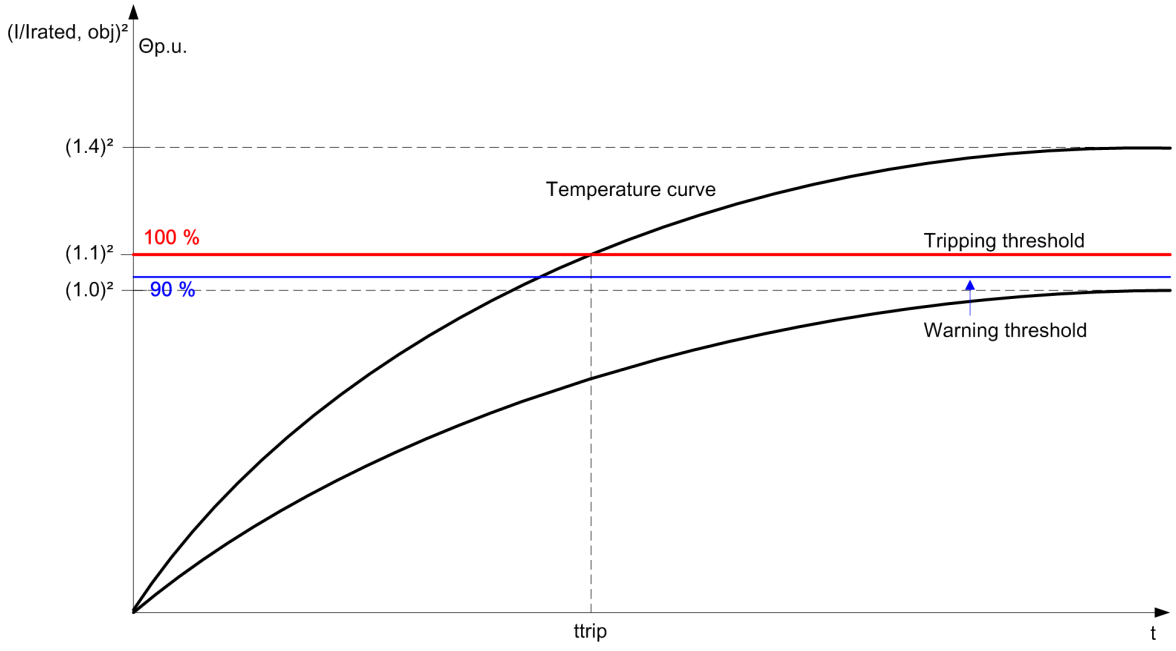
Θ	Current overtemperature, in relation to the final temperature at a maximum permissible current k $I_{rated, obj}$
Θ_V	Standardized ambient temperature, where ϑ_{Amb} describes the coupled ambient temperature. The coupled ambient temperature ϑ_{Amb} can be the measured ambient temperature or the ambient temperature preset using the **`Default temperature`** parameter.
$\Delta\vartheta_{rated\ obj}$	Overtemperature of the protected object set at rated current
τ_{th}	Thermal time constant (temperature rise/cooling) of the protected object
k	This factor indicates the maximum continuous permissible phase current. The factor refers to the rated current of the protected object ($k = I_{max}/I_{rated,\ obj}$)
$I_{rated.,\ obj}$	Rated current of the protected object

At the same time, $I_{rated,\ obj}$ is the rated current of the protected object.

In a steady state, the solution to the thermal differential equation is an e-function whose asymptote represents the final overtemperature Θ_{end}. The time constant τ_{th} determines the rise. After reaching an initial adjustable overtemperature threshold Θ_{warn} (**`Threshold thermal warn.`**), a warning indication is given.

If the overtemperature limit Θ_{Off} (tripping overtemperature) is exceeded, an operate indication is immediately issued and the equipment disconnected from the power supply. This threshold is specified at 100 % and corresponds to the final temperature set at a flowing permissible continuous current (I_{max}).

Figure 6-166 shows the temperature rise at different overload currents and the supervision thresholds.



[dwtempve-030211-01.tif, 1, en_US]

Figure 6-166 Temperature History for Different Overload Currents (**`K-factor`** = ***`1.1`***)

The current overtemperature can be obtained from the operational measured values. It is shown in percent. An indication of 100 % means that the thermal threshold has been reached.

The analysis of the RMS value of the current over a broad frequency band also includes the harmonic components. These harmonic components contribute to the temperature rise of the equipment.

Ambient Temperature

This function can take the ambient temperature into consideration The reference temperature of the thermal model is 40 °C. If the ambient temperature drops below the reference temperature, the thermal limit increases. The equipment can be stressed more. If the ambient temperature is higher, the conditions change.

The **Default temperature** parameter can be used to fix or measure the ambient temperature. The **Minimal temperature** parameter limits the coupled ambient temperature. If the measured ambient temperature is lower than the minimum temperature, the minimum temperature is processed in the thermal model.

The ambient temperature refers to the overtemperature of the protected object, which sets itself at the rated current (parameter **Temperature rise at Irated**).

The measured ambient temperature is recorded by an external RTD unit (RTD = Resistance Temperature Detector) and provided by the functions **RTD unit Ether.** or **RTD unit serial** of the function group **Analog units**. When using the **Temperature sensor** parameter, the respective temperature sensor can be selected.

If the temperature measurement is disrupted, for example, due to an open circuit between the device and the RTD unit, the device will report it. In this case, the process continues with either the temperature measured last or the value set under the **Default temperature** parameter, whichever value is the highest.

Current Influence

The thermal replica based on the single-body model applies with limitations to high overcurrent situations (short circuits). To avoid an overfunction of the overload protection, the thermal replica must be influenced for overcurrents (exceeding $\mathbf{I}_{\text{limit}}$). You can select between 2 strategies for this:

- Freezing of the thermal memory
- Limitation of the input current for the thermal replica to the set current. The temperature rise is thereby **retarded** at high currents.

Warning Thresholds

The thermal warning threshold issues a warning indication before the tripping threshold (tripping temperature) is reached. In this way, for example, a load can be reduced in sufficient time and a disconnection avoided. At a normal **K-factor** of ***1.1***, a thermal memory value of 83 % sets in at continuously flowing rated current.

Apart from the thermal warning threshold, the overload protection also has a current-warning threshold. This current-warning threshold can signal an overload current in sufficient time before the overtemperature value has reached the warning or tripping threshold.

Dropout of Tripping

Once the thermal memory has fallen below the setting value of the **Dropout threshold operate**, the trip command is cancelled upon tripping. In contrast, the current-warning threshold and the thermal warning threshold are reduced at a fixed dropout threshold (see technical data).

Behavior in the Event of Auxiliary-Voltage Failure

The behavior of the thermal replica can be controlled upon auxiliary-voltage failure via the **Storage of thermal replica** parameter. You can save the thermal state for a down time of 500 min. If the supply voltage returns, the thermal replica continues to function with the saved thermal state.

If the thermal replica is not saved, it will be reset to 0 upon failure of the auxiliary voltage.

Resetting the Thermal Map

You can reset the thermal memory via the binary input indication **>Reset thermal replica**. The thermal memory will then have a 0 value. A reparameterization will also lead to resetting the thermal memory.

Blocking the Function

Blocking will cause a picked up function to be reset. The function can be blocked externally or internally by the binary input signal **>Block stage**.

All indications then drop out and the thermal memory is set to the value 0.

Blocking Closure

The signal **Block close** can be used to prevent closure of the protected object at a high thermal load. The signal is set if the tripping overtemperature is exceeded, and cancelled if the temperature falls below the dropout threshold.

Functional Measured Values

Measured Value	Description
(_:310) Equival. current	Besides the thermal measured values in percent, the equivalent current is also issued as a thermal current-measured value (A or kA). The current equivalent is the primary current, which corresponds to the thermal measured value in percent, assuming steady-state conditions.
(_:304) Time until close	The **Time until close** is the expected time until it is possible for the protected object for reclosure. The calculation of this value is based on the assumption of constant currents. The thermal replica has then fallen below the setting value of the dropout threshold.
(_:305) Time until trip	The **Time until trip** is the expected time until tripping (100 % value exceeded) occurs. The calculation of this value is based on the assumption of constant currents.
(_:306) Overload	The value **Overload** indicates the current temperature of the protected object in percent. Tripping occurs if 100 % is exceeded.

6.21.4 Application and Setting Notes

Parameter: Threshold current warning

- Recommended setting value **(_:101) Threshold current warning** = ***1.1 A*** for I_{rated} = 1 A

Set the threshold to the maximum permissible continuous current ($I_{max, perm}$). This results in the same setting value as for **K-factor**.

Parameter: Threshold thermal warn.

- Recommended setting value **(_:104) Threshold thermal warn.** = ***90 %***

The default setting can be left at a **K-factor** of 1.1, because the thermal memory sets itself to 83 % at continuously flowing rated current. The calculation uses the rule of three: 100 % corresponds to (**K-factor**)^2 and x % corresponds to 1^2.

$$\frac{\Theta}{\Theta_{off}} = \frac{100\ \%}{k^2} = 83\ \%$$

[fowarnsc-100810-01.tif, 2, en_US]

At a **K-factor** of 1.05, the thermal memory for rated current is 91% filled. Increase the **Threshold thermal warn.** to 95%.

Parameter: Dropout threshold operate

- Recommended setting value **(_:105) Dropout threshold operate** = ***90 %***

The **Dropout threshold operate** parameter is used to cancel pickup and tripping when the value drops below this threshold. A setting on the order of magnitude of the warning threshold is recommended. You can select a lower setting value for special applications, desired additional cooling, or longer blocking of switching on.

The calculation of the operational measured value **Time until close** refers to this value.

Parameter: K-factor

- Recommended setting value **(_:106) K-factor** = ***1.1***

The **K-factor** parameter is used to describe the limiting value for the maximum permissible continuous load. The rated current $I_{rated, obj}$ of the protected object (for example, resistance) is the basic current for overload sensing.

You can determine **K-factor** on the basis of the thermally permissible continuous current $I_{max, perm.}$:

$$K\text{-factor} = \frac{I_{max,perm.}}{I_{rated,obj.}}$$

[fotoIpkf-100810-01.tif, 2, en_US]

NOTE

The thermally permissible continuous current for the protected object is known from relevant tables or from the specifications of the manufacturer!

Siemens recommends using the default value as it is a typical value for many applications.

Parameter: Thermal time constant

- Default value **(_:110) Thermal time constant** = ***900 s (15 min)***

The **Thermal time constant** parameter is used to define the operate curve of the stage. If no time constant is given, you can derive it from other values.

EXAMPLE

Protection of a current-limiting resistance

Rated current of the resistance: I_{rated} = 100 A

Values for the overload capability:

- 1.1 I_{rated} permanent (k-Factor = 1.1; k = 1.1)
- 1.5 I_{rated} for 20 s for charge by cold

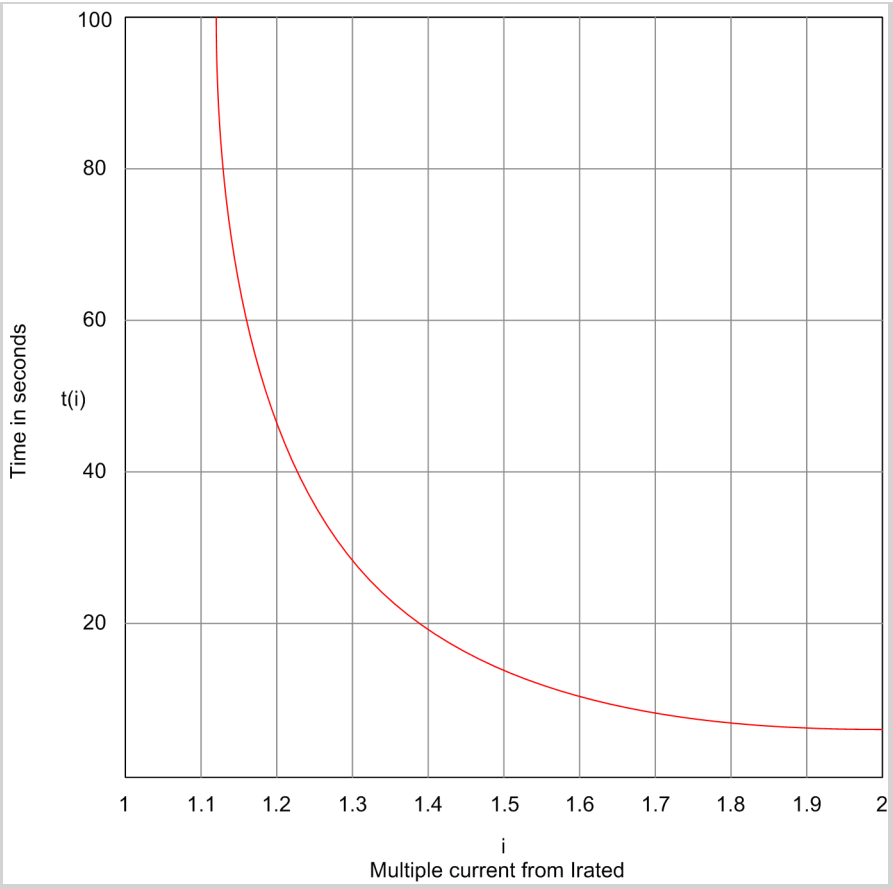
The following time constant results from these assumed values:

$$\tau_{th} = t \times \left[\ln \frac{\left(\frac{I}{k \times I_{rated\ ,obj}}\right)^2}{\left(\frac{I}{k \times I_{rated\ ,obj}}\right)^2 - 1} \right]^{-1} = 20\ s \times \left[\ln \frac{\left(\frac{1.5}{1.1}\right)^2}{\left(\frac{1.5}{1.1}\right)^2 - 1} \right]^{-1} = 20\ s \times \left[\ln \frac{1.86}{0.86} \right]^{-1} \approx 26\ s$$

[fo_time_constance_11082015, 1, en_US]

For **Thermal time constant**, set 26 s.

The following time-dependent characteristic results from the data. In case of a current increase to 1.5 I_{rated}, the tripping occurs in 20 s.



[dwtime-dependent-110815-01.vsd, 1, en_US]

Parameter: Imax thermal

- Recommended setting value **(_:107) Imax thermal** = ***2.5 A*** for I_{rated} = 1 A

The **Imax thermal** parameter allows you to set the threshold current for the **Behav. at I> Imax therm.** parameter. The selected current threshold of 2.5 $I_{rated, obj}$ is a practicable value.

Parameter: Temperature rise at Irated

- Default setting **(_:109) Temperature rise at Irated** = ***70 K***

NOTE

For an application as a 1-phase overload protection, the ambient temperature measured via the temperature sensor is not taken into account. Therefore, the setting has no influence. You can keep the default setting. If you take into account the temperature, note the following descriptions.

Set the overtemperature as the value that is the result if the equipment is continuously operated with the rated current and at an ambient temperature of 40°C. Here, the rated current refers to the protected object. You can find the temperature value in the Technical data of the equipment or you can measure the value. If you use a temperature sensor when measuring at the rated current, deduct the actual ambient temperature or the coolant temperature from the measured value.

When selecting the setting value, you can also use the specified temperature class for orientation. Usually, you will find the overtemperature expressed in Kelvin (K), which can be accepted as is. If the absolute temperature is given, the ambient temperature must be deducted. As a rule, this is 40 °C.

The overtemperature at maximum permissible current (***ϑmax***) and the **Temperature rise at Irated** (***ϑrated,obj.***) can be converted by using the following formula:

$$k^2 = \left(\frac{\Delta\vartheta_{max}}{\Delta\vartheta_{rated\ ,obj.}} \right)$$

[fo_ueb_for_Irated, 3, en_US]

EXAMPLE:

Temperature class **B** for continuous operation: permissible overtemperature = 80 K
From this, a temperature for I_{rated} of 120 °C (80 K + 40 °C) can be derived when using a measuring element for the measurement.
Temperature class **F** as thermal limiting value: permissible overtemperature = 105 K.
From this, a maximum temperature of 155 °C (105 K + 40 °C) derives.
From these values, the magnitude of the K factor can also be derived.

$$k^2 = \frac{\Delta\vartheta_{max\ ,Obj.}}{\Delta\vartheta_{rated\ ,Obj.}} = \frac{105\ K}{80\ K} = 1.31 \qquad \rightarrow\ k = 1.146$$

[fo_bsp_kfaktor, 3, en_US]

If selecting a setting value of 1.1 for the **K-factor**, your selection can be considered as conservative.

Parameter: Storage of thermal replica

- Recommended setting value **(_:113) Storage of thermal replica** = ***no***

If a continuous auxiliary voltage of the bay units is ensured, the default setting can be retained.

Parameter: Behav. at I> Imax therm.

- Recommended setting value **(_:114) Behav. at I> Imax therm.** = ***current limiting***

The **Behav. at I> Imax therm.** parameter is used to select the process by which the function reacts to short-circuit currents. To prevent premature tripping of the overload protection at low time constants, high preloading and high short-circuit currents, the thermal replica can be modified.
The default setting has been selected compatible with SIPROTEC 4 devices. If you wish to take further temperature rise into consideration, the **current limiting** procedure is recommended.

Parameter Value	Description
current limiting	The input current is limited to the value set in the **Imax thermal** parameter. If the measured current exceeds the set current value, the limited current value is supplied to the thermal replica. An advisable current threshold is approx. 2 to 2.5 $I_{rated, obj}$.
freeze therm. rep.	If the input current exceeds the **Imax thermal** parameter, the thermal replica will be frozen for the time the parameter is exceeded. This parameter value is provided to enable compatibility with older products!

Parameter: Temperature sensor

- Default setting **(_:44) Temperature sensor** = ***none***

Use the **Temperature sensor** parameter to determine which temperature sensor to use to detect the ambient temperature.
A temperature sensor (RTD = Resistance Temperature Detector) is used to measure the ambient temperature of the protected object and to feed it to the device via an RTD unit. The function **Thermal overload protection** receives the measured temperature value via the function **RTD unit Ether.** or **RTD unit Serial** from the function group **Analog units**.

Parameter: Default temperature

- Recommended setting value **(_:118) Default temperature** = ***40 °C***

Under the following conditions, the **Default temperature** will be set as ambient temperature:

- A temperature sensor for measuring the ambient temperature is not connected.
- The temperature measurement is interrupted and the measured temperature value is less than the **Default temperature**.

Siemens recommends using the default setting.

Parameter: Minimal temperature

- Default setting **(_:117) Minimal temperature** = ***-20 °C***

If the measured ambient temperature drops below the preset value, the set value will be assumed as the ambient temperature. If the overload protection works with a prespecified outside temperature, and this temperature drops below the value set in the **Minimal temperature** parameter, the **Minimal temperature** can also be used.

6.21.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
49 Th.overl. #				
_:1	49 Th.overl. #:Mode		• off • on • test	off
_:2	49 Th.overl. #:Operate & flt.rec. blocked		• no • yes	no
_:101	49 Th.overl. #:Threshold current warning	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:104	49 Th.overl. #:Threshold thermal warn.		50 % to 100 %	90 %
_:105	49 Th.overl. #:Dropout threshold operate		50 % to 99 %	90 %
_:106	49 Th.overl. #:K-factor		0.10 to 4.00	1.10
_:110	49 Th.overl. #:Thermal time constant		10 s to 60000 s	900 s
_:107	49 Th.overl. #:Imax thermal	1 A @ 100 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 100 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 50 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	12.500 A
_:109	49 Th.overl. #:Temperature rise at Irated		40 K to 200 K	70 K
_:113	49 Th.overl. #:Storage of thermal replica		• no • yes	no
_:114	49 Th.overl. #:Behav. at I> Imax therm.		• current limiting • freeze therm. rep.	current limiting
_:118	49 Th.overl. #:Default temperature		-55°C to 55°C	40°C

Addr.	Parameter	C	Setting Options	Default Setting
_:117	49 Th.overl. #:Minimal temperature		-55°C to 40°C	-20°C
_:44	49 Th.overl. #:Temperature sensor		Setting options depend on configuration	

6.21.6 Information List

No.	Information	Data Class (Type)	Type
49 Th.overl. #			
_:500	49 Th.overl. #:>Block stage	SPS	I
_:501	49 Th.overl. #:>Reset thermal replica	SPS	I
_:54	49 Th.overl. #:Inactive	SPS	O
_:52	49 Th.overl. #:Behavior	ENS	O
_:53	49 Th.overl. #:Health	ENS	O
_:301	49 Th.overl. #:Current warning	SPS	O
_:302	49 Th.overl. #:Thermal warning	SPS	O
_:303	49 Th.overl. #:Block close	SPS	O
_:55	49 Th.overl. #:Pickup	ACD	O
_:300	49 Th.overl. #:Operate alarm only	ACT	O
_:57	49 Th.overl. #:Operate	ACT	O
_:304	49 Th.overl. #:Time until close	MV	O
_:305	49 Th.overl. #:Time until trip	MV	O
_:306	49 Th.overl. #:Overload	MV	O
_:310	49 Th.overl. #:Equival. current	MV	O

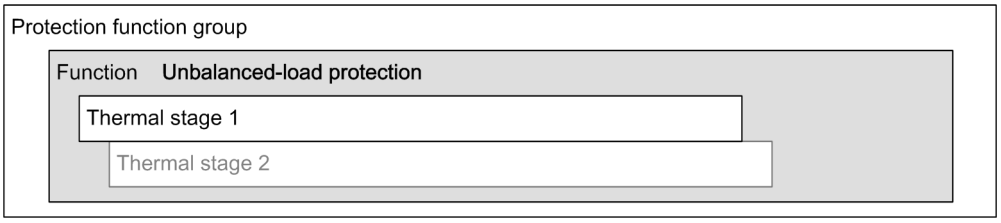
6.22 Unbalanced-Load Protection

6.22.1 Overview of Functions

The **Unbalanced-load protection** function detects unbalanced loads or line interruptions of electrical machines (generators and motors). Unbalanced loads create a counter-rotating magnetic field at double frequency in the rotor. The skin effect leads to local overheating on the surface of the rotor bars in the transition between the slot wedges and the winding bundles. Another effect of unbalanced loads is the overheating of the damper winding.

6.22.2 Structure of the Function

The **Unbalanced-load protection** function is used in the protection function group. The **Unbalanced-load protection** function is preconfigured with 1 stage. A maximum of 2 stages can operate simultaneously in the function.

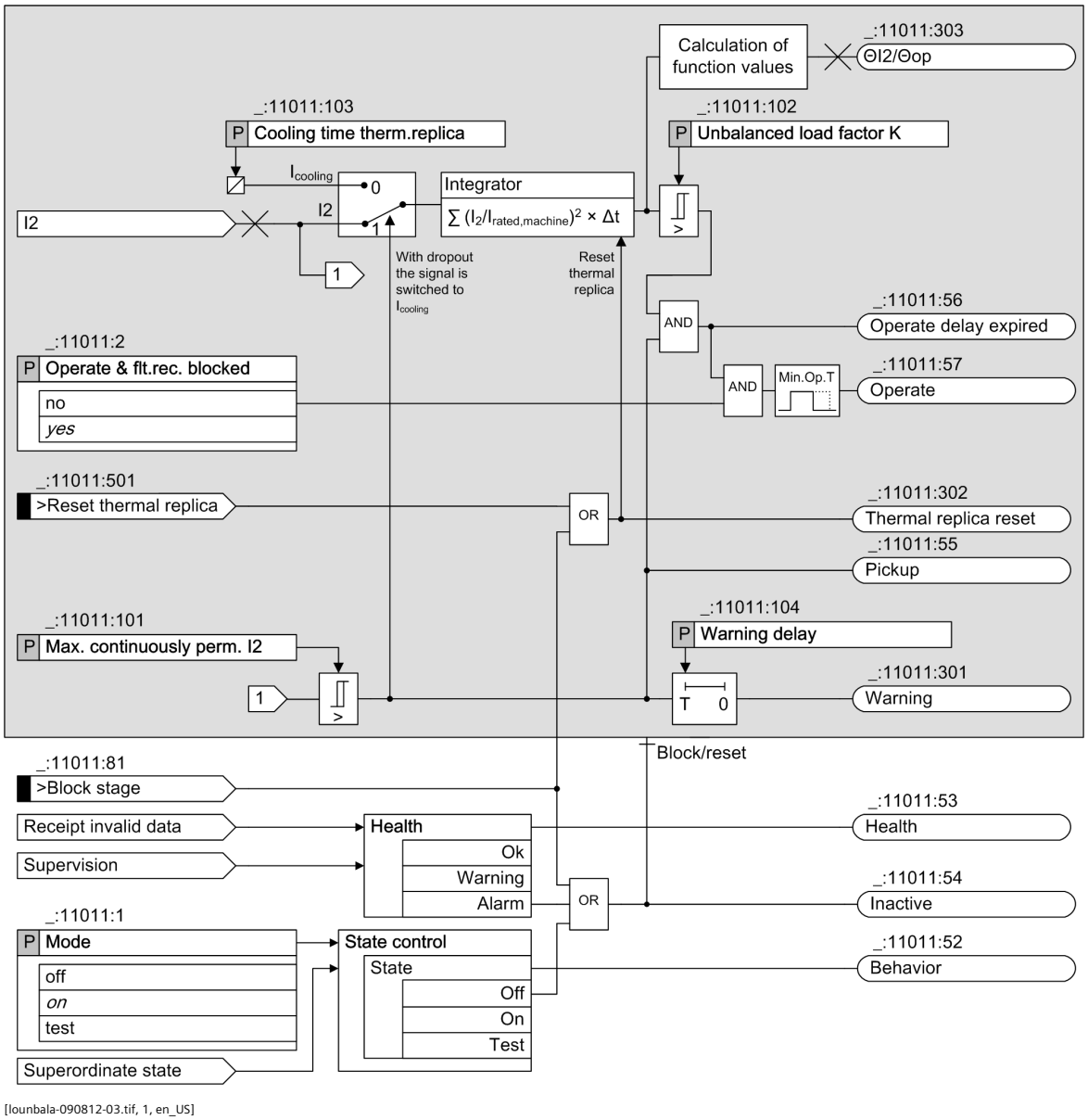


[dwunbla-240913, 1, en_US]

Figure 6-167 Structure/Embedding of the Function

6.22.3 Function Description

Logic of the Stage



[lounbala-090812-03.tif, 1, en_US]

Figure 6-168 Logic Diagram of the Unbalanced-Load Protection Function

Method of Measurement

The stage uses the negative-sequence current I_2 as a measurand. The negative-sequence current is calculated from the measured 3-phase currents according to the defining equation of symmetrical components.

Warning Stage

If the negative-sequence current I_2 continuously exceeds the parameter **`Max. continuously perm. I2`**, the *`warning`* indication is given after expiry of a set time **`Warning delay`**.

Thermal Characteristic Stage

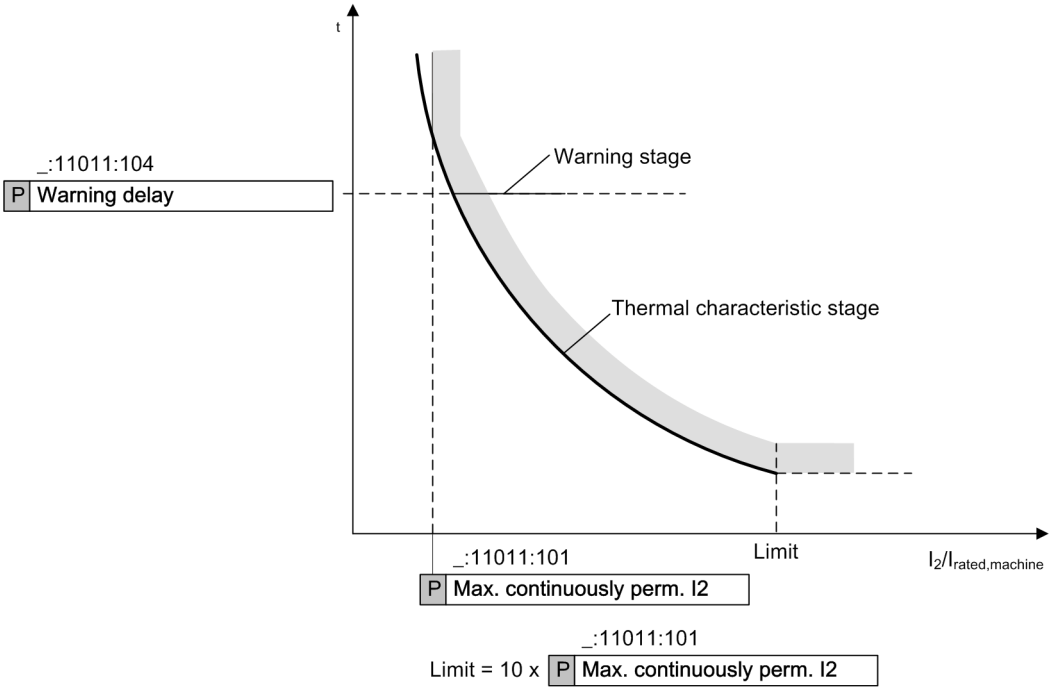
The machine manufacturers indicate the permissible unbalanced load using the following formula:

$$t_{I2\,Perm} = \frac{K}{\left(I_2 / I_{rated,machine}\right)^2}$$

[forbanl1-030812-02.tif, 1, en_US]

With:

t_{I2Perm}	Permissible time of the negative-sequence current
K	Unbalanced-load factor of the machine (parameter **Unbalanced load factor K**)
$I_2/I_{rated,machine}$	Actual unbalanced-load current as a per unit value(negative-sequence current/rated current of the machine)



[dwunbalo-230913, 2, en_US]

Figure 6-169 Operate Curve of the Unbalanced-Load Protection

The parameter **Unbalanced load factor K** depends on the machine. It also represents the time in seconds during which the machine can be loaded with a 100 % unbalanced load. This factor is typical in a range from 5 s to 40 s. The heating of the protected object starts to calculate as soon as the negative-sequence current I_2 exceeds the parameter **Max. continuously perm. I2**. The operate time is calculated from the flowing negative-sequence current I_2 with an integrating method of measurement depending on the thermal characteristic. As soon as the integrate result reaches the parameter **Unbalanced load factor K**, the thermal characteristic stage operates.

Limitation of Operate Curve

To avoid an overfunction of the thermal characteristic stage in the situation of unbalanced short circuits (for example, 2-phase short circuit), the input current I_2 is restricted to an upper limit. The limiting value is 10 times of **Max. continuously perm. I2**. If I_2 exceeds the limit, the operate time of the function is constant.

In addition, the thermal memory is limited to 200 % of **Unbalanced load factor K**. The limitation avoids a too long cooling after a delayed short-circuit tripping (for example, of external power-system faults).

Cooling Time Thermal Replica

The thermal replica starts to cool down as soon as the negative-sequence current I_2 is lower than **Max. continuously perm. I2**. The thermal replica decreases according to the parameter **Cooling time therm.replica**. The parameter **Cooling time therm.replica** is the time required by the thermal replica to cool down from 100 % to 0 %. If the parameter **Cooling time therm.replica** is set to 0, the thermal replica is reset immediately.

The parameter **Cooling time therm.replica** depends on the construction type of the machine, especially of the damper winding. Preloading is considered when unbalanced loading occurs again during the cooling time. The protection device thus operates in a shorter time.

Functional Measured Values

The following formula is used to calculate the functional measured value ΘI2/Θop:

$$\Theta I2/\Theta op = \frac{\sum_{0}^{t}\left(I_2/I_{rated,machine}\right)^2 \cdot \Delta t}{K} 100\ \%$$

[forunbl2-030812-02.tif, 1, en_US]

With

ΘI2/Θop	Functional measured value indicating the thermal replica of the unbalanced load
$\sum_{0}^{t}\left(I_2/I_{rated,\ machine}\right)^2 \cdot \Delta t$	Integrating method of measurement of the thermal replica of the negative-sequence system
K	Unbalanced-load factor of the machine (parameter **Unbalanced load factor K**)
$I_2/I_{rated,machine}$	Unbalanced-load as a per unit value (negative-sequence current/rated current of the machine)

If the functional measured value reaches 100 %, the operate of the function is initiated.

6.22.4 Application and Setting Notes

The function is used in the applications of machines. You can get the necessary settings from the technical data of the synchronous generators and motors. The setting example is applied for a generator application.

Parameter: Max. continuously perm. I2, Warning delay

- Default setting **(_:11011:101) Max. continuously perm. I2** = ***10.0 %***
- Default setting **(_:11011:104) Warning delay** = ***15 s***

If the negative-sequence current I_2 exceeds **Max. continuously perm. I2** , the stage picks up and a warning indication is given after the set time delay **Warning delay** .

The parameter **Max. continuously perm. I2** is given in percentage of the rated current of the protected object.

The setting value of the parameter **Max. continuously perm. I2** depends on following parts:

- Design of the machine (salient pole or non-salient pole rotor synchronous machine)
- Cooling system (directly or indirectly cooled)
- Size of the machine

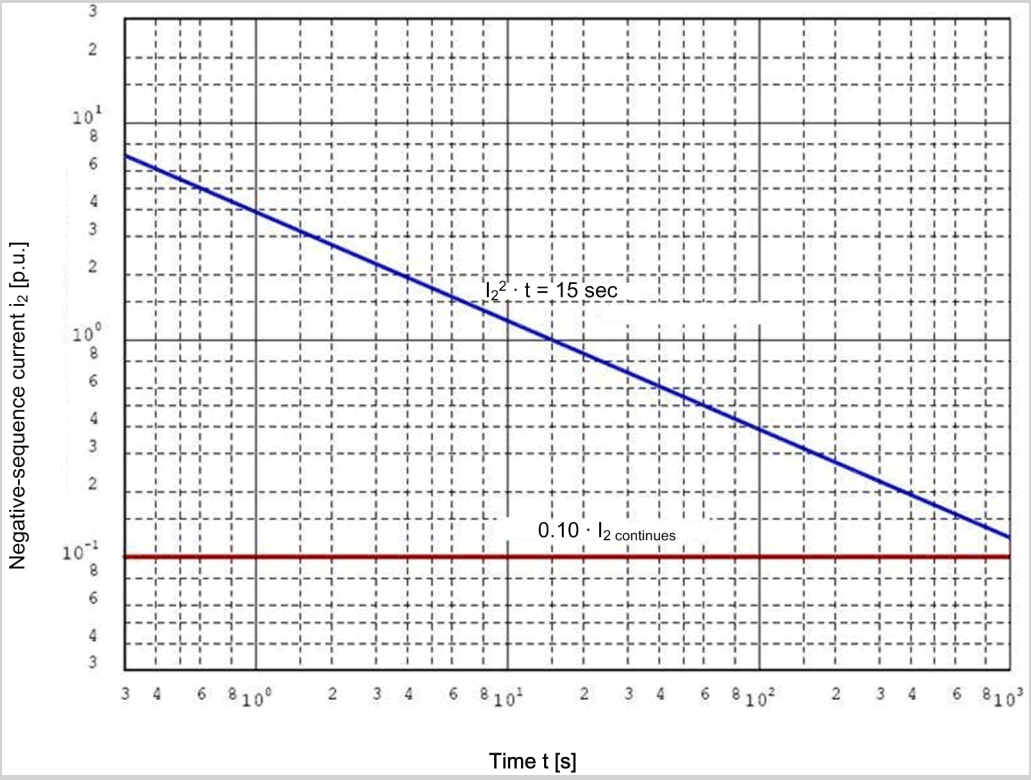
Depending on the standards IEEE C50.12 and IEC 60034-1, the parameter is given in the range between 5 % and 12 %. To set the parameter **Max. continuously perm. I2** , technical data of the machine is

required. The technical data of the machine is provided in the Technical Data Sheet of the machine manufacturer.

EXAMPLE

The following example shows the setting of the parameter **Max. continuously perm. I2** . The value 10 % is selected in the example.

To avoid issuing the *Warning* indication too fast, Siemens recommends a longer delay. Setting the parameter **Warning delay** in the range of 10 s to 20 s is practicable. 15 s is selected in the example.



[dwunbloc-030812, 1, en_US]

Figure 6-170 Example of an Unbalanced-Load Characteristic Specified by the Machine Manufacturer

Parameter: Unbalanced load factor K

- Default setting **(_:11011:102) Unbalanced load factor K** = ***15 s***

Unbalanced load factor K can be derived from the unbalanced-load characteristic according to *Figure 6-170* . You can read the time corresponding to **Unbalanced load factor K** at the point I_2 / $I_{rated,machine}$= 1. In the example, this is the p.u. value 10° which corresponds to a time of 15 s. As the example shows, the time is often written directly on the characteristic curve.

Parameter: Cooling time therm.replica

- Default setting **(_:11011:103) Cooling time therm.replica** = ***1500 s***

The parameter **Cooling time therm.replica** establishes the time required by the protected object to cool down the thermal replica to the initial value. If the machine manufacturer does not provide this information, the setting value of **Cooling time therm.replica** can be calculated from the setting values of **Unbalanced load factor K** and **Max. continuously perm. I2** by the formula in the following example.

EXAMPLE

$$\text{Cooling time therm. replica} = \frac{\text{Unbalanced load factor K}}{(\text{Max. continuously perm. I 2})^2}$$

[forbala2-290812-02.tif, 1, en_US]

Max. continuously perm. I_2	= 10.0 % (corresponds to 0.1)
Unbalanced load factor K	= 15 s
Cooling time therm. replica	= 1500 s

6.22.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Therm. Stage 1				
_:11011:1	Therm. Stage 1:Mode		• off • on • test	off
_:11011:2	Therm. Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:11011:101	Therm. Stage 1:Max. continuously perm. I2		3.0 % to 30.0 %	10.0 %
_:11011:102	Therm. Stage 1:Unbalanced load factor K		1.0 s to 100.0 s	15.0 s
_:11011:103	Therm. Stage 1:Cooling time therm.replica		0 s to 50000 s	1500 s
_:11011:104	Therm. Stage 1:Warning delay		0.0 s to 60.0 s;∞	15.0 s

6.22.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Therm. Stage 1			
_:11011:81	Therm. Stage 1:>Block stage	SPS	I
_:11011:501	Therm. Stage 1:>Reset thermal replica	SPS	I
_:11011:53	Therm. Stage 1:Health	ENS	O
_:11011:54	Therm. Stage 1:Inactive	SPS	O
_:11011:52	Therm. Stage 1:Behavior	ENS	O
_:11011:302	Therm. Stage 1:Thermal replica reset	SPS	O
_:11011:301	Therm. Stage 1:Warning	ACD	O
_:11011:55	Therm. Stage 1:Pickup	ACD	O
_:11011:56	Therm. Stage 1:Operate delay expired	ACT	O
_:11011:57	Therm. Stage 1:Operate	ACT	O
_:11011:303	Therm. Stage 1:ΘI2/Θop	MV	O

6.23 Overvoltage Protection with 3-Phase Voltage

6.23.1 Overview of Functions

The function **Overvoltage protection with 3-phase voltage** (ANSI 59) is used to:

- Monitor the permissible voltage range
- Protect equipment (for example, plant components, machines, etc.) against damages caused by overvoltage
- Decouple systems (for example, wind power supply)

Abnormally high voltages in power systems are caused by voltage controller failure at the transformer or on long transmission lines under low-load conditions.

When using common-mode reactors in the protected power system, the device must shut down the line quickly if the reactors fail (for example, due to fault clearance). The insulation is endangered by the overvoltage condition.

Overvoltages at capacitor banks can be caused by resonances with line or transformer inductances.

In power plants increased voltage levels can be due to one of these factors:

- Incorrect operation when controlling the excitation system manually
- Failure of the automatic voltage controller
- After full load shedding of a generator
- Generators which are disconnected from the network or in island mode

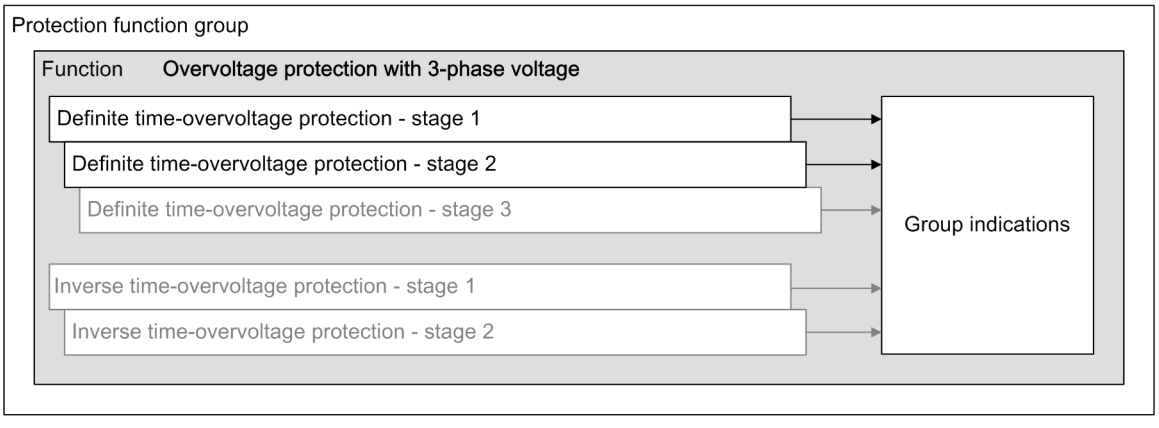
6.23.2 Structure of the Function

The **Overvoltage protection with 3-phase voltage** function is used in protection function groups with voltage measurement.

The **Overvoltage protection with 3-phase voltage** function is preconfigured by the manufacturer with 2 **Definite time-overvoltage protection** stages. In this function, the following stages can operate simultaneously:

- 3 stages **Definite time-overvoltage protection**
- 2 stages **Inverse time-overvoltage protection**

Stages that are not preconfigured are shown in gray in the following figure.



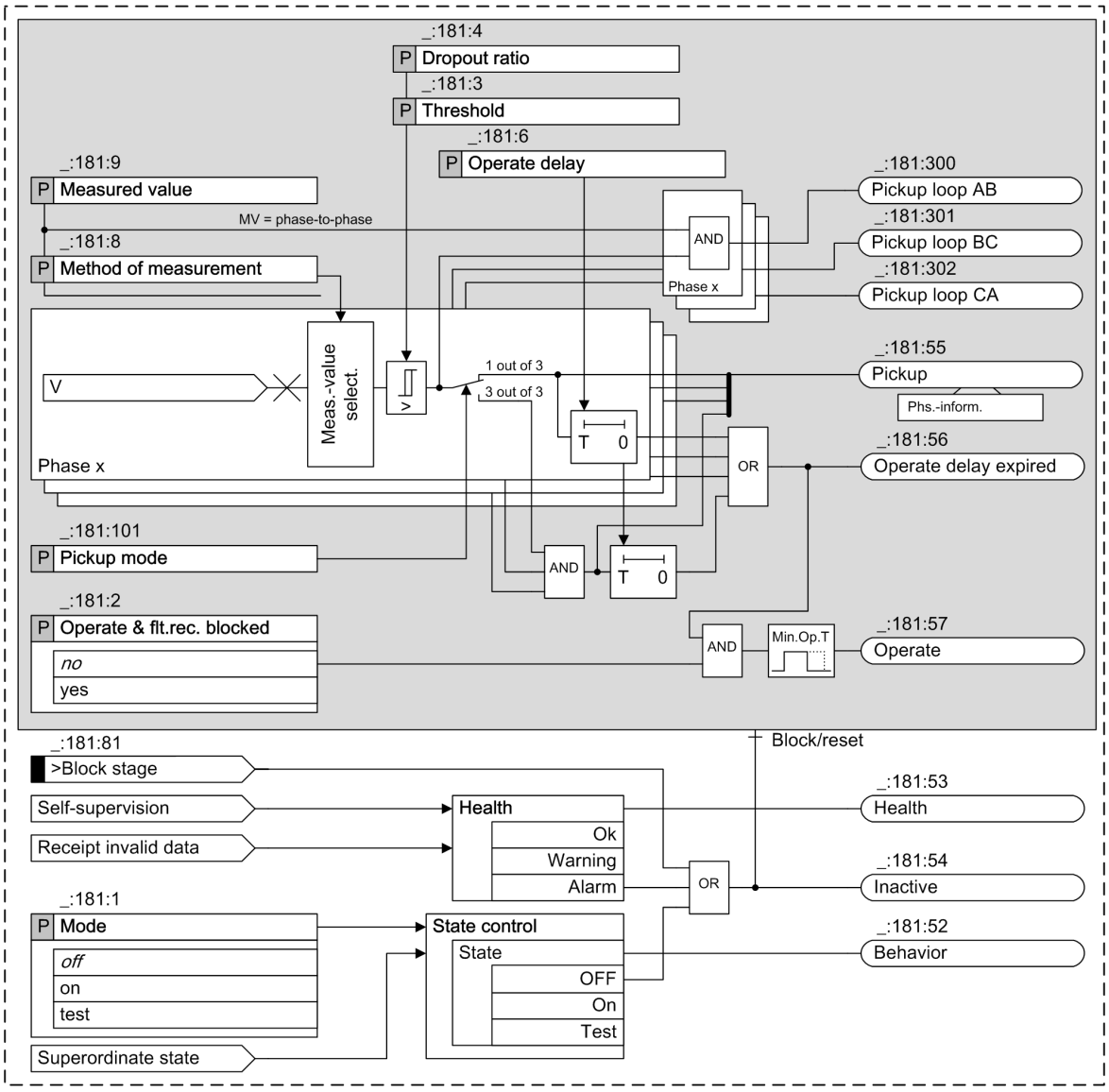
[dw3phovp-030211-01.tif, 3, en_US]

Figure 6-171 Structure/Embedding of the Function

6.23.3 Stage with Definite-Time Characteristic Curve

6.23.3.1 Description

Logic of the Stage



[lo3phasi-090611-01.tif, 3, en_US]

Figure 6-172 Logic Diagram of the Definite Time-Overvoltage Protection with 3-Phase Voltage

Method of Measurement

Use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the ***RMS value***.

- Measurement ***fundamental comp.***:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement ***RMS value***:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Pickup Mode

The **Pickup mode** parameter defines whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (***3 out of 3***) or if only 1 measuring element detects the overvoltage condition (***1 out of 3***).

Measured Value

Use the **Measured value** parameter to define whether the tripping stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal *>Block stage*.

6.23.3.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:181:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends this method of measurement as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Do not set the **threshold value** of the stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting **(_:181:9) Measured value** = ***phase-to-phase***

With the **Measured value** parameter, you define whether the stage monitors the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA} or the phase-to-ground voltages V_A, V_B, and V_C.

Parameter Value	Description
phase-to-phase	If you want to monitor the voltage range, keep ***phase-to-phase*** as the default setting. In this case, the function will not pick up on ground faults. Siemens recommends the measured value ***phase-to-phase*** as the default setting.
phase-to-ground	Select the ***phase-to-ground*** setting if you want to detect voltage unbalances and overvoltage conditions caused by ground faults.

Parameter: Threshold

- Default setting **(_:181:3) Threshold** = ***110 V***

Depending on the **Measured value** , the **Threshold** is set either as phase-to-phase quantity or as phase-to-ground quantity. The default setting assumes that the voltage range is monitored on long-distance transmission lines under low-load conditions.

Specify the **Threshold** (pickup threshold) for the specific application.

Parameter: Operate delay

- Default setting **(_:181:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:181:4) Dropout ratio** = ***0.95***

The recommended set value of ***0.95*** is appropriate for most applications. To achieve high measurement precision, the **Dropout ratio** can be reduced, to 0.98, for example.

Parameter: Pickup mode

- Recommended setting value **(_:181:101) Pickup mode** = ***1 out of 3***

With the **Pickup mode** parameter, you define whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (***3 out of 3***) or if only 1 measuring element detects the overvoltage condition (***1 out of 3***).

Parameter Value	Description
1 out of 3	Select the setting for protection applications or for monitoring the voltage range. Siemens recommends ***1 out of 3*** as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Operation as Supervision Function

If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

EXAMPLE

Example for 2-stage overvoltage protection

The example describes the possible settings for a 2-stage overvoltage protection function. We will look at the settings of the parameters **Threshold** and **Operate delay**.

- 1. Stage:

  To detect stationary overvoltages, set the threshold value of the first overvoltage-protection element at least 10 % above the max. stationary phase-to-phase voltage anticipated during normal operation. When setting the parameter **Measured value** to phase-to-phase voltage and a secondary rated voltage of 100 V, the secondary setting value of the first overvoltage-protection element is calculated as follows:

Threshold value: 10 % above V_{rated}

$V_{threshold, sec} = 1.1\ V_{rated, sec} = 1.1 \times 100\ V = 110\ V$

This requires that the primary rated voltages of protected object and voltage transformer are identical. If they are different, you have to adjust the pickup value.

For the **Operate delay** set a value of 3 s.

- 2. Stage:

  The second overvoltage-protection stage is intended for high overvoltages with short duration. A high pickup value is selected here, for example, 1.5 times the rated voltage. A time delay setting of 0.1 s to 0.2 s is sufficient then.

Stage	Setting Values	
	Threshold value	Time delay
1	Time delay 1.1 V_{rated}	3 s

Stage	Setting Values	
2	1.5 V_{rated}	0.1 s to 0.2 s

6.23.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Definite-T 1				
_:181:1	Definite-T 1:Mode		• off • on • test	off
_:181:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:181:9	Definite-T 1:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:181:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:181:101	Definite-T 1:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:181:3	Definite-T 1:Threshold		0.300 V to 340.000 V	110.000 V
_:181:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:181:6	Definite-T 1:Operate delay		0.00 s to 300.00 s	3.00 s
Definite-T 2				
_:182:1	Definite-T 2:Mode		• off • on • test	off
_:182:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:182:9	Definite-T 2:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:182:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:182:101	Definite-T 2:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:182:3	Definite-T 2:Threshold		0.300 V to 340.000 V	130.000 V
_:182:4	Definite-T 2:Dropout ratio		0.90 to 0.99	0.95
_:182:6	Definite-T 2:Operate delay		0.00 s to 300.00 s	0.50 s

6.23.3.4 Information List

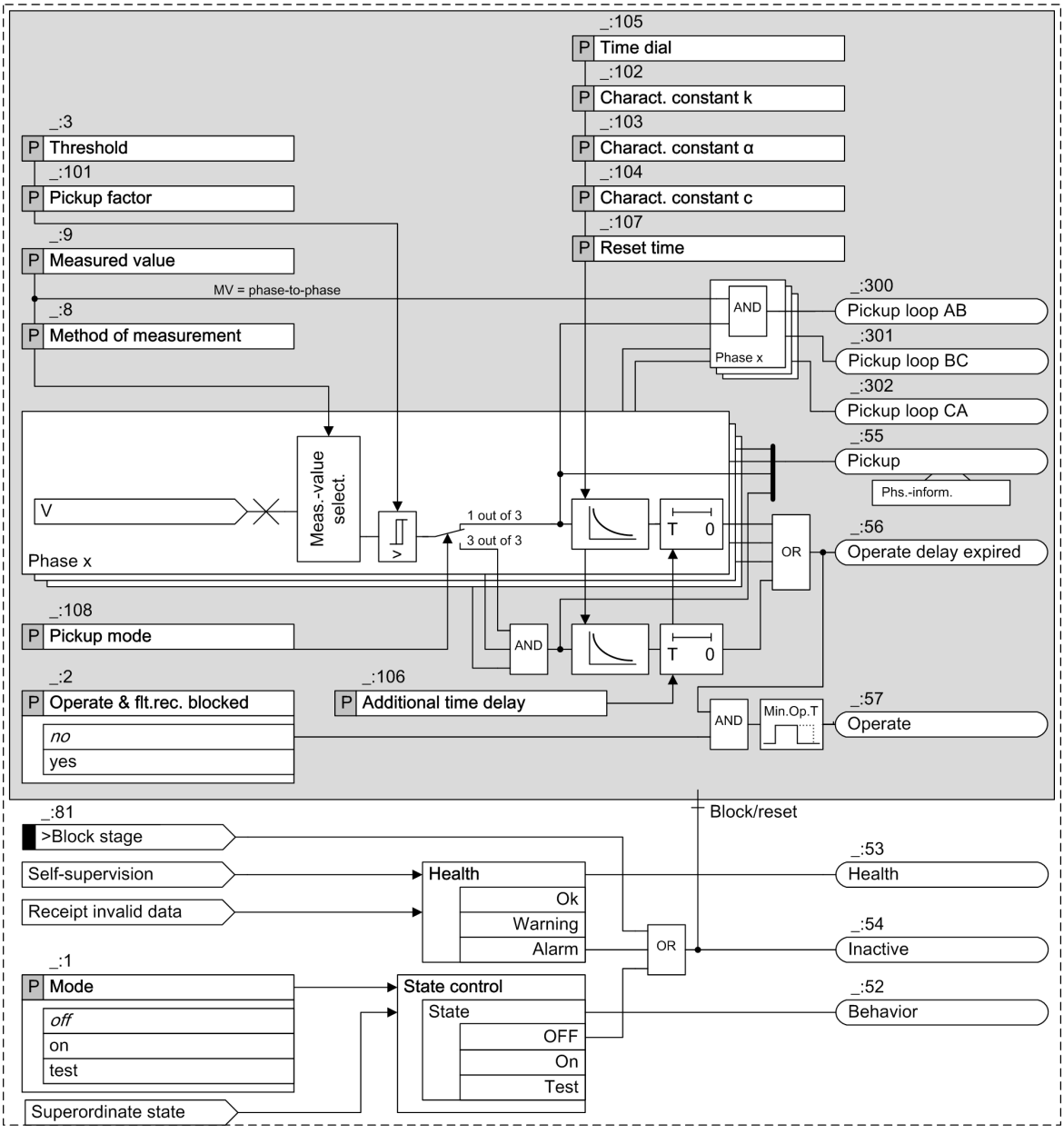
No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:181:81	Definite-T 1:>Block stage	SPS	I
_:181:54	Definite-T 1:Inactive	SPS	O
_:181:52	Definite-T 1:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:181:53	Definite-T 1:Health	ENS	O
_:181:55	Definite-T 1:Pickup	ACD	O
_:181:300	Definite-T 1:Pickup loop AB	SPS	O
_:181:301	Definite-T 1:Pickup loop BC	SPS	O
_:181:302	Definite-T 1:Pickup loop CA	SPS	O
_:181:56	Definite-T 1:Operate delay expired	ACT	O
_:181:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:182:81	Definite-T 2:>Block stage	SPS	I
_:182:54	Definite-T 2:Inactive	SPS	O
_:182:52	Definite-T 2:Behavior	ENS	O
_:182:53	Definite-T 2:Health	ENS	O
_:182:55	Definite-T 2:Pickup	ACD	O
_:182:300	Definite-T 2:Pickup loop AB	SPS	O
_:182:301	Definite-T 2:Pickup loop BC	SPS	O
_:182:302	Definite-T 2:Pickup loop CA	SPS	O
_:182:56	Definite-T 2:Operate delay expired	ACT	O
_:182:57	Definite-T 2:Operate	ACT	O

6.23.4 Stage with Inverse-Time Characteristic Curve

6.23.4.1 Description

Logic of the Stage



[lo3phinv, 2, en_US]

Figure 6-173 Logic Diagram of the Inverse Time-Overvoltage Protection with 3-Phase Voltage

Method of Measurement

Use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the ***RMS value*** .

- Measurement ***fundamental comp.*** :

  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

- Measurement ***RMS value*** :
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Pickup Mode

With the **Pickup mode** parameter, you define whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (***3 out of 3***) or if only 1 measuring element detects the overvoltage condition (***1 out of 3***).

Measured Value

Use the **Measured value** parameter to define whether the stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Pickup and Operate Curve

When the input voltage exceeds the threshold value by a settable value **Pickup factor** , the stage picks up and the inverse-time characteristic curve is processed. Operate delay starts. The operate delay is the sum of inverse-time delay and additional time delay.

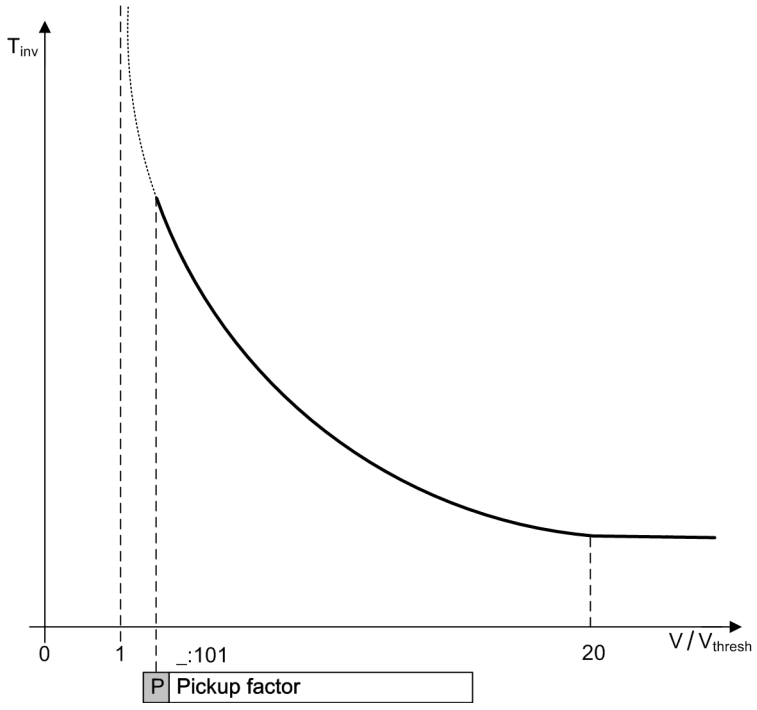
$$T_{op} = T_{inv} + T_{add}$$

Where

T_{op}	Operate delay
T_{inv}	Inverse-time delay
T_{add}	Additional time delay (parameter **Additional time delay**)

After pickup, the time value T_{inv} is calculated for every input voltage that exceeds the threshold. An integrator accumulates the value $1/T_{inv}$. Once the accumulated integral reaches the fixed value 1, the inverse-time delay expires. The additional time delay T_{add} starts. The stage operates after the additional time delay expires.

The inverse-time characteristic is shown in the following figure.



[dwovpinv, 2, en_US]

Figure 6-174 Operate Curve of Inverse-Time Characteristic

The inverse-time delay is calculated with the following formula:

$$T_{inv} = T_p \left(\frac{k}{\left(\frac{V}{V_{thresh}}\right)^{\alpha} - 1} + c \right) [s]$$

Where

T_{inv}	Inverse-time delay
T_p	Time multiplier (parameter **`Time dial`**)
V	Measured voltage
V_{thresh}	Threshold value (parameter **`Threshold`**)
k	Curve constant k (parameter **`Charact. constant k`**)
α	Curve constant α (parameter **`Charact. constant α`**)
c	Curve constant c (parameter **`Charact. constant c`**)

When V/V_{thresh} is equal to or greater than 20, the inverse-time delay does not decrease any further.

Dropout Behavior

When the voltage falls below the dropout threshold (0.95 × pickup factor × threshold value), the pickup signal is going and the dropout is started. You can define the dropout behavior via parameter **`Reset time`** . Instantaneous reset takes place by setting **`Reset time`** to 0 s. A delayed reset takes place by setting the desired delay time.

During the **`Reset time`** (> 0 s), the elapsed operate delay is frozen. If the pickup value is exceeded again within this period, the stage operates when the rest of operate delay expires.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal *>Block stage* .

6.23.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:8) Method of measurement** = ***fundamental comp.***

With the **Method of measurement** parameter, you define whether the tripping stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends this method of measurement as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Do not set the **threshold value** of the tripping stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting **(_:9) Measured value** = ***phase-to-phase***

With the **Measured value** parameter, you define whether the tripping stage monitors the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA} or the phase-to-ground voltages V_A, V_B, and V_C.

Parameter Value	Description
phase-to-phase	If you want to monitor the voltage range, keep ***phase-to-phase*** as the default setting. In this case, the function will not pick up on ground faults. Siemens recommends the measured value ***phase-to-phase*** as the default setting.
phase-to-ground	Select the ***phase-to-ground*** setting if you want to detect voltage unbalances and overvoltage conditions caused by ground faults.

Parameter: Threshold, Pickup factor

- Default setting **(_:3) Threshold** = ***110.000 V***
- Default setting **(_:101) Pickup factor** = ***1.10***

The stage picks up when the measured voltage value exceeds the pickup value **Threshold** × **Pickup factor**.

Depending on the **Measured value**, the **Threshold** is set either as phase-to-phase quantity or as phase-to-ground quantity.

With the **Pickup factor** parameter, you modify the pickup value. To avoid a long-time operate delay after pickup when the measured value is slightly over the threshold, Siemens recommends using the default setting.

Specify the **Threshold** (pickup threshold) and **Pickup factor** for the specific application.

Parameter: Pickup mode

- Recommended setting value **(_:182:101) Pickup mode** = ***1 out of 3***

With the **Pickup mode** parameter, you define whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (***3 out of 3***) or if only 1 measuring element detects the overvoltage condition (***1 out of 3***).

Parameter Value	Description
1 out of 3	Select the setting for protection applications or for monitoring the voltage range. Siemens recommends ***1 out of 3*** as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Parameter: Charact. constant k, Charact. constant α, Charact. constant c

- Default setting **(_:102) Charact. constant k** = ***1.00***
- Default setting **(_:103) Charact. constant α** = ***1.000***
- Default setting **(_:104) Charact. constant c** = ***0.000***

With the parameters **Charact. constant k**, **Charact. constant α**, and **Charact. constant c**, you define the required inverse-time characteristic curve.

Parameter: Time dial

- Default setting **(_:105) Time dial** = ***1.00***

With the **Time dial** parameter, you displace the characteristic curve in the time direction.

As usually, there is no time grading for voltage protection and therefore no displacement of the characteristic curve, Siemens recommends leaving the **Time dial** parameter at ***1.00*** (default setting).

Parameter: Additional time delay

- Default setting **(_:106) Additional time delay** = ***0.00 s***

With the **Additional time delay** parameter, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, only the inverse-time delay is operative.

Parameter: Reset time

- Default setting **(_:107) Reset time** = ***0.00 s***

With the **Reset time** parameter, you define the reset time delay which is started when the voltage falls below the dropout threshold. Set the parameter **Reset time** to 0 s when instantaneous reset is desired.

Under network conditions of intermittent faults or faults which occur in rapid succession, Siemens recommends setting the **Reset time** to an appropriate value (> 0 s) to ensure the operation. Otherwise Siemens recommends to keep the default value to ensure a fast reset of the function.

6.23.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T #				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:9	Inverse-T #:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:8	Inverse-T #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:108	Inverse-T #:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3

Addr.	Parameter	C	Setting Options	Default Setting
_:3	Inverse-T #:Threshold		0.300 V to 340.000 V	110.000 V
_:101	Inverse-T #:Pickup factor		1.00 to 1.20	1.10
_:102	Inverse-T #:Charact. constant k		0.00 to 300.00	1.00
_:103	Inverse-T #:Charact. constant α		0.010 to 5.000	1.000
_:104	Inverse-T #:Charact. constant c		0.000 to 5.000	0.000
_:105	Inverse-T #:Time dial		0.05 to 15.00	1.00
_:106	Inverse-T #:Additional time delay		0.00 s to 60.00 s	0.00 s
_:107	Inverse-T #:Reset time		0.00 s to 60.00 s	0.00 s

6.23.4.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	Inverse-T #:>Block stage	SPS	I
_:54	Inverse-T #:Inactive	SPS	O
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:55	Inverse-T #:Pickup	ACD	O
_:300	Inverse-T #:Pickup loop AB	SPS	O
_:301	Inverse-T #:Pickup loop BC	SPS	O
_:302	Inverse-T #:Pickup loop CA	SPS	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:57	Inverse-T #:Operate	ACT	O

6.24 Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage

6.24.1 Overview of Functions

The **Overvoltage protection with zero-sequence voltage/residual voltage** function (ANSI 59):

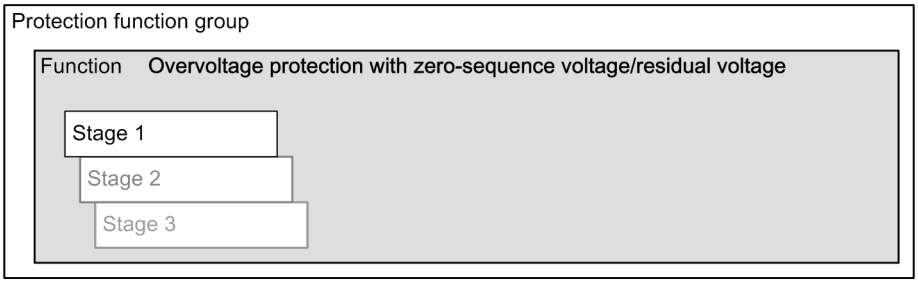
- Is used in isolated or arc-suppression-coil-grounded systems to detect ground faults
- determines the phase affected by the ground fault, if needed
- is used with electrical machines to detect ground faults in the stator winding.

6.24.2 Structure of the Function

The **Overvoltage protection with zero-sequence voltage/residual voltage** function is used in protection function groups, which are based on voltage measurement.

The **Overvoltage protection with zero-sequence voltage/residual voltage** function comes with 1 factory-set tripping stage. A maximum of 3 tripping stages can be operated simultaneously in the function.

The tripping stages have an identical structure.

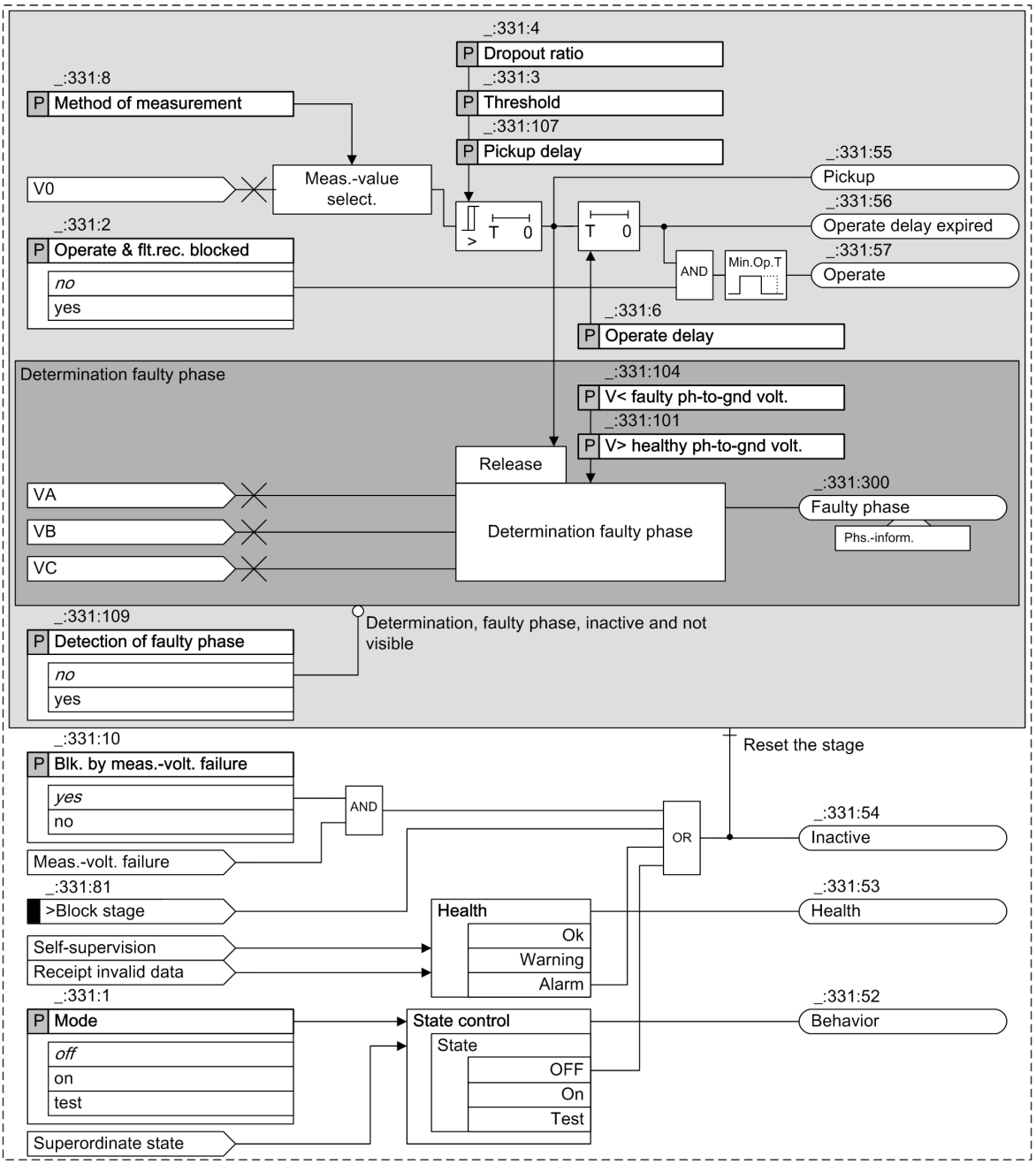


[dwu0ovps-030211-01.tif, 1, en_US]

Figure 6-175 Structure/Embedding of the Function

6.24.3 Stage Description

Logic of a Stage



[loovpu03-090611-01.tif, 2, en_US]

Figure 6-176 Logic Diagram of an Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage Stage

Measured Value, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V_0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V_0 is calculated from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

Use the **Method of measurement** parameter to select the relevant method of measurement, depending on the application.

- Measurement of the ***fundamental comp.*** (standard filter):

  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

- Measurement of the ***RMS value*** parameter value (true RMS):

  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value.

- ***fund. comp. long filter*** (fundamental component over 2 cycle filters with triangular window):

  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically. The extended filter length compared to the standard filter and the use of the triangular window results in a particularly strong attenuation of harmonics and transient faults. The extended filter length causes the pickup time to increase slightly compared to the standard filter (see Technical Data).

Pickup, Dropout

The stage compares the **Threshold** with the zero-sequence voltage V_0. The **Pickup delay** parameter allows you to delay the pickup of the stage depending on the residual voltage.

With the **Dropout ratio** parameter you can define the ratio of the dropout value to the **Threshold**.

Determination of the Faulty Phase

You can use the **Detection of faulty phase** parameter to enable or disable the determining of the phase affected by the ground fault. Determining is released when the stage picks up. If 2 phases exceed the threshold value **V> healthy ph-to-gnd volt.** and 1 phase falls below the threshold value **V< faulty ph-to-gnd volt.**, the last phase is considered to be affected by the ground fault and is signaled as such.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal **>Block stage** from an external or internal source
- From inside on pick up of the **measuring-voltage failure detection** function (see chapter *9.3.2.1 Overview of Functions*). The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal **>Open** of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.24.4 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:331:8) Method of measurement** = ***fundamental comp.***

The **Method of measurement** parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

Parameter Value	Description
fundamental comp.	This method of measurement suppresses the harmonics or transient voltage peaks. Siemens recommends using this setting as the standard method.

Parameter Value	Description
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Do not set the **threshold value** of the tripping stage under 10 V for this method of measurement.
fund. comp. long filter	To implement particularly strong damping of harmonics and transient disturbances, select this method of measurement. At 2 periods, the length of the filter is longer than that of the standard filter. Please note that in this case the pickup time of the tripping level increases slightly (see Technical Data).

Parameter: Pickup delay

- Recommended setting value **(_:331:107) Pickup delay** = ***0 ms***

The **Pickup delay** parameter allows you to delay the analysis of the measurand (to generate the pickup) depending on the occurrence of the residual voltage. A pickup delay can be necessary if high transients are anticipated after fault inception due to high line and ground capacitances.
Siemens recommends using the default setting **Pickup delay** = ***0 ms***.

Parameter: Threshold

- Default setting **(_:331:3) Threshold** = ***30 V***[13]

The threshold value of the function is set as the zero-sequence voltage V_0. The device calculates the zero-sequence voltage V_0 either from the residual voltage measured via the broken-delta winding or from the 3 phase-to-ground voltages.
The setting value depends on the system grounding:

- Since virtually the full residual voltage occurs during ground faults in isolated or arc-suppression-coil-grounded systems, the setting value is uncritical there. It should range between 20 V and 40 V. A higher sensitivity (= lower threshold value) can be necessary for high fault resistances.
- You should select a more sensitive (smaller) value in a grounded system. This value must be higher than the maximum residual voltage anticipated during operation caused by system unbalances.

EXAMPLE

For an isolated system
The residual voltage is measured via the broken-delta winding:

- If the ground fault is fully unbalanced, a residual voltage of 100 V is present at the device terminals.
- The threshold value should be set so that the stage picks up on 50 % of the full residual voltage.
- At full residual voltage, the zero-sequence voltage is 100 V/$\sqrt{3}$ = 57.7 V
  Setting value: 0.5 * 57.7 V = 28.9 V ≈ 30 V

Parameter: Dropout ratio

- Recommended setting value **(_:331:4) Dropout ratio** = ***0.95***

The recommended set value of ***0.95*** is appropriate for most applications. The dropout ratio can be reduced for example, to 0.98 to achieve a high measurement precision.

Parameter: Operate delay

- Default setting **(_:331:6) Operate delay** = ***3.00 s***

The **Operate delay** allows you to prevent transient residual voltages from initiating a trip. The setting depends on the specific application.

[13] The specific setting limits depend on the transformer data and transformer connections set.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:331:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following two conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see Chapter *9.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: Detection of faulty phase

- Default setting **(_:331:109) Detection of faulty phase** = ***no***

The **Detection of faulty phase** parameter controls how the stage responds to determine which phase is affected by the ground fault.

Parameter Value	Description
no	The phase affected by the ground fault is not determined. Select the default setting if you do not want to use the stage to detect ground faults. For example, applications in grounded systems.
yes	After a pickup by the residual voltage the device tries to determine, which phase is affected by the ground fault. Select this setting for applications in isolated or arc-suppression-coil-grounded systems.

Parameter: V< faulty ph-to-gnd volt.

- Default setting **(_:331:104) V< faulty ph-to-gnd volt.** = ***30.000 V***[14]

Set the threshold value for determining which phase is affected by the ground fault in the **V< faulty ph-to-gnd volt.** parameter. The setting value is a phase-to-ground quantity.

The set value must be smaller than the minimum phase-to-ground voltage occurring during operation. Siemens recommends using the default setting **V< faulty ph-to-gnd volt.** = ***30.000 V***.

Parameter: V> healthy ph-to-gnd volt.

- Default setting **(_:331:101) V> healthy ph-to-gnd volt.** = ***75.000 V***[15]

Set the threshold value for the two healthy phases in the **V> healthy ph-to-gnd volt.** parameter. The setting value is a phase-to-ground quantity.

The set value must lie above the maximum phase-to-ground voltage occurring during operation, but below the minimum phase-to-phase voltage present during operation. At V_{rated} = 100 V, the value has to be set to 75 V, for example. Siemens recommends using the default setting **V> healthy ph-to-gnd volt.** = ***75.000 V***.

Operation as Supervision Function

If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

[14] The specific setting limits depend on the transformer data and transformer connections set.
[15] The specific setting limits depend on the transformer data and transformer connections set.

6.24.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:331:1	Stage 1:Mode		• off • on • test	off
_:331:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:331:10	Stage 1:Blk. by meas.-volt. failure		• no • yes	yes
_:331:109	Stage 1:Detection of faulty phase		• no • yes	no
_:331:8	Stage 1:Method of measurement		• fundamental comp. • fund. comp. long filter • RMS value	fundamental comp.
_:331:3	Stage 1:Threshold		0.300 V to 340.000 V	30.000 V
_:331:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:331:107	Stage 1:Pickup delay		0.00 s to 320.00 s	0.00 s
_:331:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
_:331:101	Stage 1:V> healthy ph-to-gnd volt.		0.300 V to 200.000 V	75.000 V
_:331:104	Stage 1:V< faulty ph-to-gnd volt.		0.300 V to 200.000 V	40.000 V

6.24.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:331:81	Stage 1:>Block stage	SPS	I
_:331:54	Stage 1:Inactive	SPS	O
_:331:52	Stage 1:Behavior	ENS	O
_:331:53	Stage 1:Health	ENS	O
_:331:300	Stage 1:Faulty phase	ACT	O
_:331:55	Stage 1:Pickup	ACD	O
_:331:56	Stage 1:Operate delay expired	ACT	O
_:331:57	Stage 1:Operate	ACT	O

6.25 Overvoltage Protection with Positive-Sequence Voltage

6.25.1 Overview of Functions

The function **Overvoltage protection with positive-sequence voltage** (ANSI 59) is used to:

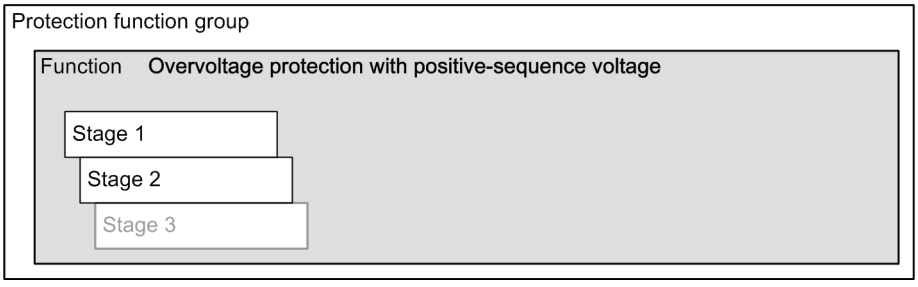
- Detect symmetric stationary overvoltages
- Supervise the voltage range if the positive-sequence voltage is the decisive quantity

Unbalanced overvoltages, for example, caused by ground faults and unbalanced faults, are not detected due to the evaluation of the positive-sequence voltage.

6.25.2 Structure of the Function

The **Overvoltage protection with positive-sequence voltage** function is used in protection function groups, which are based on voltage measurement.

The function **Overvoltage protection with positive-sequence voltage** comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

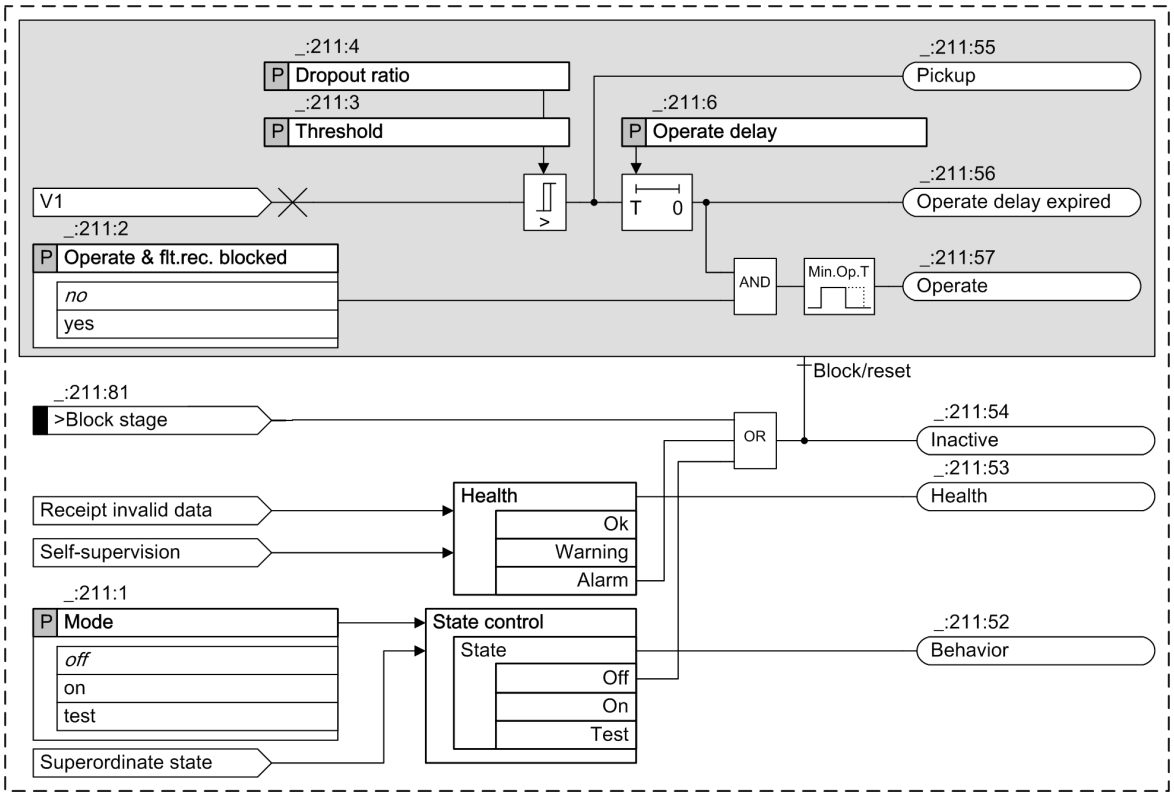


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Figure 6-177 Structure/Embedding of the Function

6.25.3 Stage Description

Logic of a Stage



[logovpu1-090611-01.tif, 1, en_US]

Figure 6-178 Logic Diagram of a Stage: Overvoltage Protection with Positive-Sequence Voltage

Method of Measurement

The stage uses the positive-sequence voltage. The positive-sequence voltage is calculated from the measured phase-to-ground voltages according to the defining equation.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal **>Block stage**.

6.25.4 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:211:3) Threshold** = ***65 V***

The Threshold is set according to the definition of the positive-sequence system.

Specify the Threshold (pickup threshold) for the specific application.

Parameter: Operate delay

- Default **(_:211:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:211:4) Dropout ratio** = ***0.95***

The default value of ***0.95*** is appropriate for most applications. To achieve high measurement precision, the **Dropout ratio** can be reduced, to 0.98, for example.

General Notes

If the overvoltage is high, the first stage can trip with a short time delay. If overvoltages are lower, the second stage can either only signal the threshold value violation (see Operation as monitoring function) or trip with a longer delay to allow the voltage controller to regulate the voltage back into the nominal range.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

6.25.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:211:1	Stage 1:Mode		• off • on • test	off
_:211:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:211:3	Stage 1:Threshold		0.300 V to 200.000 V	65.000 V
_:211:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:211:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:212:1	Stage 2:Mode		• off • on • test	off
_:212:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:212:3	Stage 2:Threshold		0.300 V to 200.000 V	75.000 V
_:212:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:212:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.25.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:211:81	Stage 1:>Block stage	SPS	I
_:211:54	Stage 1:Inactive	SPS	O
_:211:52	Stage 1:Behavior	ENS	O
_:211:53	Stage 1:Health	ENS	O
_:211:55	Stage 1:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:211:56	Stage 1:Operate delay expired	ACT	O
_:211:57	Stage 1:Operate	ACT	O
Stage 2			
_:212:81	Stage 2:>Block stage	SPS	I
_:212:54	Stage 2:Inactive	SPS	O
_:212:52	Stage 2:Behavior	ENS	O
_:212:53	Stage 2:Health	ENS	O
_:212:55	Stage 2:Pickup	ACD	O
_:212:56	Stage 2:Operate delay expired	ACT	O
_:212:57	Stage 2:Operate	ACT	O

6.26 Overvoltage Protection with Negative-Sequence Voltage

6.26.1 Overview of Functions

The function **Overvoltage protection with negative-sequence voltage** (ANSI 47) is used to:

- Monitor the power system and electric machines for voltage unbalances
- Establish a release criterion of overcurrent protection for unbalanced faults

Voltage unbalances can be caused by various factors:

- The most common cause is unbalanced load, caused by different consumers in the individual phases, for example.
- Voltage unbalance can also be caused by phase failure, for example due to a tripped 1-phase fuse, a broken conductor, etc.
- Other causes can include faults in the primary system, for example, at the transformer or in installations for reactive-power compensation.

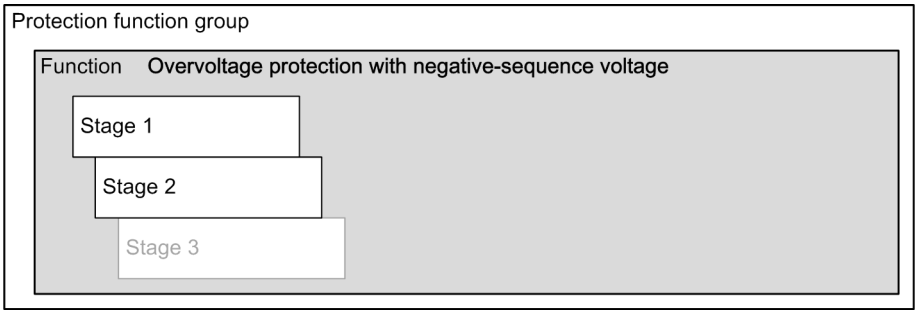
6.26.2 Structure of the Function

The **Overvoltage protection with negative-sequence voltage** function is used in protection function groups, which are based on voltage measurement.

The **Overvoltage protection with negative-sequence voltage** function comes with 2 factory-set stages.

A maximum of 3 stages can be operated simultaneously in the function.

The stages have an identical structure.



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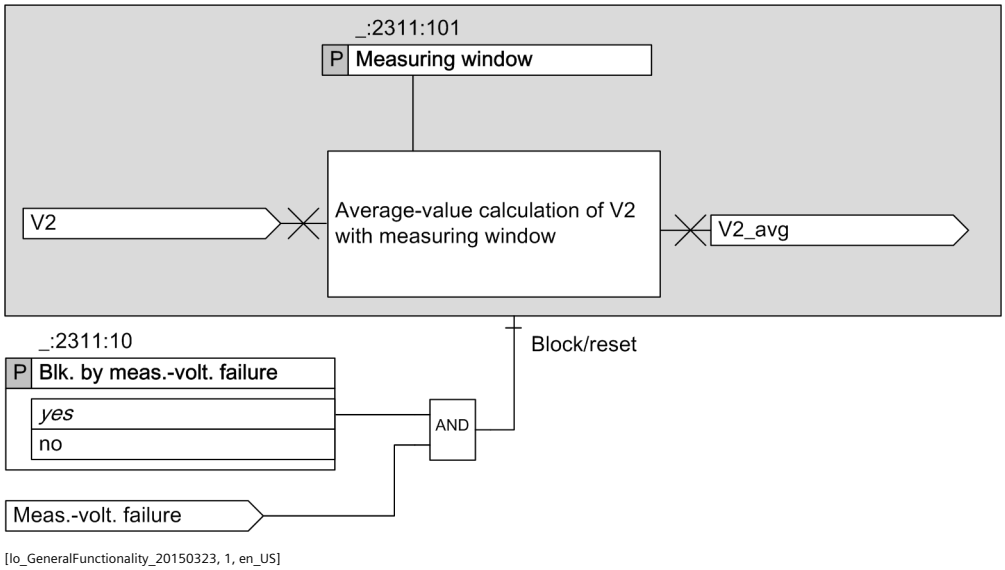
Figure 6-179 Structure/Embedding of the Function

6.26.3 General Functionality

6.26.3.1 Description

Logic

The following figure represents the logic of the average-value calculation of the negative-sequence voltage. The average value is forwarded to all subordinate stages.



[lo_GeneralFunctionality_20150323, 1, en_US]

Figure 6-180 Logic Diagram of the General Functionality

Measurand

The average value of negative-sequence voltage is determined by a settable time interval (parameter: **Measuring window**). With the parameter **Measuring window**, you can adapt this function to all power-system conditions.

You can set the parameter **Measuring window** with a large value to get a more accurate calculated result, which leads to a longer pickup time however.

Blocking the Function with Measuring-Voltage Failure Detection

In case of blocking, the picked up function is reset. The following blocking options is available for the function:

- From inside on pick up of the **Measuring-voltage failure detection** function (see section *9.3.2.1 Overview of Functions*).
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker.

The parameter **Blk. by meas.-volt. failure** can be set so that the measuring-voltage failure detection blocks the function or does not block it.

6.26.3.2 Application and Setting Notes

Parameter: Measuring window

- Default setting **(_:2311:101) Measuring window** = ***1 cycle***

  With the parameter **Measuring window**, you can optimize the measuring accuracy or the pickup time of this function.

  For sensitive settings of the parameter **Threshold**, for example, lower than 10 % of the rated voltage, Siemens recommends using a higher number of cycles. Siemens recommends ***10 cycles***, and in this case, the pickup time is increased.

  For further information, refer to chapter *12.32 Overvoltage Protection with Negative-Sequence Voltage* .

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:2311:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the function when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see chapter *9.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection function is blocked (= default setting). Siemens recommends using the default setting.
no	The protection function is not blocked.

6.26.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:10	General:Blk. by meas.-volt. failure		• no • yes	yes
_:2311:101	General:Measuring window		1 cycles to 10 cycles	1 cycles

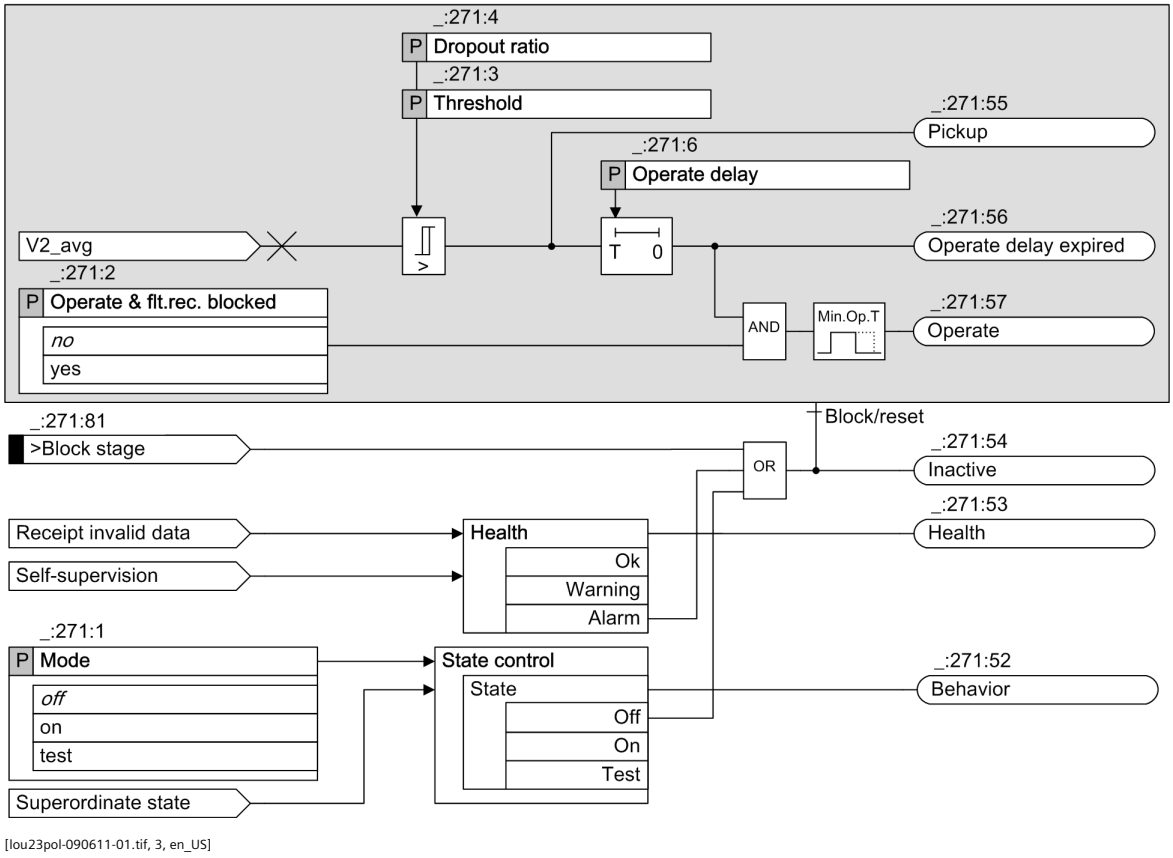
6.26.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:V2 average	MV	O

6.26.4 Stage with Negative-Sequence Voltage

6.26.4.1 Description

Logic of a Stage



[lou23pol-090611-01.tif, 3, en_US]

Figure 6-181 Logic Diagram of the Stage: Overvoltage Protection with Negative-Sequence Voltage

Method of Measurement

The stage uses the average value of the negative-sequence voltage, which is calculated from the function block **General Functionality**. For more information, refer to chapter *6.26.3.1 Description*.

Blocking the Stage

In case of blocking, the picked up function is reset. The following blocking option is available for the function:

- From an external or internal source via the binary input signal *>Block stage*

6.26.4.2 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:271:3) Threshold** = *5.800 V*

The parameter **Threshold** is set according to the definition of the negative-sequence system.

Specify the **Threshold** (pickup threshold) for the specific application.

The secondary voltage of the voltage transformer can be used if the voltage transformer is adapted to the rated voltage. The value of the 10 % negative-sequence voltage at a 100 V rated secondary voltage is:

100 V / 1.73 * 0.1 = 5.77 V

Parameter: Dropout ratio

- Default setting **(_:271:4) Dropout ratio** = ***0.95***

The default setting of ***0.95*** is appropriate for most applications.

You can decrease the dropout ratio to avoid chattering of the stage if the threshold value is low. For example, for the stage with a 2 % setting, you can use a dropout ratio of 0.90.

Parameter: Operate delay

- Default setting **(_:271:6) Operate delay** = ***3.00 s***

Specify the **Operate delay** for the specific application. 3.00 s is a practicable value.

For a higher threshold value, a shorter tripping delay is required.

Operation as Supervision Function

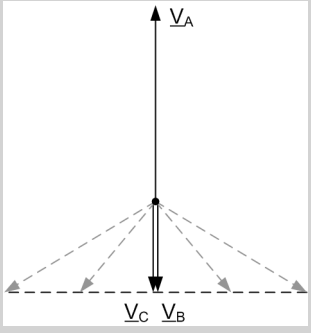
If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

Example 1:

Releasing an overcurrent protection stage for unbalanced faults

The following section describes how to set the function to release an **Overcurrent-protection** stage when unbalanced faults occur. Set the **Overcurrent-protection** stage only slightly higher than the load current, that is very sensitive. To prevent the **Overcurrent-protection** stage from picking up inadvertently, the **Overcurrent-protection** stage is released when the **Negative-sequence voltage** stage picks up. The **Overcurrent-protection** stage remains blocked as long as the **Negative-sequence voltage** stage has not picked up.

Figure 6-182 shows the voltage phasors during a 2-phase local fault between phases B and C. The phase-to-phase voltage V_{BC} is virtually 0.



[dwuazeig-020412-01.tif, 1, en_US]

Figure 6-182 Voltage Phasors during a 2-Phase Local Fault

A 2-phase local fault generates a relatively large negative-sequence voltage of up to 50 % referred to the phase-to-ground voltage. The portion of the negative-sequence decreases in case of a remote fault. The lower setting limit results from the possible unbalance at full load. If you assume for example 5 % negative-sequence voltage, the pickup value must be higher. A setting value of 10 % warrants sufficient stability during unbalanced operating states and sufficient sensitivity to release the **Overcurrent-protection** stage when a fault occurs.

For a secondary rated voltage of 100 V, set the following secondary threshold value:

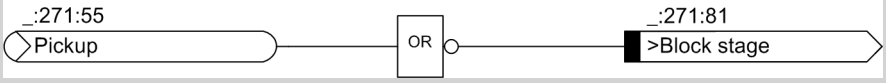
$$V2_{sec} = \frac{V_{rated}}{\sqrt{3}} \times 10\,\% = \frac{100\ V}{\sqrt{3}} \times 0.1 \approx 5.8\ V$$

[fo_OVP_V2_Secondary Threshold, 1, en_US]

You can keep the default setting of 0.95 for the dropout ratio. This avoids chattering of the stage.

Set the **Negative-sequence voltage** stage so that it does not generate a fault when it picks up and does not initiate tripping. The **Overcurrent-protection** stage generates a fault indication. The pickup of the **Negative-sequence voltage** stage is used as the release criterion because the **Short-circuit** function must be released immediately when the **Negative-sequence voltage** stage has picked up. The time delay is thus not relevant and can be left at the default setting.

You implement the release of the **Overcurrent-protection** stage using a logic block chart. An inverter links the pickup of the **Negative-sequence voltage** stage with the **Overcurrent-protection** stage blocking.



[loinvert-020412-01.tif, 1, en_US]

Figure 6-183 Linking the Pickup of the Negative-Sequence Voltage Stage

Stage	Setting Values		
	Secondary Threshold Value	Time Delay	Dropout Ratio
1	5.800 V	3.00 s	0.95

The second stage is not needed. It is deleted or remains off.

Example 2:

A negative-sequence voltage in the auxiliary system of the power plant causes negative-sequence currents on motors. This leads to a thermal overload of the rotors. The following estimation can be used as a basis: 1 % negative-sequence voltage can lead to approximately 5 % or 6 % negative-sequence current.

A negative-sequence voltage can be caused by a broken conductor on the high-voltage side. If a negative-sequence voltage occurs, this can, for example, initiate a switching of the infeed in order to prevent a protection trip of an unbalanced-load protection of the motors.

Siemens recommends using multiple stages for a better grading, whereby a sensitive setting of the threshold permits an increased tripping delay.

For a reference, only 2 stages are discussed.

The first stage has a pickup threshold of 10 % with a time delay of 1.5 s. The second stage has a pickup threshold of 3 % with a time delay of 8 s, see *Table 6-14*. Further, it is assumed that the voltage transformer is well adapted to the rated voltage.

$$V2_{sec} = \frac{100\ V}{1.73} \times \frac{V2\ [\%]}{100\%}$$

[fo_OVP_V2_SecondaryThreshold2, 1, en_US]

Table 6-14 Recommended Settings

Stage	Threshold	Operate Delay
Stage 1	5.800 V	1.50 s
Stage 2	1.730 V	8.00 s

6.26.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:271:1	Stage 1:Mode		• off • on • test	off
_:271:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:271:3	Stage 1:Threshold		0.300 V to 200.000 V	5.800 V

Addr.	Parameter	C	Setting Options	Default Setting
_:271:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:271:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:272:1	Stage 2:Mode		• off • on • test	off
_:272:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:272:3	Stage 2:Threshold		0.300 V to 200.000 V	9.000 V
_:272:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:272:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.26.4.4 Information List

No.	Information	Data Class (Type)	Type
Stage 1			
_:271:81	Stage 1:>Block stage	SPS	I
_:271:54	Stage 1:Inactive	SPS	O
_:271:52	Stage 1:Behavior	ENS	O
_:271:53	Stage 1:Health	ENS	O
_:271:55	Stage 1:Pickup	ACD	O
_:271:56	Stage 1:Operate delay expired	ACT	O
_:271:57	Stage 1:Operate	ACT	O
Stage 2			
_:272:81	Stage 2:>Block stage	SPS	I
_:272:54	Stage 2:Inactive	SPS	O
_:272:52	Stage 2:Behavior	ENS	O
_:272:53	Stage 2:Health	ENS	O
_:272:55	Stage 2:Pickup	ACD	O
_:272:56	Stage 2:Operate delay expired	ACT	O
_:272:57	Stage 2:Operate	ACT	O

6.27 Overvoltage Protection with Any Voltage

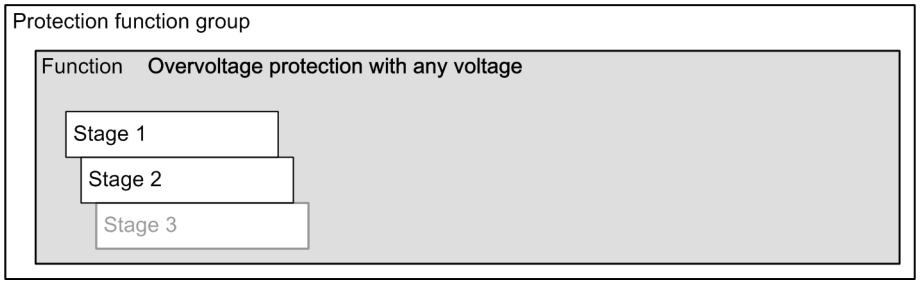
6.27.1 Overview of Functions

The function **Overvoltage protection with any voltage** (ANSI 59) detects any 1-phase overvoltages and is intended for special applications.

6.27.2 Structure of the Function

The **Overvoltage protection with any voltage** function is used in protection function groups, which are based on voltage measurement.

The function **Overvoltage protection with any voltage** comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

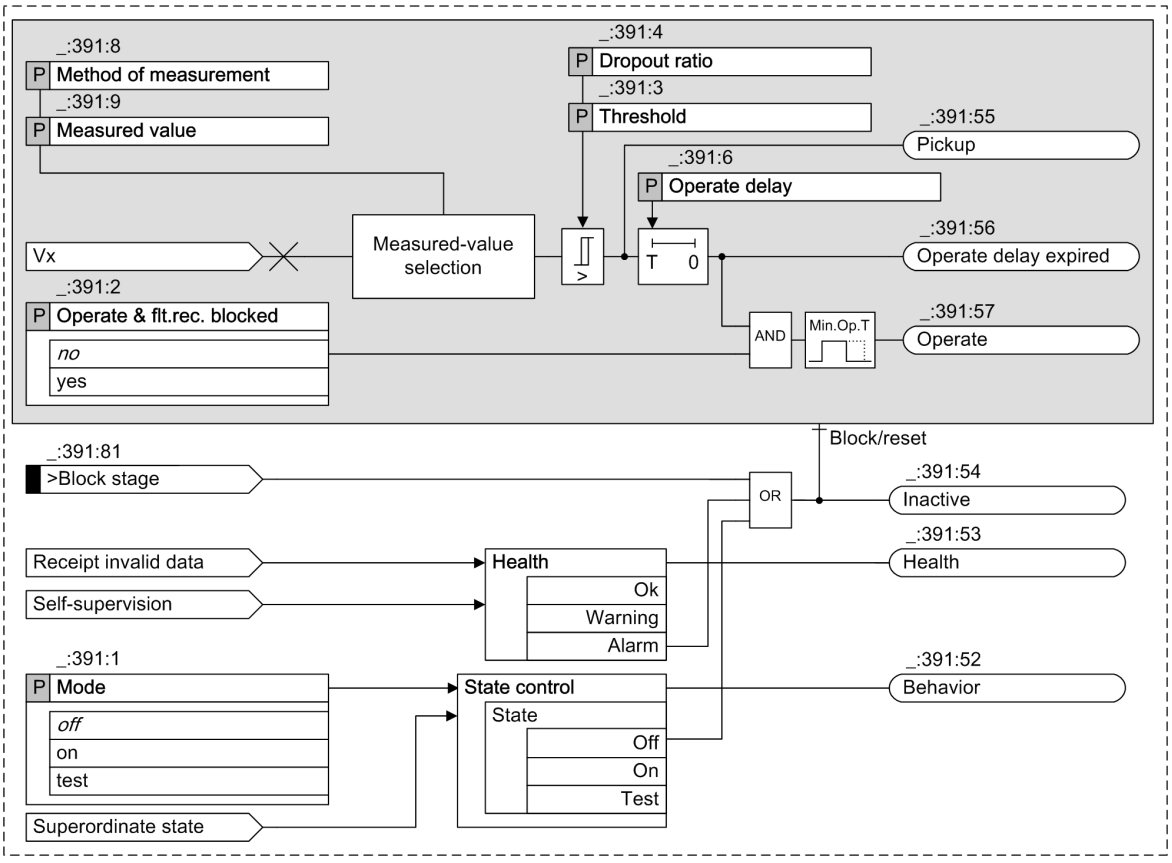


[dwovpuxs-030211-01.tif, 1, en_US]

Figure 6-184 Structure/Embedding of the Function

6.27.3 Stage Description

Logic of a Stage



[louxovpr-211212-01.tif, 1, en_US]

Figure 6-185 Logic Diagram of a Stage: Overvoltage Protection with Any Voltage

NOTE

If the function **Overvoltage protection with any voltage** is used in a 1-phase function group, the parameter **`Measured value`** is not visible.

Method of Measurement

The **`Method of measurement`** parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

- Measurement of the ***`fundamental comp.`***:

  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

- Measurement of the parameter value ***`RMS value`***:

  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

The parameter **`Measured value`** allows you to select whether the stage uses a measured (directly connected) voltage or a calculated phase-to-phase voltage.

If the function **Overvoltage protection with any voltage** is used in a 1-phase function group, the parameter **`Measured value`** is not visible.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal *>Block stage*.

6.27.4 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:391:8) Method of measurement** = ***fundamental comp.***

Use the **Method of measurement** parameter to define whether the tripping stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends this method of measurement as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks). Do not set the **threshold value** of the tripping stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting **(_:391:9) Measured value** = ***VA measured***

The **Measured value** parameter is used to specify which voltage is monitored by the stage.

The scope of setting options depends on the connection type for the voltage transformers and the routing of the measured values to the terminals of the voltage measuring point. You can find connection examples for voltage transformers in the Appendix.

The following setting options can be available:

- Measured phase-to-ground voltage V_A (***VA measured***)
- Measured phase-to-ground voltage V_B (***VB measured***)
- Measured phase-to-ground voltage V_C (***VC measured***)
- Measured phase-to-phase voltage V_{AB} (***VAB measured***)
- Measured phase-to-phase voltage V_{BC} (***VBC measured***)
- Measured phase-to-phase voltage V_{CA} (***VCA measured***)
- Calculated phase-to-phase voltage V_{AB} (***VAB calculated***)
- Calculated phase-to-phase voltage V_{BC} (***VBC calculated***)
- Calculated phase-to-phase voltage V_{CA} (***VCA calculated***)
- Calculated voltage V0 (***V0 calculated***)

The selection depends on the corresponding application.

NOTE

If the function **Overvoltage protection with any voltage** is used in a 1-phase function group, the parameter **Measured value** is not visible.

Parameter: Threshold

- Default setting **(_:391:3) Threshold** = ***110 V***

Specify the **Threshold** (pickup threshold) for the specific application.

Depending on the measured value, the **Threshold** is set either as **Measured voltage** or as **Phase-to-phase** quantity.

Parameter: Operate delay

- Default setting **(_:391:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:391:4) Dropout ratio** = ***0.95***

The recommended set value of ***0.95*** is appropriate for most applications. To achieve high measurement precision, the **Dropout ratio** can be reduced, to 0.98, for example.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

6.27.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:391:1	Stage 1:Mode		• off • on • test	off
_:391:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:391:9	Stage 1:Measured value		• VA measured • VB measured • VC measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:391:8	Stage 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:391:3	Stage 1:Threshold		0.300 V to 340.000 V	110.000 V
_:391:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:391:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:392:1	Stage 2:Mode		• off • on • test	off
_:392:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:392:9	Stage 2:Measured value		• VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:392:8	Stage 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:392:3	Stage 2:Threshold		0.300 V to 340.000 V	130.000 V
_:392:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:392:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.27.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:391:81	Stage 1:>Block stage	SPS	I
_:391:54	Stage 1:Inactive	SPS	O
_:391:52	Stage 1:Behavior	ENS	O
_:391:53	Stage 1:Health	ENS	O
_:391:55	Stage 1:Pickup	ACD	O
_:391:56	Stage 1:Operate delay expired	ACT	O
_:391:57	Stage 1:Operate	ACT	O
Stage 2			
_:392:81	Stage 2:>Block stage	SPS	I
_:392:54	Stage 2:Inactive	SPS	O
_:392:52	Stage 2:Behavior	ENS	O
_:392:53	Stage 2:Health	ENS	O
_:392:55	Stage 2:Pickup	ACD	O
_:392:56	Stage 2:Operate delay expired	ACT	O
_:392:57	Stage 2:Operate	ACT	O

6.28 Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage

6.28.1 Overview of Functions

The function **Overvoltage protection with negative-sequence voltage/positive-sequence voltage** is used to:

- Monitor the power system and electric machines for voltage unbalances
- Establish a release criterion of overcurrent protection for unbalanced faults

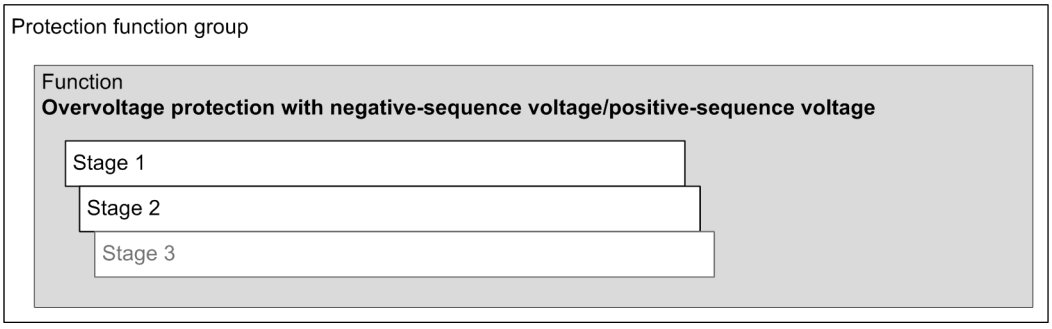
Voltage unbalances can be caused by various factors:

- The most common cause is unbalanced load, caused by different consumers in the individual phases, for example.
- Voltage unbalance can also be caused by phase failure, for example due to a tripped 1-phase fuse, a broken conductor, etc.
- Other causes can include faults in the primary system, for example, at the transformer or in installations for reactive-power compensation.

6.28.2 Structure of the Function

The **Overvoltage protection with negative-sequence voltage/positive-sequence voltage** function is used in protection function groups, which are based on voltage measurement.

The **Overvoltage protection with negative-sequence voltage/positive-sequence voltage** function comes with 2 factory-set stages. A maximum of 3 stages can be operated simultaneously in the function. The stages have an identical structure.



[Structure-V2/V1_20150521, 2, en_US]

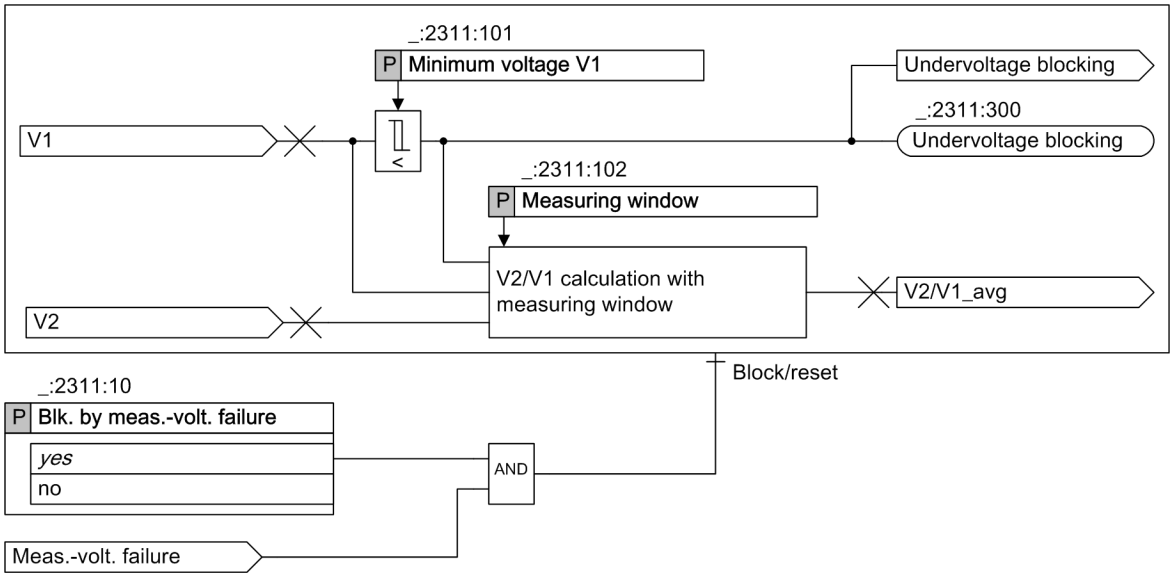
Figure 6-186 Structure/Embedding of the Function

6.28.3 General Functionality

6.28.3.1 Description

Logic

The following figure represents the logic of the average-value calculation of the ratio of negative-sequence voltage to positive-sequence voltage. The average value is forwarded to all subordinate stages.



[lo_V2toV1_FB General_20150326, 1, en_US]

Figure 6-187 Logic Diagram of the General Functionality

Measurand

The average value of the ratio of negative-sequence voltage to positive-sequence voltage is determined by a settable time interval (parameter: **Measuring window**). With the parameter **Measuring window**, you can adapt this function to all power-system conditions.

You can set the parameter **Measuring window** with a large value to get a more accurate calculated result, which leads to a longer pickup time however.

Blocking the Function with Measuring-Voltage Failure Detection

In case of blocking, the picked up function is reset. The following blocking options is available for the function:

- From inside on pick up of the **Measuring-voltage failure detection** function (see section *9.3.2.1 Overview of Functions*).
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker.

The parameter **Blk. by meas.-volt. failure** can be set so that the measuring-voltage failure detection blocks the function or does not block it.

6.28.3.2 Application and Setting Notes

Parameter: Measuring window

- Default setting **(_:2311:102) Measuring window** = ***1 cycle***

  With the parameter **Measuring window**, you can optimize the measuring accuracy or the pickup time of this function.

  For sensitive settings of the parameter **Threshold**, for example, lower than 10 % of the rated voltage, Siemens recommends using a higher number of cycles. Siemens recommends ***10 cycles***, and in this case, the pickup time is increased.

  For further information, refer to chapter *12.35 Overvoltage Protection with Negative-Sequence Voltage/ Positive-Sequence Voltage* .

Parameter: Blk. by meas.-volt. failure

- Recommended setting value **(_:2311:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the function when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see chapter *9.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection function is blocked (= default setting). Siemens recommends using the default setting.
no	The protection function is not blocked.

6.28.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:10	General:Blk. by meas.-volt. failure		• no • yes	yes
_:2311:102	General:Measuring window		1 cycles to 10 cycles	1 cycles
_:2311:101	General:Minimum voltage V1		0.300 V to 60.000 V	5.000 V

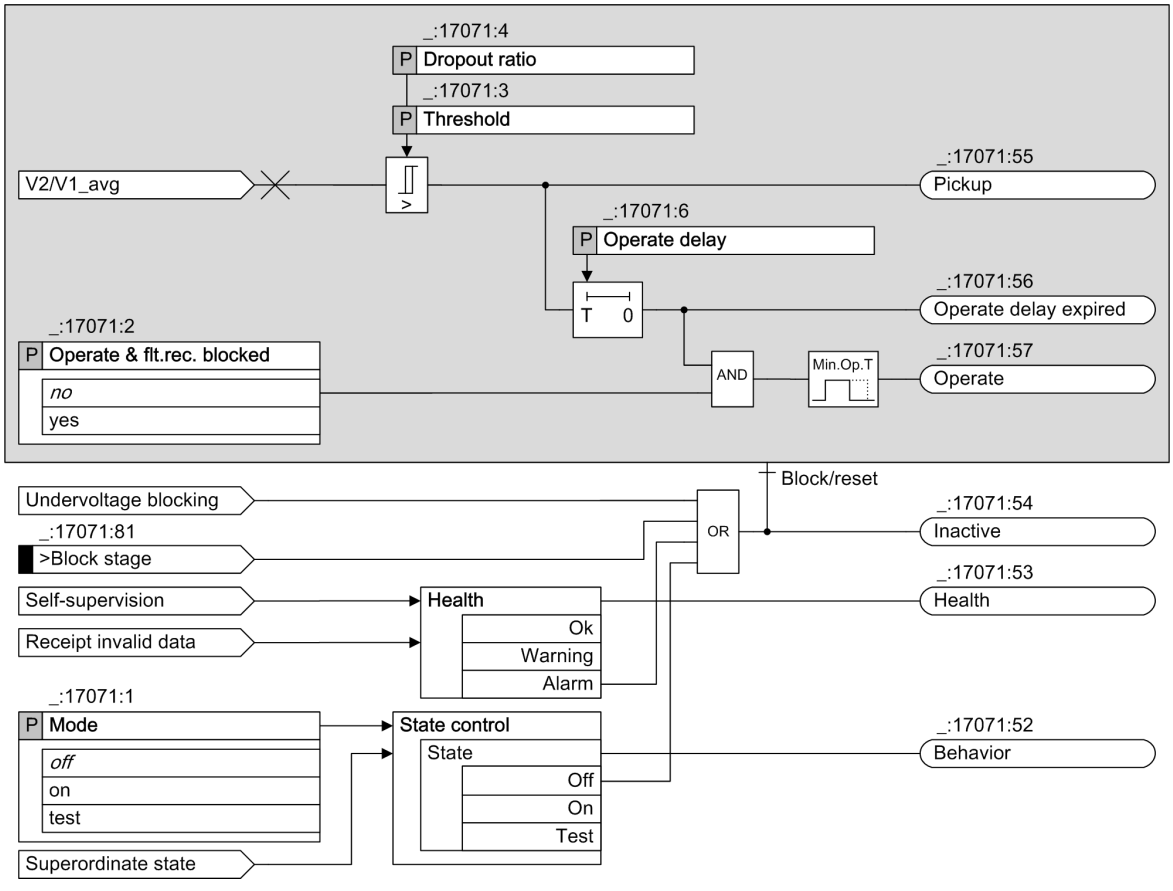
6.28.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
_:2311:301	General:V2/V1	MV	O

6.28.4 Stage with Negative-Sequence Voltage/Positive-Sequence Voltage

6.28.4.1 Description

Logic of a Stage



[lo_V2V1_PROV_20150326, 1, en_US]

Figure 6-188 Logic Diagram of the Stage: Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage

Method of Measurement

The stage uses the average value of the negative-sequence voltage/positive-sequence voltage, which is calculated from the function block **General Functionality**. For more information, refer to chapter *6.28.3.1 Description* .

Blocking the Stage

In case of blocking, the picked up function is reset. The following blocking option is available for the function:

- From an external or internal source via the binary input signal *>Block stage*

6.28.4.2 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:17071:3) Threshold** = *10.00 %*

The parameter **Threshold** is set in percentage according to the definition of the symmetrical compents. It is the ratio of the negative-sequence voltage to positive-sequence voltage.

Specify the **Threshold** (pickup threshold) for the specific application.

In the application with a lower threshold setting of about 2.00 %, there is a risk of an overfunction due to the measuring errors with small values as well as an influence via disturbances.

Parameter: Dropout ratio

- Default setting **(_:17071:4) Dropout ratio** = ***0.95***

The default setting of ***0.95*** is appropriate for most applications if a higher threshold is used.

You can decrease the dropout ratio to avoid chattering of the stage if the threshold value is low. For example, for the stage with a 2 % setting, you can use a dropout ratio of 0.90.

Parameter: Operate delay

- Default setting **(_:17071:6) Operate delay** = ***3.00 s***

Specify the **Operate delay** for the specific application. When using the sensitive setting of the threshold value that is described in this chapter, the function can be delayed by 3.00 s.

For a higher threshold value, a shorter tripping delay is required.

Operation as Supervision Function

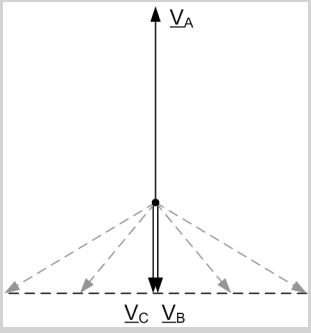
If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

Example 1:

Releasing an overcurrent protection stage for unbalanced faults

The following section describes how to set the function to release an **Overcurrent-protection** stage when unbalanced faults occur. Set the **Overcurrent-protection** stage only slightly higher than the load current, that is very sensitive. To prevent the **Overcurrent-protection** stage from picking up inadvertently, the **Overcurrent-protection** stage is released when the **Negative-sequence voltage** stage picks up. The **Overcurrent-Protection** stage remains blocked as long as the **Negative-sequence voltage** stage has not picked up.

Figure 6-189 shows the voltage phasors during a 2-phase local fault between phases B and C. The phase-to-phase voltage V_{BC} is virtually 0.



[dwuazeig-020412-01.tif, 1, en_US]

Figure 6-189 Voltage Phasors during a 2-Phase Local Fault

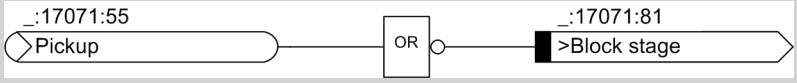
A 2-phase local fault generates a relatively large negative-sequence voltage of up to 100 % referred to the positive-sequence voltage. The portion of the negative-sequence decreases in case of a remote fault. The lower setting limit results from the possible unbalance at full load. If you assume for example 5 % of the negative-sequence voltage to positive-sequence voltage, the pickup value must be higher. A setting value of 10 % warrants sufficient stability during unbalanced operating states and sufficient sensitivity to release the **Overcurrent-protection** stage when a fault occurs.

You can keep the default setting of 0.95 for the dropout ratio. This avoids chattering of the stage.

Set the **Negative-sequence voltage** stage so that it does not generate a fault when it picks up and does not initiate tripping. The **Overcurrent-protection** stage generates a fault indication. The pickup of the **Negative-sequence voltage** stage is used as the release criterion because the **Short-circuit** function must be released

immediately when the **Negative-sequence voltage** stage has picked up. The time delay is thus not relevant and can be left at the default setting.

You implement the release of the **Overcurrent-protection** stage using a logic block chart. An inverter links the pickup of the **Negative-sequence voltage** stage with the **Overcurrent-protection** stage blocking.



[lo_Pickup of V2_20150507, 1, en_US]

Figure 6-190 Linking the Pickup of the Negative-Sequence Voltage Stage

Stage	Setting Values		
	Percentage of the Negative-Sequence Voltage to Positive-Sequence Voltage	Time Delay	Dropout Ratio
1	10.00 %	3.00 s	0.95

The second stage is not needed. It is deleted or remains off.

Example 2:

A negative-sequence voltage in the auxiliary system of the power plant causes negative-sequence currents on motors. This leads to a thermal overload of the rotors. The following estimation can be used as a basis: 1 % negative-sequence voltage can lead to approximately 5 % or 6 % negative-sequence current.

A negative-sequence voltage can be caused by a broken conductor on the high-voltage side. If a negative-sequence voltage occurs, this can, for example, initiate a switching of the infeed in order to prevent a protection trip of an unbalanced-load protection of the motors.

Siemens recommends using multiple stages for a better grading, whereby a sensitive setting of the threshold permits an increased tripping delay.

For a reference, only 2 stages are discussed.

The first stage has a pickup threshold of 10 % with a time delay of 1.5 s. The second stage has a pickup threshold of 3 % with a time delay of 8 s, see *Table 6-15* .

Table 6-15 Recommended Settings

Stage	Threshold	Operate Delay
Stage 1	10.00 %	1.50 s
Stage 2	3.00 %	8.00 s

6.28.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:17071:1	Stage 1:Mode		• off • on • test	off
_:17071:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:17071:3	Stage 1:Threshold		0.50 % to 100.00 %	10.00 %
_:17071:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:17071:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:17072:1	Stage 2:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:17072:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:17072:3	Stage 2:Threshold		0.50 % to 100.00 %	15.00 %
_:17072:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:17072:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.28.4.4 Information List

No.	Information	Data Class (Type)	Type
Stage 1			
_:17071:81	Stage 1:>Block stage	SPS	I
_:17071:54	Stage 1:Inactive	SPS	O
_:17071:52	Stage 1:Behavior	ENS	O
_:17071:53	Stage 1:Health	ENS	O
_:17071:55	Stage 1:Pickup	ACD	O
_:17071:56	Stage 1:Operate delay expired	ACT	O
_:17071:57	Stage 1:Operate	ACT	O
Stage 2			
_:17072:81	Stage 2:>Block stage	SPS	I
_:17072:54	Stage 2:Inactive	SPS	O
_:17072:52	Stage 2:Behavior	ENS	O
_:17072:53	Stage 2:Health	ENS	O
_:17072:55	Stage 2:Pickup	ACD	O
_:17072:56	Stage 2:Operate delay expired	ACT	O
_:17072:57	Stage 2:Operate	ACT	O

6.29 Undervoltage Protection with 3-Phase Voltage

6.29.1 Overview of Functions

The function **Undervoltage protection with 3-phase voltage** (ANSI 27) is used to:

- Monitor the permissible voltage range
- Protect equipment (for example, plant components and machines) against damages caused by undervoltage
- Handle disconnection or load shedding tasks in a system

6.29.2 Structure of the Function

The **Undervoltage protection with 3-phase voltage** function is used in protection function groups with voltage measurement.

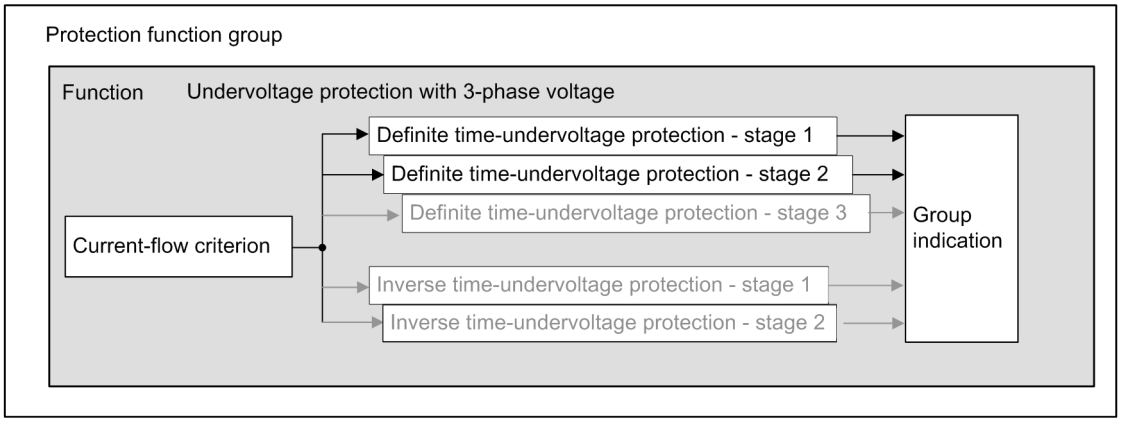
The **Undervoltage protection with 3-phase voltage** function is preconfigured by the manufacturer with 2 **Definite time-undervoltage protection** stages.

In the function **Undervoltage protection with 3-phase voltage**, the following stages can be operated simultaneously:

- 3 stages **Definite time-undervoltage protection**
- 2 stages **Inverse time-undervoltage protection**

Stages that are not preconfigured are shown in gray in the following figure.

The protection function is structured such that one current-flow criterion can act on all undervoltage protection stages (see *Figure 6-191*). If the protection function group used has no current measurement, you can only set the current-flow criterion as **fulfilled** via the corresponding binary input signal.



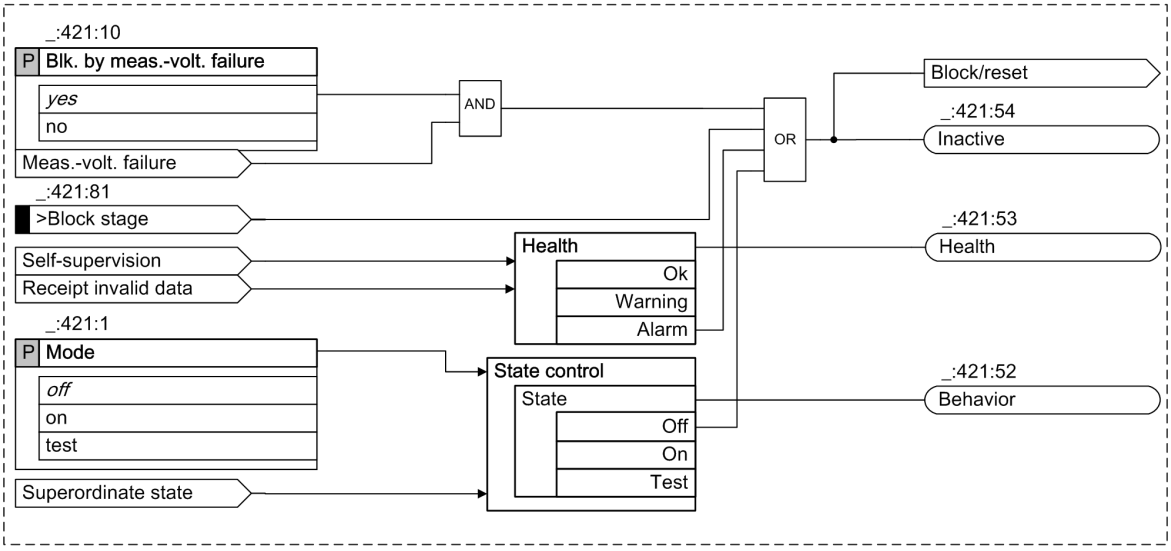
[dwstru3p-110211-01.tif, 3, en_US]

Figure 6-191 Structure/Embedding of the Function

6.29.3 Stage with Definite-Time Characteristic Curve

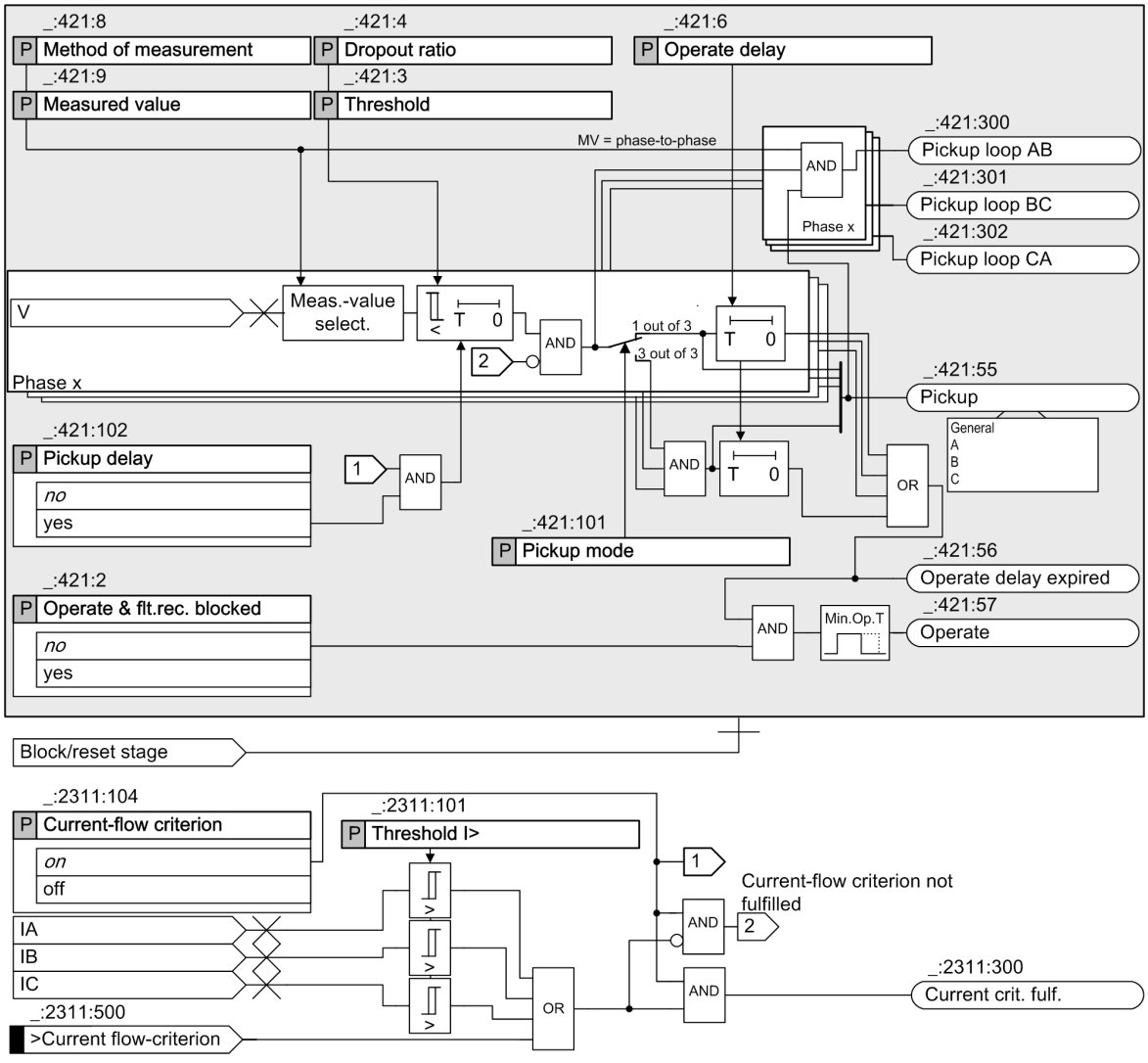
6.29.3.1 Description

Logic of a Stage



[louvp3ph-140611-01_stagecontrol.vsd, 1, en_US]

Figure 6-192 Logic Diagram of the Stage Control



[louvp3ph-140611-01.tif, 2, en_US]

Figure 6-193 Logic Diagram of the Function

Method of Measurement

With the **`Method of measurement`** parameter, you select the relevant method of measurement, depending on the application.

- Measurement fundamental component:

  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

- Measurement RMS value:

  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

With the **`Measured value`** parameter, you define whether the stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Pickup Mode

With the **Pickup mode** setting, you define whether the stage picks up when there is a lower threshold-value violation in one measuring element (***1 out of 3***) or when there is a lower threshold-value violation in all 3 measuring elements (***3 out of 3***).

Pickup Delay

The **Pickup delay** parameter is only available and of relevance if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***).

If the circuit breaker opens when the current-flow criterion is being used, the undervoltage detection and current-flow dropout functions conflict with one another. Depending on the threshold value settings for undervoltage detection and current-flow criterion, it is possible that the undervoltage is detected before the current-flow criterion has dropped out. In this case, the stage picks up briefly. Use the **Pickup delay** parameter to prevent the stage from briefly picking up in this way when the circuit breaker opens. This is achieved by delaying pickup by approximately 40 ms.

Current-Flow Criterion

The undervoltage protection stages work optionally with a current-flow criterion. The **Current-flow criterion** works across all tripping stages.

When the **Current-flow criterion** parameter is activated, the undervoltage protection stages only pick up if a settable minimum current (**Threshold I>**) is exceeded. A current below the minimum current blocks the stages.

The current-flow criterion can also be set to **fulfilled** with the binary input signal **>Current flow-criterion**. The function reports when the current-flow criterion is fulfilled.

Figure 6-193 illustrates the influence of the current-flow criterion.



NOTE

If the **(_:2311:104) Current-flow criterion** parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked-up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal *>Block stage* from an external or internal source
- From inside on pick up of the **measuring-voltage failure detection** function (see section *9.3.2.1 Overview of Functions*). The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.29.3.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:421:8) Method of measurement** = ***fundamental comp.***

Use the **Method of measurement** parameter to define whether the stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends using this parameter value as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks). Do not set the **threshold value** of the stage under 10 V for this method of measurement.

Parameter: Measured value

- Recommended setting value **(_:421:9) Measured value** = ***phase-to-phase***

Use the **Measured value** parameter to define whether the stage monitors the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C. Parameter Value

Parameter Value	Description
phase-to-phase	If you want to detect voltage dips caused by multiphase short circuits, or generally monitor the voltage range, keep phase-to-phase as the default setting. The function will not pick up on ground faults. Siemens recommends the measured value ***phase-to-phase*** as the default setting.
phase-to-ground	Select the ***phase-to-ground*** setting if you want to detect voltage unbalances or overvoltage conditions caused by ground faults.

Parameter: Threshold

- Default setting **(_:421:3) Threshold** = ***80 V***

The **Threshold** is set in accordance with the **Measured value** as either a ***phase-to-phase*** or ***phase-to-ground*** variable.

Specify the **Threshold** (pickup threshold) for the specific application.

For the default setting, the lower limit of the voltage range to be monitored is assumed to be 80% of the rated voltage of the protected object.

EXAMPLE:

Rated voltage of the protected object: $V_{rated,\ obj.} = 10\ kV$

Voltage transformer:

$$Ratio_V = \frac{10\ kV/\sqrt{3}}{100\ V/\sqrt{3}}$$

Threshold value: 80 % of $V_{rated,\ obj.}$

The secondary setting value is calculated as follows:

$$V_{Threshold\ value,\ sec} = \frac{0.8 \cdot V_{rated,obj.}}{Ratio_V} = \frac{0.8 \cdot 10\ kV \cdot 100\ V}{10\ kV} = 80\ V$$

[foschwlw-190309-01.tif, 2, en_US]

Parameter: Pickup mode

- Recommended setting value **(_:421:101) Pickup mode** = ***1 out of 3***

With the **Pickup mode** parameter, you specify whether the stage picks up when there is a lower threshold-value violation in one measuring element (***1 out of 3***) or when there is a lower threshold-value violation in all 3 measuring elements (***3 out of 3***).

Parameter Value	Description
1 out of 3	Use this setting for protection applications or for monitoring the voltage range. Siemens recommends ***1 out of 3*** as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Parameter: Pickup delay

- Default setting **(_:421:102) Pickup delay** = ***no***

The **Pickup delay** parameter is only available if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***). If the current-flow criterion is deactivated, no pickup delay is required.

With the parameter **Pickup delay** you set whether pickup of the stage is to be delayed by approximately 40 ms or not. The delay avoids possible brief pickup of the stage when the circuit breaker opens.

Parameter Value	Description
no	Use this setting if you definitely do not want stage pickup to be subject to a time delay in the event of a fault. This setting results in pickup and, where applicable, tripping being performed as quickly as possible. Note that switching procedures (opening of the CB) can result in brief pickup of the stage, depending on the threshold-value settings for undervoltage pickup and the current-flow criterion. To prevent unwanted tripping, you must set a minimum tripping delay of 50 ms.
yes	Use this setting when switching procedures (opening of the CB) are not permitted to result in stage pickup. Note that pickup is delayed by approximately 40 ms. This delay is added to the operate time.

Parameter: Operate delay

- Default **(_:421:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:421:4) Dropout ratio** = ***1.05***

The recommended set value of ***1.05*** is appropriate for most applications. To achieve high-precision measurements, the **Dropout ratio** can be reduced (to 1.02, for example).

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:421:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following two conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see Chapter *9.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.

Parameter Value	Description
no	The protection stage is not blocked.

Parameter: Current-flow criterion

- Recommended setting value **(_:2311:104) Current-flow criterion** = ***on***

Depending on the system, the voltage transformers are arranged either on the supply side or the junction side. These 2 possible voltage transformer locations induce a different behavior of the function after tripping and opening of the circuit breaker:

- If they are located on the supply side, the voltage remains on
- If they are located on the junction side, the voltage is cleared.

Parameter Value	Description
on	If the voltage transformers are located on the junction side, you can use the current-flow criterion to make the pickup fall back when the current falls below a minimum value (parameter **Threshold I>**).
off	Since the voltage is switched off, the pickup of the undervoltage protection stage persists when the current-flow criterion is not used.

Parameter: Threshold I>

- Recommended setting value **(_:2311:101) Threshold I>** = ***0.05 A***

The **Threshold I>** parameter makes it possible to detect when the circuit-breaker is closed. Siemens recommends setting the **Threshold I>** parameter to 5% of the rated current. With a secondary rated transformer current of 1 A, the secondary setting value for **Threshold I>** would be 0.05 A.

If the sensitivity of the **Threshold I>** parameter is set too high, compensation processes in the secondary circuit of the current transformer will extend the dropout time when breaking extremely high currents. To speed up dropout, increase the default setting.

Operation as Supervision Function

If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

6.29.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:104	General:Current-flow criterion		• off • on	on
_:2311:101	General:Threshold I>	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
Definite-T 1				
_:421:1	Definite-T 1:Mode		• off • on • test	off
_:421:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:421:10	Definite-T 1:Blk. by meas.-volt. failure		• no • yes	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:421:9	Definite-T 1:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:421:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:421:101	Definite-T 1:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:421:102	Definite-T 1:Pickup delay		• no • yes	no
_:421:3	Definite-T 1:Threshold		0.300 V to 175.000 V	80.000 V
_:421:4	Definite-T 1:Dropout ratio		1.01 to 1.20	1.05
_:421:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	3.00 s
Definite-T 2				
_:422:1	Definite-T 2:Mode		• off • on • test	off
_:422:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:422:10	Definite-T 2:Blk. by meas.-volt. failure		• no • yes	yes
_:422:9	Definite-T 2:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:422:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:422:101	Definite-T 2:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:422:102	Definite-T 2:Pickup delay		• no • yes	no
_:422:3	Definite-T 2:Threshold		0.300 V to 175.000 V	65.000 V
_:422:4	Definite-T 2:Dropout ratio		1.01 to 1.20	1.05
_:422:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.29.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Current flow-criterion	SPS	I
_:2311:300	General:Current crit. fulf.	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:421:81	Definite-T 1:>Block stage	SPS	I
_:421:54	Definite-T 1:Inactive	SPS	O
_:421:52	Definite-T 1:Behavior	ENS	O
_:421:53	Definite-T 1:Health	ENS	O
_:421:55	Definite-T 1:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:421:300	Definite-T 1:Pickup loop AB	SPS	O
_:421:301	Definite-T 1:Pickup loop BC	SPS	O
_:421:302	Definite-T 1:Pickup loop CA	SPS	O
_:421:56	Definite-T 1:Operate delay expired	ACT	O
_:421:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:422:81	Definite-T 2:>Block stage	SPS	I
_:422:54	Definite-T 2:Inactive	SPS	O
_:422:52	Definite-T 2:Behavior	ENS	O
_:422:53	Definite-T 2:Health	ENS	O
_:422:55	Definite-T 2:Pickup	ACD	O
_:422:300	Definite-T 2:Pickup loop AB	SPS	O
_:422:301	Definite-T 2:Pickup loop BC	SPS	O
_:422:302	Definite-T 2:Pickup loop CA	SPS	O
_:422:56	Definite-T 2:Operate delay expired	ACT	O
_:422:57	Definite-T 2:Operate	ACT	O

6.29.4 Stage with Inverse-Time Characteristic Curve

6.29.4.1 Description

Logic

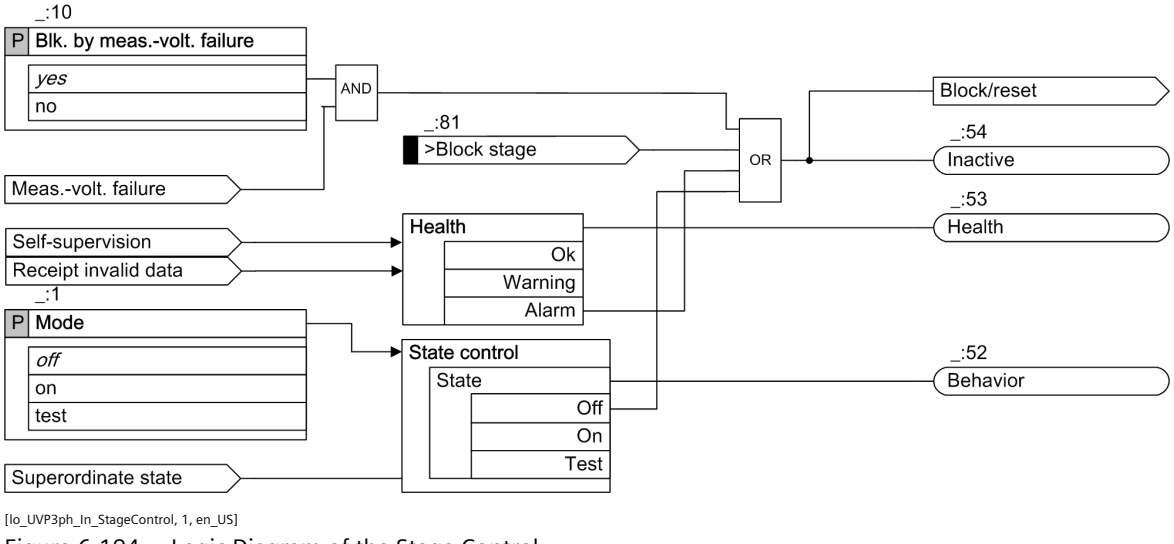
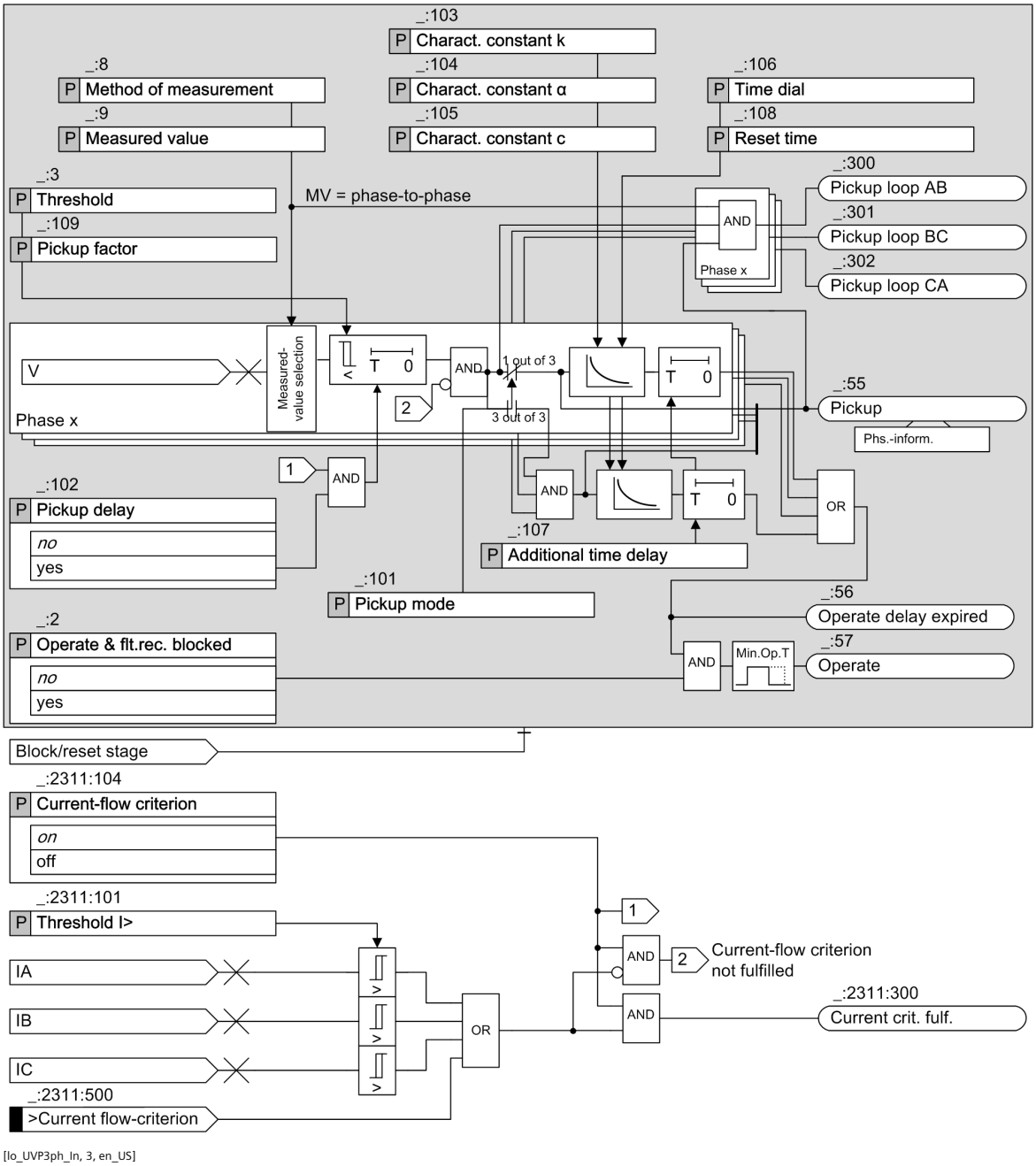


Figure 6-194 Logic Diagram of the Stage Control



[lo_UVP3ph_In, 3, en_US]

Figure 6-195 Logic Diagram of the Function

Method of Measurement

Use the **Method of measurement** parameter to define whether the stage uses the ***fundamental comp.*** or the ***RMS value***.

- Measurement ***fundamental comp.***:

  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

- Measurement ***RMS value***:

  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

Use the **Measured value** parameter to define whether the stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Pickup Mode

Use the **Pickup mode** parameter to define whether the stage picks up when there is a lower threshold-value violation in one measuring element (***1 out of 3***) or when there is a lower threshold-value violation in all 3 measuring elements (***3 out of 3***).

Pickup and Operate Curve

When the input voltage falls below the threshold value by a settable value **Pickup factor**, the stage picks up and the inverse-time characteristic curve is processed. The operate delay starts. The operate delay is the sum of inverse-time delay and additional time delay.

$T_{op}=T_{Inv}+T_{add}$

Where:

T_{op}	Operate delay
T_{Inv}	Inverse-time delay
T_{add}	Additional time delay (Parameter **Additional time delay**)

After pickup the time value T_{Inv} is calculated for every input voltage less than the dropout value. An integrator accumulates the value $1/T_{Inv}$. Once the accumulated integral reaches the fixed value 1, the inverse-time delay expires. The stage operates after the additional time delay.

The inverse-time delay is calculated with the following formula:

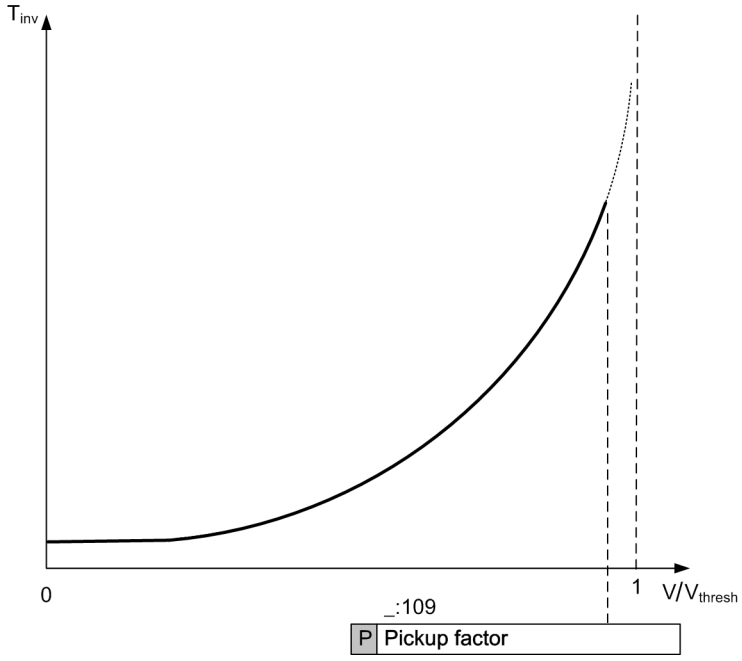
$$T_{Inv} = T_p \left(\frac{k}{1 - \left(\frac{V}{V_{Thresh}} \right)^{\alpha}} + c \right) [s]$$

[fo_UVP3ph_inverse, 2, en_US]

Where

T_{Inv}	Inverse-time delay
T_p	Time multiplier (Parameter **Time dial**)
V	Measured undervoltage
V_{Thresh}	Threshold value (Parameter **Threshold**)
k	Curve constant k (Parameter **Charact. constant k**)
α	Curve constant α (Parameter **Charact. constant α**)
c	Curve constant c (Parameter **Charact. constant c**)

The inverse-time characteristic is shown in the following figure:



[dwUVP3ph_inverse, 1, en_US]

Figure 6-196 Inverse-Time Characteristics for Undervoltage Protection

Pickup Delay

The **Pickup delay** parameter is only available and of relevance if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***).

If the circuit breaker opens when the current-flow criterion is being used, the undervoltage detection and current-flow dropout functions conflict with one another. Depending on the threshold value settings for undervoltage detection and current-flow criterion, it is possible that the undervoltage is detected before the current-flow criterion has dropped out. In this case, the stage picks up briefly. Use the **Pickup delay** parameter to prevent the stage from briefly picking up in this way when the circuit breaker opens. This is achieved by delaying pickup by approximately 40 ms.

Dropout Behavior

When the voltage exceeds the dropout value (1.05 x pickup factor x threshold value), the pickup signal is going and the dropout is started. You can define the dropout behavior via parameter **Reset time**. Instantaneous reset takes place by setting **Reset time** to 0 s. A delayed reset takes place by setting the desired delay time.

During the Reset time (> 0 s), the elapsed operate delay is frozen. If the stage picks up again within this period, the stage operates when the rest of operate delay expires.

Current-Flow Criterion

The undervoltage protection stages work optionally with a current-flow criterion. The **Current-flow criterion** works across all tripping stages.

When the **Current-flow criterion** parameter is activated, the undervoltage-protection stages only pick up if a settable minimum current (**Threshold I>**) is exceeded. A current below the minimum current blocks the stages.

The current-flow criterion can also be set to **fulfilled** with the binary input signal **>Current flow-criterion**. The function reports when the current-flow criterion is fulfilled.

Figure 6-193 illustrates the influence of the current-flow criterion.

NOTE

If the **(_:2311:104) Current-flow criterion** parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked-up stage is reset. The following blocking options are available for the stage:

- Via the binary input signal *>Block stage* from an external or internal source
- From inside on pick up of the **Measuring-voltage failure detection** function (see chapter *9.3.2.1 Overview of Functions*) . The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.29.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:8) Method of measurement** = ***fundamental comp.***

Use the **Method of measurement** parameter to define whether the stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends using this parameter value as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks). Do not set the **threshold value** of the stage under 10 V for this method of measurement.

Parameter: Measured value

- Recommended setting value **(_:9) Measured value** = ***phase-to-phase***

Use the **Measured value** parameter to define whether the stage monitors the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}, or the phase-to-ground voltages V_A, V_B, and V_C.

Parameter Value	Description
phase-to-phase	If you want to detect voltage dips caused by multiphase short circuits, or generally monitor the voltage range, keep phase-to-phase as the default setting. The function will not pick up on ground faults. Siemens recommends the measured value ***phase-to-phase*** as the default setting.
phase-to-ground	Select the ***phase-to-ground*** setting if you want to detect voltage unbalances or overvoltage conditions caused by ground faults.

Parameter: Threshold, Pickup factor

- Default setting **(_:3) Threshold** = ***80.000 V***
- Default setting **(_:109) Pickup factor** = ***0.90***

The stage picks up when the measured voltage value falls below the pickup value **Threshold** × **Pickup factor**.

Depending on the **Measured value**, the **Threshold** is set either as ***phase-to-phase*** quantity or as ***phase-to-ground*** quantity.

With the **Pickup factor**, you modify the pickup value. To avoid a long operate delay time after pickup, Siemens recommends using the default value of **Pickup factor** .

Specify the **Threshold** (pickup threshold) and **Pickup factor** for the specific application.

Parameter: Pickup mode

- Recommended setting value **(_:101) Pickup mode** = ***1 out of 3***

With the **Pickup mode** parameter, you specify whether the stage picks up when there is a lower threshold-value violation in one measuring element (***1 out of 3***) or when there is a lower threshold-value violation in all 3 measuring elements (***3 out of 3***).

Parameter Value	Description
1 out of 3	Use this setting for protection applications or for monitoring the voltage range. Siemens recommends ***1 out of 3*** as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Parameter: Pickup delay

- Default setting **(_:102) Pickup delay** = ***no***

The **Pickup delay** parameter is only available if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***). If the current-flow criterion is deactivated, no pickup delay is required.

With the parameter **Pickup delay**, you set whether pickup of the stage is to be delayed by approximately 40 ms or not. The delay avoids possible brief pickup of the stage when the circuit breaker opens.

Parameter Value	Description
no	Use this setting if you definitely do not want stage pickup to be subject to a time delay in the event of a fault. This setting results in pickup and, where applicable, tripping being performed as quickly as possible. Note that switching procedures (opening of the CB) can result in brief pickup of the stage, depending on the threshold-value settings for under-voltage pickup and the current-flow criterion. To prevent unwanted tripping, you must set a minimum tripping delay of 50 ms.
yes	Use this setting when switching procedures (opening of the CB) are not permitted to result in stage pickup. Note that pickup is delayed by approximately 40 ms. This delay is added to the operate time.

Parameter: Charact. constant k, Charact. constant α, Charact. constant c

- Default setting **(_:103) Charact. constant k** = ***1.00***
- Default setting **(_:104) Charact. constant α** = ***1.000***
- Default setting **(_:105) Charact. constant c** = ***0.000***

With the **Charact. constant k**, **Charact. constant α**, and **Charact. constant c** parameters, you define the required inverse-time characteristic.

Parameter: `Time dial`

- Default setting **`(_:106) Time dial`** = ***`1.00`***

With the **`Time dial`** parameter, you displace the characteristic curve in the time direction.

As usually, there is no time grading for voltage protection and therefore no displacement of the characteristic curve, Siemens recommends leaving the **`Time dial`** parameter at ***`1.00`*** (default setting).

Parameter: `Reset time`

- Default setting **`(_:108) Reset time`** = ***`0.00 s`***

With the **`Reset time`** parameter, you define the reset time delay which is started when the voltage exceeds the dropout value. Set the parameter **`Reset time`** to 0 s when instantaneous reset is desired.

Under network conditions of intermittent faults or faults which occur in rapid succession, Siemens recommends setting the **`Reset time`** to an appropriate value > 0 s to ensure the operation. Otherwise, Siemens recommends to keep the default value to ensure a fast reset of the function.

Parameter: `Additional time delay`

- Default setting **`(_:107) Additional time delay`** = ***`0.00 s`***

With the parameter **`Additional time delay`**, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, only the inverse-time delay is operative.

Parameter: Blk. by meas.-volt. failure

- Default setting **`(_:10) Blk. by meas.-volt. failure`** = ***`yes`***

You use the **`Blk. by meas.-volt. failure`** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following two conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **`>Open`** of the function block **`VTCB`** is connected to the voltage-transformer circuit breaker (see chapter *9.3.4.1 Overview of Functions*).

Parameter Value	Description
`yes`	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
`no`	The protection stage is not blocked.

Parameter: Current-flow criterion

- Recommended setting value **`(_:2311:104) Current-flow criterion`** = ***`on`***

Depending on the system, the voltage transformers are arranged either on the supply side or the junction side. These 2 possible voltage-transformer locations induce a different behavior of the function after tripping and opening of the circuit breaker:

- If they are located on the supply side, the voltage remains on.
- If they are located on the junction side, the voltage is cleared.

Parameter Value	Description
`on`	If the voltage transformers are located on the junction side, you can use the current-flow criterion to make the pickup fall back when the current falls below a minimum value (parameter **`Threshold I>`**).
`off`	Since the voltage is switched off, the pickup of the undervoltage protection stage persists when the current-flow criterion is not used.

6.29.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T #				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:10	Inverse-T #:Blk. by meas.-volt. failure		• no • yes	yes
_:9	Inverse-T #:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:8	Inverse-T #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:101	Inverse-T #:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:102	Inverse-T #:Pickup delay		• no • yes	no
_:3	Inverse-T #:Threshold		0.300 V to 175.000 V	80.000 V
_:109	Inverse-T #:Pickup factor		0.80 to 1.00	0.90
_:103	Inverse-T #:Charact. constant k		0.00 to 300.00	1.00
_:104	Inverse-T #:Charact. constant α		0.010 to 5.000	1.000
_:105	Inverse-T #:Charact. constant c		0.000 to 5.000	0.000
_:106	Inverse-T #:Time dial		0.05 to 15.00	1.00
_:107	Inverse-T #:Additional time delay		0.00 s to 60.00 s	0.00 s
_:108	Inverse-T #:Reset time		0.00 s to 60.00 s	0.00 s

6.29.4.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	Inverse-T #:>Block stage	SPS	I
_:54	Inverse-T #:Inactive	SPS	O
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:55	Inverse-T #:Pickup	ACD	O
_:300	Inverse-T #:Pickup loop AB	SPS	O
_:301	Inverse-T #:Pickup loop BC	SPS	O
_:302	Inverse-T #:Pickup loop CA	SPS	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:57	Inverse-T #:Operate	ACT	O

6.30 Undervoltage Protection with Positive-Sequence Voltage

6.30.1 Overview of Functions

The **Undervoltage protection with positive-sequence voltage** function (ANSI 27) is used to:

- Monitor the permissible voltage range
- Protect equipment (for example, plant components and machines) from damage caused by undervoltage
- Protect motors and generators from inadmissible operating states and a possible loss of stability in the event of voltage dips

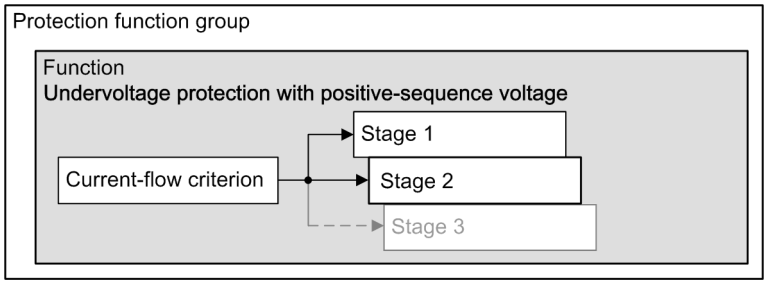
2-phase short circuits or ground faults lead to an unbalanced voltage collapse. In comparison to three 1-phase measuring systems, such events have no noticeable impact on the positive-sequence voltage. This makes this function particularly suitable for the assessment of stability problems.

6.30.2 Structure of the Function

The **Undervoltage protection with positive-sequence voltage** function is used in protection function groups, which are based on voltage measurement.

The **Undervoltage protection with positive-sequence voltage** function comes with 2 factory-set tripping stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The protection function is structured such that one current-flow criterion can act on all undervoltage protection stages (see *Figure 6-197*). If the protection function group used has no current measurement, you can only set the current- flow criterion as **fulfilled** via the corresponding binary input signal.

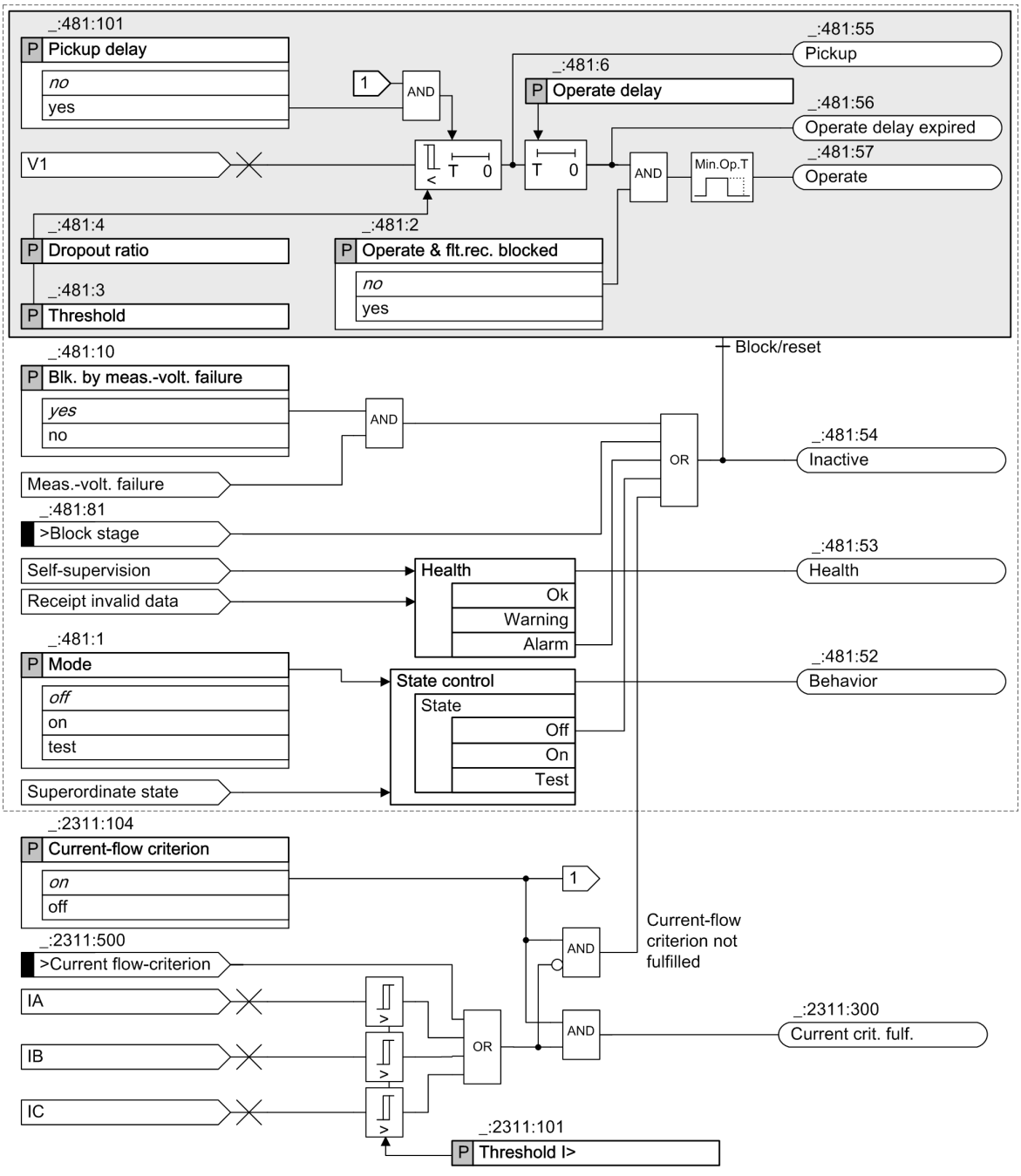


[dwstuvu1-110211-01.tif, 3, en_US]

Figure 6-197 Structure/Embedding of the Function

6.30.3 Stage Description

Logic of a Stage



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Figure 6-198 Logic Diagram of a Stage: Undervoltage Protection with Positive-Sequence Voltage

Method of Measurement

The stage uses the positive-sequence voltage. The positive-sequence voltage is calculated from the measured phase-to-ground voltages according to the defining equation.

Pickup Delay

The **Pickup delay** parameter is only available and of relevance if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***).

If the circuit breaker opens when the current-flow criterion is being used, the undervoltage detection and current-flow dropout functions conflict with one another. Depending on the threshold value settings for undervoltage detection and current-flow criterion, it is possible that the undervoltage is detected before the current-flow criterion has dropped out. In this case, the tripping stage picks up briefly. Use the **Pickup delay** parameter to prevent the tripping stage from briefly picking up in this way when the circuit breaker opens. This is achieved by delaying pickup by approximately 40 ms.

Current-Flow Criterion

The undervoltage-protection stages work optionally with a current-flow criterion. The current-flow criterion works across all stages.

When the **Current-flow criterion** parameter is activated, the undervoltage protection stages only pick up if a settable minimum current (**Threshold I>**) is exceeded in at least one phase. A current below the minimum current blocks the tripping stages.

The current-flow criterion can also be set to **fulfilled** with the binary input signal **>Current flow-criterion**. The function reports when the current-flow criterion is fulfilled.

Figure 6-198 illustrates the influence of the current-flow criterion.

NOTE

If the **Current-flow criterion** parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal *>Block stage* from an external or internal source
- From inside on pickup of the **Measuring-voltage failure detection** function (see chapter *9.3.2.1 Overview of Functions*). The **Blk. by meas.-volt. failure** parameter can be set to either block or not block the tripping stage when the measuring-voltage failure detection picks up.
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker. The **Blk. by meas.-volt. failure** parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.30.4 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:481:3) Threshold** = ***46 V***

Specify the **Threshold** (pickup threshold) for the specific application. For the default setting, it has been assumed that the lower voltage range, that is, 80 % of the rated voltage of the protected object, is to be monitored.

Parameter: Pickup delay

- Default setting **(_:481:101) Pickup delay** = ***no***

The **Pickup delay** parameter is only available if you are using the current-flow criterion of the function (parameter **Current-flow criterion** = ***on***). If the current-flow criterion is deactivated, no pickup delay is required.

With the parameter **Pickup delay** you set whether pickup of the stage is to be delayed by approximately 40 ms or not. The delay avoids possible brief pickup of the stage when the circuit breaker opens.

Parameter Value	Description
no	Use this setting if you definitely do not want tripping-stage pickup to be subject to a time delay in the event of a fault. This setting results in pickup and, where applicable, tripping being performed as quickly as possible. Note that switching procedures (opening of the CB) can result in brief pickup of the tripping stage, depending on the threshold-value settings for undervoltage pickup and the current-flow criterion. To prevent unwanted tripping, you must set a minimum tripping delay of 50 ms.
yes	Use this setting when switching procedures (opening of the CB) are not permitted to result in tripping-stage pickup. Note that pickup is delayed by approximately 40 ms. This delay is added to the operate time.

Parameter: Operate delay

- Default setting **(_:481:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:481:4) Dropout ratio** = ***1.05***

The recommended setting value of 1.05 is sufficient for many applications. To obtain extremely accurate indications, the **Dropout ratio** can be reduced.

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:481:10) Blk. by meas.-volt. failure** = ***yes***

You use the **Blk. by meas.-volt. failure** parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following two conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and switched on.
- The binary input signal **>Open** of the function block **VTCB** is connected to the voltage-transformer circuit breaker (see chapter *9.3.4.1 Overview of Functions*).

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: Current-flow criterion

- Recommended setting value **(_:2311:104) Current-flow criterion** = ***on***

Depending on the system, the voltage transformers can be located on the supply or the outgoing side. These 2 possible voltage transformer locations induce a different behavior of the function after tripping and opening of the circuit breaker:

- If they are located on the supply side, the voltage remains on
- If they are located on the output side, the voltage is switched off

Parameter Value	Description
on	The current-flow criterion allows to achieve, in the case of voltage transformers located on the output side, that the pickup drops out when the current drops below a minimum value (parameter Threshold value I>).

Parameter Value	Description
off	Since the voltage is switched off, the pickup of the undervoltage-protection stage persists when the current-flow criterion is not used.

Parameter: Threshold I>

- Recommended setting value **(_:2311:101) Threshold I>** = ***0.05 A***

The **Threshold I>** parameter makes it possible to detect when the circuit-breaker is closed. We recommend that you set the **Threshold I>** parameter to 5% of the rated current. With a secondary rated transformer current of 1 A, the secondary setting value for **Threshold I>** would be 0.05 A.

If the sensitivity of the **Threshold I>** parameter is set too high, compensation processes in the secondary circuit of the current transformer can extend the dropout time when breaking extremely high currents. To speed up dropout, increase the default setting.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

EXAMPLE of a 2-stage undervoltage protection

The undervoltage protection can be used for the protection of motors within the power plant's own power system. The example describes the possible settings for a two-stage undervoltage-protection function. We will look at the settings of the parameters **Threshold** and **Operate delay**.

1. Stage:

Set the **Threshold** to approx. 80 % of the rated voltage. In the case of voltage dips down to that value, the motors can still start up. Depending on the machine characteristic, the **Threshold** can also be set somewhat lower.

The following data apply:

Rated motor voltage:	$V_{rated,M} = 6\ kV$
Minimum startup voltage:	80 % of rated motor voltage
Voltage-transformer ratio:	$Ratio_V = \frac{6\ kV/\sqrt{3}}{100\ V/\sqrt{3}}$

When setting the threshold value, make sure that the positive-sequence voltage as defined is equal to the value of one phase-to-ground voltage. Taking into account the rated primary voltage of the motor, the primary setting value of the first stage is calculated as follows:

$$V_{prim} = 0.8 \cdot V_{rated,M} = 0.8 \cdot \frac{6\ kV}{\sqrt{3}} = 2.77\ kV$$

[fobglei1-190309-01.tif, 2, en_US]

When setting secondary values, you calculate the secondary setting value as follows, taking into account the voltage-transformer ratio:

$$V_{sec} = \frac{V_{prim}}{Ratio_V} = \frac{2.77\ kV}{6\ kV/\sqrt{3}} \cdot 100\ V/\sqrt{3} = 46.2\ V$$

[fobglei3-190309-01.tif, 2, en_US]

Set a value of 3 s for the **Operate delay**.

2. Stage:

Undervoltage cause excessive torques and current surges which place inadmissible strains on the motor. The voltage at which motors do no longer start up is in the range of (0.55 ... 0.70) $V_{rated,M}$. If no data are available, use the empirical value of approx. 70% of the rated voltage for setting the parameter **Threshold**. Set the **Operate delay** so that it slightly overlaps the tripping time of the overcurrent protection for the power-plant auxiliary power. Unless otherwise required by the motor manufacturer, set a **Operate delay** between 0.5 s and 3 s. The shorter time should be preferred.

Stage	Setting Values	
	Threshold value	Time delay
1	0.70 to 0.85 $V_{rated,M}$ (for example, 0.80 $V_{rated,M}$)	Approx. 3 to 5 s
2	0.55 to 0.70 $V_{rated,M}$ (for example, 0.70 $V_{rated,M}$)	0.5 s to 3 s

6.30.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:104	General:Current-flow criterion		• off • on	on
_:2311:101	General:Threshold I>	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
Stage 1				
_:481:1	Stage 1:Mode		• off • on • test	off
_:481:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:481:10	Stage 1:Blk. by meas.-volt. failure		• no • yes	yes
_:481:101	Stage 1:Pickup delay		• no • yes	no
_:481:3	Stage 1:Threshold		0.300 V to 200.000V	46.000V
_:481:4	Stage 1:Dropout ratio		1.01 to 1.20	1.05
_:481:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:482:1	Stage 2:Mode		• off • on • test	off
_:482:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:482:10	Stage 2:Blk. by meas.-volt. failure		• no • yes	yes
_:482:101	Stage 2:Pickup delay		• no • yes	no
_:482:3	Stage 2:Threshold		0.300 V to 200.000 V	40.000V

Addr.	Parameter	C	Setting Options	Default Setting
_:482:4	Stage 2:Dropout ratio		1.01 to 1.20	1.05
_:482:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.30.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Current flow-criterion	SPS	I
_:2311:300	General:Current crit. fulf.	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:481:81	Stage 1:>Block stage	SPS	I
_:481:54	Stage 1:Inactive	SPS	O
_:481:52	Stage 1:Behavior	ENS	O
_:481:53	Stage 1:Health	ENS	O
_:481:55	Stage 1:Pickup	ACD	O
_:481:56	Stage 1:Operate delay expired	ACT	O
_:481:57	Stage 1:Operate	ACT	O
Stage 2			
_:482:81	Stage 2:>Block stage	SPS	I
_:482:54	Stage 2:Inactive	SPS	O
_:482:52	Stage 2:Behavior	ENS	O
_:482:53	Stage 2:Health	ENS	O
_:482:55	Stage 2:Pickup	ACD	O
_:482:56	Stage 2:Operate delay expired	ACT	O
_:482:57	Stage 2:Operate	ACT	O

6.31 Undervoltage Protection with Any Voltage

6.31.1 Overview of Functions

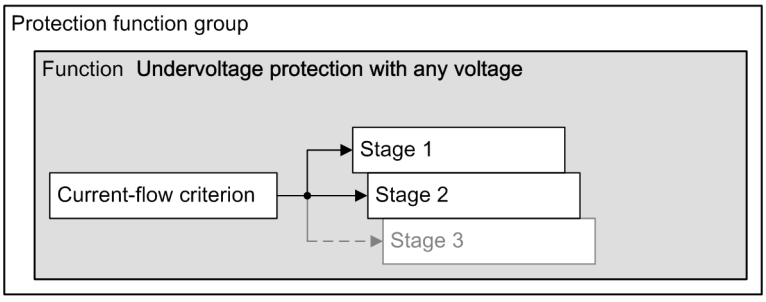
The function **Undervoltage protection with any voltage** (ANSI 27) detects any 1-phase undervoltage and is intended for special applications.

6.31.2 Structure of the Function

The **Undervoltage protection with any voltage** function is used in protection function groups, which are based on voltage measurement.

The function **Undervoltage protection with any voltage** comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The protection function is structured such that one current-flow criterion can act on all undervoltage protection stages (see *Figure 6-199*).

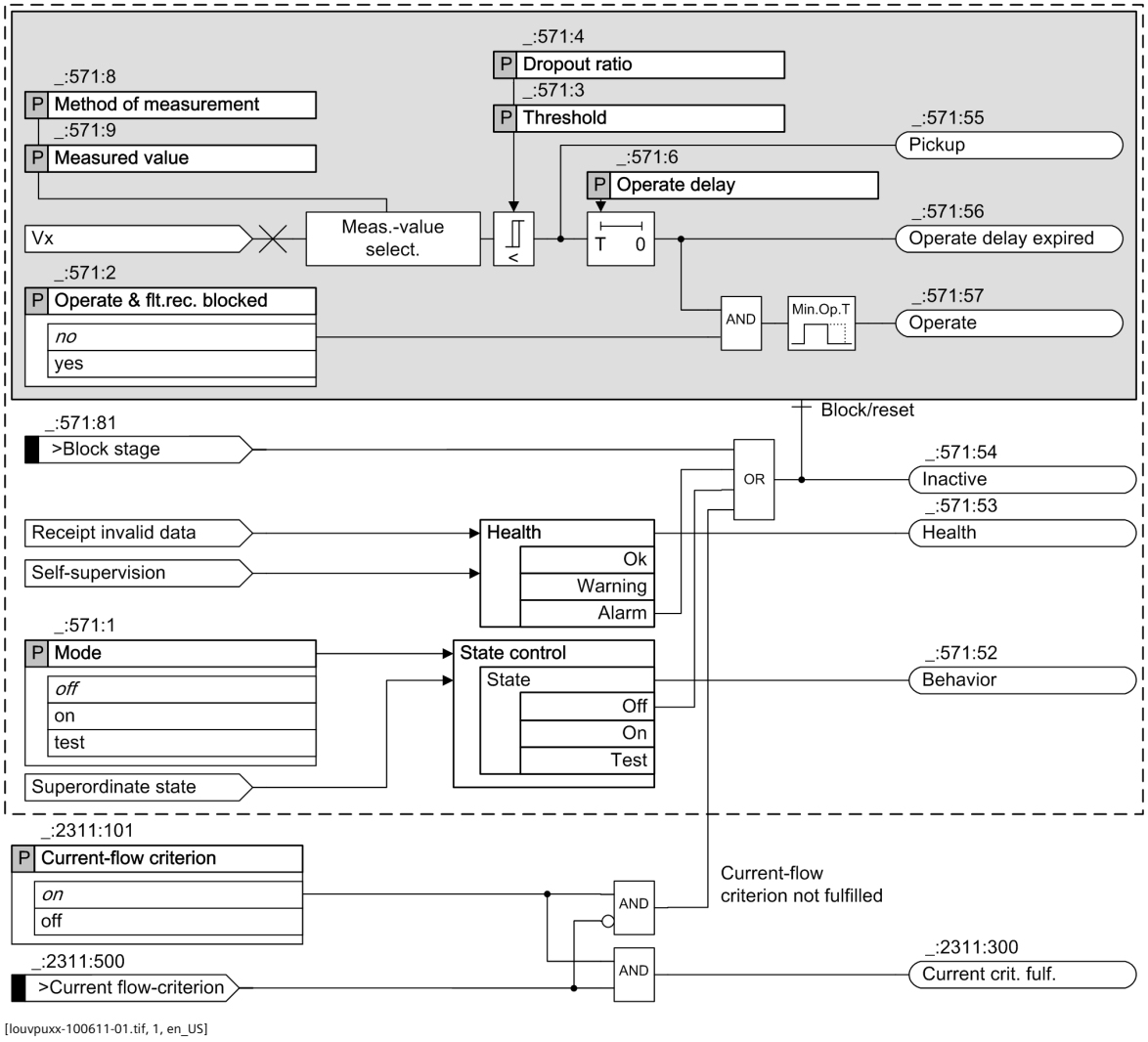


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Figure 6-199 Structure/Embedding of the Function

6.31.3 Stage Description

Logic of a Stage



[louvpuxx-100611-01.tif, 1, en_US]

Figure 6-200 Logic Diagram of a Stage: Undervoltage Protection with Any Voltage

NOTE

If the function is used in 1-phase function groups, the parameter **`Measured value`** is not available.

Method of Measurement

The **`Method of measurement`** parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

- Measurement of the fundamental component:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

The parameter **Measured value** allows you to select whether the stage uses a measured (directly connected) voltage or a calculated phase-to-phase voltage.

If the function is used in 1-phase function groups, the parameter **Measured value** is not available.

Current-Flow Criterion

The undervoltage-protection stages work optionally with a current-flow criterion. The current-flow criterion works across all stages.

When the **Current-flow criterion** parameter is switched on, the undervoltage protection stages only pick up when the current-flow criterion has been set to **fulfilled** via the binary input signal **>Current flow-criterion**. The function reports when the current-flow criterion is fulfilled.

Figure 6-200 illustrates the influence of the current-flow criterion.



NOTE

If the **(_:2311:101) Current-flow criterion** parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking the stage is possible externally or internally via the binary input signal *>Block stage*.

6.31.4 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value **(_:571:8) Method of measurement** = ***fundamental comp.***

Use the **Method of measurement** parameter to define whether the tripping stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends using this parameter value as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks). Do not set the **threshold value** of the tripping stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting **(_:571:9) Measured value** = ***VA measured***

The **Measured value** parameter is used to specify which voltage is monitored by the stage.

The scope of setting options depends on the connection type for the voltage transformers and the routing of the measured values to the terminals of the voltage measuring point. You can find connection examples for voltage transformers in the Appendix.

The following setting options can be available:

- Measured phase-to-ground voltage V_A (***VA measured***)
- Measured phase-to-ground voltage V_B (***VB measured***)
- Measured phase-to-ground voltage V_C ***VC measured***)
- Measured phase-to-phase voltage V_{AB} (***VAB measured***)

- Measured phase-to-phase voltage V_{BC} (***VBC measured***)
- Measured phase-to-phase voltage V_{CA} (***VCA measured***)
- Calculated phase-to-phase voltage V_{AB} (***VAB calculated***)
- Calculated phase-to-phase voltage V_{BC} (***VBC calculated***)
- Calculated phase-to-phase voltage V_{CA} (***VCA calculated***)
- Calculated voltage V0 (***V0 calculated***)

The selection depends on the corresponding application.

NOTE

If the function is used in 1-phase function groups, the parameter **Measured value** is not available.

Parameter: Threshold

- Default setting **(_:571:3) Threshold** = ***80 V***

Specify the **Threshold** (pickup threshold) for the specific application.

Depending on the **Measured value**, the **Threshold** is set either as **measured voltage** or as a **phase-to-phase** variable.

Parameter: Operate delay

- Default setting **(_:571:6) Operate delay** = ***3 s***

The **Operate delay** must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value **(_:571:4) Dropout ratio** = ***1.05***

The recommended set value of ***1.05*** is appropriate for most applications. To achieve high measurement precision, the **Dropout ratio** can be reduced to 1.02, for example.

Parameter: Current-flow criterion

- Recommended setting value **(_:2311:101) Current-flow criterion** = ***on***

Parameter Value	Description
on	Because of the application, it makes sense that the stage is only active (that is, not blocked) when a certain current flow is present (see note).
off	Current flow monitoring does not make sense for the application.

NOTE

Because of the flexible setting options of the voltage measurand, the function itself does not determine the current associated with the voltage. A suitable current-flow monitoring function must be created by the user with the Continuous Function Chart (CFC), and connected to the binary input signal **>Current flow-criterion**.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the **Operate & flt.rec. blocked** parameter.

6.31.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Current-flow criterion		• off • on	on
Stage 1				
_:571:1	Stage 1:Mode		• off • on • test	off
_:571:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:571:9	Stage 1:Measured value		• VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:571:8	Stage 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:571:3	Stage 1:Threshold		0.300 V to 340.000 V	80.000 V
_:571:4	Stage 1:Dropout ratio		1.01 to 1.20	1.05
_:571:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:572:1	Stage 2:Mode		• off • on • test	off
_:572:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:572:9	Stage 2:Measured value		• VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:572:8	Stage 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:572:3	Stage 2:Threshold		0.300 V to 340.000 V	65.000 V
_:572:4	Stage 2:Dropout ratio		1.01 to 1.20	1.05
_:572:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.31.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Current flow-criterion	SPS	I
_:2311:300	General:Current crit. fulf.	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:571:81	Stage 1:>Block stage	SPS	I
_:571:54	Stage 1:Inactive	SPS	O
_:571:52	Stage 1:Behavior	ENS	O
_:571:53	Stage 1:Health	ENS	O
_:571:55	Stage 1:Pickup	ACD	O
_:571:56	Stage 1:Operate delay expired	ACT	O
_:571:57	Stage 1:Operate	ACT	O
Stage 2			
_:572:81	Stage 2:>Block stage	SPS	I
_:572:54	Stage 2:Inactive	SPS	O
_:572:52	Stage 2:Behavior	ENS	O
_:572:53	Stage 2:Health	ENS	O
_:572:55	Stage 2:Pickup	ACD	O
_:572:56	Stage 2:Operate delay expired	ACT	O
_:572:57	Stage 2:Operate	ACT	O

6.32 Overfrequency Protection

6.32.1 Overview of Functions

The **Overfrequency protection** function (ANSI 81O):

- Detect overfrequencies in electrical power systems or machines
- Monitor the frequency band and output failure indications
- Disconnect generating units when the power frequency is critical
- Provide additional turbine protection if the speed limiter fails

Frequency deviations are caused by an unbalance between the active power generated and consumed. Overfrequency is caused by load shedding (island network), power system disconnection or disturbances of the frequency controller. Overfrequency implies a risk of self excitation of machines which are connected to long lines without load.

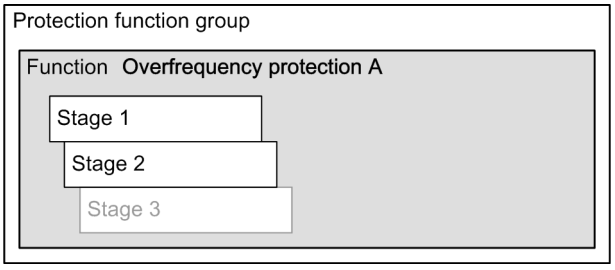
Overfrequency protection is available in two functional configurations (selectable from the DIGSI functions library). The functional configurations differ in the frequency measurement method they use.

6.32.2 Structure of the Function

The **Overfrequency protection** function is used in protection function groups, which are based on voltage measurement.

The overfrequency protection function comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The parameters **`Dropout differential`** and **`Minimum voltage`** are set for all stages.

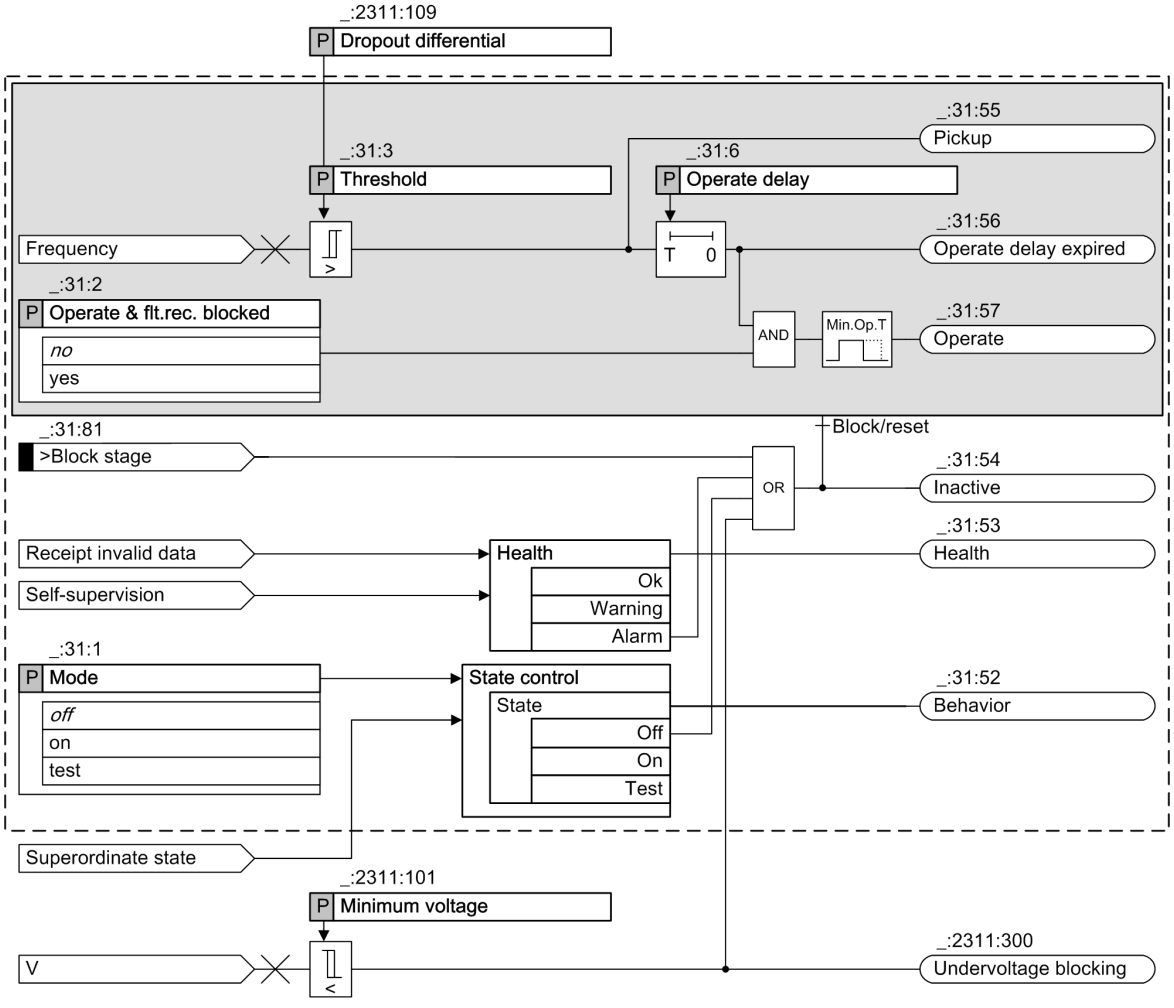


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Figure 6-201 Structure/Embedding of the Function

6.32.3 Overfrequency-Protection Stage

Logic of a Stage



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Figure 6-202 Logic Diagram of the Overfrequency-Protection Stage

Frequency-Measurement Method

Overfrequency protection is available in 2 functional configurations. These work with different frequency-measurement methods. You select the frequency-measurement method in dependence of the application.

- Angle-difference method (method A):

  The angle-difference method determines the phasor of the positive-sequence voltage in multiphase systems. In the case of 1-phase connection, it always processes the phasor of the connected voltage. Since the change of angle of the voltage phasor over a given time interval is proportional to the frequency change, the current frequency can be derived from it.

- Filtering method (method B):

  The filtering method processes the instantaneous voltage values and determines the current frequency using a suitable combination of filters. The frequency-protection function selects automatically the largest voltage as the measurand. In a multiphase connection, the phase-to-phase voltage is always the largest. If in a multiphase connection the selected voltage is no longer available, the function changes over automatically to the next maximum voltage. The function can even operate with just one voltage.

Both methods of measurement are characterized by a high measuring accuracy combined with a short pickup time. Disturbance values such as harmonics, high frequency disturbances, phase-angle jumps during switching operations and compensation processes due to power swings are effectively suppressed.

Functional Measured Value

The angle-difference method provides the following measured value:

Value	Description
f	Calculated frequency with the angle-difference method

Behavior on Leaving the Operating Range

The sampling frequency tracking makes an additional frequency-operating range possible. If the stage has picked up before leaving the frequency-operating range and the measuring voltage is higher than the set minimum voltage, the pickup is maintained. A dropout of the pickup is only possible by means of a blocking.

Blocking the Stage

Blocking will cause a tripping stage that has picked up to dropout. The following blocking options are available for the stage:

- Externally or internally via the logical binary input *>Block stage*
- Internally when the voltage drops below the **Minimum voltage**

6.32.4 Application and Setting Notes

Frequency-Measurement Method

The frequency measurement method is selected with the functional configuration from the DIGSI functions library. The letter at the end of the function name describes the method of measurement.

Redundant solutions can be implemented by combining 2 different methods of frequency measurement. You can implement a **2-out-of-2 decision** by connecting the operate indications of both functions in a CFC with a logical AND gate. This increases the reliability of protection.

Frequency-Measurement Method	Description
Angle difference method (method A)	Select this method of measurement if the frequency protection stage is used for the protection of machines.
Filtering method (method B)	Select this method of measurement if the frequency protection stage is used in an electrical power system.

Parameter: Threshold

- Recommended setting value **(_:31:3) Threshold** = ***50.20 Hz*** for f_{rated} = 50 Hz

The **Threshold** parameter is used to define the pickup threshold of the overfrequency protection stage in dependence of the application. 50.20 Hz is a typical warning threshold in 50-Hz systems.

Parameter: Operate delay

- Recommended setting value **(_:31:6) Operate delay** = ***10 s***

The **Operate delay** parameter is used to set the stage so that overfunctions due to disturbing influences (for example, switching operations) are avoided. Fairly high time delays are sufficient for warning indications.

Parameter: Minimum voltage

- Recommended setting value **(_:2311:101) Minimum voltage** = **37.5 V**

For the **Undervoltage blocking**, 65 % of the protected object's rated voltage is recommended.

When determining the setting value, please keep in mind the measurement method and the measuring connection that you have selected. If you work with the positive-sequence voltage, remember that the maximum voltage is equal to the phase-to-ground voltage. The default setting is referred to this value.

Parameter: Dropout differential

- Recommended setting value **(_:2311:109) Dropout differential** = ***20 mHz***

Due to the high-precision frequency measurement, the recommended setting value for the **Dropout differential** can remain at 20 mHz. If in your application you wish a subsequent dropout of the tripping stage, then increase the setting value of the dropout differential. For instance, if the pickup value (parameter **Threshold**) of the tripping stage is set to 50.20 Hz and the **Dropout differential** to 100 mHz, the stage will drop out at 50.10 Hz.

Application example of the overfrequency protection

Overfrequency protection can be used for monitoring the frequency range. If the frequency deviates from the rated frequency by for example, 0.2 Hz, a fault indication is generated. The trip command is delayed to avoid overfunction due to disturbing influences (for example, switching operations). A delay of a few seconds (for example, 10 s) is deemed to be a good value. You can leave the **Dropout differential** at the default value of ***20 mHz***. The following table shows a setting recommendation.

For this application, 1 stage of the overfrequency protection is used. The following table shows a setting suggestion.

Stage	Caused by	Setting Values		
		At f_{rated} = 50 Hz	At f_{rated} = 60 Hz	Delay
f1>	Warning	50.20 Hz	60.20 Hz	10.00
f2>	Not used (OFF)	-	-	-

NOTE

This table shows one example of a possible frequency protection setting. The setting values can differ depending on the application.

6.32.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Minimum voltage		3.000 V to 175.000 V	37.500 V
_:2311:109	General:Dropout differential		20 mHz to 2000 mHz	20 mHz
Stage 1				
_:31:1	Stage 1:Mode		• off • on • test	off
_:31:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:31:3	Stage 1:Threshold		40.00 Hz to 70.00 Hz	51.50 Hz
_:31:6	Stage 1:Operate delay		0.00 s to 600.00 s	10.00 s
Stage 2				
_:32:1	Stage 2:Mode		• off • on • test	off
_:32:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:32:3	Stage 2:Threshold		40.00 Hz to 70.00 Hz	54.00 Hz

Addr.	Parameter	C	Setting Options	Default Setting
_:32:6	Stage 2:Operate delay		0.00 s to 600.00 s	5.00 s

6.32.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
_:2311:301	General:f	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:31:81	Stage 1:>Block stage	SPS	I
_:31:54	Stage 1:Inactive	SPS	O
_:31:52	Stage 1:Behavior	ENS	O
_:31:53	Stage 1:Health	ENS	O
_:31:55	Stage 1:Pickup	ACD	O
_:31:56	Stage 1:Operate delay expired	ACT	O
_:31:57	Stage 1:Operate	ACT	O
Stage 2			
_:32:81	Stage 2:>Block stage	SPS	I
_:32:54	Stage 2:Inactive	SPS	O
_:32:52	Stage 2:Behavior	ENS	O
_:32:53	Stage 2:Health	ENS	O
_:32:55	Stage 2:Pickup	ACD	O
_:32:56	Stage 2:Operate delay expired	ACT	O
_:32:57	Stage 2:Operate	ACT	O

6.33 Underfrequency Protection

6.33.1 Overview of Functions

The **Underfrequency protection** function (ANSI 81U) is used to:

- Detect underfrequencies in electrical power systems or machines
- Monitor the frequency band and output failure indications
- Decouple power systems
- Load shedding to ensure power system stability and protect motors
- Disconnect generating units when the power system frequency is critical (for example, $f < 0.95\ f_{rated}$)

Frequency deviations are caused by an unbalance between the active power generated and consumed. Underfrequency is caused by an increase of the consumers' active power demand or by a decrease of the power generated. These conditions occur in the case of power system disconnection, generator failure, or disturbances of the power and frequency controller.

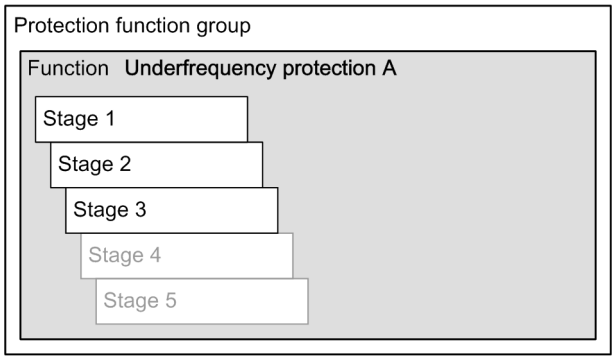
Underfrequency protection is available in 2 functional configurations (selectable from the DIGSI functions library). The functional configurations differ in the frequency measurement method they use.

6.33.2 Structure of the Function

The **Underfrequency protection** function is used in protection function groups, which are based on voltage measurement.

The **Underfrequency protection** function comes with 3 factory-set stages. A maximum of 5 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The parameters **`Dropout differential`** and **`Minimum voltage`** are set for all stages.

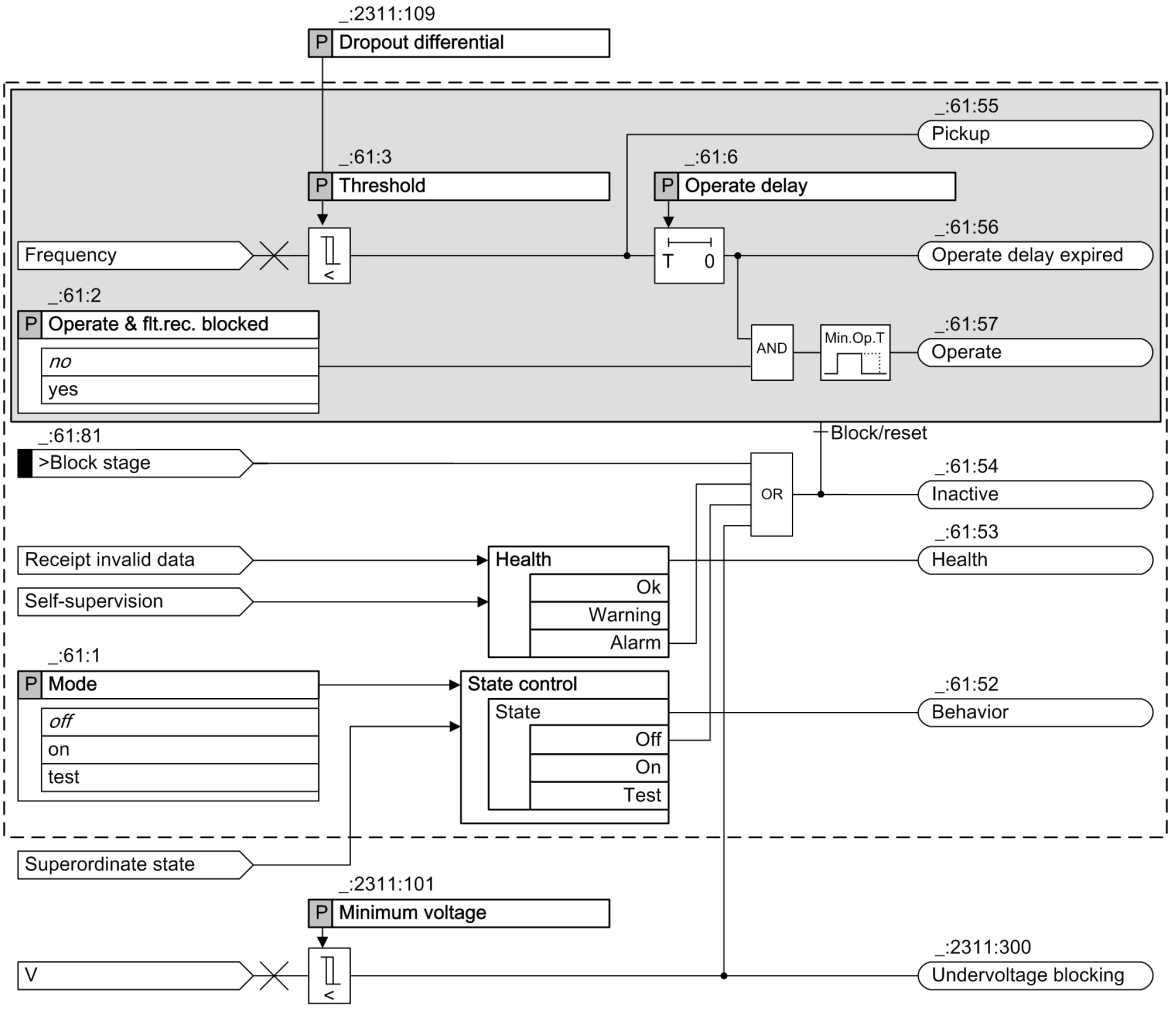


[dwstufqp-090211-01.tif, 1, en_US]

Figure 6-203 Structure/Embedding of the Function

6.33.3 Underfrequency-Protection Stage

Logic of a Stage



[lostufqp-040411-01.tif, 2, en_US]

Figure 6-204 Logic Diagram of the Underfrequency-Protection Stage

Frequency-Measurement Method

Underfrequency protection is available in 2 functional configurations. These work with different frequency-measurement methods. You select the frequency-measurement method in dependence of the application.

- Angle-difference method (method A):

  The angle-difference method determines the phasor of the positive-sequence voltage in multiphase systems. In the case of 1-phase connection, it always processes the phasor of the connected voltage. Since the change of angle of the voltage phasor over a given time interval is proportional to the frequency change, the current frequency can be derived from it.

- Filtering method (method B):

  The filtering method processes the instantaneous voltage values and determines the current frequency using a suitable combination of filters. The frequency-protection function selects automatically the largest voltage as the measurand. In a multiphase connection, the phase-to-phase voltage is always the largest. If in a multiphase connection the selected voltage is no longer available, the function changes over automatically to the next maximum voltage. The function can even operate with just one voltage.

Both methods of measurement are characterized by a high measuring accuracy combined with a short response time. Disturbance values such as harmonics, high frequency disturbances, phase-angle jumps during switching operations and compensation processes due to power swings are effectively suppressed.

Behavior on Leaving the Operating Range

The sampling frequency tracking makes an additional frequency-operating range possible. If the stage has picked up before leaving the frequency-operating range and the measuring voltage is higher than the set minimum voltage, the pickup is maintained. A dropout of the pickup is only possible by means of a blocking.

Blocking the Stage

Blocking will cause a tripping stage that has picked up to dropout. The following blocking options are available for the stage:

- Via the binary input signal *>Block stage* from an external or internal source
- Internally when the voltage drops below the **Minimum voltage**

6.33.4 Application and Setting Notes

Frequency-Measurement Method

The frequency measurement method is selected with the functional configuration from the DIGSI functions library. The letter at the end of the function name describes the method of measurement.

Redundant solutions can be implemented by combining 2 different methods of frequency measurement. You can implement a **2-out-of-2 decision** by connecting the operate indications of both functions in a CFC with a logical AND gate. This increases the reliability of protection.

Method of Measurement	Description
Angle difference method (method A)	Select this method of measurement if the frequency protection stage is used for the protection of machines.
Filtering method (method B)	Select this method of measurement if the frequency protection stage is used in an electrical power system.

Parameter: Threshold

- Recommended setting value **(_:61:3) Threshold** = ***49.80 Hz*** for f_{rated} = 50 Hz

The **Threshold** parameter is used to define the pickup threshold of the underfrequency protection stage in dependence of the application. 49.8 Hz is a typical warning threshold in 50-Hz systems.

Parameter: Operate delay

- Recommended setting value **(_:61:6) Operate delay** = ***10.00 s***

The **Operate delay** parameter is used to set the stage so that overfunctions due to disturbing influences (for example, switching operations) are avoided. Fairly high time delays are sufficient for warning indications.

Parameter: Minimum voltage

- Recommended setting value **(_:2311:101) Minimum voltage** = **37 500 V**

For the **Undervoltage blocking**, 65 % of the protected object's rated voltage is recommended.

When determining the setting value, please keep in mind the measurement method and the measuring connection that you have selected. If you work with the positive-sequence voltage, remember that the maximum voltage is equal to the phase-to-ground voltage. The default setting is referred to this value.

Parameter: Dropout differential

- Recommended setting value **(_:2311:109) Dropout differential** = ***20 mHz***

Due to the high-precision frequency measurement, the recommended setting value for the **Dropout differential** can remain at 20 mHz. If in your application you wish a subsequent dropout of the tripping stage, then increase the setting value of the dropout differential. For instance, if the pickup value (parameter **Threshold**) of the tripping stage is set to 49.8 Hz and the **Dropout differential** to 100 mHz, the stage will drop out at 49.9 Hz.

Application example of the underfrequency protection

Frequency protection can be used for load shedding. The UCTE has defined a 5-stage plan for the Western European power grid. The setting values of the stages are based on that plan (see table below).

Table 6-16 Stage Plan

Frequency	Activity
49.80 Hz	Alarm and activation of reserves following an established plan
49.00 Hz	Undelayed disconnection of 10 % to 15 % of the power system load
48.70 Hz	Undelayed disconnection of another 10 % to 15 % of the power system load
48.40 Hz	3rd load shedding stage. Another 15 % to 20 % of the power system load is disconnected.
47.50 Hz	Power plants are decoupled from the electrical power system

For this application, 3 stages of the underfrequency protection are used. 2 of these stages are used for load shedding. The following table shows a setting suggestion.

Stage	Caused by	Setting Values		
		At f_{rated} = 50 Hz	At f_{rated} = 60 Hz	Delay
f1<	Warning	49.80 Hz	59.80 Hz	10.00
f2<	1st load shedding	49.00 Hz	59.00 Hz	0.00
f3<	2nd load shedding	48.70 Hz	58.70 Hz	0.00

NOTE

This table shows one example of a possible frequency protection setting. The setting values can differ depending on the application.

6.33.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Minimum voltage		3.000 V to 175.000 V	37.500 V
_:2311:109	General:Dropout differential		20 mHz to 2000 mHz	20 mHz
Stage 1				
_:61:1	Stage 1:Mode		• off • on • test	off
_:61:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:61:3	Stage 1:Threshold		40.00 Hz to 70.00 Hz	49.80 Hz
_:61:6	Stage 1:Operate delay		0.00 s to 600.00 s	10.00 s
Stage 2				
_:62:1	Stage 2:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:62:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:62:3	Stage 2:Threshold		40.00 Hz to 70.00 Hz	47.50 Hz
_:62:6	Stage 2:Operate delay		0.00 s to 600.00 s	10.00 s
Stage 3				
_:63:1	Stage 3:Mode		• off • on • test	off
_:63:2	Stage 3:Operate & flt.rec. blocked		• no • yes	no
_:63:3	Stage 3:Threshold		40.00 Hz to 70.00 Hz	47.00 Hz
_:63:6	Stage 3:Operate delay		0.00 s to 600.00 s	10.00 s

6.33.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:61:81	Stage 1:>Block stage	SPS	I
_:61:54	Stage 1:Inactive	SPS	O
_:61:52	Stage 1:Behavior	ENS	O
_:61:53	Stage 1:Health	ENS	O
_:61:55	Stage 1:Pickup	ACD	O
_:61:56	Stage 1:Operate delay expired	ACT	O
_:61:57	Stage 1:Operate	ACT	O
Stage 2			
_:62:81	Stage 2:>Block stage	SPS	I
_:62:54	Stage 2:Inactive	SPS	O
_:62:52	Stage 2:Behavior	ENS	O
_:62:53	Stage 2:Health	ENS	O
_:62:55	Stage 2:Pickup	ACD	O
_:62:56	Stage 2:Operate delay expired	ACT	O
_:62:57	Stage 2:Operate	ACT	O
Stage 3			
_:63:81	Stage 3:>Block stage	SPS	I
_:63:54	Stage 3:Inactive	SPS	O
_:63:52	Stage 3:Behavior	ENS	O
_:63:53	Stage 3:Health	ENS	O
_:63:55	Stage 3:Pickup	ACD	O
_:63:56	Stage 3:Operate delay expired	ACT	O
_:63:57	Stage 3:Operate	ACT	O

6.34 Rate of Frequency Change Protection

6.34.1 Overview of Functions

The function **Rate of frequency change protection** is used to:

- Detect a frequency change quickly
- Prevent the system from not secure states caused by unbalance between the generated and consumed active power
- Network decoupling
- Load shedding

6.34.2 Structure of the Function

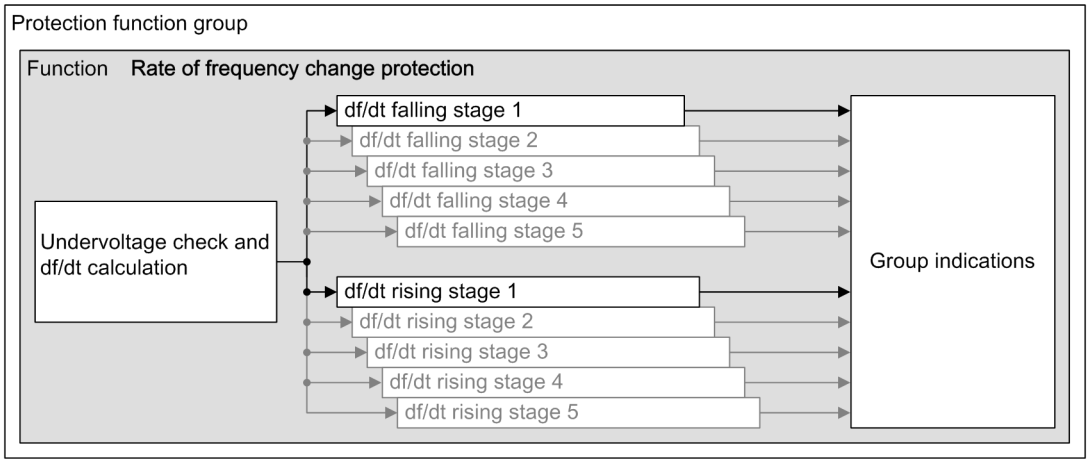
The function **Rate of frequency change protection** can be used in protection function groups containing a 3-phase voltage measurement.

2 function block types are available:

- **df/dt rising**
- **df/dt falling**

The function **Rate of frequency change protection** is preconfigured by the manufacturer with 1 df/dt rising stage and 1 df/dt falling stage. A maximum of 5 df/dt rising stages and 5 df/dt falling stages can operate simultaneously within the function. Both of the function block types are similar in structure.

Undervoltage check and df/dt calculation are general functionalities and take place on the function level. All stages use these general functionalities.



[dwdfdt01-160113-01.tif, 1, en_US]

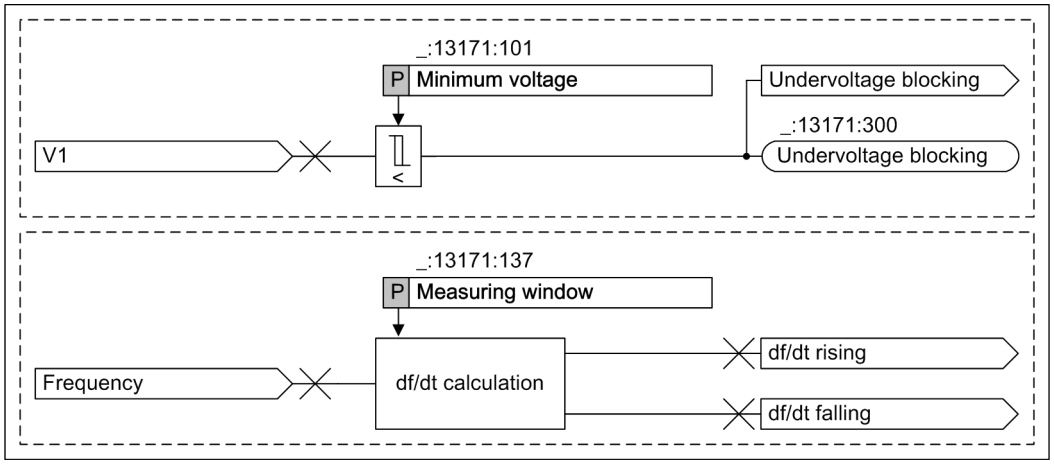
Figure 6-205 Structure/Embedding of the Function

6.34.3 General Functions (Undervoltage Test, df/dt Calculation)

6.34.3.1 Description

Logic

The following figure represents the logic of undervoltage check and df/dt calculation. It applies to all types of stages.



[lodfdtgf-160113-01.tif, 1, en_US]

Figure 6-206 Logic Diagram of General Functionality

Measurand

This function uses the frequency calculated via the angle difference algorithm.

For more information, refer to chapter *6.32.3 Overfrequency-Protection Stage* .

The frequency difference is calculated over a settable time interval (default setting: 5 periods).

The ratio between the frequency difference and the time difference reflects the frequency change which can be positive or negative.

A stabilization counter works to avoid overfunction. This counter is increased if the set threshold value is exceeded. If the value drops below the threshold value, the counter is reset immediately. The counter is set to 8 internally and is activated at each half system cycle.

Undervoltage Blocking

If the measuring voltage drops below the **`Minimum voltage`**, the **Rate of frequency change protection** is blocked because precise frequency values cannot be calculated anymore.

Functional Measured Value

Value	Description
df/dt	Calculated rate of frequency change

6.34.3.2 Application and Setting Notes

Parameter: `Minimum voltage`

- Recommended setting value **`(_:13171:101) Minimum voltage`** = ***`37.500 V`***

For the **Undervoltage blocking**, 65 % of the rated voltage of the protected object is recommended.

The method of measurement uses the phasor of the positive-sequence voltage. When determining the setting value, keep in mind that the absolute value of the sound positive-sequence voltage is equal to the absolute value of the phase-to-ground voltage. The default setting is referred to this value.

Parameter: `Measuring window`

- Default setting **`(_:13171:137) Measuring window`** = ***`5 periods`***

You can use the **`Measuring window`** parameter to optimize the measuring accuracy or the pickup time of the function. For information regarding pickup time and measuring accuracy, refer to the technical data.

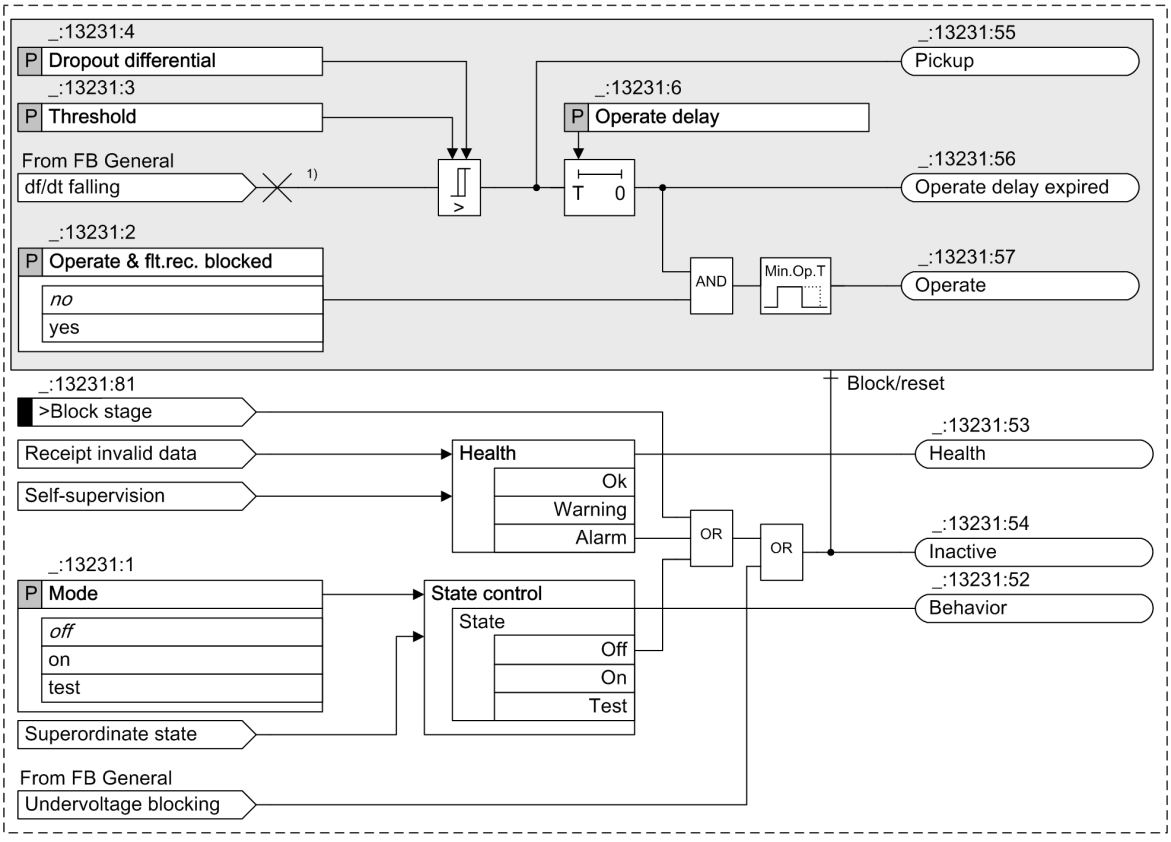
The default setting provides maximum measuring accuracy. If you do not have specific requirements for a decreased pickup time, Siemens recommends using the default setting.

The default setting is a reasonable compromise between measuring accuracy and pickup time. For a non-sensitive setting (high threshold value), you can set the parameter **`Measuring window`** to a smaller value.

6.34.4 Stage Description

6.34.4.1 Description

Logic of the Stage



[lodfdtst-160113-01.tif, 1, en_US]

Figure 6-207 Logic Diagram of Rate of Frequency Change Protection

(1) For the stage type **df/dt rising**, the value **df/dt rising** is used.

Frequency Rising/Falling

The stage **df/dt falling** is used to detect frequency falling and the stage **df/dt rising** is used to detect frequency rising.

You set the threshold value as an absolute value. You define the frequency-change direction via the selected stage type.

Blocking of the Stage

The following blockings reset the picked up stage completely:

- Via the binary input signal *`>Block stage`*
- Via the undervoltage blocking when the voltage drops below the **`Minimum voltage`**

6.34.4.2 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:13231:3) Threshold** = ***3.0 Hz/s***

The pickup value depends on the application and is determined by power-system conditions. In most cases, a network analysis will be necessary. A sudden disconnection of loads leads to a surplus of active power. The frequency rises and causes a positive frequency change. On the other hand, a failure of generators leads to a deficit of active power. The frequency drops and results in a negative frequency change.

The following relations can be used as an example for estimation. They apply for the change rate at the beginning of a frequency change (approximate 1 s).

$$\frac{df}{dt} = -\frac{f_{rated}}{2H} \cdot \frac{\Delta P}{S_{rated}}$$

Where:

f_{rated}	Rated frequency
ΔP	Active power change $\Delta P = P_{Consumption} - P_{Generation}$
S_{rated}	Rated apparent power of the machines
H	Inertia constant

Typical data for H:

For hydro generators (salient-pole machines)	H = 1.5 s to 6 s
For turbine-driven generators (non-salient pole rotors)	H = 2 s to 10 s
For industrial turbine-driven generators	H = 3 s to 4 s

EXAMPLE

f_{rated} = 50 Hz

H = 3 s

Case 1: $\Delta P/S_{rated}$ = 0.12

Case 2: $\Delta P/S_{rated}$ = 0.48

Case 1: df/dt = -1 Hz/s

Case 2: df/dt = -4 Hz/s

Parameter: Operate delay

- Default setting **(_:13231:6) Operate delay** = ***1.00 s***

You can use the **Operate delay** parameter to avoid overfunction due to disturbing influences (for example, switching operations). If the protection function is supposed to respond quickly, set the **Operate delay** parameter to 0 s.

For monitoring small changes (< 1 Hz/s), a small time delay is useful to avoid overfunctioning.

Parameter: Dropout differential

- Recommended setting value **(_:13231:4) Dropout differential** = ***0.10 Hz/s***

You can use the **Dropout differential** parameter to define the dropout value. The recommended value is ***0.10 Hz/s***.

NOTE

In case of power-system incidents, especially in case of transmission incidents and influence of voltage-stabilizing measures via power-electronic components (reactive-power compensation through SVC), the magnitude and the phase angle of the voltage can change. Sensitive settings can lead to overfunction. Therefore, it is reasonable to block the **Rate of Frequency Change Protection** if other protection functions, for example, residual voltage or negative-sequence voltage, pick up. To do this, use the blocking input *>Block stage* and connect it via CFC.

6.34.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:13171:101	General:Minimum voltage		3.000 V to 175.000 V	37.500 V
_:13171:137	General:Measuring window		2 periods to 5 periods	5 periods
df/dt falling1				
_:13231:1	df/dt falling1:Mode		• off • on • test	off
_:13231:2	df/dt falling1:Operate & flt.rec. blocked		• no • yes	no
_:13231:3	df/dt falling1:Threshold		0.1 Hz/s to 20.0 Hz/s	3.0 Hz/s
_:13231:4	df/dt falling1:Dropout differential		0.02 Hz/s to 0.99 Hz/s	0.10 Hz/s
_:13231:6	df/dt falling1:Operate delay		0.00 s to 60.00 s	1.00 s
df/dt rising1				
_:13201:1	df/dt rising1:Mode		• off • on • test	off
_:13201:2	df/dt rising1:Operate & flt.rec. blocked		• no • yes	no
_:13201:3	df/dt rising1:Threshold		0.1 Hz/s to 20.0 Hz/s	3.0 Hz/s
_:13201:4	df/dt rising1:Dropout differential		0.02 Hz/s to 0.99 Hz/s	0.10 Hz/s
_:13201:6	df/dt rising1:Operate delay		0.00 s to 60.00 s	1.00 s

6.34.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:13171:300	General:Undervoltage blocking	SPS	O
_:13171:301	General:df/dt	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
df/dt falling1			
_:13231:81	df/dt falling1:>Block stage	SPS	I
_:13231:54	df/dt falling1:Inactive	SPS	O
_:13231:52	df/dt falling1:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:13231:53	df/dt falling1:Health	ENS	O
_:13231:55	df/dt falling1:Pickup	ACD	O
_:13231:56	df/dt falling1:Operate delay expired	ACT	O
_:13231:57	df/dt falling1:Operate	ACT	O
df/dt rising1			
_:13201:81	df/dt rising1:>Block stage	SPS	I
_:13201:54	df/dt rising1:Inactive	SPS	O
_:13201:52	df/dt rising1:Behavior	ENS	O
_:13201:53	df/dt rising1:Health	ENS	O
_:13201:55	df/dt rising1:Pickup	ACD	O
_:13201:56	df/dt rising1:Operate delay expired	ACT	O
_:13201:57	df/dt rising1:Operate	ACT	O

6.35 Power Protection (P,Q), 3-Phase

6.35.1 Overview of Functions

The **3-phase power protection (P, Q)** function (ANSI 32) is used to:

- Detect whether the active or reactive power rises above or drops below a set threshold
- Monitor agreed power limits and output warning indications
- Detect both active and reactive power feedback in the power systems or on electric machines
- Detect machines (motors, generators) running without load and output an indication to shut them down.
- Be integrated into any automation solution, for example, to monitor very specific power limits (further logical processing in CFC)

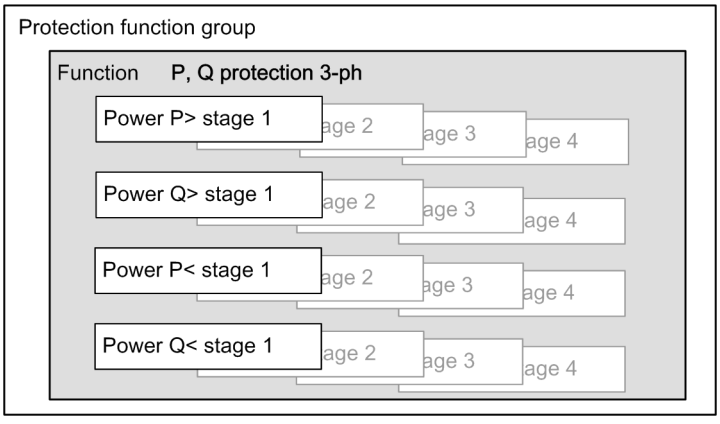
6.35.2 Structure of the Function

The **3-phase power protection (P, Q)** function can be integrated in function groups, which provide measured voltages and currents of the 3-phases for calculation of the power.

The **3-phase power protection (P,Q)** function comes with one factory-set stage each for the active and the reactive power. The following stages are preconfigured:

- Power P>
- Power Q>
- Power P<
- Power Q<

A maximum of 4 active power stages and 4 reactive power stages can be operated simultaneously in the function. The tripping stages have an identical structure.

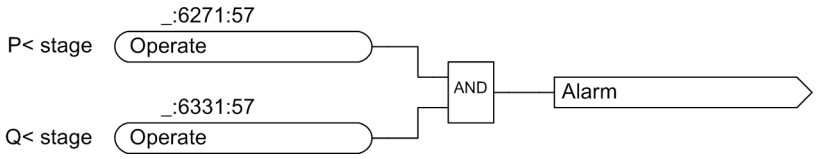


[dwstpq3p-110211-01.tif, 1, en_US]

Figure 6-208 Structure/Embedding of the Function

Logical Combination of Output Signals

The operate indications of the active and reactive power stage(s) can be logically combined in CFC. When an operate indication is present in both the active and the reactive power stage, an alarm indication is generated.

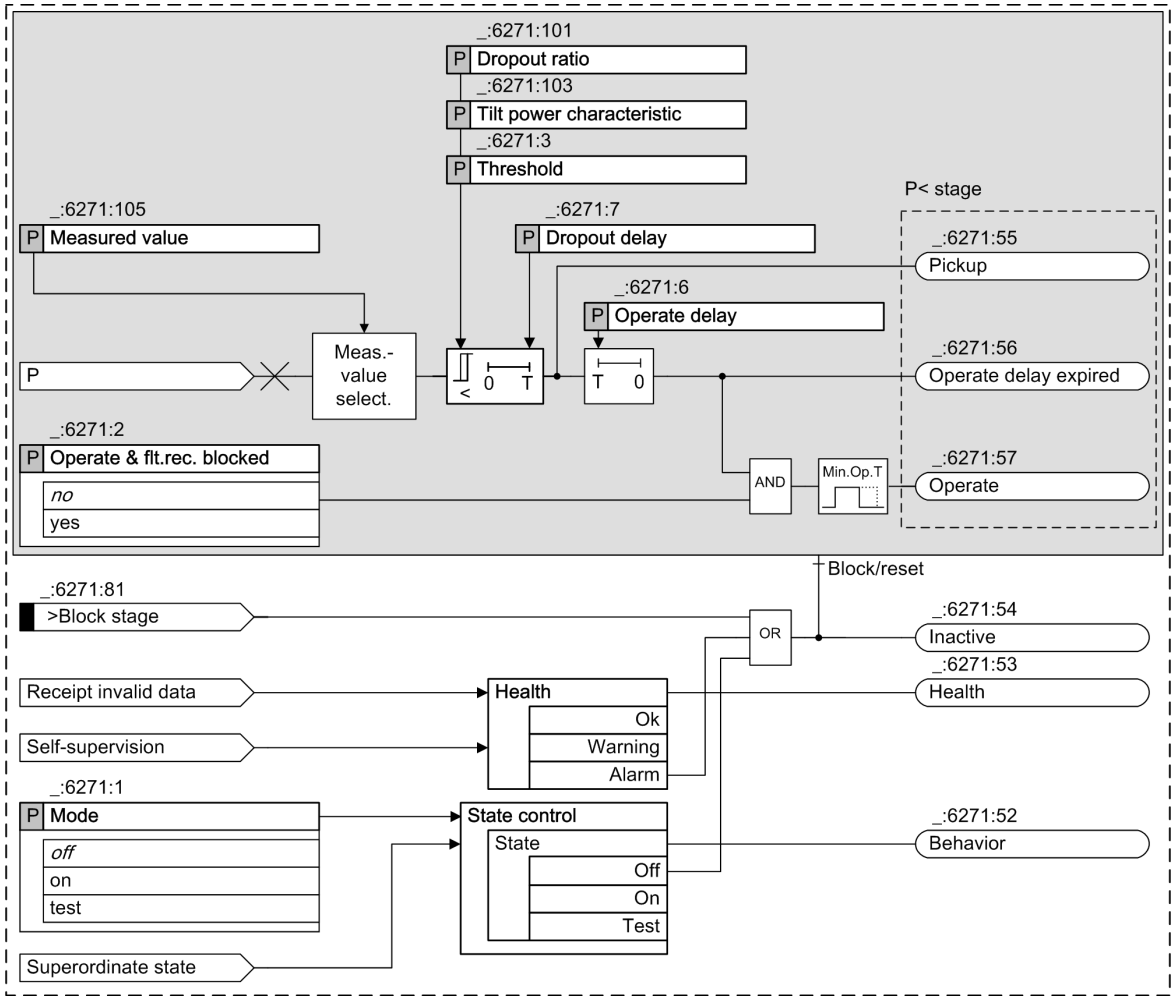


[loausmel-050411-01.tif, 1, en_US]

Figure 6-209 Logical Combination of Operate Indications in CFC

6.35.3 Active Power Stage

Logic of a Stage



[lop3phas-040411-01.tif, 1, en_US]

Figure 6-210 Logic Diagram of the Active Power Stage (Stage Type: Power P<)

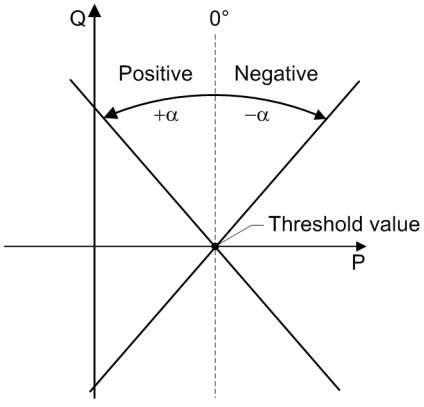
Measured Value

The **Measured value** parameter is used to specify which measured power value is analyzed by the tripping stage. Possible settings are ***positive seq. power*** and the phase-selective powers ***power of phase A***, ***power of phase B*** or ***power of phase C***.

Pickup Characteristic

With the stage type you specify if the stage work as a **greater stage** (stage type: **Power P>**) or as a **smaller stage** (stage type: **Power P<**).

The **Threshold** parameter is used to define the pickup threshold of the stage. The **Tilt power characteristic** parameter is used to define the tilt of the pickup characteristic. The figure below shows the definition of the signs.



[dwdvzpgr-100611-01.tif, 1, en_US]

Figure 6-211 Tilt-Power Characteristic

Pickup

The stage compares the selected power value with the set **Threshold**. Depending on the stage type (**Power P>** or **Power P<**) being above or falling below the threshold value will lead to a pickup.

Dropout Delay

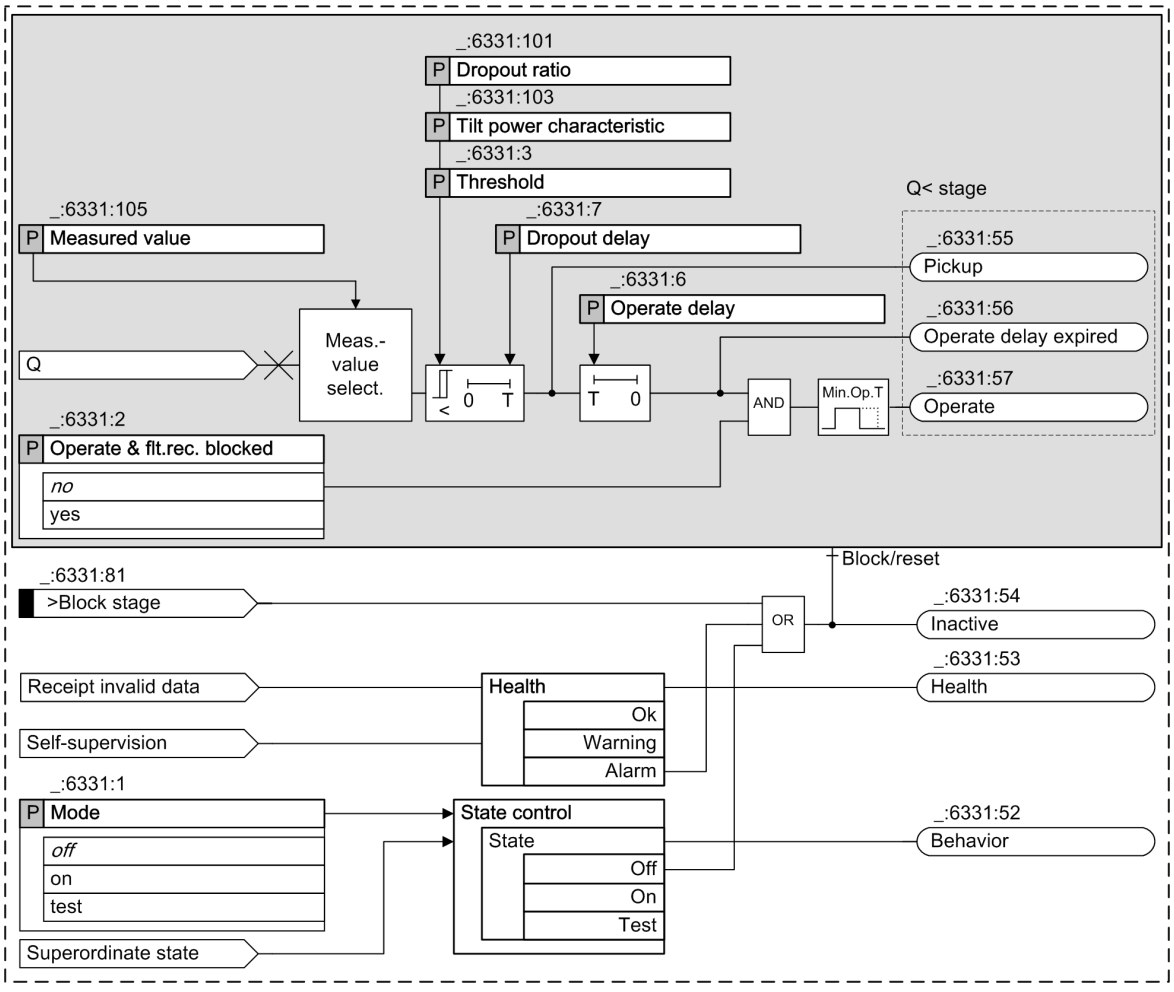
A delay can be set for the dropout when the measured value falls below the dropout threshold. The pickup is maintained for the specified time. The time delay of the tripping (parameter **Operate delay**) continues to run. Once the **Operate delay** has elapsed, the stage trips.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking the stage is possible externally or internally via the binary input signal *>Block stage*.

6.35.4 Reactive Power Stage

Logic of a Stage



[loq3phas-040411-01.tif, 1, en_US]

Figure 6-212 Logic Diagram of the Reactive Power Stage (Stage Type: Power Q<)

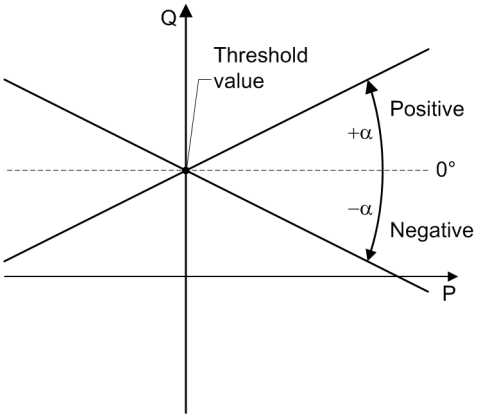
Measured Value

The **Measured value** parameter is used to specify which measured power value is processed by the tripping stage. Possible settings are ***positive seq. power*** and the phase-selective powers ***power of phase A***, ***power of phase B*** or ***power of phase C***.

Pickup Characteristic

With the stage type you specify if the stage work as a **greater stage** (stage type: **Power Q>**) or as a **smaller stage** (stage type: **Power Q<**).

The **Threshold** parameter is used to define the pickup threshold of the stage. The **Tilt power characteristic** parameter is used to define the tilt of the pickup characteristic. The figure below shows the definition of the signs.



[dwdvzqgr-100611-01.tif, 1, en_US]

Figure 6-213 Tilt-Power Characteristic

Pickup

The stage compares the selected power value with the set **Threshold**. Depending on the stage type (**Power Q>** or **Power Q<**) being above or falling below the threshold value will lead to a pickup.

Dropout Delay

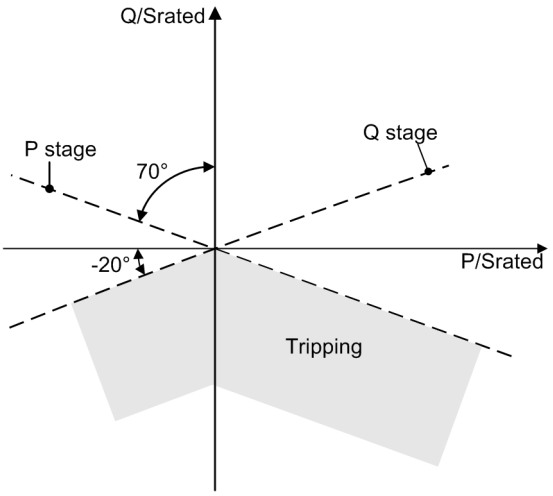
A delay can be set for the dropout when the measured value falls below the dropout threshold. The pickup is maintained for the specified time. The time delay of the tripping (parameter **Operate delay**) continues to run. Once the **Operate delay** has elapsed, the stage trips.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking the stage is possible externally or internally via the binary input signal *>Block stage*.

6.35.5 Application Example

The setting of the function will be explained using an active/reactive power range as an example. If the apparent power phasor is within the power range (in *Figure 6-214* tripping zone defined by characteristics), an alarm indication is generated. For this purpose, you have to make an AND operation of the stage indications of the active and reactive power stage in CFC. The function used is 3-phase power measurement. *Figure 6-214* shows the threshold values and the location of the characteristics in the PQ diagram.



[dwpqd7sa-110211-01.tif, 1, en_US]

Figure 6-214 Pickup Values and Characteristic Curves

6.35.6 Setting Notes for the Active Power Stage

Stage Type

In the following example, a drop of the active power below a threshold is to be monitored. In the **3-phase circuit breaker (P, Q)** function, work with the stage type **Power P<**.

Parameter: Measured value

- Recommended setting value **(_:6271:105) Measured value** = ***positive seq. power***

The **Measured value** parameter is used to specify which measured power value is evaluated. For 3-phase measurement, Siemens recommends to evaluate the positive-sequence system power.

Parameter: Threshold

- Recommended setting value **(_:6271:3) Threshold** = ***0 %***

The **Threshold** parameter is used to define the pickup threshold of the active power stage. In the example, the pickup characteristic runs across the point of origin of the coordinates. Set the parameter **Threshold** to ***0%***.

NOTE

If you use several settings groups, consider the following:

- The dropout value of a stage must have the same sign in all settings groups.
- Switching from a positive dropout value to a negative dropout value or vice versa is not allowed. As a result, DIGSI reports an inconsistency.
- If you want to change the sign of the dropout value of a stage in an additional settings group, instantiate a new stage and enable it. If the new stage should not be effective in another settings group, disable the stage there.

Parameter: Dropout ratio

- Recommended setting value **(_:6271:101) Dropout ratio** = ***1.05***

A hysteresis of 5 % is sufficient for most applications. The setting value for the **lower stage** is therefore 1.05.

Parameter: Tilt power characteristic

- Recommended setting value **(_:6271:103) Tilt power characteristic** = ***+70°***

The **Tilt power characteristic** parameter is used to incline the pickup characteristic. In the above example, an inclination is required. The setting value is ***+70°*** (for a definition of the sign, see *Figure 6-211*).

Parameter: Dropout delay

- Recommended setting value **(_:6271:7) Dropout delay** = ***20 ms***

The **Dropout delay** parameter maintains the pickup even if the measured value drops momentarily below the threshold value. A delay is required for very low pickup values to prevent a so-called chattering of the function. In the example, the setting value is 20 ms.

Parameter: Operate delay

- Recommended setting value **(_:6271:6) Operate delay** = ***100 ms***

The **Operate delay** must be set for the specific application. In the example, a setting value of 100 ms has been selected.

6.35.7 Setting Notes for the Reactive Power Stage

Stage Type

In the example, the reactive power is to be monitored if it falls below the threshold. In the **3-phase circuit breaker (P, Q)** function, work with the stage type **Power Q<**.

Parameter: Measured value

- Recommended setting value **(_:6331:105) Measured value** = ***positive seq. power***

The **Measured value** parameter is used to specify which measured power value is evaluated. For 3-phase measurement, Siemens recommends to evaluate the positive-sequence system power.

Parameter: Threshold

- Recommended setting value **(_:6331:3) Threshold** = ***0 %***

The **Threshold** parameter is used to define the pickup threshold of the reactive power stage. In the example, the pickup characteristic runs across the point of origin of the coordinates. Set the parameter **Threshold** to ***0%***.



NOTE

If you use several settings groups, consider the following:

- The dropout value of a stage must have the same sign in all settings groups.
- Switching from a positive dropout value to a negative dropout value or vice versa is not allowed. As a result, DIGSI reports an inconsistency.
- If you want to change the sign of the dropout value of a stage in an additional settings group, instantiate a new stage and enable it. If the new stage should not be effective in another settings group, disable the stage there.

Parameter: Dropout ratio

- Recommended setting value **(_:6331:101) Dropout ratio** = ***0.95***

A hysteresis of 5 % is sufficient for most applications. The setting value for the **lower stage** is therefore 0.95.

Parameter: Tilt power characteristic

- Recommended setting value **(_:6331:103) Tilt power characteristic** = ***+20°***

The **Tilt power characteristic** parameter is used to incline the pickup characteristic. In the example (see *Figure 6-214*), the power characteristic has a tilt of 20°. Set the **Tilt power characteristic** parameter to ***+20°*** (for a definition of the sign, see *Figure 6-213*).

Parameter: Dropout delay

- Recommended setting value **(_:6331:7) Dropout delay** = ***20 ms***

The **Dropout delay** parameter maintains the pickup even if the measured value drops momentarily below the threshold value. A delay is required for very low pickup values to prevent a so-called chattering of the function. In the example, the setting value is 20 ms.

Parameter: Operate delay

- Recommended setting value **(_:6331:6) Operate delay** = ***100 ms***

The **Operate delay** must be set for the specific application. In the example, a setting value of 100 ms has been selected.

6.35.8 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Power P> 1				
_:6241:1	Power P> 1:Mode		• off • on • test	off
_:6241:2	Power P> 1:Operate & flt.rec. blocked		• no • yes	no
_:6241:104	Power P> 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6241:3	Power P> 1:Threshold		-200.0 % to 200.0 %	80.0 %
_:6241:101	Power P> 1:Dropout ratio		0.90 to 0.99	0.95
_:6241:103	Power P> 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °
_:6241:7	Power P> 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6241:6	Power P> 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power P< 1				
_:6271:1	Power P< 1:Mode		• off • on • test	off
_:6271:2	Power P< 1:Operate & flt.rec. blocked		• no • yes	no
_:6271:105	Power P< 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6271:3	Power P< 1:Threshold		-200.0 % to 200.0 %	5.0 %
_:6271:101	Power P< 1:Dropout ratio		1.01 to 1.10	1.05
_:6271:103	Power P< 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °

Addr.	Parameter	C	Setting Options	Default Setting
_:6271:104	Power P< 1:Pickup delay		• no • yes	yes
_:6271:7	Power P< 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6271:6	Power P< 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power Q> 1				
_:6301:1	Power Q> 1:Mode		• off • on • test	off
_:6301:2	Power Q> 1:Operate & flt.rec. blocked		• no • yes	no
_:6301:105	Power Q> 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6301:3	Power Q> 1:Threshold		-200.0 % to 200.0 %	70.0 %
_:6301:101	Power Q> 1:Dropout ratio		0.90 to 0.99	0.95
_:6301:103	Power Q> 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °
_:6301:7	Power Q> 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6301:6	Power Q> 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power Q< 1				
_:6331:1	Power Q< 1:Mode		• off • on • test	off
_:6331:2	Power Q< 1:Operate & flt.rec. blocked		• no • yes	no
_:6331:105	Power Q< 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6331:3	Power Q< 1:Threshold		-200.0 % to 200.0 %	-30.0 %
_:6331:101	Power Q< 1:Dropout ratio		0.90 to 0.99	0.95
_:6331:103	Power Q< 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °
_:6331:104	Power Q< 1:Pickup delay		• no • yes	yes
_:6331:7	Power Q< 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6331:6	Power Q< 1:Operate delay		0.00 s to 60.00 s	1.00 s

6.35.9 Information List

No.	Information	Data Class (Type)	Type
Power P> 1			
_:6241:81	Power P> 1:>Block stage	SPS	I
_:6241:54	Power P> 1:Inactive	SPS	O
_:6241:52	Power P> 1:Behavior	ENS	O
_:6241:53	Power P> 1:Health	ENS	O
_:6241:55	Power P> 1:Pickup	ACD	O
_:6241:56	Power P> 1:Operate delay expired	ACT	O

No.	Information	Data Class (Type)	Type
_:6241:57	Power P> 1:Operate	ACT	O
Power P< 1			
_:6271:81	Power P< 1:>Block stage	SPS	I
_:6271:54	Power P< 1:Inactive	SPS	O
_:6271:52	Power P< 1:Behavior	ENS	O
_:6271:53	Power P< 1:Health	ENS	O
_:6271:55	Power P< 1:Pickup	ACD	O
_:6271:56	Power P< 1:Operate delay expired	ACT	O
_:6271:57	Power P< 1:Operate	ACT	O
Power Q> 1			
_:6301:81	Power Q> 1:>Block stage	SPS	I
_:6301:54	Power Q> 1:Inactive	SPS	O
_:6301:52	Power Q> 1:Behavior	ENS	O
_:6301:53	Power Q> 1:Health	ENS	O
_:6301:55	Power Q> 1:Pickup	ACD	O
_:6301:56	Power Q> 1:Operate delay expired	ACT	O
_:6301:57	Power Q> 1:Operate	ACT	O
Power Q< 1			
_:6331:81	Power Q< 1:>Block stage	SPS	I
_:6331:54	Power Q< 1:Inactive	SPS	O
_:6331:52	Power Q< 1:Behavior	ENS	O
_:6331:53	Power Q< 1:Health	ENS	O
_:6331:55	Power Q< 1:Pickup	ACD	O
_:6331:56	Power Q< 1:Operate delay expired	ACT	O
_:6331:57	Power Q< 1:Operate	ACT	O

6.36 Reverse Power Protection

6.36.1 Overview of Functions

The **Reverse-power protection** function (ANSI 32R):

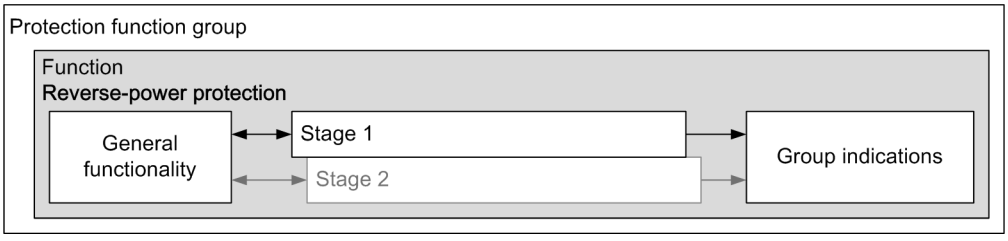
- Monitors the motor operation of generators and thus detects driving-power failure
- Prevents endangering the turbine (e.g. the turbine-blade damage due to overheating) by opening the circuit breaker of the system
- Protects a turbo-generator set

For the generator, there is a danger that the turbo-generator set accelerates and reaches overspeed in case of an incorrect residual-steam passage (quick-stop valves defective) after the circuit breaker has opened. Consequently, disconnecting the system (opening the circuit breaker of the system) shall only occur after reverse power (active-power consumption) has been detected.

6.36.2 Structure of the Function

The **Reverse-power protection** function comes factory-set with 1 stage. A maximum of 2 stages can be operated simultaneously within the function.

In all function groups, the function works with a 3-phase voltage and current interface.



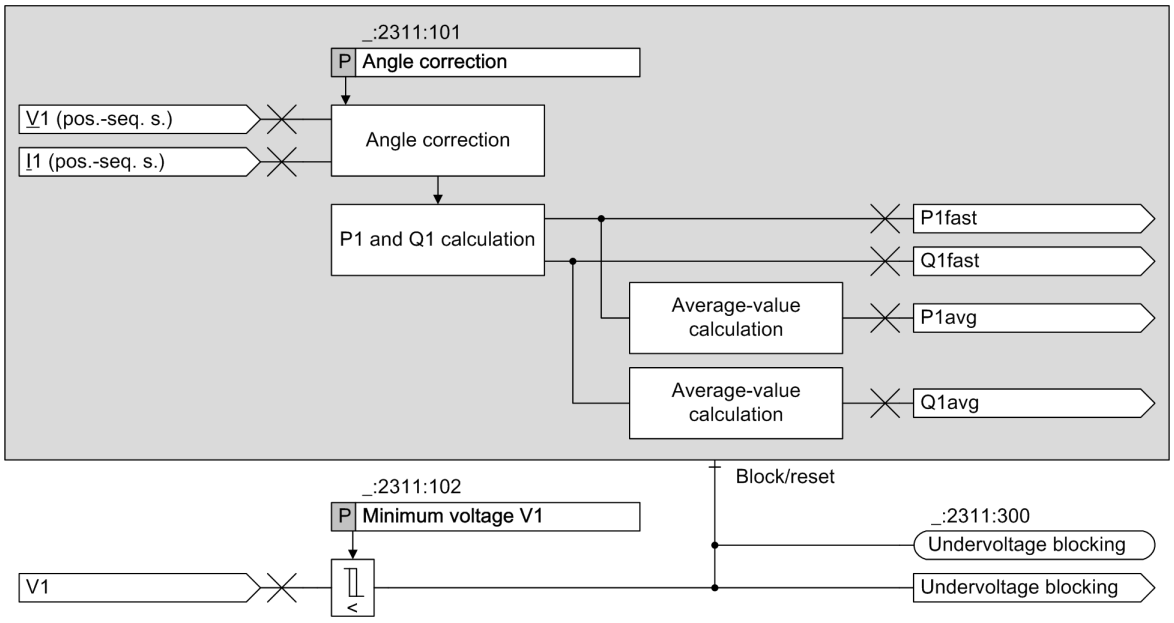
[dwstruct-160410-01.tif, 2, en_US]

Figure 6-215 Structure/Embedding of the Function

6.36.3 General Functionality

6.36.3.1 Description

Logic of the Function



[lo_RPP_01, 1, en_US]

Figure 6-216 Logic Diagram of the Cross-Stage Functionality

Calculating the Reverse Power

The reverse-power protection calculates the active power from the symmetrical components of the fundamental components of the voltages and currents. It generates the average value of the active power over a fixed number of cycles. Since positive-sequence variables are used for evaluation, the reverse power is determined independently of unbalance in currents or voltages. The frequency-tracking sampled values are used for calculation. The determined reverse power corresponds to the load on the driving-power side. The calculated active-power value corresponds to the total active power.

Taking the phase-displacement angle of the voltage and current transformers into account, the function calculates the exact active power even with a high apparent power and a small cos φ. A constant correction angle φ_{corr} makes correction possible. The influence of the current-transformer angle error is predominant here.

Determine this constant correction angle when you commission the protection device in the plant and adjust it as specified in the table (see *Table 11-1*).

Power Calculation and Angle Correction

To satisfy the high measuring-accuracy requirements, the power measured value is additionally averaged over 16 cycles before it is supplied to the protection function. The active power is calculated from the symmetrical-component vectors of voltage V1 and current I1. The total power is evaluated as power. The complex apparent power results from the following relationship. The real component is the active power:

$\underline{S} = 3\underline{V}_1 \cdot \underline{I}_1^{\,*} = 3V_1 e^{j\varphi V} \cdot I_1 e^{-j\varphi I} = 3V_1 I_1 e^{j(\varphi V - \varphi I)}$

$P = 3V_1 I_1 \cos(\varphi_V - \varphi_I)$

The angle error between voltage transformer and current transformer has a strong influence on the measuring accuracy. With the parameter **(_:2311:101) Angle correction** , you can correct the angle error. The following 2 methods are possible here:

- Determine the angle error from the transformer test report data. Ask the transformer manufacturer for these values when you order the transformer.
- While the generator is connected to the power system, measure to determine the angle error (see chapter *11.14.2 Primary Test*).

The influence on the power-system voltage makes it very difficult to test high-power generators with a measurement while the generator is connected to the power system. In this case, you must determine the angle error from the transformer test report data (see chapter *6.36.3.2 Application and Setting Notes*). Alternatively, you can use instrument transformers with small angle errors. This is ensured with class 0.2 instrument transformers (voltage and current). The following equation describes the influence of the angle error:

$P = 3V_1\ I_1 \cos(\varphi_V + \varphi_{V,F} - (\varphi_I + \varphi_{I,F})) = 3V_1\ I_1 \cos(\varphi_U - \varphi_I + (\varphi_{V,F} - \varphi_{I,F}))$

The angle error to be corrected results as:

$\varphi_{Corr} = \varphi_{V,F} - \varphi_{I,F}$

To rotate in the correct direction, the correction angle is considered with inverted sign inside the unit.

Functional Measured Values

You can use the following functional measured values to check the behavior of the protection function and to support commissioning. The total power is represented as the measured value.

Measured Value	Description	
P1fast	Positive-sequence system active power calculated per cycle	Angle correction influences the measured value
Q1fast	Positive-sequence system reactive power calculated per cycle	Angle correction influences the measured value
P1avg	Positive-sequence system active power calculated from **P1fast** over 16 cycles	Input value for Reverse-power protection
Q1avg	Positive-sequence system reactive power calculated from **Q1fast** over 16 cycles	–

6.36.3.2 Application and Setting Notes

In the general functionality, you can adjust the parameter **(_:2311:101) Angle correction** . The parameter results from the angle error of the primary transformer. In SIPROTEC 5, the input transformers are calibrated so that the angle error is negligible. You can assume an error of < 0.1°. There is no difference between a protection input and an instrument-transformer input.



NOTE

If you use class 0.2 instrument transformers on the primary side to avoid the influence of the angle, you can connect a protection device with a protection current transformer without any problems.

Class 0.2 voltage transformers have a maximum admissible angle error of 10 min (0.17°). The angle error of a class 0.2 measuring current transformer at rated current is approximately 10 min, at 0.2 I_{rated} = 15 min, and at 0.05 I_{rated} = 30 min.

Parameter: Angle correction

- Default setting **(_:2311:101) Angle correction** = 0°

To determine the correction angle via measurement with the primary system, follow the instructions in chapter *11.14.2 Primary Test* .

You can use the method that is explained in the following section to derive the necessary correction angle from the transformer measuring reports.

Example

This example uses a class 0.2 voltage transformer with a rated burden of 45 VA. The following data was taken from the measuring report.

Table 6-17 For Phase A

V/Vn	$S_b = S_{br}$		$S_b = S_{br}/4$	
	ε_v [%]	δ_v [min]	ε_v [%]	δ_v [min]
0.8	-0.14	0.31	0.16	-0.34
1	-0.15	0.43	0.15	-0.24
1.2	-0.16	0.68	0.14	-0.06

The values resulting for the phases B and C are almost identical.

Furthermore, a termination with a rated burden (other measuring devices are still connected) is assumed so that an angle error of +0.43 min (rated-voltage value) is used as the calculation variable.

A current transformer of type 5PR is used here. This current transformer features a gap that limits the remanence to 10 %. However, this gap results in larger angle errors. The following tables show excerpts from the test reports.

Table 6-18 Phase A

I/I_n [%]	$Sb = S_{br}$ (cos β = 0.8)	
	ε_i [%]	δ_i [min]
100	0.314	46.40

Table 6-19 Phase B

I/I_n [%]	$Sb = S_{br}$ (cos β = 0.8)	
	ε_i [%]	δ_i [min]
100	0.247	35.10

Table 6-20 Phase C

I/I_n [%]	$Sb = S_{br}$ (cos β = 0.8)	
	ε_i [%]	δ_i [min]
100	0.702	41.10

Since the positive-sequence system power is evaluated in the device, take the sign into account when you add the angle errors per phase, and divide the result by 3.

The following value results in this example:

$$\delta_i[\text{min}] = \frac{1}{3}\left(\delta_{i,A} + \delta_{i,B} + \delta_{i,C}\right) = \frac{1}{3}(46.40 + 35.10 + 41.10) = 40.87 \text{ min}$$

The resulting correction angle is:

$$\varphi_{corr}[\text{min}] = \varphi_{V,F} - \varphi_{I,F} = 0.43 \text{ min} - 40.87 \text{ min} = -40.44 \text{ min}$$

$$\varphi_{corr}[^\circ] = \frac{\varphi_{corr[\text{min}]}}{60} \cdot 1^\circ = \frac{-40.44}{60} \cdot 1^\circ = -0.674^\circ$$

Set the parameter **(_:2311:101) Angle correction = *-0.67*°**.

Parameter: `Minimum voltage V1`

- Default setting **`(_:2311:102) Minimum voltage V1`** = 5.000 V

With the parameter **`Minimum voltage V1`** , you can limit the operating range of the reverse-power protection. If the positive-sequence voltage falls below the set value, the reverse-power protection is deactivated. If no other restrictions are known, Siemens recommends using the default setting.

6.36.3.3 Parameter

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Angle correction		-10.00 ° to 10.00 °	0.00 °
_:2311:102	General:Minimum voltage V1		0.300 V to 60.000 V	5.000 V

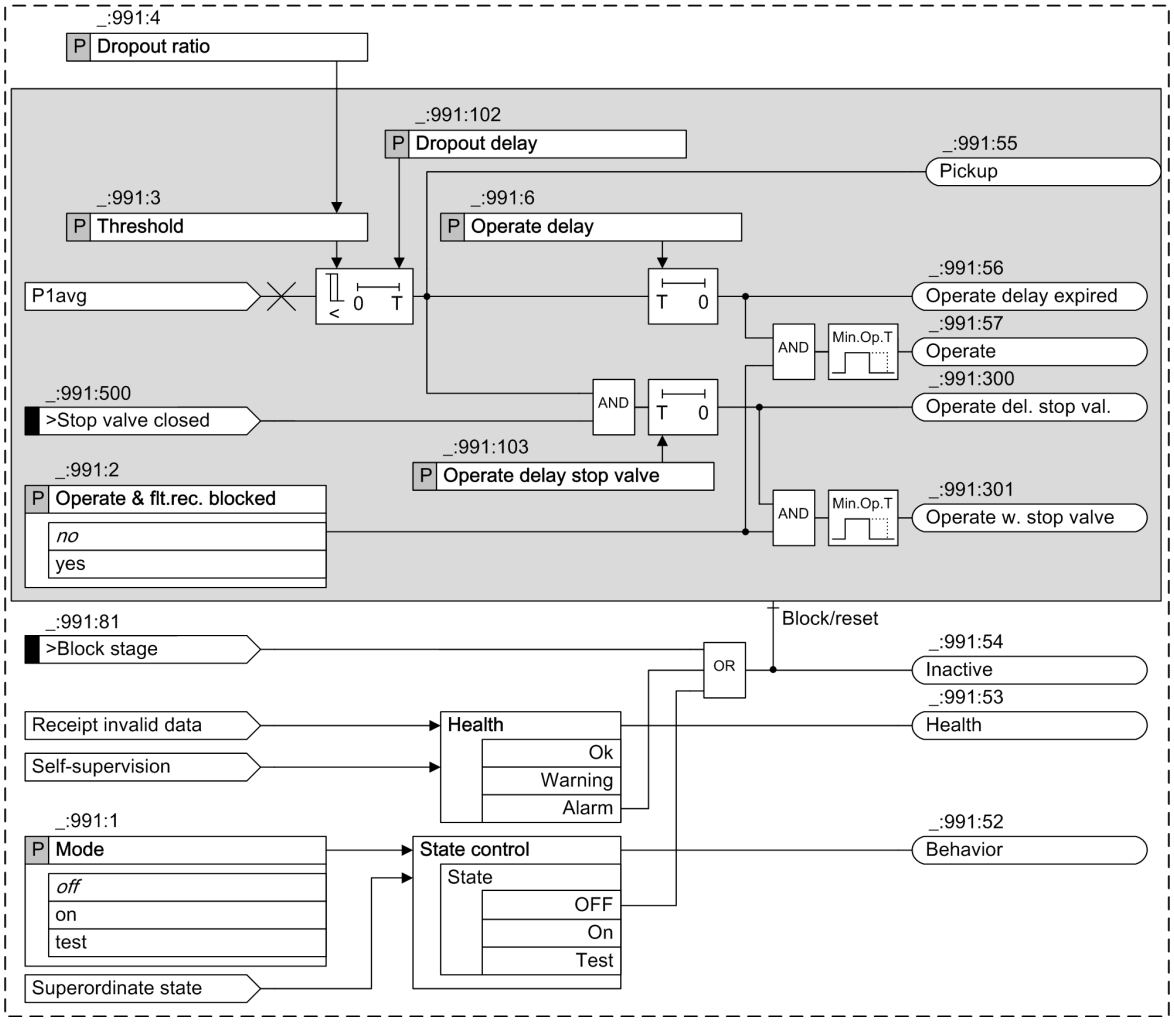
6.36.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
_:2311:301	General:P1avg	MV	O
_:2311:302	General:Q1avg	MV	O
_:2311:303	General:P1fast	MV	O
_:2311:304	General:Q1fast	MV	O

6.36.4 Stage Description

6.36.4.1 Description

Logic of the Stage



[lo_RPP_02, 1, en_US]

Figure 6-217 Logic Diagram of the Reverse-Power Protection Stage

Trip Command

To bridge brief power consumption during synchronization or during power swings caused by system incidents, tripping (shutdown of the generator via reverse power) is delayed by a settable time (for example, 10 s).

A brief delay is enough when the quick-stop valve is closed. Couple the position of the quick-stop valve via the binary input signal **>Stop valve closed** . When quick stop is tripped, the short Operate delay thus becomes effective.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking of the stage is possible externally or internally via the binary input signal **>Block stage** .

6.36.4.2 Application and Setting Notes

If reverse power occurs in a power plant, the turbo-generator set must be disconnected from the electrical power system. Operating the turbine without the minimum steam flow (cooling effect) is dangerous. For a gas turbine cogeneration unit, the motor load can also be too great for the electrical power system.

Parameter: `Threshold`

- Recommended setting value **`(_:991:3) Threshold`** = ***`-1.00 %`***

The friction losses that have to be overcome mainly determine the active power consumed by a turbo-generator set. Depending on the plant, the consumed active power is of the following ranges:

Steam turbines	$P_{reverse}/S_{rated}$ = 1.00 % to 3.00 %
Diesel drives	$P_{reverse}/S_{rated}$ > 5.00 %
Gas turbines	$P_{reverse}/S_{rated}$ = up to 30.00 %

You can measure the reverse power of the turbo-generator set yourself in a primary test by using the protection function. Set the setting value **`P`** $_{reverse}$, for example, to 0.5 times the value of the measured reverse power. This power is shown additionally in the functional measured values in the **Reverse-power protection** function (**`P1avg`**). For large machines with very small reverse power, you must use the angle-error correction option of the current and voltage transformers.



NOTE

In the current-input selection, you can select protection current transformers or instrument transformers on the device side. Since the transformers are calibrated at the factory, there are hardly any differences between the transformers for the **Reverse-power protection** function. You can thus always select device inputs with a protection current transformer.

In contrast, a primary current transformer significantly influences the measuring accuracy via its angle error. The angle error of a class 0.2 instrument transformer is significantly smaller than the angle error of a class 5P protection current transformer. A separate function group is necessary for the connection to an instrument transformer. Use a **Voltage/current 3-phase** function group and load the **Reverse-power protection** function from the library.

Do not connect the **Reverse-power protection** function to a linear core-type transformer (for example, a TPZ type), as these transformers have a large angle error (for example, approx. 180 min).

6.36.4.3 Parameter

Addr.	Parameter	C	Setting Options	Default Setting
`Stage 1`				
_:991:1	Stage 1:Mode		• off • on • test	off
_:991:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:991:3	Stage 1:Threshold		-30.00 % to -0.30 %	-1.00 %
_:991:4	Stage 1:Dropout ratio		0.40 to 0.99	0.60
_:991:102	Stage 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:991:6	Stage 1:Operate delay		0.00 s to 60.00 s	10.00 s
_:991:103	Stage 1:Operate delay stop valve		0.00 s to 60.00 s	1.00 s

6.36.4.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:991:81	Stage 1:>Block stage	SPS	I
_:991:500	Stage 1:>Stop valve closed	SPS	I
_:991:54	Stage 1:Inactive	SPS	O
_:991:52	Stage 1:Behavior	ENS	O
_:991:53	Stage 1:Health	ENS	O
_:991:55	Stage 1:Pickup	ACD	O
_:991:56	Stage 1:Operate delay expired	ACT	O
_:991:57	Stage 1:Operate	ACT	O
_:991:300	Stage 1:Operate del. stop val.	ACT	O
_:991:301	Stage 1:Operate w. stop valve	ACT	O

6.37 Overexcitation Protection

6.37.1 Overview of Functions

The **Overexcitation protection** (ANSI 24) is used for detecting high induction values in generators and transformers. It protects the equipment from excessive thermal loads.

The induction is recorded indirectly by analyzing the V/f ratio (also referred to as Volt per Hertz protection). Overvoltage leads to excessive magnetizing currents, while underfrequency leads to higher losses when resetting the magnetization.

If the power system is disconnected and the voltage and frequency control function in the remaining system does not react quickly or the power imbalance is excessive, there is a risk of overexcitation.

6.37.2 Structure of the Function

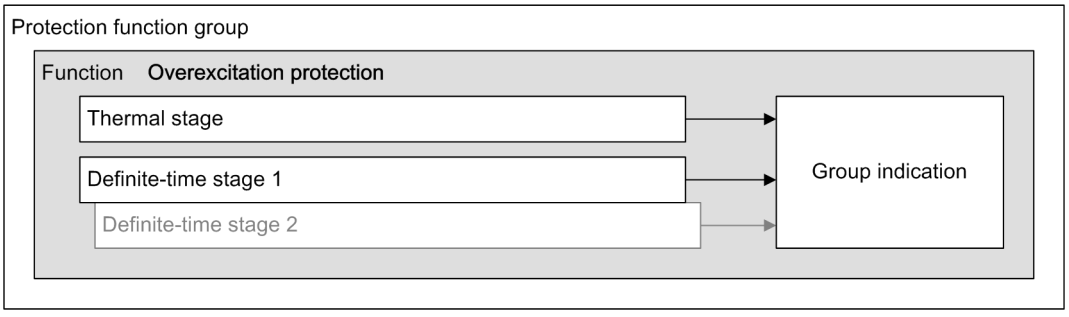
The **Overexcitation protection** function is used within protection function groups that have a 3-phase voltage input. The function comes with the following factory-set stages:

- Thermal stage adjustable with a user-defined characteristic curve
- Definite-time stage which can be delayed using a time component

Within this function, the following maximum number of stages can be operated simultaneously: one stage with a user-defined characteristic curve and 2 definite-time stages.

The group-indication output logic (see following figure) uses the logical OR function from the stage-selective indications to generate the following group indications of the entire **Overexcitation protection** function:

- Pickup
- Operate Indication



[dwovexuf-080513-01.tif, 3, en_US]

Figure 6-218 Structure/Embedding of the Function

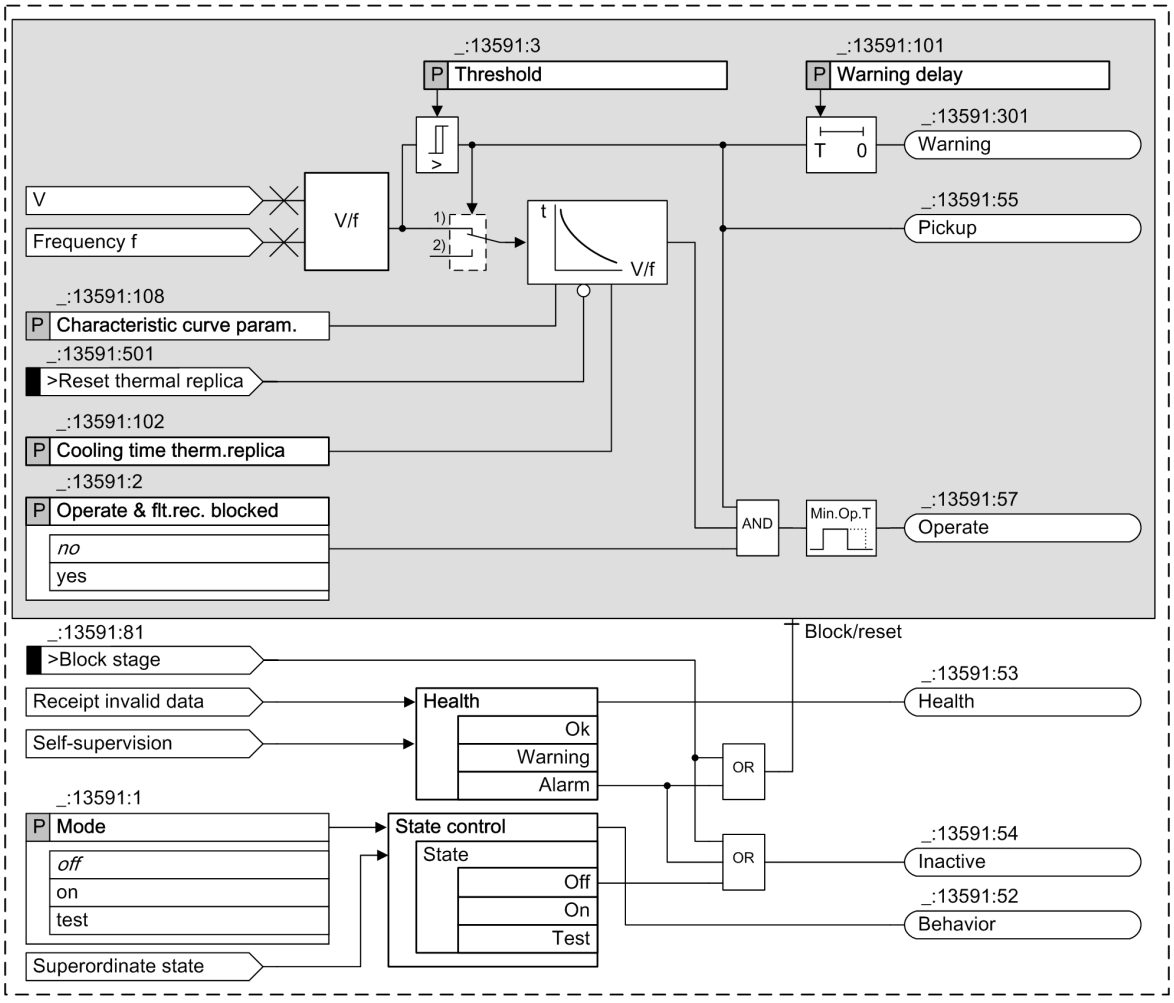
Function Measured Value

Measured Value	Description
(_:2311:322) V/f	Value calculated by the voltage and the frequency

6.37.3 Stage with Dependent Characteristic Curve (Thermal Stage)

6.37.3.1 Function Description

Logic



[lothchuf-080513-01.tif, 1, en_US]

Figure 6-219 Logic of the Overexcitation Protection with Thermal Characteristic Curve

(1) Heating
(2) Cooling

V/f Method of Measurement

The input values of the protection function are the continuously measured voltage and the frequency. The phase-to-phase voltage is used to process the voltage. The angle difference method (see *6.32 Overfrequency Protection*) is used to determine the frequency. Both values form the V/f ratio. In order to arrive at an absolute value, standardized data is applied.

Thus, the ratio is derived from:

$$\frac{V/V_{rated,obj.}}{f/f_{rated}}$$

[foverufn-080523-01.tif, 1, en_US]

with

V	Measured voltage (maximum phase-to-phase voltage)
$V_{rated, obj.}$	Adjusted rated voltage of the protected object
f	Measured frequency
f_{rated}	Adjusted rated frequency

Based on the definition above, the protection function refers exclusively to primary values of the protected object. A deviation between the primary rated voltage of the voltage transformer and the protected object is corrected automatically.

NOTE

This fact must be considered during a secondary test.

More information can be found in chapter *11.16 Functional Test for Overexcitation Protection* .

The function compares the calculated value of the measured V/f ratio with the threshold value and the user-defined thermal characteristic curve.

Depending on the characteristic curve, a **thermal** trip signal is triggered after a pre-determined duration.

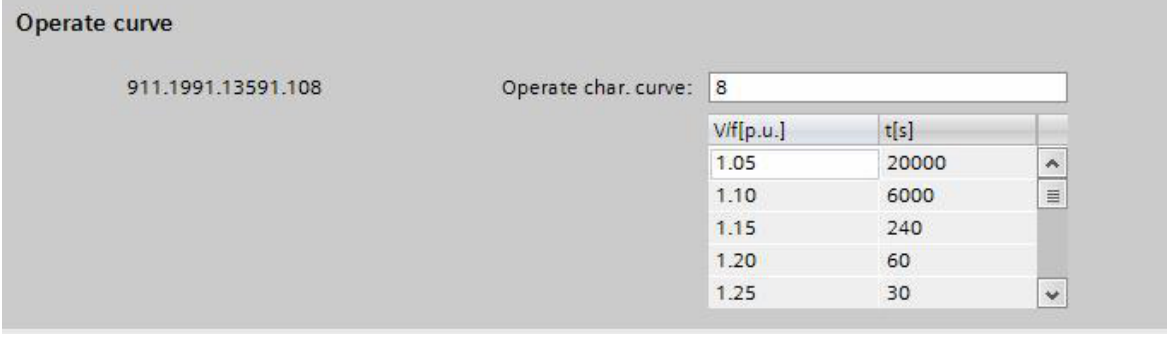
Characteristic Curve

You can freely configure the thermal characteristic curve with the user-defined values. This provides a flexible adjustment to the specified characteristics of the protected object. If the set threshold value (parameter **(_:13591:3) Threshold**) is exceeded, the evaluation of the characteristic curve is initiated. Exceeding the threshold value triggers an indication (*(_:13591:55) Pickup*). In addition, a definite-time stage may be used to generate a delayed indication output as (*(_:13591:301) warning*).

The pickup is used to start the integration process (weighted counting) of the thermal characteristic curve. If the time as a factor of V/f is reached, the pickup is triggered. Based on the replica of the thermal behavior, the trigger value is always 100 % (see *Thermal Behavior, Page 776*).

If the value drops below the pickup threshold, the trip command is rescinded and the **internal counter** of the parameterized cooling time (parameter **(_:13591:102) Cooling time therm.replica**) is reduced. The dropout threshold of the pickup threshold is fixed to 0.98 * **Threshold**.

A maximum of 30 overexcitation value pairs V/f (referring to the rated values) and operate time t can be set. The default characteristic curve refers to a standard transformer.

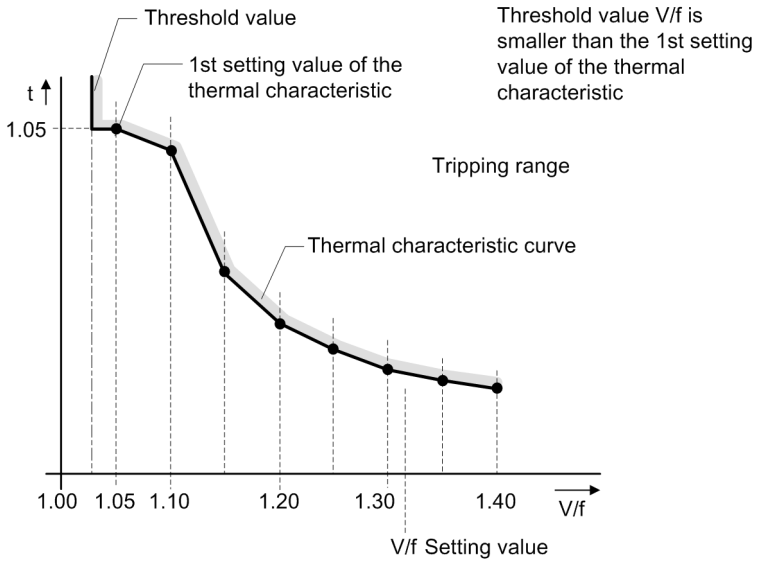


[scaulskn-200214-01, 1, en_US]

Figure 6-220 Data Sheet for Adjustment of Thermal Characteristic Curve

The parameter **Threshold** (pickup threshold) affects the evaluation of the characteristic curve as follows:

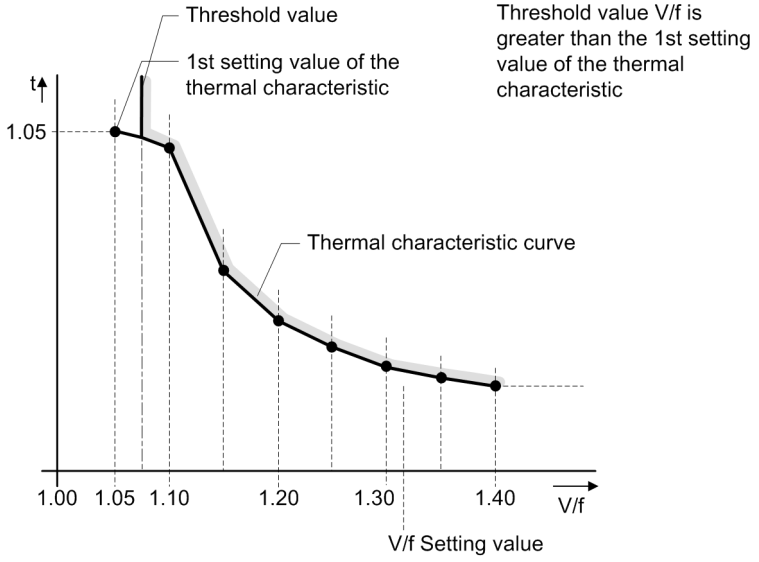
If the **Threshold** is smaller than the first characteristic pair, the set time will be extended (see *Figure 6-221*).



[dwovexak-210313-01.tif, 1, en_US]

Figure 6-221 Tripping Zone of the Thermal Characteristic Curve (I)

If the **Threshold** is greater, then a cutoff occurs (see *Figure 6-222*).



[dwovexab-210313-01.tif, 1, en_US]

Figure 6-222 Tripping Zone of the Thermal Characteristic Curve (II)

Warning Threshold

If the **Threshold** is exceeded, the time delay (parameter **(_:13591:101) Warning delay**) is started. If the time delay has elapsed, the indication (*(_:13591:301) Warning*) will be displayed.

Thermal Behavior

The time derived from the characteristic curve and associated with the V/f value is set to 100 %. With each function call, the time will be increased according to the respective weighted invocation interval. If the 100 % value is exceeded, tripping is initiated. If the V/f value is changed, the associated time from the characteristic curve is added as a new 100 % value.

In order to prevent excessive cooling times, the thermal storage has been limited internally to 150 %. The *fill level* of the thermal storage will be provided as functional measured value.

Measured Value	Description
(_:13591:321) V/f th.	Thermal tripping of the overexcitation protection. If the value reaches 100 %, the tripping occurs.

Cooling Time

If the value drops below the threshold (**(_:13591:3) Threshold**), tripping of the thermal characteristic curve (dependent characteristic curve) is reverted. However, the parameterized cooling time (**Cooling time therm.replica**) reduces the thermal storage (counter content) to 0. This parameter is defined as time. It is required by the thermal replica in order to cool down from 100 % to 0 %.

Resetting the Thermal Map

The binary input indication *(_:13591:501) >Reset thermal replica* can be applied to reset the thermal replica. The thermal replica will then have a value of 0. A reparameterization will also lead to resetting the thermal replica.

Blocking the Stage

The function can be blocked externally or internally by the binary input signal *(_:13591:81) >Block stage*. Blocking will cause a picked up function to be reset.

6.37.3.2 Application and Setting Notes

Thermal overloads extended over a longer period will jeopardize electric equipment, for example, synchronous motors, generators, or transformers and may cause damage. When using the thermal, user-defined characteristic curve, the overexcitation protection lends itself perfectly for adjustment to the specified limits of the protection equipment.

The following provides the recommended settings:



NOTE

It must be noted that one requirement for the correct mode of operation of the function is based on the proper setting of the power-system data.

You can find more detailed information on this in chapter *6.1 Power-System Data* .

For additional setting recommendations, verity the following parameter in the power-system data:

- Adjusted rated frequency
- Adjusted rated voltage of the protected object
- Adjusted rated voltage of the voltage transformer of the applicable measuring point

Parameter: Threshold Value

- Default setting **(_:13591:3) Threshold** = *1.10*

  The **Threshold** parameter is used to describe the value for the permissible continuous overexcitation. The default value is a practical value used for transformers. The value may be less for generator applications. These values can be found in the manufacturer's information.

Parameter: Time Delayed Warning

- Default setting **(_:13591:101) Warning delay** = *10.00 s*

  When using the **Warning delay** parameter, the time can be determined by which the warning indication of the stage should be delayed after the pickup. This time delay depends on the specific application. This time must clearly exceed the reaction time of the regulators. 10 seconds is a feasible value.

Parameter: Cooling Time Therm. Replica

- Default setting **(_:13591:102) Cooling time therm.replica** = *3600 s*

The **Cooling time therm.replica** parameter is used to define the cooling characteristics of the thermal replica. If concrete specifications are not given, the default value can be maintained.

Parameter: V/f/time value pairs (operate curve)

With this parameter, the number of potting points along the thermal operate curve are defined. This is required for the calculation. The number of points defines the accuracy of the image of the specified characteristic curve. Adjust the value individually.

Set a V/f/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize. The default settings refer to a Siemens standard transformer.

NOTE

The value pairs must be entered in continuous order.

NOTE

Note that the V/f values that are lower than the V/f values of the smallest characteristic-curve point do not extend the operate time. Up to the smallest characteristic-curve point, the characteristic curves runs parallel to the V/f axis. V/f values that are larger than the V/f value of the largest characteristic-curve point do not reduce the operate time. From the largest characteristic-curve point, the pickup characteristic runs parallel to the V/f axis (see *Characteristic Curve, Page 775*).

6.37.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Definite-T 1				
_:13621:1	Definite-T 1:Mode		• off • on • test	off
_:13621:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:13621:3	Definite-T 1:Threshold		1.00 to 1.40	1.40
_:13621:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	1.00 s
General				
_:13591:1	Therm.charact.:Mode		• off • on • test	off
_:13591:2	Therm.charact.:Operate & flt.rec. blocked		• no • yes	no
_:13591:3	Therm.charact.:Threshold		1.00 to 1.20	1.10
_:13591:101	Therm.charact.:Warning delay		0.00 s to 60.00 s	10.00 s
_:13591:102	Therm.charact.:Cooling time therm.replica		0 s to 100000 s	3600 s

6.37.3.4 Information List

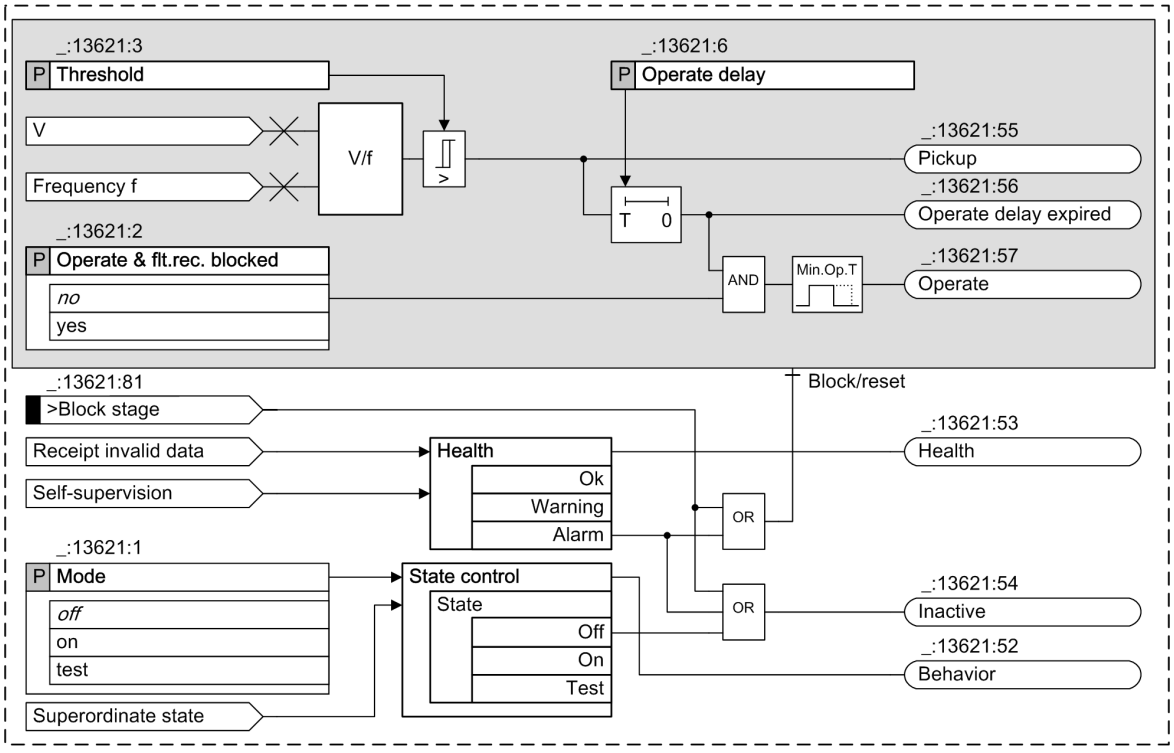
No.	Information	Data Class (Type)	Type
General			
_:2311:322	General:V/f	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:13621:81	Definite-T 1:>Block stage	SPS	I
_:13621:54	Definite-T 1:Inactive	SPS	O
_:13621:52	Definite-T 1:Behavior	ENS	O
_:13621:53	Definite-T 1:Health	ENS	O
_:13621:55	Definite-T 1:Pickup	ACD	O
_:13621:56	Definite-T 1:Operate delay expired	ACT	O
_:13621:57	Definite-T 1:Operate	ACT	O
Therm.charact.			
_:13591:81	Therm.charact.:>Block stage	SPS	I
_:13591:501	Therm.charact.:>Reset thermal replica	SPS	I
_:13591:54	Therm.charact.:Inactive	SPS	O
_:13591:52	Therm.charact.:Behavior	ENS	O
_:13591:53	Therm.charact.:Health	ENS	O
_:13591:55	Therm.charact.:Pickup	ACD	O
_:13591:301	Therm.charact.:Warning	ACT	O
_:13591:57	Therm.charact.:Operate	ACT	O
_:13591:321	Therm.charact.:V/f th.	MV	O

6.37.4 Stage with Independent Characteristic Curve

6.37.4.1 Function Description

Logic



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Figure 6-223 Logic of the Overexcitation Protection with Inpendent Characteristic Curve (Definite-Time Stage)

Method of Measurement

This stage evaluates also the V/f value that is identical to the input value of the thermal stage.

Measurement-relevant details can be found in chapter *6.37.3 Stage with Dependent Characteristic Curve (Thermal Stage)* .

How the Definite-Time Stage Works

The stage comprises a threshold and a time-delay stage. If the V/f value is greater than the set threshold value (**(_:13621:3) Threshold**), then the stage is tripped after an adjustable time delay has elapsed. You can set the time delay with the parameter **(_:13621:6) Operate delay**.

The dropout ratio for the **Threshold** is fixed to 98 %.

6.37.4.2 Application and Setting Notes

The definite-time stage can be applied when fast tripping is required in the presence of high V/f values. In this case, the stage acts superimposed on the thermal, dependent stage.

Parameter: Threshold Value

- Default setting **(_:13621:3) Threshold** = ***1.40***

  The **Threshold** parameter is used to describe the overexcitation value that causes the tripping function. The default value matches a feasible upper limit.

Parameter: `Tripping delay`

- Default setting **`(_:13621:6) Operate delay`** = ***`1.00 s`***

  The **`Operate delay`** parameter is used to determine the time by which the stage is delayed after the pickup. This time delay depends on the specific application. The default value is practical for the application described in the previous chapter.

6.37.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Definite-T 1`				
_:13621:1	Definite-T 1:Mode		• off • on • test	off
_:13621:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:13621:3	Definite-T 1:Threshold		1.00 to 1.40	1.40
_:13621:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	1.00 s
`Therm.charact.`				
_:13591:1	Therm.charact.:Mode		• off • on • test	off
_:13591:2	Therm.charact.:Operate & flt.rec. blocked		• no • yes	no
_:13591:3	Therm.charact.:Threshold		1.00 to 1.20	1.10
_:13591:101	Therm.charact.:Warning delay		0.00 s to 60.00 s	10.00 s
_:13591:102	Therm.charact.:Cooling time therm.replica		0 s to 100 000 s	3600 s

6.37.4.4 Information List

No.	Information	Data Class (Type)	Type
`General`			
_:2311:322	General:V/f	MV	O
`Group indicat.`			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
`df/dt falling1`			
_:13621:81	Definite-T 1:>Block stage	SPS	I
_:13621:54	Definite-T 1:Inactive	SPS	O
_:13621:52	Definite-T 1:Behavior	ENS	O
_:13621:53	Definite-T 1:Health	ENS	O
_:13621:55	Definite-T 1:Pickup	ACD	O
_:13621:56	Definite-T 1:Operate delay expired	ACT	O
_:13621:57	Definite-T 1:Operate	ACT	O
`Therm.charact.`			
_:13591:81	Therm.charact.:>Block stage	SPS	I
_:13591:501	Therm.charact.:>Reset thermal replica	SPS	I
_:13591:54	Therm.charact.:Inactive	SPS	O

No.	Information	Data Class (Type)	Type
_:13591:52	Therm.charact.:Behavior	ENS	O
_:13591:53	Therm.charact.:Health	ENS	O
_:13591:55	Therm.charact.:Pickup	ACD	O
_:13591:301	Therm.charact.:Warning	ACT	O
_:13591:57	Therm.charact.:Operate	ACT	O
_:13591:321	Therm.charact.:V/f th.	MV	O

6.38 Undervoltage-Controlled Reactive-Power Protection

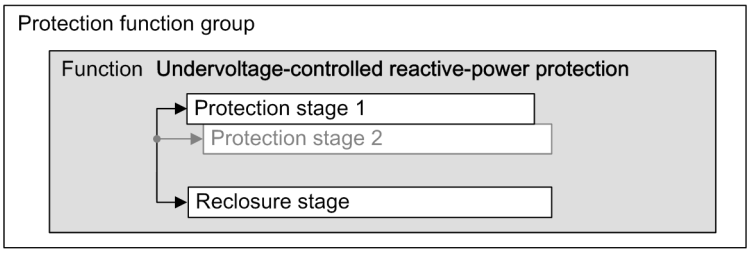
6.38.1 Overview of Functions

The **Undervoltage-controlled reactive-power protection** function (ANSI 27/Q):

- Detects critical power-system situations, mainly in case of regenerative generation
- Prevents a voltage collapse in power system by disconnecting the power-generation facility from the main power systems
- Ensures reconnection under stable power-system conditions

6.38.2 Structure of the Function

The **Undervoltage-controlled reactive-power protection** function can be used in protection function groups containing 3-phase voltage and current measurement. Depending on the device, it is preconfigured by the manufacturer with 1 **Protection stage** and 1 **Reclosure stage**. A maximum of 2 **Protection stages** and 1 **Reclosure stage** can operate simultaneously within the function.



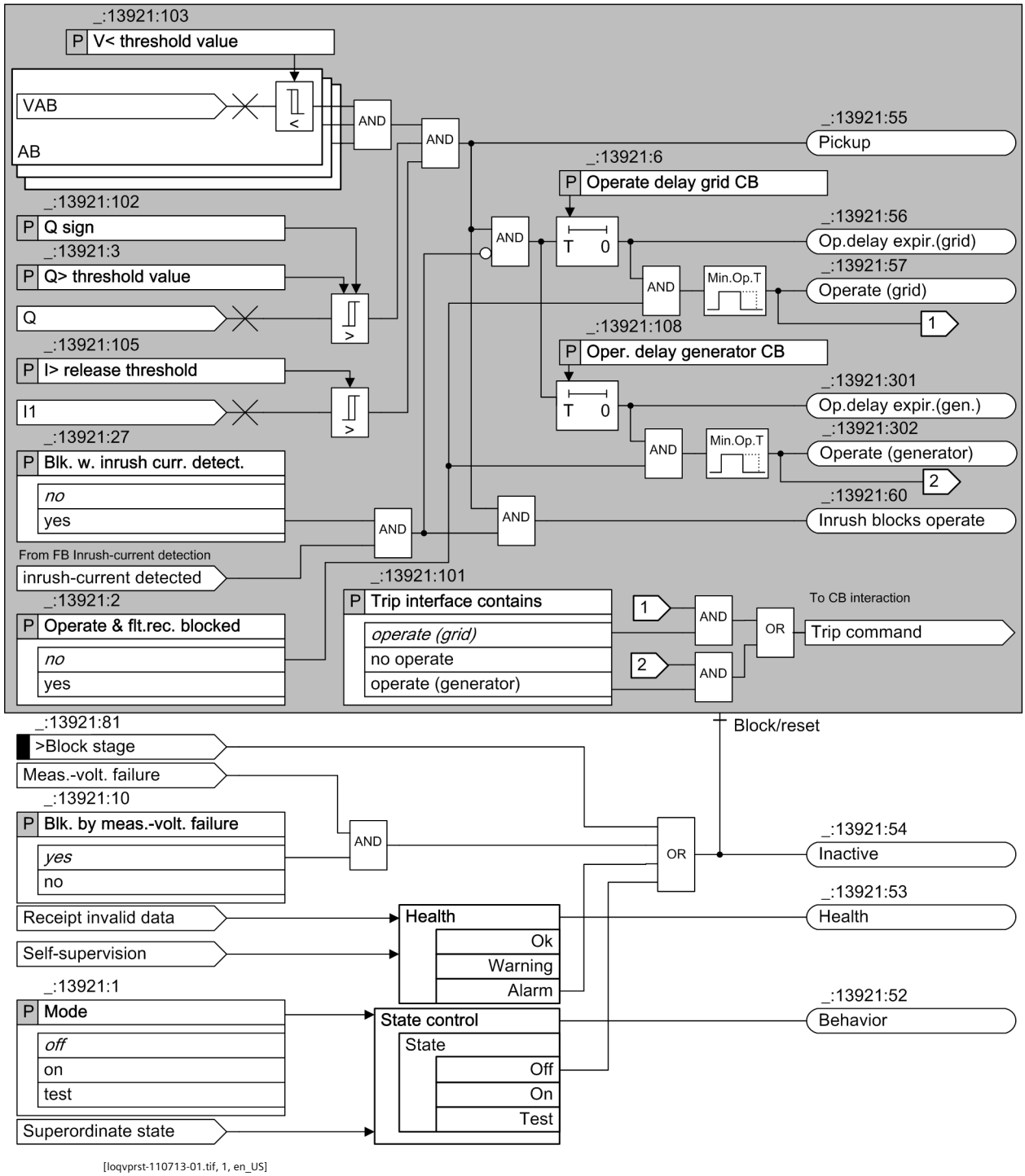
[dwqvprot-110713-01.tif, 1, en_US]

Figure 6-224 Structure/Embedding of the Function

6.38.3 Description Protection Stage

6.38.3.1 Description

Logic of the Stage



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Figure 6-225 Logic Diagram of the Protection Stage of the Undervoltage-Controlled Reactive-Power Protection

Measurand

To detect critical power-system situations, the **Undervoltage-controlled reactive-power protection** function uses the fundamental values of the phase-to-phase voltages, the positive-sequence current, and the reactive power.

Q-Measurement Direction

The default directions of the positive reactive-power flow Q and the forward direction of the short-circuit protection are identical, in the direction of the protected object. Via parameter **`Q sign`**, the direction of the positive reactive-power flow Q can be changed by inverting the sign of the reactive power Q.

Pickup

The protection stage picks up under the following conditions:

- All 3 phase-to-phase voltages are below the parameterized threshold value.
- The positive-sequence current I_1 is above the parameterized threshold value.
- The power-generation facility requires more than the parameterized reactive power (Q is above the parameterized threshold value).

Trip Interface

The stage provides 2 operate signals, the *`Operate (generator)`* and the *`Operate (grid)`*. Depending on the parameter **`Trip interface contains`**, one or none of them will be forwarded to the trip interface of the circuit-breaker interaction.

Blocking of the Stage

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal *`>Block stage`*
- Measuring-voltage failure
  For further information, refer to chapter *6.7.4.1 Description*.

Blocking of the Operate Delay and Operate Signal via the Device-Internal Inrush-Current Detection Function

The **`Blk. w. inrush curr. detect.`** parameter permits you to define whether the operate delay should be blocked by a threshod-value violation due to an inrush current.

For further information about device-internal **Inrush-current detection** function, refer to chapter *6.3.7.1 Description* .

6.38.3.2 Application and Setting Notes

Parameter: `Blk. by meas.-volt. failure`

- Recommended setting value **`(_:13921:10) Blk. by meas.-volt. failure`** = ***`yes`***

You use the **`Blk. by meas.-volt. failure`** parameter to control the response of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal **Measuring-voltage failure detection** function is configured and switched on.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
`yes`	The **Protection stage** is blocked when a measuring-voltage failure is detected. Siemens recommends using the default setting, as there is no assurance that the **Protection stage** will function correctly if the measuring voltage fails.

no	The **Protection stage** is not blocked when a measuring-voltage failure is detected.

Parameter: **Blk. w. inrush curr. detect.**

- Default setting **(_:13921:27) Blk. w. inrush curr. detect.** = ***no***

You use the **Blk. w. inrush curr. detect.** parameter to determine whether the operate delay and operate signal are blocked during the detection of an inrush current.

Parameter: **I> release threshold**

- Recommended setting value **(_:13921:105) I> release threshold** = ***0.100 A***

You use the **I> release threshold** parameter to define a precondition that the stage can pick up. The default setting is at 10 % of the rated current. Siemens recommends using the default setting.

Parameter: **V< threshold value**

- Recommended setting value **(_:13921:103) V< threshold value** = ***85.000 V***

You use the **V< threshold value** parameter to define one of the 2 pickup criteria. If all 3 phase-to-phase voltages drop below the parameterized undervoltage threshold value, the pickup criterion is fulfilled.

The setting should be set below the lower value of the permissible voltage range, according to the national transmission code. In Germany, the recommended undervoltage threshold is 85 % of the rated voltage. Therefore Siemens recommends using the default setting.

Parameter: **Q> threshold value**

- Default setting **(_:13921:3) Q> threshold value** = ***5 %***

You use the **Q> threshold value** parameter to define the second of the 2 pickup criteria. If the positive reactive power exceeds the parameterized **Q> threshold value**, the pickup criterion is fulfilled.

In the following example, the pickup takes place if Q exceeds 5 % of the power-supply system rated power.

EXAMPLE

The following example is given for settings in secondary values.

Rated voltage: $V_{rated,\ sec}$ = 100 V

Rated current: $I_{rated,\ sec}$ = 1 A

Threshold value: 5 % of the power-supply system rated power

You can calculate the setting value as follows:

$$Q>_{threshold} = 100\ V \cdot 1\ A \cdot \sqrt{3} \cdot 0.05 = 8.7\ VAr$$

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Parameter: **Operate delay**

- Default setting **(_:13921:6) Operate delay grid CB** = ***1.50 s***
- Default setting **(_:13921:108) Oper. delay generator CB** = ***0.50 s***

You can set the **Operate delay grid CB** for the circuit breaker at the power-supply system connection point, or set the **Oper. delay generator CB** for the circuit breaker of the facility, for example, the generator.

The time of the **Operate delay grid CB** should always be set longer than the time of the **Oper. delay generator CB**.

Parameter: `Trip interface contains`

- Default setting **`(_:13921:101) Trip interface contains`** = ***`operate (grid)`***

The stage provides 2 operate signals, the *`Operate (generator)`* and the *`Operate (grid)`*.
You use the **`Trip interface contains`** parameter to define whether one or none of them will be forwarded to the trip interface of the circuit-breaker interaction. The selected operate signal will trip the circuit breaker that has been connected to the protection function group.
The setting depends on the specific application.

Parameter: `Q sign`

- Default setting **`(_:13921:102) Q sign`** = ***`not reversed`***

The default directions of the positive reactive-power flow Q and the forward direction of the short-circuit protection are identical, in the direction of the main protected object (for example, a feeder). You use the **`Q sign`** parameter to reverse the sign and therefore the direction of the reactive-power flow Q. This reversal may be required for specific application, where the main protected object (for example, a line towards the main power systems) is in different direction to the power-generation facility.

Parameter Value	Description
`not reversed`	The protected object is in the same direction as the power-generation facility.
`reversed`	The protected object is not in the same direction as the power-generation facility.

6.38.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Prot. stage 1`				
_:13921:1	Prot. stage 1:Mode		• off • on • test	off
_:13921:2	Prot. stage 1:Operate & flt.rec. blocked		• no • yes	no
_:13921:10	Prot. stage 1:Blk. by meas.-volt. failure		• no • yes	yes
_:13921:27	Prot. stage 1:Blk. w. inrush curr. detect.		• no • yes	no
_:13921:101	Prot. stage 1:Trip interface contains		• no operate • operate (generator) • operate (grid)	operate (grid)
_:13921:102	Prot. stage 1:Q sign		• not reversed • reversed	not reversed
_:13921:3	Prot. stage 1:Q> threshold value		1.00 % to 200.00 %	5.00 %
_:13921:103	Prot. stage 1:V< threshold value		3.000 V to 175.000 V	85.000 V
_:13921:105	Prot. stage 1:I> release threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:13921:108	Prot. stage 1:Oper. delay generator CB		0.00 s to 60.00 s	0.50 s

Addr.	Parameter	C	Setting Options	Default Setting
_:13921:6	Prot. stage 1:Operate delay grid CB		0.00 s to 60.00 s	1.50 s

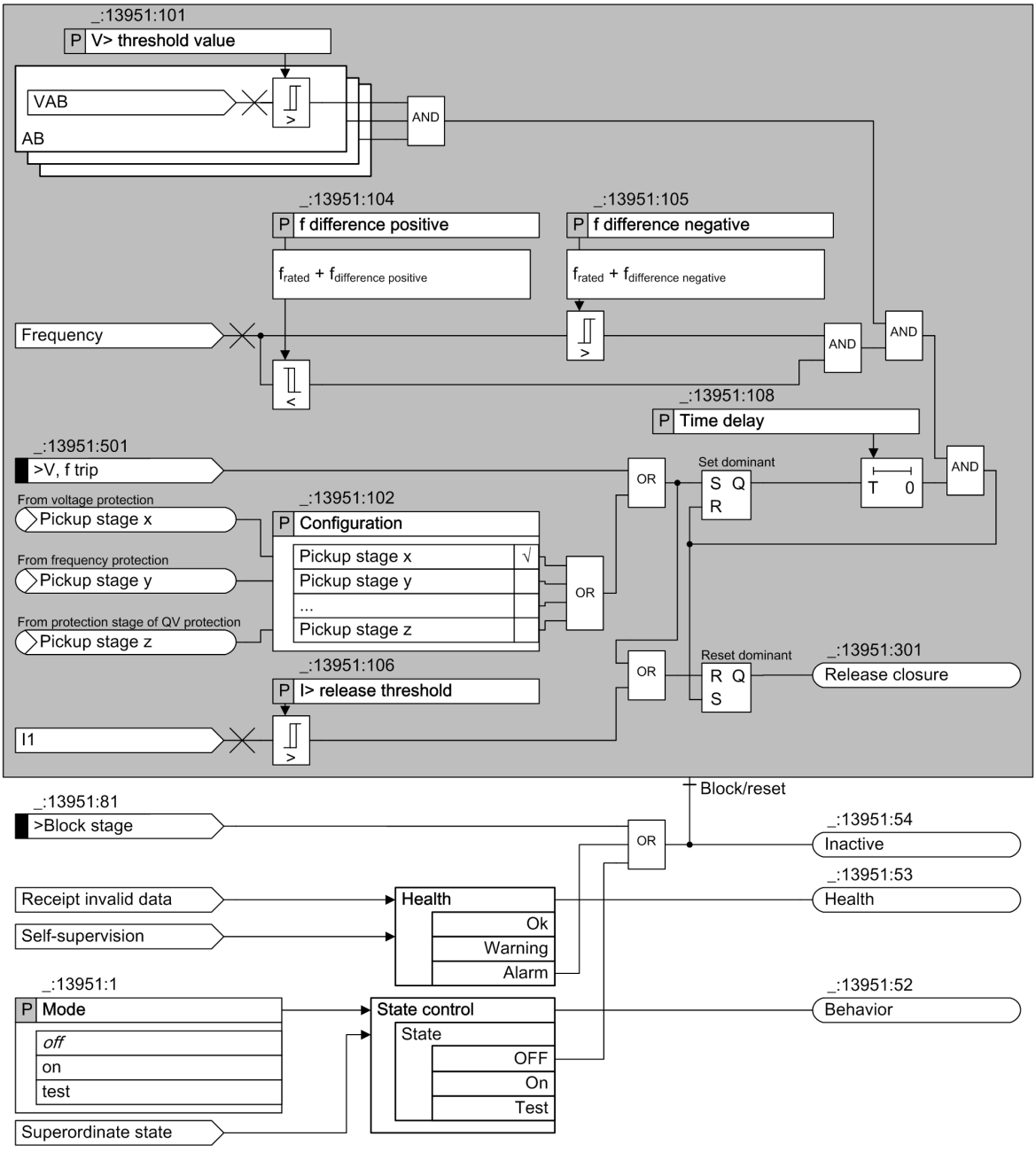
6.38.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Prot. stage 1			
_:13921:81	Prot. stage 1:>Block stage	SPS	I
_:13921:54	Prot. stage 1:Inactive	SPS	O
_:13921:52	Prot. stage 1:Behavior	ENS	O
_:13921:53	Prot. stage 1:Health	ENS	O
_:13921:60	Prot. stage 1:Inrush blocks operate	ACT	O
_:13921:55	Prot. stage 1:Pickup	ACD	O
_:13921:301	Prot. stage 1:Op.delay expir.(gen.)	ACT	O
_:13921:302	Prot. stage 1:Operate (generator)	ACT	O
_:13921:56	Prot. stage 1:Op.delay expir.(grid)	ACT	O
_:13921:57	Prot. stage 1:Operate (grid)	ACT	O

6.38.4 Description Reclosure Stage

6.38.4.1 Description

Logic of the Stage



[loqvclst-110713-01.tif, 3, en_US]

Figure 6-226 Logic Diagram of Reclosure Stage in Undervoltage-Controlled Reactive-Power Protection

Measurand

The stage works with fundamental values of voltage and current.

Release for Reconnecting

The release for reconnecting the power-generation facility is given under the following conditions:

- All 3 phase-to-phase voltages are above the threshold value.
- The power frequency is within a specified range.
- The reclosure time delay, started by the operate of specific protection functions, has elapsed. The time delay is started by the first operate signal of the protection stages configured via the **Configuration** parameter. All protection stages of the voltage protection, the frequency protection, and the QV protection are available for configuration.

External Start of Reclosure Time Delay

Reclosure time delay can be started via the binary input signal *>V, f trip*, which can be connected to external voltage and frequency protection trip signals.

Blocking of the Stage

The stage can be blocked via the binary input signal *>Block stage*.

6.38.4.2 Application and Setting Notes

Parameter: Configuration

- Default setting **(_:13951:102) Configuration** = ***no stage***

You use the **Configuration** parameter to define which operate signal of specific protection functions starts the release time delay of the **Reclosure stage**:

- Overfrequency protection
- Underfrequency protection
- Overvoltage protection
- Undervoltage protection
- Protection stage of undervoltage-controlled reactive-power protection

When the protection stage of undervoltage-controlled reactive-power protection is selected, only the signal *Operate (generator)* can start the release time delay of this stage. The signal *Operate (grid)* cannot start the release time delay.
The configuration depends on the specific application.

Parameter: I> release threshold

- Recommended setting value **(_:13951:106) I> release threshold** = ***0.100 A***

You use the **I> release threshold** parameter to define a precondition that the stage can work.
The default setting is at 10 % of the rated current. Siemens recommends using the default setting.

Parameter: V> threshold value

- Recommended setting value **(_:13951:101) V> threshold value** = ***95.000 V***

You use the **V> threshold value** parameter to set one of the 2 release criteria. The setting should be set above the lower value of the allowed voltage range, according to the national transmission code. In Germany, the recommended overvoltage threshold is 95 % of the rated voltage. Therefore Siemens recommends using the default setting.

Parameter: Frequency range

- Recommended setting value **(_:13951:104) f difference positive** = ***0.05 Hz***
- Recommended setting value **(_:13951:105) f difference negative** = ***-2.50 Hz***

You use these 2 parameters to define the admitted frequency deviation from the rated frequency. **f difference positive** defines the upper frequency range limit. **f difference negative** defines the lower frequency range limit.

Siemens recommends using the default settings, which reflect common practice in Germany. Other national transmission codes may require a slightly different range.

Parameter: `Time delay`

- Default setting **`(_:13951:108) Time delay`** = ***`0.00 s`***

You use the **`Time delay`** parameter to specify the minimum time delay for releasing the reconnection of the power-generation facility after tripping by protection.

The setting depends on the specific application.

6.38.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Reclos. stage`				
_:13951:1	Reclos. stage:Mode		• off • on • test	off
_:13951:101	Reclos. stage:V> threshold value		3.000 V to 340.000 V	95.000 V
_:13951:104	Reclos. stage:f difference positive		0.01 Hz to 5.00 Hz	0.05 Hz
_:13951:105	Reclos. stage:f difference negative		-5.00 Hz to -0.01 Hz	-2.50 Hz
_:13951:106	Reclos. stage:I> release threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:13951:108	Reclos. stage:Time delay		0.00 s to 3600.00 s	0.00 s
_:13951:102	Reclos. stage:Configuration		Setting options depend on configuration	

6.38.4.4 Information List

No.	Information	Data Class (Type)	Type
`Reclos. stage`			
_:13951:81	Reclos. stage:>Block stage	SPS	I
_:13951:501	Reclos. stage:>V, f trip	SPS	I
_:13951:54	Reclos. stage:Inactive	SPS	O
_:13951:52	Reclos. stage:Behavior	ENS	O
_:13951:53	Reclos. stage:Health	ENS	O
_:13951:301	Reclos. stage:Release closure	ACT	O

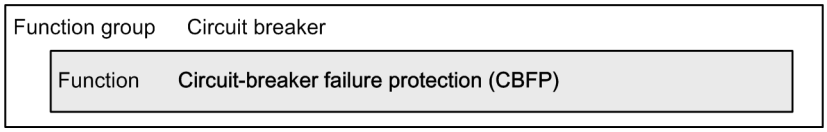
6.39 Circuit-Breaker Failure Protection

6.39.1 Overview of Functions

The **Circuit-breaker failure protection** function (ANSI 50BF) monitors the tripping of the associated circuit-breaker (CB) and generates a backup trip signal if the circuit-breaker fails.

6.39.2 Structure of the Function

The function **Circuit-breaker failure protection** (CBFP) can be used in the **Circuit-breaker** function group.



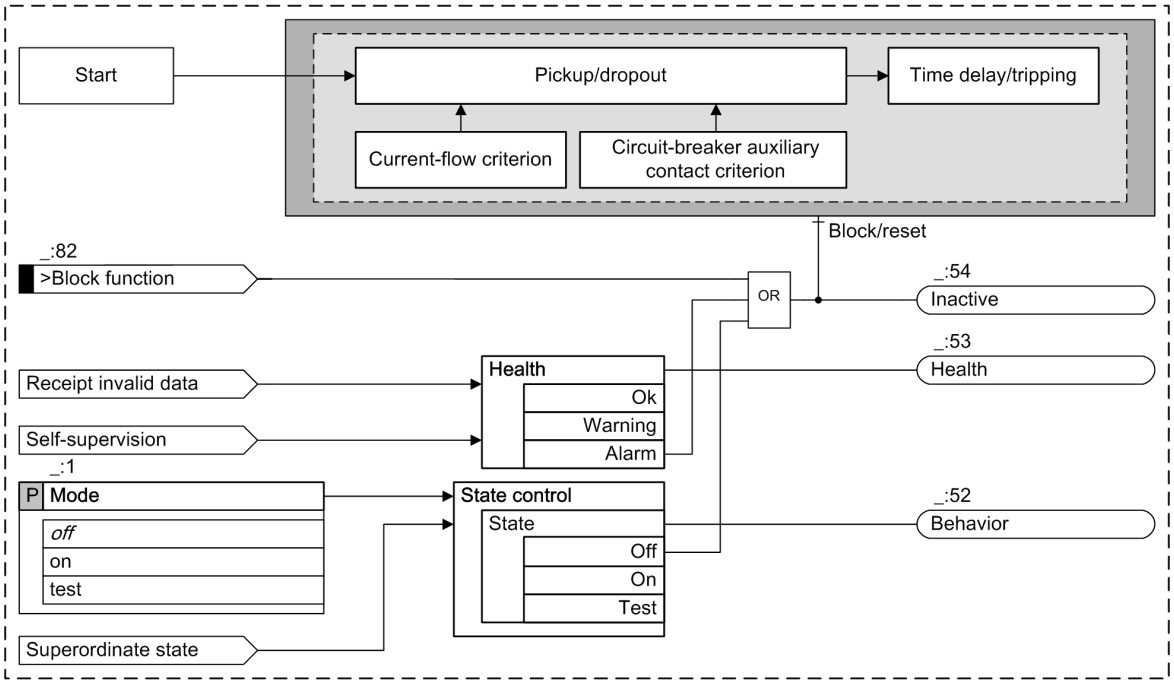
[dwstrbfp-260213-01.tif, 1, en_US]

Figure 6-227 Structure/Embedding of the Function

Figure 6-228 shows the functionalities and the function control of the function.

The start is initiated by the device-internal protection function or by an external protection. Along with the start, the current-flow criterion or the circuit-breaker auxiliary contact criterion is used to check whether the circuit breaker is closed. If the circuit breaker is closed, the function picks up and starts the time delay. During the time delay, the system checks continuously whether the circuit breaker has opened. If this is the case, the function drops out. If the circuit breaker is not opened, the function trips upon expiration of the time delay.

The following description elaborates on the detailed functionality of the individual function blocks.



[losvsbfp-090712-01.tif, 2, en_US]

Figure 6-228 Function Logic Overview

6.39.3 Function Description

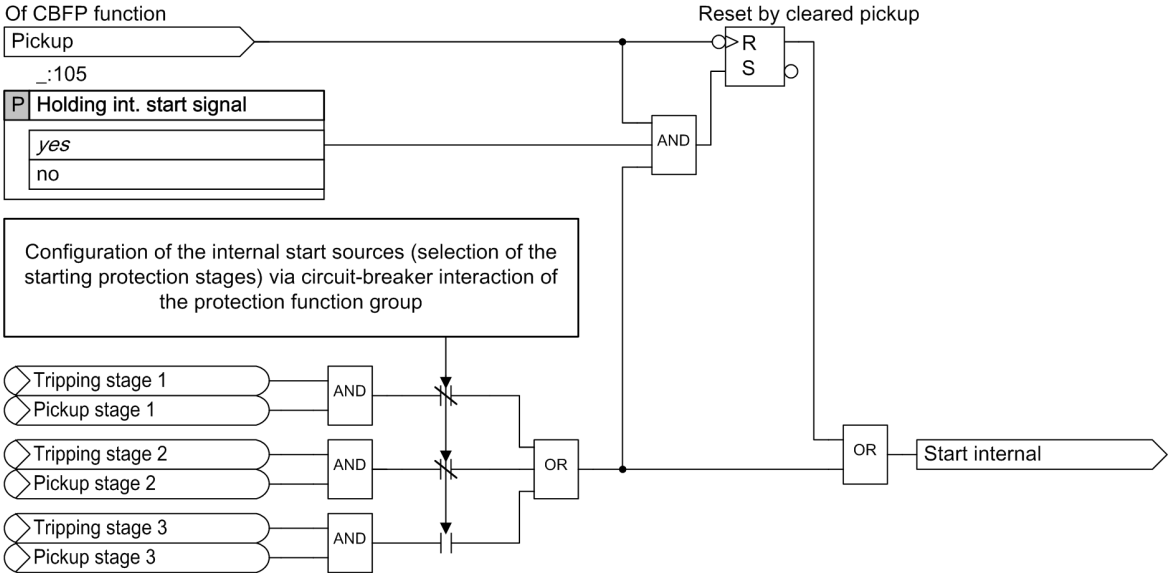
The Circuit-breaker failure protection function is started by device-internal protection functions and/or externally (via a binary input or an interface, such as GOOSE). *Figure 6-229* and *Figure 6-230* show the functionality.

Internal Start

By default, each device-internal protection stage, which has to control the local circuit breaker, starts the circuit-breaker failure protection. The function is started by the tripping of the protection stage. In the default setting, the starting signal **`Internal start`** (see *Figure 6-229*) is held when the pickup signal has a falling edge or the protection function has tripped. The Circuit-breaker failure protection function can in this case only dropout if the circuit breaker is detected to be open. This is detected using the current flow or circuit-breaker auxiliary contact criterion. If necessary, the Circuit-breaker failure protection function can also drop out when the pickup signal has a falling edge or the protection function trips (internal starting signal is not held).

Using routing, you can specify whether individual protection stages or protection functions are to be used as the starting source or whether starting happens only externally.

The internal starting sources are routed in the protection function groups via the **Circuit-breaker interaction** entry (for this, see *2.1 Function Embedding in the Device Figure 2-6*).

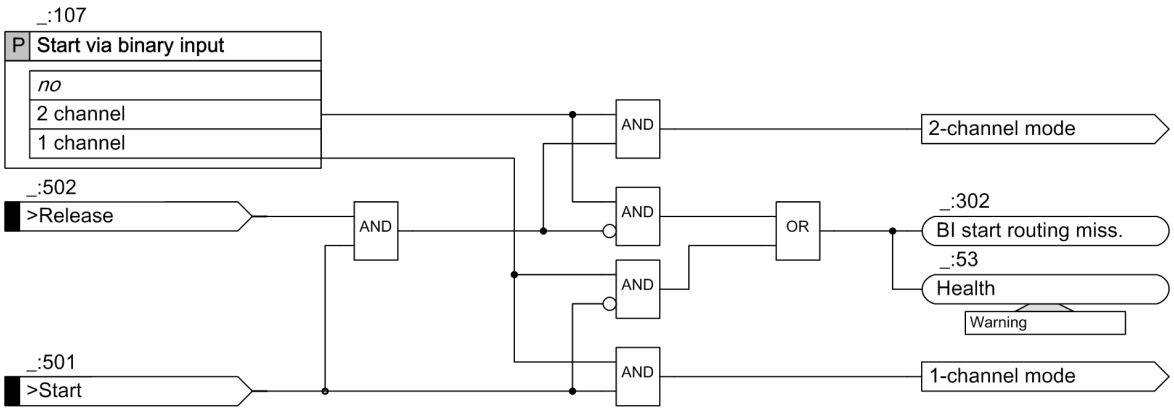


[loanwint-160611-01.tif, 1, en_US]

Figure 6-229 Internal Start of the Circuit-Breaker Failure Protection Function

External Start

The parameter **`Start via binary input`** is used to set whether the external start is initiated by a 1-channel or 2-channel signal. The required routing of the input signals is compared with the setting. If a routing is missing, an error message is generated. The Health signal changes to the state *`warning`*.



[loanwext-030211-01.tif, 1, en_US]

Figure 6-230 Configuration of the External Start of the Circuit-Breaker Failure Protection Function

In 1-channel operation, the start is initiated with the binary input signal **>Start** only.

In 2-channel operation, the binary input signal **>Release** must also be activated to initiate the start. In the default setting, the starting signal **External start** drops out immediately when the input signals have a falling edge (see *Figure 6-231*). If necessary, the starting signal can be held. In this case the start remains active when the binary input signals have a falling edge.

The input signals are monitored to avoid an unwanted pickup of the function.

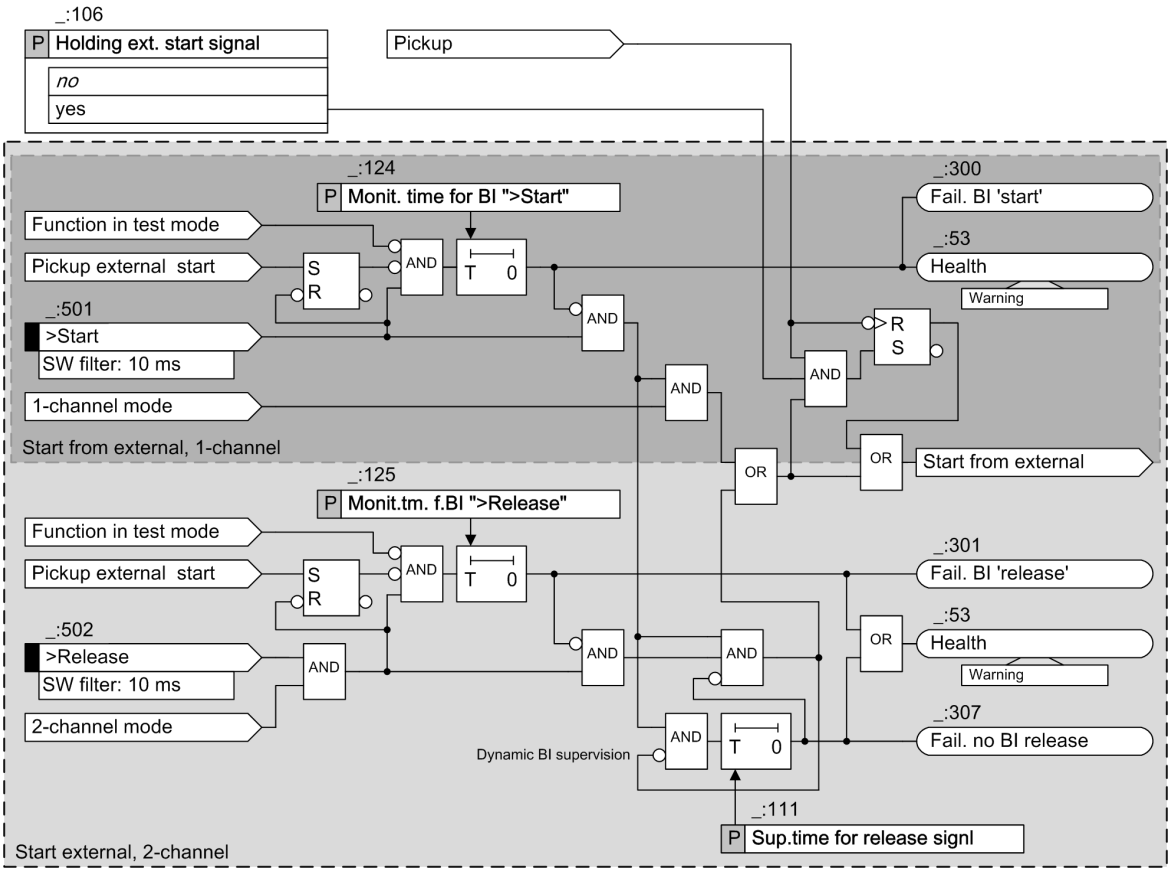
If either of the signals **>Start** or **>Release** is active for more than the set time without the function picking up, an error in the binary input circuit is assumed. The corresponding signal is blocked to exclude an external pickup of the function. An indication to this effect is output, and the Health signal changes to the state *warning*. The blocking is reset as soon as the binary input signal drops out.

Supervision is disabled in the following cases:

- On pickup of the Circuit-breaker failure protection function (only in the case of an external start). This prevents an unwanted pickup of the supervision if the external protection that starts the Circuit-breaker failure protection function uses a lockout functionality. When the starting signal drops out, the supervision is active again.
- As long as the function or the device is in **test mode**. This allows to check the function without the supervision blocking the function.

If the **>Start** signal is active but no release signal is present after the settable supervision time expires, the pickup is blocked and an indication to this effect is output. The Health signal changes to the state Warning. The blocking is reset with the dropout of the starting signal.

The binary input signals only take effect if the binary inputs are activated for at least 10 ms (SW filter, see *Figure 6-231*).



[logikext-070611-02.tif, 2, en_US]

Figure 6-231 External Start of the Circuit-Breaker Failure Protection Function, Logic

Current-Flow Criterion

The current-flow criterion is the primary criterion for determining the circuit-breaker position. A circuit-breaker pole is supposed to be closed, and the current-flow criterion fulfilled, as soon as one of the phase currents exceeds the phase-current threshold value, and at the same time a plausibility current exceeds the associated threshold value. The plausibility current can be either a 2nd phase current (to compare with the threshold value for phase currents) or the zero-sequence or negative-sequence current (to compare with the sensitive threshold value). The additional evaluation of the plausibility current increases the safety of the criterion.

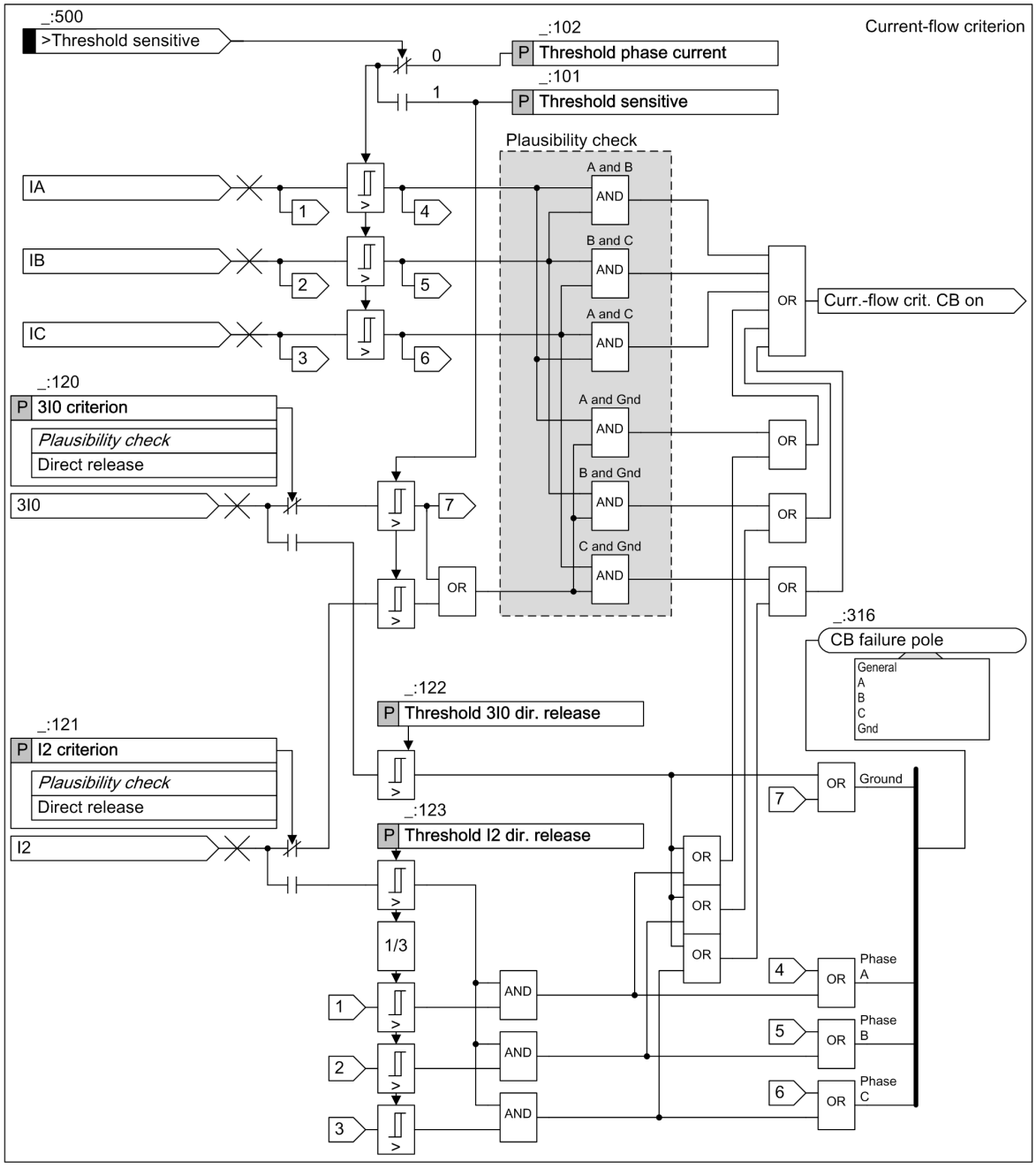
In the case of ground faults, the sensitive threshold value can be dynamically applied to the phase currents as well. The current-flow criterion is fulfilled when the currents exceed the sensitive threshold value. The phase-current threshold value is then ineffective. The binary signal **>Threshold sensitive** is used for the switch-over.

If you set the **3I0 criterion** parameter to ***Direct release***, you prevent the plausibility check of the zero-sequence current. In this way, a pickup only by way of this current can be achieved. Using the **Threshold 3I0 dir. release** parameter, you set the threshold value to be exceeded.

If you set the **I2 criterion** parameter to ***Direct release***, you also switch off the plausibility check of the negative-sequence current. Using the **Threshold I2 dir. release** parameter, you set the threshold value to be exceeded.

If you set the **I2 criterion** parameter to ***Direct release***, a plausibility check is performed via the phase currents with 1/3 * **Threshold I2 dir. release**.

The measuring algorithm is optimized for fast dropout when the value drops below the threshold value.



[lostrom1-030211-01.tif, 3, en_US]

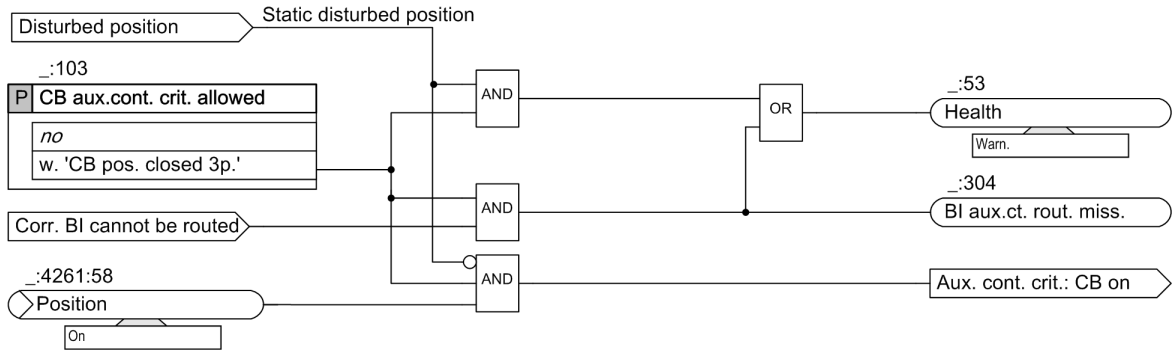
Figure 6-232 Current-Flow Criterion

Circuit-Breaker Auxiliary-Contact Criterion

Settings allow you to specify whether the circuit-breaker auxiliary contacts are permitted for determining the circuit-breaker position.

The double-point indication **`3-pole position`** (from the **Circuit-breaker** function block) is used to determine whether all 3 poles of the circuit breaker are closed. If the double-point indication is not routed, the output is an error message. Furthermore, the Health signal changes to the state *`warning`*.

The detection of a static disturbed position (not an intermediate position) has the effect that the circuit-breaker auxiliary-contact criterion is not used (the internal signal **`Aux.co.crit.: CB Clsd`** is disabled).



[lokriter-140611-01.tif, 1, en_US]

Figure 6-233 Circuit-Breaker Auxiliary-Contact Criterion

Pickup/Dropout

After the start, a check is performed whether the circuit breaker is closed. The current-flow criterion and the circuit-breaker auxiliary-contact criterion are available for this purpose.

Even if the circuit-breaker auxiliary-contact criterion is permitted, preference is given to the fulfilled current-flow criterion because the current-flow criterion is the most reliable criterion for detecting whether the circuit breaker is closed. This means that the circuit breaker is deemed to be closed if it is closed according to the current-flow criterion but at the same time open according to the circuit-breaker auxiliary-contact criterion.

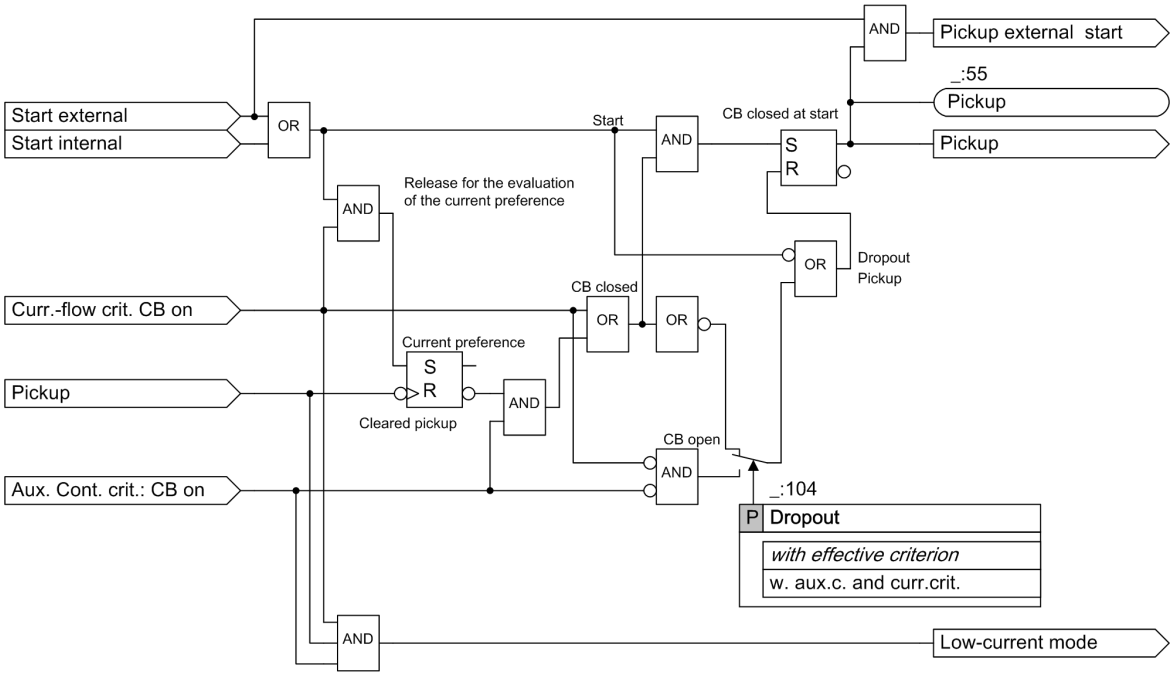
If no current is flowing at the start time, the function can only pick up on the basis of the circuit-breaker auxiliary-contact criterion. For this purpose, the circuit-breaker auxiliary contacts must be permitted as criterion. When the current begins to flow after the start, the function switches over to the current-flow criterion.

If the circuit breaker is detected to be closed, the function picks up.

The pickup starts a time delay (see Delay/Tripping). While the delay is running, the system checks continuously whether the circuit breaker has opened. In the default setting, the opening of the circuit breaker is checked on the basis of the currently valid criterion, which is normally the current-flow criterion because it is preferred. If until expiration of the time delay, no current flow above the set threshold values has been detected, the circuit-breaker auxiliary-contact criterion becomes effective.

The function has also a setting in which dropout is only possible if both criteria in parallel detect the circuit breaker to be open (dropout with auxiliary contact and current-flow criterion).

In the default setting, the internal starting signal is held (see *Figure 6-229* and *Figure 6-231*). This means that dropout is controlled solely by the switch or the circuit-breaker auxiliary-contact criterion. If dropout is also to occur on the falling edge of the starting signal (that is, when the pickup signal has a falling edge or the protection function trips), holding of the start signal must be disabled.



[loanreg1-030211-01.tif, 3, en_US]

Figure 6-234 Pickup/Dropout of the Circuit-Breaker Failure Protection Function

Delay/Tripping

In a first step, tripping at the local circuit breaker can be repeated. Tripping is repeated after expiration of the settable delay T1. If the local CB was not yet tripped, for example, in the event of an external start of the circuit-breaker failure protection, the trip logic of the circuit breaker itself is activated when the time delay T1 elapses.

Time delay T2 (backup tripping) can commence in parallel either with the start of time T1 or after expiration of time T1.

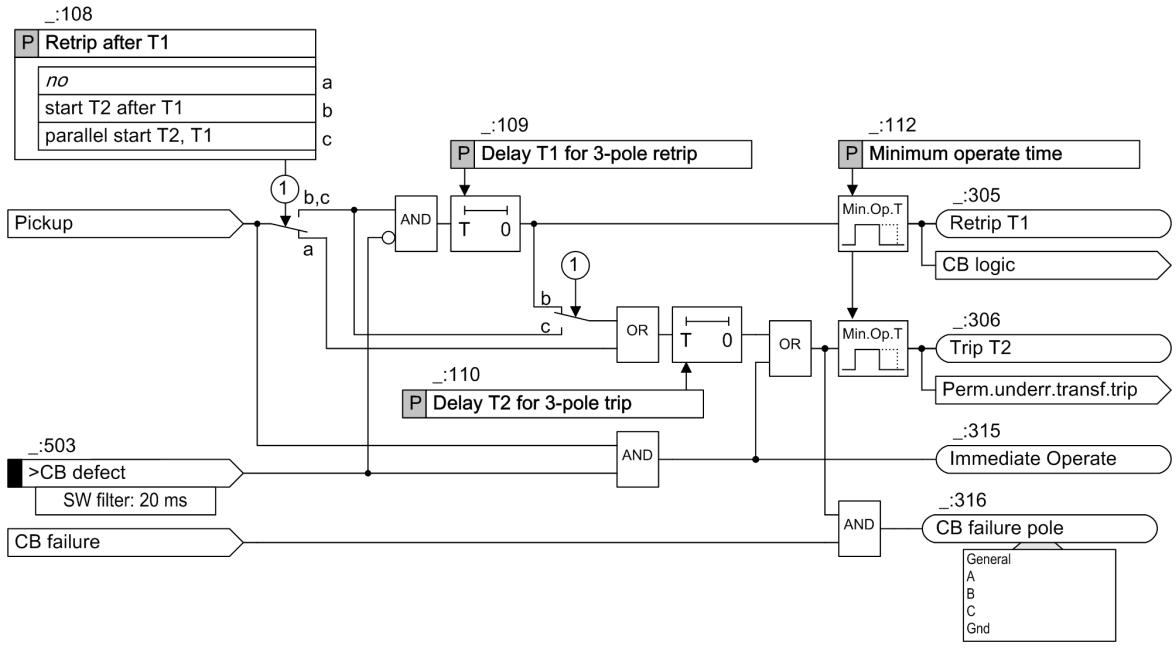
If time delay T2 expires without a dropout of the function, a circuit-breaker failure is assumed and the backup tripping signal **`Tripping T2`** is output. If there is a protection interface in the device, if needed a transfer-trip signal can be sent to the opposite end.

You can find detailed information in the chapter *3.5.3 Protection Interface and Protection Topology*.

If the **`>CB defect`** input signal is valid, any repetition of the trip signal is suppressed, and the backup tripping signal T2 is generated immediately (without delay). The binary input of the **`>CB defect`** input signal must be activated for at least 20 ms before the signal becomes valid.

With help of the *`CB failure pole`* indication, you can determine the phase currents that are above the threshold value at the tripping time T2.

The **`Minimum operate time`** parameter defines the minimum duration for tripping the function. In contrast to other protection functions, the parameter is set within its own function. As a result, the setting is independent of the identically named global parameter that is set in the **Device settings**.

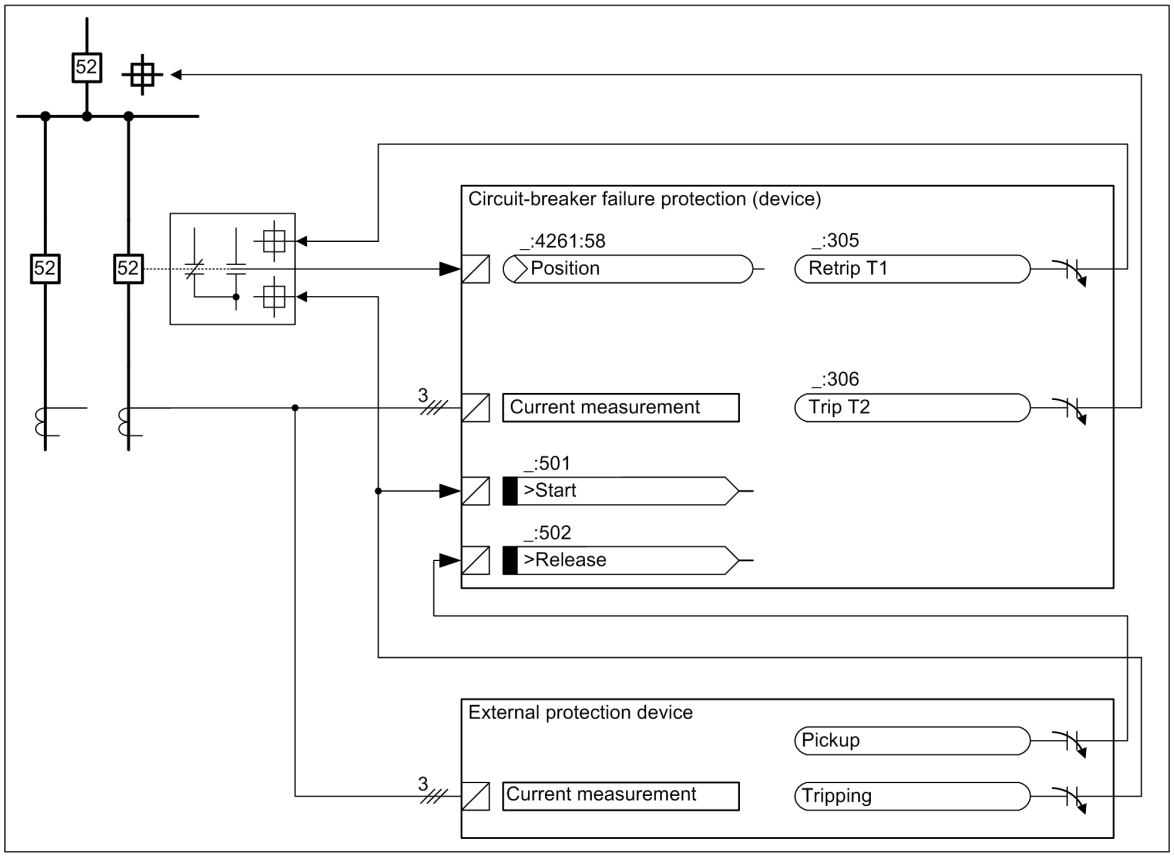


[lo-bbp-verza-3ph.vsd, 4, en_US]

Figure 6-235 Delay/Tripping of the Circuit-Breaker Failure Protection Function

6.39.4 Application and Setting Notes

Figure 6-236 gives an overview of the functions involved in an external start of the CBFP function. In the case of an internal start, there is no external protection device and the protection functionality is located in the CBFP device.



[loextpol-021112-01.tif, 1, en_US]

Figure 6-236 Circuit-Breaker Failure Protection with External Start, Tripping Repetition and 3-Pole Tripping (T2)

Routing: Configuration of Internal Starting Sources (Internal Protection Function)

Configuration of the internal starting sources takes place in the protection function groups via the **Circuit-breaker interaction** entry (for this, see *2.1 Function Embedding in the Device*, *Figure 2-2*).

By default, the function can be started by any tripping of the internal protection functions, which control the local circuit breaker. Depending on the specific application, it can be necessary to exclude certain device-internal protection functions from starting the CBFP. For instance, busbar disconnection following a local circuit-breaker failure can be undesirable in the case of load-shedding applications or ground faults in isolated/resonant-grounded systems.

Where a start exclusively from external sources is required, all internal protection functions must be routed so that they are excluded as a starting source.

Parameter: Start via binary input

- Default setting **(_:107) Start via binary input** = ***no***

Parameter Value	Description
no	If no external start is intended, the parameter is set to ***no***.

Parameter Value	Description
2 channel	2-channel start is used if there is a risk that the circuit-breaker failure protection causes a tripping due to a faulty activation of the start binary input. This is the case in the following situations: a) The CBFP pickup value (threshold value) is set to less than the load current. b) There can be operating conditions under which the current flow is higher than the pickup value. To avoid a possible overfunction, Siemens recommends using the 2-channel start.
1 channel	The 1-channel start must be used where only one control circuit of a binary input is available for starting the CBFP.

Input Signals: >Start, >Release

The start and release input signals have a filtering time of ***10 ms*** as default setting. If a transient control signal to the binary inputs is to be expected due to the design of the external binary-input control circuits and due to environmental conditions, the filtering time can be extended. This delays the start of the CBFP function.

Input Signals	Description
>Start	The start input signal is linked with the tripping of the external protection device (see *Figure 6-236*).
>Release	The enabling input signal is normally linked with the pickup of the external protection device (see *Figure 6-236*). Another common configuration is the parallel wiring of the external trip initiation to both binary inputs (start and release).

Parameter: Supervision time release signal

- Default setting **(_:111) Sup.time for release signl** = ***0.06 s***

The setting depends on the external function which generates the release signal. If the pickup or tripping of the external protection is used as release signal, the default setting can be kept. If it is ensured that the release signal is always present before the starting signal, the time can be set to 0.

Parameter: Holding internal signal

- Recommended setting value **(_:105) Holding int. start signal** = ***yes***

Parameter Value	Description
yes	For an internal start, the starting signal is hold by default. The dropout of the CBFP depends exclusively on the determination of the CB position. This setting must be selected if it is not ensured that all 3 poles of the CB have opened when the pickup signal of the protection function has a falling edge. Siemens recommends using this method as the standard method.
no	Holding of the starting signal can be disabled if it is ensured by the application that the CB has reliably opened when the starting signal has a falling edge, or if the CBFP is explicitly required to dropout when the starting signal has a falling edge.

EXAMPLE

Holding internal starting signal (setting value: yes)

In the event of a 2-pole fault, only one contact of the CB opens. The fault current is thus reduced, and the starting phase short-circuit protection drops out.

Parameter: Holding ext. start signal

- Recommended setting value **(_:106) Holding ext. start signal** = ***no***

Parameter Value	Description
no	The CBFP drops out when the external starting signal has a falling edge. This setting prevents the CBFP from generating a tripping signal when an unwanted pulse is received at the binary input and the current flow is high enough. Siemens recommends using this method as the standard method.
yes	You can hold the starting signal if it is not ensured that the circuit breaker is open when the external starting signal has a falling edge.

EXAMPLE

Holding external starting signal (setting value: yes)

The function is started from the opposite end via an auxiliary device for command transmission. This device generates only a signal pulse.

NOTE

Siemens would like to point out that, with a hold signal, the CBFP generates a trip signal each time a starting pulse is received and the current flow is high enough. Remember this particularly in the case of an external start.

Parameter: Threshold phase current/Threshold sensitive

- Recommended setting value **(_:102) Threshold phase current** = ***approx. 0.50 $I_{sc,min}$***
- Recommended setting value **(_:101) Threshold sensitive** = ***approx. 0.50 $I_{sc,min}$***

In order to ensure that the disconnection of the fault is promptly detected and the function can drop out quickly, Siemens recommends setting both thresholds to half the minimum short-circuit current ($I_{sc, min}$).

If – depending on the neutral-point treatment and/or load conditions – ground faults lead to relatively low fault currents, a sensitive setting of the parameter **Threshold sensitive** must be selected according to the rule (0.5 $I_{sc,min}$). There can also be values which are noticeably below the rated or load current.

Input Signal: >Threshold sensitive

In order to ensure that the function picks up reliably in all switch positions of the power-supply system (examples: opposite end of line open, switching onto a ground fault), the setting of the parameter **Threshold sensitive** can be applied dynamically to all currents – including phase currents – in the presence of ground faults. For this purpose, the binary signal **>Threshold sensitive** must be activated. This can be done via a device-internal function for ground-fault detection (if provided in the device), for example, using **Overvoltage protection with zero-sequence voltage**. In this case, the pickup of the V0> function must be linked with the binary signal. Alternatively, the signal can be coupled from a separate device for sensitive ground-fault detection via a binary input.

Parameter: Circuit-breaker auxiliary-contact criterion allowed for protection

- Recommended setting value **(_:103) CB aux.cont. crit. allowed** = ***no***

Parameter Value	Description
no	If sufficient current flow is ensured under all conditions with the CB closed, Siemens recommends not to permit the auxiliary contacts as a further criterion for determining the CB position, because measurement based on the current flow is the most reliable criterion.

Parameter Value	Description
w. 'CB pos. closed 3p.'	The auxiliary contacts are permitted as a further criterion in applications (see the following examples) where the current is no reliable criterion for determining the circuit-breaker position.

Parameter: 3I0 criterion

- Recommended setting value (_:120) **3I0 criterion** = ***Plausibility check***

Parameter Value	Description
Plausibility check	The ground current serves only for the plausibility check of the phase currents. The threshold for the ground current uses the value set in the **Threshold sensitive** parameter.
Direct release	The current-flow criterion can be satisfied only by the ground current without the phase currents exceeding the set threshold value. The threshold for the ground current uses the value set in the **Threshold 3I0 dir. release** parameter in this case.

Parameter: I2 criterion

- Recommended setting value (_:121) **I2 criterion** = ***Plausibility check***

Parameter Value	Description
Plausibility check	The negative-sequence current serves only for the plausibility check of the phase currents. The threshold for the negative-sequence current uses the value set in the **Threshold sensitive** parameter.
Direct release	If one phase current exceeds 1/3 of the **Threshold I2 dir. release**, the current-flow criterion can be satisfied just by the negative-sequence current without the phase currents exceeding their set threshold value. The threshold for the negative-sequence current uses the value set in the **Threshold I2 dir. release** parameter in this case.

EXAMPLES

Applications which require you to permit the circuit-breaker auxiliary-contact criterion:

- Tripping of the high and low-voltage side CB on the transformer. If only one of the 2 CBs trips, there is no more current flow.
- Tripping of protection functions whose tripping decision is not based on current measurement, in combination with low-load situations.
- Injection of the tripping signal from Buchholz protection

Parameter: Dropout

- Recommended setting value **(_:104) Dropout** = ***with effective criterion***

The parameter **Dropout** is available if the circuit-breaker auxiliary-contact criterion is permitted (see parameter **CB aux.cont. crit. allowed**).

Parameter Value	Description
with effective criterion	Siemens recommends keeping the default setting, because it prefers the current as a reliable criterion for detection of an open CB and thus for dropout of the CBFP function.
w. aux.c. and curr.crit.	Select this setting for applications on transformers or generators (see the preceding examples) in which the current flow is such that the current is no longer a reliable criterion for detecting the opening of the CB.

Parameter: Retrip

- Default setting **(_:108) Retrip after T1** = ***no***

Parameter Value	Description
no	Where no redundant CB control is provided, a repetition of the trip signal to the local CB is not required.
start T2 after T1	Where a redundant CB control (2nd trip coil with 2 trip circuits) is provided, a repetition of the trip signal to the local CB makes sense. Siemens recommends the setting ***start T2 after T1*** because it provides a clear chronological separation of the processes for trip repeat and backup tripping. Remember here that the overall fault-clearance time in case of a failure of the local CB is the sum of T1 and T2.
parallel start T2, T1	As an alternative to the setting ***start T2 after T1***, the user can start T2 and T1 in parallel.

Parameter: Delay T1 for 3-pole retrip

- Default setting **(_:109) Delay T1 for 3-pole retrip** = ***0.05 s***

The parameter is visible only when retripping is set.

The setting depends on the user's philosophy.

The following settings make sense:

- If the minimum fault-clarification time has top priority, Siemens recommends setting the time to 0. This setting causes initiation of the retrip immediately upon the start. The drawback is that a defect of the 1st trip circuit is not detected.
- With a small time delay of, for instance, 50 ms, the defect of the 1st trip circuit can be detected based on the evaluation of the fault record.
- With a long time delay which reliably ensures the dropout of the CBFP with the CB open, the rising edge indication of the trip repeat **Retrip T1** is a sure signal for a fault in the 1st trip circuit. The following example shows how this time is determined.

EXAMPLE

Determining the T1 Time that Reliably Ensures the Dropout of the CBFP with the CB Open:

Time of binary device output (when tripping is caused by the device-internal protection)	5 ms
CB inherent time up to current interruption	2 periods (assumed rated frequency = 50 Hz)
Dropout time of CBFP function	1 period
Subtotal	65 ms
Security	Factor 2
Total (time T1)	130 ms

Parameter: Delay T2 for 3-Pole Trip

- Default setting **(_:110) Delay T2 for 3-pole trip** = ***0.13 s***

This setting has to ensure that after opening of the local CB the function drops out reliably and that backup tripping is avoided under all circumstances. The setting depends on the parameter **Retrip after T1**.

If T2 is started afterT1, there is no need to consider the time T1 for the setting of T2.

EXAMPLE

Determining the T2 Time that Reliably Ensures the Dropout of the CBFP with the CB Open:

Time of binary device output (when tripping is caused by the device-internal protection)	5 ms
CB inherent time up to current interruption	2 periods (assumed rated frequency = 50 Hz)
Dropout time of CBFP function	1 period
Subtotal	65 ms
Security	Factor 2
Total (time T2)	130 ms

If T1 and T2 are started in parallel, take into account the time T1 for the setting of T2.

EXAMPLE

Simultaneous start of T2 and T1

Time for a reliable dropout after the local CB has opened	130 ms
Setting of T1	50 ms
Total (= T2)	180 ms

Parameter: Minimum operate time

- Default setting **(_:112) Minimum operate time** = **-**

The **Minimum operate time** parameter is used to set the minimum duration for tripping the function.



CAUTION

Do not set a time that is too short.

If you set a time that is too short, there is a danger (dropout of the function without the current-flow criterion) that the device contacts will interrupt the control circuit. If this happens, the device contacts will burn out.

✧ Set a duration that is long enough to ensure that the circuit breaker reaches its final position **open** reliably after a control operation.

Input Signal: >CB defect

The input signal **>CB defect** has a default filtering time of 20 ms. This filtering time prevents the input signal from becoming effective in the case of a transient activation of the physical binary input, which can be caused by the pressure change when the CB opens.

This time can be set to 0 if such a transient pickup of the physical binary input can be excluded due to the CB design.

Output Signal: Retrip T1

If only one control circuit is available for the local CB, it is not mandatory to route the output signal because the signal also controls the CB trip logic.

If a 2nd control circuit is present, the output signal **Retrip T1** must be routed to the associated binary output.

Output Signal: Trip T2

In order to operate the adjacent circuit breakers, the backup tripping (indication **Trip T2**) must be routed to a binary output; andif necessary, to an interface (intertripping to opposite end).

6.39.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
50BF CB fail.#				
_:1	50BF CB fail.#:Mode		• off • on • test	on
_:105	50BF CB fail.#:Holding int. start signal		• no • yes	yes
_:107	50BF CB fail.#:Start via binary input		• no • 2 channel • 1 channel	no
_:106	50BF CB fail.#:Holding ext. start signal		• no • yes	no
_:111	50BF CB fail.#:Sup.time for release signl		0.06 s to 1.00 s	0.06 s
_:103	50BF CB fail.#:CB aux.cont. crit. allowed		• no • w. 'CB pos. closed 3p.'	no
_:104	50BF CB fail.#:Dropout		• with effective criterion • w. aux.c. and curr.crit.	with effective criterion
_:108	50BF CB fail.#:Retrip after T1		• no • start T2 after T1 • parallel start T2, T1	no
_:102	50BF CB fail.#:Threshold phase current	1 A @ 100 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	2.500 A
_:101	50BF CB fail.#:Threshold sensitive	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A
_:109	50BF CB fail.#:Delay T1 for 3-pole retrip		0.000 s to 60.000 s	0.050 s
_:110	50BF CB fail.#:Delay T2 for 3-pole trip		0.050 s to 60.000 s	0.130 s
_:112	50BF CB fail.#:Minimum operate time		0.00 s to 60.00 s	0.10 s
_:120	50BF CB fail.#:3I0 criterion		• Direct release • Plausibility check	Plausibility check
_:121	50BF CB fail.#:I2 criterion		• Direct release • Plausibility check	Plausibility check
_:122	50BF CB fail.#:Threshold 3I0 dir. release	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A

Addr.	Parameter	C	Setting Options	Default Setting
_:123	50BF CB fail.#:Threshold I2 dir. release	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A
_:124	50BF CB fail.#:Monit. time for BI ">Start"		0.05 s to 60.00 s	15.00 s
_:125	50BF CB fail.#:Monit.tm. f.BI ">Release"		0.05 s to 60.00 s	15.00 s

6.39.6 Information List

No.	Information	Data Class (Type)	Type
50BF CB fail.#			
_:501	50BF CB fail.#:>Start	SPS	I
_:502	50BF CB fail.#:>Release	SPS	I
_:82	50BF CB fail.#:>Block function	SPS	I
_:503	50BF CB fail.#:>CB defect	SPS	I
_:500	50BF CB fail.#:>Thresh. ground curr.	SPS	I
_:54	50BF CB fail.#:Inactive	SPS	O
_:52	50BF CB fail.#:Behavior	ENS	O
_:53	50BF CB fail.#:Health	ENS	O
_:55	50BF CB fail.#:Pickup	ACD	O
_:305	50BF CB fail.#:Retrip T1	ACT	O
_:306	50BF CB fail.#:Trip T2	ACT	O
_:302	50BF CB fail.#:BI start routing miss.	SPS	O
_:304	50BF CB fail.#:BI aux.ct. rout. miss.	SPS	O
_:300	50BF CB fail.#:Fail. BI 'start'	SPS	O
_:307	50BF CB fail.#:Fail. no BI release	SPS	O
_:301	50BF CB fail.#:Fail. BI 'release'	SPS	O

6.40 Circuit-Breaker Restrike Protection

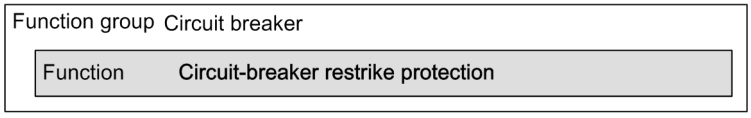
6.40.1 Overview of Function

The **Circuit-breaker restrike protection** function:

- Monitors the circuit breaker against restriking, for example, caused by an overvoltage over the circuit-breaker poles after switching off a capacitor bank
- Generates a backup operate signal in case of a circuit-breaker restriking

6.40.2 Structure of the Function

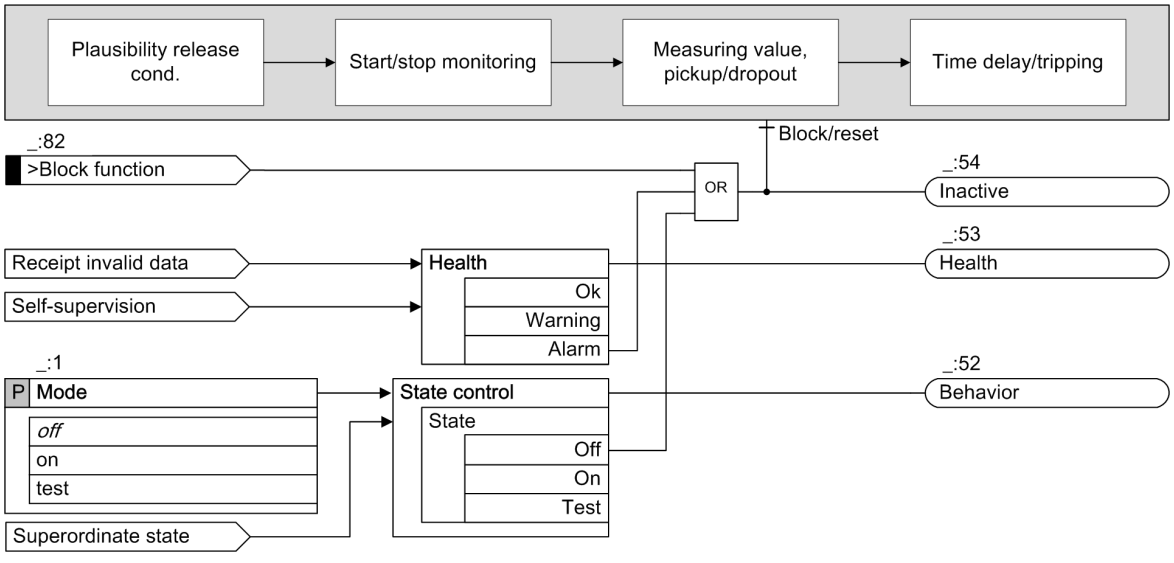
The **Circuit-breaker restrike protection** function is used in the **Circuit-breaker** function group. A maximum of 2 functions can operate simultaneously within the function group.



[lo_strrestrike_2014-03-05.vsd, 2, en_US]

Figure 6-237 Structure/Embedding of the Function

The function logic is grouped into the parts shown in *Figure 6-238*. In the following chapter, these logic parts are described in detail.



[lo_respro-210113-01.vsd, 1, en_US]

Figure 6-238 Logic Overview of the Function

6.40.3 Function Description

Plausibility Release

The function **Circuit-breaker restrike protection** issues a trip command to a superordinated circuit breaker, usually the infeed circuit breaker of a busbar. Overfunction of this protection can cause extreme problems for the whole application.

The logic of plausibility release strongly reduces the risk of a false start of the function by adding an extra release criteria for a function start.

Each criterion can be switched on or off individually.

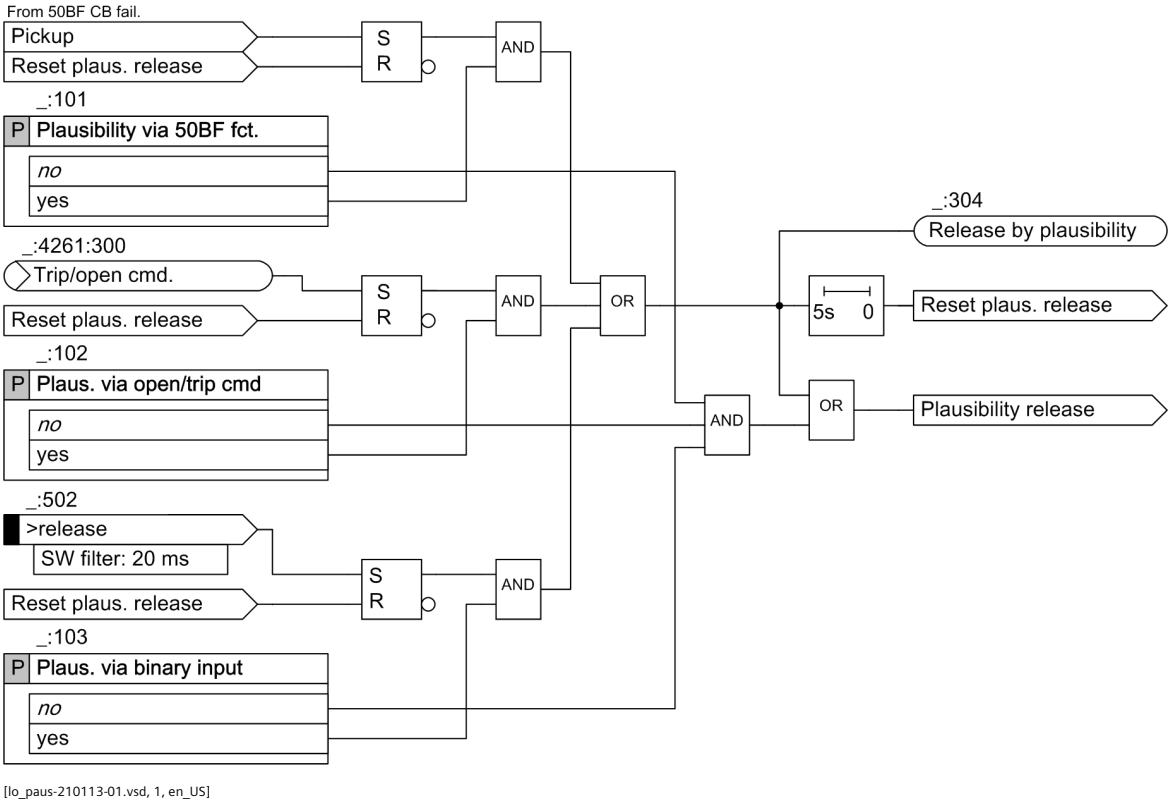


Figure 6-239 Logic Diagram for the Plausibility Release of the Circuit-Breaker Restrike Protection

The plausibility-release logic checks the following conditions:

- When the parameter **Plausibility via 50BF fct.** is set to ***yes***, the pickup signal of the **Circuit-breaker failure protection** is monitored. The plausibility release is given if the **Circuit-breaker failure protection** has picked up.
- When the parameter **Plaus. via open/trip cmd** is set to ***yes***, the trip/open command is monitored. The plausibility release is given if the trip/open command has been generated.
- When the parameter **Plaus. via binary input** is set to ***yes***, the *>release* signal is monitored. The plausibility release is given if the *>release* signal has been received.

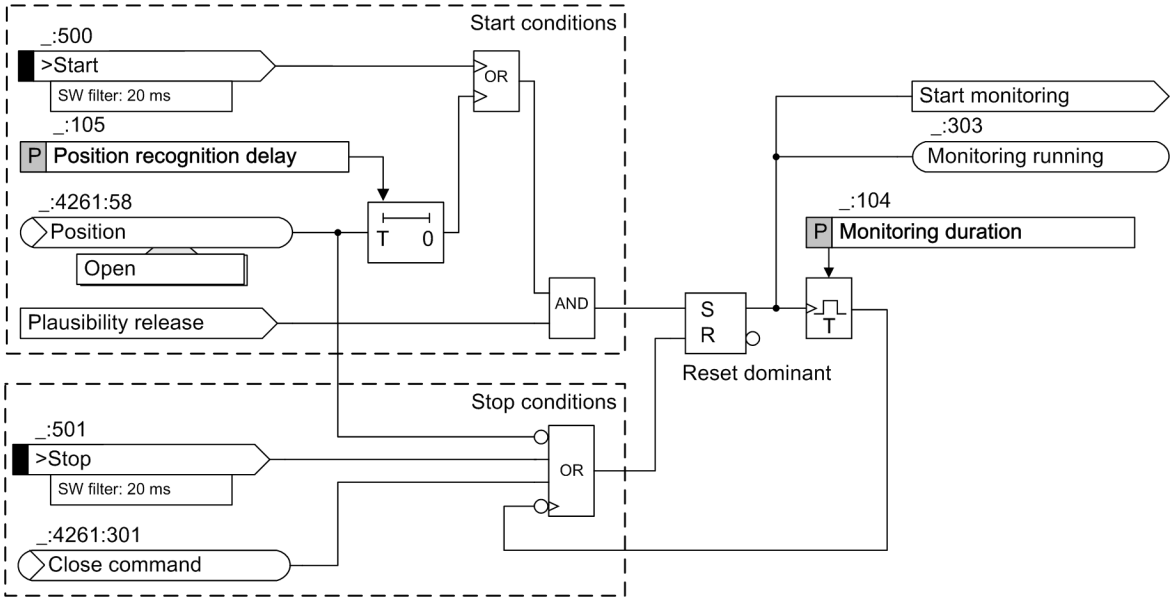
If one of the conditions is fulfilled, the plausibility release is given for 5 s. The 5-s timer ensures that the release criterion and start condition relate to the same circuit-breaker opening/tripping process.

If all the 3 plausibility settings are set to ***no***, the start/stop-monitoring logic considers the release as fulfilled.

For safety reasons, the input signal *>release* has a preset software filtering time of 20 ms.

Start/Stop Monitoring

Via the start/stop monitoring logic, the monitoring duration of the current signal regarding restriking is determined.



[lo_starstop-210113-01.vsd, 2, en_US]

Figure 6-240 Logic Diagram for Start/Stop Monitoring of the Circuit-Breaker Restrike Protection

The monitoring is started if one of the following conditions is met:

- The circuit-breaker position is detected as **open** via the circuit-breaker auxiliary contacts during the time set with the parameter **`Position recognition delay`**.

  The **`Position recognition delay`** time is used for safety means to ensure that the circuit breaker is definitely open when the monitoring starts. This parameter allows to adapt this start criterion to all kinds of auxiliary-contact configurations.

- The binary input signal *`>Start`* is activated.

For safety reasons, the input signal has a preset software filtering time of 20 ms.

In addition to the active start criterion, the plausibility release (refer to the *Plausibility Release, Page 808*) must be present to start the monitoring duration.

With the fulfilled start condition, the **`Monitoring duration`** timer is started. This timer defines how long the current signal is monitored regarding restriking. If the time expires, the monitoring is terminated.

The monitoring is also terminated immediately if one of the following conditions is met:

- The circuit-breaker position is detected no longer as **open**.
- A close command is given by the device.
- The binary input signal *`>Stop`* is activated.

  For safety reasons, the input signal has a preset software filtering time of 20 ms.

Measuring Value, Pickup/Dropout

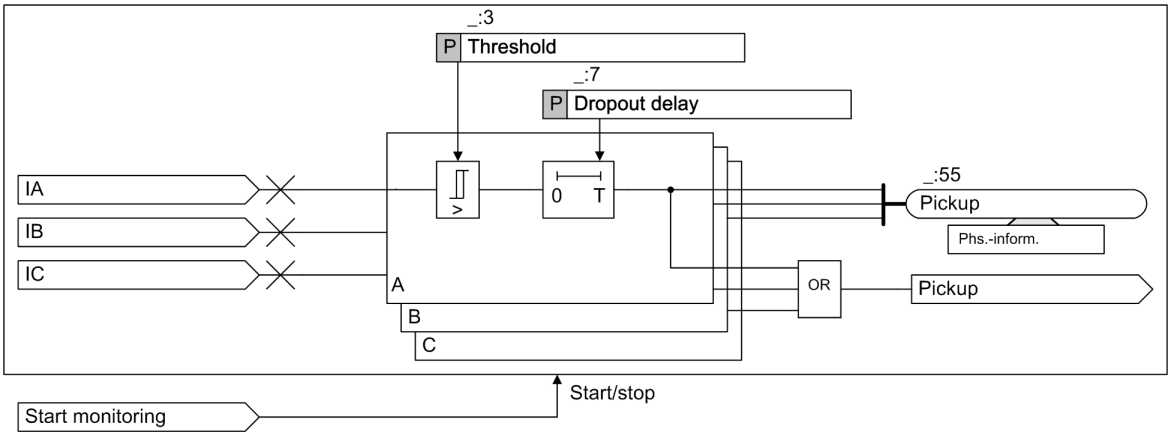
During the **`Monitoring duration`**, the current signal is monitored phase-selectively regarding restriking.

As a measuring value, the fundamental component of the current is used.

- On one hand, current peaks are damped but still detected reliably by the fundamental-component value.
- On the other hand, a DC (Direct Current) component is suppressed. A DC component can occur after switching off the circuit breaker.

Thus, the fundamental-component value is a good choice for a reliable restrike detection.

If any phase current exceeds the set current threshold value, the function picks up. The coming pickup indicates the first restrike current pulse. With the pickup, the operate delay timers are started, see also the following description *Delay/Tripping, Page 811*.



[lo_pickdrop-210113-01.vsd, 1, en_US]

Figure 6-241 Logic Diagram for Measuring Value, Pickup/Dropout of the Circuit-Breaker Restrike Protection

If restriking occurs, the current signal drops below the current threshold if the time between restrike pulses is long enough. In this case, the operate delay must not be reset. During the dropout delay, the pickup is extended to ensure that the operate delay timers are not reset. However, if the dropout delay time expires (no new current peak occurred), the function drops out and the operate delay timers are reset.

Delay/Tripping

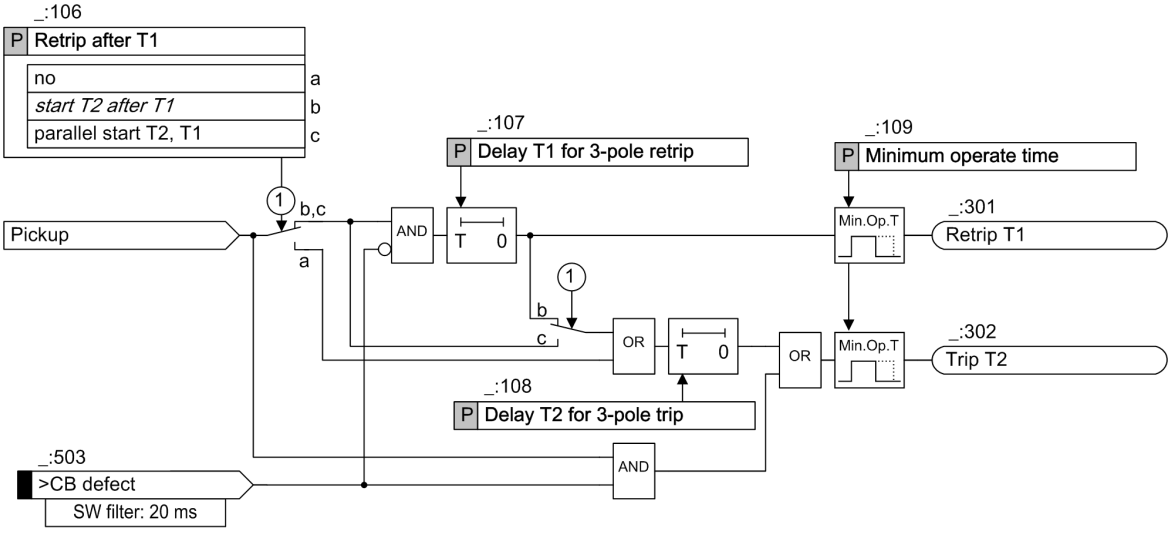
In the first step, tripping of the local circuit breaker can be repeated. Tripping is repeated after expiration of the settable delay T1. The retrip on the local circuit breaker is as a safety mechanism as well. In the event of a wrong start and pickup, only the local circuit breaker is opened instead of the superordinated circuit breaker.

Time delay T2 (backup tripping) can start in parallel either with the start of time T1 or after expiration of time T1.

If time delay T2 expires, circuit-breaker restriking takes place and the backup-tripping signal *Trip T2* is generated.

If the *>CB defect* input signal is valid, any repetition of the trip signal is suppressed and the backup-tripping signal *Trip T2* is generated immediately (without delay). For safety reasons, a default software filter time of 20 ms is preset (configurable in DIGSI) for the binary input signal *>CB defect*.

The **Minimum operate time** parameter defines the minimum duration for the trip command of the function. In contrast to other protection functions, the parameter is set within its own function. As a result, the setting is independent of the identically named comprehensive parameter that is set in the **Device settings**.



[lo_deltrip-030211-01.vsd, 2, en_US]

Figure 6-242 Logic Diagram for Delay/Tripping of the Circuit-Breaker Restrike Protection

6.40.4 Application and Setting Notes

Parameter: Switch On or Off Additional Plausibility Release Criteria

- Default setting **(_:101) Plausibility via 50BF fct.** = *no*
- Default setting **(_:102) Plaus. via open/trip cmd** = *no*
- Default setting **(_:103) Plaus. via binary input** = *no*

When using the plausibility release, the start condition and the release condition instead of only the start condition must be present to start the current monitoring regarding restriking. Since the current threshold value is set below the operating current, a false start would directly cause tripping. Thus, the plausibility release strongly reduces the risk that a falsely given start criterion leads to a wrong tripping of the superordinated circuit breaker.

3 different release criteria are available. You can use one or more than one or none of them. The selection depends on the application.

NOTE

When using release criteria, it must be ensured that the criteria are given under all the conditions where the **Circuit-breaker restrike protection** shall be started. If you choose no release criteria, the release is permanently given.

- **Open/trip command by the device**

Use this criterion in case that all control or trip commands are given by the protection device.

NOTE

Opening the circuit breaker manually without using the device will not release the start of the **Circuit-breaker restrike protection**.

- **Pickup of the Circuit-breaker failure protection**

Use this criterion if the **Circuit-breaker restrike protection** should only be started in case that the **Circuit-breaker failure protection** was started (picked up) before.

NOTE

Opening the circuit breaker by control or manually will not trigger the circuit breaker failure protection. Consequently the **Circuit-breaker restrike protection** cannot be released either.

- **Binary input signal**

Use this option if neither of the above 2 release criteria fit the application and you want to define your own release criterion.

Input signals: *>Start, >release, >Stop*

Input Signals	Description
>Start	This input signal allows to start the monitoring, for example, via protocol commands from a master (by use of a CFC chart) or by other specific conditions.
>release	This input signal allows to define specific release conditions by use of a CFC chart. Also refer to *Parameter: Switch On or Off Additional Plausibility Release Criteria , Page 812*.
>Stop	This input signal allows to stop the monitoring, for example, via protocol commands from a master (by use of a CFC chart) or by other specific conditions.

The input signals *>Start* , *>release* , and *>Stop* have a filtering time of *20 ms* as default setting. If a transient spurious signal to the binary inputs is expected due to the design of the external binary-input control circuits and environmental conditions, the filtering time can be extended.

Parameter: Position recognition delay

- Default setting **(_:105) Position recognition delay** = *0.02 s*

With the parameter **Position recognition delay**, you define how long the circuit breaker must be detected as **open** (via the circuit-breaker auxiliary contacts) before the monitoring time is started. This definition is a safety feature to ensure that the monitoring is not started too early. For example, in case that due to a non-standard auxiliary-contacts configuration, the circuit-breaker is already detected as **open** while current flow is still present.

The setting depends on the circuit-breaker auxiliary-contacts configuration. If it can be ensured that the auxiliary contacts announce the circuit breaker as **open** after the current flow is interrupted, the time can be set to zero.

Parameter: Monitoring duration

- Default setting **(_:104) Monitoring duration** = *200.00 s*

With the parameter **Monitoring duration** , you define how long the current signal is monitored regarding restriking after the circuit breaker has been opened.

With ongoing discharging of the capacitor bank, the probability of restriking is decreasing. There is no need to set the monitoring time longer than the discharging time. Siemens recommends setting the monitoring time in the range of 0.5 * discharging time to 1 * discharging time.

Parameter: Threshold

- Default setting **(_:3) Threshold** = *0.250 A*

After opening of the circuit breaker, the phase currents are compared with the threshold value. If no restriking takes place, the current is zero. Consequently the threshold for detecting restriking can be set much smaller than the operating current. A typical value is 25 % of the operating current.

With a threshold below the operating current, a falsely-given start directly cause tripping. For minimizing this risk, Siemens recommends applying a release criterion additionally. Refer to *Parameter: Switch On or Off Additional Plausibility Release Criteria , Page 812*.

Parameter: Dropout delay

- Default setting **(_:7) Dropout delay** = *0.05 s*

The parameter **Dropout delay** ensures that a short dropping below the current threshold does not cause the operate delay timers to be reset.

Since restriking is normally a periodical effect, the dropout delay can be set to a rather small time. Siemens recommends applying the default value of 50 ms.

Input signal: *>CB defect*

The input signal *>CB defect* has a preset filtering time of 20 ms. This filtering time prevents the input signal from becoming effective in the case of a transient activation of the physical binary input, which can be caused by the pressure change when the circuit breaker opens.

This time can be set to 0 if such a transient response of the physical binary input can be excluded due to the circuit-breaker design.

Parameter: Retrip after T1

- Default setting **(_:106) Retrip after T1** = *start T2 after T1*

Parameter Value	Description
start T2 after T1	The retrip on the local circuit breaker is a safety mechanism to avoid false tripping of the superordinated circuit breaker. With generating a retrip, only the local circuit breaker is tripped in the event of a false start. Afterwards the **Circuit-breaker restrike protection** function drops out during the T2 delay time. Siemens recommends applying a retrip on the local circuit breaker. Siemens also recommends applying the parameter value ***start T2 after T1***. The parameter value provides a clear chronological separation of the processes for trip repeat and backup tripping. Remember that the overall fault-clearance time in case of circuit-breaker restriking is the sum of T1 and T2.
no	No retrip is given
parallel start T2, T1	As an alternative to the setting ***parallel start T2, T1*** the customer can start T2 and T1 in parallel.

Parameter: **Delay T1 for 3-pole retrip**

- Default setting (_:109) **Delay T1 for 3-pole retrip** = ***0.00 s***

The parameter is visible only when the parameter **Retrip after T1** is set to ***start T2 after T1*** or ***parallel start T2, T1*** .

The retrip on the local circuit breaker is as a safety mechanism to avoid false tripping of the superordinated circuit breaker. In the event of a false start, only the local circuit breaker is tripped by the retrip. Afterwards the **Circuit-breaker restrike protection function** will drop out during the T2 delay time.

Siemens recommends applying a retrip on the local circuit breaker. Since the retrip is a safety mechanism, it can be given without a delay time. Siemens recommends setting the delay time to 0 s.

Parameter: **Delay T2 for 3-pole trip**

- Default setting (_:110) **Delay T2 for 3-pole trip** = ***0.15 s***

This parameter defines the duration of restriking after the backup tripping is sent. The following should be considered:

- When using the retrip functionality, this delay time must ensure a safe function dropout after giving the retrip on the local circuit breaker.

Siemens recommends applying a delay time of 150 ms which is the default setting.

Parameter: **Minimum operate time**

- Default setting **(_:109) Minimum operate time** = ***0.15 s***

The **Minimum operate time** parameter is used to set the minimum duration for the trip command of the function.



CAUTION

Do not set a time that is too short.

If you set a time that is too short, there is a danger (dropout of the function without the current-flow criterion) that the device contacts interrupt the control circuit. If this happens, the device contacts burn out.

✧ Set a duration that is long enough to ensure that the circuit breaker reliably reaches its final position (**open**) after a control operation.

Output signal: *Retrip T1*

The output signal *Retrip T1* must be routed to a binary output.

If only one control circuit is available for the local circuit breaker, the output signal must be routed to the binary output to which the general circuit breaker trip command (command *Position*) is routed.

If a second control circuit is present, the *Retrip T1* output signal can be routed to the associated binary output.

Output signal: *Trip T2*

In order to trip the adjacent circuit breakers, the backup tripping (indication *Trip T2*) must be routed to a binary output and if necessary, to an interface (intertripping to the opposite end). Thus, the circuit breaker on the opposite end can be tripped without delay.

6.40.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Restrike prt.#				
_:1	Restrike prt.#:Mode		• off • on • test	off
_:101	Restrike prt.#:Plausibility via 50BF fct.		• no • yes	no
_:102	Restrike prt.#:Plaus. via open/trip cmd		• no • yes	no
_:103	Restrike prt.#:Plaus. via binary input		• no • yes	no
_:106	Restrike prt.#:Retrip after T1		• no • start T2 after T1 • parallel start T2, T1	start T2 after T1
_:104	Restrike prt.#:Monitoring duration		1.00 s to 600.00 s	200.00 s
_:105	Restrike prt.#:Position recognition delay		0.00 s to 60.00 s	0.02 s
_:3	Restrike prt.#:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A
_:7	Restrike prt.#:Dropout delay		0.00 s to 60.00 s	0.05 s
_:107	Restrike prt.#:Delay T1 for 3-pole retrip		0.00 s to 60.00 s	0.00 s
_:108	Restrike prt.#:Delay T2 for 3-pole trip		0.05 s to 60.00 s	0.15 s
_:109	Restrike prt.#:Minimum operate time		0.00 s to 60.00 s	0.15 s

6.40.6 Information List

No.	Information	Data Class (Type)	Type
Restrike prt.#			
_:500	Restrike prt.#:>Start	SPS	I
_:501	Restrike prt.#:>Stop	SPS	I
_:502	Restrike prt.#:>release	SPS	I
_:82	Restrike prt.#:>Block function	SPS	I
_:503	Restrike prt.#:>CB defect	SPS	I
_:54	Restrike prt.#:Inactive	SPS	O
_:52	Restrike prt.#:Behavior	ENS	O
_:53	Restrike prt.#:Health	ENS	O
_:304	Restrike prt.#:Release by plausibility	SPS	O
_:303	Restrike prt.#:Monitoring running	SPS	O
_:55	Restrike prt.#:Pickup	ACD	O
_:301	Restrike prt.#:Retrip T1	ACT	O
_:302	Restrike prt.#:Trip T2	ACT	O

6.41 Restricted Ground-Fault Protection

6.41.1 Overview of Functions

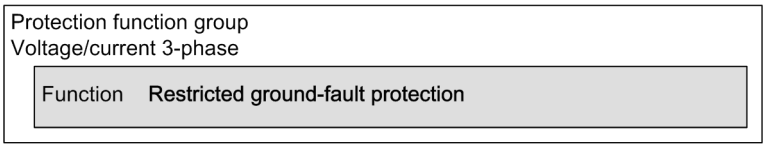
The **Restricted ground-fault protection** function (ANSI 87N):

- Detects ground faults in transformers, shunt reactors, neutral reactors or rotating machinery in which the neutral point is grounded.
- Has high sensitivity to ground faults near the neutral point.
- Is supplemental main protection to longitudinal differential protection.
- Protects grounding transformers in the protection range. It is required that a current transformer be used in the case of neutral point feed, that is, between neutral point and grounding conductor. The neutral point transformer and the phase current transformer define the protection range.
- Adapts itself to the highest-amperage side with auto transformers and thereby prevents overfunction in the event of external ground faults.

6.41.2 Structure of the Function

The **Restricted ground-fault protection** function is used in the **Transformer side** or **Auto transformer** protection function group. Furthermore, you can use the function in the stabilizing winding of the auto transformer or also in the **Standard UI** function. The function depends upon application in the corresponding application template preconfigured by the manufacturer or can be copied during the engineering into the corresponding function group.

The **Restricted ground-fault protection** function is stepless.

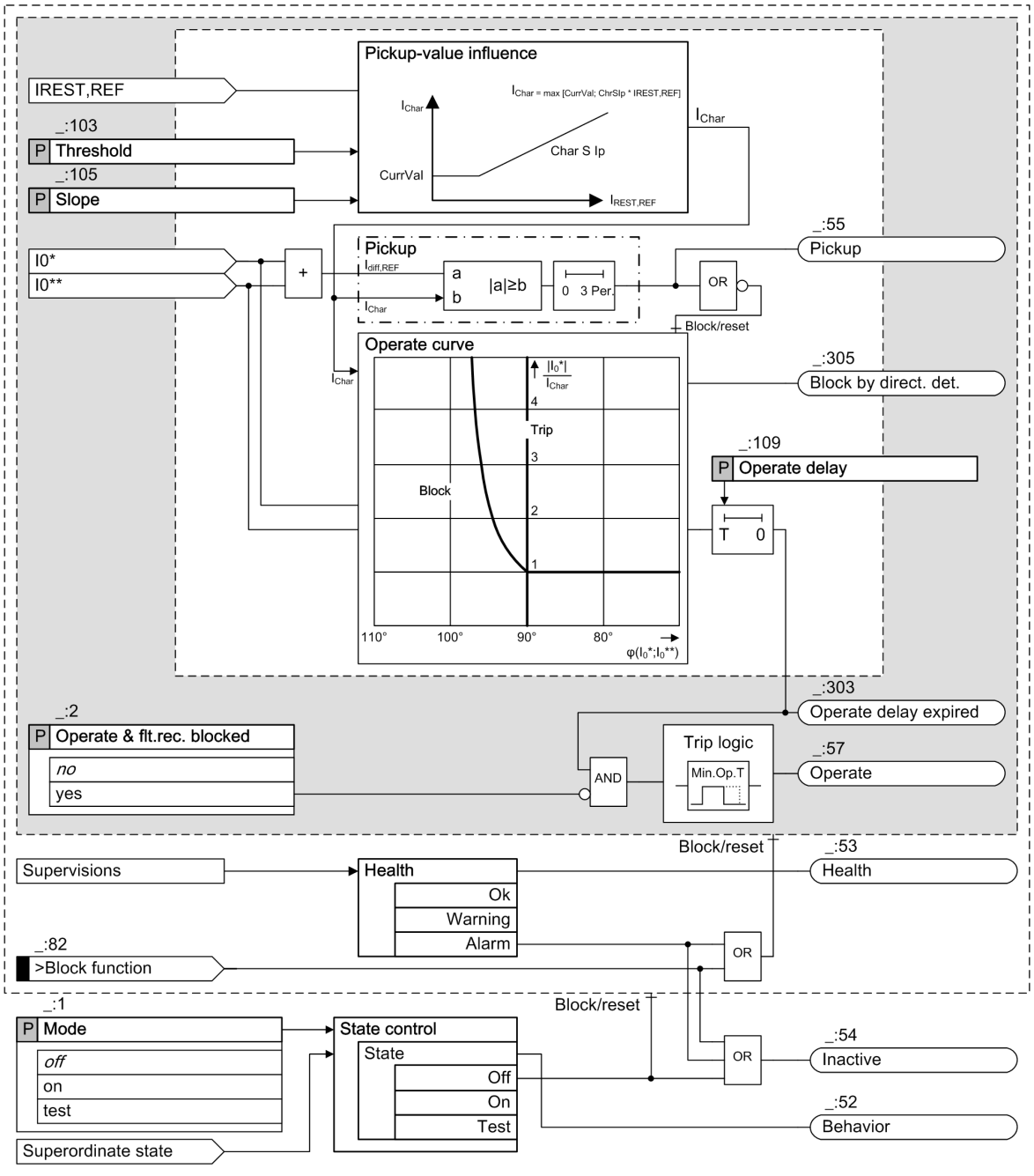


[dwstrupt-170712-01.tif, 2, en_US]

Figure 6-243 Structure/Embedding of the Function

6.41.3 Function Description

Logic of the Function

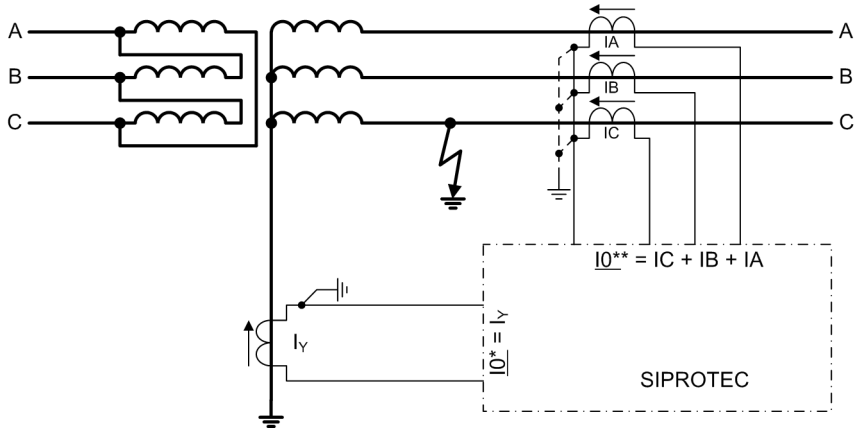


[loreffkt-170712-01.tif, 1, en_US]

Figure 6-244 Logic Diagram of the Restricted Ground-Fault Protection Function

The protection function processes the neutral-point current I_0* (exactly $3I_0$) and the calculated zero-sequence current I_0** (exactly $3I_0$) from the phase currents (see following figure). The protection range extends exclusively over the transformer winding, including current transformer. The amount-adapted (compensated) currents are described by the * icon. They are normalized to the rated object current of the respective side.

In case of an internal ground fault, the residual currents flow to the fault location. With an external ground fault, the fault current inverts itself in the phase current transformers. In this way, the direction of current flow serves as the decisive criterion for an internal fault.



[dwgrdpri-170712-01.tif, 1, en_US]

Figure 6-245 Basic Principle of the Function

In accordance with the logic diagram, *Figure 6-244* the protection function consists of 3 parts:

Effect of Pickup Value

The differential current and the restraint current are calculated from the residual currents. The reference arrows are defined as positive when pointing to the protected object (see *Figure 6-245*). Consider that the ground current in the fault record and in the DIGSI 5 Test Suite are displayed as positive if the current flows to ground from the protected object.

NOTE

The following calculation applies to the configurations with a current transformer for the side. In a special case of several current transformers per side, the calculation of the restraint current must be performed in greater detail.

$\underline{I}_0^* = k_m \cdot 3\underline{I}_0'$

$\underline{I}_0^{**} = k_m \cdot 3\underline{I}_0'' \rightarrow 3\underline{I}_0'' = \underline{I}_A + \underline{I}_B + \underline{I}_C$

with $k_m = I_{N,transformer}/I_{N,side}$

$I_{Diff,REF} = |\underline{I}_0^* + \underline{I}_0^{**}|$

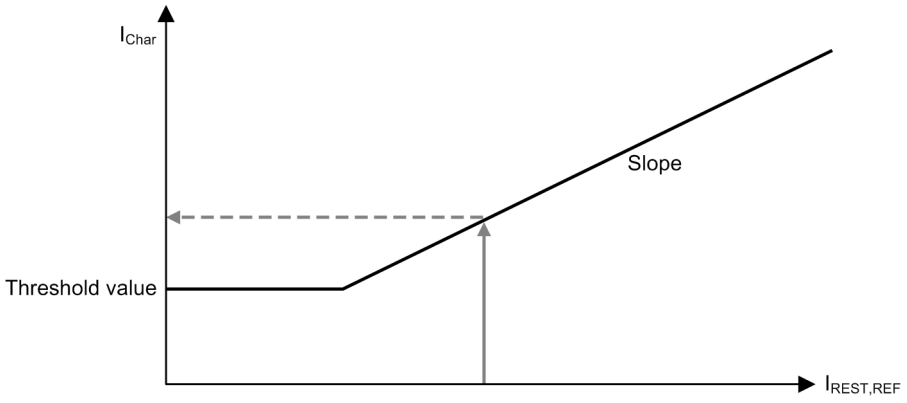
$I_{rest,REF} = |\underline{I}_0^*| + |\underline{I}_A| + |\underline{I}_B| + |\underline{I}_C|$

where:

$3\underline{I}_0'$	Measured zero-sequence current at neutral point
$3\underline{I}_0''$	Zero-sequence current calculated from the phase currents
k_m	Factor for amount adaptation (compensation)
$I_{rated,trans-former}$	Primary transformer rated current
$I_{rated,side}$	Primary rated current of the transformer side
$I_{Diff,REF}$	Differential current
$I_{Rest.,REF}$	Restraint current

Using the calculated restraint current, a current $I_{char.\ curve}$ which represents the pickup value for the tripping is determined from the characteristic curve (*Figure 6-246*). In this way, the protection function is stabilized in the event of external, multiphase ground faults, for example, a 2-pole ground fault. This means that the protection function becomes less sensitive.

If the **`Slope = 0`** is set here, the set **`Threshold`** of the operate curve is delivered independent of the restraint current.

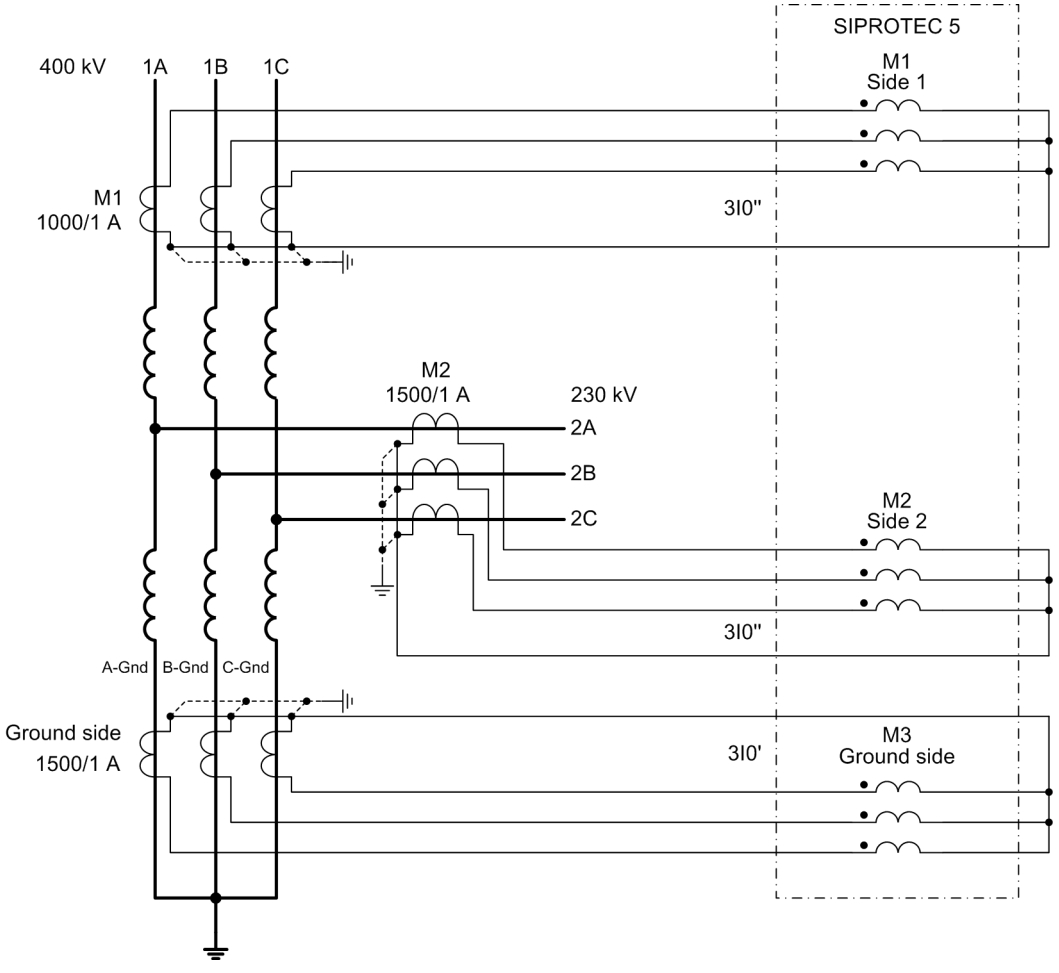


[dwstabke-170712-01.tif, 1, en_US]

Figure 6-246 Stabilized Characteristic Curve

Processing a Ground Side for Auto Transformer

Instead of a 1-phase neutral point, with an auto transformer a 3-phase ground side can also be used.



[dwautraf-201112-01.tif, 1, en_US]

Figure 6-247 Connecting a Ground Side on the Auto Transformer

In this case the neutral-point current calculates as sum of the phase currents of the ground side:

$I_0^* = k_m \cdot 3I_0' \rightarrow 3I_0' = I_{gnd,A} + I_{gnd,B} + I_{gnd,C}$

with $k_m = I_{N,transformer}/I_{N,side}$

The following applies for the restraint current:

The following applies for the restraint current: $I_{rest.,REF} = |I_{gnd,A}| + |I_{gnd,B}| + |I_{gnd,C}| + |I_A| + |I_B| + |I_C|$

NOTE

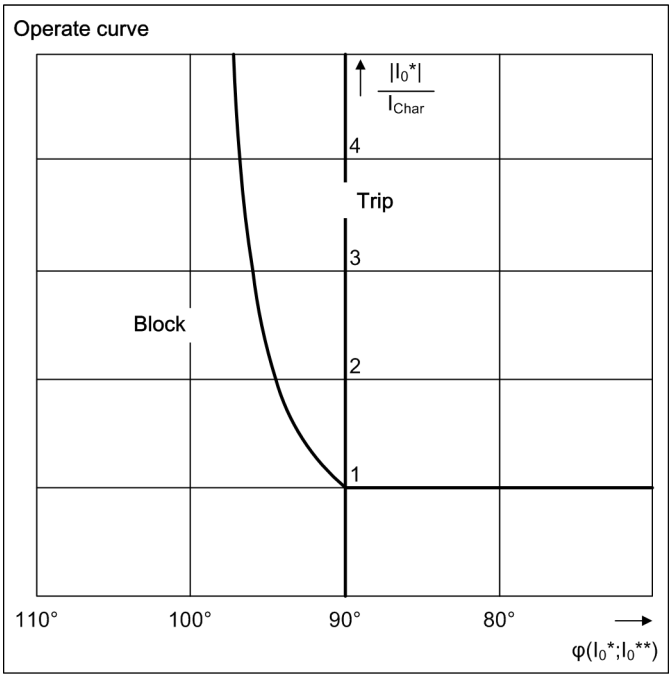
If both 1-phase neutral point and 3-phase ground side are connected, only the 1-phase neutral point is used by the restricted ground-fault protection. The 3-phase ground side is not considered.

Pickup

If the $I_{Diff,REF}$ calculated differential current exceeds the $I_{char.\ curve}$ calculated current (see *Figure 6-244*), pickup occurs and the internal processing is enabled. The pickup is indicated.

Operate Curve

The operate curve represented in the following figure consists of 2 parts. In the right part of the characteristic curve, you will find a case of an **internal ground fault**. Under ideal conditions, the angle between the two residual currents ($\angle(\underline{I}_0^*, \underline{I}_0^{**})$) equals 0. With current-transformer saturation, angle errors can result. The right part of the characteristic curve is valid for angles ≤ 90°. The tripping current is the current flowing at the neutral point ($\underline{I}_0^*$). It is compared to the set or increased threshold value.



[dwausken-170712-01.tif, 1, en_US]

Figure 6-248 Operate Curve Depending on the Phase Angle between $\underline{I}_0^*$ and $\underline{I}_0^{**}$ at $|\underline{I}_0^*| = |\underline{I}_0^{**}|$ (180° = External Fault)

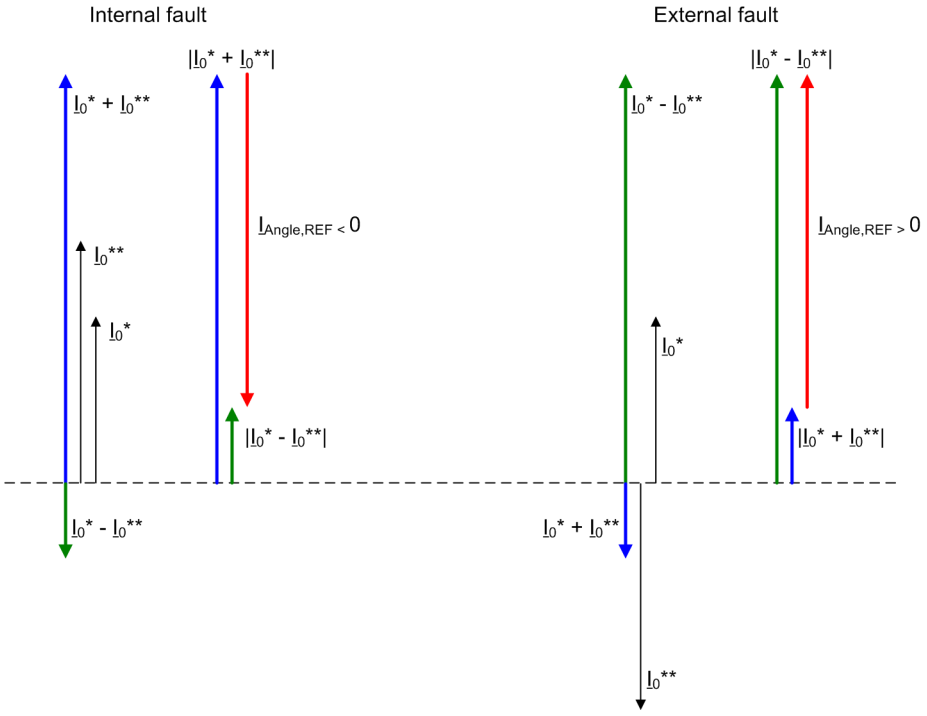
In case of an **external ground fault** the zero-sequence current calculated from the phase currents reverses by 180°. The phase angle between the residual currents thus ($\angle(\underline{I}_0^*, \underline{I}_0^{**})$) equals 180°. They are located in the left part of the operate curve and recognize a clearly increased pickup value. Angle deviations of 180° are caused by transformer saturation in conjunction with external short-circuits.

The current $I_{angle,REF}$ for the **Angle Decision** is determined from the following subtraction and summation:

$I_{angle,REF} = |\underline{I}_0^* - \underline{I}_0^{**}| - |\underline{I}_0^* + \underline{I}_0^{**}|$

The resulting current $I_{angle,REF}$ results from the respective fault conditions, which are illustrated in the following figure. With an internal fault (angle = 0°) a current results that has a negative sign. If angle errors occur, the sign remains negative. The amount of the current decreases.

In an external short-circuit (180°), the current becomes positive. At a smaller angle (<180°) due to transformer saturation, the angle remains positive. The amount also decreases.



[dwwinken-011112-01.tif, 1, en_US]

Figure 6-249 Angle Decision in Internal and External Faults

For tripping to occur, the neutral-point current I_0* must reach the value $I_{REF,off}$. The characteristic curve in the left part of the figure can be determined from the following relationship:

$I_{REF,off} = I_{char.\ curve} + k \cdot I_{angle,REF}$

where:

$I_{char.\ curve}$	Pickup value resulting from the pickup value increase
k	Factor (permanently set to 4.05657. With this value, the limit angle at $\|I_0^*\| = \|I_0^{**}\|$ is precisely 100°. No tripping is possible from this angle on.)

Processing of Several Measuring Points on One Side

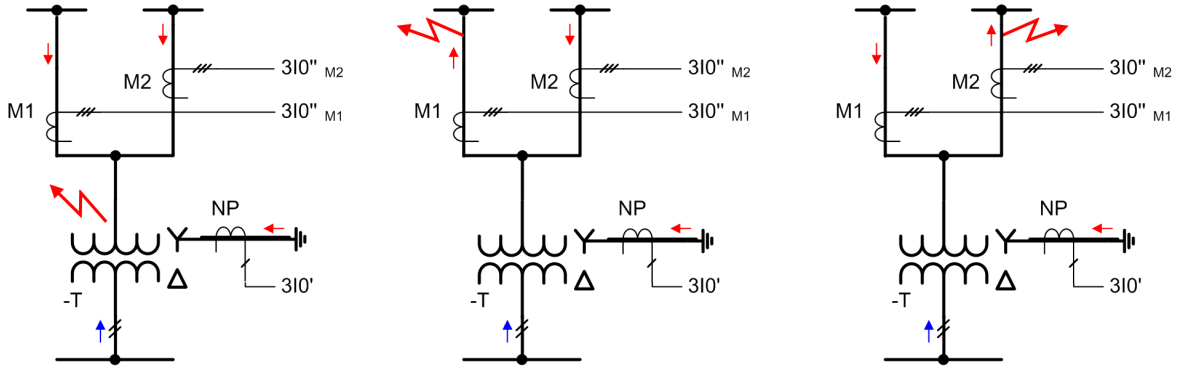
If several measuring points are present on one side of a star winding, as with a 1 1/2 circuit-breaker application, the angle decision occurs separately for each measuring point. The maximum current $I_{angle,REF}$ is used to establish the tripping decision.

NOTE

With an external fault, the current $I_{angle,REF}$ is always > 0.

The following figure shows the behavior under different fault conditions.

Also observe that the restraint current ($I_{rest.,REF}$) always results from the sum of all currents (phase currents of the measuring points and the neutral-point current). For pickup, the differential current $I_{Diff,REF}$ is necessary. This differential current results from the geometric sum of all adapted residual currents. The residual currents of the measuring points on the outgoing side and of the neutral-point current are meant here.



[dwfehler-291112-01.tif, 1, en_US]

Figure 6-250 Behavior under Different Fault Conditions

Functional Measured Values

Measured Value	Description
(_:306) I REF,operate	Operate quantity of the restricted ground-fault protection from the angle criterion
(_:307) I Angle,REF	Stabilizing value (angle) of the restricted ground-fault protection from the angle criterion
(_:311) I REF,Trip operate	Operate quantity of the restricted ground-fault protection when OFF
(_:312) I angle,REF operate	Stabilizing value of the restricted ground-fault protection when OFF
(_:301) I diff.	Differential current
(_:302) I restr.	Restraint current

You will find the measured values for the **Restricted ground-fault protection** under the following device menu entries:

- Main menu → Measurements → function → Function values → 87N REF

6.41.4 Application and Setting Notes

NOTE

The following conditions must be observed when setting the threshold values:

Threshold value ≥ max { *0.05 I/Irated,S* ; *0.05 I/Irated,S* * $I_{prim\ transf.\ max}$ / $I_{rated,\ protected\ object}$ }

Threshold value ≤ min { *2.00 I/Irated,S* ; *100.00 I/Irated,S* * $I_{prim\ transf.\ max}$ / $I_{rated,\ protected\ object}$ }

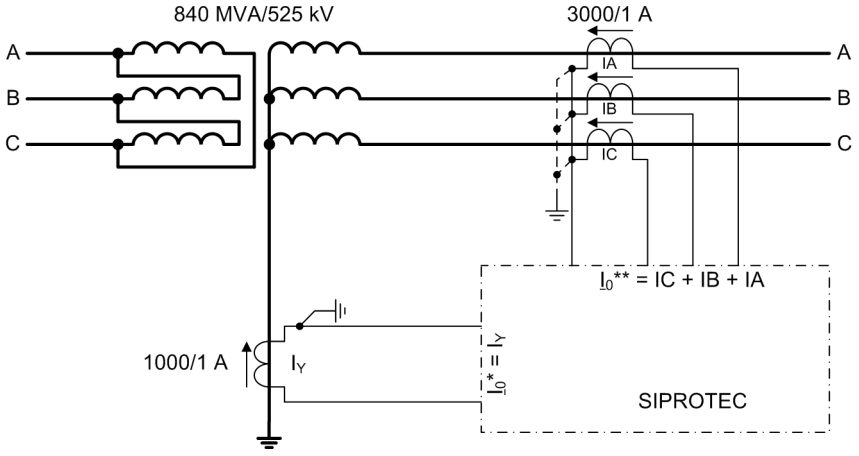
The value ***0.05 I/Irated,S*** is the minimum possible setting value and ***2.00 I/Irated,S*** the maximum possible. $I_{prim,transf.\ max}$ is the largest transformer current and $I_{rated,protected\ object}$ the protected object rated current. ***100.00 I/Irated,S*** is the upper measurement limit.

If otherwise it could happen that there is chattering of the pickup indication, the minimum threshold limit is lifted. The maximum limit on the other hand is corrected downward, if the exceeding current otherwise through the magnitude scaling must be so large, that it would already be outside of the measuring range of the transformer.

The adaptation of the setting limits is done automatically. In addition a setting is prevented outside of these limits.

In the following, typical applications are described for the restricted ground-fault protection.

Protection of a Solidly Grounded Star Winding (Y Side)



[dwanster-170712-01.tif, 1, en_US]

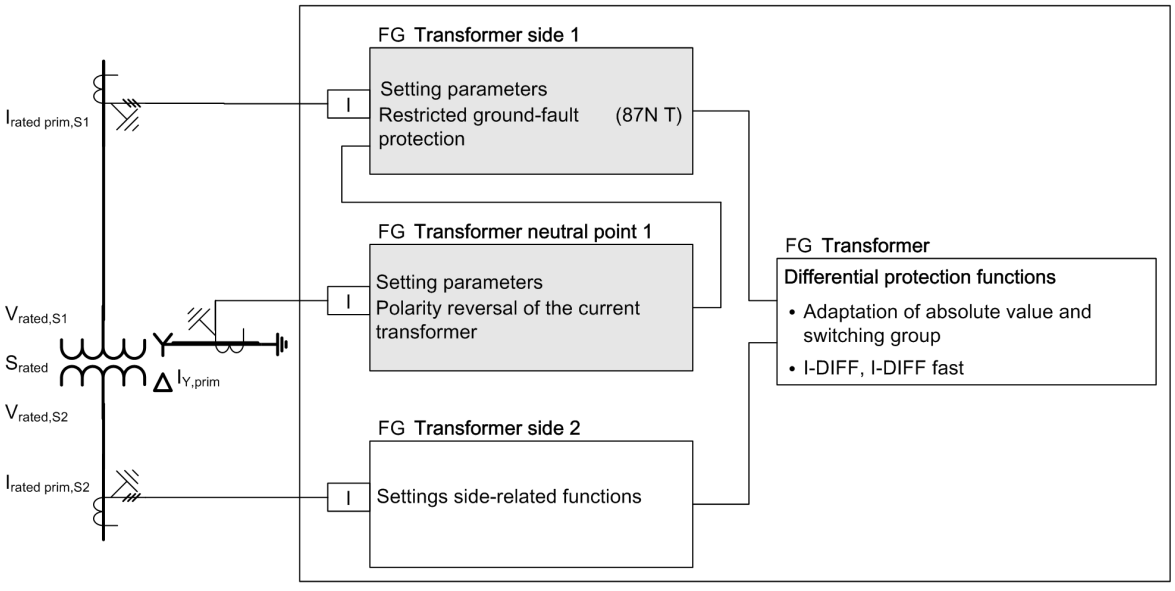
Figure 6-251 Application Star Side

This application is a standard application. Here the phase currents of one side and the neutral-point current are processed. The function is located in the **Transformer Side** function group.

The following figure show the structural division of the function. The restricted ground-fault protection gets its measurands from the current transformers, which are connected to the **Transformer side** function group. The neutral-point current is guided via the **Transformer neutral point** function group to the **Transformer side** function group. To be compatible with SIPROTEC 4 (including reference arrow definition of the restricted ground-fault protection), in addition to the magnitude scaling of the neutral-point current, a rotation of the polarity (phase rotation by 180°) is also done in the **Transformer neutral point** function group.

NOTE

The fault record indicates the analog traces according to the connection. For this reason the neutral-point current is shown rotated by 180° in comparison to SIPROTEC 4.



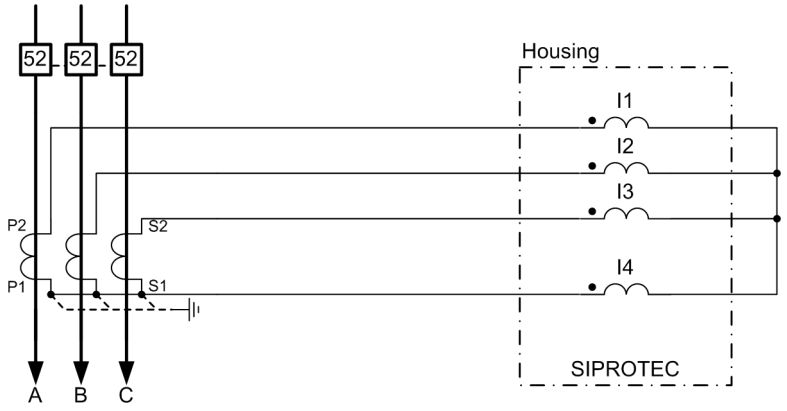
[dw2wtyde-201112-01.tif, 2, en_US]

Figure 6-252 Function Group Structure of the Restricted Ground-Fault Protection

Explanations on the Connection and Current-Direction Definition

Uniform reference arrows and transformer burdens are defined for the SIPROTEC 5 device series. These agreements also apply to the transformer protection devices. The special handling of the neutral-point current described previously is a result of this.

The current definition states that the sum of the currents flowing into the protected object is equal to 0 ($\underline{I}_A + \underline{I}_B + \underline{I}_C + \underline{I}_N = 0$ or $\underline{I}_A + \underline{I}_B + \underline{I}_C = -\underline{I}_N$). The protected object is located to the right or left of the transformer set. The following basic connections result from this.

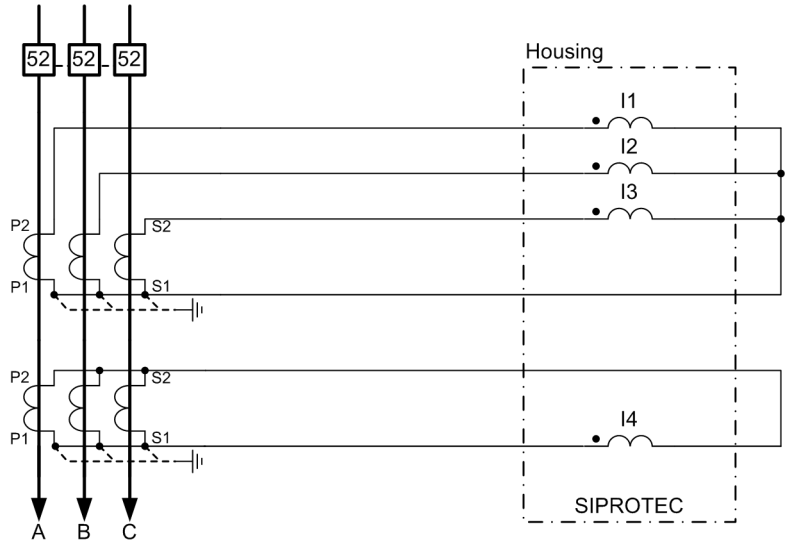


Current transformer 3-phase: connection = **3-phase + IN**

[tileite2-070211-01.tif, 1, en_US]

Figure 6-253 Current Transformer Connection (1) According to Definition

or



Current transformer 3-phase: connection = **3-phase + IN-separate**

[tileite4-260313-01.tif, 1, en_US]

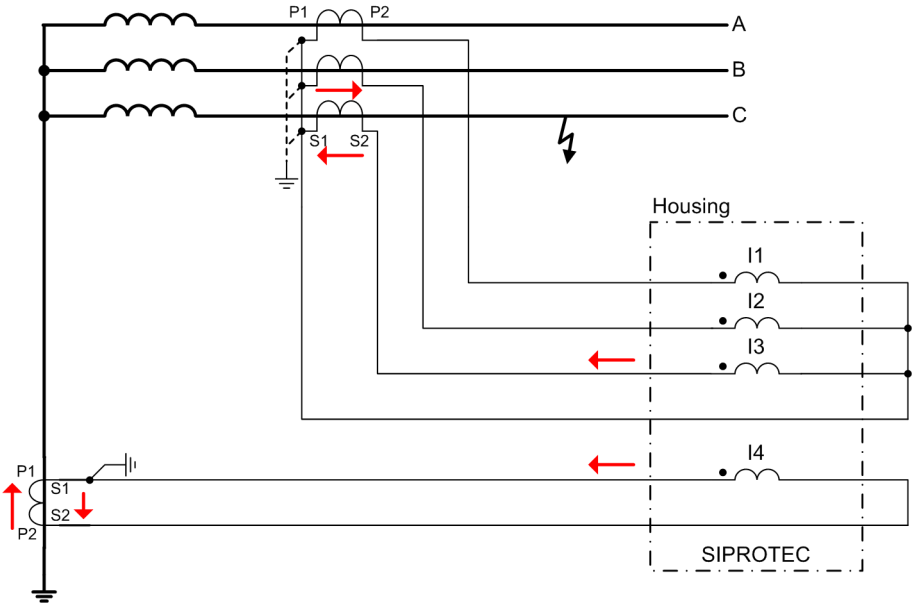
Figure 6-254 Current-Transformer Connection (2) According to Definition

The following connection is defined for the transformer according to *Figure 6-255*. The current flow for an external ground fault is entered at the same time. It is recognized that the secondary currents each flow from the device. From this, a differential current ($I_{diff,REF} = |\underline{I}_Y + \underline{I}_A + \underline{I}_B + \underline{I}_C| = |-\underline{I}_4 - \underline{I}_3|$) results, according to the reference arrow definition for the restricted ground-fault protection (positive to the protected object) with an

external ground fault. To prevent that, the neutral-point current is rotated in the **Transformer neutral-point** function group. It follows that: $I_{Diff, REF} = |\underline{I}_4 - \underline{I}_3| = 0$.

NOTE

If the neutral-point current is included in the protection function (zero-sequence current correction), this rotation also has an effect for the differential protection.



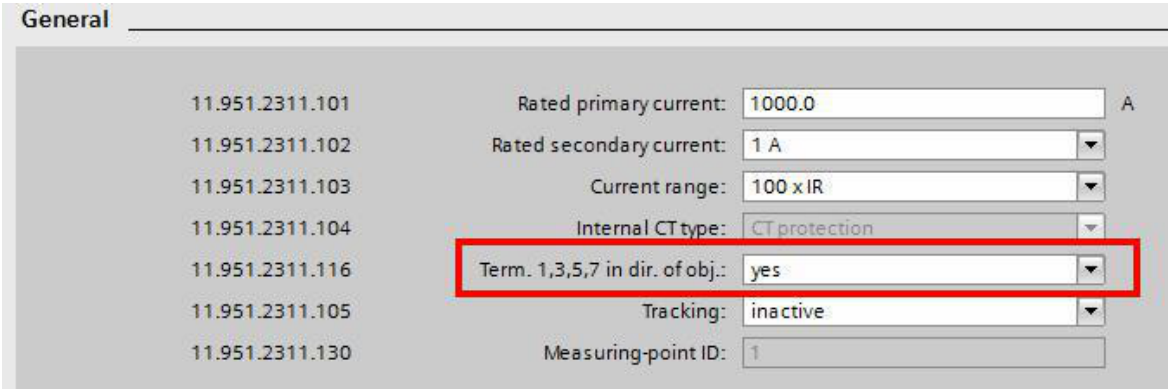
Current transformer 3-phase: connection = **3-phase**

Current transformer 1-phase: connection = **IN**

[dwstwnas-281112-01.tif, 1, en_US]

Figure 6-255 Current Transformer Connection on the Transformer

The setting of the 1-phase measuring point based on the definition is done as follows:



[scedsall-200214-01, 1, en_US]

Figure 6-256 DIGSI 5 Setting

The point in *Figure 6-255* describes the polarity of the current transformer. At the same time the current terminal is designed so that this side is fed out on an odd number terminal point. Since in the SIPROTEC 5 system each current transformer can be assigned a 1-phase measuring point, the odd number terminal points are named in the setting parameters. According to *Figure 6-255* the setting must be ***yes***.

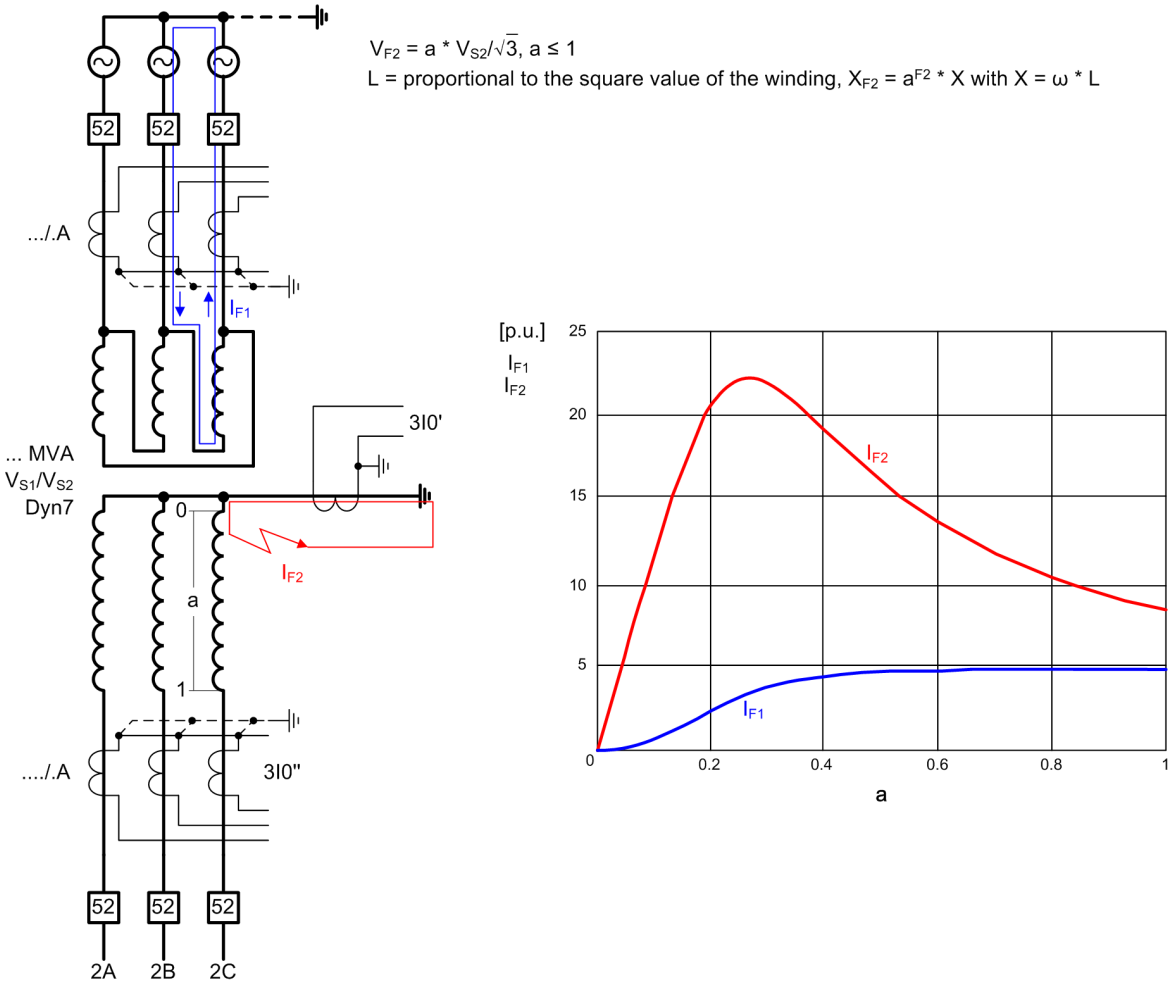
- Default setting **(_:115) terminal 1,3,5,7 in dir.obj.** = ***yes***

The following view can be used to derive the threshold value. The transformer is supplied, for example, via the delta winding and a 1-pole ground fault occurs on the star side.

NOTE

For estimation of the short-circuit current, note that the inductance changes quadratically with the winding and the linearly with the voltage.

The right part in the following figure represents the fault current as a function of the fault location. The fault current curve $_{F1}$ shows that the longitudinal differential protection with faults near the neutral point has sensitivity problems due to the sinking current. On the other hand, the neutral-point current $_{F2}$ is sufficiently large. There is therefore no need to set the **Threshold** (current through the neutral point transformer) to sensitive.



[dwf1pole-170712-01.tif, 1, en_US]

Figure 6-257 Principal Fault Current Curves with a 1-Pole Ground Fault

- Recommended setting value **(_:103) Threshold** = ***0.2 I/Irated,S***

The previously mentioned condition must be maintained during the setting.

$$\text{Threshold value} \geq 0.05\ \text{I/Irated, S} \cdot \frac{I_{CT\,max,prim}}{I_{rated,side}}$$

[foschwe1-170712-01.tif, 1, en_US]

The following lower limiting value results from the data from *Figure 6-251*:

$$\text{Threshold value} \geq 0.05\ \text{I/Irated,S} \cdot \frac{3000\,\text{A}}{924\,\text{A}} = 0.162\ \text{I/Irated,S}$$

$$\text{with } I_{\text{object,side}} = \frac{S_{\text{rated}}}{\sqrt{3}\ V_{\text{rated}}} = \frac{840\,\text{MVA}}{\sqrt{3}\ 525\text{kV}} = 924\,\text{A}$$

[foschwe2-041012-01.tif, 1, en_US]

The recommended setting value of ***0.2 I/Irated,S*** lies above it.

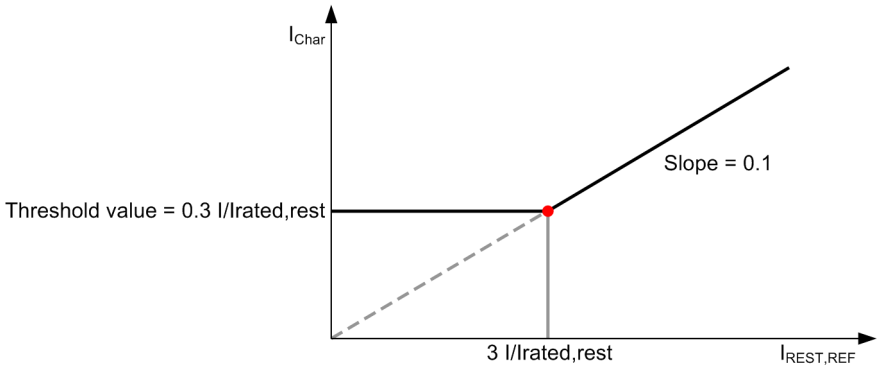
- Recommended setting value **(_:105) Slope** = ***0.07***

You can stabilize the protection function (less sensitive setting) with external multiphase short-circuits to ground with the parameter **Slope**. To determine the setting value, no pickup value increase can occur up to the rated current. After this, the gradient must be active. To derive the gradient, it is assumed that continuation of the straight line must go through the coordinate origin (see *Figure 6-258*). Determine the intersection from the threshold value and the restraint current at rated current. Calculate the gradient as follows:

$$I_{\text{rest,REF}} = \left|I_{:0}^{*}\right| + \left|I_{:A}\right| + \left|I_{:B}\right| + \left|I_{:C}\right| = 0 + 3\ \text{I/Irated, S} = 3\ \text{I/Irated, S}$$

$$\text{Slope} = \frac{\text{Threshold value}}{I_{\text{rest,REF}}} = \frac{0.2\ \text{I/Irated, S}}{3\ \text{I/Irated, S}} = 0.07$$

[fostbref-231012-01.tif, 1, en_US]



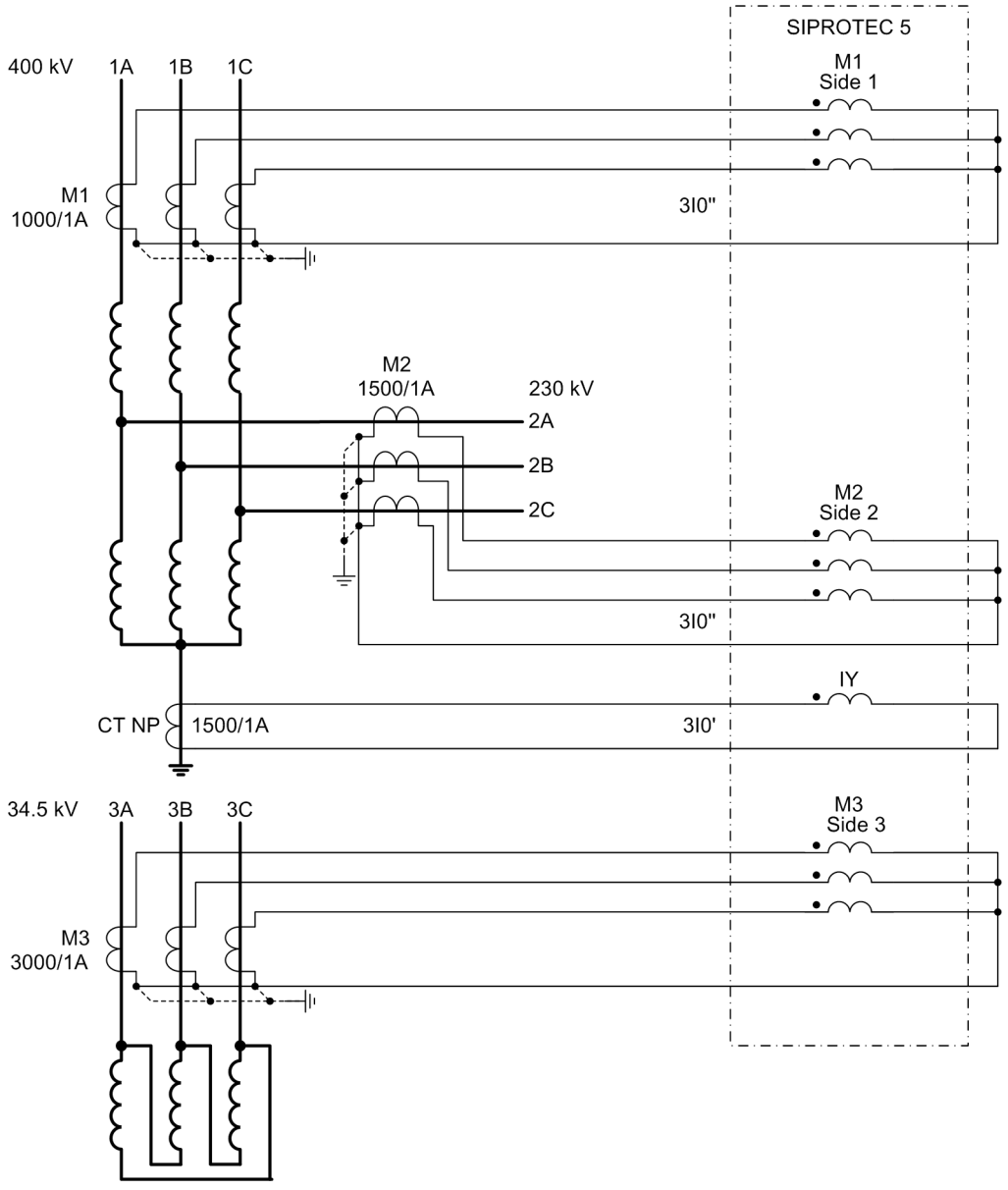
[dwsteiga-221012-01.tif, 1, en_US]

Figure 6-258 Derivation of the Setting Value for the Gradient

If you have several measuring points on an outgoing side (see *Figure 6-250*), Siemens recommends using the value **3 I/Irated,S** in the intersection calculation for the restraint current. In the load case, the maximum transformer rated current flows on one side.

If, however, several measuring points are on the supply side (for example, breaker-and-a-half layout), Siemens recommends including all phase currents in the intersection calculation, in order to avoid too strong of a stabilization. With 2 measuring points, a value of **6 I/Irated,S** results as intersection with the threshold value. The slope becomes flatter (**0.2 I/Irated,S/6 I/Irated,S = 0.03**).

Protection of an Auto Transformer



[dwsptran-170712-01.tif, 1, en_US]

Figure 6-259 Activation and Application Example of an Auto Transformer (500 MVA: 400 kV, 230 kV; 125 MVA: 34.5 kV)

Use the highest side rated current with the auto transformer for normalization. In the example (*Figure 6-259*), the measuring point is M2 (230 kV side). For this side, a rated current of 500 MVA/(√(3) · 230 kV) = 1255 A results. The primary transformer rated current is 1500 A. With this, you can estimate the minimum permissible pickup value.

$$\text{Threshold value} \geq 0.05\ \text{I/Irated,S} \cdot \frac{I_{\text{CT max,prim}}}{I_{\text{object,side}}} = 0.05\ \text{I/Irated,S} \cdot \frac{1500\text{A}}{1255\text{A}} = 0.06\ \text{I/rated,S}$$

[foscwe01-170712-01.tif, 1, en_US]

Siemens recommends a setting value of **0.2 I/Irated,S**.

- Recommended setting value **(_:103) Threshold** = ***0.2 I/Irated,S***

To determine the **Slope**, the restraint current of both sides (400 kV and 230 kV) must be used. The rated current is used as starting value for the gradient. Since side 2 (230 kV) is the reference side for the normalization, the value of the 400 kV side must be adapted to this rated current. The adaptation factor results from the inverse ratio (230 kV/400 kV). The following restraint current goes into the calculation:

$$I_{rest,REF} = 3\ I/Irated,S2 + 3\frac{230\,kV}{400\,kV}\ I/Irated,S2 = 3\ I/Irated,S2 + 1.725\ I/Irated,S2 = 4.73\ I/Irated,S$$

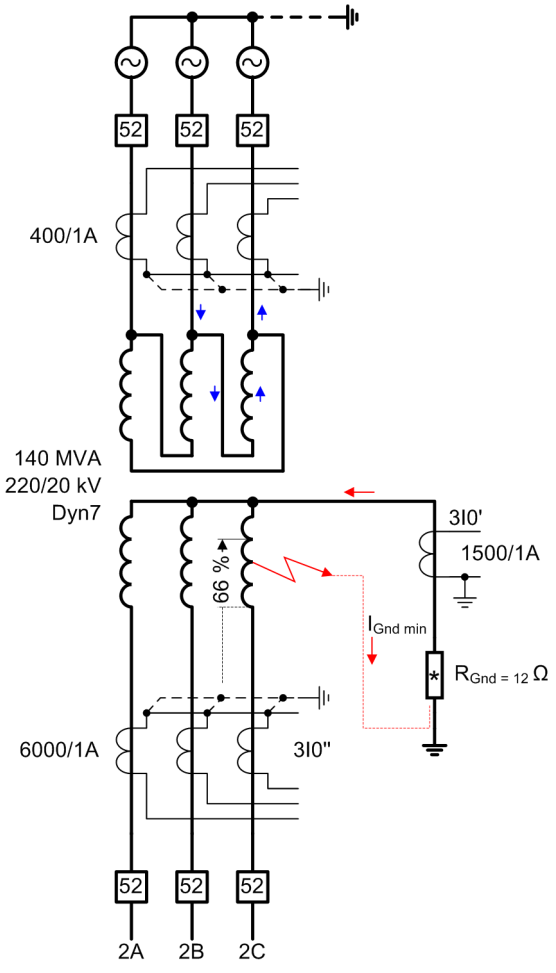
$$Slope = \frac{Threshold\ value}{I_{rest,REF}} = \frac{0.2\ I/Irated,S}{4.73\ I/Irated,S} \approx 0.042$$

[fostbrst-231012-01.tif, 1, en_US]

Siemens recommends using the setting 0.07.

- Recommended setting value **(_:105) Slope** = ***0.07***

Protection of a Resistance-Grounded Star Winding (Y Side)



[dwrefspa-170712-01.tif, 1, en_US]

Figure 6-260 Application with Resistance-Grounded Neutral Point

To also capture faults in the resistance to ground, a current transformer must be installed at the neutral point of the protected object (see *Figure 6-260*). The pickup values can be derived from the data in the example. As side rated value, the following results:

140 MVA/(√3 · 20 kV) = 4042 A

The following threshold value results as lower limit:

$$\text{Threshold value} \geq 0.05\ \text{I/Irated,S} \cdot \frac{6000\,\text{A}}{4042\,\text{A}} = 0.07422\ \text{I/Irated,S}$$

$$\text{with } I_{\text{object,side}} = \frac{S_{\text{rated}}}{\sqrt{3} \cdot V_{\text{rated}}} = \frac{840\text{MVA}}{\sqrt{3} \cdot 525\text{kV}} = 924\,\text{A}$$

[foschwe3-170712-01.tif, 1, en_US]

So that the function is responsive, select a setting value of 0.08 I/Irated,S.

- Recommended setting value **(_:103) Threshold** = ***0.08 I/Irated,S***

As gradient, the following results:

$$\text{Slope} = \frac{\text{Threshold value}}{I_{\text{rest,REF}}} = \frac{0.08\ \text{I/Irated,S}}{3\ \text{I/Irated,S}} \approx 0.03$$

[fosteig1-170712-01.tif, 1, en_US]

- Recommended setting value **(_:105) Slope** = ***0.03***

Because of the grounding resistance R_E reduced protection range results. This can be estimated as follows: The grounding resistance is much larger than the winding reactance, thus the following maximum ground current results:

$I_{\text{Gnd max}}$ = 20 kV/(√3 · 12 Ω) = 962 A

You can determine the minimum tripping current from the setting value:

$I_{\text{Gnd min}}$ = side rated current * threshold value = 4042 A · 0.08 = 323 A

Thus, the following protection range results:

$$\text{Protection range} = 1 - \frac{I_{\text{gnd min}}}{I_{\text{gnd max}}} = 1 - \frac{323\,\text{A}}{962\,\text{A}} = 0.664$$

[foschwe4-170712-01.tif, 1, en_US]

The attainable protection range amounts to approx. 66.4 %. In order to capture ground faults near the neutral point, it is also recommended to connect a sensitive ground current protection to the neutral point transformer. You must coordinate its operate time with the line protection.



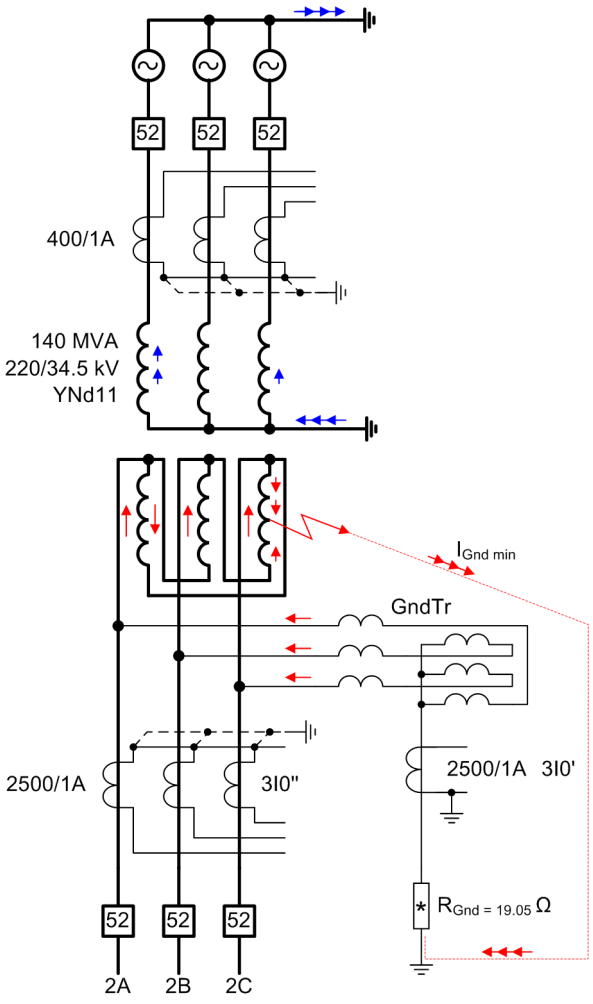
NOTE

Ensure that the protection range further limits itself with larger neutral-point resistances, or the restricted ground-fault protection can no longer be used.

Protection with Neutral Reactors on the Delta Side

To produce ground currents on the delta side of a transformer, neutral reactors (zigzag reactors) are used. A resistance for ground current limitation can also be present. In this case, the resistance is much greater than the reactor and delta reactance of the transformer. The following figure shows a typical implementation. The restricted ground-fault protection works between output-sided phase current transformers and the current transformer in the neutral point of the neutral reactor.

In the example, the fault current curve with the ground fault in a delta winding is also represented. The fault location in which the lowest fault current flows can also be seen. This current influences the protection setting set close.



[dwstrpkt-170712-01.tif, 1, en_US]

Figure 6-261 Application with Neutral Reactor

As side rated value, the following results:

140 MVA/($\sqrt{3}$ · 34.4 kV) = 2343 A

You can thus define the lower limit for the threshold value:

$$\text{Threshold value} \geq 0.05\ \text{I/Irated,S} \cdot \frac{2500\ \text{A}}{2343\ \text{A}} = 0.06\ \text{I/Irated,S}$$

[foschwe5-170712-01.tif, 1, en_US]

If the fault is in the middle of the winding, the minimum ground current will arise, as shown in *Figure 6-261*. The driving voltage is:

$V_{Gnd\ min} = V_{rated,S2}/(2\sqrt{3}) = 34.5\ kV/(2\sqrt{3}) = 9.96\ kV$

The following minimum ground current results:

$I_{Gnd\ min} = V_{Gnd\ min}/R_{Gnd} = 9.96\ kV/19.05\ \Omega = 523\ A$

With reference to the side rated current, the relationship is:

$I_{Gnd\ min}/I_{rated,S} = 523\ A/2343\ A = 0.223$

With a safety margin of 2, 0.223/2 = 0.1115 results. Select this value as threshold value (rounded: 0.12 I/Irated,S).

- Recommended setting value **(_:103) Threshold** = ***0.12 I/Irated,S***

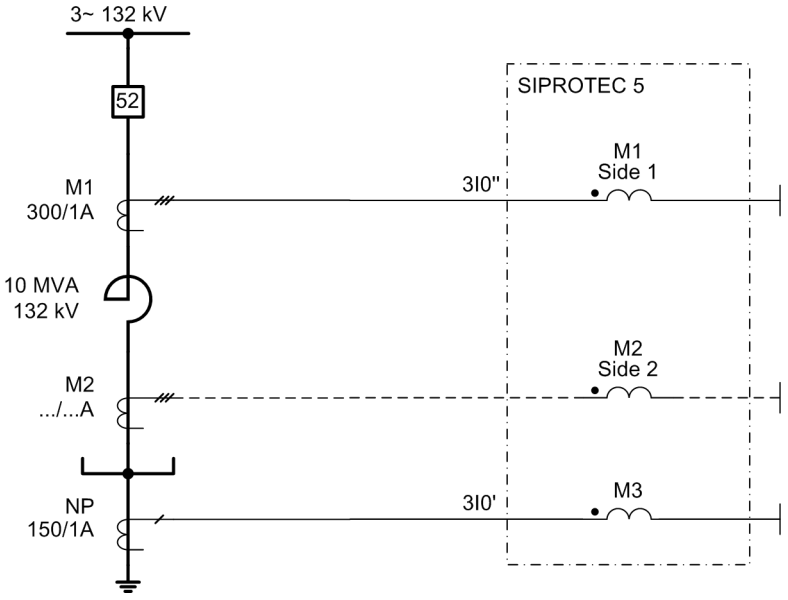
As gradient, the following results:

$$\text{Slope} = \frac{\text{Threshold value}}{I_{rest,REF}} = \frac{0.12\ I/I_{rated,S}}{3\ I/I_{rated,S}} \approx 0.04$$

[fosteig2-170712-01.tif, 1, en_US]

- Recommended setting value **(_:105) Slope** = ***0.04***

Protection of a Shunt Reactor



[dwanquer-170712-01.tif, 1, en_US]

Figure 6-262 Application with Neutral Reactor

As side rated value, the following results:

10 MVA/($\sqrt{3}$ · 132 kV) = 43.7 A

You can thus define the lower limit for the threshold value:

$$\text{Threshold value} \geq 0.05\ I/I_{rated,S} \cdot \frac{300\ A}{43.7\ A} = 0.343\ I/I_{rated,S}$$

[foschwe6-170712-01.tif, 1, en_US]

Select 0.35 I/Irated,S as threshold value.

- Recommended setting value **(_:103) Threshold** = ***0.35 I/Irated,S***

For the shunt reactor, there is no external fault that can lead to overfunction. Siemens recommends a minimum rise (0.05).

- Recommended setting value **(_:105) Slope** = ***0.05***

6.41.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
87N REF #				
_:1	87N REF #:Mode		• off • on • test	off
_:2	87N REF #:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:103	87N REF #:Threshold		0.05 I/IrObjto 2.00 I/IrObj	0.20 I/IrObj
_:105	87N REF #:Slope		0.00 to 0.95	0.07
_:109	87N REF #:Operate delay		0.00 s to 60.00 s; ∞	0.00 s
_:191	87N REF #:Reference side is		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	not assigned

6.41.6 Information List

No.	Information	Data Class (Type)	Type
87N REF #			
_:82	87N REF #:>Block function	SPS	I
_:54	87N REF #:Inactive	SPS	O
_:52	87N REF #:Behavior	ENS	O
_:53	87N REF #:Health	ENS	O
_:55	87N REF #:Pickup	ACD	O
_:57	87N REF #:Operate	ACT	O
_:303	87N REF #:Operate delay expired	ACT	O
_:305	87N REF #:Block by direct. det.	SPS	O
_:306	87N REF #:I REF,operate	MV	O
_:307	87N REF #:I Angle,REF	MV	O
_:311	87N REF #:I REF,Trip operate	MV	O
_:312	87N REF #:I angle,REF operate	MV	O
_:301	87N REF #:I diff.	MV	O
_:302	87N REF #:I restr.	MV	O

6.42 External Trip Initiation 3-Pole

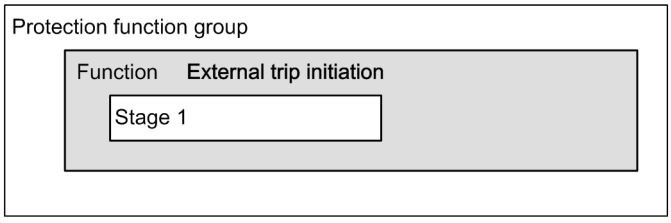
6.42.1 Overview of Functions

The **External trip initiation** function:

- Processes any signals from external protection or supervision devices
- Enables the integration of any signals from external protection equipment in the indication and tripping processing, for example from transient ground-fault relays or Buchholz protection
- Enables direct tripping of the circuit breaker in conjunction with busbar-protection applications
- Enables direct tripping of the circuit-breaker in the case of circuit-breaker failure at the other line end

6.42.2 Structure of the Function

The **External trip initiation** function contains one step. The **External trip initiation** function can be instantiated in DIGSI 5 multiple times.

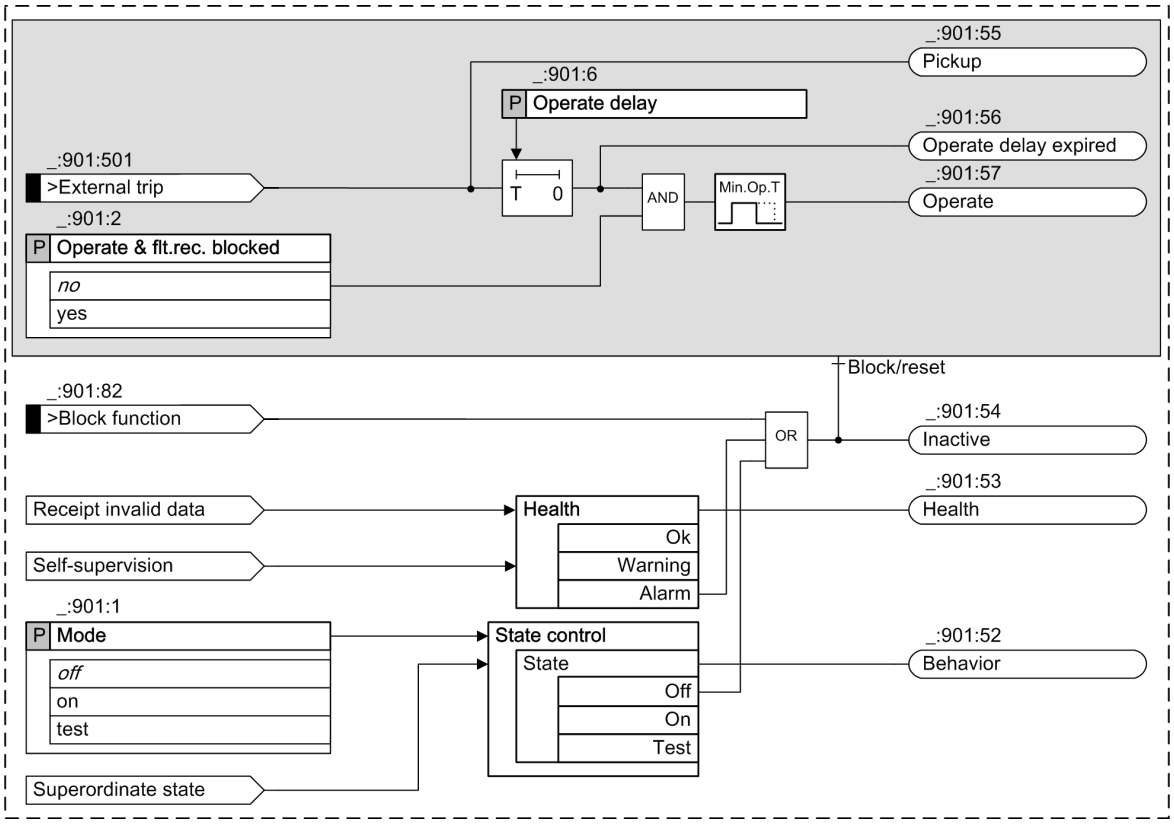


[dwstrext-030211-01.tif, 1, en_US]

Figure 6-263 Structure/Embedding of the Function

6.42.3 Stage Description

Logic of the Stage



[lotrip3p-070611-01.tif, 1, en_US]

Figure 6-264 Logic Diagram for the External Trip-Initiation Stage

Binary Input Signal >External Trip

The binary input signal **>External trip** starts the **Pickup** and the **Operate delay**.

Blocking the Stage

The stage can be switched to ineffective via a number of signals. If the stage is in the pickup state at the time of blocking, it will be immediately reset. However, the operate indication remains stopped for the minimum operating time **(_:102) Minimum operate time**.

6.42.4 Application and Setting Notes

Parameter: Operate delay

- Recommended setting value **(_:901:6) Operate delay** = ***0.05 s***

The **Operate delay** parameter must be set for the specific application. After expiry of the **Operate delay** the time expiry and tripping are signaled. The duration of the initiation signal as well as the adjustable minimum command time determine the signal duration of the **Operate**.

6.42.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:901:1	Stage 1:Mode		• off • on • test	off
_:901:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:901:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.05 s

6.42.6 Information List

No.	Information	Data Class (Type)	Type
Stage 1			
_:901:82	Stage 1:>Block function	SPS	I
_:901:501	Stage 1:>External trip	SPS	I
_:901:54	Stage 1:Inactive	SPS	O
_:901:52	Stage 1:Behavior	ENS	O
_:901:53	Stage 1:Health	ENS	O
_:901:55	Stage 1:Pickup	ACD	O
_:901:56	Stage 1:Operate delay expired	ACT	O
_:901:57	Stage 1:Operate	ACT	O

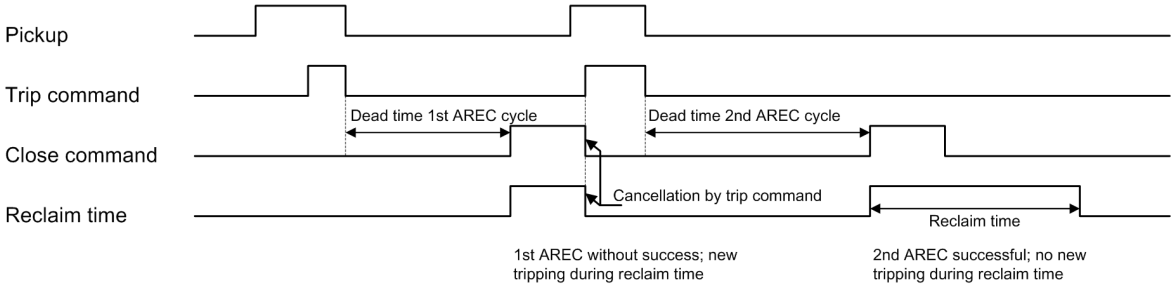
6.43 Automatic Reclosing Function

6.43.1 Overview of Functions

The Automatic reclosing function:

- Automatically closes overhead lines after arc short-circuits
- Is only permissible for overhead lines, because only the possibility of self-activated extinguishing of an arc short-circuit exists here
- Can be controlled by integrated protection functions and by external protection devices
- The automatic reclosing can occur through an external automatic reclosing function via binary inputs.

The automatic reclosing after switching off through a short-circuit protection is taken over by the automatic reclosing function (AREC). The following figure shows an example for the normal procedure with a two-time automatic reclosing where the second automatic reclosing attempt is successful.



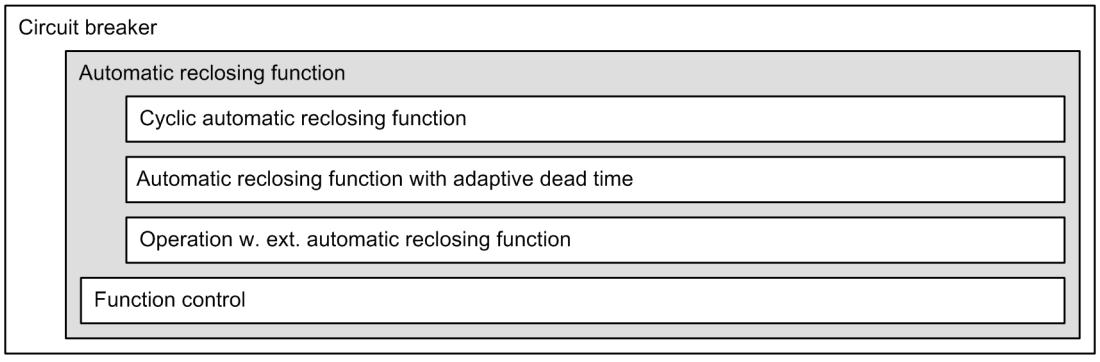
[dw2awewz-090210-01.tif, 1, en_US]

Figure 6-265 Process Diagram of a Two-Time Reclosing With Action Time (2nd Reclosing Successful)

The integrated Automatic reclosing function allows for up to 8 reclosing attempts. Each of the 8 disruption cycles can work with different parameters.

6.43.2 Structure of the Function

The automatic reclosing function is used in function groups for circuit breakers. In a function group for circuit breakers, one of the 3 types of functions illustrated in the following figures can be used. The Automatic reclosing function has a central function control.



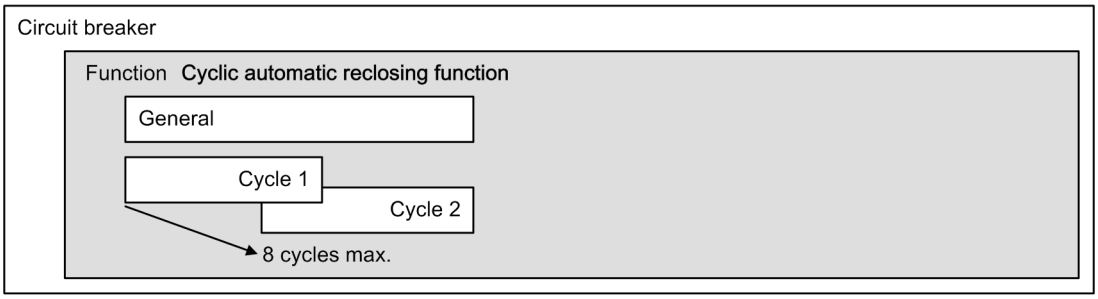
[dwfktawe-100611-01.tif, 1, en_US]

Figure 6-266 Structure/Embedding of the Function

Cyclic Automatic Reclosing Function

The Cyclic automatic reclosing function (*Figure 6-267*) allows for up to 8 reclosing attempts. Here each disruption cycle may work with different settings.

For the Cyclic automatic reclosing function, 1 cycle is preset. The preset cycle cannot be deleted. You can add and delete additional cycles from the function library in DIGSI 5.

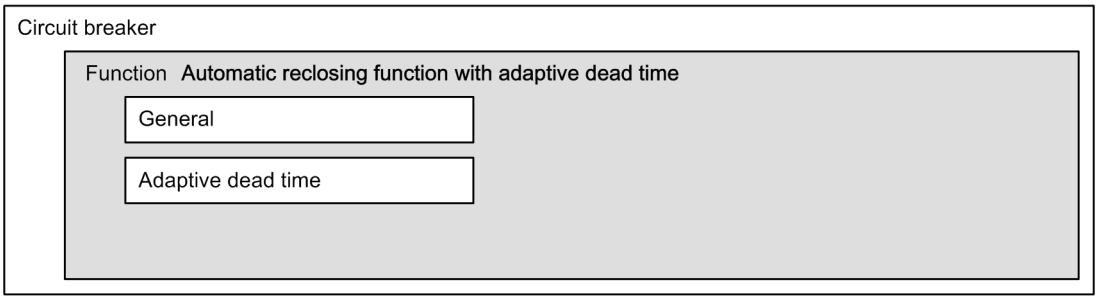


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Figure 6-267 Structure/Embedding of the Cyclic Automatic Reclosing Function

Automatic Reclosing Function with Adaptive Dead Time

The Automatic reclosing function with adaptive dead time (ADT) works without fixed disruption cycles (*Figure 6-268*). The requirement for the usage of ADT is that voltage transformers on the line-side are connected or there is a possibility to transfer a close command to a remote line end. With the ADT, the Automatic reclosing function decides independently if and when an automatic reclosing is reasonable and permissible and when it is not. The criteria is the phase-to-ground voltage, which is switched through after reclosing from the opposite line end. The Automatic reclosing function with ADT occurs as soon as it is known that the line from the opposite end has been placed back under voltage.

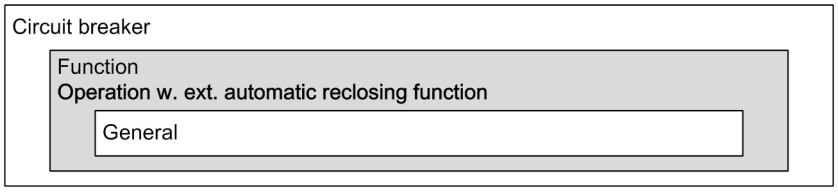


[dwaweasp-100611-01.tif, 1, en_US]

Figure 6-268 Structure/Embedding of the Automatic Reclosing Function With Adaptive Dead Time (ADT)

Operation with External Automatic Reclosing Function

The cooperation of an external reclosing device with the SIPROTEC protection device occurs through the function mode **Operation with external automatic reclosing function** (*Figure 6-269*). The function only provides binary inputs for the influence of the protection functions in the SIPROTEC protection device. The external automatic reclosing device delivers the close command. The SIPROTEC protection functions then provide for the trip commands.

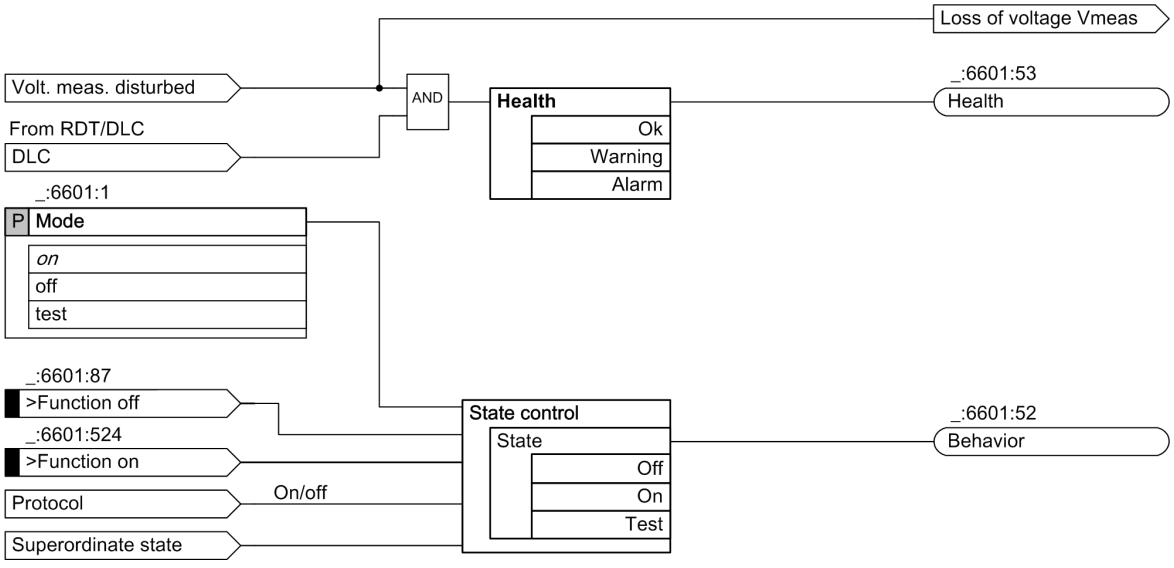


[dwextawe-100611-01.tif, 1, en_US]

Figure 6-269 Structure/Embedding of the Operating Function With External Automatic Reclosing Function

Function Control

The automatic reclosing function contains a central function control, see the following figure. You can find detailed information on the function control in the section **Function/Stage Control**.



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Figure 6-270 Function Control for the Automatic Reclosing Function

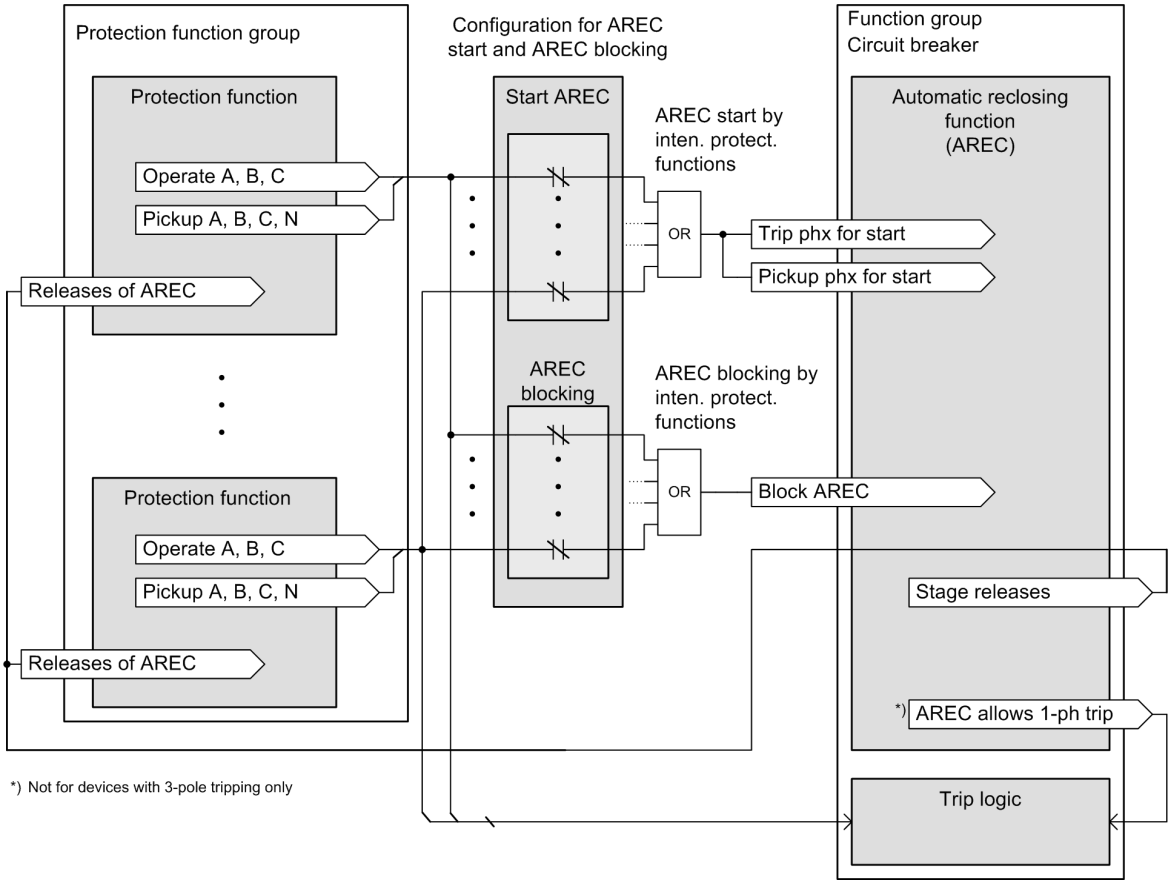
6.43.3 Cooperation of the Automatic Reclosing Function and Protection Functions

The Automatic reclosing function (AREC) can be influenced by the protection functions in the following way:

- The AREC is started through pickup indications and operate indications by the selected protection functions or protection stages. The start is independent of the set operating mode for the AREC.
- Individual protection functions or protection stages can be configured so that their operate indication blocks the AREC. If such a blocking exists, the AREC cannot be started. If the AREC is already started, the blocking will lead to the cancellation of the AREC.

The automatic reclosing device can thus have an influence on the effects of the protection functions. The following influence possibilities exist:

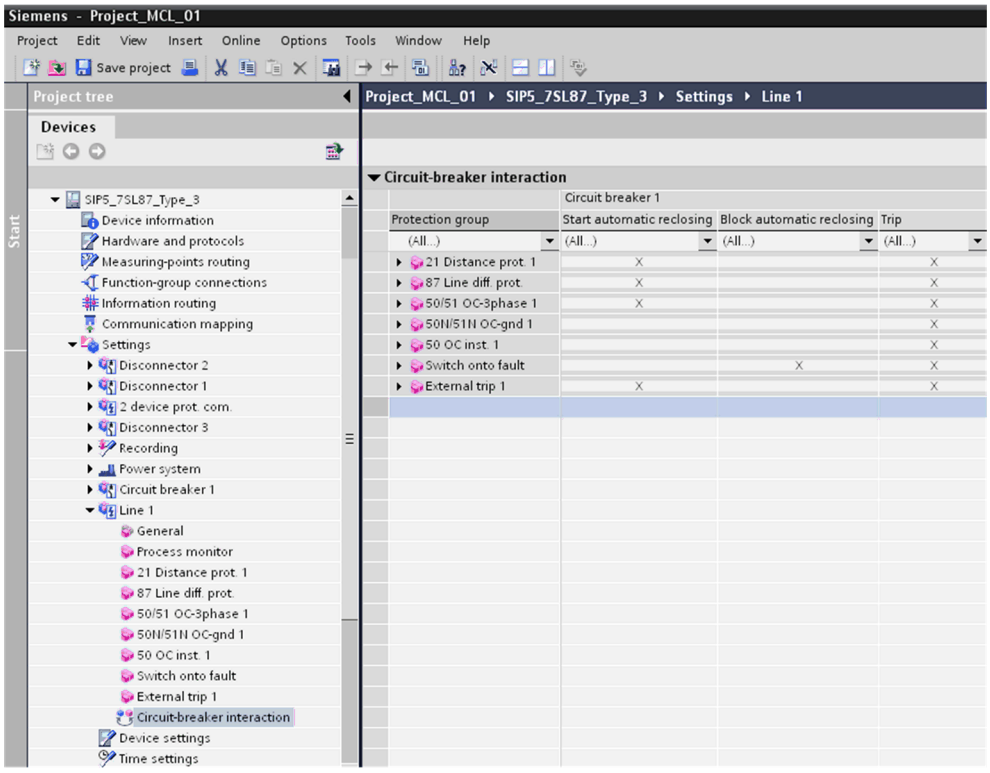
- The AREC provides signals that can be used by protection functions for the blocking or release of special stages or zones. An example is the release of overreaching zones with distance protection.



[loawesig-190912-01.tif, 1, en_US]

Figure 6-271 Signals between Protection Functions and Automatic Reclosing Functions

The configuration of the interaction between internal protection functions and automatic reclosing functions can be set separately for each protection function, see *Figure 6-271*. The configuration occurs in a matrix view in DIGSI, see the following figure..



[scdigsia-080311-01.tif, 1, en_US]

Figure 6-272 Configuration of the Protection Functions for Starting and Blocking the Automatic Reclosing Function in DIGSI 5

If a protection function or the stage of a protection function is connected with the AREC through the matrix, this means that the respective pickup and operate indications are forwarded to the AREC.

The links can be conducted separately

- For starting the automatic reclosing function and
- For the blocking of the automatic reclosing function

The Automatic reclosing function also has the corresponding binary inputs and binary outputs through which the external protection devices can be connected to the internal Automatic reclosing function.

6.43.4 Cyclic Automatic Reclosing Function

6.43.4.1 Operating Modes for Cyclic Automatic Reclosing Function

For the cyclic automatic reclosing function, there are 4 operating modes, from which one can be selected for the parameterization (parameter **(_:6601:101) 79 operating mode**).

The selection of the operating mode is dependent on the tripping behavior of the protection functions and the circuit breaker.

For applications with 3-pole tripping, all 4 operating modes are available.

- Operating mode 1: ***with op., with act. time***
- Operating mode 2: ***w.pickup, w. action time***
- Operating mode 3: ***with op., w/o act. time***
- Operating mode 4: ***w.pickup, w/o act. time***

Operating Mode 1: with op., with act. time

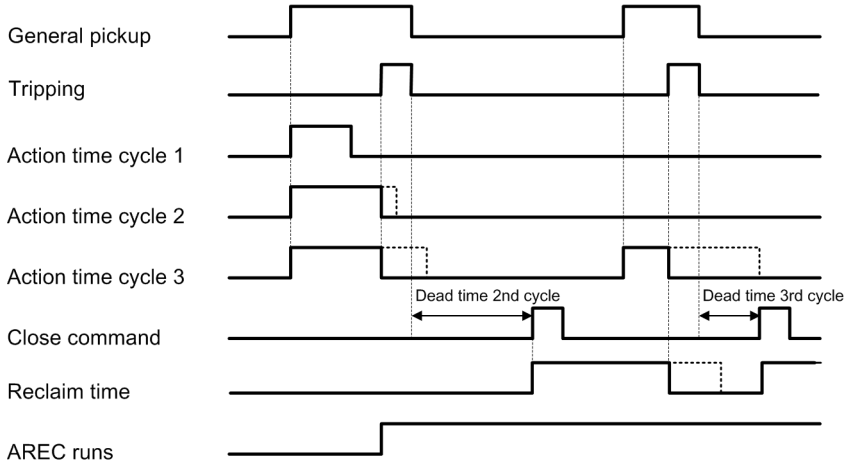
The operating mode ***with op., with act. time*** allows different automatic reclosing cycles depending on the tripping type and operate time of the protection function(s). With this operating mode, the automatic reclosing must be started with the operate indications. Additionally, the general pickup must also be considered.

With raising general pickup, the action times of the configured automatic reclosing cycles start. The general pickup is in this connection the group indication of all internal protection functions configured for starting the automatic reclosing and the external binary input for general pickup *>Gen. pickup for start*.

Through the time between the raising general pickup and clearing operate indication, the automatic reclosing cycle to be started will be determined. Here for multiple automatic reclosing cycles, the sequence of the expiring automatic reclosing cycles is not fixed, like the operating modes without action time.

The following example in *Figure 6-273* shows a tripping that comes after expiration of the action time of cycle 1, but still before the expiration of the action times from cycle 2 and cycle 3. Cycle 2 is now active.

Within the following reclaim time, there will be another pickup and tripping. Since cycle 2 is already complete, these and all lower cycles are no longer able to expire. The 2nd operate indication comes during the running action time of cycle 3. Thus, cycle 3 is now active.



[dwarce1d-190912-01.tif, 1, en_US]

Figure 6-273 Operating-Mode Signal Examples: With Tripping/With Action Time

Through the action time, there is a direct influence on the dead time behavior of the automatic reclosing function. With faults with short operate times, other dead times can be realized than for removed faults with longer tripping time. With faults with short operate time, an automatic reclosing is executed, with removed faults this does not occur with longer operate time. The operating mode ***with op., with act. time*** allows for different automatic reclosing cycles depending on the operate time of the protection function(s).

Operating Mode 2: w.pickup, w. action time

The operating mode ***w.pickup, w. action time*** allows different automatic reclosing cycles depending on the operate time and type of fault. It is only suitable and applicable for applications with 3-pole tripping.

With this operating mode, the automatic reclosing must be started with the operate indications from the protection functions. Additionally, the pickup sample from the conductor pickups and the general pickup are considered:

- With 1-phase pickup, the automatic reclosing cycles set for 1-phase dead times are activated. 1-phase pickup includes both pickup samples **phase-to-ground** and **only grounding**.
- With 2-phase pickup, the automatic reclosing cycles set for 2-phase dead times are activated.
- With 3-phase pickup, the automatic reclosing cycles set for 3-phase dead times are activated.

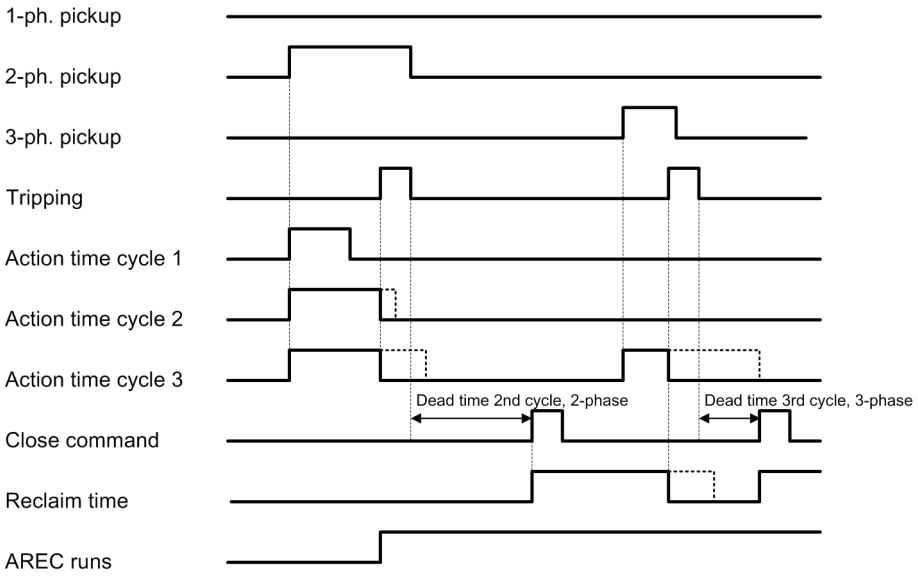
With each automatic reclosing cycle, it is checked to see if it is a 1-phase, 2-phase or 3-phase pickup.

With raising general pickup, the action times of the configured automatic reclosing cycles start. The general pickup is in this connection the group indication of all internal protection functions configured for starting the automatic reclosing and the external binary input for general pickup *>Gen. pickup for start*.

Through the time between the raising general pickup and raising trip command, the automatic reclosing cycle to be started will be determined. Here for multiple automatic reclosing cycles, the sequence of the expiring automatic reclosing cycles is not fixed, like the operating modes without action time.

The following example shows a tripping that comes after expiration of the action time of cycle 1, but still before the expiration of the action times from cycle 2 and cycle 3. Since it is a 2-phase pickup, cycle 2 is active with the dead-time setting for 2-phase faults.

After reclosing, there will be another, this time 3-phase, pickup and tripping within the following reclaim time. Since cycle 2 is already complete, these and all lower cycles are no longer able to expire. The trip command comes during the current action time of cycle 3. Thus, cycle 3 is active, with the dead time setting for 3-phase faults.

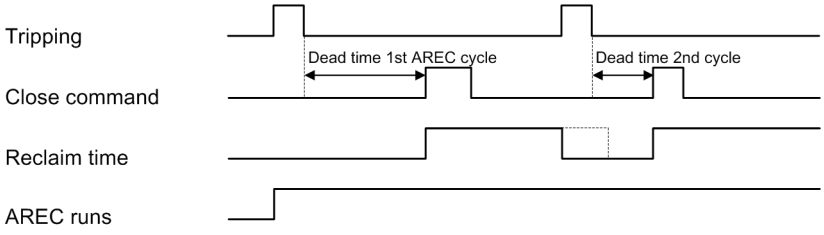


[dwarcbm2-190912-01.tif, 1, en_US]

Figure 6-274 Operating-Mode Signal Examples: With Pickup/With Action Time

Operating Mode 3: with op., w/o act. time

With the operating mode ***with op., w/o act. time***, the respective dead time is started after each trip command. The pickups are not considered. If more than one automatic reclosing cycle is configured, the sequence of the expiring automatic reclosing cycles is identical with the cycle number (1, 2, and 3.).



[dwaweb3d-240810-01.tif, 1, en_US]

Figure 6-275 Operating-Mode Signal Examples: With Tripping/Without Action Time

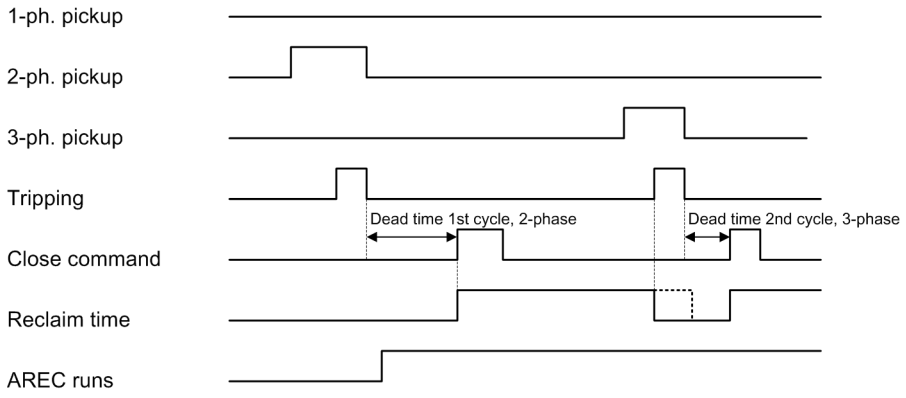
Operating Mode 4: w.pickup, w/o act. time

With the operating mode ***w.pickup, w/o act. time***, the automatic reclosing must be started with the operate indications from the protection functions. It is only suitable and applicable for applications with 3-pole tripping.

The start of the dead time occurs after each trip command. Additionally, the pickup sample from the conductor pickups is considered:

- With 1-phase pickup, the automatic reclosing cycles set for 1-phase dead times are activated. 1-phase pickup includes both pickup samples **phase-to-ground** and **only grounding**.
- With 2-phase pickup, the automatic reclosing cycles set for 2-phase dead times are activated.
- With 3-phase pickup, the automatic reclosing cycles set for 3-phase dead times are activated.

With each automatic reclosing cycle, it is checked to see if it is a 1-phase, 2-phase or 3-phase pickup. If more than one automatic reclosing cycle is configured, the sequence of the expiring automatic reclosing cycles is identical with the cycle number (1, 2, 3, etc.).



[dwarcbs4-170311-01.tif, 1, en_US]

Figure 6-276 Operating-Mode Signal Examples: With Pickup/Without Action Time

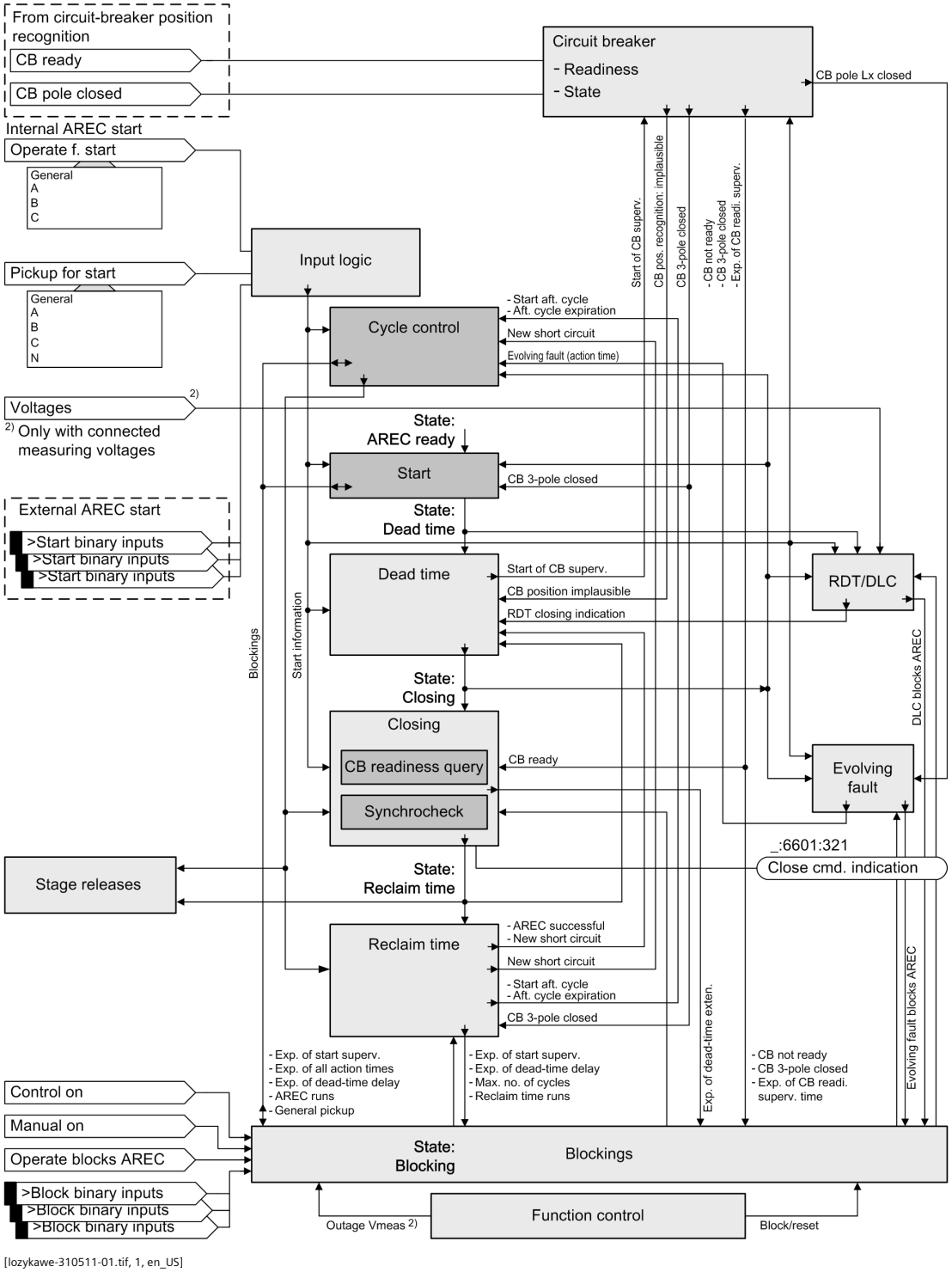
6.43.4.2 Structure of the Cyclic Automatic Reclosing Function

In *Figure 6-277*, the functional structure of the cyclic automatic reclosing function is illustrated as a block diagram. The figure displays the important signals, coming from outside of the cyclic automatic reclosing function, and the most important signals between the individual function blocks.

The automatic reclosing function works as a state machine. From the idle state **AREC ready**, the automatic reclosing function gets through the tripping or pickup indications of the protection functions to the **Dead time** state. After expiration of the dead time, the subsequent state is reached with the closing indication. The reclaim time is also started together with the closing indication. If the reclaim time can expire without further operate or pickup indications, the automatic reclosing is successful and the automatic reclosing function turns back to idle state.

If the automatic reclosing function is restarted during the current reclaim time, there will be either a dynamic blocking or other reclosing cycles will be executed. If other reclosing cycles are possible, there will be a dead time start and the described process starts again.

After the end of a dynamic blocking, the automatic reclosing function switches back to idle state or it goes into the state **Static Blocking** if the blocking condition is permanently present. In the following sections, the individual function blocks are described in detail.



[lozykawe-310511-01.tif, 1, en_US]

Figure 6-277 Cyclic Reclosing Function: Block Diagram of Automatic Reclosing

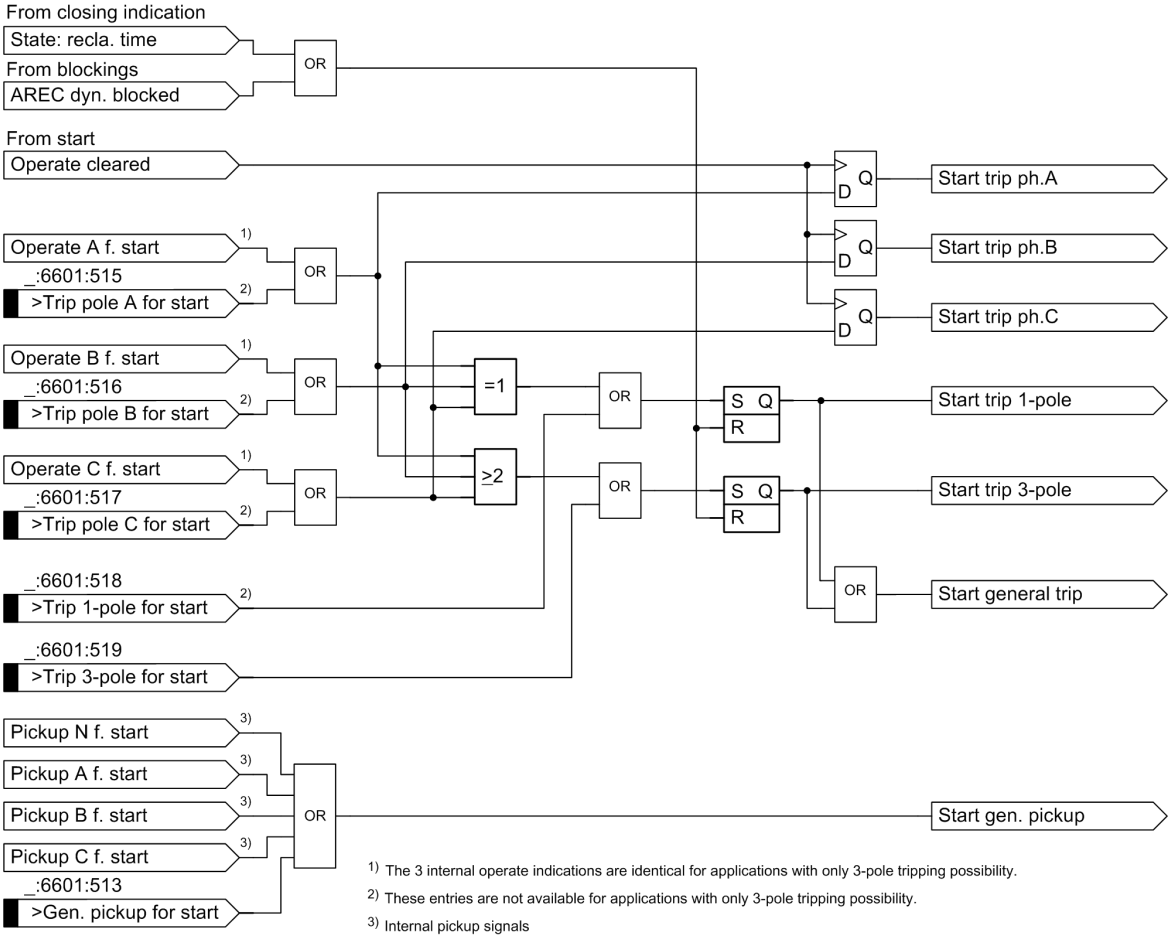
6.43.4.3 Input Logic for Operating Modes with Tripping

The operate indications are used as starting signals. For operating modes **with action time**, the start of the action time(s) occurs with the pickup messages. During all operating modes, the pickup indications are also required during the processing of faults and for supervision during the reclaim time.

Applications with 3-Pole Tripping

For applications with only 3-pole tripping options, the internal operate indications are always 3-pole. For external starts, there is a binary input, which signalizes a 3-pole tripping of the external protection device.

The outputs of the input logic signalize that the reclosing start has occurred through a 3-pole operate indication.



[lobtaaus-100611-01.tif, 2, en_US]

Figure 6-278 Input Logic for Operating Modes: With Tripping

6.43.4.4 Input Logic for Operating Modes with Pickup

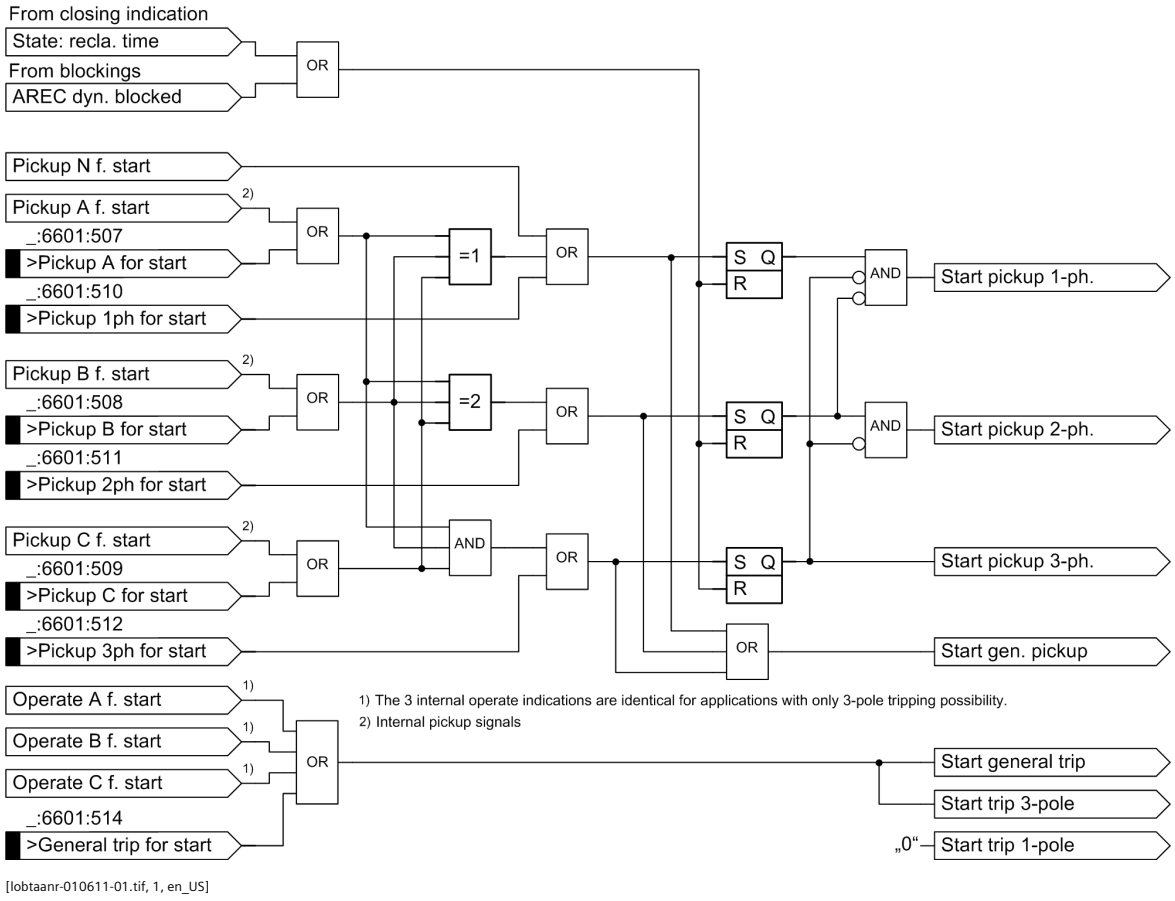
The operate indications and the pickup indications are used as starting signals. The internal pickup indications are processed selective to the phase. Through binary inputs, the pickup information can also be coupled by external protection devices (*>Pickup A for start*, *>Pickup B for start* and *>Pickup C for start*). Optionally, the pickup information can be externally captured as a pickup sample, thus, as a 1-phase, 2-phase and 3-phase pickup.

The outputs of the input logic signalize if the automatic reclosing start occurs through a 1-phase, 2-phase, or 3-phase pickup:

- On **Start with 3-phase pickup**, it is recognized if all 3 phases were picked up in the period from the first raising pickup indication up to the last clearing outgoing pickup indication.
- On **Start with 2-phase pickup**, it is recognized if all 2 phases were picked up in the period from the first raising pickup indication up to the last clearing pickup indication and at no time 3 phases.
- On **Start with 1-phase pickup**, it is recognized if only 1 phase was picked up in the period from the first raising pickup indication up to the last clearing pickup indication.

For operating modes **with action time**, the start of the action time(s) occurs with the pickup indications. During operating modes **with pickup**, the pickup indications affect the selection of the dead times. During all operating modes, the pickup indications are also required during the processing of faults and for supervision during the reclaim time.

The automatic reclosing operating modes **with pickup** are only ideal for applications with 3-pole tripping. Therefore, the outputs of the input logic always signal 3-pole operate indications.



[lobtaanr-010611-01.tif, 1, en_US]

Figure 6-279 Input Logic for Operating Modes: With Pickup

6.43.4.5 Start

In the **Start** function block, the automatic reclosing function is switched from the idle state **AREC ready** to the state **Dead time**, see *Figure 6-280*. The length of the starting signals is controlled with a supervision time.

Start-Signal Supervision Time

The start-signal supervision stops the automatic reclosing if the short circuit is not switched off within the normal time; for example, in the case of a circuit-breaker failure.

With the first raising operate indication, the start-signal supervision time is initiated, parameter **`Start signal supervis.time`**. The time is stopped as soon as no operate indications are active or if the circuit breaker is recognized as being no longer 3-pole closed.

The automatic reclosing function is blocked if there is an expiration of the start-signal supervision time through a long operate indication. The blocking lasts until the operate indication stops, extended by a further 0.5 s.

Transition to the Dead-Time State

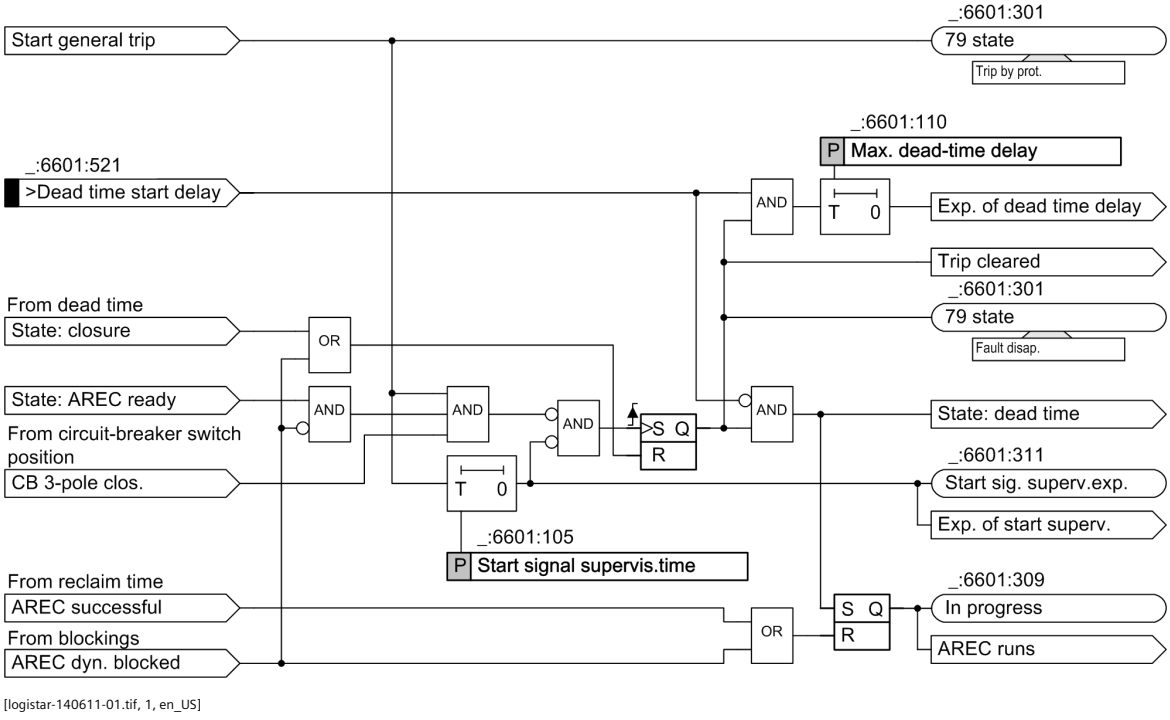
The transition of the automatic reclosing function to the **dead-time** state occurs for:

- Clearing operate indications if none of the signal inputs for operate indications are active
- or if the circuit breaker can no longer be recognized as 3-pole
- and the start-signal supervision time is not expired

Additionally, the following conditions must be fulfilled:

- The circuit breaker signalizes the readiness for automatic reclosing typically through a binary input. If the circuit breaker is not ready, the automatic reclosing function can be statically blocked. In this situation, the automatic closing function is not in idle state **automatic closing function ready**. The control of the circuit-breaker readiness is optional and can be turned off through settings, see also chapter *6.43.4.16 Circuit-Breaker Readiness* and *6.43.4.17 Blockings*.
- The circuit breaker must be closed before the 3-pole trip command. This condition is not considered if the circuit-breaker auxiliary contacts are not connected to the protection device.

You can delay the transition to the **dead time** state through the binary input *>Dead time start delay*. As long the corresponding binary signal is present, the dead time of the automatic reclosing function will not be started. The maximum duration of this binary signal is monitored through a time stage that can be set, parameter **Max. dead-time delay**. Upon expiration of this time stage, that is, if the binary signal is present longer than permitted, the automatic reclosing function will be blocked until the end of the binary signal, additionally extended by another 0.5 s. See also chapter *6.43.4.17 Blockings*.



[logistar-140611-01.tif, 1, en_US]

Figure 6-280 Logic for Function Block Start

6.43.4.6 Cycle Control with Operating Mode 1: With Tripping/With Action Time

The cycle control checks the readiness for each automatic reclosing cycle and controls the process of the action time(s). In *Figure 6-281*, the cycle control is illustrated.

Cycle Availability

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter **Dead time aft. 3-pole trip** to ***invalid*** avoids an automatic reclosing after 3-pole tripping. Correspondingly, there is no automatic reclosing function if the **Dead time**

aft. 1-pole trip [16] is set to ***invalid***. If both dead times are set to ***invalid***, the respective automatic reclosing cycle will be completely blocked. With the binary input *>Block 79 cycle*, you can block the associated automatic reclosing cycle.

For applications with 1-pole tripping, the cycle control provides a signal, based on which the protection functions can recognize that the automatic reclosing function only occurs after 1-pole tripping (*AR only after 1p. trip*). The approval or switch over of special protection stages only occurs for types of fauts that lead to 1-pole tripping.

Action Time

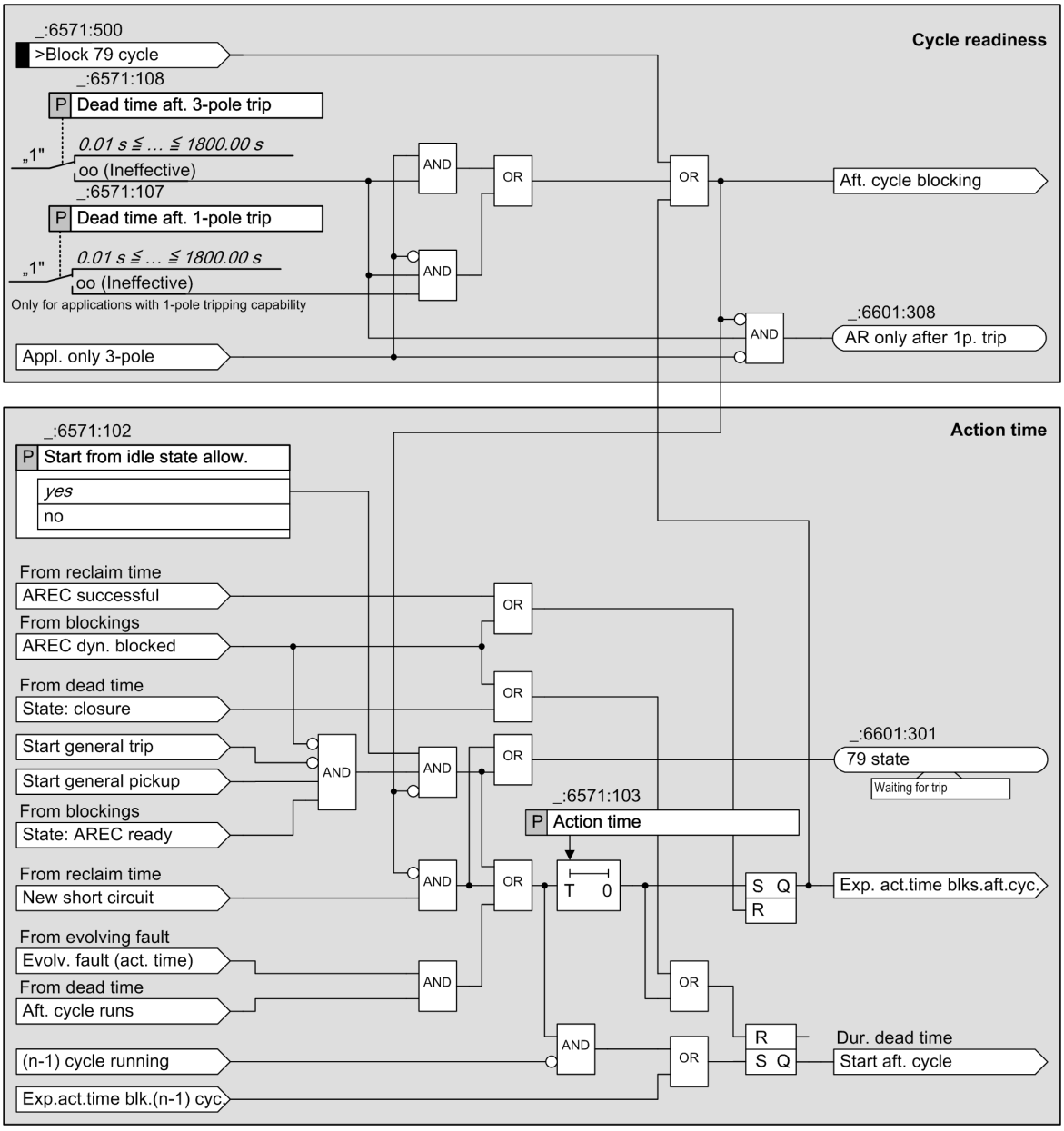
If the automatic reclosing function is in the idle state **automatic reclosing function ready**, an incoming general pickup will affect the start of the action time. This applies for the reclosing function cycles that are released through the parameter **Start from idle state allow.** and not blocked.

During one of the started action times, the corresponding reclosing cycle is blocked and the reclosing cycle is assigned the next highest cycle number, whose action time is running and is not blocked.

With raising trip commands, the action times are stopped and reset. The process state of the action times existing at this moment determines the automatic reclosing cycle that should be started.

If all initiated action times expire without capturing a tripping, the automatic reclosing function does not take place. However, if a tripping function is initiated after expiry of the action time, the automatic closing function is blocked for 3 seconds. A new start of the reclosing function is only possible if the general pickup is no longer active.

[16] is not available for devices with only 3-pole tripping



[loauswir-140611-01.tif, 1, en_US]

Figure 6-281 Cycle Control with Operating Mode: With Tripping/With Action Time

6.43.4.7 Cycle Control with Operating Mode 2: With Pickup/With Action Time

The cycle control checks the readiness for each automatic reclosing cycle and controls the process of the action time(s). In *Figure 6-282*, the cycle control is illustrated.

Cycle Availability

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter **Dead time aft.1ph. pickup** to ***invalid*** avoids an automatic reclosing after 3-pole tripping due to 1-phase short circuits. This also applies to **Dead time aft.2ph. pickup** and **Dead time aft.3ph. pickup**. If all 3 dead times are set to ***invalid***, the respective reclosing cycle will be completely blocked. With the binary input *>Block 79 cycle*, you can block the associated automatic reclosing cycle.

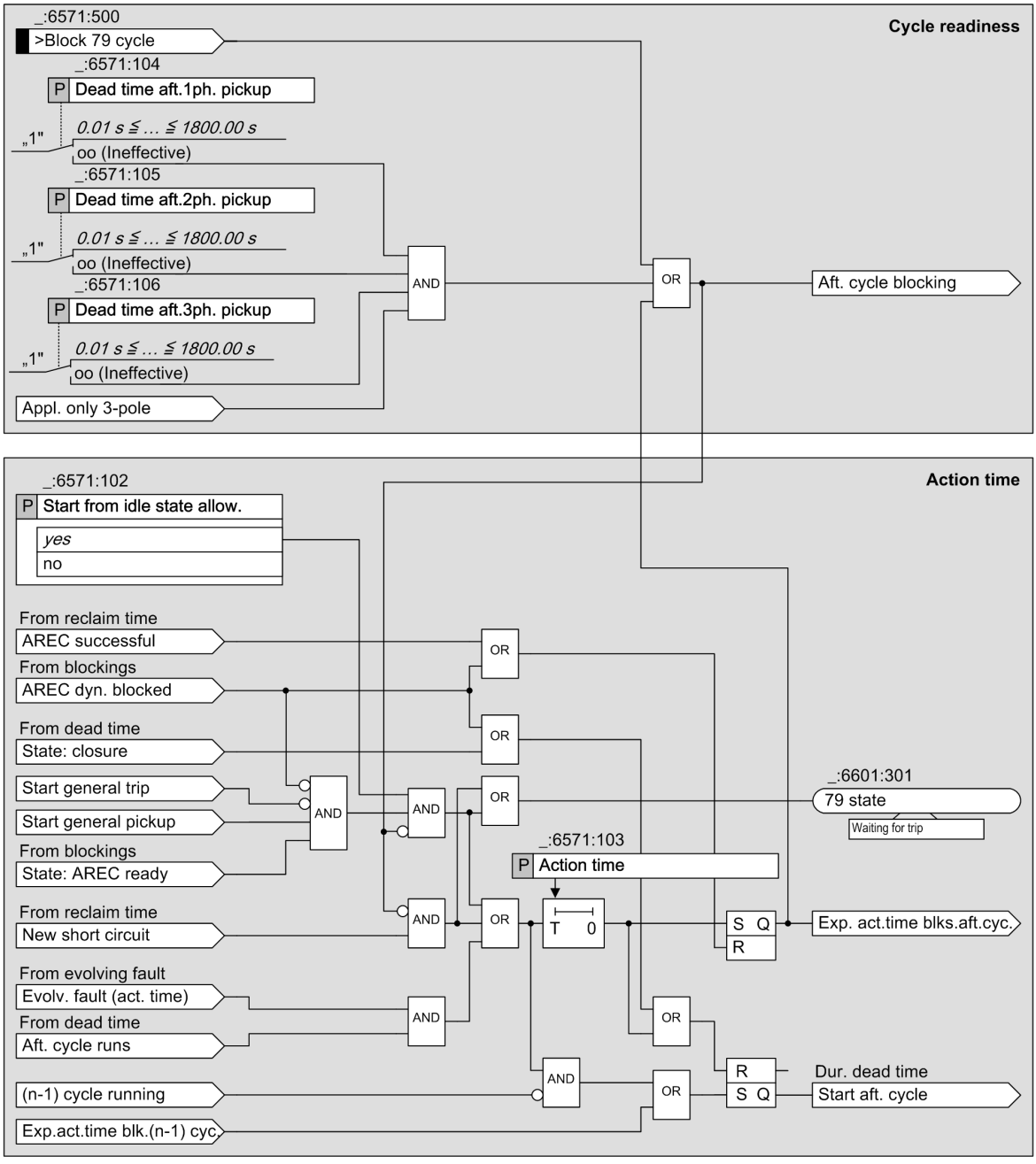
Action Time

If the automatic reclosing function is in the idle state **automatic reclosing function ready**, an incoming general pickup will affect the start of the action time. This applies for the reclosing function cycles that are released through the parameter **`Start from idle state allow.`** and not blocked.

During one of the started action times, the corresponding reclosing cycle is blocked and the reclosing cycle is assigned the next highest cycle number, whose action time is running and is not blocked.

With raising trip commands, the action times are stopped and reset. The process state of the action times existing at this moment determines the automatic reclosing cycle that should be started.

If all initiated action times expire without capturing a tripping, the automatic reclosing function does not take place. However, if a tripping function is initiated after expiry of the action time, the automatic closing function is blocked for 3 seconds. A new start of the reclosing function is only possible if the general pickup is no longer active.



[loanrwir-140611-01.tif, 1, en_US]

Figure 6-282 Cycle Control with Operating Mode: With Pickup/With Action Time

6.43.4.8 Cycle Control with Operating Mode 3: With Tripping/Without Action Time

The cycle control checks the availability for each automatic reclosing cycle. In *Figure 6-283*, the cycle control for the 1st automatic reclosing cycle and other reclosing cycles is illustrated. The further automatic reclosing cycles are generally described with the cycle number **n** and apply for all other configured automatic reclosing cycles.

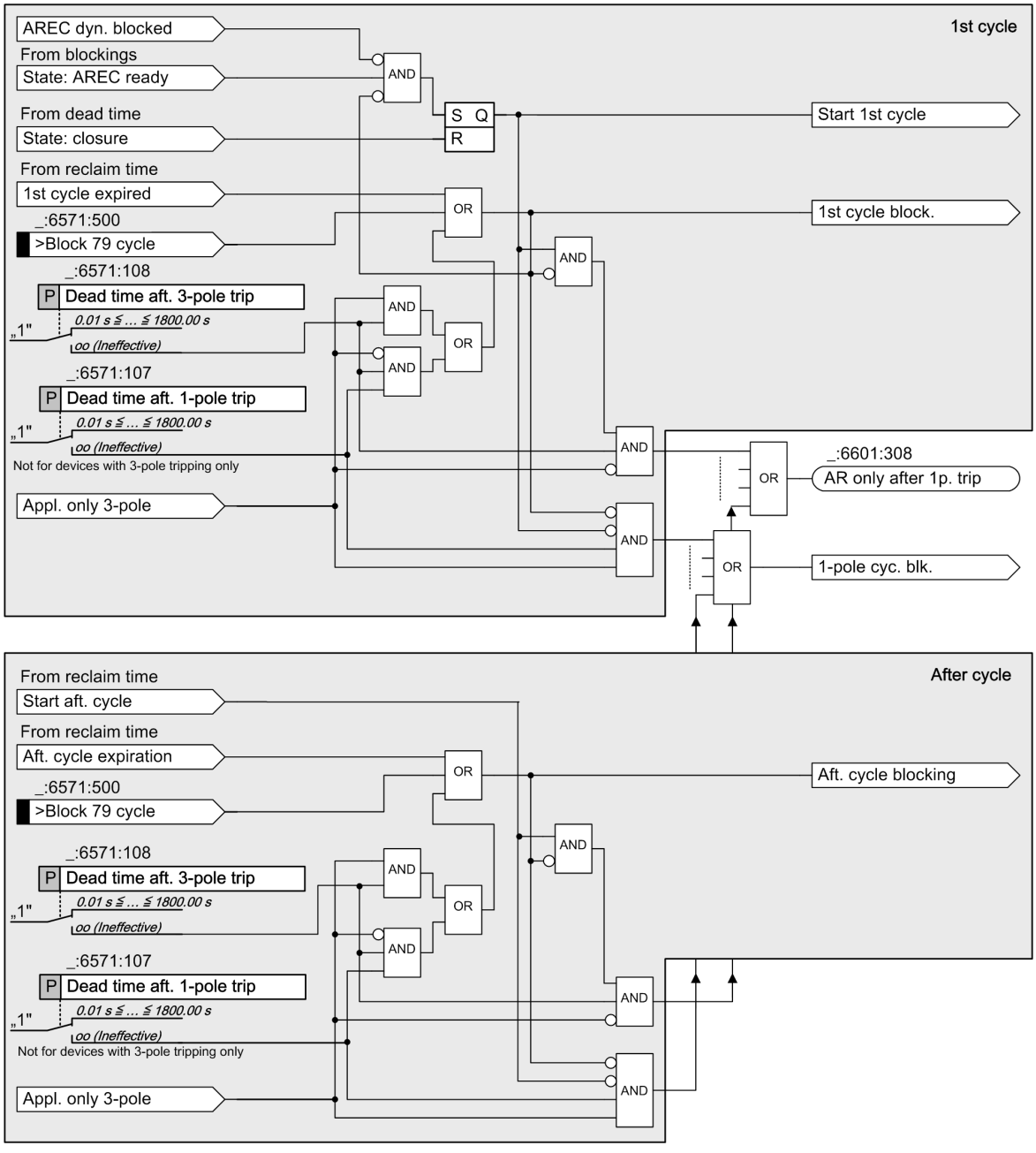
The cycle availability is influenced through the parameterization of the dead time and through a binary input.

In this way, setting the parameter **`Dead time aft. 3-pole trip`** to ***`invalid`*** avoids an automatic reclosing after 3-pole tripping. Correspondingly, there is no automatic reclosing function after 1-pole tripping if the **`Dead time aft. 1-pole trip`** [17] to ***`invalid`***. If both dead times are set to ***`invalid`***, the respec-

[17] is not available for devices with only 3-pole tripping

tive automatic reclosing cycle will be completely blocked. With the binary input *>Block 79 cycle*, you can block the associated automatic reclosing cycle.

For applications with 1-pole tripping, the cycle control provides a signal, based on which the protection functions can recognize that the automatic reclosing function only occurs after 1-pole tripping (*AR only after 1p. trip*). The approval or switch over of special protection stages only occurs for types of faults that lead to 1-pole tripping.



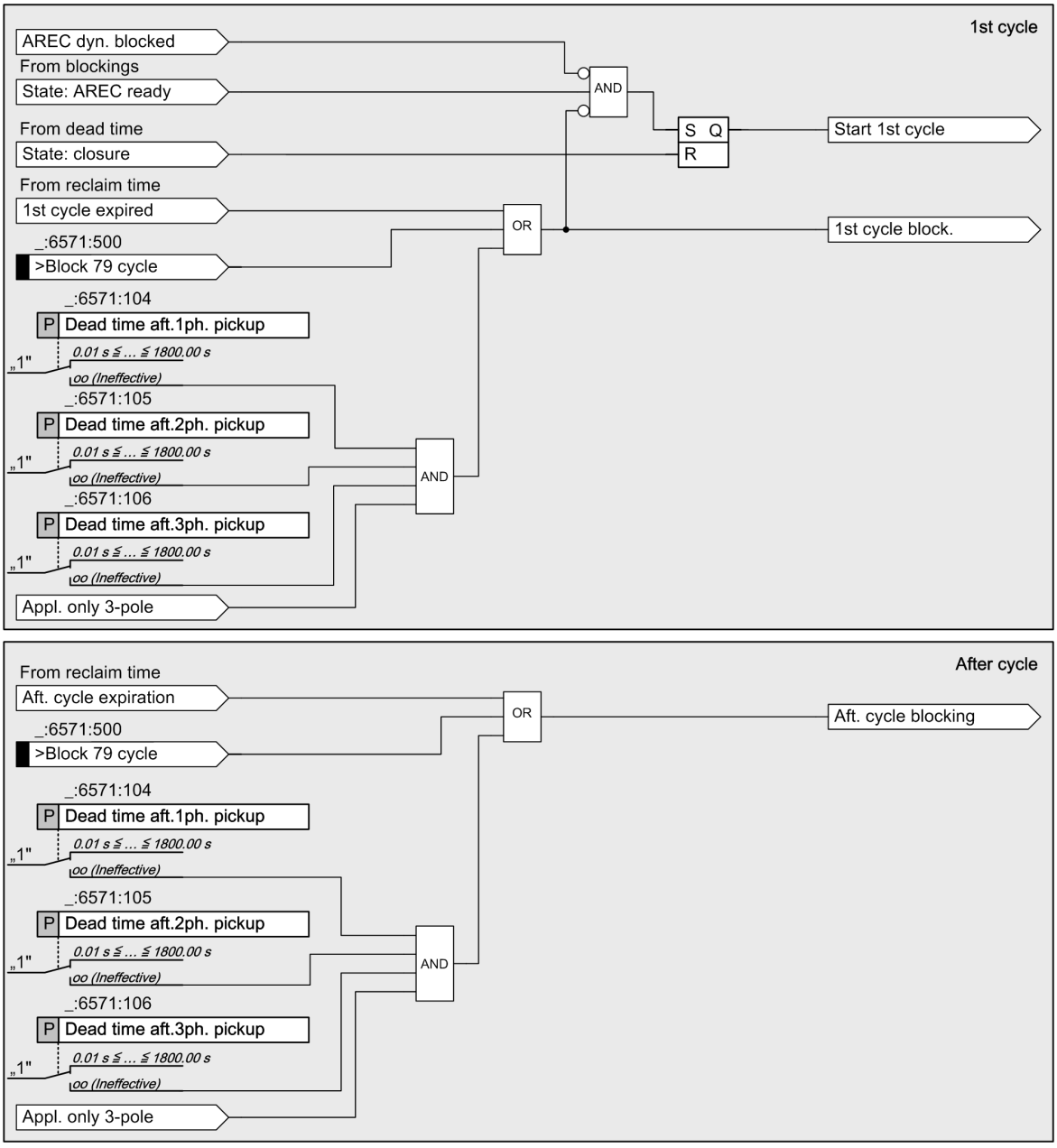
[loauowrk-210311-01.tif, 1, en_US]

Figure 6-283 Cycle Control with Operating Mode: With Tripping/Without Action Time

6.43.4.9 Cycle Control with Operating Mode 4: With Pickup/Without Action Time

The cycle control checks the availability for each automatic reclosing cycle. In *Figure 6-284*, the cycle control for the 1st automatic reclosing cycle and other reclosing cycles is illustrated. The further automatic reclosing cycles are generally described with the cycle number **n** and apply for all other configured automatic reclosing cycles.

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter **Dead time aft.1ph. pickup** to ***invalid*** avoids an automatic reclosing after 3-pole tripping due to 1-phase short circuits. This also applies to **Dead time aft.2ph. pickup** and **Dead time aft.3ph. pickup**. If all 3 dead times are set to ***invalid***, the respective reclosing cycle will be completely blocked. With the binary input *>Block 79 cycle*, you can block the associated automatic reclosing cycle.



[loanowrk-100611-01.tif, 1, en_US]

Figure 6-284 Cycle Control with Operating Mode: With Pickup/Without Action Time

6.43.4.10 Stage Release

The function block **Stage release** creates output indications for the release or switching over of special stages for protection functions (stage release in the 1st cycle or stage release in the n. cycle). Examples for this are the release of overreaching zones with distance protection and the dynamic adjustment of delays or threshold values with overcurrent protection.

Figure 6-285 shows the tripping stage release for the 1st automatic reclosing cycle. With available automatic reclosing functions, the tripping stage release typically occurs up to the expiration of the dead time. The cycle number in this state is on 1. However, if the automatic reclosing cycle is set only for 1-phase [18], the tripping stage release will be reset to the beginning of the 1-phase dead time. This is necessary, since every additional evolving fault that occurs within the dead time causes a 3-pole cut-off, and subsequently, the automatic reclosing function can no longer take place.

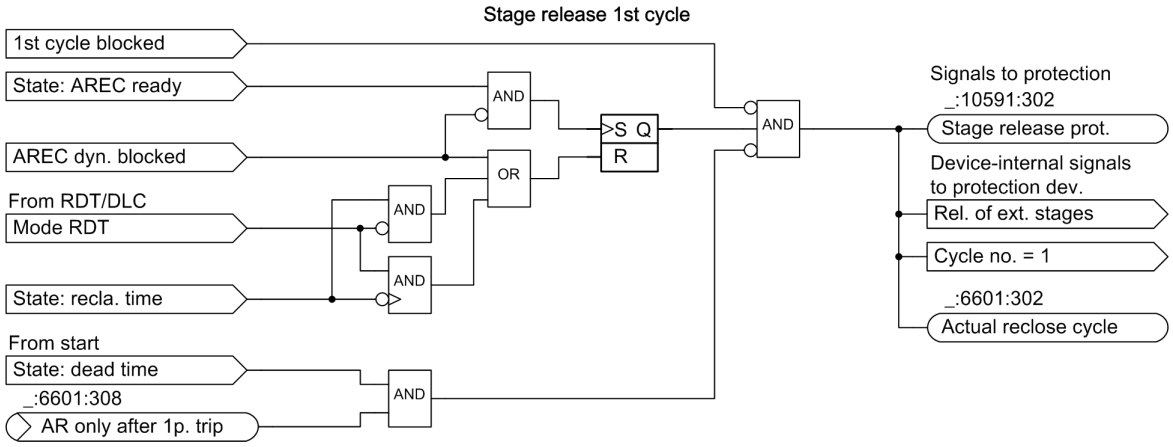


Figure 6-285 Stage Release for Protection Functions in the 1st Automatic Reclosing Cycle

The tripping stage release for higher automatic reclosing cycles is set to the beginning of the reclaim time for rising edge close commands. Simultaneously, the cycle number is increased. The reset condition is identical to the condition for the 1st automatic reclosing cycle. If the reduced dead time (RDT) mode is selected and no additional reduced dead time occurs, the release of the 2nd cycle will be maintained, since it can be assumed that the opposite end is open.

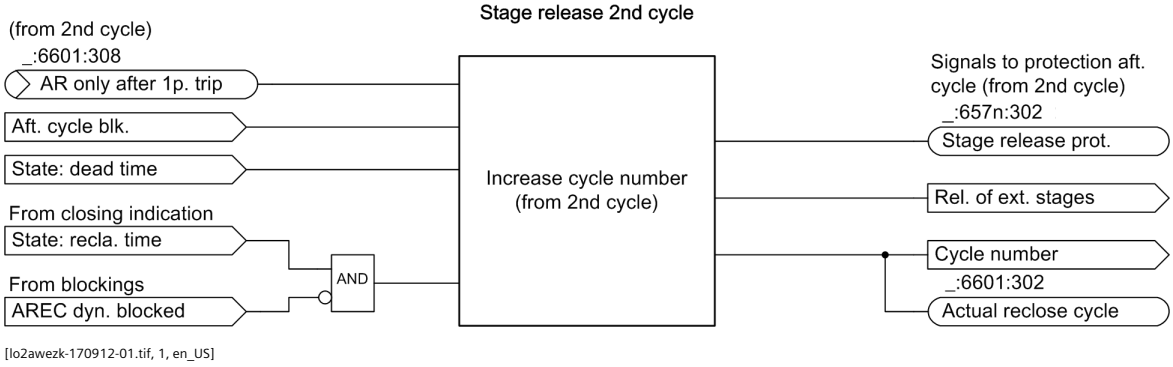


Figure 6-286 Stage Release for Protection Functions Starting With the 2nd Automatic Reclosing Cycle

6.43.4.11 Dead Time for Operating Modes With Tripping

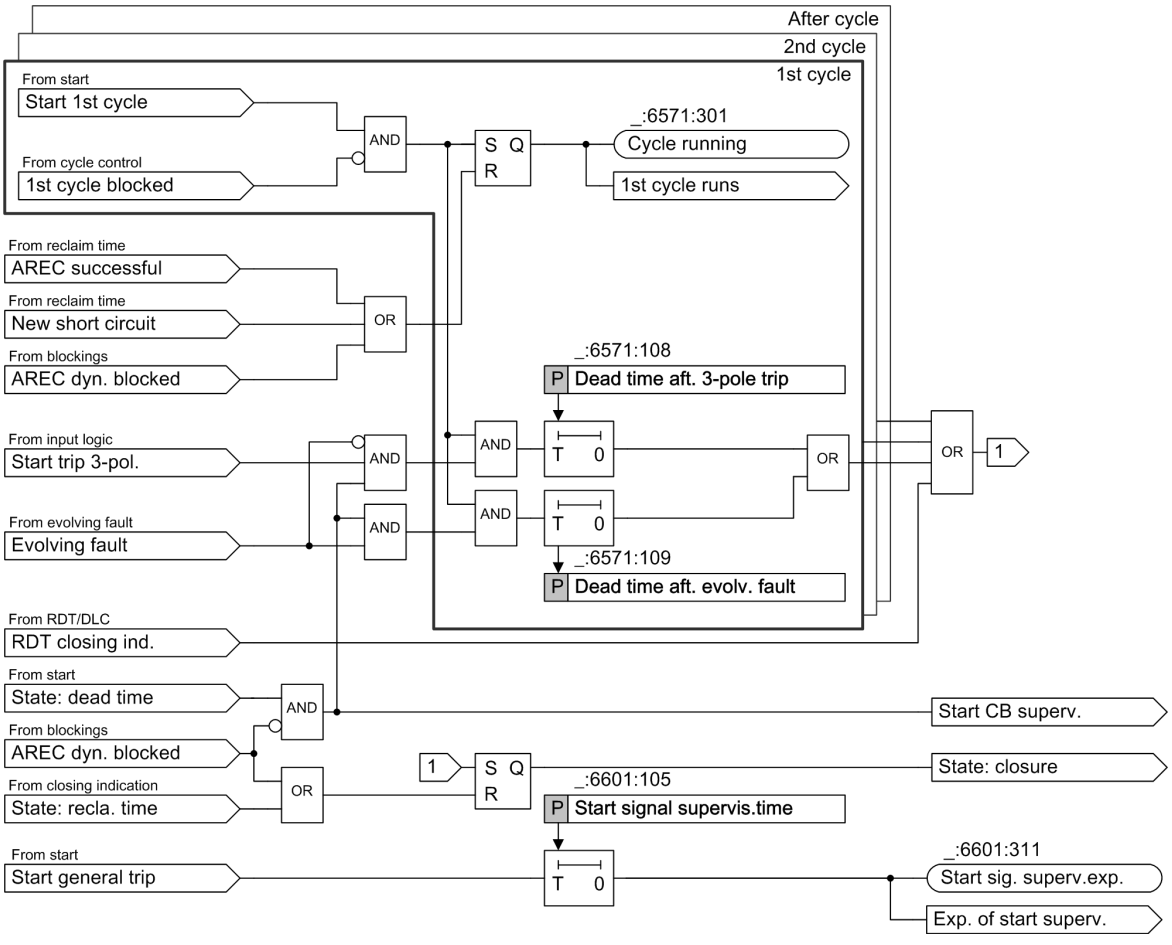
In the **Dead time** function block, that dead time which corresponds with the previous trip command is started. After expiration of the dead time, the automatic reclosing function changes to the status **Switch on**.
Figure 6-287 shows the dead time logic.
There are the following time stages that can be set differently:

- Dead time after 3-pole tripping
- Dead time after evolving fault

Setting the parameter **`Dead time aft. 3-pole trip`** to ∞ (= invalid) avoids an automatic reclosing after 3-pole tripping.

[18] not for devices with only 3-phase tripping

As soon as an evolving fault is recognized (see chapter *6.43.4.13 Evolving-Fault Detection During Dead Time*), switching to an automatic reclosing cycle for 3-pole interruption occurs. With the 3-pole cut-off of the evolving fault, a separate adjustable dead time for the evolving fault begins. The total dead time is composed of the part of the dead time that expired until the evolving fault was stopped for the first disruption plus the dead time for the evolving fault. With the setting of the parameter **`Dead time aft. evolv. fault`** to ∞ (= invalid), no other automatic reclosing cycle is executed after tripping by the evolving fault. The tripping through evolving faults is then finished.



[lopausjk-021212-01.tif, 1, en_US]

Figure 6-287 Cyclic Automatic Reclosing Function - Logic of the Dead Time for the Operating Modes: With Tripping

6.43.4.12 Dead Time for Operating Modes with Pickup

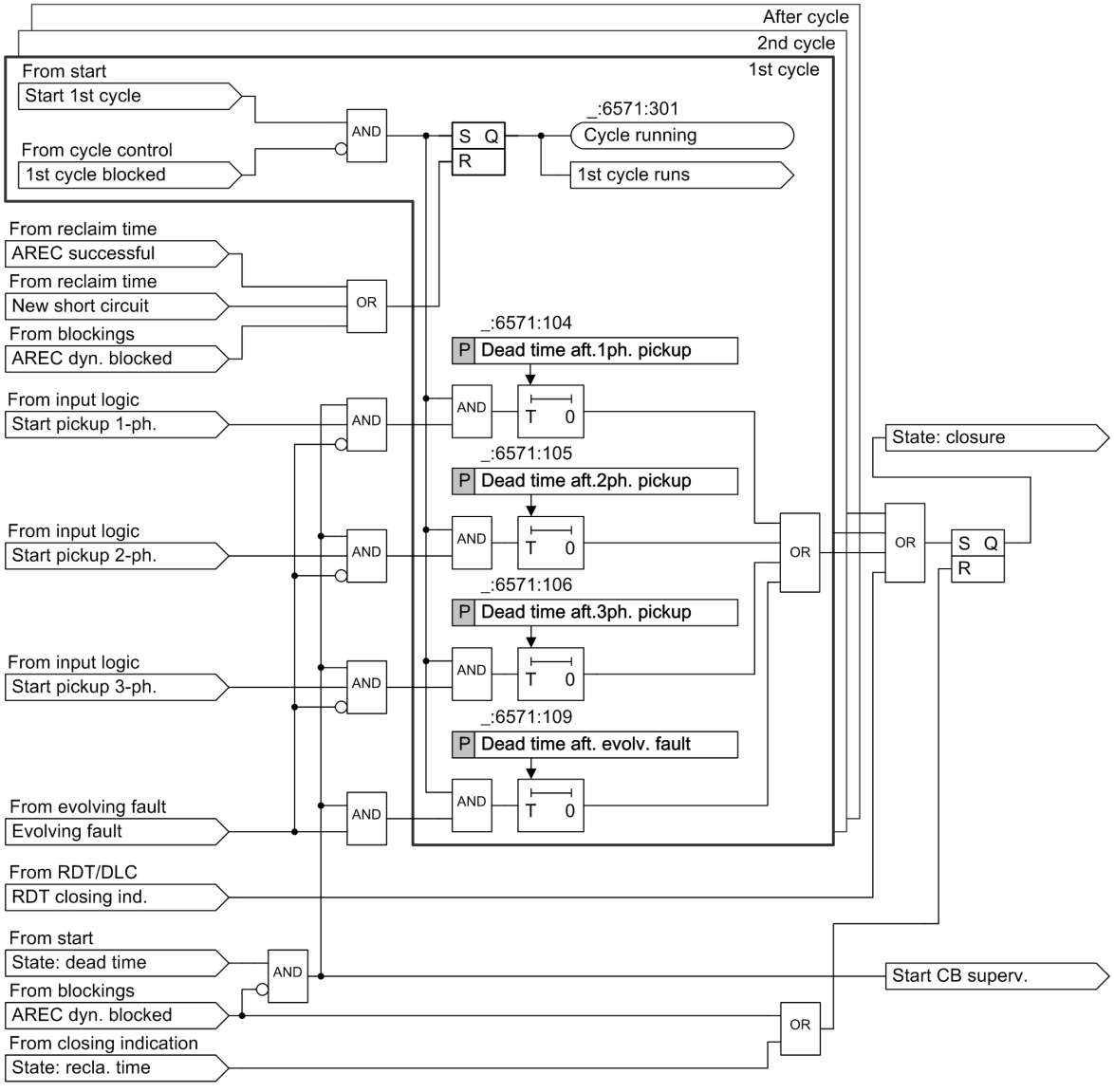
In the **dead time** function block, the dead time corresponding to the type of short circuit that led to the trip command is started. The automatic reclosing operating modes **with pickup** are only ideal for applications with 3-pole tripping. After expiration of the dead time, the automatic reclosing function changes to the status **Switch on**. *Figure 6-288* shows the dead time logic.

There are 4 time stages that can be set differently:

- Dead time after 1-phase short circuits
- Dead time after 2-phase short circuits
- Dead time after 3-phase short circuits
- Dead time for evolving faults

In this way, setting the parameter **`Dead time aft.1ph. pickup`** to ***`invalid`*** avoids an automatic reclosing after 3-pole tripping due to 1-phase short circuits. This also applies to **`Dead time aft.2ph. pickup`** and **`Dead time aft.3ph. pickup`** .

As soon as an evolving fault is recognized (see chapter *6.43.4.13 Evolving-Fault Detection During Dead Time*), a separate dead time for faults begins with the stopping of the fault. The total dead time is composed of the part of the dead time that expired until the evolving fault was stopped for the 1st disruption plus the dead time for the evolving fault. With the setting of the **Dead time aft. evolv. fault** to ***invalid***, no other automatic reclosing cycle is executed after tripping through the evolving fault. The tripping through evolving faults is then finished.



[lopauare-010611-01.tif, 1, en_US]

Figure 6-288 Cyclic Automatic Reclosing Function - Logic of the Dead Time for the Operating Modes: With Pickup

6.43.4.13 Evolving-Fault Detection During Dead Time

Evolving faults are short circuits, which occur after switching off a short circuit during dead time. This may be the case during 1-pole tripping and there is a short circuit in the non-switched conductors after this.

After 3-pole tripping there may also be evolving faults if the line is fed through a second (non-3-pole) opened circuit breaker, for example, for systems with a 1 1/2 circuit breaker layout.

The evolving-fault detection is divided into components:

- Detection of Evolving Faults
- Evolving-Faults Processing
- 3-pole circuit-breaker intertripping during evolving faults

The procedure during evolving faults is illustrated in *Figure 6-289*.

Detection of Evolving Faults

For the detection of an evolving fault, the following criteria can be selected through parameters:

- Parameter **Evolving-fault detection** = ***with trip***

  For this setting, **any tripping** during the dead time leads to evolving-fault detection. At **any tripping** it is decided if an internal protection function is tripped or if the tripping is signaled through a binary input. Thus, it does not matter if the tripping-protection function is configured for the start of the automatic reclosing function or not.

- Parameter **Evolving-fault detection** = ***with pickup***

  Evolving faults are detected if during the dead time a protection function configured for the automatic reclosing function start is picked up or if an external pickup is recognized through a binary input.

- Binary input *>Evolving fault start*

  The evolving-fault detection can also be introduced through a binary input without an internal protection pickup being available.

Reaction to Evolving Faults

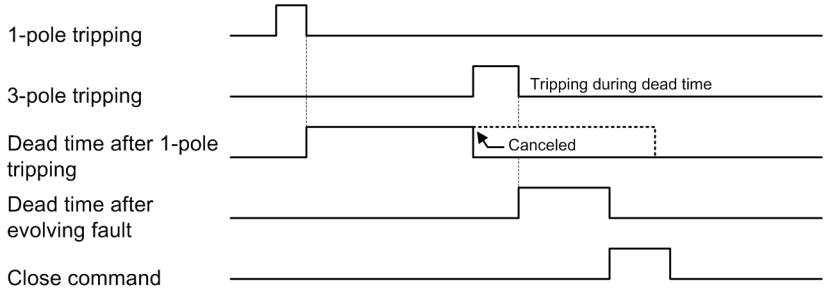
After a recognized evolving fault, the automatic reclosing function can be influenced in 2 ways.

- Parameter **Response to evolv. faults** = ***blocks 79***

  As soon as an evolving fault is recognized, the reclosing function will be blocked. There are no other reclosing attempts and the automatic reclosing function is blocked until the pickup and operate indications causing the evolving fault disappear.

- Parameter **Response to evolv. faults** = ***strt. evol.flt.dead time***

  As soon as an evolving fault is recognized, an automatic reclosing cycle for 3-pole interruption is switched to. The automatic reclosing function does not allow any 1-pole tripping until the fault is solved or there is a final switch off; thus, every following trip command will be 3-pole. When the evolving fault is fixed, the separate dead time for faults will start, see also chapter **Dead time**. The further process is as by 3-pole cycles.

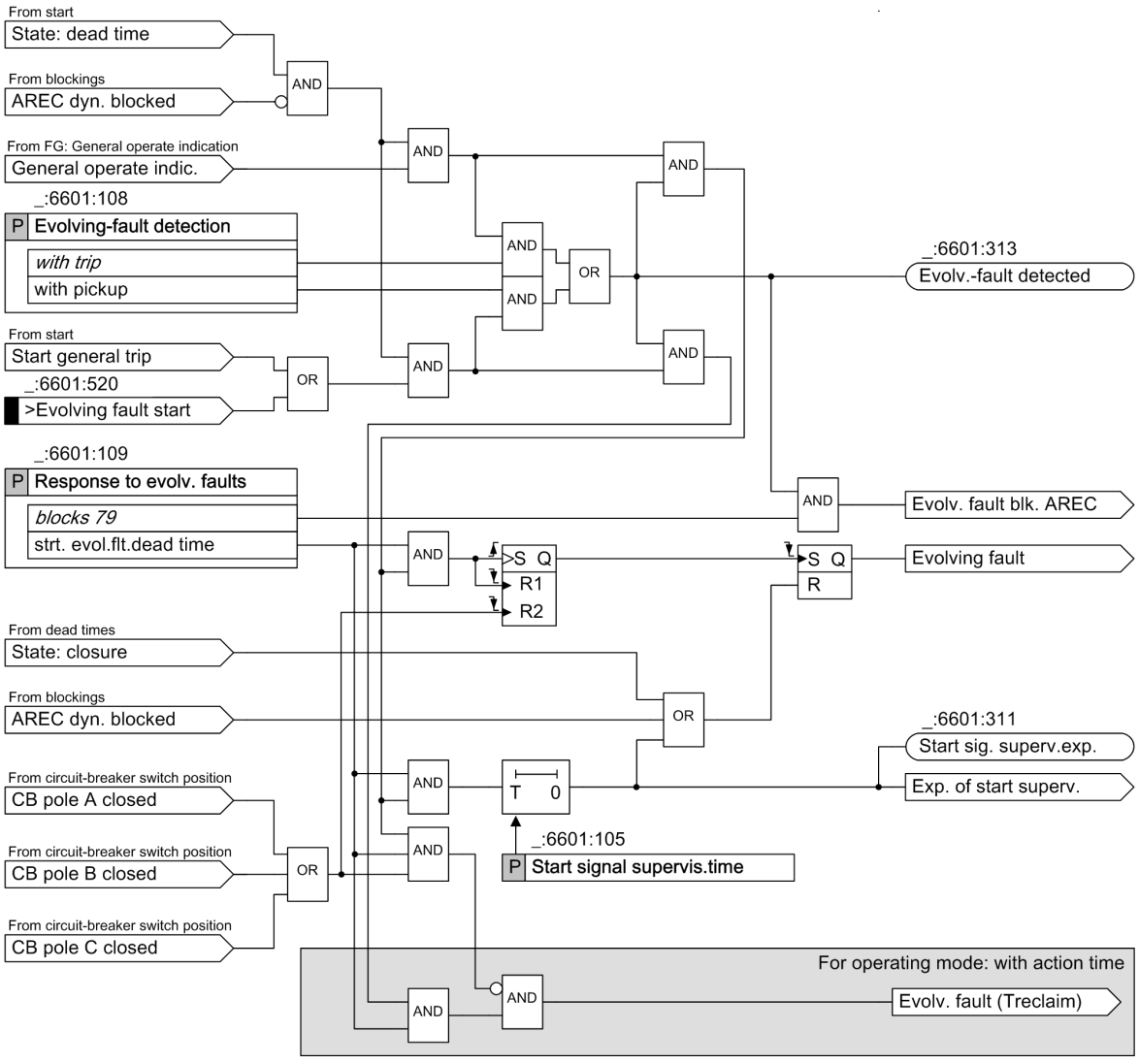


[dwbspffe-100611-01.tif, 1, en_US]

Figure 6-289 Cyclic Automatic Reclosing Function - Example for an Evolving Fault

For tripping through evolving faults, the entire dead time consists of the part of the dead time expired until disconnecting the evolving fault for the 1-pole interruption plus the dead time for the fault together, see *Figure 6-290*.

The dead time for evolving faults is started with the return of the operate indication or with the opening of all 3 circuit-breaker poles, provided the circuit-breaker auxiliary contacts are connected.



[lofolsjk-021212-01.tif, 1, en_US]

Figure 6-290 Cyclic Automatic Reclosing Function - Logic of Evolving-Fault Detection

6.43.4.14 Closing Indication and Close Command

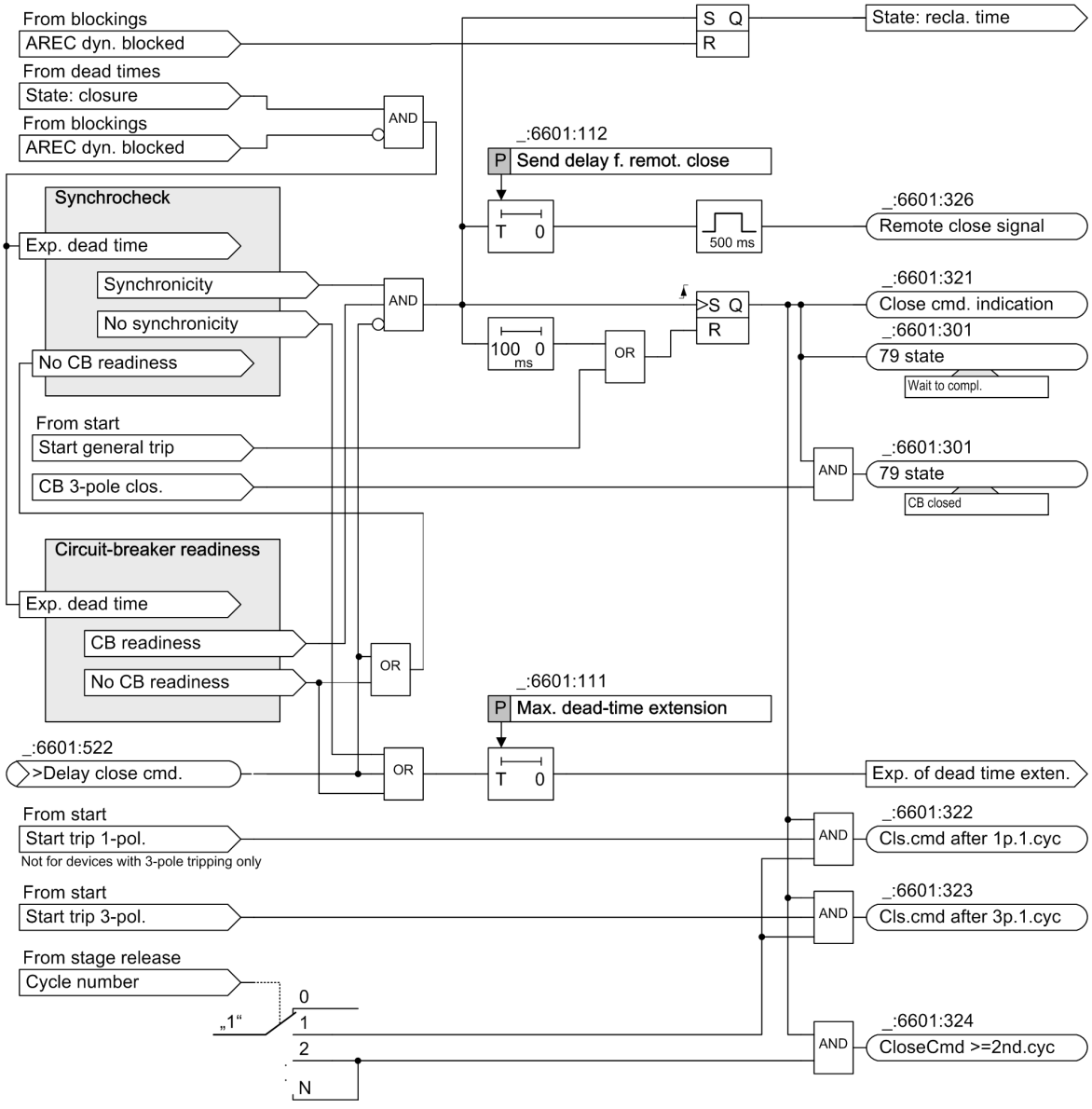
After the expiration of the dead time, the Automatic reclosing function will be in the **closing** state.

The **closing** state can depend on the following influences, see *Figure 6-291*:

- through a synchrocheck if the circuit breaker was opened during the 3-pole dead time
- Through the readiness of the circuit breaker signaled through the binary input
- Through a binary input for delaying the close command (*>Delay close cmd.*)

The *Close cmd. indication* is a requirement for the assignment of the actual close command to the circuit breaker.

The mentioned criteria must not be fulfilled directly after expiration of the dead time. If a dead-time prolongation is set, the mentioned criteria will be checked during the prolongation. With the release of the closing indication, the automatic reclosing function will switch to the **reclaim time** state.

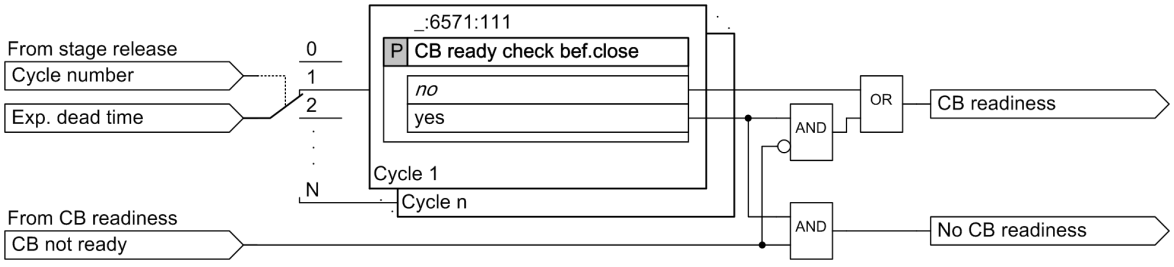


[loeinsha-141111-01.tif, 1, en_US]

Figure 6-291 Cyclic Reclosing Function: Logic for the Closing Indication

Testing the Circuit-Breaker Readiness Directly before Closing

For each of the automatic reclosing cycles, you can set if a test of the circuit-breaker readiness should occur directly before closing (parameters **`CB ready check bef.close`**, *Figure 6-292*). Independent of this, a test of the circuit-breaker readiness before the start of the 1st automatic reclosing cycle can be set, see Chapter *6.43.4.5 Start* and chapter *6.43.4.16 Circuit-Breaker Readiness* .



[lolsvoei-130511-01.tif, 1, en_US]

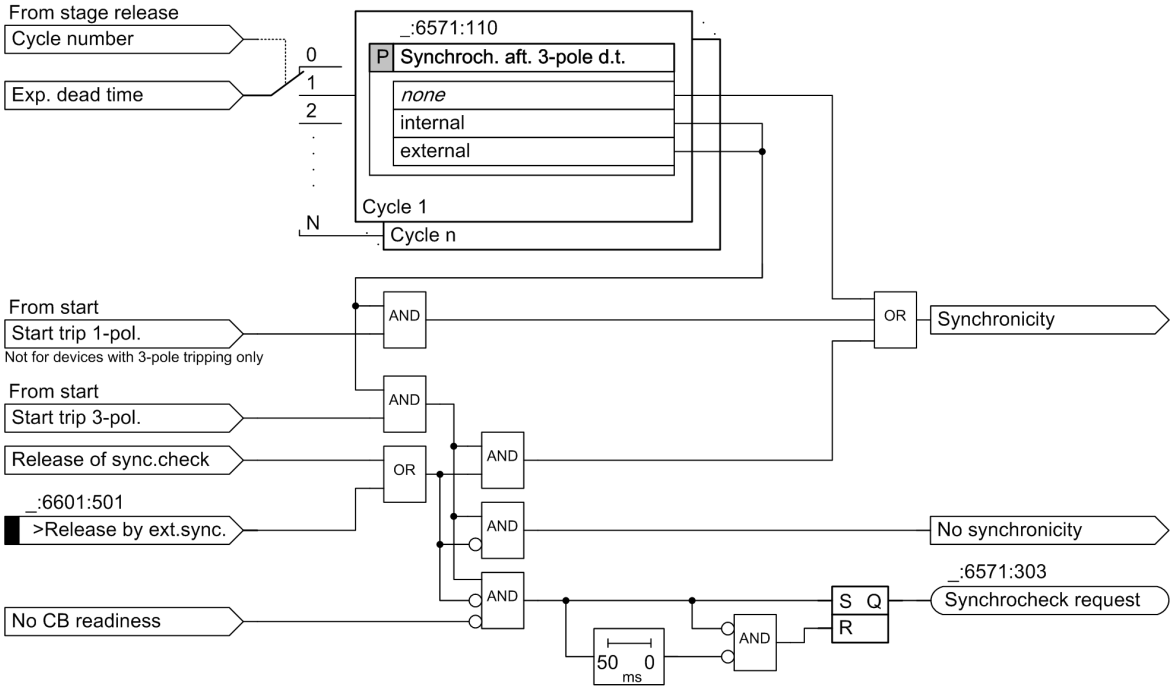
Figure 6-292 Cyclic Reclosing Function: Logic for the Query of the Circuit-Breaker Readiness Directly before Closing

Synchrocheck

For each of the configured automatic reclosing cycles, you can set if a synchrocheck should be executed and which functionality should be used here, see *Figure 6-293*. You may only use the internal synchrocheck if the device is connected to a voltage transformer.

Alternatively, you can also connect an external device with synchrocheck through a binary input.

The measuring request for the synchrocheck is placed if the optional test of the circuit-breaker readiness was positive. The measuring request for the synchrocheck exists until the synchrocheck assigns the allowance for the closure. If the allowance is not given within the set maximum dead time extension, the closure will be cancelled through the blocking of the automatic reclosing function. The minimum duration of the measuring request is 50 ms.



[losyncro-130511-01.tif, 1, en_US]

Figure 6-293 Cyclic Reclosing Function: Logic for the Inquiry of the Synchronism

Close Command

As soon as the test of the circuit-breaker readiness and the synchrocheck deliver a positive result, the closing indication will be created. It will be assigned for 100 ms. The actual close command is not created by the automatic reclosing function, but rather from the circuit-breaker function block outside of the automatic reclosing function. Here the set maximum duration of the close command is also considered.

In addition to the closing indication, additional indications will be created that describe the type of closure. These include:

- Close command after 3-pole tripping in the first cycle (*Cls.cmd after 3p.1.cyc*)
- Close command after 1-pole or 3-pole tripping starting with the second cycle (*CloseCmd >=2nd.cyc*)

Creation of the Signal Remote close signal

The cyclic automatic reclosing function can create information *Remote close signal*. This information can be transferred to the protection device as a binary signal on the line that is to be protected on the opposite end. From the reclosing function, it can be processed in the operating mode **adaptive dead time (ASP)**. Furthermore, the binary signal may be arranged as data for transmission via an existing protection interface.

The information *Remote close signal* is created by the closing logic. It can be delayed by a set time over the local close indication. With this delay, you can make sure that information is only set if the automatic reclosing was successful and there was no further tripping. The pulse duration of the inter-close signal has a fixed length of 500 ms.

6.43.4.15 Reclaim Time

With the assignment of the close command, the automatic reclosing function goes into the **reclaim time** state. During this time, it is decided if the current reclosing cycle was successful or not.

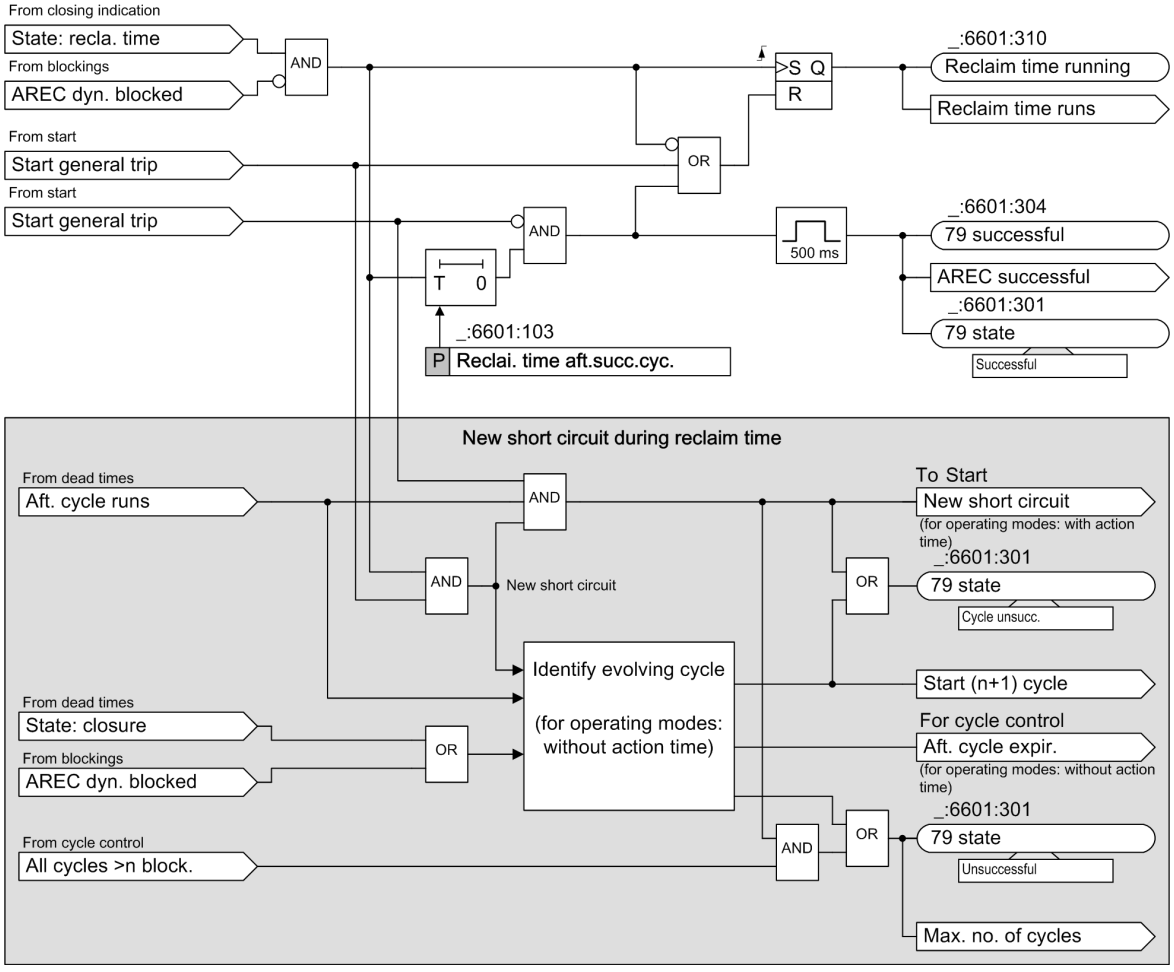
- If during the reclaim time no further tripping occurs, the currently running automatic reclosing cycle, and thus the entire automatic reclosing, was successful.
- If during the reclaim time another tripping occurred, the currently running automatic reclosing cycle was not successful. If other automatic reclosing cycles are permitted, one of these cycles will be used to continue the process. If, in contrast, the currently executed cycle was the last permissible cycle, the automatic reclosing process will end and be reported as unsuccessful.

In both cases, the automatic reclosing function switches back to the idle state **automatic reclosing function ready**.

Short Circuits during Running Reclaim Time

A trip command that occurs during a reclaim time leads to a cancellation of the reclaim time. If further automatic reclosing cycles are allowed, the regulation of the cycle depends on if the automatic reclosing function is executed in an operating mode **with action times** or **without action times**, see *Figure 6-294*.

- With operating modes **with action time**, the action times of all higher cycles are started with the beginning of the new general pickup if these are not blocked. The cycle with the lowest cycle number is selected, whose action time is not yet expired with the incoming trip indication. If no further cycles are possible or if the action times of all possible cycles are expired before the operate indication, there will be no further reclosing.
- With the operating modes **without action time**, the cycle following the current cycle will always be selected in the set cycle. If this is blocked, the cycle following this one will be selected, etc. If no higher cycles exist or if they are all blocked, there will be no further automatic reclosing.



[losperre-140611-01.tif, 1, en_US]

Figure 6-294 Cyclic Reclosing Function: Logic for the reclaim time

6.43.4.16 Circuit-Breaker Readiness

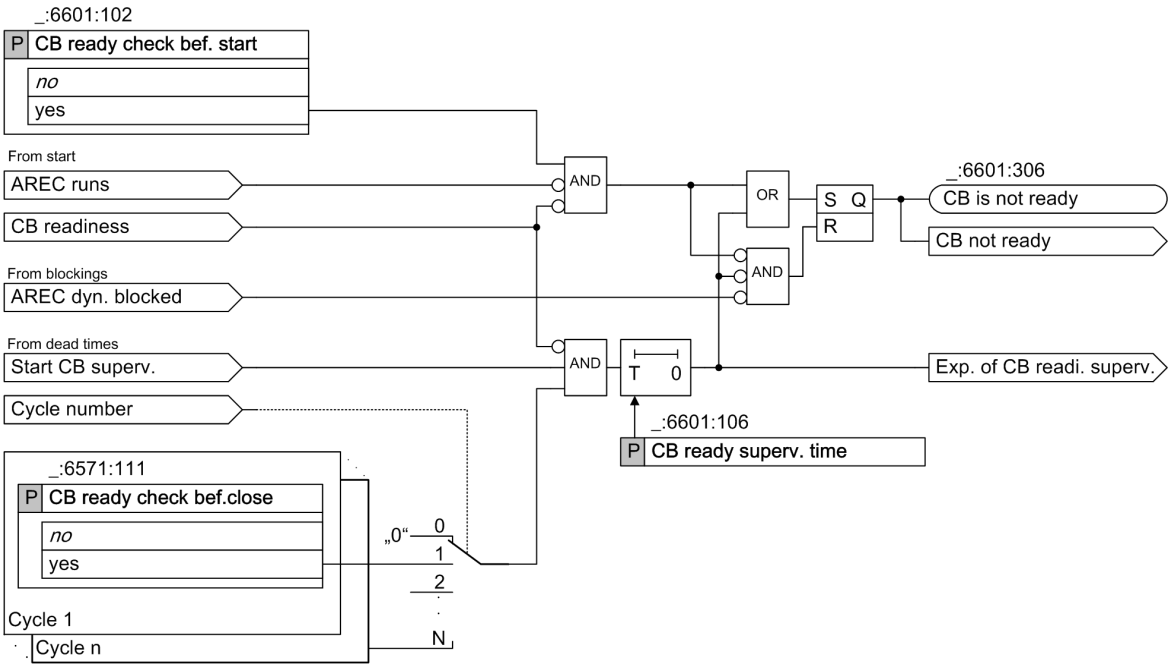
The automatic reclosing function requires the readiness of the circuit breaker for the following purposes, see *Figure 6-295*:

- Recognition of the circuit-breaker readiness from the beginning:

  In idle state of the automatic reclosing function, an unavailable circuit breaker leads to the blocking of the automatic reclosing function. This monitoring is optional and must be switched off through settings if the readiness signal is not available for the protection device.

- Analysis of the circuit-breaker readiness directly before the close command:

  For each of the configured automatic reclosing cycles, it can be set whether the circuit-breaker readiness is a requirement for the assignment of the close command. This monitoring is also optional.



[lolsbere-130511-01.tif, 1, en_US]

Figure 6-295 Cyclic Reclosing Function: Logic for the Circuit-Breaker Readiness

6.43.4.17 Blockings

The Automatic reclosing function differentiates between 2 types of blockings, see *Figure 6-296*:

- Static blocking
- Dynamic blocking

Static Blocking

The Automatic reclosing function is statically blocked if the function is switched on, but is not ready for reclosing and also cannot be started as long as this blocking is present. The dynamic blocking is signaled with the indication *Inactive*.

The following conditions lead to the static blocking:

Condition	Indication
Manual closing of the circuit breaker, recognition through binary input or internal device control. The blocking is temporary, the duration can be set with the parameter **Block. time aft. man.close**.	Inactive
Circuit breaker not available for automatic reclosing function, recognition through binary input. This cause can be switched on or off through the parameter **CB ready check bef.close**.	Inactive
Circuit breaker of non-closed 3-pole, recognition through binary input. This criteria is used if the circuit-breaker auxiliary contacts are connected.	Inactive

Condition	Indication
No reclosing cycle possible Recognition due to the following causes: • Automatic reclosing cycle is not set. • Automatic reclosing cycles are set, but all are blocked, for example, via binary input. • There is no internal device function and no binary input configured for starting the automatic reclosing function. • With operating modes **with tripping**: – both 1-pole and 3-pole cycles are blocked via binary inputs • With operating modes **with pickup**: – 1-phase, 2-phase and 3-phase automatic reclosing cycles, the blocking is done through binary inputs. • With operating modes **without action time**: – the first automatic reclosing cycle is blocked via binary input. • With the **dead-line check** functionality: – if the voltage measurement is not available or is disrupted.	Inactive

Dynamic Blocking

The automatic reclosing function is **blocked dynamically** if a blocking condition occurs while an automatic reclosing function is running. The dynamic blocking is signalized with the indication *Not ready*.

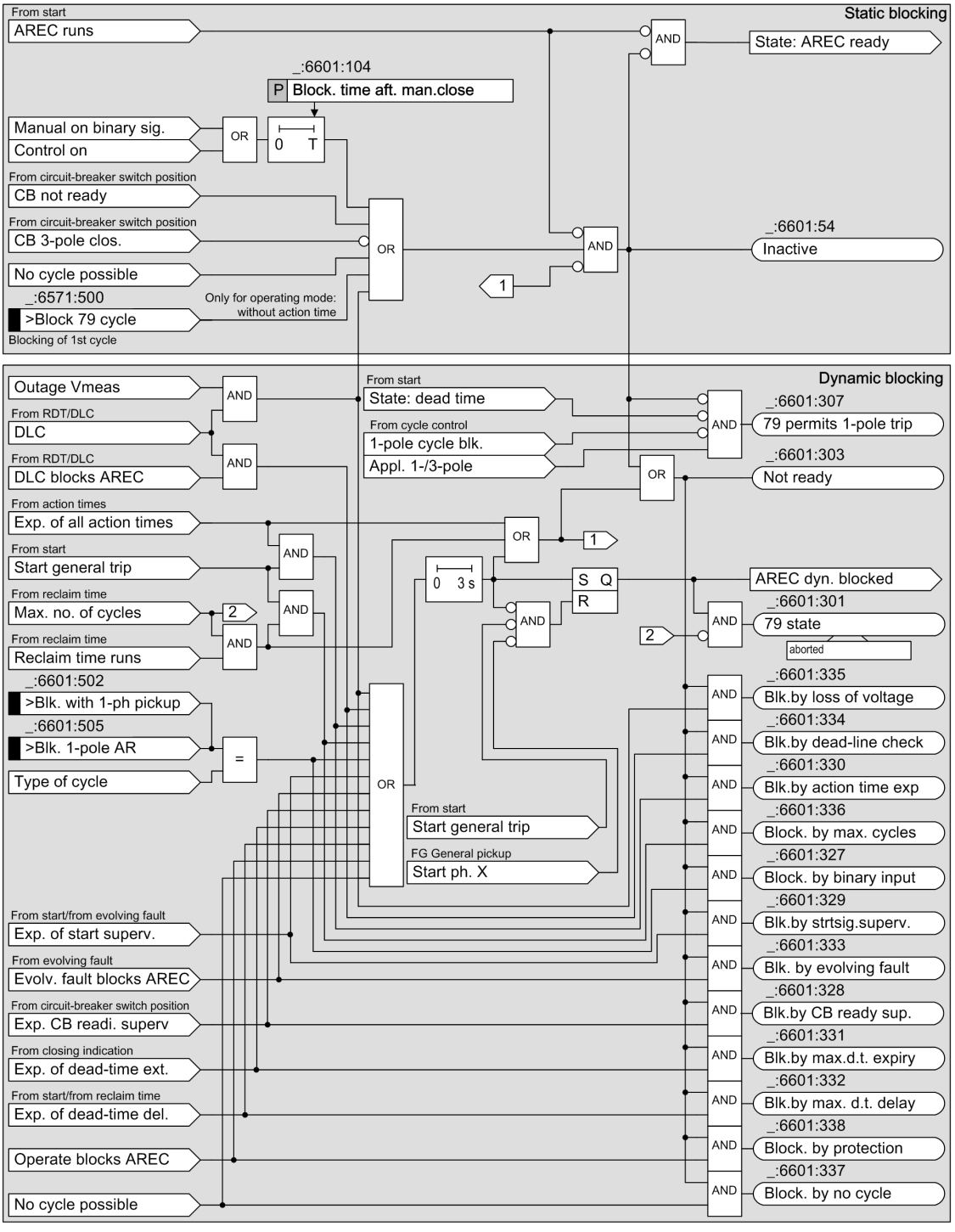
After the occurrence of a dynamic blocking, it is checked in intervals of 0.5 s to see if the blocking can be removed. If the blocking condition remains or if a different blocking condition occurs in the meantime, the blocking will remain. If, in contrast, the cause of the blocking disappears, the dynamic blocking will be removed if no general pickup or no tripping configured for the automatic reclosing function start is available.

A separate indication for logging exists for each individual blocking cause.

The following conditions lead to the dynamic blocking:

Condition	Indication
If no reclosing cycle fitting the fault type is released: • With operating modes **with tripping**: If a 1-pole or 3-pole operate indication occurs during the automatic reclosing function start input, however, the automatic reclosing function does not start in accordance with the parameterization for this type of tripping, the respective dead time will be set to ***invalid***. • With operating modes **with pickup**: If a 1-phase, 2-phase or 3-phase pickup indication occurs during the automatic reclosing function starting process, but the automatic reclosing function may not be started in accordance with the parameterization for this type of pickup.	*Not ready* Block. by no cycle
If a protection function causes the automatic reclosing function to be blocked in accordance with the configuration	*Not ready* Block. by protection
If the maximum set waiting time for the delay of the start of the dead time through the binary input *>Dead time start delay* expires without the binary input becoming inactive during this time lapse	*Not ready* Blk.by max. d.t. delay
If the synchrocheck is set and the synchronism conditions after the expiration of the maximum dead-time prolongation are not fulfilled before the assignment of the close command	*Not ready* *Blk.by max.d.t. expiry*

Condition	Indication
If the inquiry of the circuit-breaker readiness is switched on directly before the close command through the parameter and the maximum dead-time prolongation expires	*Not ready* *Blk.by CB ready sup.* *Blk.by max.d.t. expiry*
If the closing indication is delayed through the binary input *>Delay close cmd.* for so long until the maximum dead time extension is exceeded before the assignment of the close command	*Not ready* *Blk.by max.d.t. expiry*
If an evolving fault occurs and the parameter **Response to evolv. faults** is set to ***blocks 79***	*Not ready* *Blk. by evolving fault*
If the start-signal supervision time for the operate indication starting from the automatic reclosing function or the starting binary input expires. In this case, a circuit-breaker failure is assumed.	*Not ready* *Blk.by strtsig.superv.*
If after the start of the automatic reclosing function a dead time is already running and a blocking binary input is active, with the following binary inputs: *>Blk. 1-pole AR*, *>Blk. 3-pole AR*, *>Blk. with 1-ph pickup*, *>Blk. with 2-ph pickup*, >Blk. with 3-ph pickup	*Not ready* *Block. by binary input*
If the maximum number of automatic reclosing attempts is reached and there is a trip command within the reclaim time	*Not ready* *Block. by max. cycles*
With operating modes **with action time**: If the action times of all released automatic reclosing cycles expire without a trip command	*Not ready* *Blk.by action time exp*
For applications with voltage measurement and switched on functionalities with **dead-line check**: If during the dead time the required voltage criteria is not fulfilled	*Not ready* *Blk.by dead-line check*
For applications with voltage measurement and switched on functionalities with **dead-line check**: If during a running automatic reclosing cycle a failure of the measuring voltage is determined. After the completion of the automatic reclosing cycle, the dynamic blocking becomes static blocking if there is a continued failure of the measuring voltage.	*Not ready* *Blk.by loss of voltage*



[lobloawe-100611-01.tif, 3, en_US]

Figure 6-296 Cyclic Reclosing Function: Blocking Logic in the Example for a 1-Pole Cycle (Static and Dynamic Blocking)

6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT)

The additional functions **Dead-line check (DLC)** and **Reduced dead time (RDT)**, are only possible for applications with a voltage-transformer connection. Another requirement is that the voltage of the line being switched on can be correctly measured with an open circuit breaker. This is only possible if the voltage transformer is aligned on the line-side - seen from the circuit breaker.

Both additional functions DLC and RDT are mutually exclusive, because the DLC checks if the value falls below a voltage threshold, while the RDT checks if the value exceeds the voltage threshold.

The respectively selected additional function runs in the automatic reclosing state **dead time**.

Reduced Dead Time (RDT)

With the **Reduced dead time**, a close command can be assigned before the expiration of the set dead times if the line to switch on is recognized as fault-free through the measurement of the line voltage.

The voltage measurement occurs with the 3 phase-to-phase-voltages.

In systems with a grounded neutral point, the 3 phase-to-ground voltages are additionally observed.

In systems with compensated or with isolated neutral points, the largest 2 of the 3 phase-to-ground voltages are additionally considered. Through this, a RDT can also be executed with 1-phase ground connections.

For the approval of the close command with RDT, the following conditions apply:

- The automatic reclosing function is in the state **dead time**.
- Each measured voltage is above the set threshold values **`Volt. thres.f. live line/bus`**
  The phase-to-phase voltages are divided by √3 prior to comparing the threshold value. Thus, the phase-to-ground voltage $U_N\sqrt{3}$ applies as the reference size for the parameterization.
- Exceeding the threshold is fulfilled for the set duration **`Voltage supervision time`**.

Dead-Line Check (DLC)

If after switching off a short-circuit the voltage on the switched off line does not disappear, the automatic reclosing function can be avoided with the **dead-line check (DLC)**.

The voltage measurement occurs with the 3 phase-to-ground voltages.

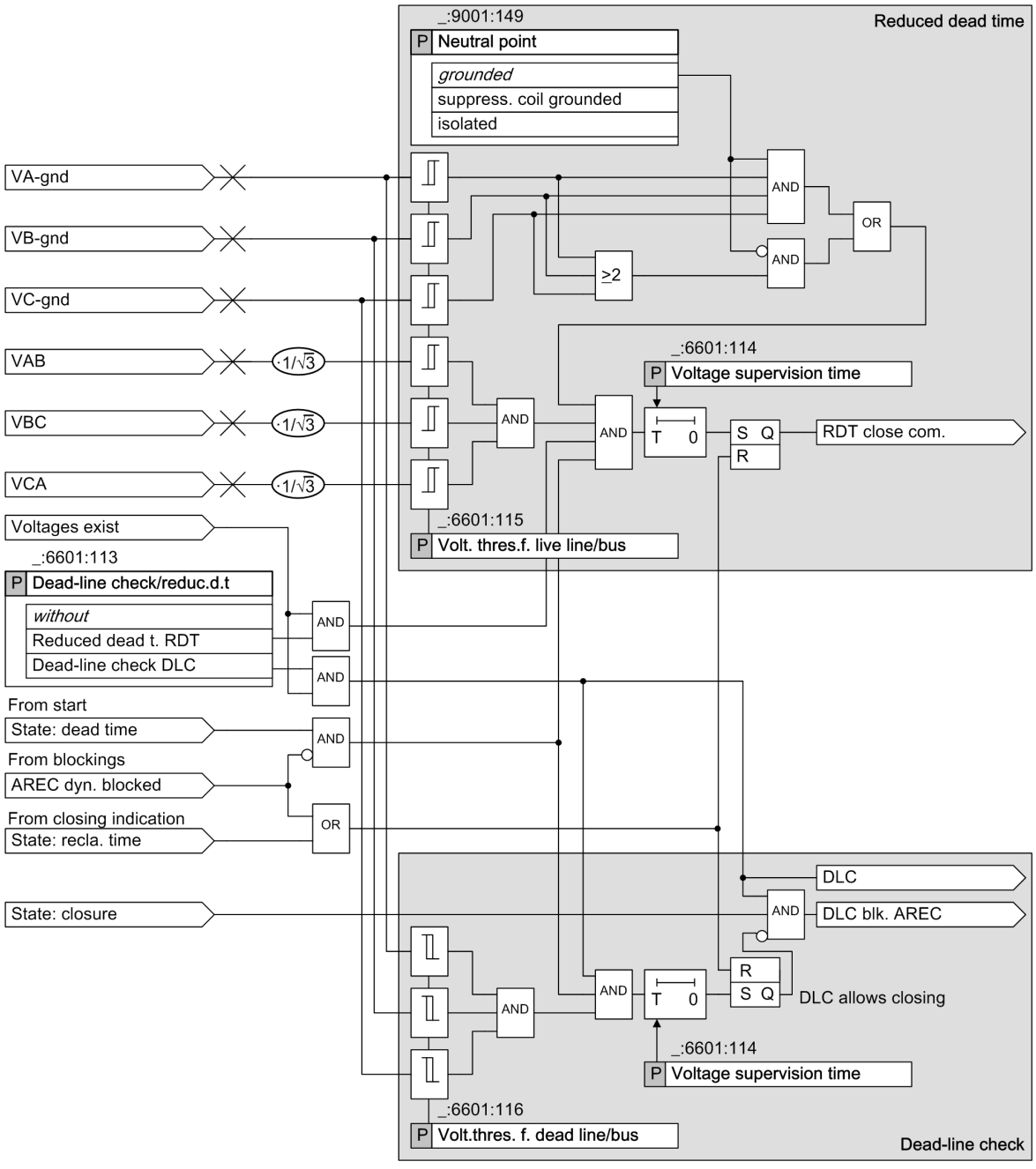
For the release of the close command with DLC, the following conditions apply:

- The automatic reclosing function is in the state **dead time**.
- All measured voltages for the set duration **`Voltage supervision time`** are below the set threshold **`Volt. thres.f. live line/bus`**.
- The set dead time is expired.

As soon as the voltages fall below the threshold value for the set duration, the allowance for automatic reclosing with DLC is assigned. This also applies if the values are not below the voltage threshold until the expiration of the set dead time. In this way, an automatic reclosing is executed if the automatic reclosing function is first switched to at the end of the protected line and thus, the line is exposed to voltage again.

The automatic reclosing function is blocked by the DLC under the following conditions:

- The automatic reclosing function is in the **Closure** state, the dead time has expired
- All measured voltages were not simultaneously below the set threshold values **`Volt.thres. f. dead line/bus`** for the set duration **`Voltage supervision time`** during the dead time.



[lovrkarc-130511-01.tif, 1, en_US]

Figure 6-297 Cyclic Reclosing Function: Logic for the Functions of Reduced Dead Time and Dead-Line Check

6.43.4.19 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:6601:1	General:Mode		• off • on • test	on
_:6601:101	General:79 operating mode		• with op., w/o act. time • with op., with act. time • w.pickup, w/o act. time • w.pickup, w. action time	with op., with act. time

Addr.	Parameter	C	Setting Options	Default Setting
_:6601:102	General:CB ready check bef. start		• no • yes	no
_:6601:103	General:Reclai. time aft.succ.cyc.		0.50 s to 300.00 s	3.00 s
_:6601:104	General:Block. time aft. man.close		0.00 s to 300.00 s	1.00 s
_:6601:105	General:Start signal supervis.time		0.01 s to 300.00 s	0.13 s
_:6601:106	General:CB ready superv. time		0.01 s to 300.00 s	3.00 s
_:6601:107	General:3-pole operate by 79		• no • yes	yes
_:6601:108	General:Evolving-fault detection		• with trip • with pickup	with trip
_:6601:109	General:Response to evolv. faults		• strt. evol.flt.dead time • blocks 79	blocks 79
_:6601:110	General:Max. dead-time delay		0.01 s to 300.00 s	0.50 s
_:6601:111	General:Max. dead-time extension		0.00 s to 300.00 s; ∞	1.20 s
_:6601:112	General:Send delay f. remot. close		0.00 s to 300.00 s; ∞	∞
DLC, RDT				
_:6601:113	General:Dead-line check/ reduc.d.t		• without • Reduced dead t. RDT • Dead-line check DLC	without
_:6601:114	General:Voltage supervision time		0.10 s to 30.00 s	0.10 s
_:6601:115	General:Volt. thres.f. live line/bus		0.300 V to 340.000 V	48.000 V
_:6601:116	General:Volt.thres. f. dead line/bus		0.300 V to 340.000 V	30.000 V
Cycle 1				
_:6571:102	Cycle 1:Start from idle state allow.		• no • yes	yes
_:6571:103	Cycle 1:Action time		0.00 s to 300.00 s; ∞	0.20 s
_:6571:108	Cycle 1:Dead time aft. 3-pole trip		0.00 s to 1800.00 s; ∞	0.50 s
_:6571:107	Cycle 1:Dead time aft. 1-pole trip		0.00 s to 1800.00 s; ∞	1.20 s
_:6571:104	Cycle 1:Dead time aft. 1ph. pickup		0.00 s to 1800.00 s; ∞	1.20 s
_:6571:105	Cycle 1:Dead time aft. 2ph. pickup		0.00 s to 1800.00 s; ∞	1.20 s
_:6571:106	Cycle 1:Dead time aft. 3ph. pickup		0.00 s to 1800.00 s; ∞	0.50 s
_:6571:109	Cycle 1:Dead time aft. evolv. fault		0.01 s to 1800.00 s	1.20 s
_:6571:111	Cycle 1:CB ready check bef.close		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:6571:110	Cycle 1:Synchroch. aft. 3-pole d.t.		• none • internal • external	none
_:6571:112	Cycle 1:Intern. synchro-check with		Setting options depend on configuration	

6.43.4.20 Information List

No.	Information	Data Class (Type)	Type
General			
_:6601:51	General:Mode (controllable)	ENC	C
_:6601:87	General:>Function off	SPS	I
_:6601:524	General:>Function on	SPS	I
_:6601:347	General:Function on	SPC	C
_:6601:82	General:>Block function	SPS	I
_:6601:501	General:>Release by ext.sync.	SPS	I
_:6601:502	General:>Blk. with 1-ph pickup	SPS	I
_:6601:503	General:>Blk. with 2-ph pickup	SPS	I
_:6601:504	General:>Blk. with 3-ph pickup	SPS	I
_:6601:505	General:>Blk. 1-pole AR	SPS	I
_:6601:506	General:>Blk. 3-pole AR	SPS	I
_:6601:507	General:>Pickup A for start	SPS	I
_:6601:508	General:>Pickup B for start	SPS	I
_:6601:509	General:>Pickup C for start	SPS	I
_:6601:510	General:>Pickup 1ph for start	SPS	I
_:6601:511	General:>Pickup 2ph for start	SPS	I
_:6601:512	General:>Pickup 3ph for start	SPS	I
_:6601:513	General:>Gen. pickup for start	SPS	I
_:6601:514	General:>General trip for start	SPS	I
_:6601:515	General:>Trip pole A for start	SPS	I
_:6601:516	General:>Trip pole B for start	SPS	I
_:6601:517	General:>Trip pole C for start	SPS	I
_:6601:518	General:>Trip 1-pole for start	SPS	I
_:6601:519	General:>Trip 3-pole for start	SPS	I
_:6601:520	General:>Evolving fault start	SPS	I
_:6601:521	General:>Dead time start delay	SPS	I
_:6601:522	General:>Delay close cmd.	SPS	I
_:6601:52	General:Behavior	ENS	O
_:6601:53	General:Health	ENS	O
_:6601:54	General:Inactive	SPS	O
_:6601:301	General:79 state	ENS	O
_:6601:302	General:Actual reclose cycle	INS	O
_:6601:303	General:Not ready	SPS	O
_:6601:304	General:79 successful	SPS	O
_:6601:305	General:CB ready superv.expir	SPS	O
_:6601:306	General:CB is not ready	SPS	O
_:6601:307	General:79 permits 1-pole trip	SPS	O

No.	Information	Data Class (Type)	Type
_:6601:308	General:AR only after 1p. trip	SPS	O
_:6601:309	General:In progress	SPS	O
_:6601:310	General:Reclaim time running	SPS	O
_:6601:311	General:Start sig. superv.exp.	SPS	O
_:6601:313	General:Evolv.-fault detected	SPS	O
_:6601:314	General:RDT CloseCmd indicat.	SPS	O
_:6601:315	General:Dead t. aft.1pole trip	SPS	O
_:6601:316	General:Dead t. aft.3pole trip	SPS	O
_:6601:317	General:Dead t. aft.1ph pickup	SPS	O
_:6601:318	General:Dead t. aft.2ph pickup	SPS	O
_:6601:319	General:Dead t. aft.3ph pickup	SPS	O
_:6601:320	General:Dead t. aft.evolv.flt.	SPS	O
_:6601:321	General:Close cmd. indication	ACT	O
_:6601:322	General:Cls.cmd after 1p.1.cyc	SPS	O
_:6601:323	General:Cls.cmd after 3p.1.cyc	SPS	O
_:6601:324	General:CloseCmd >=2nd.cyc	SPS	O
_:6601:325	General:3-pole operate by 79	SPS	O
_:6601:326	General:Remote close signal	SPS	O
_:6601:327	General:Block. by binary input	SPS	O
_:6601:328	General:Blk.by CB ready sup.	SPS	O
_:6601:329	General:Blk.by strtsig.superv.	SPS	O
_:6601:330	General:Blk.by action time exp	SPS	O
_:6601:331	General:Blk.by max.d.t. expiry	SPS	O
_:6601:332	General:Blk.by max. d.t. delay	SPS	O
_:6601:333	General:Blk. by evolving fault	SPS	O
_:6601:337	General:Block. by no cycle	SPS	O
_:6601:338	General:Block. by protection	SPS	O
_:6601:334	General:Blk.by dead-line check	SPS	O
_:6601:335	General:Blk.by loss of voltage	SPS	O
_:6601:336	General:Block. by max. cycles	SPS	O
_:6601:339	General:Cyc1 1p AR	INS	O
_:6601:340	General:Cyc1 3p AR	INS	O
_:6601:341	General:Cyc2+ 1p AR	INS	O
_:6601:342	General:Cyc2+ 3p AR	INS	O
Cycle 1			
_:6571:51	Cycle 1:Mode (controllable)	ENC	C
_:6571:500	Cycle 1:>Block 79 cycle	SPS	I
_:6571:52	Cycle 1:Behavior	ENS	O
_:6571:53	Cycle 1:Health	ENS	O
_:6571:301	Cycle 1:Cycle running	SPS	O
_:6571:302	Cycle 1:Stage release prot.	SPS	O
_:6571:303	Cycle 1:Synchrocheck request	SPS	O

6.43.5 Automatic Reclosing Function with Adaptive Dead Time (ADT)

6.43.5.1 Description

Considering the cyclic automatic reclosing function, it is assumed that defined and similar dead times were set at both line ends and, if applicable, they are set for different types of faults and/or disruption cycles.

It is also possible to set the dead times only at one line end and to configure the adaptive dead time at the other end or ends. The requirements for this is that the voltage transformer aligned on the line side or a possibility to transfer a close command to a remote line end exists.

Figure 6-298 shows an example with a voltage measurement. It is assumed that device I works with defined dead times, while the adaptive dead time is configured in device II. It is important that the line is at least fed from the busbar A, so from the side with the defined dead times.

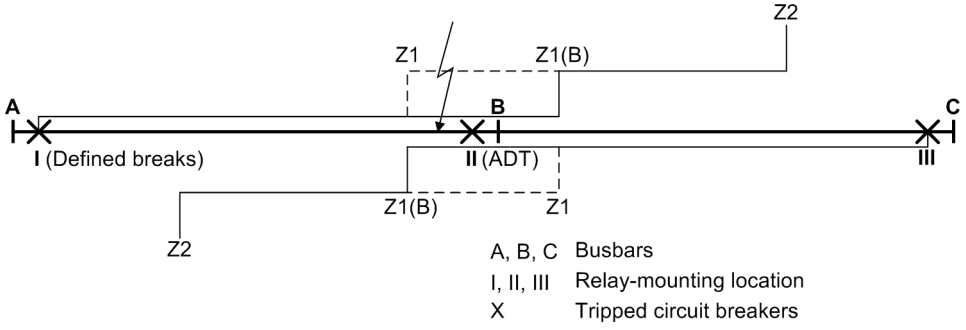
With the adaptive dead time, the automatic reclosing function at the line end II decides independently if and when a reclosing is reasonable and permissible and when it is not. The criteria is the voltage of the line at the end II, which is switched through after reclosing from end I. The reclosing at end II occurs, as soon as it exists, so that the line from end I is set back under voltage. Basically, all phase-to-phase and phase-to-ground voltages are monitored.

With an implied short-circuit, the lines at the positions I, II, and III in the example are switched off. Position I is switched on again after the dead time set there. At position III the reduced dead time (RDT) can be executed with the appropriate configuration (see chapter *6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT)*) if an infeed is also available on busbar B.

If the short circuit has been cleared after successful reclosing, the line A-B from the busbar A will be set under voltage through the position I. Device II recognizes this voltage and switches on to warrant adequate voltage measurement time after a short delay The system incident is thus successfully cleared.

If the short circuit is not cleared after closure at position I, I will be switched to the fault again. At line end II, now no healthy voltage will appear. The device here recognizes this and does not close again.

With multiple reclosing, the process may repeat if the reclosing is unsuccessful until one of the reclosings is successful or a final closing occurs.



[dwarcasp-100611-01.tif, 1, en_US]

Figure 6-298 Example for Adaptive Dead Time (ADT)

As the example shows, the adaptive dead time brings along the following advantages:

- The circuit breaker at position II does not switch off again with a remaining fault and is protected through this.
- With a non-selective tripping through flashing over to position III, no more disruption cycles may exist here, because the short-circuit path through busbar B and the position II remains disrupted even with multiple reclosing.
- At position I, with multiple reclosing and even with a final tripping, an overlapping is allowed, because the line at position II remains open and thus, no actual overreaching can occur at position I.

The adaptive dead time also contains the reduced dead time (VWE), because the criteria are the same. A special setting of the reduced dead time (VWE) is unnecessary if the automatic reclosing function is used with adaptive dead time (ASP).

6.43.5.2 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:6601:1	General:Mode		• off • on • test	on
_:6601:101	General:79 operating mode		• with op., w/o act. time • with op., with act. time • w.pickup, w/o act. time • w.pickup, w. action time	with op., with act. time
_:6601:102	General:CB ready check bef. start		• no • yes	no
_:6601:103	General:Reclai. time aft.succ.cyc.		0.50 s to 300.00 s	3.00 s
_:6601:104	General:Block. time aft. man.close		0.00 s to 300.00 s	1.00 s
_:6601:105	General:Start signal supervis.time		0.01 s to 300.00 s	0.13 s
_:6601:106	General:CB ready superv. time		0.01 s to 300.00 s	3.00 s
_:6601:107	General:3-pole operate by 79		• no • yes	yes
_:6601:111	General:Max. dead-time extension		0.00 s to 300.00 s; ∞	1.20 s
_:6601:114	General:Voltage supervision time		0.10 s to 30.00 s	0.10 s
_:6601:115	General:Volt. thres.f. live line/bus		0.300 V to 340.000 V	48.000 V
ADT				
_:6631:101	ADT:1-pole trip allowed		• no • yes	no
_:6631:104	ADT:Action time		0.00 s to 300.00 s; ∞	0.20 s
_:6631:105	ADT:Maximum dead time		0.50 s to 3000.00 s	5.00 s
_:6631:102	ADT:CB ready check bef.close		• no • yes	no
_:6631:103	ADT:Synchroch. aft. 3-pole d.t.		• none • internal • external	none
_:6631:106	ADT:Intern. synchrocheck with		Setting options depend on configuration	

6.43.5.3 Information List

No.	Information	Data Class (Type)	Type
General			
_:6601:51	General:Mode (controllable)	ENC	C
_:6601:87	General:>Function off	SPS	I
_:6601:524	General:>Function on	SPS	I
_:6601:347	General:Function on	SPC	C
_:6601:82	General:>Block function	SPS	I
_:6601:501	General:>Release by ext.sync.	SPS	I

No.	Information	Data Class (Type)	Type
_:6601:502	General:>Blk. with 1-ph pickup	SPS	I
_:6601:503	General:>Blk. with 2-ph pickup	SPS	I
_:6601:504	General:>Blk. with 3-ph pickup	SPS	I
_:6601:505	General:>Blk. 1-pole AR	SPS	I
_:6601:506	General:>Blk. 3-pole AR	SPS	I
_:6601:507	General:>Pickup A for start	SPS	I
_:6601:508	General:>Pickup B for start	SPS	I
_:6601:509	General:>Pickup C for start	SPS	I
_:6601:510	General:>Pickup 1ph for start	SPS	I
_:6601:511	General:>Pickup 2ph for start	SPS	I
_:6601:512	General:>Pickup 3ph for start	SPS	I
_:6601:513	General:>Gen. pickup for start	SPS	I
_:6601:514	General:>General trip for start	SPS	I
_:6601:515	General:>Trip pole A for start	SPS	I
_:6601:516	General:>Trip pole B for start	SPS	I
_:6601:517	General:>Trip pole C for start	SPS	I
_:6601:518	General:>Trip 1-pole for start	SPS	I
_:6601:519	General:>Trip 3-pole for start	SPS	I
_:6601:522	General:>Delay close cmd.	SPS	I
_:6601:52	General:Behavior	ENS	O
_:6601:53	General:Health	ENS	O
_:6601:54	General:Inactive	SPS	O
_:6601:301	General:79 state	ENS	O
_:6601:302	General:Actual reclose cycle	INS	O
_:6601:303	General:Not ready	SPS	O
_:6601:304	General:79 successful	SPS	O
_:6601:305	General:CB ready superv.expir	SPS	O
_:6601:306	General:CB is not ready	SPS	O
_:6601:307	General:79 permits 1-pole trip	SPS	O
_:6601:308	General:AR only after 1p. trip	SPS	O
_:6601:309	General:In progress	SPS	O
_:6601:310	General:Reclaim time running	SPS	O
_:6601:311	General:Start sig. superv.exp.	SPS	O
_:6601:312	General:Max. dead time expired	SPS	O
_:6601:315	General:Dead t. aft.1pole trip	SPS	O
_:6601:316	General:Dead t. aft.3pole trip	SPS	O
_:6601:317	General:Dead t. aft.1ph pickup	SPS	O
_:6601:318	General:Dead t. aft.2ph pickup	SPS	O
_:6601:319	General:Dead t. aft.3ph pickup	SPS	O
_:6601:321	General:Close cmd. indication	ACT	O
_:6601:322	General:Cls.cmd after 1p.1.cyc	SPS	O
_:6601:323	General:Cls.cmd after 3p.1.cyc	SPS	O
_:6601:325	General:3-pole operate by 79	SPS	O
_:6601:327	General:Block. by binary input	SPS	O
_:6601:328	General:Blk.by CB ready sup.	SPS	O
_:6601:329	General:Blk.by strtsig.superv.	SPS	O

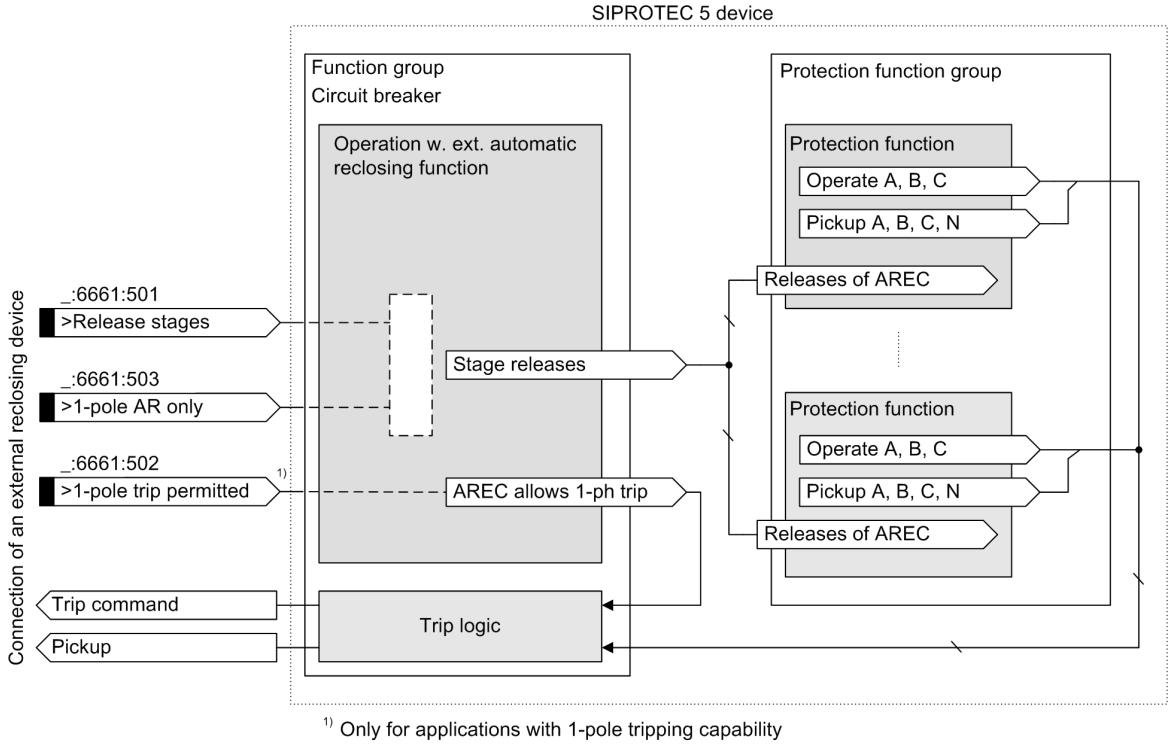
No.	Information	Data Class (Type)	Type
_:6601:330	General:Blk.by action time exp	SPS	O
_:6601:331	General:Blk.by max.d.t. expiry	SPS	O
_:6601:337	General:Block. by no cycle	SPS	O
_:6601:338	General:Block. by protection	SPS	O
_:6601:335	General:Blk.by loss of voltage	SPS	O
_:6601:336	General:Block. by max. cycles	SPS	O
_:6601:339	General:Cyc1 1p AR	INS	O
_:6601:340	General:Cyc1 3p AR	INS	O
ADT			
_:6631:51	ADT:Mode (controllable)	ENC	C
_:6631:501	ADT:>Remote close signal	SPS	I
_:6631:52	ADT:Behavior	ENS	O
_:6631:53	ADT:Health	ENS	O
_:6631:301	ADT:ADT is running	SPS	O
_:6631:302	ADT:Stage release prot.	SPS	O
_:6631:303	ADT:Synchrocheck request	SPS	O

6.43.6 Cooperation with External Automatic Reclosing Function

6.43.6.1 Description

The operation of an external reclosing device with the SIPROTEC protection device occurs through the function mode **Operation with external automatic reclosing function**. In this function mode, the SIPROTEC protection functions create the trip command and the external reclosing device creates the close command.

The following figure shows the interaction of an external reclosing device with the functions of the SIPROTEC 5 device.



[loaweext-140212-01.tif, 1, en_US]

Figure 6-299 Connection of an External Automatic Reclosing Function

There are no setting parameters for operation with external automatic reclosing functions. The function provides exclusively the following described binary inputs. The external reclosing device can thus have an influence on the effects of the internal protection functions.

The following connection possibilities exist:

- From the external reclosing function, the signal *>Release stages* can be coupled so that the protection functions use special stages or zones for release. An example is the release of an overreaching zone with a distance protection or the non-delayed tripping of an overcurrent protection stage in the 1st reclosing cycle.
- For applications with 1-pole tripping, the external reclosing can provide the signal *>1-pole trip permitted*, based on which the protection functions can switch off the 1-pole circuit breaker.
- For applications with reclosing functions only with 1-pole faults and stage or zone releases through the reclosing function can the signal *>1-pole AR only* be connected. The protection functions use this information to allow the stage or zone release only affect 1-pole faults.

6.43.6.2 Information List

No.	Information	Data Class (Type)	Type
Ext			
_:6661:51	Ext:Mode (controllable)		C
_:6661:501	Ext:>Release stages		I
_:6661:502	Ext:>1-pole trip permitted		I
_:6661:503	Ext:>1-pole AR only		I
_:6661:52	Ext:Behavior		O
_:6661:53	Ext:Health		O
_:6661:54	Ext:Inactive		O

6.43.7 Application and Setting Notes for General Settings

For the automatic reclosing function, there are 3 functions available in the function library. In each circuit-breaker function group, a function from the automatic reclosing function can be used.

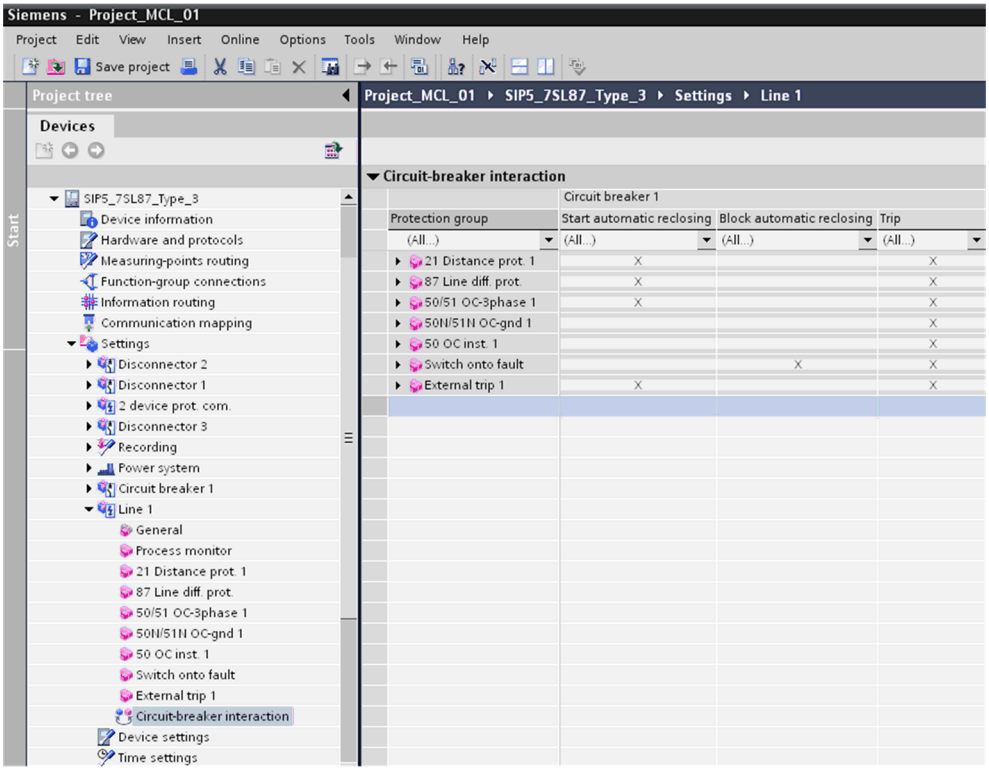
Configure one of the 3 following function specifications:

- Cyclic Automatic reclosing function
- Automatic reclosing function with adaptive dead time (ADT)
- Operation with External Automatic Reclosing Function

Starting the Automatic Reclosing Function

The configuration of the interaction between internal protection functions and the automatic reclosing function can be set separately for each protection function. The configuration occurs in a matrix view in DIGSI. The Automatic reclosing function also has the corresponding binary inputs and binary outputs through which the external protection devices can be connected to the internal Automatic reclosing function.

Configure the starting and blocking condition for the automatic reclosing function at the position shown in *Figure 6-300* in DIGSI (for example, a protection function group **Line** is shown here) or route the corresponding binary inputs.



[scdigsia-080311-01.tif, 1, en_US]

Figure 6-300 Configuration of the Protection Functions for Starting and Blocking the Automatic Reclosing Function in DIGSI

General Settings

If you use the **Cyclic automatic reclosing function** or **Automatic reclosing function with adaptive dead time** function, set the following settings under **General**.

There are no settings for the function **Operation with external automatic reclosing function**. The control occurs exclusively through binary inputs and binary outputs.

Parameter: 79 operating mode

- Default setting **(_:6601:101) 79 operating mode** = ***with op., with act. time***

You can use the **79 operating mode** parameter to determine which start criteria the automatic reclosing function works with.

Parameter Value	Description
with op., with act. time	The automatic reclosing function cycles are dependent on the operate time of the protection function(s). The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. Siemens generally recommends this setting for applications with 1/3-pole tripping and for applications with 3-pole tripping if a single dead time, independent of the type of connection working, is required in the automatic reclosing function cycle. Detailed information can be found in Chapter *6.43.4.1 Operating Modes for Cyclic Automatic Reclosing Function* , section **Operating mode 1**
w.pickup, w. action time	The automatic reclosing function cycles are dependent on the operate time of the protection function(s) and the type of fault. The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. For applications with 3-pole tripping and dead time dependent on the circuit type, Siemens recommends this setting. Detailed information can be found in the chapter *6.43.4.1 Operating Modes for Cyclic Automatic Reclosing Function* , section **Operating Mode 2**
with op., w/o act. time	Each operate indication starts the automatic reclosing function. The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. The automatic reclosing function start must be configured so that it only occurs from the protection stages/zones for which an automatic reclosing should occur after tripping. Detailed information can be found in the chapter *6.43.4.1 Operating Modes for Cyclic Automatic Reclosing Function* , section **Operating Mode 3**
w.pickup, w/o act. time	Each operate indication starts the automatic reclosing function. The automatic reclosing function cycles are dependent on the type of fault. The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. The automatic reclosing function start must be configured so that it only occurs from the protection stages/zones for which an automatic reclosing should occur after tripping. Detailed information can be found in the chapter *6.43.4.1 Operating Modes for Cyclic Automatic Reclosing Function* , section **Operating Mode 4**

Parameter: CB ready check bef. start

- Default setting **(_:6601:102) CB ready check bef. start** = ***no***

With the **CB ready check bef. start** parameter, you can determine if the readiness of the circuit breaker should be tested **before starting** the automatic reclosing function.

Additionally or alternatively, it is possible to check the readiness of the circuit breaker after the expiration of the dead time, directly before the assignment of the close command. There is another parameter described in the chapter *6.43.8 Application and Setting Notes for 1 Cycle of the Cyclic Automatic Reclosing Function* for this function.

Parameter Value	Description
yes	The automatic reclosing function checks the readiness of the circuit breaker for a switching cycle, consisting of a tripping-reclosing-switching. If the circuit breaker is ready - signaled through a binary input - the startup of the automatic reclosing function can occur. If the circuit breaker is not ready, the automatic reclosing function reports the static blocking. Siemens recommends using this setting. **Note:** The presetting of this parameter does not correspond with the recommended setting for operation. The automatic reclosing function would otherwise be blocked with a non-available circuit breaker-ready-signal. Please set the parameter as recommended.
no	The readiness of the circuit breaker is not checked before starting the automatic reclosing function. The test also does not occur if the readiness signal from the circuit breaker is connected to a binary input on the device.

Parameter: Reclai. time aft.succ.cyc.

- Default setting **(_:6601:103) Reclai. time aft.succ.cyc.** = ***3.00 s***

With the **Reclai. time aft.succ.cyc.** parameter, set the time used to decide if the currently running reclosing cycle was successful or not. Detailed information about the function of the reclaim time can be found in the chapter *6.43.4.15 Reclaim Time* .

The presetting for the reclaim time can be frequently maintained. In regions where thunderstorms and storms often occur, a shorter reclaim time makes sense in order to minimize the danger of the final disconnection due to sequential lightning strikes or cable spark over.

Select a long reclaim time if there is no possibility for circuit-breaker supervision with multiple automatic reclosing, for example, due to missing auxiliary contacts or lacking circuit-breaker-ready-information. In this case, the reclaim time must be longer than the recovery time of the circuit breaker.

Parameter: Block. time aft. man.close

- Default setting **(_:6601:104) Block. time aft. man.close** = ***1.00 s***

With the **Block. time aft. man.close** parameter, the time is determined for which the automatic reclosing should be blocked after a manual connection.

Set the time so that the circuit breaker can be safely switched on and off during connection to a short circuit without the automatic reclosing function being automatically closed.

Parameter: Start signal supervis.time

- Default setting **(_:6601:105) Start signal supervis.time** = ***0.25 s***

With the **Start signal supervis.time** parameter, set the maximum time after which a circuit breaker must be opened after a trip command. If the time expires, a failure of the circuit breaker is assumed and the automatic reclosing function is dynamically blocked.

Detailed information about the function of the start supervision time can be found in the chapter *6.43.4.5 Start* .



NOTE

With the use of an internal or external circuit-breaker failure protection at the same line branch, observe the following:

The start supervision time should be the same as the circuit-breaker failure protection time delay. With this, you can make sure that in the case of a circuit-breaker failure followed by the tripping of the busbar, no automatic reclosing will be executed.

(Note: An exception to this recommendation is described below.)

Parameter: CB ready superv. time

The setting of this parameter is only important if the cycle-specific parameter **CB ready check bef.close** is set to ***yes*** . Otherwise, this parameter has no effect.

- Default setting **(_:6601:106) CB ready superv. time** = ***3.00 s***

With the **CB ready superv. time** parameter, you can determine after which maximum time after the tripping the circuit breaker must be ready for the reclosing function.

Set the time somewhat longer than the regeneration time of the circuit breaker after an OFF-ON-OFF cycle.

Detailed information about the function can be found in Chapters *6.43.4.16 Circuit-Breaker Readiness* and *6.43.4.14 Closing Indication and Close Command* .

Parameter: Evolving-fault detection

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting **(_:6601:108) Evolving-fault detection** = ***with trip***

With the **Evolving-fault detection** parameter, you can determine which criteria is used to recognize an evolving fault. The actual effect of the recognized evolving fault on the automatic reclosing function can be set with the parameter described below **Response to evolv. faults** .

Evolving faults are short circuits, which occur after switching off a short circuit during dead time.

You can find detailed information about evolving-fault detection in the chapter *6.43.4.13 Evolving-Fault Detection During Dead Time* .

Parameter Value	Description
with trip	Evolving faults are recognized if an operate indication occurs during the dead time. Thus, it does not matter if the tripping-protection function is configured for the start of the automatic reclosing function or not. The pickup of a protection function without an operate indication does not lead to evolving-fault detection.
with pickup	Evolving faults are detected if during the dead time a protection function configured for the automatic reclosing function start is picked up or if an external pickup is detected through a binary input.

For applications with 1-/3-pole tripping, Siemens recommends the setting ***with trip*** if the system is adequately interconnected.

If multiple individual lines in a row form a total transmission path, the setting ***with pickup*** may be better suitable. With this setting, you can prevent 2 lines following each other from switching to 1-pole in different conductors during evolving faults. The consequence of this fault would be the remainder of a single conductor in the dead time for the overall transmission path. This is particularly important if power plants are coupled through the overall transmission path.

Parameter: Response to evolv. faults

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting **(_:6601:109) Response to evolv. faults** = ***blocks 79***

With the **Response to evolv. faults** parameter, you can determine how the automatic reclosing function reacts to recognized faults.

You can find detailed information about the automatic reclosing function for faults in the chapter *6.43.4.13 Evolving-Fault Detection During Dead Time* .

Parameter Value	Description
blocks 79	The automatic reclosing function is immediately blocked until the disconnection of the fault. For blockings through faults during the 1-pole dead times, you can force a 3-pole trip command through the automatic reclosing function if the you set the parameter **3-pole operate by 79** to ***yes*** .
strt. evol.flt.dead time	After the 3-pole trip command to clear up the fault, the automatic reclosing function starts a new 3-pole automatic reclosing function cycle with the set **Dead time aft. evolv. fault** .

Parameter: Max. dead-time delay

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting **(_:6601:110) Max. dead-time delay** = ***0.5 s***

With the **Max. dead-time delay** parameter, you determine at which time the starting of the dead time may be delayed before the automatic reclosing function is dynamically blocked.

The delay of the start of the dead time is possible with the binary input **>Dead time start delay** .

You can find detailed information about the functionality in the chapter *6.43.4.5 Start* .

Parameter: Max. dead-time extension

- Default setting **(_:6601:111) Max. dead-time extension** = ***1.2 s***

With the **Max. dead-time extension** parameter, you determine the time by which the dead time may be extended before the automatic reclosing function is dynamically blocked.

With the setting ***oo (invalid)***, the extension is unlimited.

An extension of the dead time can be required under the following conditions:

- Waiting for the readiness of the circuit breaker
- Inquiry of a synchronous test
- Delay through binary input in order e.g. to give the leading automatic reclosing function priority in a system with 1 1/2 circuit breaker layout.

Remember that longer dead times after 3-pole disconnection are only permissible if no stability problems occur or if a synchronous test occurs before the reclosing.

You can find detailed information about the functionality in the chapter *6.43.4.14 Closing Indication and Close Command* .

Parameter: Voltage supervision time

This parameter is only important if you use the subfunctions RDT, DLC, or the ADT function. If you do not use any of these functions, the setting of this parameter is free to select.

- Default setting **(_:6601:114) Voltage supervision time** = ***0.1 s***

With the **Voltage supervision time** parameter, you can determine the measuring time that is available as a criteria for the voltage decision. It should be longer than all transient oscillations through switching operations.

For the subfunctions **Reduced dead time** and **Reclosing function with adaptive dead time**, this measuring time applies for the determination of the surpassing of a voltage threshold. For the subfunction **Dead-line check**, the surpassing of a voltage threshold is checked.

Siemens recommends the setting 0.10 s.

Detailed information about the functionality can be found in the following parameters and in the chapters *6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT)* and *6.43.5.1 Description* .

Parameter: Volt. thres.f. live line/bus

This parameter is only important if you use the subfunction **RDT** or the function **ADT**. If you do not use any of these functions, the setting of this parameter is free to select.

- Default setting **(_:6601:115) Volt. thres.f. live line/bus** = ***48 V***

With the **Volt. thres.f. live line/bus** parameter, you can determine the limit voltage above which the line should be seen as fault-free. It must be lower than the smallest expected operating voltage. The phase-to-ground voltage applies as the reference value.

Detailed information about the functionality can be found in the following settings and in the chapters *6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT)* and *6.43.5.1 Description* .

Parameter: Dead-line check/reduc.d.t

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting **(_:6601:113) Dead-line check/reduc.d.t** = ***without***

With the **Dead-line check/reduc.d.t** parameter, you can determine if the automatic reclosing function should work with one of the additional functions ***Dead-line check DLC*** or ***Reduced dead t. RDT*** .

Parameter Value	Description
without	The automatic reclosing function occurs after the expiration of the parameterized dead times. DLC or RDT are not activated.
Reduced dead t. RDT	The automatic reclosing function works with a reduced dead time (RDT).
Dead-line check DLC	The automatic reclosing functions works with dead-line check. The closing indication is only assigned if the line was really de-energized during the dead time.

You can find detailed information about the functionality in the chapter *6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT)* .



NOTE

Use RDT or DLC only if the voltages of the line can be correctly measured with an open circuit breaker. This is only possible if the voltage transformer is aligned on the line-side - seen from the circuit breaker.

Parameter: Volt.thres. f. dead line/bus

This parameter is only important if you use the Dead-line check subfunction. If you do not use any of this subfunction, the setting of this parameter is free to select.

- Default setting **(_:6601:116) Volt.thres. f. dead line/bus** = ***30 V***

With the **Volt.thres. f. dead line/bus** parameter, you can determine the limit voltage below which the line should be seen with certainty as idle or switched off. The threshold value is used by the Dead-line check subfunction (dead-line check). The reference size is the phase-to-ground voltage.

You can find detailed information about the functionality in the chapter *6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT)* .

Parameter: Send delay f. remot. close

With the **Send delay f. remot. close** parameter, you can determine after which time after the automatic reclosing function the information is sent to the remote closing.

- Default setting **(_:6601:112) Send delay f. remot. close** = ***oo (invalid)***

The transmission delay prevents the device operating in the adaptive dead time mode on the opposite side from closing unnecessarily if the local reclosing function remains unsuccessful. On the other hand, it must be remembered that the line is not available for transporting energy as long as the opposite end is also closed. Thus, the **Send delay f. remot. close** must be added to the dead time in order to determine the system stability.

You can find detailed information about this functionality in the chapter *6.43.4.14 Closing Indication and Close Command* .

6.43.8 Application and Setting Notes for 1 Cycle of the Cyclic Automatic Reclosing Function

For the function of the cyclic automatic reclosing function, 1 cycle is preset. The preset cycle cannot be deleted. You can add and delete more cycles from the function library in **DIGSI 5**.

Parameter: Start from idle state allow.

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode ***with action time***.

- Default setting **(_:6571:102) Start from idle state allow.** = ***yes***

With the parameter **Start from idle state allow.** you can determine whether the action time of this automatic reclosing cycle is started, if the automatic reclosing function is in idle state during with incoming general pickup. Please set the parameter always to ***yes*** , if the automatic reclosing function is configured for only 1 cycle. If several cycles are configured, you can control the effectiveness of the automatic reclosing cycles with this parameter and various action times.

Detailed information about the functionality can be found in Chapters *6.43.4.6 Cycle Control with Operating Mode 1: With Tripping/With Action Time* und *6.43.4.7 Cycle Control with Operating Mode 2: With Pickup/With Action Time* .

Parameter: Action time

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode ***with action time***.

- Default setting **(_:6571:103) Action time** = ***0.2 s***

With this parameter **Action time** you can determine, within which time frame the trip command must appear, in order to start the automatic reclosing function. If the trip command occurs only after the action time has expired, automatic reclosing does not occur within the active automatic reclosing cycle.

You can find detailed information about the functionality in

Chapters *6.43.4.6 Cycle Control with Operating Mode 1: With Tripping/With Action Time* and *6.43.4.7 Cycle Control with Operating Mode 2: With Pickup/With Action Time* .

Parameter: Dead time aft. 3-pole trip

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode ***with tripping***.

- Default setting **(_:6571:108) Dead time aft. 3-pole trip** = ***0.5 s***

With this parameter **Dead time aft. 3-pole trip** , you can determine after which dead time the automatic reclosing function will be executed. After a 3-pole trip of the circuit breaker, the system stability is priority. Since the switched off line cannot develop synchronizing forces, only a short dead time is permitted in most cases. The usual duration is 0.3 s to 0.6 s. A longer period can be tolerated if a synchrocheck is carried out prior to reclosing. Longer 3-pole dead times are also possible in radial systems.

Parameter: Dead time aft.1ph. pickup, Dead time aft.2ph. pickup, Dead time aft.3ph. pickup

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode ***with pickup***.

- Default setting **(_:6571:104) Dead time aft.1ph. pickup** = ***1.2 s***
- Default setting **(_:6571:105) Dead time aft.2ph. pickup** = ***1.2 s***
- Default setting **(_:6571:106) Dead time aft.3ph. pickup** = ***0.5 s***

With the 3 dead-time parameters, you can determine after which dead time the automatic reclosing function will be executed. Please set the times as desired for the respective type of short circuit.

- The parameter **Dead time aft.1ph. pickup** applies to dead times after 1-phase short circuits and the following protection tripping: A, B, C, or A-Gnd, B-Gnd, C-Gnd
- The parameter **Dead time aft.2ph. pickup** applies to dead times after 2-phase short circuits and the following protection tripping: A-B, B-C, C-A, or A-B-gnd, B-C-gnd, C-A-gnd
- The parameter **Dead time aft.3ph. pickup** applies to dead times after 3-phase short circuits and the following protection tripping: A-B-C or A-B-C-Gnd

NOTE

If you would like to avoid automatic reclosing during individual short-circuit types, please set the respective dead times to ***oo (invalid)***.

Example:

After 1-phase short-circuits, the automatic reclosing function should occur after 1.2 s. The automatic reclosing function should not occur for 2-phase and 3-phase short circuits.

For this application, the parameters should be set as follows:

- **Dead time aft.1ph. pickup** = ***1.2 s***
- **Dead time aft.2ph. pickup** = ***oo (invalid)***
- **Dead time aft.3ph. pickup** = ***oo (invalid)***

Parameter: Dead time aft. evolv. fault

These parameters are only significant if the parameter **(_:6601:109) Response to evolv. faults** is set to ***strt. evol.flt.dead time*** .

- Default setting **(_:6571:109) Dead time aft. evolv. fault** = ***1.2 s***

With the parameter **Dead time aft. evolv. fault** , you can determine after which dead time the automatic reclosing function should be executed, if based on an evolving fault during the current dead time, a 3-pole trip has occurred. For this 3-pole dead time, stability concerns for the system are also important. Often, this dead time as well as the parameter **(_:6571:108) Dead time aft. 3-pole trip** can be set.

Detailed information about the function during evolving faults during dead time are described in Chapter *6.43.4.13 Evolving-Fault Detection During Dead Time* .

Parameter: CB ready check bef.close

- Default setting **(_:6571:111) CB ready check bef.close** = ***no***

With the parameter **CB ready check bef.close** you can determine if after the expiration of the dead time (meaning, directly prior to assigning the close command) readiness of the circuit breaker should be queried.

Parameter Value	Description
no	With the setting ***no*** , the automatic reclosing function does not check again the readiness of the circuit breaker prior to assigning the close demand. Siemens recommends this setting, if it is sufficient to check the readiness of the circuit breaker for the entire switching cycle once before the start of a reclosing function, consisting of tripping-reclosing-tripping. The setting for checking the readiness of the circuit breaker prior to the start of the automatic reclosing function is done using the parameter **(_:6601:102) CB ready check bef. start** .

Parameter Value	Description
yes	With the setting ***yes*** , the dead time can be extended if after the expiration of the dead time the circuit breaker is not ready for the next ON-OFF cycle. The maximum delay of the dead time can be set with the parameter **(_:6601:111) Max. dead-time extension** . Siemens recommends this setting, if it can be assumed that the circuit breaker becomes available to switch on the reclosing function only after an additional waiting period.

Detailed information about the function can be found in Chapters *6.43.4.16 Circuit-Breaker Readiness* and *6.43.4.14 Closing Indication and Close Command* .

Parameter: Synchroch. aft. 3-pole d.t.

- Default setting **(_:6571:110) Synchroch. aft. 3-pole d.t.** = ***none***

With the parameter **Synchroch. aft. 3-pole d.t.** you can determine if a synchrocheck must be carried out for the configured automatic reclosing cycle.

If during a 3-pole interruption in the system stability problems may be a concern, the synchrocheck should be carried out. If only 1-pole reclosure cycles are possible or stability problems are not to be expected during the 3-pole dead time, for example, due to a highly intermeshed system or radial system, please select the parameter ***none*** .

Parameter Value	Description
none	During the automatic reclosing cycle a synchrocheck is not executed.
internal	In the configured automatic reclosing cycle, a synchrocheck is executed after a 3-pole dead time prior to the close command of the circuit breaker. For the synchrocheck a synchrocheck stage of the internal synchronization function is used, which is contained in the same function group as the circuit breaker and the automatic reclosing function. The selection of the synchrocheck stage that is used in the automatic reclosing cycle occurs through the following described parameter **Internal synchrocheck**.
external	In the configured automatic reclosing cycle, a synchrocheck is executed after a 3-pole dead time prior to the close command of the circuit breaker. An external synchrocheck device initiates the synchrocheck. The external synchrocheck device is connected with the binary signals *Synchrocheck request* and *>Release by ext.sync.* . Detailed information about the function can be found in Chapter *6.43.4.14 Closing Indication and Close Command* under the section **Synchrocheck**.

Parameter: Internal Synchrocheck

These parameters are only significant if the previously described parameter **(_:6571:110) Synchroch. aft. 3-pole d.t.** is set to ***internal*** .

With the parameter **Internal Synchrocheck**, you can determine which function block of the synchronization function for the automatic reclosing function is used after a 3-pole dead time. This selection is only possible for function blocks of the synchronization function, and which are included in the same circuit-breaker function group as the automatic reclosing function. The setting options of the parameter will be generated dynamically, according to the actual parameterization.

6.44 Fault Locator

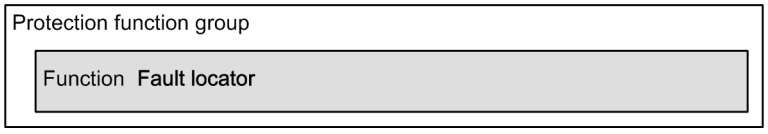
6.44.1 Overview of Functions

The **Fault locator** function serves for measuring the fault distance in the event of a short circuit.

Quick determination of fault location and the associated rapid troubleshooting increase the availability of the line for the power transmission in the electrical power system. Determining the fault location is based on the loop-impedance calculation of short-circuited measuring loops.

6.44.2 Structure of the Function

The **Fault locator** function can be used in protection function groups with 3-phase current and voltage measurement.



[dwstbafo-090812-01.tif, 1, en_US]

Figure 6-301 Structure/Embedding of the Function

The recording of phase currents and voltages is a prerequisite for calculation of fault locations. The **Fault locator** function contains all necessary control parameters.

The fault location is calculated based on the line parameter. The fault-location calculation starts ***with operate indication*** or ***for dropout*** of the short-circuit protection.

The following functions can start the fault locator:

- Overcurrent protection, phases or ground
- Directional overcurrent protection, phases or ground
- Instantaneous high-current tripping



NOTE

The **Fault locator** function does not work with all possible current and voltage transformer connection types. An error message is displayed in DIGSI 5 if the **Fault locator** function cannot work with the set connection types. In this case check the current and voltage transformer connection type. You will find the **`current transformer connection`** or **`voltage transformer connection`** settings in DIGSI 5 under **Power-system data** → **Measuring point I-3ph** or **Power-system data** → **Measuring point V-3ph**.

The **Fault locator** function only works with the following current and voltage transformer connection types (see parameter value).

Parameter	Parameter Value
`CT connection`	***`3-phase + IN-separate`***
	`3-phase + IN`
	`3-phase`
`VT connection`	***`3 ph-to-gnd volt. + VN`***
	`3 ph-to-gnd voltages`

6.44.3 Function Description

Starting Conditions

The fault location is an independent function with its own measurand memory and its own filter algorithms. To define the valid measuring loop and the most favorable time interval for the measured variable saving, only a start command is required by the short-circuit protection. The fault location can be started by tripping of the short-circuit protection or also at each pickup. If another protection device causes the disconnection of a short-circuit, a fault-location calculation is then also possible for each pickup. In the event of a fault outside the line to be protected, the fault-location indication cannot always be relevant, however, because the measurands can be falsified by the center infeed for example.

Determining the Fault Location

The recorded sampled values of the short-circuit voltage and voltage are frozen shortly after tripping of the protection. No error in the measured value has then occurred through the switch-off process, even in the case of very fast circuit-breakers. The measurands and the impedance calculations are automatically filtered and only indicate a steady-state measured value in the determined data window.

After disconnection of the short-circuit, the measured values are analyzed and the fault location calculated from the short-circuit loops. If no fault location can be calculated, the indication *FO invalid* is output.

Output of the Fault Location

The following results for the fault location are output:

- Short-circuit loop determined from the fault reactance
- Fault reactance X in Ω primary
- Fault resistance R in Ω primary
- Fault impedance in polar coordinates (amount in Ω, angle in degrees)
- Fault distance ***d*** of the line proportional to the reactance in kilometers or miles, converted on the basis of the parameterized reactance per unit length of the line
- Fault distance ***d*** as a percentage of the line length, calculated on the basis of the parameterized reactance per unit length and the parameterized line length
- Selected fault loop for calculation of the fault location



NOTE

Specification of distance in kilometers, miles, or percent is relevant only for homogenous line sections. If the line comprises parts which exhibit different reactances per unit of length (for example, overhead-line-cable sections), you can then analyze the reactance determined from the fault location for separate calculation of the fault distance.

Measured-Value Correction for Parallel Lines

In the event of ground faults on double lines, the values determined for the impedance calculation are influenced by the coupling of the ground impedances of both line systems. Without special measures, this leads to measuring errors in the impedance-calculation result. The device is therefore equipped with parallel-line compensation. This parallel-line compensation takes into account the ground current of the parallel line in the line equation and consequently compensates the coupling influence, similar to determining of the distance in distance protection. The ground current of the parallel line must be connected to the device and configured for this. The parallel-line compensation applies only to faults on the line to be protected. Compensation is not possible for faults located externally including those on the parallel line.

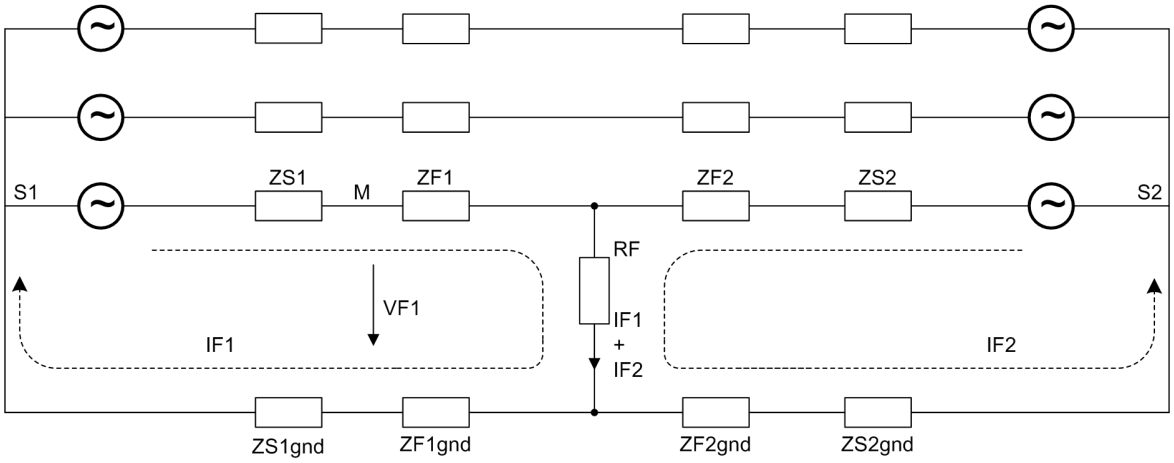
You can activate and deactivate the parallel-line compensation with the **`Parallel-line compensat.`** parameter.

Measured-Value Correction at Load Current on Lines Fed on Both Sides

In the case of faults on lines fed on both sides and with load transport (see next figure), the fault voltage Y_{F1} is not only influenced by the source voltage E_1, but also by the source voltage E_2, if both voltage sources feed to the common fault resistance R_F. Without special measures, this leads to measuring errors in the impedance-calculation result, since the current component I_{F2} cannot record at the measuring point M. For long lines and lines subject to high loads, this measuring error can be considerable in the crucial X component of the fault impedance (for the distance calculation).

The fault location has a load compensation, which corrects this measuring error in 1-pole short-circuits. A correction is not possible for the R component of the fault impedance. However, the measuring error is not critical here, as only the X component is decisive for the fault distance.

The load compensation acts in 1-phase short circuits. In doing so, both the positive-sequence and zero-sequence system of the balanced components are analyzed for the correction. You can activate and deactivate the load compensation via the **`Load compensation`** parameter.



[dwfailur-190912-01.tif, 1, en_US]

Figure 6-302 Fault Currents and Voltages in a Line Fed on Both Sides

M	Measuring point
S1, S2	Source voltage (EMF)
IF1, IF2	Partial fault currents
IF1 + IF2	Total fault current
VF1	Fault voltage at the measuring point
RF	Common fault resistance
ZF1, ZF2	Fault impedances
ZF1gnd, ZF2gnd	Ground fault impedances
ZS1, ZS2	External impedances
ZS1gnd, ZS2gnd	Ground external impedances

6.44.4 Application and Setting Notes

The function requires the following key line data to calculate fault distance:

- Reactance per unit length of the line per kilometer or per mile
- Line length for the correct output of the fault distance as a percentage of the line length
- The residual compensation factors in setting format **`Kr`** and **`Kx`**

Parameter: Start

- Default setting **(_:101) Start** = ***with dropout***

The **Start** parameter is used to define the criterion for starting the fault location. The following functions can start the fault locator:

- Overcurrent protection, phases or ground
- Directional overcurrent protection, phases or ground
- Instantaneous high-current tripping

Parameter Value	Description
with dropout	The fault-location calculation starts with the dropout of one of the protection functions listed previously.
with operate indication	If one of the protection functions listed previously generates an operate indication, calculation of the fault location starts.

As an alternative, the fault locator can be started using external binary input.

Parameter: Load compensation

- Default setting **(_:103) Load compensation** = ***no***

The **Load compensation** parameter can be used to correct measuring errors for 1-pole short circuits on lines fed on both sides. This is the case for overhead lines without grounding cable or with unfavorable grounding conditions of the towers, if high transition resistances can occur in the event of 1-pole short circuits.

Parameter Value	Description
no	The load compensation is deactivated with this setting.
yes	The load compensation becomes effective with this setting.

Parameter: X per length unit

- Default setting **(_:113) X per length unit** = ***0.210 Ω/km***

With the **X per length unit** parameter you set the reactance per unit length for the line to be protected. You set the **X per length unit** parameter as a relative value in Ω/km or Ω/miles.

Parameter: Line length

- Default setting **(_:114) Line length** = ***60 km***

With the **Line length** parameter, you can set the length of the line to be protected as unit of length in km or miles.

Parameter: Line angle

- Default setting **(_:108) Line angle** = ***85.00°***

Calculate the setting value for the parameter **Line angle** from the line constants for the line to be protected as follows:

$$\tan\varphi = \frac{X_L}{R_L} \qquad \text{or} \qquad \varphi = \arctan\left(\frac{X_L}{R_L}\right)$$

[folwinkl-050509-01.tif, 1, en_US]

where:

R_L	Resistance of the line to be protected
X_L	Reactance of the line to be protected

EXAMPLE

110-kV overhead line, 150 mm² with the data

$R'_1 = 0.19\ \Omega/km$

$X'_1 = 0.42\ \Omega/km$

You calculate the setting value for the line angle as follows:

$$\tan\varphi = \frac{X_L}{R_L} = \frac{X'_1}{R'_1} = \frac{0.42\ \Omega/km}{0.19\ \Omega/km} = 2.21$$

$$\arctan(2.21) = 65.7°$$

[folwibsp-050912-01.tif, 1, en_US]

Parameter: Kr and Kx

- Default setting **(_:104) Kr** = ***1.00***
- Default setting **(_:105) Kx** = ***1.00***

The **Kr** and **Kx** parameters are used to set the residual compensation factors as scalar values. The **Kr** and **Kx** parameters are relevant for the **Fault locator** function.

Calculate the setting values for the parameters **Kr** and **Kx** from the line data as follows:

Resistance ratio

$$Kr = \frac{R_{gnd}}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1 \right)$$

Reactance ratio

$$Kx = \frac{X_{gnd}}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1 \right)$$

where:

R_0	Zero-sequence system resistance of the line
X_0	Zero-sequence system reactance of the line
R_1	Positive-sequence system resistance of the line
X_1	Positive-sequence system reactance of the line

This data can either be used for the entire line or as length-related values, since the quotients are length-independent. You can calculate the data both from the primary values and from the secondary values.

EXAMPLE

110-kV overhead line, 150 mm² with the data:

R_1/s	0.19 Ω/km positive-sequence system resistance
X_1/s	0.42 Ω/km positive-sequence system reactance
R_0/s	0.53 Ω/km zero-sequence system resistance
X_0/s	1.19 Ω/km zero-sequence system reactance
s	Line length

You receive the following setting values for the parameters **Kr** and **Kx** :

$$Kr = \frac{R_{gnd}}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1 \right) = \frac{1}{3} \cdot \left(\frac{0.53\ \Omega/km}{0.19\ \Omega/km} - 1 \right) = 0.60$$

$$Kx = \frac{X_{gnd}}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1 \right) = \frac{1}{3} \cdot \left(\frac{0.19\ \Omega/km}{0.42\ \Omega/km} - 1 \right) = 0.61$$

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Parameter: K0 and Angle (K0)

- Default setting **K0** = *1.000*
- Default setting **Angle (K0)** = *0.00°*

NOTE

The visibility of the **K0** and **Angle (K0)** parameters depends on the selected setting format of the residual compensation factors. The parameters **K0** and **Angle (K0)** only become visible after you have set the parameter **Set. format residu. comp.** = *K0* for the device. The **Set. format residu. comp.** parameter can be found in the DIGSI 5 project tree under **Name of the device** → **Parameter** → **Device settings**.

The **K0** and **Angle (K0)** parameters are used to set the complex residual compensation factor.

Make sure that the line angle is set correctly because the device needs the line angle for calculation of the compensation components from the K0 factor. The complex residual compensation factor is defined by the value and the angle. You can calculate the complex residual compensation factor from the line data as follows:

$$\underline{K}_0 = \left| \frac{\underline{Z}_{gnd}}{\underline{Z}_L} = \frac{1}{3} \cdot \left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1 \right) \right|$$

[foforlk0-180912-01.tif, 1, en_US]

where:

$\underline{Z}_0$	(complex) zero-sequence impedance
$\underline{Z}_1$	(complex) positive-sequence impedance

This data can either be used for the entire line or as length-related values, since the quotients are length-independent. The data can be calculated both from the primary values and from the secondary values.

For overhead lines, you can use the values for the calculation because the angles of the zero-sequence system and the positive-sequence system differ only slightly. For cables, however, significant angular differences can occur, as the following example illustrates.

EXAMPLE

110-kV single-conductor liquid-filled cable 3 · 185 mm² Cu with the data:

$\underline{Z}_1/s$	$0.408 \cdot e^{j73°}$ Ω/km positive-sequence impedance
$\underline{Z}_0/s$	$0.632 \cdot e^{j18.4°}$ Ω/km zero-sequence impedance
s	Line length

The values for calculation of the residual compensation factor **K0** are:

$$\frac{\underline{Z}_0}{\underline{Z}_1} = \frac{0.632}{0.408} \cdot e^{j(18.4° - 73°)} = 1.55 \cdot e^{-j54.6°} = 1.55 \cdot (0.579 - j0.815)$$
$$= 0.898 - j1.263$$

[foforlk02-180912-01.tif, 1, en_US]

$$K_0 = \left| \frac{1}{3} \cdot \left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1 \right) \right| = \left| \frac{1}{3} \cdot (0.898 - j1.263 - 1) \right| = \left| \frac{1}{3} \cdot (-0.102 - j1.263) \right|$$

[foforlk03-180912-01.tif, 1, en_US]

The setting value of the parameter **K0** is calculated from:

$$K_0 = \left| \frac{1}{3} \cdot \sqrt{(-0.102^2) + (-1.263^2)} \right| = 0.42$$

[fofork04-180912-01.tif, 1, en_US]

When determining the angle, take note of the quadrant of the result. The following table lists the quadrants and the angle range obtained from the operational signs of the real and imaginary parts of **K0** .

Real Part	Imaginary Part	tan Phi (K0)	Quadrant/Range		Calculation Method
+	+	+	I	0° to 90°	arc tan (|Im| / |Re|)
+	-	-	IV	-90° to 0°	–arc tan (|Im| / |Re|)
-	-	+	III	-90° to -180°	arc tan (|Im| / |Re|) –180°
-	+	-	II	+90° to +180°	–arc tan (|Im| / |Re|) +180°

In this example, the following setting value for the **Angle (K0)** parameter is obtained:

$$\varphi(k_0) = \arctan\left(\frac{1.263}{0.102}\right) - 180° = -94.6°$$

[fofork05-050509-01.tif, 1, en_US]

6.44.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Fault locator				
_:1	Fault locator:Mode		• off • on • test	off
_:101	Fault locator:Start		• with operate • with going pickup	with going pickup
_:103	Fault locator:Load compensation		• no • yes	no
_:113	Fault locator:X per length unit	1 A	0.0001 Ω/km to 9.5000 Ω/km	Ω/km
		5 A	0.0000 Ω/km to 1.9000 Ω/km	0.0000 Ω/km
_:114	Fault locator:Line length		0.10 km to 1000.00 km	60.00 km
_:108	Fault locator:Line angle		10.00 ° to 89.00 °	85.00 °
_:104	Fault locator:Kr		-0.33 to 11.00	1.00
_:105	Fault locator:Kx		-0.33 to 11.00	1.00
_:118	Fault locator:K0		0.000 to 11.000	1.000
_:150	Fault locator:Angle (K0)		-180.00 ° to 180.00 °	0.00 °

6.44.6 Information List

No.	Information	Data Class (Type)	Type
Fault locator			
_:54	Fault locator:Inactive	SPS	O
_:52	Fault locator:Behavior	ENS	O
_:53	Fault locator:Health	ENS	O
_:302	Fault locator:Fault resistance prim.	MV	O
_:303	Fault locator:Fault reactance prim.	MV	O

No.	Information	Data Class (Type)	Type
_:308	Fault locator:Fault resistance sec.	MV	O
_:309	Fault locator:Fault reactance sec.	MV	O
_:304	Fault locator:Fault distance	MV	O
_:305	Fault locator:Fault distance in %	MV	O
_:306	Fault locator:Fault loop	ENS	O
_:307	Fault locator:FLO invalid	ENS	O

6.45 Temperature Supervision

6.45.1 Overview of Functions

The **Temperature supervision** function checks the thermal state of:

- Motors
- Generators
- Transformers

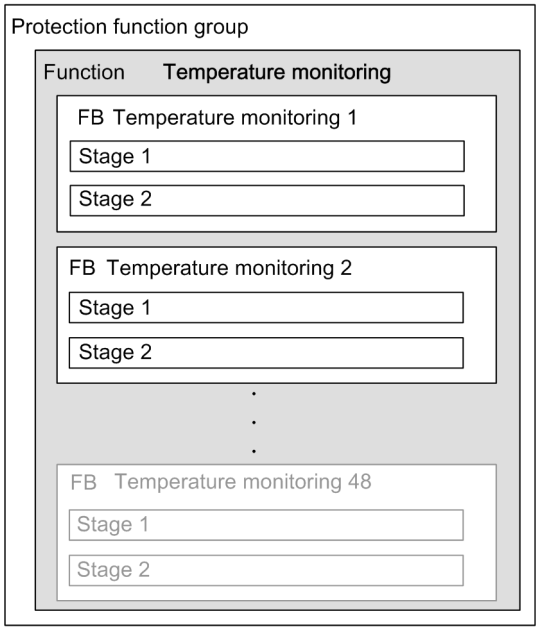
In rotating machines, it also checks bearing temperatures for a limit violation.

The temperatures are measured at various locations of the protected object using temperature sensors (RTD = Resistance Temperature Detector) and are sent to the device via one or more RTD units.

The **Temperature supervision** function receives its measured temperature values via the **RTD unit Ether.** or **Serial RTD unit** functions from the **Analog units** function group.

6.45.2 Structure of the Function

The Temperature supervision function can work in all protection function groups. A maximum of 48 temperature supervision locations can operate simultaneously in the **Temperature supervision function** function. Each temperature supervision location has 2 threshold stages.

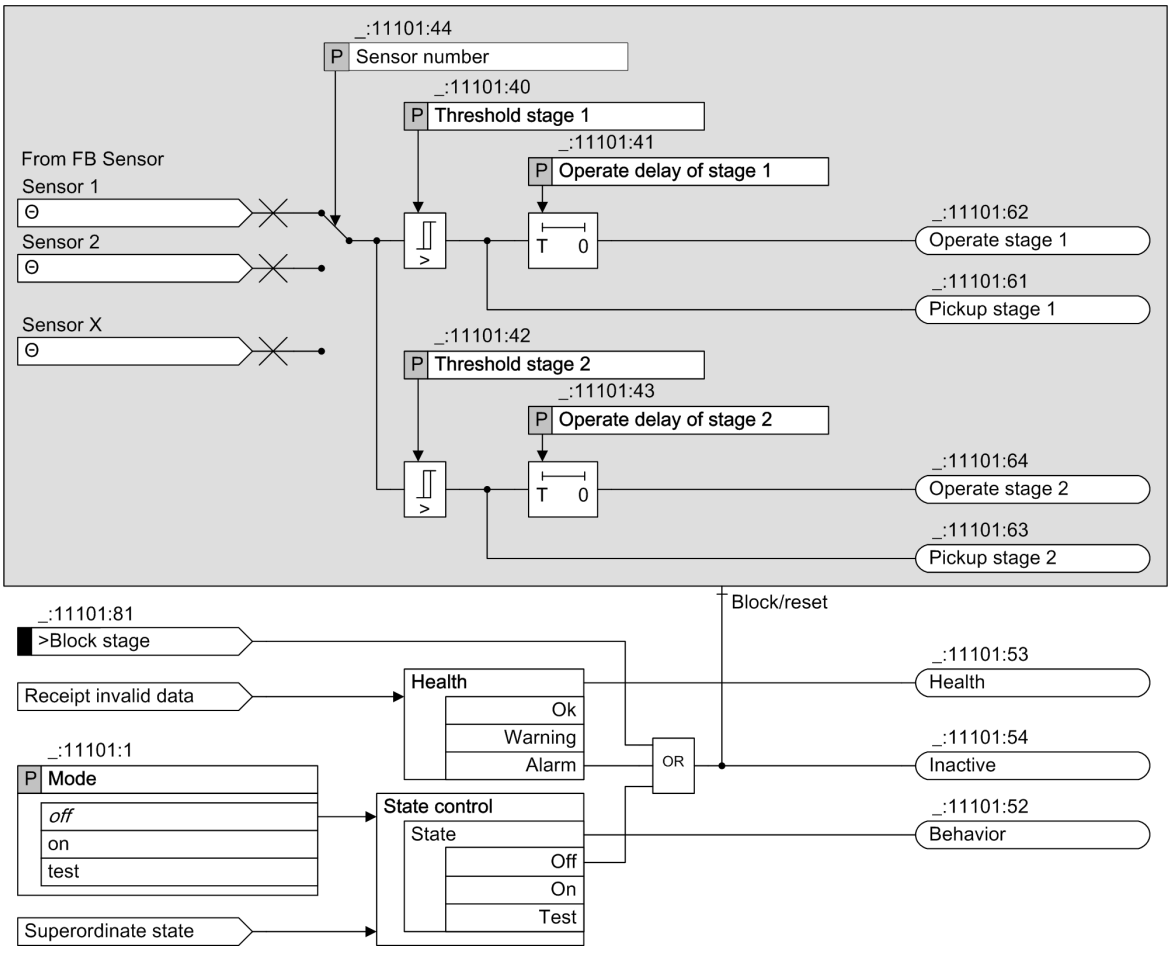


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Figure 6-303 Structure/Embedding of the Function

6.45.3 Function Description

Logic



[lotmpsup-170712-01.tif, 1, en_US]

Figure 6-304 Logic Diagram for a Temperature Supervision Location

The **Temperature supervision location** function block (**Location** FB) receives a measured temperature value in °C or °F as an input variable delivered from the temperature sensor function blocks of the **Analog units** function group. The **Sensor number** parameter is used to select the temperature sensor.

2 threshold value decisions can be performed for each measuring point. If the measured temperature value is greater than or equal to the set threshold values, the stages generate a pickup indication independent of one another and, after a set tripping time delay, an operate indication.

The indications from the supervision locations remain available for further processing.

NOTE

The pickup of the stages does not result in fault logging. The operate indications of the stages do not go into the trip logic of the device.

6.45.4 Application and Setting Notes

If you use an external RTD unit, connect the RTD unit via an interface (Ethernet or serial) to the SIPROTEC 5 device. Observe the setting notes for configuration of the interfaces in chapter Analog Transformer Function Group Type under *5.6.7.3 Communication with an RTD Unit* .

Parameter: `Sensor location`

- Default setting **`(_:11101:46) Sensor location`** = ***`Other`***

You inform the device of the sensor installation location using the **`Sensor location`** parameter. ***`Oil`***, ***`Ambient`***, ***`Turn`***, ***`Bearing`*** and ***`Other`*** are available for selection. The selection is not evaluated in the device, it only serves an informational purpose in the medium in which the temperature measurement takes place.

Parameter: `Sensor number`

- Default setting **`(_:11101:44) sensor number`** = ***`no function block selected`***

With the **`sensor number`** parameter, you assign a specific sensor whose temperature is to be monitored to the **Location** function block. You perform the assignment in DIGSI using a list box that contains all connected RTD units and their sensors.

Parameter: `Threshold stage 1`

- Default setting **`(_:11101:40) Threshold stage 1`** = ***`100 °C`***

With the **`Threshold stage 1`** parameter you establish the temperature value whose exceedance causes a pickup of the 1st tripping stage.

Parameter: `Operate delay of stage 1`

- Default setting **`(_:11101:41) Operate delay of stage 1`** = ***`5 s`***

With the **`Operate delay of stage 1`** parameter you establish the time the operate indication of the 1st tripping stage should be delayed after the pickup. This time delay depends on the specific application. If you set the time delay to ∞ the operate indication is blocked.

Parameter: `Threshold stage 2`

- Default setting **`(_:11101:42) Threshold stage 2`** = ***`120 °C`***

With the **`Threshold stage 2`** parameter you establish the temperature value whose exceedance causes a pickup of the 2nd tripping stage.

Parameter: `Operate delay of stage 2`

- Default setting **`(_:11101:43) Operate delay of stage 2`** = ***`0 s`***

With the **`Operate delay of stage 2`** parameter you establish the time the operate indication of the 2nd tripping stage should be delayed after the pickup. This time delay depends on the specific application. If you set the time delay to ∞ the operate indication is blocked.

Temperature Unit

Temperature Unit To change the display and evaluation of measured temperature values from °C to °F, adapt the DIGSI user default settings accordingly (see *5.6.7.5 Temperature Sensor*).

6.45.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Point 1`				
_:11101:46	Point 1:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11101:1	Point 1:Mode		• off • on • test	off
_:11101:40	Point 1:Threshold stage 1		-50°C to 250°C	100°C
_:11101:41	Point 1:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11101:42	Point 1:Threshold stage 2		-50°C to 250°C	120°C
_:11101:43	Point 1:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11101:44	Point 1:Sensor		Setting options depend on configuration	
Point 2				
_:11102:46	Point 2:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11102:1	Point 2:Mode		• off • on • test	off
_:11102:40	Point 2:Threshold stage 1		-50°C to 250°C	100°C
_:11102:41	Point 2:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11102:42	Point 2:Threshold stage 2		-50°C to 250°C	120°C
_:11102:43	Point 2:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11102:44	Point 2:Sensor		Setting options depend on configuration	
Point 3				
_:11103:46	Point 3:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11103:1	Point 3:Mode		• off • on • test	off
_:11103:40	Point 3:Threshold stage 1		-50°C to 250°C	100°C
_:11103:41	Point 3:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11103:42	Point 3:Threshold stage 2		-50°C to 250°C	120°C
_:11103:43	Point 3:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11103:44	Point 3:Sensor		Setting options depend on configuration	
Point 4				
_:11104:46	Point 4:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11104:1	Point 4:Mode		• off • on • test	off
_:11104:40	Point 4:Threshold stage 1		-50°C to 250°C	100°C
_:11104:41	Point 4:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11104:42	Point 4:Threshold stage 2		-50°C to 250°C	120°C
_:11104:43	Point 4:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11104:44	Point 4:Sensor		Setting options depend on configuration	
Point 5				
_:11105:46	Point 5:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11105:1	Point 5:Mode		• off • on • test	off
_:11105:40	Point 5:Threshold stage 1		-50°C to 250°C	100°C
_:11105:41	Point 5:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11105:42	Point 5:Threshold stage 2		-50°C to 250°C	120°C
_:11105:43	Point 5:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11105:44	Point 5:Sensor		Setting options depend on configuration	
Point 6				
_:11106:46	Point 6:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11106:1	Point 6:Mode		• off • on • test	off
_:11106:40	Point 6:Threshold stage 1		-50°C to 250°C	100°C
_:11106:41	Point 6:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11106:42	Point 6:Threshold stage 2		-50°C to 250°C	120°C
_:11106:43	Point 6:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11106:44	Point 6:Sensor		Setting options depend on configuration	
Point 7				
_:11107:46	Point 7:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11107:1	Point 7:Mode		• off • on • test	off
_:11107:40	Point 7:Threshold stage 1		-50°C to 250°C	100°C
_:11107:41	Point 7:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11107:42	Point 7:Threshold stage 2		-50°C to 250°C	120°C
_:11107:43	Point 7:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11107:44	Point 7:Sensor		Setting options depend on configuration	
Point 8				
_:11108:46	Point 8:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11108:1	Point 8:Mode		• off • on • test	off
_:11108:40	Point 8:Threshold stage 1		-50°C to 250°C	100°C
_:11108:41	Point 8:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11108:42	Point 8:Threshold stage 2		-50°C to 250°C	120°C
_:11108:43	Point 8:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11108:44	Point 8:Sensor		Setting options depend on configuration	
Point 9				
_:11109:46	Point 9:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11109:1	Point 9:Mode		• off • on • test	off
_:11109:40	Point 9:Threshold stage 1		-50°C to 250°C	100°C
_:11109:41	Point 9:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11109:42	Point 9:Threshold stage 2		-50°C to 250°C	120°C
_:11109:43	Point 9:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11109:44	Point 9:Sensor		Setting options depend on configuration	
Point 10				
_:11110:46	Point 10:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11110:1	Point 10:Mode		• off • on • test	off
_:11110:40	Point 10:Threshold stage 1		-50°C to 250°C	100°C
_:11110:41	Point 10:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11110:42	Point 10:Threshold stage 2		-50°C to 250°C	120°C
_:11110:43	Point 10:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11110:44	Point 10:Sensor		Setting options depend on configuration	
Point 11				
_:11111:46	Point 11:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11111:1	Point 11:Mode		• off • on • test	off
_:11111:40	Point 11:Threshold stage 1		-50°C to 250°C	100°C
_:11111:41	Point 11:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11111:42	Point 11:Threshold stage 2		-50°C to 250°C	120°C
_:11111:43	Point 11:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11111:44	Point 11:Sensor		Setting options depend on configuration	
Point 12				
_:11112:46	Point 12:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11112:1	Point 12:Mode		• off • on • test	off
_:11112:40	Point 12:Threshold stage 1		-50°C to 250°C	100°C
_:11112:41	Point 12:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11112:42	Point 12:Threshold stage 2		-50°C to 250°C	120°C
_:11112:43	Point 12:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11112:44	Point 12:Sensor		Setting options depend on configuration	

6.45.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
Point 1			
_:11101:81	Point 1:>Block stage	SPS	I
_:11101:54	Point 1:Inactive	SPS	O
_:11101:52	Point 1:Behavior	ENS	O
_:11101:53	Point 1:Health	ENS	O
_:11101:61	Point 1:Pickup stage 1	SPS	O
_:11101:62	Point 1:Operate stage 1	SPS	O
_:11101:63	Point 1:Pickup stage 2	SPS	O
_:11101:64	Point 1:Operate stage 2	SPS	O
Point 2			
_:11102:81	Point 2:>Block stage	SPS	I
_:11102:54	Point 2:Inactive	SPS	O
_:11102:52	Point 2:Behavior	ENS	O
_:11102:53	Point 2:Health	ENS	O
_:11102:61	Point 2:Pickup stage 1	SPS	O
_:11102:62	Point 2:Operate stage 1	SPS	O
_:11102:63	Point 2:Pickup stage 2	SPS	O
_:11102:64	Point 2:Operate stage 2	SPS	O
Point 3			
_:11103:81	Point 3:>Block stage	SPS	I
_:11103:54	Point 3:Inactive	SPS	O
_:11103:52	Point 3:Behavior	ENS	O
_:11103:53	Point 3:Health	ENS	O
_:11103:61	Point 3:Pickup stage 1	SPS	O
_:11103:62	Point 3:Operate stage 1	SPS	O
_:11103:63	Point 3:Pickup stage 2	SPS	O
_:11103:64	Point 3:Operate stage 2	SPS	O
Point 4			
_:11104:81	Point 4:>Block stage	SPS	I
_:11104:54	Point 4:Inactive	SPS	O
_:11104:52	Point 4:Behavior	ENS	O
_:11104:53	Point 4:Health	ENS	O
_:11104:61	Point 4:Pickup stage 1	SPS	O
_:11104:62	Point 4:Operate stage 1	SPS	O
_:11104:63	Point 4:Pickup stage 2	SPS	O
_:11104:64	Point 4:Operate stage 2	SPS	O
Point 5			
_:11105:81	Point 5:>Block stage	SPS	I
_:11105:54	Point 5:Inactive	SPS	O
_:11105:52	Point 5:Behavior	ENS	O
_:11105:53	Point 5:Health	ENS	O
_:11105:61	Point 5:Pickup stage 1	SPS	O

No.	Information	Data Class (Type)	Type
_:11105:62	Point 5:Operate stage 1	SPS	O
_:11105:63	Point 5:Pickup stage 2	SPS	O
_:11105:64	Point 5:Operate stage 2	SPS	O
Point 6			
_:11106:81	Point 6:>Block stage	SPS	I
_:11106:54	Point 6:Inactive	SPS	O
_:11106:52	Point 6:Behavior	ENS	O
_:11106:53	Point 6:Health	ENS	O
_:11106:61	Point 6:Pickup stage 1	SPS	O
_:11106:62	Point 6:Operate stage 1	SPS	O
_:11106:63	Point 6:Pickup stage 2	SPS	O
_:11106:64	Point 6:Operate stage 2	SPS	O
Point 7			
_:11107:81	Point 7:>Block stage	SPS	I
_:11107:54	Point 7:Inactive	SPS	O
_:11107:52	Point 7:Behavior	ENS	O
_:11107:53	Point 7:Health	ENS	O
_:11107:61	Point 7:Pickup stage 1	SPS	O
_:11107:62	Point 7:Operate stage 1	SPS	O
_:11107:63	Point 7:Pickup stage 2	SPS	O
_:11107:64	Point 7:Operate stage 2	SPS	O
Point 8			
_:11108:81	Point 8:>Block stage	SPS	I
_:11108:54	Point 8:Inactive	SPS	O
_:11108:52	Point 8:Behavior	ENS	O
_:11108:53	Point 8:Health	ENS	O
_:11108:61	Point 8:Pickup stage 1	SPS	O
_:11108:62	Point 8:Operate stage 1	SPS	O
_:11108:63	Point 8:Pickup stage 2	SPS	O
_:11108:64	Point 8:Operate stage 2	SPS	O
Point 9			
_:11109:81	Point 9:>Block stage	SPS	I
_:11109:54	Point 9:Inactive	SPS	O
_:11109:52	Point 9:Behavior	ENS	O
_:11109:53	Point 9:Health	ENS	O
_:11109:61	Point 9:Pickup stage 1	SPS	O
_:11109:62	Point 9:Operate stage 1	SPS	O
_:11109:63	Point 9:Pickup stage 2	SPS	O
_:11109:64	Point 9:Operate stage 2	SPS	O
Point 10			
_:11110:81	Point 10:>Block stage	SPS	I
_:11110:54	Point 10:Inactive	SPS	O
_:11110:52	Point 10:Behavior	ENS	O
_:11110:53	Point 10:Health	ENS	O
_:11110:61	Point 10:Pickup stage 1	SPS	O
_:11110:62	Point 10:Operate stage 1	SPS	O

No.	Information	Data Class (Type)	Type
_:11110:63	Point 10:Pickup stage 2	SPS	O
_:11110:64	Point 10:Operate stage 2	SPS	O
Point 11			
_:11111:81	Point 11:>Block stage	SPS	I
_:11111:54	Point 11:Inactive	SPS	O
_:11111:52	Point 11:Behavior	ENS	O
_:11111:53	Point 11:Health	ENS	O
_:11111:61	Point 11:Pickup stage 1	SPS	O
_:11111:62	Point 11:Operate stage 1	SPS	O
_:11111:63	Point 11:Pickup stage 2	SPS	O
_:11111:64	Point 11:Operate stage 2	SPS	O
Point 12			
_:11112:81	Point 12:>Block stage	SPS	I
_:11112:54	Point 12:Inactive	SPS	O
_:11112:52	Point 12:Behavior	ENS	O
_:11112:53	Point 12:Health	ENS	O
_:11112:61	Point 12:Pickup stage 1	SPS	O
_:11112:62	Point 12:Operate stage 1	SPS	O
_:11112:63	Point 12:Pickup stage 2	SPS	O
_:11112:64	Point 12:Operate stage 2	SPS	O

6.46 Current-Jump Detection

6.46.1 Overview of Functions

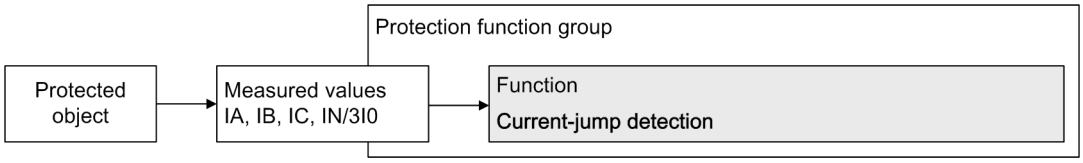
The **Current jump detection** function has the following tasks:

- Detection of jumps in the phase or zero-sequence current (ΔI)
- Generation of an indication when the measurands change by more than a configured threshold value from one system period to the next.

The function for detecting jumps in the phase or zero-sequence current is an additional function used for indication purposes or for further processing in user-specific CFC logics. Pick up of the function therefore neither opens a separate fault in the fault log nor generates an operate indication.

6.46.2 Structure of the Function

The **Current-jump detection** function is used in protection function groups based on current measurement. It can be instantiated multiple times.



[dwstruki-111026-01.tif, 1, en_US]

Figure 6-305 Structure/Embedding of the Function

6.46.3 Function Description

Current-jump detection operates directly with the sampled values without numeric filtering. This provides very short response times to sudden changes in the current. The method used is not sensitive to slow changes of amplitude or frequency.

Using a configurable selection of measured values, you can select from 3 line currents or the residual current. Current-jump detection is phase-selective for the line current A, B and C.

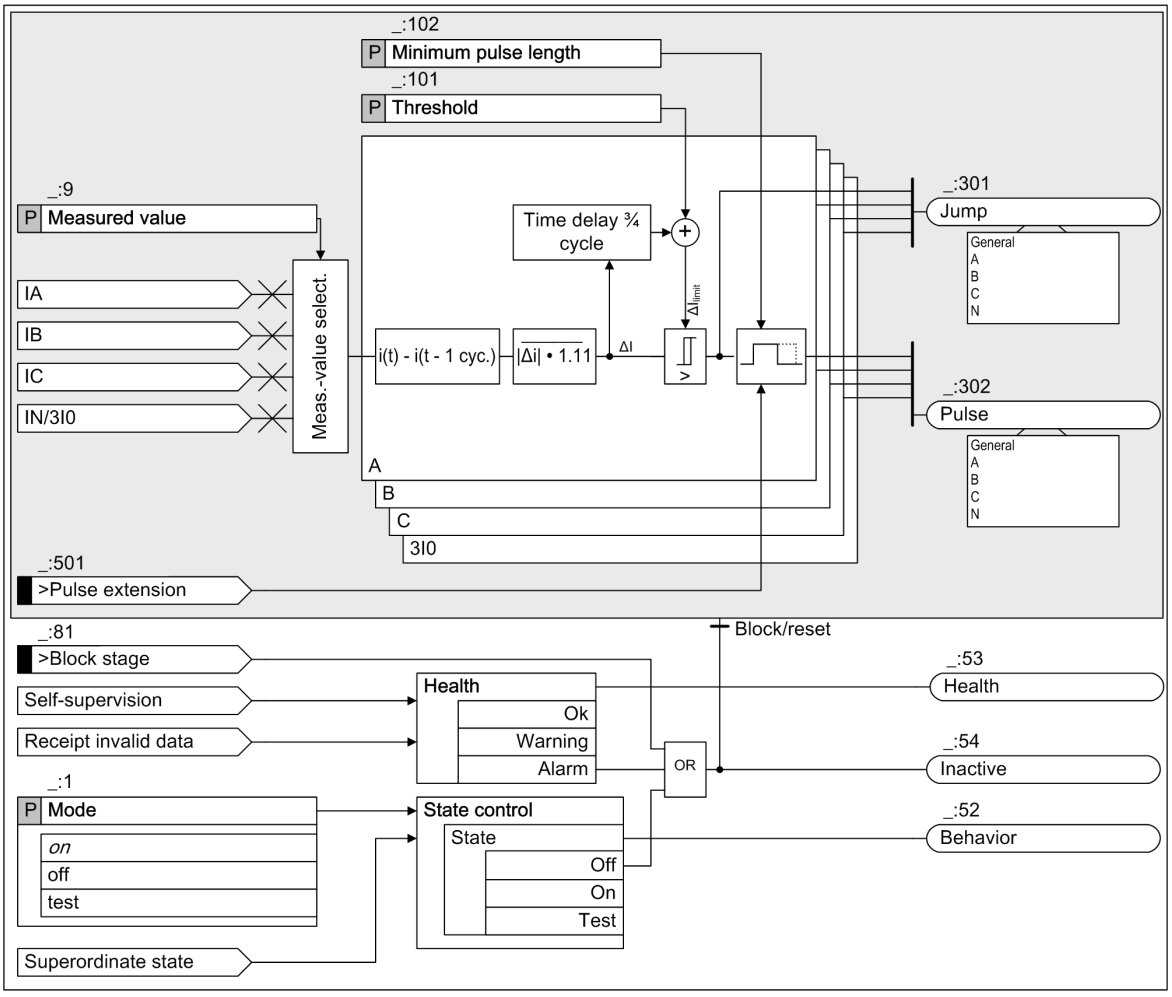
The difference from the previous sampled value of the first system cycle is calculated for each sampled value. The rectified average is then determined for a ½ system cycle from this differential signal Δi(t). The rectified average for sinusoidal measurands is then converted to a RMS value ΔI by subsequent multiplication by 1.11. The resultant measurand ΔI is then compared with the threshold value.

If the parameter **(_:101) Threshold** is exceeded, the output indication *Jump* is generated. If you have selected the phase currents for measurement, the output indication data type used includes the separate phase information. If you have selected the residual current for measurement, the output indication data type used includes the NI information. If the current-jump detection responds (ΔI_{Limit}), the general information is generated in the output indication in all cases.

Dropout occurs with a dynamically increased threshold value (ΔI_{Limit}) in accordance with the logic in *Figure 6-306*. Dynamic increase of the dropout threshold value achieves optimally short dropout times.

The output indication *Pulse* is formed with the configurable timer **(_:102) Minimum pulse length**. As a consequence this output indication has a consistent minimum size. If you activate the binary input *>Pulse extension*, you can prolong the pulse duration even further. If the binary input *>Pulse extension* has been activated, the indication *Pulse* drops off when the configured time has elapsed and the falling edge of the binary input is detected.

Logic



[lojumpii-271011-01.tif, 1, en_US]

Figure 6-306 Current-Jump Detection Logic

6.46.4 Application and Setting Notes

Parameter: `Measured value`

- Default setting **`(_:9) Measured value`** = ***`phase currents`***

With the parameter **`Measured value`**, you set whether the line current(s) or the residual current is to be used for jump detection.

Parameter Value	Description
`phase currents`	The tripping stage evaluates the line currents IL1, IL2 and IL3 phase-selectively to detect a jump.
`zero-sequence current`	The tripping stage evaluates the residual current IN/3I0 to detect a jump.

Parameter: `Threshold`

- Default setting **`(_:101) Threshold`** = ***`0.10 A`*** for I_{rated} = 1A or ***`0.50 A`*** for I_{rated} = 5 A

With the parameter **`Threshold`**, you set the threshold value for the measurand which, when exceeded, generates the output indication *`Jump`*.

Parameter: `Minimum pulse length`

- Default setting **`(_:102) Minimum pulse length`** = ***`0.10 s`***

With the parameter **`Minimum pulse length`**, you specify a consistent minimum size for the output indication *`Pulse`*.

6.46.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`I-jump det. #`				
_:1	I-jump det. #:Mode		• off • on • test	off
_:9	I-jump det. #:Measured value		• phase currents • zero-sequence current	phase currents
_:101	I-jump det. #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:101	I-jump det. #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:102	I-jump det. #:Minimum pulse length		0.01 s to 60.00 s	0.10 s

6.46.6 Information List

No.	Information	Data Class (Type)	Type
`I-jump det. #`			
_:81	I-jump det. #:>Block stage	SPS	I
_:501	I-jump det. #:>Pulse extension	SPS	I
_:54	I-jump det. #:Inactive	SPS	O
_:52	I-jump det. #:Behavior	ENS	O
_:53	I-jump det. #:Health	ENS	O
_:301	I-jump det. #:Jump	ACT	O
_:302	I-jump det. #:Pulse	ACT	O

6.47 Voltage-Jump Detection

6.47.1 Overview of Functions

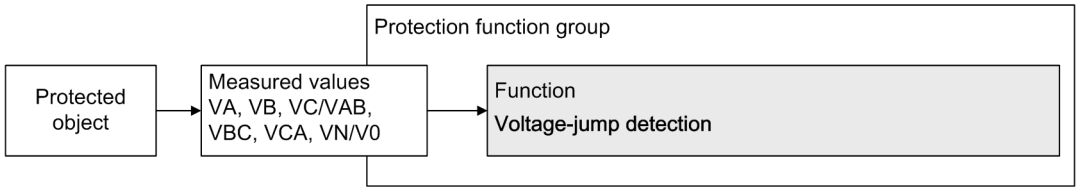
The **Voltage-jump detection** function has the following tasks:

- Recognition of jumps in the phase or zero-sequence voltage (ΔV)
- Generation of an indication when the measurands change by more than a configured threshold value from one system cycle to the next.

The function for detecting jumps in the phase or zero-sequence voltage is an additional function used for indication purposes or for further processing in user-specific CFC logics. Pick up of the function therefore neither opens a separate fault in the fault log nor generates an operate indication.

6.47.2 Structure of the Function

The **Voltage-jump detection** function is used in protection function groups based on voltage measurement. It can be instantiated multiple times.



[dwstruku-011211-01.tif, 1, en_US]

Figure 6-307 Structure/Embedding of the Function

6.47.3 Function Description

Voltage-jump detection operates directly with the sampled values without numeric filtering. This provides very short response times to sudden changes in the voltage. The method used is not sensitive to slow changes of amplitude or frequency.

By using a configurable selection of measured values, you can select from phase-to-ground voltages, phase-to-phase voltages or the zero-sequence voltage. Voltage-jump detection is phase-selective.

The difference from the previous sampled value of 1 system cycle is calculated for each sampled value. The rectified average is then determined for a ½ system cycle from this differential signal Δv(t). The rectified average for sinusoidal measurands is then converted to a RMS value ΔV by subsequent multiplication by 1.11. The resultant measurand ΔV is then compared with the threshold value.

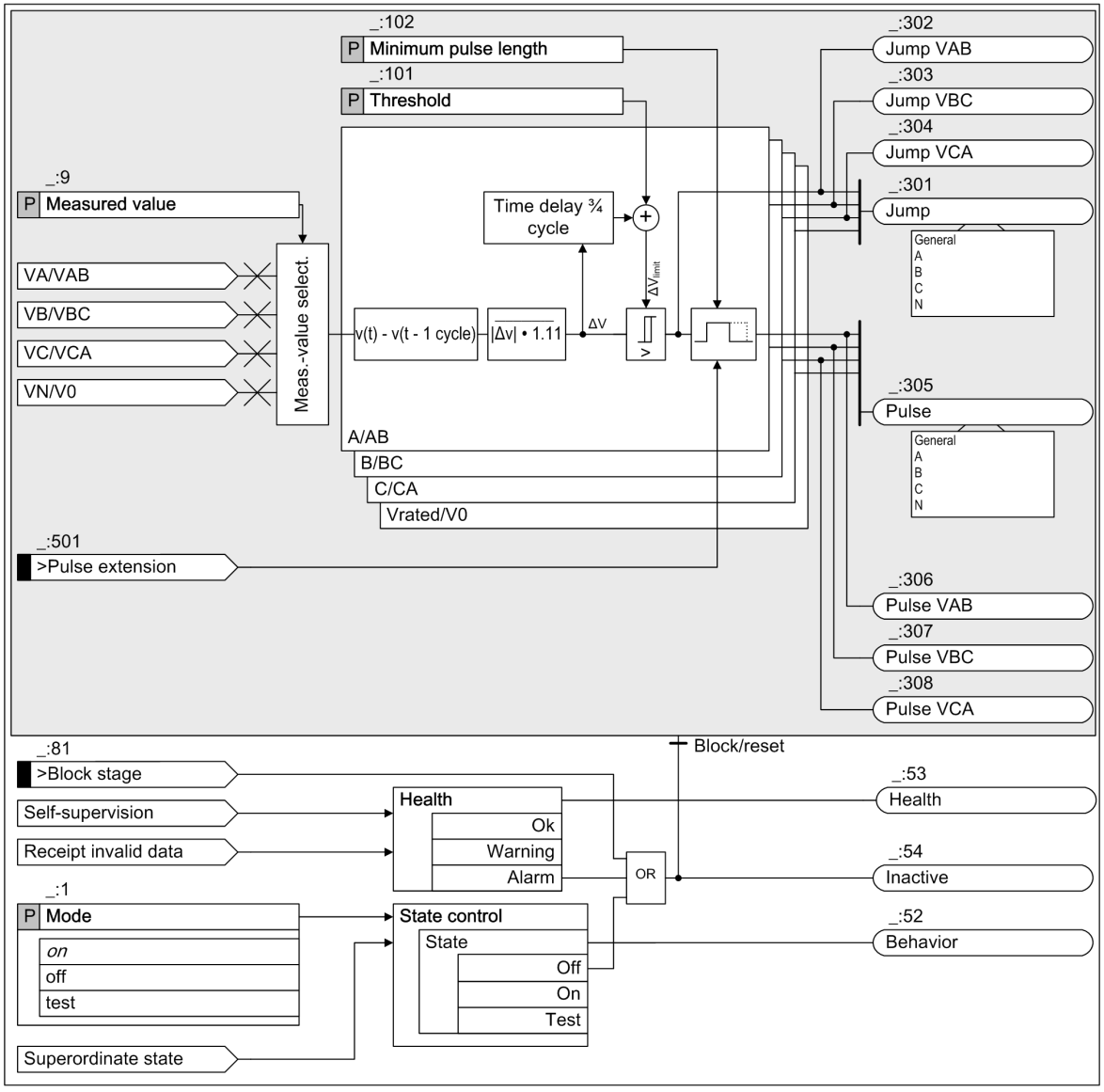
If the parameter **(_:101) Threshold** is exceeded, the output indication *Jump* is generated. If the measured value is set to phase-to-phase, the sudden change in voltage is signaled selectively for the individual measuring elements that have picked up (*Jump VAB*, *Jump VBC* or *Jump VCA*). If you have selected the phase-to-phase or phase-to-ground voltages for measurement, the output indication data type used included the separate phase information. If you have selected the zero-sequence voltage for measurement, the output indication data type used includes the N information. If the voltage-jump detection responds (ΔV_{Limit}), the general information is generated in the output indication in all cases.

Dropout occurs with a dynamically increased threshold value ΔU_{Limit} in accordance with the information in *Figure 6-308*. Dynamic increase of the dropout threshold value achieves optimally short dropout times.

A timing element is added to the indication *Jump*. The element generates a pulse from this. The length of this pulse can be set using the parameter **(_:102) Minimum pulse length**. This gives the output indication *Pulse* a reliable minimum size. If you activate the binary input *>Pulse extension*, you can prolong the pulse duration even further. If the binary input *>Pulse extension* has been activated, the indication *Pulse* drops off when the configured time has elapsed and the falling edge of the binary input is detected. If

the measured value is set to phase-to-phase, the pulse duration is signaled selectively for the individual measuring elements that have picked up (*Pulse VAB*, *Pulse VBC* or *Pulse VCA*).

Logic



[lojumpuu-011211-01.tif, 1, en_US]

Figure 6-308 Voltage-Jump Detection Logic

6.47.4 Application and Setting Notes

Parameter: `Measured value`

- Default setting **`(_:9) Measured value`** = ***`phase-to-ground`***

With the parameter **`Measured value`** , you specify which measured values of voltage are to be used for determining the voltage jumps.

Parameter Value	Description
`phase-to-ground`	The tripping stage evaluates the phase-to-ground voltages VA, VB and VC.

Parameter Value	Description
phase-to-phase	The tripping stage evaluates the phase-to-phase voltages VAB, VBC and VCA.
zero-sequence voltage	The tripping stage evaluates the zero-sequence voltage VN/V0.

Parameter: `Threshold`

- Default setting **`(_:101) Threshold`** = ***`5.000 V`***

With the parameter **`Threshold`** , you set the threshold value for the measurand which, when exceeded, generates the output indication *`Jump`* .

Parameter: `Minimum pulse length`

- Default setting **`(_:102) Minimum pulse length`** = ***`0.10 s`***

With the parameter **`Minimum pulse length`** , you specify a consistent minimum size for the output indication *`Pulse`* .

6.47.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-jump det. #				
_:1	V-jump det. #:Mode		• off • on • test	off
_:9	V-jump det. #:Measured value		• phase-to-ground • phase-to-phase • zero-sequence voltage	phase-to-ground
_:101	V-jump det. #:Threshold		0.300 V to 340.000 V	5.000 V
_:102	V-jump det. #:Minimum pulse length		0.01 s to 60.00 s	0.10 s

6.47.6 Information List

No.	Information	Data Class (Type)	Type
V-jump det. #			
_:81	V-jump det. #:>Block stage	SPS	I
_:501	V-jump det. #:>Pulse extension	SPS	I
_:54	V-jump det. #:Inactive	SPS	O
_:52	V-jump det. #:Behavior	ENS	O
_:53	V-jump det. #:Health	ENS	O
_:301	V-jump det. #:Jump	ACT	O
_:302	V-jump det. #:Jump VAB	SPS	O
_:303	V-jump det. #:Jump VBC	SPS	O
_:304	V-jump det. #:Jump VCA	SPS	O
_:305	V-jump det. #:Pulse	ACT	O
_:306	V-jump det. #:Pulse VAB	SPS	O
_:307	V-jump det. #:Pulse VBC	SPS	O
_:308	V-jump det. #:Pulse VCA	SPS	O

6.48 Voltage Measuring-Point Selection

6.48.1 Overview of Functions

The function block **Voltage measuring-point selection** can:

- Provide the ability to switchover the voltage measuring points to be applied, if various voltage measuring points are connected to the voltage interface of the function group
- Select the correct voltage based on the switch position of the plant

If more than one voltage measuring points are connected to the same voltage interface of the function group, use the **Voltage measuring-point selection** function block in the function group to select the correct voltage based on the switch position of the plant.

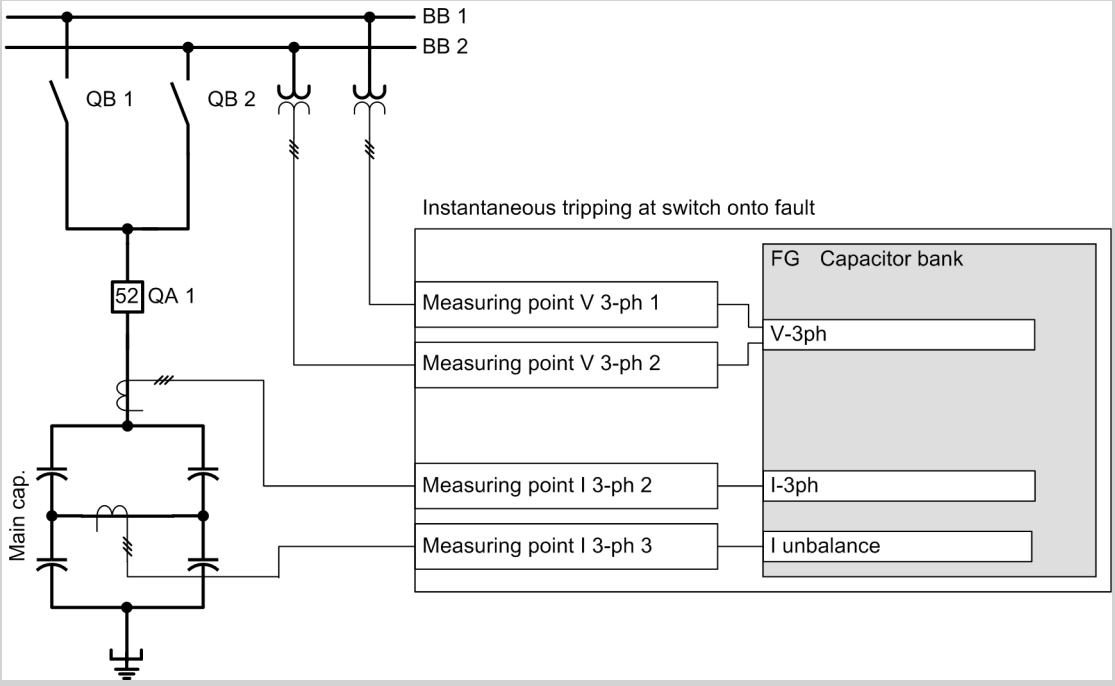
The **Voltage measuring-point selection** is a common functionality for the function groups of the protected objects.

6.48.2 Function Description

The **Voltage measuring-point selection** function block realizes the selection of voltage measuring points by a logic block chart. The logic block chart controls the input *>MP-ID selection* depending on the switch positions of disconnectors.

Example

Figure 6-309 shows an example of voltage measuring points selection for the function group **Capacitor bank** in a double busbar application.

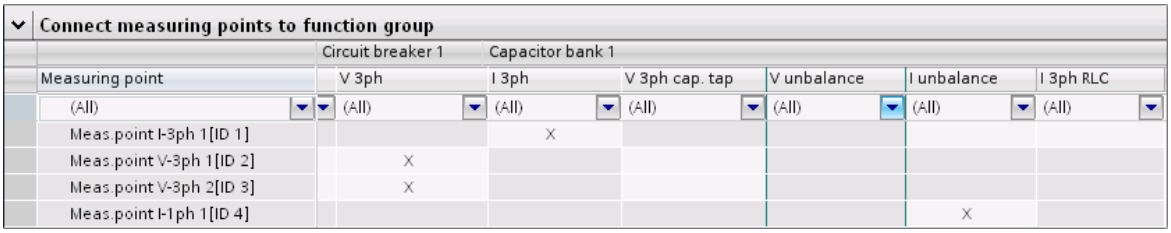


[dwbusbardouble.vsd, 2, en_US]

Figure 6-309 Double Busbar with Capacitor Bank

Connecting Measuring Points to Capacitor Bank Function Group

Figure 6-310 shows the connection of the function group **Capacitor bank** with several measuring points in DIGSI. The ID of each measuring point appears in the bracket after the name.



[scconnection, 1, en_US]

Figure 6-310 Connecting the Measuring Points with the Capacitor Bank Function Group

There are consistency checks that validate the connections of voltage measuring points to the function group:

- The connection type must be identical for all measuring points connected to the same interface of the function group.
- The rated voltage (primary and secondary) must be identical for all measuring points connected to the same interface.
- If more than 1 measuring point is connected to one voltage interface, a function block must be added to enable the selection of the voltage measuring points.

6.48.3 Application and Setting Notes

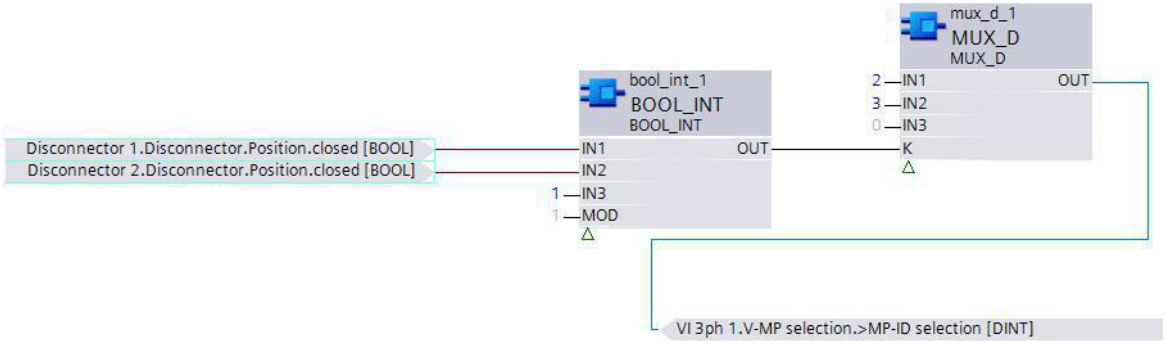
CFC Control

The voltage measuring point is selected by logic block chart on basis of the measuring point IDs. If more than one measuring point is connected to the interface of the function group, instantiate the function block **Voltage measuring-point selection** from the library in the corresponding function group.

In order to ensure the correct measuring-point connection for the function group, a logic block chart has to define the actual valid IDs for the input *>MP-ID selection* of the function block.

The following logic block chart implementation is based on the example given in *Figure 6-309*.

If the Disconnector 1 (QB1) is closed and no matter what the position the Disconnector 2 (QB2) is, the value 2 is the output of CFC block **mux_d_1** and transferred to the input *>MP-ID selection*. Then, the **Meas.point V-3ph** with ID 2 is selected as the reference voltage. Similarly, the **Meas.point V-3ph** with ID 3 is selected as the reference voltage if the Disconnector 1 (QB1) is not closed (open or in intermediate position) while Disconnector 2 (QB2) is closed.



[SclocfcVP, 1, --_--]

Figure 6-311 Logic Block Chart: Voltage Selection Using Measuring Point ID

However, the disconnectors might be both open or in a transient state. In this case, the input IN3 of the block **bool_int_1** becomes true, the value 0 is used as the ID for voltage selection input (*>MP-ID selection*). If ID 0 is selected, then all voltage values of the respective function-group interface are set to 0 V immediately. An alarm indication *Selection invalid* is issued and the indication *Health* is issued as ***OK***. In case you want to supply the function group with voltage values under the condition that both disconnectors are open or in transient state from one or the other busbar, you can alter the CFC chart respectively.

NOTE

An invalid measuring-point selection (ID < 0 or an ID of a unconnected measuring point) for input *>MP-ID selection* results in the following:

- The voltage measured values are displayed as **failure**.
- The validity of the voltage measured values is set to **invalid**.
- The indication *Health* is set to ***Alarm***.
- The indication *Selection invalid* becomes true.

6.48.4 Information List

No.	Information	Data Class (Type)	Type
V-MP selection			
_:501	V-MP selection:>MP-ID selection	INS	I
_:53	V-MP selection:Health	ENS	O
_:301	V-MP selection:Selection invalid	SPS	O

7 Capacitor Bank Protection

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7.1 Introduction

Capacitors and capacitor banks are used for various applications. Examples are:

- Reactive-power compensation for voltage stabilization
- Fast voltage- and reactive-power control
- Filter circuits for the elimination of certain frequencies

Capacitor banks for transmission systems are complex systems customized for the special application. The design depends much on the used switching technology (for example, mechanically or via thyristor). In detail hardly one capacitor bank resembles another. However, a capacitor bank consists always of the same components (C, R, L, and switches). A capacitor bank often consists of several subcomponents which are connected to the capacitor-bank busbar via the circuit breakers.

The modularity of hardware and protection functionality allows to tailor the protection device exactly to the needs of the capacitor bank or the subcomponent of the capacitor bank and to realize the complete protection of the whole capacitor bank or the capacitor- bank subcomponent with only one 7SJ8 device.

Capacitor banks require the use of extensive protection functionality. The protection consists of standard protection functions and specific capacitor protection functions. The following topics are described in the next chapters:

- Extensions on standard protection functions for optimal utilization in a capacitor bank
- Specific capacitor protection functions
- Application of standard protection functions for specific protection tasks within a capacitor bank

7.2 Overcurrent Protection for Capacitor Banks

7.2.1 Overview

You can use the following overcurrent protection function types in the **Capacitor Bank** function group:

- **Overcurrent protection, phases** with phase-segregated operate indications for short-circuit protection in the area between the busbar and the capacitor and for protecting against overload of a subbank.
- **Overcurrent protection, phases** for protection against overload of RLC filter circuit elements (**Overcurrent -3ph RLC**)
- **Overcurrent protection, ground** as protection or backup protection in the event of ground faults

Figure 5-15 in Chapter *5.4.2 Structure of the Function Group* shows

- The standard protection functions that you can use in the **Capacitor Bank** function group.
- The specific protection functions that are available for protecting a capacitor bank.
- The assignment of protection functions to the interfaces of the function group.

Figure 5-13 in Chapter *5.4.2 Structure of the Function Group* shows the assignment of the interfaces in the **Capacitor Bank** function group to the measuring points of the device with reference to an example.



NOTE

The structure of the function **Overcurrent protection, Phases for protecting RLC elements of a filter circuit** differs only slightly from the standard function **Overcurrent protection, Phases – Advanced**.

In this chapter, only the differences between this and the standard function are described.

For more information, please refer to the function description **Overcurrent protection, Phases** starting from Chapter *6.3.1 Overview of Functions* .



NOTE

Starting from V07.30, the function type **50/51 OC-3ph 1p** is no longer offered in the DIGSI 5 global library in the function group **Capacitor bank**. Instead you can use now the standard advanced overcurrent function **Overcurrent protection, phases – advanced** to apply phase-segregated operate indications.

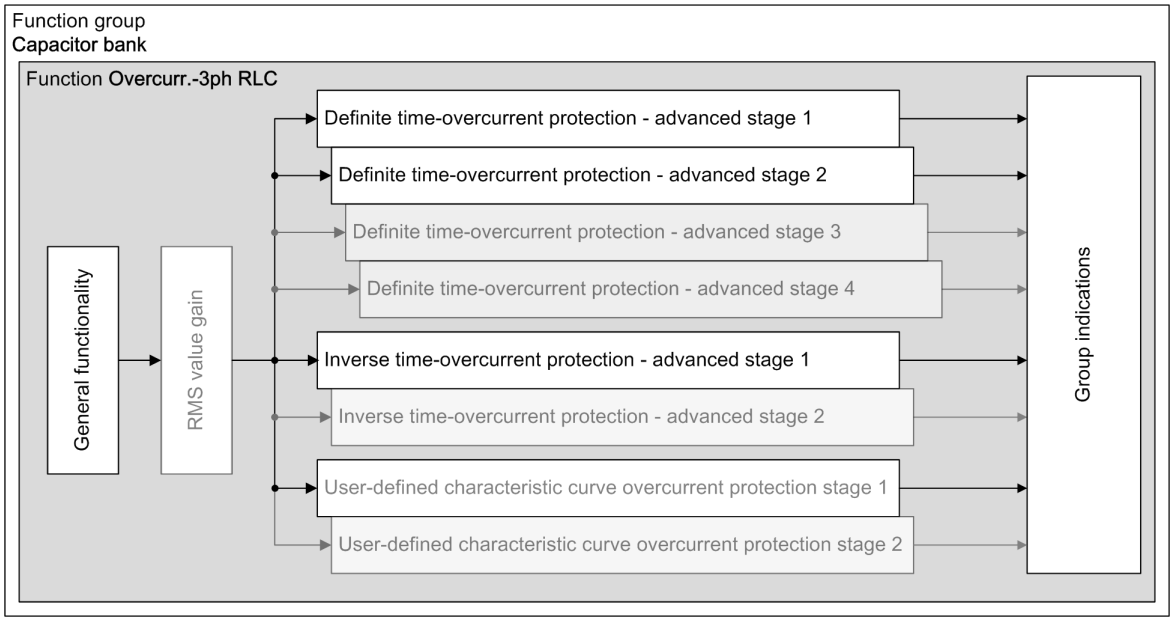
7.2.2 Overcurrent Protection, Phases for Protection of RLC Filter-Circuit Elements

7.2.2.1 Structure of the Function

In the **Capacitor Bank** function group, the **Overcurrent protection, Phases for protecting RLC filter circuit elements** function (**Overcurr. -3ph RLC**) is based on the standard protection function **Overcurrent protection, Phases – Advanced**.

The **Overcurrent protection, Phases for protecting RLC filter circuit elements** function differs from the standard protection function as follows:

- Superordinate measuring point selection
- Setting the rated current of the protected object (for example, reactor or resistor) within the function
- Measured function values of connected phase currents



[dwocpRLC-190813-01.vsd, 2, en_US]

Figure 7-1 Structure/Embedding of the Overc. -3-Ph RLC Function

7.2.2.2 Description

A feature of the **Overcurrent -3ph RLC** function is the **selection of measuring points**. A capacitor bank can include multiple filter circuits. Each filter can include, for example, a 3-phase current measurement device, each of which is assigned a measuring point. In order to protect the filter circuits, multiple instances of the **Overcurrent -3ph RLC** function can be created. Each instance of the function is assigned to a measuring point via **Measuring point selection**.

The function is structured such that the **Measuring point selection** is superordinate to the advanced overcurrent-protection stages.

Measuring-Point Selection

With the **`MP selection`** parameter, you can select from a list of measuring points a measuring point that is connected to the **I 3ph RLC** interface in the **Capacitor Bank** function group. The **Overcurrent -3ph RLC** function processes the current that is connected to the measuring point.

For more information, refer to the description of the **Capacitor Bank** function group starting from chapter *5.4.1 Overview*.

Rated Current of the Protected Object

The rated current for the whole capacitor bank is set in the **Capacitor Bank** function group. However, the capacitor bank rated current does not apply for individual reactors or resistors used within a capacitor-bank installation. Such reactors or resistors require an individual rated current setting.

Functional Measured Values

The function provides the connected phase currents as measured function values for display, further processing or transmission to a station.

Values	Description	Primary	Secondary	% Referenced to
Iph:A Iph:B Iph:C	Phase current of measuring point	kA	A	% referenced to parameter **RLC rated current**

You can find the parameter **RLC Rated current** in the function block **General** of the **Overcurrent -3ph RLC** function.

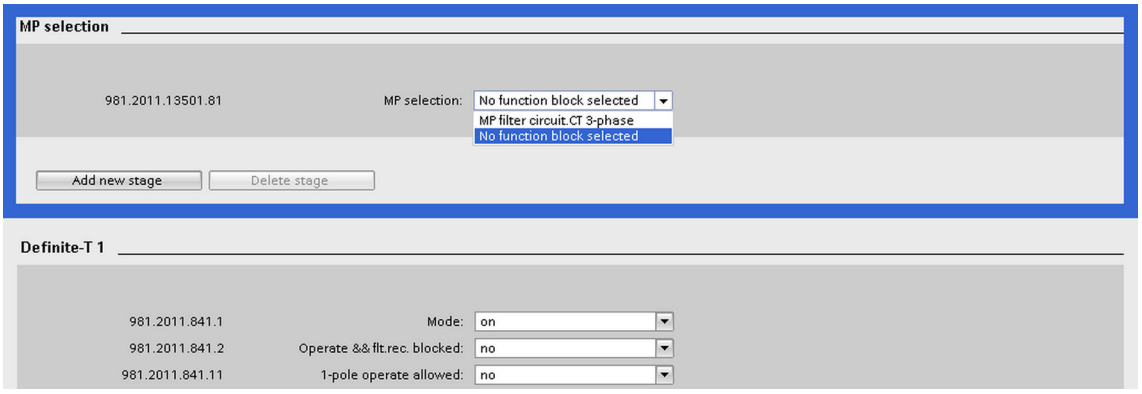
7.2.2.3 Application and Setting Notes

Parameter: MP selection

- Default setting **(_:13501) MP selection** = ***No meas. point config.***

With the **MP selection** parameter, you can select a measuring point that is connected to the **I 3ph RLC** interface in the **Capacitor Bank** function group.

The selection list displays the measuring points that are connected to the **I 3ph RLC** interface of the **Capacitor Bank** function group:

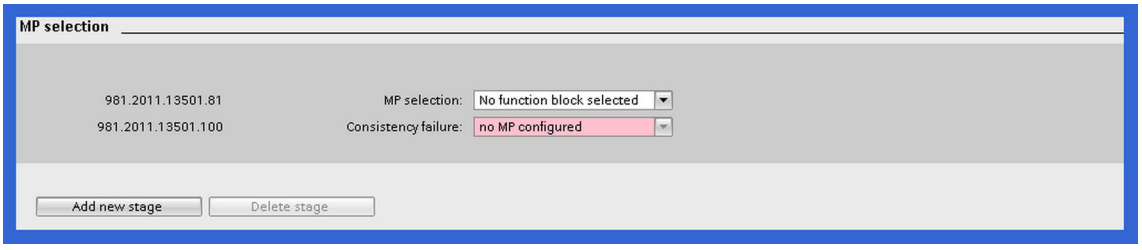


[scmpselection_ocp_rlc-150813, 2, en_US]

Figure 7-2 Example of Measuring-Point Selection

The **MP selection** parameter is set for all stages. The setting applies equally to all stages of the function.

In the default setting, a measuring point is not selected. You must select a measuring point. If you do not select a measuring point, an inconsistency is indicated via the read-only parameter **Consistency failure**:



[scinconsistency_ocp_rlc-150813, 2, en_US]

Figure 7-3 Function Inconsistency Indication

Parameter: RLC Rated Current

- Default setting **(_:2311:101) RLC rated current** = ***1000 A***

The parameter **RLC rated current** is used to set the primary rated current of the respective protected object which is usually a reactor or resistor branch within the capacitor bank installation. The **RLC rated current** specified here is the reference value for the percentage-measured values and setting values made in percentages.

7.3 Thermal Overload Protection for Capacitor Banks

7.3.1 Overview of Functions

The function **Overload RLC** protects RLC filter circuit elements in a capacitor bank from thermal overload.

NOTE

The structure of the function **Overload RLC** differs only slightly from that of the standard **Thermal overload protection, 3-phase** function. In this chapter, only the differences between these and the standard function are described.

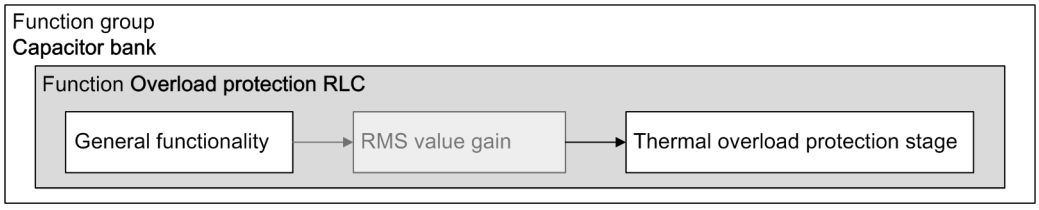
For more information, refer to the function description **Thermal overload protection, 3-phase** starting from chapter *6.19.1 Overview of Functions* .

7.3.2 Structure of the Function

The function **Overload protection RLC** is used in the **Capacitor bank** function group.

The **General functionality** differs from the standard **Thermal overload protection** function and consists of:

- Measuring-point selection
- Setting the rated current of the protected object (for example, reactor or resistor) within the function



[dwtolp_rlc-200813, 2, en_US]

Figure 7-4 Structure/Embedding of the Function

7.3.3 Description

A feature of the function **Overload RLC** is the **measuring-point selection**. A capacitor bank can include multiple filter circuits. Each filter can include, for example, a 3-phase current measurement device, each of which is assigned a measuring point. In order to protect all filter circuits, multiple instances of the function **Overload RLC** can be created. Each instance of the function is assigned to a measuring point via **measuring-point selection**.

The function is structured such that the **measuring-point selection** is superordinate to the **Thermal overload protection**.

Measuring-Point Selection

With the parameter **`MP selection`**, you can select from a list of measuring points a measuring point that is connected to the **I 3ph RLC** interface in the **Capacitor bank** function group. The function **Overload RLC** processes the current that is connected to the measuring point.

For more information, refer to the description of the **Capacitor bank** function group starting from Chapter *5.4.1 Overview* .

Rated Current of the Protected Object

The rated current for the whole capacitor bank is set in the **Capacitor Bank** function group. However, the capacitor bank rated current does not apply for individual reactors or resistors used within a capacitor bank installation. Such reactors or resistors require an individual rated current setting.

Function Values

Measured Values	Description	Primary	Secondary	% Referred to
(_:601:304) Time until close	Time until close	s	s	s
(_:601:305) Time until trip	Estimated time until trip	s	s	s
(_:601:306) Overload phase A	Thermal measured values of phases	%	%	Trip temperature
(_:601:307) Overload phase B				
(_:601:308) Overload phase C				
(_:601:309) Overload maximum	Thermal measured values of overload protection	%	%	Trip temperature
(_:601:310) Equival. current phs A	Current measured value as base for overload measured value	A	A	Parameter **RLC rated current**
(_:601:311) Equival. current phs B				
(_:601:312) Equival. current phs C				
(_:601:313) Equival. current max.	Maximum current measured value as base for overload value	A	A	Parameter **RLC rated current**

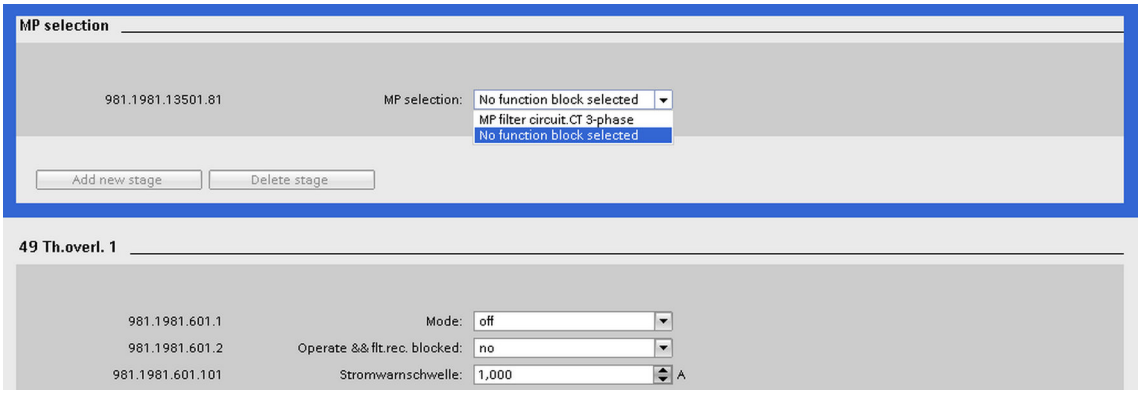
7.3.4 Application and Setting Notes

Parameter: MP selection

- Default setting **(_:13501) MP selection** = ***no MP configured***

With the **MP selection** parameter, you can select a measuring point that is connected to the **I 3ph RLC** interface in the **Capacitor bank** function group.

The selection list displays the measuring points that are connected to the **I 3ph RLC** interface of the **Capacitor bank** function group:

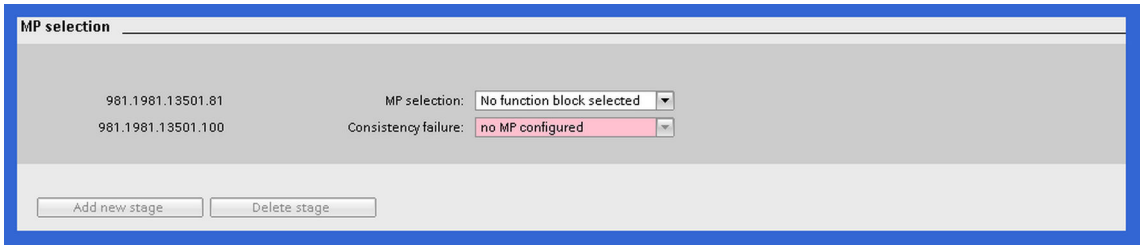


[scmpselection_tolp_rlc-150813, 2, en_US]

Figure 7-5 Example of Measuring-Point Selection

The **MP selection** parameter is set for all stages. The setting applies equally to all stages of the function.

In the default setting, a measuring point is not selected. You must select a measuring point. If you do not select a measuring point, an inconsistency is indicated via the read-only parameter **Consistency failure** :



[scinconsistency_tolp_rlc-150813, 2, en_US]

Figure 7-6 Function Inconsistency Indication

Parameter: RLC rated current

- Default setting **`RLC rated current`** = ***`1000 A`***

The parameter **`RLC rated current`** is used to set the primary rated current of the respective protected object which is usually a reactor or resistor branch within the capacitor bank installation. The setting is used as $I_{rated, obj}$ for the nominalization calculation within the thermal model.

7.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:101	General:RLC rated current		1 A to 100000 A	1000 A
`MP selection`				
_:13501:100	MP selection:Consistency failure		• no MP configured • no Sensor configured	no MP config-ured
_:13501:81	MP selection:MP selec-tion		Setting options depend on configuration	

7.3.6 Information List

No.	Information	Data Class (Type)	Type
`MP selection`			
_:13501:301	MP selection:Iph	WYE	O

7.4 Current-Unbalance Protection for Capacitors, 3-Phase

7.4.1 Overview of Functions

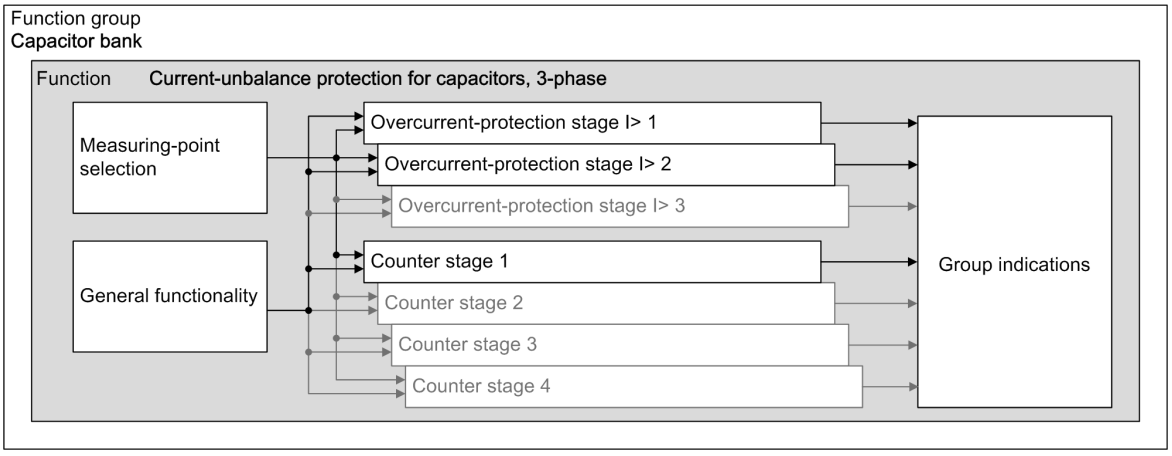
The **Current-unbalance protection for capacitors, 3-phase** function (ANSI 60C):

- Protects in case of capacitor elements (C-elements) faults of a capacitor bank in H connection
- Provides very sensitive supervision of the unbalanced current between the 2-star points
- Allows counting of individual faulty C-elements

7.4.2 Structure of the Function

The **Current-unbalance protection for capacitors, 3-phase** function is used in the **Capacitor bank** function group. It is preconfigured at the factory with 2 overcurrent-protection stages **I>** and one stage of the type **Counter**. A maximum of 3 overcurrent-protection stages and 4 counter stages can be operated simultaneously in the function.

The function is designed so that the **General functionality** (including compensation) and the **Measuring-point selection** can work across the stages.



[dwocplunbalanced-300813, 4, en_US]

Figure 7-7 Structure/Embedding of the Function

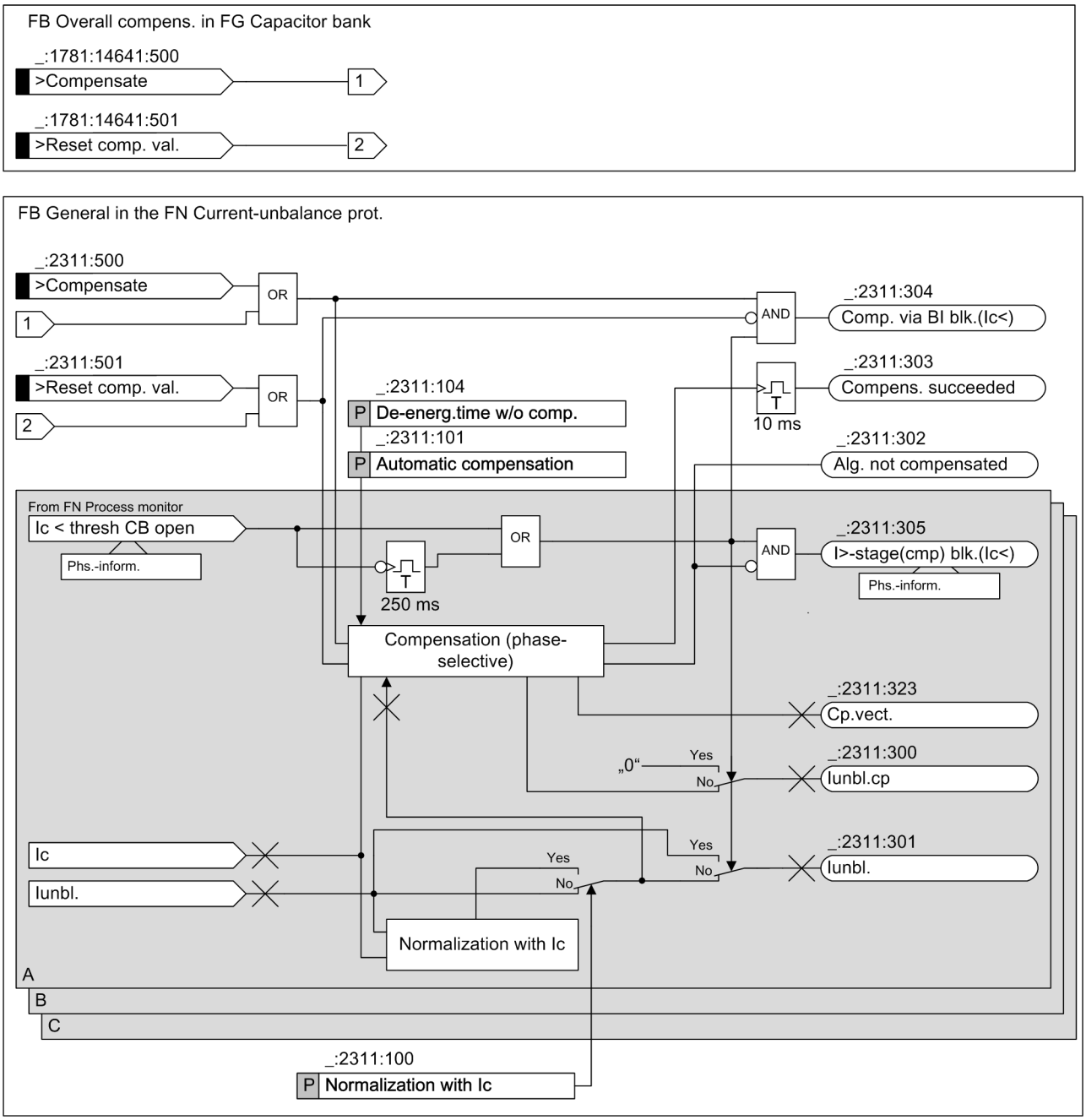
7.4.3 General Functions and Measuring-Point Selection

7.4.3.1 Description

The General functionality is structured in the following functional parts:

- Compensation of the unbalance
- Normalization of the unbalanced current with the current I_c
- Counting faulty C-elements (the stage type **Counter** is used to monitor the counter status)

Logic for Compensation and Normalization



[lo_FBallg_iunbal-020913.tif, 3, en_US]

Figure 7-8 Cross-Stage Functionality

Measuring-Point Selection

With the **`MP selection`** parameter, you can select from a list of measuring points a measuring point that is connected to the **I Unbalanced** interface in the **Capacitor bank** function group. The **Current-unbalance protection for capacitors, 3-phase** function processes the current that is connected to the measuring point.

For more information, refer to the description of the **Capacitor bank** function group starting from chapter *5.4.1 Overview* .

Measurands, Method of Measurement

The function receives its measurands via the **I Unbalanced** interface of the **Capacitor bank** function group.

The compensated and non-compensated unbalanced currents are provided for the overcurrent-protection stage. Within the protection stage, one of the 2 values is selected in the protection stage via the parameter **Measured value**. Both values are available as functional measured values (see *Figure 7-8*).

Configure across the stages whether the unbalanced current must be normalized with the current I_c that flows into the capacitor bank. You can find more information in this chapter under *Normalization with I_c , Page 926* .

The method of measurement used processes the sampled unbalanced-current values and filters out the fundamental component numerically. The protection stages evaluate the fundamental component of the unbalanced current.

General Notes on the Compensation

An operational unbalanced current is added to an unbalanced current resulting from faulty capacitor elements. This corrupts the measuring result.

Operational unbalanced currents can result from the following causes:

- Manufacturing tolerances of the capacitor
- Aging of the capacitor
- Environmental influences, for example, temperature

The compensation eliminates operational unbalanced currents by calculation. For this purpose, the phasor of the operational unbalanced current $\underline{I}_{unbal.,op.}$ is stored at specific times. The stored phasor (compensation phasor), is subtracted from the actually measured unbalanced-current phasor:

$$\underline{I}_{unbal.,comp.} = \underline{I}_{unbal.} - \underline{I}_{unbal.,op.}$$

[fo_compensatied unbal., 1, en_US]

The following indications describe the status of the compensation:

Indication	Description
Alg. not compensated	The algorithm is not compensated. The compensated values are not available under the following conditions: • After initial startup of the device before any compensation is carried out • After activating the binary input *>Reset comp. val.* • After change of $I_{rated,obj}$ Protection stages that are working with compensated values are inactive.
Compens. succeeded	This indication is issued (as transient indication with a pulse duration of 10 ms) if the existing unbalance has been compensated manually or automatically. In case of automatic compensation, the signal is issued at each event-based situation where full compensation is carried out.
Comp. via BI blk.(Ic<)	If a manual compensation has been initiated and the current I_c (current flowing into the capacitor bank) at this time is less than the threshold **Current threshold CB open**, the manual compensation is not executed. This is signaled via the *Comp. via BI blk.(Ic<)* indication.

2 different methods are available for the compensation:

- Manual compensation via binary input signals
- Automatic compensation

Manual Compensation via Binary Input Signal

If the binary input signal *>Compensate* is activated, the manual compensation starts. This will fully compensate any unbalance that exists at this time. This means the value $\underline{I}_{unbal.,comp.}$ will then become 0. You can also use the manual compensation in parallel with the automatic compensation.

Automatic Compensation

When using the parameter **Automatic compensation** , this automatic compensation function can be enabled or disabled.

The automatic compensation consists of 2 different mechanisms:

- The event-based compensation of any existing unbalance.
  This compensation is performed in the following situations:
  - After energizing the capacitor bank or a phase of the bank (phase-selective compensation)
  - After counting a faulty C-element (phase-selective compensation)
  - After each startup of the device
  - After specific parameter changes:
    - Switching on the automatic compensation
    - Changing the rated current of the capacitor bank

  In order to avoid transient inrush-current effects, the compensation is delayed by 250 ms after energizing has been detected.
  Full compensation after bank energization can be avoided in case of only short de-energization by means of parameter **De-energ.time w/o comp.**. If the de-energized duration is less than the setting of parameter **De-energ.time w/o comp.**, the full compensation is not carried out after energizing a phase or the whole bank.
- Cyclic, slow and thus gradual compensation of an existing unbalance in small increments.
  This permits, for example, the automatic compensation of environmental influences.

Resetting the Compensation

The algorithm can be reset to the non-compensated status. Compensated values are not available in this case. Protection stages that work with compensated values are rendered inactive. The binary input signal *>Reset comp. val.* of the function or function group resets the compensation (see also *Figure 7-8*).



NOTE

When operating with manual compensation, changing the value of parameter **capacitor reference current** will reset the compensation values.

Normalization with I_c

The threshold for the unbalanced current is usually set by assuming the rated capacitor current $I_{c,rated}$. The current I_c flowing into the capacitor bank determines the amount of the unbalanced current. A lower I_c also means a lower unbalanced current. If $I_c < I_{c,rated}$, the protection becomes less sensitive. This influence can be compensated via the normalization. Normalization keeps the sensitivity of the protection function constant by normalizing the unbalance value with the current I_c. When using the parameter **Normalization with Ic** , normalization is enabled or disabled.

I_c Lower than Current Thresh.CB Open

If the current I_c is lower than the threshold **Current Thresh.CB Open**, the compensated value can no longer be computed with sufficient accuracy. To avoid a malfunction, the compensated unbalanced value $I_{unbal.,comp.}$ is set to 0 A in a phase-segregated way (see *Figure 7-8*). This deactivates the affected phase measuring components of the protection stages that work with compensated values.

This condition will be indicated in a phase-segregated manner (indication *I>-stage(cmp) blk.(Ic<)*). In this case, normalization with current I_c will no longer work properly either. The normalization is canceled in a phase-segregated manner. This means that the non-normalized value is used in place of the normalized value (see *Figure 7-8*).

Charging/Energizing the Capacitor Bank or a Phase of the Bank

Charging of the bank takes place when the discharged bank is switched on to the network. Charging of a phase can occur in case of network faults. If a phase-to-ground voltage drops to 0 V due to a network fault, the respective phase is discharged and the return of the phase-to-ground (after the fault has been cleared) will charge the phase.

Charging the bank or a phase of the bank causes inrush currents in the respective phases. To avoid overfunction in case of sensitive threshold settings, the stages using compensated unbalanced values are blocked in a phase-selective way by setting $\underline{I}_{unbal.,comp.}$ to 0 A. These stages are:

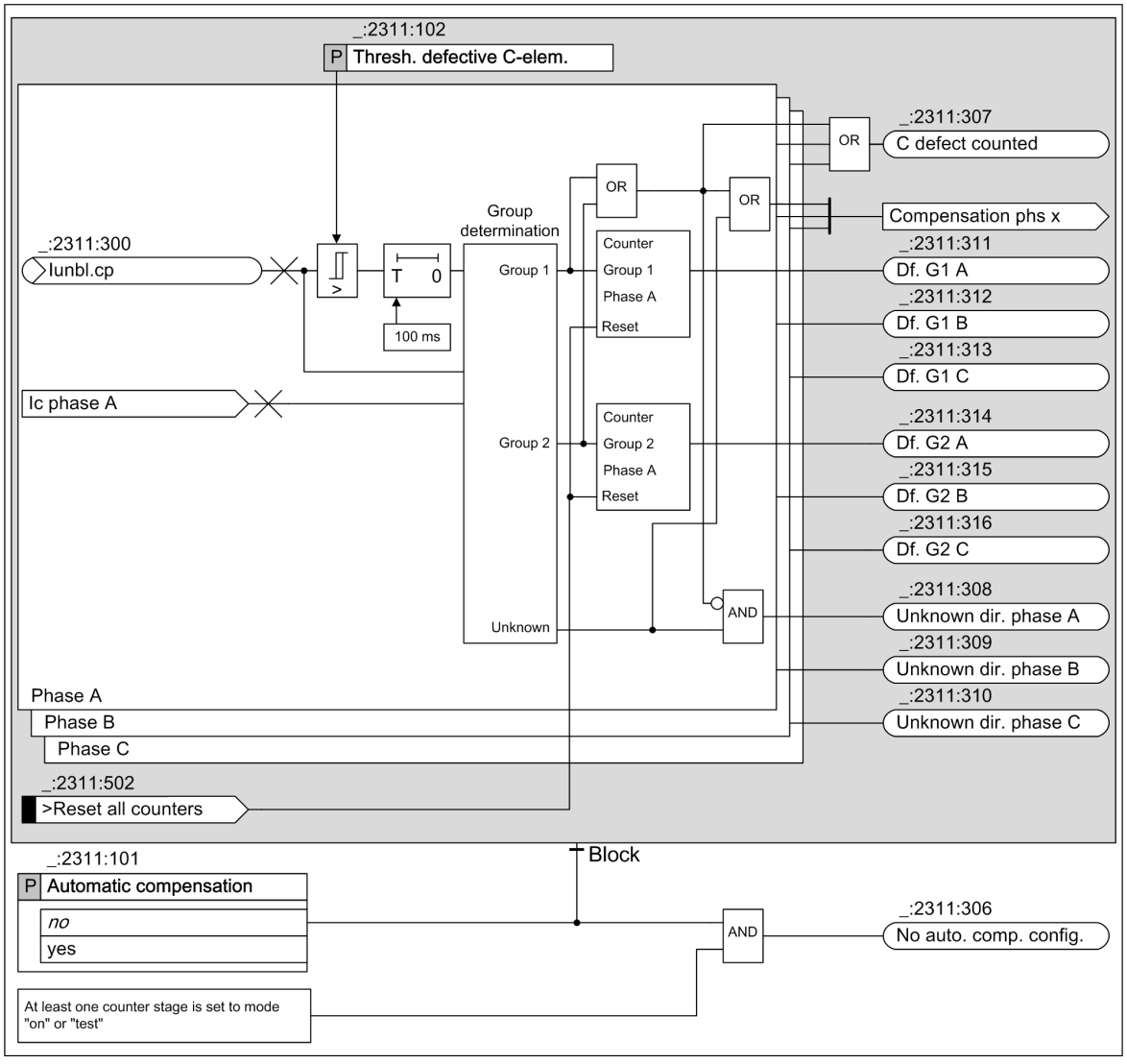
- Counter stage
- I> stage, if set to operate with compensated unbalanced values

The blocking ($\underline{I}_{unbal.,comp.}$ set to 0 A) lasts for 250 ms after energizing detection. Afterwards, the calculated $\underline{I}_{unbal.,comp.}$ is processed again.

Energizing detection takes place in a phase-selective way by monitoring the phase current I_c flowing into the bank. If a phase current exceeds the threshold **`Current Thresh.CB Open`**, energizing in this phase is detected.

Logic for Counting Faulty C-Elements

This part of the General functionality is only important if counter stages are used.



[lo-cnt-EF-260314-01, 3, en_US]

Figure 7-9 Counting Faulty C-Elements

Activation/Blocking Counting

If at least one counter stage is enabled, the counter function is active. Furthermore, the counter function works only if the automatic compensation is enabled.

In order to prevent counting as a consequence of the charging process, the counter function is implicitly blocked for 250 ms by setting $I_{unbal.,comp.}$ to 0 A, after the capacitor energizing has been detected.

Measurands, Counting

The measurand is the phase-selective compensated unbalanced current $I_{unbal.,comp.}$. If a single C-element is faulty, an unbalance occurs in the H connection. This unbalance causes an unbalanced current; this means, a small current jump is generated in the unbalanced current. Set the parameter **`Thresh. defective C-elem.`**, so that the current jump can be detected (refer also to *7.4.3.2 Application and Setting Notes*). The unbalanced current that was caused by the fault must exceed the threshold for 100 ms before the affected group is determined and counting (incrementing the counter) takes place. There is one counter for each phase and group. After the counting, the existing unbalance is compensated; this means, the unbalance is reset to 0 A. If the faulty group cannot be determined, the unbalance is also compensated.

Resetting/Setting the Counters

You can reset or set the counters of group 1 and group 2 via:

- On-site operation panel directly on the device
- Online DIGSI connection to the device
- Binary input *>Reset all counters* (only reset of all counters)
- Communication connection with the control center

You can directly set or reset the counters via IEC 61850 by setting the counter values to the desired value. If you want to reset the counters via DNP3, IEC 60870-5-103, Modbus, or IEC 60870-5-104, an additional configuration with CFC is necessary. For more information, refer to chapter *7.4.3.2 Application and Setting Notes*.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:2311:300) Iunbl.cp	Compensated unbalanced current $\underline{I}_{unbal.,comp.}$	kA	A	Parameter **Rated primary current**
(_:2311:301) Iunbl.	Non-compensated unbalanced current $\underline{I}_{unbal.}$	kA	A	Parameter **Rated primary current**
(_:2311:323) Cp.vect.	Compensation vector $\underline{I}_{comp.,vect.}$	kA	A	Parameter **Rated primary current**

You can find the value of the parameter **Rated primary current** of the preceding table in the chapter *6.1.6 Settings* according to the specified parameter **MP selection**.

$\underline{I}_{comp.,vect.}$ is normalized with I_c. The normalization is carried out no matter if the parameter **Normalization with Ic** is set to ***yes*** or ***no***. $\underline{I}_{comp.,vect.}$ keeps its value unchanged until the next compensation occurs.

$$\underline{I}_{comp.,\,vect.} = \underline{I}_{unbal.\,op.}\frac{I_{c,rated}}{I_c}$$

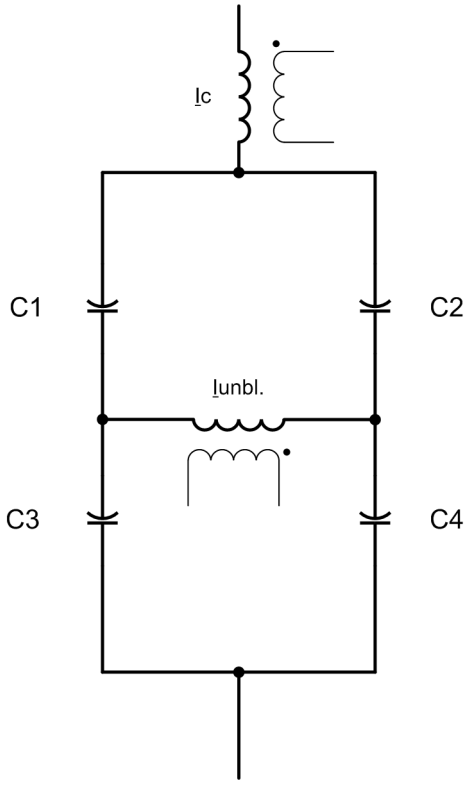
[fo_compensation vector, 1, en_US]

Where:

$\underline{I}_{unbal.op.}$	Operational unbalanced current at the moment the compensation is carried out
$I_{c,rated}$	Rated current of the capacitor bank
I_c	Current of the capacitor bank at the moment the compensation is carried out

Definition of the Group and Fault Location with the Capacitor in H Connection

If the capacitor is designed in an H connection, the following definition is assumed:



[dwfehlerortinf_iunsy-020913, 1, en_US]

Figure 7-10 Definition of the Fault-Location Information

The black dot indicates the orientation of the current transformer. For the connection of the current transformer shown in the previous figure, the following definition applies:

- Group 1: C1 and C4
- Group 2: C2 and C3

In order to determine the fault location (group 1 or 2) correctly, use the parameter **Capacitor element type** (in FB **General** of the **Capacitor bank** function group) to tell the device whether the elements of the capacitor bank have internal fuses or not.

The angle reference of the unbalanced-current phasor to the reference current I_c is used to determine the direction of the unbalanced current and, thus, the affected group is determined. If the direction cannot be determined with confidence, an appropriate indication will be generated.

7.4.3.2 Application and Setting Notes

Parameter: MP selection

- Default setting **(_:13501:81) MP selection** = ***None***

With the **MP selection** parameter, you can select from a list the measuring point that is connected to the **I Unbalanced** interface of the **Capacitor bank** function group.

The setting applies equally to all stages of the function.

In the default setting, a measuring point is not selected. You must select a measuring point. If you do not select a measuring point, an inconsistency is indicated via the read-only parameter **Consistency failure**.

Parameter: Automatic compensation

- Default setting **(_:2311:101) Automatic compensation** = ***no***

The parameter applies equally to all stages of the function that work with compensated measurands.

If no counter stages are applied, Siemens recommends switching the automatic compensation off and using the manual compensation. You can find more information on this recommendation in chapter *7.4.4.2 Application and Setting Notes* (setting notes for the operate delay of the **I>** stage).

If the counter stages are applied, the automatic compensation must be switched on, otherwise the counting function will not work.

Parameter: `De-energ.time w/o comp.`

- Default setting **`(_:2311:104) De-energ.time w/o comp.`** = ***`2.00 s`***

In case of networks faults, the faulty phases are discharged. With the returning voltage after fault clearance, charging takes place. For such conditions, Siemens recommends that no automatic full compensation takes place in the affected phases. Otherwise, C-element defects occurring in this period (for example, because of discharging stress due to network-fault inception) will not be detected.

With the parameter **`De-energ.time w/o comp.`**, you define the duration of short de-energization after which no automatic compensation takes place. The parameter must be set to a value larger than the slowest fault-clearing time in your network plus a safety margin.

If the setting is set to 0 s, an automatic full compensation is carried out after each energizing detection.

Parameter: `Normalization with Ic`

- Default setting **`(_:2311:100) Normalization with Ic`** = ***`no`***

This parameter applies equally to all stages of the function.

Parameter Value	Description
`no`	Select this setting if you can safely assume that I_c will not change for operational reasons or if you do not desire normalization of the unbalanced current with I_c. Please consider that the protection sensitivity will decrease with decreasing I_c.
`yes`	Select this setting if you want to keep the sensitivity of the protection stages constant during changes of I_c.

Parameter: `Thresh. defective C-elem.`

- Default **`(_:2311:102) Thresh. defective C-elem.`** = ***`0.030 A`***

Set the parameter **`Thresh. defective C-elem.`** to ensure that the jump in the unbalanced current caused by the faulty C-element is detected. Information about occurring unbalanced current as a consequence of single faulty C-elements will be provided by the manufacturer of the capacitor bank. Siemens recommends to set the threshold value to approx. 75 % of the unbalanced current that occurs after the fault of the 1st C-element.

Example 1: Information about the Unbalanced Current Available from the Manufacturer of the Capacitor Bank

Table 7-1 Unbalanced Current, Depending on the Number of Faulty C-Elements

Number of Faulty C-Elements	Primary Unbalanced Current
0	0.00 A
1	0.71 A
2	1.47 A
3	2.29 A
...	...

Assumed current transformer ratio: 10 A/1 A

Primary unbalanced current if 1st C-element fails: 0.71 A

Secondary unbalanced current if 1st C-element fails: 0.071 A

Secondary setting value: 0.75 · 0.071 A = 0.053 A

NOTE

Use sensitive device current inputs in order to apply secondary thresholds of < 30 mA.

If no information is provided by the manufacturer of the capacitor bank, the following example can be used as a basis in order to determine the value.

Example 2 (a to h): Unbalanced-Current Information Not Available from the Manufacturer of the Capacitor Bank, External Capacitor-Bank Structure with Cross-Linked Cans

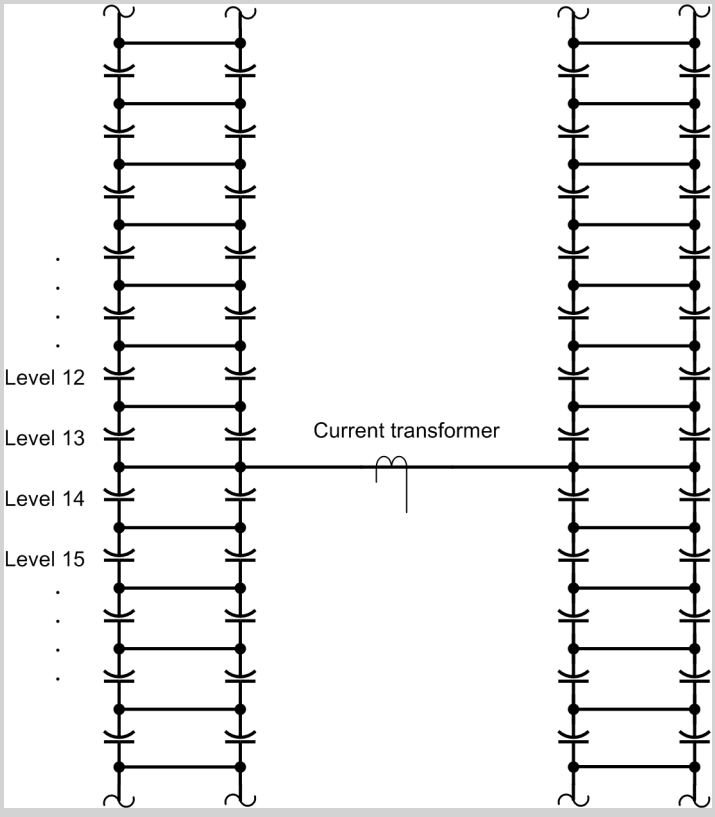
The following consideration applies to one phase.

2a) External Structure of the Capacitor Bank

The external structure of the capacitor bank must be known or must be determined. This information can be requested from the manufacturer of the capacitor bank.

This example assumes the following external structure of the capacitor bank:

- 28 levels (cans) in series
- 4 cans per level
- H transformer between levels 13 and 14, counting from top to bottom
- 2 parallel cans are always cross-linked, refer to the following diagram



[dwexaufbcb-120314-01, 1, en_US]

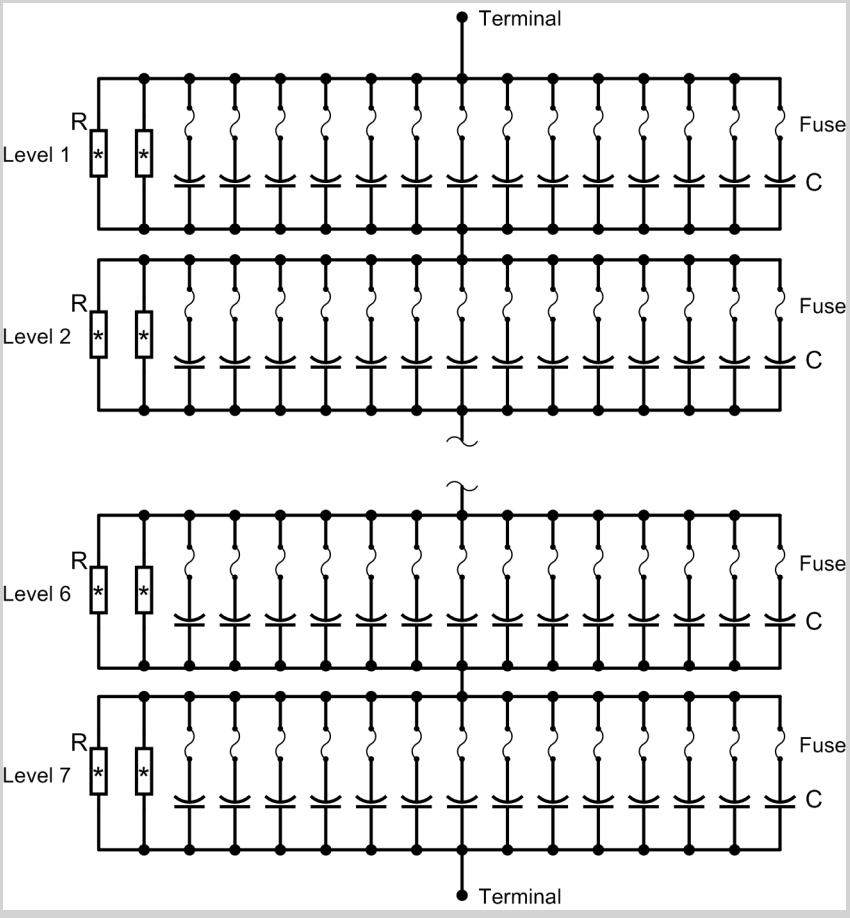
Figure 7-11 External Structure of the Capacitor Bank

2b) Internal Structure of a Can

The internal structure of a can must be known or must be determined. This information can be requested from the manufacturer of the capacitor bank.

This example assumes the following internal structure of the can:

- 14 parallel capacitances
- Internal fuses (one internal fuse per capacitance)
- 7 capacitance levels in series



[dwintauka-120314-01, 2, en_US]

Figure 7-12 Internal Structure of a Can

2c) Capacitance of a Can

The capacitance of a can must be known or must be determined. This information can be requested from the manufacturer of the capacitor bank.

- Capacitance per can: $C_K = 19.67\ \mu F$

2d) Current per Phase

The unbalanced current is derived under the assumption of a certain phase current.

In this example, the phase current is determined using the following assumptions and data:

- 1-phase rated capacitance of the capacitor bank: 2.81 µF
- Phase-to-ground voltage of the fundamental component of the capacitor bank: 249.1 kV
- Current per phase: $I_C = V_{Ph.\ fund.} \cdot \omega C = 249.1\ kV \cdot 2\pi \cdot 50\ Hz \cdot 2.81\ \mu F = 219.9\ A$

2e) Capacitance of a Can during an Element Fault

To do this, the capacitance of an individual C-element will be determined first:

- Capacitance of a C-element:

$$C_E = \frac{C_K}{\text{No. C in parallel}} \cdot \text{No. C in series} = \frac{19.67\ \mu F}{14} \cdot 7 = 9.835\ \mu F$$

- Capacitance of a can during an element fault:

$$\frac{1}{C_{K,1EF}} = \frac{\text{No. C in series without a fault}}{\text{No. C in parallel} \cdot C_E} + \frac{1}{(\text{No. C in parallel} - 1) \cdot C_E}$$

$$\frac{1}{C_{K,1EF}} = \frac{6}{14 \cdot C_E} + \frac{1}{13 \cdot C_E} = \frac{1}{0.051397\ \mu F}$$

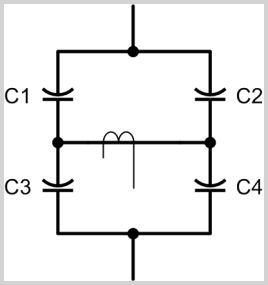
$C_{K,1EF} = 19.456\ \mu F$

2f) Capacitance in the Quarter of the H Connection during an Element Fault

Consider 2 special conditions:

- Cross-linking and therefore the parallel connection of 2 cans, refer to *Figure 7-11*
- Current transformer is not in the center of the levels

Therefore, the following calculation must be performed for the upper (C1) and lower quarter (C3).



[dw4tlkbnk-120314-01, 1, en_US]

Figure 7-13 Quarters of the Capacitor Bank

Based on the cross-linking of the cans, in case of an element fault, the capacitance of the parallel cans must be determined first:

- Capacitance of 2 parallel cans in case of an element fault:

  $C_{2K,1EF} = 19.456\ \mu F + 19.67\ \mu F = 39.126\ \mu F$

  Capacitance in the quarter of C1 in case of an element fault:

$$\frac{1}{C1_{1EF}} = \frac{\text{No. cans in series without a fault}}{2 \cdot C_K} + \frac{1}{C_{2K,1EF}}$$

$$\frac{1}{C1_{1EF}} = \frac{12}{2 \cdot 19.67\ \mu F} + \frac{1}{39.126\ \mu F} = \frac{1}{0.3306\ \mu F}$$

$C1_{1EF} = 3.0249\ \mu F$

- Capacitance in the quarter of C3 in case of an element fault:

$$\frac{1}{C3_{1EF}} = \frac{14}{2 \cdot 19.67\ \mu F} + \frac{1}{39.126\ \mu F} = \frac{1}{0.3814\ \mu F}$$

$C3_{1EF} = 2.6217\ \mu F$

2g) Capacitance in the Quarters of the H Connection without Element Fault

- Capacitance in the quarters of C1 and C3 without element fault:

$$C1 = \frac{2 \cdot C_K}{\text{No. cans in series}} = \frac{2 \cdot 19.67\ \mu F}{13} = 3.026\ \mu F$$

$$C3 = \frac{2 \cdot C_K}{\text{No. cans in series}} = \frac{2 \cdot 19.67\ \mu F}{15} = 2.623\ \mu F$$

2h) Unbalanced Current and Threshold-Value Setting in Case of a C-Element Fault

- Unbalanced current:

$$I_{unbl.} = I_C \left| \frac{C1}{(C1 + C2)} - \frac{C3}{(C3 + C4)} \right|$$

- Unbalanced current in case of an element fault in C1:

$$I_{unbl.} = 219.9\ A \left| \frac{3.0249\ \mu F}{(3.0249\ \mu F + 3.026\ \mu F)} - \frac{3.623\ \mu F}{(3.623\ \mu F + 3.623\ \mu F)} \right| = 20.0\ mA$$

- Unbalanced current in case of an element fault in C3:

$$I_{unbl.} = 219.9\ A \left| \frac{3.026\ \mu F}{(3.026\ \mu F + 3.026\ \mu F)} - \frac{3.6217\ \mu F}{(3.6217\ \mu F + 3.623\ \mu F)} \right| = 27.3\ mA$$

The lesser of both values is relevant for the setting of the threshold value. For instance, set the threshold to 75 % of this value:

- Threshold value (primary): 0.75 · 20.0 mA = 15.0 mA

The threshold is a primary value. In order to detect this, a 1:1 transformer is required. Under this assumption, the secondary setting value is equal to the primary value.

NOTE

Use sensitive device current inputs in order to apply secondary thresholds of < 30 mA.

Example 3 (a to d): Unbalanced-Current Information Not Available from the Manufacturer of the Capacitor Bank, External Capacitor-Bank Structure without Cross-Linked Cans

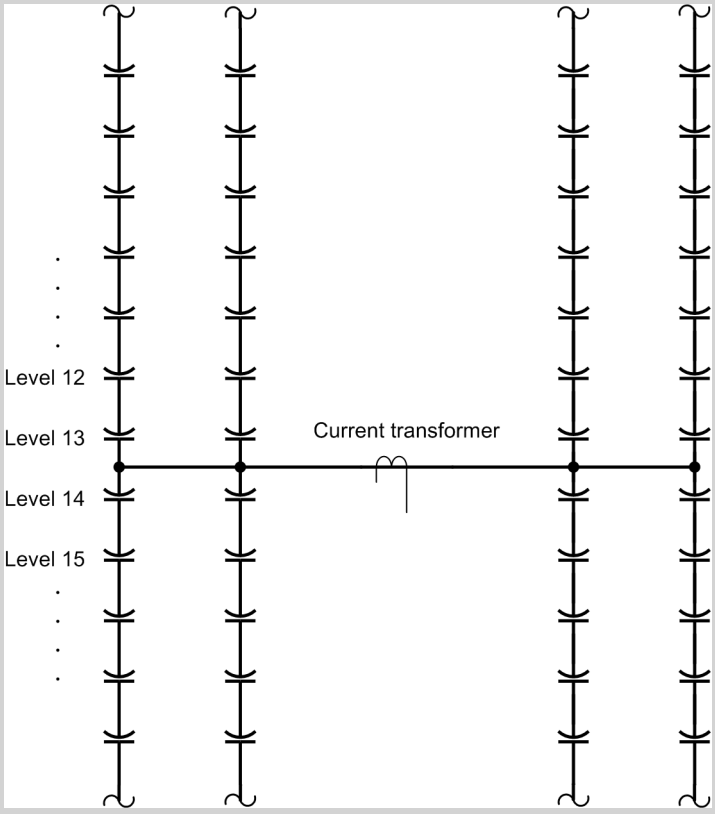
Example 3 is almost identical to example 2. The only difference is that the cans are not cross-linked. Here, only the calculation part is discussed that is a result of the different external structure. Information for additional calculations can be found in example 2.

3a) External Structure of the Capacitor Bank

The external structure of the capacitor bank must be known or must be determined. This information can be requested from the manufacturer of the capacitor bank.

This example assumes the following external structure of the capacitor bank:

- 28 levels (cans) in series
- 4 cans per level
- H transformer between levels 13 and 14, counting from top to bottom
- Parallel cans are not cross-linked, refer to the following diagram

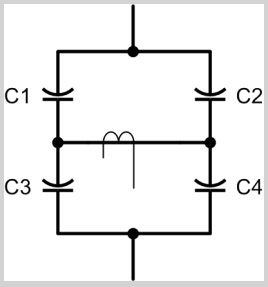


[dwexafbocb-260314-01, 1, en_US]

Figure 7-14 External Structure of the Capacitor Bank

3b) Capacitance in the Quarter of the H Connection during an Element Fault

The current transformer is not located in the center of the levels; therefore, the following calculation for the upper (C1) and the lower quarter (C3) must be performed.



[dw4tlkbnk-120314-01, 1, en_US]

Figure 7-15 Quarters of the Capacitor Bank

- Capacitance in the quarter of C1 in case of an element fault ($C1_{1EF}$):

  Capacitance in the row without element fault:

  $$\frac{1}{C1_{Ro\,EF}} = \frac{\text{No. cans in series}}{C_K} = \frac{13}{19.67\ \mu F}$$

  $C1_{RoEF} = 1.5130\ \mu F$

- Capacitance in the row with element fault:

  $$\frac{1}{C1_{Rm\,EF}} = \frac{\text{No. cans in series without a fault}}{C_K} + \frac{1}{C_{k,1EF}} = \frac{12}{19.67\ \mu F} + \frac{1}{19.456\ \mu F}$$

  $C1_{RmEF} = 1.5118\ \mu F$

  $C1_{1EF} = C1_{RoEF} + C1_{RmEF} = 1.5130\ \mu F + 1.5118\ \mu F = 3.0248\ \mu F$

- Capacitance in the quarter of C3 in case of an element fault ($C3_{1EF}$):

  Capacitance in the row without element fault:

  $$\frac{1}{C3_{Ro\,EF}} = \frac{\text{No. cans in series}}{C_K} = \frac{15}{19.67\ \mu F}$$

  $C3_{RoEF} = 1.3113\ \mu F$

- Capacitance in the row with element fault:

  $$\frac{1}{C3_{Rm\,EF}} = \frac{\text{No. cans in series without a fault}}{C_K} + \frac{1}{C_{k,1EF}} = \frac{14}{19.67\ \mu F} + \frac{1}{19.456\ \mu F}$$

  $C3_{RmEF} = 1.3104\ \mu F$

  $C3_{1EF} = C3_{RoEF} + C3_{RmEF} = 1.3113\ \mu F + 1.3104\ \mu F = 2.6217\ \mu F$

3c) Capacitance in the Quarters of the H Connection without Element Fault

The values are identical to those values in the example *2g) Capacitance in the Quarters of the H Connection without Element Fault, Page 935* .

3d) Unbalanced Current and Threshold-Value Setting in Case of a C-Element Fault

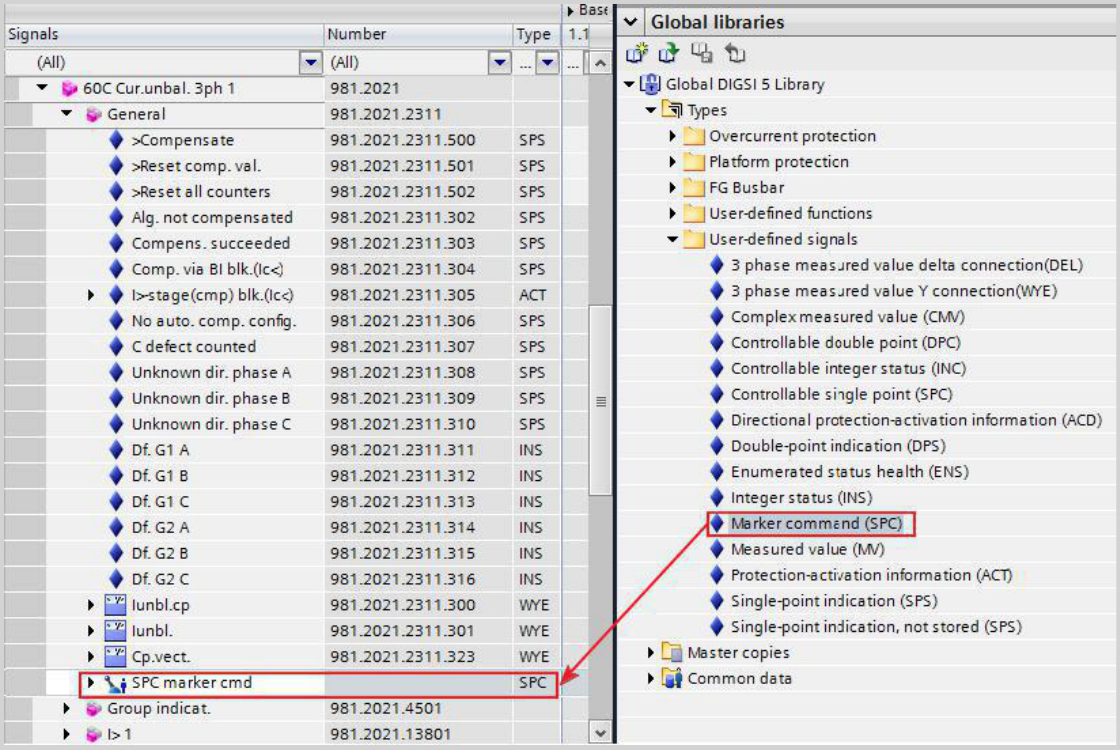
Use the values determined under 3b) for those formula listed in example *2h) Unbalanced Current and Threshold-Value Setting in Case of a C-Element Fault, Page 935* .

Resetting the Counters via Protocols IEC 60870-5-103, IEC 60870-5-104, DNP3, or Modbus

The following example shows how to use a function chart (CFC) to reset the counters with the protocols IEC 60870-5-103, IEC 60870-5-104, DNP3, or Modbus.

EXAMPLE

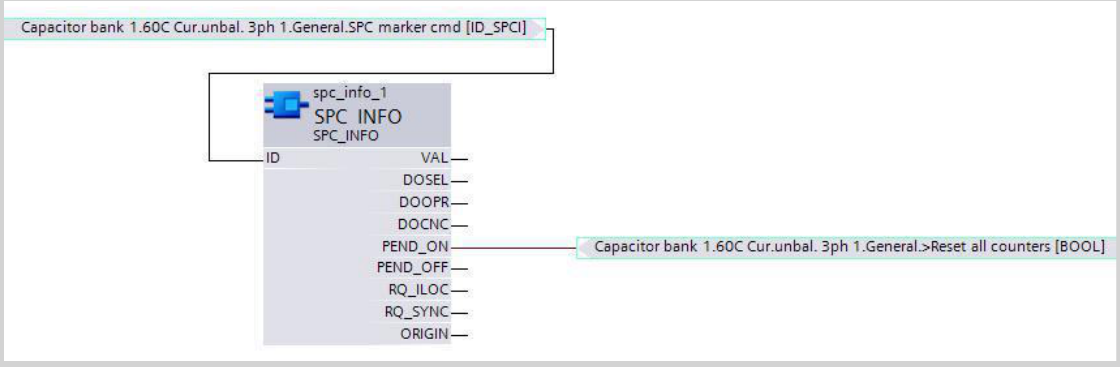
- Add a **Marker command (SPC)** signal to the information list.



[sc_add_SPC_signal, 1, en_US]

Figure 7-16 Adding Marker Command (SPC) Signal to Information List

- Set up the following CFC. Connect the SPC signal as input, and the signal *>Reset all counters* as output.



[sc_CFC_60C_3ph, 1, en_US]

Figure 7-17 Function Chart (CFC): Activating the Binary Input Signal

- Send a single-point control command from the control center to the SPC signal to activate the signal *>Reset all counters*. Then the counters are reset.

7.4.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MP selection				
_:13501:100	MP selection:Consistency failure		• no MP configured • no Sensor configured	no MP configured

Addr.	Parameter	C	Setting Options	Default Setting
_:13501:81	MP selection:MP selection		Setting options depend on configuration	
General				
_:2311:101	General:Automatic compensation		• no • yes	no
_:2311:100	General:Normalization with Ic		• no • yes	no
_:2311:102	General:Thresh. defective C-elem.	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.150 A
_:2311:104	General:De-energ.time w/o comp.		0.00 s to 60.00 s	2.00 s

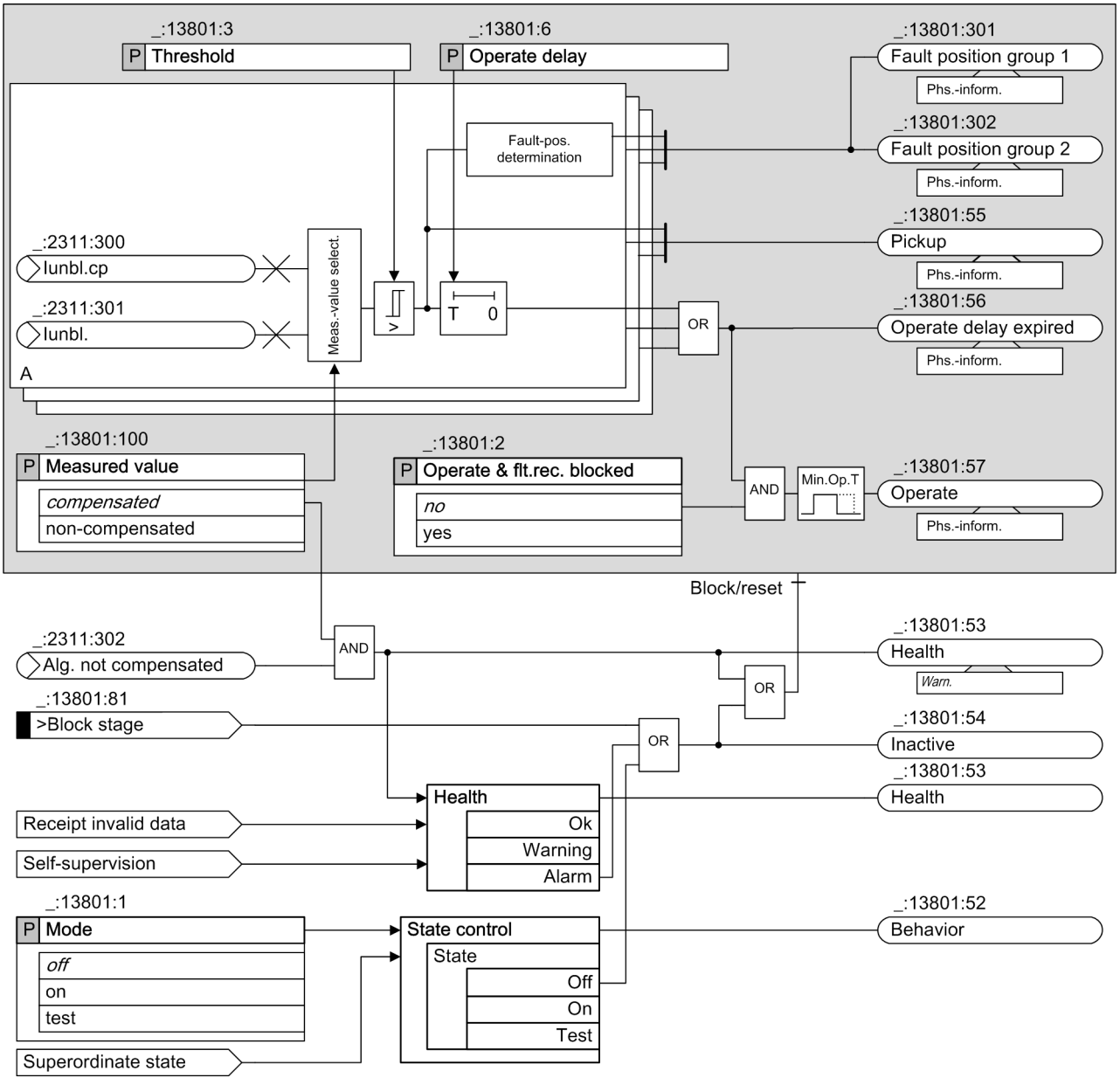
7.4.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
General			
_:2311:500	General:>Compensate	SPS	I
_:2311:501	General:>Reset comp. val.	SPS	I
_:2311:502	General:>Reset all counters	SPS	I
_:2311:302	General:Alg. not compensated	SPS	O
_:2311:303	General:Compens. succeeded	SPS	O
_:2311:304	General:Comp. via BI blk.(Ic<)	SPS	O
_:2311:305	General:I>-stage(cmp) blk.(Ic<)	ACT	O
_:2311:306	General:No auto. comp. config.	SPS	O
_:2311:307	General:C defect counted	SPS	O
_:2311:308	General:Unknown dir. phase A	SPS	O
_:2311:309	General:Unknown dir. phase B	SPS	O
_:2311:310	General:Unknown dir. phase C	SPS	O
_:2311:311	General:Df. G1 A	INS	O
_:2311:312	General:Df. G1 B	INS	O
_:2311:313	General:Df. G1 C	INS	O
_:2311:314	General:Df. G2 A	INS	O
_:2311:315	General:Df. G2 B	INS	O
_:2311:316	General:Df. G2 C	INS	O
_:2311:300	General:Iunbl.cp	WYE	O
_:2311:301	General:Iunbl.	WYE	O
_:2311:323	General:Cp.vect.	WYE	O

7.4.4 Overcurrent-Protection Stage I>

7.4.4.1 Description

Logic of a Stage



[lounbalstufe-020913, 1, en_US]

Figure 7-18 Logic Diagram of the Overcurrent-Protection Stage I>

Measurands

Within the protection stage, the compensated and the non-compensated unbalanced currents are available. Use the parameter **`Measured value`** to select one of the 2 values. Both values are displayed as measured values of the function at the function stage.

Pickup, Tripping Delay

If the selected measurand in one of the phase measuring element exceeds the threshold, the stage picks up. The pickup starts a tripping time delay, and a fault-location information is issued. More information can be found in this chapter under *Fault-Location Information, Page 941* . If the threshold is exceeded during the entire tripping delay, a phase-selective operate indication is issued.

Please note that, when using the compensated measurands as well as the automatic compensation, the currently measured current unbalance (that resulted in the threshold being exceeded) is gradually compensated. This means that even in case of a constantly existing unbalance in the primary system, the compensated measurand becomes gradually lower and may therefore fall below the threshold again at some time. The timing depends on by how much the threshold is exceeded.

For this reason and under those conditions, long time delays must not be set, see also chapter *7.4.4.2 Application and Setting Notes* .

This effect does not occur if manual compensation or the non-compensated measurand is used.

Blocking While Charging

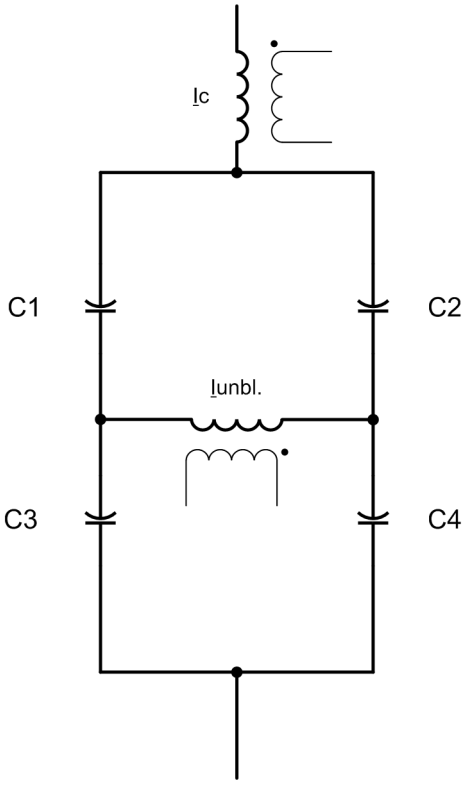
In order to prevent pickup as a consequence of the charging process, the **I>** stage is implicitly blocked in a phase-selective way for 250 ms by setting $I_{unbal.,comp.}$ to 0 A, after capacitor energizing has been detected.

Blocking only takes place if the stage operates with compensated unbalanced values.

Fault-Location Information

When picking up, the stage provides information about the faulty group of the capacitor bank. If the location can be safely determined, the corresponding indication *Fault position group 1* or *Fault position group 2* is issued.

Both indications also contain the information about the faulty phase. If the capacitor is implemented as an H connection, the following definition is assumed:



[dwfehlerortinf_iunsy-020913, 1, en_US]

Figure 7-19 Definition for the Fault-Location Information

The black dot indicates the orientation of the current transformer. For the connection of the current transformer shown in the previous figure, the following definition applies:

- Group 1: C1 and C4
- Group 2: C2 and C3

In order to determine the fault location (group 1 or 2) correctly, use the parameter **Capacitor element type** (in FB **General** of the **Capacitor bank** function group) to tell the device whether the elements of the capacitor bank have internal fuses or not.

Non-Compensated Status

If no compensated values are available and the stage has been set to use such values, the stage will be blocked. The readiness of the stage turns to *Warning*. This condition will be reported on the function stage (indication *Alg. not compensated*).

7.4.4.2 Application and Setting Notes

Parameter: Measured value

- Default setting **(_:13801:100) Measured value** = ***no***

With the parameter, you set the **Measured value**.

Parameter Value	Description
compensated	The stage uses compensated unbalanced values. This means an operational current unbalance will be eliminated. This allows you to significantly increase the sensitivity of the measurement. Note the following: If the current I_c is lower than the threshold **Current threshold CB open**, the affected phase measuring elements are rendered inactive by setting $I_{unbal.,comp.}$ to 0 A. This condition is held for 250 ms after energizing has been detected in order to avoid a pickup as a consequence of the charging process. Siemens recommends using compensated unbalanced values. In case that automatic compensation is applied, please consider the setting notes for the operate delay.
non-compensated	The stage works with non-compensated unbalanced values. This means the measurand may contain an existing operational current unbalance.

Parameter: Threshold

- Default setting **(_:13801:3) Threshold** = ***0.2 A***

Set the parameter **Threshold** for the specific application.

When using compensated unbalanced values, very sensitive settings are possible. When using non-compensated unbalanced values, the threshold must be higher than the maximum operational unbalanced current.

Parameter: Operate delay

- Default setting **(_:13801:6) Operate delay** = ***0.08 s*** (for the 1st stage)

Set the parameter **Operate delay** for the specific application.



NOTE

If the function has been set to automatic compensation and the stage works with compensated values, the maximum permitted operate delay is 80 ms. If the operate delay is set to longer than 80 ms, the automatic compensation might cause dropout of the picked-up stage. This risk does not exist when manual compensation or non-compensated values are used.

7.4.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
I> 1				
_:13801:1	I> 1:Mode		• off • on • test	off
_:13801:2	I> 1:Operate & flt.rec. blocked		• no • yes	no
_:13801:100	I> 1:Measured value		• compensated • non-compensated	compensated
_:13801:3	I> 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.000 A
_:13801:6	I> 1:Operate delay		0.00 s to 60.00 s	0.08 s

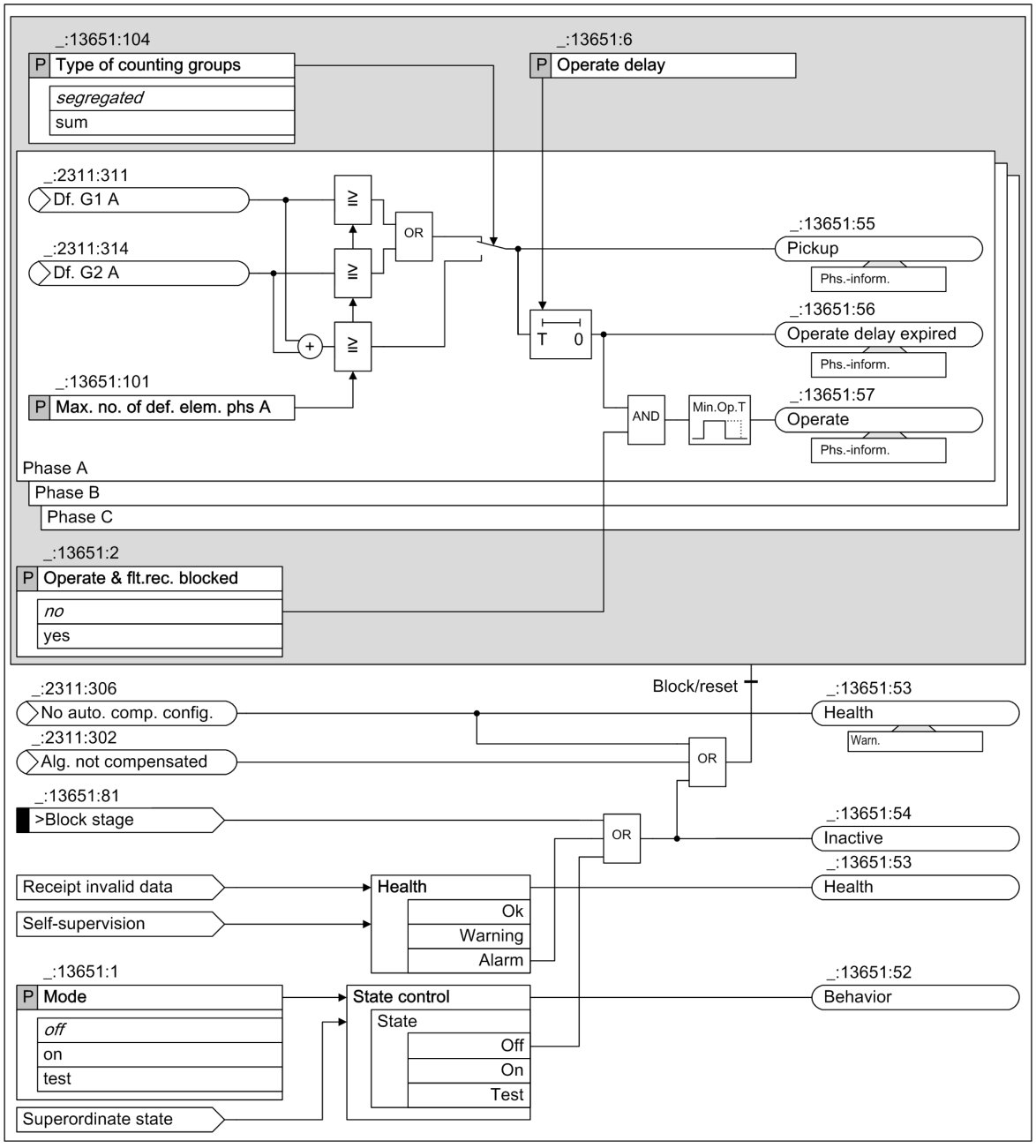
7.4.4.4 Information List

No.	Information	Data Class (Type)	Type
I> 1			
_:13801:81	I> 1:>Block stage	SPS	I
_:13801:54	I> 1:Inactive	SPS	O
_:13801:52	I> 1:Behavior	ENS	O
_:13801:53	I> 1:Health	ENS	O
_:13801:55	I> 1:Pickup	ACD	O
_:13801:56	I> 1:Operate delay expired	ACT	O
_:13801:57	I> 1:Operate	ACT	O
_:13801:301	I> 1:Fault position group 1	ACT	O
_:13801:302	I> 1:Fault position group 2	ACT	O
I> 2			
_:13802:81	I> 2:>Block stage	SPS	I
_:13802:54	I> 2:Inactive	SPS	O
_:13802:52	I> 2:Behavior	ENS	O
_:13802:53	I> 2:Health	ENS	O
_:13802:60	I> 2:Inrush blocks operate	ACT	O
_:13802:55	I> 2:Pickup	ACD	O
_:13802:56	I> 2:Operate delay expired	ACT	O
_:13802:57	I> 2:Operate	ACT	O
_:13802:301	I> 2:Fault position group 1	ACT	O
_:13802:302	I> 2:Fault position group 2	ACT	O

7.4.5 Counter Stage

7.4.5.1 Description

Logic of a Stage



[lo-cnt-stage-260314-01, 2, en_US]

Figure 7-20 Logic Diagram of the Counter Stage

Measurands/Input Values

The measurand/input values of the counter stage are the phase- and group-segregated counter contents that are determined in the **General** FB.

Pickup, Tripping Delay

Supervision of the counter contents is phase-segregated. If a counter reaches the preset threshold (parameter **Max. no. of def. elem. phs A** , **Max. no. of def. elem. phs B** , **Max. no. of def. elem. phs C**), the stage picks up. When using the parameter **Type of counting groups** , a selection is made whether the supervision function occurs group-segregated or with the sum value of both groups. The pickup starts the time delay. If the time delay has elapsed, the operate indication will be issued.

Automatic Compensation

If the automatic compensation function is enabled, the counter stage is working. If this is not the case, the readiness status of the stage changes to the state *warning.*

7.4.5.2 Application and Setting Notes

General Notes

- The setting notes for the current-threshold value for counting faulty C-elements are provided in chapter *7.4.3.2 Application and Setting Notes* as you must set this parameter across all stages.
- In order to react quickly to the simultaneous fault of many C-elements, always use an overcurrent-protection stage I> with a short tripping delay (< 100 ms) in addition to the counter stage. This is necessary as the counter function counts each current jump only once, regardless of its height.

Parameter: Type of counting groups

- Default setting **(_:13651:104) Type of counting groups** = ***segregated***

When using the parameter **Type of counting groups**, you specify whether the group-segregated counter status or the sum of both group counters are compared to the threshold.

Parameter: Maximum Number of Faulty Elements, Operate delay

- Default setting **(_:13651:101) Max. no. of def. elem. phs A** = *10*
- Default setting **(_:13651:102) Max. no. of def. elem. phs B** = *10*
- Default setting **(_:13651:103) Max. no. of def. elem. phs C** = *10*
- Default setting **(_:13651:6) Operate delay** = *0.00 s*

Set the parameters for the specific application.

It is possible to configure several stages for different tasks:

- Reporting only (with or without fault record)

  Use this stage to report 1 or 2 faulty C-elements. To do this, set the 3 parameters **Max. no. of def. elem. phs A**, **Max. no. of def. elem. phs B** and **Max. no. of def. elem. phs C** to a small value (1 or 2). The parameter **Operate delay** can be set to 0.

  If you would like to prevent the operate (tripping) and fault logging (fault log and fault record), set the parameter **Operate & flt.rec. blocked** to ***yes***.

  If you would like to prevent only the operate (tripping) and the fault logging must occur, remove this stage from the interface **Trip** to the circuit breaker (see also *5.4.2 Structure of the Function Group*, **Interfaces with Circuit-Breaker Function Group**).

- Indication with delayed operate

  Use this stage to report in case of some faulty C-elements and set a relatively long time delay of the operate, for example, 2 hours. During this time, the fault of the C-elements can be clarified. If it is possible to find a solution, the counter status can be reset manually. This way, the stage drops out. If a solution cannot be found within 2 hours, the stage trips and disconnects the capacitor bank.

- Immediate operate

  The stage is used to initiate the operate immediately after a larger number of C-elements became faulty.

7.4.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Counter 1				
_:13651:1	Counter 1:Mode		• off • on • test	off
_:13651:2	Counter 1:Operate & flt.rec. blocked		• no • yes	no
_:13651:104	Counter 1:Type of counting groups		• segregated • sum	segregated
_:13651:101	Counter 1:Max. no. of def. elem. phs A		1 to 1000	10
_:13651:102	Counter 1:Max. no. of def. elem. phs B		1 to 1000	10
_:13651:103	Counter 1:Max. no. of def. elem. phs C		1 to 1000	10
_:13651:6	Counter 1:Operate delay		0.00 s to 10000.00 s	0.00 s

7.4.5.4 Information List

No.	Information	Data Class (Type)	Type
Counter 1			
_:13651:81	Counter 1:>Block stage	SPS	I
_:13651:54	Counter 1:Inactive	SPS	O
_:13651:52	Counter 1:Behavior	ENS	O
_:13651:53	Counter 1:Health	ENS	O
_:13651:55	Counter 1:Pickup	ACD	O
_:13651:56	Counter 1:Operate delay expired	ACT	O
_:13651:57	Counter 1:Operate	ACT	O

7.5 Current-Unbalance Protection for Capacitors, 1-Phase

7.5.1 Overview of Functions

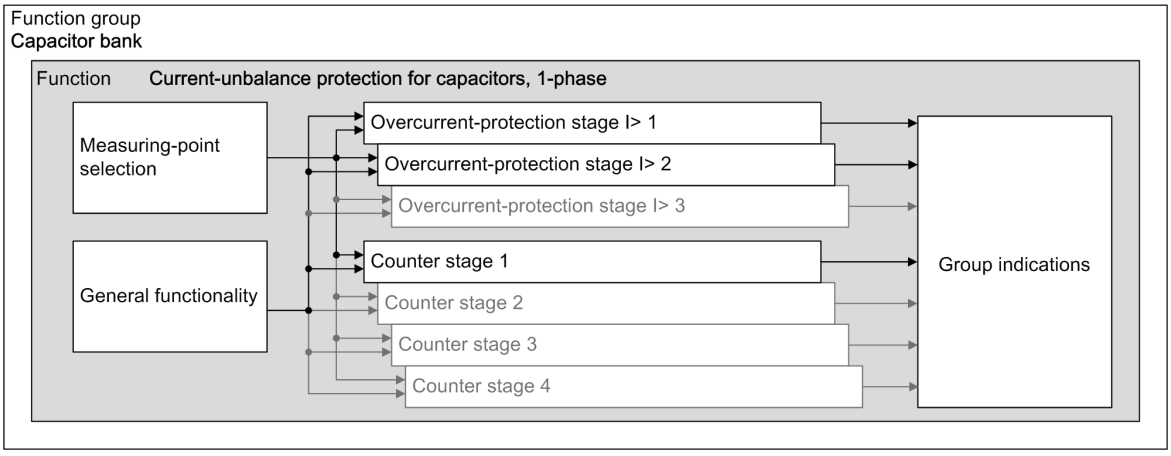
The **Current-unbalance protection for capacitors, 1-phase** function (ANSI 60C):

- Protects in case of faults in capacitor elements (C-elements) of a double neutral point capacitor bank
- Provides very sensitive supervision of the unbalanced current between the 2 neutral points
- Allows counting individual faulty C-elements

7.5.2 Structure of the Function

The **Current-unbalance protection for capacitors, 1-phase** function is used in the **Capacitor bank** function group. It is preconfigured at the factory with 2 overcurrent-protection stages **I>** and 1 stage of the type **Counter**. A maximum of 3 overcurrent-protection stages and 4 counter stages can be operated simultaneously in the function.

The function is designed so that the **General functionality** (including adjustment) and the **Measuring-point selection** can work across the stages.



[dwocplunb1ph-020714, 3, en_US]

Figure 7-21 Structure/Embedding of the Function

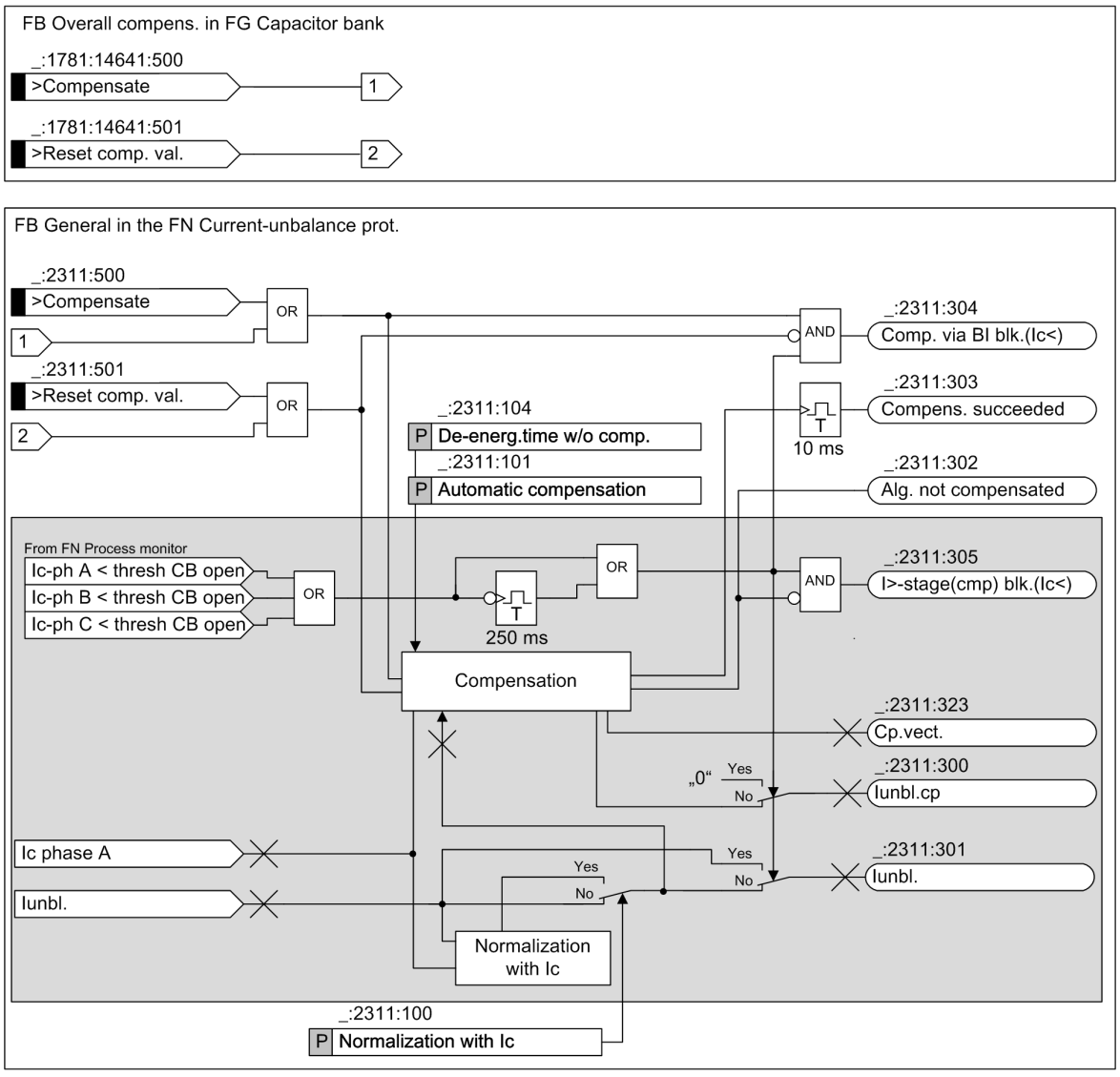
7.5.3 General Functions and Measuring-Point Selection

7.5.3.1 Description

The General functionality is structured in the following functional parts:

- Compensation of the unbalance
- Normalization of the unbalanced current with the current I_c
- Counting faulty C-elements (the stage type **Counter** is used to monitor the counter status)

Logic for Compensation and Normalization



[lo_FBallgiunb1ph-070714-01, 3, en_US]

Figure 7-22 Cross-Stage Functionality

Measuring-Point Selection

With the **`MP selection`** parameter, you can select from a list of measuring points a 1-phase measuring point that is connected to the **I Unbalanced** interface in the **Capacitor bank** function group. The **Current-unbalance protection for capacitors, 1-phase** function processes the 1-phase current that is connected to the measuring point.

For more information, refer to the description of the **Capacitor bank** function group starting from chapter *5.4.1 Overview* .

Measurands, Method of Measurement

The function receives its measurands via the **I Unbalanced** interface of the **Capacitor bank** function group.

The compensated and non-compensated unbalanced currents are provided for the overcurrent-protection stage. Within the protection stage, one of the 2 values is selected in the protection stage via the parameter **`Measured value`**. Both values are available as functional measured values (see *Figure 7-22*).

Configure across the stages whether the unbalanced current must be normalized with the current I_c that flows into the capacitor bank. Phase A component of the current I_c flowing into the capacitor bank is used as the reference for the normalization. You can find more information in this chapter under *Normalization with I_c*, *Page 950* .

The method of measurement used processes the sampled unbalanced-current values and filters out the fundamental component numerically. The protection stages evaluate the fundamental component of the unbalanced current.

General Notes on the Compensation

An operational unbalanced current is added to an unbalanced current resulting from faulty capacitor elements. This corrupts the measuring result.

Operational unbalanced currents can result from the following causes:

- Manufacturing tolerances of the capacitor
- Aging of the capacitor
- Environmental influences, for example, temperature

The compensation eliminates operational unbalanced currents by calculation. For this purpose, the phasor of the operational unbalanced current $\underline{I}_{unbal.,op.}$ is stored at specific times. The stored phasor (compensation phasor), is subtracted from the actually measured unbalanced-current phasor:

$$\underline{I}_{unbal.,comp.} = \underline{I}_{unbal.} - \underline{I}_{unbal.,op.}$$

[fo_compensatied unbal., 1, en_US]

The following indications describe the status of the compensation:

Indication	Description
Alg. not compensated	The algorithm is not compensated. The compensated values are not available under the following conditions: • After initial startup of the device before any compensation is carried out • After activating the binary input *>Reset comp. val.* • After change of $I_{rated,obj}$ Protection stages that are working with compensated values are inactive.
Compens. succeeded	This indication is issued (as transient indication with a pulse duration of 10 ms) if the existing unbalance has been compensated manually or automatically. In case of automatic compensation, the signal is issued at each event-based situation where full compensation is carried out.
Comp. via BI blk.(Ic<)	If a manual compensation has been initiated and the current I_c (current flowing into the capacitor bank) at this time is less than the threshold **Current threshold CB open**, the manual compensation is not executed. This is signaled via the *Comp. via BI blk.(Ic<)* indication.

2 different methods are available for the compensation:

- Manual compensation via binary input signals
- Automatic compensation

Manual Compensation via Binary Input Signal

If the binary input signal *>Compensate* is activated, the manual compensation starts. This will fully compensate any unbalance that exists at this time. This means, the value $\underline{I}_{unbal.,comp.}$ will then become 0. You can also use the manual compensation in parallel with the automatic compensation.

Automatic Compensation

When using the parameter **Automatic compensation**, this automatic compensation function can be enabled or disabled.

The automatic compensation consists of 2 different mechanisms:

- Event-based compensation of any existing unbalance
  This compensation is performed in the following situations:
  - After energizing the capacitor bank or a phase of the bank
  - After counting a faulty C-element
  - After each startup of the device
  - After specific parameter changes:
    - Switching on the automatic compensation
    - Changing the rated current of the capacitor bank

  In order to avoid transient inrush-current effects, the compensation is delayed by 250 ms after energizing has been detected.
  Full compensation after bank energization can be avoided in case of only short de-energization by means of parameter **De-energ.time w/o comp.**. If the de-energized duration is less than the setting of parameter **De-energ.time w/o comp.**, the full compensation is not carried out after energizing a phase or the whole bank.
- Cyclic, slow and thus gradual compensation of an existing unbalance in small increments
  This permits, for example, the automatic compensation of environmental influences.

Resetting the Compensation

The algorithm can be reset to the non-compensated status. Compensated values are not available in this case. Protection stages that work with compensated values are rendered inactive. The binary input signal *>Reset comp. val.* of the function or function group resets the compensation (see also *Figure 7-22*).

Normalization with I_c

The threshold for the unbalanced current is usually set by assuming the rated capacitor current $I_{c,rated}$. The current I_c flowing into the capacitor bank determines the amount of the unbalanced current. A lower I_c also means a lower unbalanced current. If $I_c < I_{c,rated}$, the protection becomes less sensitive. This influence can be compensated via the normalization. Normalization keeps the sensitivity of the protection function constant by normalizing the unbalance value with the current I_c. Phase A component of the current I_c flowing into the capacitor bank is used as the reference for the normalization. When using the parameter **Normalization with Ic**, normalization is enabled or disabled.

I_c Lower than Current Thresh. CB Open

If any phase current of I_c is lower than the threshold **Current thresh. CB open**, the compensated value can no longer be computed with sufficient accuracy. To avoid a malfunction, the compensated unbalanced value $I_{unbal.,comp.}$ is set to 0 A (see *Figure 7-22*). This deactivates the protection stages that work with compensated values.
This condition will be indicated (indication *I>-stage(cmp) blk.(Ic<)*).
In this case, normalization with current I_c will no longer work properly either. Normalization is canceled. This means that the non-normalized value will be used instead of the normalized value (see *Figure 7-22*).

Charging/Energizing the Capacitor Bank or a Phase of the Bank

Charging of the bank takes place when the discharged bank is switched on to the network. Charging of a phase can occur in case of network faults. If a phase-to-ground voltage drops to 0 V due to a network fault, the respective phase is discharged and the return of the phase-to-ground voltage (after the fault has been cleared) will charge the phase.

Charging the bank causes inrush currents in the respective phases. To avoid overfunction in case of sensitive threshold settings, the stages using compensated unbalanced values are blocked by setting $I_{unbal.,comp.}$ to 0 A.

These stages are:

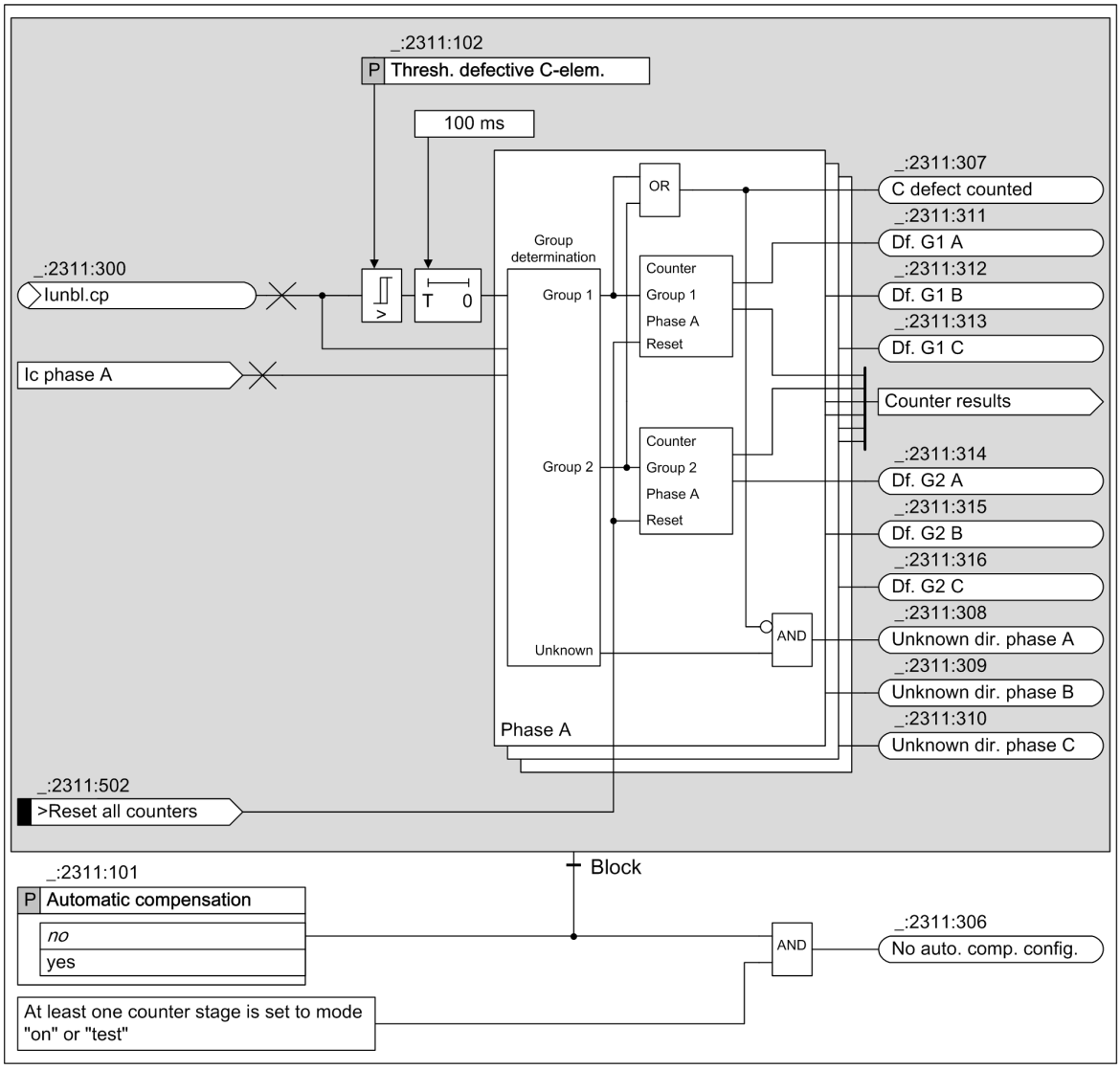
- Counter stage
- I> stage, if set to operate with compensated unbalanced values

The blocking ($I_{unbal.,comp.}$ set to 0 A) lasts for 250 ms after energizing detection. Afterwards, the calculated $I_{unbal.,comp.}$ is processed again.

Energizing detection takes place by monitoring the phases currents I_c flowing into the bank. If all three phase currents exceed the threshold **`Current Thresh.CB Open`**, energizing is detected.

Logic for Counting Faulty C-Elements

This part of the General functionality is only important if counter stages are used.



[locntEF1ph-070714-01, 3, en_US]

Figure 7-23 Counting Faulty C-Elements

Activation/Blocking Counting

If at least one counter stage is enabled, the counting function is active. Furthermore, the counting function works only if the automatic compensation is enabled.

In order to prevent counting as a consequence of the charging process, the counter function is implicitly blocked for 250 ms by setting $\underline{I}_{unbal.,comp.}$ to 0 A, after the capacitor energizing has been detected.

Measurands, Counting

The measurand is the 1-phase compensated unbalanced current $\underline{I}_{unbal.,comp.}$. If a single C-element is faulty, an unbalance occurs between the neutral points of the 2 capacitor banks. This unbalance causes an unbalanced current; this means, a small current jump occurs in the unbalanced current. Set the parameter **Thresh. defective C-elem.**, so that this current jump can be detected (see also *7.5.3.2 Application and Setting Notes*). The unbalanced current that was caused by the fault must exceed the threshold for 100 ms before the affected phase and the affected group are determined and counting (incrementing the counter) takes place. The angle reference of the unbalanced-current phasor to the reference current $I_{c,A}$ is used to determine the phase of the faulty C element. Thus, phase-segregated counting is possible. There is one counter for each phase and group. After the counting, the existing unbalance is compensated; this means, the unbalance is reset to 0 A. If the faulty group cannot be determined, the unbalance is also compensated.

Resetting/Setting the Counters

You can reset or set the counters of group 1 and group 2 via:

- On-site operation panel directly on the device
- Online DIGSI connection to the device
- Binary input *>Reset all counters* (only reset of all counters)
- Communication connection with the control center

You can directly set or reset the counters via IEC 61850 by setting the counter values to the desired value. If you want to reset the counters via DNP3, IEC 60870-5-103, Modbus, or IEC 60870-5-104, an additional configuration with CFC is necessary. For more information, refer to chapter *7.5.3.2 Application and Setting Notes*.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:2311:300) Iunbl.cp	Compensated unbalanced current $\underline{I}_{unbal.,comp.}$	kA	A	Parameter **Rated primary current**
(_:2311:301) Iunbl.	Non-compensated unbalanced current $\underline{I}_{unbal.}$	kA	A	Parameter **Rated primary current**
(_:2311:323) Cp.vect.	Compensation vector $\underline{I}_{comp.,vect.}$	kA	A	Parameter **Rated primary current**

You can find the value of the parameter **Rated primary current** of the preceding table in the chapter *6.1.6 Settings* according to the specified parameter **MP selection**.

$\underline{I}_{comp.,vect.}$ is normalized with I_c. The normalization is carried out no matter if the parameter **Normalization with Ic** is set to ***yes*** or ***no***. $\underline{I}_{comp.,vect.}$ keeps its value unchanged until the next compensation occurs.

$$\underline{I}_{comp.,\,vect.} = \underline{I}_{unbal.\,op.}\frac{I_{c,rated}}{I_c}$$

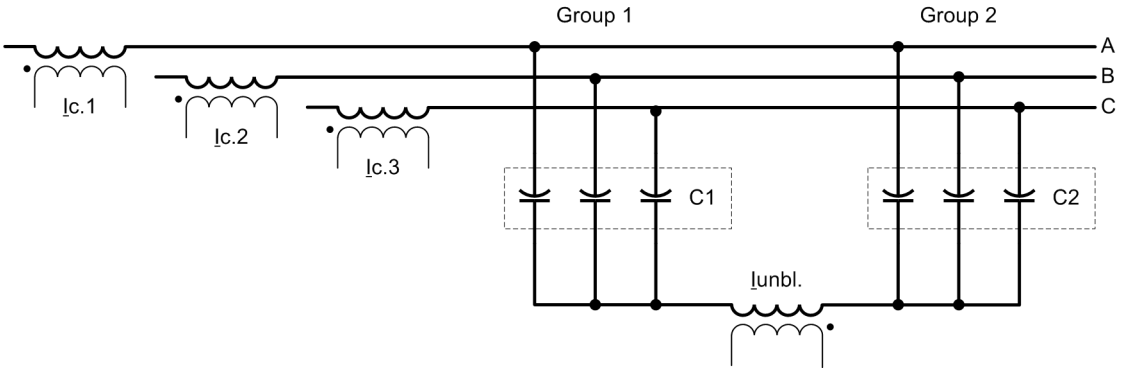
[fo_compensation vector, 1, en_US]

Where:

$\underline{I}_{unbal.op.}$	Operational unbalanced current at the moment the compensation is carried out
$I_{c,rated}$	Rated current of the capacitor bank
I_c	Current of the capacitor bank at the moment the compensation is carried out

Definition of the Group and Fault Location in Case of a Capacitor Dual Switching

If the capacitor is designed with dual switching function, the following definition is assumed:



[dwfehlerortinf_iunsy1ph-070714-01, 1, en_US]

Figure 7-24 Definition of the Fault-Location Information

The black dot indicates the orientation of the current transformer. For the connection of the current transformer shown in the previous figure, the following definition applies:

- Group 1: C1
- Group 2: C2

In order to determine the fault location (group 1 or 2) correctly, use the parameter **Capacitor element type** (in FB **General** of the **Capacitor bank** function group) to tell the device whether the elements of the capacitor bank have internal fuses or not.

The angle reference of the unbalanced-current phasor to the reference current I_c is used to determine the direction of the unbalanced current and, thus, the affected group is determined. If the direction cannot be determined with confidence, an appropriate indication will be generated.

7.5.3.2 Application and Setting Notes

Parameter: MP selection

- Default setting **(_:13501:81) MP selection** = ***None***

With the **MP selection** parameter, you can select from a list the measuring point that is connected to the **I Unbalanced** interface of the **Capacitor bank** function group.

The setting applies equally to all stages of the function.

In the default setting, a measuring point is not selected. You must select a measuring point. If you do not select a measuring point, an inconsistency is indicated via the read-only parameter **Consistency failure**.

Parameter: Automatic compensation

- Default setting **(_:2311:101) Automatic compensation** = ***no***

The parameter applies equally to all stages of the function that work with compensated measurands.

If no counter stages are applied, Siemens recommends to switch the automatic compensation off and use the manual compensation. You can find more information on this recommendation in chapter *7.5.4.2 Application and Setting Notes* (setting notes for the operate delay of the **I>** stage).

If the counter stages are applied, the automatic compensation must be switched on, otherwise the counting function will not work.

Parameter: De-energ.time w/o comp.

- Default setting **(_:2311:104) De-energ.time w/o comp.** = ***2.00 s***

In case of networks faults, the faulty phases are discharged. With the returning voltage after fault clearance, charging takes place. For such conditions, Siemens recommends that no automatic full compensation takes place in the affected phases. Otherwise, C-element defects occurring in this period (for example, because of discharging stress due to network-fault inception) will not be detected.

With the parameter **De-energ.time w/o comp.**, you define the duration of short de-energization after which no automatic compensation takes place. The parameter must be set to a value larger than the slowest fault clearing time in your network plus a safety margin.

If the setting is set to 0 s, an automatic full compensation is carried out after each energizing detection.

Parameter: Normalization with Ic

- Default setting **(_:2311:100) Normalization with Ic** = ***no***

This parameter applies equally to all stages of the function.

Parameter Value	Description
no	Select this setting if you can safely assume that I_c will not change for operational reasons or if you do not desire normalization of the unbalanced current with I_c. Please consider that the protection sensitivity will decrease with decreasing I_c.
yes	Select this setting if you want to keep the sensitivity of the protection stages constant during changes of I_c.

Parameter: Thresh. defective C-elem.

- Default setting **(_:2311:102) Thresh. defective C-elem.** = ***0.030 A***

Set the parameter **Thresh. defective C-elem.** to ensure that the jump in the unbalanced current caused by the faulty C-element is detected. Information about occurring unbalanced current as a consequence of single faulty C-elements will be provided by the manufacturer of the capacitor bank. Siemens recommends to set the threshold value to approx. 75 % of the unbalanced current that occurs after the fault of the 1st C-element.

Example 1: Information about the Unbalanced Current Available from the Manufacturer of the Capacitor Bank

Table 7-2 Unbalanced Current, Depending on the Number of Faulty C-Elements

Number of Faulty C-Elements	Primary Unbalanced Current
0	0.00 A
1	0.71 A
2	1.47 A
3	2.29 A
...	...

Assumed current transformer ratio: 10 A/1 A

Primary unbalanced current if 1st C-element fails: 0.71 A

Secondary unbalanced current if 1st C-element fails: 0.071 A

Secondary setting value: 0.75 · 0.071 A = 0.053 A



NOTE

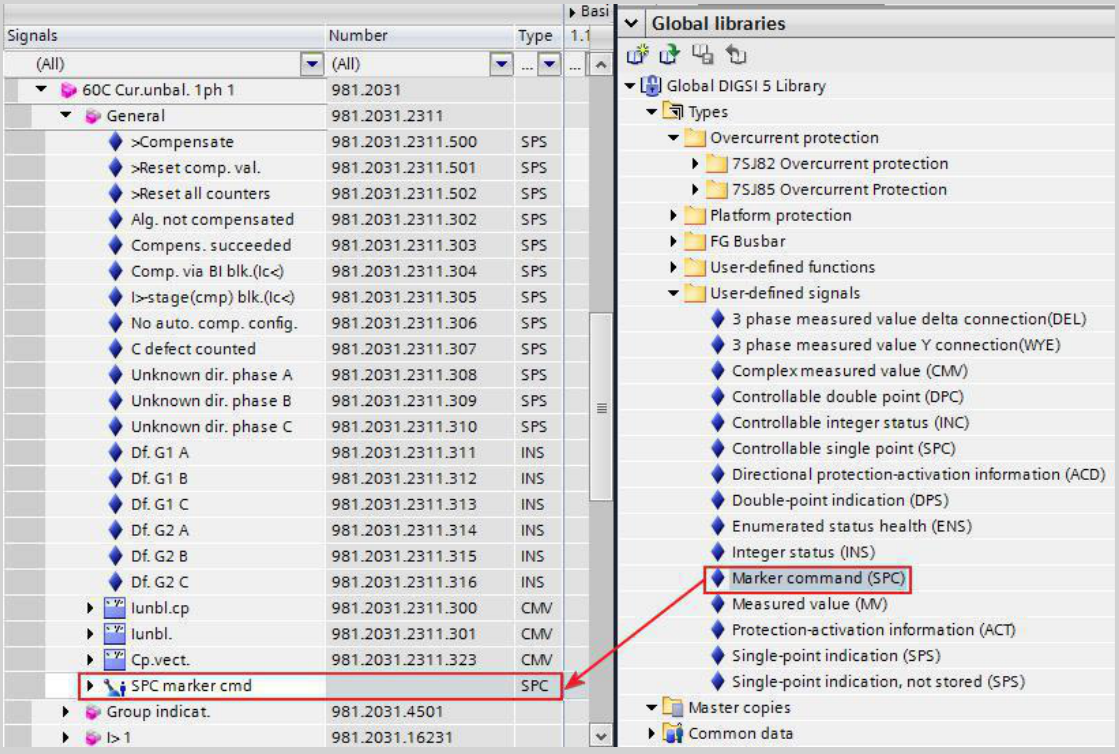
Use senstive device current inputs in order to apply secondary thresholds of < 30 mA.

Resetting the Counters via Protocols IEC 60870-5-103, IEC 60870-5-104, DNP3, or Modbus

The following example shows how to use a function chart (CFC) to reset the counters with the protocols IEC 60870-5-103, IEC 60870-5-104, DNP3, or Modbus.

EXAMPLE

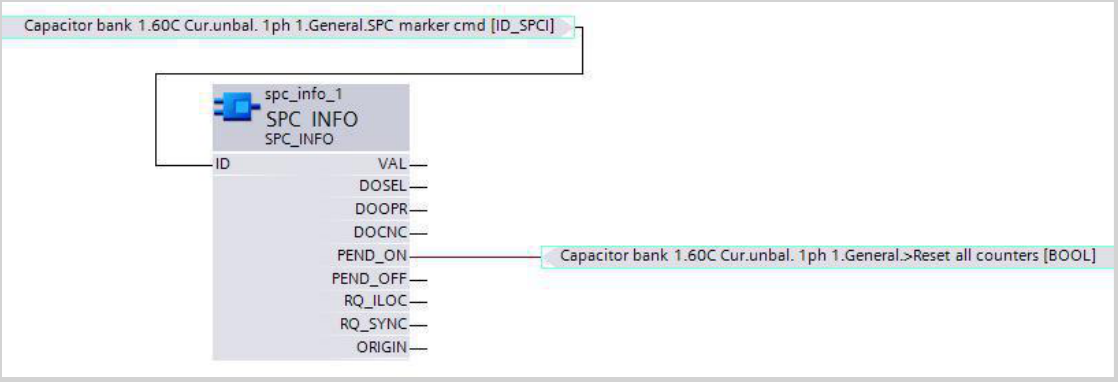
- Add a **Marker command (SPC)** signal to the information list.



[sc_add_SPC_signal_1ph, 1, en_US]

Figure 7-25 Adding Marker Command (SPC) Signal to Information List

- Set up the following CFC. Connect the SPC signal as input, and the signal *>Reset all counters* as output.



[sc_CFC_60C_1ph, 1, en_US]

Figure 7-26 Function Chart (CFC): Activating the Binary Input Signal

- Send a single-point control command from the control center to the SPC signal to activate the signal *>Reset all counters*. Then the counters are reset.

7.5.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MP selection				
_:13501:100	MP selection:Consistency failure		• no MP configured • no Sensor configured	no MP configured

Addr.	Parameter	C	Setting Options	Default Setting
_:13501:81	MP selection:MP selection		Setting options depend on configuration	
General				
_:2311:101	General:Automatic compensation		• no • yes	no
_:2311:100	General:Normalization with Ic		• no • yes	no
_:2311:102	General:Thresh. defective C-elem.	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.150 A
_:2311:104	General:De-energ.time w/o comp.		0.00 s to 60.00 s	2.00 s

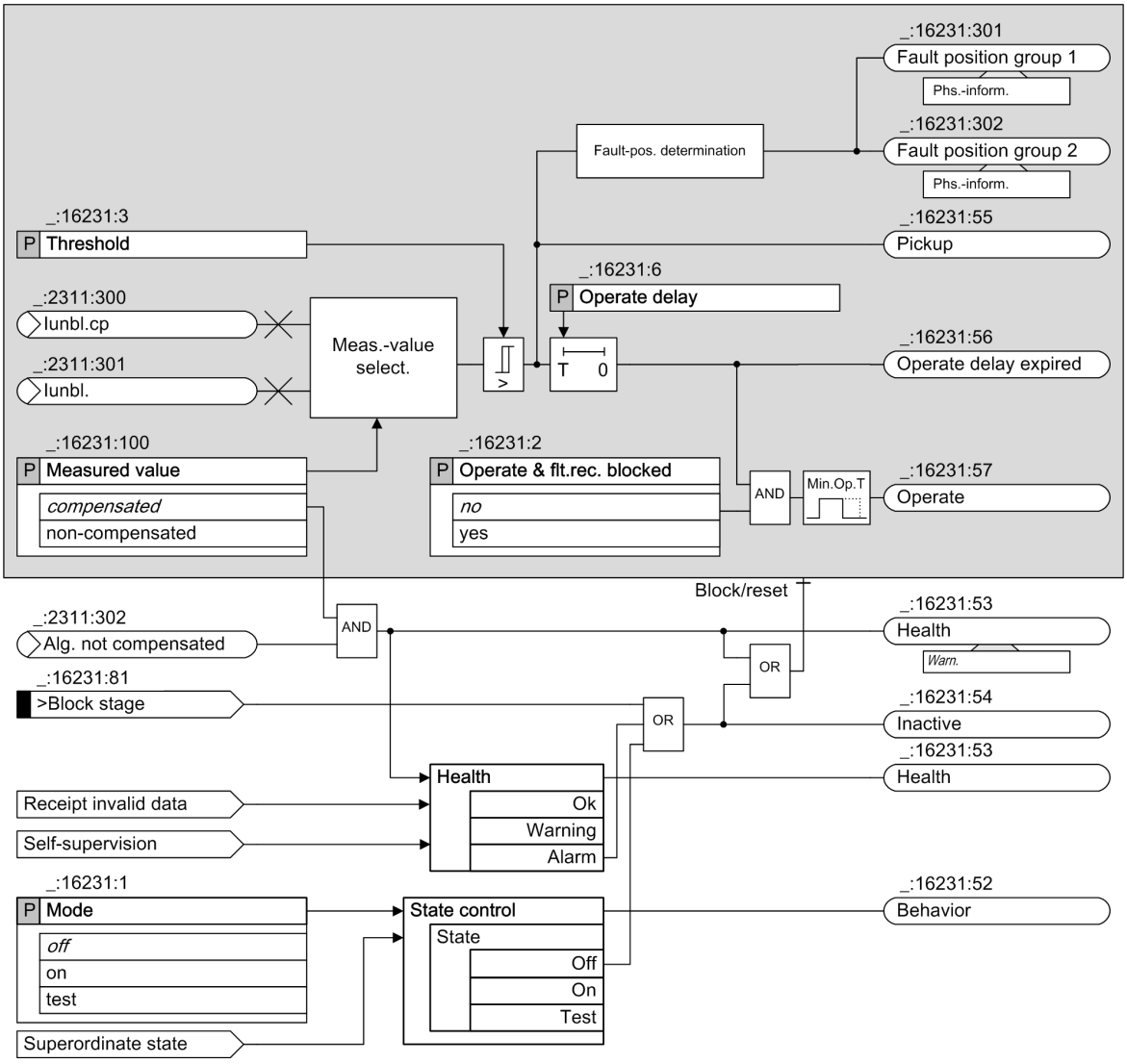
7.5.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
General			
_:2311:500	General:>Compensate	SPS	I
_:2311:501	General:>Reset comp. val.	SPS	I
_:2311:502	General:>Reset all counters	SPS	I
_:2311:302	General:Alg. not compensated	SPS	O
_:2311:303	General:Compens. succeeded	SPS	O
_:2311:304	General:Comp. via BI blk.(Ic<)	SPS	O
_:2311:305	General:I>-stage(cmp) blk.(Ic<)	SPS	O
_:2311:306	General:No auto. comp. config.	SPS	O
_:2311:307	General:C defect counted	SPS	O
_:2311:308	General:Unknown dir. phase A	SPS	O
_:2311:309	General:Unknown dir. phase B	SPS	O
_:2311:310	General:Unknown dir. phase C	SPS	O
_:2311:311	General:Df. G1 A	INS	O
_:2311:312	General:Df. G1 B	INS	O
_:2311:313	General:Df. G1 C	INS	O
_:2311:314	General:Df. G2 A	INS	O
_:2311:315	General:Df. G2 B	INS	O
_:2311:316	General:Df. G2 C	INS	O
_:2311:300	General:Iunbl.cp	CMV	O
_:2311:301	General:Iunbl.	CMV	O
_:2311:323	General:Cp.vect.	CMV	O

7.5.4 Overcurrent-Protection Stage I>

7.5.4.1 Description

Logic of a Stage



[lounbalstu1ph-080714-01, 1, en_US]

Figure 7-27 Logic Diagram of the Overcurrent-Protection Stage I>

Measurands

Within the protection stage, the compensated and the non-compensated unbalanced currents are available. Use parameter **Measured value** to select one of the 2 values. Both values are displayed as measured values of the function at the function stage.

Pickup, Operate Delay

If the selected measurand exceeds the threshold, the stage picks up. The pickup starts the operate delay, and a fault-location information is issued. More information can be found in this chapter under *Fault-Location Information, Page 958* . If the threshold is exceeded during the entire operate delay, the operate indication is issued.

Please note that, when using the compensated measurands as well as the automatic compensation, the currently measured current unbalance (that resulted in the threshold being exceeded) is gradually compensated. This means that even in case of a constantly existing unbalance in the primary system, the compensated measurand becomes gradually lower and may therefore fall below the threshold again at some time. The timing depends on by how much the threshold is exceeded.

For this reason and under those conditions, long time delays must not be set, see also chapter *7.5.4.2 Application and Setting Notes* .

This effect does not occur if manual compensation or the non-compensated measurand is used.

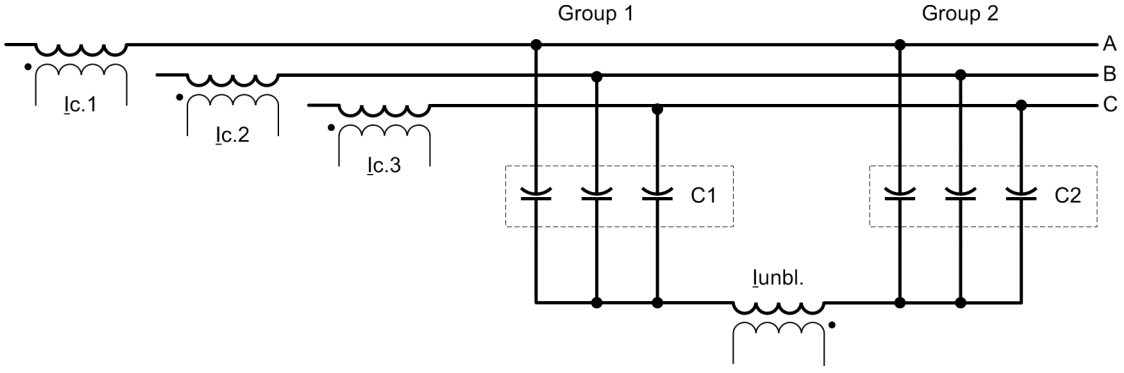
Blocking While Charging

In order to prevent pickup as a consequence of the charging process, the **I>** stage is implicitly blocked for 250 ms by setting $I_{unbal.,comp.}$ to 0 A, after capacitor energizing has been detected. Blocking only takes place if the stage operates with compensated unbalanced values.

Fault-Location Information

When picking up, the stage provides information about the faulty group of the capacitor bank. If the location can be safely determined, the corresponding indication *Fault position group 1* or *Fault position group 2* is issued.

Both indications also contain the information about the faulty phase. If the capacitor is implemented with 2 neutral points, the following definition is assumed:



[dwfehlerortinf_iunsy1ph-070714-01, 1, en_US]

Figure 7-28 Definition for the Fault-Location Information

The black dot indicates the orientation of the current transformer. For the connection of the current transformer shown in the previous figure, the following definition applies:

- Group 1: C1
- Group 2: C2

In order to determine the fault location (group 1 or 2) correctly, use the parameter **Capacitor element type** (in FB **General** of the **Capacitor bank** function group) to tell the device whether the elements of the capacitor bank have internal fuses or not.

Non-Compensated Status

If no compensated values are available and the stage has been set to use such values, the stage will be blocked. The readiness of the stage turns to *Warning*. This condition will be reported on the function stage (indication *Alg. not compensated*).

7.5.4.2 Application and Setting Notes

Parameter: Measured value

- Default setting **(_:16231:100) Measured value** = ***compensated***

With this parameter you set the **Measured value** .

Parameter Value	Description
compensated	The stage uses compensated unbalanced values. This means an operational current unbalance will be eliminated. This allows you to increase significantly the sensitivity of the measurement. Note: If any phase current I_c is lower than the threshold **Current threshold CB open**, the stage is rendered inactive by setting $I_{unbal.,comp.}$ to 0 A. This condition is held for 250 ms after energizing has been detected in order to avoid a pickup as a consequence of the charging process. Siemens recommends using compensated unbalanced values. In case that automatic compensation is applied, consider the setting notes for the operate delay.
non-compensated	The stage works with non-compensated unbalanced values. This means the measurand may contain an existing operational current unbalance.

Parameter: Threshold

- Default setting **(_:16231:3) Threshold** = ***1.500 A***

Set the parameter **Threshold** for the specific application.

When using compensated unbalanced values, very sensitive settings are possible. When using non-compensated unbalanced values, the threshold must be higher than the maximum operational unbalanced current.

Parameter: Operate delay

- Default setting **(_:16231:6) Operate delay** = ***0.30 s*** (for the 1st stage)

Set the parameter **Operate delay** for the specific application.



NOTE

If the function has been set to automatic compensation and the stage works with compensated values, the maximum permitted operate delay is 80 ms. If the operate delay is set to longer than 80 ms the automatic compensation might cause dropout of the picked-up stage. This risk does not exist when manual compensation or non-compensated values are used.

7.5.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
I> 1				
_:16231:1	I> 1:Mode		• off • on • test	off
_:16231:2	I> 1:Operate & flt.rec. blocked		• no • yes	no
_:16231:100	I> 1:Measured value		• compensated • non-compensated	compensated
_:16231:3	I> 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.000 A
_:16231:6	I> 1:Operate delay		0.00 s to 60.00 s	0.08 s

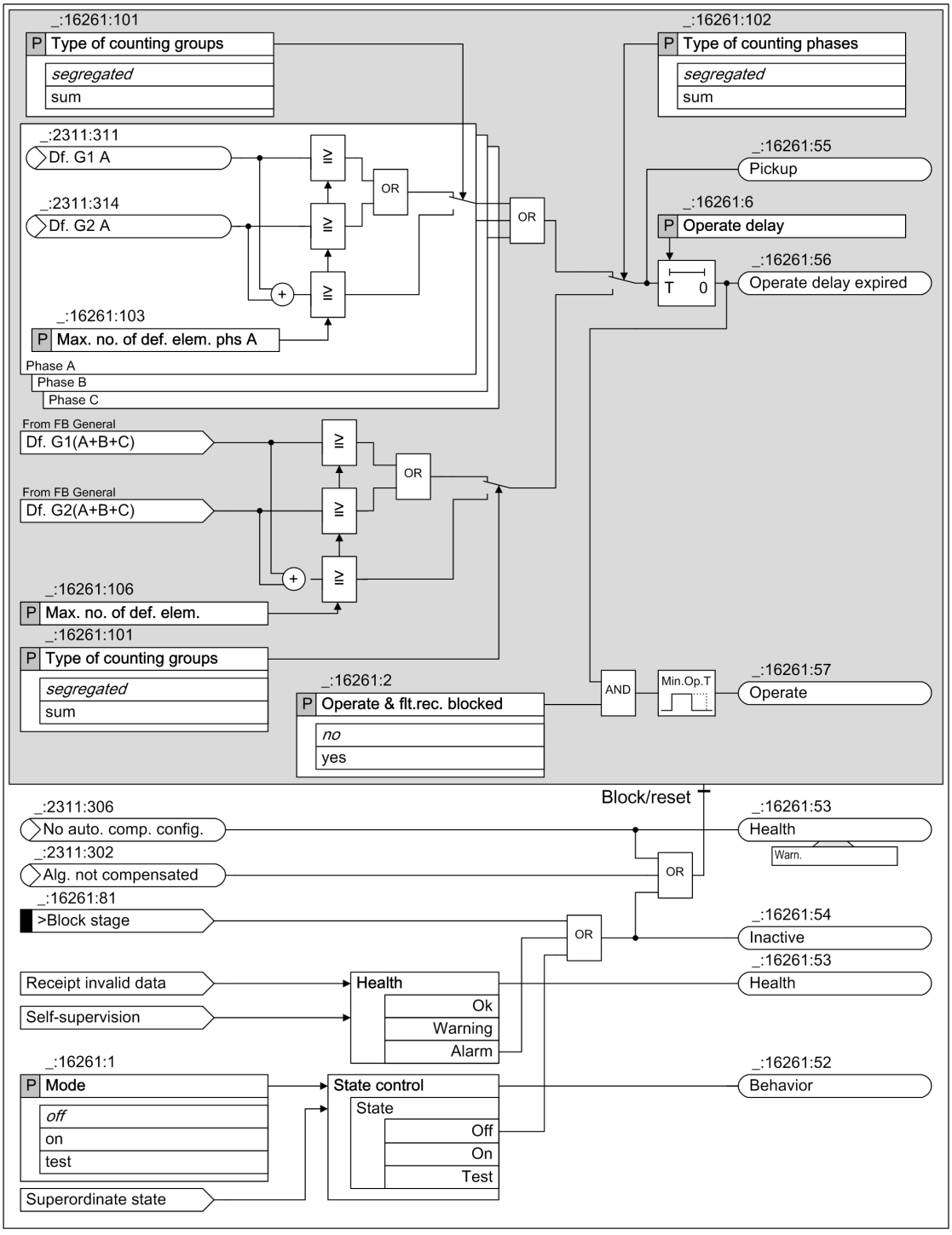
7.5.4.4 Information List

No.	Information	Data Class (Type)	Type
I> 1			
_:16231:81	I> 1:>Block stage	SPS	I
_:16231:54	I> 1:Inactive	SPS	O
_:16231:52	I> 1:Behavior	ENS	O
_:16231:53	I> 1:Health	ENS	O
_:16231:55	I> 1:Pickup	ACD	O
_:16231:56	I> 1:Operate delay expired	ACT	O
_:16231:57	I> 1:Operate	ACT	O
_:16231:301	I> 1:Fault position group 1	ACT	O
_:16231:302	I> 1:Fault position group 2	ACT	O

7.5.5 Counter Stage

7.5.5.1 Description

Logic of a Stage



[lo-cnt-stage1ph-080714-01, 2, en_US]

Figure 7-29 Logic Diagram of the Counter Stage

Measurands/Input Values

The measurand/input values of the counter stage are phase-segregated and group-segregated counter contents that are determined in the **General** FB.

Pickup, Operate Delay

With the parameter **Type of counting phases**, a selection is made whether the supervision function occurs in a phase-segregated way or with the sum value of the phases. With the parameter **Type of counting groups**, a selection is made whether the supervision function occurs in a group-segregated way or with the sum value of both groups. If a counter reaches the set threshold, the stage picks up. The pickup starts the time delay. If the time delay has elapsed, the operate indication will be issued.

Automatic Compensation

If the automatic compensation function is enabled, the counter stage is working. If this is not the case, the readiness status of the stage changes to the state *warning*.

7.5.5.2 Application and Setting Notes

General Notes

- The setting notes for the current-threshold value for counting faulty C-elements are provided in chapter *7.5.3.2 Application and Setting Notes* as you must set this parameter across all stages.
- In order to react quickly to the simultaneous fault of many C-elements, always use an overcurrent-protection stage I> with a short operate delay (< 100 ms) in addition to the counter stage. This is necessary as the counter function counts each current jump only once, regardless of its height.

Parameter: Type of counting groups

- Default setting **(_:16261:101) Type of counting groups** = ***segregated***

With the parameter **Type of counting groups**, you specify whether the group-segregated counter status or the sum value of both group counters are compared to the threshold.

Parameter: Type of counting phases

- Default setting **(_:16261:102) Type of counting phases** = ***segregated***

With the parameter **Type of counting phases**, you specify whether the supervision function occurs in a phase-segregated way or with the sum value of the phases.

Parameter: Maximum Number of Faulty Elements, Operate delay

- Default setting **(_:16261:103) Max. no. of def. elem. phs A** = ***10***
- Default setting **(_:16261:104) Max. no. of def. elem. phs B** = ***10***
- Default setting **(_:16261:105) Max. no. of def. elem. phs C** = ***10***
- Default setting **(_:16261:106) Max. no. of def. elem.** = ***10***
- Default setting **(_:16261:6) Operate delay** = ***0.00 s***

Set the parameters for the specific application.

It is possible to configure several stages for different tasks:

- Reporting only (with or without fault record)

  Use this stage to report 1 or 2 faulty C-elements. To do this, set the parameters **Max. no. of def. elem. phs A**, **Max. no. of def. elem. phs B** , **Max. no. of def. elem. phs C** , or **Max. no. of def. elem.** to a small value (1 or 2). The parameter **Operate delay** can be set to 0.

  If you would like to prevent the operate (tripping) and fault logging (fault log and fault record), set the parameter **Operate & flt.rec. blocked** to ***yes***.

  If you would like to prevent only the operate (tripping) and the fault logging must occur, remove this stage from the interface **Trip** to the circuit breaker (see also *5.4.2 Structure of the Function Group* **Interfaces with Circuit-Breaker Function Group**).

- Indication with delayed operate

  Use this stage to report in case of some faulty C-elements and to set a relatively long time delay of the operate, for example, 2 hours. During this time, the fault of the C-elements can be clarified. If it is possible to find a solution, the counter status can be reset manually. This way, the stage drops out. If a solution cannot be found within 2 hours, the stage trips and disconnects the capacitor bank.

- Immediate operate

  The stage is used to initiate the operate immediately after a larger number of C-elements became faulty.

7.5.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Counter 1				
_:16261:1	Counter 1:Mode		• off • on • test	off
_:16261:2	Counter 1:Operate & flt.rec. blocked		• no • yes	no
_:16261:101	Counter 1:Type of counting groups		• segregated • sum	segregated
_:16261:102	Counter 1:Type of counting phases		• segregated • sum	segregated
_:16261:103	Counter 1:Max. no. of def. elem. phs A		1 to 1000	10
_:16261:104	Counter 1:Max. no. of def. elem. phs B		1 to 1000	10
_:16261:105	Counter 1:Max. no. of def. elem. phs C		1 to 1000	10
_:16261:106	Counter 1:Max. no. of def. elem.		1 to 1000	10
_:16261:6	Counter 1:Operate delay		0.00 s to 10000.00 s	0.00 s

7.5.5.4 Information List

No.	Information	Data Class (Type)	Type
Counter 1			
_:16261:81	Counter 1:>Block stage	SPS	I
_:16261:54	Counter 1:Inactive	SPS	O
_:16261:52	Counter 1:Behavior	ENS	O
_:16261:53	Counter 1:Health	ENS	O
_:16261:55	Counter 1:Pickup	ACD	O
_:16261:56	Counter 1:Operate delay expired	ACT	O

No.	Information	Data Class (Type)	Type
_:16261:57	Counter 1:Operate	ACT	O

7.6 Peak Overvoltage Protection for Capacitors

7.6.1 Overview of Functions

The **Peak overvoltage protection for capacitors (ANSI 59C)** function protects capacitors against:

- Peak overvoltages that stress the dielectric medium in the capacitor causing accelerated aging
- Peak overvoltages that in extreme cases can destroy the dielectric medium in the capacitor

7.6.2 Structure of the Function

The **Peak overvoltage protection for capacitors** function can be applied in the **Capacitor bank** function group.

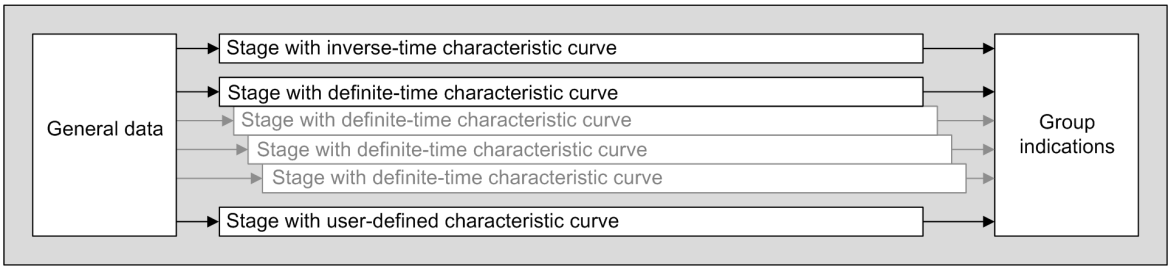
3 types of stages are available:

- Stage with inverse-time characteristic curve according to IEC and IEEE Standards
- Stage with definite-time characteristic curve
- Stage with user-defined characteristic curve

The function is preconfigured at the factory with a stage having an inverse-time characteristic curve and a stage having a definite-time characteristic curve.

Within the function, the following maximum number of stages can be operated simultaneously:

- 1 stage with an inverse-time characteristic curve
- 4 stages with a definite-time characteristic curve
- 1 stage with a user-defined characteristic curve



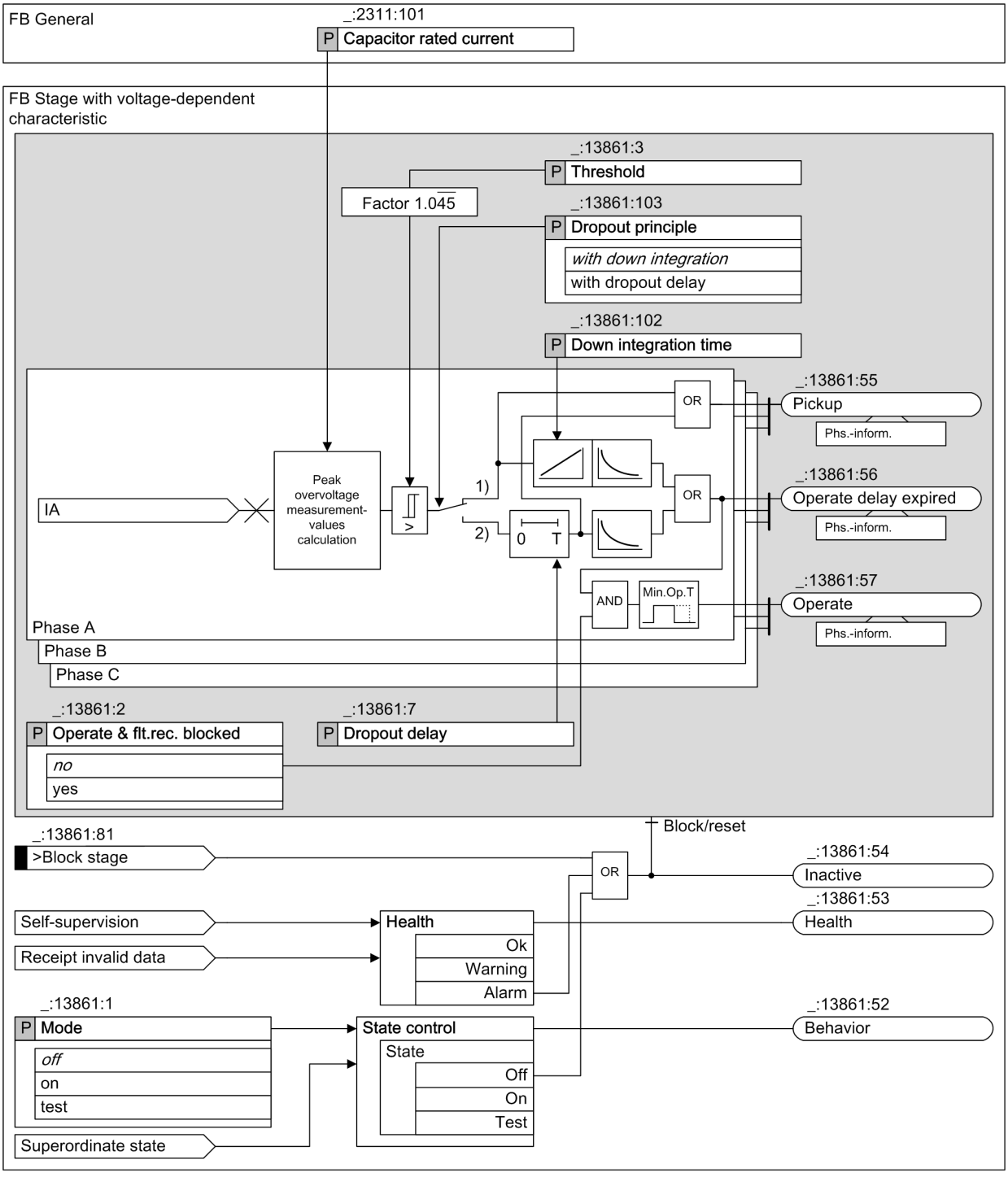
[dw_strpea-230813, 2, en_US]

Figure 7-30 Structure/Embedding of the Function

7.6.3 Stage with Inverse-Time Characteristic Curve

7.6.3.1 Description

Logic of the Stage



[lo_peainv-230813, 2, en_US]

Figure 7-31 Logic Diagram of the Stage with Inverse-Time Characteristic Curve

(1) With down integration time

(2) With dropout delay

Measurand, Method of Measurement

The function calculates the peak voltage in a phase-segregated way from the fundamental component and superimposed harmonics. Integration of the phase currents then yields the voltage. This approach captures the higher harmonics considerably better since they are transferred better by current transformers than by voltage transformers.

The peak voltage determined is then set with reference to the rated voltage of the capacitor. The resulting measurand is $\hat{U}/V_{C\text{-}rated}(t)$. The threshold value for the stage is thus set as a referenced quantity.

The phase-selective peak overvoltages $\hat{U}/V_{C\text{-}rated}(t)$ are available as measured values for display or further processing.

Pickup, Tripping and Dropout Behavior with the Inverse-Time Characteristic Curve

If the measurand $\hat{U}/V_{C\text{-}rated}(t)$ exceeds $1.0\overline{45}$ times the set threshold value (for example, $1.0\overline{45} \times 1.1 \approx 1.15$), pickup occurs and the inverse-time characteristic curve is then followed. For each input value that exceeds the pickup value ($1.0\overline{45}$ × threshold value), the time value T_{trip} is calculated. An integrator accumulates the value $1/T_{trip}$. When the accumulated integral reaches the fixed value of 1, the stage trips.

If the measurand falls below $1.0\overline{45}$ times the set threshold value (pickup value), processing of the characteristic (accumulation of the time values) stops. In the hysteresis region between the pickup value and dropout value (95 % of the pickup value, for example, 0.95 × 1.15 = 1.0925), the integral value remains unchanged. The stage, however, remains in the picked-up state.

Use the parameter **`Dropout principle`** to select the method for the dropout of the stage:

- Method **with down integration time**:

  If the measurand falls below the dropout threshold, the pickup drops out immediately. If the value drops below the pickup threshold, the internal integral value that depends on the selected **`Down integration time`** is slowly reduced. The **`Down integration time`** defines the duration in order to reduce the internal integral value linear from 100 % to 0 %. The internal integral value is limited to 100 % and is reached with the tripping function.

- Method **with dropout delay**:

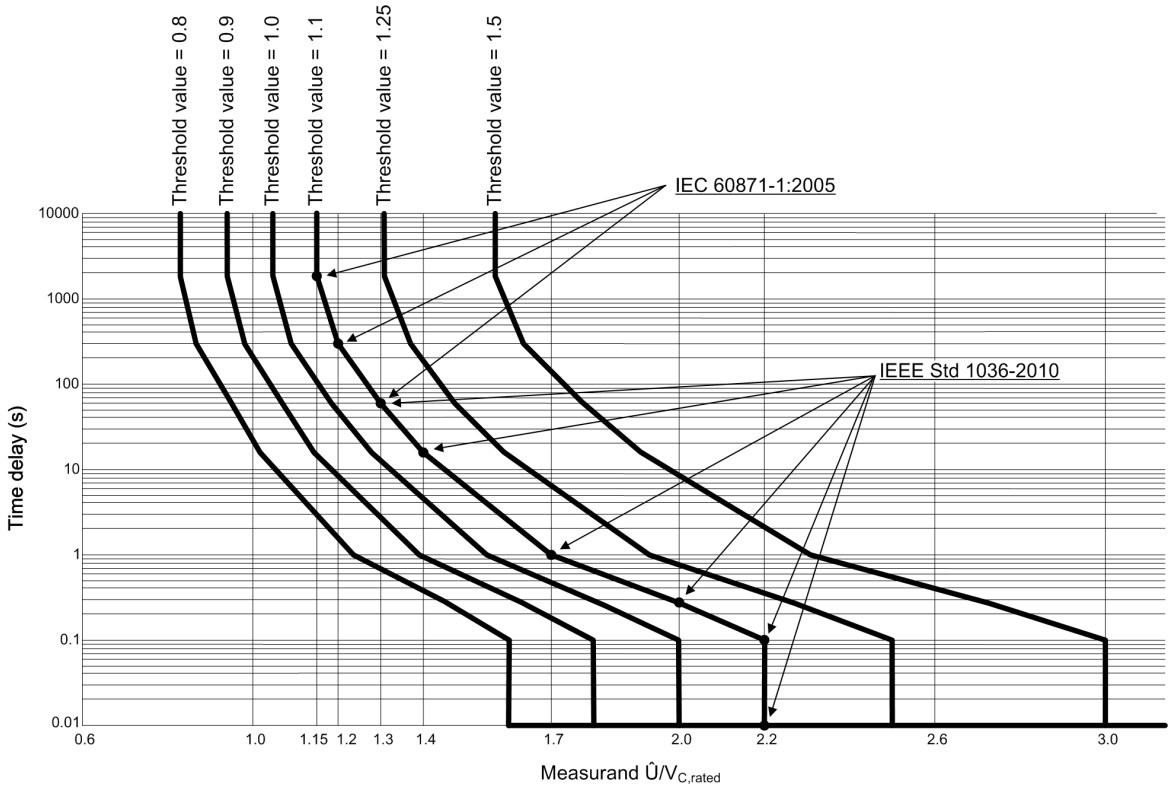
  If the measurand falls below the dropout threshold, the pickup drops not out immediately. The pickup remains for the duration of the set **`Dropout principle`** . The integral value remains frozen during this time. If the pickup value is not exceeded again during this time, a dropout occurs and the integral value is reset to 0. If the pickup value is exceeded during this time again, the integrator continues with the integration of frozen values. The pickup remains active and the **`Dropout principle`** is reset.

Inverse-Time Characteristic Curve

The characteristic curve is defined by the Standards IEC 60871-1:2005 and IEEE Std 1036-2010, see *Figure 7-32* .

The points on the characteristic curve defined in the standards result from a threshold setting of 1.1. Threshold values differing from this value shift the characteristic as shown in *Figure 7-32* .

Straight-line segments are implemented between the defined points on semi-logarithmic coordinates.



[dw_pecinv-230813, 2, en_US]

Figure 7-32 Inverse-Time Characteristic Curve

Phase-Segregated Operate Indications

In contrast to what normally occurs in a 3-phase protection device, the function generates phase-segregated operate indications. These indications are needed for supervision applications.

Function Values

Values	Description	Primary	Secondary	% Referenced to
(_:2311:301) VpeakA	Peak voltage phase A	kV	V	Parameter **Capacitor reference volt.**/√3
(_:2311:302) VpeakB	Peak voltage phase B	kV	V	Parameter **Capacitor reference volt.**/√3
(_:2311:303) VpeakC	Peak voltage phase C	kV	V	Parameter **Capacitor reference volt.**/√3

You can find the parameter **Capacitor reference volt.** of the preceding table in the function block **General** of the function group **Capacitor bank**.

7.6.3.2 Application and Setting Notes

Parameter: Capacitor rated current

- Default setting **(_:2311:101) Capacitor rated current** = ***1000.0 A***

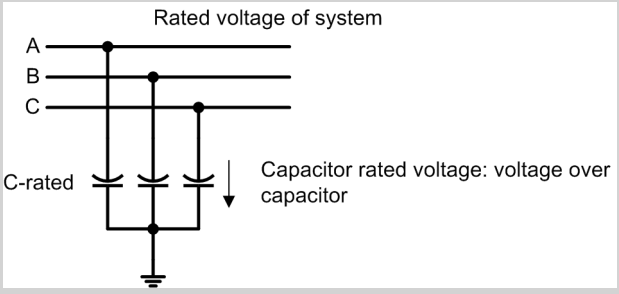
With the **Capacitor rated current** parameter, you set the primary rated current $I_{C\text{-rated}}$ of the capacitor or the capacitor bank.

Keep in mind that the rated current of the capacitor considers harmonics in addition to the fundamental component.

The rated current $I_{C\text{-rated}}$ is determined from the rated capacity and the rated voltage across the bank. Both values are listed in the Technical Data for the capacitor. Take note of the following:

- The rated voltage for the capacitor also takes harmonics into account. This is not the rated voltage of the system.
- The rated voltage to be used is the voltage applied across the capacitor; depending on the application, this can be a phase-to-phase or phase-to-ground voltage.

Example: Determining the Capacitor Rated Current for a Capacitor in a Star Connection



[dw_UC-Y-Schalt-110813, 1, en_US]

Figure 7-33 Capacitor in Star Connection

Rated voltage of the system	220 kV
Rated capacity per phase	5.233 µF
Capacitor rated voltage $V_{C\text{-rated}}$	192.30 kVrms
Rated frequency f	50 Hz

$I_{C\text{-rated}} = \omega C \times U_{C\text{-rated}} = 2\pi f \times C \times U_{C\text{-rated}} = 2\ \pi\ 50 \times 5.233\ 10^{-6} \times 192.3\ 10^{3}$ [Hz × F × U] = 316.1 [A]

Parameter: `Threshold`

- Default setting **`(_:13861:3) Threshold`** = ***`1.10`***

The peak voltage determined is then set with reference to the rated voltage of the capacitor. The threshold value is thus set as a referenced quantity.

The points on the characteristic curve defined in the Standards IEC 60871-1:2005 and IEEE Std 1036-2010 result from a threshold setting of ***`1.10`*** (see *Figure 7-32*). Threshold values differing from this shift the characteristic as shown in *Figure 7-32*.

Siemens recommends using the default setting.

Parameter: `Dropout principle`

- Default setting **`(_:13861:103) Dropout principle`** = ***`with down integration`***

Use the parameter **`Dropout principle`** to select the method for the dropout of the stage:

Parameter Value	Description
`with down integration`	If the measurand for the dropout threshold falls below the limit, the pickup drops out immediately. If the value drops below the pickup threshold, the internal integral value that depends on the selected down integration time is reduced from 100 % to 0 %
`with dropout delay`	If the measurand falls below the dropout threshold, the measurand remains active for the duration of the preset dropout delay. The integral value remains frozen during this time.

Parameter: **Down integration time**

- Default setting **(_:13861:102) Down integration time** = ***3.00 min***

Use the parameter **Down integration time** in order to determine the duration until the internal integration value is linearly reduced from 100 % to 0 %.

For example, if the integration value is 52 %, a duration of 52 % × down integration time is required until the integration value 0 % is reached. When using this parameter, the preloading of a capacitor can be considered and therefore released quicker.

If you are knowledgeable about recovery time of stressed capacitors, they can be considered with this parameter.

Parameter: **Dropout delay**

- Default setting **(_:13861:7) Dropout delay** = ***1.00 s***

The parameter **Dropout delay** can be used to prevent resetting of the integral value in the event that the measured value briefly falls below the dropout threshold.

7.6.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Capacitor rated current		1.0 A to 100000.0 A	1000.0 A
Inverse-T 1				
_:13861:1	Inverse-T 1:Mode		• off • on • test	off
_:13861:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:13861:103	Inverse-T 1:Dropout principle		• with dropout delay • with down integration	with down integration
_:13861:3	Inverse-T 1:Threshold		0.80 p.u. to 3.00 p.u.	1.10 p.u.
_:13861:102	Inverse-T 1:Down integration time		1 min to 1500 min	3 min
_:13861:7	Inverse-T 1:Dropout delay		0.00 s to 3600.00 s	1.00 s

7.6.3.4 Information List

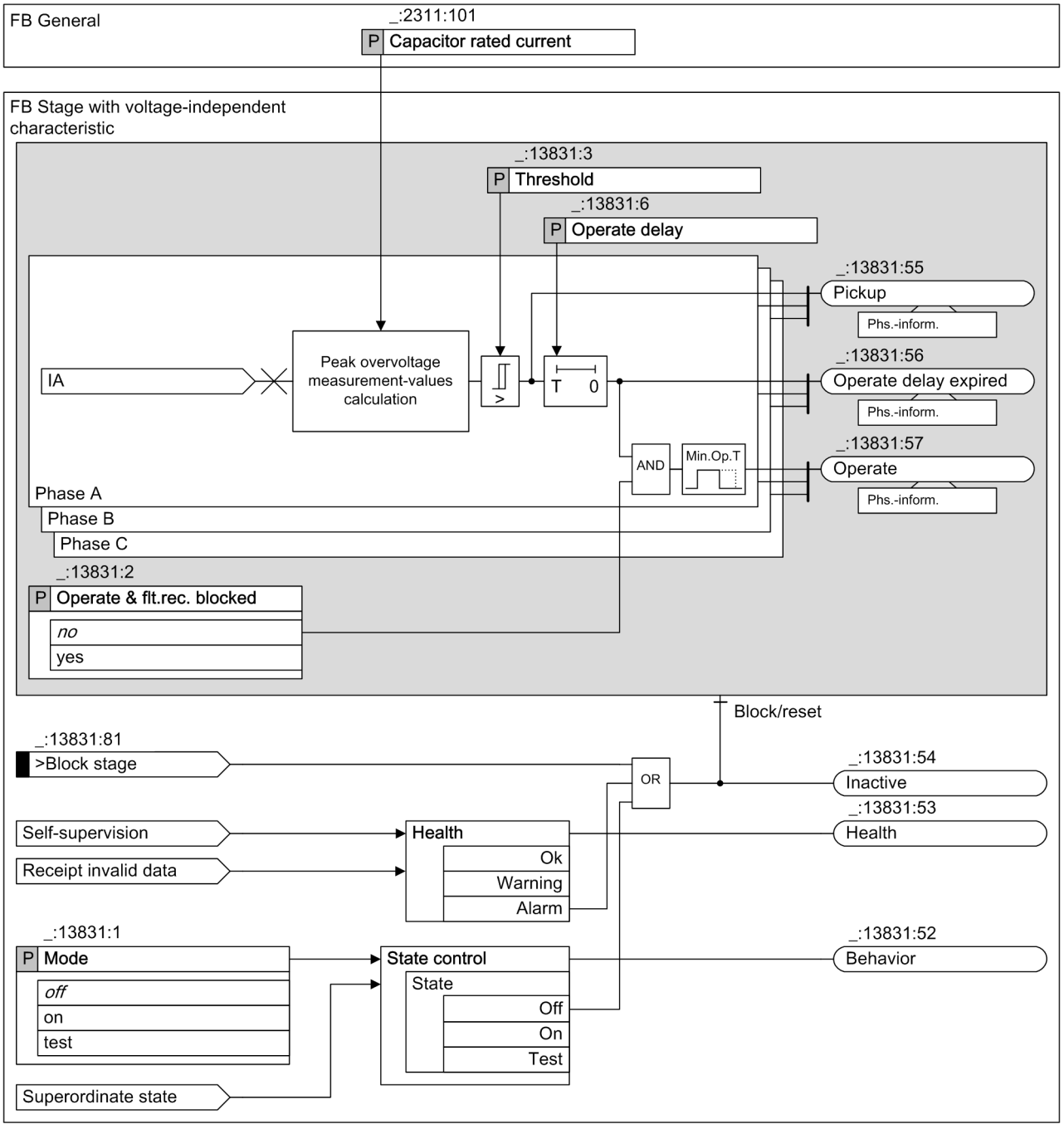
No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:VpeakA	MV	O
_:2311:302	General:VpeakB	MV	O
_:2311:303	General:VpeakC	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:13861:81	Inverse-T 1:>Block stage	SPS	I
_:13861:54	Inverse-T 1:Inactive	SPS	O
_:13861:52	Inverse-T 1:Behavior	ENS	O
_:13861:53	Inverse-T 1:Health	ENS	O

No.	Information	Data Class (Type)	Type
_:13861:55	Inverse-T 1:Pickup	ACD	O
_:13861:301	Inverse-T 1:Down integr. running	SPS	O
_:13861:56	Inverse-T 1:Operate delay expired	ACT	O
_:13861:57	Inverse-T 1:Operate	ACT	O

7.6.4 Stage with Definite-Time Characteristic Curve

7.6.4.1 Description

Logic of the Stage



[lo_peadef-230813, 1, en_US]

Figure 7-34 Logic Diagram of the Stage with Definite-Time Characteristic Curve

Measurand, Method of Measurement

The function calculates the peak voltage in a phase-segregated way from the fundamental component and superimposed harmonics. Integration of the phase currents then yields the voltage. This approach captures

the higher harmonics considerably better since they are transferred better by current transformers than by voltage transformers.

The peak voltage determined is then set with reference to the rated voltage of the capacitor. The resulting measurand is $\hat{U}/V_{C\text{-rated}}(t)$. The threshold value for the stage is thus set as a referenced quantity.

The phase-segregated peak overvoltages $\hat{U}/V_{C\text{-rated}}(t)$ are available as measured values for display or further processing.

Pickup, Tripping and Dropout Behavior with the Definite-Time Characteristic Curve

If the measurand $\hat{U}/V_{C\text{-rated}}(t)$ exceeds the set threshold value, pickup occurs and the tripping delay starts. If the measurand remains above the dropout value (95 % of the threshold value) during the tripping delay, the stage trips.

Phase-Segregated Operate Indications

In contrast to what normally occurs in a 3-phase protection device, the function generates phase-segregated operate indications. These indications are needed for supervision applications.

Function Values

For the detailed information of the function values, refer to *Function Values, Page 968*.

7.6.4.2 Application and Setting Notes

Parameter: `Capacitor rated current`

- Default setting **`(_:2311:101) Capacitor rated current`** = ***`1000.0 A`***

You can find the setting notes for the parameter **`Capacitor rated current`** under *Parameter: **`Capacitor rated current`**, Page 968*.

Parameter: `Threshold`

- Default setting **`(_:13831:3) Threshold`** = ***`1.10`***

The peak voltage determined is then set with reference to the rated voltage of the capacitor. The **`Threshold`** is thus set as a referenced quantity.

The setting depends on the application of the stage. If this stage is intended to operate as a warning stage, a very sensitive setting of approx. ***`1.05`*** can be selected. If the stage is used for instantaneous tripping in addition to the stage with inverse-time characteristic curve, Siemens recommends a setting of ≥ ***`3.00`***.

Parameter: `Operate delay`

- Default setting **`(_:13831:6) Operate delay`** = ***`3.00 s`***

The setting depends on the application of the stage. If this stage is intended to operate as a warning stage, the time delay can be selected in a range of seconds. If the stage is used for instantaneous tripping in addition to the stage with inverse-time characteristic curve, the **`Operate delay`** can be set to ***`0.00 s`***.

7.6.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:101	General:Capacitor rated current		1.0 A to 100000.0 A	1000.0 A
`Definite-T 1`				
_:13831:1	Definite-T 1:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:13831:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:13831:3	Definite-T 1:Threshold		0.80 p.u. to 10.00 p.u.	5.00 p.u.
_:13831:6	Definite-T 1:Operate delay		0.01 s to 3600.00 s	0.03 s

7.6.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:VpeakA	MV	O
_:2311:302	General:VpeakB	MV	O
_:2311:303	General:VpeakC	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:13831:81	Definite-T 1:>Block stage	SPS	I
_:13831:54	Definite-T 1:Inactive	SPS	O
_:13831:52	Definite-T 1:Behavior	ENS	O
_:13831:53	Definite-T 1:Health	ENS	O
_:13831:55	Definite-T 1:Pickup	ACD	O
_:13831:56	Definite-T 1:Operate delay expired	ACT	O
_:13831:57	Definite-T 1:Operate	ACT	O

7.6.5 Stage with User-Defined Characteristic Curve

7.6.5.1 Description

This stage is structured the same way as the stage with a **voltage-dependent** characteristic (see chapter *7.6.3.1 Description*). The only difference is that you can define the characteristic curve as desired. This means that you can also define a dropout characteristic curve. This makes the **dropout delay** parameter superfluous and unneeded.

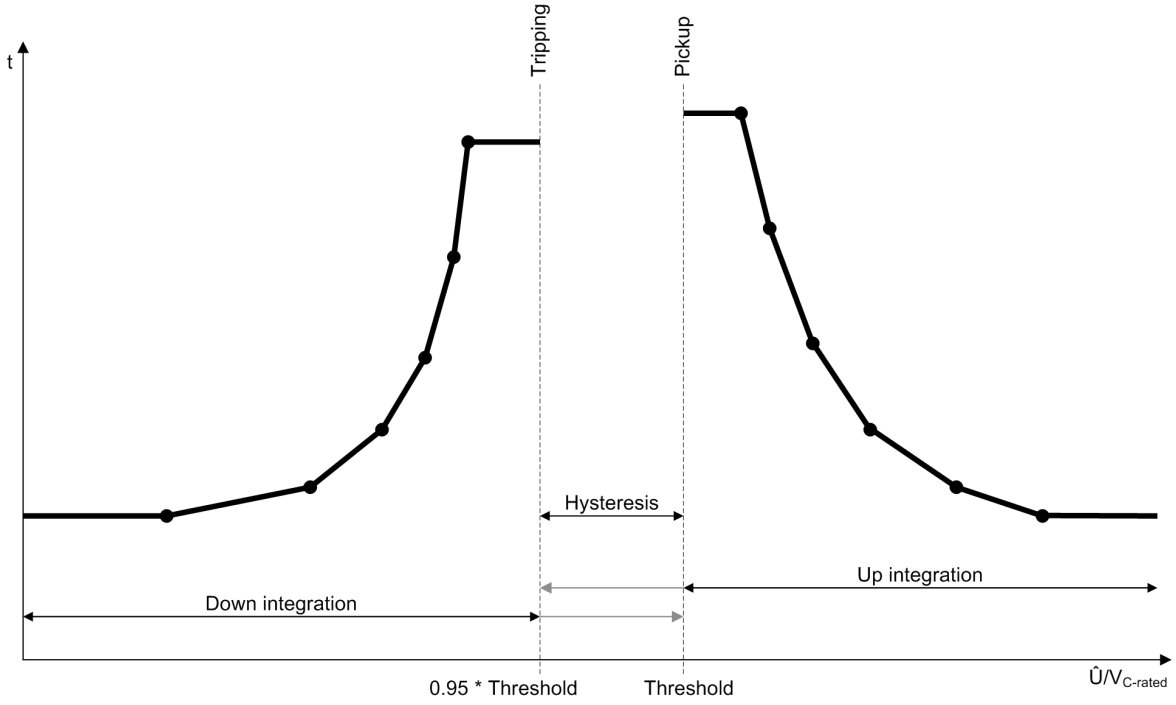
User-Defined Characteristic Curve

With the user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of voltage and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

Pickup and Dropout Behavior with the User-Defined Characteristic Curve

If the measurand $\hat{U}/V_{C\text{-rated}}(t)$ exceeds the threshold value, the characteristic is followed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. This means that the time associated with the present measured value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

If the measured value falls below 95 % of the set threshold value, the dropout is initiated. The pickup will be indicated as clearing. The weighted time results from the dropout characteristic curve. The integral value is reduced until it reaches 0.



[dw_pecuse-230813, 1, en_US]

Figure 7-35 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

7.6.5.2 Application and Setting Notes

This stage is structured the same way as the stage with a **inverse-time** characteristic (see chapter *7.6.3.2 Application and Setting Notes*). The only difference is that you can define the characteristic curve as desired. This chapter provides only application and setting notes for setting characteristic curves.

Parameter: `Voltage/Time Value Pairs` (from the Operate Curve)

Use these settings to define the characteristic curve. Set a voltage/time value pair for each point on the characteristic curve. The setting depends on the characteristic curve you want to realize.

Set the voltage to a multiple of the threshold value. In order to obtain a simple relation, Siemens recommends setting the **`Threshold`** parameter to ***`1.00`***. You can change the threshold value setting afterwards if you want to shift the characteristic curve.

Set the time value in seconds. The characteristic curve is shifted via the **`Time dial`** parameter.

Set the number of value pairs to be used with DIGSI. You can define a maximum of 30 value pairs.

NOTE

The value pairs must be entered in continuous order.

Parameter: `Time dial`

- Default setting **`(_:101) Time dial`** = ***`1`***

Use the **`Time dial`** parameter to displace the characteristic curve in the time direction.

Where no time grading of tripping and thus no shifting of the characteristic curve is required, leave the parameter **`Time dial`** at 1.

Parameter: `Voltage/Time Value Pairs` (from the Dropout Characteristic Curve)

Use these settings to define the characteristic curve. Set a voltage/time value pair for each point on the characteristic curve. The setting depends on the characteristic curve you want to realize.

Set the voltage to a multiple of the threshold value. Siemens recommends setting the **Threshold** parameter to ***1.00*** in order to obtain a simple relation. You can change the threshold value afterwards if you want to shift the characteristic curve.

Set the time value in seconds. The characteristic curve is shifted via the **Time dial** parameter.

Set the number of value pairs to be used with DIGSI. You can define a maximum of 30 value pairs.



NOTE

The value pairs must be entered in continuous order.

7.6.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:3	User curve #:Threshold		0.80 p.u. to 3.00 p.u.	1.10 p.u.
_:101	User curve #:Time dial		0.05 to 15.00	1.00

7.6.5.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O
_:301	User curve #:Down integr. running	SPS	O

7.7 Voltage Differential Protection for Capacitors

7.7.1 Overview of the Functions

The function **Voltage-differential protection** (ANSI 87V) can be applied if the capacitor offers a voltage tap to measure the 3-phase voltage within the capacitor installation. The function:

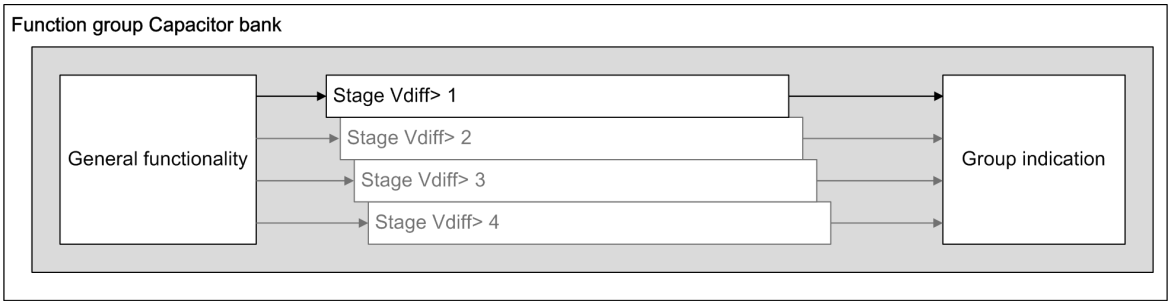
- Calculates the differential voltage between bus and tap voltage by applying a matching factor
- Works as a capacitor unbalance function for protection of faults in capacitor elements (C elements)

7.7.2 Structure of the Function

The function **Voltage-differential protection** is used in the function group **Capacitor bank**. The function is preconfigured at the factory with one protection stage **V_{diff} >**.

A maximum of 4 protection stages **V_{diff} >** can be operated simultaneously in the function.

The **General functionality** (including compensation) works across all stages.



[dw_strucVoldi-060213-01.vsd, 1, en_US]

Figure 7-36 Structure of the Function Voltage-Differential Protection

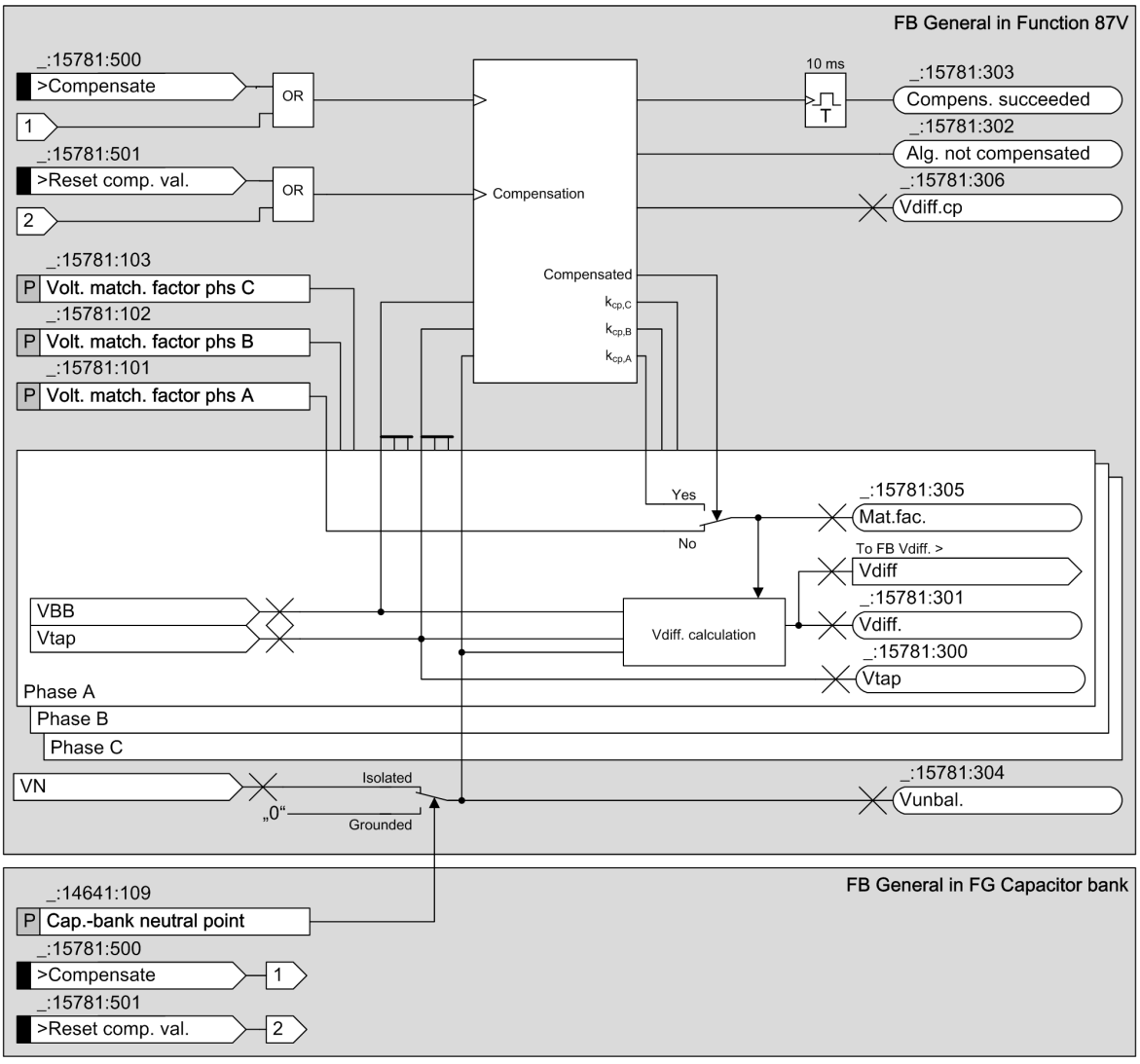
7.7.3 General Functionality

7.7.3.1 Description

The **General functionality** is structured in the following parts:

- Calculation of the differential voltage $V_{diff.}$
- Compensation of an operational differential voltage $V_{diff.}$

Logic for Calculation and Compensation



[Lo_voltdiffgeneral_20140714.vsd, 2, en_US]

Figure 7-37 Logic Diagram of the General Functionality

Measurands, Method of Measurement

The function receives the 3-phase bus and tap voltage measurands (see also V_{BB} and V_{tap} in *Figure 7-37*) via the **3-phase voltage** and **3-phase voltage CB tap** interfaces of the function group **Capacitor bank**. For an isolated capacitor-bank system, the function receives the capacitor-bank neutral-point voltage V_N via the **Voltage unbalance** interface. The method of measurement used processes the sampled voltage values and filters out the fundamental component numerically.

The compensated or not compensated differential voltage is provided to the protection stage for evaluation.

Voltage Matching Factor

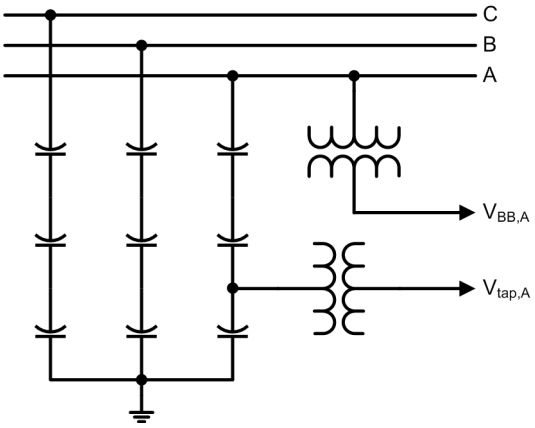
The phase-selective voltage matching factor k is used as a multiplier for the tap voltage to obtain an equivalent voltage value compared to the bus voltage. The voltage matching factor k is obtained either from the parameter **`Volt. match. factor phs A`**, **`Volt. match. factor phs B`**, and **`Volt. match. factor phs C`** or from the compensation functionality. If the compensation is carried out, the function calculates the voltage matching factor k through dividing the measured bus voltage by the measured tap voltage.

Calculation of the Differential Voltage

The calculation of the differential voltage depends on the capacitor-bank neutral-point grounding. With the parameter **`Cap. bank neutral point`**, you can set the grounding type.

2 capacitor-bank neutral-point grounding types are as follows:

- **Grounded capacitor-bank system**



[dw_voltage_measurement_grounded, 1, en_US]

Figure 7-38 Voltage Measurement for a Grounded Capacitor-Bank System

The following formula is used to calculate the differential voltage $V_{diff.}$ of phase A:

$$\underline{V}_{diff,A} = |\underline{V}_{BB,A} - \underline{k}_A \cdot \underline{V}_{tap,A}|$$

$V_{BB,A}$	Voltage from the busbar, phase A
$V_{tap,A}$	Voltage from the tap, phase A
k_A	Voltage matching factor, phase A

This calculation also applies to the calculation of the $V_{diff.}$ of phase B and phase C.

The voltage measuring-points are connected with the corresponding function-group interfaces.

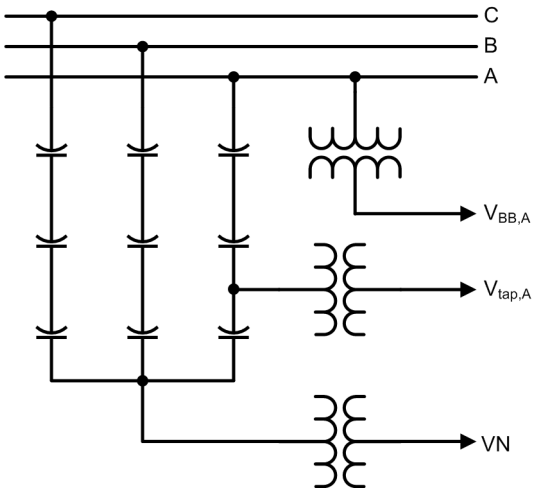
Connect measuring points to function group

	Capacitor bank 1				
Measuring point	V 3ph	I 3ph	V 3ph cap. tap	I unbalance	I 3ph RLC
(All)	(All)	(All)	(All)	(All)	(All)
Meas.point I-3ph 1[ID 1]		X			
Meas.point V-3ph 1[ID 2]	X				
Meas.point V-3ph 2[ID 3]			X		

[Sc_grounded_ground, 1, en_US]

Figure 7-39 Connecting Measuring Points to the Function Group Capacitor Bank for the Grounded Capacitor-Bank System

- **Isolated capacitor-bank system**



[dw_voltage_measurement_isolated, 1, en_US]

Figure 7-40 Voltage Measurement for an Isolated Capacitor-Bank System

The following formula is used to calculate the differential voltage $V_{diff.}$ of phase A:

$$V_{diff,A} = |(\underline{V}_{BB,A} - \underline{V}_N) - \underline{k}_A \cdot (\underline{V}_{tap,A} - \underline{V}_N)|$$

$V_{BB,A}$	Bus voltage, phase A
$V_{tap,A}$	Tap voltage, phase A
k_A	Voltage matching factor, phase A
V_N	Neutral-point-to-ground voltage

This calculation also applies to the calculation of the $V_{diff.}$ of phase B and phase C.

The voltage V_N is obtained by connecting the measuring point **V-1ph** to the interface $\mathbf{V}_{\mathbf{unbalance}}$. **V-1ph** is used for measuring V_N.

Connect measuring points to function group

	Capacitor bank 1					
Measuring point	V 3ph	I 3ph	V 3ph cap. tap	V unbalance	I unbalance	I 3ph RLC
(All)	(All)	(All)	(All)	(All)	(All)	(All)
Meas.point I-3ph 1[ID 1]		X				
Meas.point V-3ph 1[ID 2]	X					
Meas.point V-3ph 2[ID 3]			X			
Meas.point V-1ph 1[ID 4]				X		

[Sc_isolate_ground, 1, en_US]

Figure 7-41 Connecting Measuring Points to the Function Group Capacitor Bank for the Isolated Capacitor-Bank System

Both the capacitor-bank tap voltage and the calculated differential voltage are displayed as measured values of the function.

General Notes on the Compensation

An operational differential voltage is added to a differential voltage resulting from faulty capacitor elements. This corrupts the measuring result.

The operational differential voltages can result from the following factors:

- Manufacturing tolerances of the capacitor
- Aging of the capacitor
- Environmental influences, for example, temperature

The compensation eliminates the operational differential voltage by adjusting the voltage matching factors. The adjusted phasors of the matching factor are calculated at the compensation moment, with the following formula (for phase A):

- **Grounded capacitor-bank system**
  $\underline{k}_{cp,A} = \underline{V}_{BB,A} / \underline{V}_{tap,A}$
- **Isolated capacitor-bank system**
  $\underline{k}_{cp,A} = (\underline{V}_{BB,A} - \underline{V}_{N}) / (\underline{V}_{tap,A} - \underline{V}_{N})$

With

$V_{BB,A}$	Bus voltage, phase A
$V_{tap,A}$	Tap voltage, phase A
$k_{cp,A}$	Calculated matching factor at the compensation moment, phase A
V_{N}	Neutral-point-to-ground voltage

The calculation also applies to the calculation of the voltage matching factors of phase B and phase C.
The phasors of the calculated voltage matching factors k_{cp} are stored and used for calculation of the differential voltage until the next compensation is applied or until the compensation is reset.
The phasors of the calculated voltage matching factors k_{cp} are displayed as functional measured values after the compensation is applied. In addition, the compensated differential voltage **Vdiff.cp** is available as functional measured value. **Vdiff.cp** is the differential voltage at the moment of the compensation compared to the uncompensated status. The compensated differential voltage **Vdiff.cp** is calculated with the following formula (for phase A):

- **Grounded capacitor-bank system**
  $V_{diff.cp,A} = | (\underline{V}_{BB,A} - \underline{V}_{N}) - k_{A} \cdot (\underline{V}_{tap,A} - \underline{V}_{N})|$
- **Isolated capacitor-bank system**
  $V_{diff.cp,A} = | \underline{V}_{BB,A} - k_{A} \cdot \underline{V}_{tap,A}|$

With

k_{A}	Parameter **Volt. match. factor phs A**
$V_{BB,A}$	Voltage from the busbar, phase A
$V_{tap,A}$	Voltage from the tap, phase A
V_{N}	Neutral-point-to-ground voltage

This calculation also applies to the calculation of the compensated differential voltage of phase B and phase C.

Manual Compensation via Binary Input Signal

Manual compensation via binary input signals is available.
The following indications describe the status of the compensation:

Indication	Description
Alg. not compensated	The algorithm is not compensated. Compensated values are not available.
Compens. succeeded	If the existing unbalance has been compensated manually, this indication is issued (as transient indication).

By activation of the binary input signal *>Compensate* , the manual compensation is started and the differential voltage that exists at that moment is compensated to 0. The value of $V_{diff.}$ becomes 0.

NOTE

If the measured bus voltage or tap voltage is too low, the manual compensation cannot be performed. No manual compensation is carried out under the following conditions:

- In the **grounded** system:
  $V_{BB} < 10\% * V_{BB,rated}$ or $V_{tap,sec} < 1\ V$
- In the **isolated** system:

$$\left| \underline{V}_{BB,prim} - \underline{V}_{N,prim} \right| < 10\% * V_{BB,rated,prim} \quad \text{or}$$

$$\left| \underline{V}_{tap,prim} - \underline{V}_{N,prim} \right| * \frac{V_{tap,rated,sec}}{V_{tap,rated,prim}} < 1\ V$$

[fo_isolated-system, 1, en_US]

Resetting the Compensation

If one of the following conditions is met, the function works in the not compensated status:

- Initial startup of the device before any compensation has been carried out
- Activation of the binary input *>Reset comp. val.*
- Change of the parameter **Capacitor-bank neutral point** in the function group **Capacitor bank** (refer to chapter *5.4.3 Application and Setting Notes*)

The not compensated status is indicated via the signal *Alg. not compensated*.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:15781:300) Vtap	Tap voltage	kV	V	Parameter **Capacitor reference volt.**/√3
(_:15781:304) Vunbal.	Neutral-point voltage	kV	V	Parameter **Capacitor reference volt.**
(_:15781:301) Vdiff.	Differential voltage	kV	V	Parameter **Capacitor reference volt.**/√3
(_:15781:306) Vdiff.cp	The compensated differential voltage at the compensation moment	kV	V	Parameter **Capacitor reference volt.**/√3
(_:15781:101) Volt. match. factor phs A	Voltage matching factor of phase A	-	-	-
(_:15781:102) Volt. match. factor phs B	Voltage matching factor of phase B	-	-	-
(_:15781:103) Volt. match. factor phs C	Voltage matching factor of phase C	-	-	-

You can find the parameter **Capacitor reference volt.** in the function block **General** of the function group **Capacitor bank**.

NOTE

If the function works in the uncompensated status, the values of parameter **Volt. match. factor phs A**, **Volt. match. factor phs B** and **Volt. match. factor phs C** are displayed as functional measured values of the voltage matching factors. And the functional measured values of **Vdiff.cp** are shown as **---**.

7.7.3.2 Application and Setting Notes

Parameter: `Volt. match. factor phs A`, `Volt. match. factor phs B` and `Volt. match. factor phs C`

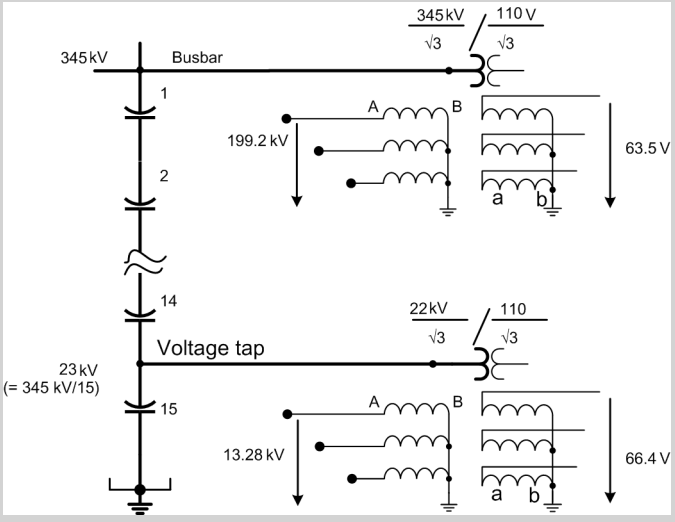
- Default setting **`(_:15781:101) Volt. match. factor phs A`** = ***2.0000***
- Default setting **`(_:15781:102) Volt. match. factor phs B`** = ***2.0000***
- Default setting **`(_:15781:103) Volt. match. factor phs C`** = ***2.0000***

The phase-selective parameters **`Volt. match. factor phs A`**, **`Volt. match. factor phs B`** and **`Volt. match. factor phs C`** are applied as multiplier for the primary tap voltage to calculate the differential voltage. It depends on the position of the tap-voltage measurement in the specific capacitor installation. The setting is defined as the ratio of the capacitor-bank reference voltage to the tap voltage.

EXAMPLE

The application consists of:

- Capacitor-bank busbar, with a rated voltage of 345 kV
- Capacitor bank, consisting of 15 can levels in series
- Capacitor-bank tap-voltage measurement between level 14 and 15



[lo_application example, 2, en_US]

Figure 7-42 Application Example for Setting the Voltage Matching Factor

Capacitor-bank bus voltage as phase-to-phase voltage (it equals to a phase-to-ground voltage of 199.2 kV)	345 kV
Capacitor-bank tap voltage as phase-to-phase voltage (it equals a phase-to-ground voltage of 13.28 kV)	23 kV
Voltage matching factors are set as: (including parameters **`Volt. match. factor phs A`**, **`Volt. match. factor phs B`**, and **`Volt. match. factor phs C`**)	345 kV/23 kV = 15

The voltage measuring points must be set as indicated in the figure:

Busbar transformer, rated primary voltage:	345 kV
Busbar transformer, rated secondary voltage:	110 V
Tap transformer, rated primary voltage:	22 kV
Tap transformer, rated secondary voltage:	110 V

Under normal operation, these settings result in a differential voltage of approximately 0 V and in the primary and secondary measured voltage values as indicated in the *7.7.3.2 Application and Setting Notes*.

NOTE

The sound secondary tap voltage must not be smaller than 1 V. Otherwise the function cannot work properly. Fulfill this condition by applying an appropriate voltage transformer for the tap voltage. Siemens recommends applying a tap voltage transformer which provides under normal operation a secondary voltage in the area of the rated secondary voltage.

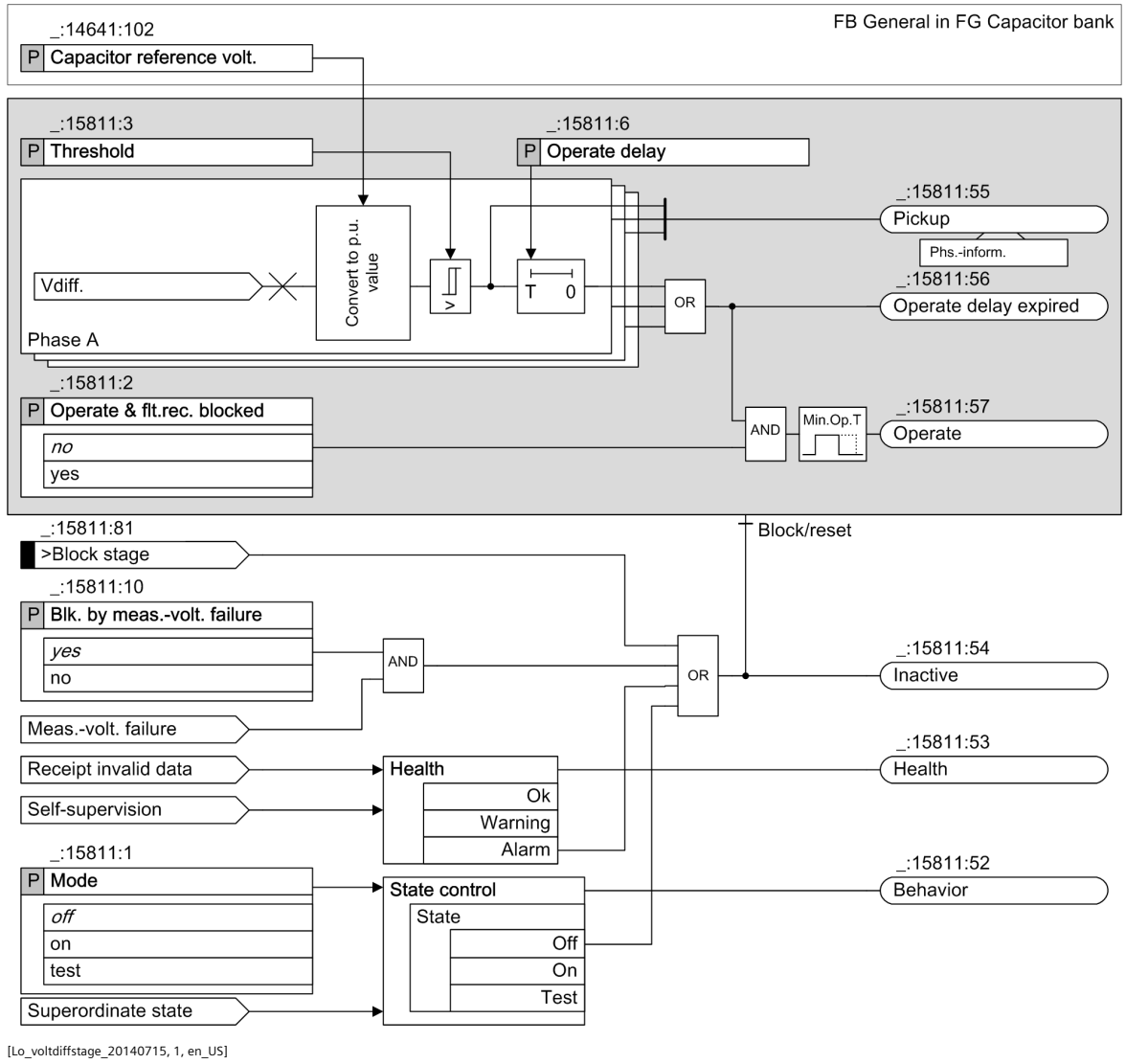
EXAMPLE

In the **grounded** system:
Ratio of the capacitor-bank bus voltage to the tap voltage: matching factor k = 400 kV/400 V = 1000
Busbar transformer, rated primary voltage: 400 kV
Busbar transformer, rated secondary voltage: 100 V
To ensure an optimal tap-voltage measurement, the following transformer ratio is recommended:
Tap transformer, rated primary voltage: 400 V
Tap transformer, rated secondary voltage: 100 V

7.7.4 Description Protection Stage

7.7.4.1 Description

Logic of the Stage V_{diff}



[Lo_voltdiffstage_20140715, 1, en_US]

Figure 7-43 Logic of the Protection Stage V_{diff}

Measurand, Pickup and Operate

In the protection stage, the differential-voltage value is converted to a p.u. value in relation to the capacitor-bank reference voltage.

If the converted value exceeds the **`Threshold`** value, a *`Pickup`* indication is issued. If the threshold is exceeded continuously during the operate delay, an *`Operate`* signal is issued.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal *>Block stage* from an external or internal source.
- From inside on pickup of the function **Measuring-voltage failure detection** (see section *9.3.2.1 Overview of Functions*). The parameter **Blk. by meas.-volt. failure** can be set so that the measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal *>Open* of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker. The parameter **Blk. by meas.-volt. failure** can be set so that the measuring-voltage failure detection blocks the stage or does not block it.

7.7.4.2 Application and Setting Notes

Parameter: Threshold

- Default setting **(_:15811:3) Threshold** = ***0.200 p.u.***

The parameter **Threshold** is set as a p.u. value related to the parameter **Capacitor bank reference voltage** in the function group **Capacitor bank**.

The setting of the parameter **Threshold** depends on the differential voltage that occurs with the number of defective C elements for which a warning indication or a trip command shall be generated. Determine this differential voltage and set the **Threshold** slightly lower, for example, to 80 % of the value.

Parameter: Operate delay

- Default setting **(_:15811:6) Operate delay** = ***1.00 s***

Set the parameter **Operate delay** for the specific application.

Parameter: Blk. by meas.-volt. failure

- Default setting **(_:15811:10) Blk. by meas.-volt. failure** = ***yes***

You can use the parameter **Blk. by meas.-volt. failure** to control the response of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal **Measuring-voltage failure detection** function is configured and switched on.
- The binary input signal *>Open* of the function block **Voltage-transformer circuit breaker** is connected to the voltage-transformer circuit breaker. This binary input is available in the voltage transformers connected to the bus voltage and capacitor-bank tap voltage. The binary input is also available in the voltage transformer connected to the VN voltage in case of an isolated capacitor bank.

Parameter Value	Description
no	The stage Vdiff > is not blocked when a measuring-voltage failure is detected.
yes	The stage Vdiff > is blocked when a measuring-voltage failure is detected. Siemens recommends using the default setting, as correct operation of the stage cannot be guaranteed if a measuring-voltage failure occurs.

7.7.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:15781:101	General:Volt. match. factor phs A		0.5000 to 2000.0000	2.0000
_:15781:102	General:Volt. match. factor phs B		0.5000 to 2000.0000	2.0000

Addr.	Parameter	C	Setting Options	Default Setting
_:15781:103	General:Volt. match. factor phs C		0.5000 to 2000.0000	2.0000
Vdiff> 1				
_:15811:1	Vdiff> 1:Mode		• off • on • test	off
_:15811:2	Vdiff> 1:Operate & flt.rec. blocked		• no • yes	no
_:15811:10	Vdiff> 1:Blk. by meas.-volt. failure		• no • yes	yes
_:15811:3	Vdiff> 1:Threshold		0.005 p.u. to 1.000 p.u.	0.200 p.u.
_:15811:6	Vdiff> 1:Operate delay		0.00 s to 60.00 s	1.00 s

7.7.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:15781:500	General:>Compensate	SPS	I
_:15781:501	General:>Reset comp. val.	SPS	I
_:15781:302	General:Alg. not compensated	SPS	O
_:15781:303	General:Compens. succeeded	SPS	O
_:15781:300	General:Vtap	WYE	O
_:15781:301	General:Vdiff.	WYE	O
_:15781:304	General:Vunbal.	CMV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Vdiff> 1			
_:15811:81	Vdiff> 1:>Block stage	SPS	I
_:15811:54	Vdiff> 1:Inactive	SPS	O
_:15811:52	Vdiff> 1:Behavior	ENS	O
_:15811:53	Vdiff> 1:Health	ENS	O
_:15811:55	Vdiff> 1:Pickup	ACD	O
_:15811:56	Vdiff> 1:Operate delay expired	ACT	O
_:15811:57	Vdiff> 1:Operate	ACT	O

7.8 Differential Protection for Capacitor Banks

7.8.1 Function Overview

The function **Differential protection for capacitor banks** (ANSI 87C):

- Detects ground faults and multiphase short circuits at capacitor banks
- Detects ground faults during the operation of capacitors in systems with a grounded neutral point
- Uses the necessary stabilization procedures during energizing operations
- Trips safely and very fast in the case of internal high-current faults through an additional high-current stage

7.8.2 Structure of the Function

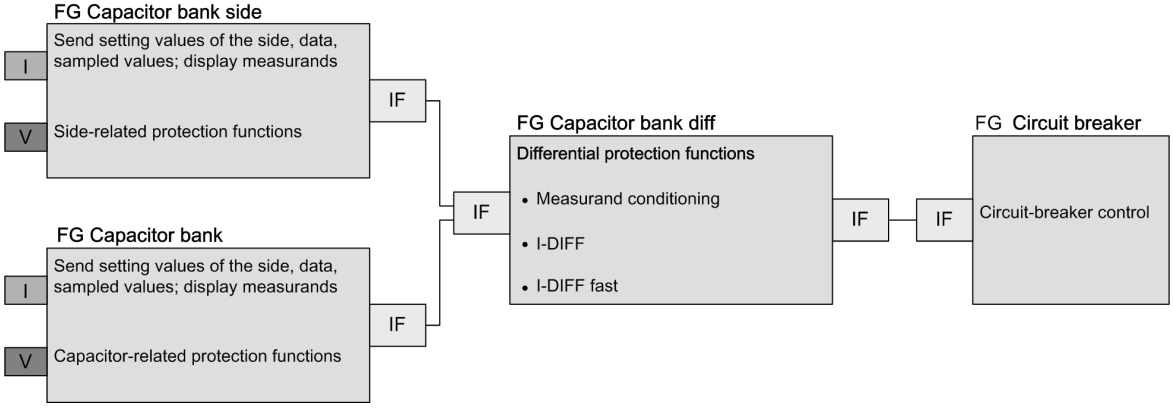
The **Differential capacitor bank protection** function is used in the **Capacitor Bank diff** protection function group. The function is preconfigured by the manufacturer in the corresponding application template depending on the application and can be copied during the engineering into the corresponding function group.

The **Differential capacitor bank protection** function consists of the stages IDiff and IDiff fast. The stages can be blocked, in addition you can switch the stages on and off.

The function group **Capacitor bank side** has the following characteristics:

- The side-related protection settings are performed
- The side-related calculations are performed
- All data (setting values, detected currents) are relayed to the **Capacitor bank Diff** function group

The side-related protection functions can run in the **Capacitor bank side** function group, for example overload protection, overcurrent protection, etc.



[dweimcapbk-030314-01, 2, en_US]

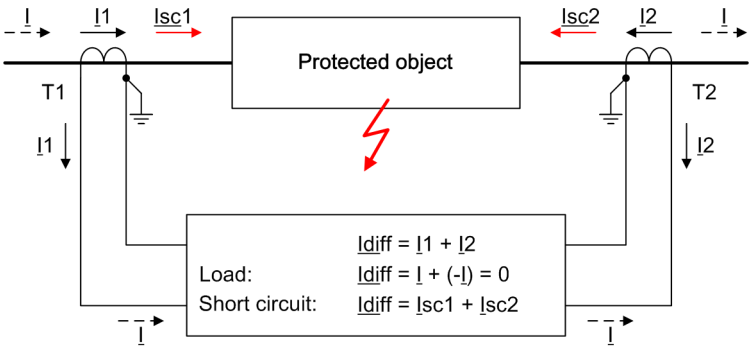
Figure 7-44 Structure/Embedding of the Function

7.8.3 Function Description

Basic Principle of Differential Protection

Differential protection is based on a comparison of currents (Kirchhoff current law). When comparing the current, use is made of the fact that a protected object uses the same current I in a non-faulty operating state on both sides (dotted in *Figure 7-45*). This current flows into the range being observed on one side and leaves it again on the other side. A current differential is a sure indication of a fault within the protected object. The calculation of the difference is determined through the current-direction definition. The current direction is

defined as positive to the protected object. The current difference results from the vector addition of the currents.



[dwprin2s-170712-01.tif, 1, en_US]

Figure 7-45 Basic Principle of Differential Protection Using the Example of 2 Sides

For safe operation, additional functions are required. The implementation of these additional functions is described in chapter *Differential Protection Function (Idiff), Page 993*.

Current Stabilization

If very large currents flow through the protection range in the case of external faults, with different transmission behavior of the transformers **W1** and **W2** (*Figure 7-45*), a corresponding differential current I_{diff} occurs. When this is larger than the corresponding pickup threshold, the device can issue a trip command, even though no fault is present in the protection range. Such a malfunction of the protection is avoided by the restraint current (I_{rest}) and is implemented in the form of a characteristic curve $I_{diff} = f(I_{rest})$.

The largest current of 2 or more measuring points of the protected object is used for stabilization.

The definition for 2 measuring points is:

A trip or differential current is

$I_{diff} = (\underline{I}_1 + \underline{I}_2)$

as well as a restraint current of

$I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2|)$

For more than 2 measuring points, this definition is expanded. This restraint method allows a reliable trip decision for more than 2 measuring points and different feeding behavior for internal short circuits.

$I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2| ; \ldots |\underline{I}_n|)$

To clarify the effect, 3 important operating states are observed with ideal and adapted measurands.

- Through fault current in healthy operation or externally caused error:
  $\underline{I}_1$ flows into the protection range, $\underline{I}_2$ flows out of the protection range, that is, negative compared with the prefix definition, thus $\underline{I}_2 = -\underline{I}_1$;

  in addition $|\underline{I}_2| = |\underline{I}_1|$

  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 - \underline{I}_1| = 0$

  $I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2|) = |\underline{I}_1| = |\underline{I}_2|$

  No tripping quantity ($I_{diff} = 0$); the stabilization (I_{rest}) corresponds to the flowing current.

- Internal short circuit, feed from both sides with equal amount of currents, for example:
  Then $\underline{I}_2 = \underline{I}_1$; In addition $|\underline{I}_2| = |\underline{I}_1|$;

  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 + \underline{I}_1| = 2 \cdot |\underline{I}_1|$

  $I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2|) = |\underline{I}_1| = |\underline{I}_2|$

  The tripping quantity (I_{diff}) is twice as large as the short-circuit current and the restraining quantity (I_{rest}).

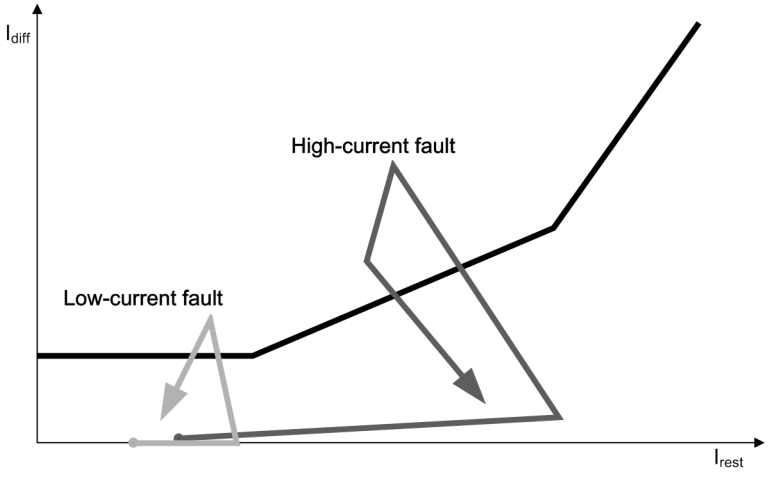
- Internal short circuit, feed only from one side:
  Then $\underline{I}_2 = 0$
  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 + 0| = |\underline{I}_1|$
  $I_{rest} = \text{Max}\,(|\underline{I}_1| ; |\underline{I}_2|) = |\underline{I}_1|$
  The tripping quantity (I_{diff}) and the restraining quantity (I_{rest}) are of the same size and correspond to the short-circuit current.

Additional Stabilization with External Short Circuits

In case of an external short circuit, high short-circuit currents flowing through can lead to current-transformer saturation. This saturation can be more or less strongly pronounced at the measuring points, and in this way simulate a differential current. The differential current can lie in the tripping range of the characteristic curve for a certain time and lead to unwanted tripping without any particular measures. In accordance with *Figure 7-46*, there are 2 typical scenarios:

- High-current, external short circuit
  First, the current on both sides is transferred and leads to a large restraint current. After this, a transformer becomes saturated, resulting in a differential current I_{diff} that can exceed the operate curve. Simultaneously, the restraint current I_{rest} drops. Once the transformer is no longer saturated, the differential current decreases and falls below the characteristic curve.
- Low-current, external short circuit
  Current transformers can also become saturated through the large direct-current time constant (switching of transformers, motors), but small currents flowing through. This manifests itself as a phase-angle rotation of the current. Exceeding the characteristic curve in a non-stabilized area is possible.

Intelligent saturation-detection methods capture this state and lead to a temporally limited blocking of the Differential protection function.



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Figure 7-46 Principle Current Course in External Short Circuit and Temporary Current-Transformer Saturation on One Side

Inrush-Current Detection

The inrush-current detection evaluates the calculated instantaneous values of the differential current. The inrush current develops with Sympathetic Inrush – connection of a parallel transformer or Recovery Inrush – inrush current subsequent to returning voltage after fault in the system considerably higher than in the side currents. An assignment to the corresponding blocking phases is possible only in the differential current due to the vector-group correction.

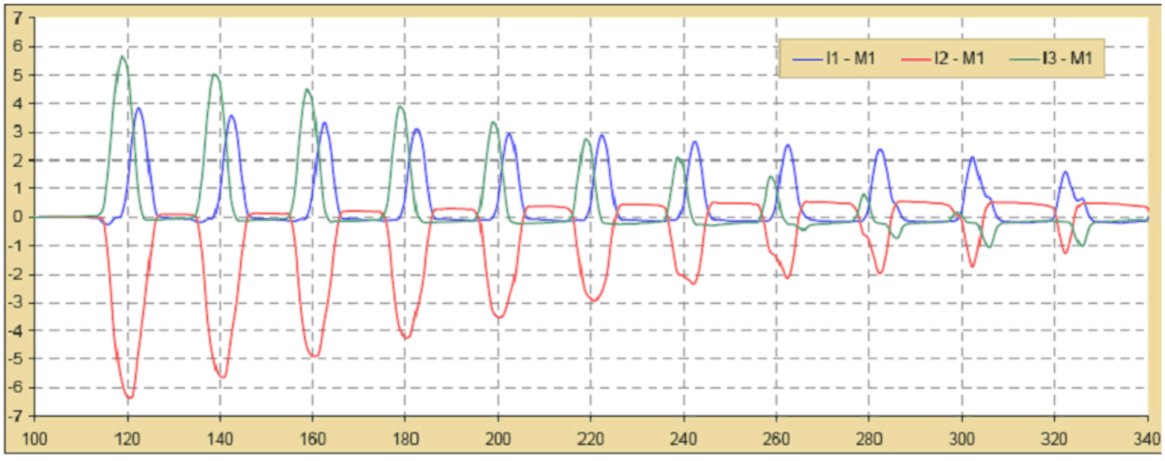
The inrush-current detection is activated when the pickup characteristic is exceeded. It is deactivated when it is blocked by an external fault.

For inrush-current detection, 2 methods working in parallel are used:

- **Share of the 2nd harmonic relative to the fundamental component in the differential current ($I_{2nd\ harm}/I_{1st\ harm}$)**

  As *Figure 7-47* also shows, the 2nd harmonic is clearly pronounced in the inrush current. If the share of the 2nd harmonic exceeds the set threshold value (parameter: **`2nd harmonic content`**), a phase-segregated blocking occurs. The harmonics develop differently in the different phases. If exceeding of the 2nd harmonic is detected in a phase, it may be necessary to block all phases simultaneously. This blocking must be limited with regard to time and is controlled by the parameter **`Crossblock. time 2nd har.`**. The correct positioning of the filter windows is controlled by the internal pickup.

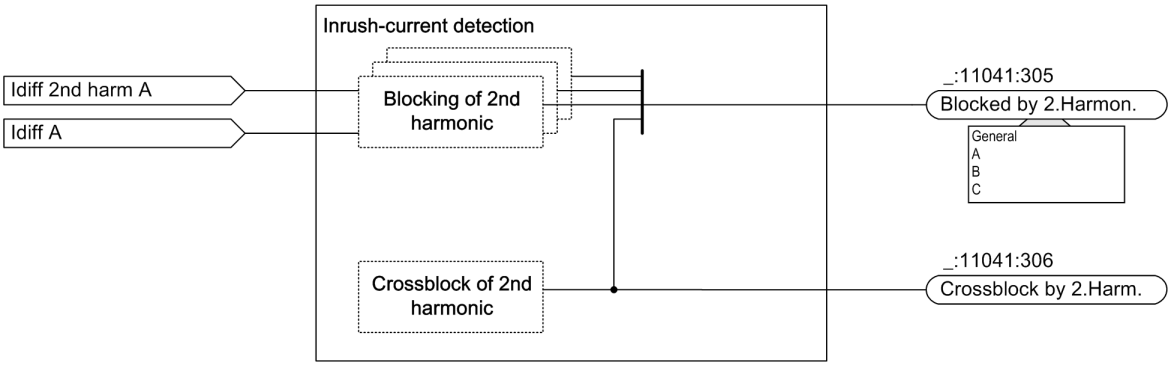
If you want only one method to be active, the other method can be changed to inactive. For this, parameter **`Blocking with 2. harmonic`** = ***no*** is used.



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Figure 7-47 Inrush Current with Pronounced Flat Areas

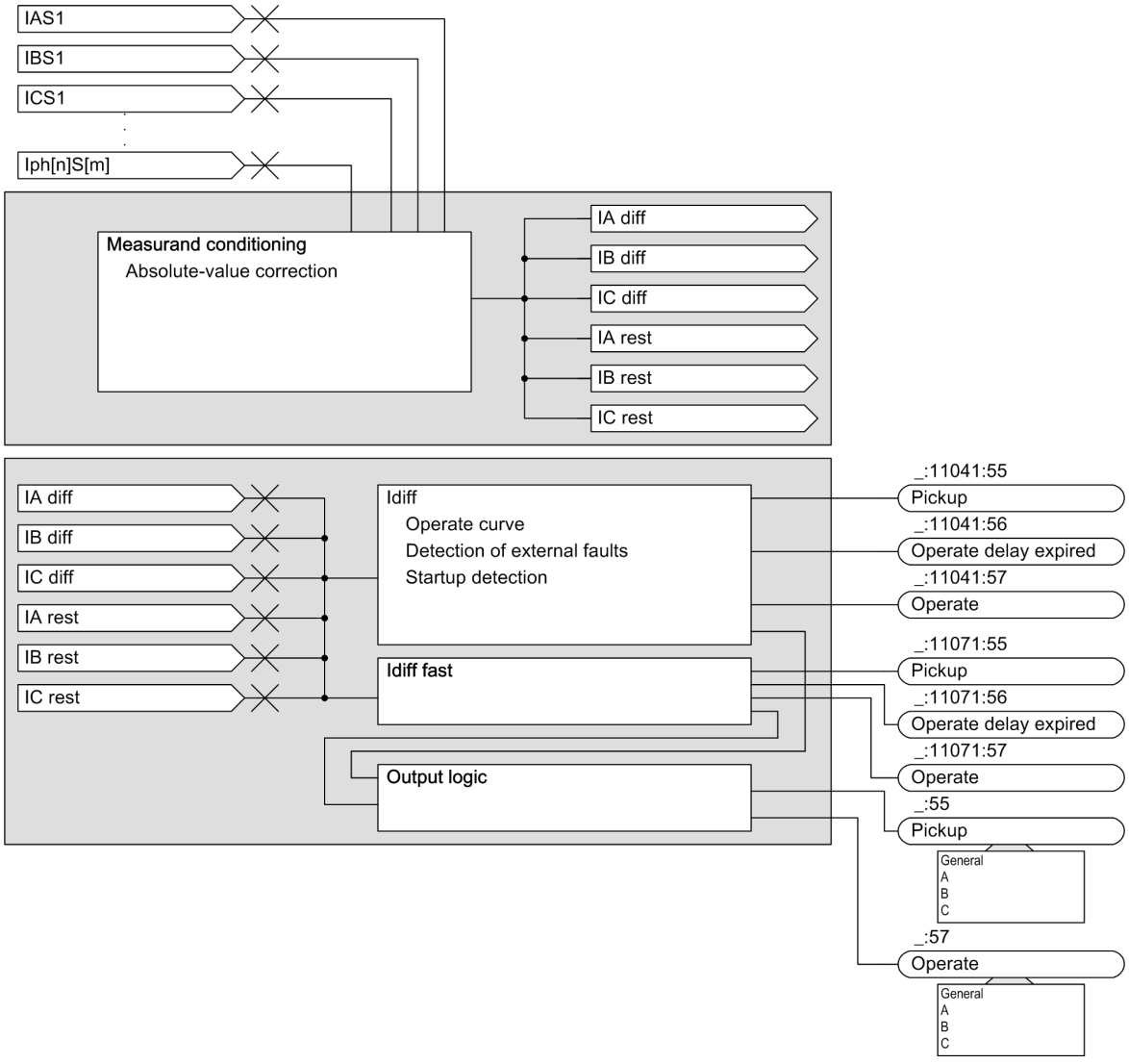
Figure 7-48 shows the logical input and output signals.



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Figure 7-48 Logic Inrush-Current Detection

Logic of the Function



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Figure 7-49 Logic Diagram of the Capacitor Bank Differential Protection Function

Measurand Processing

Absolute-Value Correction

Since the current transformers cannot be adapted exactly to the rated currents of the protected object with regard to their primary rated data, a standardization to the nominal sizes of the protected object takes place. The conversion occurs every sampling time (thus, for instantaneous values). The differential protection function processes 20 sampled values per period. In addition, the sampled values tracked are used. A high degree of accuracy can be attained over the entire tracking range (from 10 Hz to 80 Hz).

The Idiff-fast stage works on non-frequency tracked values and thus, implements fast operate times with low frequencies.

The absolute value is adapted via the following formula:

$$i^*_{phsx} = k\, i_{phsx}$$

$$\text{with } k = \frac{I_{rated\,prim,Sx}}{I_{rated\,obj,Sx}} = \frac{I_{rated\,prim,Sx}}{\frac{S_{rated,ref}}{V_{rated,Sx}\sqrt{3}}}$$

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i_{phsx}*	Adapted instantaneous value per phase (x = A, B, C)
i_{phsx}	Instantaneous value per phase (x = A, B, C)
k	Correction value per measuring point
$I_{rated\ prim,Sx}$	Primary transformer rated current per measuring point
$I_{rated\ obj,Sx}$	Primary rated current of the protected object
$S_{rated,ref}$	Reference power (maximum rated apparent power of the protected object)
$V_{rated,Sx}$	Rated voltage of the respective side (measuring point) of the protected object

NOTE

For more than 2 capacitor bank sides (teed feeder), , the winding with the highest power is used as the reference winding. If several sides have the same highest amount of power, then the highest current side is selected as reference side. The absolute value of the neutral-point transformer is also adapted according to the previous formula. In this case, the absolute value should be adapted to the side with the greatest power.

Vector-Group Correction

The vector groups of the capacitor bank sides occur due to couplings that are different on each side. Therefore, the measured currents cannot be used directly for summation. The vector-group correction replicates the coupling of the capacitors and makes the measured currents comparable. The correction occurs such that each side is converted to vector group 0. Since you are in the 3-phase system, the conversion occurs via matrices which are stored for the respective vector-group type. The general description is given in the following formula. In the same calculation step, the absolute value is corrected:

$$\begin{bmatrix} i^*_A \\ i^*_B \\ i^*_C \end{bmatrix} = k * M_{SG} * \begin{bmatrix} i_A \\ i_B \\ i_C \end{bmatrix}$$

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with

i_{phsx}*	Adapted instantaneous value per phase (x = A, B, C)
i_{phsx}	Instantaneous value per phase (x = A, B, C)
k	Absolute-value correction per measuring point
M_{SG}	Correction matrix

Differential Protection Function (Idiff)

A differential current per phase based on the instantaneous value variables is calculated from the processed currents (see section Measurand Processing). The direction of current flow is defined as to the **protected object as positive**. The fundamental component contribution to the differential current (I_{diff}) is calculated via a Fourier filter (filter length = 1 period (20 sampled values)).

The currents of that measuring point whose RMS value is the largest are used as restraint current. If, for example, the current collapses at a measuring point as a consequence of current-transformer saturation, the measuring point that has the largest current is automatically switched to at the point in time of the calculation.

NOTE

Differential protection does not work with sensitive ground-current transformers. Since sensitive transformers can go into saturation too quickly, false differential currents arise.

$$I_{diff,phsx} = \sum_{m=1}^{N} i^{*}_{phsx,Mm} \rightarrow I_{diff,phsx} = FIR(i_{diff,phsx})$$

$$I_{phsx,Mm} = \sqrt{\frac{1}{n}\sum_{k=1}^{n} i^{*2}_{phsx,Mm}(k)}$$

$$I_{rest,phsx} = \underset{m=1}{\overset{N}{MAX}}\, I_{phsx,Mm}$$

[fogrds16-170712-01.tif, 1, en_US]

with

x	Variable (1, 2, 3) for the phase currents (A, B, C)
m	Variable (1, 2, ..., N) for the measuring points
N	Number of measuring points
n	Number of samples per period (n = 20)
FIR	Fourier filter
MAX	Maximum-value determination

Pickup Characteristic

Figure 7-50 shows the pickup characteristic of the differential protection. The characteristic curve branch **a** represents the sensitivity threshold of the differential protection (parameter **`Threshold`**) and considers constant fault currents like magnetizing currents.

The characteristic branch **b** (parameter **`Intersection 1 Irest`** and **`Slope 1`**) considers current-proportional faults under normal operating conditions.

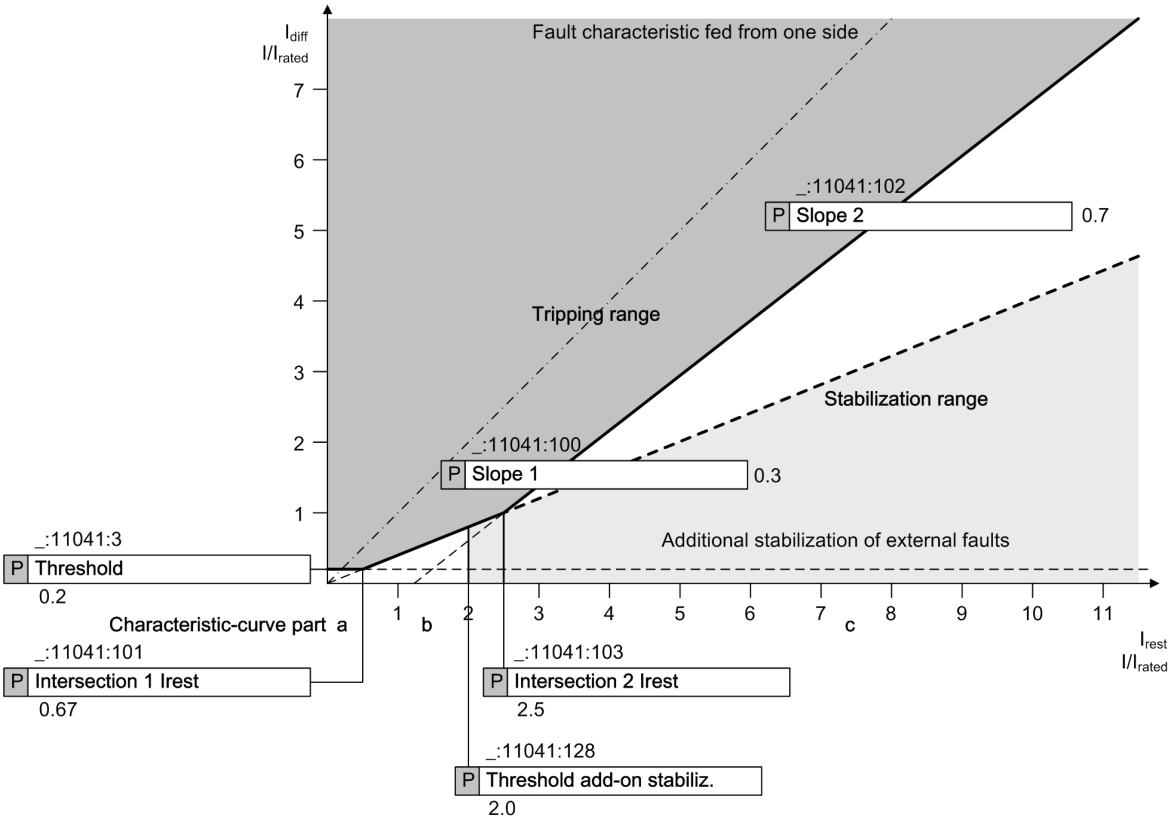
These faults can occur for the following reasons:

- Transformation errors in the current transformer and the input transformer of the device
- Adaptation deviations

The characteristic curve branch **c** (parameter **`Intersection 2 Irest`** and **`Slope 2`**) protects the differential protection against overfunction in case of high-current external faults and transformer saturation. In this area, transformer saturation can arise due to high short-circuit currents, and because of this, a higher differential current results.

In order to avoid overfunction in the event of external faults with transformer saturation, a logic is implemented that uses the characteristic curve **Additional stabilization of external faults**. If the operating point is located in the additional stabilization area and exceeds the operate curve from there, then the logic becomes active and blocks the differential protection.

The additional stabilization range is derived from the **`Threshold add-on stabiliz.`** and **`Slope 1`** parameters.



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Figure 7-50 Pickup Characteristic of the Differential Protection

If the differential current multiplied by the dropout ratio of 0.7 does not reach the pickup characteristic, the pickup drops out.

Detection of External Faults

To detect external faults with transformer saturation in a reliable way, the measurand curve is evaluated in the Diff.-Rest level by means of a detector. The detector has 2 essential tasks:

- **Blocking in the case of a definite high-current external fault**

  The differential current and the restraint current are monitored on a phase basis in the Diff/Restr level immediately after fault inception. To ensure the stability of the saturation detection for low saturation-free times of the primary current transformer, estimated values based on the difference quotients of the instantaneous values are used.

  If the estimated restraint current exceeds the **`Threshold add-on stabiliz.`** parameter and the expected value of the differential current of all phases is in the additional stabilization range (parameter **`Slope 1`**) (*Figure 7-50*) at the same time, the detector is active and the indication ***`Blocked by ext. fault phsx`*** appears. The tripping of the Differential protection function is blocked.

  If an external fault arises and is cleared by the protection responsible for it, the additional stabilization drops out. If the dropout ratio (0.7) of the RMS value of the restraint current does not reach the **`Threshold add-on stabiliz.`** parameter (*Figure 7-50*), the additional stabilization drops out. The indication ***`Blocked by ext. fault phsx`*** is reset.

  If the differential current exceeds **`Slope 1`** as a result of transformer saturation, that is, there is a pickup phsx, the blocking is limited in time (parameter: **`Time of add-on stabiliz.`**).

  Starting with the indication ***`Blocked by ext. fault phsx`***, the other phases can be blocked with it via the **`Cross-blk. time add-on st.`** parameter. If differential currents due to transformer saturation spread to the other phases through the vector-group correction or residual current elimination, this blocking is necessary.

- **Removal of the blocking with a change in fault location from external to internal**

  An internal fault can arise as a consequence of an external fault. This fault change must be recognized and the blocking must be removed. The critical case is a short-circuit with current-transformer saturation. The saturation detection examines here the instantaneous values of the differential current. With transformer saturation, the instantaneous values fall below an internal threshold in the saturation-free time. If this threshold is permanently exceeded and a pickup is present in the corresponding phase, an internal error is assumed. The other phases are also examined during the parameterization with cross block.

  The blocking of the tripping is removed and the indication *Blocked by ext. fault phsx* is reset.

DC-Component Detection

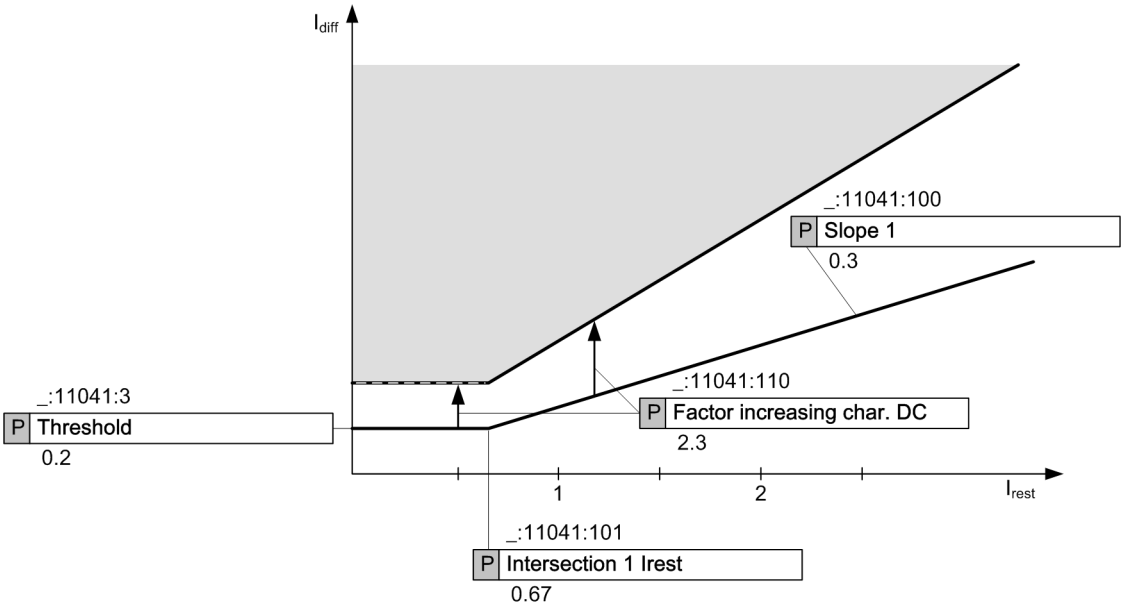
Low-current external faults with large DC components can also lead to exceeding of the operate curve. The additional stabilization area is not attained, however.

To avoid an overfunction, the following steps are taken:

- The restraint current $I_{rest.;phsx}$ is monitored for a jump.
- If the jump occurs, the DC component is calculated, with a temporal delay (1 period), from the instantaneous value of the restraint current (current at the measuring point with the largest current) $i_{rest.,phsx} = i_{phsx,Mm}$. The result is $I_{rest.DC,phsx}$. This current is compared to the restraint current $I_{rest.,\ phsx}$ and is checked for exceeding of the internal threshold.
- The differential current $I_{diff,phsx}$ must lie below the dropout characteristic curve (characteristic curve · 0.7) in all 3 phases.
- If the first 3 points lead to positive results, then the operate curve is raised by the parameter **Factor increasing char.** with a default setting of ***2.3***. Here, only the threshold value and the gradient 1 are raised (see *Figure 7-51*). The indication *Increase of char. (DC)* is output. If the product of parameter **Factor increasing char.** and **Slope 1** exceeds **0.85**, the maximum increase of the raised **Slope 1** is limited to 0.85.
- As additional criterion, the pickup indication *Pickup* (internal fault is present) or the indication of the additional stabilization *Blocked by ext. fault phsx* (high-current external fault) is sampled. If one of the 2 conditions is present, the characteristic-curve increase is stopped. A retroactive pickup no longer resets the characteristic-curve increase. A pickup with DC-component detection occurs only if the raised operate curve is exceeded.

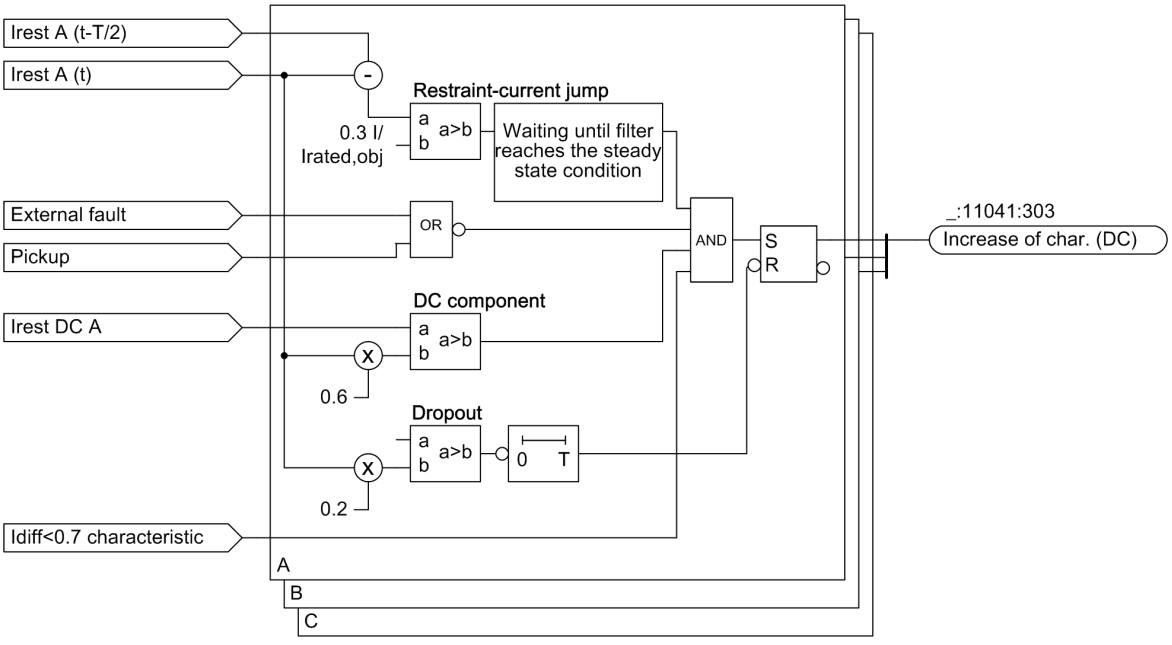
If the DC component $I_{rest.DC,phsx}$ falls below the internal dropout threshold, the dropout delay is determined as follows:

It is assumed that the de- and remagnetization of the transformer last equally long. The magnetization is at the highest at the point in time in which the internal dropout threshold is attained. The time is measured from the start of the DC-component detection until the internal dropout threshold is reached. Added to this time are 5 periods and from this, the dropout delay is derived. Following this, the characteristic-curve increase is reset to the original value. *Figure 7-52* shows the overall logic.



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Figure 7-51 Increasing the Characteristic Curve after DC Detection



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Figure 7-52 Logic DC Detection

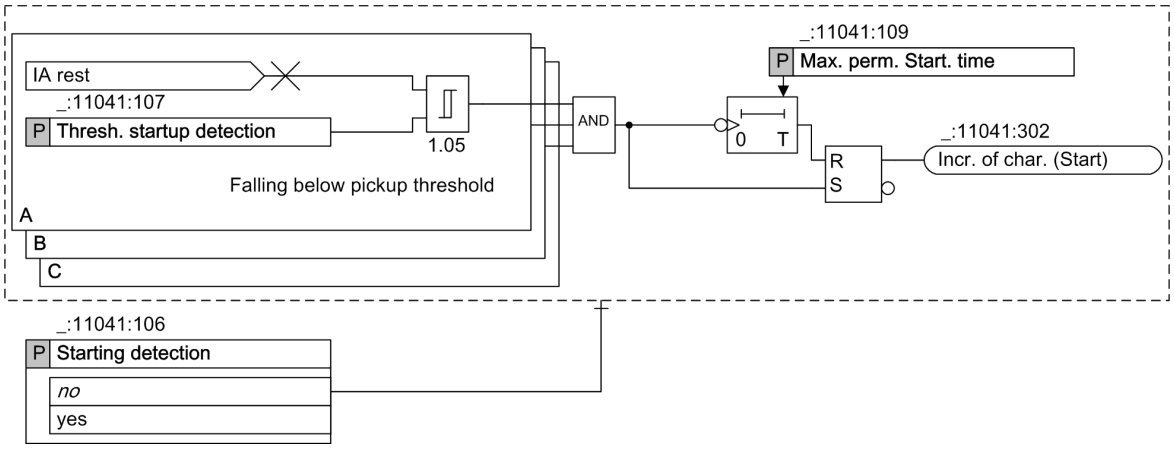
Startup Detection

The pickup-value increase is particularly useful in the case of motors. In contrast to transformers, the inrush current with motors is a flowing current. Differential currents can arise, however, by the current transformers having different residual magnetization and being supplied with current at different operating points of their hysteresis. These differential currents are low in fact, but they can lead to overfunction with sensitive setting of the differential protection.

You can use the pickup-value increase at startup as an additional security against overfunction when switching in a previously currentless protected object. If the restraint current falls below a settable value **`Thresh. startup detection`** in all phases, the pickup-value increase is activated. The pickup value **`Threshold`**

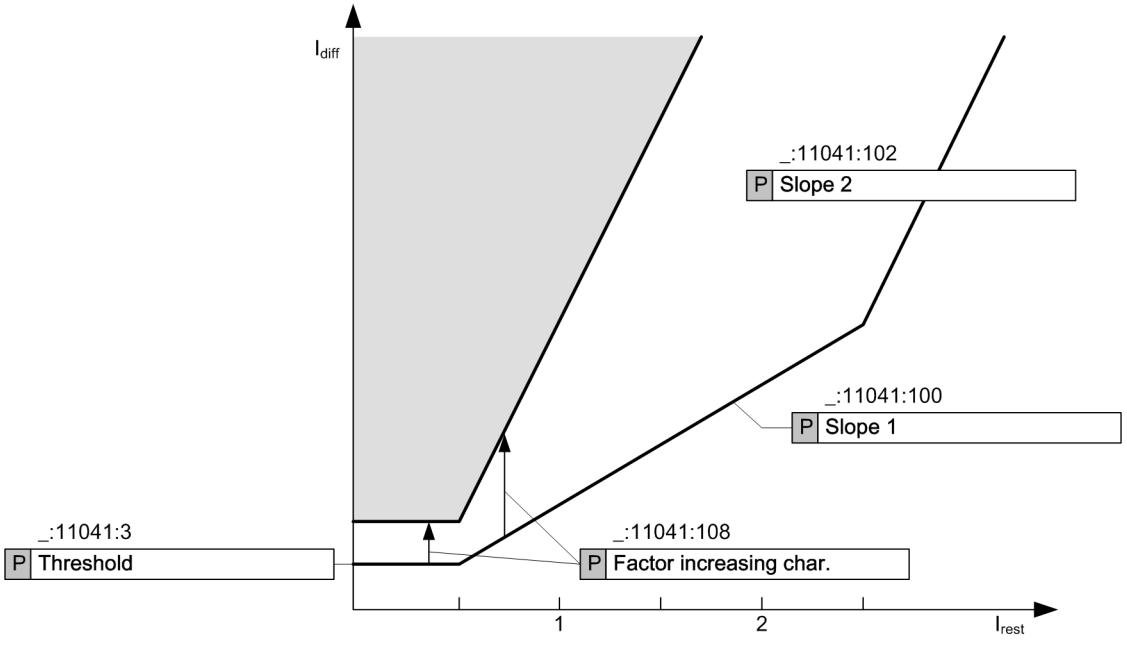
and **Slope 1** are raised by the set value in accordance with parameter **Factor increasing char.** . As a rule here, **Slope 1** cannot exceed a value of 0.85.

If the parameter **Thresh. startup detection** is exceeded, dropout occurs and a timing element (parameter **Max. perm. Start. time**) is started. Once this time has elapsed, the characteristics curve that was raised in all phases is reset to its original value. *Figure 7-53* shows the logic diagram of the pickup recognition and *Figure 7-54* the increased characteristic curve.



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Figure 7-53 Logic Pickup Recognition



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Figure 7-54 Characteristic-Curve Increase at Startup

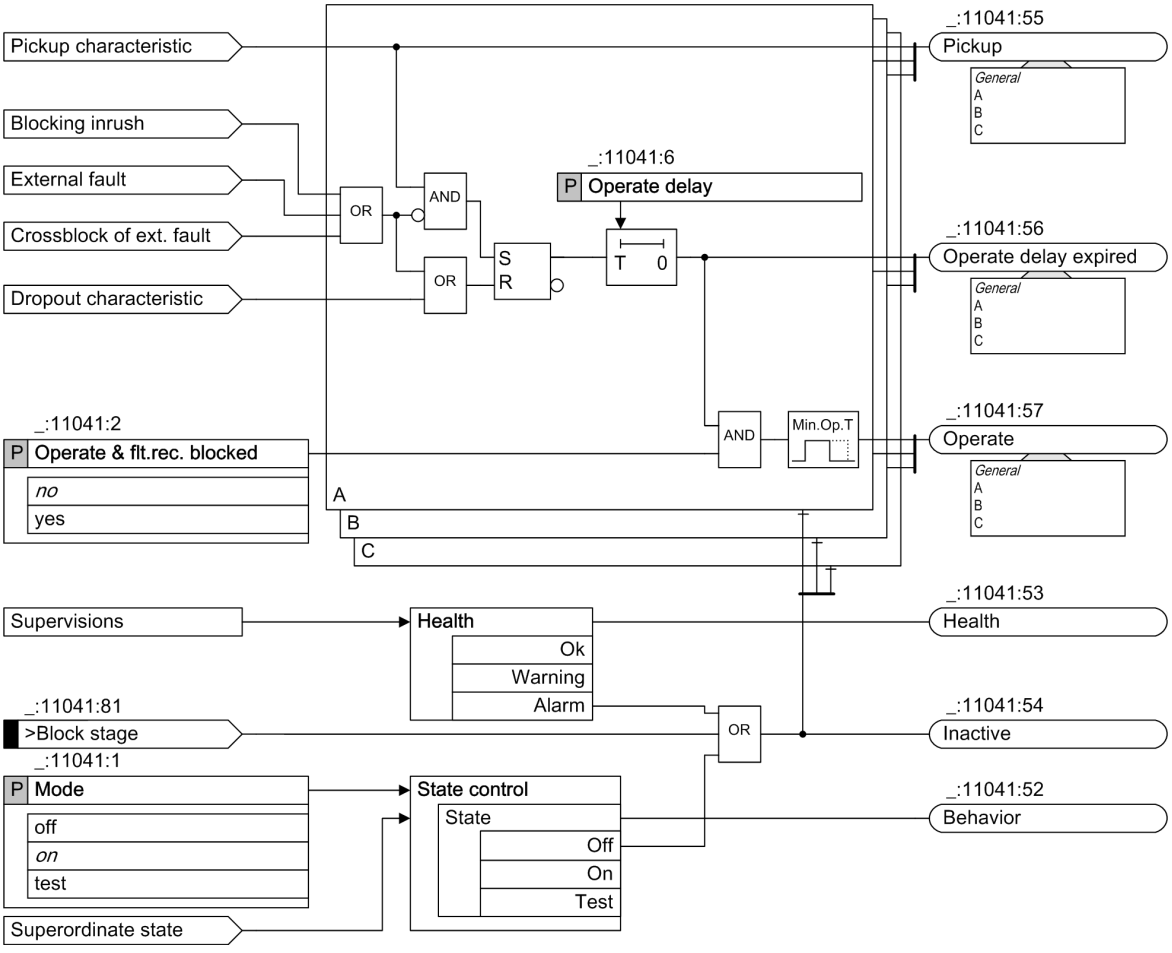
Trip Logic of the Differential Function Idiff

Figure 7-55 shows the trip logic. If the characteristic curve is exceeded (see *Figure 7-50*), a pickup occurs. Redirection of the information for tripping can be blocked by the additional functions.

Blocking is possible through use of the following variables:

- Recognition of external faults that can simulate an internal fault through transformer saturation
- Recognition of the connection process (2nd harmonic)

In addition, in case of blocking due to an *external error*, a **Crossblock** mechanism comes into effect.



[loauscod-290414-01, 1, en_US]

Figure 7-55 Trip Logic of Idiff

Differential Protection Function (Idiff Fast)

As a supplement to the differential protection function (Idiff), the Idiff fast function is available. The main task consists in switching off high-current internal faults in the shortest amount of time. The method controls current-transformer saturation and is stable in the event of external transverse faults (integration in breaker-and-a-half arrangements).

Metrologically, 2 methods are combined:

- Instantaneous-value method
- Filter-based method

Instantaneous-Value Method

Through the instantaneous-values method, an immediate evaluation of the sampled values of the differential $i_{Diff}(t)$ and restraint current $i_{rest}(t)$ occurs. The absolute-value adapted and vector-group adapted currents (i*) are also the basis. The currents are defined positively to the node. The restraint current is the maximum current of all measuring points.

$$i_{diff,phsx}(t) = \left| \sum_{m=1}^{N} i^{*}_{phsx,Mm}(t) \right|$$

$$i_{rest,phsx}(t) = \frac{1}{2} \underset{m=1}{\overset{N}{MAX}} \left| i^{*}_{phsx,Mm}(t) \right|$$

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with

x	Variable (1, 2, 3) for the phase currents (A, B, C)
m	Variable (1, 2, ..., N) for the measuring points
N	Number of measuring points

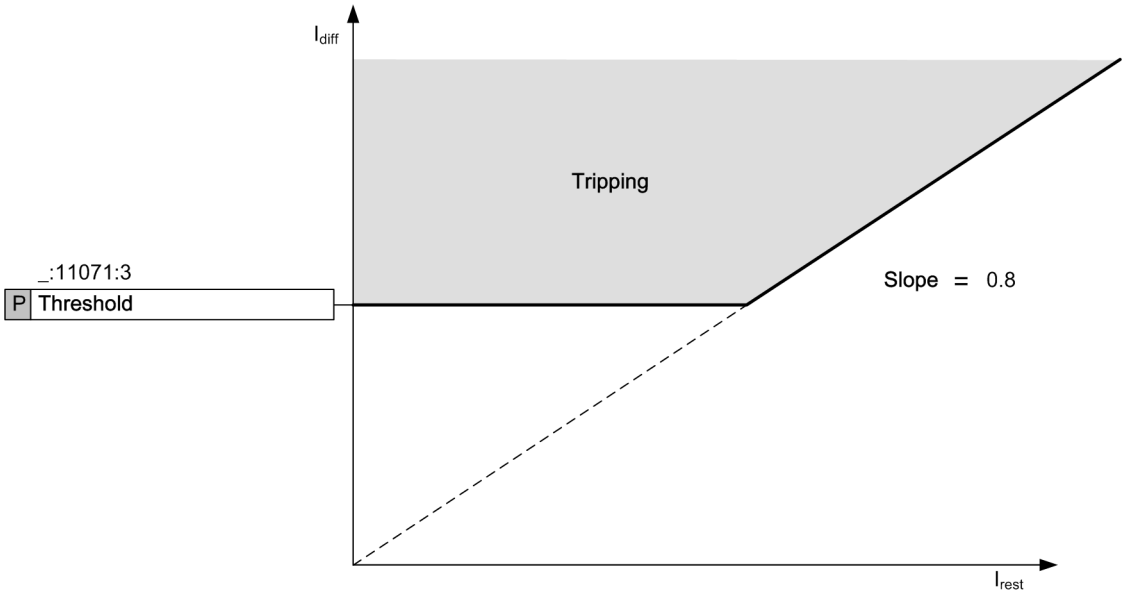
The evaluation of the restraint current is used to recognize saturated, high-current external faults.

Figure 7-56 shows the operate curve. The parameter **Threshold** is set here such that it lies over the maximum fault current flowing. The gradient of the characteristic curve is fixed at 0.8.

In the algorithm, the following conditions are processed:

- Condition 1: The increase of the restraint current $di_{rest}(t)/dt$ is determined continuously and compared with an internal threshold.
- Condition 2: After that, a comparison determines whether the differential current is larger than the restraint current (characteristic curve **Gradient** in *Figure 7-56*): $i_{diff}(t) > 0.8 \cdot i_{rest}(t)$.
- Condition 3: After that, a comparison determines whether the differential current exceeds the parameter **Threshold**.

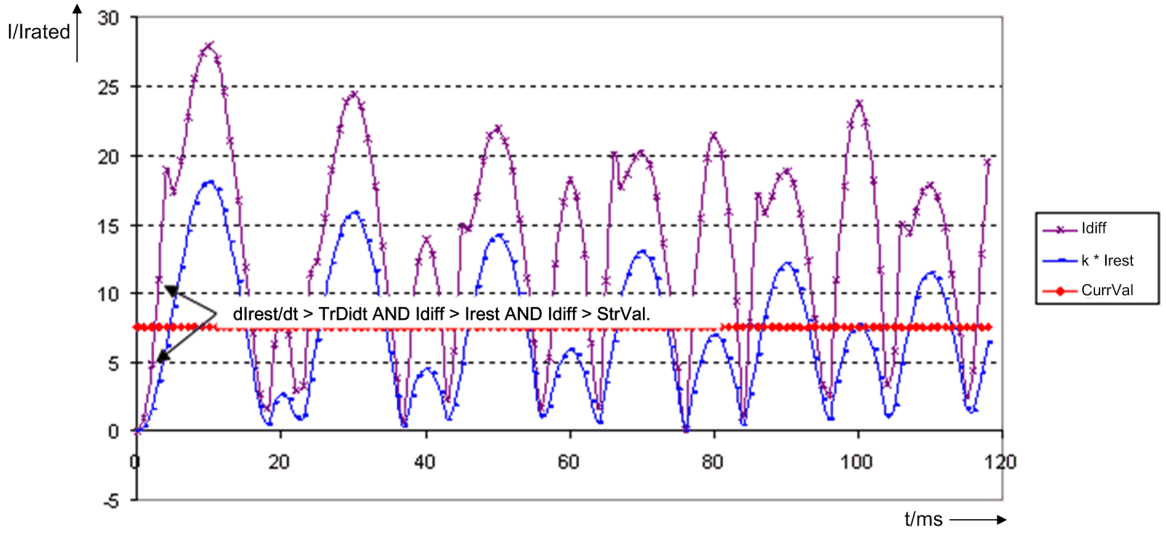
When all conditions are met, tripping occurs immediately. If the 1st condition is recognized and not the 2nd condition, then the function is blocked for 300 ms.



[dwidfast-300114-01.tif, 1, en_US]

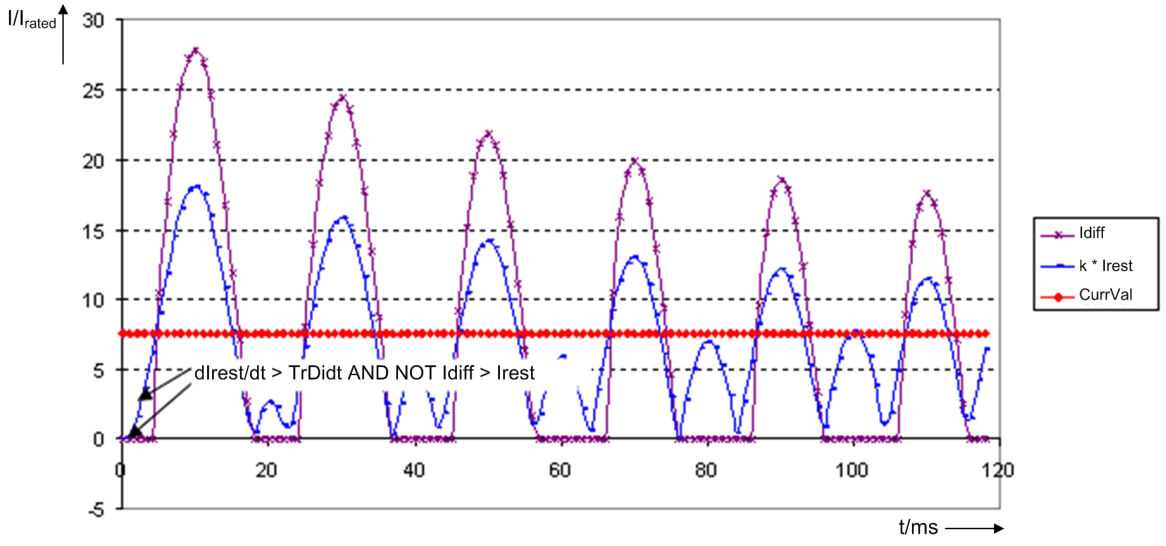
Figure 7-56 Characteristic Curve of Idiff fast

The 2 following figures show the behavior during an internal and an external fault. It is typical for the internal fault (*Figure 7-57*) that the differential current rises more quickly than the restraint current. After a few sampled values, the trip signal is issued. In case of an external fault, a differential current arises only after transformer saturation occurs. You can always assume, however, that the current is transferred a few milliseconds after occurrence of the fault. In accordance with *Figure 7-59*, the restraint current is larger than the differential current after occurrence of the fault, but condition 2 is not met and the function is therefore blocked.



[dwinnfel-201112-01.tif, 1, en_US]

Figure 7-57 Curve Plot for Internal Fault with Transformer Saturation (k= 0.65)



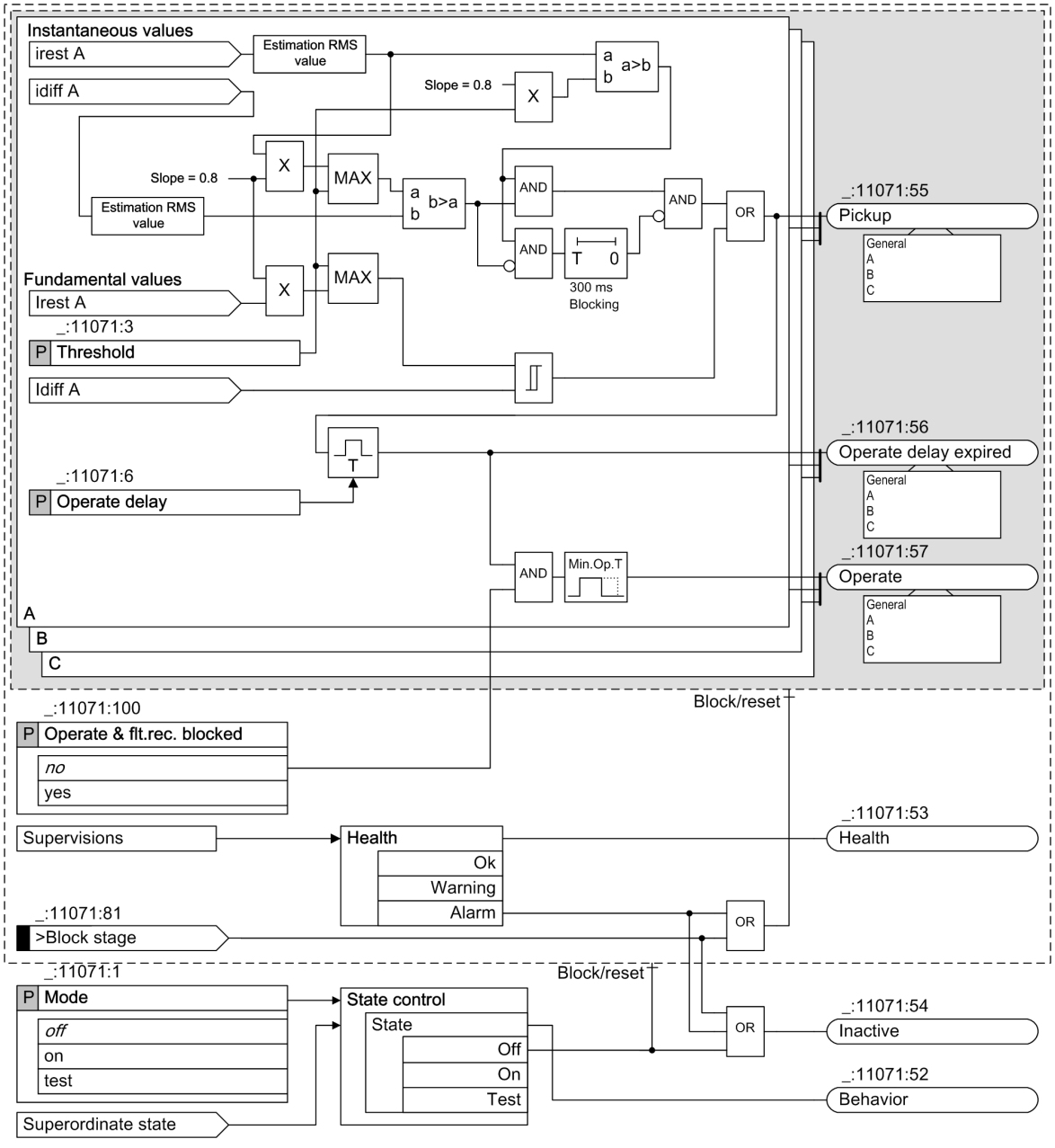
[dwextfel-170712-01.tif, 1, en_US]

Figure 7-58 Curve Plot for External Fault with Transformer Saturation (k= 0.65)

Fundamental-Component Method

Parallel to the instantaneous-value method, the fundamental-component method works with a temporal delay. Here, the same measured values are processed as with the Idiff method. The fundamental component of the differential current I_{diff} and the stabilization value (maximum current of a measuring point) $I_{rest.}$ are ordered in the operate curve according to *Figure 7-56* and the trip decision is made.

Figure 7-59 shows the overall logic.

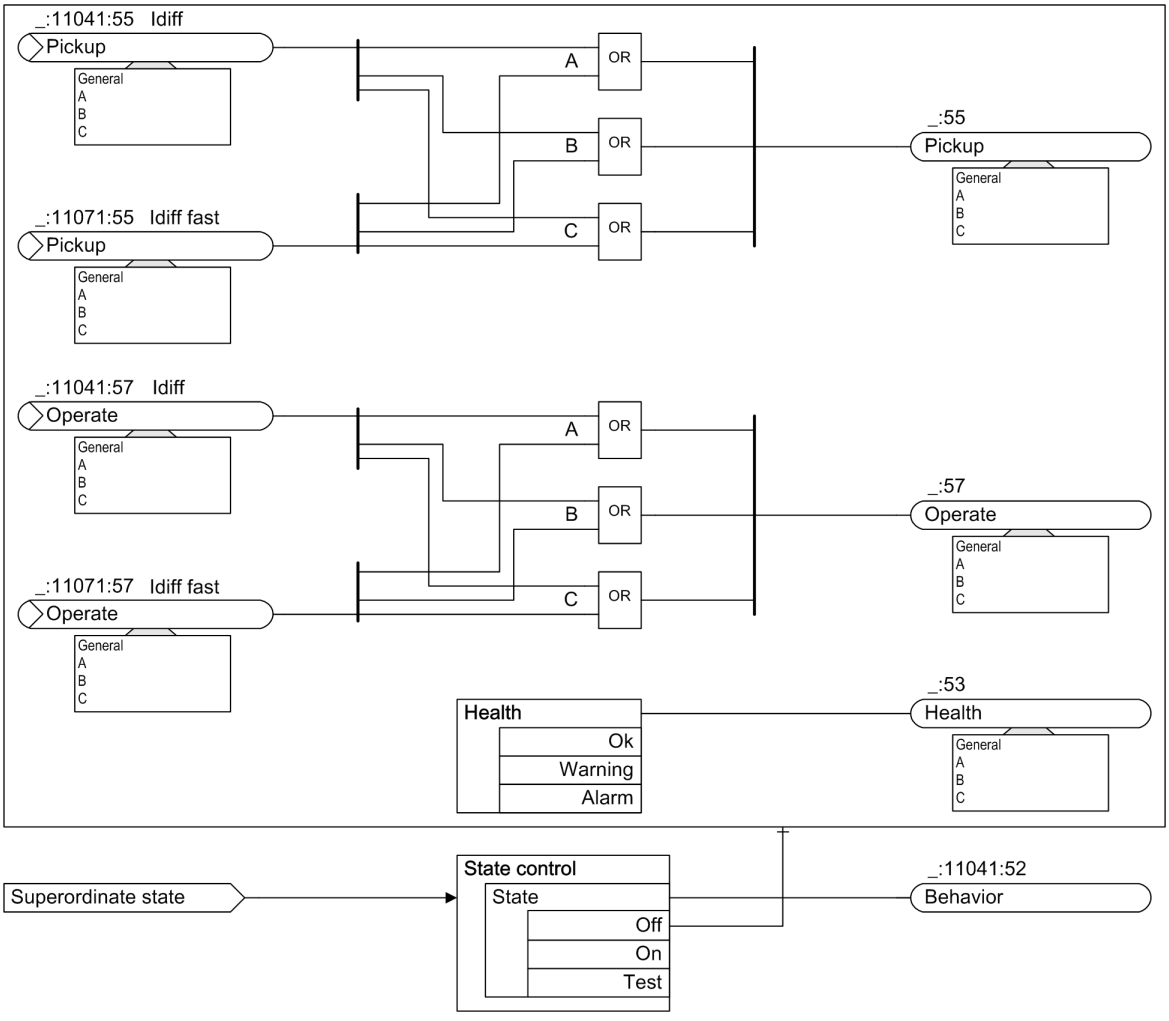


[loidfast-151012-01.tif, 2, en_US]

Figure 7-59 Logic of the Differential Protection Function Idiff Fast

Trip Logic of the Differential Protection

A common trip signal is formed from both subfunctions Idiff and Idiff fast. *Figure 7-60* shows the respective logic.



[logesamt-170712-01.tif, 1, en_US]

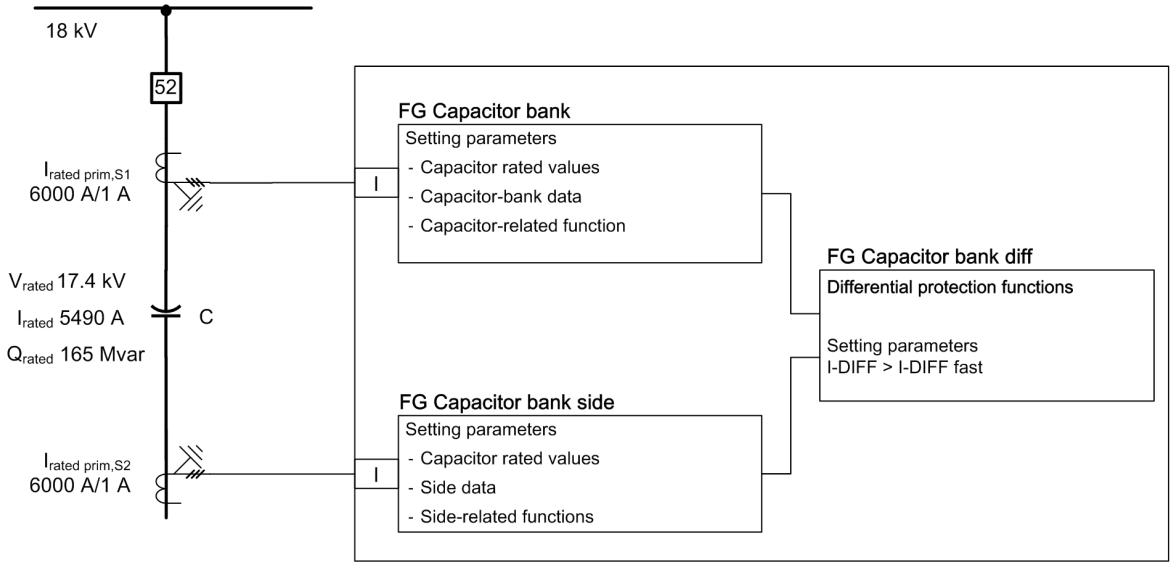
Figure 7-60 Overall Trip Logic

Fault Logging and Fault Recording

A fault is opened with every protection pickup. This means that a fault log and a fault recording are started. Saving of the fault record depends on the setting (see *3.4.3 Function Description*). Since pickup and tripping are the same in differential protection, the recording setting can be used with the pickup function. To enable fault recording even with external errors, along with the exceedance of the characteristic curve, a fault record is opened in case of a blocking by an external error or in case of a characteristic-curve increase through component recognition. This has the advantage that you can evaluate the transformer transfer method of the current transformers very well in case of a fault.

7.8.4 Application and Setting Notes

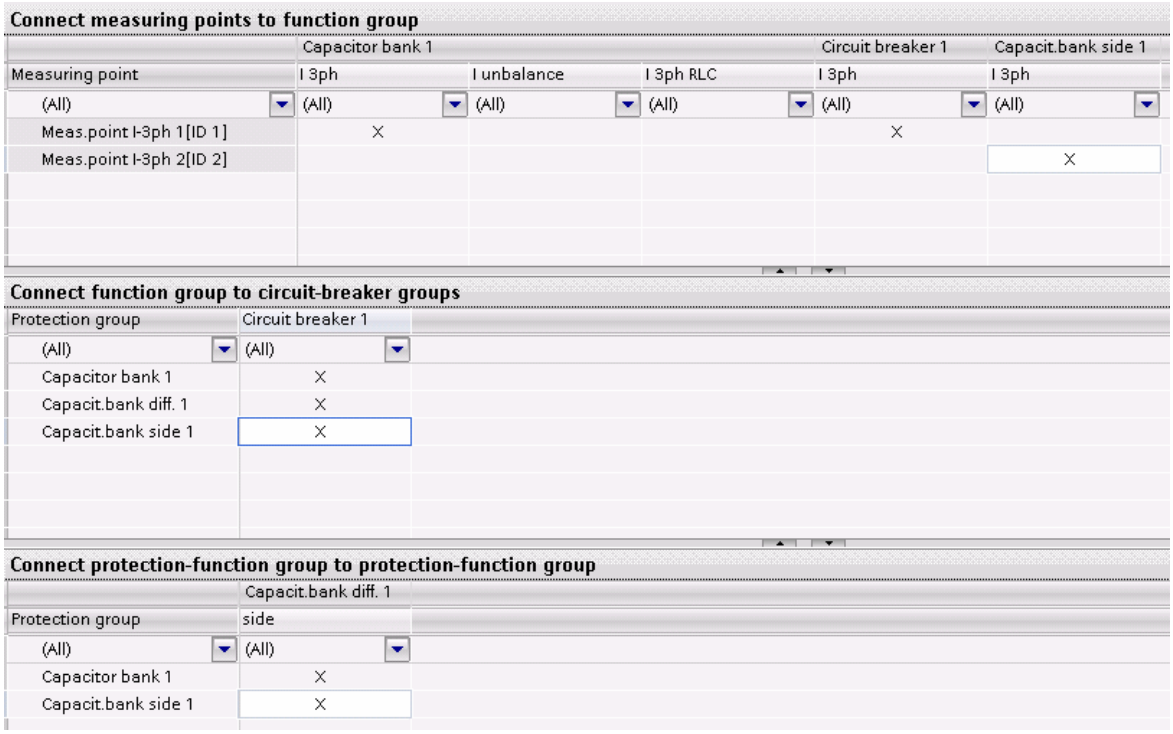
Figure 7-61 shows the application of a differential protection via a capacitor bank in a simplified way.



[dwanslbca-130514-01, 2, en_US]

Figure 7-61 Connection Example

The measuring points must be interconnected with the corresponding function groups.
Figure 7-62 shows the corresponding screenshot from DIGSI 5.



[sccapbak-130514-01, 1, en_US]

Figure 7-62 Internal Interconnection in DIGSI 5

Function Group Capacitor Bank

This chapter only refers to parameters that are important for the differential protection function application. You can find more information on further parameters in chapter *5.4.3 Application and Setting Notes* (**Capacitor bank** function group).

Parameter: `Capacitor reference curr.`

- Default setting **`(_:14641:101) Capacitor reference curr.`** = ***`1000 A`***

With the parameter **`Capacitor reference curr.`**, you set the reference current for the capacitor bank to be protected. The capacitor reference current set here is the reference value for the percentage measured values and for setting values in percent.

For the Differential protection, these values are used for absolute-value correction (rated current of the protected object).

Depending on the application, you can use the capacitor-bank rated current including the harmonics or the capacitor-bank fundamental-component current as a reference value.

Function Group Capacitor Bank Side

Proceed with the following settings in the **Capacitor bank side** function group:

Parameter: `Capacitor reference curr.`

- Default setting **`(_:1781:15571:101) Capacitor reference curr.`** = ***`1000 A`***

With the parameter **`Capacitor reference curr.`**, you set the reference current for the capacitor bank to be protected. The capacitor reference current set here is the reference value for the percentage measured values and for setting values in percent.

For the Differential protection, these values are used for absolute-value correction (rated current of the protected object).

If the capacitor bank is part of a delta connection, the value to be set here can differ from the capacitor reference current set in the **Capacitor bank** function group (by factor $\sqrt{3}$). Otherwise, set always the same values.

Depending on the application, you can use the capacitor-bank rated current including the harmonics or the capacitor-bank fundamental-component current as a reference value.

Parameter: `Capacitor reference volt.`

- Default setting **`(_:1781:15571:102) Capacitor reference volt.`** = ***`400.00 kV`***

With the parameter **`Capacitor reference volt.`**, you set the reference voltage of the capacitor bank to be protected. The reference voltage set here is the reference value for the percentage measured values and for setting values in percent.

Depending on the application, you can use the system rated voltage (busbar voltage) or the capacitor rated voltage as a reference value.

Parameter: `Neutral point`

- Default setting **`(_:1781:15571:149) Neutral point`** = ***`isolated`***

With the parameter **`Neutral point`**, you specify whether the neutral point in the protection range of the differential protection is ***`grounded`*** or ***`isolated`***. As this is not the case for the described application example, use the default setting ***`isolated`***.

You can find further information in the 7UT8 Device Manual in chapter 6.2.3 Function Description Neutral-Point Current Treatment .



NOTE

For the described application example, you do not need to change the parameters **`Winding configuration`** and **`Vector group numeral`**. If the capacitor bank is part of a delta connection, create the phase reference via the vector group.

You can find further information in the 7UT8 Device Manual in chapter 6.2.3 Function Description Vector-Group Correction .

Parameter: `Winding configuration`

- Default setting **`(_:1781:15571:104) Winding configuration`** = ***`Y (Wye)`***

With the parameter **Winding configuration**, you set ***D (Delta)*** for a delta connection. Another setting option is ***Y (Wye)*** for a star connection. The parameter **Winding configuration** is relevant for the differential protection function. You do not need to change this setting for the described application example.

Parameter: Vector group numeral

- Default setting **(_:1781:15571:100) Vector group numeral** = ***0***

This parameter is used to account for phase-angle rotation, which is expressed by a number.

Phase-angle rotation	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
Vector group numeral	0	1	2	3	4	5	6	7	8	9	10	11

In the function group, the following information is displayed additionally in the setting sheet:

- Side number
- Identification of the measuring points used
- Adaptation factor for the 3-phase measuring point (with reference to the side)

Each **Vector group numeral** from 0 to 11 can be set to the extent possible. Thus, for example, only even numbers are possible for the vector group Yy and Dd and only odd numbers are possible for Yd and Dy.

You do not need to change this setting for the described application example.

Function Group Capacitor Bank Diff

Proceed with the following settings in the **Capacitor bank Diff** function group for the IDiff function:

Parameter: Threshold (Setting of the Characteristic-Curve Parameters)

- Default setting **(_:11041:3) Threshold** = ***0.20 I/Irated,obj***

You set the pickup threshold for the differential current with this parameter. This is the total current flowing into the protection range during a short-circuit, regardless of how it is distributed on the sides of the protected object. The pickup value is relative to the rated current of the protected object. The default setting of ***0.20 I/Irated,obj*** is a practical value between sensitivity and possible disturbing influence.

Parameter: Intersection 1 Irest

- Default setting **(_:11041:101) Intersection 1 Irest** = ***0.67 I/Irated,obj***

The maximum current of the measuring point is used as restraint current. If you have to expect dynamic transmission errors of the current transformer even with small currents, half of the rated current is an appropriate setting value.

Parameter: Slope 1

- Default setting **(_:11041:100) Slope 1** = ***0.30***

With the **Slope 1**, you avoid an overfunction of the differential protection with low-current external faults as a consequence of current-transformer transmission errors (stationary and dynamic faults). The default setting of ***0.30*** is sufficient for many applications.

Parameter: Intersection 2 Irest

- Default setting **(_:11041:103) Intersection 2 Irest** = ***2.50 I/Irated,obj***



NOTE

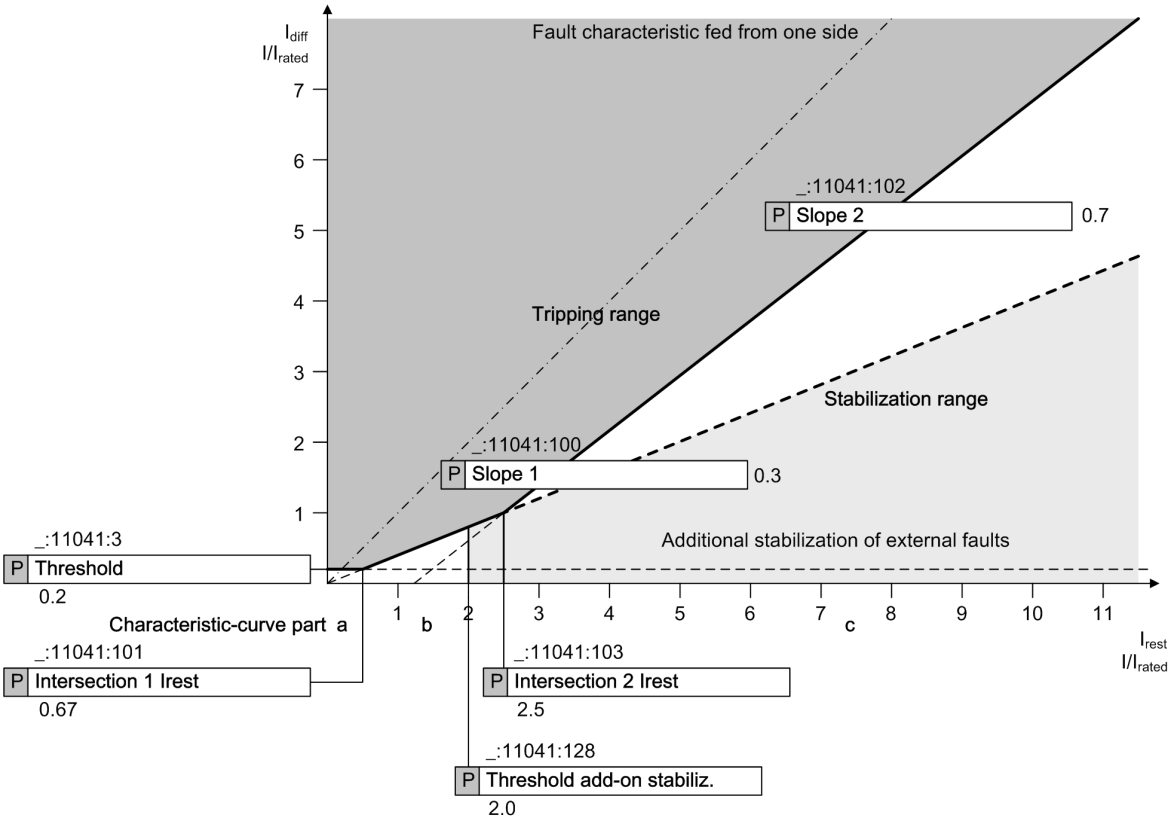
If you expect transmission problems for the current transformer in case of excessive current flows, set the **Slope 2** to a higher value.

The parameter **Intersection 2 Irest** determines from which restraint current the **Slope 2** begins. The default setting ***2.50 I/Irated,obj*** is a practical value.

Parameter: Slope 2

- Default setting **(_:11041:102) Slope 2** = ***0.70***

With the parameter **Slope 2**, an overfunction of the differential protection is avoided with high-current external faults as a consequence of current-transformer transmission errors (for example, due to saturation). A value greater than or equal to double the value of **Slope 1** is practical. As the default setting, ***0.70*** was selected.



[dwdifaus-030912-01.tif, 1, en_US]

Figure 7-63 Characteristic Curve with the Default Settings

Parameter: Starting detection

- Default setting **(_:11041:106) Starting detection** = ***yes***

To avoid an overfunction when switching on capacitor banks, you can set the parameter **Starting detection** = ***yes***. Siemens recommends the setting **Starting detection** = ***yes***.

Parameter: Thresh. startup detection

- Default setting **(_:11041:107) Thresh. startup detection** = ***0.1 I/Irated,Obj***

If the restraint current falls below this threshold value, the subsequently set characteristic-curve increase becomes effective with activated function. The default setting value of ***0.1 I/Irated,obj*** is recommended for the application.

Parameter: Factor increasing char.

- Default setting **(_:11041:108) Factor increasing char.** = ***2.0***

An increase to the value 2.0 has proven itself to be sufficient for many applications.

Parameter: Max. perm. Start. time

- Default setting **(_:11041:109) Max. perm. Start. time** = ***5.0 s***

The setting value must lie above the maximum inrush time of the connected capacitor bank. To guarantee tripping through the capacitor-bank protection (inrush/starting time supervision) and avoid overfunctions, select a somewhat longer time (factor 1.2 or higher).

Parameter: Factor increasing char. DC (DC-Component Recognition)

- Default setting **(_:11041:110) Factor increasing char. DC** = ***2.3***

The DC-component recognition is always active. As a result of the DC components, transmission problems can arise (for example, phase-angle rotations) in current transformers with small currents flowing. For this reason, the **Threshold** and the **Slope 1** are raised by the set factor. The default setting of 2.3 has proven itself with numerous applications.

Parameter: Blocking with 2. harmonic (Inrush-Current Detection)

- Default setting **(_:11041:115) Blocking with 2. harmonic** = ***no***

The inrush-current detection is not necessary for capacitor-bank applications.

Parameter: 2nd harmonic content

- Default setting **(_:11041:116) 2nd harmonic content** = ***15 %***

For many practical applications, the default setting value of ***15 %*** has proven useful. In exceptional cases, the setting value can be decreased with a small proportion of 2nd harmonic. Avoid a setting below 10 %, however. With an internal fault and current-transformer saturation, some proportion of 2nd harmonic also arises. A setting that is too sensitive leads to a blocking of the protection function.

Parameter: Crossblock. time 2nd har.

- Default setting **(_:11041:117) Crossblock. time 2nd har.** = ***0.00 s***

Since the inrush currents develop differently in the 3 phases, the pickup value, for example, is not attained in a phase, but the differential current exceeds the characteristic curve. Corrective action creates a mutual blocking. If a time unequal to 0 s is set, the crossblock function works. If an overfunction arises, the setting cannot be made until commissioning takes place. Do not set the duration for an excessive amount of time. Practical values showed a setting between 3 and 5 periods.

Recognition of External Faults

In *Figure 7-63* the range **Additional stabilization with external fault** is represented. The range is described by the parameters **Threshold add-on stabiliz.** and **Slope 1**. With an external short circuit, the differential currents can increase beyond this range and reach into the tripping area. With the following parameters, time-limited blocking can be performed.

Parameter: Threshold add-on stabiliz.

- Default setting **(_:11041:128) Threshold add-on stabiliz.** = ***2.00***

With the **Threshold add-on stabiliz.** parameter, you set the pickup value for the additional stabilization. Due to the selected method of measurement, a setting value of 2.00 is practical. The additional stabilization range is limited by the parameters **Threshold add-on stabiliz.** and **Slope 1**.

Parameter: Time of add-on stabiliz.

- Default setting **(_:11041:129) Time of add-on stabiliz.** = ***0.30 s***

You can use the operate time of the external feeder protection as an orientation for the setting value. Additionally, take into account the circuit-breaker opening time. Thus, the following calculation rule results:

$t_{Z\ rest.} \geq t_{off,ext\ protection} + t_{off,circuit\ breaker}$

The default value is a practical value. You must adapt the value according to the use case. The value 0 deactivates the recognition of external errors.

Parameter: `Cross-blk. time add-on st.`

- Default setting **`(_:11041:130) Cross-blk. time add-on st.`** = ***`0.30 s`***

The additional stabilization acts separately on each phase. However, it can be extended to block all phases. Siemens recommends the activation of the crossblock function by means of a corresponding setting of the time. The set time must be identical to the time that is set for the duration of the additional stabilization.

Protection Stage Idiff Fast

The task of this protection stage is the fast detection of high-current internal short circuits (see also *Differential Protection Function (Idiff Fast), Page 999*). For this reason, the protection stage must always be activated.

Parameter: `Threshold`

- Default setting **`(_:11071:3) Threshold`** = ***`7.5 I/Irated,obj`***

Siemens recommends setting the threshold value greater than or equal to the starting current.

7.8.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:11041:1	I-DIFF:Mode		• off • on • test	off
_:11041:2	I-DIFF:Operate & flt.rec. blocked		• no • yes	no
_:11041:6	I-DIFF:Operate delay		0.00 s to 60.00 s	0.00 s
Operate curve				
_:11041:3	I-DIFF:Threshold		0.05 I/IrObj to 2.00 I/IrObj	0.20 I/IrObj
_:11041:100	I-DIFF:Slope 1		0.00 to 0.80	0.30
_:11041:101	I-DIFF:Intersection 1 Irest		0.00 I/IrObj to 5.00 I/IrObj	0.67 I/IrObj
_:11041:102	I-DIFF:Slope 2		0.25 to 0.95	0.70
_:11041:103	I-DIFF:Intersection 2 Irest		1.00 I/IrObj to 20.00 I/IrObj	2.50 I/IrObj
Starting detection				
_:11041:106	I-DIFF:Starting detection		• no • yes	no
_:11041:107	I-DIFF:Thresh. startup detection		0.1 I/IrObj to 2.0 I/IrObj	0.1 I/IrObj
_:11041:108	I-DIFF:Factor increasing char.		1.0 to 5.0	2.0
_:11041:109	I-DIFF:Max. perm. Start. time		0.1 s to 180.0 s	5.0 s
DC offset detection				
_:11041:110	I-DIFF:Factor increasing char. DC		1.0 to 5.0	2.3
Inrush blocking				
_:11041:115	I-DIFF:Blocking with 2. harmonic		• no • yes	no
_:11041:116	I-DIFF:2nd harmonic content		10 % to 45 %	15 %

Addr.	Parameter	C	Setting Options	Default Setting
_:11041:117	I-DIFF:Crossblock. time 2nd har.		0.00 s to 200.00 s; ∞	0.00 s
Ext. fault detection				
_:11041:128	I-DIFF:Threshold add-on stabiliz.		1.00 I/IrObj to 20.00 I/IrObj	2.00 I/IrObj
_:11041:129	I-DIFF:Time of add-on stabiliz.		0.00 s to 5.00 s; ∞	0.30 s
_:11041:130	I-DIFF:Cross-blk. time add-on st.		0.00 s to 2.00 s; ∞	0.30 s
I-DIFF fast				
_:11071:1	I-DIFF fast:Mode		• off • on • test	off
_:11071:3	I-DIFF fast:Threshold		0.5 I/IrObj to 35.0 I/IrObj	7.5 I/IrObj
_:11071:6	I-DIFF fast:Operate delay		0.00 s to 60.00 s	0.00 s
_:11071:100	I-DIFF fast:Operate & flt.rec. blocked		• no • yes	no

7.8.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:I diff.	WYE	O
_:2311:301	General:I restr.	WYE	O
_:2311:311	General:I diff. operate phA	MV	O
_:2311:312	General:I diff. operate phB	MV	O
_:2311:313	General:I diff. operate phC	MV	O
_:2311:314	General:I restr. operate phA	MV	O
_:2311:315	General:I restr. operate phB	MV	O
_:2311:316	General:I restr. operate phC	MV	O
_:2311:317	General:Adapt. adjustm. inact.	SPS	O
I-DIFF			
_:11041:81	I-DIFF:>Block stage	SPS	I
_:11041:54	I-DIFF:Inactive	SPS	O
_:11041:52	I-DIFF:Behavior	ENS	O
_:11041:53	I-DIFF:Health	ENS	O
_:11041:55	I-DIFF:Pickup	ACD	O
_:11041:56	I-DIFF:Operate delay expired	ACT	O
_:11041:57	I-DIFF:Operate	ACT	O
_:11041:301	I-DIFF:Slope 1	MV	O
_:11041:302	I-DIFF:Incr. of char. (Start)	SPS	O
_:11041:303	I-DIFF:Increase of char. (DC)	SPS	O
_:11041:304	I-DIFF:Blocked by inrush	SPS	O
_:11041:305	I-DIFF:Blocked by 2.Harmon.	ACT	O
_:11041:306	I-DIFF:Crossblock by 2.Harm.	SPS	O
_:11041:312	I-DIFF:Blocked by ext. fault	ACT	O
_:11041:313	I-DIFF:Crossbl. by ext. fault	SPS	O

No.	Information	Data Class (Type)	Type
_:11041:316	I-DIFF:CWA int. fault detected	SPS	O
I-DIFF fast			
_:11071:81	I-DIFF fast:>Block stage	SPS	I
_:11071:54	I-DIFF fast:Inactive	SPS	O
_:11071:52	I-DIFF fast:Behavior	ENS	O
_:11071:53	I-DIFF fast:Health	ENS	O
_:11071:55	I-DIFF fast:Pickup	ACD	O
_:11071:57	I-DIFF fast:Operate	ACT	O
_:11071:56	I-DIFF fast:Operate delay expired	ACT	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O

7.9 Detuning Supervision for Capacitor Banks

7.9.1 AC-Filter Detuning Supervision

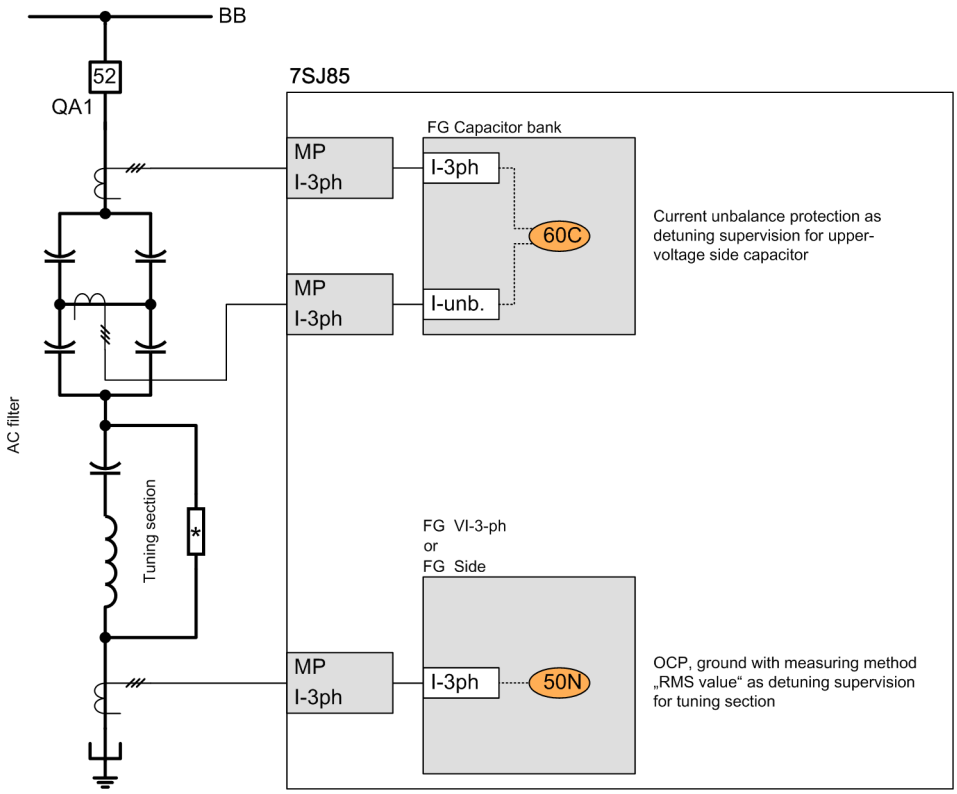
Tuned AC filters serve to provide reactive power and to absorb specific frequencies from the busbar. They usually consist of the upper-voltage side capacitor (for providing reactive power) and the tuning section (for tuning to the frequencies to be absorbed). The tuning section consists of primary C, L and, if required, R elements, refer also to *Figure 7-64*.

Under normal operation, the RLC characteristics of the filter – the impedances – are identical per phase. A change in the impedance of one phase indicates that the filter characteristic of this phase has changed. This situation (a detuned filter) is not wanted and shall be detected.

The primary elements of the AC filter shall be subject of regular maintenance intervals where the compliance with the tolerances of the rated values specified in the design need to be checked. For the detection of detuning between the maintenance intervals, the protection device can be applied. Detuning supervision for the upper-voltage side voltage capacitor can be achieved by applying the phase-selective **Current unbalance** function (ANSI 60C), especially by using the counter function.

A criterion for the supervision of the primary elements of the tuning section is the ground or zero-sequence current (3I0) of the AC filter. The fundamental phase current of the AC filter is determined by the phase capacitance of the upper-voltage side capacitor. Consequently, a difference in the phase capacitances of the upper-voltage side capacitor will cause a fundamental ground current. Therefore it is not sufficient for the tuning-section supervision to evaluate only the fundamental ground current. Under normal operation and symmetrical network conditions, the fundamental ground current will be **0**. An unbalance in the phase impedances (detuning) will cause a ground current. A detuning of the tuning section will mainly cause harmonics in the ground current. Thus, the RMS value of the ground current needs to be evaluated. For a detuning supervision of the tuning section, the function OCP, ground (ANSI 50N) with the measuring method **RMS value** is applied. This allows detecting harmonics up to the 50th harmonic with high precision (refer also to Technical data).

When selecting the settings (pickup value, operate delay and function mode) for the function OCP, ground (ANSI 50N) the present network connecting conditions must be considered! Otherwise short-term power-system unbalances (for example, 1-pole fast auto reclosing) or statically present harmonics in the zero-sequence system may cause an overfunction. Since the primary elements of the AC filter are directly or inherently protected by other protection functions and due to the possible influence of the network conditions on the function OCP, ground (ANSI 50N), this function should be configured only as alarm function and not as tripping function.



[dw_AC-Filter_detuning-supervision, 1, en_US]

Figure 7-64 Application Overview

8 Control Functions

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8.2	Switching Devices	1019
8.3	Control Functionality	1046
8.4	Synchronization Function	1070
8.5	Switching Sequences	1106
8.6	User-Defined Function Block [Control]	1113
8.7	CFC-Chart Settings	1115
8.8	Transformer Tap Changers	1117
8.9	Voltage Controller	1128

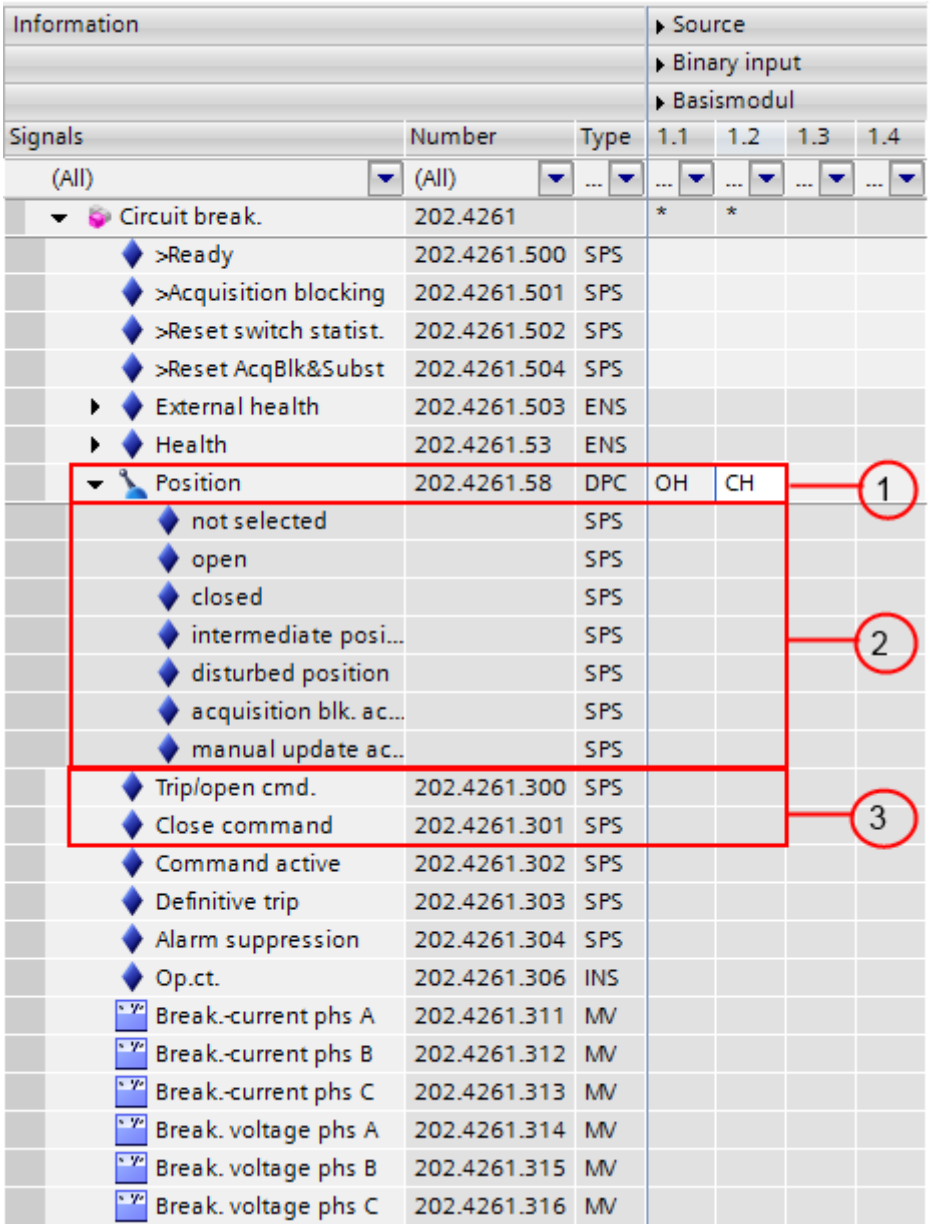
8.1 Introduction

8.1.1 Overview

The SIPROTEC 5 series of devices offers powerful command processing capability as well as additional functions that are needed when serving as bay controllers for the substation automation technology or when providing combi-protection. The object model for the devices is based on the IEC 61850 standard, making the SIPROTEC 5 series of devices ideally suited for use in systems employing the IEC 61850 communication protocol. In view of the function blocks necessary for the control functions, other logs are also used.

8.1.2 Concept of Controllables

The concept of so-called controllables is based on the data model described in IEC 61850. Controllables are objects that can be controlled, such as a switch with feedback. The model of a transformer tap changer , for example, contains controllables. The controllables are identifiable by their last letter **C** of the data type (for example, DPC = Double Point Controllable/Double Command with feedback or BSC = Binary-Controlled Step Position Indication / transformer tap command with feedback).



[sc_contrl, 1, en_US]

(1) Position (connect with binary inputs)

(2) Signalization of the current condition

(3) Command output (connect with relay)

The trip, opening and the close commands are connected to the relays. For the trip command, a choice between saved and unsaved output is possible. The position is connected with 2 binary inputs (double-point indication). In addition, signals are available that display the current state of the switch (**not selected**, **off**, **on**, **intermediate position**, **disturbed position**). These signals can be queried in CFC for example, in order to build interlocking conditions.

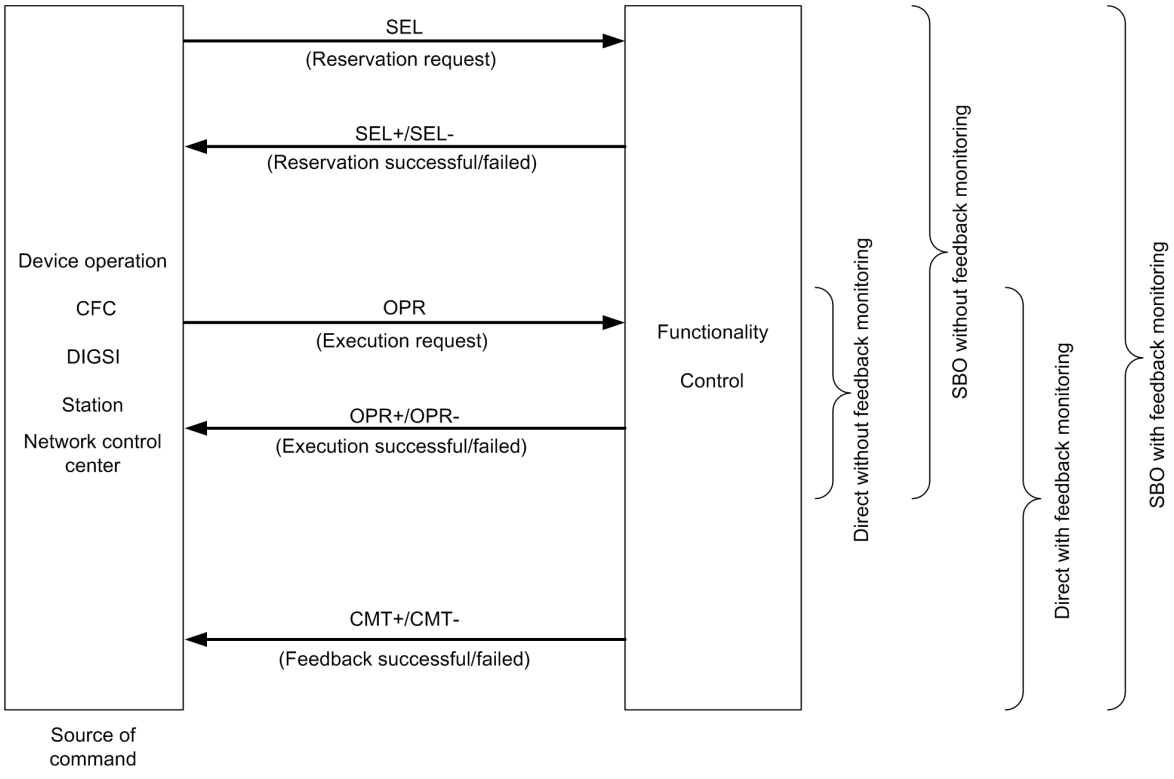
Control Models

You can set the operating mode of the controllables by selecting the control model.

4 different control models are available:

- Direct without feedback monitoring (**`direct w. normal secur.`**)
- With reservation (SBO)[19] without feedback monitoring (**`SBO w. normal secur.`**)
- Direct with feedback monitoring (**`direct w. enh. security`**)
- With SBO with feedback monitoring (**`SBO w. enh. security`**)

The next figure shows the command sources, command types, and control models.



[dwsteuer-190912-01.tif, 1, en_US]

Figure 8-1 Command Sources, Command Types and Control Models

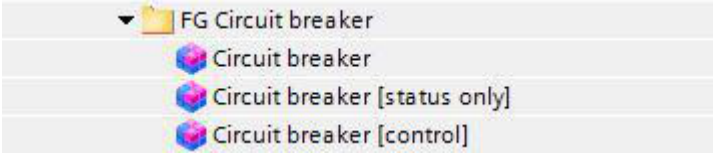
The figure shows the control models (right) with the respective control mechanisms (center). The standard control model for a switching command in an IEC 61850 compliant system is **SBO with feedback monitoring** (**`SBO w. enh. security`**). This control model is the default setting for newly created switching devices.

[19] SBO: Select Before Operate

8.2 Switching Devices

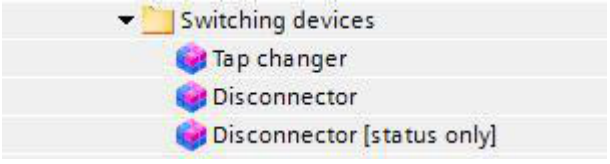
8.2.1 General Overview

The following switching devices can be found in the DIGSI 5 library in the **Circuit-breaker** and **Switching-devices** function groups (see the following images).



[sccbausw, 1, en_US]

Figure 8-2 Selecting the Circuit-Breaker Switching Device Using the DIGSI Circuit-Breaker Function Group Menu



[scswausw, 1, en_US]

Figure 8-3 Selecting the Remaining Switching Devices Using the DIGSI Switching-Devices Menu

8.2.2 Switching Device Circuit Breaker

8.2.2.1 Structure of the Circuit-Breaker Switching Device

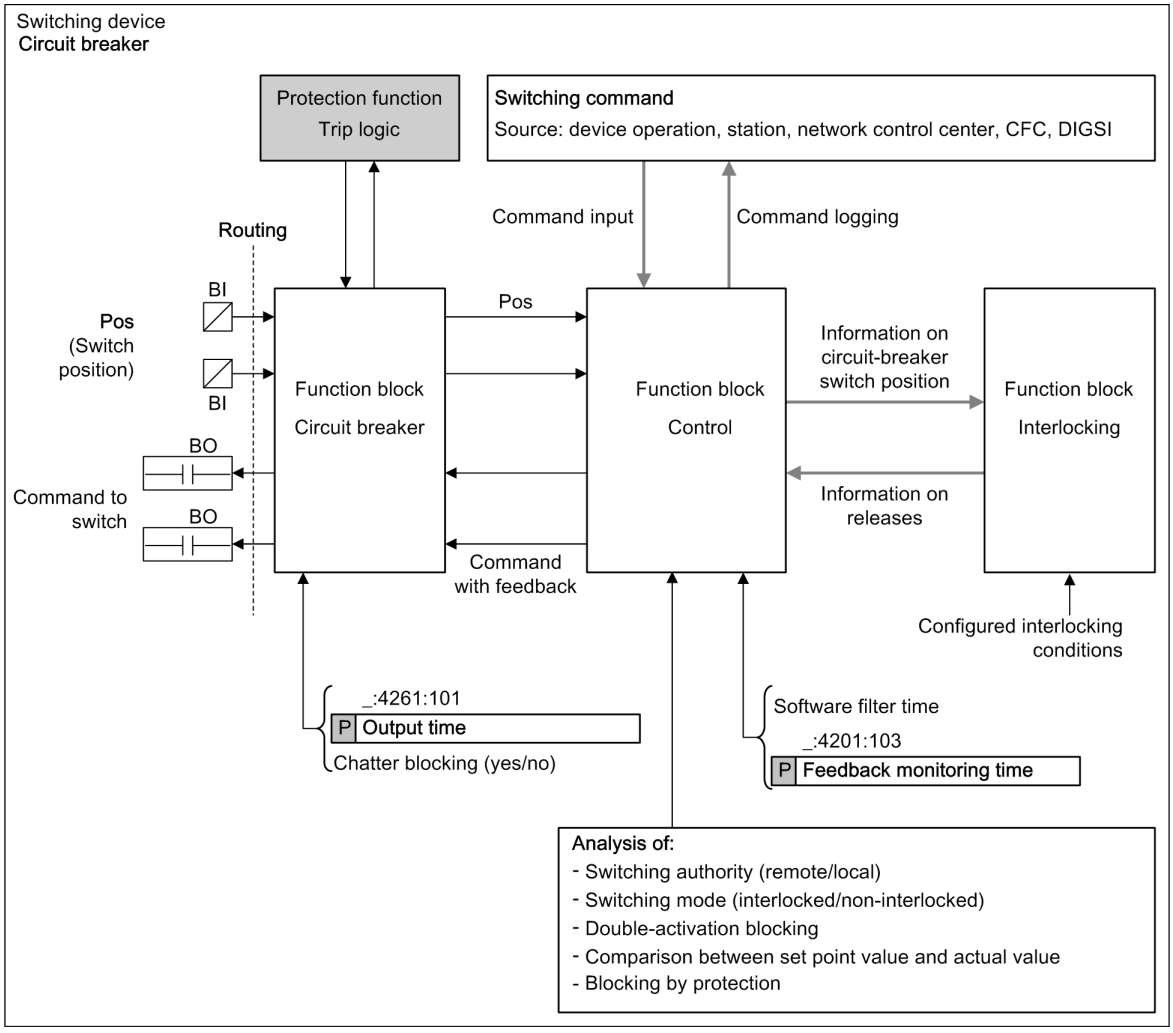
This chapter describes the control properties of the **Circuit breaker** switching device.

The **Circuit breaker** switching device contains the following function blocks that are needed for control:

- Function block **Circuit breaker**
- Function block **Control**
- Function block **Interlocking**

This corresponds to the logical nodes XCBR, CSWI, and CILO in IEC 61850.

In the case of protection devices or combined protection and control devices, additional functions can be contained in the **circuit breaker** switching device, for example, **synchrocheck**, the **automatic reclosing (AREC)**, the **trip logic** or **manual On function**. However, these are not relevant for the control function. The description of these functions is in the chapter Protection and Automatic Functions..



[dwbreake-220512-01.tif, 1, en_US]

Figure 8-4 Control Function Blocks of the Circuit-Breaker Switching Device

The circuit breaker in DIGSI 5 is linked with the binary inputs that acquire the switch position via information routing. The circuit breaker in DIGSI 5 is also linked with the binary outputs that issue the switching commands.

NOTE

When setting the parameters of a device, you will find 2 circuit-breaker types in the DIGSI 5 library:

- **3-pole circuit breaker** or **1-pole circuit breaker**, depending on the device type selected (3-pole or 1-pole tripping)
- **Circuit breaker (status only)**

Function Blocks of the Circuit Breaker

Table 8-1 Function Blocks of the Circuit-Breaker Function Group

Function Block	Description	Parameters	Function
Circuit breaker	The Circuit breaker function block in the SIPROTEC 5 device represents the physical switch.	**`Output time`**	The circuit breaker forms the switch position from the positions of the binary inputs and also outputs the command via the binary outputs.
Control	Command processing	**`Control model`** **`SBO time-out`** **`Feedback monitoring time`** **`Check switching authority`** **`Check if pos. is reached`** **`Check double activat. blk.`** **`Check blk. by protection`**	Command check, communication with the command source and with the function block **Circuit breaker**
Interlocking	Switchgear interlocking protection	Interlocking condition (deposited in CFC)	The **Interlocking** functionality generates the releases for switchgear interlocking protection.

The setting values of the parameter can be found in the chapter *8.2.2.2 Application and Setting Notes*.

Additional Setting Options of the Circuit-Breaker Switching Element

The setting options of the circuit breaker are assigned to the function blocks on the basis of their relevance. Additional setting options of the circuit breakers that cannot be directly assigned to one of the 3 function blocks are nevertheless available:

Table 8-2 Setting Options of the Controllable **`Command with Feedback`** in the **`Control`** Function Block of the Circuit Breaker.

Properties	Function	To Be Found in
`Software filtering time`	Software filtering time for position detection	Position of the **Control**(1) function block
`Retrigger filter` (yes/no)	Switching retriggering of the filtering time on/off by changing the position	Position of the **Control**(1) function block
`Message time before filtering` (yes/no)	Consideration of the hardware filtering time for position-detection time stamp	Position of the **Control**(1) function block
`Suppress intermediate position` (yes/no)	When activated, only the intermediate position is suppressed by the duration of the software filtering time.	Position of the **Control**(1) function block

Properties	Function	To Be Found in
Treatment of spontaneous position changes (Gen. software filt./Spont. software filt.)	If the ***General software filter*** setting is selected, the general settings for software filtering of spontaneous position changes and for position changes caused by a switching command apply. By selecting ***Spontaneous software filter***, a separate filtering is activated for spontaneous position changes.	Position of the **Control**(1) function block
Spontaneous software filtering time	Software filtering time for spontaneous position changes	Position of the **Control**(1) function block
Spontaneous retrigger filter (yes/no)	Switching on/off retriggering of the filtering time by spontaneous position change	Position of the **Control**(1) function block
Spontaneous indication timestamp before filtering (yes/no)	Consideration of the hardware filtering time for position-detection time stamp in case of a spontaneous change	Position of the **Control**(1) function block
Inhibit intermediate position for a spontaneous chng. (yes/no)	When activated, only the spontaneous change to the intermediate position is suppressed by the duration of the software filtering time.	Position of the **Control**(1) function block

(1) First click **Position** and then click the **Details** button in the **Properties** window (below).

Table 8-3 Setting Options of the Controllable **Position** in the Circuit Breaker Function Block (Chatter Blocking)

Properties	Function	To Be Found in
Chatter blocking (yes/no)	Switching chatter blocking on/off	Position of the **Circuit breaker** (1) function block

(1) First click **Position** and then click the **Details** button in the **Properties** window (below).

Table 8-4 Additional Settings in the Device Settings having Effects on the Circuit Breaker

Properties	Function	To Be Found in
Number of permissible status changes	Chatter-blocking setting value: Once for the entire device	Device settings (to be found under Settings)
Chatter test time		
Number of chatter tests		
Chatter idle time		
Chatter check time		

The inputs and outputs as well as the setting options of the **Circuit-breaker** and **Control** function blocks are described in the next section (see *8.2.2.3 Connection Variants of the Circuit Breaker*).

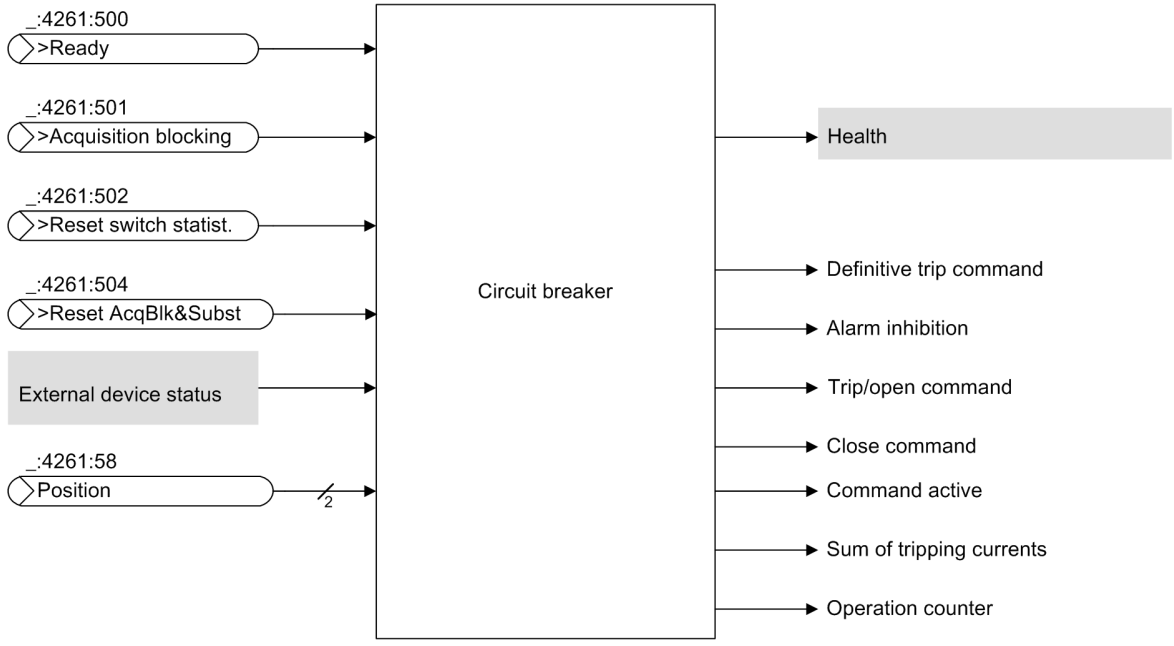
Interlocking

The **Interlocking** function block generates the releases for switchgear interlocking protection. The actual interlocking conditions are deposited in CFC. For more information on this, see chapter *8.3.1 Command Checks and Switchgear Interlocking Protection*.

8.2.2.2 Application and Setting Notes

Circuit Breaker

The Circuit breaker function block in the SIPROTEC 5 device represents the physical switch device. The task of the circuit breaker is to replicate the switch position from the status of the binary inputs.
The following figure shows the logical inputs and outputs of the **Circuit-breaker** function block.



[dwfuncls-140212-01.tif, 2, en_US]

Figure 8-5 Logical Inputs and Outputs of the Circuit-Breaker Function Blocks

Table 8-5 and *Table 8-6* list the inputs and outputs with a description of their function and type. For inputs, the effect of **Quality = invalid** on the value of the signal is described.

EXAMPLE

If the signal **>Ready** has the **Quality = invalid**, then the value is set to **cleared**. In problematic operating states, the circuit breaker should signal that it is not ready for an **Off-On-Off cycle**.

Table 8-5 Inputs of the Circuit-Breaker Function Block

Signal Name	Description	Type	Default Value if Signal Quality = invalid
>Ready	The signal **>Ready** indicates that the OFF-ON-OFF cycle is possible with the circuit breaker. This signal is used for the AREC standby status.	SPS	Going
>Acquisition blocking	The binary input activates acquisition blocking. You can also set this binary input with an external toggle switch.	SPS	Unchanged
>Reset AcqBlk&Subst	Acquisition blocking and the substitution of the circuit breaker are reset with this input. If the input is activated, setting the acquisition blocking and the substitution is blocked.	SPS	Unchanged
>Reset switch statist.	Among other things, the binary input sets the operation counter for the switch to the value 0.	SPS	Unchanged

Signal Name	Description	Type	Default Value if Signal Quality = invalid
External health	The binary input **External health** reflects the circuit-breaker status (EHealth). This input will be set by the CFC using the BUILD_ENS block. In turn, BUILD_ENS can query binary inputs that represent the conditions ***OK***, ***Warning***, ***Alarm*** (as a result of the function **Trip-circuit supervision**).	ENS	Unchanged
Position	The signal **Position** can be used to read the circuit-breaker position with double-point indication.	DPC	Unchanged

If the quality of the input signal assumes the status **Quality = invalid**, then the standby status (EHealth) of the **Circuit-breaker** function block is set to *Warning*.

Table 8-6 Outputs of the Circuit-Breaker Function Block

Signal Name	Description	Type
Definitive trip	Protection has finally been tripped.	SPS
Alarm suppression	The signaling contact for external alarm suppression is suppressed during the runtime of automatic reclosing (optional) as well as during the command output of switching commands.	SPS
Op.ct.	The information counts the number of switching cycles of the circuit breaker.	INS
Trip/open cmd.	This logic output is responsible for the command output **Off**.	SPS
Close command	This logic output is responsible for the command output **On**.	SPS
Command active	The binary output **Command active** is responsible for signaling a running command (relay active or selected switching device (SEL)).	SPS
CB open hours	The statistic value counts the hours the circuit breaker is open.	INS
Operating hours	The statistic value counts the hours where at least one phase current is greater than the **Current thresh. CB open** parameter.	INS

Control

It is the task of the controls to execute command checks and establish communication between the command source and the circuit breaker. Using the control settings, you specify how the commands are to be processed.

Through the function SBO (Select Before Operate, reservation[20]) reserves the switching device prior to the actual switching operation, thus it remains locked for additional commands. Feedback monitoring provides information about the initiator of the command while the command is in process, that means, informing whether or not the command was implemented successfully. These two options can be selected individually in the selection of the control model, so that 4 combinations in total are available (see the following table).

The control makes the following settings available (see next table).

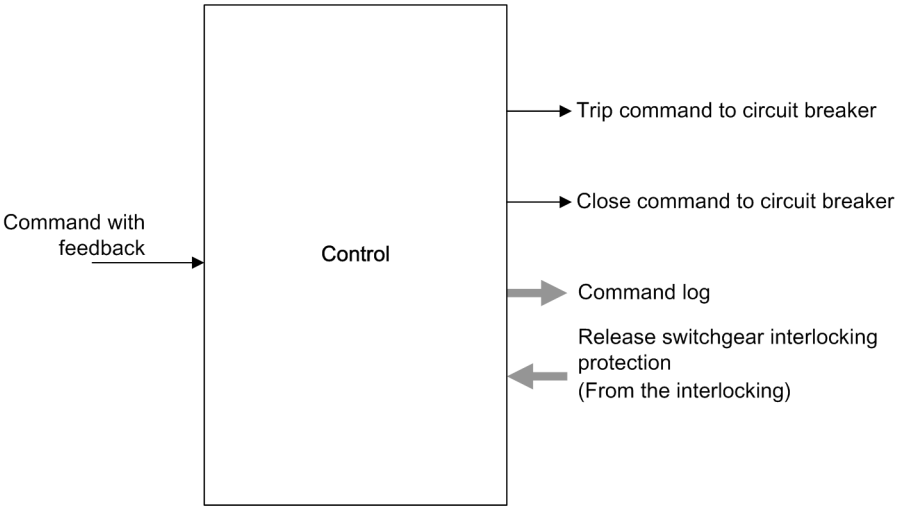
Parameters	Default Setting	Possible Parameter Values
(_:4201:101) Control model	***SBO w. enh. security***[21]	***direct w. normal secur.*** ***SBO w. normal secur.*** ***direct w. enh. security*** ***SBO w. enh. security***
(_:4201:102) SBO time-out	***30.00 s***	0.01 s to 1800 s (Increment: 0.01 s)
(_:4201:103) Feedback monitoring time	***1.00 s***	0.01 s to 1800 s (Increment: 0.01 s)

[20] In the IEC 61850 standard, reservation is described as **Select before Operate (SBO)**.

[21] This default setting is the standard control model for a switching command in an IEC 61850-compliant system.

Parameters	Default Setting	Possible Parameter Values
(_:4201:104) Check switching authority	*yes*	*no* *yes* *advanced*
(_:4201:105) Check if pos. is reached	*yes*	*no* *yes*
(_:4201:106) Check double activat. blk.	*yes*	*no* *yes*
(_:4201:107) Check blk. by protection	*yes*	*no* *yes*

The following figure shows the logical inputs and outputs of the **Control** function block.



[dwsteue1-100611-01.tif, 1, en_US]

Figure 8-6 Logical Inputs and Outputs of the Control Function Block

Table 8-7 Control Function Block Input and Output

Signal Name	Description	Type	Value if Signal Quality=Invalid
Cmd. with feedback	With the **Cmd. with feedback** signal, the circuit-breaker position is accepted via the double-point indication of the **Circuit breaker** function block and the command is submitted.	Controllable (DPC) Unchanged	Unchanged

In the information routing of DIGSI 5, you may select a function key as a possible command source. In addition, it is displayed here if the command is activated by CFC. The logging is routed here.

8.2.2.3 Connection Variants of the Circuit Breaker

For each switching device, you can establish the number of poles (for example, 1-pole, 1.5-pole or 2-pole) that are switched with or without feedback. This results in the necessary amount of information to be processed, thus establishing the command type.

Whether the circuit breaker is triggered 1-, 1.5-, or 2-phase, depends on the design of the auxiliary and control-voltage system. In most cases, the activation of the opening coil of the circuit breaker is 1-pole.

Table 8-8 Meaning of the Abbreviations of the Connection Variants

Abbreviation	Meaning of the Abbreviations of the Connection Variants
BO	Binary output

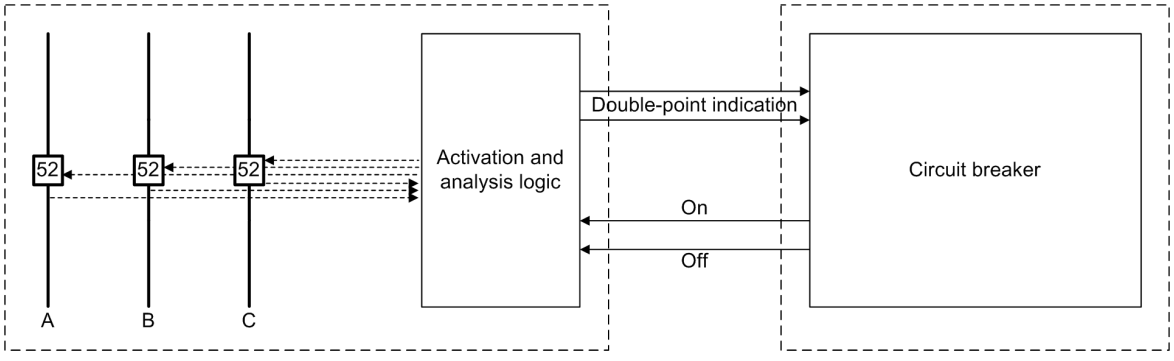
Abbreviation	Meaning of the Abbreviations of the Connection Variants
L+; L-	Control voltage
A	Trip command
Gnd	Close command

Table 8-9 Meaning of the Abbreviations in DIGSI

Abbreviation	Description of the Input in DIGSI
U	Unsaved trip command Click the right mouse button and enter **U**.
X	Close Command Click the right mouse button and enter **X** for the respective binary output.
OH	The switching-device feedback is in the position **OFF**, if there is voltage at the routed binary input (H). Click the right mouse button and enter **OH**.
OL	The switching-device feedback is in the position **OFF**, if there is no voltage at the routed binary input (L). Click the right mouse button and enter **OL**.
GH	The switching-device feedback is in the position **ON**, if there is voltage at the routed binary input (H). Click the right mouse button and enter **CH**.
CL	The switching-device feedback is in the position **ON**, if there is no voltage at the routed binary input (H). Click the right mouse button and enter **CL**.
TL	Trip command stored Click the right mouse button and enter **TL**.

Connection Variant: 3-Pole Circuit Breaker

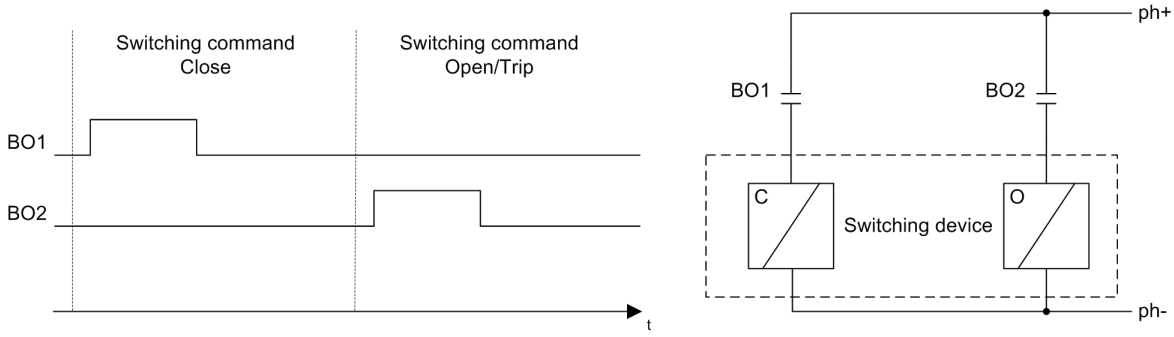
This is the standard type for the control function. All 3 individual poles of the circuit breaker are triggered together by a double command.



[dw3polls-070611-01.tif, 1, en_US]

Figure 8-7 3-Pole Circuit Breaker

1-Pole Triggering



[dw1polig-020211-01.tif, 1, en_US]

Figure 8-8 1-Pole Triggering

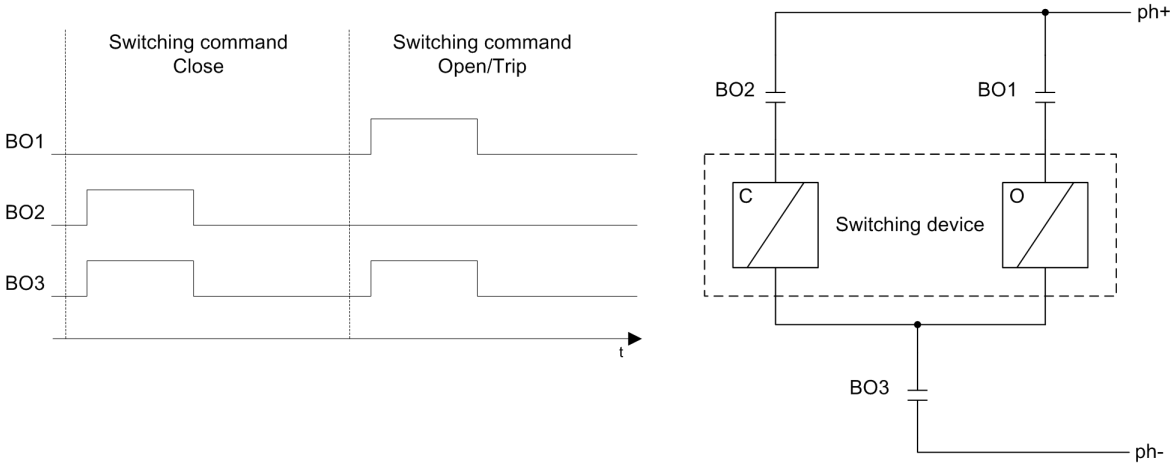
Information			S	Destination				
				Binary output				
				Base module				
Signals	Number	Type		1.1	1.2	1.3	1.4	1.5
(All)	(All)	...		...	...	...	...	...
Trip logic	301.5341							
Circuit break.	301.4261			*	*			
>Ready	301.4261.500	SPS						
>Acquisition blocking	301.4261.501	SPS						
>Reset switch statist.	301.4261.502	SPS						
>Reset AcqBlk&Subst	301.4261.504	SPS						
External health	301.4261.503	ENS						
Health	301.4261.53	ENS						
Position 3-pole	301.4261.58	DPC						
Position 1-pole phsA	301.4261.459	DPC						
Position 1-pole phsB	301.4261.460	DPC						
Position 1-pole phsC	301.4261.461	DPC						
Trip/open cmd. 3-pole	301.4261.300	SPS			U			
Trip only pole A	301.4261.401	SPS						
Trip only pole B	301.4261.402	SPS						
Trip only pole C	301.4261.403	SPS						
Close command	301.4261.301	SPS		X				

[scrang1pLS1p, 1, en_US]

Figure 8-9 1-Pole Triggering, Routing in DIGSI

You can select the contacts for ***On*** and ***Off*** as desired. They need not necessarily be next to one another. The letter **U** represents an unlatched command. Alternatively, **TL** (latched tripping) may be selected.

1.5-Pole Triggering



[dw5polig-020211-01.tif, 1, en_US]

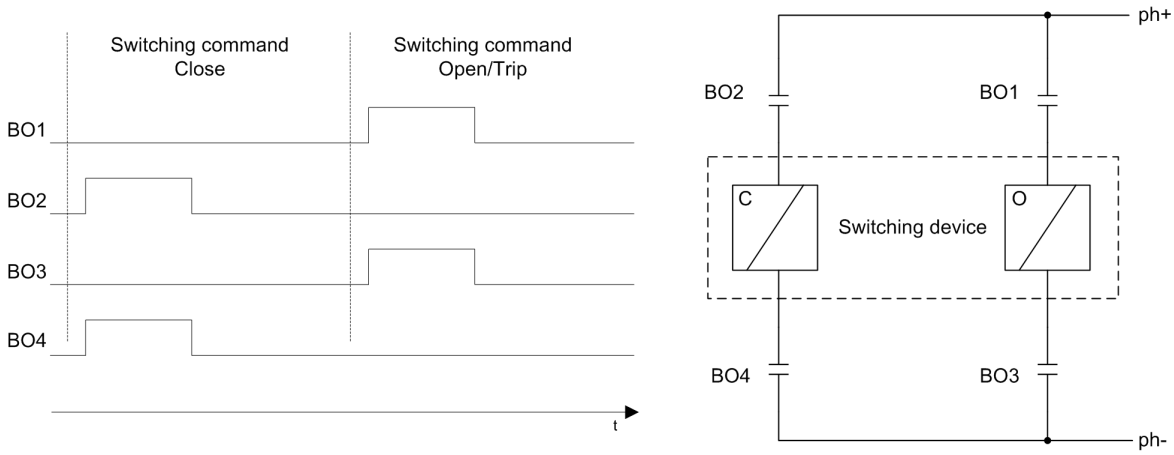
Figure 8-10 1.5-Pole Triggering

Information			S	Destination				
				Binary output				
				Base module				
Signals	Number	Type		1.1	1.2	1.3	1.4	1.5
(All)	(All)	...		...	...	...	...	...
Trip logic	301.5341							
Circuit break.	301.4261			*	*	*		
>Ready	301.4261.500	SPS						
>Acquisition blocking	301.4261.501	SPS						
>Reset switch statist.	301.4261.502	SPS						
>Reset AcqBlk&Subst	301.4261.504	SPS						
External health	301.4261.503	ENS						
Health	301.4261.53	ENS						
Position 3-pole	301.4261.58	DPC						
Position 1-pole phsA	301.4261.459	DPC						
Position 1-pole phsB	301.4261.460	DPC						
Position 1-pole phsC	301.4261.461	DPC						
Trip/open cmd. 3-pole	301.4261.300	SPS		U		U		
Trip only pole A	301.4261.401	SPS						
Trip only pole B	301.4261.402	SPS						
Trip only pole C	301.4261.403	SPS						
Close command	301.4261.301	SPS			X	X		

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Figure 8-11 1.5-Pole Triggering, Routing in DIGSI

2-Pole Triggering



[dw2polan-020211-01.tif, 1, en_US]

Figure 8-12 2-Pole Triggering

Information			Source								Destination			
			Binary input							CFC	Binary output			
			Base module							Em	Base module			
Signals	Number	Type	1.1	1.2	1.3	1.4	2.1	2.2	2.3		1.1	1.2	1.3	1.4
(All)	(All)	...	...	...	...	...	...	...	...	...	...	...	...	...
Line 1	21													
Circuit breaker 1	301		*	*	*	*	*				*	*	*	*
Trip logic	301.5341													
Circuit break.	301.4261		*	*	*	*	*				*	*	*	*
>Ready	301.4261.500	SPS					H							
>Acquisition blocking	301.4261.501	SPS												
>Reset switch statist.	301.4261.502	SPS												
>Reset AcqBlk&Subst	301.4261.504	SPS												
External health	301.4261.503	ENS												
Health	301.4261.53	ENS												
Position 3-pole	301.4261.58	DPC	OH											
Position 1-pole phsA	301.4261.459	DPC		CH										
Position 1-pole phsB	301.4261.460	DPC			CH									
Position 1-pole phsC	301.4261.461	DPC				CH								
Trip/open cmd. 3-pole	301.4261.300	SPS									U	U	U	
Trip only pole A	301.4261.401	SPS									X			
Trip only pole B	301.4261.402	SPS										X		
Trip only pole C	301.4261.403	SPS											X	
Close command	301.4261.301	SPS												X
Command active	301.4261.302	SPS												

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Figure 8-13 2-Pole Triggering, Routing in DIGSI

Connection Variant: 1-Pole Circuit Breaker

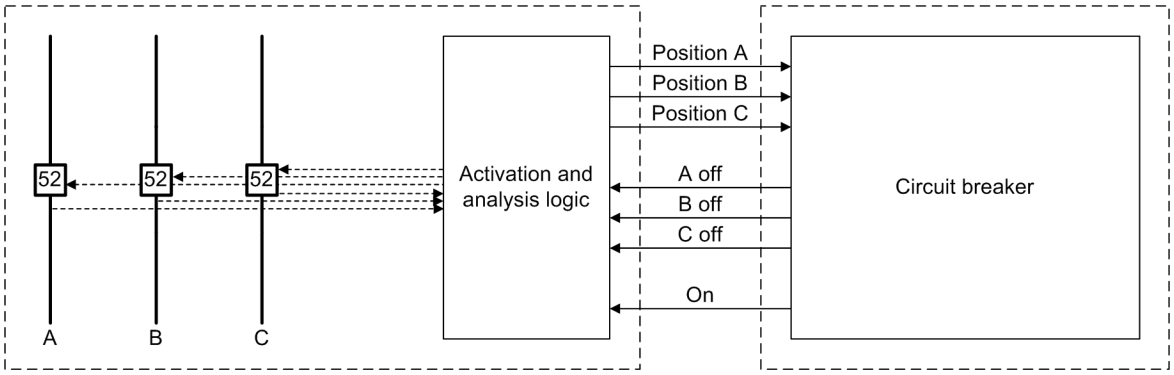
The 1-pole circuit breaker is used for separate activation and acquisition of the individual poles of a circuit breaker. It is intended for common use by 1-pole working protection and control functions.

NOTE

The wiring of the **Circuit-breaker** function group with binary inputs and binary outputs occurs once per device .

The control function in this type switches all 3 poles on or off simultaneously.

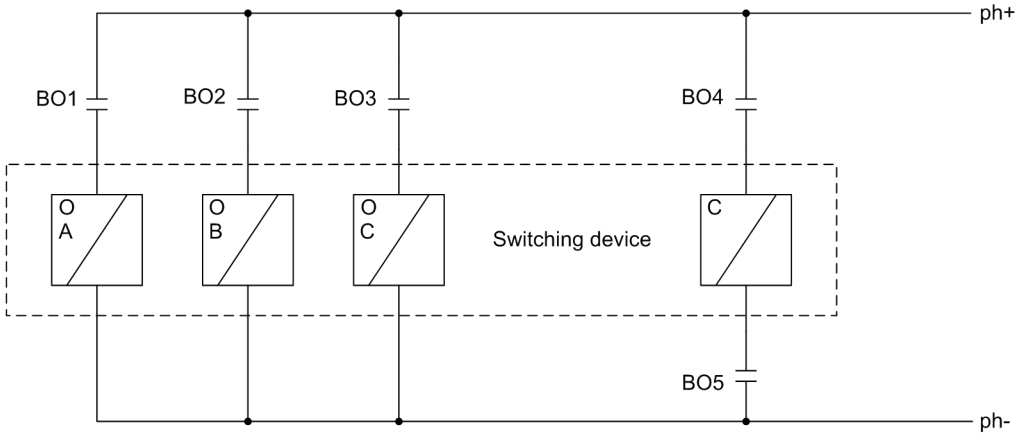
The protection functions can switch off 1-pole. The close command is always 3-pole. Optionally, only the open poles close.



[dw1polls-020211-01.tif, 1, en_US]

Figure 8-14 Circuit Breaker with 1-Pole Triggering

For the circuit breaker with 1-pole triggering, triggering takes place via one relay per phase for the trip command and via a 4th relay for the close command (see next figure).



[dw1panls-020211-01.tif, 1, en_US]

Figure 8-15 1-Pole Connection of a Circuit Breaker

Information			S	Destination				
				Binary output				
				Base module				
Signals	Number	Type		1.1	1.2	1.3	1.4	1.5
(All)	(All)	...		...	...	...	...	...
Trip logic	301.5341							
Circuit break.	301.4261			*	*	*	*	*
>Ready	301.4261.500	SPS						
>Acquisition blocking	301.4261.501	SPS						
>Reset switch statist.	301.4261.502	SPS						
>Reset AcqBlk&Subst	301.4261.504	SPS						
External health	301.4261.503	ENS						
Health	301.4261.53	ENS						
Position 3-pole	301.4261.58	DPC						
Position 1-pole phsA	301.4261.459	DPC						
Position 1-pole phsB	301.4261.460	DPC						
Position 1-pole phsC	301.4261.461	DPC						
Trip/open cmd. 3-pole	301.4261.300	SPS		U	U	U		
Trip only pole A	301.4261.401	SPS		X				
Trip only pole B	301.4261.402	SPS			X			
Trip only pole C	301.4261.403	SPS				X		
Close command	301.4261.301	SPS					X	X

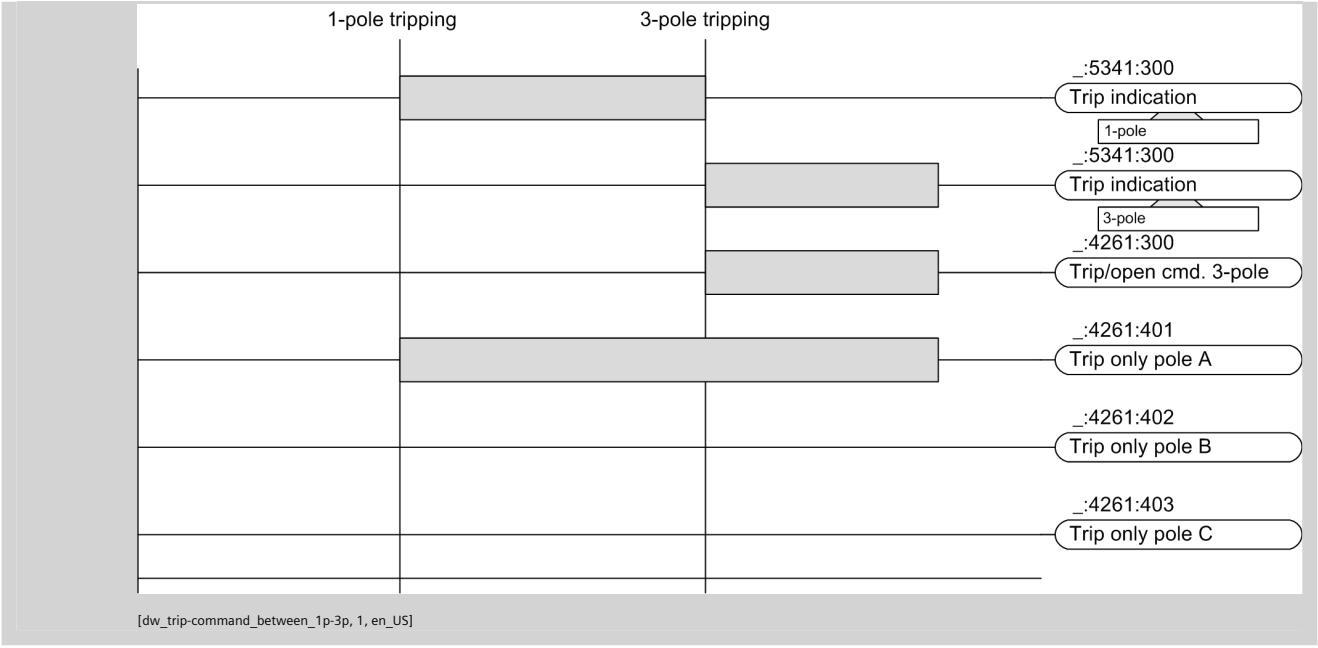
[scrang1pLS13pz, 1, en_US]

Figure 8-16 Routing in DIGSI

In the previous figure, the switch is connected 1-pole. The protection trip command is routed individually for the 3 phases (**`Trip only pole A`** to **`Trip only pole C`**). The protection trip command is routed for the 3 phases (**`Trip/open cmd. 3-pole`**). The control will always switch off the 3 poles of the switch. In addition, the 3 **U** (Unsaved) allocations of the activation and trip command are set to 3-pole. This routing is also used by protection functions that trip 3 poles. The close command is issued simultaneously for all 3 phases.

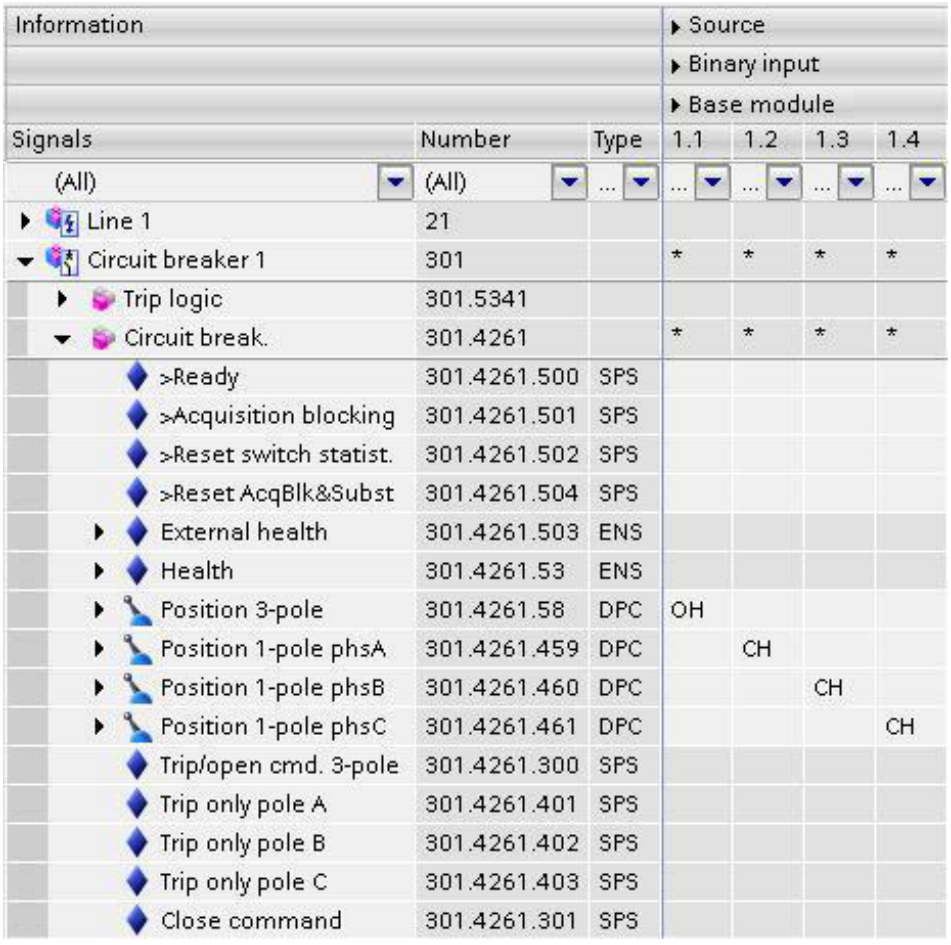
Example: Trip Command during Transition from 1-Pole to 3-Pole

During a transition from 1-pole to 3-pole tripping, **`Trip only pole A`** remains active. To inform, for example, an external AREC whether it is a 1-pole or 3-pole trip, you can use the indications *`Trip logic:Trip indication:1-pole`* and *`Trip logic:Trip indication:3-pole`*.



Acquisition of the Circuit-Breaker Position

The routing of the binary inputs for feedback of the switch position is done as shown in the previous figure (also see Chapter *5.7.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information*).



Information			Source			
			Binary input			
			Base module			
Signals	Number	Type	1.1	1.2	1.3	1.4
(All)	(All)	...	...	...	...	...
Line 1	21					
Circuit breaker 1	301		*	*	*	*
Trip logic	301.5341					
Circuit break.	301.4261		*	*	*	*
>Ready	301.4261.500	SPS				
>Acquisition blocking	301.4261.501	SPS				
>Reset switch statist.	301.4261.502	SPS				
>Reset AcqBlk&Subst	301.4261.504	SPS				
External health	301.4261.503	ENS				
Health	301.4261.53	ENS				
Position 3-pole	301.4261.58	DPC	OH			
Position 1-pole phsA	301.4261.459	DPC		CH		
Position 1-pole phsB	301.4261.460	DPC			CH	
Position 1-pole phsC	301.4261.461	DPC				CH
Trip/open cmd. 3-pole	301.4261.300	SPS				
Trip only pole A	301.4261.401	SPS				
Trip only pole B	301.4261.402	SPS				
Trip only pole C	301.4261.403	SPS				
Close command	301.4261.301	SPS				

[scrang1pLSHk, 1, en_US]

Figure 8-17 Routing of the 1-Pole in DIGSI

The meaning of abbreviations can be found in *Table 8-8* and *Table 8-9* .

The indication **`Command active`** can also be routed to a binary output. This binary output is always active if either an On or trip command is pending, or the switching device was selected by the command control.

8.2.2.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Ref. for %-values				
_:2311:101	General:Rated normal current		0.20 A to 100000.00 A	1000.00 A
_:2311:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Breaker settings				
_:2311:112	General:Current thresh. CB open	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2311:136	General:Op. mode BFP		• unbalancing • I> query	unbalancing

Addr.	Parameter	C	Setting Options	Default Setting
Trip logic				
_:5341:103	Trip logic:Reset of trip command		• with I< • with I< & aux.contact • with dropout	with I<
Circuit break.				
_:4261:101	Circuit break.:Output time		0.02 s to 1800.00 s	0.10 s
Manual close				
_:6541:101	Manual close:Action time		0.01 s to 60.00 s	0.30 s
Control				
_:4201:101	Control:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:4201:102	Control:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:4201:103	Control:Feedback monitoring time		0.01 s to 1800.00 s	1.00 s
_:4201:104	Control:Check switching authority		• no • yes • advanced	yes
_:4201:105	Control:Check if pos. is reached		• no • yes	yes
_:4201:106	Control:Check double activat. blk.		• no • yes	yes
_:4201:107	Control:Check blk. by protection		• no • yes	yes
Switching authority				
_:4201:151	Control:Swi.dev. related sw.auth.		• 0 • 1	false
_:4201:152	Control:Specific sw. authorities		• 0 • 1	true
_:4201:115	Control:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:4201:153	Control:Num. of specific sw.auth.		2 to 5	2
_:4201:155	Control:Ident. sw.auth. 1		Freely editable text	
_:4201:156	Control:Ident. sw.auth. 2		Freely editable text	
_:4201:157	Control:Ident. sw.auth. 3		Freely editable text	
_:4201:158	Control:Ident. sw.auth. 4		Freely editable text	
_:4201:159	Control:Ident. sw.auth. 5		Freely editable text	
_:4201:154	Control:Multiple specific sw.auth.		• 0 • 1	false
CB test				
_:6151:101	CB test:Dead time		0.00 s to 60.00 s	0.10 s

8.2.2.5 Information List

No.	Information	Data Class (Type)	Type
Trip logic			
_:5341:300	Trip logic:Trip indication	ACT	O
Circuit break.			
_:4261:500	Circuit break.:>Ready	SPS	I
_:4261:501	Circuit break.:>Acquisition blocking	SPS	I
_:4261:502	Circuit break.:>Reset switch statist.	SPS	I
_:4261:503	Circuit break.:External health	ENS	I
_:4261:53	Circuit break.:Health	ENS	O
_:4261:58	Circuit break.:Position 3-pole	DPC	C
_:4261:459	Circuit break.:Position 1-pole phsA	DPC	C
_:4261:460	Circuit break.:Position 1-pole phsB	DPC	C
_:4261:461	Circuit break.:Position 1-pole phsC	DPC	C
_:4261:300	Circuit break.:Trip/open cmd. 3-pole	SPS	O
_:4261:401	Circuit break.:Trip only pole A	SPS	O
_:4261:402	Circuit break.:Trip only pole B	SPS	O
_:4261:403	Circuit break.:Trip only pole C	SPS	O
_:4261:301	Circuit break.:Close command	SPS	O
_:4261:302	Circuit break.:Command active	SPS	O
_:4261:303	Circuit break.:Definitive trip	SPS	O
_:4261:304	Circuit break.:Alarm suppression	SPS	O
_:4261:306	Circuit break.:Op.ct.	INS	O
_:4261:407	Circuit break.:Op.ct. A	INS	O
_:4261:408	Circuit break.:Op.ct. B	INS	O
_:4261:409	Circuit break.:Op.ct. C	INS	O
_:4261:322	Circuit break.:CB open hours	INS	O
_:4261:323	Circuit break.:Operating hours	INS	O
_:4261:307	Circuit break.:ΣI Brk.	BCR	O
_:4261:308	Circuit break.:ΣIA Brk.	BCR	O
_:4261:309	Circuit break.:ΣIB Brk.	BCR	O
_:4261:310	Circuit break.:ΣIC Brk.	BCR	O
_:4261:311	Circuit break.:Break.-current phs A	MV	O
_:4261:312	Circuit break.:Break.-current phs B	MV	O
_:4261:313	Circuit break.:Break.-current phs C	MV	O
_:4261:314	Circuit break.:Break. voltage phs A	MV	O
_:4261:315	Circuit break.:Break. voltage phs B	MV	O
_:4261:316	Circuit break.:Break. voltage phs C	MV	O
Manual close			
_:6541:501	Manual close:>Block manual close	SPS	I
_:6541:500	Manual close:>Input	SPS	I
_:6541:300	Manual close:Detected	SPS	O
Reset LED Group			
_:13381:500	Reset LED Group:>LED reset	SPS	I
_:13381:320	Reset LED Group:LED have been reset	SPS	O
Control			
_:4201:53	Control:Health	ENS	O

No.	Information	Data Class (Type)	Type
_:4201:58	Control:Cmd. with feedback	DPC	C
Interlocking			
_:4231:500	Interlocking:>Enable opening	SPS	I
_:4231:501	Interlocking:>Enable closing	SPS	I
_:4231:502	Interlocking:>Enable opening(fixed)	SPS	I
_:4231:503	Interlocking:>Enable closing (fixed)	SPS	I
_:4231:53	Interlocking:Health	ENS	O
CB test			
_:6151:53	CB test:Health	ENS	O
_:6151:301	CB test:Test execution	ENS	O
_:6151:302	CB test:Trip command issued	ENS	O
_:6151:303	CB test:Close command issued	ENS	O
_:6151:304	CB test:Test canceled	ENS	O
_:6151:311	CB test:3-pole open-close	SPC	C
_:6151:312	CB test:Pole A open-close	SPC	C
_:6151:313	CB test:Pole B open-close	SPC	C
_:6151:314	CB test:Pole C open-close	SPC	C

8.2.3 Disconnector Switching Device

8.2.3.1 Structure of the Disconnector Switching Device

Like the circuit breaker, the **Disconnector** switching device contains the following 3 function blocks:

- Function block **Disconnector**
- Function block **Control**
- Function block **Interlocking**

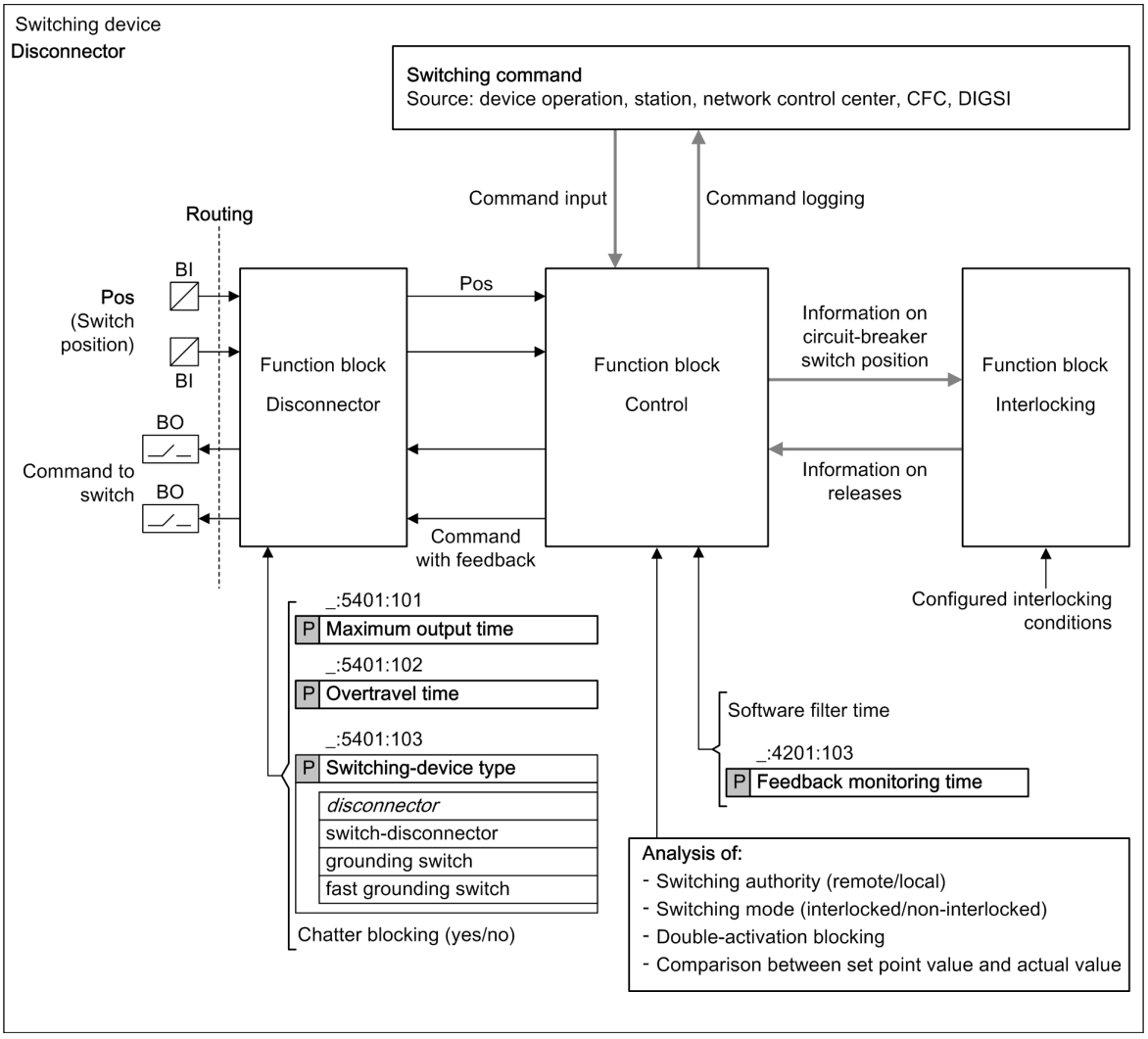
This corresponds to the logical nodes XSWI, CSWI und CILO in IEC 61850.



NOTE

In contrast to the **Circuit-breaker** switching device, the **Disconnector** switching device cannot contain any additional functions because protection functions or synchronization can have no effect on the disconnector.

The following figure shows the structure of the **Disconnector** switching element:



[dwdiscon-190612-01.tif, 1, en_US]

Figure 8-18 Control-Relevant Function Blocks of the Disconnector Switching Device

The **Disconnector** switching device behaves like the **Circuit-breaker** switching device. The only difference is the designation of the function block that the physical switch provides (disconnector instead of circuit breaker). Blocking by protection is not provided in the analysis of the **Control** function block.

The **Disconnector** switching device is available in the DIGSI 5 library in 2 different variants:

- **Disconnector with 3-pole connection**
  The device switches all 3 poles of the disconnector on or off simultaneously.
- **Disconnector without triggering (only status detection, no control)**
  This variant is rarely encountered. It is encountered with grounding switches that frequently cannot be controlled, but only provide their current position. In addition, the position of a disconnector in a neighboring bay can be acquired.

Function Blocks of the Disconnector

Table 8-10 Function Blocks of the Disconnector Function Group

Function Block	Description	Settings	Function
Discon-nector	The disconnector represents the physical switch in the SIPROTEC 5 device.	**Maximum output time** **Overtravel time** **Switching-device type**	The disconnector replicates the switch position from the status of the binary inputs and also transmits the command via the binary outputs.
Control	Command processing	**Control model** **SBO time-out** **Feedback monitoring time** **Check switching authority** **Check if pos. is reached** **Check double activat. blk.**	Command checks, communication with the command source and with the function block **disconnector**
Inter-locking	Switchgear interlocking protection	Interlocking condition (deposited in CFC)	The **Interlocking** functionality generates the releases for switchgear interlocking protection.

The setting values of the parameter can be found in the chapter *8.2.3.2 Application and Setting Notes*.

Additional Settings of Disconnector Switching Element

The settings of the disconnector are assigned to the function blocks on the basis of their relevance. Additional disconnector settings that cannot be directly assigned to one of the 3 function blocks and are identical to the circuit-breaker settings are available:

Table 8-11 Setting positions of the Controllable **Command with Feedback** in the **Control** Function Block of the Circuit Breaker

Properties	Function	To Be Found in
Software filtering time	Software filtering time for position detection	Position of the **Control**(1) function block
Retrigger filter (yes/no)	Switching retriggering of the filtering time on/off by changing the position	Position of the **Control**(1) function block
Message time before filtering (yes/no)	Consideration of the hardware filtering time for position-detection time stamp	Position of the **Control**(1) function block
Suppress intermediate position (yes/no)	When activated,only the intermediate position is suppressed by the duration of the software filtering time.	Position of the **Control**(1) function block

Properties	Function	To Be Found in
Spontaneous position changes filtered by (Gen. software filt./Spont. software filt.	If the ***General software filter*** setting is selected, the general settings for software filtering of spontaneous position changes and for position changes caused by a switching command apply. By selecting ***Spontaneous software filter***, a separate filtering is activated for spontaneous position changes.	Position of the **Control**(1) function block
Spontaneous software filter time	Software filtering time for spontaneous position changes	Position of the **Control**(1) function block
Spontaneous retrigger filter (yes/no)	Switching on/off retriggering of the filtering time by spontaneous position change	Position of the **Control**(1) function block
Spontaneous indication timestamp before filtering (yes/no)	Consideration of the hardware filtering time for position-detection time stamp in case of a spontaneous change	Position of the **Control**(1) function block
Spontaneous suppress intermediate position (yes/no)	When activated, only the spontaneous change to the intermediate position is suppressed by the duration of the software filtering time.	Position of the **Control**(1) function block

(1) First click **Position** and then the **Details** key in the **Properties** window (below).

Table 8-12 Setting Options of the Controllable **Position** in the Disconnector Function Block (Chatter Blocking)

Properties	Function	To Be Found in
Chatter blocking (yes/no)	Switching chatter blocking on/off	Position of the **Disconnector** (1) function block

(1) First click **Position** and then the **Details** key in the **Properties** window (below).

Table 8-13 Additional Settings in the Device Settings with effect on the Disconnector

Properties	Function	To Be Found in
Number of permissible state changes	Chatter-blocking setting value: Once for the entire device	Device settings (to be found under Settings)
Chatter test time		
Number of chatter tests		
Chatter dead time		
Chatter test time		

The inputs and outputs as well as the setting options of the **Disconnector switch** function block are described in the next chapter (see *8.2.3.3 Trigger Variants of the Disconnector*. The **Control** function block is described identically as the **Circuit-breaker** function block, with the exception that the command check blocking is available through protection only with the circuit breaker.

More information on this is can be found in chapter *8.2.2.2 Application and Setting Notes*

Interlocking

The **Interlocking** function block generates the releases for switchgear interlocking protection. The actual interlocking conditions are deposited in CFC. For more information on this, see section *8.3.1 Command Checks and Switchgear Interlocking Protection*.

8.2.3.2 Application and Setting Notes

Disconnector

The disconnector represents the physical switch in the SIPROTEC 5 device. The task of the disconnector is to replicate the switch position from the status of the binary inputs.

The **Disconnector** function block is linked automatically via the information matrix with the binary inputs that register the switch position and with the binary outputs that issue the switching commands.

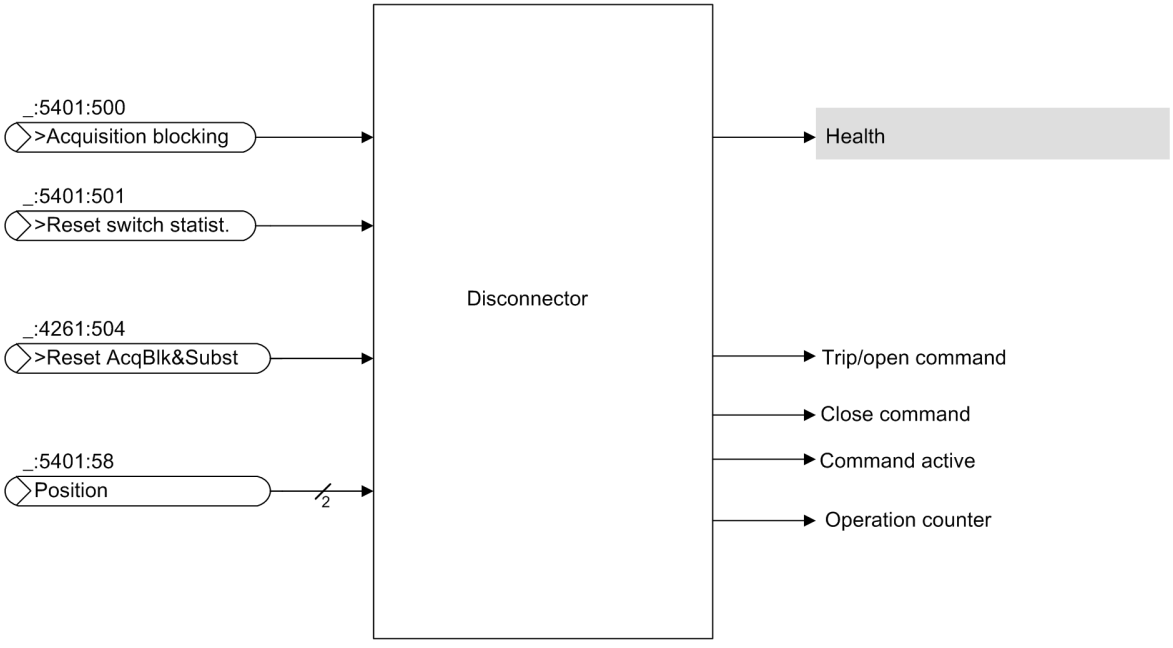
The **Disconnector** function block makes the following settings available (see next table).

Settings	Default Setting	Possible Parameter Values
(_:5401:101) Maximum output time	***10.00 s***	0.01 s to 1800 s (Increment: 0.01 s)
(_:5401:102) Overtravel time	***0.00 s***	0 s to 60 s
(_:5401:103) Switching-device type	***disconnector***	***switch-disconnector*** ***disconnector*** ***grounding switch*** ***fast grounding switch***

NOTE

The parameter **Switching-device type** is effective only on the IEC 61850 interface. This parameter is used to set the disconnector type for communication via an IEC 61850 interface. It is a mandatory data object in the IEC 61850 standard.

The following figure shows the logical inputs and outputs of the **Disconnector** function block.



[dwoutinp-150212-01.tif, 2, en_US]

Figure 8-19 Logical Inputs and Outputs of the Disconnector Function Block

Table 8-14 and *Table 8-15* list the inputs and outputs with a description of their function and type. For inputs, the effect on **Quality = invalid** on the value of the signal is described.

Table 8-14 Inputs of the Disconnector Function Block

Signal Name	Description	Type	Value if Signal Quality=Invalid
>Acquisition blocking	The binary input activates acquisition blocking. You can also set this binary input with an external toggle switch.	SPS	Unchanged
>Reset AcqBlk&Subst	Acquisition blocking and the substitution of the circuit breaker are reset with this input. If the input is activated, setting of the acquisition blocking and of the substitution is blocked.	SPS	Unchanged
>Reset switch statist.	The binary input sets the operation counter for the switch to the value 0.	SPS	Unchanged
Position	The binary input **Position** can be used to read the disconnector position with double-point indication.	DPC	Unchanged

If the quality of the input signal assumes the status **Quality = invalid**, then the standby status (Health) of the **Disconnector** function block is set to *warning*.

Table 8-15 Outputs of the Disconnector Function Block

Signal Name	Description	Type
Open command	This binary output is responsible for the command output **Off**.	SPS
Close command	This binary output is responsible for the command output **On**.	SPS
Command active	The binary output **Command active** is a running command for the signalization (command active or selected switching device). During Command active either an On or Off command is active.	SPS
Op.ct.	The information counts the number of disconnector switching cycles.	INS

Control

It is the task of the controls to execute command checks and establish communication between the command source and the disconnector. Using the control settings, you specify how the commands are to be processed.

Through the function SBO (Select Before Operate, reservation[22]) selects the switching device prior to the actual switching function, thus it remains locked for additional commands. Feedback monitoring provides information about the initiator of the command while the command is in process, that means, informing whether or not the command was implemented successfully. These two options can be selected individually in the selection of the control model, so that 4 combinations in total are available (see the following table).

The control makes the following settings available (see next table).

Settings	Default Setting	Possible Parameter Values
(_:4201:101) Control model	***SBO w. enh. security***[23]	***direct w. normal secur.*** ***SBO w. normal secur.*** ***direct w. enh. security*** ***SBO w. enh. security***
(_:4201:102) SBO time-out	***30.00 s***	-
(_:4201:103) Feedback monitoring time	***10.00 s***	-

[22] in standard IEC 61850, Reservation is described as **Select before Operate (SBO)**.

[23] The default setting is the standard control model for a switching command in an IEC 61850-compliant system.

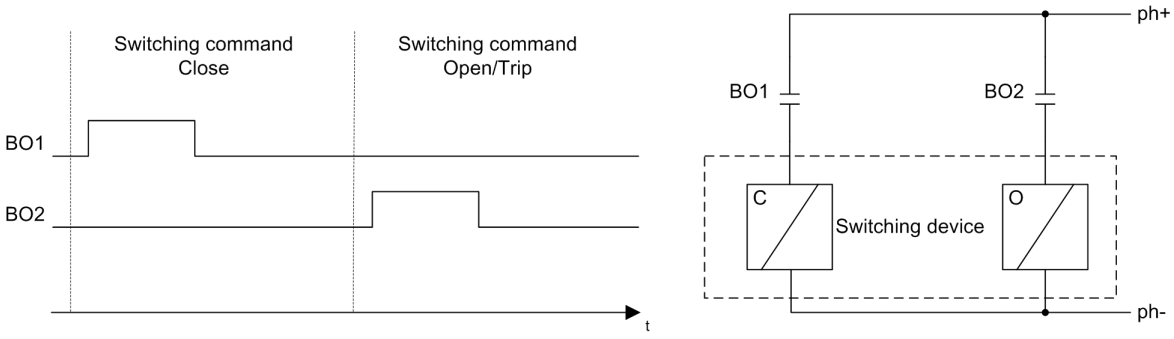
Settings	Default Setting	Possible Parameter Values
(_:4201:104) Check switching authority	*yes*	*no* *yes* *advanced*
(_:4201:105) Check if pos. is reached	*yes*	*no* *yes*
(_:4201:106) Check double activat. blk.	*yes*	*no* *yes*

8.2.3.3 Trigger Variants of the Disconnector

The activation types are identical to those for the circuit breaker. The meaning of abbreviations can be found in *8.2.2.3 Connection Variants of the Circuit Breaker* and *8.2.2.3 Connection Variants of the Circuit Breaker*.

Whether the disconnector is triggered for 1-, 1.5-, or 2-phases depends on the design of the auxiliary and control voltage system.

1-Pole Triggering



[dw1ptren-030211-01.tif, 1, en_US]

Figure 8-20 1-Pole Triggering

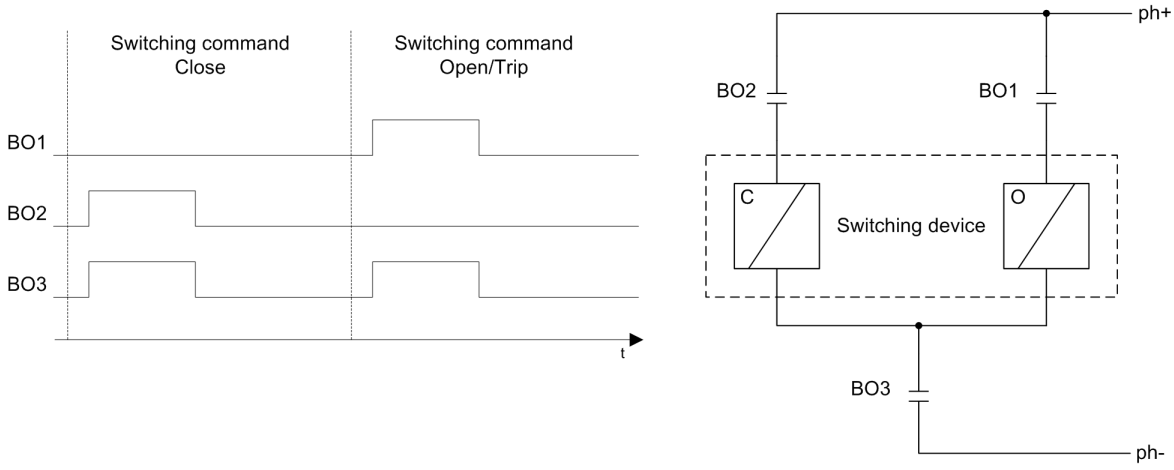
Information			S	Destination			
				Binary output			
				Basismodul			
Signals	Number	Type		1.1	1.2	1.3	1.4
	(All)	...		...	...	...	...
Disconnector 1	601			*	*		
Disconnector	601.5401			*	*		
>Acquisition blocking	601.5401.500	SPS					
>Reset switch statist.	601.5401.501	SPS					
>Reset AcqBlk&Subst	601.5401.504	SPS					
Health	601.5401.53	ENS					
Position	601.5401.58	DPC					
Open command	601.5401.300	SPS			X		
Close command	601.5401.301	SPS		X			

[scrangtrenn1p, 1, en_US]

Figure 8-21 1-Pole Triggering, Routing in DIGSI

You can select the contacts for ***On*** and ***Off*** as desired. They need not necessarily be next to one another.

1.5-Pole Triggering



[dw5polig-020211-01.tif, 1, en_US]

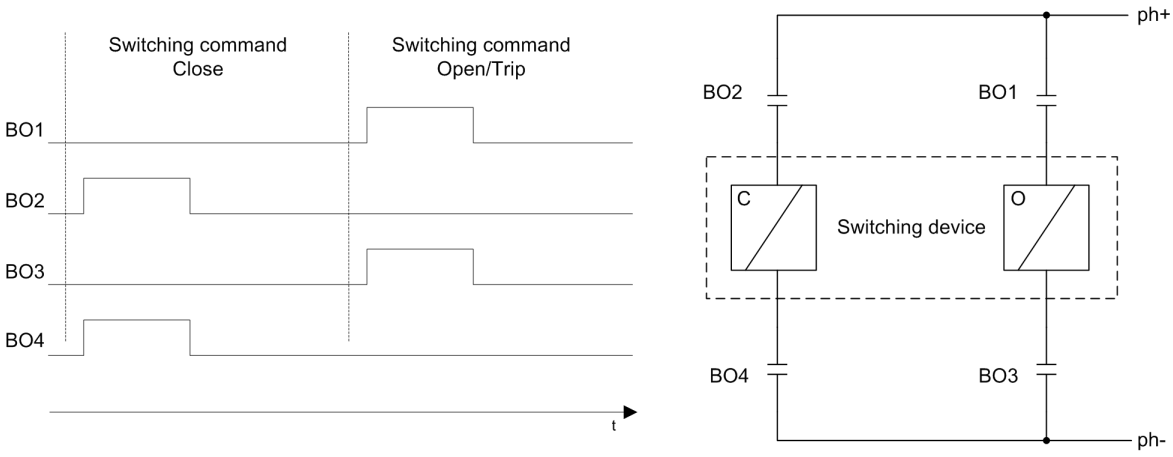
Figure 8-22 1.5-Pole Triggering

Information			S	Destination			
				Binary output			
				Basismodul			
Signals	Number	Type		1.1	1.2	1.3	1.4
	(All)	...		...	...	...	...
Disconnector 1	601			*	*	*	
Disconnector	601.5401			*	*	*	
>Acquisition blocking	601.5401.500	SPS					
>Reset switch statist.	601.5401.501	SPS					
>Reset AcqBlk&Subst	601.5401.504	SPS					
Health	601.5401.53	ENS					
Position	601.5401.58	DPC					
Open command	601.5401.300	SPS		X		X	
Close command	601.5401.301	SPS			X	X	

[scrangtrenn15p, 1, en_US]

Figure 8-23 1.5-Pole Triggering, Routing in DIGSI

2-Pole Triggering



[dw2polan-020211-01.tif, 1, en_US]

Figure 8-24 2-Pole Triggering

Information			S	Destination			
				Binary output			
				Basismodul			
Signals	Number	Type		1.1	1.2	1.3	1.4
	(All)	...		...	...	...	...
Disconnector 1	601			*	*	*	*
Disconnector	601.5401			*	*	*	*
>Acquisition blocking	601.5401.500	SPS					
>Reset switch statist.	601.5401.501	SPS					
>Reset AcqBlk&Subst	601.5401.504	SPS					
Health	601.5401.53	ENS					
Position	601.5401.58	DPC					
Open command	601.5401.300	SPS		X		X	
Close command	601.5401.301	SPS			X		X

[scrangtrenn2p, 1, en_US]

Figure 8-25 2-Pole Triggering, Routing in DIGSI

The feedback is routed via the position with the disconnector.

8.2.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Control				
_:4201:101	Control:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:4201:102	Control:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:4201:103	Control:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
_:4201:104	Control:Check switching authority		• no • yes	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:4201:105	Control:Check if pos. is reached		• no • yes	yes
_:4201:106	Control:Check double activat. blk.		• no • yes	yes
Disconnector				
_:5401:101	Disconnector:Maximum output time		0.01 s to 1800.00 s	10.00 s
_:5401:102	Disconnector:Overtravel time		0.00 s to 60.00 s	0.00 s
_:5401:103	Disconnector:Switching-device type		• switch-disconnector • disconnector • grounding switch • fast grounding switch	disconnector

8.2.3.5 Information List

No.	Information	Data Class (Type)	Type
Control			
_:4201:503	Control:>Sw. authority local	SPS	I
_:4201:504	Control:>Sw. authority remote	SPS	I
_:4201:505	Control:>Sw. mode interlocked	SPS	I
_:4201:506	Control:>Sw. mode non-interl.	SPS	I
_:4201:53	Control:Health	ENS	O
_:4201:58	Control:Cmd. with feedback	DPC	C
_:4201:302	Control:Switching auth. station	SPC	C
_:4201:308	Control:Enable sw. auth. 1	SPC	C
_:4201:309	Control:Enable sw. auth. 2	SPC	C
_:4201:310	Control:Enable sw. auth. 3	SPC	C
_:4201:311	Control:Enable sw. auth. 4	SPC	C
_:4201:312	Control:Enable sw. auth. 5	SPC	C
_:4201:313	Control:Switching authority	ENS	O
_:4201:314	Control:Switching mode	ENS	O
Interlocking			
_:4231:500	Interlocking:>Enable opening	SPS	I
_:4231:501	Interlocking:>Enable closing	SPS	I
_:4231:502	Interlocking:>Enable opening(fixed)	SPS	I
_:4231:503	Interlocking:>Enable closing (fixed)	SPS	I
_:4231:53	Interlocking:Health	ENS	O
Disconnector			
_:5401:500	Disconnector:>Acquisition blocking	SPS	I
_:5401:501	Disconnector:>Reset switch statist.	SPS	I
_:5401:53	Disconnector:Health	ENS	O
_:5401:58	Disconnector:Position	DPC	C
_:5401:300	Disconnector:Open command	SPS	O
_:5401:301	Disconnector:Close command	SPS	O
_:5401:302	Disconnector:Command active	SPS	O
_:5401:305	Disconnector:Op.ct.	INS	O

8.3 Control Functionality

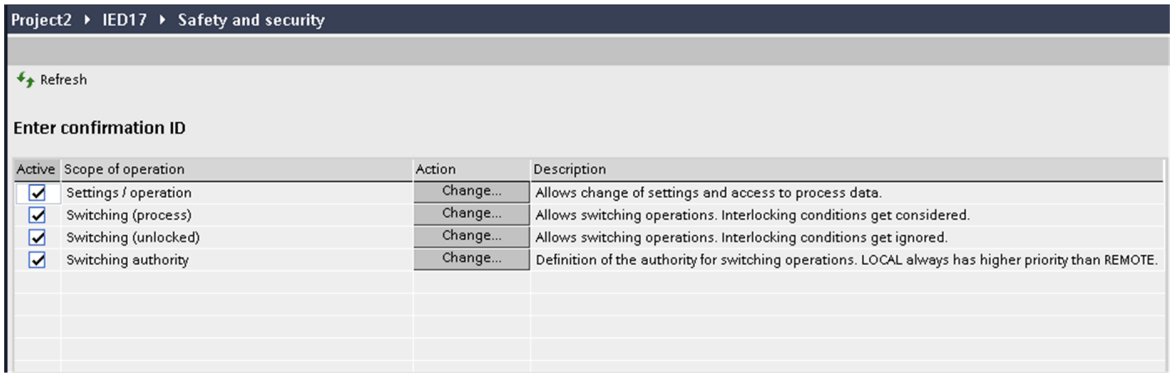
8.3.1 Command Checks and Switchgear Interlocking Protection

Before switching commands can be issued by the SIPROTEC 5 device, several steps are used to check the command:

- Switching mode (interlocked/non-interlocked)
- Switching authority (local/DIGSI/station/remote)
- Switching direction (set=actual)
- Bay interlocking and substation interlocking
- 1-out-of-n check (double-activation blocking)
- Blocking by protection function

Confirmation IDs

SIPROTEC 5 devices offer the ability to safeguard various operations with **confirmation IDs**. The following **confirmation IDs** from the **Safety** menu apply to the control functions:



[scconfir-291110-01.tif, 1, en_US]

Figure 8-26 Confirmation IDs in DIGSI 5: Settings Menu

The following table identifies the meanings of the confirmation IDs:

Table 8-16 Relevant Confirmation IDs for Controls

Confirmation ID	Meaning	Description
Set/operate	Changing settings	The confirmation ID is requested before device parameters can be changed.
Control (process)	General release for control of switching devices	The confirmation ID is usually not needed for bay controllers. In the case of protection devices, this confirmation ID can be used to safeguard control of switching devices.
Control (non-interlocked)	Switching non-interlocked	Switching mode: Release for switching without querying the interlocking conditions (***S1 operation***). The fixed interlocking conditions (for example, **>Enable opening(fixed)** and **>Enable closing (fixed)**) are still queried if this is set in the parameters. The confirmation ID is queried only for devices without a key switch; otherwise it is replaced with the key switch position.

Confirmation ID	Meaning	Description
Switching Authority	Release for switching authority **Local**	The confirmation ID is queried only for devices without a key switch; otherwise it is replaced with the key switch position.

The confirmation IDs are preset with the following values:

- Set/operate 222222
- Control (process, interlocked) 333333
- Control (not-interlocked) 444444
- Switching authority local 666666

If you have configured a device with key switches, the confirmation IDs for non-interlocked switching and switching authority are not displayed or editable in DIGSI; the function is handled by the position of the key switch.

To increase security, change these codes with DIGSI.

Switching Mode (Interlocked/Non-Interlocked)

The switching mode determines whether or not the switchgear interlocking that has been configured in the CFC is checked before the command is output.

You can change the switching mode with the key switch **S1** (interlocking off/normal). For devices without a key switch, you can change the switching mode with a corresponding menu item on the display (after entering a confirmation ID). You can also set the switching mode for switching commands from the sources DIGSI, station or remote.



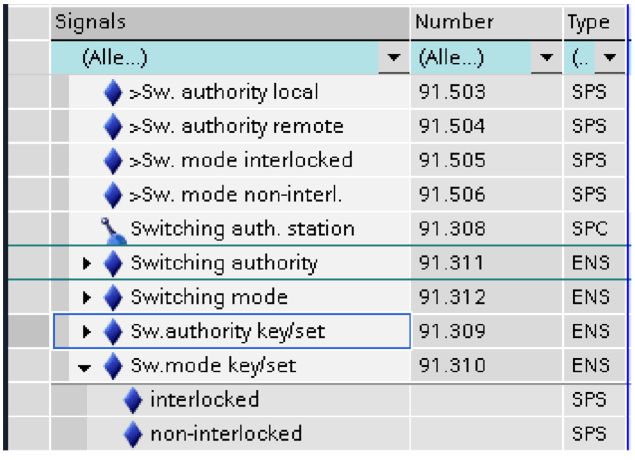
DANGER

If the switching mode = non-interlocked, the switchgear interlocking protection is shut off

Erroneous switching operations can lead to severe or fatal injuries.

✧ Ensure manually that all checks have been implemented.

In addition, you can set the switching mode directly with a binary input or CFC. Use the **General** function block (see next figure).



[scmoscha-260511-01.tif, 1, en_US]

Figure 8-27 Switching Mode in Function Block General

The following table shows the effects of changing the switching mode to use command checks.

Table 8-17 Relationship Between Switching Mode and Command Checks

Command Check	Switching Mode	
	Interlocked	Non-Interlocked
Switching authority	Checked	Checked
Switching direction (set=actual)	Checked	Checked
Fixed interlocking conditions	Checked	Checked
Interlocking conditions	Checked	Not checked
1-out-of-n check (double-activation blocking)	Checked	Not checked
Blocking by protection function	Checked	Not checked

Switching Authority

The switching authority determines which command source is allowed. The following command sources are possible:

- **Local**:

  A switching command from the local control (cause-of-error source **Location**) is possible only if the switching authority is set to **Local** and the device is capable of local operation. Setting the switching authority to **Local** is typically accomplished with key switch **S5** (Local/Remote). In this case, commands from all other sources are rejected. If the switching authority is set to **Local**, the setting cannot be changed **remotely**.

- **DIGSI**:

  A switching command from DIGSI (connected via USB or Ethernet, cause-of-error source **Maintenance**) is accepted only if the switching authority in the device is set to **Remote**. Once DIGSI has signed on the device for command output, no commands from other command sources or a different DIGSI PC will be executed.

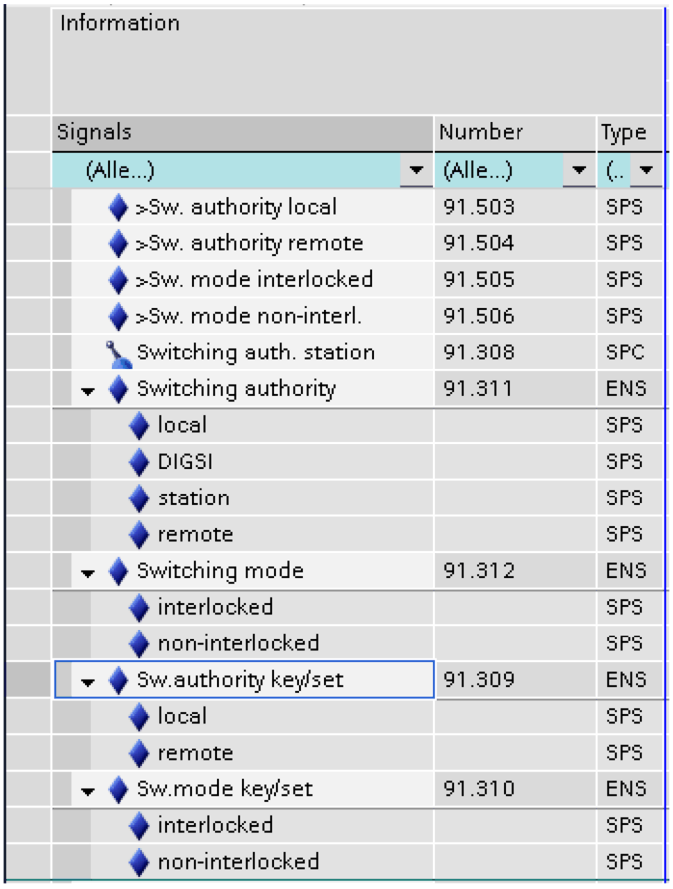
- **Station**:

  This switching authority level can be activated via a parameter in the **General** function block. A switching command from the station level (cause-of-error source **Station** or **Automatic station**) is accepted if the switching authority is set to **Remote** and the controllable **Station switching authority** is set. This is accomplished by a command from the substation automation technology. Switching commands from the device or from outside the station (cause-of-error source **Local**, **Remote** or **Automatic remote**) are rejected.

  Full support of the this switching authority level is assured only when using the IEC 61850 protocol.

- **Remote**:

  This switching authority level stands from remote control directly from the network control center or (if the switching authority level **Station** is not activated) generally for **Remote** control. The cause-of-error source is **Automatic remote**. Commands from this level are accepted if the switching authority is set to **Remote** and the controllable **Station switching authority** is not set. Switching commands from the device or from the station (cause-of-error source **Local**, **Station** or **Automatic station**) are rejected.



[schoheit-260511-01.tif, 1, en_US]

Figure 8-28 Display of Switching Authority and Switching Mode in Information Routing (in Function Block General)

Sw. authority key/set and **Sw.mode key/set** indicate the current state of the key switch or parameter for switching authority or switching mode and provide this information for further processing in the CFC. In the CFC, for example, it is possible to set up an automatic routine to ensure that the switching authority is automatically set to ***Local*** when the key switch is set to ***not interlocked***.

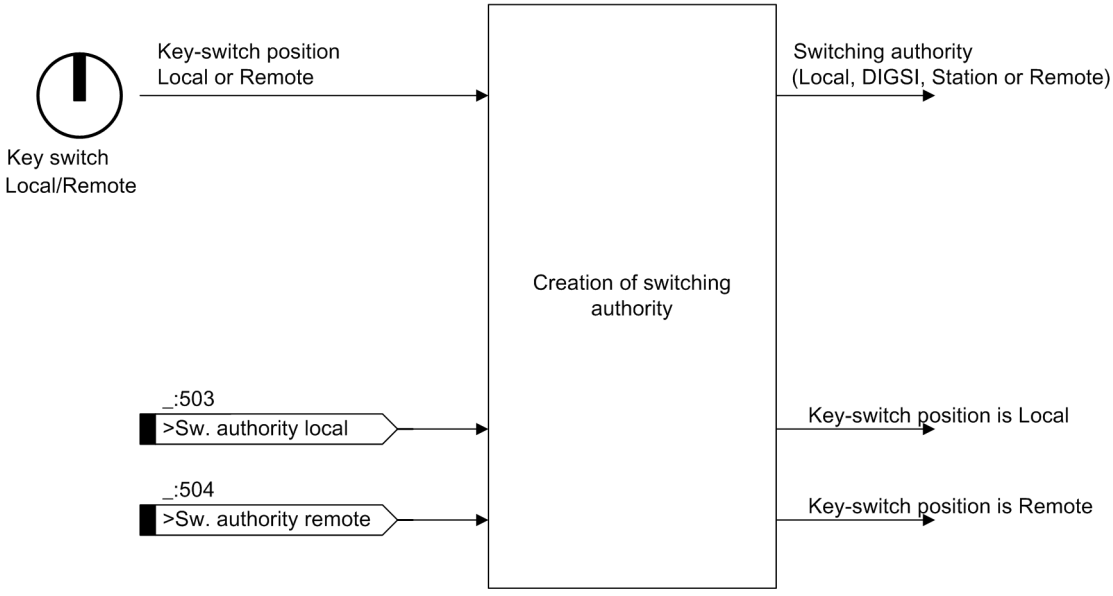
The following table shows the dependency of the switching mode on the key-switch position and the switching authority. In the case of switching commands from **Remote**, the information on whether a locked or non-interlocked switching should take place is also sent. For this reason, the position of the key switch is irrelevant for the switching mode in these cases. The information in the table assumes that, in the case of **remote** switching commands or those from the **station**, the switching mode is *interlocked* in each case.

Table 8-18 Dependency of the Switching Mode on the Key Switch Position and Switching Authority

	Switching Authority		
Key switch for switching mode	**Local**	**Remote**	**Station**
Interlocked	Interlocked	Interlocked	Interlocked
Non-Interlocked	Non-Interlocked	Interlocked	Interlocked

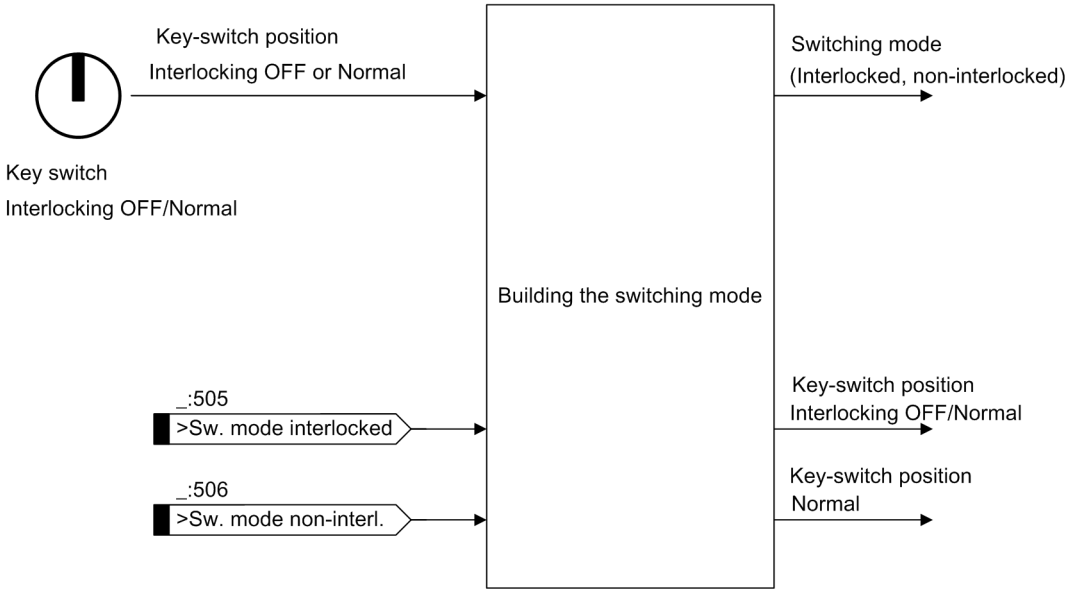
The signals shown in *Figure 8-28* in DIGSI 5 information routing have the following relationship:

- In terms of switching authority and switching mode, the respective key switch position serves as the input signal and the input signals in the matrix.
- The state of the switching authority and switching mode is indicated by corresponding output signals.
- The **Switching authority** and **Switching mode** functions link the input signals and in this way establish the output signals (see *Figure 8-29* and *Figure 8-30*).



[dwhoheit-260511-01.tif, 1, en_US]

Figure 8-29 Establishing Switching Authority



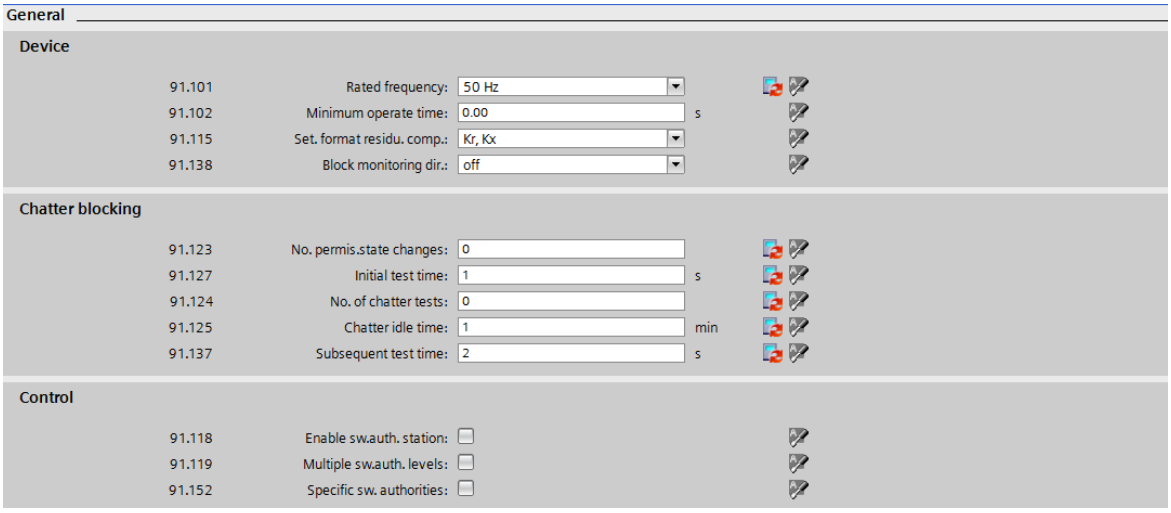
[dwmodsch-020513-01.tif, 1, en_US]

Figure 8-30 Establishing Switching Mode

In the case of both functions, the input signals overwrite the state of the key switch. This allows external inputs to also set the switching authority or switching mode, if desired (for instance, by querying an external key switch).

The following additional settings are available for the switching authority:

- **`Activation of Switching Authority Station`** (defined in IEC 61850 Edition 2):
  If you would like to use this switching authority, set the check mark **General/Control**.
- **`Multiple Switching Authority Levels`**:
  This option permits switching commands from several command sources in the device if the switching authority **Remote** is selected. Subsequently, a distinction between these command sources can also be made. You can find more details in the following table. Activate this option by setting the check mark **General/Control**.
- **`Specific sw. authorities`**:
  You can enable additional options for the switching authority check. You can find more information about these options in chapter *Specific Switching Authority, Page 1052*. By default, these are not used.



[scakthoh-161014, 1, en_US]

Figure 8-31 How to Activate the Station Switching Authority and to Enable Several Switching-Authority Levels

Table 8-19 Effect on Switching Authority when Several Switching-Authority Levels Are Enabled with/without Activation of the Station Switching Authority

Release Several Switching Authority Levels	Switching Authority in the Device	Status of DIGSI in the Device	Station Switching Authority Activated	State of the Station Switching Authority	Resulting Switching Authority
No	Local	-	-	-	Local
	Remote	Signed on	-	-	DIGSI
		Not signed on	No	-	Station and Remote
			Yes	Set	Station
				Not set	Remote
Yes	Local	-	-	-	Local
	Remote	Signed on	-	-	DIGSI
		Not signed on	No	-	Local and station and remote
			Yes	Set	Local and station
				Not set	Local and station and remote

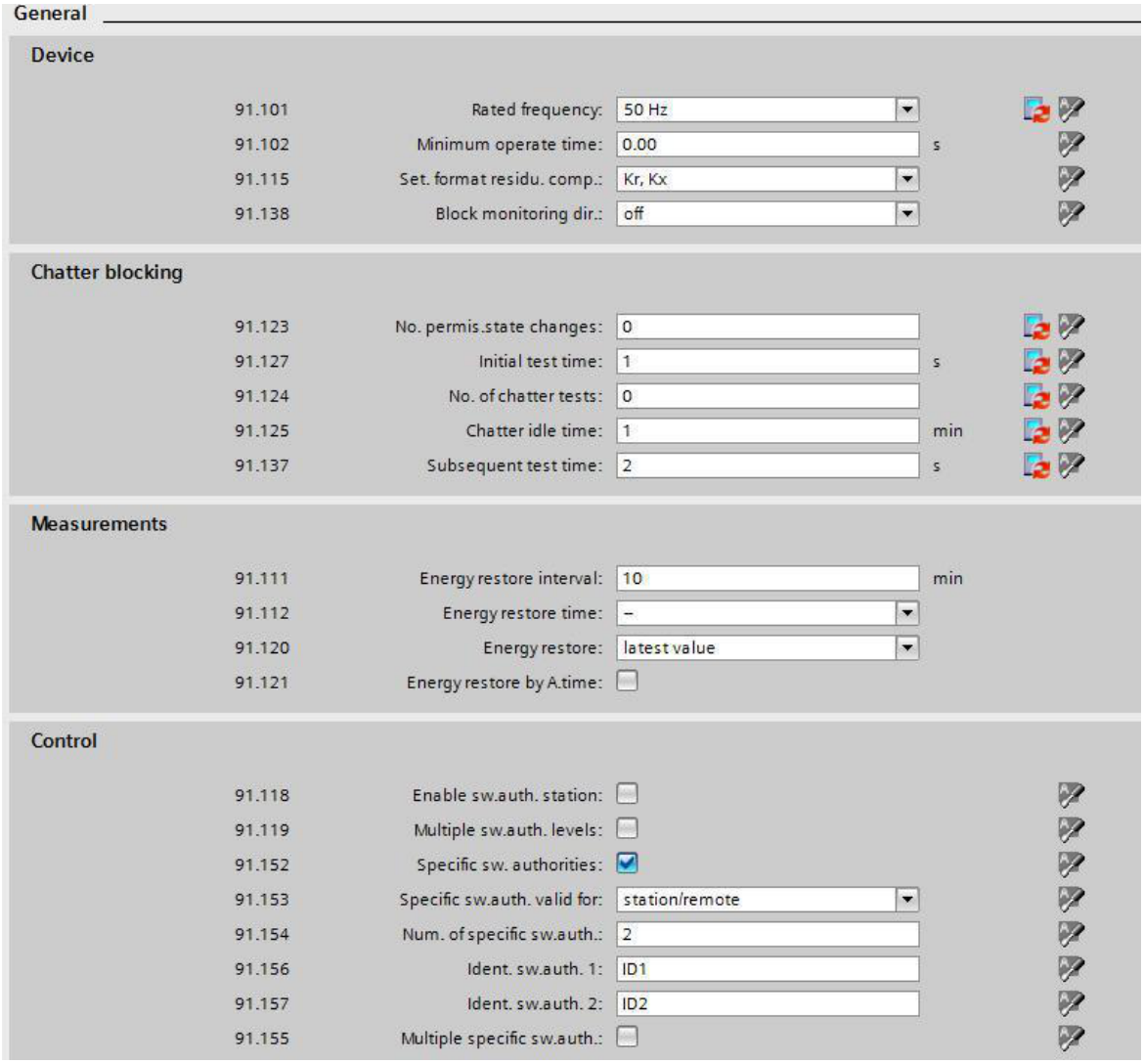
The following table shows the result of the switching-authority check, based on the set switching authority and the cause of the command. This overview represents a simplified normal case (no multiple command sources when using Station and Remote).

Table 8-20 Result of a Switching-Authority Check

Cause Source	Switching Authority			
	Local	**DIGSI**	**Station**	**Remote**
Local	Release	Blocked	Blocked	Blocked
Station	Blocked	Blocked	Release	Blocked
Remote	Blocked	Blocked	Blocked	Release
Local automatic operation	Release	Release	Release	Release
Station automatic operation	Blocked	Blocked	Release	Blocked
Remote automatic operation	Blocked	Blocked	Blocked	Release
DIGSI	Blocked	Release	Blocked	Blocked

Specific Switching Authority

Special switching authorities can be configured as extension of the switching-authority check. This makes it possible to differentiate the **Remote** command sources at the bay level. Switching authorities can be routed to or revoked from different control centers that can, for example, belong to different companies. Thus, precisely one of these command sources can switch at a certain time. This function is based on extending the switching-authority check by verifying the identifier of the command source (field **Originator/orIdent** of switching command). In order to turn on the function, go to **General/Control** and set the check mark for the parameter **`Specific sw. authorities`**. More settings for the configuration of the identifiers and the behavior of the function as well as additional signals appear (see *Figure 8-33*). In order to permit an additional command source to switch, you must activate this specific switching authority. In order to do this, set the controllable **`Enable sw. auth. 1`** to **`Enable sw. auth. 5`**.



[sc_act additional options sw authority, 3, en_US]

Figure 8-32 Activating Additional Options of the Switching Authority

The additional parameters allow you to set the following options:

- **`Specific sw.auth. valid for`** (for ***`station/remote`***, only ***`remote`*** or only ***`station`***):
  With this parameter, you determine for which command source the extended switching-authority check is used.

Table 8-21 Result Derived from the Combination of the Parameter Value **`Specific sw.auth. valid for`** and the Level of the Command Source (Field **`Originator/orCat`** of the Switching Command)

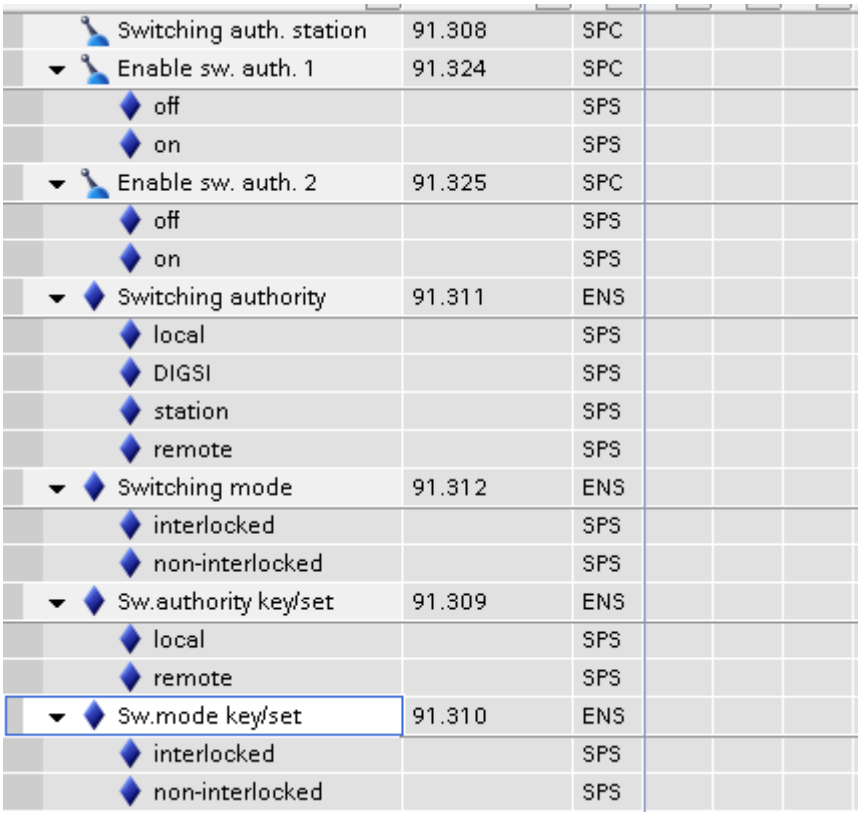
Command Source	**`Specific sw.auth. valid for`**		
	`station`	***`station/remote`***	***`remote`***
Local, local automatic	No check	No check	No check
Station, station automatic	Check	Check	No check
Remote, remote automatic	No check	Check	Check
DIGSI	No check	No check	No check

- **Num. of specific sw.auth.**:
  With this parameter, you determine how many specific switching authorities are available. This determines the number of parameters **Identifier switching authority** as well as the controllable **Active. Sw. auth.**.
- **Identifier switching authority 1** to **Identifier switching authority 5**:
  The number of names that appear corresponds to the number set in the previous parameter. You can select the names as you wish, 1 to 64 characters are allowed. The command check verifies whether these titles correspond with those sent by the command source. This applies to the switching commands as well as to the activation of a specific switching authority. The requirement for this is the system interface IEC 61850. The field **Originator/orIdent** is used.
- **Multiple specific sw.auth.** ensures the simultaneous validity of the various command sources. The following table shows how to determine the resulting specific switching authority when activating the command sources of Remote or Station. If this parameter is activated, all parameterized command sources get permissible automatically (see last row in the table) and they cannot be deactivated via the controllable **Enable sw. auth. 1** to **Enable sw. auth. 5**. Otherwise, the enabled command source with the lowest number has always the highest priority and prevails against the other numbers.

Table 8-22 Determining Switching Authority if Multiple Command Sources Are Available

Multiple specific sw.auth.	Enable sw. auth. 1	Enable sw. auth. 2	Enable sw. auth. 3	Enable sw. auth. 4	Enable sw. auth. 5	Resulting Specific Switching Authority
No	on	*	*	*	*	Switch. auth. 1
No	off	on	*	*	*	Switch. auth. 2
No	off	off	on	*	*	Switch. auth. 3
No	off	off	off	on	*	Switch. auth. 4
No	off	off	off	off	on	Switch. auth. 5
No	off	off	off	off	off	None
Yes	on	on	on	on	on	All

The * symbol in the previous table refers to any value.



[sc_sw authority and mode in info routing, 1, en_US]

Figure 8-33 Display of Switching Authority and Switching Mode in the Information Routing (in Function Block General), Example of 2 Activated Remote Switching Authorities

Individual Switching Authority and Switching Mode for the Switching Devices

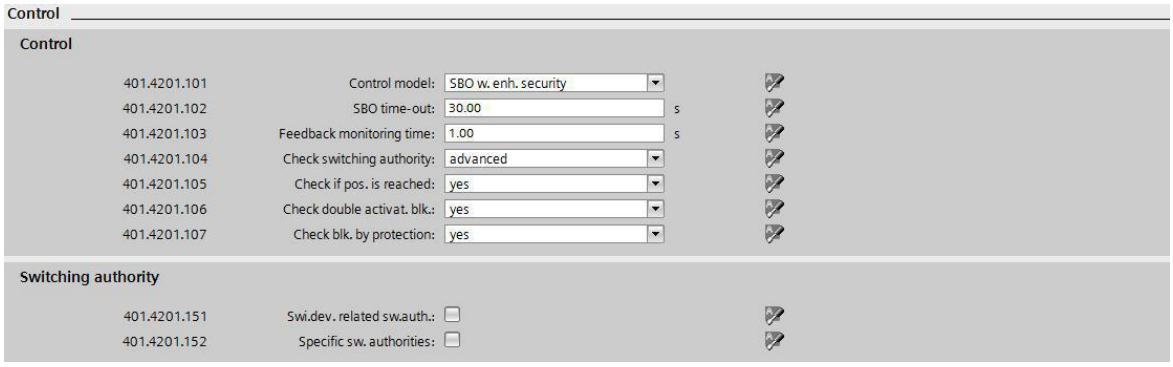
In a standard case, the functionalities switching authority, switching mode, and specific switching authority as described in the previous sections, are applicable to the entire bay unit and, therefore, are valid for all switching devices that are controlled by this bay unit. In addition, you can configure an individual switching authority and specific switching authority as well as individual switching modes for single switching devices. Therefore, individual switching devices can accept various switching authorities and switching modes simultaneously.

This is offered for the following function groups and function blocks:

- **Circuit-breaker** function group
- **Disconnector** function group
- **Transformer tap changer** function group
- **Switching sequence** function block

This allows to select individual settings for each switching device. This is useful if, for example, switching devices of different utilities are managed within a single bay.

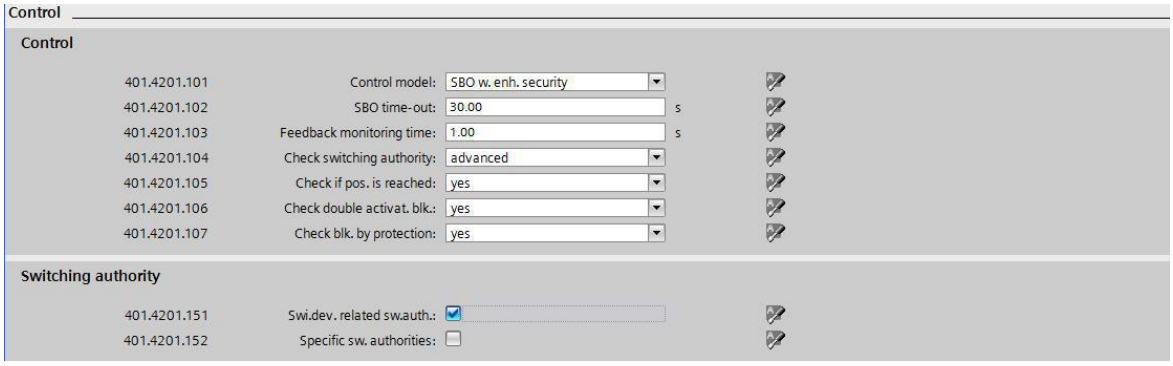
In order to activate this option, go to the function block **Control** of a switching device and set the parameter **`Check switching authority`** to ***`advanced`***. An additional table containing initially 2 parameters is displayed.



[sc_add parameters sw authority sw device, 1, en_US]

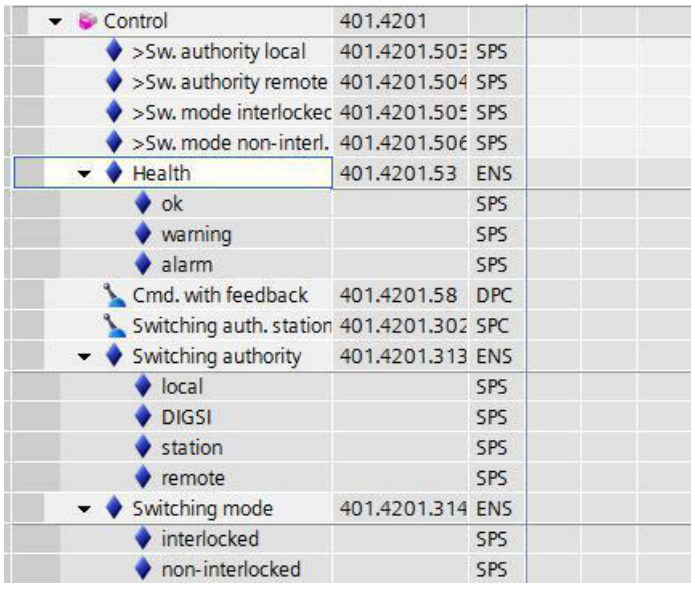
Figure 8-34 Additional Parameters for Switching Authorities in the Parameters of a Switching Device

When activating the parameter **`Swi.dev. related sw.auth.`**, an individual switching authority as well as an individual switching mode for this switching device are configured. Additional signals are displayed in the **Control** function block of the corresponding switching device.



[sc_extended parameters sw authority sw device, 1, en_US]

Figure 8-35 Expanded Parameters for the Switching Authority in the Switching Device



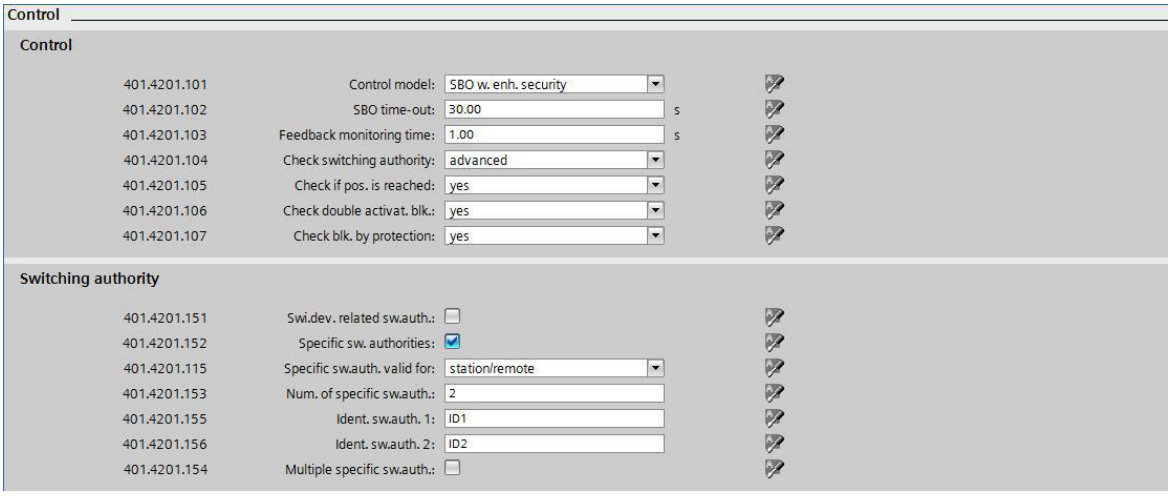
[sc_switching auth sw mode changeable, 1, en_US]

Figure 8-36 Individually Modifiable Switching Authority and Switching Mode for Switching Devices

The new input signals that are displayed allow you to set the individual switching authority and switching mode for the switching devices. For this switching device, these inputs overwrite the central switching

authority and the switching mode. The outputs *Switching authority* and *Switching mode* indicate the states only for this switching device.

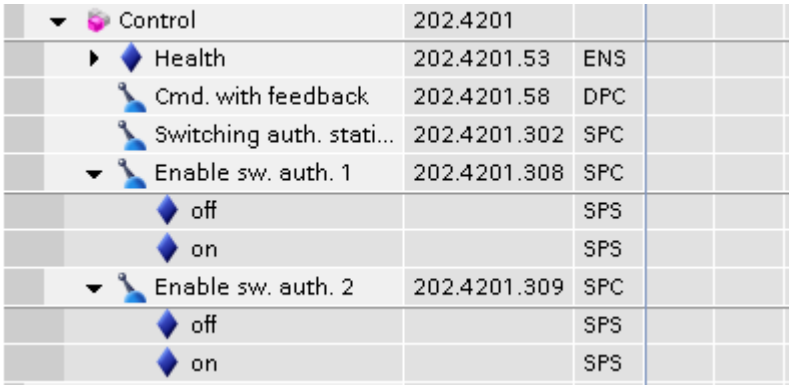
When activating **Specific sw. authorities**, an individual specific switching authority for this switching device is configured. Additional parameters are displayed.



[sc_Parameters FB control all additional options, 1, en_US]

Figure 8-37 Parameters of the FB Control with all Additional Options

The functionality of the specific switching authority for the individual switching device and the significance of the additional parameters is identical to the operating mode of the central specific switching authority. Additional signals are displayed in the **Control** function block.



[sc_Specific sw authority changeable per sw device, 1, en_US]

Figure 8-38 Specific Switching Authority, Modifiable for each Switching Device

Switching Direction (Set = Actual)

With this check, you avoid switching a switching device into a state that has already been achieved. For instance, before a trip command is issued to a circuit breaker, its current position is determined. If this circuit breaker is already in the ***Off*** position, no command is issued. This is logged accordingly.

Switchgear Interlocking Protection

Switchgear interlocking protection means avoiding maloperation by checking the bay and substation interlocking and thus preventing equipment damage and personal injury. The interlocking conditions are always system-specific and for this reason are stored as CFC charts in the devices.

SIPROTEC 5 devices recognize 2 different types of interlocking conditions:

- Normal interlocking conditions:

  These can be revoked by changing the switching mode to **non-interlocked**.

- Non-revocable (fixed) interlocking conditions:
  These are still checked even if the switching mode is set to **non-interlocked**.
  Application: Replacing mechanical interlocking, for example, that prevent actuation of a medium-voltage switch.

Each of the two categories has 2 release signals (for the ***On*** and ***Off*** switching directions) that represent the result of the interlocking plan, so that interlocking is in effect during the command check (see the figure below). The default setting for all release signals is ***TRUE***, so that no switchgear interlocking checks take place if no CFC charts have been prepared.

Information			Source							
			Binary input							
			Base module							
Signals	Number	Type	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
(All)	(All)	...	...	...	...	...	...	...	...	...
Circuit breaker 1	201									
Trip logic	201.5341									
Circuit break.	201.4261									
Manual close	201.6541									
Control	201.4201									
Interlocking	201.4231									
>Enable opening	201.4231.500	SPS								
>Enable closing	201.4231.501	SPS								
>Enable opening (fixed)	201.4231.502	SPS								
>Enable closing (fixed)	201.4231.503	SPS								
Health	201.4231.53	ENS								

[scverrie-260912-01.tif, 1, en_US]

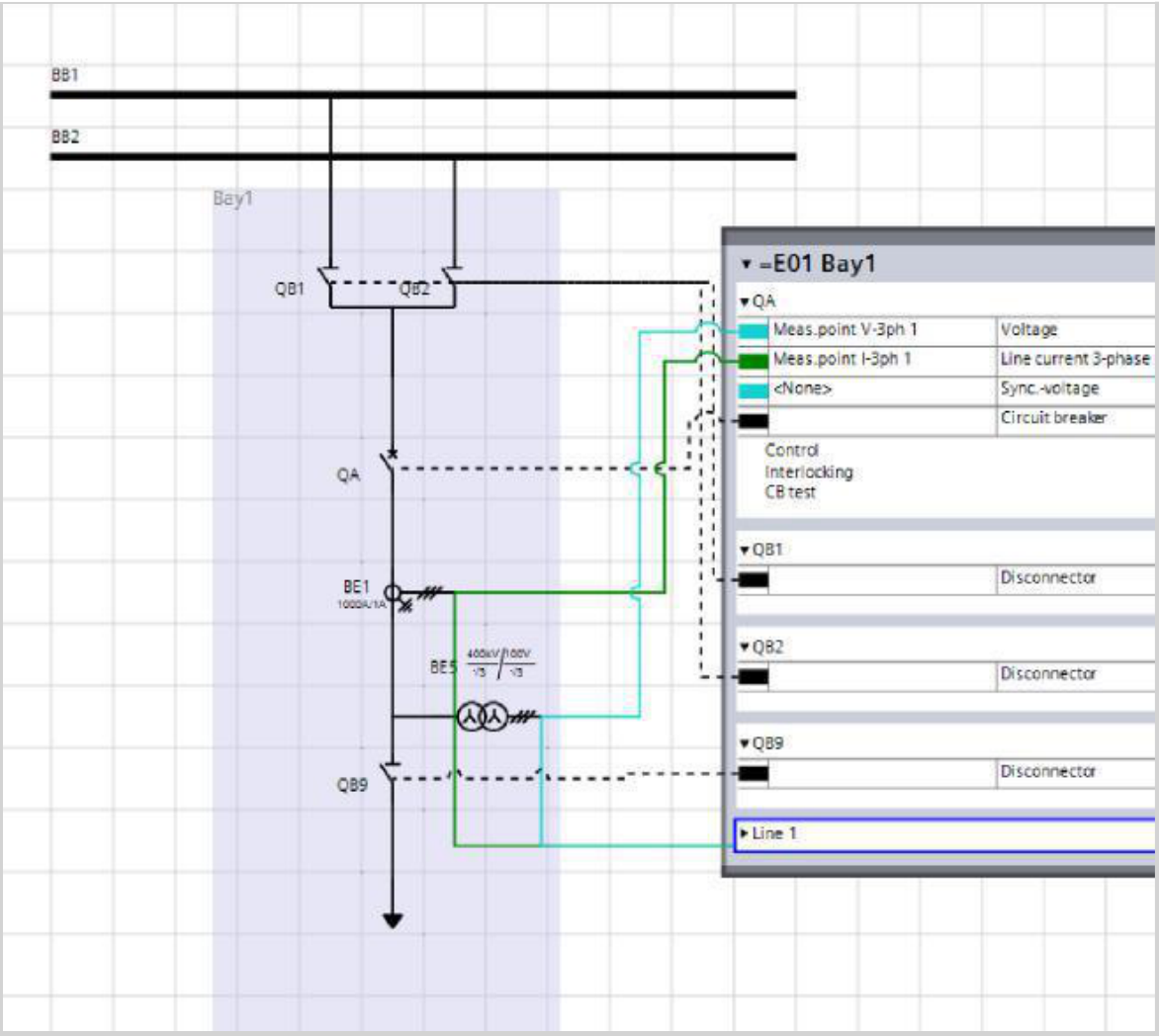
Figure 8-39 Interlocking Signals in Function Block Interlocking

EXAMPLE

For interlocking

For the making direction of the circuit breaker QA in bay E01 (see the figure below), it is necessary to check whether the disconnectors QB1, QB2, and QB9 are in the defined position, that is, either **On** or ***Off***. Opening the circuit breaker QA should be possible at any time.

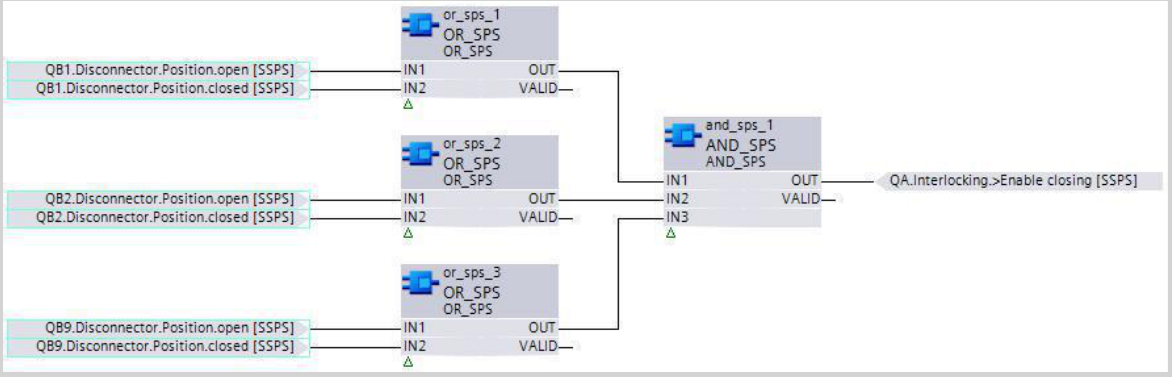
The interlocking equations are: QA_On = ((QB1 = On) or (QB1 = Off)) and ((QB2 = On) or (QB2 = Off)) and ((QB9 = On) or (QB9 = Off)). There is no condition for opening.



[ScAbgang-270410-deDE-01, 1, en_US]

Figure 8-40 Feeder Bay for a Double Busbar System

The CFC chart that is required to implement the interlocking equation is shown in the next figure.



[scverpla-270511-01.tif, 1, en_US]

Figure 8-41 Interlocking Chart for Bay Interlocking

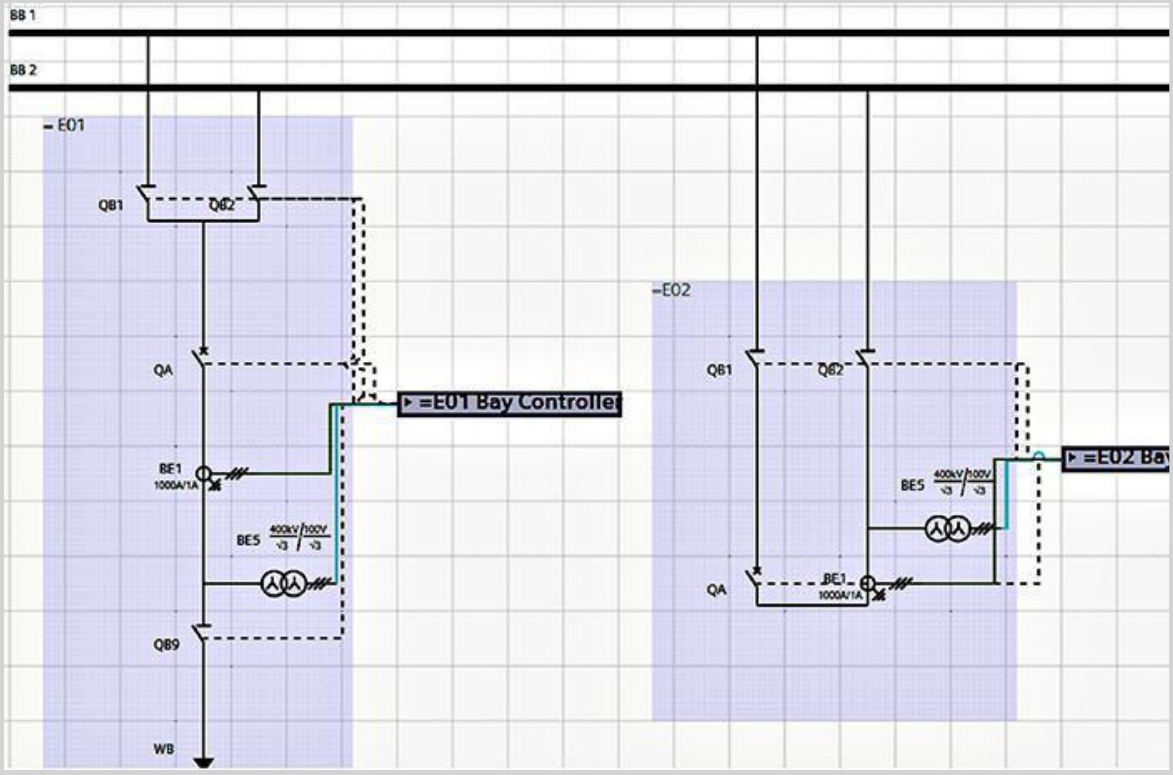
Since the **Disconnector** function block provides the defined position ***On*** or ***Off***, the exclusive OR gate XOR is not necessary for interlocking. A simple OR suffices.

As can be seen in the CFC chart, the result of the check is connected to the **>Release on** signal in the **Interlocking** function block in the **Circuit breaker QA** function group (see *Figure 8-41*).

EXAMPLE

For system interlocking

This example considers the feeder = E01 from the previous example (bay interlocking) and additionally the coupler bay = E02 (see the figure below).



[ScAnlage-270410-deDE-01, 1, en_US]

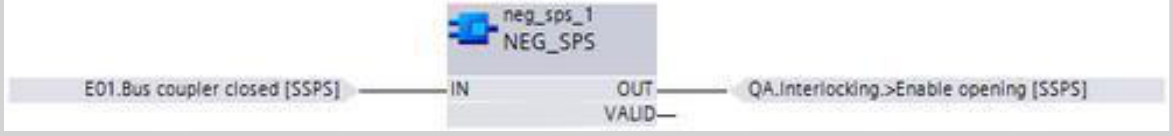
Figure 8-42 System with Feeder and Coupler Bays

The circuit breaker QA in coupler bay = E02 will be considered next. As the multibay interlocking condition, you must provide the bus-coupler command block at the end:

If the 2 busbars in bay = E01 are connected, that is, if the 2 disconnectors QB1 and QB2 in bay =E01 are closed, the circuit breaker QA in bay = E02 is not allowed to be switched off. Accordingly, bay = E01 in the CFC of the device generates the indication *Bus coupler closed* from the positions of the switches QB1 and QB2 and, using IEC 61850-GOOSE, transmits it to bay = E02 in the device. You must then store the following interlocking condition in bay = E02:

QA_Off = NOT (= E01/Bus coupler closed)

In the CFC chart for the coupling device = E02, you must create the following CFC chart (see the figure below).



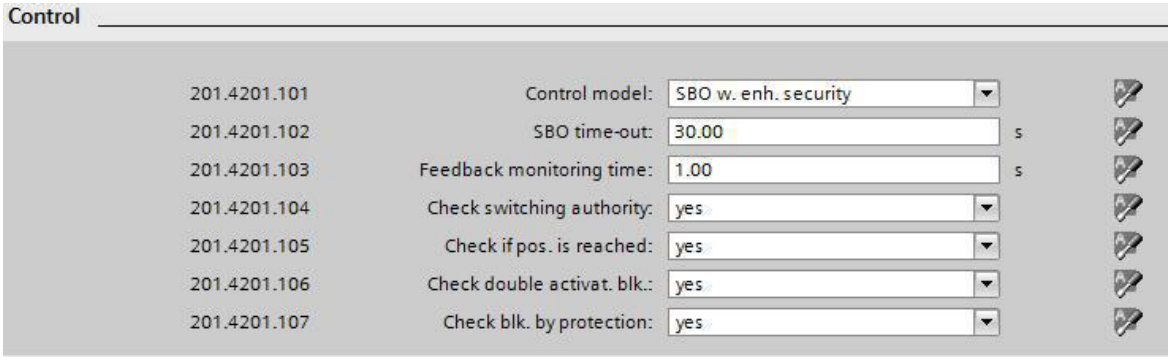
[scplanve-241013, 1, en_US]

Figure 8-43 Interlocking Chart for Substation Interlocking

1-Out-of-n Check (Double-Activation Blocking)

The double-activation blocking prevents 2 commands from being executed in the device simultaneously. You can set the device-internal check for each switching device as a parameter in the **Control** function block.

The default setting is ***Yes***, that is, double-activation blocking is active (see the figure below).



[scdoppel-260912-01.tif, 1, en_US]

Figure 8-44 Activating the Double-Activation Blocking

With SIPROTEC 5, it is also possible to achieve multibay double-activation blocking.

In this case, send the signal **`not selected`** to other devices for analysis using IEC 61850-GOOSE. This signal is available under **Position** in every **Circuit breaker** or **Disconnector** function block in the switching device function groups (see figure below).

Circuit breaker 1	201	
Trip logic	201.5341	
Circuit break.	201.4261	
>Ready	201.4261.500	SPS
>Acquisition blocking	201.4261.501	SPS
>Reset switch statist.	201.4261.502	SPS
>Reset AcqBlk&Subst	201.4261.504	SPS
External health	201.4261.503	ENS
Health	201.4261.53	ENS
Position	201.4261.58	DPC
not selected		SPS
open		SPS
closed		SPS
intermediate position		SPS
disturbed position		SPS
acquisition blk. active		SPS
manual update active		SPS

[scnotselected-090315_de, 1, en_US]

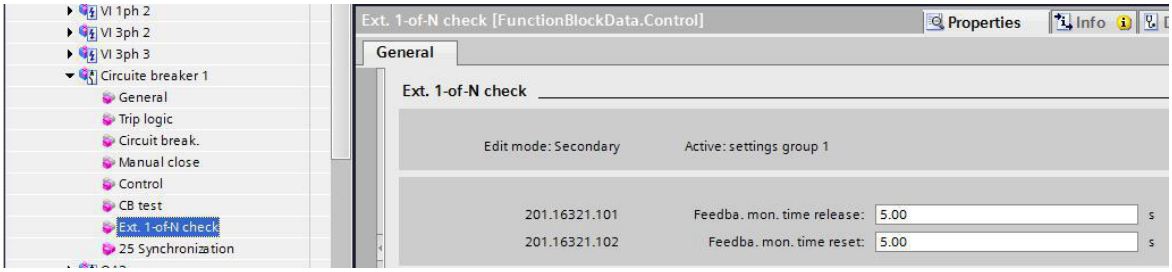
Figure 8-45 Signal *`Not selected`* in the Circuit-Breaker Function Block

The signal is then queried in the CFC interlocking conditions for the associated switching devices and is used to generate the release signal (for example, **`>Release on`**).

External 1-of-N Check (Cross-Bay Double-Activation Blocking)

The function block **Ext. 1-of-N check** offers another option to implement a cross-bay 1-out-of-n check. You can select this function block in the FG **Circuit breaker** – **Control** in the DIGSI library. This function makes it possible to interlock other switching devices across all bays before the allocation of the switching device takes place in its own assigned bay or before the switching operation can be executed.

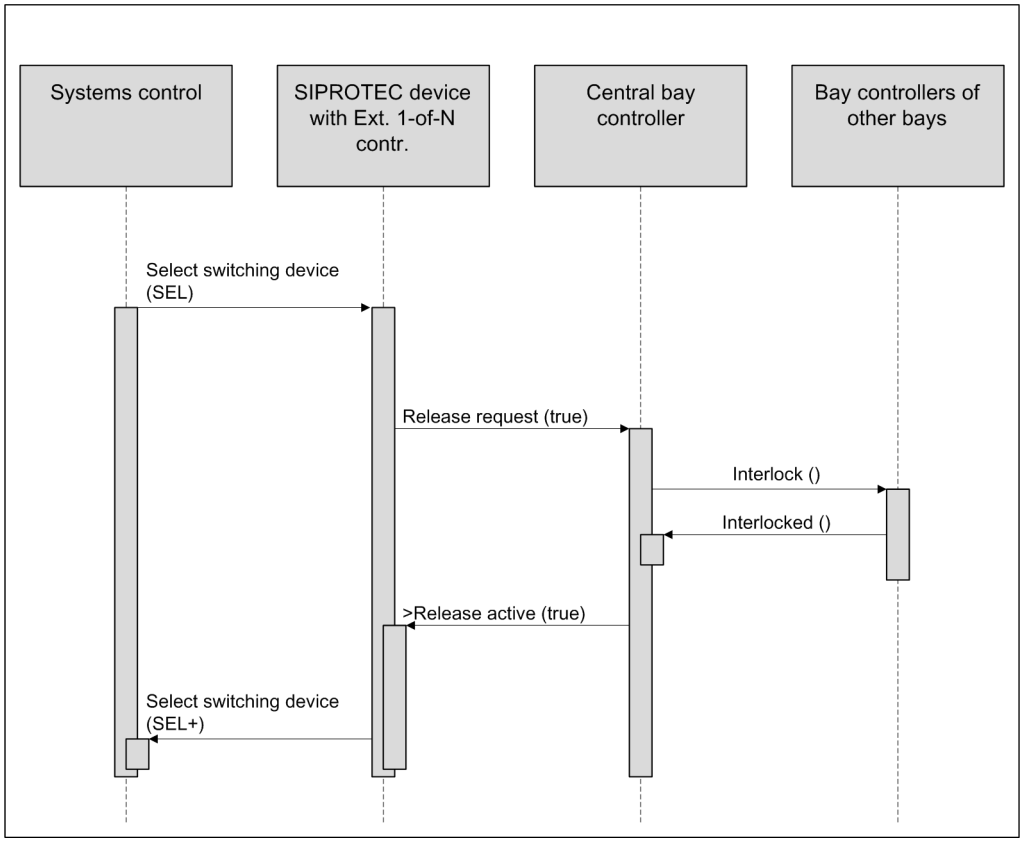
You can use the function block **Ext. 1-of-N check** in the **Circuit breaker** and **Disconnector** function groups. In order to use the function, a control model **with feedback monitoring** must be configured in the circuit-breaker control.



[sc_library properties info routing Ext 1-out-of-n control, 1, en_US]

Figure 8-46 Command Execution

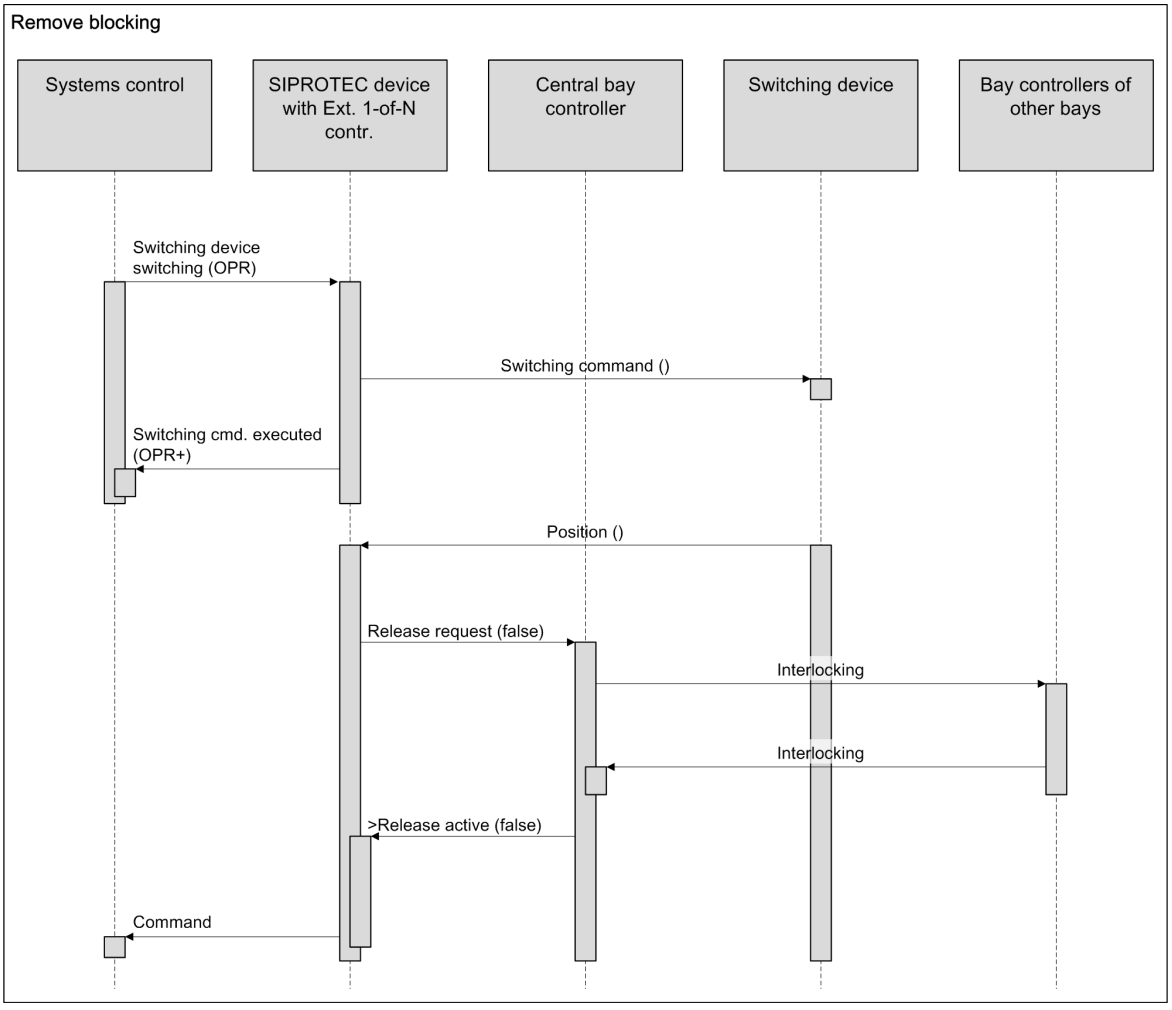
If the external 1-of-N check is instantiated, the output ***Release request*** prompts a central bay controller before executing a switching command. This bay controller must permit the switching operation (see the following figure). If the allocated switching devices were locked in another bay, the release is issued. Only when the release was issued via the input ***>Release active*** the allocations (**`Control model`**: ***`SBO w. enh. security`***) or the switching command (**`Control model`**: ***`direct w. enh. security`***) are executed and confirmed. The central bay controller is parameterized to reject a 2nd switching request.



[dw_block-ext-setzen, 1, en_US]

Figure 8-47 Setting the Blocking

Once the switch position has been reached, interlocking of the switching devices is canceled via the output ***Release request***. The switching command is completed and acknowledged with CMT (see the following figure) only when interlocking termination has been acknowledged positively via the input ***>Release active***.



[dw_block-aufheben-1, 2, en_US]

Figure 8-48 Terminating the Blocking

User I/O Objects of the External 1-of-N Check Function Block

Name	I/O	Description	Range
Release request	O	This output remains active from the time of the switching prompt until the new position is reached.	true/false
>Release active	I	If this input is set, the switching device is released for switching operation. As long as this input is set, this switching device is blocked for additional switching operations.	true/false

Blocking by Protection Function

- Default setting **(_:107) Check blk. by protection** = ***yes***

In devices with protection and control functions, Siemens recommends that no switching commands can be issued while protection functions have picked up.

This applies to automatic reclosing as well. Switching commands must be prevented as long as automatic reclosing is active.

The default setting for blocking by the protection function is therefore ***yes***. If necessary, you can disable this blocking. You can find the settings on the same page as the double-activation blocking (see *Figure 8-44*).

NOTE

Remember, for instance, that pickup of the thermal overload protection can create a fault as well and thus prevent switching commands.

NOTE

Note that the command check **Blocking by protection function** is only available for controlling circuit breakers, because in this case a unique relationship with protection functions and automatic reclosing has been configured. In disconnectors, this relationship is not always unique, precisely with regard to the 1 1/2 circuit-breaker layout, and it must be mapped for each system using CFC charts.

To carry out the command check **Blocking by protection function** for disconnectors, use the following indications (if present) in your interlocking conditions:

- Group indication: **`Pickup`** (Function group **Line**)
- Circuit-breaker failure protection: **`Pickup`** (**Circuit-breaker failure protection**)
- General: **`In progress`** (**Automatic reclosing function**)

8.3.2 Command Logging

All commands in the sequence are logged. The command log contains:

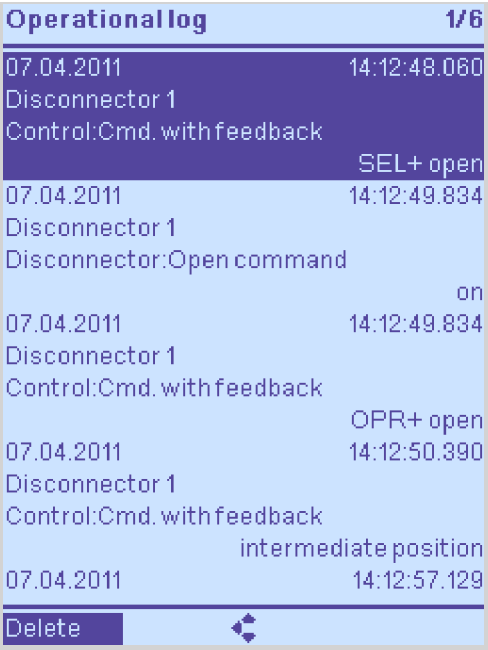
- Date and time
- Name of the switching device (or function group)
- Reason for the transmission (SEL = Selected, OPR = Operate, CMT = Command execution end, SPN = Spontaneous)
- Status or switching direction

EXAMPLE

The following example illustrates control of a disconnector QB1 for various cases.

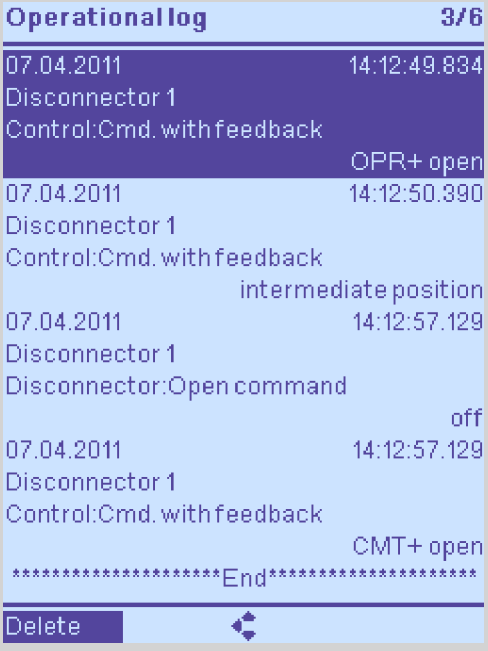
- Successful command output
- Interrupted command
- Command interrupted by switchgear interlocking
- Command ended due to missing feedback
- Spontaneous change of switch position without command output

Figure 8-49 to *Figure 8-55* indicates command logging for various scenarios of the standard control model SBO with feedback monitoring.



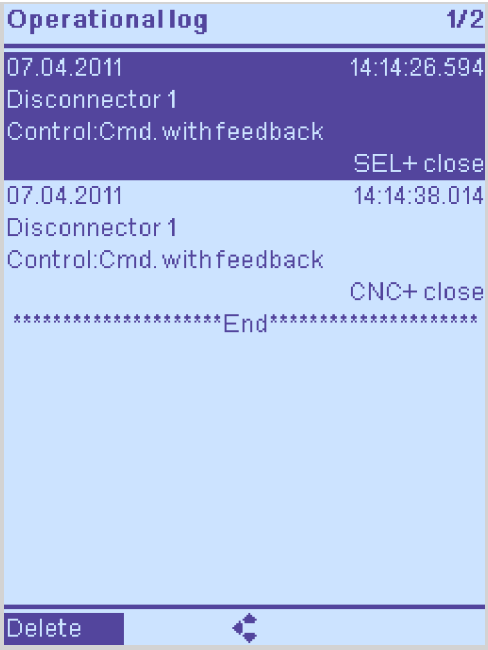
[scposcas-070411-01.tif, 1, en_US]

Figure 8-49 Positive Case (Display 1)



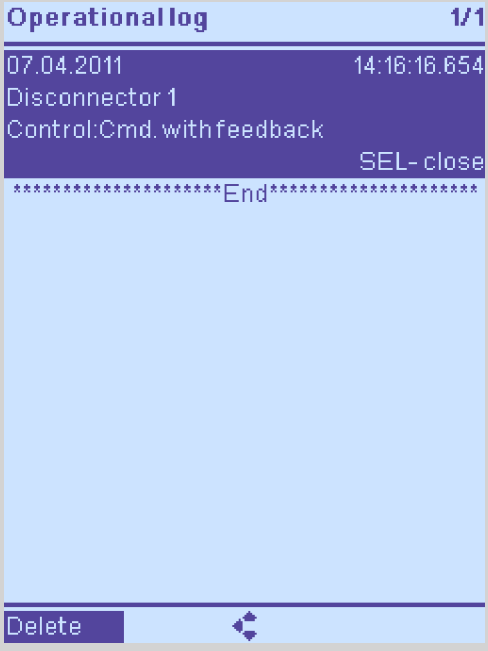
[scposca2-070411-01.tif, 1, en_US]

Figure 8-50 Positive Case (Display 2)



[scposcan-070411-01.tif, 1, en_US]

Figure 8-51 Positive Case with Command Cancellation



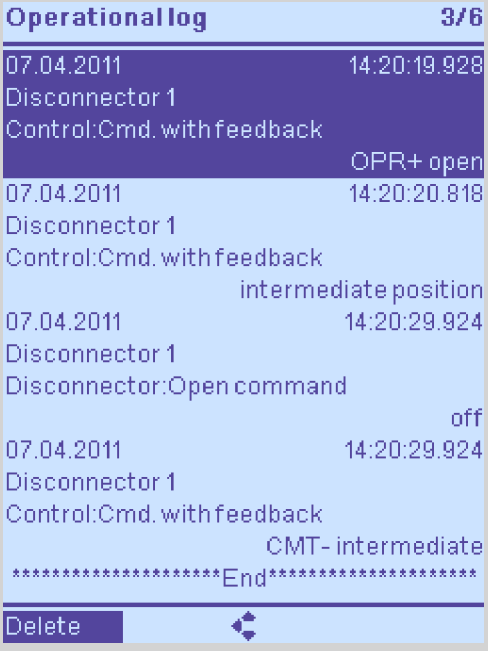
[scnegint-070411-01.tif, 1, en_US]

Figure 8-52 Negative Case (Blocked by Switchgear Interlocking)



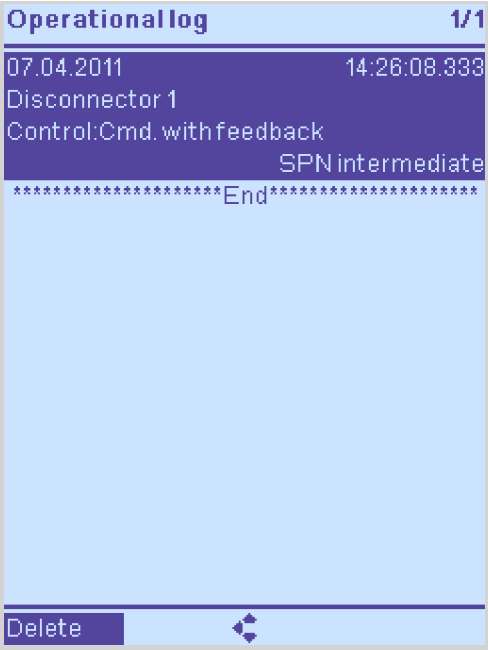
[scnegtim-070411-01.tif, 1, en_US]

Figure 8-53 Negative Case (Expiration of Feedback Supervision Time) (Display 1)



[scnegti2-070411-01.tif, 1, en_US]

Figure 8-54 Negative Case (Expiration of Feedback Supervision Time) (Display 2)



[scsponta-070411-01.tif, 1, en_US]

Figure 8-55 Spontaneous Status Change

Depending on the transmission reason, the desired control value or the actual state value of the controllable and the switching device can be contained in the log.

The following table shows the relationship.

Table 8-23 Relationship between the Reason for Transmission and the Value Logged

Reason for Transmission	Value
Selected (SEL)	Desired value
Operate (OPR)	Desired value
Command cancellation (CNC)	Desired value
Command execution and termination (CMT)	Actual value
Spontaneous change (SPN)	Actual value

8.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Control				
_:101	Control:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:102	Control:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:103	Control:Feedback monitoring time		0.01 s to 1800.00 s	1.00 s
_:104	Control:Check switching authority		• no • yes	yes
_:105	Control:Check if pos. is reached		• no • yes	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:106	Control:Check double activat. blk.		• no • yes	yes
_:107	Control:Check blk. by protection		• no • yes	yes

8.3.4 Information List

No.	Information	Data Class (Type)	Type
Control			
_:53	Control:Health	ENS	O
_:58	Control:Cmd. with feedback	DPC	C

8.4 Synchronization Function

8.4.1 Overview of Functions

The **Synchronization function** (ANSI 25) checks whether the activation is permissible without a risk to the stability of the system when interconnecting 2 parts of an electrical power system. Typical applications are the synchronization of a line and a busbar or the synchronization of 2 busbars via a cross-coupling. A power transformer between the 2 measuring points can also be taken into consideration.

The following operating modes are covered:

- Synchrocheck
- Switching synchronous power systems
- Switching asynchronous power systems
- Switching to dead line line/busbar

8.4.2 Structure of the Function

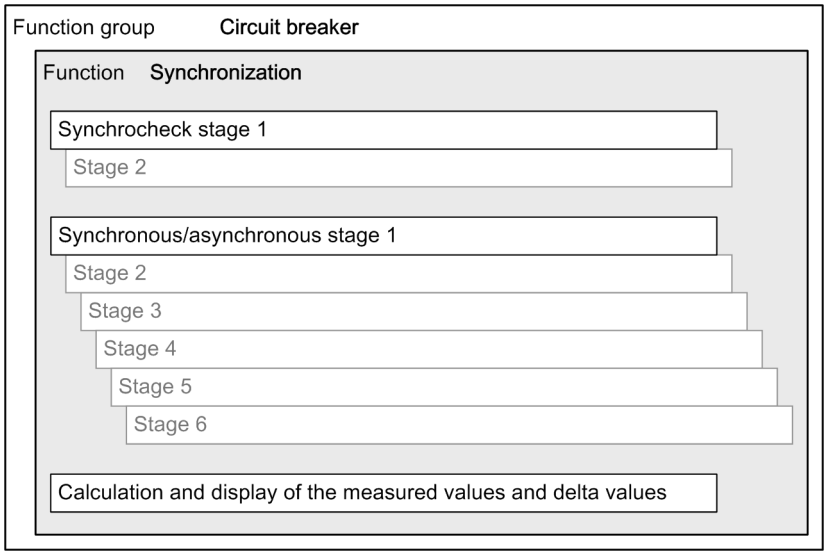
The **Synchronization** function is used in the **Circuit-breaker** function group.

2 different types of stage can be used within the function:

- Synchrocheck stage
- Synchronous/asynchronous stage

Each of the stage types is preconfigured at the factory. You can operate maximum 2 stages of the synchrocheck stage type and maximum 6 stages of the synchronous/asynchronous type in parallel. In addition, the **Expanded delta-f options** stage type is available in the function library. It is not preconfigured.

As soon as the device is functional, the function measuring points are calculated and displayed.



[dwsynfn1-270213-01.tif, 1, en_US]

Figure 8-56 Structure/Embedding of the Function

8.4.3 Connection and Definition

Connection

You can find examples for the synchronization of line and busbar in the following 2 figures. *Figure 8-59* shows an example for the synchronization of 2 busbars via bus coupler.

The synchronization function uses 2 voltages to check the connecting conditions: a voltage of the reference side 1 (V1) as well as a voltage to be used as a reference on side 2 (V2). The reference voltage of side 1 is designated in the synchronization function as V1[24]. This is always the voltage of the measuring point that is connected to the **Sync. voltage 1** interface of the Circuit-breaker function group. The voltage to be set as reference is designated with V2[1]. This is always the voltage of the measuring point that is connected to the **Sync. voltage 2** interface of the Circuit-breaker function group. The assignment of the measuring points to the interfaces of the circuit-breaker function group can be configured, see chapter *2.1 Function Embedding in the Device*.

The selection of the voltages used for the synchronization depends on the device connection to the primary system:

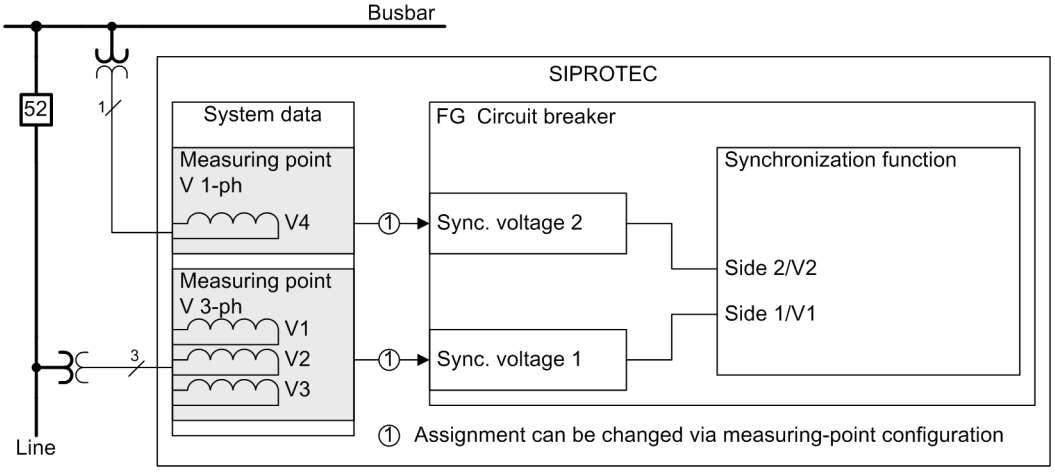
- Connection of the primary system via 4 voltage inputs and hence use of a 1-phase and a 3-phase measuring point (*Figure 8-57* and *Figure 8-59*):

  The voltage connected to the 1-phase measuring point is definitive here. If. for example, this is the phase-to-ground voltage V_A, the voltage V_A is also used by the other side of the 3-phase measuring point.

- Connection of the primary system via 6 voltage inputs and hence use of two 3-phase measuring points (*Figure 8-58*):

  The phase-to-phase voltage V_{AB} of both sides is always used for the test.

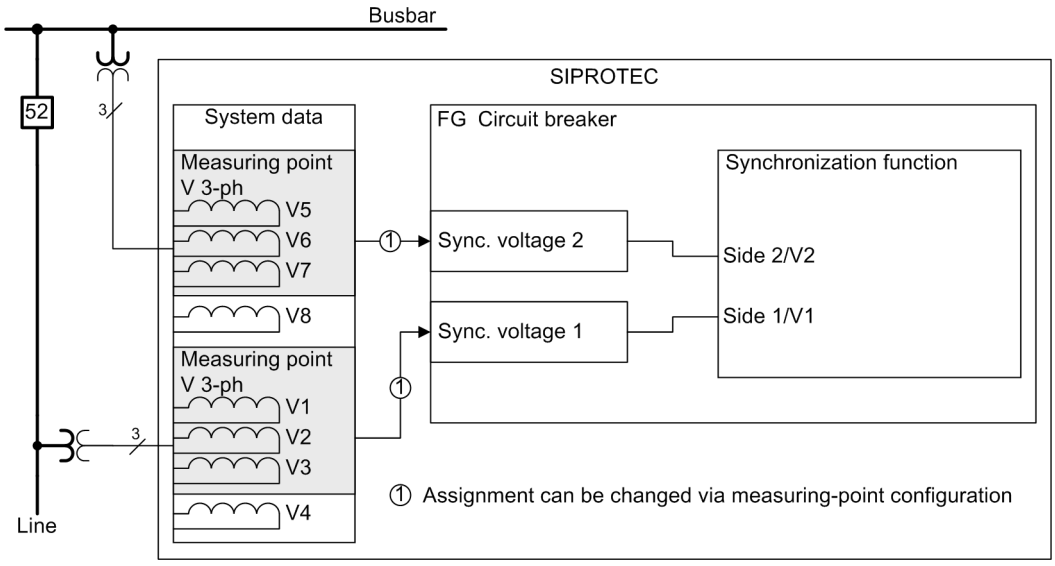
You can connect both the phase-to-ground voltages and the phase-to-phase voltages to the device. The possible interface connections are listed in the Appendix.



[dwsyns01-210912-01.tif, 1, en_US]

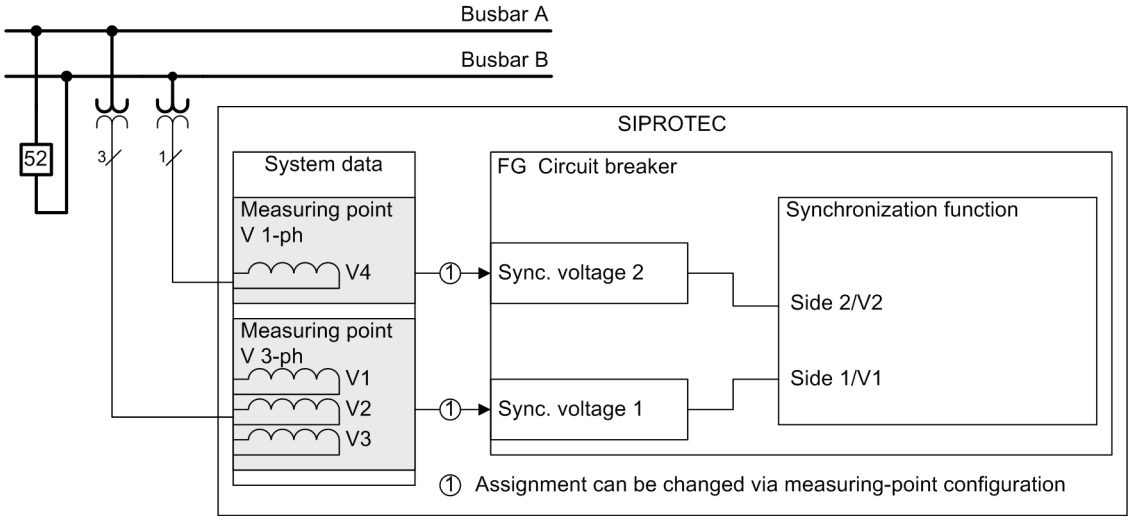
Figure 8-57 Synchronization of Line and Busbar, Connection via 4 Voltage Inputs

[24] Do not confuse the designations V1 and V2 with the numbering of the voltage inputs V1 to V4 (*Figure 8-57*) and V1 to V8 (*Figure 8-58*)



[dwsyns02-210912-01.tif, 1, en_US]

Figure 8-58 Synchronization of Line and Busbar, Connection via 6 Voltage Inputs



[dwsyns03-210912-01.tif, 1, en_US]

Figure 8-59 Synchronization of 2 Busbars via Cross-Coupling, Connection via 4 Voltage Inputs

Definition of the Variables

The definition of the variables is important for understanding the following implementation. The reference side 1 indicates the function with 1. This yields the reference values voltageV1, frequencyf1, and phase angle α1. The side to be synchronized indicates the function with 2. The electrical variables of side 2 are then the voltageV2, frequencyf2, and phase angle α2.

When forming the differential variables, the function is oriented to the definition of the absolute measuring error (Δ x = measured value – real value). The reference value and hence the real value is side 1. This results in the following calculation specifications:

Differential voltage dV = V2 – V1

A positive sign means that the voltage V2 is greater than the voltage V1. In other cases, the sign is negative.

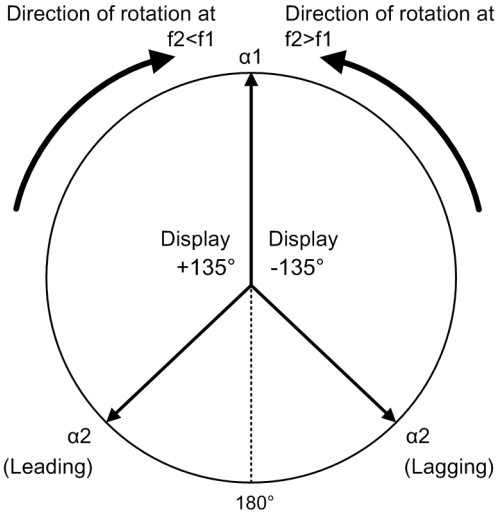
Differential frequency df = f2 – f1

A positive result means that according to the example from *Figure 8-57* the busbar frequency is greater than the line frequency.

Phase-angle difference dα = α2 – α1

The representation is limited to ±180°. A positive result means that α2 **leads** by a maximum of 180°. In the case of a negative value, α2 **lags** by a maximum of 180°. *Figure 8-60* shows the circumstances. The phase angle α1 was added to the zero axis as a reference system.

If asynchronous systems are present and the frequency f2 is greater than f1, the angle dα then changes from the negative value to 0 and then to the positive value. As shown in *Figure 8-60*, the direction of rotation is counterclockwise (mathematically positive). At f2 < f1, the direction of rotation is clockwise.



[dwsynp04-100611-01.tif, 1, en_US]

Figure 8-60 Phase-Angle Difference Representation dα

Only positive values are permissible for the setting parameters. Inequalities are used to characterize the setting parameters uniquely. The representation is explained with the example of differential voltage. 2 setting values are necessary to allow unbalanced settings.

The inequality V2 > V1 yields a positive value for dV. The associated parameter is **`Max. voltage diff. V2>V1`**. For the 2nd setting parameter **`Max. voltage diff. V2<V1`**, the inequality V2 < V1 applies. It corresponds to a negative dV.

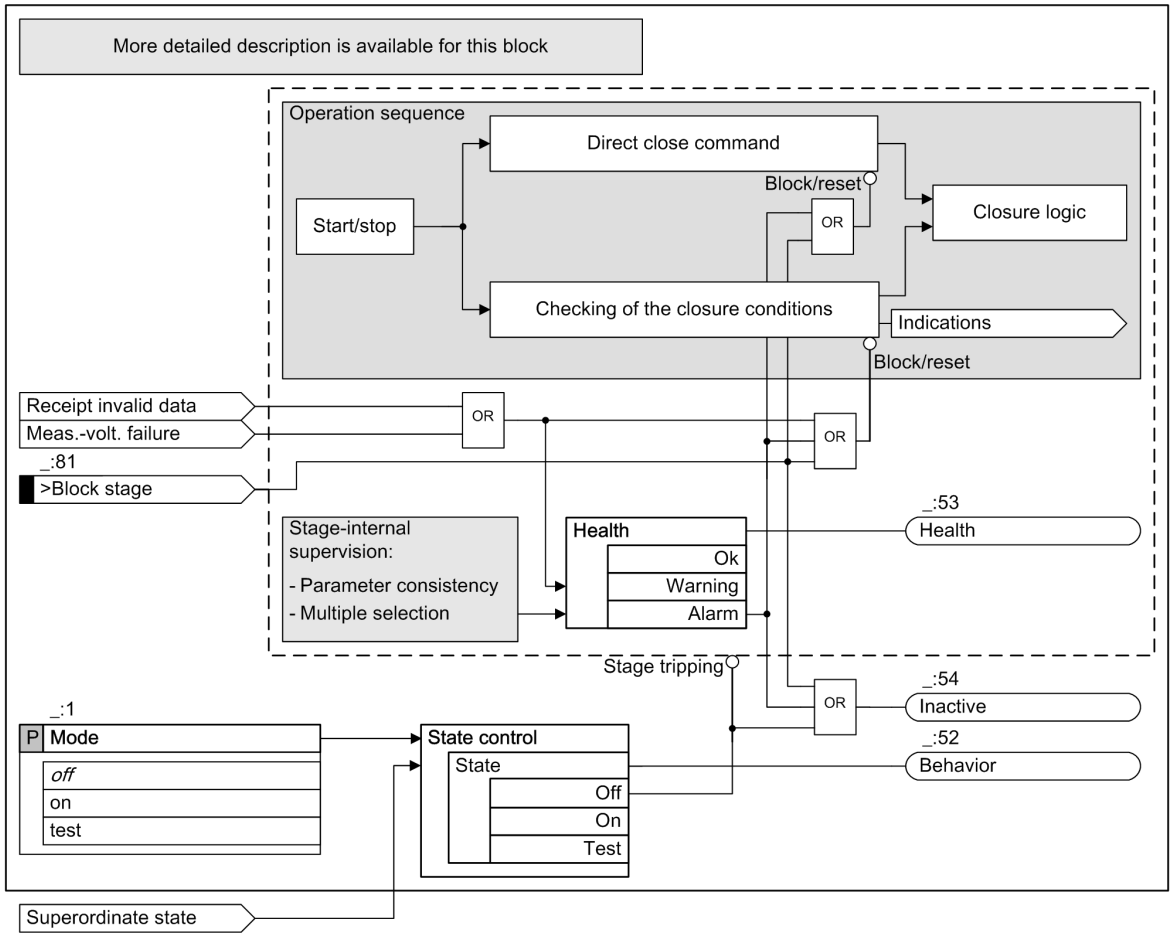
The procedure is the same for the differential frequency and differential phase angle.

8.4.4 General Functionality

Overview of a Synchronization Stage (Sync Stage)

A synchronization stage can be integrated in the following blocks (see *Figure 8-61*):

- Stage control with mode, state control, standby and blocking (description in this chapter)
- Supervision (description in this chapter)
- Functional sequence for issuing the closing release (see chapter *8.4.6 Sequence of Functions*)



[losyn001-100611-01.tif, 1, en_US]

Figure 8-61 Overview of the Stage Logic

Stage Control

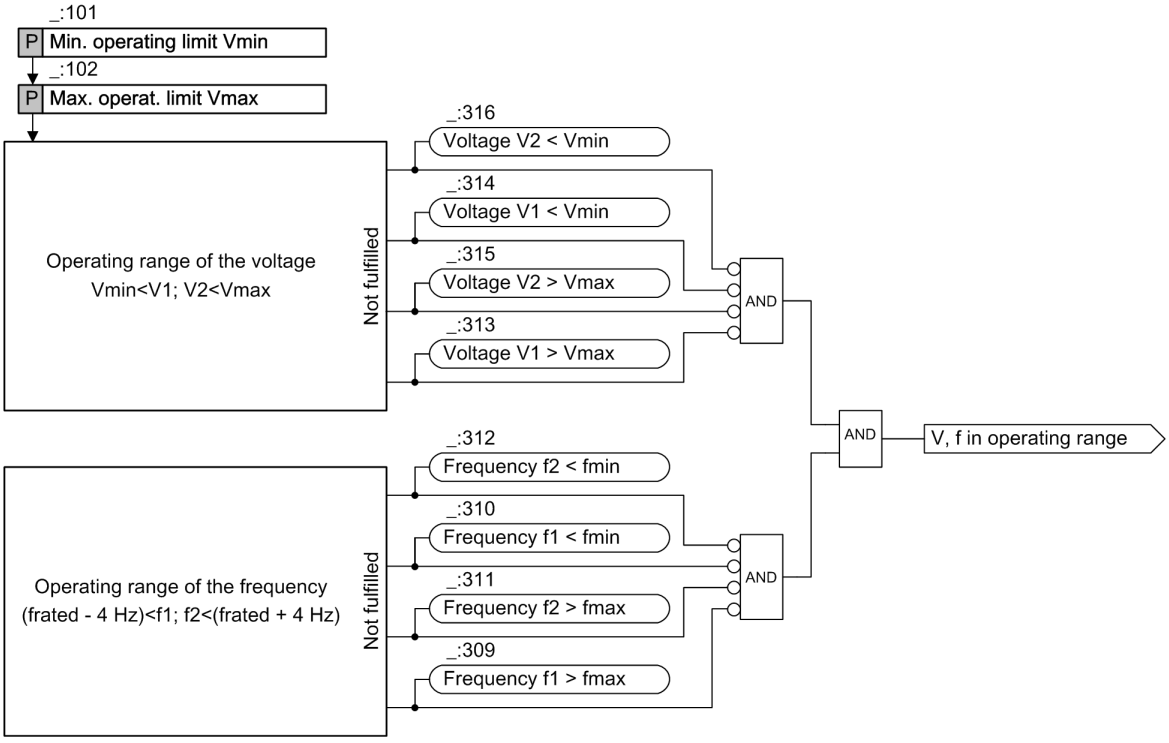
The normal stage control is used for a synchronization stage (see *Figure 8-61*).

Note the following special features:

- As soon as there is a synchronization function available in the device, the measured values are calculated and displayed. One stage must be activated for calculating all Delta settings. It is not necessary to start the stage for this purpose.
- If all synchronization stages are deactivated within the function, closure via the control will no longer be possible, as none of the stages can generate an closing release. If the synchronization function is deleted, the circuit breaker is no longer regarded as subject to compulsory synchronization. In this case, it is possible to activate via the control without synchronization.
- If more than one synchronization stage is switched on, then the **>Selection** signal must be active for exactly one stage, so that it can be activated via the controls.

You can block the entire synchronization stage via the binary signal **>Block stage**. A started process is completed and the entire stage reset after blocking. The stage must be restarted to initiate a new switching procedure. The blocking only affects the test process for the closing conditions. The measured values are still calculated and displayed.

Operating Range



[losyn002-160311-01.tif, 1, en_US]

Figure 8-62 Logic of the Operating Ranges

The operating range of the synchronization function is defined by the configurable voltage limits **Min. operating limit Vmin** and **Max. operat. limit Vmax** as well as by the specified frequency band f_{rated} ±4 Hz.

If one or both voltages are outside the permitted operating range when the measurement is started or a voltage leaves the range, this is displayed via corresponding indications **Frequency f1 > fmax**, **Frequency f1 < fmin**, **Voltage V1 > Vmax**, **Voltage V1 < Vmin** etc. The closing conditions are then not checked.

Supervision

The supervisions listed below are executed in a function-specific manner. If one of the monitors picks up, the Health goes to ***alarm***. The stage is indicated as **Inactive**. A closing release or direct close command is not possible in this case.

- For consistency of settings of specific parameters

  Definite threshold-value settings are checked after a parameter change. If there is an inconsistency, the error message **Setting error** is set.

- For multiple selection of the stage at the start time of the synchronization

  If there is a simultaneous selection of multiple closed synchronization stages at the start time, the error message **Multiple selection** is set.

Measuring-Voltage Failure

If a voltage-transformer fault (measuring-voltage failure) is recorded via the binary input signal **>Open** of one of the voltage-measuring points, then the closing commands of the synchronization stage are no longer tested. In other words, a release of the closure based on the measurement is no longer possible. The readiness of the stage turns to ***warning***. Direct close command is still possible.

The device-internal supervision function measuring-voltage failure detection (Fuse Failure Monitor) does not have any effect on the synchronization stage.

Function Measured Values

The function measured values for the Synchronization function are displayed in their own primary, secondary and percentage measured-value windows. Voltage measurements are always displayed as ph-ph voltages, even if the associated measuring point records phase-to-ground voltages. The function measured values are determined and displayed as soon as the device is functional. The difference values are calculated as soon as the stage is activated.

Table 8-24 Protection-Specific Values of the Synchronization

Values		Primary	Secon-dary	% Referenced to
V_1	Reference voltage V_1	kV	V	Rated operating voltage of the primary values
V_2	Voltage to be synchronized V_2	kV	V	Rated operating voltage of the primary values
f_1	Frequency of the voltage V_1	Hz	Hz	Rated frequency
f_2	Frequency of the voltage V_2	Hz	Hz	Rated frequency
dV	Voltage difference V_2-V_1	kV	V	–
df	Frequency difference f_2-f_1	Hz	Hz	–
dα	Angle difference α_2-α_1	°	–	–

Multiple Synchronization Points

The synchronization function can only be used within a Circuit-breaker function group. It always operates on the circuit breaker that is linked to the Circuit-breaker function group. The reference to the circuit breaker is therefore unique. If you wish to switch several circuit breakers (synchronization points) with the device, you must create several Circuit-breaker function groups.

Different Synchronization Conditions per Synchronization Point

Within the synchronization function, you can operate maximum 2 stages of the stage type **Synchrocheck** and maximum 6 stages of the type **Synchronous/asynchronous** in parallel. All setting parameters for a synchronization point are included in each synchronization stage.

If you have to synchronize with different synchronization conditions (parameter settings), several synchronization stages are used for a synchronization point/circuit breaker. In this case, you must define which of the synchronization stages is currently active via the binary signal **>Selection** (synchronization stage x). The closing conditions are checked if the respective stage is activated via the **>Selection** binary signal and the stage is activated.

The fault indication **Multiple selection** is issued upon simultaneous selection of different synchronization stages. If several synchronization stages are activated and the input signal **>Selection** (synchronization stage x) is missing at the starting time, a valid selection is awaited during the supervision time **Max.durat. sync.process**. If this does not come, the process is terminated.

Different Voltage-Transformer Ratios of Both Parts of the Electrical Power System

The settings of the rated parameters of the transformer for the measuring points automatically takes the different voltage-transformer transformation ratios of both parts of the electrical power system into account. The **Voltage adjustment** parameter is not needed for this purpose.

Synchronization via a Transformer

There are systems in which a power transformer is located between the voltage measuring points of the circuit breaker to be synchronized. The device automatically considers the different voltage stages by setting the transformer ratios (within the measuring points).

A phase displacement must be taken into account based on the transformer vector group, via the **Angle adjust. (transform.)** parameter.

The parameter is defined as -Δα = –(α2 – α1).

To calculate the Delta parameters, the voltage of side 2 is converted to the voltage of side 1 using to the settings of both parameters.

In the Application and Setting Notes, several examples are provided for using both parameters.

Different Connection Types on Both Sides

If both of the measuring points used by the synchronization functions record different voltages of the 3-phase system, the calculation of the phase displacement angle is automatically taken into consideration.

EXAMPLE:

The 1-phase measuring point connected with **Sync-voltage 1** records the phase-to-phase voltage V_{AB}. The 1-phase measuring point connected with **Sync-voltage 2** records V_A. In this case the phase angle between V_{AB} and V_A takes into consideration the delta variable Δα during calculation..

This automation guarantees that several voltage sources can be switched between during running operation, each of which records different voltages.

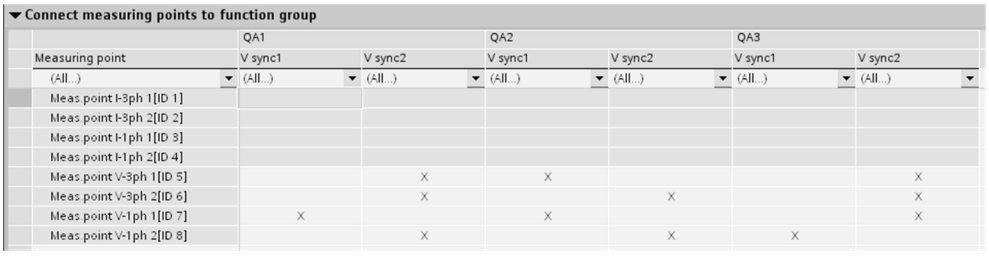
8.4.5 Dynamic Measuring-Point Switching

Dynamic measuring-point switching provides the capability to connect the voltages used in the Synchro-check function to various measuring points. In this way, for example, it is possible to use the correct voltage on the basis of the switch position on the switching devices. If more than 1 measuring point is connected to *V sync1* or *V sync2* , you must create the **`V sync select.`** function block in the **Circuit breakers** function group.

Selection of the desired voltage measuring points (*V sync1* and *V sync2*) for the **Circuit breakers** function group is controlled via Continuous Function Chart.

Connecting Measuring Points to Circuit-Breaker Function Group

The following figure shows the connection of the **Circuit-breaker** function group with several measuring points in DIGSI. The ID of each measuring point appears in parentheses after the name.



[scdynms2-211212-01.tif, 1, en_US]

Figure 8-63 Connecting the Measuring Points with the Circuit-Breaker Function Group

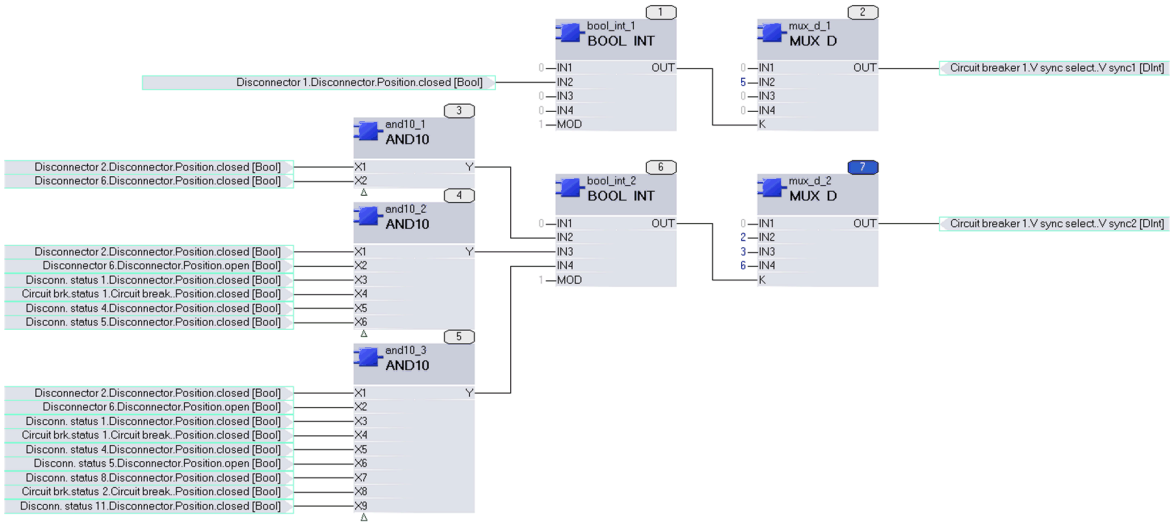
There are consistency checks that validate the connections of voltage measuring points to the function group:

- The connection type must be identical for all measuring points connected to the same interface.
- It is not permitted to route a measuring point to the function group using the option VN.
- The rated voltage (primary and secondary) must be identical for all measuring points connected to the same interface.
- If more than 1 measuring point is connected to 1 voltage interface, a function block must be expanded to enable selection of the synchronization voltage.

CFC Control

The voltages are selected by CFC logic on the basis of the measuring point IDs. If more than one measuring point is connected to interfaces V_{sync1} or V_{sync2} of the **Circuit-breaker** function group, the **`V sync select.`**

function block has to be removed from the library in the **Circuit-breaker** function group. A CFC logic (see following example) has to define IDs for the *V sync1* or *V sync2* inputs of this function block in order to ensure the correct measuring point connection for the Synchrocheck function.

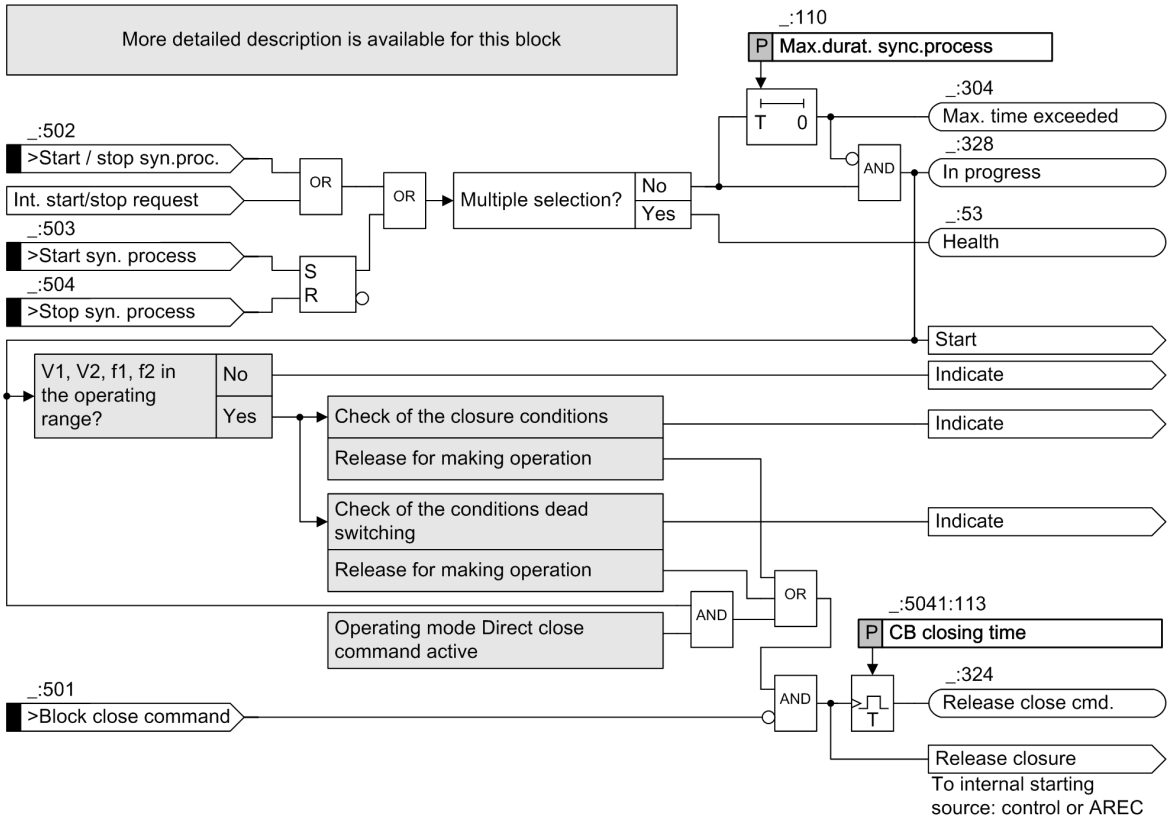


[scdynmsx-160212-01.tif, 1, en_US]

Figure 8-64 CFC Logic: Voltage Selection Using Measuring Point ID

If no measuring point can be selected because of the switch or disconnector positions, the ID0 is used. If ID0 is selected, the indication *(_:2311:304) Blocked no V selected* is set. The synchrocheck is blocked. If you have activated the parameter **(_:5071:108) Direct close command** , unsynchronized switching is still possible.

8.4.6 Sequence of Functions



[losynf01-100611-01.tif, 1, en_US]

Figure 8-65 Sequence of Functions

Start

The synchronization stage must be started to check the closing conditions. The synchronization stage can be started device-internally by the controller and the reclosing, or externally, via binary input signals, for example by an external automatic reclosing (AREC), (see section *8.4.12 Interaction with Control, Automatic Reclosing (AREC), and External Triggering*).

At the start, the system checks whether there is a multiple selection by the synchronization stage (see section **Monitoring** in chapter *8.4.4 General Functionality*). If this is the case, the process is terminated. After a successful start, the indication **`In progress`** is cleared and the supervision time for the maximum duration of the synchronization process (parameter **`Max.durat. sync.process`** is started. The system also checks whether the voltages and frequencies are in the operating range (see section *8.4.4 General Functionality*). If this is not the case, the closing conditions are not checked.

Checking the Closing Conditions, Closure

After starting, the parameterized closing conditions are checked depending on the operating mode selected (see Chapter *8.4.8 Closing Conditions for the Synchronous/Asynchronous Stage Type* to *8.4.11 Direct Close Command*). Every condition fulfilled is explicitly indicated here. Conditions not fulfilled are also indicated. If all conditions are fulfilled, the synchronization stage sets the indication **`All sync. conditio. OK`**. The indication is active until all conditions are fulfilled. The further behavior for issuing the release for closing depends on the type of the stage (see Chapters *8.4.7 Closing Conditions for the Synchrocheck Stage Type* and *8.4.8 Closing Conditions for the Synchronous/Asynchronous Stage Type*). The release is signaled via the **`Release close cmd.`** indication. This indication is active for 100 ms. With an internal start, the controller or the AREC executes the actual closure, depending on the starting source.

Switching to Dead Line/Busbar

If operating modes for switching to dead parts of an electrical power system are configured, the associated conditions are also checked after the start (see chapter *8.4.10 Closing at De-Energized Line/Busbar*). The fulfilled conditions are signaled. An adjustable supervision time is started after the closure conditions are fulfilled (parameter **CB make time**). If the conditions remain valid until expiry of the time, the function gives the release for closure after expiry of the time.

Direct Closing Command

If the **Direct close command** operation is active, the function instantaneously initiates the release for closure after the successful start (see chapter *8.4.11 Direct Close Command*). A combination of direct close command with other release conditions is not advisable, as these conditions are bypassed by the direct close command.

End of the Process

If the function is started via the device-internal controller or AREC, these functions also terminate the synchronization process upon closure. The process is terminated via the corresponding binary signals in case of external starting.

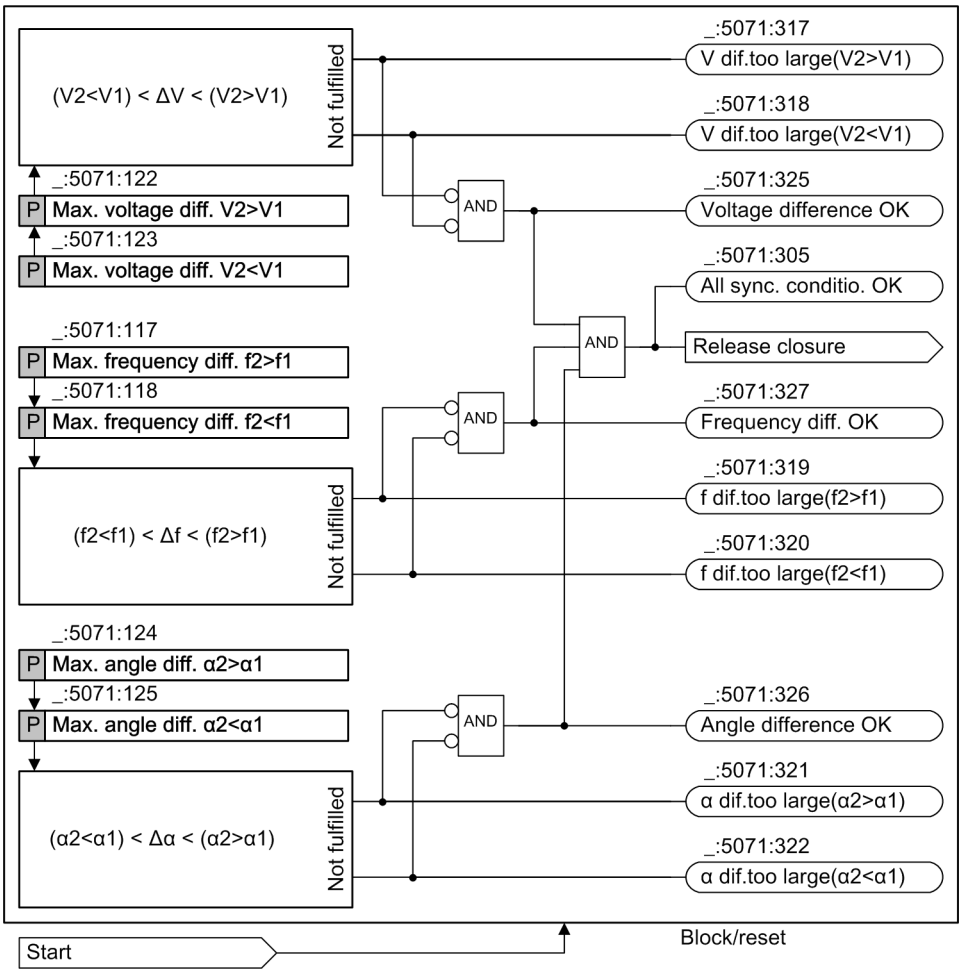
If the supervision time (**Max.durat. sync.process** parameter) has expired, the process is also completed and the indication **Max. time exceeded** is issued. A renewed synchronization is only possible if the stage is restarted.

Blocking Closure

You can use the input signal *>Block close command* to block the release signal for the closure (signal **Release close cmd.**) as well as the closure itself. The measurement continues to operate during the blocking. If the blocking is revoked and the release conditions are still fulfilled, the release is given for closure.

8.4.7 Closing Conditions for the Synchrocheck Stage Type

Checking Closing Conditions



[losynche-160311-01.tif, 1, en_US]

Figure 8-66 Closing Conditions for the Synchrocheck Function

With this operating mode, the values ΔV, Δf, and Δα are checked before connecting the 2 parts of the electrical power system. The indication **`All sync. conditio. OK`** signals that the setting values (conditions) have been reached and that the release for closure has been given (see **Checking the Closing Conditions, Closure** in section *8.4.6 Sequence of Functions*).

Every fulfilled condition is signaled individually via the indications **`Voltage difference OK`**, **`Frequency diff. OK`**, and **`Angle difference OK`**.

If a condition is not fulfilled, detailed information on why the condition is not fulfilled is provided via indications. If the differential voltage is outside the setting limits, for example, the indication **`V dif.too large (V2<V1)`** is issued. The indication indirectly contains information that the voltage V2 has to be increased for a successful synchronization.

With the **Expanded delta-f options** stage type configured and an activated **`(_:140) Limit dfdiff/dt for sync. op`** parameter, the frequency difference rate of change is also checked. If the permissible frequency change rate (parameter **`(_:141) Max. value dfdiff/dt syn`**) is exceeded, the indication **`(_:329) d fdiff/dt too large`** is issued.

8.4.8 Closing Conditions for the Synchronous/Asynchronous Stage Type

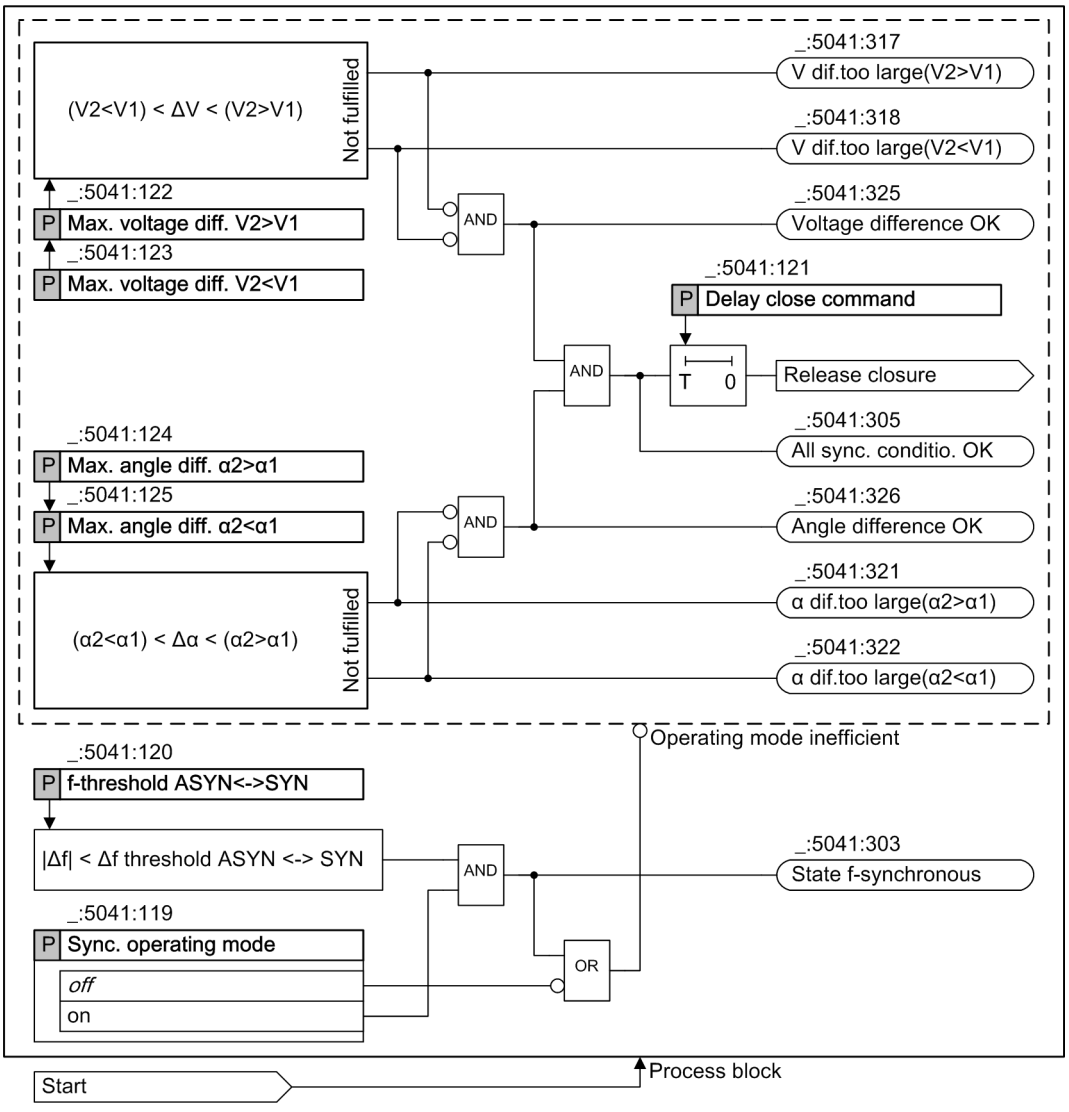
A distinction according to synchronous and asynchronous systems can be made with this type of stage.

If galvanically coupled systems are switched in parallel, synchronous systems are present. A typical characteristic for synchronous systems is equality of frequency (Δf ≈ 0). If the frequency difference falls below the setting value of the **f-threshold ASYN<->SYN** parameter, synchronous systems are to be assumed. If the frequency difference exceeds the setting value of the **f-threshold ASYN<->SYN** parameter, asynchronous systems are to be assumed. This status occurs in galvanically isolated systems, for example.

Both states have their own operating mode with its own closing conditions. Both operating modes can be switched on and off separately (parameter **Sync. operating mode** and **Async. operating mode**). The following combinations result from this:

Sync. operating mode	**Async. operating mode**	Functionality
on	***on***	If the frequency difference is below the threshold value set **f-threshold ASYN<->SYN**, the operating mode synchronous is active. In other cases, the operating mode asynchronous is active.
off	***on***	Regardless of the frequency difference and the threshold value **f-threshold ASYN<->SYN**, the operating mode is exclusively active asynchronously.
on	***off***	If the frequency difference is below the threshold value set **f-threshold ASYN<->SYN**, the operating mode synchronous is active. In other cases, the stage is inactive, i.e. a switching release cannot be issued.
off	***off***	Both operating modes are deactivated. No activation release can be be given via these operating modes either.

Checking the Closing Conditions in Synchronous Systems



[losynsyn-100611-01.tif, 1, en_US]

Figure 8-67 Closing Conditions when Switching Synchronous Systems

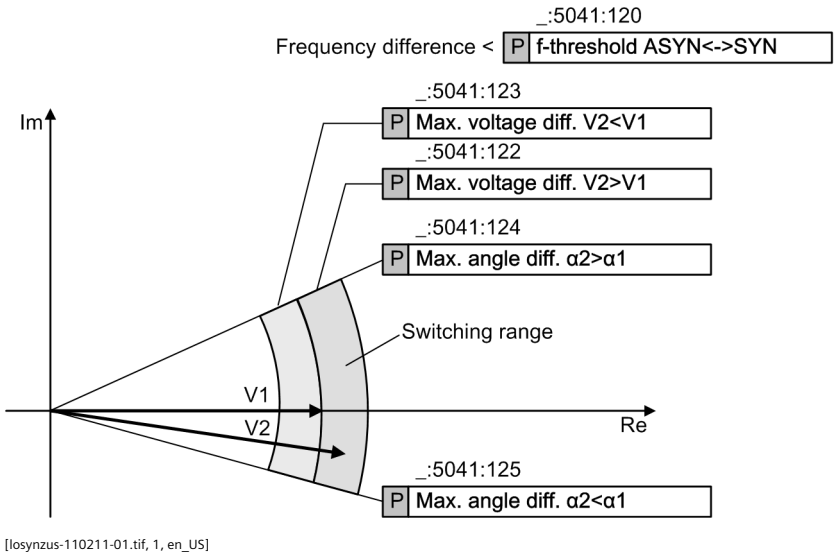
The frequency difference is very low in the synchronous systems operating mode. It is below the threshold value **f-threshold ASYN<->SYN**. The status is signaled via the **State f-synchronous** indication.

The parameters ΔV and Δα are checked for issuing an activation release (see *Figure 8-68*). The indication **All sync. conditio. OK** signals that both setting values (conditions) are reached. If the conditions remain fulfilled over the set time delay (parameter **Delay close command**), the release for closing is given (see also chapter *8.4.7 Closing Conditions for the Synchrocheck Stage Type*).

Every condition fulfilled is signaled individually via the indications **Voltage difference OK** and **Angle difference OK**.

If a condition is not fulfilled, detailed information on why the condition is not fulfilled is provided via indications. If the differential voltage is outside the setting limits, for example, the indication **V dif.too large(V2<V1)** is issued. The indication indirectly contains information that the voltage V2 has to be increased for a successful synchronization.

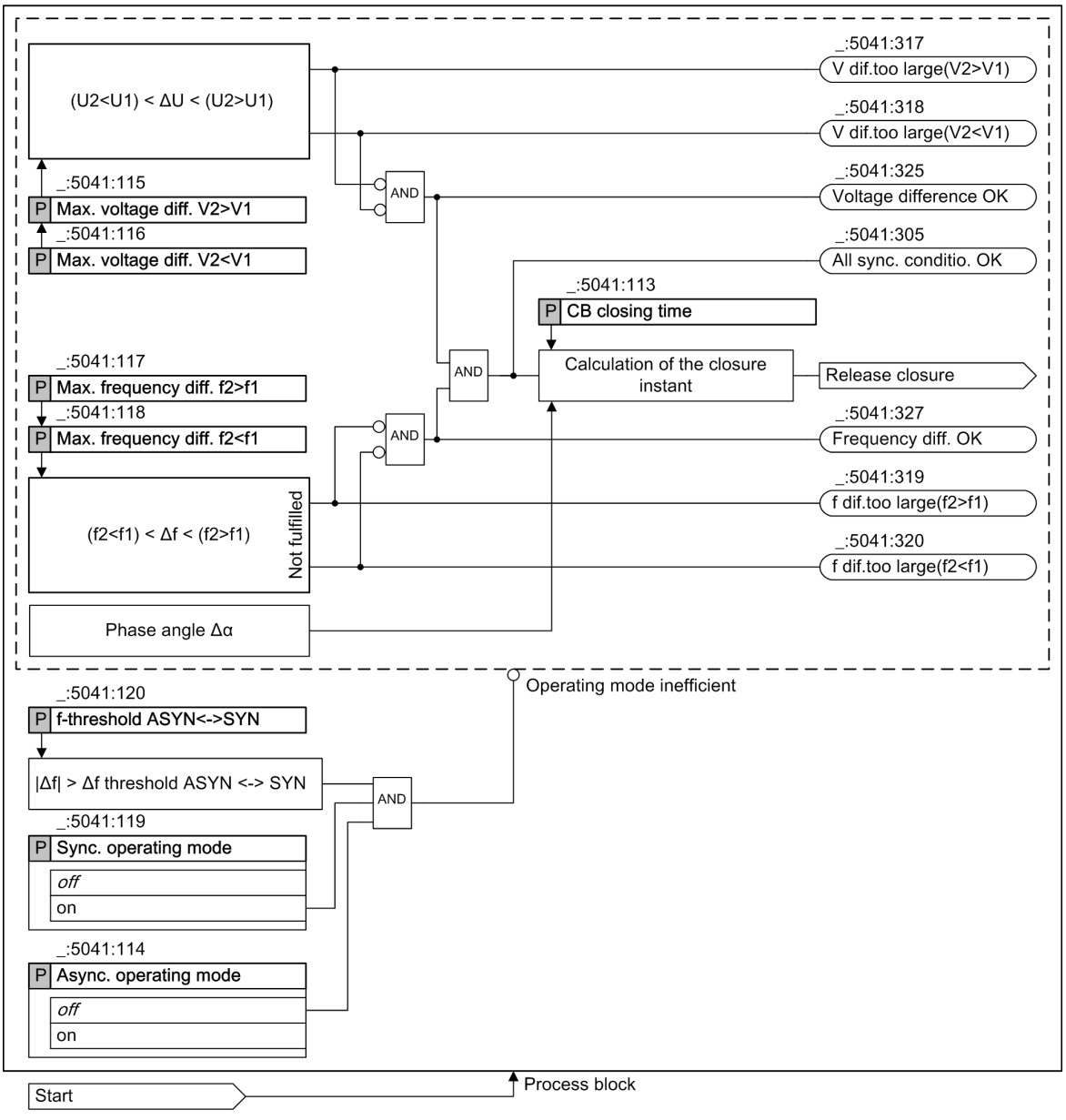
With the **Expanded delta-f options** stage type configured and an activated **(_:142) Limit dfdiff/dt for asyn. op** parameter, the frequency difference rate of change is also checked. If the permissible frequency change rate (parameter **(_:143) Max. value dfdiff/dt asyn**) is exceeded, the indication **(_:329) d fdiff/dt too large** is generated.



[losynzus-110211-01.tif, 1, en_US]

Figure 8-68 Connecting Under Synchronous System Conditions

Checking Closing Conditions in Asynchronous Systems



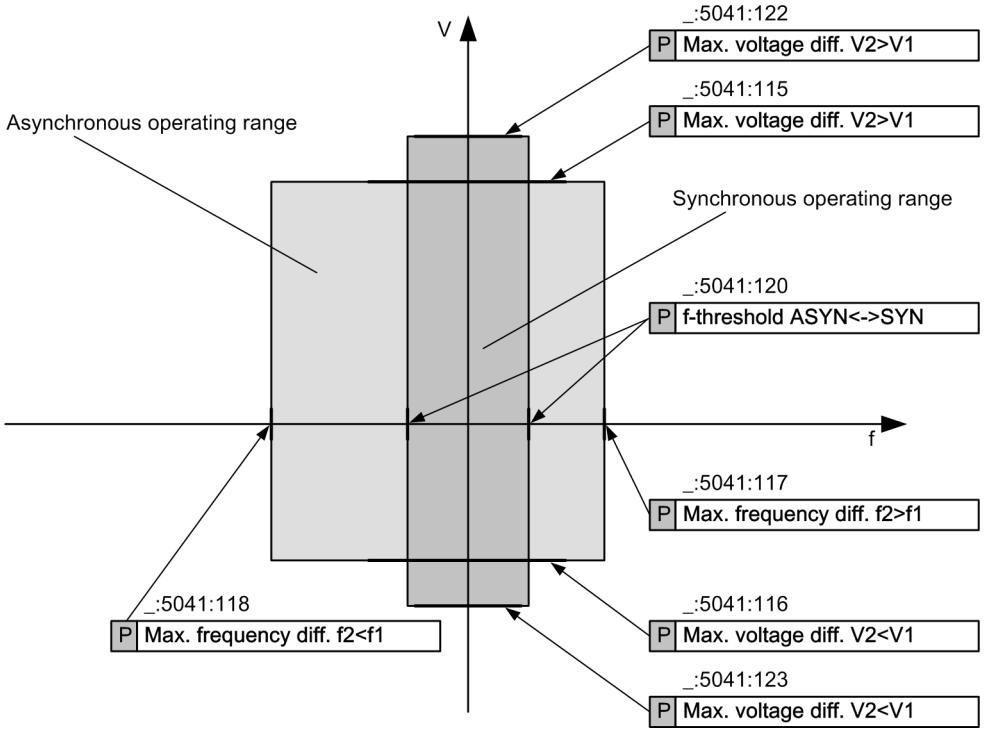
[losynasy-210912-01.tif, 1, en_US]

Figure 8-69 Closing Conditions when Switching Asynchronous Systems

In this operating mode, compliance with the voltage difference ΔV and frequency difference Δf conditions is checked. The function calculates the time point of the close command taking into account the angular difference Δα and the closing time of the circuit breaker. This is calculated so that the voltage phasors are equal at the moment of pole contact by the circuit breaker (ΔV ≈ 0, Δα ≈ 0).

Ranges in the Voltage-Frequency Diagram (V-f Diagram)

Figure 8-70 shows the setting parameters for synchronous and asynchronous conditions in the V-f diagram. The frequency range is very narrow owing to the functional principle in the case of synchronous systems.



[losynarb-080211-01.tif, 1, en_US]

Figure 8-70 Operating Range Under Synchronous and Asynchronous Conditions for Voltage (V) and Frequency (f)

8.4.9 Expanded Checks (df/dt and Smoothing of Oscillations)

When configuring the **Expanded delta-f options** function block, you can expand the synchronization checks to include the following aspects:

- Limitation of the frequency change rate

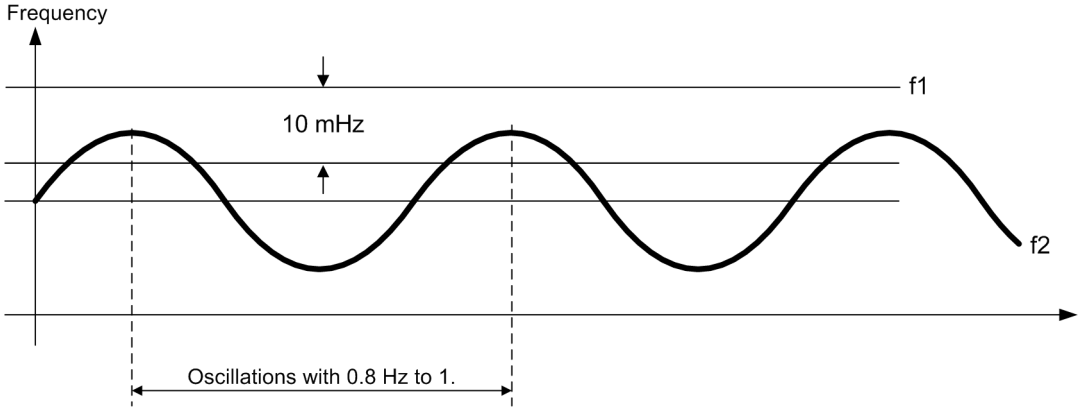
  With this option, you can define additional upper limits for the rate of permissible requency difference change. The release checks for both stage types take these additional upper limits into consideration. Both activation (parameters **(_:140) Limit dfdiff/dt for sync. op** and **(_:142) Limit dfdiff/dt for asyn. op**) and the upper limits (parameters **(_:141) Max. value dfdiff/dt syn** and **(_:143) Max. value dfdiff/dt asyn**) for the frequency change rate are adjustable selectively for synchronous and asynchronous conditions. Both stage types consider the frequency change rate when issuing the release for switching and indicate when the rate is exceeded.

  If you also activate the option to compensate for low-frequency oscillations (parameter **(_:150) Suppr. frequ. oscillations**), the frequency change rate is stabilized in the presence of such oscillations. Stabilization is in effect for asynchronous as well as synchronous operating modes.

- Compensation for low-frequency oscillations

  If you activate this option (parameter **(_:150) Suppr. frequ. oscillations**), low-frequency oscillations, for example, as a consequence of power swings in the range of 0.8 Hz to 1.6 Hz are detected and smoothed. This stabilizes the release checks in the presence of frequently changing violations of upper and lower limits for the specified frequency threshold values. The option affects the frequency check of the **Synchrocheck** stage types and the synchronous operating mode of the **Synchronous/Asynchronous** stage type. It does not affect the asynchronous operating mode.

  In the example of the following figure, the synchrocheck function would initiate energization, if the allowed frequency difference was set to 10 mHz without the parameter **Suppr. frequ. oscillations** as soon as the frequency f2 enters the 10-mHz band. If the parameter **Suppr. frequ. oscillations** is activated, energization is not initiated, since the average value of f2 is outside the band.



[dwsynfre-101013-01.vsd, 1, en_US]

Figure 8-71 Example: Frequency Difference between the Constant Frequency f1 and the Sinusoidal Oscillating Frequency f2

With this option active, the range of function measured values is expanded by the smoothed frequency. Release of switching in synchronous networks occurs after one second at the earliest. This time is needed to smooth the frequency measured values.

The actual frequency can be larger or smaller than the smoothed value at any instant. The **Max. diff. "f threshold"** parameter makes it possible to limit the increase in instantaneous frequency value in relation to the respective frequency threshold value.

8.4.10 Closing at De-Energized Line/Busbar

If at least one of 2 parts of an electrical power system is de-energized, the parts of the electrical power system can be connected together via the following operating modes.

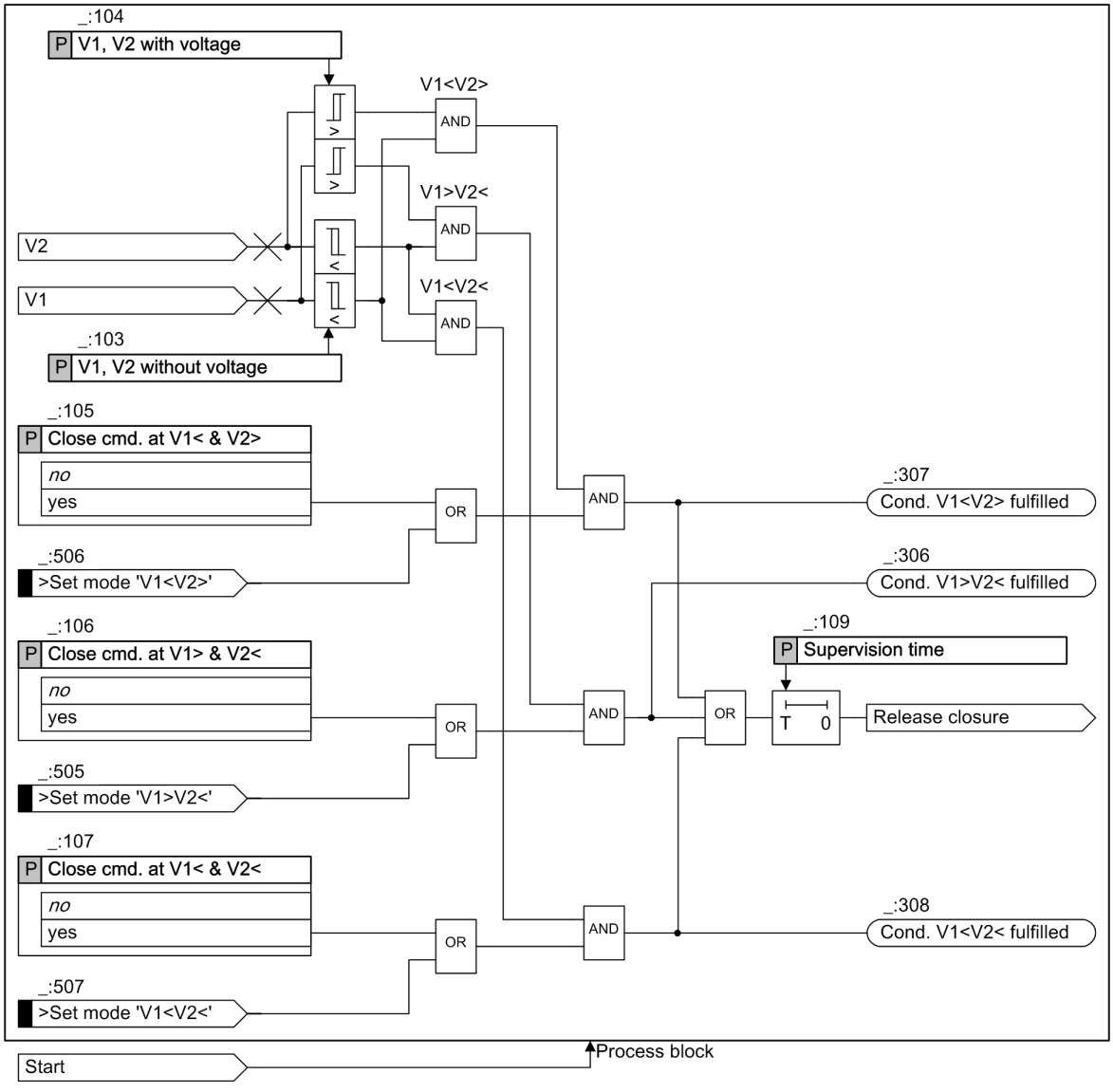
If the measured voltage is less than the threshold **V1, V2 without voltage**, the zero potential of the part of the electrical power system is detected. In this case, all phases are compared to the parameter **V1, V2 without voltage**. The energized side must be in the defined operating range with respect to voltage and frequency (see chapter *8.4.4 General Functionality*) and all phases must exceed the threshold **V1, V2 with voltage**.

The following additional closing conditions can be selected, which are then applied next to the closing conditions for the synchronism:

Settings	Description
Close cmd. at V1> & V2<	Closing release under the condition that the part V_1 of the power system is energized and the part of the electrical power system U_2 is de-energized.
Close cmd. at V1< & V2>	Closing release under the condition that the part V_1 of the power system is de-energized and the part of the electrical power system U_2 is energized.

Settings	Description
Close cmd. at V1< & V2<	Closing release provided mains adapters V_1 and V_2 are de-energized.

Each of these conditions can be made effective individually via parameters or binary input. You can also set parameters for combinations, for example a release for closure, if **Close cmd. at V1> & V2<** or **Close cmd. at V1< & V2>** has been fulfilled.



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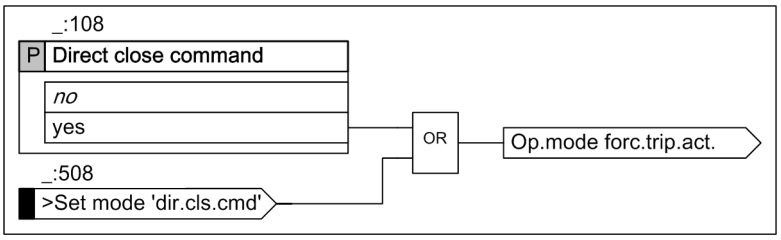
Figure 8-72 Release Conditions for Switching to De-Energized Line/Busbar

The indications **Cond. V1>V2< fulfilled**, **Cond. V1<V2> fulfilled** and **Cond. V1<V2< fulfilled** indicate that the relevant conditions are fulfilled.

You can use the **Supervision time** parameter to set a supervision time for which the closing conditions must at least be fulfilled with de-energized connection, before closing is allowed.

8.4.11 Direct Close Command

You can activate the operating mode direct close command statically via the **`Direct close command`** parameter or dynamically with the binary input signal **`>Op. mode 'dir.cls.cmd'`** (see *Figure 8-73*).



[losyndir-140611-01.tif, 1, en_US]

Figure 8-73 Activation of the Operating Mode Direct Close Command

The operating mode **Direct close command** function initiates a closure release without any testing upon start of the synchronization stage. The closure occurs immediately.

The combination **Direct close command** with other operating modes is not recommended, as the other operating data is bypassed.

If the synchronization function is defective (standby of the sync stage = alarm or warning), a direct close command is executed or not executed, depending on the type of fault (see also supervisions in chapter *8.4.4 General Functionality*).

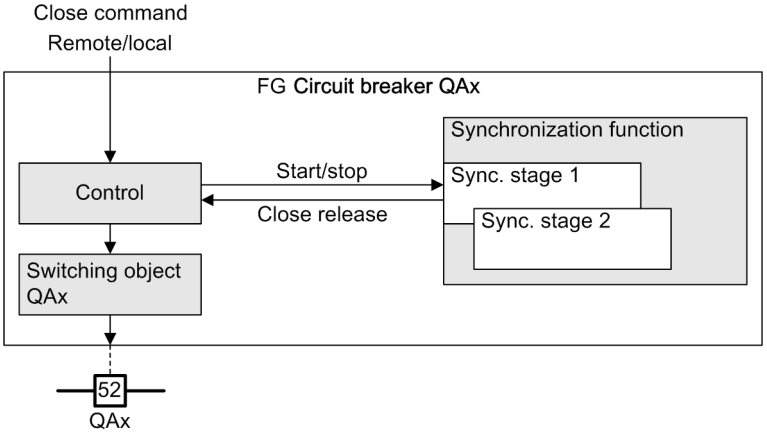
8.4.12 Interaction with Control, Automatic Reclosing (AREC), and External Triggering

With Control

The control and synchronization function are always located in a function group **Circuit breaker**. The control and also the synchronization function always operate with the circuit breaker, which is linked to the function group **Circuit breaker**.

As soon as the synchronization function is in the function group **Circuit breaker**, the circuit breaker is subject to compulsory synchronization. If all synchronization stages are deactivated, the circuit breaker cannot be activated via the control, as no release can be generated for the closure. The circuit breaker is no longer subject to compulsory synchronization after deletion of the synchronization function. Closure without synchronization is then possible via the control.

If closure is to be synchronized via the control, the control automatically generates an internal signal which starts the synchronization function. The functional sequence is described in chapter *8.4.6 Sequence of Functions*. After fulfilling all closing conditions, the synchronization sends a release signal to the control, which closes the circuit breaker and then stops and synchronization function.



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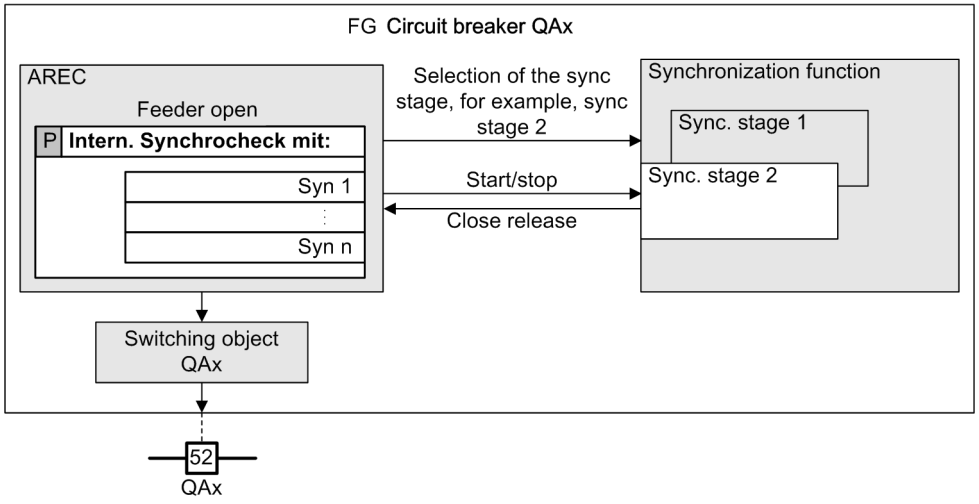
Figure 8-74 Interaction of the Control with the Synchronization Function

With Automatic Reclosing

The automatic reclosing mechanism (AREC) can also work with the synchronization function. Both functions are always located in a function group **Circuit breaker**. Consequently the AREC and synchronization function always work with the circuit.breaker that is linked to the function group **Circuit breaker**.

You must select a synchronization stage via settings within the AREC so that closure is synchronized by the AREC. The tests for the synchronization stage are used for the closure by the AREC. If no synchronization stage is selected, the AREC then activates without synchronization.

If closure is to be synchronized via the AREC, the AREC automatically generates an internal signal which starts the synchronization function. The functional sequence is described in chapter *8.4.6 Sequence of Functions*. After fulfilling all closing conditions, the synchronization sends a release signal to the AREC, which closes the circuit breaker and then stops and synchronization function.



[losynaw2-100611-01.tif, 1, en_US]

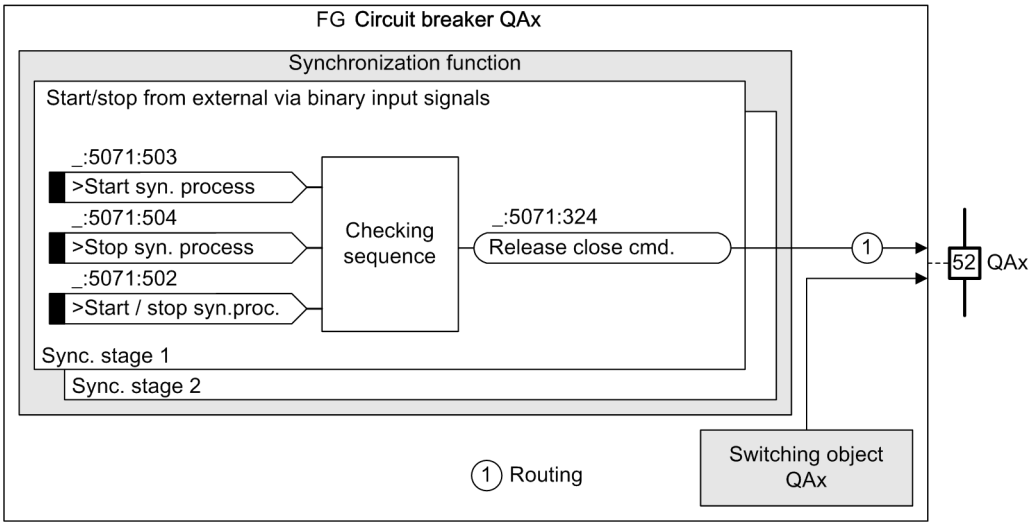
Figure 8-75 Connection of the AREC to the Synchronization Function

With External Control

You have the option of controlling the synchronization function externally via binary input signals. This can be done as follows:

- Edge-controlled
- Via the signals **>Start syn. process** and **>Stop syn. process**
- State-controlled, via the signal **>Start / stop syn.proc.** (see also chapter *8.4.6 Sequence of Functions*).

The start is followed by the functional sequence (see chapter *8.4.6 Sequence of Functions*). If the conditions are fulfilled, the output signal **Release close cmd.** is issued. The switched object QAx of the function group **Circuit breaker** is not closed. The output signal **Release close cmd.** must be explicitly assigned to the binary output in order to close the circuit breaker.



[losynaw3-160311-01.tif, 1, en_US]

Figure 8-76 Interaction of the Synchronization Function with External Control

8.4.13 Application and Setting Notes (General)

Stage-Type Selection

The following 2 types of stage are available:

Stage Type	Application
Synchrocheck stage	Select this type of stage to issue, for example, an additional release during an automatic reclosing or a manual reclosing for safety reasons. With this type, the variables ΔV, Δf and $\Delta\alpha$ are checked before connecting the 2 parts of the power system.
Synchronous/asynchronous stage	Select this type of stage if it is necessary to differentiate between synchronous and asynchronous systems, depending on the switch position. If galvanically coupled systems are switched in parallel, synchronous systems are present. A typical characteristic for synchronous systems is equality of frequency ($\Delta f \approx 0$). In this state, the conditions $\Delta\alpha$ and ΔV are checked. If the systems are galvanically isolated, asynchronous systems can be present. At the same time, compliance with the voltage difference ΔV and frequency difference Δf conditions is checked. The time of the direct close command is calculated taking into account the angle difference $\Delta\alpha$ and the closing time of the circuit breaker. The time of the direct close command is calculated so that the voltages are equal at the moment of pole contact of the circuit breaker ($\Delta V \approx 0$, $\Delta\alpha \approx 0$).

Configuration of the Voltages V1 (Reference Side) and V2

The voltages V1 and V2 are established via the connection of the measuring points to the interface of the function groups (refer to chapter *8.4.3 Connection and Definition*). The measuring point connected to the interface **Voltage** is the reference side 1 with the reference voltage V1. The measuring point connected to the interface **Sync. voltage** is the side 2 with V2. The definition of the Delta parameters that can be derived from this is also described in chapter *8.4.3 Connection and Definition* .

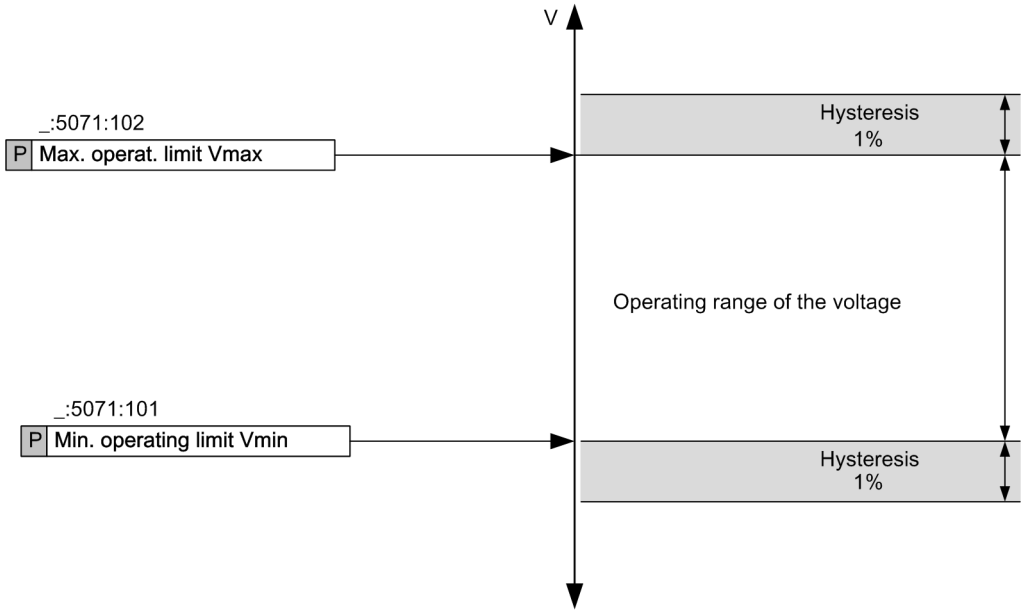
Parameter: **Min. operating limit Vmin ,Max. operat. limit Vmax**

- Recommended setting value **(_:5071:101) Min. operating limit Vmin** = ***90 V***
- Recommended setting value **(_:5071:102) Max. operat. limit Vmax** = ***110 V***

The values define the voltage operating range of the synchronization stage. A normal setting is approx. ±10 % of the rated voltage.

NOTE

All voltages connected according to the parameterized measuring-point connection type are subjected to the appropriate Vmin/Vmax test. Therefore, connected phase-to-ground voltages are multiplied by √3 as the threshold values with reference to the rated voltage (phase-to-phase voltage) must be set.



[lohyster-010415-01.vsd, 1, en_US]

If the Synchronization function is started within the hysteresis, no switching is performed as a result of the minimum and maximum operating limit (parameters **Min. operating limit Vmin** and **Max. operat. limit Vmax**). If the Synchronization function is started within the voltage operating range and the voltage exceeds the minimum or maximum operating limit during the synchronization process, selecting can occur in the area of the hysteresis.

Parameter: **Max.durat. sync.process**

- Default setting **(_:5071:110) Max.durat. sync.process** = ***30 s***

The parameterized conditions must be fulfilled within this time. If the conditions are not fulfilled, no further closing release takes place and the synchronization stage is stopped. If this time is set to ∞, the conditions are checked until they are fulfilled. This is also the default setting. Observe the operating conditions when defining the time limitation. This must be defined specifically for each system. If 0 or 0.01 s is set, then all conditions are checked once at the starting time point. Thereafter the process is stopped immediately.

Parameter: **Voltage adjustment**

- Default setting **(_:5071:126) Voltage adjustment** = ***1.00***

The parameter can be used for correction of amplitude errors, for example, due to indirect measurement (for example, tap changer).

To apply a transformer between measuring points, the **Voltage adjustment** parameter is not needed. The transformer ratios are set for the measuring points and the function will take them into account automatically.

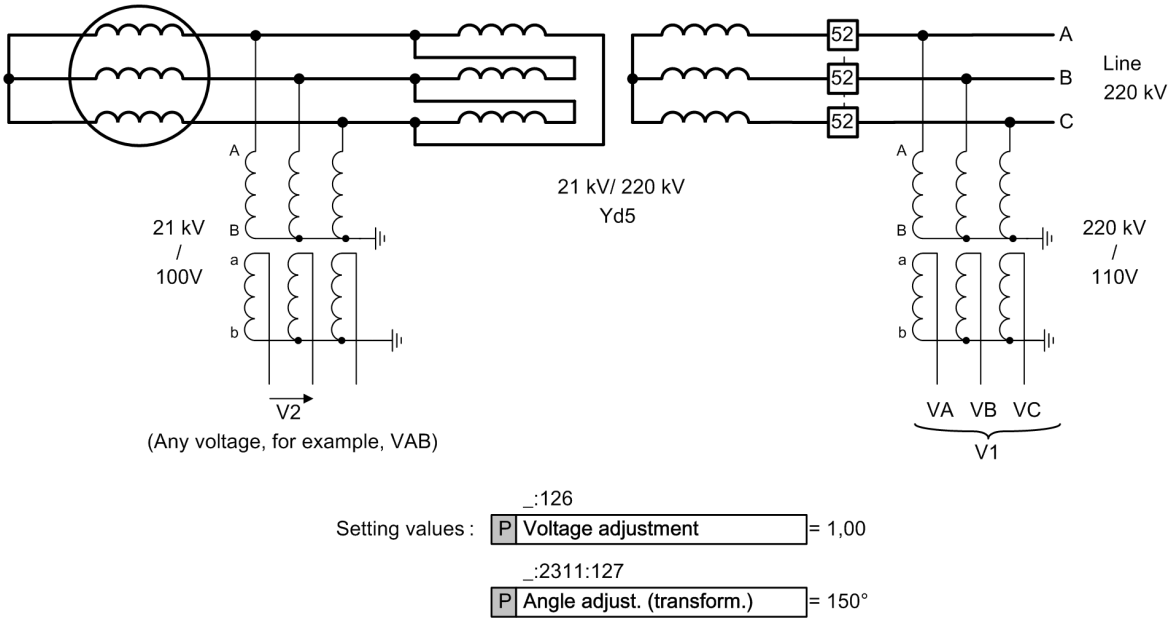
Parameter: `Angle adjust. (transform.)`

- Default setting **`(_:2311:127) Angle adjust. (transform.)`** = *0* °

The parameter can be applied under the following conditions:

- 1. Phase-angle rotation by power transformer between the measuring points
- 2. Correction of phase-angle errors

1. Phase-angle rotation by power transformer between the measuring points:



[losynae1-160311-01.tif, 1, en_US]

Figure 8-77 Transformer Between the Measuring Points

If there is a power transformer between the voltage transformers of the circuit breaker to be synchronized, you then have to correct the phase-angle rotation for a vector group deviating from 0. *Figure 8-77* shows such an application. The **`Angle adjust. (transform.)`** parameter is used to save the phase-angle rotation.

The vector group of the transformer is defined by the upper voltage side to the lower voltage side. If the reference voltage transformer V1 is connected on the upper voltage side of the transformer (as in *Figure 8-77*), enter the phase-angle rotation directly according to the vector group. A vector-group figure of 5, for example, means an angular rotation of 5 · 30° = 150°. Set this value for the **`Angle adjust. (transform.)`** parameter.

If the voltage connection V1 is on the lower voltage side due to the system, you then have to apply the extension angle with 360°. A transformer with vector group 5 yields an angular adjustment of 360° – (5 · 30°) = 210°

2. Correction of phase-angle errors: You can correct a phase-angle error between the voltage transformers in increments. Ascertain a possible correction value during commissioning.

Parameter: CB make time

- Default setting **`(_:5041:113) CB make time`** = *0.06 s*

If you are to interconnect under asynchronous system conditions with the device as well, the closing time of the circuit breaker must be taken into account. The device uses this to calculate the time of the direct close command, so that the voltages are in phase at the moment of closure of the switch poles. Note that apart from the operating time of the switch, this also includes the pickup time of an auxiliary relay that may be upstream. You can determine the closing time using the protection device (see commissioning notes in chapter *11.12 Primary and Secondary Testing of the Synchronization Function*).

This parameter only occurs for the stage type **Synchronous/asynchronous**.

8.4.14 Application and Setting Notes (Synchrocheck)

Parameter: Maximum Differential Values of Voltage, Frequency and Angle

- Default setting **(_:5071:122) Max. voltage diff. V2>V1** = ***5.0 V***
- Default setting **(_:5071:123) Max. voltage diff. V2<V1** = ***5.0 V***
- Default setting **(_:5071:117) Max. frequency diff. f2>f1** = ***0.10 Hz***
- Default setting **(_:5071:118) Max. frequency diff. f2<f1** = ***0.10 Hz***
- Default setting **(_:5071:124) Max. angle diff. α2>α1** = ***10***°
- Default setting **(_:5071:125) Max. angle diff. α2<α1** = ***10***°

2 parameters are available for the differential values voltage, frequency, and angle. Unbalanced closing ranges can be set with this, if required.

The permissible differential values must ensure that no protection tripping or damage occurs in the system owing to compensation processes (circulating current) and power swings after interconnection of the parts of the power system. The settings must not be configured too closely on the other side so that necessary closures are not blocked.

Typical differential values are selected in the default setting. Depending on the system, the settings must be checked and adjusted, if necessary.

8.4.15 Application and Setting Notes (Synchronous/Asynchronous Closure)

Parameter: Synchronous operating mode, Asynchronous operating mode

- Default setting **(_:5041:119) Sync. operating mode** = ***off***
- Default setting **(_:5041:114) Async. operating mode** = ***off***

The operating modes of the stages can be activated or deactivated via the parameters. The operating modes are deactivated in the default setting for safety reasons.

The following combination options are possible:

Sync. operating mode	Async. operating mode	Description
on	***on***	If the frequency difference is below the threshold value set **f-threshold ASYN<->SYN**, the operating mode **synchronous** is active. In other cases, the operating mode **asynchronous** is active. If you wish to interconnect galvanically isolated systems, then select this operating mode.
off	***on***	Regardless of the frequency difference and the threshold value **f-threshold ASYN<->SYN**, the operating mode active is exclusively **asynchronous**. The closing time of the circuit breaker is this always taken into account for determining the connecting point. Select this operating mode if you wish to activate machines, for example generators or asynchronous motors. If the same frequency is present on the sides to be interconnected, then this operating mode is not possible. Since, in the case of dependency on the phase angle position (Δα), release of the closure may not be issued.

Sync. operating mode	Async. operating mode	Description
on	***off***	Use this operating mode for galvanically connected systems. Closure is only possible with synchronous systems (with low Δf).
off	***off***	Both operating modes are deactivated. No closing release can be therefore be given via this operating mode. This configuration is only advisable for special applications. Select this operating mode if you only wish to switch, for example de-energized parts of the power system.

Parameter for asynchronous operation: Max. voltage diff. of voltage and frequency

- Default setting **(_:5041:115) Max. voltage diff. V2>V1** = ***2.0 V***
- Default setting **(_:5041:116) Max. voltage diff. V2<V1** = ***2.0 V***
- Default setting **(_:5041:117) Max. frequency diff. f2>f1** = ***0.10 Hz***
- Default setting **(_:5041:118) Max. frequency diff. f2<f1** = ***0.10 Hz***

For information, see **Parameter for synchronous operation**

Parameter for synchronous operation: Maximum voltage diff. of voltage and angle

- Default setting **(_:5041:122) Max. voltage diff. V2>V1** = ***5.0 V***
- Default setting **(_:5041:123) Max. voltage diff. V2<V1** = ***5.0 V***
- Default setting **(_:5041:124) Max. angle diff. α2>α1**= ***10***°
- Default setting **(_:5041:125) Max. angle diff. α2<α1**= ***10***°

2 parameters are available for the differential values voltage, frequency, and angle. Unbalanced closing ranges can be set with this, if required.

The permissible differential values must ensure that no protection tripping or damage occurs in the system owing to compensation processes (circulating current) and power swings after interconnection of the parts of the power system. The settings must not be configured too closely on the other side so that necessary closures are not blocked.

Typical differential values are selected in the default setting. Depending on the system, the settings must be checked and adjusted, if necessary.

Parameter: Switchover between synchronous and asynchronous operation

- Recommended setting value **(_:5041:120) f-threshold ASYN<->SYN** = ***0.01 Hz***

This parameter is used to set the frequency difference for switching over between synchronous and asynchronous operation.

Siemens recommends using the default setting of ***0.01 Hz***.

8.4.16 Application and Setting Notes (De-Energized Switching/Direct Close Command)

If at least one of 2 parts of an electrical power system is de-energized, the parts of the electrical power system can be connected together via the following operating modes. The above potential release conditions are independent of one another and can also be combined.

NOTE

For reasons of safety, the releases have been deactivated in the default setting and are therefore at ***no***. Even if you wish to apply one of these operating modes, Siemens recommends leaving the setting at ***no*** for reasons of safety. Set the operating mode only dynamically via the assigned binary input signal (for example **>Operating mode 'U1>U2<'**) (see also *Figure 8-72*). This prevents one of these operating modes from being incorrectly activated statically thereby resulting in an incorrect switching.

Parameter: **Close cmd. at V1< & V2>**

- Recommended setting value **(_:5071:105) Close cmd. at V1< & V2>** = ***no***

Settings	Description
no	No release for closing is possible via this operating mode.
yes	If part V1 of the power system is de-energized and part V2 of the power system is energized, the release for closure is given upon starting the synchronization stage after the supervision time has passed. The setting depends on the operational requirements. Note the above information.

Parameter: **Close cmd. at V1> & V2<**

- Recommended setting value **(_:5071:106) Close cmd. at V1> & V2<** = ***no***

Settings	Description
no	No release for closing is possible via this operating mode.
yes	If part V1 of the power system is energized and part V2 of the power system is de-energized, the release for closure is given upon starting the synchronization stage after the supervision time has passed. The setting depends on the operational requirements. Note the above information.

Parameter: **Close cmd. at V1< & V2<**

- Recommended setting value **(_:5071:107) Close cmd. at V1< & V2<** = ***no***

Settings	Description
no	No release for closing is possible via this operating mode.
yes	If the parts V1 and V2 of the power system are de-energized, the release for closure is given upon starting the synchronization stage after the supervision time has passed. The setting depends on the operational requirements. Note the above information.

Parameter: **V1, V2 with voltage**

- Recommended setting value **(_:5071:104) V1, V2 with voltage** = ***80 V***

The setting value indicates the voltage above which a part of the power system (feeder or busbar) can be regarded as activated with certainty.

You must set the value below the minimum expected operational undervoltage. Siemens therefore recommends a setting value of approx. 80 % of the rated voltage. All voltages connected according to the parameterized measuring-point connection type are subjected to the appropriate Vmin/Vmax test.

Parameter: **V1, V2 without voltage**

- Recommended setting value **(_:5071:103) V1, V2 without voltage** = ***5 V***

The setting value indicates the voltage below which a part of the power system (feeder or busbar) can be regarded as deactivated with certainty.

Siemens recommends a setting value of approx. 5 % of the rated voltage for this. All voltages connected according to the parameterized measuring-point connection type are subjected to the appropriate Vmin/Vmax test.

Parameter: `Supervision time`

- Recommended setting value **`(_:5071:109) Supervision time`** = ***`0.1 s`***

The parameter defines a supervision time for which the above additional closing conditions have to be at least fulfilled at de-energized switching, before the release for closing is given. In order to include transient phenomena, Siemens recommends a value of ***`0.1 s`***.

Parameter: `Direct close command`

- Recommended setting value **`(_:5071:108) Direct close command`** = ***`no`***

In this operating mode, the function initiates a closing release without any testing upon start of the synchronization stage. The closure occurs immediately.



NOTE

For safety reasons, Siemens recommends leaving the setting at ***`no`***. If a direct close command is necessary, Siemens recommends only using this operating mode dynamically via the binary input signal **`>Op. mode 'dir.cls.cmd'`** (see also *Figure 8-74*). This prevents this operating mode from being incorrectly activated statically thereby resulting in an incorrect switching.

8.4.17 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`General`				
_:2311:127	General:Angle adjust. (transform.)		-179.0 ° to 180.0 °	0.0 °
`General`				
_:5071:1	Synchrocheck 1:Mode		• off • on • test	off
_:5071:101	Synchrocheck 1:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:5071:102	Synchrocheck 1:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:5071:110	Synchrocheck 1:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:5071:108	Synchrocheck 1:Direct close command		• no • yes	no
_:5071:126	Synchrocheck 1:Voltage adjustment		0.500 to 2.000	1.000
`De-en.gized switch.`				
_:5071:105	Synchrocheck 1:Close cmd. at V1< & V2>		• no • yes	no
_:5071:106	Synchrocheck 1:Close cmd. at V1> & V2<		• no • yes	no
_:5071:107	Synchrocheck 1:Close cmd. at V1< & V2<		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:5071:103	Synchrocheck 1:V1, V2 without voltage		0.300 V to 170.000 V	5.000 V
_:5071:104	Synchrocheck 1:V1, V2 with voltage		0.300 V to 340.000 V	80.000 V
_:5071:109	Synchrocheck 1:Supervision time		0.00 s to 60.00 s	0.1 s
Synchr. conditions				
_:5071:122	Synchrocheck 1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:5071:123	Synchrocheck 1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5071:117	Synchrocheck 1:Max. frequency diff. f2>f1		0.000 Hzto 2.000 Hz	0.100 Hz
_:5071:118	Synchrocheck 1:Max. frequency diff. f2<f1		0.000 Hzto 2.000 Hz	0.100 Hz
_:5071:124	Synchrocheck 1:Max. angle diff. α2>α1		0 ° to 90 °	10 °
_:5071:125	Synchrocheck 1:Max. angle diff. α2<α1		0 ° to 90 °	10 °
General				
_:5041:1	Sychr./Asycr.1:Mode		• off • on • test	off
_:5041:101	Sychr./Asycr.1:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:5041:102	Sychr./Asycr.1:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:5041:110	Sychr./Asycr.1:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:5041:108	Sychr./Asycr.1:Direct close command		• no • yes	no
_:5041:126	Sychr./Asycr.1:Voltage adjustment		0.500 to 2.000	1.000
De-en.gized switch.				
_:5041:105	Sychr./Asycr.1:Close cmd. at V1< & V2>		• no • yes	no
_:5041:106	Sychr./Asycr.1:Close cmd. at V1> & V2<		• no • yes	no
_:5041:107	Sychr./Asycr.1:Close cmd. at V1< & V2<		• no • yes	no
_:5041:103	Sychr./Asycr.1:V1, V2 without voltage		0.300 V to 170.000 V	5.000 V
_:5041:104	Sychr./Asycr.1:V1, V2 with voltage		0.300 V to 340.000 V	80.000 V
_:5041:109	Sychr./Asycr.1:Supervision time		0.00 s to 60.00 s	0.1 s
Asynchr. op.mode				
_:5041:114	Sychr./Asycr.1:Async. operating mode		• off • on	on
_:5041:113	Sychr./Asycr.1:CB make time		0.01 sto 0.60 s	0.06 s

Addr.	Parameter	C	Setting Options	Default Setting
_:5041:115	Sychr./Asycr.1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:5041:116	Sychr./Asycr.1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5041:117	Sychr./Asycr.1:Max. frequency diff. f2>f1		0.000 Hzto 4.000 Hz	0.100 Hz
_:5041:118	Sychr./Asycr.1:Max. frequency diff. f2<f1		0.000 Hzto 4.000 Hz	0.100 Hz
Synchr. op.mode				
_:5041:119	Sychr./Asycr.1:Sync. operating mode		• off • on	on
_:5041:120	Sychr./Asycr.1:f-threshold ASYN<->SYN		0.010 Hzto 0.200 Hz	0.010 Hz
_:5041:122	Sychr./Asycr.1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:5041:123	Sychr./Asycr.1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5041:124	Sychr./Asycr.1:Max. angle diff. α2>α1		0 ° to 90 °	10 °
_:5041:125	Sychr./Asycr.1:Max. angle diff. α2<α1		0 ° to 90 °	10 °
_:5041:121	Sychr./Asycr.1:Delay close command		0.00 s to 60.00 s	0.00 s
dfdiff/dt limitation				
_:140	Adv. options:Limit dfdiff/dt for sync. op		• 0 • 1	false
_:141	Adv. options:Max. value dfdiff/dt syn		0.010 Hz/sto 0.025 Hz/s	0.010 Hz/s
_:142	Adv. options:Limit dfdiff/dt for asyn. op		• 0 • 1	false
_:143	Adv. options:Max. value dfdiff/dt asyn		0.050 Hz/sto 0.500 Hz/s	0.050 Hz/s
Frequ. oscillations				
_:150	Adv. options:Suppr. frequ. oscillations		• 0 • 1	false
_:151	Adv. options:Max. diff. "f threshold"		0.000 Hzto 0.100 Hz	0.000 Hz

8.4.18 Information List

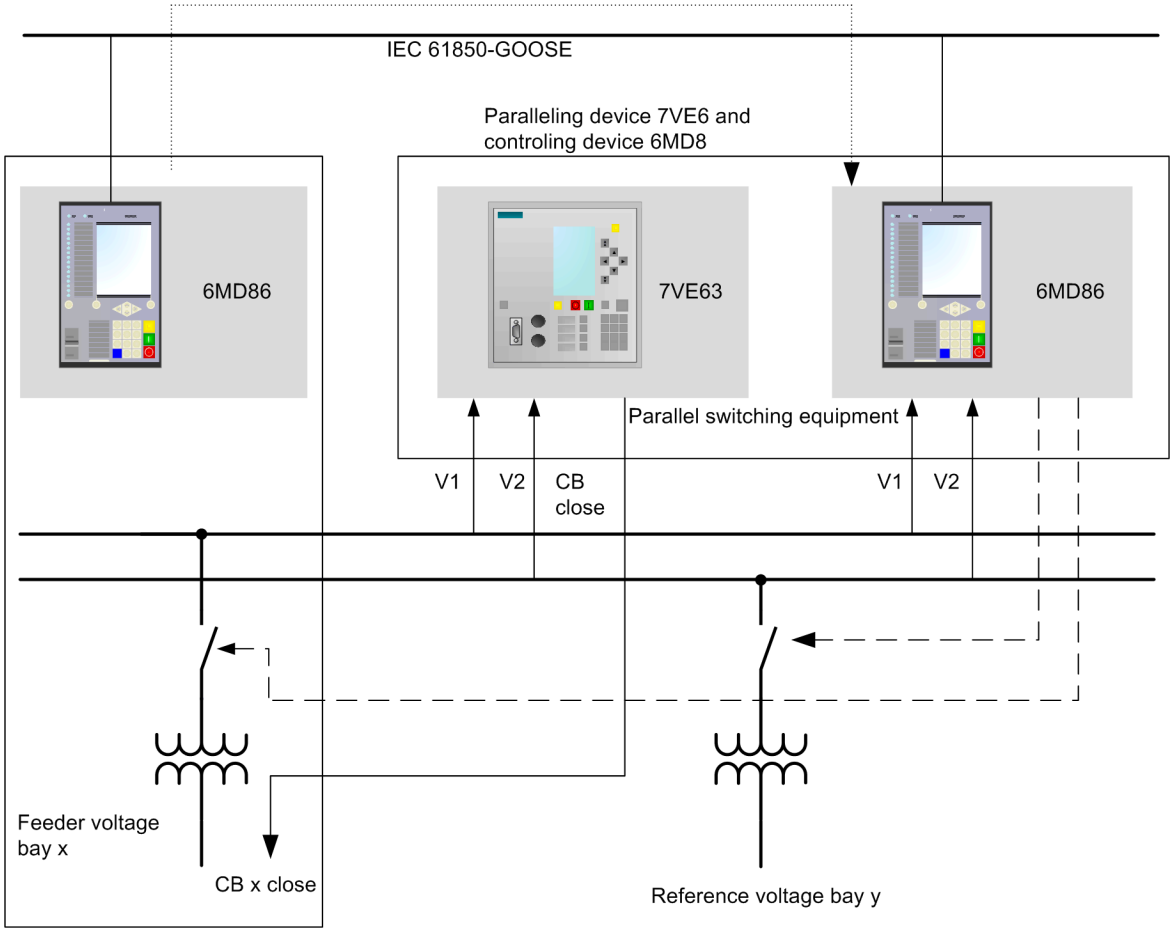
No.	Information	Data Class (Type)	Type
Measurements			
_:2311:303	General:Multiple selection	SPS	O
_:2311:304	General:Blocked no V selected	SPS	O
_:2311:329	General:V1	MV	O
_:2311:330	General:f1	MV	O
_:2311:331	General:V2	MV	O
_:2311:332	General:f2	MV	O
_:2311:300	General:dV	MV	O

No.	Information	Data Class (Type)	Type
_:2311:301	General:df	MV	O
_:2311:302	General:dα	MV	O
Synchrocheck 1			
_:5071:81	Synchrocheck 1:>Block stage	SPS	I
_:5071:500	Synchrocheck 1:>Selection	SPS	I
_:5071:502	Synchrocheck 1:>Start / stop syn.proc.	SPS	I
_:5071:503	Synchrocheck 1:>Start syn. process	SPS	I
_:5071:504	Synchrocheck 1:>Stop syn. process	SPS	I
_:5071:506	Synchrocheck 1:>Op. mode 'V1<V2>'	SPS	I
_:5071:505	Synchrocheck 1:>Op. mode 'V1>V2<'	SPS	I
_:5071:507	Synchrocheck 1:>Op. mode 'V1<V2<'	SPS	I
_:5071:508	Synchrocheck 1:>Op. mode 'dir.cls.cmd'	SPS	I
_:5071:501	Synchrocheck 1:>Block close command	SPS	I
_:5071:54	Synchrocheck 1:Inactive	SPS	O
_:5071:52	Synchrocheck 1:Behavior	ENS	O
_:5071:53	Synchrocheck 1:Health	ENS	O
_:5071:328	Synchrocheck 1:In progress	SPS	O
_:5071:324	Synchrocheck 1:Release close cmd.	SPS	O
_:5071:305	Synchrocheck 1:All sync. conditio. OK	SPS	O
_:5071:325	Synchrocheck 1:Voltage difference OK	SPS	O
_:5071:326	Synchrocheck 1:Angle difference OK	SPS	O
_:5071:327	Synchrocheck 1:Frequency diff. OK	SPS	O
_:5071:307	Synchrocheck 1:Cond. V1<V2> fulfilled	SPS	O
_:5071:306	Synchrocheck 1:Cond. V1>V2< fulfilled	SPS	O
_:5071:308	Synchrocheck 1:Cond. V1<V2< fulfilled	SPS	O
_:5071:309	Synchrocheck 1:Frequency f1 > fmax	SPS	O
_:5071:310	Synchrocheck 1:Frequency f1 < fmin	SPS	O
_:5071:311	Synchrocheck 1:Frequency f2 > fmax	SPS	O
_:5071:312	Synchrocheck 1:Frequency f2 < fmin	SPS	O
_:5071:313	Synchrocheck 1:Voltage V1 > Vmax	SPS	O
_:5071:314	Synchrocheck 1:Voltage V1 < Vmin	SPS	O
_:5071:315	Synchrocheck 1:Voltage V2 > Vmax	SPS	O
_:5071:316	Synchrocheck 1:Voltage V2 < Vmin	SPS	O
_:5071:317	Synchrocheck 1:V dif.too large(V2>V1)	SPS	O
_:5071:318	Synchrocheck 1:V dif.too large(V2<V1)	SPS	O
_:5071:319	Synchrocheck 1:f dif.too large(f2>f1)	SPS	O
_:5071:320	Synchrocheck 1:f dif.too large(f2<f1)	SPS	O
_:5071:321	Synchrocheck 1:α dif.too large(α2>α1)	SPS	O
_:5071:322	Synchrocheck 1:α dif.too large(α2<α1)	SPS	O
_:5071:304	Synchrocheck 1:Max. time exceeded	SPS	O
_:5071:323	Synchrocheck 1:Setting error	SPS	O
Sychr./Asycr.1			
_:5041:81	Sychr./Asycr.1:>Block stage	SPS	I
_:5041:500	Sychr./Asycr.1:>Selection	SPS	I
_:5041:502	Sychr./Asycr.1:>Start / stop syn.proc.	SPS	I
_:5041:503	Sychr./Asycr.1:>Start syn. process	SPS	I

No.	Information	Data Class (Type)	Type
_:5041:504	Sychr./Asycr.1:>Stop syn. process	SPS	I
_:5041:506	Sychr./Asycr.1:>Op. mode 'V1<V2>'	SPS	I
_:5041:505	Sychr./Asycr.1:>Op. mode 'V1>V2<'	SPS	I
_:5041:507	Sychr./Asycr.1:>Op. mode 'V1<V2<'	SPS	I
_:5041:508	Sychr./Asycr.1:>Op. mode 'dir.cls.cmd'	SPS	I
_:5041:501	Sychr./Asycr.1:>Block close command	SPS	I
_:5041:54	Sychr./Asycr.1:Inactive	SPS	O
_:5041:52	Sychr./Asycr.1:Behavior	ENS	O
_:5041:53	Sychr./Asycr.1:Health	ENS	O
_:5041:328	Sychr./Asycr.1:In progress	SPS	O
_:5041:324	Sychr./Asycr.1:Release close cmd.	SPS	O
_:5041:305	Sychr./Asycr.1:All sync. conditio. OK	SPS	O
_:5041:303	Sychr./Asycr.1:State f-synchronous	SPS	O
_:5041:325	Sychr./Asycr.1:Voltage difference OK	SPS	O
_:5041:326	Sychr./Asycr.1:Angle difference OK	SPS	O
_:5041:327	Sychr./Asycr.1:Frequency diff. OK	SPS	O
_:5041:307	Sychr./Asycr.1:Cond. V1<V2> fulfilled	SPS	O
_:5041:306	Sychr./Asycr.1:Cond. V1>V2< fulfilled	SPS	O
_:5041:308	Sychr./Asycr.1:Cond. V1<V2< fulfilled	SPS	O
_:5041:309	Sychr./Asycr.1:Frequency f1 > fmax	SPS	O
_:5041:310	Sychr./Asycr.1:Frequency f1 < fmin	SPS	O
_:5041:311	Sychr./Asycr.1:Frequency f2 > fmax	SPS	O
_:5041:312	Sychr./Asycr.1:Frequency f2 < fmin	SPS	O
_:5041:313	Sychr./Asycr.1:Voltage V1 > Vmax	SPS	O
_:5041:314	Sychr./Asycr.1:Voltage V1 < Vmin	SPS	O
_:5041:315	Sychr./Asycr.1:Voltage V2 > Vmax	SPS	O
_:5041:316	Sychr./Asycr.1:Voltage V2 < Vmin	SPS	O
_:5041:317	Sychr./Asycr.1:V dif.too large(V2>V1)	SPS	O
_:5041:318	Sychr./Asycr.1:V dif.too large(V2<V1)	SPS	O
_:5041:319	Sychr./Asycr.1:f dif.too large(f2>f1)	SPS	O
_:5041:320	Sychr./Asycr.1:f dif.too large(f2<f1)	SPS	O
_:5041:321	Sychr./Asycr.1:α dif.too large(α2>α1)	SPS	O
_:5041:322	Sychr./Asycr.1:α dif.too large(α2<α1)	SPS	O
_:5041:304	Sychr./Asycr.1:Max. time exceeded	SPS	O
_:5041:323	Sychr./Asycr.1:Setting error	SPS	O

8.4.19 External Synchronization

The purpose of the **External synchronization** function is to control an external synchronization device.



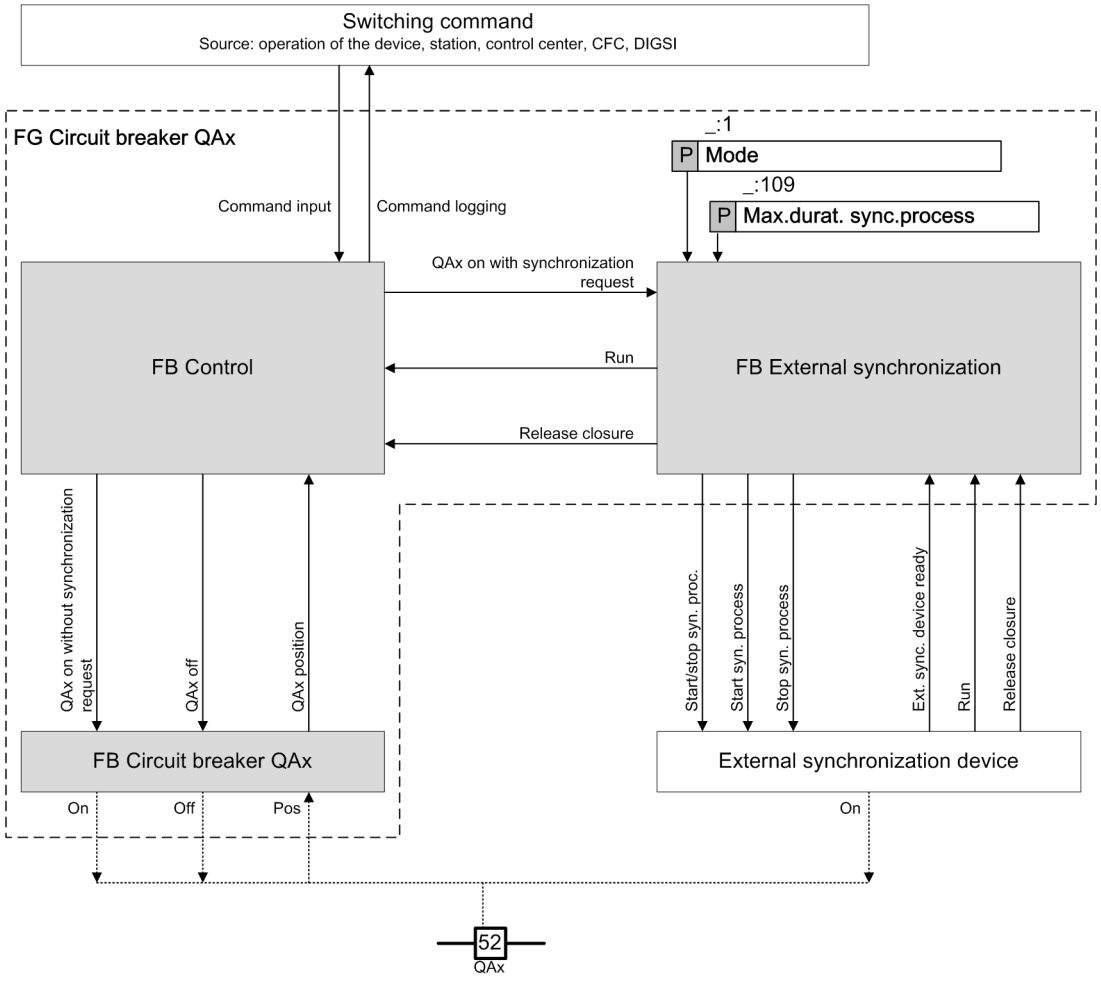
[dw_ctrl_ext_sync_device, 1, en_US]

Figure 8-78 Triggering an External Synchronization Device

The bay controller in bay x should switch the circuit breaker in bay x in synchrony. The synchronization check is carried out in the central paralleling device 7VE6. In addition to the paralleling device, another central bay controller ensures the switching of the correct measuring voltages and the routing of the CB close command from the 7VE6 to the correct circuit breaker in bay x. The bay controller x provides the information to the central bay controller via IEC61850-GOOSE.

The **External synchronization** is designed as a function block which can be used in the Circuit-breaker function group. The additional **External synchronization** function block integrates the external synchronization into command processing, so that the corresponding feedback can be forwarded to the command source.

If a circuit-breaker close command with a synchronization requirement is present, the external synchronization device is started. After successfully checking the synchronization conditions, the close command is issued from the external synchronization device to the circuit breaker. If a circuit-breaker close command without synchronization requirement is present, the circuit-breaker close command is issued directly from the **Circuit-breaker** function group to the circuit breaker. Also, each circuit-breaker trip command is issued directly to the circuit breaker.

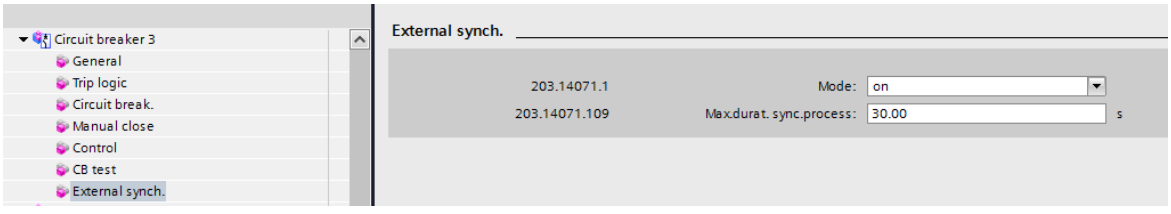


[dwextsyn-01, 1, en_US]

Figure 8-79 Interaction between Control and External Synchronization

Parameterization with DIGSI

In the DIGSI library, the function is visible inside the **Circuit-breaker** function group as the **External synchronization** function block. You can instantiate the function block in the **Circuit-breaker** function group and the **Circuit-breaker (control)** function group. You can instantiate only 1 **External synchronization** function block within these function groups at a time.



[scextsyn, 1, 1, en_US]

Figure 8-80 Instantiating the **External Synchronization** Function Block in the **Circuit-Breaker** Function Group

It is not possible to jointly instantiate the **External synchronization** function block with the **25 synchronization** function in the same **Circuit-breaker** function group.

Notes for Optional Input Interconnections

You have the option of connecting the input signals *>Close cmd. released* and *>In progress* . If you omit these interconnections, observe the following instructions:

Input *>Close cmd. released* :

If you do not interconnect the input signal *>Close cmd. released* , the execution of a circuit-breaker close command with synchronization requirement is confirmed directly (execution successful: OPR+), as soon as the output signal *Start syn. process* is set. In this case, the **(_:109) Max.durat. sync.process** setting has no meaning. If you use a control model with feedback monitoring, consider that the feedback monitoring will start immediately when the *Start syn. process* signal is tripped. The **(_:4201:103) Feedback monitoring time** setting must therefore be set higher than the maximum synchronization time of the external synchronization device plus the circuit-breaker closing time. If *>Close cmd. released* is not routed, the output *Start/stop syn. proc.* is not set.

Input *>In progress* :

The interconnection of the input signal *>In progress* is intended to check whether the synchronization device has received the *Start syn. process* signal. If you do not interconnect this input signal and the external synchronization device rejects a start command, the negative acknowledgment of the circuit-breaker close command does not occur until the maximum synchronization time (parameter **(_:109) Max.durat. sync.process**) has expired.

8.4.20 Application and Setting Notes (External Synchronization)

Parameter: Mode

- Default setting **(_:1) Mode** = ***on***

With the **Mode** setting, you switch the external synchronization function on or off. If you set the **Mode** setting to ***off***, a circuit-breaker close command with synchronization requirement is rejected.

Parameter: Max.durat. sync.process

- Default setting **(_:109) Max.durat. sync.process** = ***30 s***

The **Max.durat. sync.process** setting defines the maximum synchronization time. The time starts when the **External synchronization** function block sends a close command to the external synchronization device. The command must be executed within this time. If the close command is not executed within this time, the **External synchronization** function block sends a command to cancel closing to the external synchronization device.

8.4.21 Settings

Addr.	Parameter	C	Setting Options	Default Setting
External synch.				
_:1	External synch.:Mode		• off • on • test	on
_:109	External synch.:Max.durat. sync.process		0.00 s to 3600.00 s	30.00 s

8.4.22 Information List

No.	Information	Data Class (Type)	Type
External synch.			
_:52	External synch.:Behavior	ENS	O
_:54	External synch.:Health	ENS	O
_:55	External synch.:Start syn. process	SPS	O
_:56	External synch.:Stop syn. process	SPS	O
_:57	External synch.:Start/stop syn. proc.	SPS	O
_:506	External synch.:>Synch. device ready	SPS	I
_:507	External synch.:>Close cmd. released	SPS	I
_:508	External synch.:>In progress	SPS	I

8.5 Switching Sequences

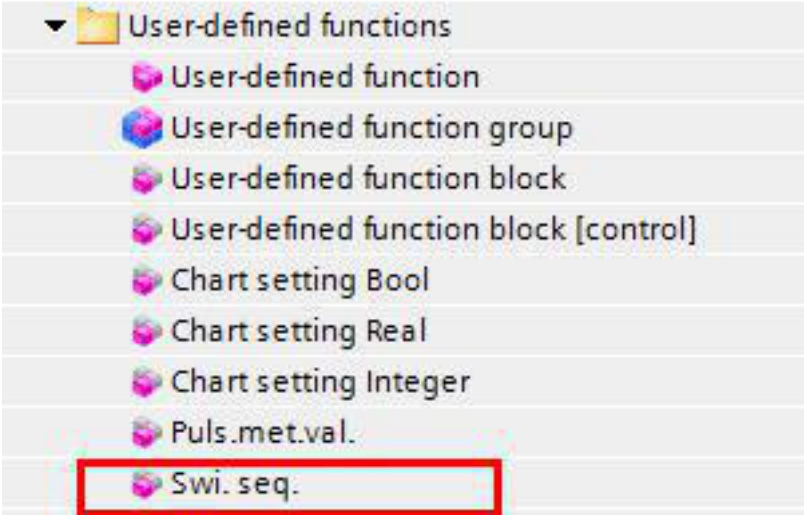
8.5.1 Overview of Functions

Switching sequences may be running inside the device that switch the switchgear automatically in a prespecified sequence.

A switching sequence consists of a special function block **Switching sequence** (Swi. seq.) from the DIGSI 5 Library and the project-specific list of the switching commands that are generated in the CFC.

8.5.2 Function Description

The function block **Switching sequence** is located in folder **User-defined functions** in the DIGSI 5 Library.

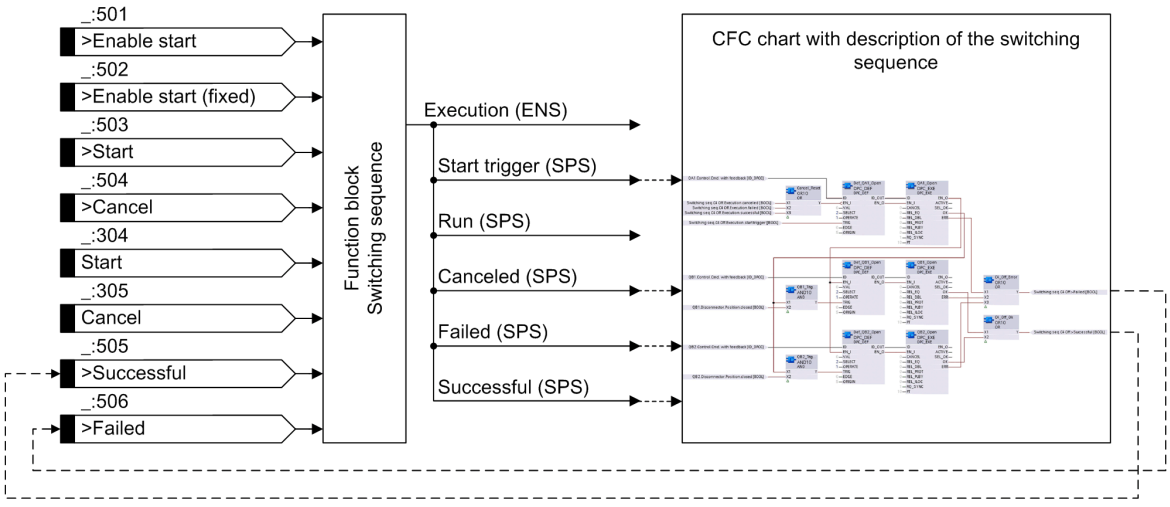


[scudeffb, 1, en_US]

Figure 8-81 Function block **Switching Sequence** in the Library

These function blocks can be used in the information matrix on the highest level (level of the function groups) or in a user-defined function group.

One **Switching sequence** function block is used per switching sequence. The function block is the interface for controlling and monitoring the condition of the CFC switching sequence. The task of the function block is to verify the relative conditions for control commands, for example, switching authority, interlocking conditions, etc. You can connect the signals of the function block with the CFC chart. They start and stop the switching sequence and provide data about the status of the switching sequence (see *Figure 8-82*). The CFC chart is used to activate the switching device that must be switched. The CFC blocks define, among other things, the switching devices that must be switched.



[dwswseq1-110913-01.vsd, 1, en_US]

Figure 8-82 **Switching Sequence** Function Block

Starting and Canceling a Switching Sequence

One of the following methods can be used to start a switching sequence:

- On-site operation: menu or display page
- Input *>Start* during rising edge, for example, via binary input
- Controllable *Start* for the start via a communication protocol, for example, IEC 61850, T103, or DNP
- Input *>Start* via a function key
- Controllable *Start* via a function key

One of the following methods can be used to cancel a switching sequence:

- On-site operation: menu or display page
- Input *>Cancel* during rising edge, for example, via binary input
- Controllable *Cancel* for the cancelation via a communication protocol, for example, IEC 61850, T103, or DNP
- Input *>Cancel* via a function key
- Controllable *Cancel* via a function key

On-Site Operation

If at least one **Switching sequence** function block is used in the device, a new **Switching sequences** entry is shown in the first line of the **Control** menu. If this menu item is selected, an overview of all switching sequences and the current status will be displayed (see *Figure 8-83* , example with 2 switching sequences). You can start or cancel the switching sequences from this menu.

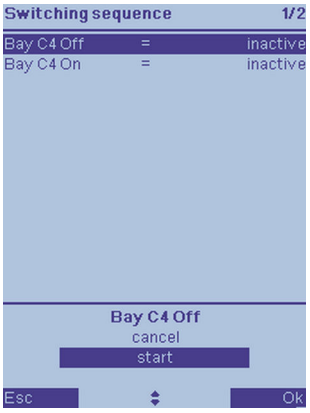
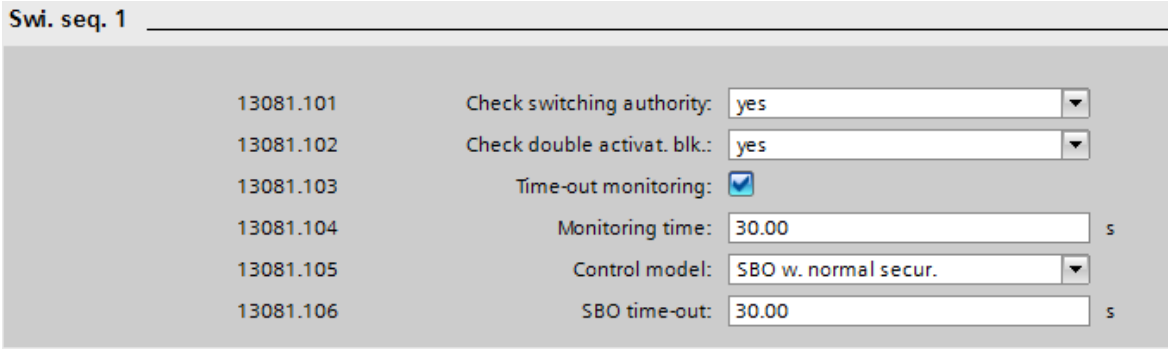


Figure 8-83
Overview of the Switching Sequences on the Device Display

8.5.3 Application and Setting Notes

This function block offers similar settings as the **Control** function block of a circuit breaker or disconnector (see chapter *8.2.1 General Overview*).



[scccs4pa-13112014_DE, 1, en_US]

Figure 8-84 Settings of the **Switching Sequence** Function Block

Parameter: **`Check switching authority`**

- Default setting **`(_:101) Check switching authority`** = ***`yes`***

With the **`Check switching authority`** parameter, you can determine whether the switching authority should be checked before the execution of the switching sequence.

Parameter: **`Check double activat. blk.`**

- Default setting **`(_:102) Check double activat. blk.`** = ***`yes`***

With the **`Check double activat. blk.`** parameter, you can determine whether the double activation of switching devices should be checked. The setting value ***`yes`*** indicates that a switching sequence will be started only if no switching commands for a circuit breaker and disconnector are activated, provided that double-activation blocking was activated for those switching devices.

Parameter: **`Time-out monitoring`**

With the **`Time-out monitoring`** parameter, you can determine whether the feedback from the process should be evaluated. The feedback is gathered via the inputs *`>Successful`* and *`>Failed`*.

Parameter: **`Monitoring time`**

- Default setting **`(_:104) Monitoring time`** = ***`30.00 s`***

With the **`Monitoring time`** parameter, you can determine the duration of the monitoring time.

Parameter: **`Control model`**

- Default setting **`(_:105) Control model`** = ***`SBO w. normal secur.`***

With the **`Control model`** parameter, you select between ***`direct w. normal secur.`*** or ***`SBO w. normal secur.`*** to start the switching sequence.

It is not possible to set a control model for cancelation of the switching sequence. The control model ***`direct w. normal secur.`*** is always used to cancel the function.

Information

The **Switching sequence** function block provides the following data:

Swi. seq. 1	13081	
>Enable start	13081.501	SPS
>Enable start (fixed)	13081.502	SPS
>Start	13081.503	SPS
>Cancel	13081.504	SPS
>Successful	13081.505	SPS
>Failed	13081.506	SPS
Health	13081.53	ENS
Execution	13081.302	ENS
start trigger		SPS
running		SPS
canceled		SPS
failed		SPS
successful		SPS
Start	13081.304	SPC
Cancel	13081.305	SPC
Switching auth. station	13081.303	SPC

[scinfof1-13112014, 1, en_US]

Figure 8-85 Data Provided by the **Switching Sequence** Function Block

In the **Switching sequence** function block, the interlocking is analog to the **Interlocking** function block and it is possible to use it in the switching sequence:

- *`>Enable start`*: Connection to interlocking conditions (CFC) for the start of the entire switching sequence. Not in effect in the **non-interlocked** switching mode.
- *`>Enable start (fixed)`*: Non-revocable interlocking conditions for the start of the entire switching sequence. In effect regardless of the switching mode.

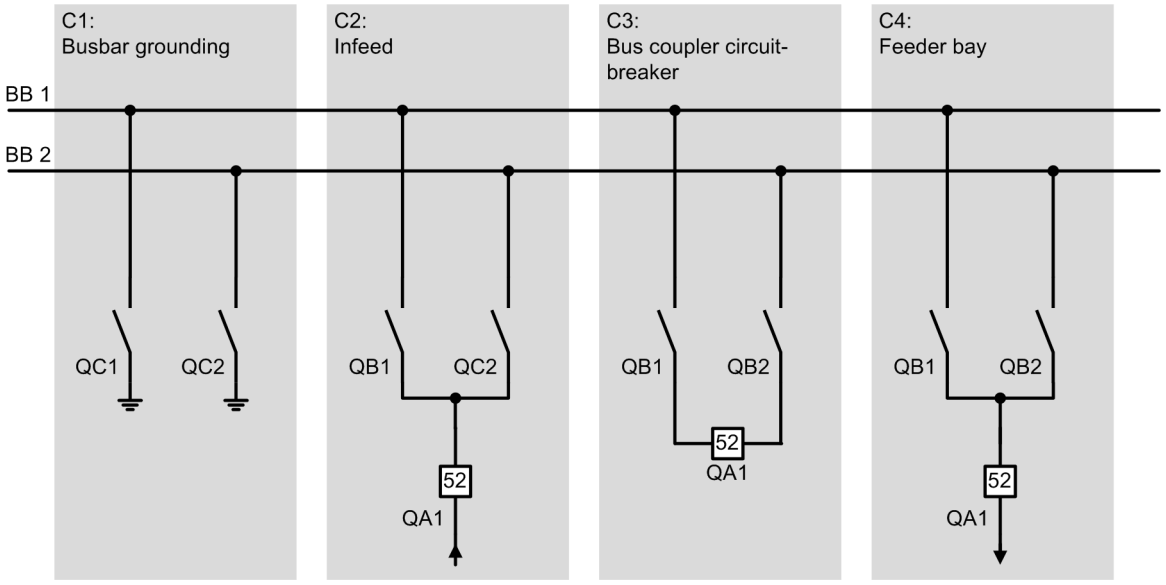
If the time-out monitoring is activated (parameter **`Time-out monitoring`**), the process feedback must take place via the inputs *`>Successful`* and *`>Failed`*. If the last switching command of the switching sequence was executed successfully, the input *`>Successful`* usually is set. To do this, connect the feedback of the last switching command from the CFC with this input of the function block during the device parameterization.

If a switching command fails, this feedback can be captured by the input *`>Failed`*. The active switching sequence will be ended immediately and does not have to wait for a time-out.

The indication *`Execution`* signals the current condition of the switching sequence. The events *`running`*, *`canceled`*, *`failed`*, and *`successful`* are generated only while the time-out monitoring is activated. The event *`Start Trigger`* is used to start the switching sequence in the CFC chart.

Example for a Switching Sequence with CFC

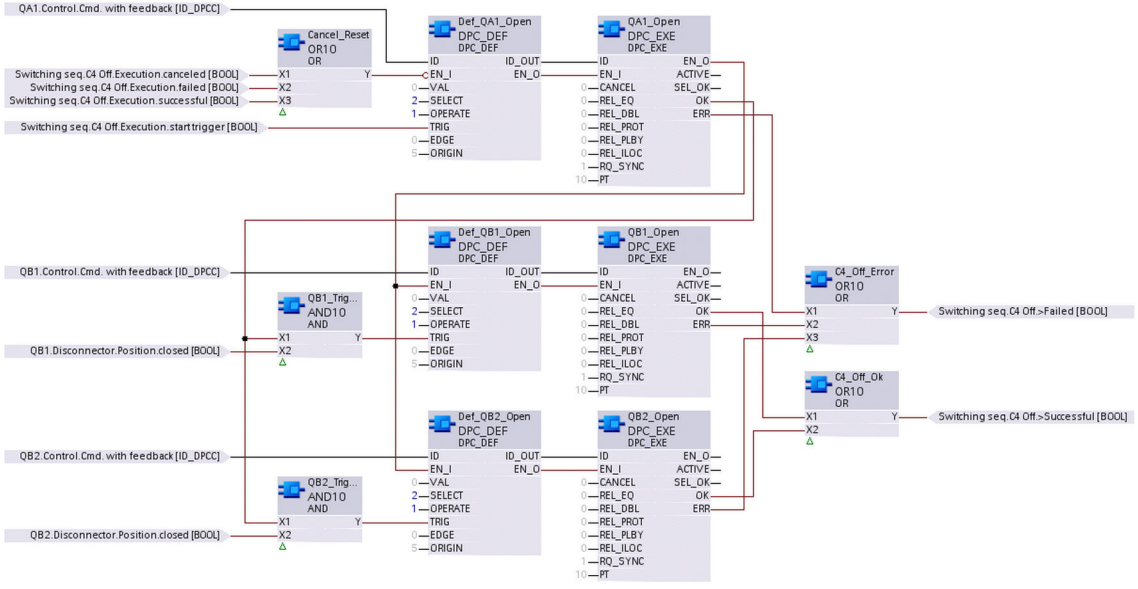
The following figure shows a single-line diagram for a substation with 4 bays: Busbar grounding, infeed, bus coupler, and feeder bay.



[dwbspunt-120913-01.vsd, 1, en_US]

Figure 8-86 Example of a Substation

The switching sequence **C4 Off** (*Figure 8-87*) should switch off feeder bay C4. The circuit breaker is opened; followed by opening of one of the 2 busbar disconnectors.



[Scssc4as-110913-01, 1, en_US]

Figure 8-87 CFC Switching Sequence **C4 Off**

Command Execution

As described in section *Starting and Canceling a Switching Sequence, Page 1107*, the display page or the **Control** menu can be used to start the switching sequence. The *Start Trigger* signal for indication *Execution* is used to recognize the start and initiates the switching sequence by pickup of **TRIG** in the DPC-DEF building block of circuit breaker QA1. Building blocks DPC-DEF and DPC-EXE are always used in pairs. The DEF building block controls the type and nature of the command

- **VAL** = Switching direction (0 = Off, 1 = On)
- **SELECT** = Select switching device (2 = Select with a value suitable for the preset control model ***SBO w. enh. security***)
- **OPERATE** = Switch switching device (1 = Switching device is switched on or off)

Using the connected DPC-EXE building block, the command checks can be deactivated (**REL_**...). In the application example, all inputs are set to 0 and therefore, all checks are activated.

After the open command of circuit breaker QA1 is acknowledged via the auxiliary contacts, the **OK** output of the CFC block DPC_EXE becomes active and triggers the next switching object. With the input **PT** the signal for the **OK** output is time-delayed (in the example by 10 ms) and creates a dead time between individual switching commands and the switching sequence. This dead time is important for the updating of the interlocking conditions.

If QB1 is closed, QB1 will be opened. If QB2 is closed, QB2 will be opened. In order to implement this logic, the **OK** output signal of QA1 is linked with the respective positions of circuit breakers QB1 and QB2 via the logical AND function. This signal serves as a trigger for the trip command of QB1 or QB2.

Because in this example the time-out monitoring is activated, the feedback about the successful or unsuccessful execution of the switching sequence must be parameterized. The **Switching sequence** function block provides the inputs *>Successful* and *>Failed*. In order to acknowledge the entire switching sequence positively, the OR operation of the **OK** outputs for the disconnectors QB1 and QB2 is sufficient. The feedback of all failed executions takes place via the OR operation of all **ERR** outputs of the switching devices. The benefit of such assessment is the fact that, in case of a failure, waiting for the time-out is not necessary, but the active switching sequence can be ended immediately.

In this example, the use of the **EN_I** input of building block DPC-DEF fulfills 2 tasks:

- Cancelation of the entire switching sequence
- Resetting of the outputs **OK** and **ERR** on building block DPC-EXE

By linking all **EN_I** inputs and **EN_O** outputs of building blocks DPC-DEF and DPC-EXE, the execution of the switching sequence can be controlled centrally since the value is transmitted between the building blocks. Only if input **EN_I** on the DPC-EXE is set to 1, a switching command is issued. If the input drops back to 0 while a command is being processed, this command will be canceled. With this behavior, cancelation of an entire switching sequence can be achieved. As recognition of a cancelation, the *canceled* signal of the indication *Execution* is used in the CFC chart and connected with the input **EN_I** of the first switching device, in this example, with the DPC-DEF building block of circuit breaker QA1.

Since the **OK** and **ERR** outputs of the DPC-EXE building block maintain their value until execution of the next command, it is necessary to reset the continuous output after each execution of the switching sequence for correct execution of the entire CFC switching sequence multiple times. In this case, the use of the **EN_I** input is also helpful. In the input drops back to 0, the **OK** and **ERR** outputs are also reset to 0. The triggers for ending the switching sequence are the events *failed* and *successful*. For this reason, in the above example, the signals *failed* and *successful* of the indication *Execution* were connected with **EN_I** of the DPC-DEF building block.

8.5.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Swi. seq. #				
_:101	Swi. seq. #:Check switching authority		• no • yes • advanced	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:102	Swi. seq. #:Check double activat. blk.		• no • yes	yes
_:103	Swi. seq. #:Time-out monitoring		• 0 • 1	true
_:104	Swi. seq. #:Monitoring time		0.02 s to 3600.00 s	30.00 s
_:105	Swi. seq. #:Control model		• direct w. normal secur. • SBO w. normal secur.	SBO w. normal secur.
_:106	Swi. seq. #:SBO time-out		0.01 s to 1800.00 s	30.00 s
Switching authority				
_:151	Swi. seq. #:Swi.dev. related sw.auth.		• 0 • 1	false
_:152	Swi. seq. #:Specific sw. authorities		• 0 • 1	true
_:115	Swi. seq. #:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:153	Swi. seq. #:Num. of specific sw.auth.		2 to 5	2
_:154	Swi. seq. #:Multiple specific sw.auth.		• 0 • 1	false

8.5.5 Information List

No.	Information	Data Class (Type)	Type
Swi. seq. #			
_:501	Swi. seq. #:>Enable start	SPS	I
_:502	Swi. seq. #:>Enable start (fixed)	SPS	I
_:503	Swi. seq. #:>Start	SPS	I
_:504	Swi. seq. #:>Cancel	SPS	I
_:505	Swi. seq. #:>Successful	SPS	I
_:506	Swi. seq. #:>Failed	SPS	I
_:53	Swi. seq. #:Health	ENS	O
_:302	Swi. seq. #:Execution	ENS	O
_:304	Swi. seq. #:Start	SPC	C
_:305	Swi. seq. #:Cancel	SPC	C

8.6 User-Defined Function Block [Control]

8.6.1 Overview of Functions

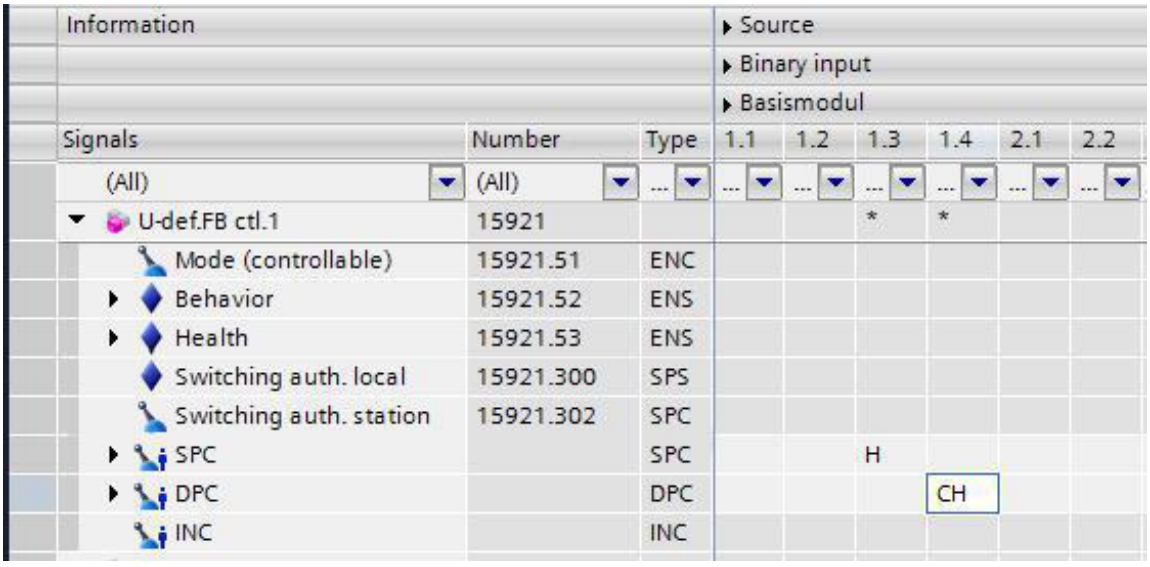
The **User-defined function block [control]** allows the switching-authority check of a control command and the check of whether the circuit breaker has reached the position for user-defined controllables.

8.6.2 Function Description

The **User-defined function block [control]** is located in the folder **User-defined functions** in the DIGSI 5 Library.

You can instantiate the user-defined function blocks on the top level (in parallel to other function groups) as well as within function groups and functions.

The task of the function block is to check the switching authority. For control commands, the function block checks whether the switching direction is the same as the current switch position. You can instantiate every user-defined signal (for example, SPS, DPC, INC) in the function block and route the corresponding indications (see following figure).

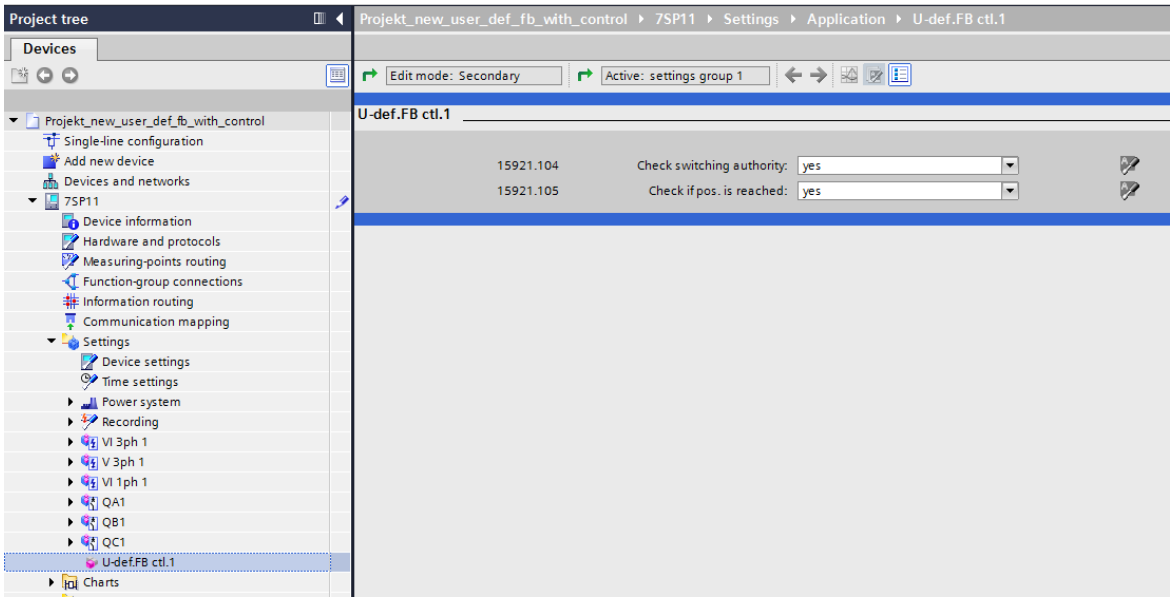


[scbenutz, 1, en_US]

Figure 8-88 Information Routing with Inserted User-Defined Function Block [Control]: Process Indications and Some Individual Indications

8.6.3 Application and Setting Notes

The function block contains the parameters **(_:104) Check switching authority** and **(_:105) Check if pos. is reached** as shown in the following figure. The parameter settings affect all controllables instantiated in the function block. Other signal types are not affected by these parameters and objects.



[user-def2, 1, en_US]

Figure 8-89 Parameterization Options of the User-Defined Function Block [Control]

Parameter: **`Check switching authority`**

- Default setting **`(_:104) Check switching authority`** = ***`yes`***

With the **`Check switching authority`** parameter, you determine whether the command source of switching commands must be checked (see chapter *8.3.1 Command Checks and Switchgear Interlocking Protection*).

Parameter: **`Check if pos. is reached`**

- Default setting **`(_:105) Check if pos. is reached`** = ***`yes`***

With the **`Check if pos. is reached`** parameter, you check at a switching command whether the switching direction equals the current position.

8.6.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`U-def.FB ctl.#`				
_:104	U-def.FB ctl.#:Check switching authority		• no • yes	yes
_:105	U-def.FB ctl.#:Check if pos. is reached		• no • yes	yes

8.6.5 Information List

No.	Information	Data Class (Type)	Type
`U-def.FB ctl.#`			
_:51	U-def.FB ctl.#:Mode (controllable)	ENC	C
_:52	U-def.FB ctl.#:Behavior	ENS	O
_:53	U-def.FB ctl.#:Health	ENS	O
_:300	U-def.FB ctl.#:Switching auth. local	SPS	O
_:302	U-def.FB ctl.#:Switching auth. station	SPC	C

8.7 CFC-Chart Settings

8.7.1 Overview of Functions

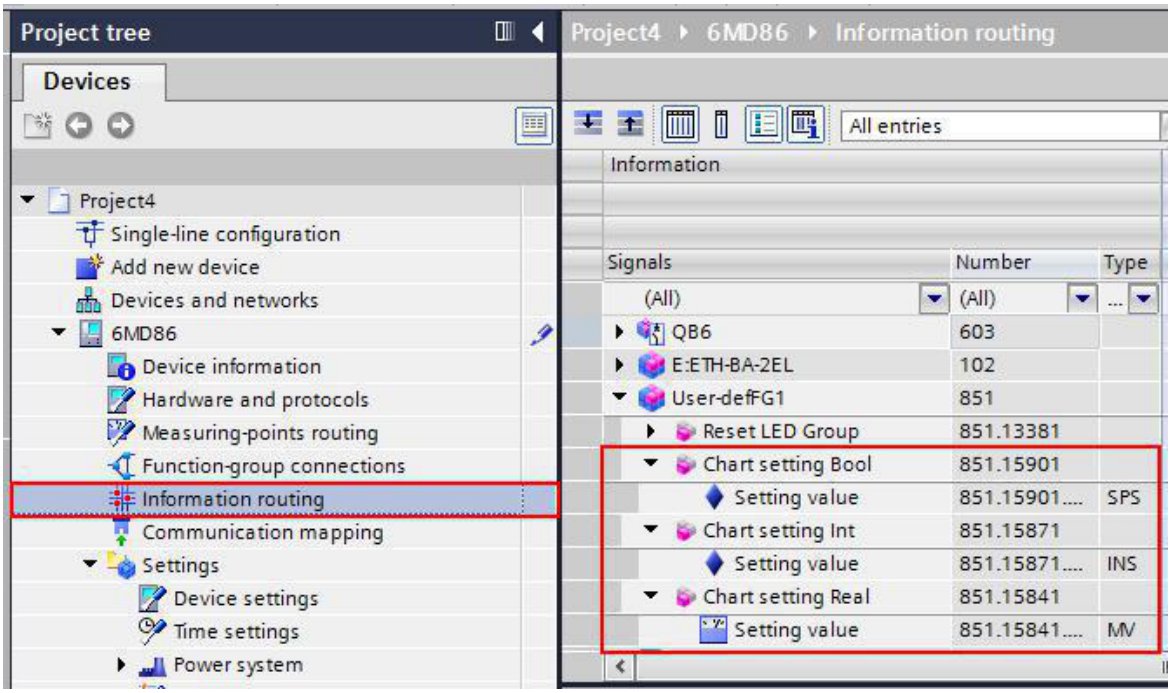
If you want to process a parameter in a CFC chart and this parameter is to be changeable via DIGSI or HMI during runtime, you can use the function blocks **Chart setting Bool**, **Chart setting Integer**, and **Chart setting Real**. Instantiate the appropriate function block depending on the needed parameter value (logical, integer, or floating point).

8.7.2 Function Description

You can find the CFC-chart parameters **`Chart setting Bool`** , **`Chart setting Int`** , and **`Chart setting Real`** in the DIGSI library in the **User-defined functions** folder. Drag and drop the desired function block into a function group or a function. Set the appropriate parameter value of the function block in DIGSI using the parameter editor or via HMI under the **Settings** menu item. You can then use the parameter as an input signal in CFC charts.

NOTE

The user-defined function groups and the user-defined functions can be used to group the CFC-chart parameters. You can rename for the function block and change the parameter value in the DIGSI Information routing matrix to suit your specific application.



[sccfcparam, 1, en_US]

Figure 8-90 CFC-Chart Parameters within Information Routing

8.7.3 Application and Setting Notes

Parameter: `Chart setting Bool`

- Default setting **`Chart setting Bool`** = ***`False`***

You can use the parameter **Chart setting Bool** in a CFC chart as an input signal with a Boolean value. This input value can then be changed during the runtime of the CFC chart.

Parameter: Chart setting Int

- Default setting **Chart setting Int** = ***10***

You can use the parameter **Chart setting Int** in a CFC chart as an input signal with an integer value. This input value can then be changed during the runtime of the CFC chart.

Parameter: Chart setting Real

- Default setting **Chart setting Real** = ***100.000***

You can use the parameter **Chart setting Real** in a CFC chart as an input signal with a floating-point number. This input value can then be changed during the runtime of the CFC chart.

8.7.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Chart setting Bool				
_:105	Chart setting Bool:Value		• 0 • 1	false

Addr.	Parameter	C	Setting Options	Default Setting
Chart setting Int				
_:105	Chart setting Int:Value		-2147483648 to 2147483647	10

Addr.	Parameter	C	Setting Options	Default Setting
Chart setting Real				
_:105	Chart setting Real:Value		-10000000000.000 % to 10000000000.000 %	100.000 %

8.7.5 Information List

No.	Information	Data Class (Type)	Type
Chart setting Bool			
_:305	Chart setting Bool:Setting value	SPS	O

No.	Information	Data Class (Type)	Type
Chart setting Int			
_:305	Chart setting Int:Setting value	INS	O

No.	Information	Data Class (Type)	Type
Chart setting Real			
_:305	Chart setting Real:Setting value	MV	O

8.8 Transformer Tap Changers

8.8.1 Function Description

With the device control function, you can change a transformer tap by moving it higher or lower and monitor the proper execution of the adjusting commands.

The function has built-in comprehensive options for measuring the tap changer position as well as supervision functions. The supervision functions are used to check the voltage and supply information about the tap position for adaptive matching of the transformer differential protection.

The following options are provided for control:

- Direct user commands via the device keypad or routed binary inputs
- User-defined conditions via the CFC

If the tap changer reaches the end positions, the control function issues the *(_:301) End higher pos.reached* or *(_:302) End lower pos.reached* indication.

The transformer tap controller is controlled by the function group **Tap changer**, which you can select from the DIGSI library (group **Switching devices**).

Tap changer 1	161		*	*	*	*
Tap changer	161.5461		*	*	*	*
>Acquisition blocking	161.5461.500	SPS				
>Enable	161.5461.501	SPS				
>Reset AcqBlk&Subst	161.5461.504	SPS				
Health	161.5461.53	ENS				
End higher pos.reached	161.5461.301	SPS				
End lower pos.reached	161.5461.302	SPS				
Position	161.5461.308	BSC	X	X	X	X
acquisition blk. active		SPS				
manual update active		SPS				
Higher command	161.5461.305	SPS				
Lower command	161.5461.306	SPS				
Command active	161.5461.307	SPS				
Motor sup. time expired	161.5461.309	SPS				
Trigger motor prot. sw.	161.5461.310	SPS				
Position failure	161.5461.311	SPS				
Op.ct.	161.5461.312	INS				
Reset failure	161.5461.319	SPC				
Switching auth. station	161.5461.317	SPC				

[sc_tssdig, 1, en_US]

Figure 8-91 Tap Changer Functionality in the DIGSI Information Matrix

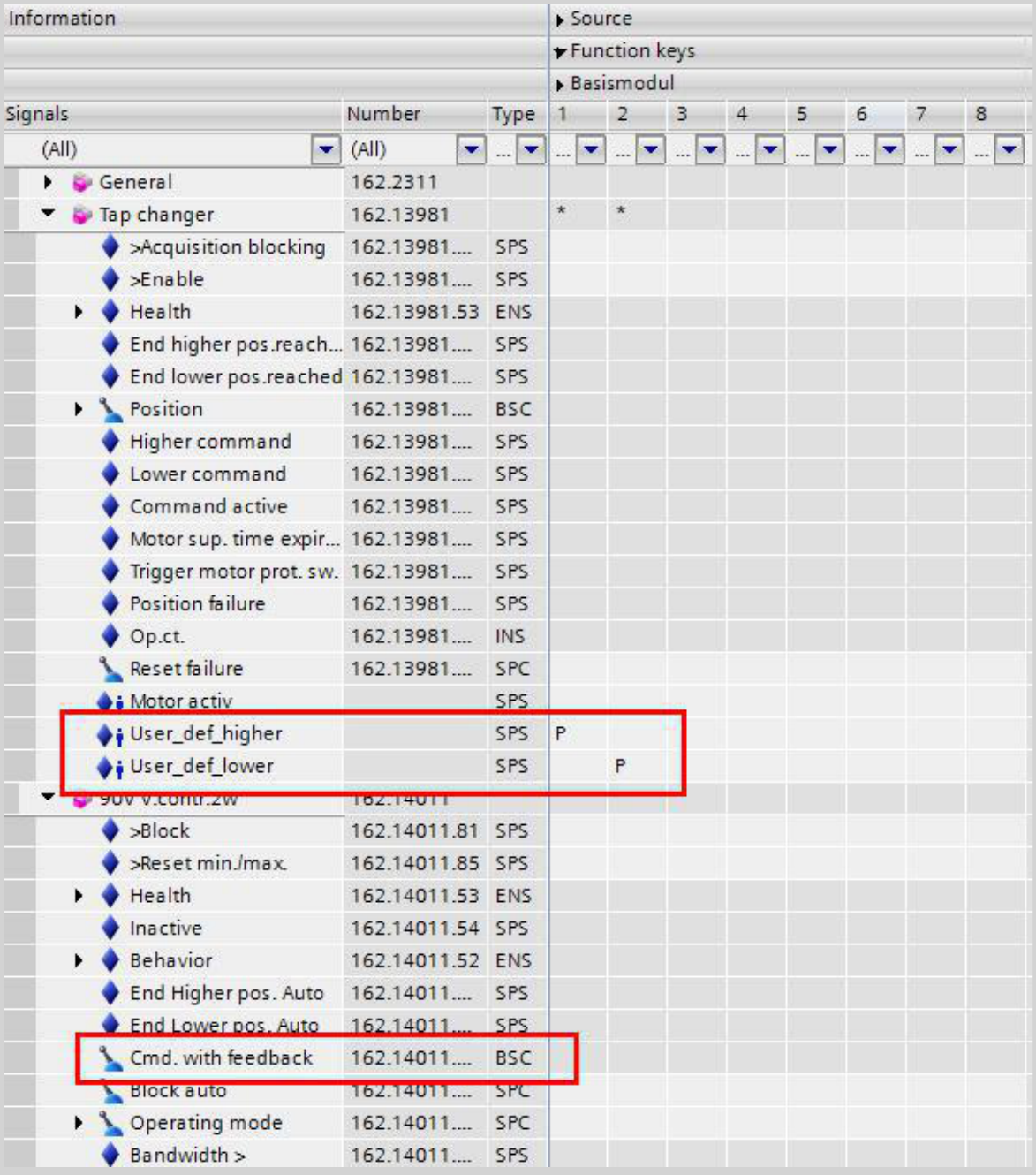
The central element is the Controllable **Position** of type BSC (Binary Controlled Step Position Information, based on IEC 61850). You connect this Controllable in the matrix to the desired number of binary inputs that indicate the current tap position.

You can find more information in chapter *8.8.2 Application and Setting Notes* .

The **Position** Controllable also contains settings. If you wish to change the settings, you must select the Controllable in the DIGSI information matrix and change the settings by way of the Properties dialog. The taps are controlled via the commands **Higher command** and **Lower command**, each of which must be connected to one binary output.

Example

The following 2 figures show a CFC chart as an example for transformer tap control with the routing of the function keys for stepping up or stepping down.



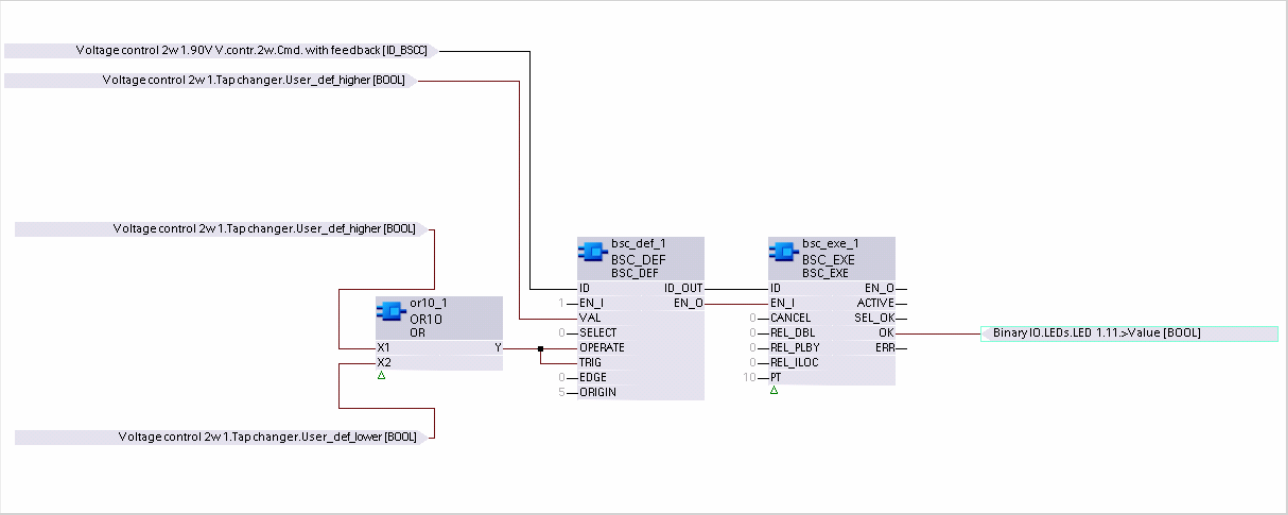
[schilocd-280316-01, 2, en_US]

Figure 8-92 Routing of the Function Keys and CFC Signals

To use the function keys, you create 2 user-defined single-point indications (SPS). These are used for the function keys (for example, <F1>, Higher function key and <F2>, Lower function key) and as the input signals for the appropriate CFC blocks. In addition, you must use the controllable **`Cmd. with feedback`** for the CFC chart.

You can select the control direction using the following values at the **Val** input of the BSC_DEF block.

- 1 means **step up**
- 0 means **step down**



[scbivctv-280715-01, 2, en_US]

Figure 8-93 CFC Chart

Using this simple CFC chart, pressing the function keys to step up or down incrementally can be displayed.

Motor Supervision Time

The runtime of the motor drive can be monitored from the device. This function is used to identify failures of the motor drive during switching and to trip actions if necessary. To use the **Motor supervision time** , you must route the motor sliding contact (highest binary input) and set the proper motor runtime.

The motor sliding contact is active until the tap changer has reached the new position. This time is compared to the **Motor supervision time** . If the new tap position is not reached within the motor runtime, the *Motor sup. time expired* indication is set. The *Trigger motor prot. sw.* indication with which the motor can be switched off is output after 1.5 s.

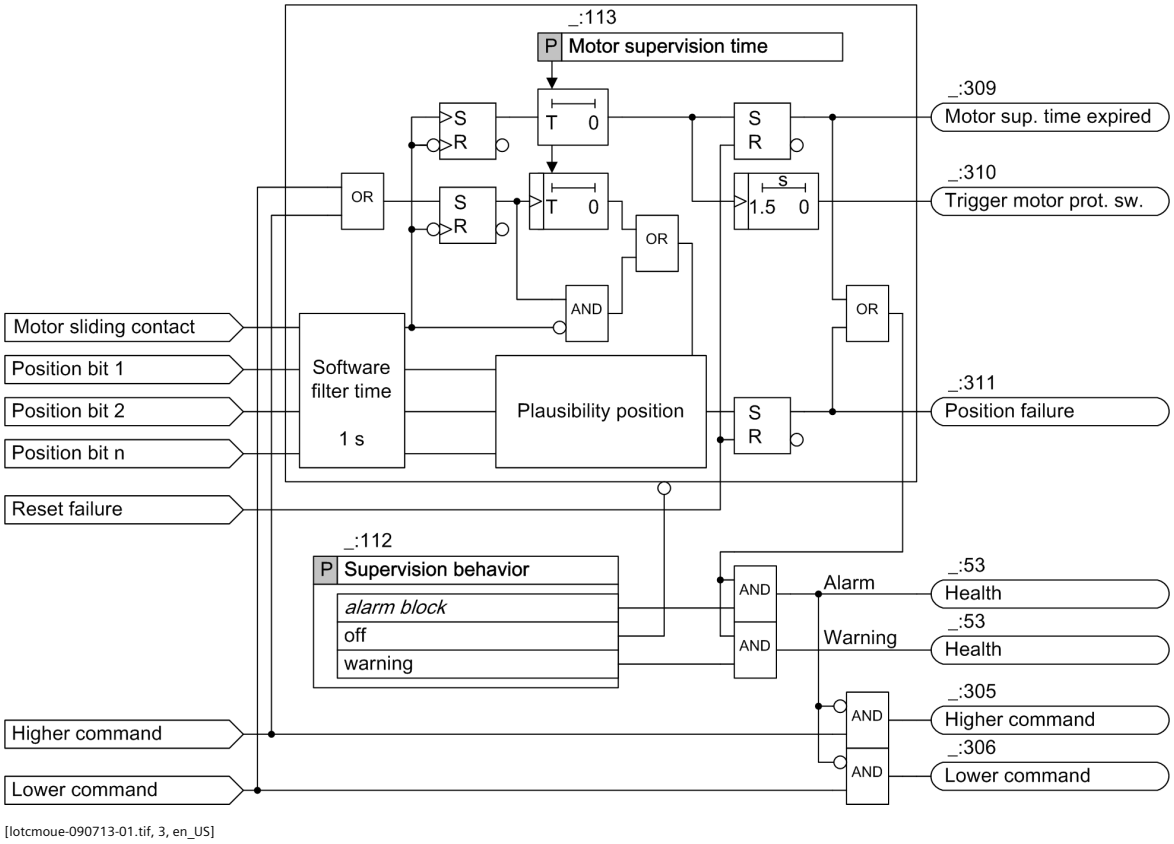
Adjusting-Command Monitoring

The adjusting-command monitoring is used for checking the proper operation of the tap-changer mechanism. The **Tap changer** function calculates the next logical tap position as a result of the higher/lower command. The time of position detection is determined as a function of the availability of the motor sliding contact. After resetting the active motor sliding contact, the **Tap changer** function reads the new tap position value. If the value for the next tap position could not be received within the parameterized time **Motor supervision time** , the error message *Position failure* is issued.

The following position errors of the tap changer considered during this:

- Invalid tap position: The tap position is outside the predefined range of **minimum value** and **maximum value**
- Position command in the wrong direction (for example, if a higher tap was commanded and the tap changer responds with a lower position or vice versa)
- No operation of the tap changer (for example, if the tap-changer motor is defective or the position indication is not functioning)
- Illogical tap-change operation (for example, if no logical tap position following the previous position is indicated)

The value of 0 during an unexpected interruption of the auxiliary voltage represents a special case. An invalid tap-changer position without a corresponding adjusting command is signaled only as an invalid tap position in the **Position** controllable.



[lotcmoue-090713-01.tif, 3, en_US]

Figure 8-94 Position and Motor Supervision Logic

Supervision Behavior

Depending on the setting of the **Supervision behavior** parameter, the function reaches a health state of **Alarm** or **Warning**. You can set the **Supervision behavior** parameter to ***off*** , ***alarm block*** , or ***warning*** .

In the ***alarm block*** mode, the function is set to the health state **Alarm**. All tap-changer commands are blocked.

In the ***warning*** mode, the function is set to the health state **Warning**. Executing tap-changer commands is still possible.

You can reset the health state of ***alarm block*** or ***warning*** manually using the controllable **Reset errors** (Main menu → Device functions → Reset functions → Tap changer). As an alternative to this, you can also switch off the supervision function and then switch it on again.

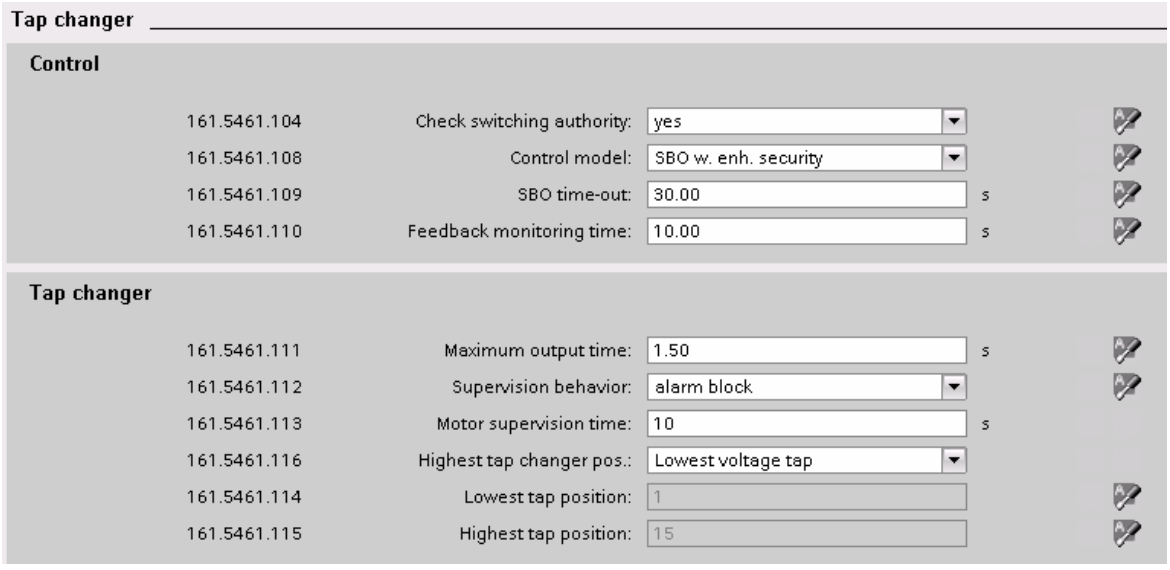
Operating Meter

The device counts the number of successfully completed adjusting commands with the ***Op.Ct.*** switching cycle metered value. The meter and memory levels are protected against an auxiliary-voltage failure. The switching cycle metered value can be preconfigured to 0 or to any other starting value.

You can access the statistical values via the operation panel on the device (measured values/statistics), via DIGSI, or using various communication protocols.

8.8.2 Application and Setting Notes

Parameters of the Transformer Tap Changer Function Group



[scstuslt-100713-01.tif, 2, en_US]

Figure 8-95 Parameters of the Tap Changer

NOTE

If run positions, this means internal tap changer positions without voltage changes, are available, the following must be observed:

If these tap changer positions contain a suffix a and c or + and -, and additional switching pulses are not required, adjust the parameter for the feedback and motor supervision time to the actual motor runtime when passing through a run position. Siemens recommends parameterization with capturing the motor sliding contact.

Parameter: `Check switching authority`

- Default setting **`(_:104) Check switching authority`** = ***`yes`***

Parameter: `Control model`

- Default setting **`(_:108) Control model`** = ***`SBO w. enh. security`***

Use the **`Control model`** parameter to specify the control model according to IEC 61850-7-2. The following selection options are available:

- ***`direct w. normal secur.`***
- ***`SBO w. normal secur.`***
- ***`direct w. enh. security`***
- ***`SBO w. enh. security`***
- ***`status only`***

Parameter: `SBO time-out`

- Default setting **`(_:109) SBO time-out`** = ***`30 s`***

With this setting, you specify the time for detecting the time-out of the SBO command. The range of values extends from 0.01 s to 1800.00 s. This is the time that can elapse between command acceptance and command execution (command model as per IEC 61850-7-2).

Parameter: Feedback monitoring time

- Default setting **(_:110) Feedback monitoring time** = ***10 s***

Reaching a new tap position after the switching command is monitored. If a new tap position is not reached, you specify with this setting the time when the command is canceled. The range of values extends from 0.01 s to 1800.00 s.

Parameter: Maximum output time

- Default setting **(_:111) Maximum output time** = ***1.50 s***

This parameter specifies the maximum output time. The range of values extends from 0.01 s to 1800.00 s. For activating motors to change the tap position, a time of 1.50 s is practical.

Parameter: Supervision behavior

- Default setting **(_:112) Supervision behavior** = ***alarm block***

You can select whether the supervision is switched off (***off***) or if only a warning is indicated (***warning***). With the ***alarm block*** setting, an alarm indication is generated and the function is blocked.

Parameter: Motor supervision time

- Default setting **(_:113) Motor supervision time** = ***10 s***

After the motor supervision time has elapsed, the indication *Motor sup. time expired* is displayed. Additional information can be found in the margin title *Motor Supervision Time, Page 1119* . The range of values extends from 5 s to 100 s.

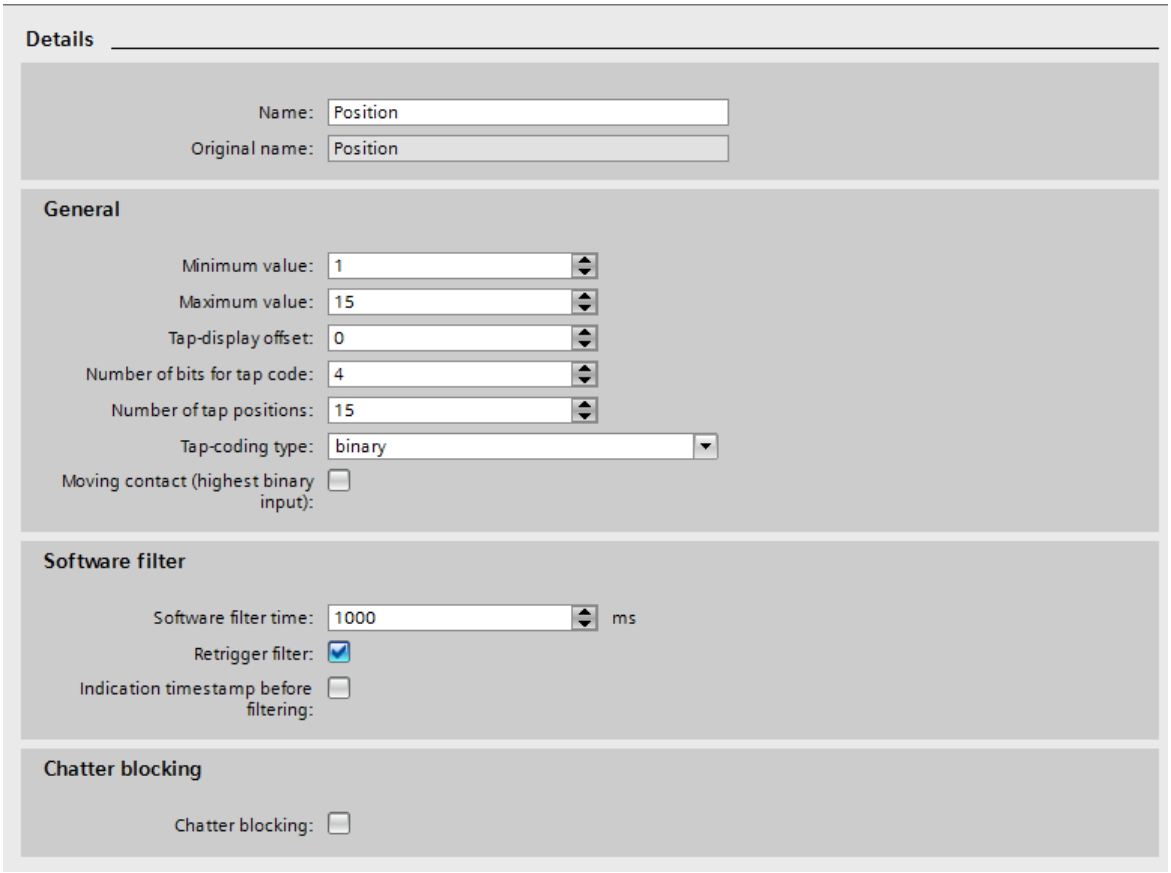
Parameter: Highest tap changer pos.

- Default setting **(_:116) Highest tap changer pos.** = ***Lowest voltage tap***

With the parameter **Highest tap changer pos.**, indicate whether the lowest or highest voltage is present at the highest tap changer position.

Additional Settings (Properties Dialog Position)

Additional settings are assigned to the controllable *Position*. To display and adjust the settings, select *Position* in the DIGSI information matrix and select the Properties dialog. To do this, click the **Properties** tab.



[scdeegts-170216-01, 1, en_US]

Figure 8-96 Properties Dialog

Parameter: `Minimum value`

- Default setting **`Minimum value`** = ***1***

Parameter: `Maximum value`

- Default setting **`Maximum value`** = ***15***

The **`Minimum value`** and **`Maximum value`** settings are initially calculated by DIGSI 5 based on the tap coding, the **`Number of tap positions`**, and the **`Tap-display offset`**. They represent the allowed control area of the position value. Positions outside this area are defined as invalid. This control area can be further restricted within the initially set physical range (see the **`Number of tap positions`** and the **`Tap-display offset`**).

Parameter: `Tap-display offset`

- Default setting **`Tap-display offset`** = ***0***

If you want to move the height of the displayed value in a positive or the negative direction with respect to the height of the actual value, enter the value for this in the **`Tap-display offset`** field.

Parameter: `Number of bits f. tap code`

- Default setting **`Number of bits f. tap code`** = ***4***

With the **`Number of bits f. tap code`** parameter, set the number of bits you need for coding the transformer taps. The number is dependent on the selected **Encoding** and on the **Moving contact**. For example, you need 3 bits for 7 binary-encoded transformer taps. The range of values extends from 2 to 32.

Parameter: `Number of tap positions`

- Default setting **`Number of tap positions`** = ***15***

With the **`Number of tap positions`** parameter, you set the number of transformer taps. The range of values extends from 2 to 127. The output of the tap position is limited from -63 to +63. If the number of taps is > 63, set the parameter **`Tap-display offset`** so that the tap position is within the range of -63 to +63.

Parameter: `Tap-coding type`

- Default setting **`Tap-coding type`** = ***binary***

In the **`Tap-coding type`** list box, select the interpretation type of the indication pending at the binary input.

You can select from the following options:

- ***binary***
- ***1-of-n***
- ***BCD***
- ***table***
- ***BCD signed***
- ***gray***

If you want to specify an individual **`Tap-coding type`**, select ***table***.

In the **`Representation of encoding`** section, select the numbering system in which your code table entries will take place, alternatively:

- ***Binary (2 characters)***
- ***Octal (8 characters)***
- ***Decimal (10 characters)***
- ***Hexadecimal (16 characters)***

The selected option is valid for all inputs in the **`Encoding`** column.

If you change the number system and there are already entries in this column these will be converted to the new number system. The selection area becomes visible as soon as you have selected the setting ***table*** in the list box **`Tap-coding type`**.



NOTE

If the binary inputs used for encoding are all inactive, this indicates an invalid tap position (regardless of the display offset). For an invalid tap position, the display shows the position **---** or **-64** with quality **invalid**; the exception is BCD with sign, see *Routing of the Binary Inputs (Tap Coding Type: BCD with Sign), Page 1125* .

Enter the encoding for the tap in the **Encoding** column in the **Code table**. Enter the value according to the numbering system previously selected. Select the desired number of taps and number of bits for tap coding. Taps with the same encoding and taps with 0 coding are not permitted.

Routing of the Binary Inputs (Tap Coding Type: Binary)

The following table shows the routing of 3 binary inputs (BI 1 to BI 3) with 4 transformer tap positions designated 3 to 6. BI4 is the moving contact. The encoding is in binary.

Table 8-25 Routing of the Binary Inputs (Tap Coding Type: Binary)

	Example					
	BI1	BI2	BI3	BI4	BI5	BI6
Tap changer	X	X	X	X		

	Example					
Meaning	Bit 1	Bit 2	Bit 3	Moving contact		
Tap = 1	1	0	0			

With 3 binary inputs, a maximum of 2^3 -1 = 7 tap positions can be mapped in binary code. If all routed binary inputs indicate 0, this is interpreted as a connection error and is reported by Position **---** or **-64** with quality **invalid**. The representation of transformer taps should start with the numerical value 3. The information properties must be configured as follows for the example:

Tap-coding type:	Binary
Number of tap positions:	4
Number of bits f. tap code:	4
Tap-display offset:	2
Moving contact (highest binary input):	Yes

The 3 binary inputs must be numbered sequentially, for example, BI 1, BI 2, BI 3 and BI 4 for the moving contact.

Routing of the Binary Inputs (Tap Coding Type: BCD with Sign)

The following table shows the routing of 3 binary inputs (BI 1 to BI 3) with 7 transformer tap positions designated -3 to 3. The encoding uses BCD with sign.

Table 8-26 Routing of the Binary Inputs (Tap Coding Type: BCD with Sign)

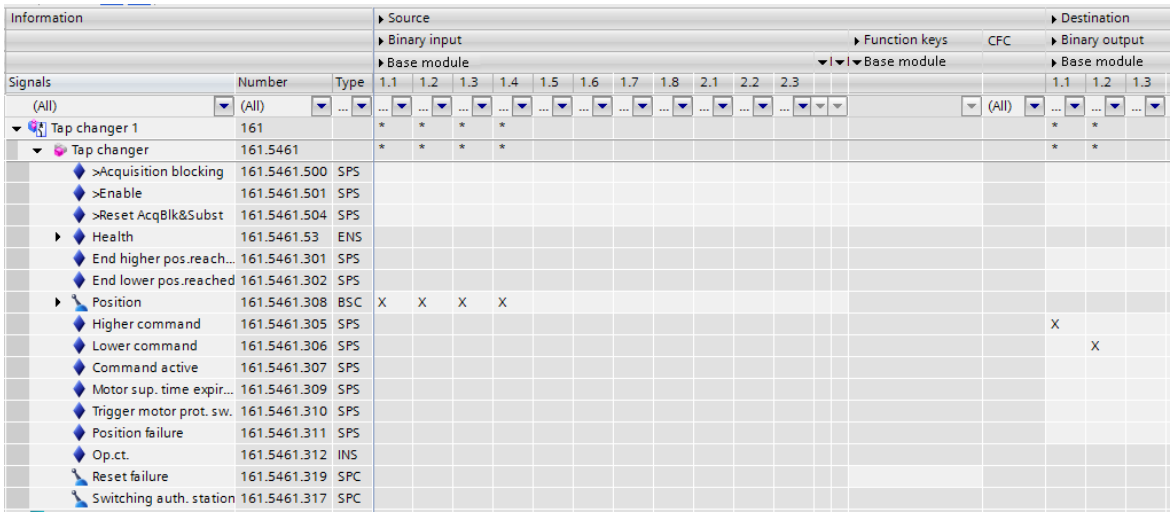
	Example					
	BI1	BI2	BI3	BI4	BI5	BI6
Tap changer	X	X	X			
Meaning	Bit 1	Bit 2	Sign			
Tap = 1	1	0	1			

Using 3 binary inputs, a maximum of 7 tap positions can be mapped with the tap coding type of BCD with sign. This yields the number of tap positions from -3 to 3. If all routed binary inputs indicate 0, this is recognized as tap 0. The 3 binary inputs must be numbered sequentially.

Tap-coding type:	BCD with sign
Number of tap positions :	7
Number of bits f. tap code:	3
Tap-display offset:	0
Moving contact (highest binary input):	No

Routing the Tap Position to Binary Outputs

For the output of the adjusting commands, route the information **step up** and **step down** on one relay each, see following figure.



Information			Source											Destination		
			Binary input									Function keys	CFC	Binary output		
			Base module									Base module		Base module		
Signals	Number	Type	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.1	2.2	2.3	1.1	1.2	1.3
(All)	(All)															
Tap changer 1	161		*	*	*	*								*	*	
Tap changer	161.5461		*	*	*	*								*	*	
>Acquisition blocking	161.5461.500	SPS														
>Enable	161.5461.501	SPS														
>Reset AcqBlk&Subst	161.5461.504	SPS														
Health	161.5461.53	ENS														
End higher pos.reach...	161.5461.301	SPS														
End lower pos.reached	161.5461.302	SPS														
Position	161.5461.308	BSC	X	X	X	X										
Higher command	161.5461.305	SPS												X		
Lower command	161.5461.306	SPS													X	
Command active	161.5461.307	SPS														
Motor sup. time expir...	161.5461.309	SPS														
Trigger motor prot. sw.	161.5461.310	SPS														
Position failure	161.5461.311	SPS														
Op.ct.	161.5461.312	INS														
Reset failure	161.5461.319	SPC														
Switching auth. station	161.5461.317	SPC														

[sc_trass7, 1, en_US]

Figure 8-97 Routing the Tap Setting Commands

Parameter: `Moving contact (highest binary input)`

- Default setting **`Moving contact (highest binary input)`** = ***no***

If the tap position is not to be recognized as valid and accepted until the motor sliding contact signals that it has reached the taps, then activate the **`Moving contact (highest binary input)`** option. If this parameter is set, the new positions are shown and labeled with an *****.

Parameter: `Software filter time`

- Default setting **`Software filter time`** = ***1000 ms***

With this parameter, you specify the **`Software filter time`** for capturing the tap position. The range of values extends from 0 ms to 86400000 ms. Within this time, brief changes on the binary inputs are suppressed.

Parameter: `Retrigger filter`

- Default setting **`Retrigger filter`** = ***yes***

With this parameter, you switch retriggering of the filtering time by a position change on or off.

Parameter: `Indication timestamp before filtering`

- Default setting **`Indication timestamp before filtering`** = ***no***

With this parameter, you specify whether the hardware filtering time is accounted for in the time stamp of position capture.

Parameter: `Chatter blocking`

- Default setting **`Chatter blocking`** = ***no***

With this parameter, you switch **`Chatter blocking`** on or off.

8.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Tap changer				
_:104	Tap changer:Check switching authority		• no • yes	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:108	Tap changer:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:109	Tap changer:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:110	Tap changer:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Tap changer				
_:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s
_:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:113	Tap changer:Motor supervision time		5 s to 100 s	10 s

8.8.4 Information List

No.	Information	Data Class (Type)	Type
Tap changer			
_:500	Tap changer:>Acquisition blocking	SPS	I
_:501	Tap changer:>Enable	SPS	I
_:53	Tap changer:Health	ENS	O
_:301	Tap changer:End higher pos.reached	SPS	O
_:302	Tap changer:End lower pos.reached	SPS	O
_:308	Tap changer:Position	BSC	C
_:305	Tap changer:Higher command	SPS	O
_:306	Tap changer:Lower command	SPS	O
_:307	Tap changer:Command active	SPS	O
_:309	Tap changer:Motor sup. time expired	SPS	O
_:310	Tap changer:Trigger motor prot. sw.	SPS	O
_:311	Tap changer:Position failure	SPS	O
_:312	Tap changer:Op.ct.	INS	O
_:319	Tap changer:Reset failure	SPC	C

8.9 Voltage Controller

8.9.1 Overview of Functions

The transformer voltage controller functionality (ANSI 90V) is used to control power transformers (two-winding transformers, three-winding transformers, grid coupling transformers) and auto transformers using a motor-operated tap changer. The function provides automatic voltage control within a specified voltage range on the secondary side of the transformers or, as an alternative, at a remote load point (Z compensation or R/X compensation) in the network. In order to compensate for the voltage variations in the meshed system, use the ***LDC-Z*** procedure (Z compensation). For voltage drops on the line, use the ***LDC-XandR*** procedure (R/X compensation).

The control principle is based on the fact that a higher or lower command to the tap changer, as a function of the voltage change (ΔV) per tap, causes a voltage increase or decrease.

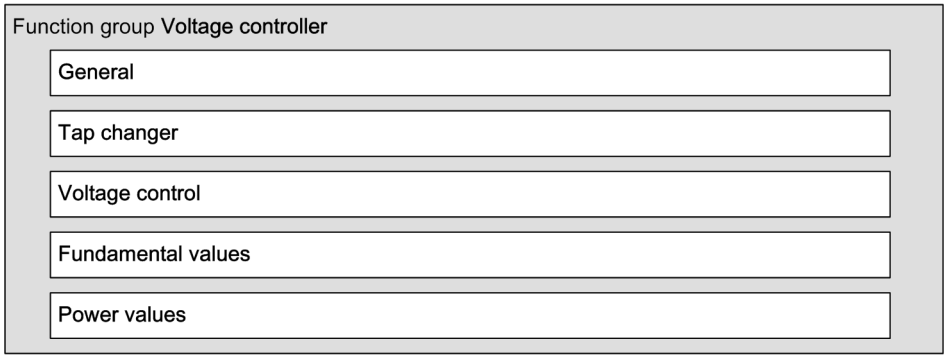
The voltage control operates on a tap-for-tap basis and compares the measured actual voltage (Vact) to the specified target voltage (Vtarget). If the voltage difference is greater than the set bandwidth (B), a higher or lower command is sent to the tap changer once the set time delay (T1) has elapsed. Specifying the time delay (T1) depends on the set controller response (inverse or linear), to avoid unnecessary adjusting commands during brief voltage deviations from the target value and for coordination with other automatic voltage controllers in the system.

The voltage controller function also monitors the currents on the upper-voltage side and the low-voltage side of the transformer to block the controller during impermissible operating states (overcurrent/undercurrent/undervoltage). The voltage controller function also has limiting values that, in special operating cases, suppress higher commands in the case of overvoltage and lower commands in the case of undervoltage.

8.9.2 Structure of the Function

The **Two-winding transformer voltage controller**, **Three-winding transformer voltage controller**, and **Grid coupling transformer voltage controller** function groups consist of 5 function blocks. Depending on the application, the function groups are preconfigured in the relevant application template by the manufacturer or can be copied into the corresponding device project during engineering.

The following figure shows, for example, the functional scope of the **Two-winding transformer voltage controller** function group.



[dwvolctl-060913-01.vsd, 2, en_US]

Figure 8-98 Structure/Embedding of the Function Group

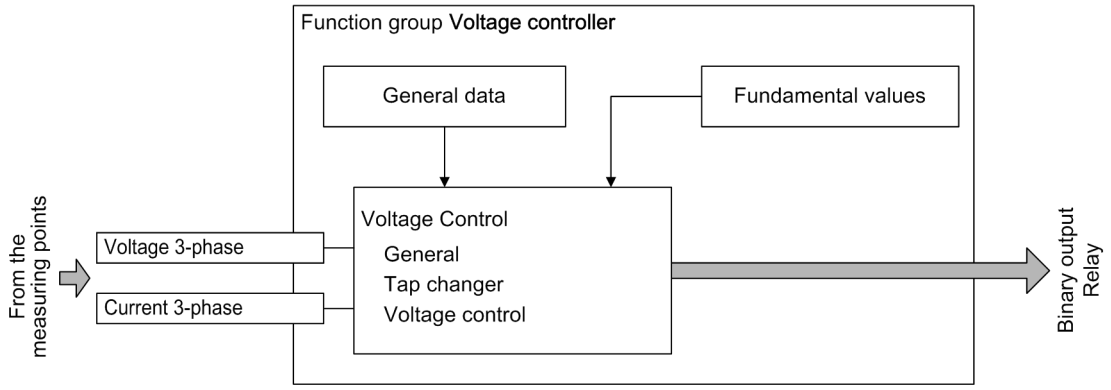
The functions **General** (GAPC), **Tap changer** (YLTC), and **Voltage controller** (ATCC) are logical node points in IEC 61850-8-1.

The tap changer (YLTC) is the interface between the voltage controller (ATCC) and the motor-operated tap changer of the transformer (OLTC). This means that the voltage controller (ATCC) sends higher and lower commands to the tap changer. This tap changer issues command pulses to the motor-operated tap changer of the transformer (OLTC). The tap changer (YLTC) measures the tap positions and monitors the action of the motor-operated tap changer (OLTC).

The function group has interfaces to the following measuring points:

- **Two-winding transformer**:
  - Voltage, 3-phase
  - Current, 3-phase (optional)
- **Three-winding transformer**:
  - 2 x voltage, 3-phase
  - 2 x current, 3-phase (optional)
- **Grid coupling transformer**:
  - 2 x 3-phase voltage
  - 2 x 3-phase current

Figure 8-99 shows these interfaces as a block structure.



[dwvocnti-060913-01.vsd, 2, en_US]

Figure 8-99 Structure of the Voltage Control Function Group

You can find the information and function measured values of the voltage controller in the DIGSI routing matrix.

8.9.3 Function Description

If the load is increased in an electricity-supply system, the voltage is reduced and vice versa. The power transformers are usually equipped with transformer tap changers (OLTC) so as to keep the power-system voltage at a constant level.

As a result, the transformer ratio is changed in predefined steps. Changing the transformer taps causes the voltage to change.

The Voltage control function is intended to control transformers with motor-operated transformer tap changers.

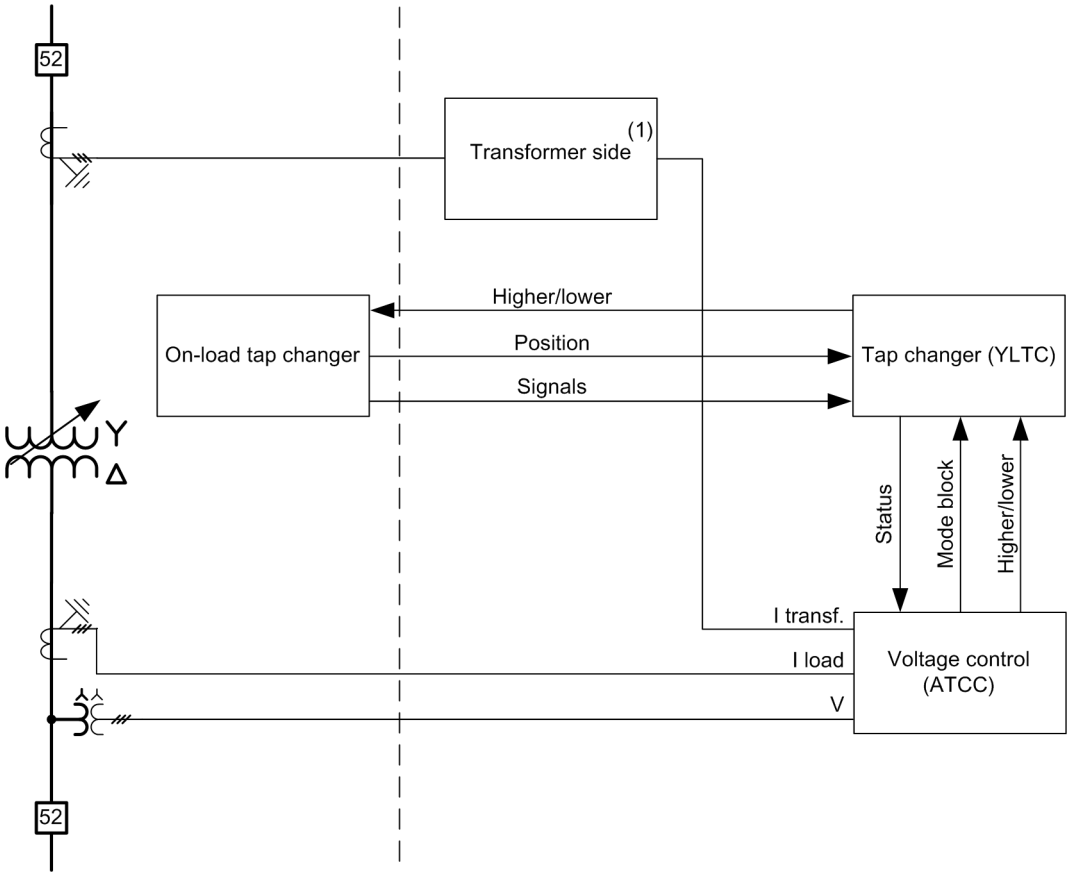
This function is designed to control the following:

- For two-winding transformers (2W): the voltage on the secondary circuit of the power transformer
- For three-winding transformers (3W): the voltage of the secondary winding 1 or winding 2
- For grid coupling transformers (GC): voltage of winding 1 or winding 2, selectively depending on the power direction

The control operation is based on a step-by-step principle. To move the tap changer one position higher or lower, a single control pulse is issued to the motor-drive mechanism of the tap changer. The length of the control pulse can be set over a large range so as to handle the very different types of tap-changer drives. The control pulse is issued if the measured voltage deviates from the set reference value by more than the preset voltage range for more than a given time period.

The voltage can be controlled at the voltage measuring point or at the load point in the electrical power system. In this case, the load-point voltage is calculated on the basis of the measured load current and the known impedance between the voltage measuring point and the load point.

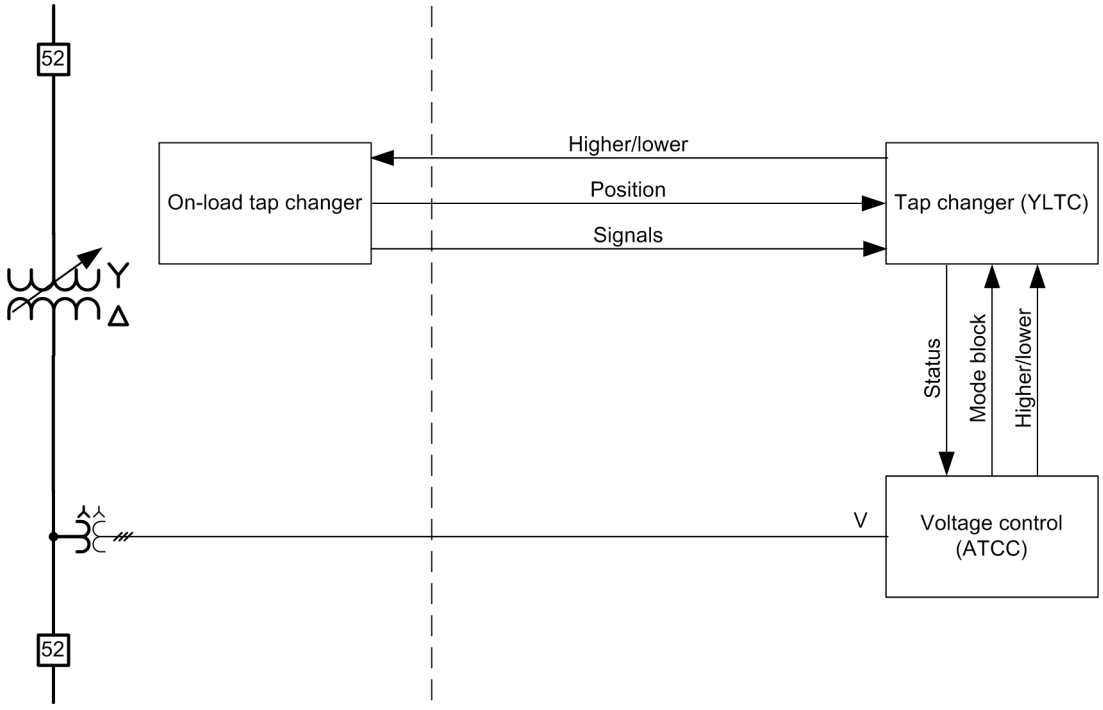
The following figures show possible configurations of the voltage controller for two-winding transformers with and without current measurement.



[dwkonlst-060913.vsd, 1, en_US]

Figure 8-100 Voltage-Controller Constellation for Two-Winding Transformers with Current Measurement for Load Compensation at the End of the Line

(1) Only if a transformer side is present



[dwkonlsK-060913.vsd, 1, en_US]

Figure 8-101 Voltage-Controller Constellation for Two-Winding Transformers without Current Measurement

Three-Winding Transformers

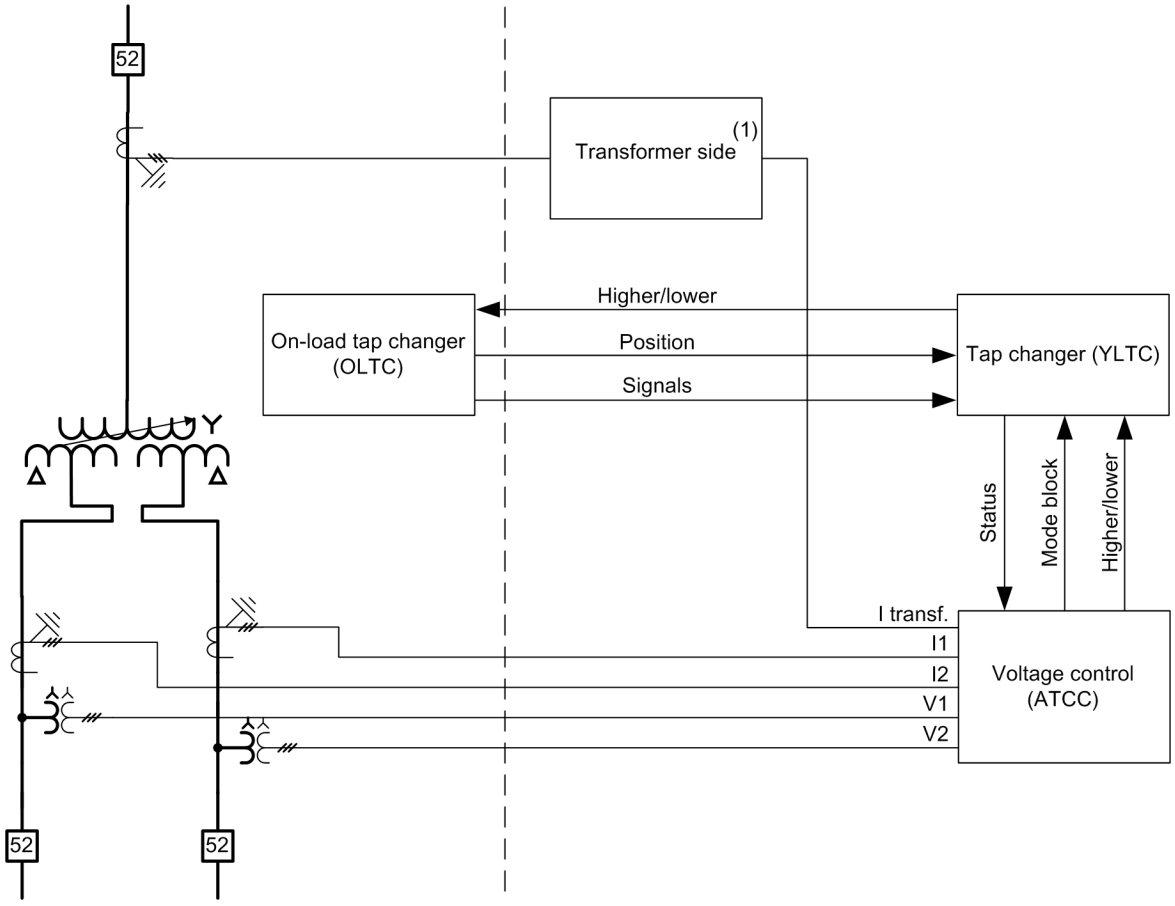
Three-winding transformers are special power transformers that have 2 separate windings on the secondary circuit and typically supply 2 different busbars. The voltage levels on the secondary circuit of the power transformers can either be the same or different. In addition to designs with 2 tap changers on the secondary circuits, in most cases, three-winding transformers are equipped with only one tap changer or on-load tap changer on the primary side. It is therefore necessary to feed both voltages of the secondary windings to the voltage measuring inputs (V1, V2) and to specify one of them, depending on the busbar situation, to the voltage controller as the control variable.

The voltages of side 1 and 2 of the three-winding transformer are simultaneously monitored. In the process, the voltage to be monitored can be automatically selected via the load current of both sides or by using one parameter. This parameter is the settings group switching via binary input, protocol or function keys. The uncontrolled voltage can be monitored in parallel to ensure that it remains within the defined voltage limits.

If a current measuring point is assigned to a function group, the voltage to be controlled can be automatically selected dependent on the load.

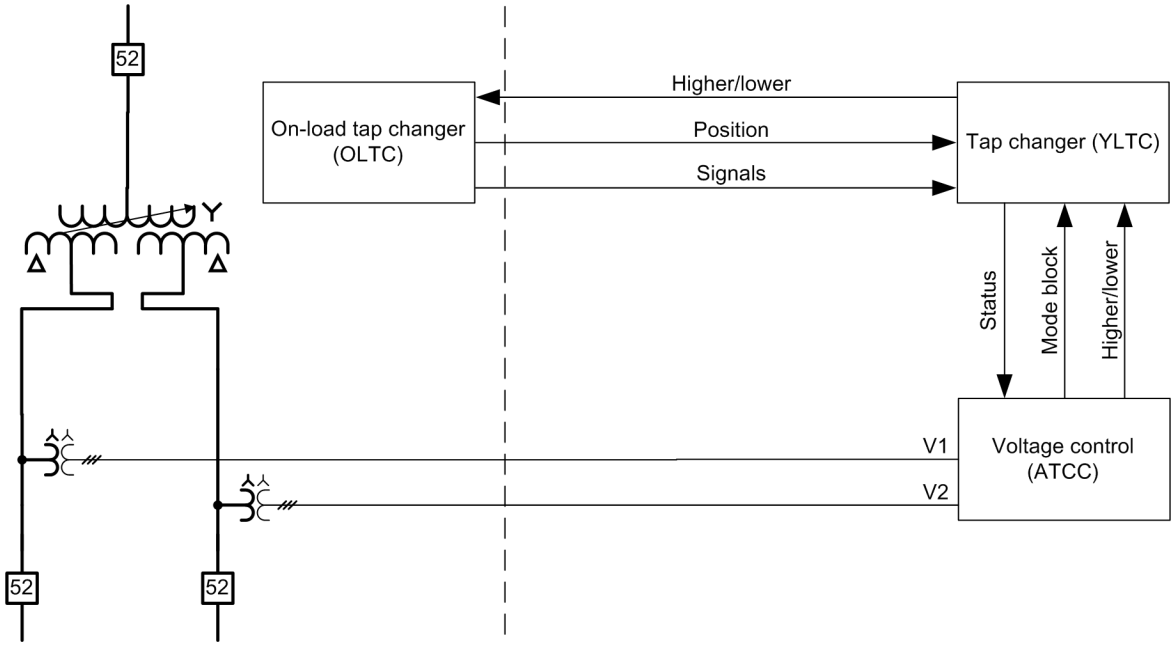
For automatic load change, the voltage of the transformer side into which the larger load current flows is controlled. The respective uncontrolled voltage is monitored for undervoltage and overvoltage.

In contrast to overvoltage on the controlled side, for overvoltage on the uncontrolled side, the higher impulse is blocked and no fast step down to a lower tap occurs. In case of undervoltage on the uncontrolled side, the lower commands are blocked if this behavior is activated for undervoltage supervision.



[dw_V-constell-3wind-with-imeas.vsd, 2, en_US]

Figure 8-102 Voltage-Controller Constellation for Three-Winding Transformers with Current Measurement for Load Compensation at the End of the Line



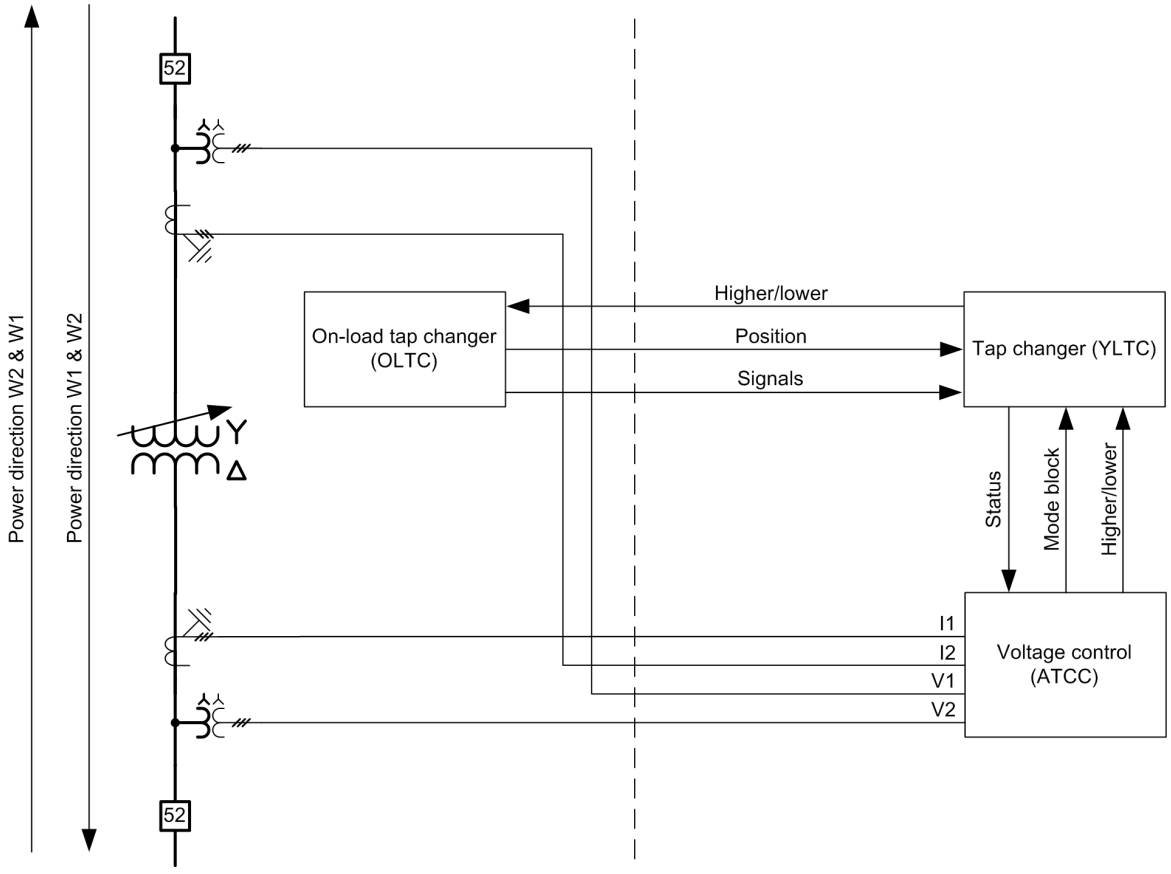
[dw_V-constell-3wind-without-imeas-091014.vsd, 2, en_US]

Figure 8-103 Voltage-Controller Constellation for Three-Winding Transformers without Current Measurement

Grid Coupling Transformers

Grid coupling transformers are special power transformers that connect 2 electrical power systems to one another. The load-side voltage is controlled. The power flow can change during operation. That is why both voltages and currents, winding 1 and winding 2, voltage measuring inputs (V1, V2) and current measuring inputs (I1 and I2) must be fed. A voltage must be specified as a function of the load situation to the voltage controller as the control variable.

The voltages of the windings 1 and 2 of the grid coupling transformers are simultaneously monitored. In the process, you can select the voltage to be controlled using one parameter. This parameter can be changed using the settings group switching via the binary input, protocol, or function keys.



[dw_V-constell-2wind-coupl-transf.vsd, 1, en_US]

Figure 8-104 Voltage-Controller Constellation for Grid Coupling Transformers

On-Load Tap Changer

On-load tap changers are used to set the desired tap of a stepped winding of the transformer while under load. During switchover, the desired tap of the stepped winding is first selected by means of the tap selector. Next, the on-load tap changer switches over from the current-carrying tap to the selected tap. During this switchover, one tap of the stepped winding is briefly bridged by an ohmic resistor so that the load switchover takes place without power interruption. Physically, the tap changer is installed in the transformer tank or in a separate tank.

Tap Changer

The **Tap changer** function issues the adjusting commands to the on-load tap changer and receives the corresponding feedback. The function of the tap changer inside the voltage controller corresponds to that of the separate tap changer. The higher and lower tap commands are generated by the voltage controller. The **`Check switching authority`**, **`Control model`**, **`SBO time-out`** and **`Feedback monitoring time`** parameters are set only in the voltage controller.

You can find more information in chapter *8.9.4 Application and Setting Notes* .

Voltage Controller

The Voltage controller function controls the voltage within the bandwidth and within the set voltage limits. Using the **Mode** parameter, you can turn the voltage controller on or off or set it for test mode.

With the parameter **Number of target voltage**, you can specify up to 4 target voltages. You can only activate one of these target voltages at a time using function key, communication, or a binary input. With the **Set point mode active** parameter, you can specify a valid target voltage via a communication network.

If the voltage controller is switched off, adjusting commands cannot be given to the tap changer in automatic operation or in manual operation. The set on-site or remote switching authority is independent of this.

You can set the controller operating mode via the **Operating mode** parameter or the **Operating mode** command to automatic operation or manual operation. In automatic operation, the voltage is controlled automatically in accordance with the set parameters.

Three-Winding Transformer Voltage Controller

For the two-winding transformer voltage controller, the measurands that are used to manage the feedback control are permanently defined.

With the three-winding transformer voltage controller, these measurands can be specified using one parameter (parameter **Winding selection** = ***Winding 1*** or ***Winding 2***) or they can be automatically selected (**Winding selection** = ***WithMaxLoad***).

The winding is automatically selected by evaluating the load current in the windings. If the load current in one of the two windings is greater than the load current in the other winding by 5 % of the rated current for 10 s, then the winding voltage is controlled using the larger load current.

Grid Coupling Transformer Voltage Controller

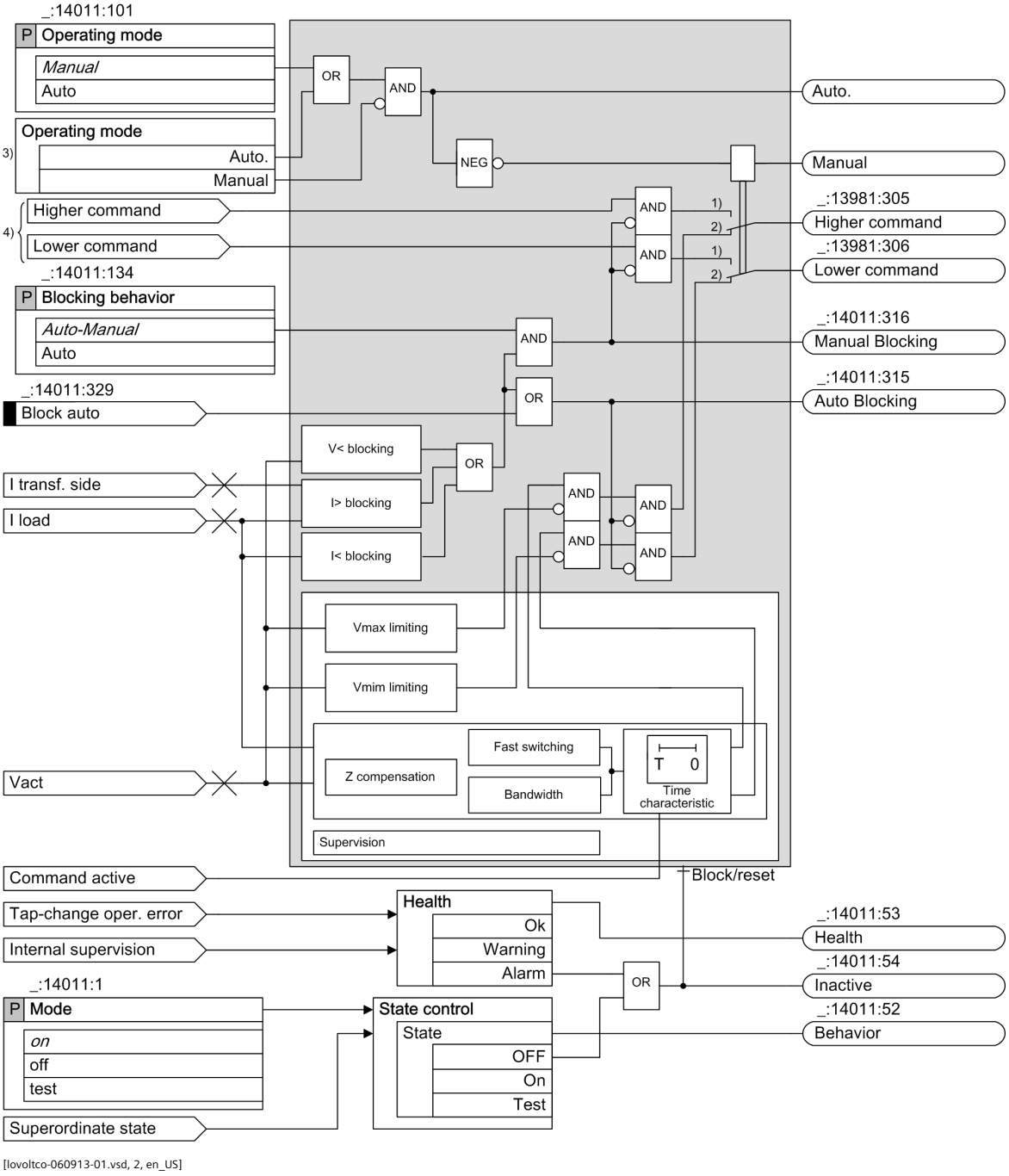
For the two-winding transformer voltage controller, the measurands that are used to manage the feedback control are permanently defined.

With the grid coupling transformer voltage controller, these measurands can be selected using a parameter (parameter **Winding selection** = ***Winding 1*** or ***Winding 2***).

You can change the winding selection during operation using the settings group switching.

You can monitor the power-flow direction. If the difference in the power of ***Winding 1*** and ***Winding 2*** is greater than 10 % of the rated power on the control side, the *Power-flow superv.* indication appears and the function switches to the alarm state.

Logic of the Function



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Figure 8-105 Higher-Level Logic of the Voltage Controller

(1) Manual operation
(2) Automatic operation
(3) Controllable
(4) Command

In accordance with the IEC 61850 standard, DOI LTCBlk (**Block automatic operation** command), automatic control can be blocked with a command.

The voltage controller measures the actual voltage (Vact) and compares it to the target voltage (Vtarget). If the difference between the measured voltage (control deviation D) is greater than the set bandwidth (B), a higher or lower command is sent to the tap changer once the set time delay (T1) has elapsed.

You can change the settings for control during operation with the settings group switching.

You can switchover the settings groups via the following alternatives:

- Via the on-site operation panel directly on the device
- Via an online DIGSI connection to the device
- Via binary inputs
- Via a communication connection to a substation automation technology (IEC 60870-5-103, IEC 61850)

You can find more information in chapter *3.10.2 Settings-Group Switching* .

Control Deviation

The control deviation is calculated from the current actual voltage and the target voltage in relation to the rated voltage.

$$D = \frac{V_{act} - V_{target}}{V_{rated}} 100\ \%$$

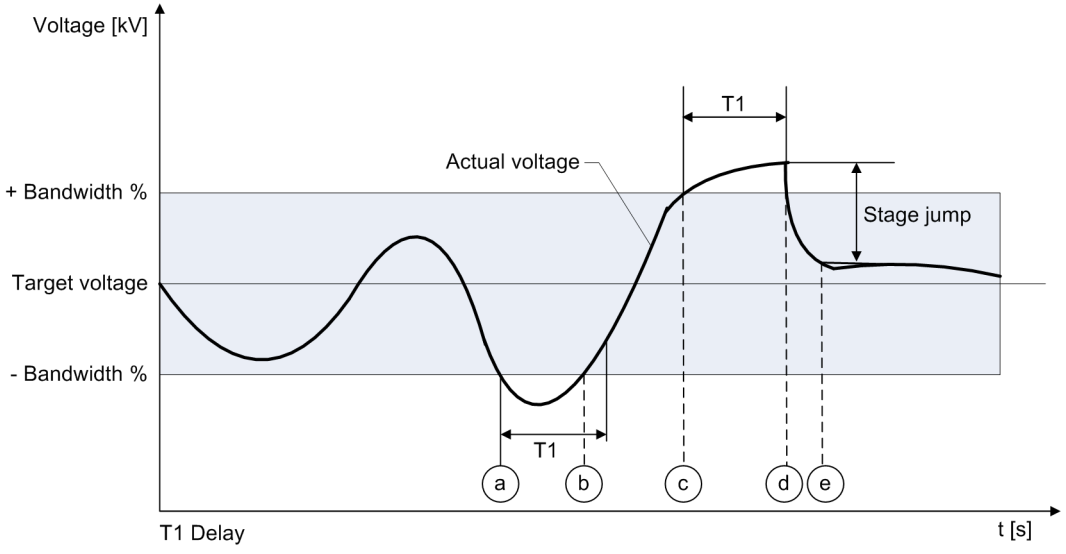
[fokonisk-211013, 2, en_US]

D = Control deviation

Bandwidth

To minimize the number of switching operations by the tap changer, a permitted bandwidth is defined. If the actual voltage is within the bandwidth, no adjusting control commands are issued to the tap changer. If the actual voltage exceeds the defined bandwidth, an adjusting command is issued after the set time delay **`T1 delay`**. If the actual voltage returns to the voltage range of the bandwidth before **`T1 delay`** elapses, no adjusting control command is issued.

If the actual voltage returns to the voltage range of the bandwidth within the time delay T1, the running time delay T1 continues to count down, starting at the already elapsed time. If the actual voltage returns again to the set bandwidth while the time is counting down, the time delay T1 is started at the remaining time. In this way, the time delay is reduced in the event of frequent violations of the lower limit of the bandwidth.



[dwistspn-060913-01.vsd, 1, en_US]

Figure 8-106 Actual Voltage Curve during Control Deviation

(a) Actual voltage outside the bandwidth
(b) Actual voltage before T1 elapses within the bandwidth - no switching
(c) Actual voltage outside the bandwidth, T1 begins to elapse
(d) Actual voltage outside the bandwidth after T1, switching procedure initiated
(e) Switching procedure concluded, actual voltage within the bandwidth

Linear, Inverse Control Response

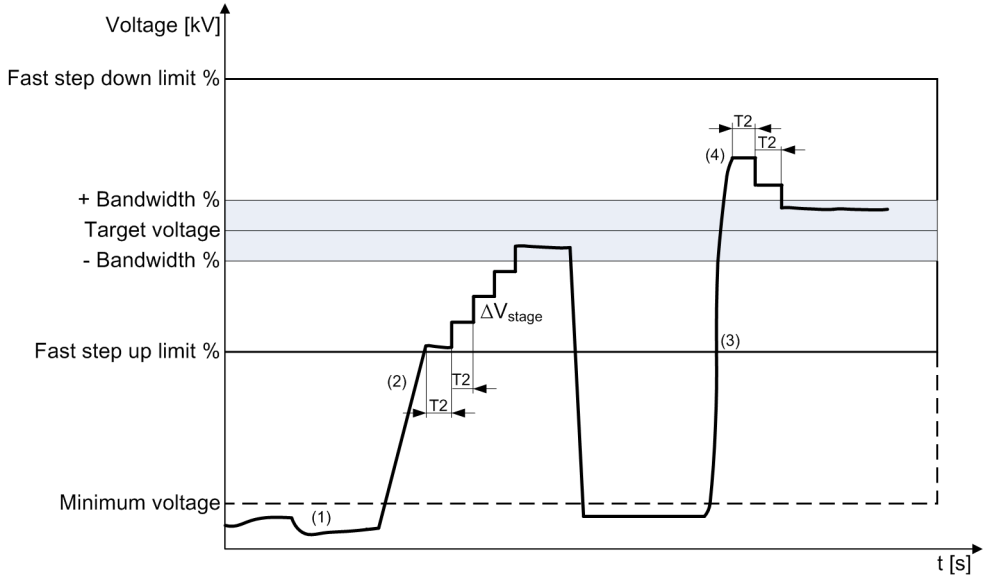
With **linear** control response, the controller reacts independently of the control deviation after the set time **`T1 delay`**. If more than one tap-position change is required to bring the actual voltage back within the bandwidth, the set time **`T2 delay`** takes effect.

With **inverse** control response, the time **`T1 delay`** depends on the magnitude of the control deviation. Small deviations are tolerated for longer than larger ones. If the time delay is very small in accordance with the set characteristic curve, the time **`T1 Inverse Min`** takes effect.

The set **inverse** characteristic curve is a function of the parameter **`T1 delay`**. The characteristic curves arising for different settings of the time **`T1 delay`** are shown in chapter *8.9.4 Application and Setting Notes* , margin title Parameter: **`T1 characteristic`**.

Control Response with Zero Potential or Voltage Recovery

If the actual voltage is not within the defined bandwidth after a voltage recovery, it can be necessary for the voltage controller to send the 1st adjusting command with the T2 time. For this purpose, the parameter **`Regulate with T2 at start`** must be switched on.

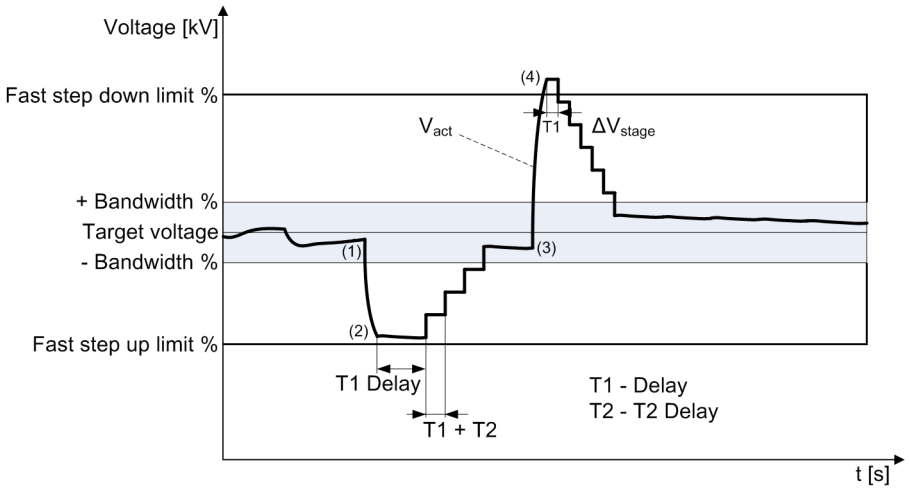


[dw_istgro-130215, 1, en_US]

Figure 8-107 Actual Voltage Curve during Control with T2

(1) Actual voltage below the minimum voltage
(2) After switching on, the change to a higher tap occurs with time T2
(3) After the voltage recovery, the actual voltage is above the bandwidth
(4) Actual voltage outside the bandwidth. A fast step down is made with the time T2 until the bandwidth is reached.

Control Response in the Event of Larger Voltage Deviations



[dwistgro-060913-01.vsd, 2, en_US]

Figure 8-108 Actual Voltage Curve During Larger Control Deviations

(1) Actual voltage outside the bandwidth

(2) The change to a higher tap occurs after T1 and then T2

(3) Actual voltage inside the bandwidth

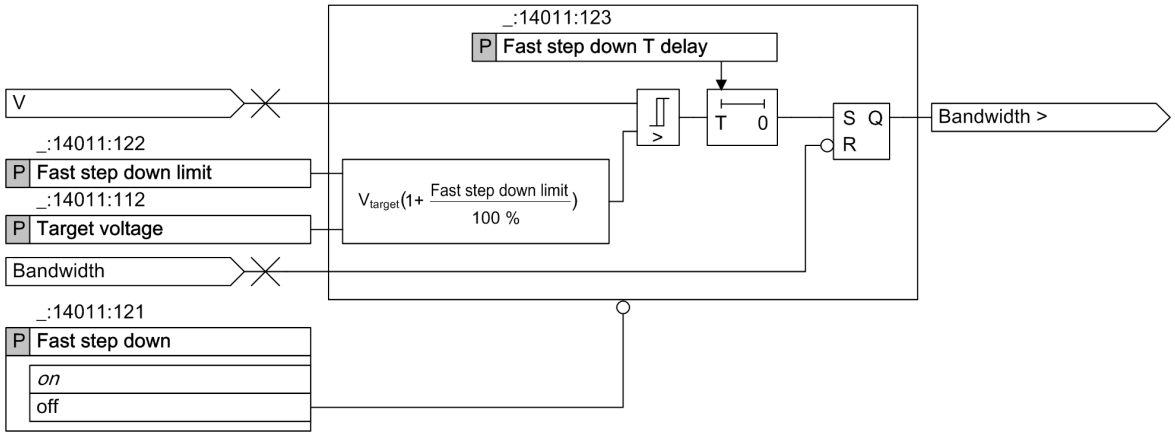
(4) Actual voltage outside the limit for a fast step down. A fast step down occurs until the bandwidth is reached.

Fast Step Up Mode and Fast Step Down Mode

The fast step down mode and the fast step up mode allow a fast reaction to abnormal voltage situations. *Figure 8-108* shows such a situation at point (4). A fast step down mode occurs until the bandwidth has been reached. The step time between 2 consecutive lower commands results from the following 2 conditions:

- The completion of a tap change command after the new valid position was detected
- The measurement time for capturing the new actual voltage

The activity of the fast step down mode and the fast step up mode is displayed with the indications *(_:14011:308) Fast Step Down active* and *(_:14011:307) Fast Step Up active*.



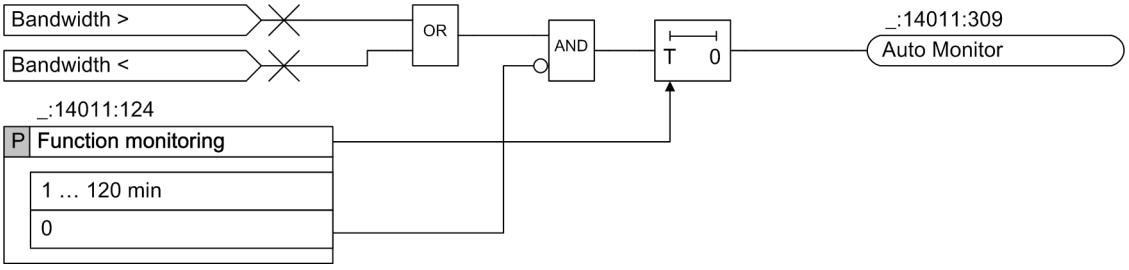
[losnlruk-090913-01.vsd, 2, en_US]

Figure 8-109 Logic of the Fast Step Down Mode

The fast step up mode operates in a similar fashion.

Function Supervision for Automatic Operation

If the actual voltage exceeds or falls below the set bandwidth for longer than the set time delay, this situation is shown by the indication *(_:14011:309) Auto Monitor*. If the actual voltage returns to the voltage range, the indication is reset. You can switch off the function monitor with a time delay = 0 min.



[lofktueb-090913-01.vsd, 1, en_US]

Figure 8-110 Logic of the Function Supervision for Automatic Operation

Phase Compensation

When using phase compensation, the voltage drop of a phase that is connected to a transformer can be included. In this case, 2 processes are available:

- Z compensation (LDC-Z)
- X and R compensation (LDC-XandR)



NOTE

The phase compensation is only active if power is flowing in the direction of the phase.

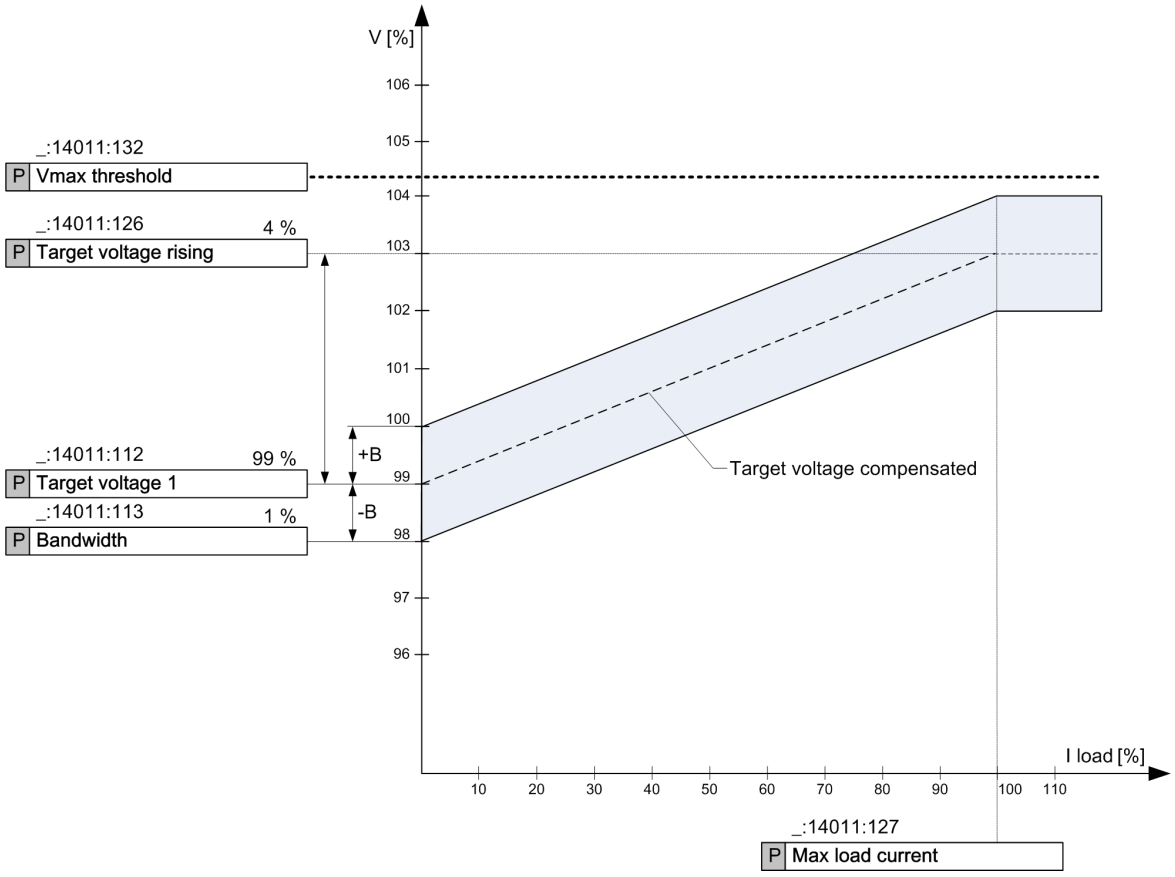
Z Compensation (LDC-Z)

Z compensation allows you to include the voltage drop of a line connected to the transformer. You can switch Z compensation on or off. If cosφ is roughly constant, you can use Z compensation. Setting the parameters requires the calculation of the voltage increase (**`Target voltage rising`**) taking into consideration the load current (**`Max load current`**).

The parameter **`Target voltage rising`** represents the voltage drop across the line as a % under rated load.

You can find more information and the calculation in chapter *8.9.4 Application and Setting Notes* .

In case of active Z compensation, you must limit the maximum permitted voltage increase in relation to the target voltage to avoid a voltage at the transformer that is too high. To do this, set the parameter **`Max load current`**. In addition, the parameter **`Vmax threshold`** is active. If the actual voltage exceeds this threshold value, no more higher tap change commands are issued.

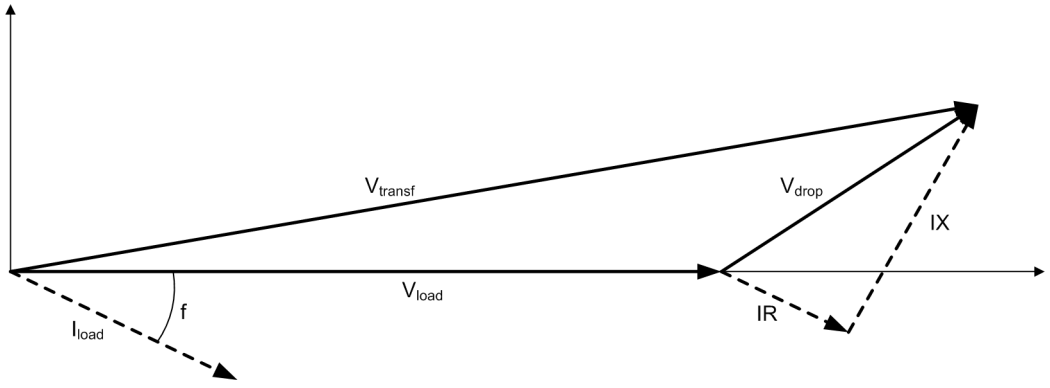


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Figure 8-111 Control Characteristic with Z Compensation

X and R Compensation (LDC-XandR)

When using the X and R compensation, you need the phase data. With this data, it is possible to precisely compensate the voltage drop of the transmission lines. The following figure shows the effect of this compensation type.



[dw-line-drop-kompensation-250214-01.vsd, 1, en_US]

Figure 8-112 Phasor Diagram of the X and R Compensation

You can also use the X and R compensation for the parallel control of transformers. If the X value is positive, the loss of voltage of the phase is compensated. If you are implementing parallel control with X and R compensation, then the X value is negative and considers the voltage increase from the busbar to the transformer.

V_{transf} Voltage on the transformer, voltage to be controlled

V_{load}	Voltage of load point (target voltage, $V_{load} = V_{transf} - V_{drop}$)
V_{drop}	Voltage drop of the phase
IR, IX	Voltage drop through R and X of the power line
I_{load}	Load current
φ	Load angle

If the X and R compensation is active, you must limit the maximum permitted voltage increase in relation to the target voltage to avoid a voltage at the transformer that is too high. To do this, set the parameter **Vmax threshold**. If the actual voltage exceeds this threshold value, no more higher tap change commands are issued.

Limiting Values

The limiting values cause no higher or lower adjusting commands to be given to the tap changer in the event of an upper limit violation (**Vmax threshold**) or lower limit violation (**Vmin threshold**). In this way, changing taps under abnormal voltage conditions and changing taps in the incorrect direction (for example, in the event of wiring errors) is prevented.

The lower and upper tap changer limits are included in the limiting values. The parameters **Lower tap-position limit** and **Higher tap-position limit** cause an additional restriction of the control range.

Blockings

The blockings prevent tap positions under abnormal network conditions. The following blocking functions are available:

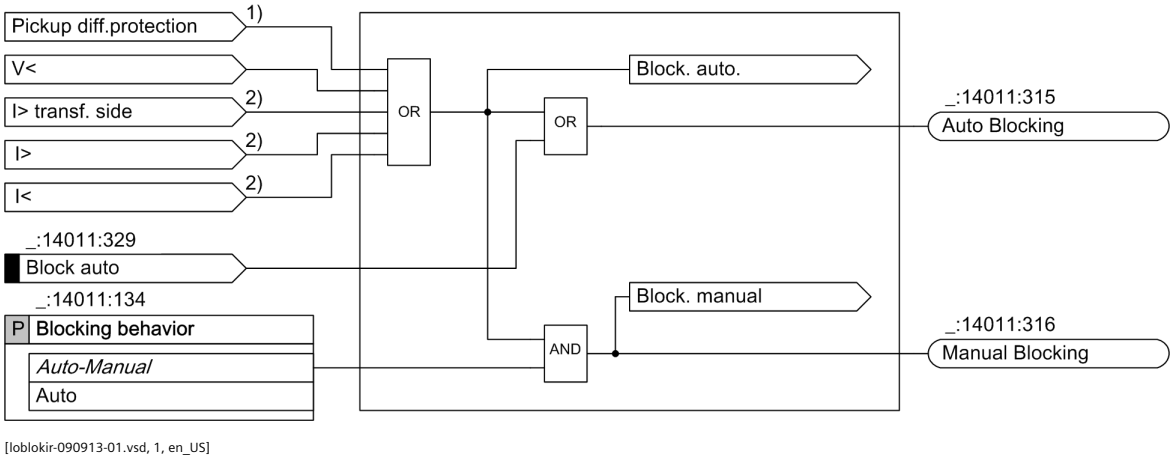
- Undervoltage
- Overcurrent, load current
- Undercurrent
- External blocking (binary input)
- Blocking command LTCBlock IEC 61850
- Blocking in the event of pickup of the transformer differential protection

Using the parameter **Blocking behavior**, you specify whether the blockings are to take effect only in automatic operation (***Auto***) or in both automatic and manual operation (***Auto-Manual***).

Overcurrent blocking prevents tap changes in the event of an overload. For the current blockings, the positive-sequence system of the load current and of the current on the upper-voltage side of transformers is calculated.

By assigning the tap changer to the transformer side, you also arrange the current of the upper-voltage side. Perform this assignment in the appropriate **Transformer side** . Here, you must use the tap changer of the voltage controller.

Undervoltage blocking prevents tap changes in the event of a network collapse. The output signals of the voltage controller are blocked and, depending on the operating mode, the indication *Auto Blocking* and/or *Manual Blocking* is issued.



[loblokir-090913-01.vsd, 1, en_US]

Figure 8-113 Logic Blockings

(1) If transformer differential protection is available

(2) If a current measurement is available

If the tap changer is assigned to the transformer side, is available, the current of the upper-voltage side is also monitored and the differential-protection pickup blocks the voltage controller automatically.

Additional Blockings for the Three-Winding Transformer Voltage Controller

The blockings described in the above sections also apply to the controlled winding of the three-winding transformer. In addition, the blockings for undervoltage, minimum voltage, and overcurrent are used for the measurands of the uncontrolled side.

Additional Blockings for the Grid-Coupling Transformer Voltage Controller

For voltage control in grid coupling transformers, the voltages and currents of both windings are always used for the blockings.

Functional Measured Values

You can read the current status of the measured values for the two-winding, three-winding, and grid-coupling transformers at any time. The following 3 tables show you the available measured values.

Measured Values, Two-Winding Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
V act.	Current, measured positive-sequence voltage (referenced to phase-to-phase)	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	kV	V	Voltage difference referenced to the rated voltage of the controlled winding
I load	Current measured load current (positive-sequence system)	A	A	Load current referenced to the rated current of the winding
V max	Maximum positive-sequence voltage ever measured (referenced to phase-to-phase)	kV	V	Maximum voltage of the winding referenced to the rated voltage of the winding
V min	Minimum positive-sequence voltage ever measured (reference to phase-to-phase)	kV	V	Minimum voltage of the winding referenced to the rated voltage of the winding

Measured Value	Description	Primary	Secondary	% Referenced to
V target	Calculated target voltage with consideration of Z compensation	kV	V	Target voltage of the winding referenced to the rated voltage of the winding

The functional measured values V max and V min can be reset with the input indication *>Reset min./max.*.

For the **two-winding transformer**, you can find the measured values under the following menu items of the device:

- Main menu → Measurements → Voltage control 2w → 90V V.contr.2w
- Main menu → Measurements → Voltage control 2w → Statistics → 90V V.contr.2w

Measured Values, Three-Winding Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
Vact.w1	Actual voltage of winding 1	kV	V	Target voltage of the primary system referenced to the rated voltage
Vact.w2	Actual voltage of winding 2	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	kV	V	Voltage difference referenced to the rated voltage of the controlled winding
I load w1	Load current of winding 1	A	A	Load current referenced to the rated current of winding 1
I load w2	Load current of winding 2	A	A	Load current referenced to the rated current of winding 2
Vmax 1	Maximum voltage of winding 1	kV	V	Maximum voltage of winding 1 referenced to the rated voltage of winding 1
Vmax 2	Maximum voltage of winding 2	kV	V	Maximum voltage of winding 2 referenced to the rated voltage of winding 2
Vmin 1	Minimum voltage of winding 1	kV	V	Minimum voltage of winding 1 referenced to the rated voltage of winding 1
Vmin 2	Minimum voltage of winding 2	kV	V	Minimum voltage of winding 2 referenced to the rated voltage of winding 2
V tar.w1	Target voltage of winding 1	kV	V	Target voltage of winding 1 referenced to the rated voltage of winding 1
V tar.w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

The functional measured values Vmax 1, Vmax 2, Vmin 1 and Vmin 2 can be reset with the input indication *>Reset min./max.*.

For the **three-winding transformer**, you can find the measured values under the following menu items of the device:

- Main menu → Measurements → Voltage control 3w → 90V V.contr.3w
- Main menu → Measurements → Voltage control 3w → Statistics → 90V V.contr.3w

Measured Values Grid Coupling Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
Vact.w1	Actual voltage of winding 1	kV	V	Target voltage of the primary system referenced to the rated voltage
Vact.w2	Actual voltage of winding 2	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	kV	V	Voltage difference referenced to the rated voltage of the controlled winding
I load w1	Load current of winding 1	A	A	Load current referenced to the rated current of winding 1
I load w2	Load current of winding 2	A	A	Load current referenced to the rated current of winding 2
Vmax 1	Maximum voltage of winding 1	kV	V	Maximum voltage of winding 1 referenced to the rated voltage of winding 1
Vmax 2	Maximum voltage of winding 2	kV	V	Maximum voltage of winding 2 referenced to the rated voltage of winding 2
Vmin 1	Minimum voltage of winding 1	kV	V	Minimum voltage of winding 1 referenced to rated voltage of winding 1
Vmin 2	Minimum voltage of winding 2	kV	V	Minimum voltage of winding 2 referenced to rated voltage of winding 2
V tar.w1	Target voltage of winding 1	kV	V	Target voltage of winding 1 referenced to the rated voltage of winding 1
V tar.w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

The functional measured values Vmax 1, Vmax 2, Vmin 1 and Vmin 2 can be reset with the input indication *>Reset min./max.*.

For the **grid coupling transformer**, you can find the measured values under the following menu items of the device:

- Main menu → Measurements → Voltage control gc → 90V V.contr.gc
- Main menu → Measurements → Voltage control gc → Statistics → 90V V.contr.gc

Fundamental Values and Power Measured Values

The fundamental values and power measured values are always present in the **Two-winding transformer voltage controller**, **Three-winding transformer voltage controller**, and the **Grid coupling transformer voltage controller** function groups. Furthermore, you can find the fundamental values and power measured values for winding 1 and winding 2 in the **Three-winding transformer voltage controller** and in the **Grid coupling transformer voltage controller** function groups. These values cannot be deleted.

Table 8-27 and *Table 8-28* show the total scope in case a 3-phase voltage measuring point is also connected.

Table 8-27 Possible Fundamental Values for the Voltage Controller Function Group

Fundamental Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
I_N	Measured zero-sequence current	A	A	Rated operating current of the primary system
V_A, V_B,V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary system
V_N	Measured neutral-point displacement voltage	kV	V	Rated operating voltage of the primary system/√3

Table 8-28 Possible Power Measured Values of the Voltage Controller Function Group

Power Measured Value		Primary	Secondary	% Referenced to
P_{total}	Active power (total power)	MW	W	Active power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q_{total}	Reactive power (total power)	Mvar	var	Reactive power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S_{total}	Apparent power (total power)	MVA	VA	Apparent power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active power factor	(abs)	(abs)	100 % corresponds to cos φ = 1

8.9.4 Application and Setting Notes

Two-Winding Transformer: General

Parameter: Rated current

- Default setting **(_:2311:101) Rated current** = ***1000.00 A***

Parameter: Rated voltage

- Default setting **(_:2311:102) Rated voltage** = ***400.00 kV***

The measured values of the voltage controller can be displayed as primary values, secondary values, or in percent. With the **Rated current** and **Rated voltage** parameters, you set the reference value for the percentage values.

Three-Winding Transformer and Grid Coupling Transformer: General

Winding 1

Parameter: Rated current

- Default setting **(_:2311:101) Rated current** = ***1000.00 A***

Parameter: Rated voltage

- Default setting **(_:2311:103) Rated voltage** = ***400.00 kV***

Winding 2

Parameter: Rated current

- Default setting **(_:2311:102) Rated current** = ***1000.00 A***

Parameter: Rated voltage

- Default setting **(_:2311:104) Rated voltage** = ***400.00 kV***

The measured values of the voltage controller can be displayed as primary values, secondary values, or in percent. With the **Rated current** and **Rated voltage** parameters, you set the reference value for the percentage values.

Tap Changer

The parameters of the tap changer inside the voltage controller correspond to those of the tap changer in chapter *8.8.2 Application and Setting Notes* .

For the tap changer inside the voltage controller, the parameters for the control model are copies of those from the voltage controller. This concerns the parameters:

- Checking the switching authority
- Control model
- SBO[25] Time-out
- Feedback.monitor.time

Voltage Controller

Parameter: Mode

- Default setting **(_:14011:1) Mode** = ***on***

With the **Mode** parameter, you switch the voltage controller in ***on***, ***off***, or in ***test*** operation.

Parameter: Operating mode

- Default setting **(_:14011:101) Operating mode** = ***Manual***

With the **Operating mode** parameter, you specify whether the controller is operating in ***Auto*** mode or in ***Manual***.

Only Three-Winding Transformer:

Parameter: Winding selection

- Default setting **(_:15601:157) Winding selection** = ***Winding 1***

With the **Winding selection** parameter, you specify whether the controller controls the voltage of ***Winding 1*** or ***Winding 2***. With the ***WithMaxLoad*** setting, the voltage to be controlled is selected automatically as a function of the load current. You can switch to this method using the parameter **Winding selection** or the controllable *Automatic winding selection*.

If the controllable *Automatic winding selection* is set to **Off** or is not set, you can influence the winding to be controlled using the following 2 options:

- Via the **Winding selection** parameter
- Via the *Manual winding selection* controllable

The function value *Active winding* shows the winding selection.

Only Grid Coupling Transformer:

Parameter: Winding selection

- Default setting **(_:16351:161) Winding selection** = ***Winding 1***

With the **Winding selection** parameter, you specify whether the controller controls the voltage of ***Winding 1*** or ***Winding 2***.

You may select the winding to be controlled via the **Winding selection** parameter or the *Manual winding selection* controllable. The function value *Active winding* shows the winding selection.

[25] In the IEC 61850 standard, reservation is known as Select Before Operate (SBO).

Controlling

Parameter: Check switching authority

- Default setting **(_:107) Check switching authority** = ***yes***

With the **Check switching authority** parameter, you specify whether the switching authority (**On-site**, **Remote**) is checked during an adjusting command.

Parameter: Control model

- Default setting **(_:109) Control model** = ***SBO w. enh. security***

This parameter **Control model** specifies the control model according to IEC 61850-7-2 that corresponds to the behavior of the data (SBO – Select Before Operate).

You can select one of the following settings:

- ***direct w. normal secur.***
- ***SBO w. normal secur.***
- ***direct w. enh. security***
- ***SBO w. enh. security***

Parameter: SBO time-out

- Default setting **(_:110) SBO time-out** = ***30.00 s***

This parameter specifies the time for detecting the time-out of the SBO command. The range of values extends from 0.01 s to 1800.00 s. This is the time that can elapse between command acceptance and command execution (command model as per IEC 61850-7-2).

Parameter: Feedback monitoring time

- Default setting **(_:111) Feedback monitoring time** = ***10.00 s***

Reaching a new tap position after the adjusting command is monitored via the feedback-monitoring time. If a new tap position is not reached, the command is canceled after this time.

Parameter: Set point mode active

- Default setting **(_:14011:160) Set point mode active** = ***on***

With the parameter **Set point mode active** = ***on***, you can send a target voltage to the controller via a communication network. The controller uses the specified voltage value as target voltage. If the controller does not receive any valid voltage values, it uses the original target voltage. You can switch the parameter on or off.

For the three-winding transformer, the address of the **Set point mode active** parameter is _:15601:171 while the address is _:16351:171 for the grid coupling transformer.

Only Two-Winding Transformer:

Parameter: Number of target voltage

- Default setting **(_:14011:156) Number of target voltage** = ***1***

With this parameter, you specify the number of available **target voltages** (**1** to **4**). You can select a target voltage from the available ones using the function key, the communication, or a binary input.



NOTE

Keep in mind that the parameter **Number of target voltage** cannot be influenced by way of the settings group switching.

You can specify the **target voltages** (**1** to **4**) in primary, secondary, or in percent.

For the activation of the target voltages 1 to 4 via a binary input, you need a CFC chart.

Parameter: Target voltage 1

- Default setting **(_:14011:112) Target voltage 1** = ***110.000 V***

With the **Target voltage 1** parameter, you specify the voltage that the controller is supposed to reach.

Parameter: Target voltage 2

- Default setting **(_:14011:157) Target voltage 2** = ***110.000 V***

With the **Target voltage 2** parameter, you specify the 2nd voltage that the controller is supposed to reach.

Parameter: Target voltage 3

- Default setting **(_:14011:158) Target voltage 3** = ***110.000 V***

With the **Target voltage 3** parameter, you specify the 3rd voltage that the controller is supposed to reach.

Parameter: Target voltage 4

- Default setting **(_:14011:159) Target voltage 4** = ***110.000 V***

With the **Target voltage 4** parameter, you specify the 4th voltage that the controller is supposed to reach.

Only Three-Winding Transformer:

Parameter: Number of target voltage

- Default setting **(_:15601:164) Number of target voltage** = ***1***

With this parameter, you specify the number of available **target voltages** (**1 W1/2** to **4 W1/2**). You can select a target voltage from the available ones via the function key, the communication, or a binary input.



NOTE

Keep in mind that the parameter **Number of target voltage** cannot be influenced by way of the settings group switching.

You can specify the **target voltages** (**1 W1/2** to **4 W1/2**) in primary, secondary, or in percent.

For the activation of the target voltages 1 to 4 via a binary input, you need a CFC chart.

Parameter: Target voltage 1 w1

- Default setting **(_:15601:112) Target voltage 1 w1** = ***110.000 V***

Parameter: Target voltage 1 w2

- Default setting **(_:15601:146) Target voltage 1 w2** = ***110.000 V***

Parameter: Target voltage 2 w1

- Default setting **(_:15601:165) Target voltage 2 w1** = ***110.000 V***

Parameter: Target voltage 2 w2

- Default setting **(_:15601:168) Target voltage 2 w2** = ***110.000 V***

Parameter: Target voltage 3 w1

- Default setting **(_:15601:166) Target voltage 3 w1** = ***110.000 V***

Parameter: Target voltage 3 w2

- Default setting **(_:15601:169) Target voltage 3 w2** = ***110.000 V***

Parameter: Target voltage 4 w1

- Default setting **(_:15601:167) Target voltage 4 w1** = ***110.000 V***

Parameter: Target voltage 4 w2

- Default setting **(_:15601:170) Target voltage 4 w2** = ***110.000 V***

Only Grid Coupling Transformer:

Parameter: Number of target voltage

- Default setting **(_:16351:164) Number of target voltage** = ***1***

With this parameter, you specify the number of available **target voltages** (**1 W1/2** to **4 W1/2**). You can select a target voltage from the available ones via the function key, the communication, or a binary input.

NOTE

Keep in mind that the parameter **Number of target voltage** cannot be influenced by way of the settings group switching.

You can specify the **target voltages** (**1 W1/2** to **4 W1/2**) in primary, secondary, or in percent.

For the activation of the target voltages 1 to 4 via a binary input, you need a CFC chart.

Parameter: Target voltage 1 w1

- Default setting **(_:16351:112) Target voltage 1 w1** = ***110.000 V***

Parameter: Target voltage 1 w2

- Default setting **(_:16351:146) Target voltage 1 w2** = ***110.000 V***

Parameter: Target voltage 2 w1

- Default setting **(_:16351:165) Target voltage 2 w1** = ***110.000 V***

Parameter: Target voltage 2 w2

- Default setting **(_:16351:168) Target voltage 2 w2** = ***110.000 V***

Parameter: Target voltage 3 w1

- Default setting **(_:16351:166) Target voltage 3 w1** = ***110.000 V***

Parameter: Target voltage 3 w2

- Default setting **(_:16351:169) Target voltage 3 w2** = ***110.000 V***

Parameter: Target voltage 4 w1

- Default setting **(_:16351:167) Target voltage 4 w1** = ***110.000 V***

Parameter: Target voltage 4 w2

- Default setting **(_:16351:170) Target voltage 4 w2** = ***110.000 V***

Voltage Controller

Parameter: Bandwidth

- Default setting **(_:113) Bandwidth** = ***1.0%***

With the **Bandwidth** parameter, you specify the voltage range where no control action higher or lower is to occur about the **Target voltage 1**. If the actual voltage is outside the bandwidth referenced to the **Target voltage 1**, no correction takes place.

Calculation of the **Bandwidth**:

NOTE

When calculating the **Bandwidth** B, keep the maximum accepted voltage deviation in the electrical power system and the tap voltage of the tap changer on the secondary side of the transformer in mind.

Calculation of the minimum bandwidth:

$$B[\%] \geq 0{,}6 \cdot \left(\frac{V_{rated,sec}}{V_{Nprim}} - \frac{V_{rated,sec}}{V_{(N-1)prim}} \right) \cdot V_{rated,sec} \cdot 100\,\% \cdot \frac{V_{max,prim}}{V_{rated,prim}}$$

[fospnvrz-211013, 1, en_US]

$V_{rated,sec}$	Secondary rated voltage of the transformer
V_{Nprim}	Primary tap voltage of the transformer of tap N
$V_{(N-1)prim}$	Primary tap voltage of the transformer of tap N-1
$V_{max,prim}$	Maximum primary voltage of the transformer

Parameter: T1 characteristic

- Default setting **(_:114) T1 characteristic** = ***Linear***

Parameter: T1 delay

- Default setting **(_:115) T1 delay** = ***40 s***

You can adjust the control action so that the smallest number of adjusting commands possible is necessary. To do this, using **T1 characteristic**, you set the control response and, using **T1 delay**, you set a time delay.

In the ***Linear*** setting (linear control response), the control response is independent of the voltage deviation. A constant time delay applies here.

In the ***Inverse*** setting (inverse control response), the time delay is a function of the voltage deviation referenced to **Target voltage 1**. The greater the control deviation, the faster the control response. The control quality improves, but the switching frequency increases. The effective time delay results from:

$$t_{1_delay} = \frac{T_1 \cdot B}{|D|}$$

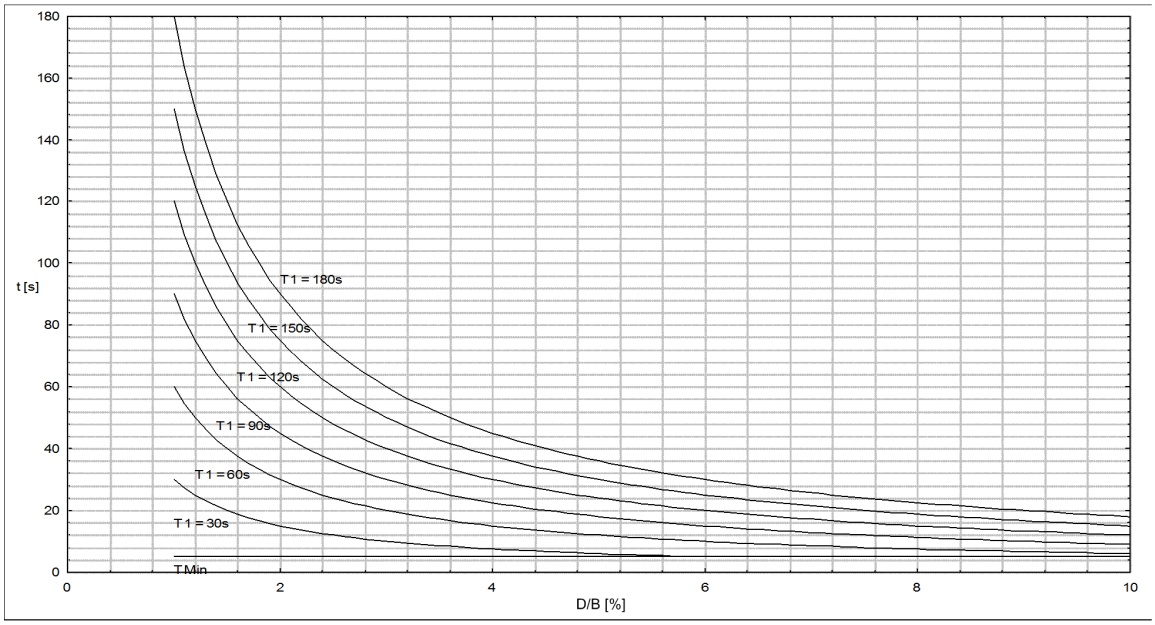
[fovrzzet-211013, 2, en_US]

T_1 – Parameter **T1 delay**

$$D = \frac{V_{act} - V_{target}}{V_{rated}} 100\ \%$$

[fokonisk-211013, 2, en_US]

D = Control deviation



[dwrglchr-160913-01.vsd, 2, en_US]

Figure 8-114 Inverse Control Characteristic

Parameter: T1 Inverse Min

- Default setting **(_:116) T1 Inverse Min** = ***5 s***

The **T1 Inverse Min** parameter is used to define the minimum time delay for the control action. This time applies only to the control response ***Inverse*** and the response cannot be shorter.

Parameter: T2 delay

- Default setting **(_:117) T2 delay** = ***5 s***

With the **T2 delay** parameter, you set the time the tap changer has to wait from one tap position to the next. During this time, several adjusting commands can be sent to the tap changer in one direction, which permits a correction of the actual voltage. The time delay T2 has an independent characteristic. The time T2 is generally set shorter than the time T1. If the time T2 is switched off by a setting equal to 0, the delay T1 is always active.

Parameter: Regulate with T2 at start

- Default setting **(_:14011:155) Regulate with T2 at start** = ***on***

With the **Regulate with T2 at start** parameter, you can activate a shorter time than T1. This can be necessary for controlling a voltage recovery or after switching on a transformer. If no voltage was available before, this setting controls with the shorter time T2 when starting the control action. You can switch this functionality on or off. If you always want to use the time T2 for control, you must set the *Block T1* controllable to ***On***.

For the three-winding transformer, the address of the **Regulate with T2 at start** parameter is _:15601:163 while the address is _:16351:163 for the grid coupling transformer.

Parameter: Fast step down

- Default setting **(_:121) Fast step down** = ***on***

Parameter: Fast step down limit

- Default setting **(_:122) Fast step down limit** = ***6.0 %***

Parameter: Fast step down T delay

- Default setting **(_:123) Fast step down T delay** = ***0.0 s***

With this parameter, you can specify the time delay of the fast step down mode. If the actual voltage is greater than the value of the limit for the fast step down mode (_:122), the fast step-down mode is activated. If the voltage limit is exceeded for only a brief period within the time delay, a fast step down mode is not activated.

Parameter: Fast step up

- Default setting **(_:118) Fast step up** = ***off***

Parameter: Fast step up limit

- Default setting **(_:119) Fast step up limit** = ***-6.0 %***

Parameter: Fast step up T delay

- Default setting **(_:120) Fast step up T delay** = ***2.0 s***

With this parameter, you can specify the time delay of the fast step up mode. If the actual voltage is less than the value of the limit for the fast step up mode (_:119), the fast step up mode is activated. If the value drops below the voltage limit for only a brief period within the time delay, a fast step up mode is not activated.

Parameter: Function monitoring

- Default setting **(_:124) Function monitoring** = ***15 min***

You can delay the pickup of the function monitor. With the setting **Function monitoring** = ***0 min***, the function monitor is switched off.

Voltage Controller Only Grid Coupling Transformer

Parameter: Power-flow supervision

- Default setting **(_:16351:162) Power-flow supervision** = ***on***

With the **Power-flow supervision** parameter, you can monitor the power flow. You can switch the parameter on or off.

Line Compensation for the Two-Winding Transformer

Parameter: Line drop compensation

- Default setting **(_:14011:125) Line drop compensation** = ***off***

You can use the **Line drop compensation** parameter to select the correction procedure of the load-dependent line voltage drop. There are 2 procedures available for selection: ***LDC-Z*** and ***LDC-XandR***.

Consider the following parameter for **Line drop compensation** = ***LDC-Z*** :

Parameter: Target voltage rising

- Default setting **(_:14011:126) Target voltage rising** = ***4.0 %***

With the **Target voltage rising** parameter, you set the voltage drop across the line. The value represents the voltage increase in % of the **Target voltage 1** that occurs at rated load. Only the magnitude of the current is considered. The set value is added to the **Target voltage 1**.

Target voltage rising [%] = ΔV_{load} [%] if I_{load} = 100 %

$$\text{Target voltage rising}[\%] = \left(V_{SetComp}[\%] - V_{Set}[\%]\right) \cdot \frac{100\ \%}{I_{load}[\%]}$$

[foschlst-211013, 1, en_US]

$V_{SetComp}$	Target voltage at the end of the line
V_{Set}	Target voltage
I_{load}	Load current in %

Parameter: Max load current

- Default setting **(_:14011:127) Max load current** = ***100.0 %***

With the setting of the parameter **Max load current**, you can prevent the voltage at the transformer from becoming too high in the event of extraordinarily high load current. If the load current exceeds the set value, no additional load-current compensation is calculated.

Consider the following parameter for **Line drop compensation** = ***LDC-XandR*** :

Parameter: R line

- Default setting **(_:14011:153) R line** = ***0.0 Ω***

With the **R line** parameter, you set the ohmic resistance of the power line.

Parameter: X line

- Default setting **(_:14011:154) X line** = ***0.0 Ω***

With the **X line** parameter, you set the reactance for the line to be protected.

In order to determine the voltage drop by the line, entering the parameter **R line** and **X line** is necessary for the procedure **Line drop compensation** = ***LDC-XandR***. If the primary values are known and you would like to set the secondary values, use the following formula for the calculation

$$X_{sec} = \frac{Ratio_I}{Ratio_V} X_{prim}$$

[fo-I-V-Ratio-250214, 1, en_US]

As an example, calculate X_{sec} with the following parameters:

Current transformer ratio	: 1000 A/1 A
Voltage transformer ratio	: 380 kV/0.1 kV
X_{prim}	: 21 Ω

Therefore, the result for X_{sec} is:

$$X_{sec} = \frac{1000\ A / 1\ A}{380\ kV / 0.1\ kV} 21\ \Omega = 5.53\ \Omega$$

[fo-I-V-Ratio_Value-250214, 1, en_US]

If you are implementing a parallel control with the X and R compensation, then the X value is negative and considers the voltage increase from the busbar to the transformer.

Line Compensation for the Three-Winding Transformers and Grid Coupling Transformers

Parameter: Line drop compensation

- Default setting **(_:125) Line drop compensation** = ***off***

Consider the following parameter for **Line drop compensation** = ***LDC-Z*** :

Parameter: Target voltage rising w1

- Default setting **(_:126) Target voltage rising w1** = ***4.0%***

Parameter: Target voltage rising w2

- Default setting **(_:147) Target voltage rising w2** = ***4.0%***

Parameter: Max load current

- Default setting **(_:127) Max load current** = ***100.0 %***

Consider the following parameter for **Line drop compensation** = ***LDC-XandR***:

Parameter: R line w1

- Default setting **(_:153) R line w1** = ***0.0 Ω***

Parameter: R line w2

- Default setting **(_:155) R line w2** = ***0.0 Ω***

Parameter: X line w1

- Default setting **(_:154) X line w1** = ***0.0 Ω***

Parameter: X line w2

- Default setting **(_:156) X line w2** = ***0.0 Ω***

Limiting Values for the Two-Winding Transformer

Parameter: Lower tap-position limit

- Default setting **(_:14011:102) Lower tap-position limit** = ***1***

Parameter: Higher tap-position limit

- Default setting **(_:14011:103) Higher tap-position limit** = ***1***

With the parameters **Lower tap-position limit** and **Higher tap-position limit**, you can restrict the taps available in automatic operation. For example, using the parameter **Higher tap-position limit**, changes to higher taps to excessive ratios that would result in overvoltages in the event of a sudden loss of load are blocked.

Parameter: Vmin limiting

- Default setting **(_:14011:128) Vmin limiting** = ***on***

Parameter: Vmin threshold

- Default setting **(_:14011:129) Vmin threshold** = ***105.000 V***

Parameter: Vmin time delay

- Default setting **(_:14011:130) Vmin time delay** = ***10 s***

Parameter: Vmax limiting

- Default setting **(_:14011:131) Vmax limiting** = ***on***

Parameter: Vmax threshold

- Default setting **(_:14011:132) Vmax threshold** = ***115.000 V***

Parameter: Vmax time delay

- Default setting **(_:14011:133) Vmax time delay** = ***10 s***

The voltage limits are necessary only for special control situations. The overvoltage limit prevents a change to a higher tap by the controller if the limiting value **Vmax threshold** is exceeded. The undervoltage limit prevents a change to a lower tap by the controller if the voltage drops below the limiting value **Vmin threshold**.

Limiting Values for Three-Winding Transformers and Grid Coupling Transformers

Parameter: Vmin threshold w1

- Default setting **(_:129) Vmin threshold w1** = ***105.000 V***

Parameter: Vmin threshold w2

- Default setting **(_:148) Vmin threshold w2** = ***105.000 V***

Parameter: Vmax threshold w1

- Default setting **(_:132) Vmax threshold w1** = ***115.000 V***

Parameter: Vmax threshold w2

- Default setting **(_:149) Vmax threshold w2** = ***115.000 V***

Blockings for the Two-Winding Transformers

Parameter: Blocking behavior

- Default setting **(_:14011:134) Blocking behavior** = ***Auto-Manual***

If the corresponding voltage limits are exceeded in either direction, the blockings prevent a change to a lower or higher tap. On the one hand, this prevents excessive wear of the contacts of the tap changer and, on the other hand, it prevents a system incident. With the parameter **Blocking behavior**, you set whether these blockings are effective only in automatic operation or in both automatic and manual operation.

Parameter: V< Blocking

- Default setting **(_:14011:135) V< Blocking** = ***on***

Parameter: V< Threshold

- Default setting **(_:14011:136) V< Threshold** = ***90.000 V***

Parameter: V< Time delay

- Default setting **(_:14011:137) V< Time delay** = ***0 s***

Parameter: I> Blocking

- Default setting **(_:14011:138) I> Blocking** = ***on***

Parameter: I> Threshold

- Default setting **(_:14011:139) I> Threshold** = ***150 %***

Parameter: I> Time delay

- Default setting **(_:14011:140) I> Time delay**= ***0 s***

If the load current exceeds the threshold value **I> Threshold** for the time **I> Time delay**, the overcurrent blocking prevents changing to a higher or lower tap. Set the threshold value **I> Threshold** in % in relation to the rated current. To do this, set the parameter **I reference** for % values.

Parameter: I< Blocking

- Default setting **(_:14011:141) I< Blocking** = ***off***

Parameter: I< Threshold

- Default setting **(_:14011:142) I< Threshold** = ***10 %***

Parameter: I< Time delay

- Default setting **(_:14011:143) I< Time delay** = ***10 s***

If the load current drops below the threshold value **I< Threshold** for the time **I< Time delay**, the undercurrent blocking prevents changing to a higher or lower tap. Set the threshold value **I< Threshold** in % in relation to the rated current. To do this, set the parameter **I reference** for % values.

Blockings for Three-Winding Transformers and Grid Coupling Transformers

Parameter: V< Threshold w1

- Default setting **(_:136) V< Threshold w1** = ***90.000 V***

Parameter: V< Threshold w2

- Default setting **(_:150) V< Threshold w2** = ***90.000 V***

8.9.5 Settings

Two-Winding Transformer

Addr.	Parameter	C	Setting Options	Default Setting
Ref. for %-values				
_:2311:101	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Tap changer				
_:13981:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s
_:13981:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:13981:113	Tap changer:Motor supervision time		5 s to 100 s	10 s
_:13981:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap
_:13981:114	Tap changer:Lowest tap position		-64 to 64	1
_:13981:115	Tap changer:Highest tap position		-64 to 64	15
General				
_:14011:1	90V V.contr.2w:Mode		• off • on • test	on
_:14011:101	90V V.contr.2w:Operating mode		• Manual • Auto	Manual
Control				
_:14011:107	90V V.contr.2w:Check switching authority		• no • yes	yes
_:14011:109	90V V.contr.2w:Control model		• direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:14011:110	90V V.contr.2w:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:14011:111	90V V.contr.2w:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Voltage Control				
_:14011:156	90V V.contr.2w:Number of target voltage		• 1 • 2 • 3 • 4	1
_:14011:112	90V V.contr.2w:Target voltage 1		10.000 V to 340.000 V	110.000 V
_:14011:157	90V V.contr.2w:Target voltage 2		10.000 V to 340.000 V	110.000 V
_:14011:158	90V V.contr.2w:Target voltage 3		10.000 V to 340.000 V	110.000 V
_:14011:159	90V V.contr.2w:Target voltage 4		10.000 V to 340.000 V	110.000 V

Addr.	Parameter	C	Setting Options	Default Setting
_:14011:113	90V V.contr.2w:Band-width		0.2 % to 10.0 %	1.0 %
_:14011:114	90V V.contr.2w:T1 char-acteristic		• Linear • Inverse	Linear
_:14011:115	90V V.contr.2w:T1 delay		5 s to 600 s	40 s
_:14011:116	90V V.contr.2w:T1 Inverse Min		5 s to 100 s	5 s
_:14011:117	90V V.contr.2w:T2 delay		0 s to 100 s	5 s
_:14011:118	90V V.contr.2w:Fast step up		• off • on	off
_:14011:119	90V V.contr.2w:Fast step up limit		-50.0 % to 0.0 %	-6.0 %
_:14011:120	90V V.contr.2w:Fast step up T delay		0.0 s to 10.0 s	2.0 s
_:14011:121	90V V.contr.2w:Fast step down		• off • on	on
_:14011:122	90V V.contr.2w:Fast step down limit		0.0 % to 50.0 %	6.0 %
_:14011:123	90V V.contr.2w:Fast step down T delay		0.0 s to 10.0 s	0.0 s
_:14011:124	90V V.contr.2w:Function monitoring		0 min to 120 min	15 min
_:14011:155	90V V.contr.2w:Regulate with T2 at start		• off • on	on
_:14011:160	90V V.contr.2w:Set point mode active		• off • on	on
Line drop comp.				
_:14011:125	90V V.contr.2w:Line drop compensation		• off • LDC-Z • LDC-XandR	off
_:14011:126	90V V.contr.2w:Target voltage rising		0.0 % to 20.0 %	4.0 %
_:14011:127	90V V.contr.2w:Max load current		0.0 % to 500.0 %	100.0 %
_:14011:153	90V V.contr.2w:R line		0.0 Ω to 30.0 Ω	0.0 Ω
_:14011:154	90V V.contr.2w:X line		-30.0 Ω to 30.0 Ω	0.0 Ω
Limiting				
_:14011:102	90V V.contr.2w:Lower tap-position limit		-128 to 127	1
_:14011:103	90V V.contr.2w:Higher tap-position limit		-128 to 127	15
_:14011:128	90V V.contr.2w:Vmin limiting		• off • on	on
_:14011:129	90V V.contr.2w:Vmin threshold		10.000 V to 340.000 V	105.000 V
_:14011:130	90V V.contr.2w:Vmin time delay		0 s to 20 s	10 s
_:14011:131	90V V.contr.2w:Vmax limiting		• off • on	on
_:14011:132	90V V.contr.2w:Vmax threshold		10.000 V to 340.000 V	115.000 V

Addr.	Parameter	C	Setting Options	Default Setting
_:14011:133	90V V.contr.2w:Vmax time delay		0 s to 20 s	10 s
Blocking				
_:14011:134	90V V.contr.2w:Blocking behavior		• Auto • Auto-Manual	Auto-Manual
_:14011:135	90V V.contr.2w:V< Blocking		• off • on	on
_:14011:136	90V V.contr.2w:V< Threshold		10.000 V to 340.000 V	90.000 V
_:14011:137	90V V.contr.2w:V< Time delay		0 s to 20 s	0 s
_:14011:138	90V V.contr.2w:I> Blocking		• off • on	on
_:14011:139	90V V.contr.2w:I> Threshold		10 % to 500 %	150 %
_:14011:140	90V V.contr.2w:I> Time delay		0 s to 20 s	0 s
_:14011:141	90V V.contr.2w:I< Blocking		• off • on	off
_:14011:142	90V V.contr.2w:I< Threshold		3 % to 100 %	10 %
_:14011:143	90V V.contr.2w:I< Time delay		0 s to 20 s	10 s

Three-Winding Transformer

Addr.	Parameter	C	Setting Options	Default Setting
Winding 1				
_:2311:101	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:103	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Winding 2				
_:2311:102	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:104	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
_:2311:106	General:Rated apparent power		-1.00 MVA to -1.00 MVA	0.00 MVA
Tap changer				
_:13981:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s
_:13981:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:13981:113	Tap changer:Motor supervision time		5 s to 100 s	10 s
_:13981:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap
_:13981:114	Tap changer:Lowest tap position		-64 to 64	1
_:13981:115	Tap changer:Highest tap position		-64 to 64	15

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:15601:1	90V V.contr.3w:Mode		• off • on • test	on
_:15601:101	90V V.contr.3w:Operating mode		• Manual • Auto	Manual
_:15601:157	90V V.contr.3w:Winding selection		• Winding 1 • Winding 2 • WithMaxLoad	Winding 1
Control				
_:15601:107	90V V.contr.3w:Check switching authority		• no • yes	yes
_:15601:109	90V V.contr.3w:Control model		• direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:15601:110	90V V.contr.3w:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:15601:111	90V V.contr.3w:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Voltage Control				
_:15601:164	90V V.contr.3w:Number of target voltage		• 1 • 2 • 3 • 4	1
_:15601:112	90V V.contr.3w:Target voltage 1 w1		10.000 V to 340.000 V	110.000 V
_:15601:165	90V V.contr.3w:Target voltage 2 w1		10.000 V to 340.000 V	110.000 V
_:15601:166	90V V.contr.3w:Target voltage 3 w1		10.000 V to 340.000 V	110.000 V
_:15601:167	90V V.contr.3w:Target voltage 4 w1		10.000 V to 340.000 V	110.000 V
_:15601:146	90V V.contr.3w:Target voltage 1 w2		10.000 V to 340.000 V	110.000 V
_:15601:168	90V V.contr.3w:Target voltage 2 w2		10.000 V to 340.000 V	110.000 V
_:15601:169	90V V.contr.3w:Target voltage 3 w2		10.000 V to 340.000 V	110.000 V
_:15601:170	90V V.contr.3w:Target voltage 4 w2		10.000 V to 340.000 V	110.000 V
_:15601:113	90V V.contr.3w:Bandwidth		0.2 % to 10.0 %	1.0 %
_:15601:114	90V V.contr.3w:T1 characteristic		• Linear • Inverse	Linear
_:15601:115	90V V.contr.3w:T1 delay		5 s to 600 s	40 s
_:15601:116	90V V.contr.3w:T1 Inverse Min		5 s to 100 s	5 s
_:15601:117	90V V.contr.3w:T2 delay		0 s to 100 s	5 s
_:15601:118	90V V.contr.3w:Fast step up		• off • on	off

Addr.	Parameter	C	Setting Options	Default Setting
_:15601:119	90V V.contr.3w:Fast step up limit		-50.0 % to 0.0 %	-6.0 %
_:15601:120	90V V.contr.3w:Fast step up T delay		0.0 s to 10.0 s	2.0 s
_:15601:121	90V V.contr.3w:Fast step down		• off • on	on
_:15601:122	90V V.contr.3w:Fast step down limit		0.0 % to 50.0 %	6.0 %
_:15601:123	90V V.contr.3w:Fast step down T delay		0.0 s to 10.0 s	0.0 s
_:15601:124	90V V.contr.3w:Function monitoring		0 min to 120 min	15 min
_:15601:162	90V V.contr.3w:Power-flow supervision		• off • on	on
_:15601:163	90V V.contr.3w:Regulate with T2 at start		• off • on	on
_:15601:171	90V V.contr.3w:Set point mode active		• off • on	on
Line drop comp.				
_:15601:125	90V V.contr.3w:Line drop compensation		• off • LDC-Z • LDC-XandR	off
_:15601:126	90V V.contr.3w:Target voltage rising w1		0.0 % to 20.0 %	4.0 %
_:15601:147	90V V.contr.3w:Target voltage rising w2		0.0 % to 20.0 %	4.0 %
_:15601:127	90V V.contr.3w:Max load current		0.0 % to 500.0 %	100.0 %
_:15601:153	90V V.contr.3w:R line w1		0.0 Ω to 30.0 Ω	0.0 Ω
_:15601:154	90V V.contr.3w:X line w1		-30.0 Ω to 30.0 Ω	0.0 Ω
_:15601:155	90V V.contr.3w:R line w2		0.0 Ω to 30.0 Ω	0.0 Ω
_:15601:156	90V V.contr.3w:X line w2		-30.0 Ω to 30.0 Ω	0.0 Ω
Limiting				
_:15601:102	90V V.contr.3w:Lower tap-position limit		-128 to 127	1
_:15601:103	90V V.contr.3w:Higher tap-position limit		-128 to 127	15
_:15601:128	90V V.contr.3w:Vmin limiting		• off • on	on
_:15601:129	90V V.contr.3w:Vmin threshold w1		10.000 V to 340.000 V	105.000 V
_:15601:148	90V V.contr.3w:Vmin threshold w2		10.000 V to 340.000 V	105.000 V
_:15601:130	90V V.contr.3w:Vmin time delay		0 s to 20 s	10 s
_:15601:131	90V V.contr.3w:Vmax limiting		• off • on	on

Addr.	Parameter	C	Setting Options	Default Setting
_:15601:132	90V V.contr.3w:Vmax threshold w1		10.000 V to 340.000 V	115.000 V
_:15601:149	90V V.contr.3w:Vmax threshold w2		10.000 V to 340.000 V	115.000 V
_:15601:133	90V V.contr.3w:Vmax time delay		0 s to 20 s	10 s
Blocking				
_:15601:134	90V V.contr.3w:Blocking behavior		• Auto • Auto-Manual	Auto-Manual
_:15601:135	90V V.contr.3w:V< Blocking		• off • on	on
_:15601:136	90V V.contr.3w:V< Threshold w1		10.000 V to 340.000 V	90.000 V
_:15601:150	90V V.contr.3w:V< Threshold w2		10.000 V to 340.000 V	90.000 V
_:15601:137	90V V.contr.3w:V< Time delay		0 s to 20 s	0 s
_:15601:138	90V V.contr.3w:I> Blocking		• off • on	on
_:15601:139	90V V.contr.3w:I> Threshold		10 % to 500 %	150 %
_:15601:140	90V V.contr.3w:I> Time delay		0 s to 20 s	0 s
_:15601:141	90V V.contr.3w:I< Blocking		• off • on	off
_:15601:142	90V V.contr.3w:I< Threshold		3 % to 100 %	10 %
_:15601:143	90V V.contr.3w:I< Time delay		0 s to 20 s	10 s

Grid Coupling Transformer

Addr.	Parameter	C	Setting Options	Default Setting
Winding 1				
_:2311:101	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:103	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Winding 2				
_:2311:102	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:104	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
_:2311:106	General:Rated apparent power		-1.00 MVA to -1.00 MVA	0.00 MVA
Tap changer				
_:13981:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s
_:13981:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:13981:113	Tap changer:Motor supervision time		5 s to 100 s	10 s
_:13981:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap

Addr.	Parameter	C	Setting Options	Default Setting
_:13981:114	Tap changer:Lowest tap position		-64 to 64	1
_:13981:115	Tap changer:Highest tap position		-64 to 64	15
General				
_:16351:1	90V V.contr.gc:Mode		• off • on • test	on
_:16351:101	90V V.contr.gc:Operating mode		• Manual • Auto	Manual
_:16351:161	90V V.contr.gc:Winding selection		• Winding 1 • Winding 2	Winding 1
Control				
_:16351:107	90V V.contr.gc:Check switching authority		• no • yes	yes
_:16351:109	90V V.contr.gc:Control model		• direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:16351:110	90V V.contr.gc:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:16351:111	90V V.contr.gc:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Voltage Control				
_:16351:164	90V V.contr.gc:Number of target voltage		• 1 • 2 • 3 • 4	1
_:16351:112	90V V.contr.gc:Target voltage 1 w1		10.000 V to 340.000 V	110.000 V
_:16351:165	90V V.contr.gc:Target voltage 2 w1		10.000 V to 340.000 V	110.000 V
_:16351:166	90V V.contr.gc:Target voltage 3 w1		10.000 V to 340.000 V	110.000 V
_:16351:167	90V V.contr.gc:Target voltage 4 w1		10.000 V to 340.000 V	110.000 V
_:16351:146	90V V.contr.gc:Target voltage 1 w2		10.000 V to 340.000 V	110.000 V
_:16351:168	90V V.contr.gc:Target voltage 2 w2		10.000 V to 340.000 V	110.000 V
_:16351:169	90V V.contr.gc:Target voltage 3 w2		10.000 V to 340.000 V	110.000 V
_:16351:170	90V V.contr.gc:Target voltage 4 w2		10.000 V to 340.000 V	110.000 V
_:16351:113	90V V.contr.gc:Bandwidth		0.2 % to 10.0 %	1.0 %
_:16351:114	90V V.contr.gc:T1 characteristic		• Linear • Inverse	Linear
_:16351:115	90V V.contr.gc:T1 delay		5 s to 600 s	40 s
_:16351:116	90V V.contr.gc:T1 Inverse Min		5 s to 100 s	5 s
_:16351:117	90V V.contr.gc:T2 delay		0 s to 100 s	5 s

Addr.	Parameter	C	Setting Options	Default Setting
_:16351:118	90V V.contr.gc:Fast step up		• off • on	off
_:16351:119	90V V.contr.gc:Fast step up limit		-50.0 % to 0.0 %	-6.0 %
_:16351:120	90V V.contr.gc:Fast step up T delay		0.0 s to 10.0 s	2.0 s
_:16351:121	90V V.contr.gc:Fast step down		• off • on	on
_:16351:122	90V V.contr.gc:Fast step down limit		0.0 % to 50.0 %	6.0 %
_:16351:123	90V V.contr.gc:Fast step down T delay		0.0 s to 10.0 s	0.0 s
_:16351:124	90V V.contr.gc:Function monitoring		0 min to 120 min	15 min
_:16351:162	90V V.contr.gc:Power-flow supervision		• off • on	on
_:16351:163	90V V.contr.gc:Regulate with T2 at start		• off • on	on
_:16351:171	90V V.contr.gc:Set point mode active		• off • on	on
Line drop comp.				
_:16351:125	90V V.contr.gc:Line drop compensation		• off • LDC-Z • LDC-XandR	off
_:16351:126	90V V.contr.gc:Target voltage rising w1		0.0 % to 20.0 %	4.0 %
_:16351:147	90V V.contr.gc:Target voltage rising w2		0.0 % to 20.0 %	4.0 %
_:16351:127	90V V.contr.gc:Max load current		0.0 % to 500.0 %	100.0 %
_:16351:153	90V V.contr.gc:R line w1		0.0 Ω to 30.0 Ω	0.0 Ω
_:16351:154	90V V.contr.gc:X line w1		-30.0 Ω to 30.0 Ω	0.0 Ω
_:16351:155	90V V.contr.gc:R line w2		0.0 Ω to 30.0 Ω	0.0 Ω
_:16351:156	90V V.contr.gc:X line w2		-30.0 Ω to 30.0 Ω	0.0 Ω
Limiting				
_:16351:102	90V V.contr.gc:Lower tap-position limit		-128 to 127	1
_:16351:103	90V V.contr.gc:Higher tap-position limit		-128 to 127	15
_:16351:128	90V V.contr.gc:Vmin limiting		• off • on	on
_:16351:129	90V V.contr.gc:Vmin threshold w1		10.000 V to 340.000 V	105.000 V
_:16351:148	90V V.contr.gc:Vmin threshold w2		10.000 V to 340.000 V	105.000 V
_:16351:130	90V V.contr.gc:Vmin time delay		0 s to 20 s	10 s
_:16351:131	90V V.contr.gc:Vmax limiting		• off • on	on
_:16351:132	90V V.contr.gc:Vmax threshold w1		10.000 V to 340.000 V	115.000 V

Addr.	Parameter	C	Setting Options	Default Setting
_:16351:149	90V V.contr.gc:Vmax threshold w2		10.000 V to 340.000 V	115.000 V
_:16351:133	90V V.contr.gc:Vmax time delay		0 s to 20 s	10 s
Blocking				
_:16351:134	90V V.contr.gc:Blocking behavior		• Auto • Auto-Manual	Auto-Manual
_:16351:135	90V V.contr.gc:V< Blocking		• off • on	on
_:16351:136	90V V.contr.gc:V< Threshold w1		10.000 V to 340.000 V	90.000 V
_:16351:150	90V V.contr.gc:V< Threshold w2		10.000 V to 340.000 V	90.000 V
_:16351:137	90V V.contr.gc:V< Time delay		0 s to 20 s	0 s
_:16351:138	90V V.contr.gc:I> Blocking		• off • on	on
_:16351:139	90V V.contr.gc:I> Threshold		10 % to 500 %	150 %
_:16351:140	90V V.contr.gc:I> Time delay		0 s to 20 s	0 s
_:16351:141	90V V.contr.gc:I< Blocking		• off • on	off
_:16351:142	90V V.contr.gc:I< Threshold		3 % to 100 %	10 %
_:16351:143	90V V.contr.gc:I< Time delay		0 s to 20 s	10 s

8.9.6 Information List

Two-Winding Transformer

No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Tap changer			
_:13981:500	Tap changer:>Acquisition blocking	SPS	I
_:13981:501	Tap changer:>Enable	SPS	I
_:13981:53	Tap changer:Health	ENS	O
_:13981:301	Tap changer:End higher pos.reached	SPS	O
_:13981:302	Tap changer:End lower pos.reached	SPS	O
_:13981:308	Tap changer:Position	BALANCED SCORECARD	C
_:13981:305	Tap changer:Higher command	SPS	O
_:13981:306	Tap changer:Lower command	SPS	O
_:13981:307	Tap changer:Command active	SPS	O
_:13981:309	Tap changer:Motor sup. time expired	SPS	O
_:13981:310	Tap changer:Trigger motor prot. sw.	SPS	O

No.	Information	Data Class (Type)	Type
_:13981:311	Tap changer:Position failure	SPS	O
_:13981:312	Tap changer:Op.ct.	INS	O
_:13981:319	Tap changer:Reset failure	SPC	C
90V V.contr.2w			
_:14011:81	90V V.contr.2w:>Block	SPS	I
_:14011:85	90V V.contr.2w:>Reset min./max.	SPS	I
_:14011:53	90V V.contr.2w:Health	ENS	O
_:14011:54	90V V.contr.2w:Inactive	SPS	O
_:14011:52	90V V.contr.2w:Behavior	ENS	O
_:14011:301	90V V.contr.2w:End Higher pos. Auto	SPS	O
_:14011:302	90V V.contr.2w:End Lower pos. Auto	SPS	O
_:14011:326	90V V.contr.2w:Cmd. with feedback	BALANCED SCORECARD	C
_:14011:329	90V V.contr.2w:Block auto	SPC	C
_:14011:312	90V V.contr.2w:Operating mode	SPC	C
_:14011:305	90V V.contr.2w:Bandwidth >	SPS	O
_:14011:306	90V V.contr.2w:Bandwidth <	SPS	O
_:14011:307	90V V.contr.2w:Fast Step Up active	SPS	O
_:14011:308	90V V.contr.2w:Fast Step Down active	SPS	O
_:14011:309	90V V.contr.2w:Auto Monitor	SPS	O
_:14011:310	90V V.contr.2w:Vmin Limiting	SPS	O
_:14011:311	90V V.contr.2w:Vmax Limiting	SPS	O
_:14011:315	90V V.contr.2w:Auto Blocking	SPS	O
_:14011:316	90V V.contr.2w:Manual Blocking	SPS	O
_:14011:317	90V V.contr.2w:V< Blocking	SPS	O
_:14011:318	90V V.contr.2w:I> Blocking	SPS	O
_:14011:319	90V V.contr.2w:I< Blocking	SPS	O
_:14011:320	90V V.contr.2w:V act.	MV	O
_:14011:321	90V V.contr.2w:ΔV act.	MV	O
_:14011:322	90V V.contr.2w:I load	MV	O
_:14011:323	90V V.contr.2w:V max	MV	O
_:14011:324	90V V.contr.2w:V min	MV	O
_:14011:325	90V V.contr.2w:V target	MV	O
_:14011:354	90V V.contr.2w:Target voltage 1	SPC	C
_:14011:355	90V V.contr.2w:Target voltage 2	SPC	C
_:14011:356	90V V.contr.2w:Target voltage 3	SPC	C
_:14011:357	90V V.contr.2w:Target voltage 4	SPC	C
_:14011:358	90V V.contr.2w:Set target voltage	APC	C
_:14011:359	90V V.contr.2w:Block T1	SPC	C

Three-Winding Transformer

No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O

No.	Information	Data Class (Type)	Type
Tap changer			
_:13981:500	Tap changer:>Acquisition blocking	SPS	I
_:13981:501	Tap changer:>Enable	SPS	I
_:13981:53	Tap changer:Health	ENS	O
_:13981:301	Tap changer:End higher pos.reached	SPS	O
_:13981:302	Tap changer:End lower pos.reached	SPS	O
_:13981:308	Tap changer:Position	BALANCED SCORECARD	C
_:13981:305	Tap changer:Higher command	SPS	O
_:13981:306	Tap changer:Lower command	SPS	O
_:13981:307	Tap changer:Command active	SPS	O
_:13981:309	Tap changer:Motor sup. time expired	SPS	O
_:13981:310	Tap changer:Trigger motor prot. sw.	SPS	O
_:13981:311	Tap changer:Position failure	SPS	O
_:13981:312	Tap changer:Op.ct.	INS	O
_:13981:319	Tap changer:Reset failure	SPC	C
90V V.contr.3w			
_:15601:81	90V V.contr.3w:>Block	SPS	I
_:15601:85	90V V.contr.3w:>Reset min./max.	SPS	I
_:15601:53	90V V.contr.3w:Health	ENS	O
_:15601:54	90V V.contr.3w:Inactive	SPS	O
_:15601:52	90V V.contr.3w:Behavior	ENS	O
_:15601:301	90V V.contr.3w:End Higher pos. Auto	SPS	O
_:15601:302	90V V.contr.3w:End Lower pos. Auto	SPS	O
_:15601:332	90V V.contr.3w:Cmd. with feedback	BALANCED SCORECARD	C
_:15601:335	90V V.contr.3w:Block auto	SPC	C
_:15601:336	90V V.contr.3w:Operating mode	SPC	C
_:15601:305	90V V.contr.3w:Bandwidth >	SPS	O
_:15601:306	90V V.contr.3w:Bandwidth <	SPS	O
_:15601:307	90V V.contr.3w:Fast Step Up active	SPS	O
_:15601:308	90V V.contr.3w:Fast Step Down active	SPS	O
_:15601:309	90V V.contr.3w:Auto Monitor	SPS	O
_:15601:357	90V V.contr.3w:Power-flow superv.	SPS	O
_:15601:310	90V V.contr.3w:Vmin Limiting w1	SPS	O
_:15601:311	90V V.contr.3w:Vmin Limiting w2	SPS	O
_:15601:312	90V V.contr.3w:Vmax Limiting w1	SPS	O
_:15601:313	90V V.contr.3w:Vmax Limiting w2	SPS	O
_:15601:314	90V V.contr.3w:Auto Blocking	SPS	O
_:15601:315	90V V.contr.3w:Manual Blocking	SPS	O
_:15601:316	90V V.contr.3w:V< Blocking w1	SPS	O
_:15601:317	90V V.contr.3w:V< Blocking w2	SPS	O
_:15601:318	90V V.contr.3w:I> Blocking	SPS	O
_:15601:319	90V V.contr.3w:I< Blocking	SPS	O
_:15601:320	90V V.contr.3w:Vact.w1	MV	O
_:15601:321	90V V.contr.3w:Vact.w2	MV	O

No.	Information	Data Class (Type)	Type
_:15601:322	90V V.contr.3w:ΔV act.	MV	O
_:15601:323	90V V.contr.3w:I load w1	MV	O
_:15601:324	90V V.contr.3w:I load w2	MV	O
_:15601:325	90V V.contr.3w:Vmax 1	MV	O
_:15601:326	90V V.contr.3w:Vmax 2	MV	O
_:15601:327	90V V.contr.3w:Vmin 1	MV	O
_:15601:328	90V V.contr.3w:Vmin 2	MV	O
_:15601:329	90V V.contr.3w:V tar.w1	MV	O
_:15601:330	90V V.contr.3w:V tar.w2	MV	O
_:15601:358	90V V.contr.3w:Target voltage 1 w1	SPC	C
_:15601:359	90V V.contr.3w:Target voltage 2 w1	SPC	C
_:15601:360	90V V.contr.3w:Target voltage 3 w1	SPC	C
_:15601:361	90V V.contr.3w:Target voltage 4 w1	SPC	C
_:15601:362	90V V.contr.3w:Target voltage 1 w2	SPC	C
_:15601:363	90V V.contr.3w:Target voltage 2 w2	SPC	C
_:15601:364	90V V.contr.3w:Target voltage 3 w2	SPC	C
_:15601:365	90V V.contr.3w:Target voltage 4 w2	SPC	C
_:15601:366	90V V.contr.3w:Set target voltage w1	APC	C
_:15601:367	90V V.contr.3w:Set target voltage w2	APC	C
_:15601:368	90V V.contr.3w:Block T1	SPC	C
_:15601:356	90V V.contr.3w:Winding act.	INS	O
_:15601:369	90V V.contr.3w:Winding selec. manual	SPC	C
_:15601:370	90V V.contr.3w:Winding selec. auto	SPC	C

Grid Coupling Transformer

No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Tap changer			
_:13981:500	Tap changer:>Acquisition blocking	SPS	I
_:13981:501	Tap changer:>Enable	SPS	I
_:13981:53	Tap changer:Health	ENS	O
_:13981:301	Tap changer:End higher pos.reached	SPS	O
_:13981:302	Tap changer:End lower pos.reached	SPS	O
_:13981:308	Tap changer:Position	BALANCED SCORECARD	C
_:13981:305	Tap changer:Higher command	SPS	O
_:13981:306	Tap changer:Lower command	SPS	O
_:13981:307	Tap changer:Command active	SPS	O
_:13981:309	Tap changer:Motor sup. time expired	SPS	O
_:13981:310	Tap changer:Trigger motor prot. sw.	SPS	O
_:13981:311	Tap changer:Position failure	SPS	O
_:13981:312	Tap changer:Op.ct.	INS	O
_:13981:319	Tap changer:Reset failure	SPC	C

No.	Information	Data Class (Type)	Type
90V V.contr.gc			
_:16351:81	90V V.contr.gc:>Block	SPS	I
_:16351:85	90V V.contr.gc:>Reset min./max.	SPS	I
_:16351:53	90V V.contr.gc:Health	ENS	O
_:16351:54	90V V.contr.gc:Inactive	SPS	O
_:16351:52	90V V.contr.gc:Behavior	ENS	O
_:16351:301	90V V.contr.gc:End Higher pos. Auto	SPS	O
_:16351:302	90V V.contr.gc:End Lower pos. Auto	SPS	O
_:16351:332	90V V.contr.gc:Cmd. with feedback	BALANCED SCORECARD	C
_:16351:335	90V V.contr.gc:Block auto	SPC	C
_:16351:336	90V V.contr.gc:Operating mode	SPC	C
_:16351:305	90V V.contr.gc:Bandwidth >	SPS	O
_:16351:306	90V V.contr.gc:Bandwidth <	SPS	O
_:16351:307	90V V.contr.gc:Fast Step Up active	SPS	O
_:16351:308	90V V.contr.gc:Fast Step Down active	SPS	O
_:16351:309	90V V.contr.gc:Auto Monitor	SPS	O
_:16351:357	90V V.contr.gc:Power-flow superv.	SPS	O
_:16351:310	90V V.contr.gc:Vmin Limiting w1	SPS	O
_:16351:311	90V V.contr.gc:Vmin Limiting w2	SPS	O
_:16351:312	90V V.contr.gc:Vmax Limiting w1	SPS	O
_:16351:313	90V V.contr.gc:Vmax Limiting w2	SPS	O
_:16351:314	90V V.contr.gc:Auto Blocking	SPS	O
_:16351:315	90V V.contr.gc:Manual Blocking	SPS	O
_:16351:316	90V V.contr.gc:V< Blocking w1	SPS	O
_:16351:317	90V V.contr.gc:V< Blocking w2	SPS	O
_:16351:318	90V V.contr.gc:I> Blocking	SPS	O
_:16351:319	90V V.contr.gc:I< Blocking	SPS	O
_:16351:320	90V V.contr.gc:Vact.w1	MV	O
_:16351:321	90V V.contr.gc:Vact.w2	MV	O
_:16351:322	90V V.contr.gc:ΔV act.	MV	O
_:16351:323	90V V.contr.gc:I load w1	MV	O
_:16351:324	90V V.contr.gc:I load w2	MV	O
_:16351:325	90V V.contr.gc:Vmax 1	MV	O
_:16351:326	90V V.contr.gc:Vmax 2	MV	O
_:16351:327	90V V.contr.gc:Vmin 1	MV	O
_:16351:328	90V V.contr.gc:Vmin 2	MV	O
_:16351:329	90V V.contr.gc:V tar.w1	MV	O
_:16351:330	90V V.contr.gc:V tar.w2	MV	O
_:16351:358	90V V.contr.gc:Target voltage 1 w1	SPC	C
_:16351:359	90V V.contr.gc:Target voltage 2 w1	SPC	C
_:16351:360	90V V.contr.gc:Target voltage 3 w1	SPC	C
_:16351:361	90V V.contr.gc:Target voltage 4 w1	SPC	C
_:16351:362	90V V.contr.gc:Target voltage 1 w2	SPC	C
_:16351:363	90V V.contr.gc:Target voltage 2 w2	SPC	C
_:16351:364	90V V.contr.gc:Target voltage 3 w2	SPC	C

No.	Information	Data Class (Type)	Type
_:16351:365	90V V.contr.gc:Target voltage 4 w2	SPC	C
_:16351:366	90V V.contr.gc:Set target voltage w1	APC	C
_:16351:367	90V V.contr.gc:Set target voltage w2	APC	C
_:16351:368	90V V.contr.gc:Block T1	SPC	C
_:16351:356	90V V.contr.gc:Winding act.	INS	O
_:16351:369	90V V.contr.gc:Winding selec. manual	SPC	C
_:16351:370	90V V.contr.gc:Winding selec. auto	SPC	C

9 Supervision Functions

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9.1 Overview

SIPROTEC 5 devices are equipped with an extensive and integrated supervision concept. Continuous supervision:

- Ensures the availability of the technology used
- Avoids subfunction and overfunction of the device
- Protects persons and primary technical devices
- Offers effective assistance during commissioning and testing

The following areas are monitored:

- Supervision the resource consumption of the application
- Supervision of the secondary system
- Supervision of device hardware
- Supervision of device firmware
- Supervision of hardware configuration
- Supervision of communication connections

When the supervision functions pick up, that will be displayed and also indicated. Error responses are defined for the device. The error responses are grouped in defect severities.

The supervision functions work selectively. When the supervision functions pick up - as far as possible - only the affected parts of the hardware and firmware are blocked. If this is not possible, the device goes out of operation into a secure state (fallback mode). In addition to safety, this warrants a high degree of availability.

9.2 Resource-Consumption Supervision

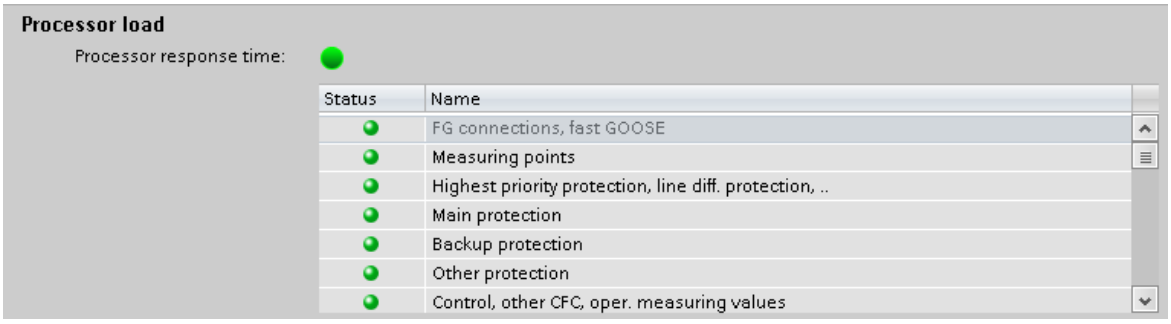
9.2.1 Load Model

SIPROTEC 5 devices are freely configurable. A load model is integrated in DIGSI 5. The load model prevents you from overloading the device with an excessively large application.

The load model shows the device utilization and the response times for device functions. If it determines that an application created is likely to overload the device, DIGSI prevents the application from being loaded into the device.

In this rare case, you must then reduce the application in order to be able to load it into the device.

The load model can be found in the DIGSI 5 project tree under **Name of the device → Device information**. In the operating range, select the **Resource consumption** setting sheet. The following figure shows an example of the view of the load model in DIGSI 5:



[sclasjsk-291112-01.tif, 1, en_US]

Figure 9-1 Visualization of the Load Model in DIGSI

A green total display for the processor response time indicates that the device is not overloaded by the present application. On the other hand, if you see a red exclamation mark, the planned application is overloading the device.

The list below the total display shows the individual functional areas. These areas combine functions with the same real-time requirements in groups. A green display in front of an area (see *Figure 9-1*) indicates that the response times of the functions grouped in this area can be maintained. A red exclamation point indicates that functions may have longer response times than are specified in the Technical data for the device. In such a case, loading of the application into the device is blocked.

The following table provides an overview of the functional areas and the most important influencing quantities on device utilization:

Functional Area	Brief Description	Change in Load
CFC event-triggered, fast	CFC charts that must be processed especially fast (for example, to invoke interlockings between protection functions)	Adding or removing CFC charts in the fast event-triggered process range • Create CFC chart • Delete CFC chart • Change the process range in the properties of the CFC chart Add to or remove from CFC charts in the fast event-triggered process area
Measuring points	Provision of measured values for protection, control, and measurement functions	Adding or removing • Measuring points (in the Measuring-points routing Editor) • Function groups that provide measured-value preprocessing for insertable functions (for example, Line function group and Circuit-breaker function group)

Functional Area	Brief Description	Change in Load
• FG connections • Fast GOOSE	• Interaction between individual function groups, for example, between the Line function group and the Circuit-breaker function group • Fast GOOSE communication	Adding or removing • Protection functions and their stages • Circuit-breaker function groups • Fast GOOSE connections
Protection Communication	Signal transmission via protection communication and differential protection communication	Adding or removing • Communication modules for the protection interface (in the DIGSI 5 Hardware and logs view) • Routings to the protection interface
Function Groups	Function Groups	Adding or removing function groups such as: • FG V/I 3-phase
Overcurrent protection	Overcurrent protection	Adding or removing • Overcurrent protection, phases • Overcurrent protection, ground
Measuring point supervising function, protection communication	• Measuring-point supervision functions • Scope of the data transmission via the protection communication	Adding or removing measuring points or individual supervising functions, such as • 3-phase current measuring point • 3-phase voltage measuring point • Measuring-voltage failure detection Add to or remove from transmission values via the protection communication • Single-point indications • Measured values
Other protection	Protection functions with low requirements for fast operate times	Adding or removing • Overload protection functions • Functions and stages of voltage protection • All functions not listed previously
CFC event-triggered, standard GOOSE	CFC charts with a maximum processing time of 40 ms	Adding or removing CFC charts in the event-triggered process range • Create CFC chart • Delete CFC chart • Change the process range in the properties of the CFC chart Add to or remove from CFC charts in the event-triggered process area
• Control • Other continuous function chart • Operational measured values	• Control and interlocking • CFC charts in the area of control, measured-value preprocessing, and event-controlled • Operational measured values	Adding or removing • Function blocks for control and interlocking • CFC charts in the control area • Switching devices (except circuit breakers), for example, disconnector function groups • Operational measured values • CFC charts in the measured values area

If the load model displays a warning, bear in mind the following general instructions:

The areas named in the table are listed in descending order of real time requirements. If a warning appears to the effect that the guaranteed response times may be exceeded in an area, you may be able to return to the permitted area by taking the following measures:

- Reduce the functional scope in the marked area (red exclamation mark)
- Reduce the functional scope in another area with higher real time requirements

When you have reduced the application, check the display in resource consumption! If a function or state has been switched off, it will continue to represent a load for the area. If you do not need the function or stage, delete it rather than switching it off.

Use the general **Circuit-breaker** function group only in the following cases:

- Interaction with a protection-function group is essential.

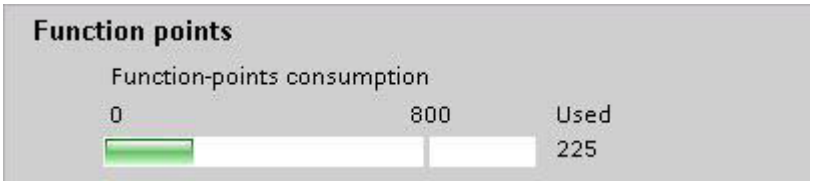
  That is, operate indications of protection functions cause the circuit breaker assigned to the **Circuit-breaker** function group to be switched off.
- You want to use functions such as the automatic reclosing function or circuit-breaker failure protection in the **Circuit-breaker** function group.

If a circuit breaker is only to be modeled for control purposes, use the **Circuit breaker [state only]** function group.

9.2.2 Function Points

When you order a SIPROTEC 5 device, you are also ordering a function-points account for use of additional functions.

The following figure illustrates consumption of function points in the current application with respect to the existing function-points account.



[scfpunkt-141210-01, 1, en_US]

Figure 9-2 Resource Overview: Function-Points Consumption

The remaining white bar shows the function points that have not yet been used up by your configuration. The number of function points available in a device depends on the device purchase order (position 20 of the product code). You can also order function points subsequently, and so increase the function-points account for the device.

NOTE

Find out the function-points requirement for the desired application before ordering the device. For this, you can use the device configurator.

9.2.3 CFC Resources

Task Levels of the CFC Function

A CFC chart, and thus the configured CFC function, runs in the SIPROTEC 5 device on exactly one of the 4 task levels. The individual task levels differ, on the one hand, in the priority of processing tasks and, on the other, in the cyclic or event-triggered processing of the CFC charts.

You can select between the following task levels:

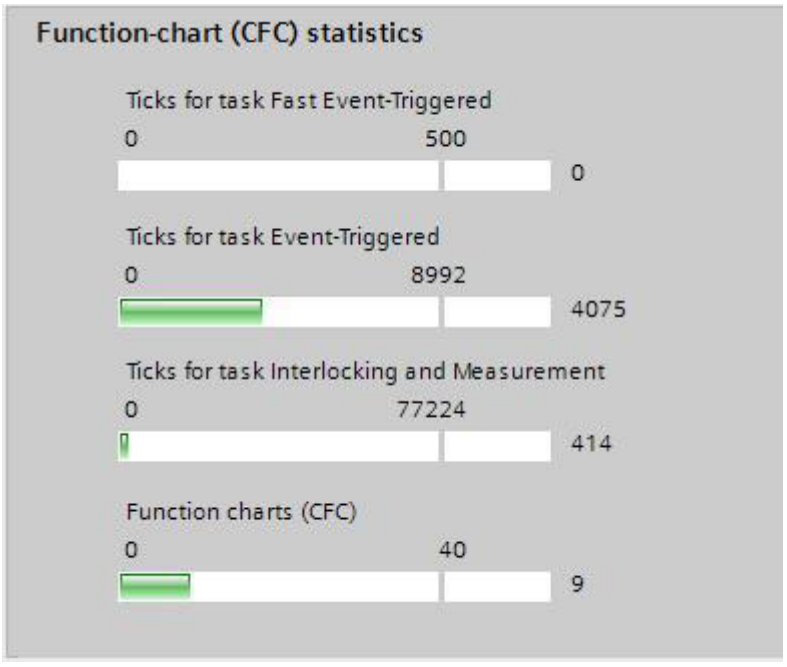
Task Level	Description
Fast Event-Triggered	Use the ***Fast Event-Triggered*** task level for time-critical tasks, for example, if a signal should block a protection function within 2 ms to 3 ms. Functions on this task level are processed in an event-triggered way with the highest priority. Each change to a logical input signal is immediately processed. Processing can interrupt the execution of protection functions and functions on the ***Event-Triggered*** task level.
Event-Triggered	Use the ***Event-Triggered*** task level preferably for logic functions that need not be executed with highest priority. Each change to a logical input signal is immediately processed. Protection functions or functions on the ***Fast event-triggered*** task level can disrupt processing. Functions on the ***Event-Triggered*** task level are typically processed within a maximum of 5 ms in all devices. For busbar protection or line protection, the functions on the ***Event-Triggered*** task level are processed within a maximum of 10 ms.
Measurement	Use the ***Measurement*** task level for processing measured values. Functions on this task level are processed cyclically every 500 ms.
Interlocking	Use the ***Interlocking*** task level preferably for logic functions that should be executed with lower priority than functions in the ***Event-Triggered*** task level. If the available ticks of the ***Event-Triggered*** task level shown in the following figure are sufficient for the required CFC functionality, you do not need to use the ***Interlocking*** task level.

All CFC function blocks can be assigned to all the task levels. There are no device-specific function blocks. If enough ticks are available, all CFC charts can be created in the same task level. A tick is the measure of the performance requirement of CFC blocks.

The number of available ticks for each task is calculated depending on the created device configuration. This calculation is based on the previously described load model. In this process, it is recommended to create all selected functions and objects first followed by configuration of the CFC charts so that a realistic information about the remaining system capacitance for CFC charts is available. Significantly exceeding the typical response time is prevented by the load model by limiting the number of CFC function blocks in the corresponding task level via the number of ticks available.

The typical response times for CFC tasks are listed in the Technical Data.

The following figure shows an example of the CFC chart capacitances in DIGSI calculated by the load model. The ticks available for each task are shown here. The green bars represent the ticks used in the task levels. You reach this dialog with the following call: Device → Device information → Resource consumption.



[sc-cfc-statistic, 1, en_US]

Figure 9-3 CFC Statistics

NOTE

The fast-event-triggered CFC charts have the highest priority and are processed before all other tasks. At this level, a considerable smaller number of ticks are available than at all other tasks. It is recommended to configure only very-high-priority logic functions at this task and to configure the other logic functions in any other level.

NOTE

Empty CFC charts also consume system resources. Empty charts that are not required any more should be deleted.

9.3 Supervision of the Secondary System

9.3.1 Overview

The secondary circuits establish a connection to the power system from the point of view of the device. The measuring-input circuit (currents, voltages) as well as the command circuits to the circuit breakers are monitored for the correct function of the device. The connection to the station battery is ensured with the supervision of the external auxiliary voltage. The secondary system has the following supervision systems:

Measuring circuits (voltage):

- Measuring-Voltage Failure
- Voltage-Transformer Circuit Breaker
- Voltage balance
- Voltage sum
- Voltage rotating field

Measuring circuits (current):

- Broken conductor of the current circuits
- Current balance
- Current sum
- Current rotating field

Trip circuits

External auxiliary voltage

When these supervisions pick up, corresponding warning indications are output. Some supervisions lead directly to the blocking of affected protection functions or to the marking of measuring points that have become invalid, so that affected protection functions can go into a secure state.

A detailed description of the supervision mechanisms and their error responses can be found in the Function Description and as overall overview at the end of chapter 8.

9.3.2 Measuring-Voltage Failure

9.3.2.1 Overview of Functions

The **Measuring-voltage failure detection** function monitors the voltage transformer secondary circuits:

- Non-connected transformers
- Pickup of the voltage transformer circuit breaker (in the event of short circuits in the secondary circuit)
- Broken conductor in one or more measuring loops

All these events cause a voltage of 0 in the voltage transformer secondary circuits which can lead to failures of the protection functions.

For the following protection functions, the response (block/not block) to a measuring-voltage failure can be set within the function:

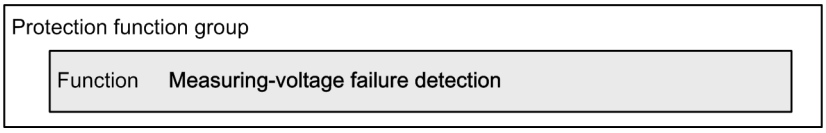
- Directional time-overcurrent protection, phases
- Overvoltage protection with negative-sequence voltage
- Overvoltage protection with zero-sequence voltage/residual voltage
- Undervoltage protection with 3-phase voltage
- Undervoltage protection with positive-sequence voltage

The following protection functions are automatically blocked in the case of a measuring-voltage failure:

- Distance protection
- Directional negative-sequence protection
- Ground-fault protection for high-resistance faults in grounded-neutral systems

9.3.2.2 Structure of the Function

The function is part of protection function groups which are connected with a 3-phase voltage and current measurement point.

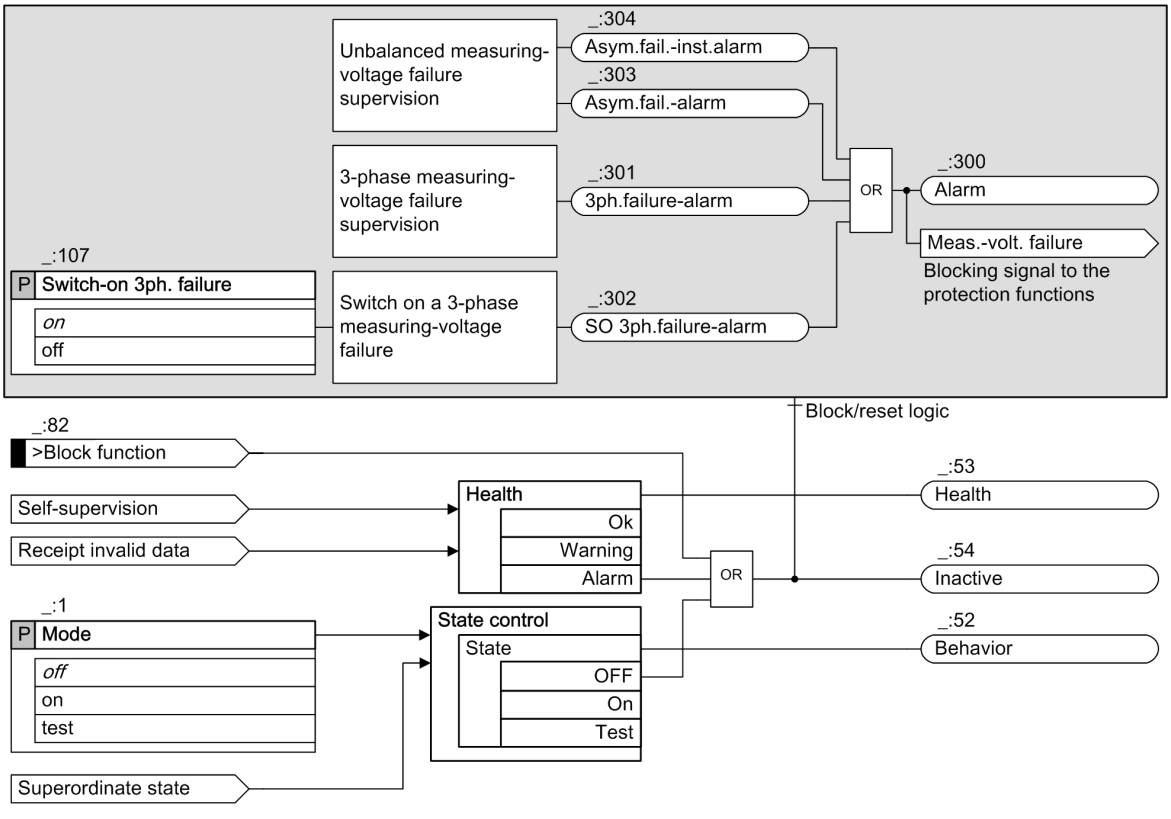


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Figure 9-4 Structure/Embedding of the Function

The function is broken down into 3 subfunctions (see *Figure 9-5*):

- Supervision for unbalanced measuring-voltage failure
- Supervision for 3-phase measuring-voltage failure
- Supervision for switching onto a 3-phase measuring-voltage failure



[lozusamm-100611-01.tif, 2, en_US]

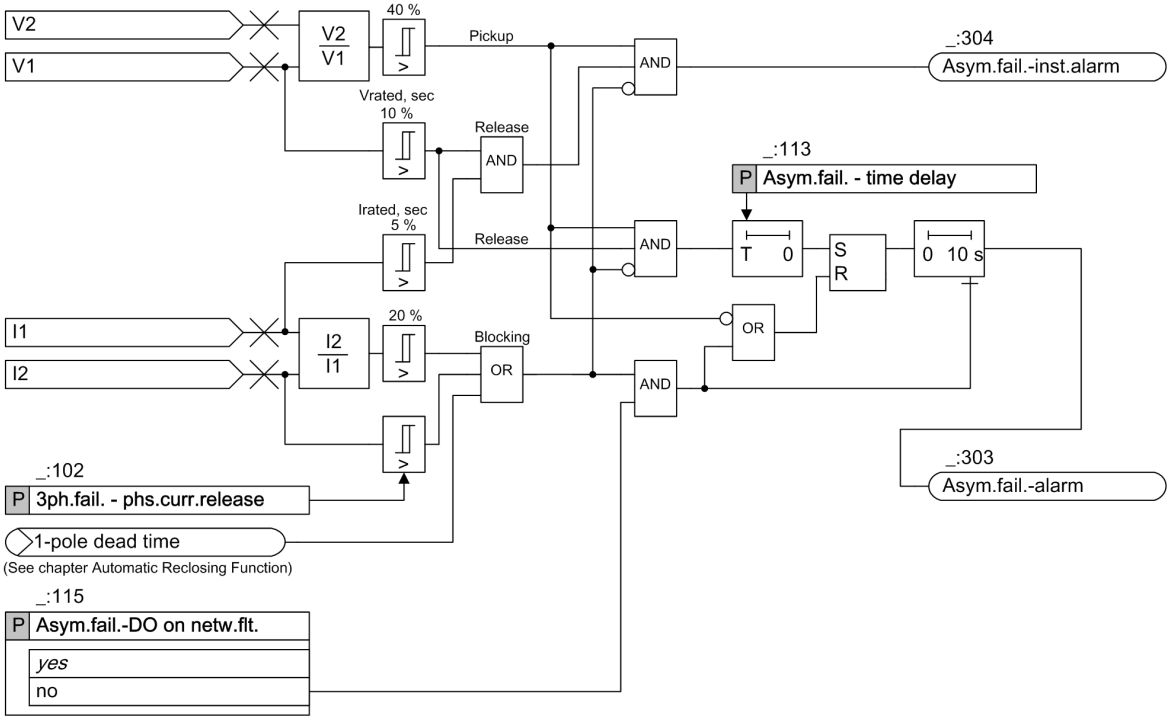
Figure 9-5 Breakdown of the Measuring-Voltage Failure Detection Function

Each subfunction creates its own monitoring indication. The function summarizes these indications via the group indication **`Alarm`**.

The response to the detection of a measuring-voltage failure is explained in the specific protection-function descriptions.

9.3.2.3 Unbalanced Measuring-Voltage Failure

Logic



[looppode-200812-05.tif, 2, en_US]

Figure 9-6 Logic Diagram Unbalanced Measuring-Voltage Failure Detection

The criterion for detection of an unbalanced measuring-voltage failure is the voltage unbalance. This unbalance is determined based on the ratio between negative and positive-sequence voltage. If the threshold value is violated and the monitoring is released and not blocked, the monitoring picks up (see *Figure 9-6*). The indication *Asym.fail.-inst.alarm* is output.

The monitoring is released as soon as a certain minimum voltage is exceeded. This prevents a spurious response in the presence of low voltage measurands or a measurand of 0 (for example, circuit breaker open). Instantaneous monitoring also requires the presence of a minimum current. This prevents a spurious instantaneous pick up of the monitoring in the presence of a weak infeed (current < 10 % of rated current) combined with a power-system incident.

If the voltage unbalance is blocked by unbalanced faults in the primary system, the supervision is blocked. The device detects an unbalanced fault based on the ratio between negative-sequence and positive-sequence current. In the event of 1-pole automatic reclosing, the supervision is blocked.

Delay/Seal-In

In the presence of a weak infeed (current < 10 % of rated current), certain protection functions require more time for detection of a system incident. For this purpose, the monitoring can be delayed using the **Asym.fail. - time delay** parameter.

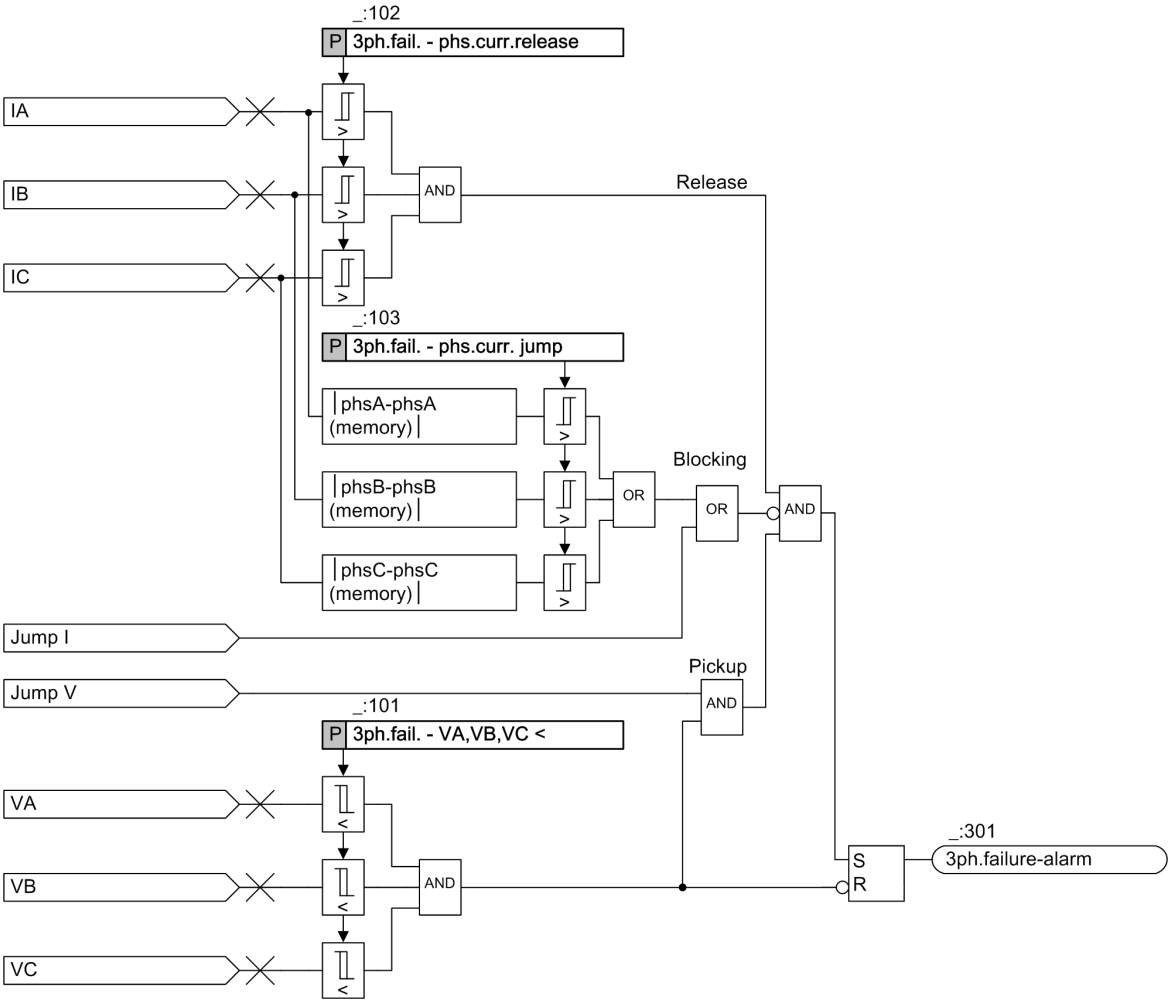
If a system incident is detected during the time delay, the supervision drops off. This is because the function assumes that the unbalance - and consequently the pickup of the supervision - is due to the system incident.

After the time delay has elapsed, it definitely assumes a measuring-voltage failure. The monitoring seals in and the *Asym.fail.-alarm* indication is output. The dropout does not happen until the voltage unbalance has disappeared after a seal-in time of 10 s. In the presence of 3-pole close-in faults outside the protection zone, this seal-in time prevents the monitoring from dropping off too quickly and thus releasing the protection functions.

The sealing-in function can be deactivated using the **Asym.fail.-DO on netw.flt.** parameter. As soon as a system incident is detected, the monitoring drops off instantaneously.

9.3.2.4 3-Phase Measuring-Voltage Failure

Logic



[losymmet-190912-01.tif, 1, en_US]

Figure 9-7 Logic Diagram 3-Phase Measuring-Voltage Failure

Balanced Fault – VA, VB, VC <

A 3-phase measuring-voltage failure is detected if the following criteria are fulfilled simultaneously:

- All 3 phase-to-ground voltages drop below the threshold value **3ph.fail. - VA,VB,VC <**
- A jump of the voltage (Signal **jump V**)

If these criteria are fulfilled and the monitoring is released and not blocked, the **3ph.failure-alarm** indication is output. When the voltage returns (even as 1-phase), the monitoring drops out.

Release by Phase Current

When all phase currents exceed the threshold value **3ph.fail. - phs.curr.release** the monitoring is released.

Blocking in the Case of a System Incident

In the case of a 3-phase system incident, supervision must be blocked. The device detects a 3-phase incident with a jump in the current. This change is detected via the internal signal **Jump I** or when the change in current of a phase current exceeds the threshold value **3ph.fail. - phs.curr. jump**. The change in

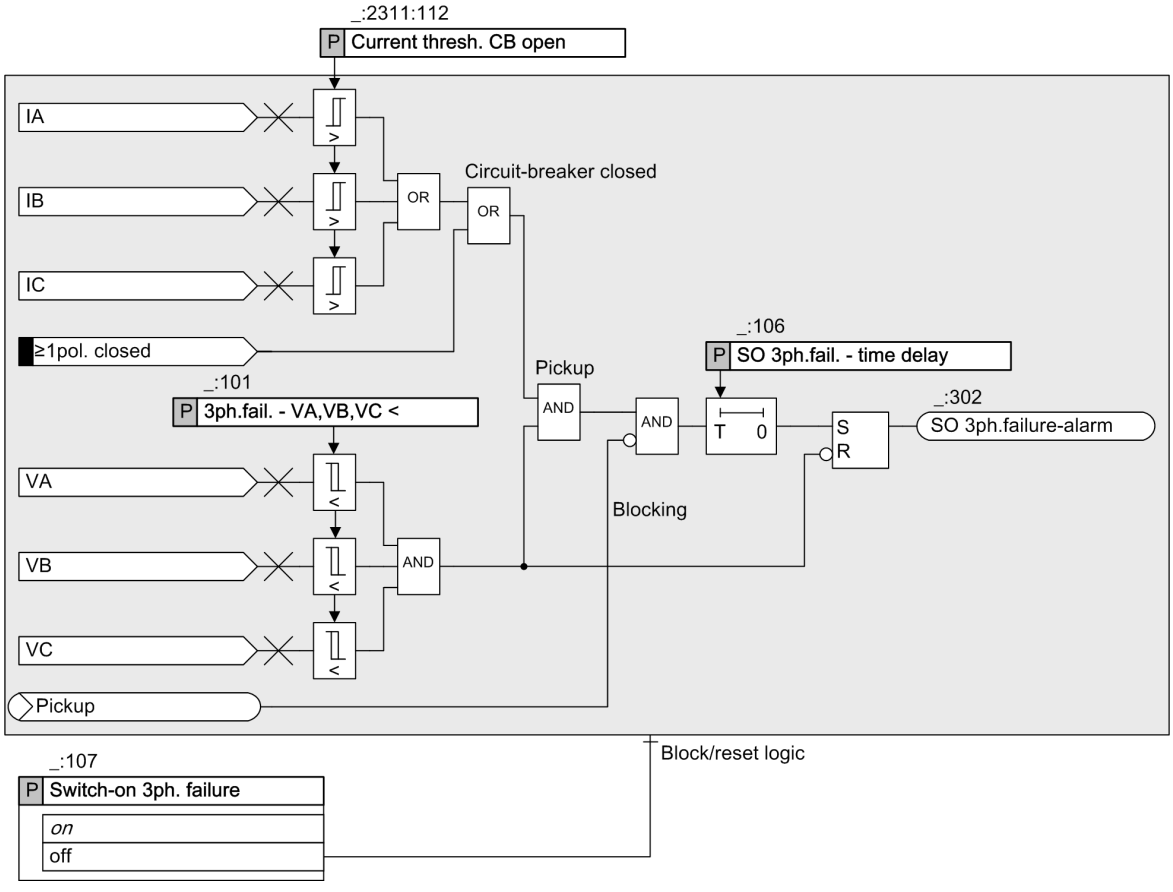
current of phase currents is formed from the difference between the present current phasor and the current phasor of the previous period. This allows to take into account a jump of the current phase.

NOTE

If a voltage transformer circuit-breaker is installed in the secondary circuit of the voltage transformers, its position is communicated to the device via a binary input (see chapter *9.3.4.1 Overview of Functions*).

9.3.2.5 Switching onto a 3-Phase Measuring-Voltage Failure, Low Load

Logic



[lozuscha-100611-01.tif, 1, en_US]

Figure 9-8 Logic Diagram Switching to 3-Phase Measuring-Voltage Failure

Switching onto a 3-phase measuring-voltage failure is detected if the following criteria are fulfilled simultaneously:

- All 3 phase-to-ground voltages have dropped below the threshold value **`3ph.fail. - VA,VB,VC <`**.
- The circuit breaker is detected to be in closed position. The detection takes place either via the phase currents or via the **`≥1-pole closed`** signal, which is generated via the circuit-breaker auxiliary contacts. You can find more detailed information in chapter *5.8.5 Circuit-Breaker Condition for the Protected Object*.

A voltage jump – such as in a 3-phase measuring-voltage failure with closed circuit breaker (see chapter*9.3.2.4 3-Phase Measuring-Voltage Failure*) – does not occur in the case of switching to a 3-phase measuring-voltage failure. If the monitoring is not blocked, the time delay **`SO 3ph.fail. - time delay`** is started. After the time has elapsed, the indication **`SO 3ph.failure-alarm`** is displayed. A dropout of the monitoring is only possible by a recovery of the voltage.

The supervision is blocked as soon as a pickup of a protection function is detected within a protection function group and the time delay of the supervision has not yet elapsed.

This subfunction also covers the situation of a low load with 3-phase measuring-voltage failure and closed circuit breaker, because the circuit-breaker condition is also determined from the circuit-breaker auxiliary contacts. The subfunction for detecting a 3-phase measuring-voltage failure (see chapter *9.3.2.4 3-Phase Measuring-Voltage Failure*) is not released in this situation, for example, because the current flow is too low.

This subfunction can be switched on or off separately using the **Switch-on 3ph. failure** parameter.

9.3.2.6 Application and Setting Notes

Parameter: Asym.fail. - time delay

- Recommended setting value **(_:113) Asym.fail. - time delay** = ***10.00 s***

The **Asym.fail. - time delay** parameter allows you to set the time during which a system incident detected after the occurrence of the unbalance resets the monitoring. This setting is important in the case of weak infeed (current < 10 % of rated current) in order to give certain protection functions (such as distance protection) more time for detecting system incidents. As long as the time delay runs, it is assumed that the unbalance is due to a system incident.

As soon as the time has elapsed, the supervision assumes a measuring-voltage failure and seals in.

Siemens recommends using the default setting.

If you want the seal-in function to operate sooner or at once, you can reduce the time.

Parameter: Asym.fail.-DO on netw.flt.

- Recommended setting value **(_:115) Asym.fail.-DO on netw.flt.** = ***No***

Parameter Value	Description
no	After elapse of the time delay the supervision function seals in. Even if the system incident criterion is fulfilled, the protection functions concerned will remain blocked. This avoids an unselective tripping of the protection functions due to an absence of the measuring voltage in the case of an unbalanced system incident. This is the default setting.
yes	The seal-in function is switched off. The supervision drops out immediately when a system incident is detected. With this setting, the unbalanced measuring-voltage failure is only reported, and in the event of a double failure (measuring-voltage failure and system incident in parallel), unselective tripping is preferred.

Parameter: 3ph.fail. - VA,VB,VC <

- Recommended setting value **(_:101) 3ph.fail. - VA,VB,VC <** = ***5 V***

The **3ph.fail. - VA,VB,VC <** parameter allows you to set the pickup value of the monitoring.

Siemens recommends using the default setting.

If you expect major disturbances acting upon the voltage inputs, you can increase this value. Increasing the values makes the supervision more sensitive to 3-phase system incidents.

Parameter: 3ph.fail. - phs.curr.release

- Recommended setting value **(_:102) 3ph.fail. - phs.curr.release** = ***0.1 A*** for I_{rated} = 1 A or ***0.5 A*** for I_{rated} = 5 A

The **3ph.fail. - phs.curr.release** parameter is used to define the phase current threshold above which the monitoring is released.

Siemens recommends using the default setting.

Parameter: 3ph.fail. - phs.curr. jump

- Recommended setting value **(_:103) 3ph.fail. - phs.curr. jump** = ***0.1 A*** for I_{rated} = 1 A or ***0.5 A*** for I_{rated} = 5 A

The **3ph.fail. - phs.curr. jump** parameter is used to set the differential current between the present current phasor and the stored phasor (from the previous period). If the value is exceeded, the function detects a system incident and blocks the monitoring.
Siemens recommends using the default setting.

Parameter: SO 3ph.fail. - time delay

- Recommended setting value **(_:106) SO 3ph.fail. - time delay** = ***3.00 s***

The **SO 3ph.fail. - time delay** parameter allows you to set the delay of the monitoring.
Siemens recommends using the default setting.



NOTE

Adapt the **SO 3ph.fail. - time delay** parameter to the inherent time of protection functions which are intended to block the monitoring function.
Note that with parameter values 0 s blocking of the monitoring function via a protection stimulation will not be possible any more.

Parameter: Switch-on 3ph. failure

- Recommended setting value **(_:107) Switch-on 3ph. failure** = ***on***

Parameter Value	Description
on	The subfunction **Switching to a 3-phase measuring-voltage failure** is active. In the case of low loads, the subfunction for detection of a 3-phase measuring-voltage failure is not released, for example, because the current flow is too low. In this situation, the subfunction **Switching to a 3-phase measuring-voltage failure** can perform the monitoring task. Siemens recommends to switch that subfunction on.
off	With the setting ***off*** the subfunction **Switching to a 3-phase measuring-voltage failure** is not active.

9.3.2.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Mes.v.fail.det				
_:1	Mes.v.fail.det:Mode		• off • on • test	on
_:115	Mes.v.fail.det:Asym.fail.-DO on netw.flt.		• no • yes	yes
_:113	Mes.v.fail.det:Asym.fail. - time delay		0.00 s to 30.00 s	10.00 s
_:102	Mes.v.fail.det:3ph.fail. - phs.curr.release	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A

Addr.	Parameter	C	Setting Options	Default Setting
_:103	Mes.v.fail.det:3ph.fail. - phs.curr. jump	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:101	Mes.v.fail.det:3ph.fail. - VA,VB,VC <		0.300 V to 340.000 V	5.000 V
_:107	Mes.v.fail.det:Switch-on 3ph. failure		• off • on	on
_:106	Mes.v.fail.det:SO 3ph.fail. - time delay		0.01 s to 30.00 s	3.00 s

9.3.2.8 Information List

No.	Information	Data Class (Type)	Type
Mes.v.fail.det			
_:82	Mes.v.fail.det:>Block function	SPS	I
_:54	Mes.v.fail.det:Inactive	SPS	O
_:52	Mes.v.fail.det:Behavior	ENS	O
_:53	Mes.v.fail.det:Health	ENS	O
_:300	Mes.v.fail.det:Alarm	SPS	O
_:304	Mes.v.fail.det:Asym.fail.-inst.alarm	SPS	O
_:303	Mes.v.fail.det:Asym.fail.-alarm	SPS	O
_:301	Mes.v.fail.det:3ph.failure-alarm	SPS	O
_:302	Mes.v.fail.det:SO 3ph.failure-alarm	SPS	O

9.3.3 Signaling-Voltage Supervision

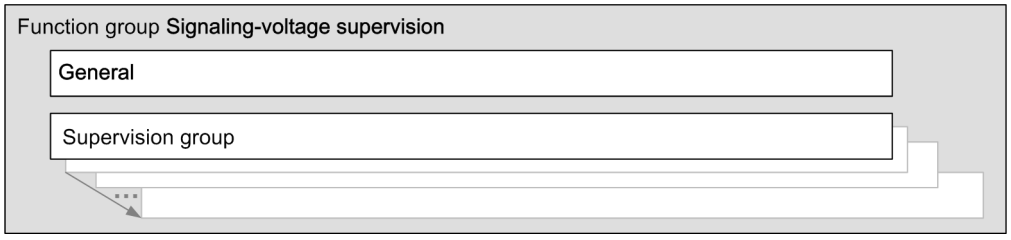
9.3.3.1 Overview of Functions

Signaling-voltage supervision is used to evaluate the validity of binary signals connected to the SIPROTEC device via binary inputs. For this purpose, one binary input is used to monitor the signaling voltage. If the signaling voltage fails, the associated binary signals are marked as invalid and a **Signaling-voltage malfunction** indication is issued.

Several signaling-voltage supervision groups can be created in one SIPROTEC device. Each of these groups monitors an adjustable area with binary inputs.

9.3.3.2 Structure of the Function

The **Signaling-voltage supervision** function group contains, besides the general functionality, one preinstantiated **Supervision group** stage. The **Supervision group** stage can be instantiated in DIGSI 5 multiple times.

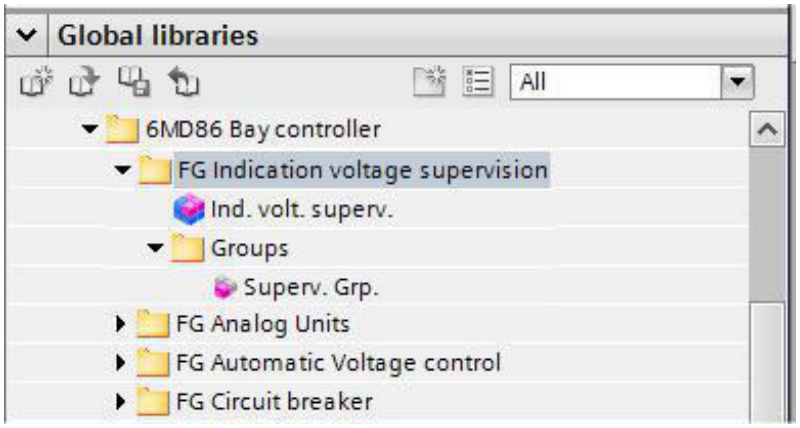


[dwivsstr-060214-01.vsd, 1, en_US]

Figure 9-9 Structure/Embedding of the Function Group

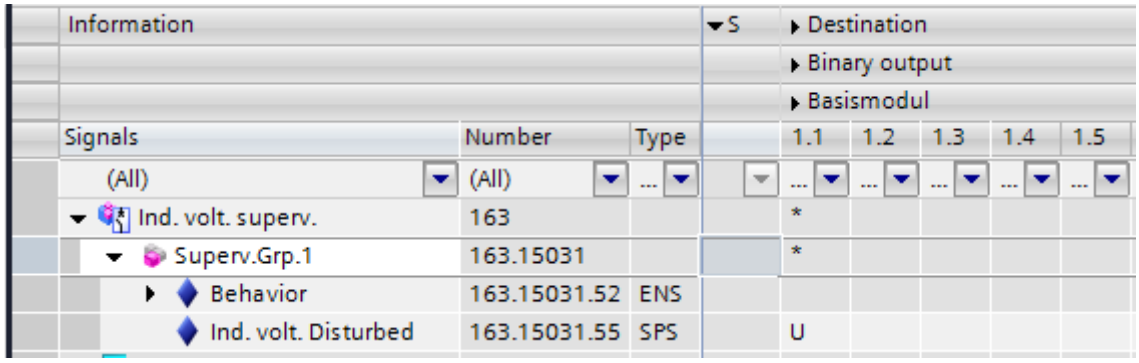
9.3.3.3 Function Description

You can instantiate the **Signaling-voltage supervision** function group in DIGSI from the global library. It contains 1 pre-instantiated **Supervision group** function block (see the following figure). You can instantiate a maximum of 25 supervision groups.



[sc_ivslib, 1, en_US]

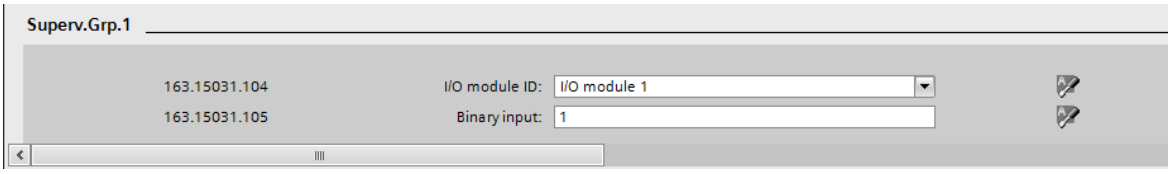
Following the instantiation of the function group in the DIGSI project tree, it appears in the information routing of DIGSI (see the following figure). The status indications of the supervision groups can be routed here, for example, to existing binary outputs and/or logs.



[sc_ivsrou, 1, en_US]

Set the binary input used for signaling-voltage supervision within one input/output module using the setting option (see the following figure). This binary input monitors the presence of the signaling voltage. If the signaling voltage fails, this sets the quality attribute for all other binary inputs of the parameterized input/output module to ***invalid***. The signal status of each of these binary inputs is frozen with its last valid value prior to the occurrence of the fault. The quality attribute of the binary inputs for other input/output modules are not taken into consideration by this.

If the signaling voltage again exceeds the binary threshold, the quality attribute of the binary inputs is reset to ***valid***.

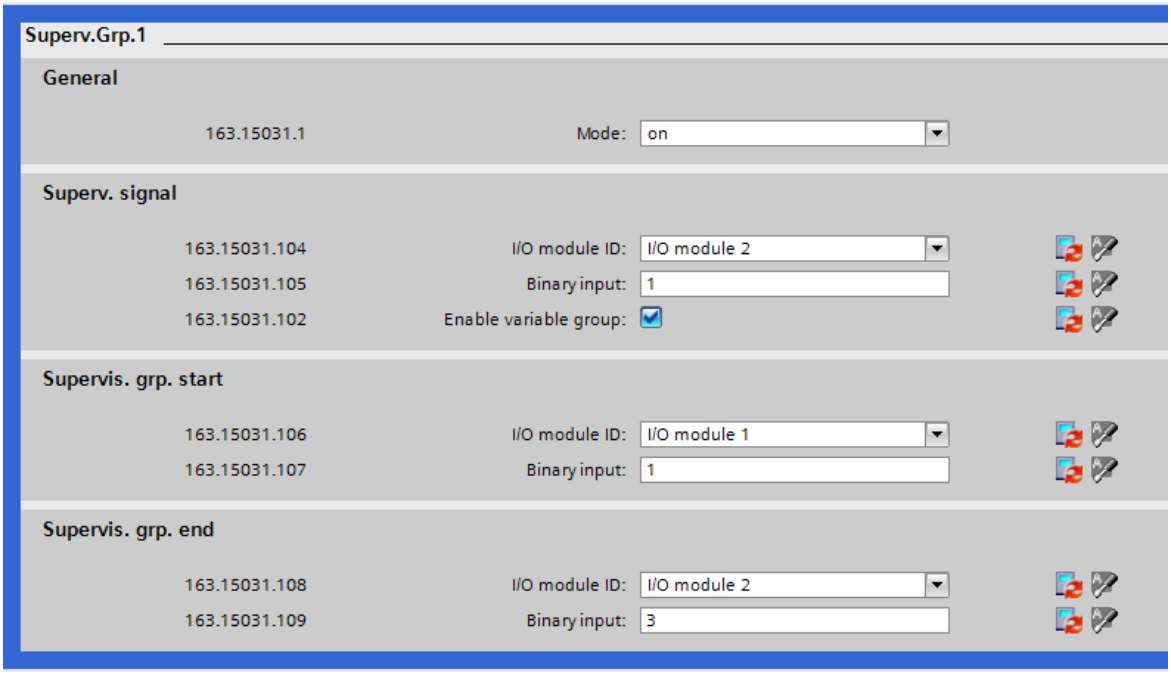


[sc_ivsgrp, 1, en_US]

NOTE

Each status change of the monitored binary inputs is delayed by 3 ms.

You can also combine binary inputs across modules in one **Supervision group** function block, and define any binary input within this group for the supervision of the signaling voltage. For this purpose, place a check mark at the parameter **(_:102) Enable variable group** when configuring the supervision group. This extends the parameter menu by the sections **Start supervision group** and **End supervision group** (see the following figure).



[sc_gruppe_de, 1, en_US]

There, for example, you are able to combine 1 to n different binary inputs into one supervision group. When doing so, the binary inputs on the input/output modules assignable to a supervision group must be related logically. With 3 input/output modules, for example, this allows only consecutive binary inputs to be grouped on the modules 1+2 or 2+3, but no binary inputs on modules 1+3. The binary inputs used for supervision can be located on any input/output module within the group defined in this manner.

If you have to monitor several binary inputs that, for example, work with different signaling voltages from different sources, then you can also instantiate and configure several **Supervision group** function blocks within the **Signaling-voltage supervision** function group accordingly.

Within different supervision groups, only those consecutive binary inputs that are not already assigned to another supervision group can be grouped. The overlapping of binary inputs in different supervision groups is not permitted.

Example: There are 4 input/output modules. Binary inputs of input/output module 1+2 are already combined in supervision group 1. The 2 last binary inputs on module 2 are not included in the grouping. Thus, only these 2 binary inputs not used in the supervision group 1 of the input/output module 2 as well as, where applicable, further consecutive binary inputs of input/output modules 3+4 can be combined in supervision group 2.

Error parameters are displayed to you by inconsistency indications in DIGSI.

9.3.3.4 Application and Setting Notes

Parameter (General): Mode

- Default setting **(_:1) Mode** = ***on***

With the **Mode** parameter, you specify whether you want to activate, deactivate, or test the supervision of the signaling voltage for the appropriate group. If you put the group into test mode, the *Sig. volt. disturbed* indication is given a test flag. If the supervision input drops out in test mode, the assigned inputs retain their status without their quality attribute being set to **invalid**.

Parameter (Supervision Signal): I/O module ID

- Default setting **(_:104) I/O module ID** = ***I/O module 1***

Using the **I/O module ID** parameter, you specify the I/O module for which you want to activate signaling-voltage supervision. Counting of the I/O modules starts in increasing order with the binary inputs of the base module. The binary inputs of the PS201 power-supply module permanently installed in the base module count as the 2nd I/O module followed by additional I/O modules (3 to n) in the expansion boards of the device.

Parameter (Supervision Signal): Binary input

- Default setting **(_:105) Binary input** = ***1***

Using the **Binary input** parameter, you specify the binary input responsible for the supervision of the signaling voltage for the parameterized I/O module. The quality attribute of all other binary inputs for this module are set to **valid** or **invalid** depending on the presence of the signaling voltage at the parameterized binary input.

Parameter (Supervision Signal): Enable variable group

- Default setting **(_:102) Enable variable group** = ***untrue***

You can activate the parameter **Enable variable group** by placing the check mark. If you have not set the check mark (default setting), only these 2 parameters are available for the configuration of the supervision signal. If you have set the check mark, the parameter menu is extended by the areas **Start supervision group** and **End supervision group**. You can then use that to carry out the grouping of binary inputs for supervision groups explained in the function description.

Parameter (Start Supervision Group): I/O module ID

- Default setting **(_:106) I/O module ID** = ***I/O module 1***

Parameter **I/O module ID** is used to define the first I/O module that you want to assign to a supervision group. As the counting of the I/O module starts in ascending order with the binary inputs of the base module, this is the module with the lowest counter number that you can use for carrying out a grouping.

Parameter (Start Supervision Group): Binary input

- Default setting **(_:107) Binary input** = ***1***

Parameter **Binary input** is used to define the lowest binary input for the first I/O module (see **(_:106) I/O module ID**) that you want to assign to a supervision group.

Parameter (End Supervision Group): I/O module ID

- Default setting **(_:108) I/O module ID** = ***I/O module 1***

Parameter **I/O module ID** is used to define the last I/O module that you want to assign to a supervision group. As the counting of the I/O module starts in ascending order with the binary inputs of the base module, this is the module with the highest counter number that you can use for carrying out a grouping.

Parameter (End Supervision Group): `Binary input`

- Default setting **`(_:109) Binary input`** = ***1***

Parameter **`Binary input`** is used to define the highest binary input for the last I/O module (see **`(_:108) I/O module ID`**) that you want to assign to a supervision group.

9.3.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Superv.Grp.#:Mode		• off • on • test	on
Superv. signal				
_:104	Superv.Grp.#:I/O module ID		• I/O module 1 • I/O module 2 • I/O module 3 • I/O module 4 • I/O module 5 • I/O module 6 • I/O module 7 • I/O module 8 • I/O module 9 • I/O module 10 • I/O module 11 • I/O module 12 • I/O module 13 • I/O module 14 • I/O module 15	I/O module 1
_:105	Superv.Grp.#:Binary input		1 to 256	1
_:102	Superv.Grp.#:Enable variable group		• 0 • 1	false
Supervis. grp. start				
_:106	Superv.Grp.#:I/O module ID		• I/O module 1 • I/O module 2 • I/O module 3 • I/O module 4 • I/O module 5 • I/O module 6 • I/O module 7 • I/O module 8 • I/O module 9 • I/O module 10 • I/O module 11 • I/O module 12 • I/O module 13 • I/O module 14 • I/O module 15	I/O module 1
_:107	Superv.Grp.#:Binary input		1 to 256	1

Addr.	Parameter	C	Setting Options	Default Setting
Supervis. grp. end				
_:108	Superv.Grp.#:I/O module ID		• I/O module 1 • I/O module 2 • I/O module 3 • I/O module 4 • I/O module 5 • I/O module 6 • I/O module 7 • I/O module 8 • I/O module 9 • I/O module 10 • I/O module 11 • I/O module 12 • I/O module 13 • I/O module 14 • I/O module 15	I/O module 1
_:109	Superv.Grp.#:Binary input		1 to 256	1

9.3.3.6 Information List

No.	Information	Data Class (Type)	Type
Superv.Grp.#			
_:52	Superv.Grp.#:Behavior	ENS	O
_:55	Superv.Grp.#:Sig. volt. disturbed	SPS	O

9.3.4 Voltage-Transformer Circuit Breaker

9.3.4.1 Overview of Functions

The **Voltage-transformer circuit breaker** function detects the tripping of the voltage-transformer circuit breaker due to short circuits in the voltage-transformer secondary circuits.

The **Voltage-transformer circuit breaker** function works independently of **Measuring-voltage failure detection** and should be used – if possible – in parallel to it.

The tripping of the voltage-transformer circuit breaker has an impact on the quality of the recorded measured-value data (see chapter *3.3 Processing Quality Attributes*).

The following protection function is automatically blocked in cases of the tripping of the voltage-transformer circuit breaker:

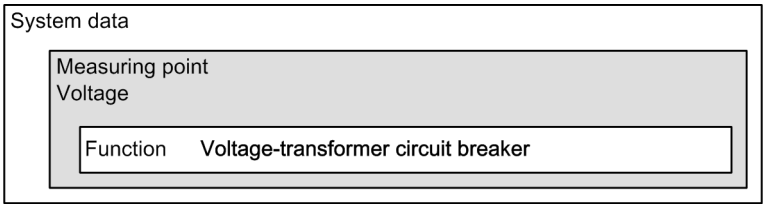
- Directional negative-sequence protection

For the following functions the reaction (block/not block) can be set within the function in cases of a tripping of the voltage-transformer circuit breaker:

- Directional time-overcurrent protection, phases
- Directional time-overcurrent protection, ground
- Directional sensitive ground-fault detection
- Overvoltage protection with negative-sequence voltage
- Overvoltage protection with zero-sequence voltage/residual voltage
- Undervoltage protection with 3-phase voltage
- Undervoltage protection with positive-sequence voltage

9.3.4.2 Structure of the Function

The *Figure 9-10* shows the position of the function in the device. Every voltage measuring point contains the **Voltage-transformer circuit breaker** function.



[dwmcbstr-040211-01.tif, 1, en_US]

Figure 9-10 Structure/Embedding of the Function

9.3.4.3 Function Description

The tripping of the voltage-transformer circuit breaker is captured via the binary input signal **>Open**. With an active input signal the information about the measuring-voltage failure is relayed to the affected functions (see *9.3.4.1 Overview of Functions*). The response to the detection of a measuring-voltage failure is explained in the specific protection-function descriptions.

Response Time of the Voltage-Transformer Circuit Breaker

The response time of the voltage-transformer circuit breaker can be slower than the pickup time of the distance protection. This bears the risk of an overfunction. The response time is communicated to the device with the **Response time** parameter. For a timely detection of the tripping of the voltage-transformer circuit breaker, the pickup of the distance protection is delayed by that response time.

9.3.4.4 Application and Setting Notes

The function is always active and need not be switched on.

Input Signal: >Open

- Input signal: **(_:500) >Open**

The input signal **>Open** must be connected to the tripping of the voltage-transformer circuit breaker. As a rule, this occurs via the routing to a binary input.

Parameter: Response time of the voltage-transformer circuit breaker

- Recommended setting value **(_:101) Response time** = ***0 ms***

When the voltage-transformer circuit breaker drops out, the device must block the distance protection immediately to prevent an unwanted tripping of the distance protection due to the absence of the measuring voltage while the load current is flowing.

The blocking must be faster than the 1st stage of the distance protection. This requires an extremely short response time of the miniature circuit breaker (≤ 4 ms at 50 Hz, ≤ 3 ms at 60 Hz rated frequency). If the circuit-breaker auxiliary contact does not fulfill this requirement, you have to set the response time accordingly.

9.3.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
VT miniatureCB				
_:101	VT miniatureCB:Response time		0.00 s to 0.03 s	0.00 s

9.3.4.6 Information List

No.	Information	Data Class (Type)	Type
Definite-T #			
_:500	VT miniatureCB:>Open	SPS	I

9.3.5 Voltage-Balance Supervision

9.3.5.1 Overview of Functions

In healthy system operation, a certain balance between voltages can be assumed.

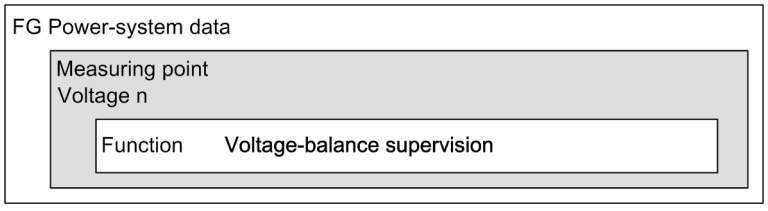
The **Voltage-balance supervision** function detects the following errors:

- Unbalance of phase-to-phase voltages in the secondary circuit
- Connection errors during commissioning or short circuits and interruptions in the secondary circuit

The voltage measurement is based on the RMS values of the fundamental component.

9.3.5.2 Structure of the Function

The **Voltage-balance supervision** function is located in the **Power-system data** of each 3-phase voltage measuring point.



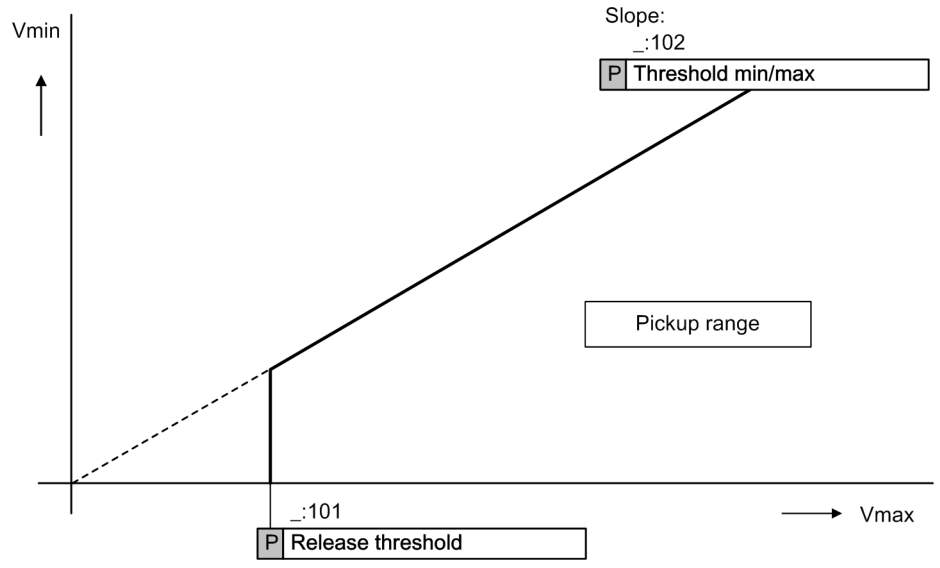
[dwstrusy-300913, 2, en_US]

Figure 9-11 Structure/Embedding of the Function

9.3.5.3 Function Description

The voltage balance is checked by a magnitude supervision function. This function relates the smallest phase-to-phase voltage to the largest phase phase-to-phase voltage. Unbalance is detected if

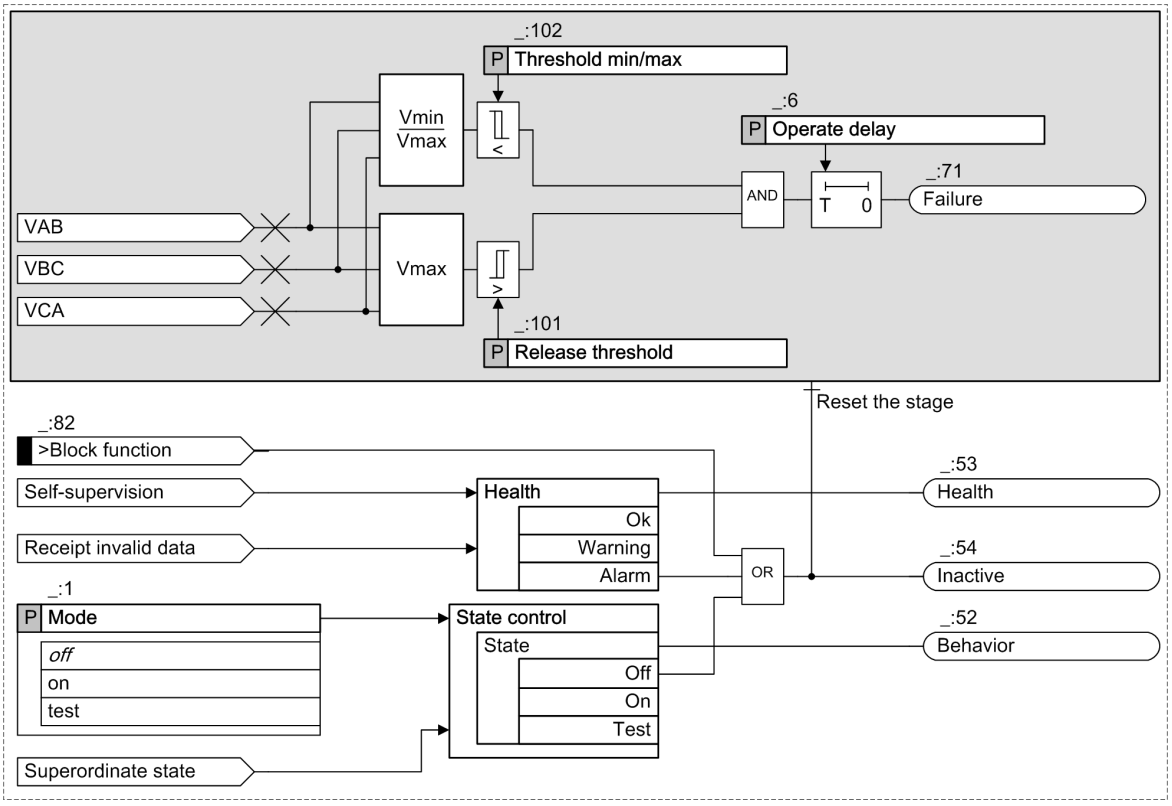
|Vmin| / |Vmax| < **`Threshold min/max`**, as long as Vmax > **`Release threshold`**.



[lokenuns-040211-01.tif, 1, en_US]

Figure 9-12 Characteristic of the Voltage-Balance Supervision

Logic



[lospasym-100611-01.tif, 2, en_US]

Figure 9-13 Logic Diagram of the Voltage-Balance Supervision

The **Threshold min/max** parameter is the criterion by which a phase-to-phase voltage unbalance is measured. The device calculates the ratio between the minimum (V_{min}) and the maximum (V_{max}) phase-to-phase voltage.

Enter the lower limit of the maximum phase-to-phase voltage (V_{max}) with the parameter **Release threshold**. This specifies the lower limit of the operating range of this function.

Operate delay

If it falls below the balance factor **Threshold min/max** and at the same time the maximum phase-to-phase voltage exceeds the **Release threshold**, the **Operate delay** begins. If both conditions persist during this time, the indication **Failure** is generated.

9.3.5.4 Application and Setting Notes

Parameter: Threshold min/max

- Recommended setting value **(_:102) Threshold min/max** = ***0.75***

The **Threshold min/max** parameter is used to set the ratio between the minimum (V_{min}) and the maximum (V_{max}) phase-to-phase voltage. Siemens recommends using the default setting.

Parameter: Release threshold

- Recommended setting value **(_:101) Release threshold** = ***50 V***

With the **Release threshold** parameter you set the lower limit of the maximum phase-to-phase voltage (V_{max}). Siemens recommends using the default setting.

Parameter: Operate delay

- Recommended setting value **(_:6) Operate delay** = ***5.00 s***

Set the **Operate delay** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

9.3.5.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. balan. V				
_:1	Supv. balan. V:Mode		• off • on • test	off
_:101	Supv. balan. V:Release threshold		0.300 V to 170.000 V	50.000 V
_:102	Supv. balan. V:Threshold min/max		0.58 to 0.95	0.75
_:6	Supv. balan. V:Delay supervision alarm		0.00 sto 100.00 s	5.00 s

9.3.5.6 Information List

No.	Information	Data Class (Type)	Type
Supv. balan. V			
_:82	Supv. balan. V:>Block function	SPS	I
_:54	Supv. balan. V:Inactive	SPS	O
_:52	Supv. balan. V:Behavior	ENS	O
_:53	Supv. balan. V:Health	ENS	O
_:71	Supv. balan. V:Failure	SPS	O

9.3.6 Voltage-Sum Supervision

9.3.6.1 Overview of Functions

In healthy system operation, the sum of all voltages at one measuring point must be approximately 0. The **Voltage-sum supervision** monitors the sum of all voltages of one measuring point in the secondary circuit. It detects connection errors during commissioning or short circuits and interruptions in the secondary circuit. For summation of the voltages, the 3 phase-to-ground voltages and the residual voltage (da-dn - voltage of an open-circuited delta winding) are required.

The voltage measurement is based on the RMS values of the fundamental component.

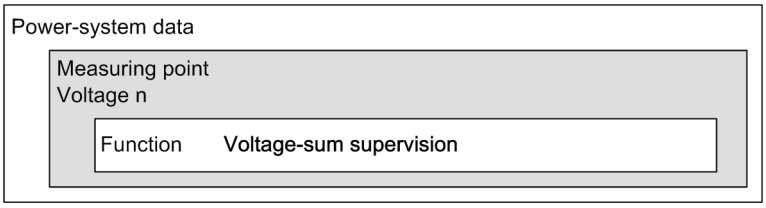
NOTE

For the **Voltage-sum supervision**, the externally generated residual voltage must be connected to the 4th voltage measuring input.

For the **Voltage-sum supervision** to work correctly, the **`Matching ratio Vph / VN`** parameter must be set accordingly.

9.3.6.2 Structure of the Function

The **Voltage-sum supervision** function is located in the **Power-system data** function group of each 3-phase voltage measuring point.

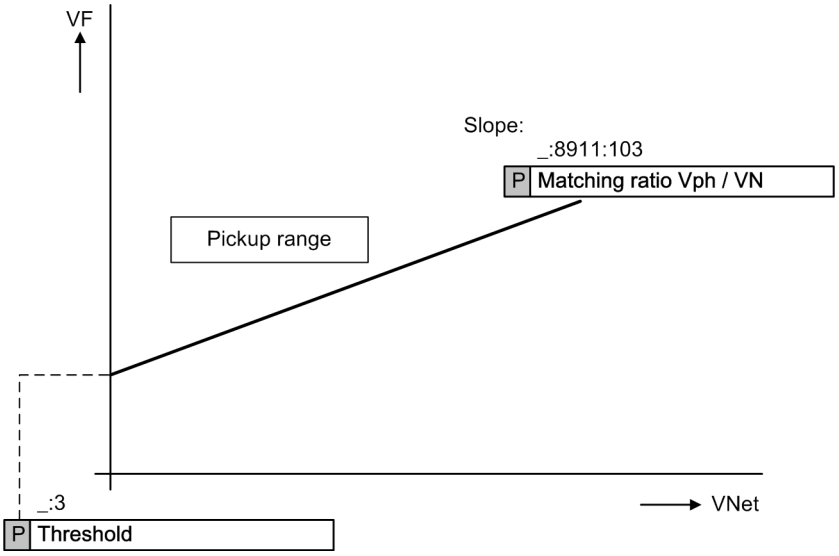


[dwstrvss-100611-01.tif, 2, en_US]

Figure 9-14 Structure/Embedding of the Function

9.3.6.3 Function Description

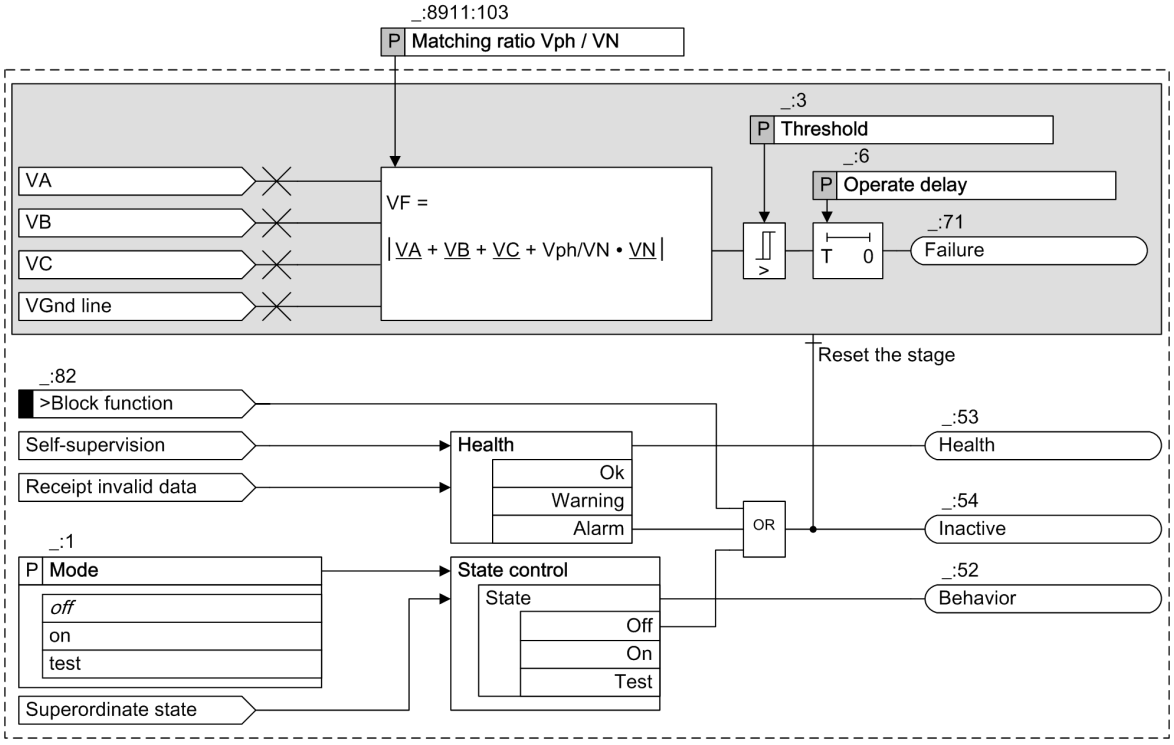
The voltage sum is generated by addition of the voltage phasors. Errors in the voltage circuits are detected if VF = |VA+ VB + VC + Vph/VN • VN | > **`Threshold`**, where Vph/VN forms the **`Matching ratio Vph / VN`** parameter.



[lokenvss-100611-01.tif, 1, en_US]

Figure 9-15 Characteristic of the Voltage-Balance Supervision

Logic



[lovssumm-140611-01.tif, 1, en_US]

Figure 9-16 Logic Diagram of the Voltage-Sum Supervision

The device measures the phase-to-ground voltage and the ground voltage of the lines to be protected. The sum of the 4 voltages must be 0.

Threshold

If the calculated fault voltage (V_F) exceeds the **Threshold**, the parameter **Operate delay** triggers the indication **Failure**.

The device calculates the fault voltage (V_F) with the formula:

VF = |VA+ VB + VC + Vph/VN • VN |, where Vph/VN forms the **Matching ratio Vph / VN** parameter.

The **Matching ratio Vph / VN** parameter takes into account the differing transformation ratios between the residual voltage input and the phase-voltage inputs.

More information in this respect can be found in chapter *9.3.6.1 Overview of Functions*).

Operate delay

When the threshold value for the **Operate delay** is exceeded, the indication **Failure** is generated.

9.3.6.4 Application and Setting Notes

Parameter: Threshold

- Recommended setting value **(_:3) Threshold** = ***25 V***

The **Threshold** parameter is used to set the voltage which the device uses to recognize the calculated fault voltage (V_F) as a failure of the voltage sums. Siemens recommends using the default setting.

Parameter: Operate delay

- Recommended setting value **(_:6) Operate delay** = ***5.00 s***

Set the **Operate delay** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

9.3.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. sum V				
_:1	Supv. sum V:Mode		• off • on • test	off
_:3	Supv. sum V:Threshold		0.300 V to 170.000 V	43.300 V
_:6	Supv. sum V:Delay supervision alarm		0.00 sto 100.00 s	5.00 s

9.3.6.6 Information List

No.	Information	Data Class (Type)	Type
Supv. sum V			
_:82	Supv. sum V:>Block function	SPS	I
_:54	Supv. sum V:Inactive	SPS	O
_:52	Supv. sum V:Behavior	ENS	O
_:53	Supv. sum V:Health	ENS	O
_:71	Supv. sum V:Failure	SPS	O

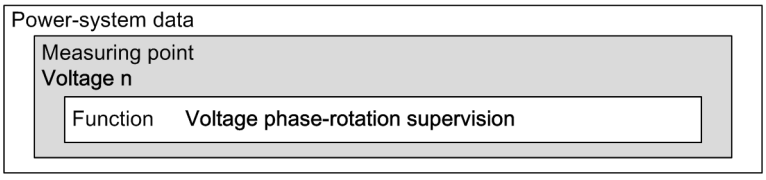
9.3.7 Voltage Phase-Rotation Supervision

9.3.7.1 Overview of Functions

The **Voltage phase-rotation supervision** function monitors the phase sequence of the secondary-circuit voltages by monitoring the sequence of the zero crossings (with same sign) of the voltages. This enables the device to detect connections that were inverted during commissioning. The criterion for the check is the setting of the **Phase sequence** parameter.

9.3.7.2 Structure of the Function

The **Voltage phase-rotation supervision** function is located in the **Power-system data** of each 3-phase voltage measuring point.

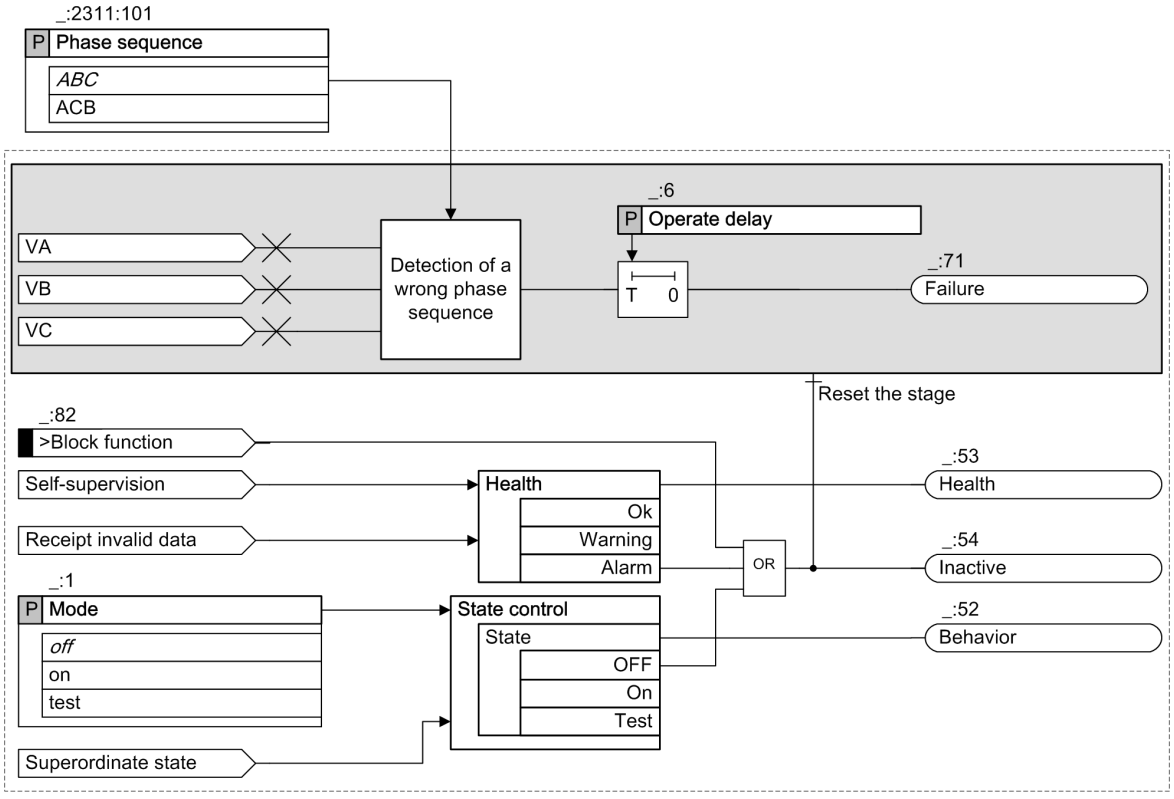


[dwstrvrs-060611-01.tif, 3, en_US]

Figure 9-17 Structure/Embedding of the Function

9.3.7.3 Function Description

Logic



[lovrsymm-100611-01.tif, 2, en_US]

Figure 9-18 Logic Diagram for the Voltage Phase-Rotation Supervision

The device compares the measured phase sequence with the set phase-rotation direction.

You can find detailed information in the section **Power-system data**.

The phase rotation is important for protection functions which process phase, loop, and directional information. The connection of the currents to the device does not depend on the selected phase sequence.

The connection diagrams are shown in the section **Appendix**.

Operate delay

When the device detects an inverted phase-rotation direction for the duration of the **Operate delay**, the indication **Failure** is generated.

9.3.7.4 Application and Setting Notes

Parameter: Operate delay

- Recommended setting value **(_:6) Operate delay** = ***5,00 s***

Set the **Operate delay** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

9.3.7.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. ph.seq.V				
_:1	Supv. ph.seq.V:Mode		• off • on • test	off
_:6	Supv. ph.seq.V:Delay supervision alarm		0.00 sto 100.00 s	5.00 s

9.3.7.6 Information List

No.	Information	Data Class (Type)	Type
Supv. ph.seq.V			
_:82	Supv. ph.seq.V:>Block function	SPS	I
_:54	Supv. ph.seq.V:Inactive	SPS	O
_:52	Supv. ph.seq.V:Behavior	ENS	O
_:53	Supv. ph.seq.V:Health	ENS	O
_:71	Supv. ph.seq.V:Failure	SPS	O

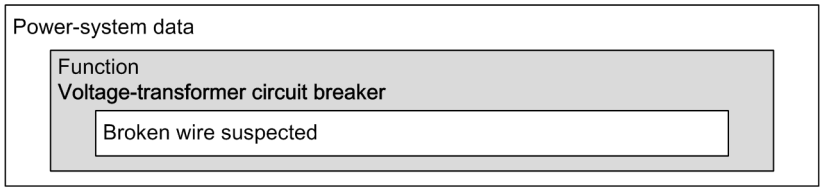
9.3.8 Broken-Wire Detection

9.3.8.1 Overview of Functions

The purpose of the broken-wire detection is to detect interruptions in the secondary circuit of the current transformers during steady-state operation.

9.3.8.2 Structure of the Function

The **Broken-wire detection** function is located in the power-system data of each 3-phase current measuring point.



[dwbwsjsk-301112-01.tif, 2, en_US]

Figure 9-19 Structure/Embedding of the Function

The tasks of **Broken-wire detection** are:

- The instantaneous values of all current measuring points are checked on a phase-selective basis for implausible values.
- The affected phases are marked with wire-break suspected.
- Depending on the supervision mode, you can add a marker for blocking protection functions for the affected phases.
- After 10 ms of broken-wire check, the wire break is reliably signaled.

9.3.8.3 Function Description

Broken Wire Suspected

The **Broken-wire detection** function monitors the dynamic behavior of the currents of each phase and of all measuring points. For this purpose, the instantaneous values of the currents are checked for their plausibility. Each expected violation must be confirmed by additional criteria before a wire break can be detected and signaled with assurance.

The detection of the local broken wire suspected is performed on each 3-phase current measuring point of the device selectively for each phase.

Detection:

A wire break initially manifests itself as a sudden decrease of the current below the minimum threshold of 0.06 $I/I_{rated.}$ A plausibility test on one period of past instantaneous values confirms this condition. If the criteria for the local wire break are satisfied, the affected phase is marked with **Broken wire suspected**.

Resetting:

The broken wire suspected is reset by phase current flowing again or by a binary input signal. Binary resetting can be useful during laboratory tests among other applications.

Indication

If the broken-wire detection has not been reset within 10 ms, it will be indicated. The indication is held stable for the duration of at least 3 periods.

When using the fast measuring transducer inputs as 4 mA to 20 mA inputs, broken-wire detection is active. With a < 2 mA current, wire breaks are detected and the *wire break* indication is set. The measured values display remains unaffected.

9.3.8.4 Application and Setting Notes

Parameter: Mode

- Recommended setting value **(_:1) Mode** = ***off***

The **Mode** parameter is used to switch the broken-wire detection to ***on***, ***off*** and ***test***.

9.3.8.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Brk.wire det.				
_:1	Brk.wire det.:Mode		• off • on • test	off

9.3.8.6 Information List

No.	Information	Data Class (Type)	Type
Brk.wire det.			
_:82	Brk.wire det.:>Block function	SPS	I
_:54	Brk.wire det.:Inactive	SPS	O
_:52	Brk.wire det.:Behavior	ENS	O
_:53	Brk.wire det.:Health	ENS	O
_:301	Brk.wire det.:Phs A BW suspected	SPS	O
_:302	Brk.wire det.:Phs B BW suspected	SPS	O
_:303	Brk.wire det.:Phs C BW suspected	SPS	O
_:304	Brk.wire det.:Phase A broken wire	SPS	O
_:305	Brk.wire det.:Phase B broken wire	SPS	O
_:306	Brk.wire det.:Phase C broken wire	SPS	O

No.	Information	Data Class (Type)	Type
_:307	Brk.wire det.:Broken wire suspected	SPS	O
_:308	Brk.wire det.:Broken wire confirmed	SPS	O

9.3.9 Current-Balance Supervision

9.3.9.1 Overview of Functions

In healthy network operation, a certain balance between currents can be assumed.

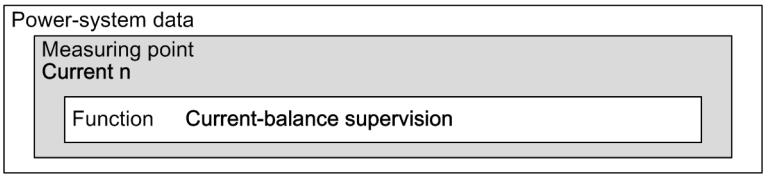
The **Current-balance supervision** function detects the following errors:

- Unbalance of phase currents in the secondary circuit
- Connection errors during commissioning or short circuits and interruptions in the secondary circuit

The current measurement is based on the RMS values of the fundamental component.

9.3.9.2 Structure of the Function

The **Current-balance supervision** function is located in the **Power-system data** of each 3-phase current measuring point.



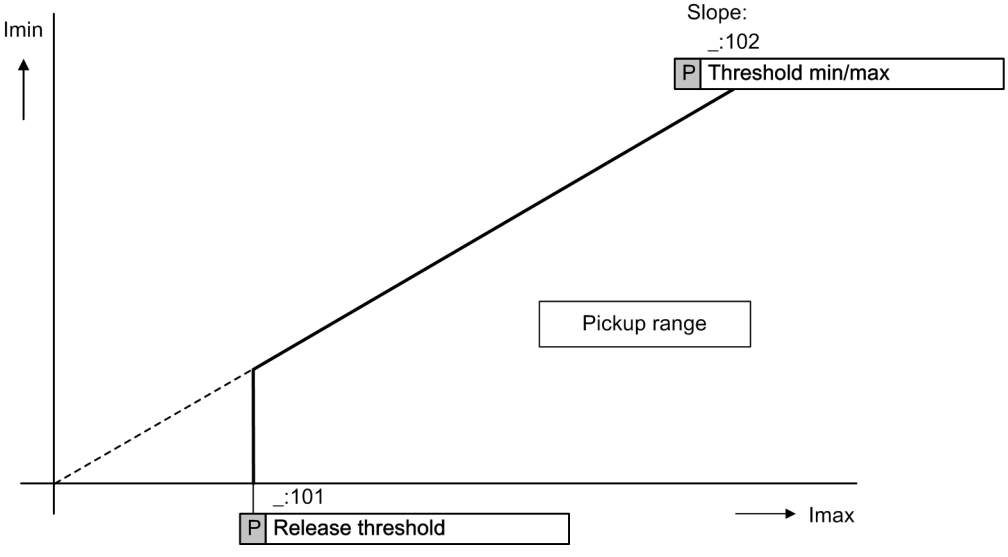
[dwstrsym-060611-01.tif, 2, en_US]

Figure 9-20 Structure/Embedding of the Function

9.3.9.3 Function Description

The current balance is checked by a magnitude monitoring function. This function relates the smallest phase current to the largest phase current. Unbalance is detected if

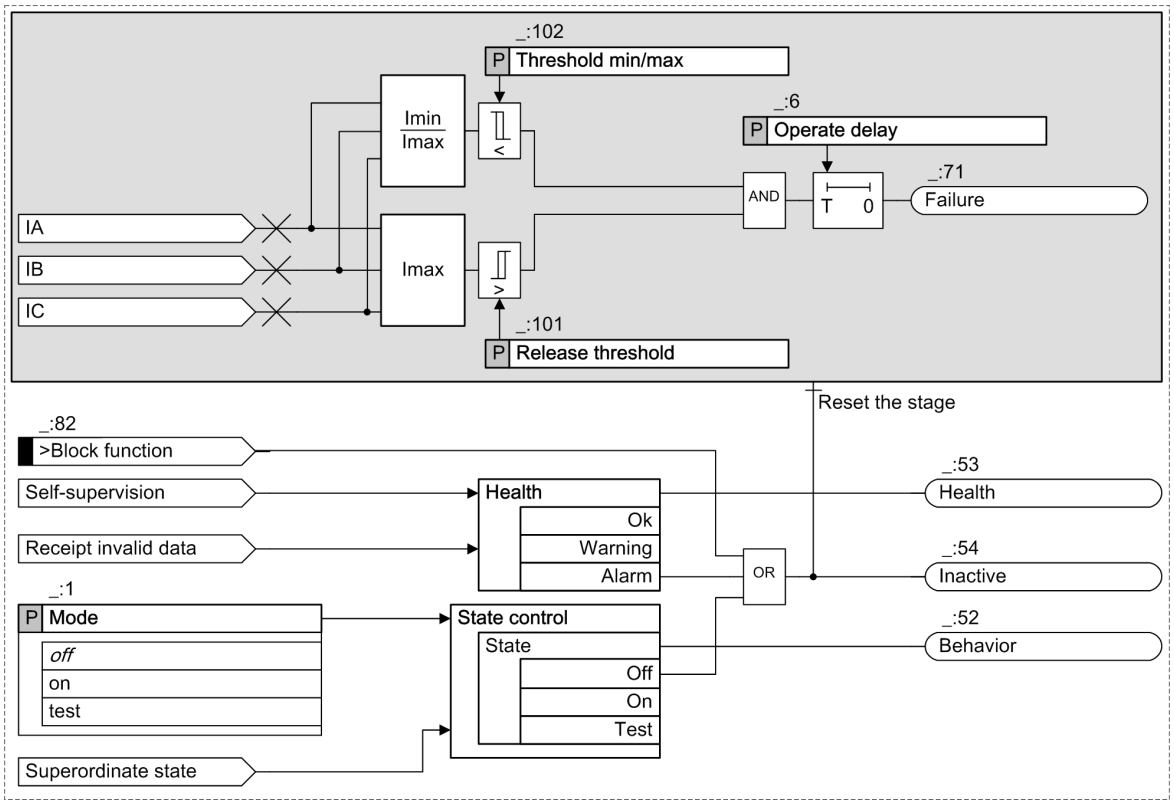
|Imin| / |Imax| < **Threshold min/max**, as long as Imax > **Release threshold** / IN.



[losymmke-040211-01.tif, 1, en_US]

Figure 9-21 Characteristic of the Current-Balance Supervision

Logic



[locbsymm-100611-01.tif, 1, en_US]

Figure 9-22 Logic Diagram of the Current-Balance Supervision

The **Threshold min/max** parameter is the criterion by which unbalance in the phase currents is measured. The device calculates the ratio between the minimum (I_{min}) and the maximum (I_{max}) phase current.

Enter the lower limit of the maximum phase current (I_{max}) with the parameter **Release threshold**. This specifies the lower limit of the operating range of this function.

Operate delay

If it falls below the balance factor **Threshold min/max** and at the same time the maximum phase current exceeds the **Release threshold**, the tripping delay begins. If both conditions persist during this time, the indication **Failure** is generated.

9.3.9.4 Application and Setting Notes

Parameter: Threshold min/max

- Recommended setting value **(_:102) Threshold min/max** = ***0.5***

The **Threshold min/max** parameter is used to set the ratio between the minimum (I_{min}) and the maximum (I_{max}) phase current.

Parameter: Release threshold

- Recommended setting value **(_:101) Release threshold** = ***0.5 A*** for I_{rated} = 1 A or ***2.5 A*** for I_{rated} = 5 A

The **Release threshold** parameter is used to set the lower limit of the maximum phase current (I_{max}).

Parameter: Operate delay

- Recommended setting value **(_:6) Operate delay** = ***5.00 s***

Set the **Operate delay** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided.

9.3.9.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. balan. I				
_:1	Supv. balan. I:Mode		• off • on • test	off
_:101	Supv. balan. I:Release threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	2.500 A
_:102	Supv. balan. I:Threshold min/max		0.10 to 0.95	0.50
_:6	Supv. balan. I:Delay supervision alarm		0.00 sto 100.00 s	5.00 s

9.3.9.6 Information List

No.	Information	Data Class (Type)	Type
Supv. sum I			
_:82	Supv. sum I:>Block function	SPS	I
_:54	Supv. sum I:Inactive	SPS	O
_:52	Supv. sum I:Behavior	ENS	O
_:53	Supv. sum I:Health	ENS	O
_:71	Supv. sum I:Failure	SPS	O

9.3.10 Current-Sum Supervision

9.3.10.1 Overview of Functions

In healthy system operation, the sum of all currents at one measuring point must be approximately 0. The **Current-sum supervision** monitors the sum of all currents of one measuring point in the secondary circuit. It detects connection errors during commissioning or short circuits and interruptions in the secondary circuit.

For summation of the currents, the device requires the phase currents and the ground current of the current transformer neutral point or of a separate ground-current transformer at this measuring point. The following connection variants are available:

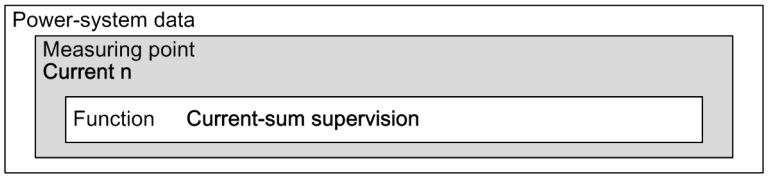
- Current-transformer connections connected to 3 current transformers and the neutral point (see *Figure A-12* in the Attachment)
- Ground current detected with 3 separate ground-current transformers (see *Figure A-14* in the Attachment)
- 3 current transformers and one summation current transformer connected (see *Figure A-13* in the Attachment)
- 2 current transformers and one summation current transformer connected (see *A.7 Connection Examples for Current Transformers* in the Attachment)

NOTE

For current-sum supervision, the ground current of the line to be protected must be connected to the 4th current measurement input (I_N).

9.3.10.2 Structure of the Function

The **Current-sum supervision** function is located in the **Power-system data** of each 3-phase current measurement point.

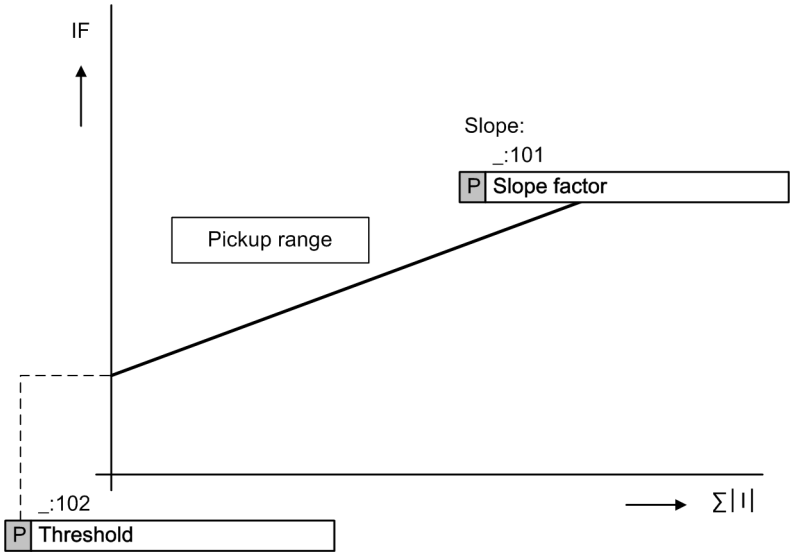


[dwstrcss-300913, 2, en_US]

Figure 9-23 Structure/Embedding of the Function

9.3.10.3 Function Description

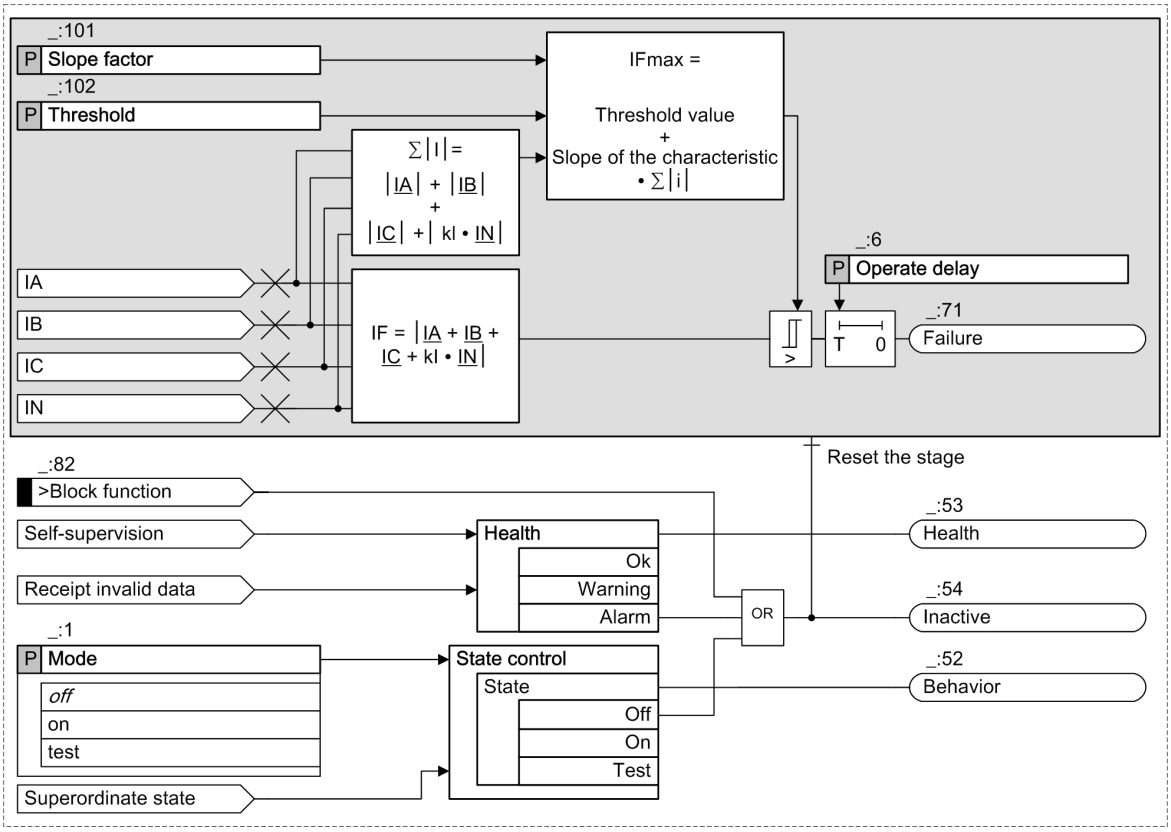
The current sum is generated by addition of the current phasors. Errors in the current circuits are detected if IF = |IA + IB + IC + kI• IN| > **Threshold** + **Slope factor** •Σ | I |.



[lokensum-300311-01.tif, 1, en_US]

Figure 9-24 Characteristic of the Current-Sum Supervision

Logic



[locssumm-140611-01.tif, 1, en_US]

Figure 9-25 Logic Diagram of the Current-Sum Supervision

Slope of the Characteristic Curve

The **Slope factor** • Σ | I | part takes into account permissible current-proportional transformation errors of the transformer, which can occur in the case of high short-circuit currents.

The **Slope factor** and **Threshold** parameters are used to set the fault-current limit (I_{Fmax}) for the current-sum supervision. The device calculates this fault current limit with the formula:

I_{Fmax} = **Threshold** + **Slope factor** • Σ| I |

The device uses the current inputs (IA, IB, IC and IN) to calculate:

- The fault current IF = |IA + IB + IC + kI• IN|
- The maximum current Σ| I | = | IA| + |IB| +| IC| + |kI• IN|

with $\mathbf{k_I}$ taking into account a possible difference from the transformation ratio of a separated ground-current transformer (I_N), for example, cable type current transformer.

- Transformation ratio of residual-current converter: $Ratio_N$
- Transformation ratio of phase-current converter: $Ratio_{ph}$

$$k_I = \frac{Ratio_N}{Ratio_{ph}}$$

[foglchki-040211-01.tif, 1, en_US]

Threshold

The **Threshold** parameter is the lower limit of the operating range of the **Current-sum supervision** function.

Operate delay

When the calculated fault current (I_F) exceeds the calculated fault current limit (I_{Fmax}), the **Operate delay** starts. If the threshold-value violation persists for that time, the **Failure** indication is generated.

9.3.10.4 Application and Setting Notes

Parameter: Slope factor

- Recommended setting value **(_:101) Slope factor** = ***0.1***

The **Slope factor** parameter is used to set the ratio between the minimum (I_{min}) and the maximum (I_{max}) phase current. This function calculates the RMS values.

Parameter: Threshold

- Recommended setting value **(_:102) Threshold** = ***0.1 A*** for I_{rated} = 1 A or ***0.5 A*** for I_{rated} = 5 A

The **Threshold** parameter is used to set the maximum phase current (I_{max}).

Parameter: Operate delay

- Recommended setting value **(_:6) Operate delay** = ***5.00 s***

Set the **Operate delay** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided.

9.3.10.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. sum I				
_:1	Supv. sum I:Mode		• off • on • test	off
_:102	Supv. sum I:Threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:101	Supv. sum I:Slope factor		0.00 to 0.95	0.10
_:6	Supv. sum I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

9.3.10.6 Information List

No.	Information	Data Class (Type)	Type
Supv. sum I			
_:82	Supv. sum I:>Block function	SPS	I
_:54	Supv. sum I:Inactive	SPS	O
_:52	Supv. sum I:Behavior	ENS	O
_:53	Supv. sum I:Health	ENS	O
_:71	Supv. sum I:Failure	SPS	O

9.3.11 Current Phase-Rotation Supervision

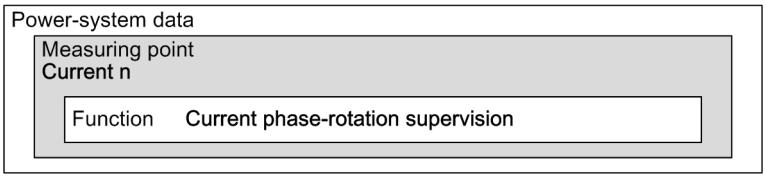
9.3.11.1 Overview of Functions

The **Current phase-rotation supervision** function monitors the phase sequence of the secondary-circuit currents by monitoring the sequence of the zero crossings (with same sign) of the currents. This enables the device to detect connections that were inverted during commissioning. The criterion for the check is the setting of the **`Phase sequence`** parameter.

The current measurement is based on the RMS values of the fundamental component.

9.3.11.2 Structure of the Function

The **Current phase rotation supervision** function is located in the **Power-system data** of each 3-phase current measurement point.

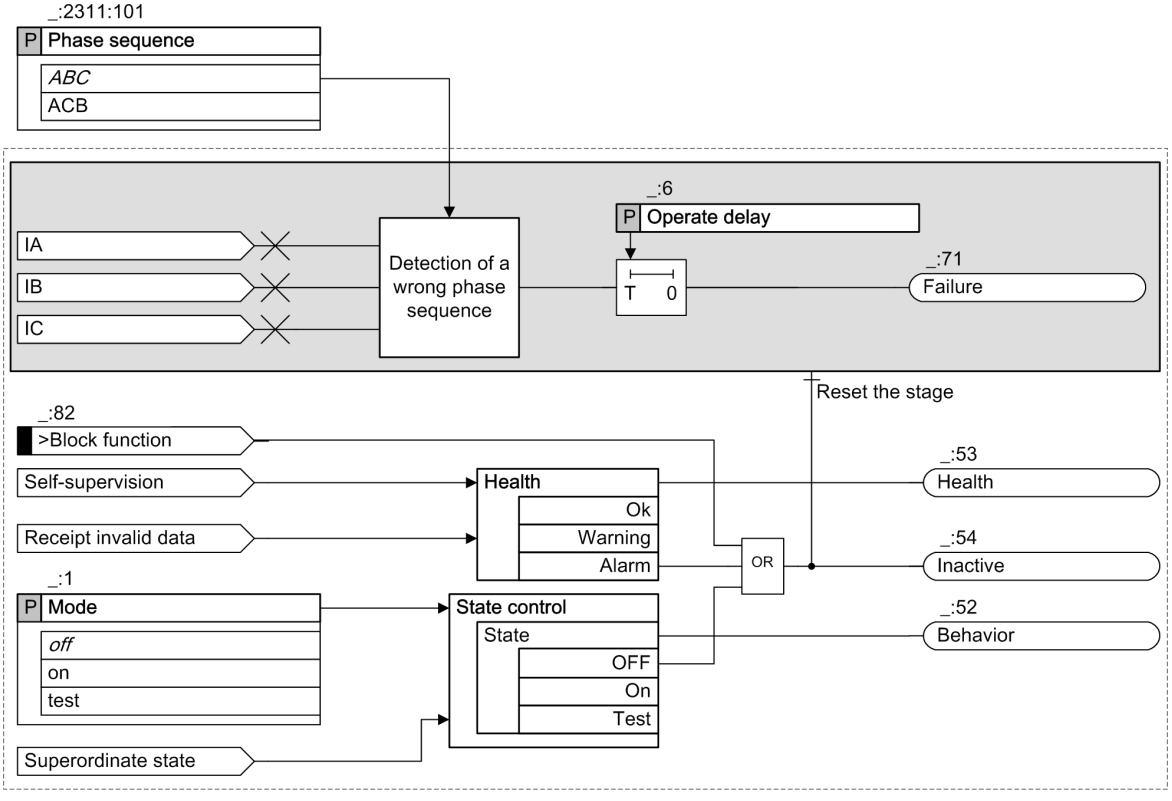


[dwstrcrs-040211-01.tif, 3, en_US]

Figure 9-26 Structure/Embedding of the Function

9.3.11.3 Function Description

Logic



[locrsymm-100611-01.tif, 2, en_US]

Figure 9-27 Logic Diagram Current Phase-Rotation Supervision

The device compares the measured phase sequence with the set phase-rotation direction.

You can find detailed information in the section **Power-system data**.

The phase rotation is important for protection functions which process phase, loop, and directional information. The connection of the currents to the device does not depend on the selected phase sequence.

The connection diagrams are shown in the section **Appendix**.

Operate delay

When the device detects an inverted phase sequence for the duration of the **Operate delay** the indication **Failure** is generated.

9.3.11.4 Application and Setting Notes

Parameter: Operate delay

- Recommended setting value **(_:6) Operate delay** = ***5.00 s***

Set the **Operate delay** parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

9.3.11.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. ph.seq.I				
_:1	Supv. ph.seq.I:Mode		• off • on • test	off
_:6	Supv. ph.seq.I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

9.3.11.6 Information List

No.	Information	Data Class (Type)	Type
Supv. ph.seq.I			
_:82	Supv. ph.seq.I:>Block function	SPS	I
_:54	Supv. ph.seq.I:Inactive	SPS	O
_:52	Supv. ph.seq.I:Behavior	ENS	O
_:53	Supv. ph.seq.I:Health	ENS	O
_:71	Supv. ph.seq.I:Failure	SPS	O

9.3.12 Trip-Circuit Supervision

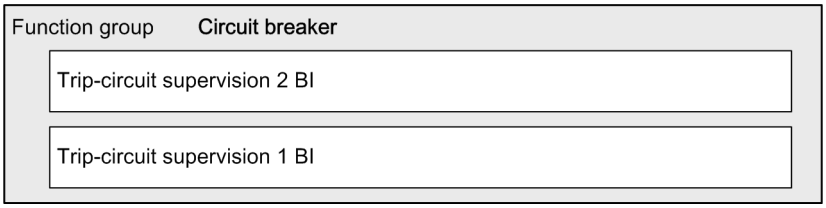
9.3.12.1 Overview of Functions

The **Trip-circuit supervision** function recognizes disruptions in the trip circuit. When 2 binary inputs are used, the function recognizes all disruptions in the trip circuit. If only 1 binary input is available, it will not recognize disruptions at the circuit-breaker.

The control voltage for the circuit breaker must be greater than the sum of the minimum voltage drops at the binary inputs $V_{Ctrl} > 2\ V_{BImin}$. At least 19 V are required for each binary input. This makes the supervision usable only with a system-side control voltage of > 38 V.

9.3.12.2 Structure of the Function

The trip-circuit supervision is integrated into the **Circuit-breaker** function group. Depending on the number of available binary inputs, it works with 1 or 2 binary inputs.



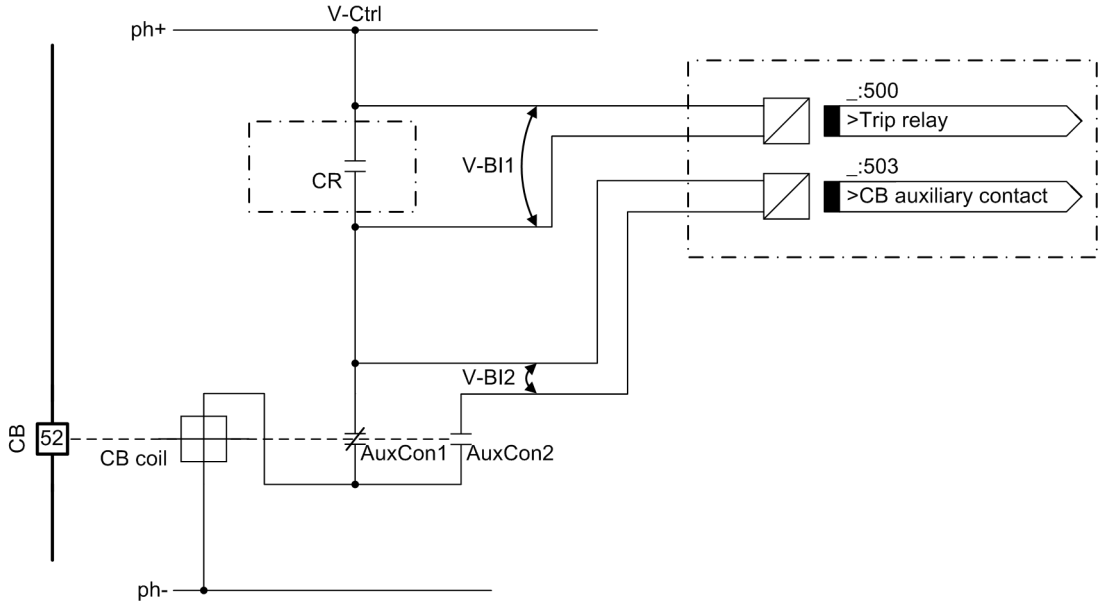
[dwtcsueb-010313-01.tif, 1, en_US]

Figure 9-28 Structure/Embedding of the Function

9.3.12.3 Trip-Circuit Supervision with 2 Binary Inputs

In order to recognize disruptions in the trip circuit for each switch position, you need 2 binary inputs. One input is connected parallel to the respective command relay of the protection, the other parallel to the circuit-breaker auxiliary contact.

The following figure shows the principle of the trip-circuit supervision with 2 binary inputs.



[dwtcs2be-110611-01.tif, 2, en_US]

Figure 9-29 Principle of Trip-Circuit Supervision with 2 Binary Inputs

CR	Command relay
CB	Circuit breaker
CB coil	Circuit-breaker coil
AuxCon1	Circuit-breaker auxiliary contact (NC)
AuxCon2	Circuit-breaker auxiliary contact (NO)
V-Ctrl	Control voltage (tripping voltage)
V-BI1	Input voltage for binary input 1
V-BI2	Input voltage for binary input 2

Supervision with 2 binary inputs identifies disruptions in the trip circuit and the outage of the control voltage. It also monitors the reaction of the circuit breaker by way of the position of the circuit-breaker auxiliary contacts.

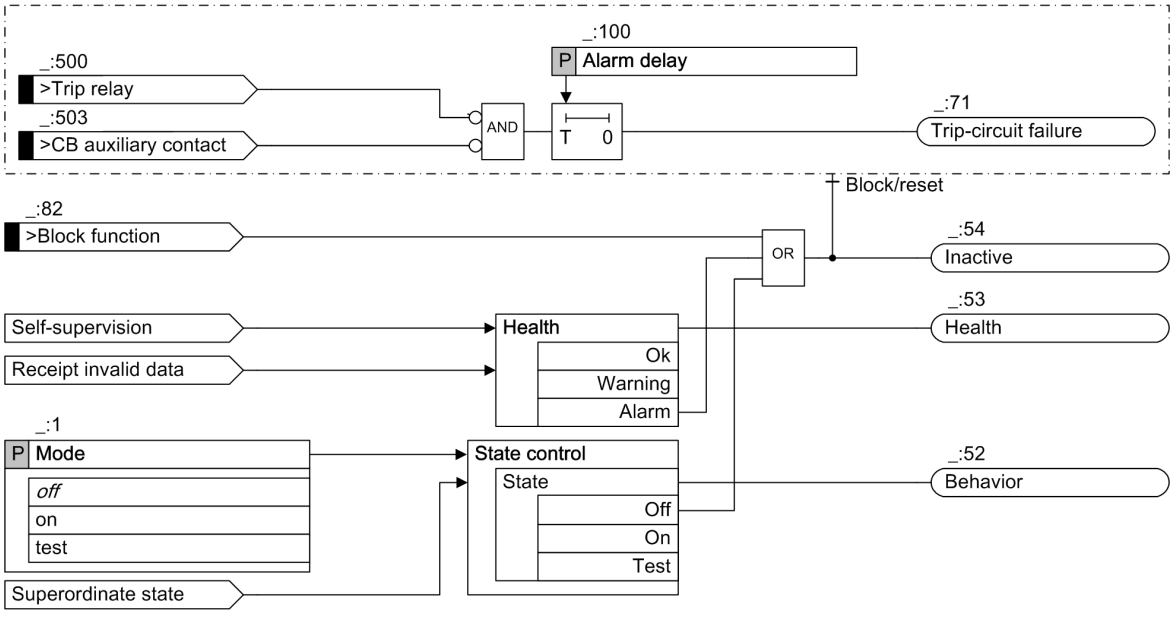
Depending on the switch position of the command relay and circuit breaker, the binary inputs are either activated (**H**) or not (**L**). If both binary inputs are not activated, there is a fault. The fault may be a interruption or a short circuit in the trip circuit, an outage of the battery voltage or a fault in the mechanics of the circuit breaker. With intact trip circuits, this state will occur only briefly while the command relay is closed and the circuit breaker has not yet been opened.

No.	Command Relay (CR)	CB	AuxCon1	AuxCon2	BI 1	BI 2	Dynamic State	Static State
1	Open	ON	Closed	Open	H	L	Normal operation with closed circuit breaker	
2	Open	OFF	Open	Closed	H	H	Normal operation with open circuit breaker	
3	Closed	ON	Closed	Open	L	L	Transmission or fault	Fault
4	Closed	OFF	Open	Closed	L	H	CR successfully activated the circuit breaker	

With the **`Alarm delay`** parameter, you can set the time delay. After fixing the fault in the trip circuit, the failure indication will automatically expire after the same time.

If the binary input signals *`>Trip relay`* or *`>CB auxiliary contact`* are not routed on the binary inputs of the device, then the *`Input sig. not routed`* indication is generated and the **Trip-circuit supervision** function is not in effect.

The following figure shows the logic diagram of the trip-circuit supervision with 2 binary inputs.



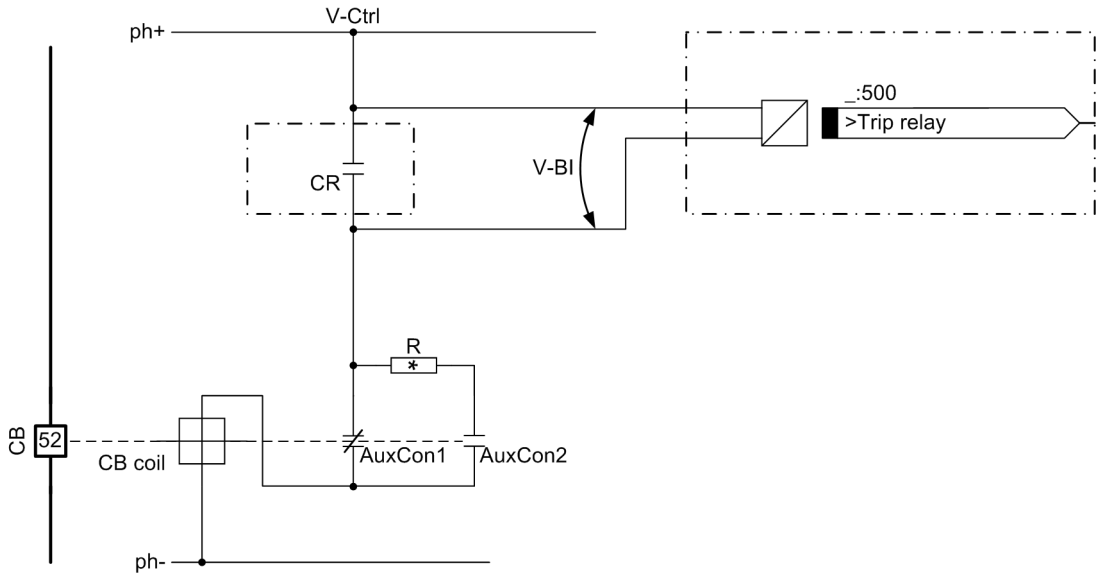
[lotcs2be-260912-01.tif, 1, en_US]

Figure 9-30 Logic Diagram of Trip-Circuit Supervision with 2 Binary Inputs

9.3.12.4 Trip-Circuit Supervision with 1 Binary Input

When using 1 binary input, you will not identify any disruptions on the circuit breaker. The binary input is connected in parallel with the respective command relay of the protection device. The circuit-breaker auxiliary contact is bridged with a high-resistance equivalent resistance R.

The following figure shows the principle of the trip-circuit supervision with 1 binary input.



[dwtcs1be-110611-01.tif, 2, en_US]

Figure 9-31 Principle of Trip-Circuit Supervision with 1 Binary Input

CR	Command relay
CB	Circuit breaker
CB coil	Circuit-breaker coil
AuxCon1	Circuit-breaker auxiliary contact (NC)
AuxCon2	Circuit-breaker auxiliary contact (NO)
V-Ctrl	Control voltage (tripping voltage)
V-BI	Input voltage for binary input
R	Equivalent resistance

The supervision with 1 binary input identifies disruptions in the trip circuit and the failure of the control voltage.

In normal operation, the binary input is activated with the command relay open and the trip circuit intact (**H**). The supervision circuit is closed with the equivalent resistance R or with the auxiliary contact AuxCon1 of the closed circuit breaker. The binary input is not activated while the command relay is closed (**L**). If the binary input is not activated for a prolonged time, there is a disruption in the trip circuit or the control voltage has failed.

No.	Command Relay	CB	AuxCon1	AuxCon2	BI	Dynamic State	Static State
1	Open	ON	Closed	Open	H	Normal operation with closed circuit breaker	
2	Open	OFF	Open	Closed	H	Normal operation with open circuit breaker	
3	Closed	ON	Closed	Open	L	Transmission or fault	Fault
4	Closed	OFF	Open	Closed	L	CR successfully activated the circuit breaker	

Use the parameter **`Blk.by trip/open cmd from`** to set the conditions under which the trip-circuit supervision is blocked. The following conditions can cause a blocking of the trip-circuit supervision function:

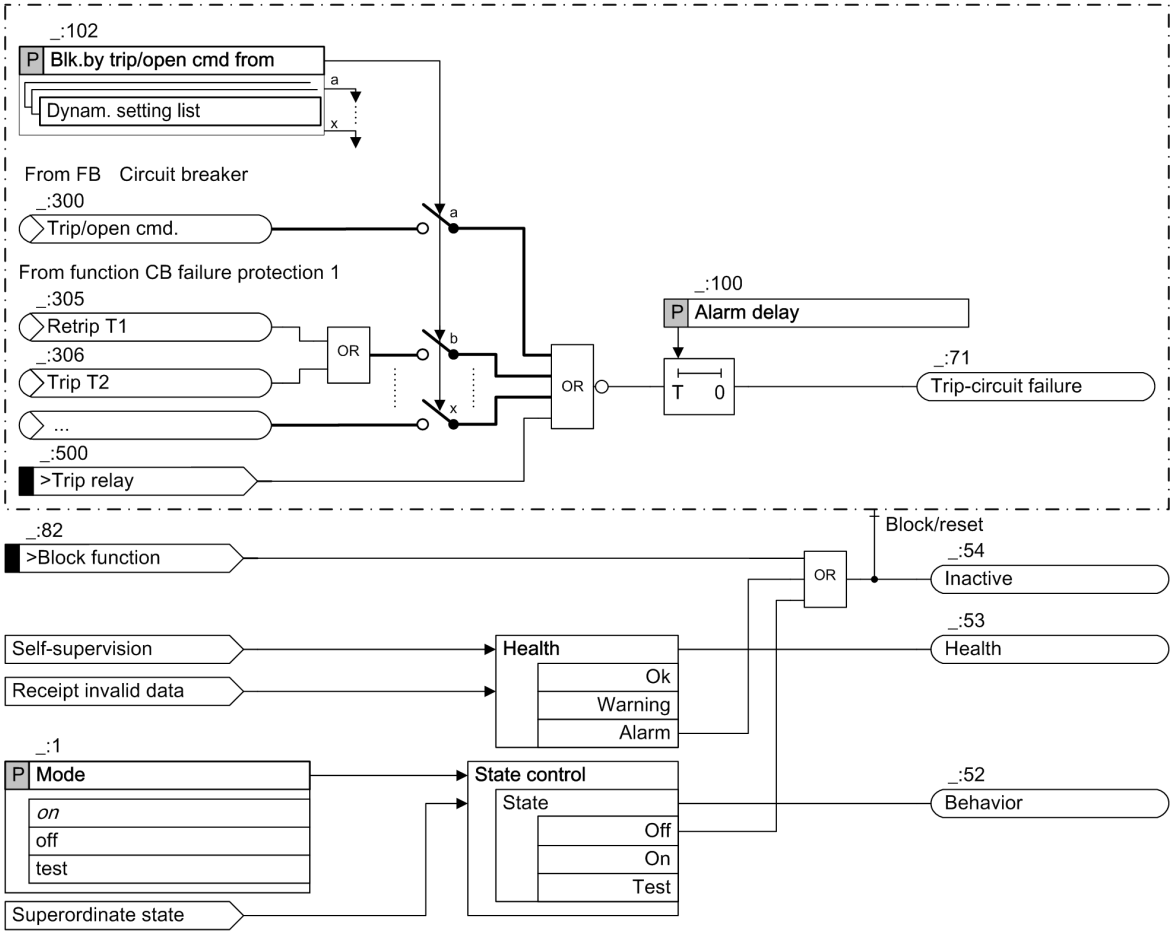
- The *`Trip/open cmd.`* of the circuit breaker is activated.
- One of the trip commands of the circuit-breaker failure protection is activated.

As long as the trip-circuit supervision function is blocked, the closed contact of the command relay does not cause a failure indication.

If the command contacts of other devices work in parallel on the trip circuit, the failure indication must be delayed. With the **`Alarm delay`** parameter, you can set the time delay. After fixing the fault in the trip circuit, the failure indication will automatically expire after the same time.

If the binary input signal *`>Trip relay`* is not routed to a binary input of the device (**information routing** in DIGSI 5), then the *`Input sig. not routed`* indication is generated and **Trip-circuit supervision** is no longer in effect.

The following figure shows the logic diagram of the trip-circuit supervision with 1 binary input.



[lotcs1be-260912-01.tif, 1, en_US]

Figure 9-32 Logic Diagram of Trip-Circuit Supervision with 1 Binary Input

Equivalent Resistance R

The equivalent resistance R must be dimensioned such that the circuit-breaker coil is no longer activated when the circuit breaker is open. Simultaneously, the binary input must still be activated when the command relay is open.

In order to ensure the minimum voltage for activating the binary input, R_{max} results in:

$$R_{max} = \left(\frac{V_{Ctrl} - V_{BImin}}{I_{BI(High)}} \right) - R_{CBC}$$

[fofr1b02-090330-01.tif, 1, en_US]

So that the circuit-breaker coil does not remain activated, R_{min} results in:

$$R_{min} = R_{CBC} \cdot \left(\frac{V_{Ctrl} - V_{CBC(Lowmax)}}{V_{CBC(Low)}} \right)$$

[fofr1b03-090330-01.tif, 1, en_US]

You can calculate the optimal value for the equivalent resistance R from the 2 values R_{min} and R_{max}:

$$R = \frac{R_{max} + R_{min}}{2}$$

[fofr1b01-090330-01.tif, 1, en_US]

The following applies for the power consumption of the equivalent resistance R:

$$P_R = I^2 \cdot R = \left(\frac{V_{Ctrl}}{R + R_{CBC}} \right)^2 \cdot R$$

[fofr1b04-090330-01.tif, 1, en_US]

9.3.12.5 Application and Setting Notes

Parameter: Alarm delay

- Recommended setting value **(_:100) Alarm delay** = ***2 s*** (Trip-circuit supervision with 2 binary inputs)
- Recommended setting value **(_:100) Alarm delay** = ***300 s*** (Trip-circuit supervision with 1 binary input)

With the parameter **Alarm delay**, you can set the time for the delayed output of the indication *Trip-circuit failure*.

For **Trip-circuit supervision with 2 binary inputs**, you set the **Alarm delay** parameter so that the short-term transient states do not cause the function to activate.

For the **Trip-circuit supervision with 1 binary input,** you set the **Alarm delay** so that the longest duration of a trip command is bridged without fail. This ensures that the indication is emitted only if the trip circuit is actually interrupted.

Parameter: Blk.by trip/open cmd from

- Possible settings, application-dependent

The parameter works only with the trip-circuit supervision with 1 binary input.

Use the parameter **Blk.by trip/open cmd from** to set the conditions under which the trip-circuit supervision is blocked. The following conditions can cause a blocking of the trip-circuit supervision function:

- The *Trip/open cmd.* of the circuit breaker is activated.
- One of the trip commands of the circuit-breaker failure protection is activated.
- One of the trip commands of the circuit-breaker reignition protection is activated.

The circuit-breaker failure protection is set to protect a different trip circuit than the local circuit breaker. Using the configuration options of the **Blk.by trip/open cmd from** parameter, multiple trip-circuit supervision functions can be operated in parallel. For instance, a trip-circuit supervision function dedicated to a local circuit breaker can also be operated parallel to a higher-level circuit breaker upon which the circuit-breaker failure protection acts.

9.3.12.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
74TC sup.1BI #				
_:1	74TC sup.1BI #:Mode		• off • on • test	on
_:100	74TC sup.1BI #:Alarm delay		1.00 s to 600.00 s	300.00 s
_:102	74TC sup.1BI #:Blk.by trip/ open cmd from		Setting options depend on configuration	
74TC sup.2BI #				
_:1	74TC sup.2BI #:Mode		• off • on • test	on
_:100	74TC sup.2BI #:Alarm delay		1.00 s to 30.00 s	2.00 s

9.3.12.7 Information List

No.	Information	Data Class (Type)	Type
74TC sup.1BI #			
_:82	74TC sup.1BI #:>Block function	SPS	I
_:500	74TC sup.1BI #:>Trip relay	SPS	I
_:54	74TC sup.1BI #:Inactive	SPS	O
_:52	74TC sup.1BI #:Behavior	ENS	O
_:53	74TC sup.1BI #:Health	ENS	O
_:71	74TC sup.1BI #:Trip-circuit failure	SPS	O
_:301	74TC sup.1BI #:Input sig. not routed	SPS	O
74TC sup.2BI #			
_:82	74TC sup.2BI #:>Block function	SPS	I
_:500	74TC sup.2BI #:>Trip relay	SPS	I
_:503	74TC sup.2BI #:>CB auxiliary contact	SPS	I
_:54	74TC sup.2BI #:Inactive	SPS	O
_:52	74TC sup.2BI #:Behavior	ENS	O
_:53	74TC sup.2BI #:Health	ENS	O
_:71	74TC sup.2BI #:Trip-circuit failure	SPS	O
_:301	74TC sup.2BI #:Input sig. not routed	SPS	O

9.4 Supervision of the Device Hardware

9.4.1 Overview

The correct state of the device hardware is a requirement for the correct functioning of the device. The failure or erroneous function of a hardware component leads to device malfunctions.

The following modules of the device hardware are monitored:

- Base module
- Expansion modules
- Plug-in modules on the interface locations

The fault responses result, depending on type and degree of the error, as follows:

Hardware errors where the device remains in operation.

The error is indicated. The signals/data affected by the failure are marked as **invalid**. In this way, the affected protection functions can switch into a secure state. Such errors are, for example:

- Communication-module failure (module x)
- Measuring-transducer module failure (module x)
- USB interface
- Integrated Ethernet interface
- Real-time clock building block
- A/D converter (fast current sum)
- Battery voltage
- Faulty or missing compensation values (magnitude/phase)

Failures which can partially be corrected by a restart of the device. The device goes briefly out of operation.

Such errors are, for example:

- Memory error (RAM) in the base module
- Faulty module
- Module-connection error (PCB Link)
- Control circuit error binary output
- Outage of an internal auxiliary voltage



NOTE

If the error has not be rectified after 3 unsuccessful attempts, the system automatically recognizes it as a severe device malfunction. The device goes permanently out of operation into a secure state (fallback mode).

Fatal device errors with outage of central components: The device goes permanently out of operation into a secure state (fallback mode).

Such errors are, for example:

- Memory error (flash) in the base module
- CPU/Controller/FPGA error in the base module
- 3 unsuccessful restarts in a row

You can find the detailed description, in table form, of the fault responses at the end of chapter 8 . You will find corresponding corrective measures there.

Device Operating Hours

The *Device operating hours* statistical value counts the operating hours of the physical device. The starting time and the time in Fallback mode are not considered.

You can neither reset nor change the statistical value.

9.4.2 Analog-Channel Supervision via Fast Current-Sum

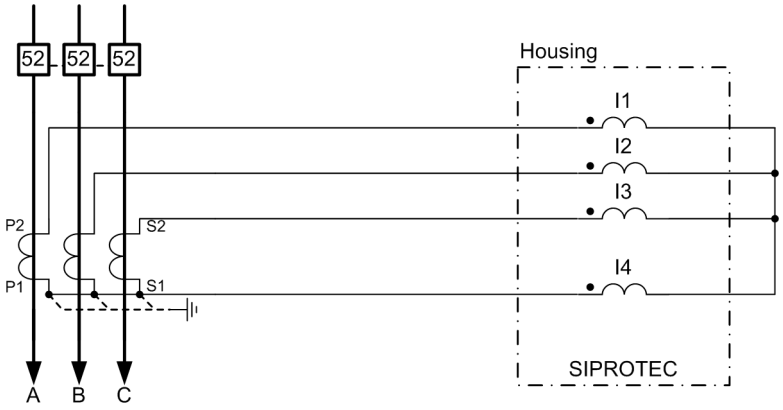
9.4.2.1 Overview of Functions

The function **Supervision of the device-internal analog-digital converters** it performs the following tasks:

- Supervision of the correct functioning of the device-internal analog-digital converters, based on the sum of all currents of one measuring point in the secondary circuit.
- Detection of failures in the device-internal measuring circuits (for example, analog-digital converter)
- Blocking of protection and control functions that process the measured values from this current measuring point (for example, differential protection). This avoids an overfunction of the device.

The supervision principle is based on fast current sum supervision with connection of the neutral-point current to the 4th current measurement input. In order to ensure that even the fast tripping stages of the protection functions can be blocked in time before a spurious pickup, the fast current measurement is based on instantaneous values.

For **Analog-digital converter supervision**, the neutral-point current of the line to be protected must be connected to the 4th current measuring input (I_N). The 4th current measuring input must be routed via the current-transformer neutral point (I_N neutral point) (see next figure).



Current transformer 3-phase: connection = **3-phase + IN**

[tileite2-070211-01.tif, 1, en_US]

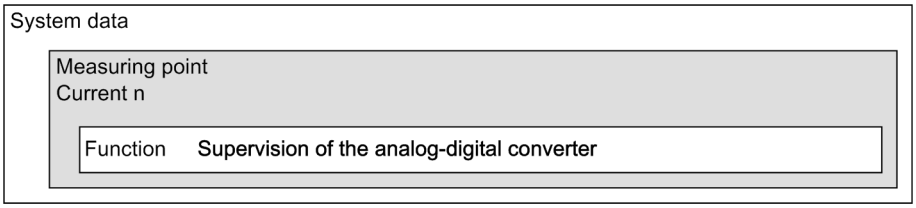
Figure 9-33 Connection to a 3-Phase Current Transformer and Measured Zero-Sequence Current (Current in Common Return Path)

NOTE

The analog channel supervision via fast current sum is only available when the 4th current input is a protection-class current transformer. In the DIGSI 5 project tree, under **Device** → **Measuring-point routing**, set the connection type ***3-phase + IN*** for the current measuring point.

9.4.2.2 Structure of the Function

The **Supervision of the device-internal analog-digital converters** function is located in the **Power-system data** function group of each 3-phase current measuring point.



[dwschstr-040211-01.tif, 1, en_US]

Figure 9-34 Structure/Embedding of the Function

9.4.2.3 Function Description

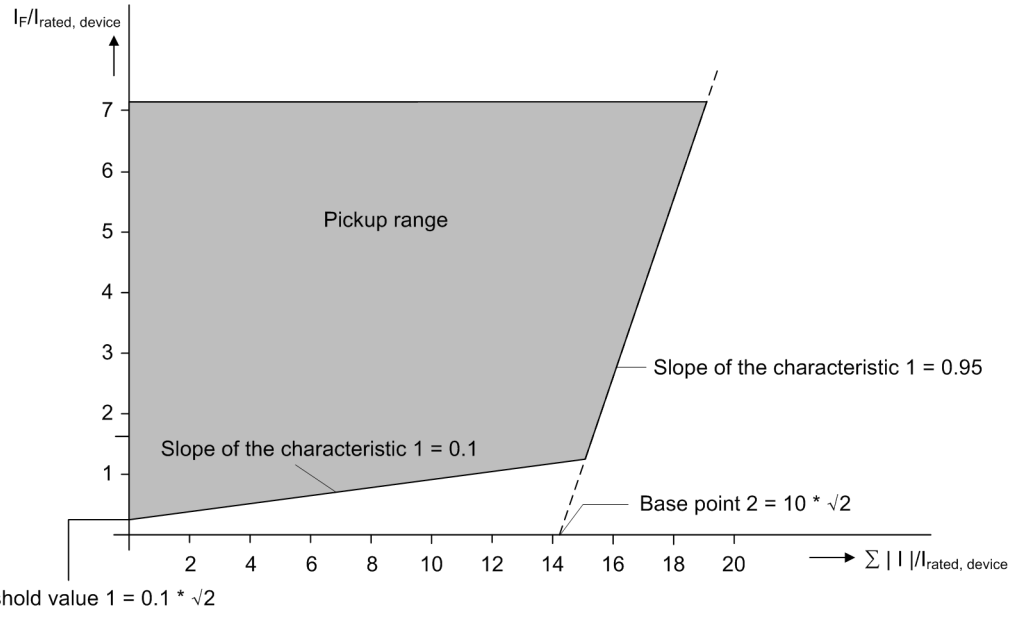
Errors in the current circuits are detected if

$I_F = |iA + iB + iC + iN| >$ **Threshold value** + **Slope of the characteristic 1** •Σ| i | and

$I_F >$ **Slope of the characteristic 2** • (Σ| i | - **Base point 2**)

With the current inputs (iA, iB, iC, and iN), the device calculates:

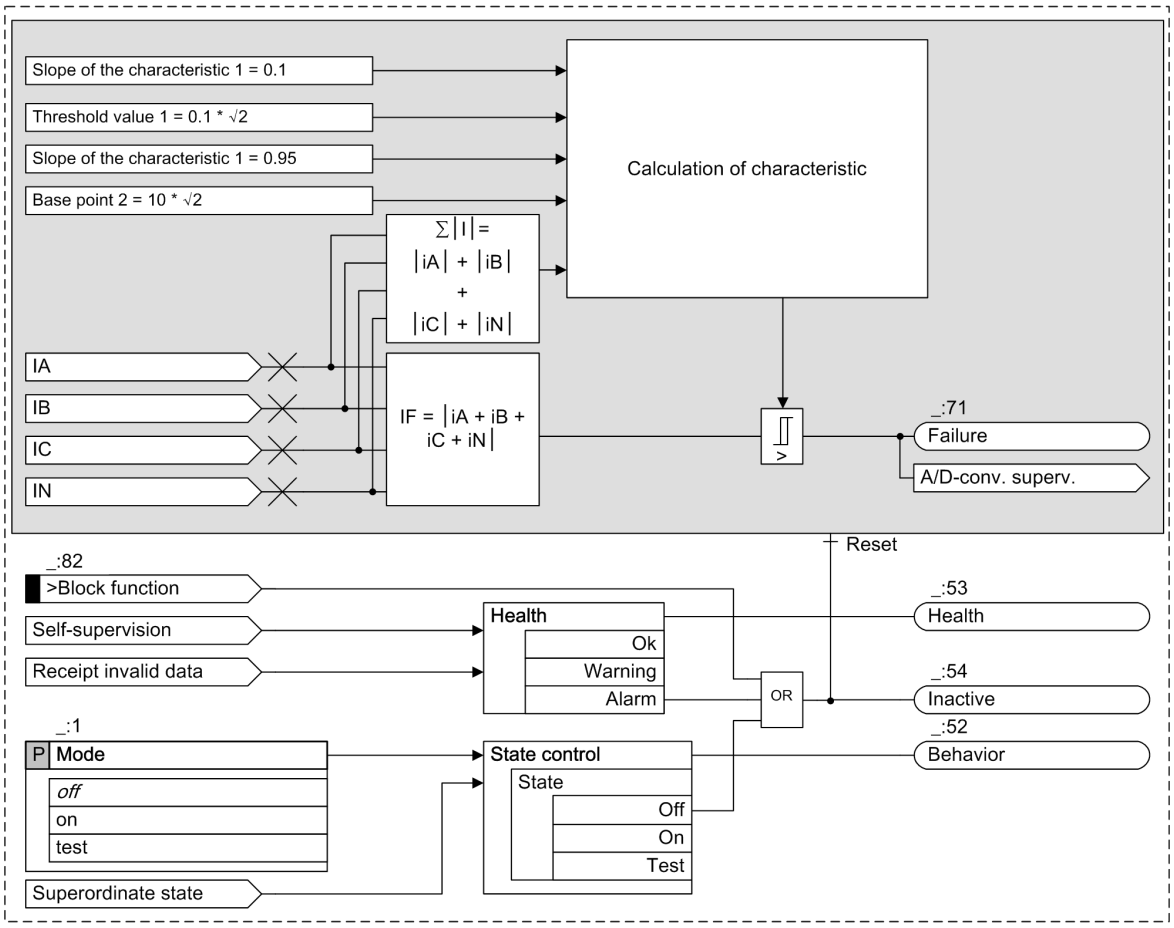
- The fault current $I_F = |iA + iB + iC + iN|$
- The maximum current Σ| i | = |iA|+|iB|+|iC| + |iN|



[lokenisu-240413-01.tif, 2, en_US]

Figure 9-35 Characteristic Curve of the Supervision of the Device-Internal Analog-Digital Converters

Logic



[losumsch-240413-01.tif, 3, en_US]

Figure 9-36 Logic Diagram of the Supervision of the Device-Internal Analog-Digital Converters

When the output signal **`A/D converter monit.`** is active, certain protection functions are blocked to avoid failures (see *12.64 Analog Channel Supervision via Fast Current Sum*).

NOTE

The parameters are fixed in the device and cannot be changed.

It is not necessary to change the parameters depending on the application.

Threshold Value

The **threshold value** is the lower limit of the operating range of the **Supervision of the device-internal analog-digital converters** function.

The **threshold value** is fixed to 10 % of the device rated current.

Slope of the Characteristic 1

The component **slope of characteristic 1** • Σ | i | takes into account permissible current-input errors, which can occur in the case of small overcurrents.

The **slope of characteristic 1** is fixed to 0.1.

Slope of the Characteristic 2

The component **slope of characteristic 2** takes into account permissible current-input errors, which can occur in the case of high overcurrents (high short-circuit currents).

The **slope of characteristic 2** is fixed to 0.95. The base point of the **slope of characteristic 2** is fixed to 10.

9.5 Supervision of Device Firmware

The device firmware determines essentially the functionality of the device.

The following supervisions ensure the stable function of the device:

- Supervisions of the data and version consistency
- Supervision of the undisturbed sequential activity of the device firmware
- Supervision of the available processor performance

When you start the device, load data via the interfaces and these supervisions of the device firmware will be in effect during the continuous operation. Depending on the type and severity of error, the following error responses will result:

Firmware failures where the device remains in operation.

The error is indicated. The signals/data affected by the failure are marked as **invalid**. In this way, the affected protection functions can go into a secure state. Such errors are, for example, errors in time synchronization (loss and errors).

Failures which can partially be corrected by a restart of the device. The device goes briefly out of operation.

Such errors are, for example:

- Device startup with faulty new parameter set. The old parameter set is still present.
- Overloading of the processor
- Program-sequence error

Fatal firmware error. The device goes permanently out of operation into a secure state (fallback mode).

Such errors are, for example:

- Device startup with faulty new parameter set. No usable parameter set is present.
- Device startup with version error
- CFC-runtime error
- 3 unsuccessful restarts in a row

You can find the detailed description, in table form, of the fault responsed at the end of chapter 8. You will find corresponding corrective measures there.

9.6 Supervision of Hardware Configuration

The modular hardware concept requires adherence to some rules within the product family and the modular system. Configuration errors show that the hardware configuration saved in the device does not agree with the hardware actually detected. Impermissible components and unallowed combinations must be detected just as missing configured components are.

Depending on the type and severity of error, the following error responses will result: The identified hardware configuration errors are assigned to the defect severities as follows:

Configuration errors where the device remains in operation.

The failure is indicated. The signals/data affected by the failure are marked as **invalid**. In this way, the affected protection functions can go into a secure state. Such errors are, for example, errors in IE converter configuration (loss and errors).

Fatal configuration error: The device goes permanently out of operation into a secure state (fallback mode).

Such errors are, for example:

- Missing hardware module (module x)
- Incorrect hardware module (module x)
- Incorrect hardware combination
- Incorrect plug-in module (module x)

You can find the detailed description, in table form, of the error reactions at the end of chapter 8 . You will find corresponding corrective measures there. You can resolve configuration errors through another synchronization with DIGSI.

9.7 Supervision of Communication Connections

SIPROTEC 5 devices offer extensive communication possibilities via fixed and optional interfaces. Beyond the hardware supervision of the communication plug-in modules the transferred data must be monitored with respect to their consistency, failure, or outage.

Supervision

With the supervision of the communication connections, every communication port is monitored selectively.

- Failures are detected and indicated via the operational log. The device remains in operation!
- Each port additionally is equipped with a separate communication log, with which details of the failures (for example, error rate) are displayed.

Marking Fault Signals/Data

The signals/data affected by the failure are marked as **invalid**. In this way, the affected protection functions can go into a secure state. In the following, some examples are named:

- GOOSE signals can automatically be set to defined values in case of disturbed IEC 61850 communication.
- Disturbed protection interfaces set phasor values, both analog measured values and binary information to **invalid** (for example, for differential protection). Binary signal traces can be set to defined values in cases of failures.
- Disturbed time-synchronization signals can lead to an automatic change of the source of time synchronization.

Normally, you can correct communication failures by checking the external connections or by replacing the affected communication modules. In chapter *9.8.2 Defect Severity 1* to *9.8.4 Defect Severity 3*, you will find the detailed description, in tabular form, of the error responses. Corresponding corrective measures can also be found there.

9.8 Error Responses and Corrective Measures

9.8.1 Overview

When device errors occur and the corresponding supervision functions pick up, this is displayed on the device and also indicated. Device errors can lead to corruption of data and signals. These data and signals are marked and tagged as **invalid**, so that affected functions automatically go into a secure state. If the supervision functions pick up, this will lead to defined error responses.

How Do Device Errors Make Themselves Noticeable

In case of a device error the supervision functions of the device pickup. The device responds according to the type and severity of the error. To report an error, supervision functions use outputs on the device and indications.

Run LED (green)	The external auxiliary voltage is present. The device is ready for operation.
Error LED (red)	The device is not ready for operation. The life contact is open.
Life contact	Signaling of device readiness following successful device startup.
Group-warning indication *Group warning*	The device remains in operation and signals an error via the prerouted LED and the log.
Log of the device	Indications of causes for defects and corrective measures

Determination of Causes for Defects and Corrective Measures

To determine the cause for defect and the corresponding corrective measure, proceed step by step.

Step 1: Pick up of supervisions leads to one of the following defect severities in all cases.

- **Defect severity 1:**
  Internal or external device error that is reported. The device stays in operation.
- **Defect severity 2:**
  Severe device failure, the device restarts (reset) to correct the cause for defect.
- **Defect severity 3:**
  Severe device failure, the device goes to a safe condition (fallback mode), as the correction of defects by a restart is not possible. In fallback mode, the protection and automated functions are inactive. The device is out of operation.
- **Defect severity 4:**
  Severe device-external failure, the device switches the protection and automatic functions to inactive for safety, but stays in operation. Normally, the user can correct the fault by himself.

Step 2: For every defect severity, you will find detailed tables with information about causes for defects, error responses, and corrective measures in the following chapters.

	Error Responses						
	Group-Warning Indication Group Warning	Indication in the Operational Log	Indication in the Device-Diagnosis Log	Indication of the Life Contact	All Protection and Automation Functions Are Inactive	Device Restart (Reset)	Fallback Mode
Defect severity 1	x	x	x				
Defect severity 2			x	x	During the starting time of the device	x	
Defect severity 3			x	x	x		x
Defect severity 4		x		x	x		

9.8.2 Defect Severity 1

Defect severity 1 faults allow the continued safe operation of the device. Defect severity 1 faults are indicated. The device remains in operation.

When the supervision functions pick up, corrupted data and signals are marked as **invalid**. In this way, the affected functions can go into a secure state. Whether functions are blocked is decided in the appropriate function itself. For more detailed information, refer to the function descriptions.

Live status contact	Remains activated
Red error LED	Is not activated

Log

For every device fault, a corresponding supervision indication is generated. The device records these indications with a real-time stamp in the operational log. In this way they are available for further analyses. If supervisions in the communication interfaces area of the device pick up, there is a separate communication log available for each port. Extended diagnostic indications and measured values are available there. The device-diagnosis log contains expanded fault descriptions. There you also receive recommendations of corresponding corrective measures for each detected device error.

You can find further information on handling the logs in chapter 3.

Group-Warning Indication Group Warning

As delivered, all supervision indications of Defect Severity 1 are routed to the signal `(_:301)` **`Group warning`**. In this way, a device error can be indicated with only one indication. The majority of supervision indications are permanently connected to the **`Group warning`** indication (**Group warning** column = fixed). However, some supervision indications are routed flexibly to the **`Group warning`** via a CFC chart (**Group warning** column = CFC). If necessary, you can remove the routings via a CFC chart from the group indication.

In delivery condition, the **`Group warning`** is prerouted to an LED.

You can find further information on handling the logs in chapter 3.

Overview of Errors

Indication	Type	Group Warning	Explanation
General: (_:53) **Health**	ENS	CFC	If the **Health** of an individual function block, for example, a protection stage or an individual function, goes to the *warning* or *Alarm* state, this state is processed via the associated function group up to the general group indication **Health** (_:53). Check via the operational log from which function or function block the error originates. You can find additional information as to why the health of the function or a function block can change in the associated function description.
(_:53) **Health** = **Warning**	SPS		
(_:53) **Health** = **Alarm**	SPS		
Device: (_:320) **AuxVolt.fault**	SPS	Fixed	Fault with the auxiliary power supply: Check the external power supply.
Device: (_:305) **Battery fault**	SPS	Fixed	Battery fault: Replace the device battery.
Device: (_:312) **Compensation fault** x	ENS	Fixed	Calibration error in module x: Contact the Customer Support Center. **Quality**: Measured values are marked with the quality attribute of *questionable* (measured value display with ~).
Device: (_:314) **Offset error** x	ENS	Fixed	Offset error on module x: If this indication persists after the device start, contact the Customer Support Center. **Quality**: Measured values are marked with the quality attribute of *questionable* (measured value display with ~).
Device: (_:306) **Time failure**	SPS	Fixed	Internal time failure • Check the time settings first. • Then replace the device battery. • If the fault is not remedied, contact the Customer Support Center. **Quality**: The internal clock is marked with the quality attribute of *Clock Failure*.
Device: (_:319) **Memory fault**	SPS	Fixed	Checksum (CRC) error in monitored memory areas of the device
Device: Measuring-transducer error (x)	ENS	Fixed	Hardware error on measuring-transducer module in plug-in module position E/F/M/N/P: Contact the Customer Support Center.
Handling an alarm: (_:504) **>Group warning**	SPS	Fixed	Input signal for user-defined generation of the group warning
Time sync.: (_:305) **Time sync Fault**	SPS	Fixed	Time synchronization error, the timing master is faulty: • Check the external time source first. • Check the external connections. • If the fault is not remedied, contact the Customer Support Center. **Quality**: The internal clock is marked with the quality attribute of *Clock not synchronized*.

Indication	Type	Group Warning	Explanation
Power-system data:meas. point I-3ph:wire break: Wiring: (_:301) **Phase A possible wire break** (_:302) **Phase B possible wire break** (_:303) **Phase C possible wire break** (_:304) **Phase A wire break** (_:305) **Phase B wire break** (_:306) **Phase C wire break** (_:307) **Possible wire break** (_:308) **Confirmed wire break**	SPS SPS SPS SPS SPS SPS SPS SPS	 CFC CFC	Broken-wire detection indications (see chapter *9.3.8.1 Overview of Functions*) **Blocking**: Protection functions tending to over-function in the event of a wire break are blocked.
Power-system data:meas. point I-3ph:superv. sym I (_:71) **Failure**	SPS	CFC	Current balance failure (see chapter *9.3.9.1 Overview of Functions*)
Power-system data:meas. point I-3ph:superv. Phsseq.I: (_:71) **Failure**	SPS	CFC	Failure of current phase-rotation reversal (see chapter *9.3.11.1 Overview of Functions*)
Power-system data:meas. point I-3ph:superv. Sum I (_:71) **Failure**	SPS	CFC	Failure of current sum (see chapter *9.3.10.1 Overview of Functions*)
Power-system data:meas. point I-3ph:superv.ADC sum.I: (_:71) **Failure**	SPS	CFC	Failure of the quick current sum (see chapter *9.4.2.1 Overview of Functions*) The failure indication indicates a fault in the analog-digital converter at the power input. • Check the exterior wiring. • If the fault is not remedied, contact the Customer Support Center. **Quality**: The internally managed current measured values are marked with the *invalid* quality attribute. **Blocking**: The protection functions based on current measurement are blocked.
Power-system data:meas. point V-3ph: Volt.Trans.Cir.B: (_:500) **>Open**	SPS	CFC	Voltage-transformer circuit breaker is open. **Blocking**: Appropriate functions are either blocked definitely or you can set the blocking individually.
Power-system data:meas. point V-3ph: Superv. sym V: (_:71) **Failure**	SPS	CFC	Voltage balance failure (see chapter *9.3.5.1 Overview of Functions*)
Power-system data:meas. point V-3ph: Superv. Phsseq.V: (_:71) **Failure**	SPS	CFC	Failure of voltage phase-rotation monitoring (see chapter *9.3.7.1 Overview of Functions*)

Indication	Type	Group Warning	Explanation
Power-system data:meas. point V-3ph: Superv. of Sum V: (_:71) **Failure**	SPS	CFC	Failure of voltage sum (see chapter *9.3.6.1 Overview of Functions*)
2 devices prot. comm.: Protection interface #: (_:303) **Open connection** (_:316) **Fault rate/min exceeded** (_:317) **Fault rate/h exceeded** (_:318) **Runtime exceeded** (_:320) **Runtime jump detected**	SPS SPS SPS SPS SPS	CFC[26]	Protection interface connection defective: • Check the connections and the external communication infrastructure. • If the fault is not remedied, contact the Customer Support Center. **Transferred Signals**: Faulty or not received telegrams are detected at the receive end and discarded. They do not result in failure of the applications. Configured binary signals are reset after a time that can be set.
VI-3ph: Mess.Volt.Fail detected: (_:300) **Failure**	SPS	CFC	Measuring-voltage failure detected: Check the exterior wiring. **Blocking**: Appropriate functions are either blocked definitely or you can set the blocking individually.

9.8.3 Defect Severity 2

Faults of defect severity 2 are fatal device faults that lead to an immediate restart of the device (reset).

This occurs when the device data is corrupted (for example, RAM memory), if a restart prevents restoration of data consistency. The device goes briefly out of operation, a failure is avoided.

Life contact	Is terminated during the restart
Red error LED	Is activated during the restart



NOTE

If the fault of defect severity 2 has not be been removed after 3 unsuccessful restarts (reset), the fault is automatically assigned to defect severity 3. The device will automatically turn to the fallback mode.

Log

For every device error with a subsequent restart (reset), only the restart can be detected in the operational log. The actual supervision indication is entered in the device-diagnosis log at the point in time of the fault detection and before the restart. These indications are recorded with a real-time stamp and are thus available for later analyses. The device-diagnosis log contains expanded fault descriptions. There you also receive recommendations of corresponding corrective measures for each detected device error.

You can find further information on handling the logs in chapter 3 .

Overview of Errors

Number	Device-Diagnosis Log
826	Processor error on the base module: If the fault occurs numerous times, contact the Customer Support Center.
830	FPGA hardware error on the base module: Contact the Customer Support Center.

[26] The indications are not prerouted in the CFC chart. The indications must be added to the CFC chart by the user!

Number	Device-Diagnosis Log
834	Memory error (short term): Reset initiated.
3823	Program run error: If the fault occurs numerous times, contact the Customer Support Center.
826	CPU overload: If the fault occurs numerous times, contact the Customer Support Center.
Miscellaneous	Internal firmware error: If the fault occurs numerous times, contact the Customer Support Center.

9.8.4 Defect Severity 3

Faults of defect severity 3 are fatal device faults that lead to device immediately going into the fallback mode. The signal *(_:301) Device status* goes to the ***Alarm*** state. The ***Warning*** state is not supported for this signal.

Fatal device errors are errors that cannot be resolved by a restart of the device. In this case, contact the Customer Support Center. The device goes permanently out of operation, a failure is avoided. In the fallback mode, minimal operation of the device via the on-site operation panel and DIGSI is possible. In this way, for example, you can still read out information from the device-diagnosis log.

Life contact	Is terminated in the fallback mode
Red error LED	Is activated in the fallback mode

Log

For every device error that immediately leads to entry into the fallback mode, entries from supervision messages and from the signal *(_:301) Device status* into the operational log are not possible. The actual supervision indication is entered in the device-diagnosis log at the point in time of the fault detection, that is, before entry into the fallback mode. These indications are recorded with a real-time stamp and are thus available for later analyses. The device-diagnosis log contains expanded fault descriptions. There, you are offered recommendations of corresponding corrective measures for each detected device error.

You can find further information on handling the logs in chapter 3 .

Overview of Errors

Number	Device-Diagnosis Log
2822	Memory error (continuous) Contact the Customer Support Center.
4727, 5018-5028	Hardware failure at module 1-12: Contact the Customer Support Center.
4729	Device bus error (repeated): • Check the module configuration and the module connections. • Contact the Customer Support Center.
4733	Incorrect hardware configuration: Synchronize the hardware configuration of the device with DIGSI.
5037-5048	Wrong module 1-12 detected: Synchronize the hardware configuration of the device with DIGSI.
5031-5035	Identified wrong plug-in module on plug-in module position E/F/M/N/P: Synchronize the hardware configuration of the device with DIGSI.
	Wrong application configuration: Search for the cause in the operational log and load a valid configuration to the device.
3640, 4514	Data-structure error: Contact the Customer Support Center.

Number	Device-Diagnosis Log
956	Firmware-version error: Contact the Customer Support Center.
2013, 2025	Signature error: Contact the Customer Support Center.
	CFC error: In DIGSI, check your CFC chart for the cause.
5050-5061	Binary-output error in module 1 - 12: Contact the Customer Support Center.
5088, 5089	A missing display configuration was established: Synchronize the hardware configuration of the device with DIGSI.

9.8.5 Defect Severity 4 (Group Alarm)

Errors of defect severity 4 are not device failures in the classical meaning. These errors do not affect the device hardware and are not detected or reported by internal device supervision functions. The condition of the defect severity 4 – the group alarm – is set user-specifically by the binary input signal *(_:503) >Group alarm*. If the binary input signal is reset, the device is no longer in the *Group alarm* condition and all functions return to the normal operating state.

If the group alarm is generated, the device reacts as follows:

- The group indication *(_:300) Group alarm* is generated and recorded in the operational log.
- The life contact is terminated.
- The red Error LED is activated.
- All protection and automation functions are blocked.
- The device remains in operation, does not carry out any restart (reset), and does not switch to the safe condition (Fallback mode).
- The signals managed internally are marked with the ***invalid*** quality attribute. Signals managed internally are, for example, measured values, binary input and output signals, GOOSE and CFC signals.

In the delivery condition, every device has the CFC chart **Process mode inactive**, that initiates the Group alarm (see chapter *9.9 Group Indications and Predefined CFC Charts*).

Life contact	Is terminated in case of Group alarm
Red error LED	Is initiated in case of Group alarm

Log

The group indication *(_:300) Group alarm* is recorded in the operational log. Depending on the cause of the initiation, further information can be found in the operational log.

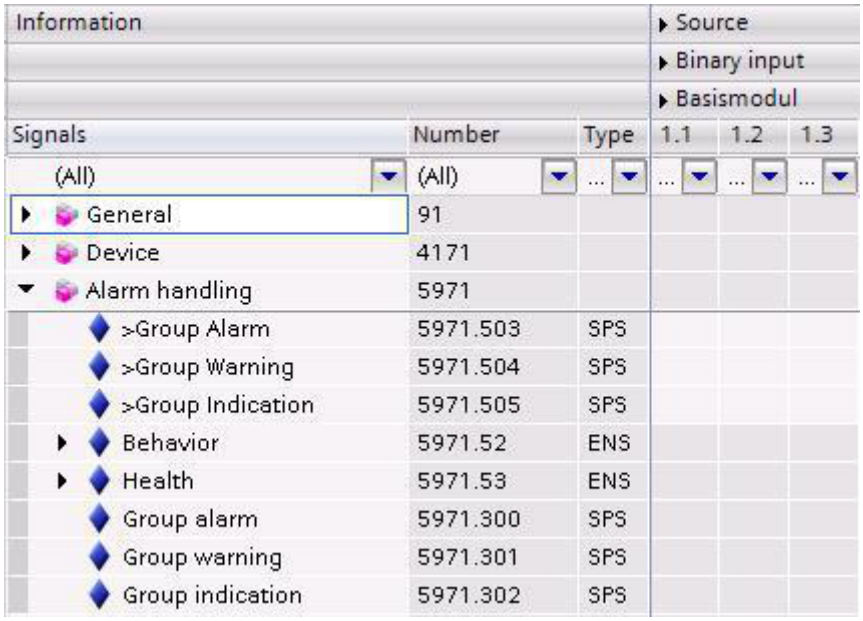
You can find further information on handling the logs in chapter 3 .

9.9 Group Indications and Predefined CFC Charts

The following group indications are available:

- *(_:300) Group alarm*
- *(_:301) Group warning*
- *(_:302) Group indication*

You can find the signals in the DIGSI 5 project tree under **Name of the device**) → **Information routing**. In the operating range, you can find the signals under **Alarm handling** (see the following figure).



[scgrwarn-010313-01, 1, en_US]

Figure 9-37 Group Monitoring Indication in the DIGSI 5 Information Routing Matrix

Group Indication Group Alarm

The indication *(_:300) Group alarm* is the group indication for defect-severity 4 monitoring. This monitoring has a special purpose, as it is set in a user-specific way by a binary input signal and not by internal device supervision. Nevertheless, the response of the device is serious, for example, the blocking of all protection and automatic functions (see chapter *9.8.5 Defect Severity 4 (Group Alarm)*).

If the binary input signal *(_:503) >Group Alarm* is set, the group indication *(_:300) Group alarm* is activated. If the binary input signal *(_:503) >Group Alarm* is reset, the signal *(_:300) Group alarm* is also reset and the device returns to the normal operating state.

In the delivery condition, every device has the CFC chart **Process mode inactive** that initiates the *>Group Alarm*. This CFC chart checks whether the device is still accidentally in the simulation or commissioning mode.

You can adapt the CFC chart as needed. You can find the CFC chart in the DIGSI 5 project tree under **Name of the device** → **Charts**.

Group Indication Group Warning

The indication *(_:301) Group warning* is the group indication for defect-severity 1 monitoring. Some error messages of defect severity 1 are firmly connected to the signal *(_:301) Group warning*, others are connected in a flexible way via a CFC chart in the device delivery condition. This allocation is described in chapter *9.8.2 Defect Severity 1* .

In the delivery condition, every device has the CFC chart **Group warning** that initiates the *Group warning*.

You can adapt the CFC chart as needed. You can find the CFC chart in the DIGSI 5 project tree under **Name of the device** → **Charts**.

The group-warning indication *(_:301) Group warning* is prerouted to an LED of the base module.

Group Indication

The *Group indication* is used only for user-specific purposes. There is no internal device supervision function that activates this indication. If the binary input signal *(_:505) >Group Indication* is set, the indication *(_:302) Group indication* is activated and recorded in the operational log. In the delivery condition, there is no further response of the device. If the binary input signal is reset, the signal *(_:302) Group indication* drops out. You can define via a CFC chart when the binary input signal *(_:505) >Group Indication* is to be set.

10 Measured Values, Energy Values, and Supervision of the Primary System

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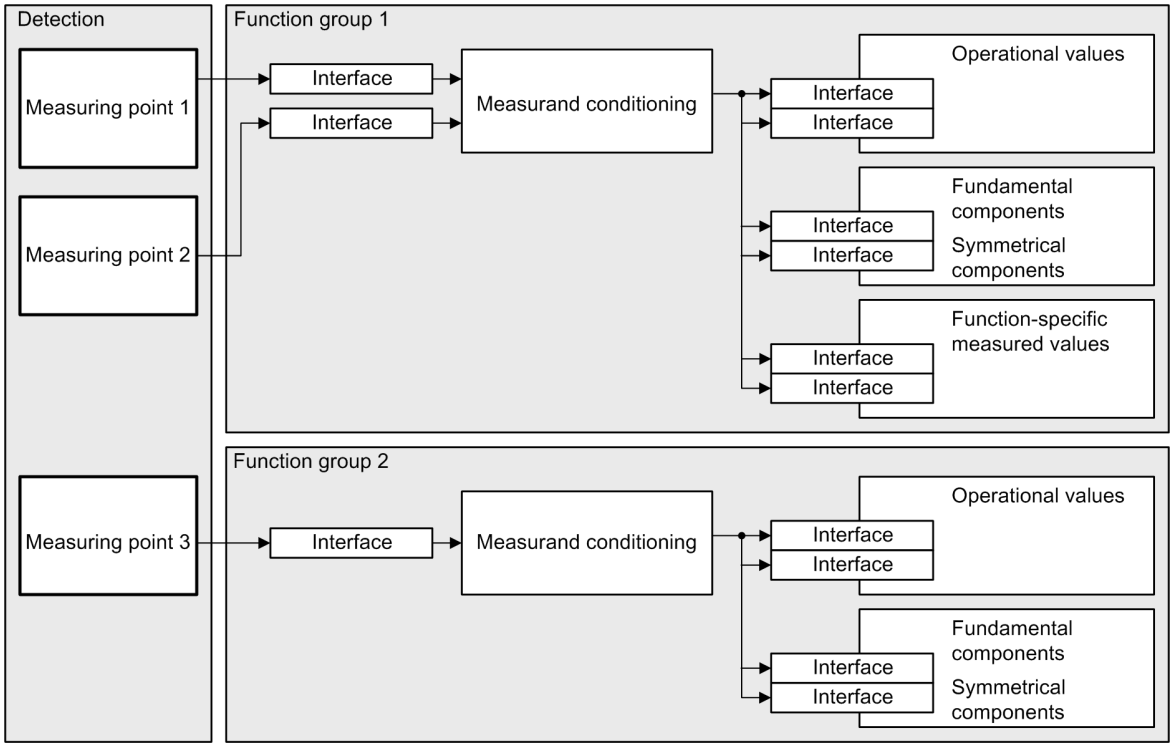
10.1 Overview of Functions

The measurands are recorded at the measuring points and forwarded to the function groups.

Within the function groups, further measurands are calculated from these measured values, which are required for the functions of this function group. This is how, for example, the electric power is calculated from the voltage and current measurands.

Measuring transducers are an exception as they already form various calculation parameters from the analog current and voltage inputs themselves.

Basic instructions for recording and editing process data can be found in the chapter *2.1 Function Embedding in the Device*.



[dwomverf-010212-01.tif, 1, en_US]

Figure 10-1 Structure of Measured-Value Acquisition and Processing

For the display, the measured values of a SIPROTEC 5 device are summed up in the following groups:

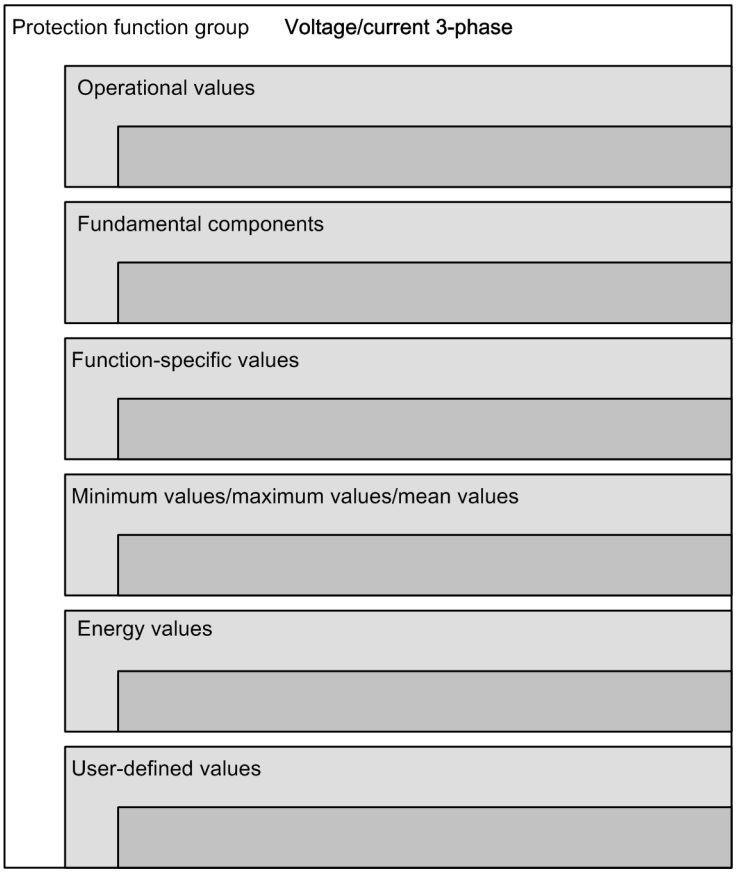
- Operational measured values
- Fundamental and symmetrical components
- Function-specific measured values
- Minimum values, maximum values, average values
- Energy metered values
- User-defined measured and metered values
- Statistic Values

10.2 Structure of the Function

Depending on the interconnection of the function groups, these can contain different measured-value groups. A typical function group is displayed below.

Voltage/Current 3-Phase Function Group Type

In the simplest version the **Voltage/Current 3-phase** function group obtains the measured values of the 3-phase voltage and current system and contains the following measured-value groups:



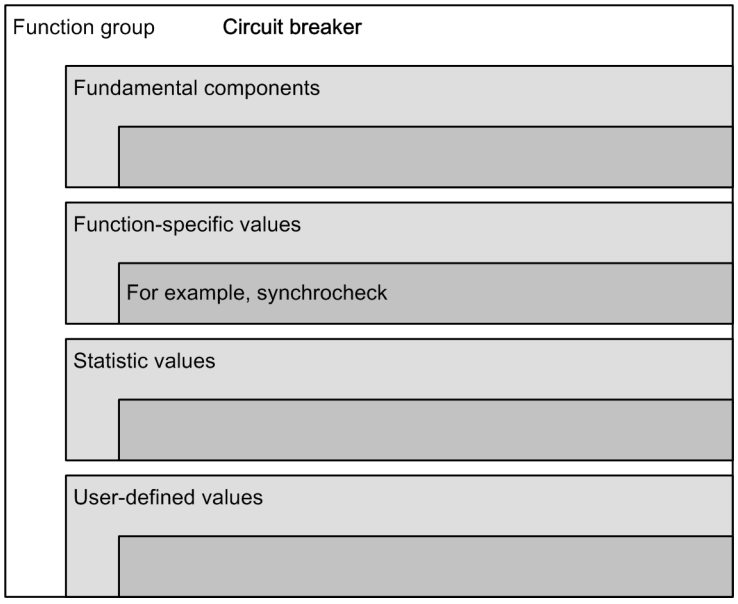
[dwstrciv-011012-01.tif, 1, en_US]

The **Minimum values/Maximum values/Average values** and **User-defined values** can be inserted from the library into the **Voltage/Current 3-phase** function group.

Details regarding the individual measured value groups can be found in the tables in the following chapters.

Circuit-Breaker Function Group

The **Circuit breaker** function group may contain the following measured values:



[dwomvls1-250211-01.tif, 1, en_US]

Inversion of Output-Related Measured and Statistical Values

The calculated, directional values in the operational measured values (power, power factor, energy and minimum, maximum, and average values based on these) are normally defined as positive in the direction of the protected object. This requires that the connection polarity for the measuring points used be correctly set (also compare **(_:8881:116) Neutr.point in dir.of ref.obj** parameter of the measuring point current, 3-phase). It is, however, possible, to set the "forward" direction for the protection functions and the positive direction for the powers, etc., differently, for example, such that the active power import (from the line to the busbar) is displayed positively. Then set the option **P, Q sign** in the affected function groups on the ***reversed*** parameter. With the parameter ***not reversed*** (default setting), the positive direction for the powers, etc., corresponds with the "forward" direction for the protection functions.

The affected values are given in detail in the Chapters *10.3 Operational Measured Values* - *10.11 Statistical Values of the Primary System* .

10.3 Operational Measured Values

Operational measured values are assigned to different function groups.
The values can be displayed as primary and secondary values and as percentage values.
The operational measured values are calculated according to the following definition equations:

RMS values

$$X = \sqrt{\frac{1}{T}\int_{t}^{t+T} x^2(t)dt}$$

Active power

$$P = \frac{1}{T}\int_{t}^{t+T} v(t)\,i(t)\,dt$$

Apparent power

$$S = \sqrt{3} * V * I$$

Reactive power

$$Q = \sum_{n} V_n \cdot I_n \cdot \sin(\varphi_n)$$

n Harmonic order

φ_n The angle difference between the voltage and current of the nth harmonic

Power factor

$$\lambda = \frac{|P|}{S}$$

Active power factor

$$\cos\varphi = \frac{P}{S}$$

Voltage/Current 3-Phase Function Group Type

The following table describes the operational measured values of the **3-phase voltage/current** function group.
All protection functions have access to the values.

Table 10-1 Operational Measured Values of the Voltage/Current 3-Phase Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary values
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary values
I_N	Neutral-point phase current	A	A	Rated operating current of the primary values
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of primary values/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltage	kV	V	Rated operating voltage of the primary values
V_0	Calculated zero-sequence voltage	kV	V	Rated operating voltage of primary values/√3
V_N	Measured neutral-point displacement voltage	kV	V	Rated operating voltage of primary values/√3
f	Frequency	Hz	Hz	Rated frequency
P	Active power (total power)	MW	–	Active power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q	Reactive power (total power)	Mvar	–	Reactive power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S	Apparent power (total power)	MVA	–	Apparent power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$

Measured Values		Primary	Secon-dary	% Referenced to
Cos φ	Active power factor	(abs)	(abs)	100 % corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	–	Active power of the phase $V_{rated\ Lx} \cdot I_{rated\ Lx}$
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	–	Reactive power of the phase $V_{rated\ Lx} \cdot I_{rated\ Lx}$
S_A, S_B, S_C	Phase-related apparent power	MVA	–	Apparent power of the phase $V_{rated\ Lx} \cdot I_{rated\ Lx}$

NOTE

With the **`P, Q sign`** parameter in the function block **General** of the respective function group, the sign of the following measured values can be inverted:

- Active power (total): P total
- Active power (phase-related): P_A, P_B, P_C
- Reactive power (total): Q total
- Reactive power (phase-related): Q_A, Q_B and Q_C

10.4 Fundamental and Symmetrical Components

The fundamental components are calculated from the frequency-tracked instantaneous values through a Fourier filter (integration interval: one period). The results are phasor values that are described by way of the amount and phase angle.

In accordance with the transformation matrix, the symmetrical components are calculated from the voltage and current phasors. These are also phasor quantities.

Fundamental Components

Table 10-2 Fundamental Components

Values		Primary	Secondary	Phase Angle	% Referenced to
$\underline{V}_A$, $\underline{V}_B$, $\underline{V}_C$	Phase-to-ground voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{V}_N$	Measured neutral-point displacement voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{V}_{12}$, $\underline{V}_{23}$, $\underline{V}_{31}$	Phase-to-phase voltage	kV	V	°	Rated operating voltage of the primary values
$\underline{I}_A$, $\underline{I}_B$, $\underline{I}_C$	Phase currents	A	A	°	Rated operating current of the primary values
$\underline{I}_N$	Neutral-point phase current	A	A	°	Rated operating current of the primary values

Symmetrical Components

Table 10-3 Symmetrical Components

Values		Primary	Secondary	Phase Angle	% Referenced to
$\underline{V}_0$	Zero-sequence component of the voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{V}_1$	Positive-sequence component of the voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{V}_2$	Negative-sequence component of the voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{I}_0$	Zero-sequence component of the current	A	A	°	Rated operating current of the primary values
$\underline{I}_1$	Positive-sequence component of the current	A	A	°	Rated operating current of the primary values
$\underline{I}_2$	Negative-sequence component of the current	A	A	°	Rated operating current of the primary values

10.5 Average Values

10.5.1 Function Description of Average Values

Average values can be formed based on different measurands:

- Operational measured values
- Symmetrical components

Through the settings, you can set how and when the average values are formed. The settings describe:

- Time slot over which the average value is formed
  (Parameter: **`Average calc. interval`**)
- Update interval for the display of the average values
  (Parameter: **`Average update interval`**)
- Synchronization time for establishing the date of commencement updating information, for example, at the top of the hour (hh:00) or at one of the other times (hh:15, hh:30, hh:45).
  (Parameter: **`Average synchroniz. time`**)

Average values are formed through the following measurands:

- Operational measured values except for phase-related ratings
- Amounts of the symmetrical components

You reset the average value formation via the

- Binary input >Reset average value
- DIGSI
- The integrated operation panel



NOTE

With the **`P, Q sign`** parameter in the function block **General**, the sign of the following measured values of the respective function group can be inverted (see Chapter *10.2 Structure of the Function* Structure of the Function, section Inversion of Output-Related Measured and Statistical Values):

- Active power (total): P total
- Reactive power (total): Q total

10.5.2 Application and Setting Notes for Average Values

The average value formation functionality is not preconfigured with the devices in the function group. If you use the functionality, you must load it from the library into the respective function group.

The following settings listed for the calculation of the average values can be set with DIGSI and at the device. You find the setting parameters in DIGSI in the project tree under **Settings > Device settings**.

Parameter: Average calc. interval

- Default setting: **`(_:104) Average calc. interval`** = ***`60 min`***

Parameter Value	Description
1 min to 60 min	Time slot for averaging, for example 60 minutes

Parameter: Average update interval

- Default setting: **`(_:105) Average update interval`** = ***`60 min`***

Parameter Value	Description
1 min to 60 min	Update interval for displaying the average value, for example 60 minutes

Parameter: Average synchroniz. time

- Default setting: **(_:106) Average synchroniz. time** = ***hh:00***
  The parameter describes the synchronization time for average value formation.

Parameter Value	Description
hh:00	The parameter **Average update interval** will be effective on the full hour
hh:15	The parameter **Average update interval** will be effective 15 minutes after the full hour
hh:30	The parameter **Average update interval** will be effective 30 minutes after the full hour
hh:45	The parameter **Average update interval** will be effective 45 minutes after the full hour



NOTE

The average value calculation restarts after

- Changing one of the 3 settings for the average-value calculation
- Resetting the device (initial or normal reset)
- Changing the time
- Resetting the average values

The average values are reset immediately. The display changes to "---".

The following examples explain how to set parameters and to make a change.

Average calc. interval = **60 min**
Average update interval = **30 min**
Average synchroniz. time = ***hh:15***.

A new average value is formed every 30 min, at hh:15 (15 min after the top of the hour) and hh:45 (15 min before the top of the hour). All measured values obtained during the last 60 min are used for average value formation.

If these settings are changed to 11:03:25, for instance, the average values are first reset and "---" appears in the display. The 1st average value is then formed at 12:15:00.

In this example, the **Average synchroniz. time** = ***hh:45*** acts as described above for = ***hh:15***.

Average calc. interval = **60 min**
Average update interval = **60 min**
Average synchroniz. time = ***hh:15***.

A new average value is formed every 60 min at hh:15 (15 min after the top of the hour). All measured values obtained during the last 60 min are used for average value formation.

If these settings are changed to 11:03:25, for instance, the average values are first reset and "---" appears in the display. The 1st average value is then formed at 12:15:00.

Average calc. interval = **5 min**
Average update interval = **10 min**
Average synchroniz. time = ***hh:00***.

A new average value is formed every 10 min at hh:00, hh:10, hh:20, hh:30, hh:40, hh:50. All measured values obtained during the last 5 min are used to form the average value.

If these settings are changed to 11:03:25, for instance, the average values are first reset and "---" appears in the display. The 1st average value is then formed at 11:10:00.

10.6 Minimum/Maximum Values

10.6.1 Function Description of Minimum/Maximum Values

Minimum and maximum values can be formed based on different measured or calculated measurands:

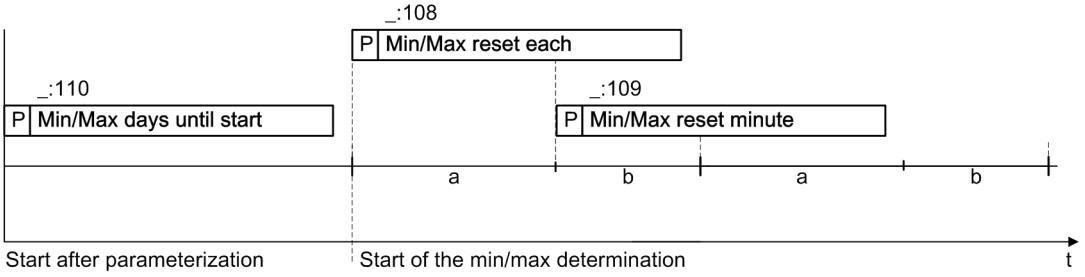
- Operational measured values
- Symmetrical components
- Selected values

You can set which measurand will be used. The measurands for the minimum/maximum formation are loaded from DIGSI.

Calculation and resetting of the minimum and maximum values are controlled through settings. The settings describe the following points:

- Memories of the minimum/maximum values are reset to 0 cyclically or not at all.
  (Setting **`Min/Max cyclic reset`**)
- Point in time when the memories of the minimum/maximum values are reset to 0.
  (Setting **`Min/Max reset each`** and setting **`Min/Max reset minute`**)
- Point in time at which the cyclical reset procedure of the minimum/maximum values begins (after the parameterization)
  (Setting **`Min/Max days until start`**)

The following figure shows the effect of the settings.



[dwminmax-100611-01.tif, 1, en_US]

Figure 10-2 Minimum and Maximum-Value Formation

Minimum and maximum values are time-stamped.

Minimum/maximum values are formed through:

- Operational measured values except for phase-related ratings
- Amounts of the symmetrical components
- Average values

The minimum and maximum values are reset on a regular basis or via the

- Binary input >Reset min/max
- DIGSI
- The integrated operation panel

NOTE

With the **P, Q sign** parameter in the function block **General**, the sign of the following measured values of the respective function group can be inverted (see Chapter *10.2 Structure of the Function* Structure of the Function, section Inversion of Output-Related Measured and Statistical Values):

- Minimum/maximum values of the active and reactive power:
  Min:Ptotal, Max:Ptotal, Min:Qtotal, Max:Qtotal
- Minimum/maximum values of the average values of the active and reactive power:
  AverageMin:Ptotal, AverageMax:Ptotal, AverageMin:Qtotal, AverageMax:Qtotal

10.6.2 Application and Setting Notes for Minimum/Maximum Values

The minimum/maximum values functionality is not preconfigured. If you want to use the functionality, you must load it from the library into the respective function group.

The following settings listed for the calculation of the minimum/maximum values can be set with DIGSI or at the device. You find the setting parameters in DIGSI in the project tree under **Settings > Device settings**.

Parameter: Min/Max cyclic reset

- Default setting: **(_:107) Min/Max cyclic reset** = ***yes***

Parameter Value	Description
Yes	Cyclical resetting of the minimum and maximum value memories is activated
No	Cyclical resetting of the minimum and maximum value memories is deactivated None of the following parameters are visible

Parameter: Min/Max reset each

- Default setting: **(_:108) Min/Max reset each** = ***1 day***

Parameter Value	Description
1 day to 365 days	Resetting of the minimum value and the maximum value, cyclically on all specified days, for example each day (1 day)

Parameter: Min/Max reset minute

- Default setting: **(_:109) Min/Max reset minute** = ***0 min***

Parameter Value	Description
0 min to 1439 min	Resetting the minimum value and the maximum value at the specified minute of the day, which is stated in the parameter **Min/Max Reset takes place every**, for example 0 min (= 00:00)

Parameter: Min/Max days until start

- Default setting: **(_:110) Min/Max days until start** = ***1 day***:

Parameter Value	Description
1 day to 365 days	Indication of when the cyclical reset procedure of the minimum values and maximum values begins, for example in 1 day (after the parameterization)

10.7 Energy Values

10.7.1 Function Description of Energy Values

The device continually determines the values for the active and reactive energy from the power-measured values. It calculates the exported and imported electrical energy. The calculation (summation over time) begins immediately after the device startup. You can read the present energy values on the device display or through DIGSI, delete the energy value (set to 0), or set it to any initial value. After input, the energy-value calculation will continue with the new setting values.

Energy values can be transferred to a control center through an interface. The energy values are converted into energy metered values. Here the following applies:

$$\text{Energy metered value} = \frac{\text{Energy value}}{S_{N,obj.}} \cdot 60000 \frac{\text{Pulses}}{\text{h}}$$

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Through the settings, you set how the metered values are processed. The setting parameters apply for all energy metered values of the device, and do not have a function-group specific effect. You determine the following points:

- Parameter **`Energy restore time`**

  Hour-related point in time; at this point in time, the device will provide a metered value at the communication interface for transmission. After this, it will be transferred in accordance with the selected log.

  Note: If the parameter is activated through a time setting, the parameter **`Energy restore interval`** will automatically be deactivated.

- Parameter **`Energy restore interval`**

  Adjustable period in minutes until the first and every further transfer of the metered value to the communication interface of the device. After this, it will be transferred in accordance with the selected log.

  Note: The transfer interval is used alternatively to the transfer time, and deactivates the set transfer time. The display of the device is always up to date.

  You will find these parameters in the device settings under **measured values**.

In addition, restoring can be triggered via a routable binary input (*`>Restoring`*). The rising edge of the binary input leads to restoring, that is, provision of the energy-metered value at the communication interface.

The metered-value memory and the energy values can be set to 0 via a binary input (*`>Resetting`*) if there is a rising edge.

Note: The binary inputs affect all energy/energy metered values simultaneously.

The following energy values are available:

Energy Values		**Primary**
Wp+	Active energy, output	kWh, MWh, GWh
Wp-	Active energy, input	kWh, MWh, GWh
Wq+	Reactive energy, output	kvarh, Mvarh, Gvarh
Wq-	Reactive energy, input	kvarh, Mvarh, Gvarh

In compliance with IEC 61850, when individually measured values are missing, the quality of the energy-metered values changes to the state **Questionable**.

This quality state is retained until a new meter content is specified for the energy value by:

- Confirmation of the current meter content via **Set**
- **Setting** a new meter content
- **Resetting** the meter content to 0

NOTE

With the **P, Q sign** parameter in the function block **General**, the sign of the following measured values of the respective function group can be inverted (see Chapter *10.2 Structure of the Function* Structure of the Function, section Inversion of Output-Related Measured and Statistical Values):

- Active energy, output: Wp+
- Active energy, input: Wp-
- Reactive energy, output: Wq+
- Reactive energy, input: Wq-

10.7.2 Application and Setting Notes for Energy Values

The set parameters apply for all electricity meters of the device. You find the setting parameters in DIGSI in the project tree under **Settings > Device settings**.

Parameter: Energy restore interval

- Default setting: **(_:111) Energy restore interval** = ***10 min***

Parameter Value	Description
0 min	Restoring deactivated
60 min	Cyclical restoring after the set time 1 minute to 60 minutes

Note: If the parameter is activated through a time setting, the parameter **Energy restore time** is not in effect and will be deactivated automatically.

Parameter: Energy restore time

- Default setting: **(_:112) Energy restore time** = **--**

Parameter Value	Description
--	Deactivated
hh:00	Restoring on the full hour
hh:15	Restoring 15 minutes after the full hour
hh:30	Restoring 30 minutes after the full hour
hh:45	Restoring 45 minutes after the full hour

Note: If the parameter is activated through a time setting, the parameter **Energy restore interval** is not in effect and will be deactivated automatically.

Parameter: Energy restore

- Default setting: **(_:120) Energy restore** = ***latest value***

Parameter Value	Description
latest value	Restoring of the current energy value
delta value	Restoring the difference value between the current energy value and the energy value of the last restoring operation

Parameter: Energy restore by A.time

- Default setting: **(_:121) Energy restore by A.time** = ***Wrong***

Parameter Value	Description
Wrong	Restoring deactivated

Parameter Value	Description
True	The cyclic restoring after the set time of the parameter **(_:111) Energy restore interval** will be synchronized with the system time as well. Example: **Energy restore interval** = 30 min; current system time: 12:10 o'clock. First restore: 12:30 o'clock; next restore: 13:00 o'clock etc.

Note: If the parameter is activated, the following setting values are possible for the parameter **(_:111) Energy restore interval** : 1 min; 2 min; 3 min; 4 min; 5 min; 6 min; 10 min; 12 min; 15 min; 20 min; 30 min; 60 min.

Input Signals: >Restoring and >Resetting

Binary Inputs	Description
>Restoring	The restoring of the metered values is initiated via a binary input.
>Reset	The metered value memory is set to 0 through the binary input.

You route these logical signals in the DIGSI routing matrix. Open the function group, for example, Line, where you created the energy value. Under the tab **Measured values** you will find the tab **Energy, 3-phase**. In this tab, you will find the logical signals in addition to the measured values.

10.8 User-Defined Metered Values

10.8.1 Pulse-Metered Values Function Description



NOTE

You can define additional metered values through DIGSI for user-specific applications.

Use pulse meters; then you can define the respective metered values through DIGSI and set parameters for them analogously to the energy values. You can read out the metered values on the display of the device or via DIGSI.

Through settings, you can individually set how each pulse-metered value is processed:

- Parameter **`Restore time`**

  Hour-related point in time when the device will provide a metered value at the communication interface for transmission. After this, the transfer takes place in accordance with the selected protocol.

  Note: If the parameter is activated through a time setting, the parameter **`Restore interval`** will automatically be deactivated.

- Parameter **`Restore interval`**

  Adjustable period in minutes until the first and every further transfer of the metered value to the communication interface of the device. After this, it will be transferred in accordance with the selected log.

  Note: If the parameter is activated through a time setting, the parameter **`Restore time`** will automatically be deactivated.

In addition, restoring can be triggered via a routable binary input (**`>Restore trigger`**) or via a logical internal binary input. The rising edge of the binary input leads to restoring and thus to provision of the metered value at the communication interface.

The counter pulse of any external/internal pulse generator is connected to the device via a routable binary input (**`>Pulse input`**). If this does not deliver any plausible values, this can be signaled to the device via another routable binary input (**`>External error`**).

In compliance with IEC 61850, in the event of an external error, the quality of the pulse-metered value changes to the state **Questionable**. No more pulses are added as long as the external error persists. Once the external fault condition has been cleared, pulses are added again.

The quality of the pulse-metered value remains **Questionable** until a new meter content is specified for the pulse-metered value by:

- Confirmation of the current meter content via **Setting**
- **Setting** a new meter content
- **Resetting** the meter content to 0

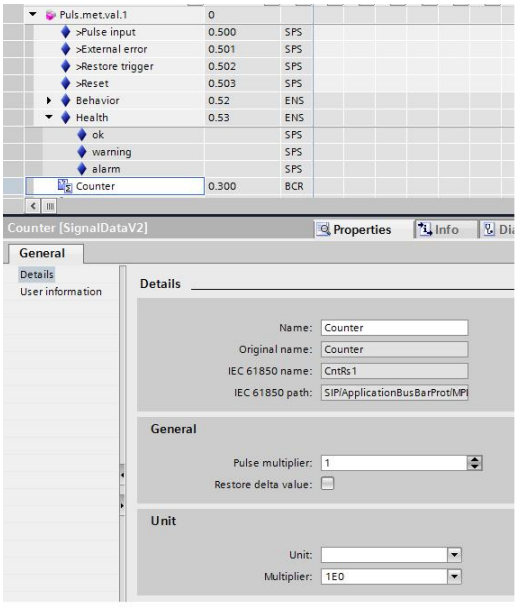
- Parameter **`Edge trigger`**

  Through settings, you can select between counting only with a rising edge or with rising and falling edges on the pulse input.

The pulse counter can be reset to 0. You can perform this resetting via the rising edge of a routable binary input (**`>Reset`**) or via operation on the device.

To display the counting amount at the device display, use DIGSI to set the desired weighting of the counter pulses, the unit of the metered value and a multiplication factor for every pulse generator. You can also assign a user-specific name.

To do this, open the functional area **Pulse-metered value** in DIGSI information routing. (see *Figure 10-3*). Select the metered value and enter the settings under **Properties**.



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Figure 10-3 Setting with DIGSI, General Settings, Pulse-Metered Values

10.8.2 Application and Setting Notes for Pulse-Metered Values

The functionality **Pulse-metered values** is not preconfigured. If you want to use the functionality, you must load it from the library into the respective function group.

The parameters can be set individually for every pulse counter. You will find the setting parameters in DIGSI in the project tree under **Parameter > Function group**

For pulse-metered values, the following described settings and binary inputs are available.

Parameter: `Restore time`

- Default setting: **`(_:101) Restore time`** = **`--`**

Parameter Value	Description
--	Deactivated
hh:00	Transfer on the full hour
hh:15	Transfer 15 minutes after the full hour Note:
hh:30	Transfer 30 minutes after the full hour Note:
hh:45	Transfer 45 minutes after the full hour Note:

Note: If the parameter is activated through a time setting, the parameter **`Restore interval`** is not in effect and will be deactivated automatically.

Parameter: `Restore interval`

- Default setting: **`(_:102) Restore interval`** = ***`0 min`***

Parameter Value	Description
0 min	Deactivated
1 min to 60 min	Cyclical transfer after the set time 1 minute to 60 minutes

Note: If the parameter is activated through a time setting, the parameter **Restore time** is not in effect and will be deactivated automatically.

Parameter: Edge trigger

- Default setting: **(_:103) Edge trigger** = ***rising edge***

Parameter Value	Description
rising edge	Counting with rising edge at the pulse input
rising & falling edge	Counting with rising and falling edge at the pulse input

Parameter: Restore by absolute time

- Default setting: **(_:104) Restore by absolute time**= ***False***

Parameter Value	Description
False	Deactivated
True	The cyclic restoring of setting **Restore interval** after the set time is also synchronized with the system time. Example: **Restore interval** = 30 min; current system time: 12:10 o'clock. First restoring operation: 12:30 o'clock; next restoring operation: 13:00 o'clock, etc.

Input Signals: >Pulse input, >External error, >Restore trigger, >Reset

Binary inputs	Description
>Pulse input	Input for the counting pulses of an external pulse generator
>External error	Indication that the counter pulses of the external pulse generator are faulty. The indication has an effect on the quality identifier of the pulse value.
>Restore trigger	The transfer of the metered values is initiated via a binary input.
>Reset	The rising edge at the binary input resets the pulse counter to 0.

The amount of energy indicated by a pulse generator is to be displayed as a measured value.

1 pulse corresponds to 100 Wh.

The pulse weighting, the SI unit, and the factor must be adjusted to one another.

Display value = Calculated metered value * Pulse weighting * Factor * SI unit.

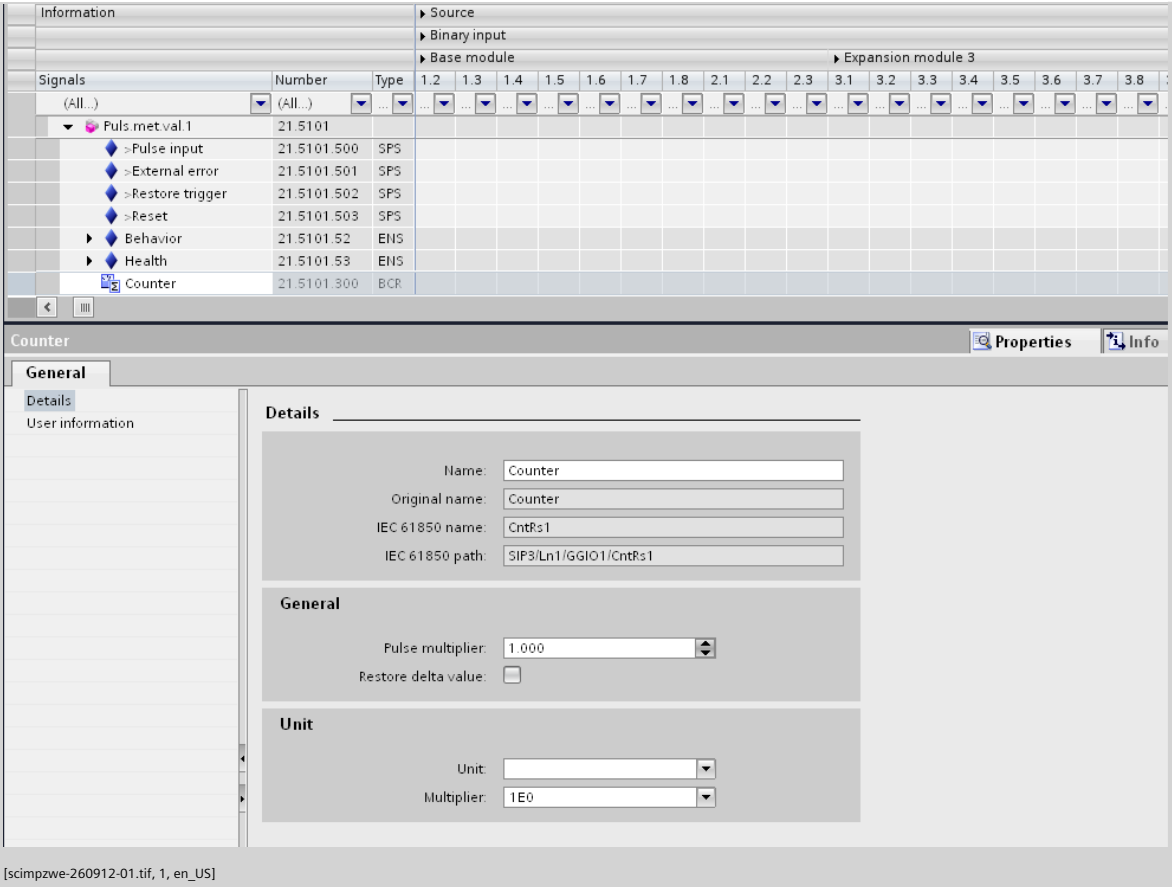
If the check box **Restore delta value** is activated, the differential value is transferred at the restore time set via the communication interface. The difference value is formed by subtracting the counter content of the last restoring operation from the current counter content.

You route the logical signal ***>Pulse input*** to a binary input to which the pulse generator is connected.

Set the following values:

Name	Active Power Meter
Pulse weighting	100
Restore differential value	Activated
SI unit	Wh
Factor	1

The factor is used for adaptation to larger units (for instance, 1000 for kWh). It is adjustable in powers of ten (1, 10, 100, 1000, etc.). The following figure shows the signals that can be arranged in the DIGSI information matrix. Open the function group where you created the pulse-metered value, for example, Line 1. There, you will find the function area **Pulse-metered value**. Here you will also find the logical signals next to the metered value. Select the metered value and enter the settings under **Properties**.



[scimpzwe-260912-01.tif, 1, en_US]

Figure 10-4 Setting with DIGSI

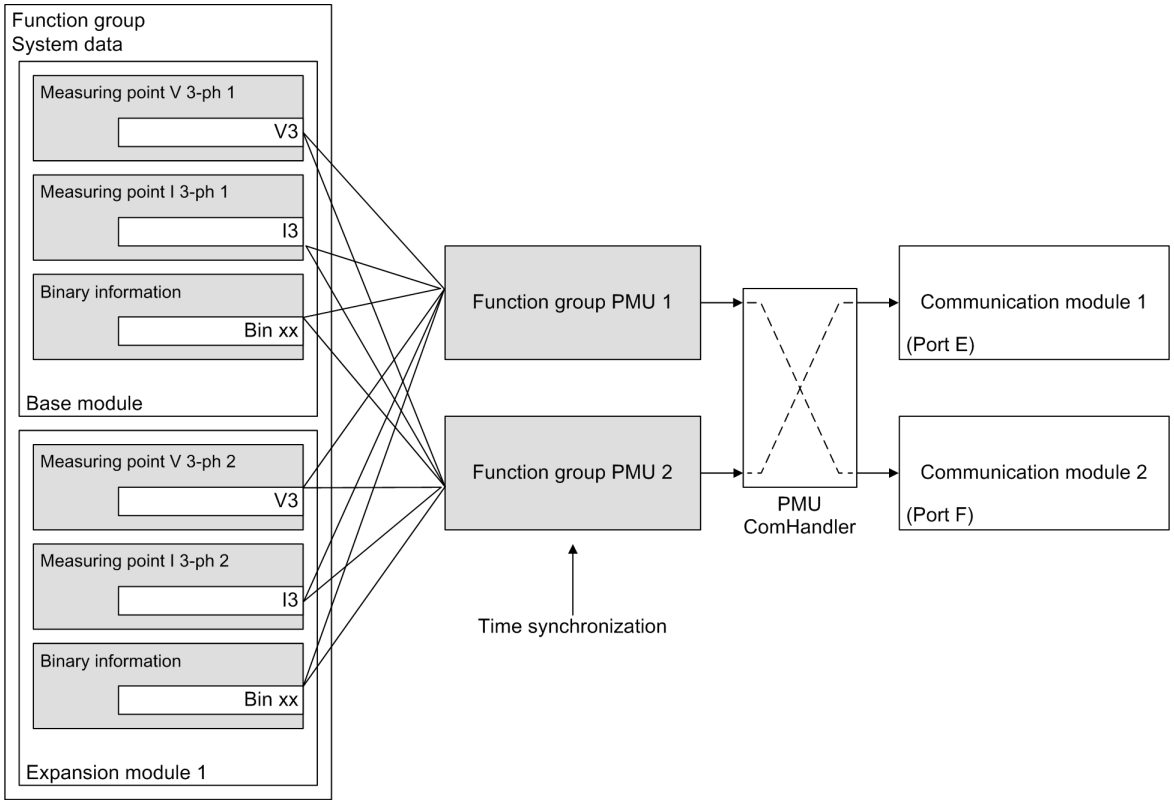
10.9 Phasor Measurement Unit (PMU)

10.9.1 Overview of Functions

A Phasor Measurement Unit (PMU) measures the phasor values of current and voltage. These values get a high precision time stamp and together with the values of power frequency, power frequency change rate and optional binary data that are also time stamped are transmitted to a central analysis station. The standardized transmission protocol IEEEC 37.118 is used to do this.

10.9.2 Structure of the Function Group

The **PMU** function group is activated by selecting the protocol *IEEE C37.118PMU* on an Ethernet module (electrical or optical). The PMU obtains the measured values from the measuring points and the precise time from time synchronization. The time-stamped synchrophasors for current and voltage are formed from this and transferred together with additional values via the communication module to a server (PDC, Phasor Data Concentrator).



[dwstrpmu-250613-01.tif, 2, en_US]

Figure 10-5 Structure/Embedding of the Function

10.9.3 Function Description

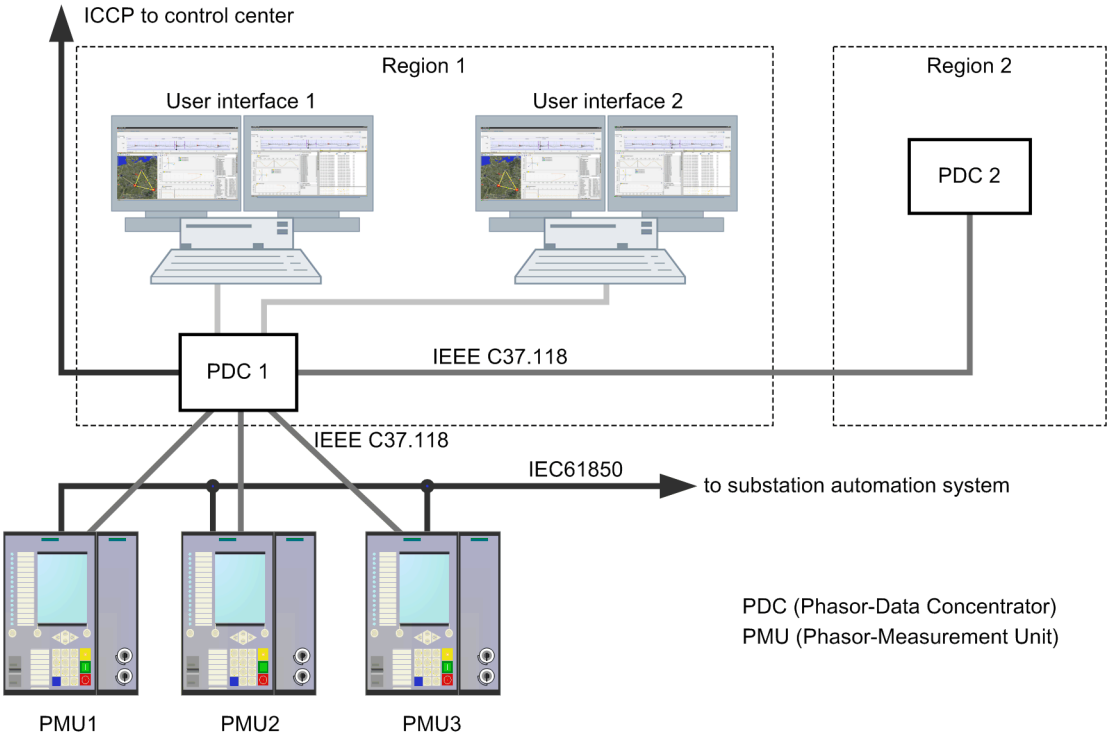
The synchrophasors, sent from the **PMU** in a continuous data stream to a PDC, are provided with time stamps and thus are comparable with the measured values of other PMUs. The power frequency, the power frequency change rate and optional binary information are also transmitted as time-stamped measured values. Therefore, you receive an overview of the transient processes in a distributed energy transfer system, for example network fluctuations and compensating processes.

The following table shows the differences between the PMU measured values and the remaining measured values of the device.

Table 10-4 Comparison of Synchrophasors and Conventional Measured Values

Synchrophasors of the PMU	Measured Values from the Measuring Points
Continuous updating (measured value of current) with, for example, 10 values per second (reporting rate)	Slow updating (typically every 5 seconds)
Every measured value has a time stamp	No time stamp for the measured values
Phasor values of current and voltage (amplitude and phase angle)	RMS values without phase angle

The following figure shows the structure of such a Wide Area Monitoring System. The data delivered from the PMUs on the PDC are transmitted via the Inter-Control Center Communications Protocol (ICCP) according to DIN EN 60870-6 to the network control center.



[dwstrwam-120124-01.tif, 1, en_US]

Figure 10-6 Structure of a Wide-Area Monitoring System with Phasor-Measurement Units

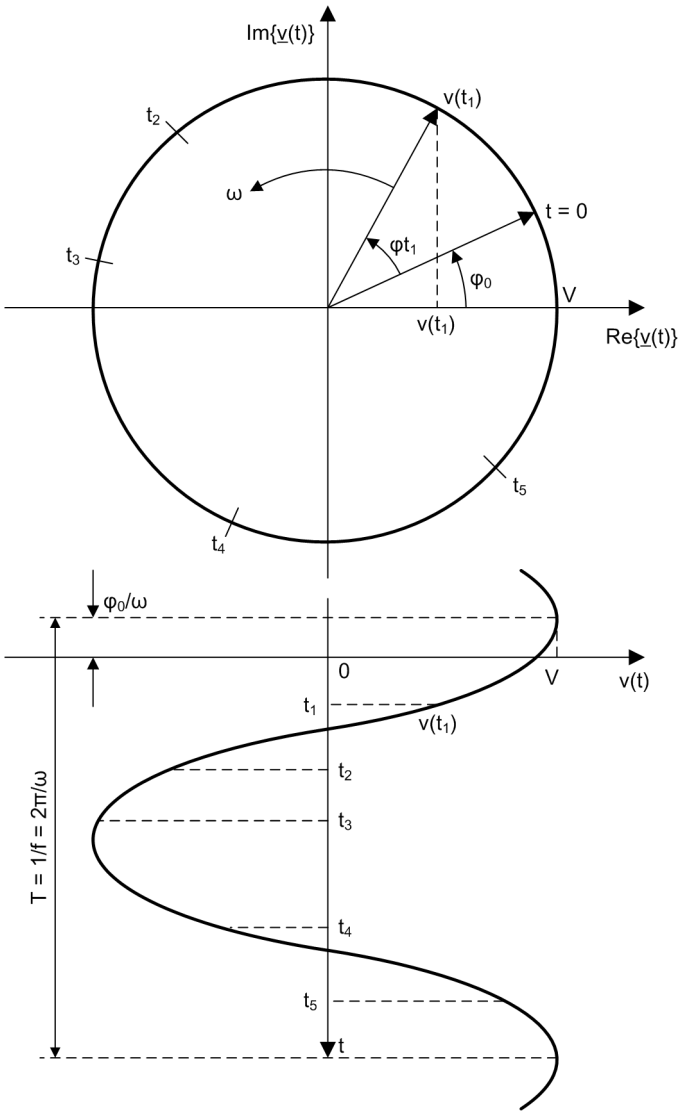
The phasor-measurement units each have 2 communication interfaces: an Ethernet module for synchrophasor communication via IEEE C37.118 and another module for communication with the substation automation technology, for example, through the IEC 61850 protocol.

The central evaluation system, e.g. SIGUARD PDP Phasor Data Processor, receives the data, files, archives them and graphically displays them on a User Interface. In this system, a self-checking function may also be performed, for example, on undamped power swings. The further distribution of information to other PDCs or to a control station is done here.

To maintain the required maximum errors (TVE) required in the standard IEEE C37.118, the time tolerance relative to the UTC time reference (UTC = Universal Time Coordinated) may be maximum 10 µs. Therefore, the device must be directly synchronized with a GPS precise time signal for the correct function of the PMU.

Phasors

A phasor $u(t) = \underline{U}e^{j\omega t}$ can be displayed as a phasor that moves counterclockwise in the complex plane at the angular frequency ω. Therefore, the voltage function $u(t) = Re\{\underline{u}(t)\}$ is obtained as a projection of the phasor $\underline{u}(t)$ on the real axis.

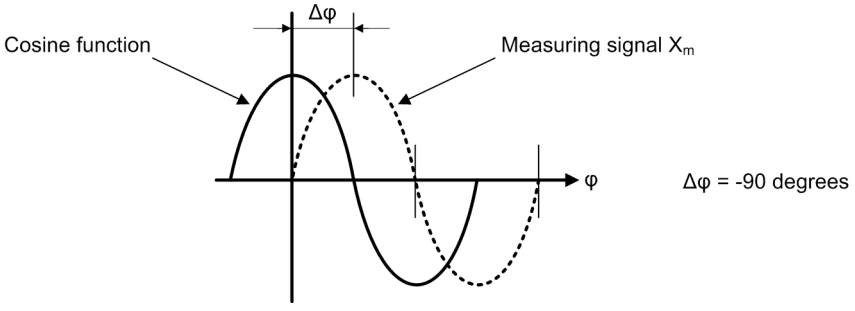


[dwgeopdc-061011-01.tif, 1, en_US]

Figure 10-7 Geometric Representation of a Phasor

Reference Point for Determining the Angle

The phase angle of a measuring signal X_m is determined relative to a cosine function having a rated frequency, which is synchronized with the UTC time reference (see *Figure 10-8*).



[dwutcphi-260112-01.tif, 1, en_US]

Figure 10-8 Determination of Phase Angle ρ of Measuring Signal X_m Relative to the Cosine Function

The number of phasors that are transmitted per second is configurable. The transmission rate is defined according to IEEE C37.118 as the reporting rate. The reporting rate defines the number of phasors that are transmitted per second. Extremely precise time synchronization is essential so that phasor measurement can be carried out to enable phasors from different sites to be compared.

Reporting Rate

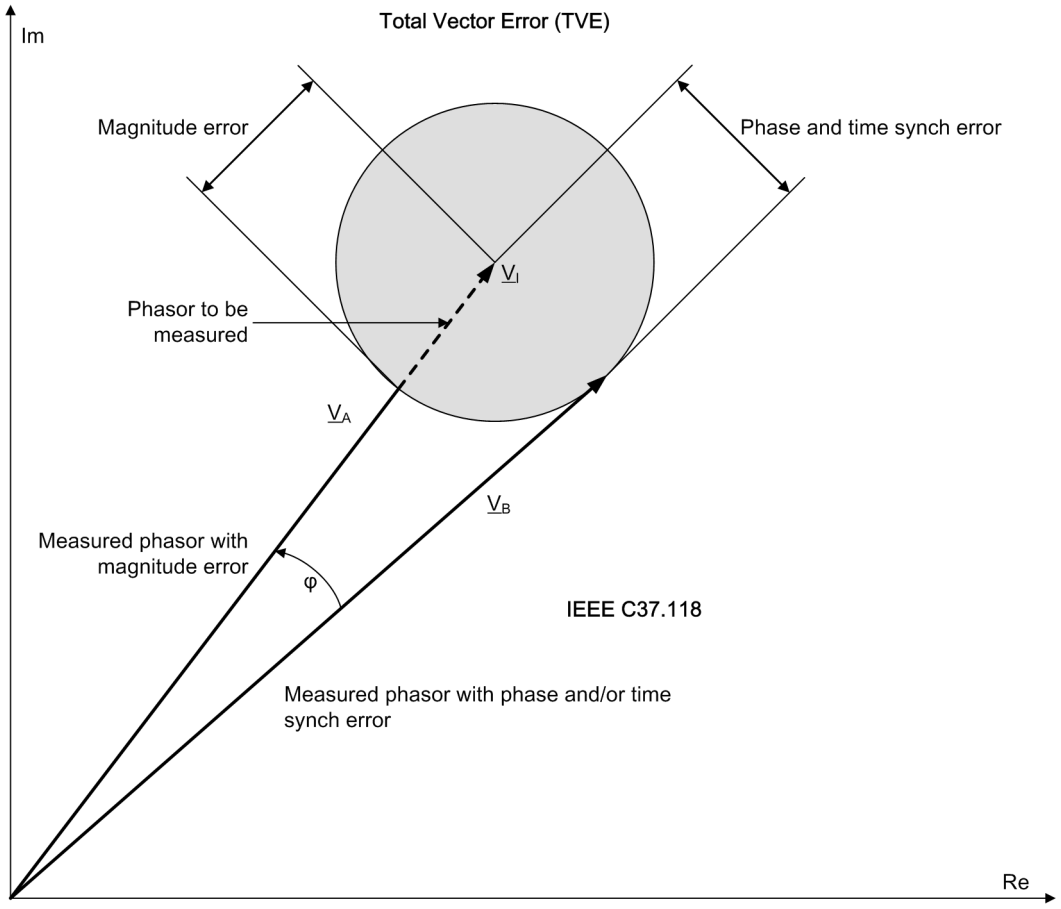
You use the configurable reporting rate (parameter **(_:10621:102) Reporting rate**) to specify the number of telegrams that are compiled and sent to the PDC per second. It is adjustable, depending on the rated frequency, and applies to all currents and voltages of the relevant **PMU** function group. If several **PMU** function groups are created on the device, these can work with different reporting rates.

Total Vector Error (TVE)

The TVE describes the error between the actual and the measured values of the input signal. The Synchrophasor Standard IEEE 37.118 defines upper limiting values of 120 % V_N and 200 % I_N, among other things. Up to these limiting values, the TVE of 1 % must not be exceeded for stationary signals. The standard defines the 2 performance classes, Class P and Class M, as ranges within which influencing variables are acceptable and the TVE of ≤1 % must be maintained. The SIPROTEC 5 devices support Class P and Class M, which specify the following influencing variables for a TVE of 1 %:

- Signal frequency (relative to f_N)
- Signal magnitude (relative to 100 % nominal magnitude) for voltage and current
- Phase angle (relative to 0°)
- Harmonic distortions (relative to < 0.2 % (THD) up to the 50th harmonic

The following figure graphically represents the total vector error. As well as the amplitude, the TVE also enters into the angle error.



[dwklatve-120124-01.tif, 1, en_US]

Figure 10-9 Representation of the Total Vector Error

The TVE is defined as follows:

$$TVE = \sqrt{\frac{(X_{r(n)} - X_r)^2 + (X_{i(n)} - X_i)^2}{X_r^2 + X_i^2}}$$

[fo_utcphi-111011-01.tif, 1, --_--]

where:

- $X_{r(n)}$ = Real part of measured signal
- $X_{i(n)}$ = Imaginary part of measured signal
- X_r = Real part of input signal
- X_i = Imaginary part of input signal

Variables that influence the TVE are:

- Amplitude errors
- Phase errors
- Synchronization accuracy (deviation from the UTC)

Synchronization accuracy is affected by a GPS timer and the precise correction of the time delay within the GPS receiver module, as well as by the optimal setup of the GPS antenna.

10.9.4 Transmitted Data

The following data is transmitted from the PMU to the PDC:

- Current and voltage phasors
- Frequency
- Frequency rate of change
- Binary information

The current and voltage channels transferred from a **PMU** function group are selected through the **Function group connections** editor in DIGSI 5. The frequency and frequency change rate are determined once per PMU. In this case, only the current and voltage channels selected via the **Function group connections** editor for this PMU are taken into consideration. You may route the binary information in the information routing matrix of DIGSI 5.

The channel used for specifying the frequency is selected dynamically during the device runtime. Each channel is checked for the presence of a signal in the following order:

1. 3-phase voltage measuring points
2. 1-phase voltage measuring points
3. 3-phase current measuring points
4. 1-phase current measuring points

The 1st measuring point found with a valid signal is used for specifying the frequency in the **PMU** function group.

In the case of 3-phase measuring points, the positive-sequence system can also be transmitted instead of 3 individual sychrophasors. This setting can be made via the parameter **(_:10621:103) Only positive sequence**.

10.9.5 PMU Communication (IEEE C37.118)

PMU communication according to standard IEEE C37.118 is a client-server communication format in which the PDC (Phasor Data Concentrator) functions as both the client and the server.

Once the PDC has been successfully connected to the device PMU and the PMU configuration data has been queried, the PDC initiates transmission of the synchrophasor data by sending a close command to the PMU. In addition to the phasors, the channel names of the routed measuring points and the binary information are transferred. Per default, these are automatically generated by the respective PMU function groups.

Where applicable, you can also edit the channel names of the measuring point and assign a designation of its own for this purpose. For more information, see chapter *10.9.6 Parameterizing the PMU with DIGSI*. The names for the binary information carried out are however, generally automatically generated by the respective PMU function group and cannot be edited.

As an example, the names (generated) for measuring points or binary information may be as follows:

Table 10-5 Possible Measuring-Point Names

Name Displayed in the DIGSI Function Group Connections	Depending on the Connection Type, Name Transferred to the PDC (in case it cannot be assigned automatically)
Measuring point U-3ph 1[ID 1]	MP-V3ph VAB ID01 MP-V3ph VBC ID01 MP-V3ph VCA ID01 MP-V3ph VA ID01 MP-V3ph VB ID01 MP-V3ph VC ID01 MP-V3ph V1 ID01

Name Displayed in the DIGSI Function Group Connections	Depending on the Connection Type, Name Transferred to the PDC (in case it cannot be assigned automatically)
Measuring point I-3ph 1[ID 2]	MP-I3ph IA ID02 MP-I3ph IB ID02 MP-I3ph IC ID02 MP-I3ph I1 ID02
Measuring point I-1ph 1[ID 3]	MP-I1ph ID03
Measuring point U-1ph 1[ID 4]	MP-V1ph ID03

Table 10-6 Possible Binary Information Names

Path Displayed in DIGSI 5 (Can Be Edited)	Name Transferred to the PDC (Cannot be Edited)
PMU 1: Transf.bin.1: >BinaryInfo.6	BIN-01-INFO-6
PMU 1: Transf.bin.2: >BinaryInfo.8	BIN-02-INFO-8
PMU 1: Transf.bin.10: >BinaryInfo.3	BIN-10-INFO-3

Data is transmitted continuously from the PMU to the PDC at the configured reporting rate. The transmission is terminated by a corresponding switch-off command from the PDC or when the connection between the PDC and the PMU is interrupted.

Communication between the PMU and the PDC can be passed via TCP or UDP protocols.

The following ports are used for data transmission:

- TCP: Port 4712
- UDP: Port 4713

The ports must be configured on the PDC.

Up to 3 different PDCs can be connected to one device PMU at the same time. The IP addresses of the maximum 3 PDCs are set in the **PMU** function group. If 4 device PMUs are configured, this enables support for up to 12 PDCs.

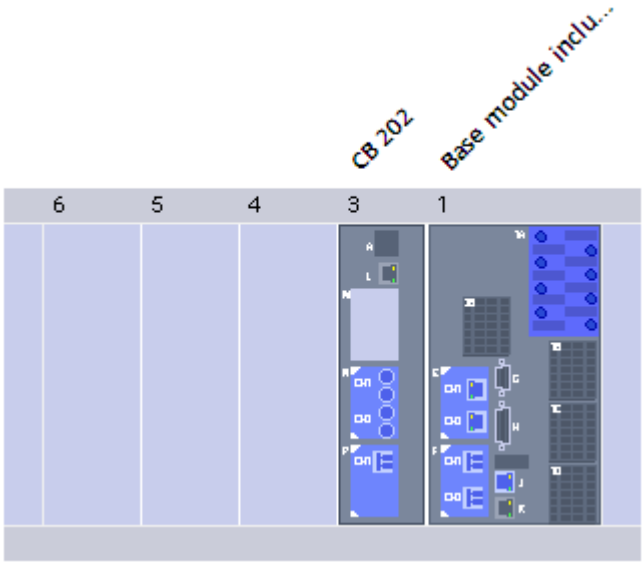
10.9.6 Parameterizing the PMU with DIGSI

You configure and parameterize the Phasor-Measurement Unit with DIGSI. After a device has been added in a DIGSI project, one or more communication modules that support synchrophasors can be configured as PMUs. The device module supports a maximum of 2 communication modules that can be configured as PMUs. If more than 2 PMUs are needed, the device must be expanded with a CB202 plug-in module assembly (expansion module), which can accommodate 2 more communication modules.

The following communication modules support synchrophasors:

- ETH-BA-2EL (2 x Ethernet electric, RJ45)
- ETH-BB-2FO (2 x Ethernet optical, 2 km, LC duplex)

These modules are then freely assignable to ports E, F, N or P of the device, see *Figure 10-10*. You can view the selected port in the **(_:10621:104) Port**. This parameter is automatically managed by DIGSI and cannot be changed.



[sccommod-140213-01.tif, 1, en_US]

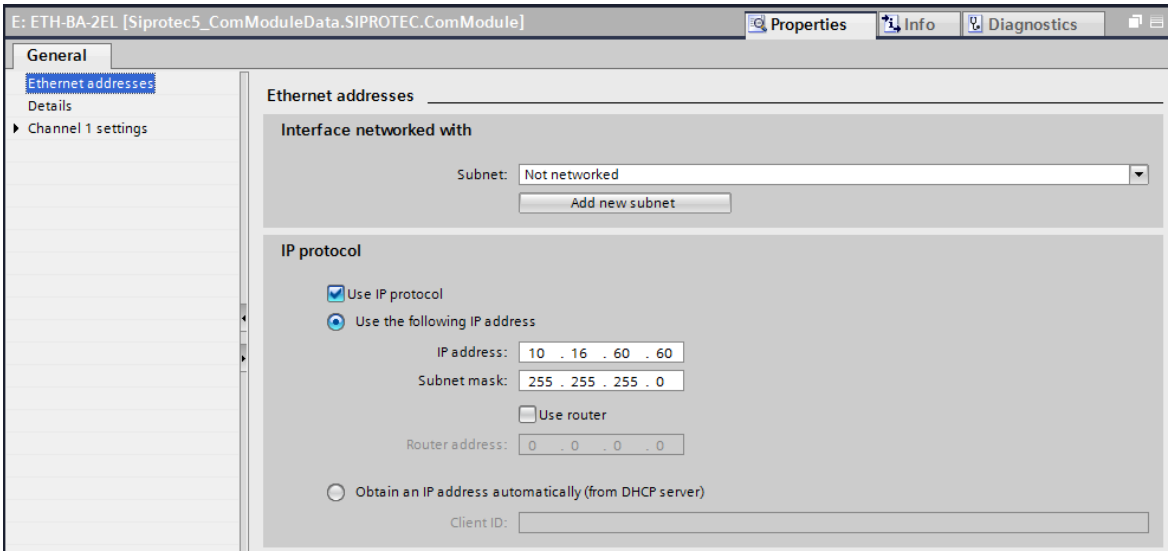
Figure 10-10 Placement of Communication Modules

NOTE

Port M of the CB202 plug-in module assembly is used to accommodate measuring-transducer modules and cannot be used for the installation of communication modules.

Addressing

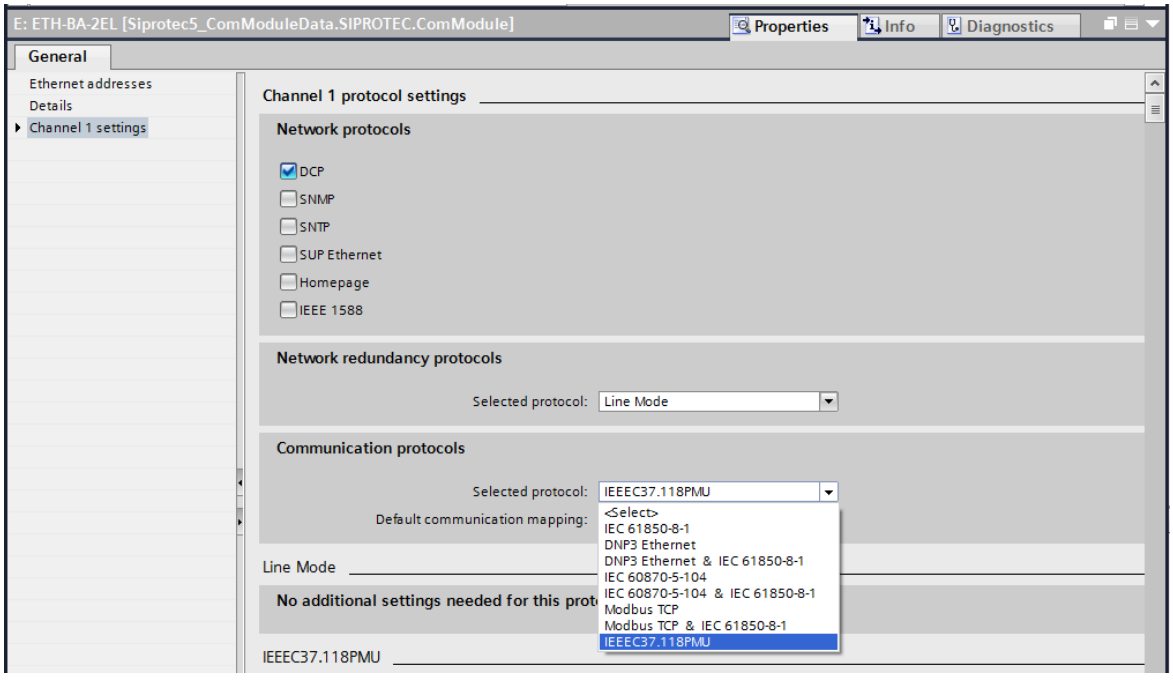
You must configure the respective Ethernet address (IP address, subnet mask, etc.) for each communication module in DIGSI. This is done in the DIGSI **General settings** properties dialog of the communication module in item **Ethernet addresses** and so forms the IP address for the respective PMU.



[scethern-210415, 1, en_US]

Figure 10-11 Ethernet Address Configuration

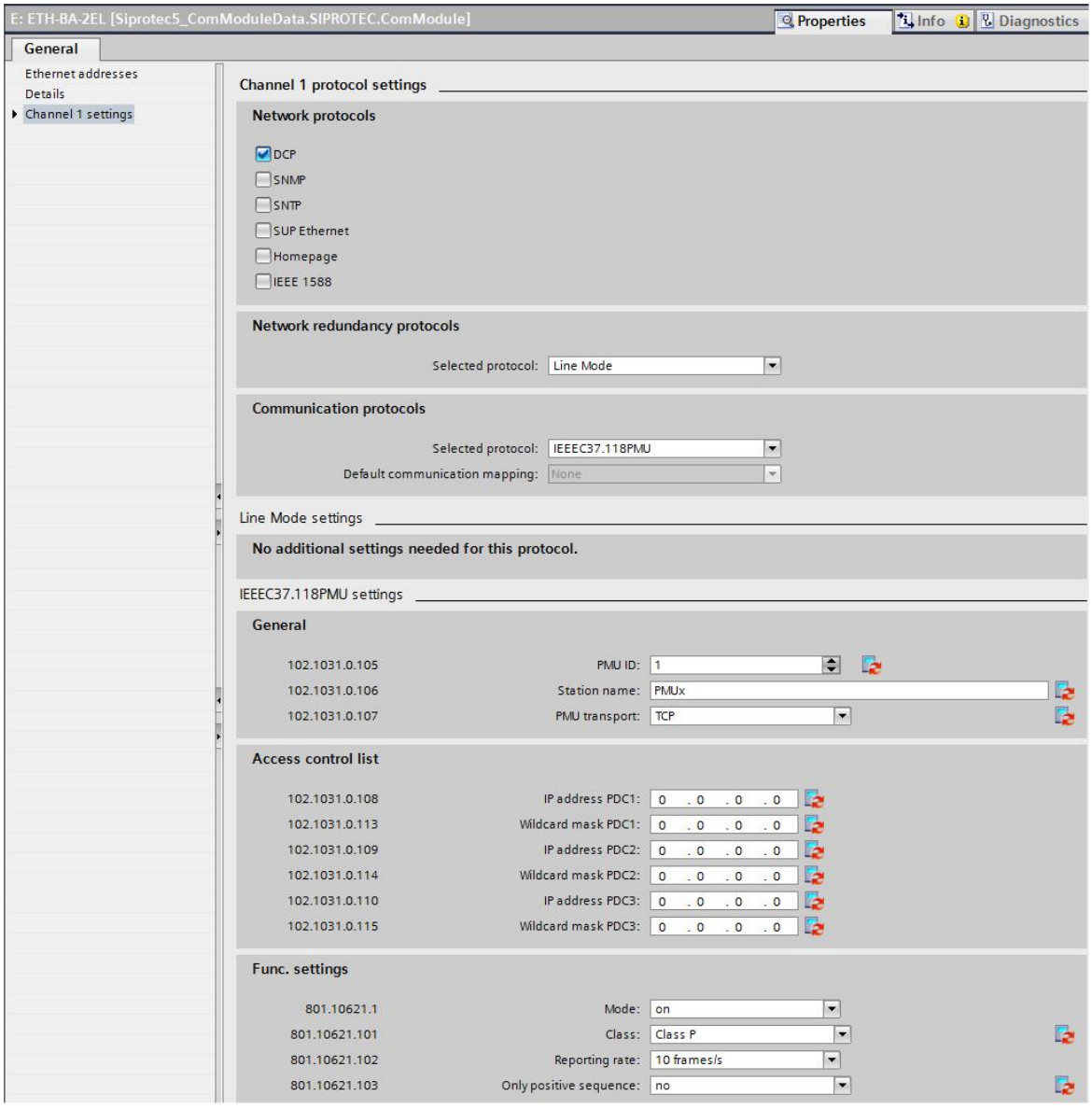
In the DIGSI properties dialog for channel 1, select the synchrophasor protocol, see the following figure.



[scprotoc-210415, 1, en_US]

Figure 10-12 Protocol Selection

After you have selected the synchrophasor protocol for the communication module, an advanced settings dialog for PMU-specific configuration opens, see the following figure.



[scwildcard_de, 1, en_US]

Figure 10-13 PMU-Specific Configuration

You configure the specific settings for the communication protocol in the top section of this settings dialog. In the bottom section, you specify the corresponding PMU-specific settings.

In order to permit a better configuration of larger wide-area supervision systems, changes have been implemented in the IEEE C37.118 communication configuration that permit a flexible IP configuration without the loss of safety aspects in the systems administrated.

Configurable placeholders are permitted for each PDC IP address. These placeholders allow you to define a range of IP addresses where they are accepted within these accesses. The purpose of this is to permit each individual device or system access within the respective system without limits with regard to their hierarchy level. Therefore, with regard to security aspects, the limitation to individual IP addresses is eliminated. You are thus allowed to configure complete sections of IP addresses in each PMU and, as a result, very flexible when making changes to the configuration of the entire system, for example. The placeholder character must follow consecutively at the bit level, starting with the bit with the lowest value.

EXAMPLE of Placeholder Characters:

Example 1:

- binary 00000000.00000000.00000000.00101011 is not permitted
- binary 00000000.00000000.00000000.00111111 is permitted

Example 2:

- The PDC IP address is: 192.172.16.1
- Placeholder: 0.0.0.127

The device accepts requests within the IP address range of 192.172.16.1 to 192.172.16.127.

Example 3:

- The PDC IP address is: 192.172.16.100
- Placeholder: 0.0.0.3

The device accepts requests within the IP address range of 192.172.16.100 to 192.172.16.103.

If a PDC attempts to establish a connection to the device, the PDC IP addresses and corresponding placeholders are checked in the same order as they had been configured (IP address PDC1, IP address PDC2, IP address PDC3). Running through the list is stopped with the first match of the IP address, placeholder and requested IP address range and the connection is built-up. If there are no matches, the attempt to connect is rejected.

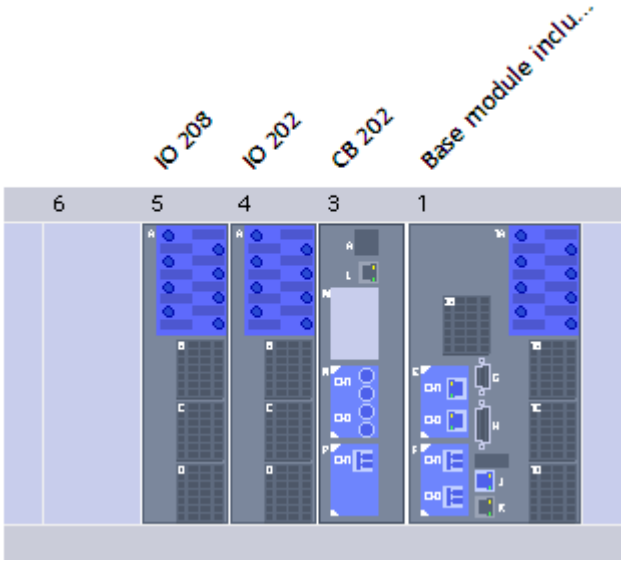
If you have configured IP address 0.0.0.0 and the placeholder 255.255.255.255, every IP address received is accepted as valid. This could be of use in the course of commissioning measures.

NOTE

You must have configured at least 1 IP address in order to establish a connection between the device and PDC.

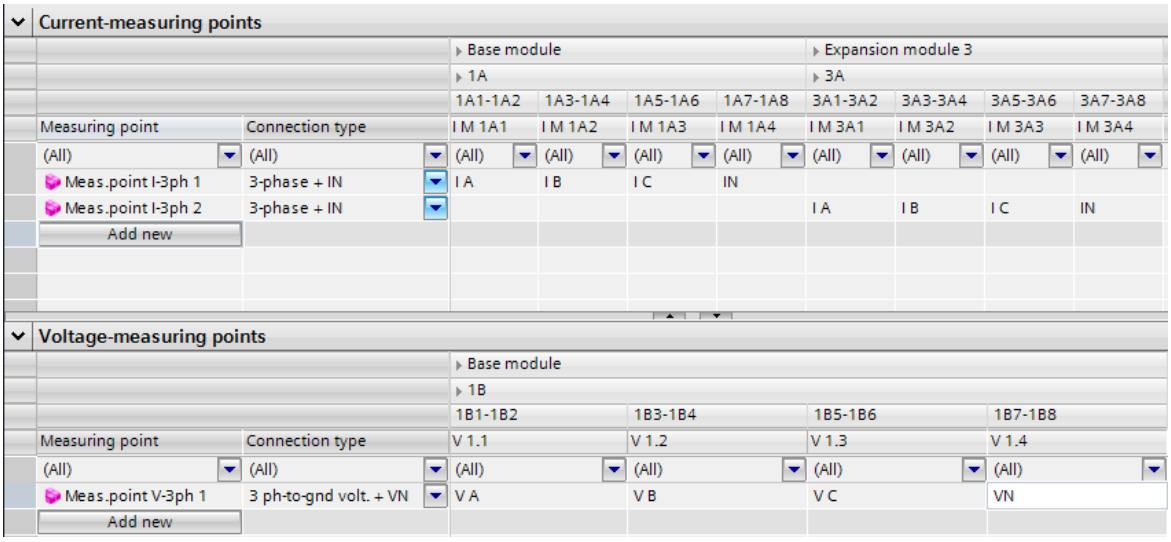
Measuring-Point Assignment

After adding measuring points to the device, you can assign these measuring points to each configured PMU. *Figure 10-14* shows as an example expansion of the device configuration by 2 additional input/output modules. You connect the current and voltage inputs of these I/O modules to measuring points via the DIGSI routing matrix, see example in *Figure 10-15*.



[scaddios-140213-01.tif, 1, en_US]

Figure 10-14 Adding Additional Input/Output Modules



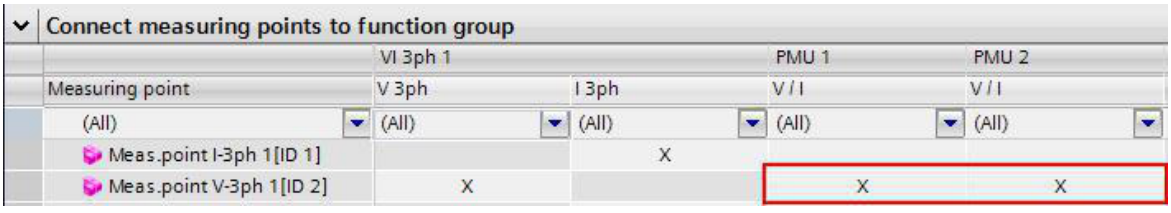
[scroutin-210415, 1, en_US]

Figure 10-15 Assignment of the Current and Voltage Inputs of the Added Input/Output Modules on Measuring Points

The maximum numbers of measuring points that can be routed for one PMU are:

- 2 x 3-phase voltage measuring points
- 2 x 3-phase current measuring points
- 2 x 1-phase voltage measuring points
- 2 x 1-phase current measuring points

You can assign all supported measuring points to any PMU, see the following figure. However, each PMU must be connected to a 3-phase voltage measuring point.



[scfgconn-210415, 1, en_US]

Figure 10-16 Connecting Measuring Points to the Configured PMU Function Groups

When these setting steps have been completed, the PMUs are fully configured. The **PMU** is a function group that functions independently of all the other function groups instantiated in the device.

The device load, however, is dependent on:

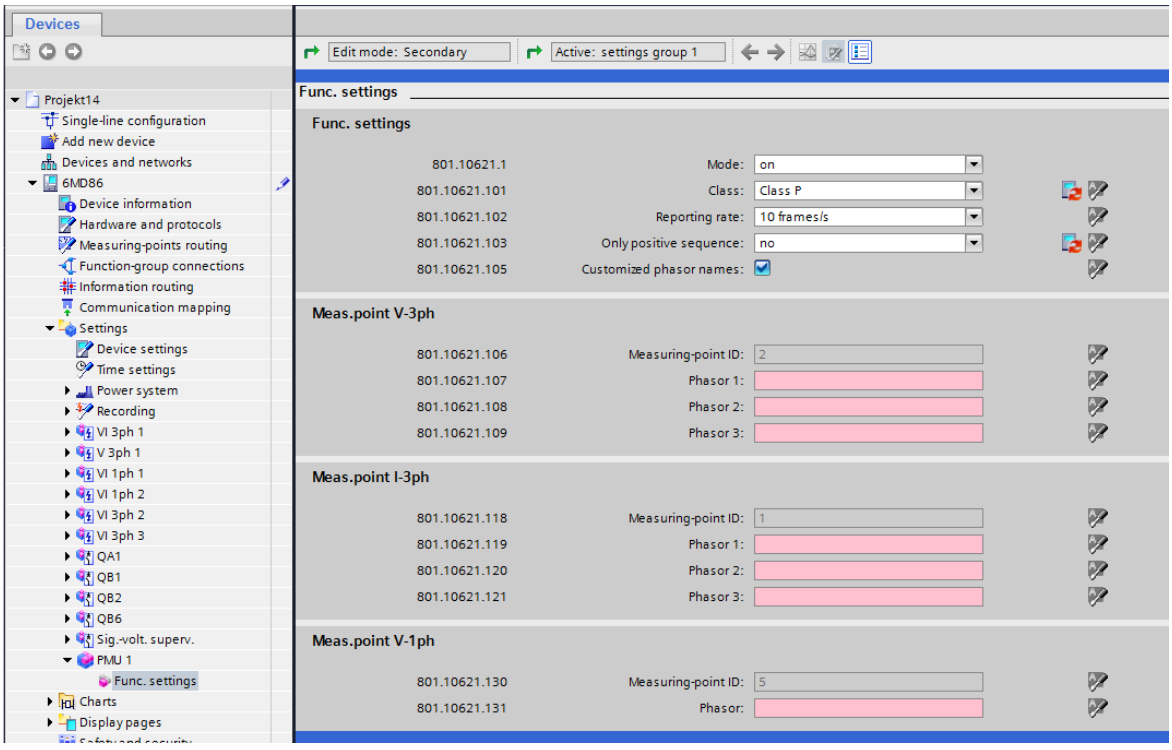
- Number of PMUs
- Performance class (where Class M generates the greater load)
- Number of assigned channels
- Configured reporting rate of each PMU
- Number of binary signals to be transferred

Changing the Channel Names of Phasors

You can edit the names of the individual phasor channels for voltage and current in DIGSI. The clearly structured channel designations assist with when testing and commissioning PMU systems. Furthermore, only the names visible in the IEEE C37.118 interface can be changed. The function block designations themselves cannot.

The IEEE C37.118 defines the ASCII character set for changing the channel names in the scope of the SIPROTEC 5-PMU support. Due to the protocol, the designation length is limited to 16 ASCII characters per channel. However, when renaming, you have to assign at least 1 character. The renaming of binary channels is not supported in the current implementation.

You can start the renaming by setting the check mark at **Own phasor names** with the parameterization in the PMU function block **Functional settings**. Once you have activated this check mark, define a separate name for each phasor. For this purpose, DIGSI shows all routed measuring points on the PMU in the function group connections (see following figure).



[scPMUnam_de, 1, en_US]

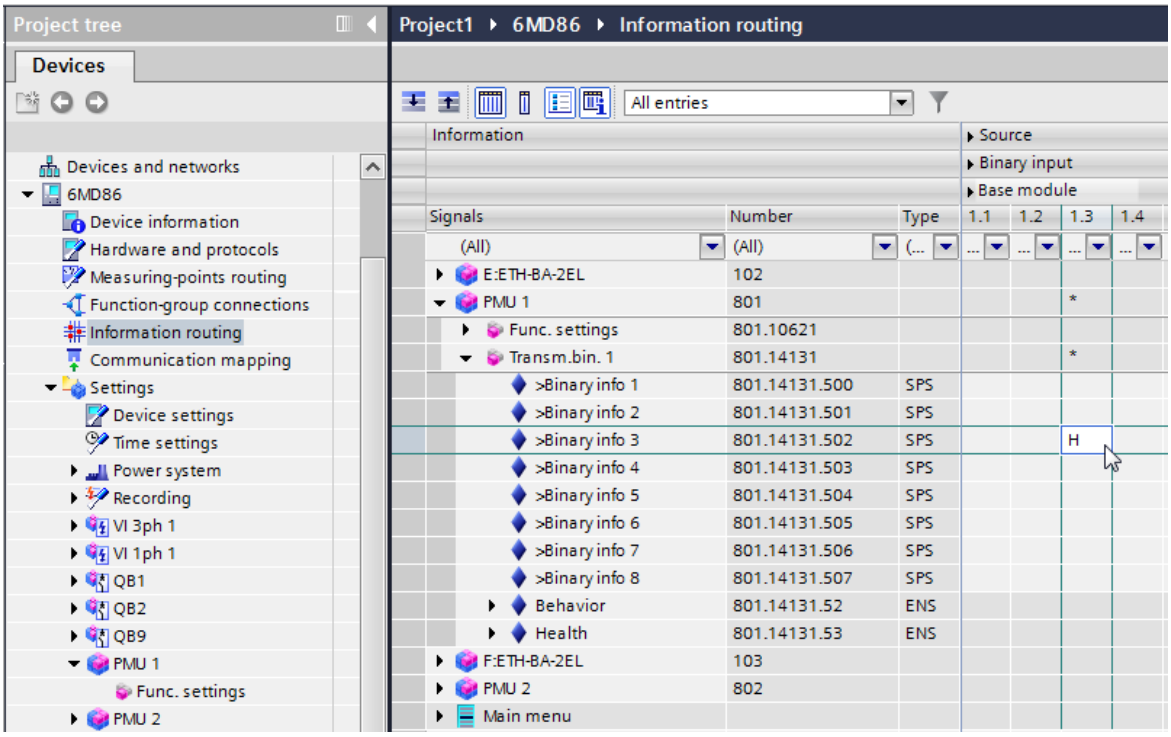
Figure 10-17 Options for Editing the Names of the Individual Phasors

NOTE

You can only rename each individual phasor when you set the parameter **Positive-sequence system only** to ***No*** in the functional settings. Otherwise you will only be offered one single phasor for each 3-phase measuring point for renaming.

Routing Binary Signals

You can connect binary inputs or CFC information with binary channels of the PMU via DIGSI information routing. You will find, in the **Phasor Measurement Unit (PMU)** folder, the **Binary information transmission** function block in the DIGSI function library (see the following figure). You can instantiate this function block up to 10 times in one **PMU** function group. Each of these function blocks contains 8 options for routing binary channels.



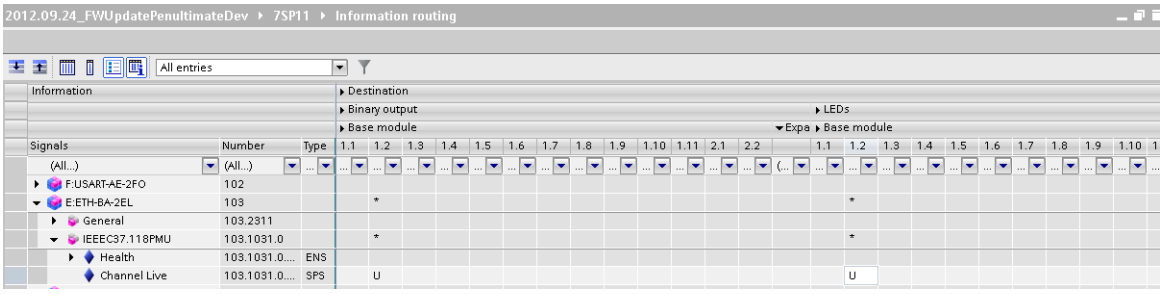
[scpmubif-210415, 1, en_US]

Figure 10-18 Information Routing in DIGSI 5

Routing Indications

The routable indication *ChannelLive* of the PMU log

- raises when the PMU is connected to the PDC
- clears when the connection to the PDC is interrupted.



[scparami-260912-01.tif, 1, en_US]

Figure 10-19 Log Indication for Display of the PMU/PDC Connection

10.9.7 Parameterizing the PMU on the Device

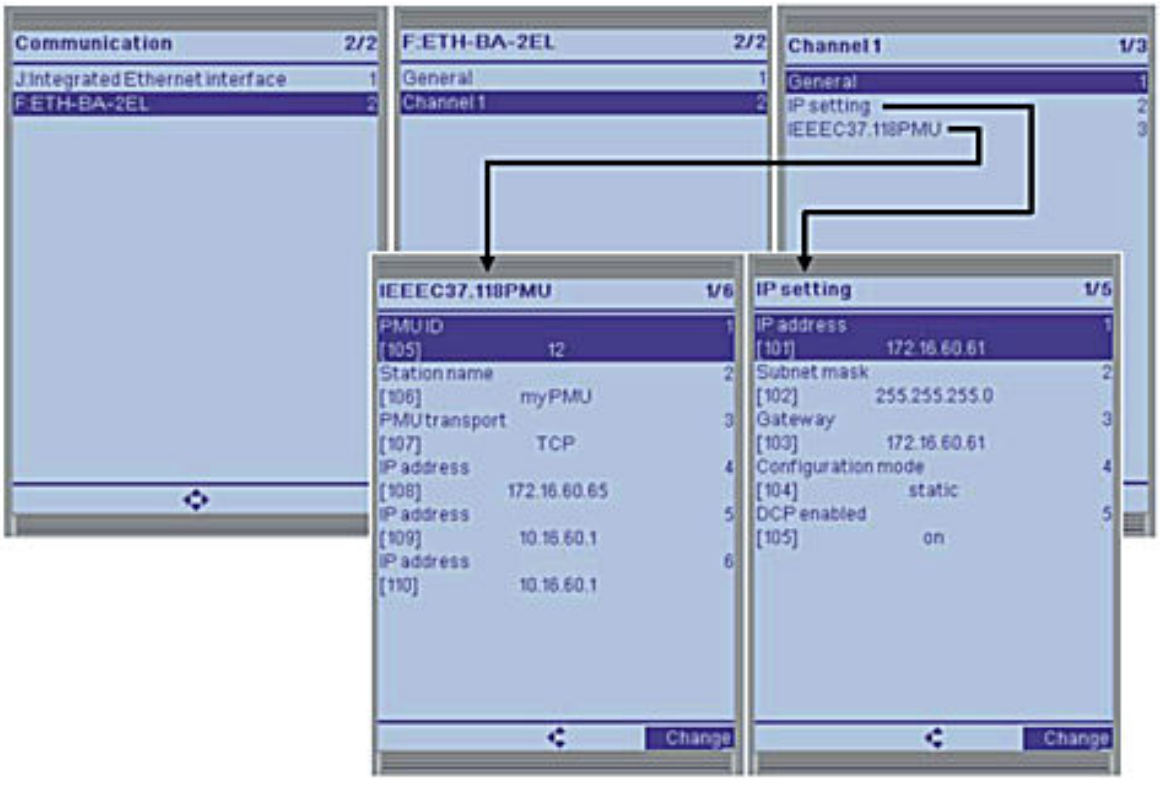
You can also change the PMU settings directly on the device. To do this, select the desired PMU instance on the device display. By selecting menu item **Settings** you then access the editable setting values (see *Figure 10-20*). Note that the parameter **Port** cannot be changed, because this corresponds to the physical slot position of the communication module in question.



[scdevpmu-210415, 1, en_US]

Figure 10-20 Changing the PMU Setting Values via the Device Display

You can also change the communication settings in the same way. To do this, select the corresponding communication port in the **Communication** menu on the device display. From the **Channel 1** menu item, you can then access the detailed setting options for the IP or PMU communication settings (see *Figure 10-21*).



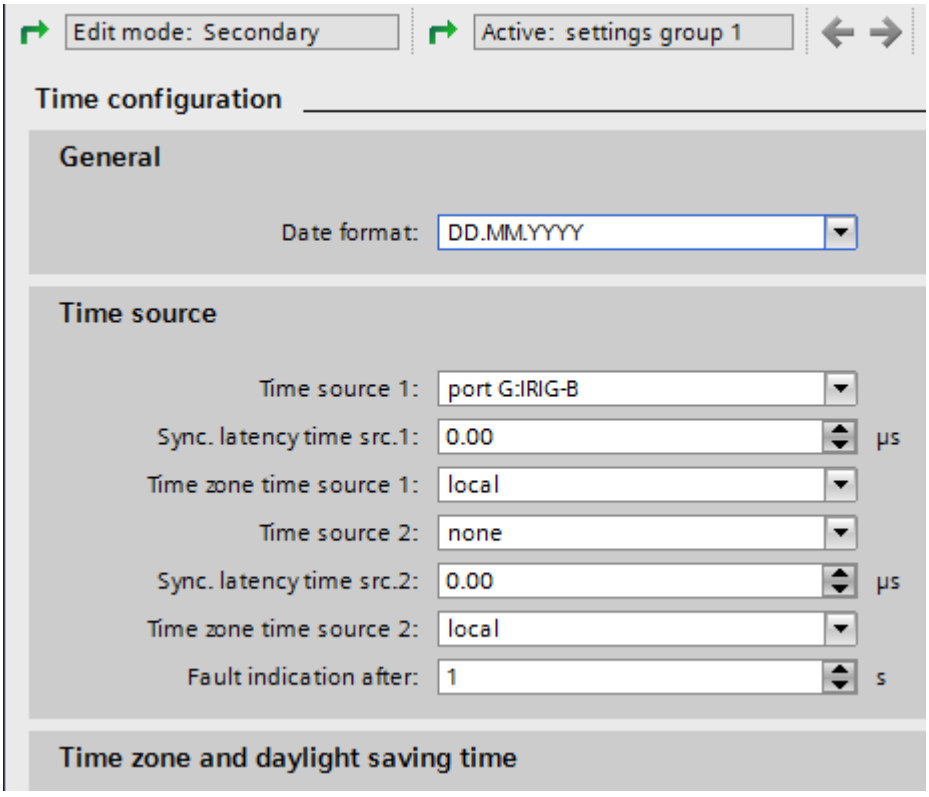
[scdevcom-210415, 1, en_US]

Figure 10-21 Changing the Communication Setting Values Via the Device Display

10.9.8 Application and Setting Notes

Time Synchronization

In order to ensure the time accuracy of the PMU, you must select **IRIG-B** as protocol for the GPS clock, see the following figure. With other settings, the **PMU function** function group indicates that it is not time synchronized.



[sc_setting time source_2014-09-09, 1, en_US]

Figure 10-22 Setting Time Synchronization

To detect a lack of synchronization quickly, also set the waiting time for the failure indication of the loss of time synchronization to the smallest possible value, thus to 1 s.

Parameter: Mode

- Default setting **(_:10621:1) Mode** = ***on***

Activate and deactivate the PMU or switch to Test mode via the parameter **Mode**. The possible setting values are ***on***, ***off*** and ***test***. In Test mode, the PMU data is marked as invalid.

Parameter: Reporting rate

- Default setting **(_:10621:102) Reporting rate** = ***10 frames/s***

With the parameter **Reporting rate**, you specify the number of telegrams that are compiled and sent to the PDC per second.



NOTE

Different setting values are shown or hidden, depending on the rated frequency set.

Parameter: Only positive sequence

- Default setting **(_:10621:103) Only positive sequence** = ***no***

With the parameter **Only positive sequence**, you set whether the positive-sequence system is to be transmitted instead of 3 individual synchrophasors in the case of 3-phase measuring points. The setting you make here is then valid for all PMUs with 3-phase measuring points.

Parameter: Class

- Default setting **(_:10621:101) Class** = ***Class P***

With the setting **Class**, you set which performance class is used for the calculation of the measured values. ***Class P*** is the standard case for PMUs. In this case, filters are used that are suitable for a short response time and therefore are well suited for recording dynamic processes. ***Class M*** is conceived for applications that are unfavorably affected by alias effects and in which short response times are not relevant.

Parameter: Port

This parameter cannot be set because the **Port** results from the physical position where the corresponding communication module is inserted.

10.9.9 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Func. settings				
_:10621:1	Func. settings:Mode		• off • on • test	on
_:10621:101	Func. settings:Class		• Class P • Class M	Class P
_:10621:102	Func. settings:Reporting rate		• 1 frame/s • 5 frames/s • 6 frames/s • 10 frames/s • 12 frames/s • 15 frames/s • 20 frames/s • 25 frames/s • 30 frames/s • 50 frames/s • 60 frames/s • 100 frames/s • 120 frames/s	10 frames/s
_:10621:103	Func. settings:Only positive sequence		• no • yes	no
_:10621:104	Func. settings:Port		• port J • port F • port E • port P • port N • port G •	port F
_:10621:105	Func. settings:Customized phasor names		• 0 • 1	false

Addr.	Parameter	C	Setting Options	Default Setting
Meas.point V-1ph				
_:10621:130	Func. settings:Measuring-point ID		0to0	0
_:10621:131	Func. settings:Phasor		Freely editable text	
Meas.point V-1ph				
_:10621:133	Func. settings:Measuring-point ID		0to0	0
_:10621:134	Func. settings:Phasor		Freely editable text	
Meas.point I-1ph				
_:10621:136	Func. settings:Measuring-point ID		0to0	0
_:10621:137	Func. settings:Phasor		Freely editable text	
Meas.point I-1ph				
_:10621:139	Func. settings:Measuring-point ID		0to0	0
_:10621:140	Func. settings:Phasor		Freely editable text	
Meas.point V-3ph				
_:10621:106	Func. settings:Measuring-point ID		0to0	0
_:10621:107	Func. settings:Phasor 1		Freely editable text	
_:10621:108	Func. settings:Phasor 2		Freely editable text	
_:10621:109	Func. settings:Phasor 3		Freely editable text	
_:10621:111	Func. settings:Phasor		Freely editable text	
Meas.point V-3ph				
_:10621:112	Func. settings:Measuring-point ID		0to0	0
_:10621:113	Func. settings:Phasor 1		Freely editable text	
_:10621:114	Func. settings:Phasor 2		Freely editable text	
_:10621:115	Func. settings:Phasor 3		Freely editable text	
_:10621:117	Func. settings:Phasor		Freely editable text	
Meas.point I-3ph				
_:10621:118	Func. settings:Measuring-point ID		0to0	0
_:10621:119	Func. settings:Phasor 1		Freely editable text	
_:10621:120	Func. settings:Phasor 2		Freely editable text	
_:10621:121	Func. settings:Phasor 3		Freely editable text	
_:10621:123	Func. settings:Phasor		Freely editable text	
Meas.point I-3ph				
_:10621:124	Func. settings:Measuring-point ID		0to0	0
_:10621:125	Func. settings:Phasor 1		Freely editable text	
_:10621:126	Func. settings:Phasor 2		Freely editable text	
_:10621:127	Func. settings:Phasor 3		Freely editable text	
_:10621:129	Func. settings:Phasor		Freely editable text	

10.9.10 Information List

No.	Information	Data Class (Type)	Type
General			
_:10621:52	Func. settings:Behavior	ENS	O
_:10621:53	Func. settings:Health	ENS	O

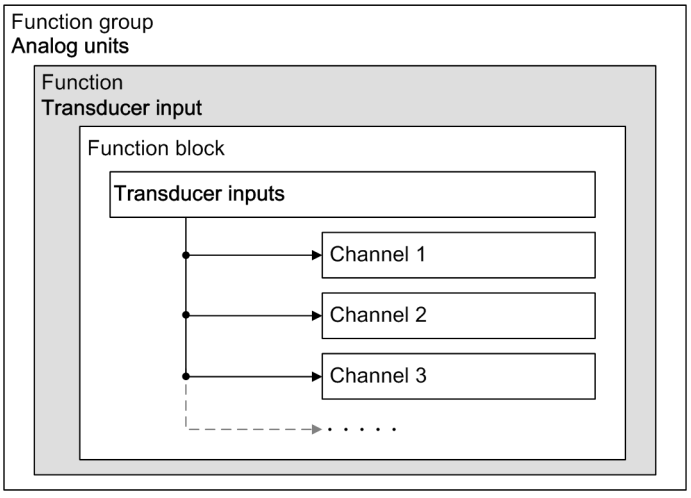
10.10 Measuring Transducers

10.10.1 Overview of Functions

Measuring transducers with an input rated at 20 mA can be used in the devices. 4 such inputs are available as module ANAI-CA-4EL, which can be plugged into a communication module slot (for instance, port E or F). Up to 4 such modules can be plugged in. Typically, slowly changing process variable such as temperature or gas pressure are recorded with such 20-mA measured values and reported to the substation automation technology.

10.10.2 Structure of the Function

The measuring-transducer blocks are embedded in the **Analog units** function group and contain input and output channels that are configurable independently of each other.

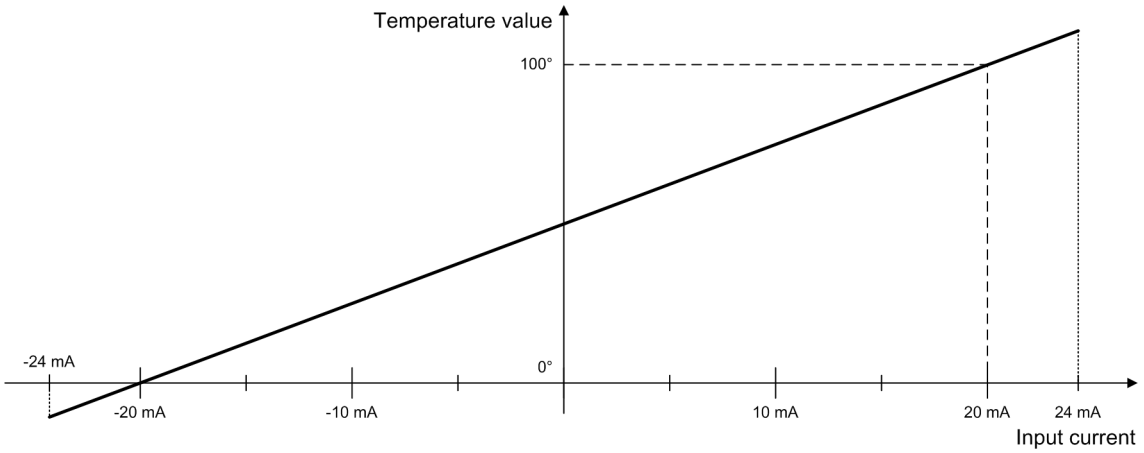


[dwstrumu-050313-01.tif, 1, en_US]

Figure 10-23 Structure/Embedding of the Function

10.10.3 Function Description

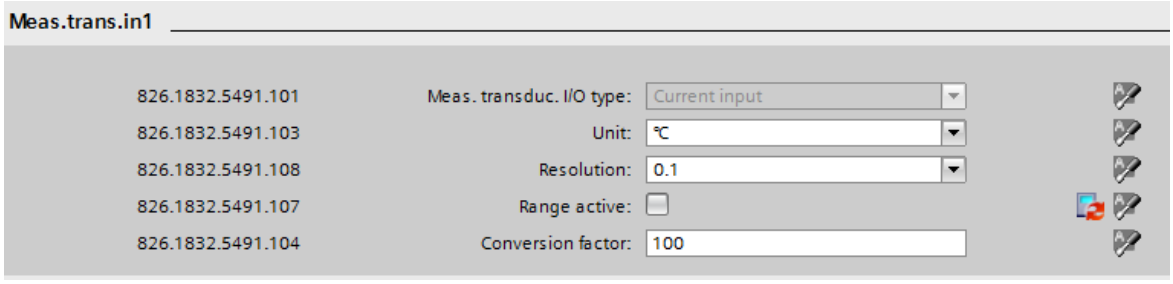
The 20-mA inputs typically transmit a value which represents a physical quantity such as a temperature or a pressure. Therefore, the device must contain a characteristic curve that assigns the physical quantity to the 20-mA value. If the parameter **Range active** is not activated (no x in the check box), the function operates over the range -24 mA to +24 mA. The setting of the range for the scaled value goes from a usable range of -20 mA to +20 mA. The following figure shows an example.



[dwklbsp1-120124-01.tif, 1, en_US]

Figure 10-24 Characteristic Curve of a 20-mA Input (Example 1)

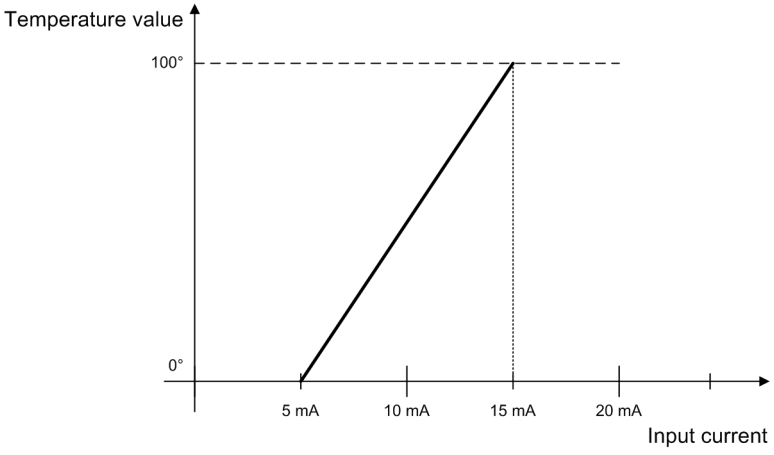
In this example, the measured value -20 mA means a temperature of 0 degrees Celsius and the measured value 20 mA a temperature of 100 degrees Celsius. Thus, **Unit** = ***°C*** and **Conversion factor** = ***100*** are entered. The resolution (decimal place) of the temperature value can be chosen; for a decimal place, select **Resolution** = ***0.1***.



[sctransd-210415, 1, en_US]

Figure 10-25 Settings for Example 1

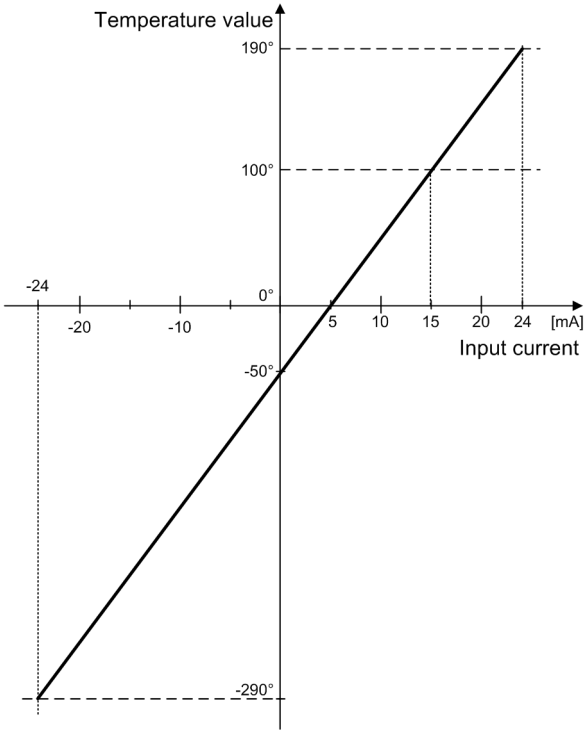
If a value smaller than -24 mA or larger than +24 mA is applied to the measuring-transducer input, the measured value is marked as **invalid**. If the parameter **Range active** is activated, the 2 additional parameters **Upper limit** and **Lower limit** appear. Both limiting values indicate the input currents in mA, for which the value set by the **Conversion factor** (**Upper limit**) and the value 0 (**Lower limit**) of the calculated measurand are valid (see following figure).



[dwklbsp2-120124-01.tif, 1, en_US]

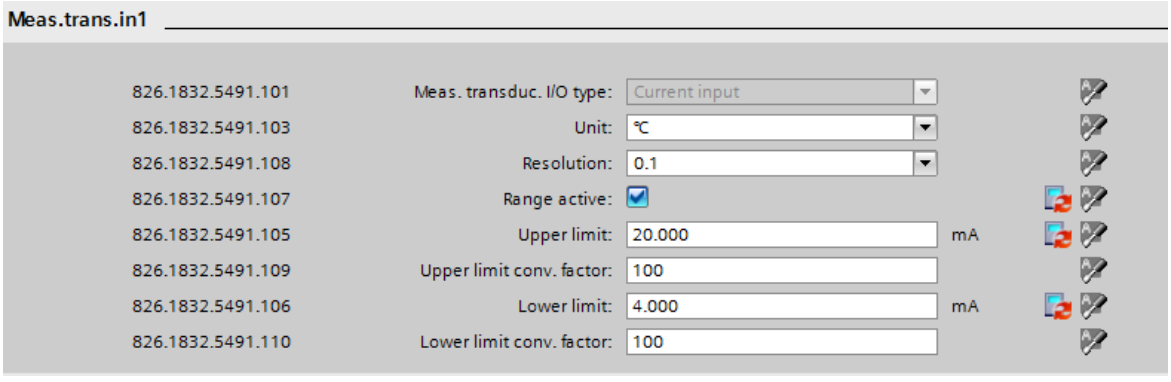
Figure 10-26 Characteristic Curve of a 20-mA Input (Example 2)

In this example, **Range active** is selected. The **Upper limit** is at 15 mA, the **Lower limit** is at 5 mA and the **Conversion factor** remains at 100. The total results in a characteristic curve as shown in the following figure, taking into account all possible valid measured values from -24 mA to +24 mA. The parameter **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The parameter **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting.



[dwklges2-120124-01.tif, 2, en_US]

Figure 10-27 Total Characteristic Curve in Example 2



[sctrans2-210415, 1, en_US]

Figure 10-28 Settings for Example 2

Each measuring transducer makes available the scaled measured value in the information matrix (these are the temperature values in the examples) and the original current measured value in mA for further processing. The measuring-transducer values can be displayed in the display image and processed with CFC charts.

10.10.4 Application and Setting Notes

Parameter: Unit

- Recommended setting value **(_:103) Unit** = ***°C***

You use the setting **Unit** to specify which physical unit of measurement the measured values represent. The possible setting values are listed in the settings table.

Parameter: Conversion factor

The **(_:104) Conversion factor** setting allows you to set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting **(_:108) Resolution** = ***0.1***

The **Resolution** setting is used to specify the measured value resolution.

Parameter: Range active

- Default setting **(_:107) Range active** = ***false***

If you do not activate the **Range active** setting (no x in the check box), the function operates over the range -24 mA to +24 mA. The setting of the range for the scaled value goes from a usable range of -20 mA to +20 mA.

If you activate the **Range active** setting, then 4 additional settings **Upper limit**, **Upper limit - Sensor**, **Lower limit** and **Lower limit - Sensor** appear.

Parameter: Upper limit, Lower limit, Upper limit - Sensor and Lower limit - Sensor

- Default setting **(_:105) Upper limit** = ***20000 mA***
- Default setting **(_:109) Upper limit - Sensor** = ***100***
- Default setting **(_:106) Lower limit** = ***4000 mA***
- Default setting **(_:110) Lower limit - Sensor** = ***100***

If you activate the **Range active** setting, then 4 additional settings **Upper limit**, **Lower limit**, **Upper limit - Sensor**, and **Lower limit - Sensor** appear. The setting **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The setting **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting.

10.10.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MT in #				
_:101	MT in #:Meas. transduc. I/O type		• Voltage input • Current input • Voltage output • Current output • Temperature input	Current input

Addr.	Parameter	C	Setting Options	Default Setting
_:103	MT in #:Unit		• • % • ° • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • in • J • J/Wh • K • l/s • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • W/s • W • Wh	m
_:108	MT in #:Resolution		• 1 • 0.1 • 0.01 • 0.001	0.1
_:107	MT in #:Range active		• 0 • 1	false
_:104	MT in #:Conversion factor		1 to 10000	100
_:105	MT in #:Upper limit		-20.00 mA to 20.00 mA	20.00 mA
_:109	MT in #:Upper limit - Sensor		-10000 to 10000	100
_:106	MT in #:Lower limit		-20.00 mA to 20.00 mA	4.00 mA
_:110	MT in #:Lower limit - Sensor		-10000 to 10000	100

10.10.6 Information List

No.	Information	Data Class (Type)	Type
MT in #			
_:301	MT in #:TD scale MV	MV	O
_:302	MT in #:TD direct MV	MV	O

10.11 Statistical Values of the Primary System

The device has statistical values for circuit breakers and disconnectors.

The following values are available for each circuit-breaker:

- Total number of trippings of the circuit-breaker initiated by the device.
- Number of trippings of the circuit breaker initiated by the device, separately for each circuit breaker pole (if 1-pole tripping is possible)
- Total sum of primary breaking currents
- Sum of the primary breaking currents, separately for each breaker pole
- Hours with open circuit breaker
- Hours under load

The following values are available for each disconnector switch:

- Total number of switching operations of the disconnector switch initiated by the device
- Number of switching operations of the disconnector switch initiated by the device, separately for each switch pole (if 1-pole switching is possible)

10.12 Circuit-Breaker Wear Monitoring

10.12.1 Overview of Functions

The **Circuit-breaker wear monitoring** function:

- Records the wear of circuit breakers
- Allows maintenance intervals of the CB poles to be carried out when their actual degree of wear makes it necessary
- Sends a warning signal when the wear of a circuit breaker reaches a specified degree
- Allows the supervision of the circuit-breaker make time

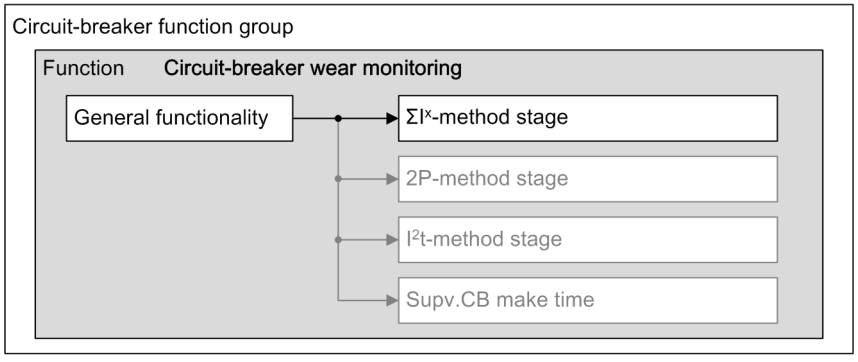
Savings on maintenance and servicing costs is one of the main benefits this functionality offers.

10.12.2 Structure of the Function

The **Circuit-breaker wear monitoring** function can be used in the **Circuit breaker** function group.
The function offers 4 independent operating stages with different measuring methods:

- **ΣI^x-method** stage
  Sum of tripping current powers
- **2P-method stage**
  2 points method for calculating the remaining switching cycles
- **I^2t-method stage**
  Sum of all squared fault-current integrals
- **Supv.CB make time stage**
  Supervision of the circuit-breaker make time

The function is preconfigured by the manufacturer with 1 **ΣI^x-method** stage. A maximum of 1 **ΣI^x-method** stage, 1 **2P-method** stage, 1 **I^2t-method** stage, and 1 **Supv.CB make time** stage can be operated simultaneously within this function.
The general functionality is available across stages and provides a uniform start criterion for the stages.



[DwCBWear, 2, en_US]
Figure 10-29 Structure/Embedding of the Function

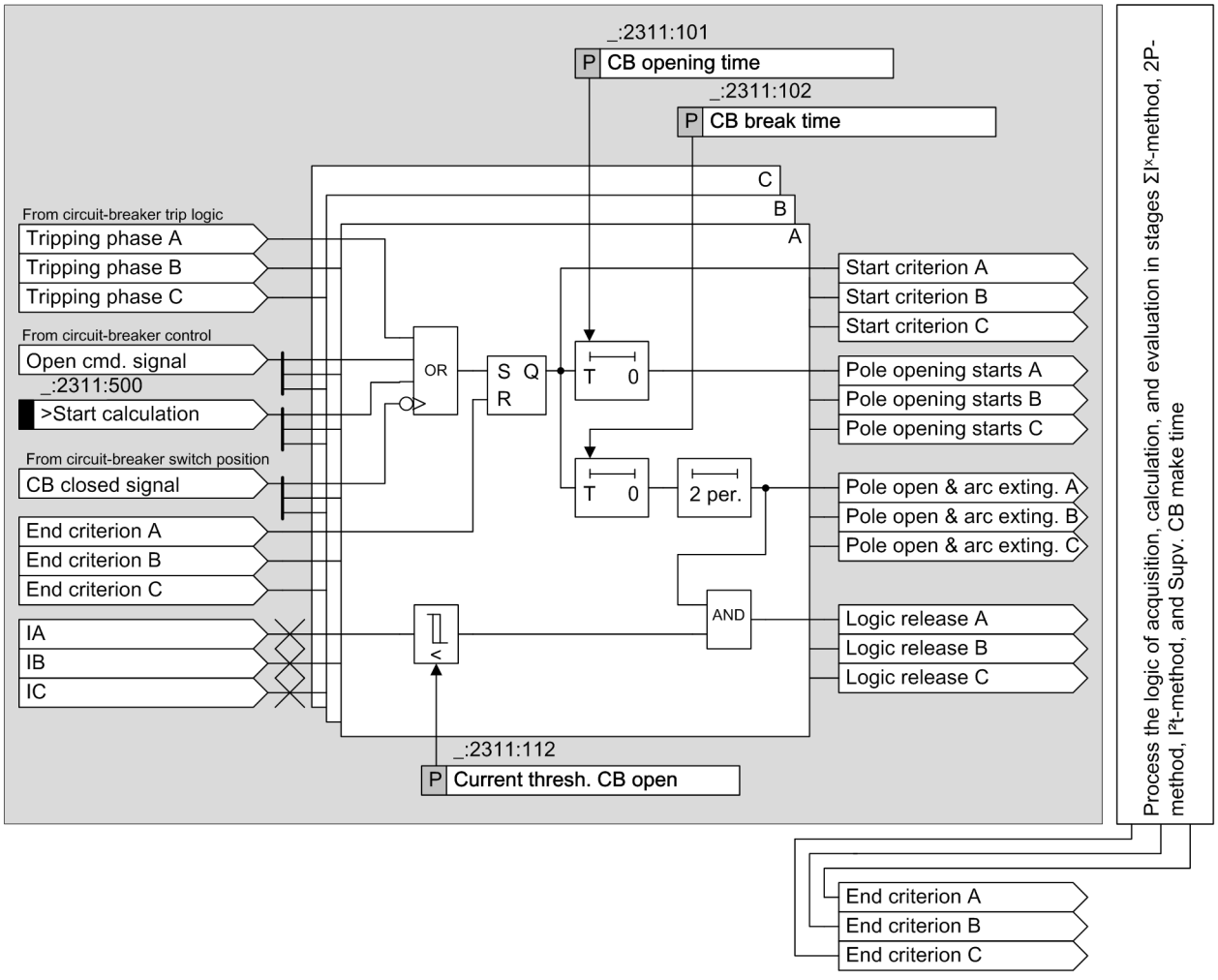
10.12.3 General Functionality

10.12.3.1 Description

Logic

As the wear on the circuit breaker depends on the current amplitude and duration of the actual switching action, including arc deletion, determination of the start and end criteria is important. The following general functionality provides starting and further timing information to the different stages (methods).

The general functionality operates phase-selectively. The following figure shows the logic of the functionality across stages.



[LoCBWear, 3, en_US]

Figure 10-30 Logic Diagram of the Functionality Across Stages of the Circuit-Breaker Wear Monitoring Function

Start Criterion for the Circuit-Breaker Wear Monitoring Function

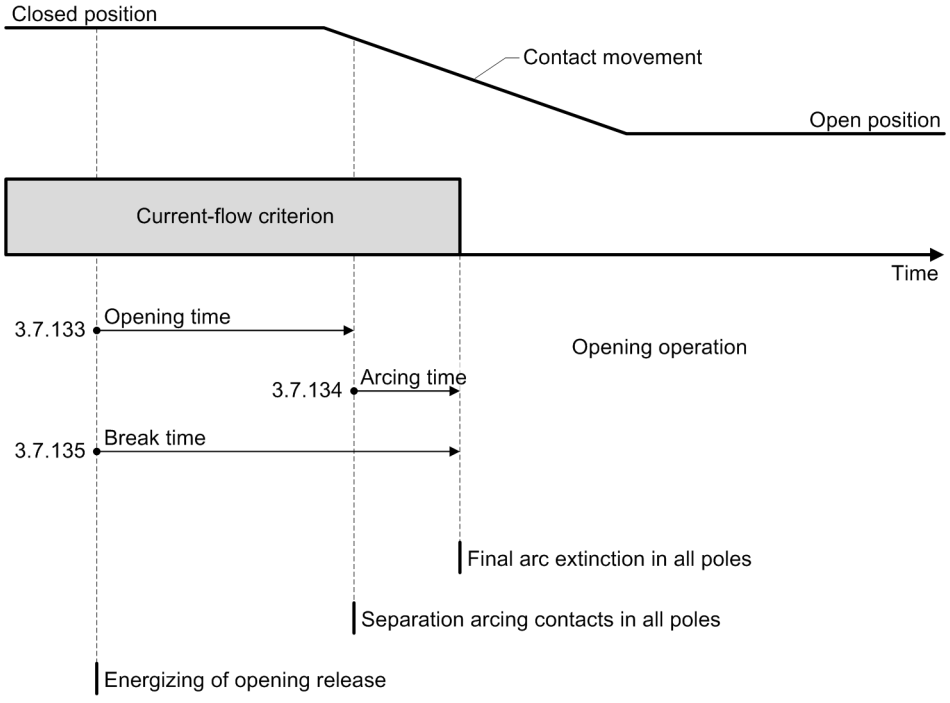
The **Circuit-breaker wear monitoring** function starts when any of the following criteria is fulfilled:

- Internal protection-function tripping signal from the function block **Trip logic** is received
- Open command signal from the internal **Control** function is received.
- Binary input signal *>Start calculation* is initiated, for example, from external.

- Closed position signal of circuit breaker is going
  This signal is derived form the circuit-breaker auxiliary contacts. In this way, opening the circuit-breaker manually is detected.

Logic Input Signals for Stages

As soon as the start criterion has been fulfilled, the timers of the parameterized opening time and break time are started. With the parameter **CB opening time**, the time when the circuit-breaker pole begins to open is defined. With the parameter **CB break time**, the time of the pole being open including the arc extinction is defined. The following figure shows the relationship between these circuit-breaker times.



[DwCBTime, 2, en_US]

Figure 10-31 Circuit-Breaker Times

In order to prevent an incorrect calculation in case of a circuit-breaker failure, the parameter **Current thresh. CB open** is used to verify whether the current actually returns to 0 after 2 additional cycles. Fundamental components are used for comparing the threshold values. When the current criterion fulfills the requirement of the phase-selective logic release, the calculation and evaluation of the respective methods are initiated.

End Criterion for the Circuit-Breaker Wear Monitoring Function

After calculation and evaluation have been completed, the end criterion of the circuit-breaker maintenance is fulfilled. The **Circuit-breaker wear monitoring** function is ready for a new initiation.

10.12.3.2 Application and Setting Notes

Parameter: CB opening time

- Default setting value **(_:2311:101) CB opening time** = ***0.065 s***

You use the **CB opening time** parameter to define the time span from energizing the shunt release of the circuit breaker until the start of opening of switching poles.

You can find the information on the setting value in the technical data of the used circuit breaker. Also refer to *Figure 10-31*.

Parameter: CB break time

- Default setting **(_:2311:102) CB break time** = ***0.080 s***

You use the **CB break time** parameter to define the time span from energizing the shunt release of the circuit breaker to the instant of arc extinction (and switching pole open).

You can find the information on the setting value in the technical data of the used circuit breaker. Also refer to *Figure 10-31*.

Parameter: CB make time

- Default setting **(_:2311:103) CB make time** = ***0.080 s***

With the parameter **CB make time**, you define the typical time interval between the activation of the closing procedure for the circuit breaker and the point in time when the first current flows.

You can find more information on the setting value in the technical data of the used circuit breaker.

10.12.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:CB opening time		0.001 s to 0.500 s	0.065 s
_:2311:102	General:CB break time		0.001 s to 0.600 s	0.080 s
_:2311:103	General:CB make time		0.001 s to 0.600 s	0.080 s

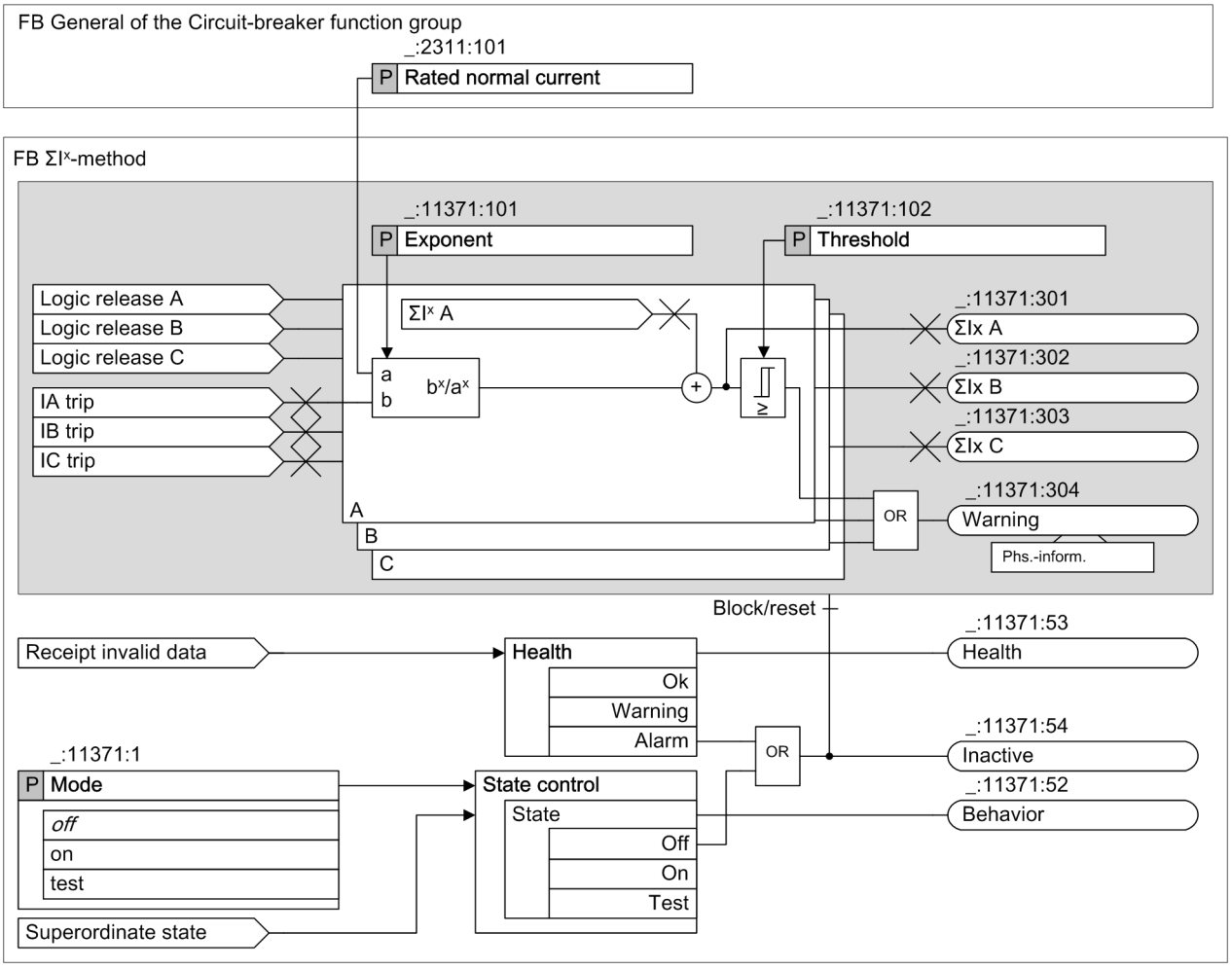
10.12.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Start calculation	SPS	I

10.12.4 Stage Description ΣI* Method

10.12.4.1 Description

Logic of the Stage



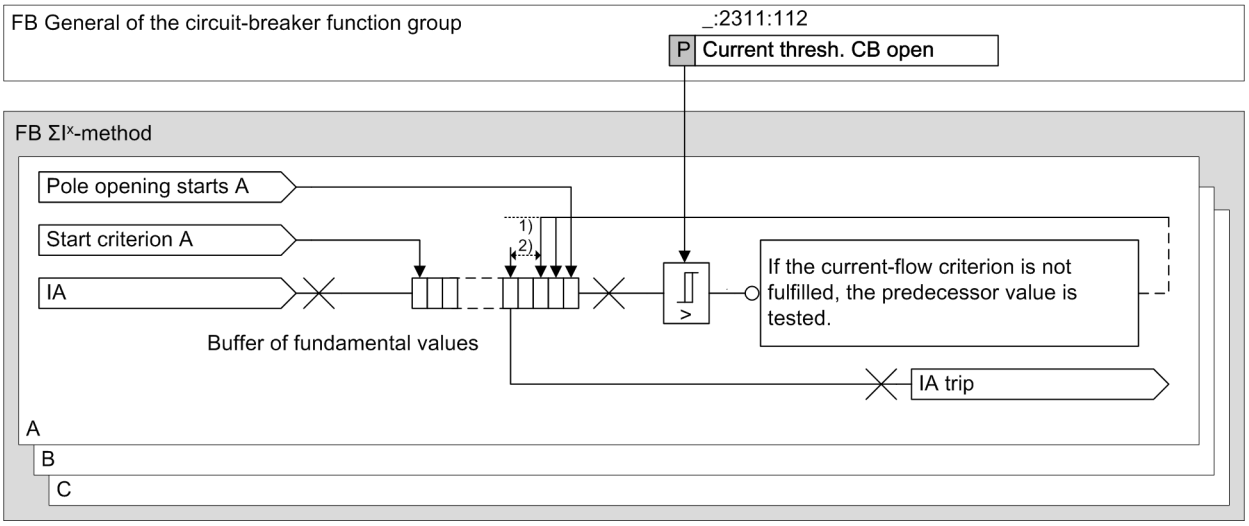
[LoCBWIxS, 3, en_US]

Figure 10-32 Logic of the ΣIx-Method Stage

Determination of the Tripping/Opening Current Value

RMS values of the fundamental components are stored for each phase in a buffer during the time between the start criterion and the pole-opening-starts criterion. With the coming pole-opening-starts criterion, the latest value in the buffer is searched for whose value is above the setting of parameter **`Current thresh. CB open`**. The 20 ms prior value is used as tripping/opening current for further calculation.

If no value within the buffer is above the setting value, this circuit-breaker opening affects only the mechanical lifetime of the circuit breaker and is consequently not considered by this method.



[LoCBWIxF, 1, en_US]

Figure 10-33 Logic of the Determination of the Tripping Current Value

(1) Current-flow criterion fulfilled

(2) 20 ms prior value

Calculation of the Wear

If the **ΣIx-method** stage receives the logic release signal, the determined tripping current is used in the calculation of wear. The calculation results are then added to the existing statistic values of the ΣIx method as follows, with phase A as example.

$$\sum I_A^x = \frac{1}{I_{rated}^x} \sum_{q=1}^{m} I_{A\,trip,q}^x$$

[FoCBWIxA-301012-01.tif, 1, en_US]

Where:

x	Parameter exponent
q	No. of circuit-breaker switching cycle
$I_{A\,trip,q}^x$	Tripping/opening current of phase A to the power of x in the qth circuit-breaker operation
I_{rated}^x	Rated normal current to the power of x
$\sum I_A^x$	Statistic value of current phase A calculated with the ∑Ix method
m	Total number of switching cycles

The phase-selective ΣIx value is available as statistical value. You can reset or preset the statistics according to the specific application.

To simplify the interpretation of the sum of the tripping current powers, the values are set in relation to the exponentiated rated normal current I_{rated} of the circuit-breaker (see also Setting notes).

Circuit-Breaker Maintenance Warning

If the summated ΣIx value of any phase is greater than the threshold, a phase-selective warning signal is generated.

10.12.4.2 Application and Setting Notes

Parameter: `Exponent`

- Default setting **`(_:11371:101) Exponent`** = ***2.0***

You use the **`Exponent`** parameter to specify the exponent for the ΣI^x method.

A typical value is the default setting of 2. However, due to practical experiences with individual circuit breakers, slightly different values may be requested.

Parameter: `Threshold`

- Default setting **`(_:11371:102) Threshold`** = ***10 000.00***

You use the parameter **`Threshold`** to define the threshold of the statistic value.

The relation of the tripping current powers to the exponentiated rated normal current I_{rated} allows the limiting value of the ΣI^x method to correspond to the maximum number of make-break operations. For a circuit breaker, whose contacts have not yet been worn, the maximum number of make-break operations can be entered directly as limiting value.

10.12.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
ΣIx-method				
_:11371:1	ΣIx-method:Mode		• off • on • test	off
_:11371:101	ΣIx-method:Exponent		1.0 to 3.0	2.0
_:11371:102	ΣIx-method:Threshold		0 to 10000000	10000

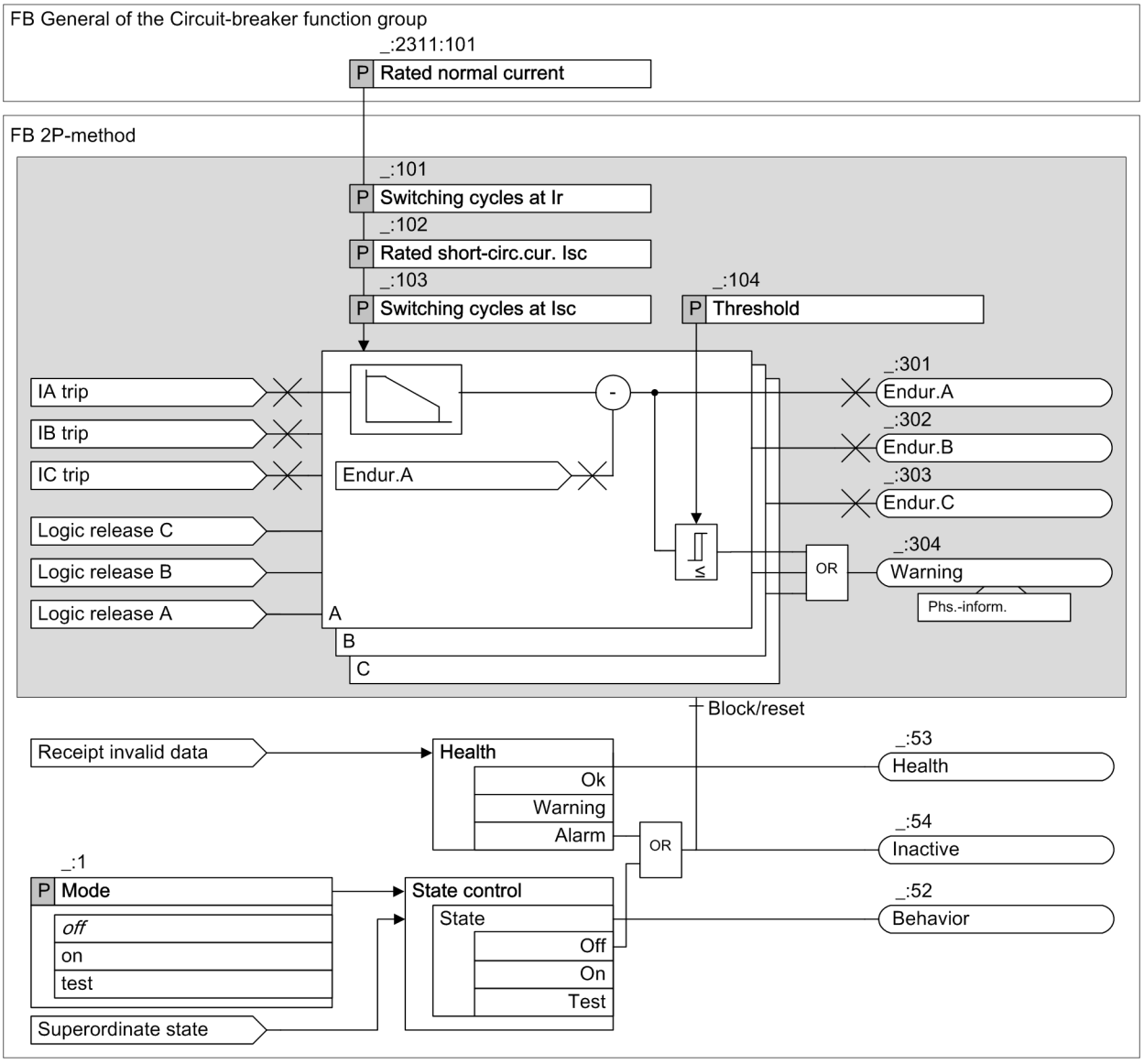
10.12.4.4 Information List

No.	Information	Data Class (Type)	Type
ΣIx-method			
_:11371:54	ΣIx-method:Inactive	SPS	O
_:11371:52	ΣIx-method:Behavior	ENS	O
_:11371:53	ΣIx-method:Health	ENS	O
_:11371:301	ΣIx-method:ΣIx A	BCR	O
_:11371:302	ΣIx-method:ΣIx B	BCR	O
_:11371:303	ΣIx-method:ΣIx C	BCR	O
_:11371:304	ΣIx-method:Warning	ACT	O

10.12.5 Stage Description 2P Procedure

10.12.5.1 Description

Logic of the Stage



[LoCBW2PS, 2, en_US]

Figure 10-34 Logic of the 2P-Method Stage

Determination of the Tripping/Opening Current Value

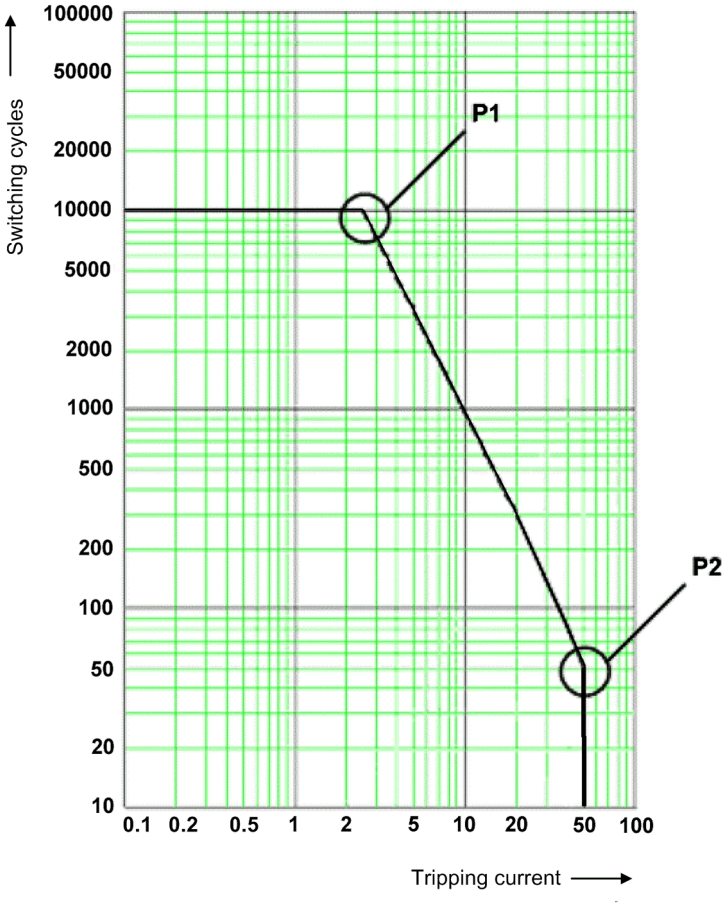
For the description to determine the tripping/opening current value, refer to chapter *10.12.4.1 Description*.

Calculation of Remaining Switching Cycles

A double-logarithmic diagram provided by the circuit-breaker manufacturer illustrates the relationship of permitted switching cycles and the tripping/opening current, see the following figure. According to the example, this circuit breaker can operate approximately 1000 times at a tripping current of 10 kA.

2 points and their connecting line determine the relationship of switching cycles and tripping current. Point P1 is determined by the number of permitted switching cycles at rated normal current I_{rated}. Point P2 is deter-

mined by the maximum number of switching cycles at rated short-circuit breaking current I_{sc}. The 4 associated values can be configured with the parameters **`Rated normal current`**, **`Switching cycles at Ir`**, **`Rated short-circ.cur. Isc`**, and **`Switching cycles at Isc`**.



[DwCBWOpC, 1, en_US]

Figure 10-35 Diagram of Switching Cycles for the 2P Method

As shown in the preceding figure, a double-logarithmic diagram, the straight line between P1 and P2 can be expressed by the following exponential function:

$$n = b \cdot \left(\frac{I_{rated}}{I_{trip}} \right)^{m}$$

[FoCBW2P1-301012-01.tif, 1, en_US]

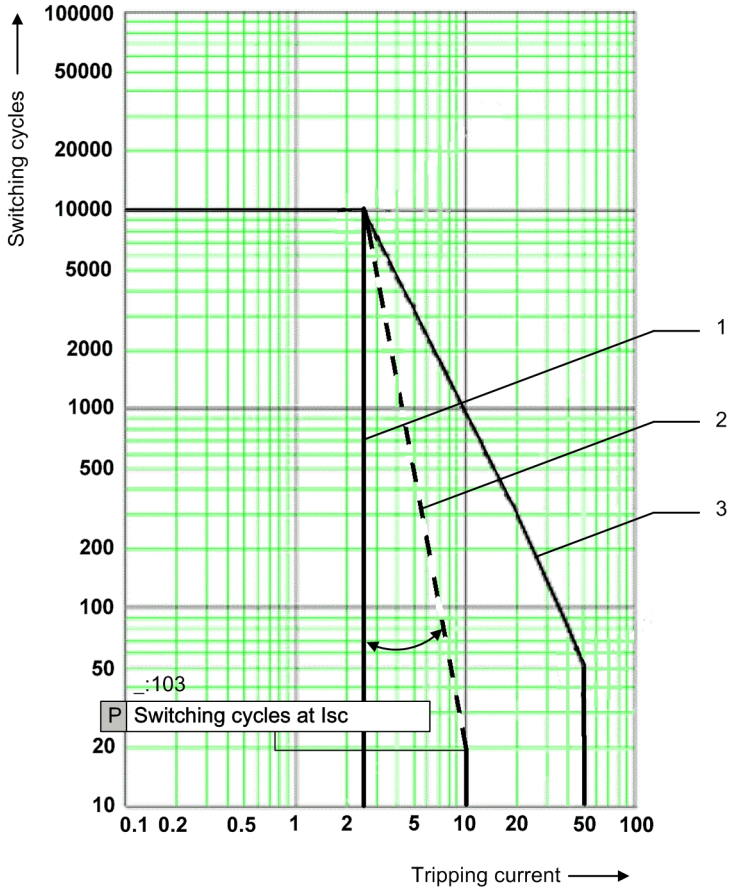
Where:

I_{trip}	Tripping/opening current
I_{rated}	Rated normal current
m	Slope coefficient
b	Switching cycles at rated normal current
n	Number of switching cycles

The general line equation for the double-logarithmic representation can be derived from the exponential function and leads to the coefficients b and m.

NOTE

Since a slope coefficient of m < -4 is technically irrelevant, but could theoretically be the result of incorrect settings, the slope coefficient is limited to -4. If a coefficient is smaller than -4, the exponential function in the switching-cycles diagram is deactivated. The maximum number of switching cycles with I_{sc} is used instead as the calculation result for the current number of switching cycles, as the dashed line with m = -4.48 shows in following figure.



[DwCBWSlo, 1, en_US]

Figure 10-36 Value Limitation of Slope Coefficient

(1) Applied function from m < -4

(2) Parameterized function with m = -4.48

(3) Parameterized function with m = -1.77

If the **2P-method** stage receives the logic release signal, the current number of used up switching cycles (in relation to the number of switching cycles at rated normal current) is calculated based on the determined tripping current. This value is subtracted from the the remaining lifetime (switching cycles). The remaining lifetime is available as statistic value. For better understanding, refer to the example below.

You can reset or preset the statistical values according to the specific application. The reset operation changes the statistic values to 0, and not to their default values of 10 000.

The statistic value of the residual switching cycles is calculated according to the following formula:

$$Endur_{\cdot i} = Endur_{\cdot i-1} - \frac{n_{rated}}{n_{trip}}$$

[FoCBW2P2-301012-01.tif, 1, en_US]

Where:

i	No. of latest circuit-breaker switching cycle
$Endur._i$	Residual switching cycles with rated normal current, after the ith switching cycle
n_{rated}	Overall permissible switching cycles at rated normal current
n_{trip}	Overall permissible switching cycles at tripping current I_{trip}
n_{rated}/n_{trip}	Lost switching cycles referring to rated normal current

EXAMPLE

For calculating the residual switching cycles of a circuit breaker, the following is assumed:
P1 (2.5 kA, 10 000)
P2 (50.0 kA, 50)
The circuit breaker has made 100 opening operations with rated normal current, 2 tripping operations with rated short-circuit breaking current, and 3 tripping operations with 10 kA tripping current. Then, the residual switching cycles with rated normal current are:

$$\text{Endurance} = n_{rated} - \left(100 \cdot \frac{n_{rated}}{n_{2.5kA}}\right) - \left(2 \cdot \frac{n_{rated}}{n_{50kA}}\right) - \left(3 \cdot \frac{n_{rated}}{n_{10kA}}\right)$$

$$= 10000 - \left(100 \cdot \frac{10000}{10000}\right) - \left(2 \cdot \frac{10000}{50}\right) - \left(3 \cdot \frac{10000}{861}\right) = 9465$$

[FoCBW2P3-301012-01.tif, 1, en_US]

There are still 9465 possible break operations at rated normal current.

Circuit-Breaker Maintenance Warning

If the residual switching cycles of any phase lie below the threshold, a phase-selective warning signal is generated.

10.12.5.2 Application and Setting Notes

Parameter: `Switching cycles at Ir`

- Default setting **`(_:101) Switching cycles at Ir`** = ***`10 000`***

You use the **`Switching cycles at Ir`** parameter to define the number of permitted switching cycles at rated normal current.
You can find the information on the setting value in the technical data of the used circuit breaker.

Parameter: `Rated short-circ.cur. Isc`

- Default setting **`(_:102) Rated short-circ.cur. Isc`** = ***`25 000 A`***

You use the **`Rated short-circ.cur. Isc`** parameter to define the rated short-circuit breaking current.
You can find the information on the setting value in the technical data of the used circuit breaker.

Parameter: `Switching cycles at Isc`

- Default setting **`(_:103) Switching cycles at Isc`** = ***`50`***

You use the **`Switching cycles at Isc`** parameter to define the number of permitted switching cycles at rated short-circuit breaking current.
You can find the information on the setting value in the technical data of the used circuit breaker.

Parameter: `Threshold`

- Default setting **`(_:104) Threshold`** = ***1000***

You use the **`Threshold`** parameter to define the threshold of residual switching cycles with rated normal current. A warning signal is generated when the statistic is less than the **`Threshold`**.

Example

Here is an example that shows you how to set the **`Threshold`** parameter. Assuming a circuit breaker with the same technical data as provided in the example for residual switching cycles, 50 breaking operations with rated short-circuit breaking current are permitted.

A warning signal should be issued when the number of possible breaking operations with rated short-circuit breaking current is less than 3. For that condition, you set the **`Threshold`** value based on the following calculation:

$$3 \cdot \frac{n_{rated}}{n_{50kA}} = 3 \cdot \frac{10000}{50} = 600$$

[FoCBW2P4-301012-01.tif, 1, en_US]

10.12.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
2P-method				
_:1	2P-method:Mode		• off • on • test	off
_:101	2P-method:Switching cycles at Ir		100 to 1000000	10000
_:102	2P-method:Rated short-circ.cur. Isc		10 A to 100000 A	25000 A
_:103	2P-method:Switching cycles at Isc		1 to 1000	50
_:104	2P-method:Threshold		0 to 10000000	100

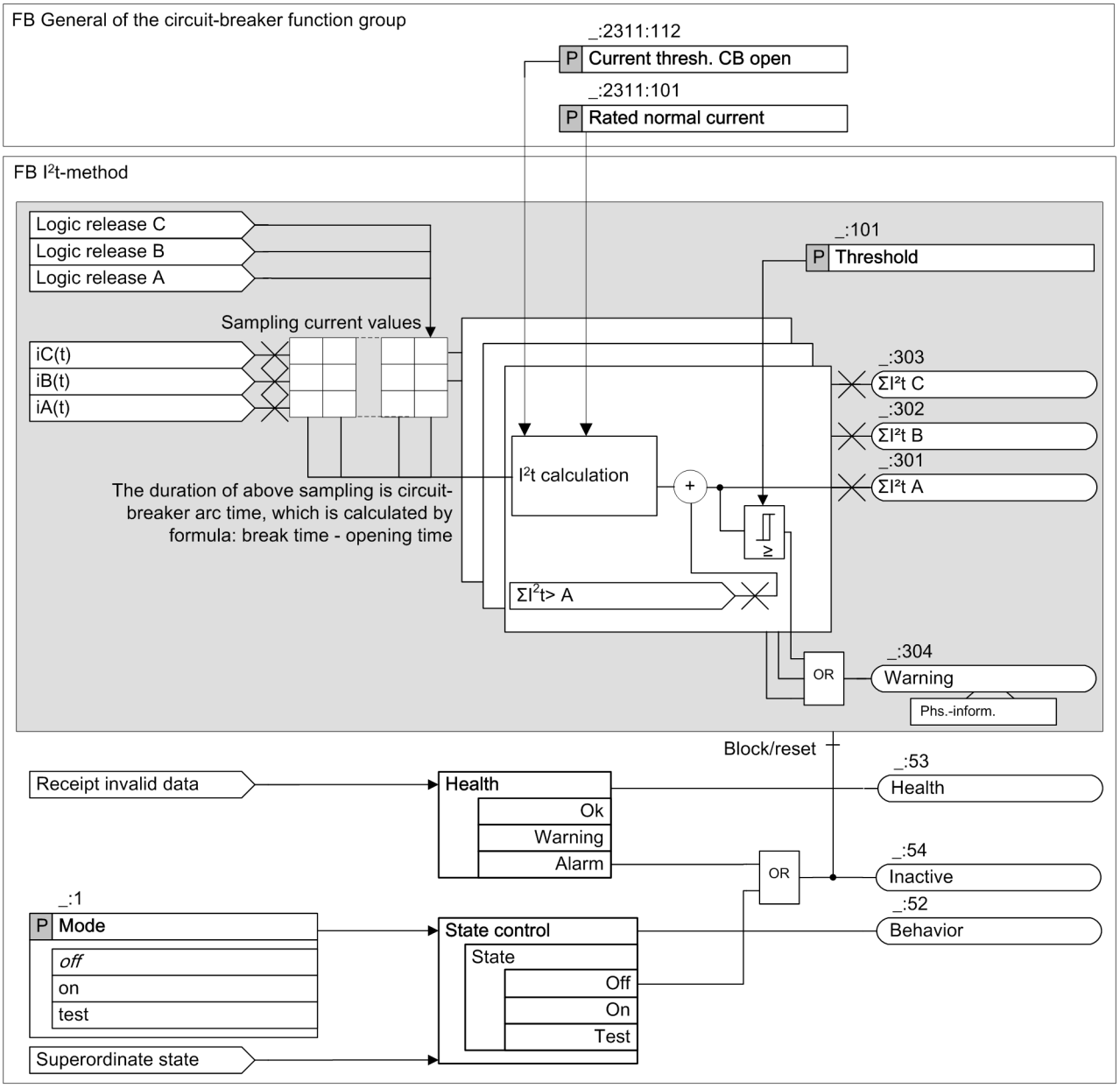
10.12.5.4 Information List

No.	Information	Data Class (Type)	Type
2P-method			
_:54	2P-method:Inactive	SPS	O
_:52	2P-method:Behavior	ENS	O
_:53	2P-method:Health	ENS	O
_:301	2P-method:Endur.A	INS	O
_:302	2P-method:Endur.B	INS	O
_:303	2P-method:Endur.C	INS	O
_:304	2P-method:Warning	ACT	O

10.12.6 Stage Description I²t Method

10.12.6.1 Description

Logic of the Stage



[LoCBWI2t, 1, en_US]

Figure 10-37 Logic of the I²t-Method Stage

Calculation of the Wear

The I²t method evaluates the wear of a circuit breaker based the sampled measuring values of the phase currents during the arc time. The duration of the arc time is defined by the difference between the 2 settings of parameters **`CB break time`** and **`CB opening time`** (see also *Figure 10-31*). The stage determines the ending point of the arc time by searching backward the zero-crossing point of the phase currents after it receives the logic release signal. Then, the squared fault currents during the arc time are integrated phase-

selectively. The integrals are referred to the squared rated normal current of the circuit breaker as shown in the following formula, with phase A as example.

$$I^2t_A = \frac{1}{I^2_{rated}} \int_{\text{Start arc time}}^{\text{End arc time}} i^2_A(t)\,dt$$

[FoCBWI2T-301012-01.tif, 1, en_US]

Where:

I_{rated}	Rated normal current
$i_A(t)$	Sampled measured current value of phase A

The calculated squared tripping current integrals are added to the existing statistic values.You can reset or preset the statistic value according to the specific application.

Circuit-Breaker Maintenance Warning

If the statistic value of any phase lies above the threshold, a phase-selective warning signal is generated.

10.12.6.2 Application and Setting Notes

Parameter: `Threshold`

- Default setting **`(_:101) Threshold`** = ***`10 000.00 I/Ir*s`***

You use the **`Threshold`** parameter to specify the maximum permitted integral of squared sampled measured values of the phase currents.

10.12.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`I2t-method`				
_:1	I2t-method:Mode		• off • on • test	off
_:101	I2t-method:Threshold		0.00 I/Ir*s to 21400000.00 I/Ir*s	10000.00 I/Ir*s

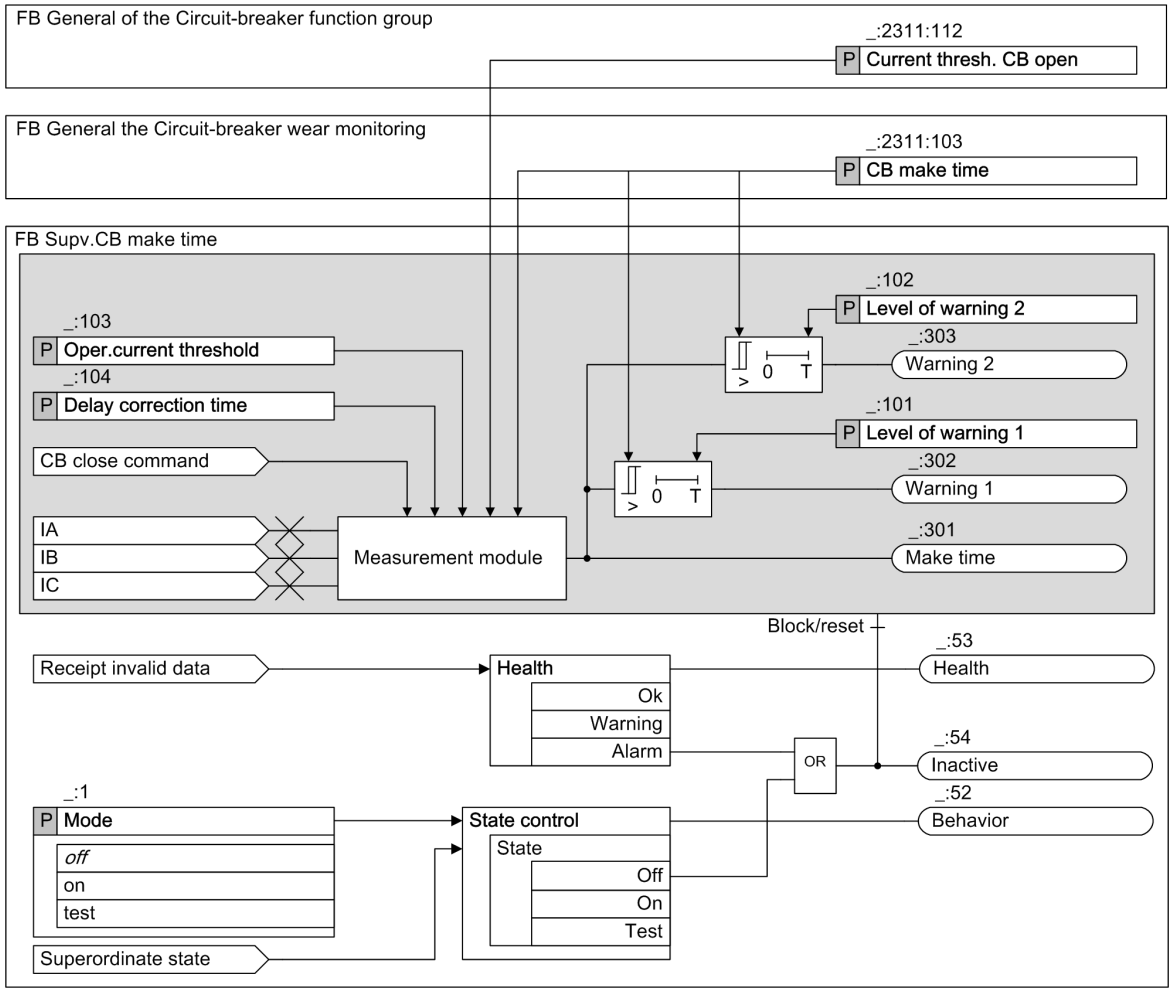
10.12.6.4 Information List

No.	Information	Data Class (Type)	Type
`I2t-method`			
_:54	I2t-method:Inactive	SPS	O
_:52	I2t-method:Behavior	ENS	O
_:53	I2t-method:Health	ENS	O
_:301	I2t-method:ΣI²t A	BCR	O
_:302	I2t-method:ΣI²t B	BCR	O
_:303	I2t-method:ΣI²t C	BCR	O
_:304	I2t-method:Warning	ACT	O

10.12.7 Stage Description Supervision CB Make Time

10.12.7.1 Description

Logic of the Stage



[Lo_sup-cb-make-time, 1, en_US]

Figure 10-38 Logic of the Supv.CB Make Time Stage

Operating Mode

The stage for the supervision of the circuit-breaker make time calculates the time between the circuit-breaker closing command and the point in time when the current from at least one phase exceeds the **Oper.current threshold**. If this threshold has not been exceeded after 2.5 times the value of the parameter **CB make time**, the measurement is canceled and the output value *Make time* is set to 0 and marked with the quality invalid.

If at least one phase of the current has exceeded the parameter **Oper.current threshold** or the parameter **Current thresh. CB open** at the time of the circuit-breaker closing command, the measurement is canceled and the output value *Make time* is marked with the quality invalid.

You can define 2 independent thresholds for the supervision of the measured make time. When these thresholds are exceeded, the corresponding outputs *Warning 1* and *Warning 2* are activated for 100 ms. These can be routed in the log.

10.12.7.2 Application and Setting Notes

Parameter: `Level of warning 1`

- Default setting **`(_:101) Level of warning 1`** = ***`5 %`***

With the parameter **`Level of warning 1`**, you define the percentage the measured value is allowed to exceed the parameter **`CB make time`** at the output *`Make time`*, before the output *`Warning 1`* is set. The output *`Warning 1`* then drops out after 100 ms.

Parameter: `Level of warning 2`

- Default setting **`(_:102) Level of warning 2`** = ***`10 %`***

With the parameter **`Level of warning 2`**, you define the percentage the measured value is allowed to exceed the parameter **`CB make time`** at the output *`Make time`*, before the output *`Warning 2`* is set. The output *`Warning 2`* then drops out after 100 ms.

Parameter: `Oper.current threshold`

- Default setting **`(_:103) Oper.current threshold`** = ***`0.100 A`***

With the parameter **`Oper.current threshold`**, you define the current threshold. If the measured value exceeds this threshold, the measured value is detected as flowing operating current. As soon as an operating current flows, the end of the time interval *`Make time`* is detected.

Parameter: `Delay correction time`

- Default setting **`(_:104) Delay correction time`** = ***`0.000 s`***

With the parameter **`Delay correction time`**, you define a correction value which will be subtracted from the *`Make time`* during calculation. This allows you to compensate delays caused by the system, for example, relay residual times, if necessary.

10.12.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
`Supv.CB make time`				
_:1	Supv.CB make time:Mode		• off • on • test	off
_:101	Supv.CB make time:Level of warning 1		1 % to 100 %	5 %
_:102	Supv.CB make time:Level of warning 2		1 % to 100 %	10 %
_:103	Supv.CB make time:Oper.current threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:104	Supv.CB make time:Delay correction time		-0.050 s to 0.050 s	0.000 s

10.12.7.4 Information List

No.	Information	Data Class (Type)	Type
Supv.CB make time			
_:54	Supv.CB make time:Inactive	SPS	O
_:52	Supv.CB make time:Behavior	ENS	O
_:53	Supv.CB make time:Health	ENS	O
_:301	Supv.CB make time:Make time	MV	O
_:302	Supv.CB make time:Warning 1	SPS	O
_:303	Supv.CB make time:Warning 2	SPS	O

11 Functional Tests

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11.1 General Notes

Various tests have to be performed for commissioning to warrant the correct function of the device.

For tests using secondary test equipment, make sure that no other measurands are locked in and trip and close commands to the circuit breakers are interrupted, unless otherwise indicated.

Secondary tests can never replace primary tests because they cannot include connection faults. They provide a theoretical check of the setting values only.

Primary tests may be done only by qualified personnel who are familiar with the commissioning of protection systems, with the operation of the system, and with safety regulations and provisions (switching, grounding, etc.).

Switching operations also have to be performed for the commissioning. The described tests require that these be capable of being performed safely. They were not conceived for operational checks.

11.2 Direction Test of the Phase Quantities (Current and Voltage Connection)

The proper connection of the current and voltage transformer is checked with load current over the line to be protected. For this, the line must be switched on. A load current of at least 0.1 I_{rated} has to flow over the line; it should be ohmic to ohmic inductive. The direction of the load current has to be known. In case of doubt, meshed and ring systems should be unraveled. The line remains switched on the for the duration of the measurements.

The direction can be derived directly from the operational measured value. First make sure that the power measured values correspond to the power direction. Normally, it can be assumed that the forward direction (measuring direction) goes from the busbar toward the line.

Using the power measured values at the device or DIGSI 5, make sure that it corresponds to the power direction:

- **P** is positive if the active power flows in the line or protected object.
- **P** is negative if the active power flows to the busbar or out of the protected object.
- **Q** is positive if the inductive reactive power flows in the line or protected object.
- **Q** is negative if the inductive reactive power flows to the busbar or out of the protected object.

If the power measured values have a different sign than expected, then the power flow is opposite the current-direction definition. This can be the case, for example, at the opposite end of the line . The current-transformer neutral point then points in the direction of the protected object (for example line).

If the values are not as expected, it may be due to a polarity reversal at the voltage connection.

As a final step, switch off the system.

11.3 Direction Test of Ground Quantities for Directional Ground-Fault Functions

11.3.1 Overview

If the CT and VT connections are in the way that the ground quantities (3I0 and V0) are calculated by the device from the phase quantities, then, no additional directional test is required. Testing according to *11.2 Direction Test of the Phase Quantities (Current and Voltage Connection)* is sufficient.

If the ground current IN or the ground voltage VN is directly measured via a device input (usually I4 or V4), the correct polarity of the ground current and the ground voltage path must be checked.



DANGER

Live system parts! Capacitive coupled voltages on dead parts!

Noncompliance with the following measures can lead to death, serious physical injury, or considerable material damage.

✧ Primary measures may be performed only on dead and grounded system parts.

11.3.2 Directional Testing for Solid or Resistive-Grounded Systems

Primary Test

The primary test is used for the evaluation of the correct polarity of the transformer connections for the determination of the ground-fault direction.

To generate a zero-sequence voltage V0, the e-n winding of one phase in the voltage-transformer set (for example, phase A) is bypassed, see *Figure 11-1*. If no connection on the e–n windings of the voltage transformer is provided, the corresponding phase is disconnected on the secondary side, see *Figure 11-2* . Only the current of the transformer in the phase of which the voltage is missing is transferred via the current circuit. If the line carries resistive-inductive load, the protection is subject to the same conditions as existing during a ground fault in line direction.

For directional testing, the **Directional ground-fault protection** function (67N) is configured and at least one stage is switched on. The pickup threshold of the stage must be below the load current of the line. If not, the binary input signal *(_:2311:501) >Test of direction* can be activated to lower the threshold temporarily for testing means without changing the respective parameter.

After switching the line on and off again, you can check the pickup signal of the directional protection stage in the fault log. A forward information must be logged. If no pickup information is logged at all, the 3I0 or U0 threshold is not exceeded.

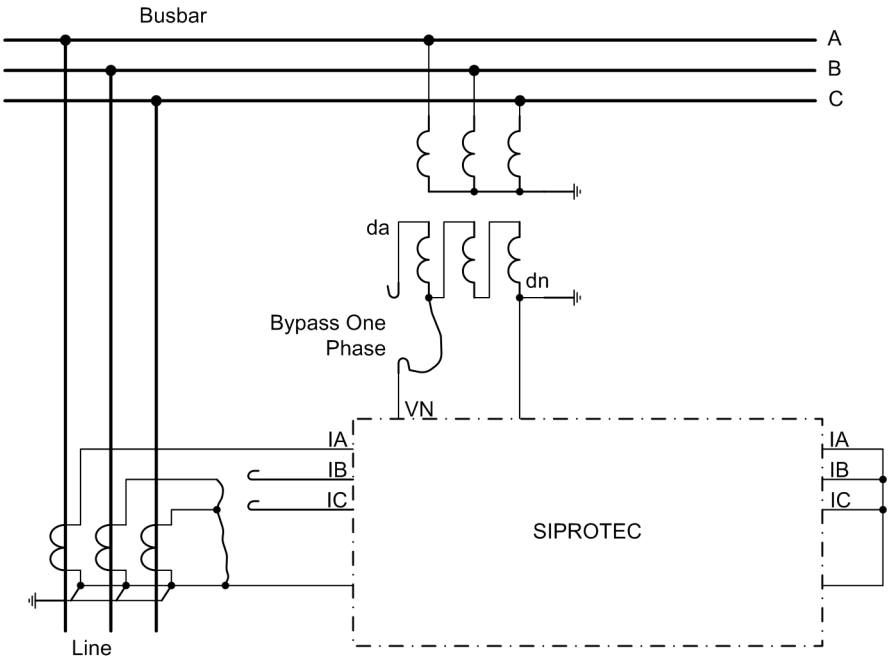
If a wrong direction is logged, one of the following conditions may have occurred:

- The direction of the load flow is from the line towards the busbar.
- The ground-current connection is incorrect.
- The voltage connection is incorrect.



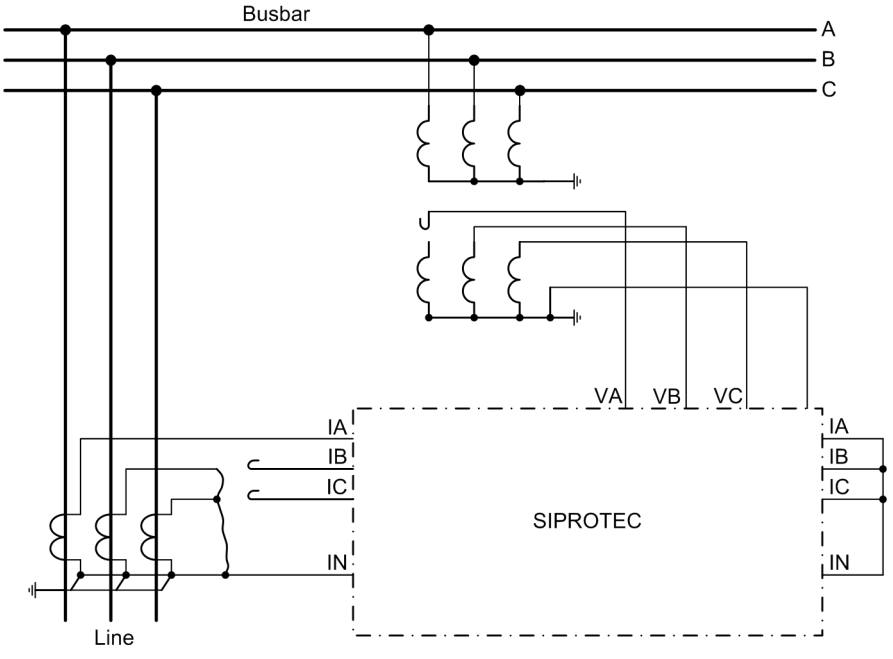
NOTE

Siemens recommends not to change parameter settings for the test. However, if parameters were changed for this test, they must be returned to their original state after completing the test!



[ConnPolarit1_diagram, 1, en_US]

Figure 11-1 Polarity Testing, Example with Current Transformers Configured in a Holmgreen-Connection and VTs with Broken-Delta Connection



[ConnPolarit2_201507, 1, en_US]

Figure 11-2 Polarity Testing, Example with Current Transformers Configured in a Holmgreen-Connection and VTs with Star Connection

11.3.3 Directional Testing for Isolated or Resonant-Grounded Systems

Primary Test

The primary test is used for the evaluation of the correct polarity of the transformer connections for the determination of the ground-fault direction.

For directional testing, the **Directional sensitive ground-fault detection** function (67Ns) is configured and a directional stage is switched on. For example, the directional 3I0> stage with cos φ or sin φ measurement.

The most reliable test is the one with a primary ground fault. Proceed as follows:

- ✧ Isolate the line and ground it on both sides; on the farthest line end it must remain open during the entire test.
- ✧ Place a **1-phase** ground fault bridge on the line. For overhead lines, this can be done at an arbitrary location, in any case behind the current transformer (as seen from the busbar of the feeder to be tested). For cables, the grounding is done on the farthest end (sealing end).
- ✧ Remove the protective grounding from the line.
- ✧ Switch on the circuit breaker on the line to be tested.
- ✧ Check direction indicator (LED if routed).
- ✧ Check the indication *(_:302) Ground fault* in the ground-fault log or fault log with regard to its direction. The indication *(_:302) Ground fault forward* must be logged as direction information.

  If *backward* is determined as the direction, either with the current connections or the voltage connections, there is an inversion in the neutral path. For the display *unknown*, the ground current is probably too low.
- ✧ Switch the line off and ground it.

This completes the test.

11.4 Functional Test of Thermal Overload Protection

Secondary Test

For the secondary test for the overload protection, note that all setting parameters refer to primary variables of the protected object. The protection device extracts the current transformer ratio from the power-system data and internally performs the adjustments to device nominal variables. Take these characteristics into account for the test.

✧ Reset the thermal memory before you repeat the test. This is possible, for instance, via the binary input indication **>Reset thermal replica**. If the function is reparameterized or is switched off, the thermal replica will also be reset.

Test without Previous Load

✧ Test the operate time at 1.5 $I/I_{rated,\ obj.}$

In the example, the following power-system data are assumed:

$I_{rated,\ obj}$ = 483 A

$I_{rated,\ transf.prim}$ = 750 A

$I_{rated,\ transf.sec}$ = 1 A

The primary test current is 1.5 * 483 A = 724.5 A. This results in a secondary current of 724.5 A *1A/750A = 0.966 A. A secondary current of 0.966 A must therefore be supplied.

✧ Calculate the operate time with the following formula. Enter only primary variables here.

✧ Set $I_{previous\ load}$ = 0. The setting parameters reveal the **K-factor** (for example, 1.1) and the **Thermal time constant** (for example, 600 s or 10 min).

✧ Test from the cold state.

$$t = \tau_{th} \cdot \ln\left(\frac{\frac{1}{k^2}\left(\frac{I}{I_{rated,obj.}}\right)^2 - \frac{1}{k^2}\left(\frac{I_{preload}}{I_{rated,obj.}}\right)^2}{\frac{1}{k^2}\left(\frac{I}{I_{rated,obj.}}\right)^2 - 1}\right) = 600\,s \cdot \ln\left(\frac{\frac{1}{1.1^2}\left(\frac{1.5 I_{rated,obj.}}{I_{rated,obj.}}\right)^2 - 0}{\frac{1}{1.1^2}\left(\frac{1.5 I_{rated,obj.}}{I_{rated,obj.}}\right)^2 - 1}\right) = 600\ s \cdot 0.772 = 463\ s$$

[foauslpr-190309-01.tif, 2, en_US]

✧ At a current of 0.966 A supplied on the secondary side, the protection function must trip after 463 s.

Test with Previous Load

✧ The object rated current ($I_{previous\ load} = I_{rated,\ obj}$) flows at a previous load of 1 (100 %).

✧ Supply 483 A *1 A/750 A = 0.644 A in this case.

After a finite time (greater than 5 τ_{th}), the stationary previous load sets in.

K-factor

✧ If you abruptly increase the supplied secondary current from 0.644 A to 0.966 A (1.5 $I/I_{rated,\ obj}$), the overload protection will trip in the following time.

$$t = \tau_{th} \cdot \ln\left(\frac{\frac{1}{k^2}\left(\frac{I}{I_{rated,obj.}}\right)^2 - \frac{1}{k^2}\left(\frac{I_{preload}}{I_{rated,obj.}}\right)^2}{\frac{1}{k^2}\left(\frac{I}{I_{rated,obj.}}\right)^2 - 1}\right) = 600\,s \cdot \ln\left(\frac{\frac{1}{1.1^2}\left(\frac{1.5 I_{rated,obj.}}{I_{rated,obj.}}\right)^2 - \frac{1}{1,1^2}\left(\frac{1.0 I_{rated,obj.}}{I_{rated,obj.}}\right)^2}{\frac{1}{1.1^2}\left(\frac{1.5 I_{rated,obj.}}{I_{rated,obj.}}\right)^2 - 1}\right) = 600\,s \cdot 0.184 = 110\,s$$

[foauslpr-190309-02.tif, 2, en_US]

✧

NOTE

Owing to the relatively large time constants in practice, the tests are carried out with significantly reduced time constants. Reset the original setting value after completing the tests.

11.5 Primary and Secondary Tests of the Circuit-Breaker Failure Protection

Integration of the Protection Function into the Station

The integration of the protection function into the station must be tested in the real-life application. Because of the multitude of possible applications and possible system configurations, the required tests cannot be described here in detail.

NOTE

Always keep the local conditions, the station plans, and protection plans in mind.

NOTE

Siemens recommends isolating the circuit breaker of the tested feeder at both ends before starting the tests. Line disconnector switches and busbar disconnector switches must be open so that the circuit breaker can be operated without risk.

General Precautions

CAUTION

Tests on the local circuit-breaker of the feeder cause a trip command to the output to the adjacent (busbar) circuit breakers.

Noncompliance with the following measure can result in minor personal injury or physical damage.

✧ In a first step, interrupt the trip commands to the adjacent (busbar) circuit breakers, for example, by disconnection of the corresponding control voltages.

For testing the circuit-breaker failure protection, it must be ensured that the protection (external protection device or device-internal protection functions) cannot operate the circuit breaker. The corresponding trip command must be interrupted.

Although the following list does not claim to be complete, it can also contain points, which have to be ignored in the current application.

Test Modes

The device and the function can be switched to test mode. These test modes support the test of the function in different ways:

Test Modes	Explanation
Device in test mode	This operating mode is relevant for the following tests: 1. Approach of current thresholds in the case of an external start: Supervision of the binary input signals in the case of an external start is disabled. This setting allows a static activation of the starting signals in order to approach the current threshold. 2. Check whether the issued trip commands actuate the corresponding circuit breakers, because the device contacts are also actuated in the device test mode.
CBFP function in test mode (device is NOT in test mode)	This operating mode is important for function tests in which the generated operate indications are NOT supposed to actuate the binary outputs.

NOTE

When the function or device is in test mode, all indications are given a test bit.

NOTE

In the mode **Device in test mode**, the operate indications generated by the function operate the binary outputs.

The function must also be tested in its normal, switched-on condition.

Consider the following in this case:

- ✧ The device contacts are actuated.
- ✧ Binary input signal supervision (in the case of an external start) is enabled and blocks the function.
- ✧ All indications generated are generated without test bit.

Circuit-Breaker Auxiliary Contacts

When circuit-breaker auxiliary contacts are connected to the device, they make an essential contribution to the reliability of the circuit-breaker failure protection, provided that their settings are set accordingly.

- ✧ Make sure that the correct assignment has been checked.

Internal Starting Conditions (Trip Command from Internal Protection Function)

The internal start can be tested by means of tripping a protection function, for example, the main protection function of the device.

- ✧ Check the settings for circuit-breaker failure protection. See also chapter *6.39.4 Application and Setting Notes* .
- ✧ For the circuit-breaker failure protection to be able to pick up, a phase current (see current-flow criterion) must be present. This can be generated by a device-internal test sequence (see description in the Operating manual). It can also be a secondary test current.
- ✧ Generate the trip for the protection function. This can be generated within the device by a test sequence (see description in the Operating manual) or by creating corresponding secondary test values.
- ✧ The trip command(s) and their time delay compared to the pickup, depending on the parameterization.

External Starting Conditions (Trip Command from External Protection Function)

If external protection devices are also able to start the circuit-breaker failure protection, the external starting conditions require checking.

- ✧ Check the settings for circuit-breaker failure protection.
  See also chapter *6.39.4 Application and Setting Notes* .
- ✧ For the circuit-breaker failure protection to be able to pick up, a phase current (see current-flow criterion) must be present. This can be generated by a device-internal test sequence (see description in the Operating manual). It can also be a secondary test current.
- ✧ Activate the binary input or inputs to which the start signal and possibly also the release signal for the CBFP function are routed. This can be done in 2 ways:
  – 1) Via internal test sequences
  – 2) By controlling the binary input or inputs via an auxiliary voltage
- ✧ Check the start input signal, and if available, check the enable input signal in the spontaneous or fault messages.
- ✧ Check the pickup indication in spontaneous or fault indications.
- ✧ The trip command(s) and their time delay compared to the pickup, depending on the parameterization.

Start by Trip Command from the External Protection

- ✧ Check the static and - in case of 2-channel operation - also the dynamic supervision of the binary input signals. For this purpose, induce pickup of the supervision and check the supervision indications and the ready signal in the event log buffer.

Start by Trip Command from the External Protection without Current Flow

- ✧ If start is possible without current flow: (see **Start by trip command from the external protection**).

Repetition of the Local Tripping (T1)

- ✧ Make sure that the trip repeat signal controls a 2nd circuit (2nd coil) for switching off the circuit-breaker.

Backup Tripping in the Case of a Circuit-Breaker Failure (T2)

For tests in the station, it is important to check that the distribution of trip commands to the adjacent circuit breakers in the case of a circuit-breaker failure is correct. The adjacent circuit breakers are all circuit breakers, which must be tripped in order to ensure interruption of the short-circuit current if the feeder circuit-breaker fails. They are therefore the circuit breakers of all feeders which feed the busbar or busbar section to which the feeder with the fault is connected.

A general detailed test guide cannot be specified because the layout of the adjacent circuit-breakers depends largely on the system topology.

- ✧ With multiple busbars, the trip distribution logic for the adjacent circuit breakers must be checked.

  The test has to check for every busbar section that, in case of a failure of the feeder circuit-breaker under observation, only those circuit-breakers which are connected to the same busbar section are tripped.

Backup Tripping on Circuit-Breaker Failure (T2), Tripping of the Opposite End

If the trip command of the circuit-breaker failure protection must also trip the circuit-breaker at the opposite end of the tested feeder, the communication channel for this remote trip has to be tested as well.

- ✧ It is practical to test the communication channel for the remote trip while transmitting other signals in accordance with *11.15.1 Checking the Protection-Data Communication* .

Termination

- ✧ All temporary measures taken for testing must be undone, such as special switch positions, interrupted trip commands, changes to setting values, or individually switched off protection functions.

11.6 Circuit-Breaker Test

The **Circuit-breaker test** function enables you to easily perform a complete test of the trip circuit, the closing circuit, and the circuit breaker. For this, the circuit-breaker test carries out an automatic opening and closing cycle of the circuit breaker during operation.

NOTE

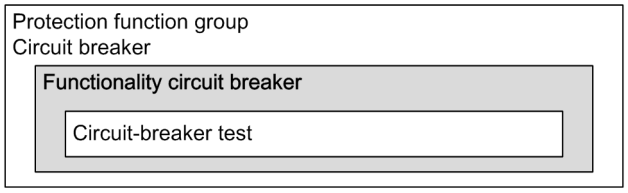
If the auxiliary contacts are not connected, a circuit breaker that has been opened may be permanently closed.

The following test program is available for you to carry out the circuit-breaker test.

No.	Test Program
1	3-phase open/closed cycle

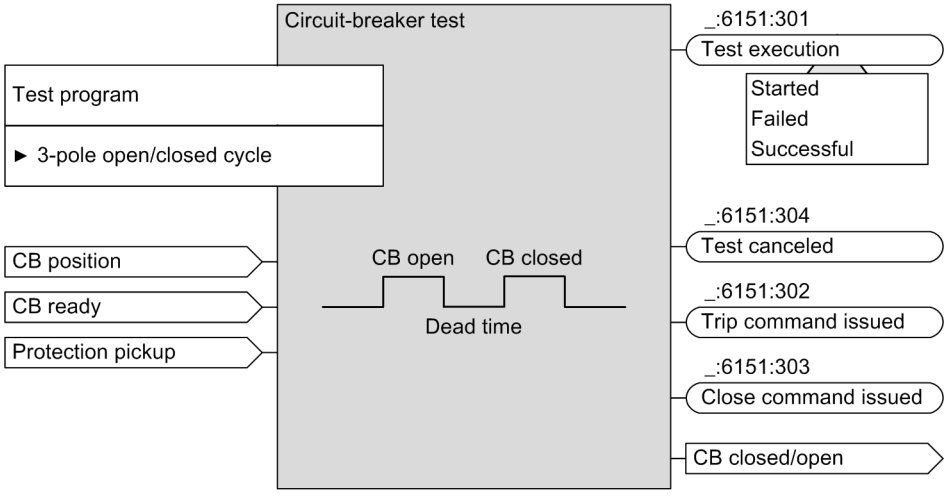
Structure of the Function

The **Circuit-breaker test** function is used in protection function groups for circuit breakers.



[dwcbch01-300913, 1, en_US]

Figure 11-3 Embedding of the Function



[dwcbc3p2-300913, 1, en_US]

Figure 11-4 Structure of the Function

Test Procedure

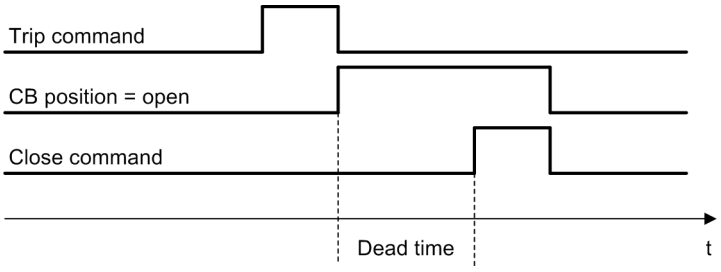
The following conditions must be satisfied before the circuit-breaker test can start:

- If a circuit-breaker auxiliary contact signals the position of the breaker pole to the device via the **Position** binary input, the test cycle is not initiated unless the circuit breaker is closed. If the circuit-breaker auxiliary contact has not been routed, you must ensure that the circuit breaker is closed.
- The circuit breaker must be ready for an open-closed-open cycle (indication **>Ready**).
- A protection function must not have been picked up in the circuit-breaker protection function group responsible for the circuit breaker.

Figure 11-5 shows the progression over time of an open-close test cycle.

If a circuit-breaker auxiliary contact is connected, the function waits for the indication circuit breaker **Position** = ***open*** after the trip command is generated. When the indication **Position** = ***open*** is received, the close command is transmitted after a dead time (parameter **(_:6151:101) Dead time**). If the feedback from the circuit-breaker positions is not received within the maximum transmission time (**Dead time**+ 2 · **Output time** + 5 s), the circuit-breaker test is aborted and considered to be failed. The proper functioning of the circuit breaker is monitored via the feedback on the circuit-breaker positions.

If the circuit-breaker auxiliary contact is not connected, the trip command is generated for the parameterized output time (parameter **(_:4261:101) output time**)). After the dead time (parameter **(_:6151:101) Dead time**) has elapsed, the close command follows, also for the duration of the parameterized time (**Output time**). In this case, you must ensure that the circuit breaker is closed.



[dwcbch03-300913, 1, en_US]

Figure 11-5 Progress over Time of a Circuit-Breaker Test Cycle

The **Circuit-breaker test** function is used in protection function groups for circuit breakers. If the actual **Circuit-breaker** functionality has been configured and wired further configuration is not necessary.

✧ You define the time between the trip command and the close command with the **(_:6151:101) Dead time** parameter.

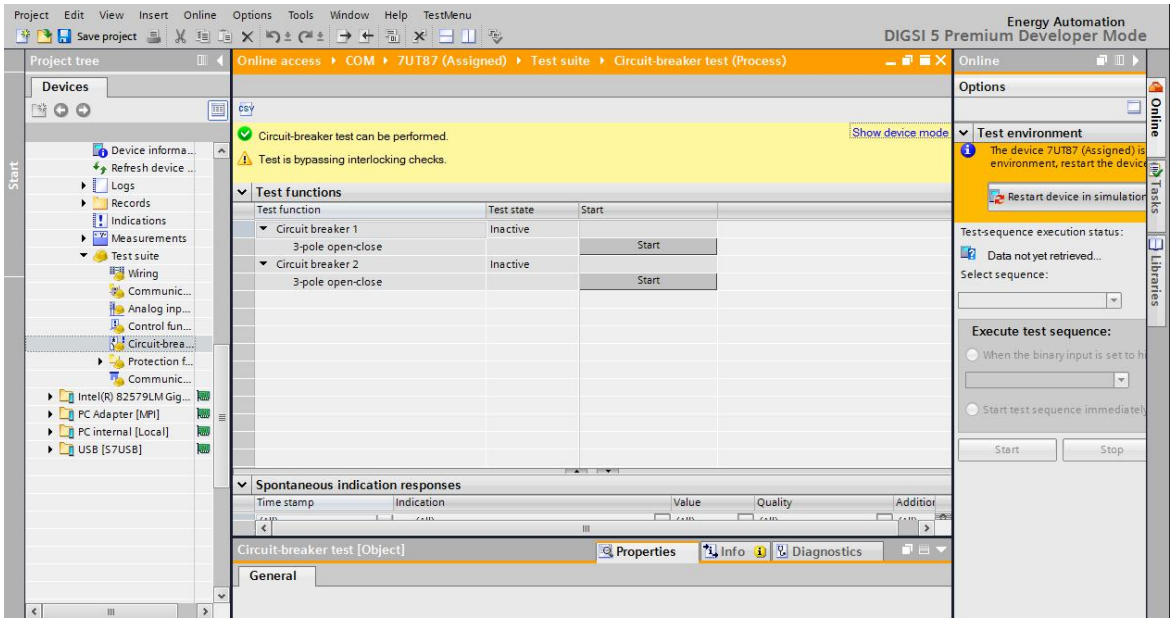
NOTE

The circuit-breaker test does not perform a synchrocheck even if the synchrocheck has been configured in the protection-function groups for circuit breakers. This may cause stability problems in the system during a 3-pole interruption. Therefore, a 3-pole circuit-breaker test should be very short, or not performed at all under load.

You can start the test program as follows:

- Via the device-control panel
- Via DIGSI
- Via control commands, which you can also connect in the CFC

The following figure illustrates operation of the circuit-breaker test in DIGSI.



[sccb_3pol, 1, en_US]

Figure 11-6 Circuit-Breaker Test in the Test Suite in DIGSI

- ✧ Select the function in the project tree on the left in the online access.
- ✧ Start the desired test program in the upper portion of the middle window.
- ✧ The corresponding feedback is displayed in the bottom portion of the middle window. Additional information about the behavior of other functions while the circuit-breaker test is being performed can be read in the operational log.

11.7 Functional Test of the Inrush-Current Detection

General

- ✧ For the test, make sure that the test current reflects the typical inrush current.
- ✧ Perform the test with transient signals. These can be recorded inrush currents or simulated currents from a transient system model.
- ✧ When using synthetic signals, observe the notes on the individual measuring principles.

Harmonic Analysis

- ✧ Superimpose on the fundamental-component current a test current of double frequency (2nd harmonic) and test the pickup behavior with this.
- ✧ Cause a threshold value excess (internal pickup) for one of the protection functions that you want to block.

  - or -

- ✧ Apply a test current with a load current as lead (current step).

The inrush current detection creates a blocking signal.

CWA Process

- ✧ Create a test current that has flat ranges of a minimum width of 3 ms simultaneously in all 3 phase currents.

The inrush current detection creates a blocking signal.

11.8 Functional Test of Transient Ground-Fault Protection

General

This function requires the correct polarity of the ground current IN and the neutral-point displacement voltage VN respectively the zero-sequence voltage V0. For the direction test of these quantities, refer to chapter *11.3 Direction Test of Ground Quantities for Directional Ground-Fault Functions*.

The function is based on the evaluation of the transient in the zero-sequence system after the ground-fault ignition.

For issuing the signal *(_:302) Ground fault*, the following 2 conditions must be met:

- There is a transient in the ground quantities.
- The fundamental compoment of the zero-sequence voltage V0 exceeds the threshold **(_:103) V0> threshold value**.

The following 2 methods are available for testing of the signal *(_:302) Ground fault* :

- Replaying real transient ground-fault recordings to the device
- Using secondary test equipment which allows to simulate transients ground faults

However, the setting of parameter **(_:103) V0> threshold value** cannot be tested precisely with the mentioned 2 methods, since this test requires a static V0. An easy way to test the setting is described in the following.

Secondary Test

This test must be carried out by injecting static secondary quantities. The test equipment needs to be configured in a way that it generates zero-sequence current 3I0 and zero-sequence voltage V0, which are injected to the SIPROTEC 5 device. By carrying out a shot, for example, a status change from zero-sequence values of 0 A and 0 V to the values not equal to zero, a transient is generated. The signal *(_:302) Ground fault* is issued as long as the static zero-sequence voltage of the 2nd state is greater than the set threshold. As amplitude for the secondary 3I0, 100 mA is a suitable value. In this test, the directional result contained in the signal *(_:302) Ground fault* is not defined and relevant, since the task is to test the setting of parameter **(_:103) V0> threshold value** only.

For testing the threshold, shots must be carried out with a static V0 slightly below the threshold and slightly above the threshold, for example, to 98 % and 102 % of the threshold value or to a threshold value of -0.2 V and +0.2 V (the greater absolute deviation of the threshold value must be selected) .

Consider that the V0 threshold is defined according to the definition of the symmetrical components. A full neutral-point displacement voltage VN of 100 V causes V0 = 57.7 V.

Example

- **(_:103) V0> threshold value** = 15 V
- 3 shots from 0 to V0 = 14.7 V and 3I0 = 100 mA
  No signal *(_:302) Ground fault* is issued.
- 3 shots from 0 to V0 = 15.3 V and 3I0 = 100 mA
  Signal *(_:302) Ground fault* is issued

If the test result is not as expected, check the injected static V0 voltage via the operational measurement of the device which contains the zero-sequence components.

11.9 Functional Test of the Trip-Circuit Supervision

General

- ✧ For the test, make sure that the switching threshold of the binary inputs is clearly below half the rated value of the control voltage.

2 Binary Inputs

- ✧ Make sure that the binary inputs used are isolated.

1 Binary Input

- ✧ Make sure that, in the circuit of the 2nd circuit-breaker auxiliary contact, an equivalent resistance R is connected.
- ✧ Observe the dimensioning notes under the section **Equivalent resistance R**.

11.10 Functional Test for the Phase-Rotation Reversal

- ✧ Check the phase sequence (direction of rotating field) at the device terminals. It must correspond to the setting of the **Phase sequence** parameter.
- ✧ The output indication *Phase sequence ABC* or *Phase sequence ACB* displays the determined phase sequence. This must correspond to the phase sequence that was set.
- ✧ You can also determine the phase sequence via the **Symmetrical components** measured values. If you obtain negative-sequence system variables (V_2, I_2) and no positive-sequence system variables (V_1, I_1) with symmetrical 3-phase infeed, the setting parameter **Phase sequence** does not correspond to the connection.

11.11 Functional Test for Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage

Checking the Stator Ground-Fault Protection with the Machine

You have to check whether the protection function and the protection ranges are functioning correctly. The following tests are intended for the unit connection.

You can check the protection range by performing a test with a ground fault at the generator terminals. The ground fault test in the power system enables you to verify the noise suppression of the load resistor.

Checking the Protection Range with a Machine Ground Fault



DANGER

Touching live parts or reaching into rotating machines will result in death or serious injury.

✧ Perform primary measures only when the machine is at standstill and the system components are de-energized and grounded.

✧ Insert a 1-phase-to-ground jumper into the terminal circuit of the machine.

✧ Set the **Mode** parameter in the protection stage to ***test***. This prevents the trip command from being generated for the stage.

✧ Start the machine and excite it slowly up to approx. 20 % of the rated machine voltage.

✧ From the operational measured values, check the plausibility of the zero-sequence voltage V_0 and the input voltage at the connected input.

✧ Determine the protection range from the pickup voltage.
The following applies for the protection range S:

$$S = \frac{\frac{V_{NG}}{\sqrt{3}} - V_{0,\text{pickup value}}}{\frac{V_{NG}}{\sqrt{3}}} \cdot 100\ \%$$

[foschzbe-130309-01.tif, 2, en_US]

Example: Measurement with secondary voltages

V_{NG} Generator voltage transformed to the transformer secondary side = 100 V

$V_{0,\text{ pickup value}}$: Measured zero-sequence voltage at pickup = 5.68 V

S: Resulting protection range = 90 %

✧ Check the messages in the message buffer. If the **Detection of faulty phase** parameter is set to ***yes***, check the display of the phase affected by the fault.

✧ Shut the machine down and remove the ground fault bridge.

✧ Set the **Mode** protection stage parameter to ***on***.

Checking Disturbance-Voltage Suppression in the Load Resistor with a System Ground Fault

DANGER

Touching live parts or reaching into rotating machines will result in death or serious injury.

✧ Perform primary measures only when the machine is at standstill and the system components are de-energized and grounded.

✧ With the primary system de-energized and grounded, insert a 1-pole ground fault bridge on the high-voltage side of the unit transformer.

CAUTION

Material can be damaged during the test if there is a neutral-point grounding at the transformer and simultaneously a grounding on the high-voltage side.

✧ Neutral grounding at the transformer must be interrupted during the test.

✧ Start the machine and excite it slowly up to 30 % of the rated machine voltage.

✧ Read the zero-sequence voltage $V_{0,\ measured\ value}$ from the operational measured values.

✧ Extrapolate the zero-sequence voltage to 100 % of the machine voltage ($V_{0,\ fault}$).

✧ Calculate the safety margin by dividing the calculated fault value by the set threshold value.

If the result is less than 0.5, the safety margin is sufficient. If the fault voltage is lower, you can increase the sensitivity of the protection function.

EXAMPLE:

$V_{0,\ meas.}$ = 0.75 V

$V_{threshold\ value}$ = 5.68 V

$V_{0,\ fault}$ = 0.75 V * 100 % / 30 % = 2.5 V

Safety margin = 2.5 V / 5.68 V = 0.44

The calculated safety margin of 0.44 is sufficient because it is below 0.5.

✧ Shut the machine down and de-excite it. Remove the ground-fault bridge.

✧ Restore neutral-point grounding if you require grounded operation of the neutral on the high-voltage side of the unit transformer.

When using the function for startup ground-fault protection on a busbar connection, carry out the same check as for the unit connection, but only the part **Test during machine ground fault**.

11.12 Primary and Secondary Testing of the Synchronization Function

Measuring the Circuit-Breaker Closing Time

Under asynchronous system conditions, the circuit-breaker closing time must be measured and set correctly. This achieves an exact parallel switching with a phase angle 0°. If switching occurs only in synchronous system conditions, this section can be skipped.

The closing time can be determined via the following 2 methods:

- 1. By reading from a fault record (recommended method)
- 2. With external timer

1. A simple option for determining the closing time involves reading out the time between the close command and closure of the switch pole via the fault record. The time determined here is the real closing time and not the operating time of the circuit beaker. You do not have to add any further time.

Siemens recommends the following procedure:

✧ Establish a condition in which the circuit breaker can be closed without hazard.

✧ If V2 switching through, activate the operating mode **Close cmd. at V1< & V2>** for the synchronization stage by setting to ***yes***.

If V1 is switched through, activate the operating mode **Close cmd. at V1> & V2<**.

✧ Make sure that the fault recorder is turned on. Via a temporary CFC chart, link the signal **Release close cmd.** of the active synchronization stage to the binary input signal **>Manual start** (of the fault recorder). With the release of closure, a fault record of the parameterized duration is set up (the default setting of 500 ms is more than adequate for this).

✧ Starting the synchronization stage. The device activates immediately.

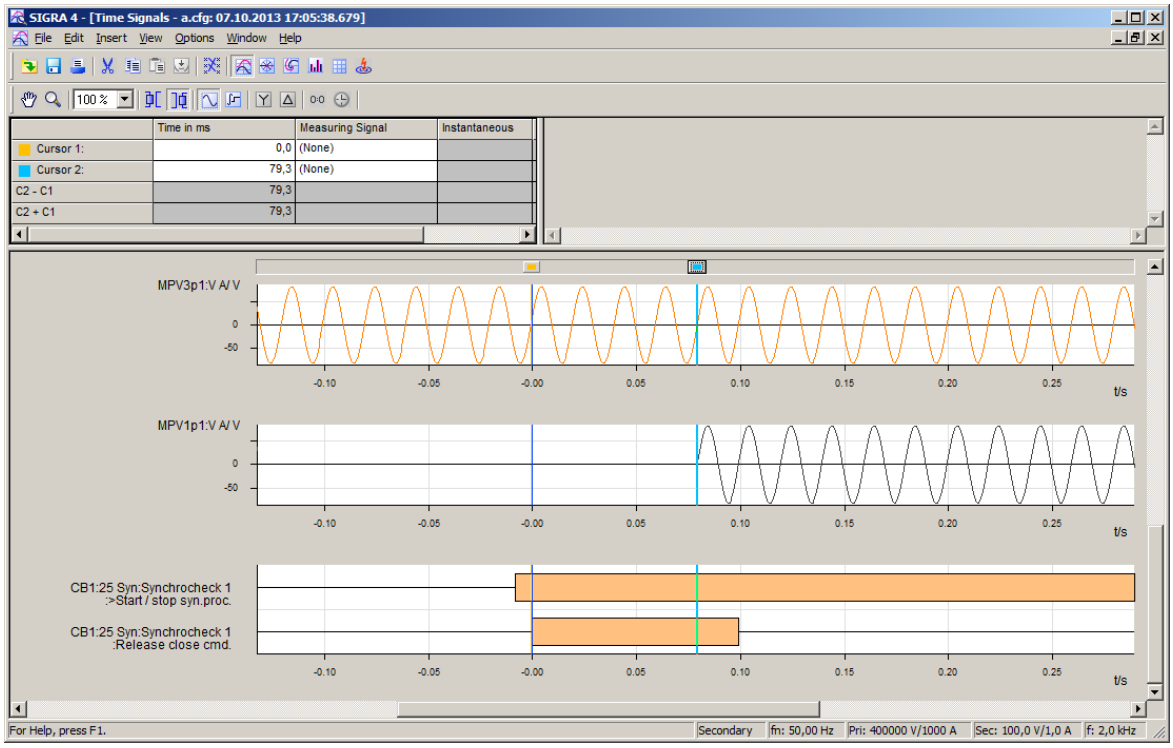
✧ Read the fault record and determine the closing time via SIGRA (see *Figure 11-7*).

Use the 2 cursors and the time-measuring function for this. Position the first cursor on the raising close command. The occurrence of the second voltage signals the closed power-switching poles. Place the second cursor on the raising second voltage.

✧ Set the determined time with the **CB make time** parameter. Round off to the next lower adjustable value. Proceed in the same way for all other sync stages.

✧ Set the parameter **Close cmd. at V1< & V2>** or parameter **Close cmd. at V1< & V2<** back to its original value.

✧ Delete the CFC chart.



[scsyn001-170510-01.tif, 1, en_US]

Figure 11-7 Measurement of the Circuit-Breaker Closing Time

2. The arrangement in *Figure 11-8* is suitable for measuring the circuit-breaker operating time with external timer. Set the timer to the range 1 s or a tripping of 1 ms.

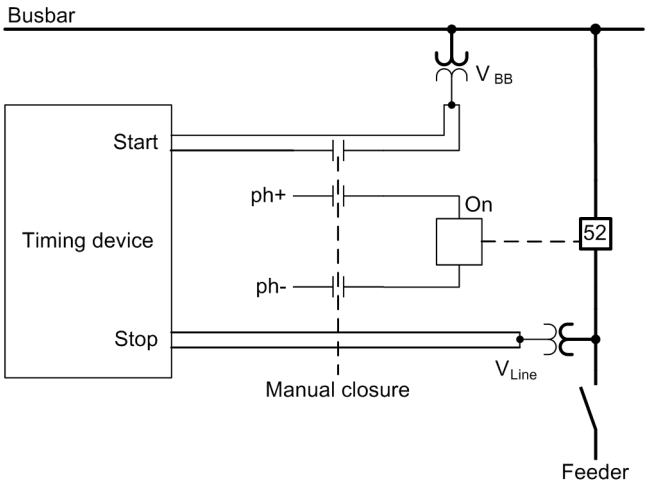
Connect the circuit breaker manually. The timer is started simultaneously by this. After the poles of the circuit breaker close, the voltage V_{Line} appears. The timer is then stopped.

If the timer is not stopped owing to an unfavorable closing moment, repeat the attempt.

Siemens recommends calculating the average value from several (3 to 5) successful switching attempts.

NOTE

Add the command output time of the protected device to measured time. This exclusively depends in good approximation on the binary output used for the close command. You can find the switching times for the different binary outputs in the Technical data. Set the total time with the parameter **`CB make time`**. Round off to the next lower adjustable value. Proceed in the same way for all other synchronization stages used.



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Figure 11-8 Measurement of the Circuit-Breaker Closing Time

Checking the Measurement Chain

The measurement chain for the voltage measurement must be checked. As soon as one of the synchronization stages to be used is closed, all the necessary functional measured values are calculated. The synchronization stage, thus, does not have to be started for this check.

Proceed as follows when checking the measurement chain as a primary or secondary test:

a) As primary test

✧ Establish a synchronous state by closing the circuit breaker, if possible.

✧ Check the functional measured values within the synchronization function:

– The delta values must be 0.

– Check the voltages V1 and V2 for plausible values in comparison with the operational measured values for the voltage.

– Check the frequencies f1 and f2 for plausible values in comparison with the operational measured value for the frequency.

b) As secondary test

✧ Establish a synchronous state by applying synchronous voltage values at both measuring points.

✧ Check the functional measured values within the synchronization function:

– The delta values must be 0.

– Check the voltages V1 and V2 for plausible values in comparison with the operational measured values for the voltage.

– Check the frequencies f1 and f2 for plausible values in comparison with the operational measured value for the frequency.

Blind Switching Attempts when Used in Machines

Perform blind switching attempts when using the function in machines.

Requirement:

✧ You have checked the setting values again.

✧ The circuit breaker is switched off. The close command for the circuit breaker is interrupted (disconnecting the close command). The system voltage is switched through for the measurement.

a) Attempt with asynchronous systems:

✧ Via manual control set the generator to a speed slightly below the permitted frequency difference according to the setting values **`Max. frequency diff. f2>f1`** and **`Max. frequency diff. f2<f1`**. The generator is excited to line voltage. You can read out the values in the operational measured values.

- ✧ Start the synchronization stage, for example, externally with binary input signal or via the integrated controller. You can use a synchroscope to trigger the start at synchronism, that is, at **12 hours**. The duration until the close command then corresponds to a cycle with the duration 1/Δf. At a frequency difference of 0.1 Hz, the duration is thus 10 s.
- ✧ Insofar as permissible, perform this attempt several time for oversynchronous switching and subsynchronous switching.
- ✧ The switching performance can be checked with an external recorder or the integrated fault recording function. You have to start the fault recording explicitly.
- ✧ You can repeat the blind switching attempts at the limits of the permissible voltage difference.

b) Attempt with synchronous systems:

- ✧ Start the synchronization stage, for example, externally with binary input signal or via the integrated controller.
- ✧ Check the proper release for activation with the message log or via a fault record. You have to start the fault recording explicitly. All activation conditions have to be fulfilled within the time **`Delay close command`**.

  If you observe the change between synchronous and asynchronous operation, raise the changeover threshold **`f-threshold ASYN<->SYN`** slightly.

c) Attempt with synchrocheck:

- ✧ If you use this function in conjunction with the manual synchronization, check the proper release for closure.
- ✧ Synchronize the generator manually. Start the synchronization stage externally via a binary input. Check the proper release for closure with the indicatiion log or via the fault record. You have to start the fault recording explicitly.

11.13 Testing the Negative-Sequence Current

When testing, keep in mind that the measured values are standardized. In the setting $I_2/I_{rated, obj.}$, they are standardized to the rated current of the protected object. The conversion to secondary transformer values is accomplished in the device.

EXAMPLE:

The threshold value is set to 10 % of the protected object.

Transformer: 100 A/1 A

Rated current of the protected object: 80 A

Action Steps

✧ At a setting of 10 %, the primary negative-sequence current is 80 A • 10 %/100 % = 8 A.

For a current transformer ratio of 100, test with a secondary current of 0.08 A.

✧ With a transformer of 100 A/5 A, the test current is higher by the factor 5. Test with 0.4 A. The pickup value is at 1.1 • 0.4 A = 0.44 A.

✧ If deviations occur during the testing, you must check whether the power-system data were entered correctly.



NOTE

Keep in mind that the function works starting from the set minimum current.

11.14 Reverse Power Protection

11.14.1 Secondary Test

When performing the secondary test, note that the setting value for the reverse power refers to the machine variables. Due to the mismatching of the current transformer, you must check with reduced currents. You can deduce the reduction from the ratio $I_{rated, generator}$/ $I_{rated, CT}$. Check the reverse-power protection at rated voltage.

If the voltage transformer is not adjusted to the rated generator voltage, correct the secondary voltage, too. Use the following ratio:

$V_{rated, generator}/V_{rated, VT}$

11.14.2 Primary Test

For measurements on the protection current transformers and with sensitive setting of the reverse-power protection, Siemens recommends determining the reverse power and the angle-correction values. Regardless of the generator excitation, that is regardless of the reactive power Q, the reverse power P as a pure active power is constant. The resulting characteristic curve is a straight line that runs parallel to the Q axis. Due to possible angle errors of current transformers and voltage transformers, the protection device does not measure a constant active power. The current flowing at this time, which can be assumed as being proportional to the reactive power, has a substantial influence.

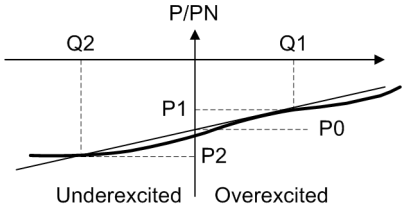
The deviations are determined with 3 measurements and the correcting quantity φ_{corr} is determined from the results.

To calculate the correction angle, enter the active power and reactive power measured with the device in the following table.

Use the functional measured values **`P1avg`** and **`Q1avg`** (type averaged).

Table 11-1 Value Table for Angle Correction

State	Reverse Power	Reactive Power
Reactive power near zero	P_0 =	Q_0 =
Overexcited	P_1 =	Q_1 =
Underexcited	P_2 =	Q_2 =



[dw_RPP_02, 1, en_US]

Figure 11-9 Determining the Correction Angle φ_{corr}



CAUTION

Be careful if you operate the turbine without a certain minimum steam flow (cooling effect).

Operating the turbine without a certain minimum steam flow (cooling effect) can overheat the turbine blades!

✧ The consumption of reverse power for a turbo-generator set is only allowed for a short time!

CAUTION

If the generator is underexcited, there is the risk of an out-of-step condition!

Non-observance of the following measures can result in minor personal injury or material damage.

✧ The following measures prevent the risk of an out-of-step condition.

✧ Regulate the driving power to 0 by closing the control valves. The generator draws its reverse power from the electrical power system.

✧ Change the excitation until the reactive power Q = 0. As a control measurement, read the active power P_0 and the reactive power Q_0 with the sign, and enter the values in *Table 11-1* .

✧ Increase the excitation slowly until reaching approx. 30 % of the rated apparent power of the generator (overexcited).
Read the reverse power P_1 with the sign (negative) and the reactive power Q_1 with the sign (positive) in the functional measured values and note these 2 values in the values table.

✧ Reduce the excitation slowly until reaching approx. 30 % of the rated apparent power of the generator (underexcited).
Read the reverse power P_2 with the sign (negative) and the reactive power Q_2 with the sign (negative) in the functional measured values and note these 2 values in the values table.

✧ Run the generator again at no-load excitation and select the desired operating state.

✧ With the measured value pairs (P_1, Q_1 and P_2, Q_2), calculate the correction angle φ_{corr} with the following formula:

$$\varphi_{corr} = \arctan \frac{P_1 - P_2}{Q_1 - Q_2}$$

[fo_RPP_01, 1, en_US]

NOTE

Insert the power values with the signs that you read previously!

✧ Enter this angle φ_{corr} with the same sign as the new correction angle (parameter ***(_:2311:101) Angle correction***):

Setting value ***(_:2311:101) Angle correction*** = φ_{corr}

✧ You can determine the pickup value of the reverse-power protection from the measured values P1 and P2.

Use the following formula: $P_{pickup} = (P_1+P_2)/4$

Set the value as pickup value: Parameter **(_:991:3) Threshold** = ***Ppickup***

Check of the Reverse-Power Protection

With a generator that is connected to the power system, the reverse power results from closing the control valves or from closing the quick stop.

✧ In both cases, check the consumed active power (reverse power). The valves could be leaking.

✧ Repeat the reverse-power measurement to confirm that the settings are correct.

✧ To check the efficiency of the reverse-power protection on the basis of the indications, use the parameter **(_:991:1) Mode** to switch the reverse-power protection to ***test*** .
Proceed as follows:

- ✧ Start the generator and synchronize it with the power system.
- ✧ Close the control valves.
- ✧ From the functional measured value, take the reverse power that was measured by the protection device as the active power. Use 50 % of the functional measured value as setting value for the reverse-power protection.
- ✧ Increase the driving power up to normal operation.
- ✧ Check the quick-stop criterion.
  Proceed as follows:



NOTE

Make sure that the binary input **>Stop valve closed** is properly routed. The quick-stop criterion (the pressure-operated switch or the limit switch on the quick-stop valve) must control this binary input.

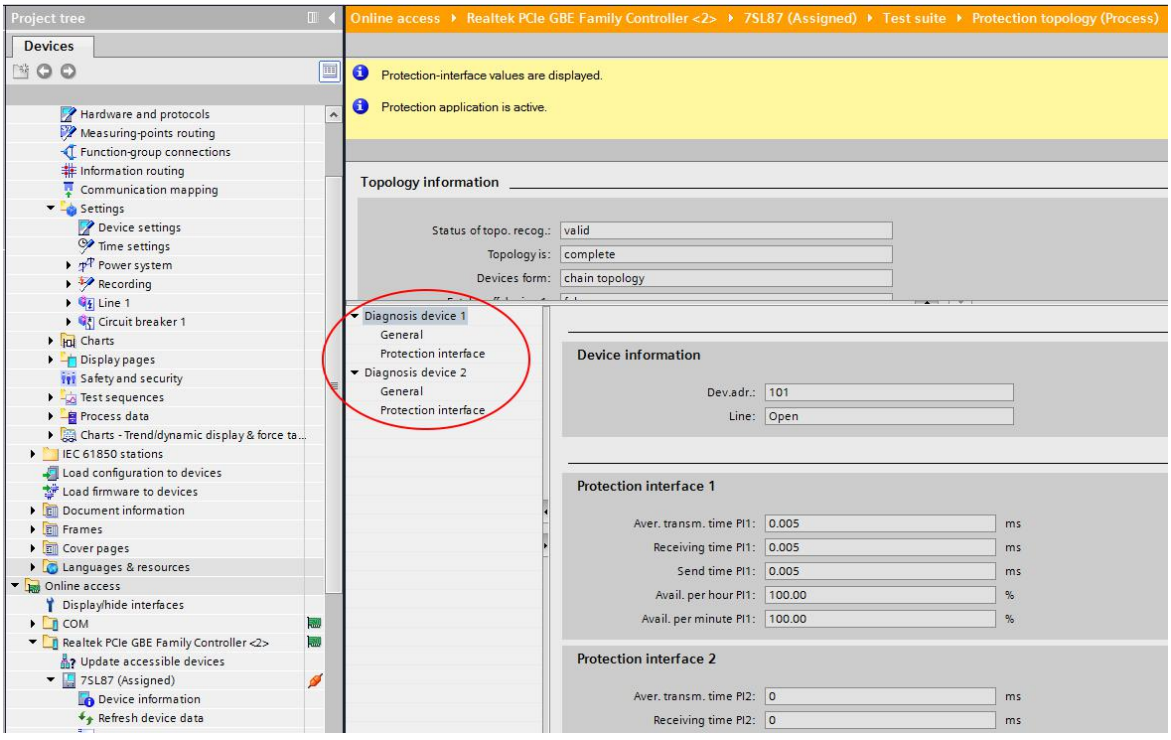
- ✧ Close the quick-stop valve.
- ✧ From the functional measured value **P1avg** , take the reverse power that was measured by the protection device as the active power.
- ✧ If – contrary to expectations – this value is smaller than the reverse power when the control valves are closed, take 50 % of this value as the setting value for the reverse-power protection.
- ✧ Shut down the machine by activating the reverse-power protection. Set the parameter **(_:991:1) Mode** to ***on*** .

11.15 Functional Test Protection Communication

11.15.1 Checking the Protection-Data Communication

Checking the Protection-Data Communication

If the devices are connected to one another via the protection interface and switched on, they contact each other automatically. If, for example, device 1 recognizes device 2, the successful connection is indicated (see next figure). Accordingly, each device signals to all devices that aProtection-data communication is available.



[scprotec, 1, en_US]

Figure 11-10 Connection Establishment in DIGSI 5

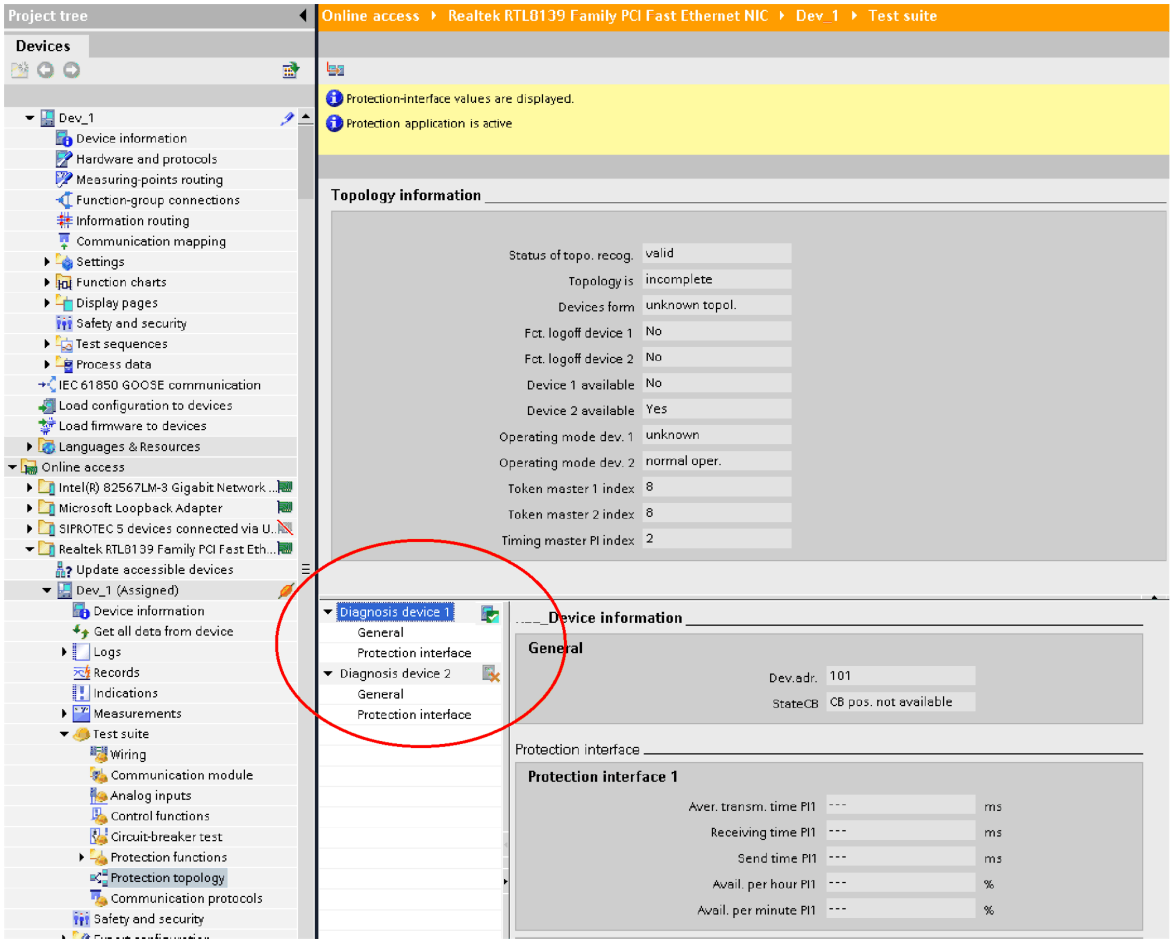
Proper communication of the devices among each other can be supervised during operation.

✧ Check the connections for each protection interface in DIGSI 5.

If a connection is successfully established, the field **Status of topo recog.** shows the indication *valid* in DIGSI 5 (see *Figure 11-10*).

If 2 devices are parameterized incorrectly, the **Status of topo recog.** field shows the indication *invalid* (see *Figure 11-10*).

In *Figure 11-11* there is no protection-data communication between device 1 and device 2, that is, the protection interfaces 1 and 2 of device 1 do not receive data. The transmission of protection data is interrupted and differential protection is ineffective. One reason for this can be a remote control with DIGSI via the protection interface. In this case, the protection connection is interrupted and the connection is used exclusively for DIGSI.



[scprotco-061210-01.tif, 1, en_US]

Figure 11-11 Protection-Data CommunicationDeactivated

11.15.2 Directional Test

In the case of protection interfaces of type 1 and type 2, the complex phasors of the voltage and current measuring point are exchanged between devices of one communication topology in order to be able to carry out a directional test during commissioning, for example. DIGSI 5 depicts this in the form of a phasor diagram. You can only route the measuring point to the protection interface. For 1 1/2 circuit-breaker layouts, a measuring point can therefore be transferred and checked optionally. You can also check and test the 2nd measuring point by rerouting. Furthermore, communication with DIGSI 5 can take place via the protection interface to other devices of the constellation. For this purpose, the protection-interface connection is interrupted and DIGSI 5 uses this connection for communication with the remote device.

✧ After completing the remote connection by DIGSI 5, the system switches back over to protection communication.

11.16 Functional Test for Overexcitation Protection

Secondary Test

NOTE

While performing the secondary test, ensure that the data of the protected object refer to the protection function.

This means that a mismatch between the voltage transformer and the protected object will be corrected automatically. For instance, when applying the secondary rated voltage and the rated frequency, this must not result in a V/f value of 1.

The mismatch of the voltage transformer must be taken into consideration when selecting the test voltage. Multiply the secondary test voltage with the following 'k' factor.

$$k = \frac{V_{rated,obj}}{V_{rated,transf.}}$$

[fokfakuf-070513-01.tif, 1, en_US]

Example

$V_{rated,obj}$ = 110 kV; $V_{rated,\ transf.}$ = 100 kV

It follows from the above that k = 1.1. For example, when verifying the nominal conditions if the secondary rated voltage is 100 V, a voltage of 1.1 * 100 V = 110 V must be supplied. The measured value of the function **Measured value V/f** must display 1.0000.

NOTE

When checking the dependent stage, ensure it is associated with a **thermal replica**. When repeating a test, always reset the replica, using the binary input indication **>Reset therm. replica** (_:13951:501).

Primary Test

The plausibility check between instantaneous overexcitation and the displayed operational measured value is used to verify the functionality of overexcitation.

Instantaneous overexcitation is a result of the following function:

$$\frac{V}{f} \cdot \frac{f_{rated}}{V_{rated}}$$

[fomoweuf-070513-01.tif, 1, en_US]

where:

V	Instantaneous voltage
V_{rated}	Primary rated voltage of the protected object
f	Instantaneous frequency in f
f_{rated}	Rated frequency

11.17 Functional Test Differential Protection for Capacitor Banks

11.17.1 Secondary Tests

Secondary tests can never replace the primary tests described in the following chapter *11.17.2 Primary Tests*, because they cannot include connection faults.

Secondary tests are used to check the following:

- Checking the setting values
- Proper reaction of the protection function
- Engineering (for example, routing the respective logic signals, display images with measured values, logics in CFC, and much more)

If you want to perform secondary tests, observe the following instructions.



NOTE

For tests with secondary test equipment, ensure that no other measurands are connected and the trip commands to the circuit breakers are interrupted, otherwise, the circuit breakers could be activated.

Perform the tests with the current setting values for the device. If these values are not (yet) present, check with the default values.



NOTE

The measuring accuracy to be attained depends on the electrical data of the test sources. The accuracies stated in the Technical Data can be expected only if the reference conditions stipulated in VDE 0435/ part 303 and IEC 60255 are ensured and precision instruments are used. The stated tolerances refer to the default data for the protected objects. If the rated current of the protected object in relation to the rated current of the current transformer deviates considerably from the rated current of the device, you must assume higher response tolerances.

For differential protection, you can check each side separately. This corresponds to the simulation of a fault supplied from one side. If a side has several measuring points, the measuring inputs not included in the test carry no current. The pickup value is tested by increasing the test current slowly.



NOTE

Tests of currents via quadruple device-rated current (or a maximum of 20 A) lead to an overload of the input circuits and may be performed only briefly. You can find more information in chapter *12.28 Differential Protection for Capacitor Banks*. Interrupt testing to allow cool-down!

The set pickup values refer to symmetrical 3-phase current in the case of 3-phase protected objects.

If you are testing parameters set during operation, you must ensure that the setting value for the differential protection refers to the rated current of the protected object.

If you wish to check the characteristic curve, Siemens recommends using the standard testing programs of digital test equipment. For the manual checking of points on the characteristic curve, feed in a **through-flowing** current which corresponds to a current value on the stabilization axis. Then change the phase angle of the test current on one side, so that the necessary differential current is achieved. Check a value with a tolerance of 5 % above and below the point on the characteristic curve which is to be tested.

For capacitor banks, the actual pickup values for 2-phase testing also depend on the vector group of the capacitor bank.

To obtain the actual pickup value, multiply the setting value by a vector-group factor k_{SG} according to the following formula:

$$\frac{I_{\text{rated transf.}}}{I_{\text{rated transf. prim}}} k_{SG}$$

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The following table shows this factor k_{SG} in dependence of the vector group and the fault type.

Table 11-2 Correction Factor k_{SG} for the Vector Group (SG) and Fault Type

Fault Type	Reference Winding (High Voltage)	Even SG Number (0, 2, 4, 6, 8, 10)	Odd SG Number (1, 3, 5, 7, 9, 11)
3-phase	1	1	1
2-phase	1	1	$\sqrt{3}/2 \approx 0.866$
1-phase with I_0 elimination	3/2 = 1.5	3/2 = 1.5	$\sqrt{3} \approx 1.73$
1-phase without I_0 elimination	1	1	$3/(1+\sqrt{3}) \approx 1.1$

11.17.2 Primary Tests

Restricted primary testing is possible for capacitor-bank applications. A wiring fault in the connection to the system could be a possible cause of the fault. With the system at a standstill, you can apply a test current of approx. 10 % to 20 % of the rated current directly to the transformer terminals and connected transformer with a primary testing device. Simulate a load (through-flowing current). The differential current must be 0 and the restraint current is the current which is fed in.

To rule out overfunction on initial switch-on, for example, due to the incorrect installation of a transformer, Siemens recommends switching the differential protection to test mode. The protection function operates, but does not issue a trip command. With the protection measurement values in the fault log, check the differential and the restraint current. The differential current must be 0 and the restraint current must correspond to the actual capacitor current.

If the differential protection is functioning correctly, switch the protection function **ON**.



NOTE

If the differential protection is disabled (for example, function in test mode), an overcurrent protection must be active as short-circuit protection (without delay and set via the starting current).

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12.1 General Device Data

12.1.1 Analog Inputs

Current Inputs

All current, voltage, and power data are specified as RMS values.			
Rated frequency f_{rated}	50 Hz, 60 Hz		
Protection-class current transformers	Rated current I_{rated}	Measuring range of the modular devices	Measuring range of the non-modular devices
	5 A 1 A	0 A to 500 A 0 A to 100 A	0 A to 250 A 0 A to 50 A
Instrument transformers	5 A 1 A	0 A to 8 A 0 A to 1.6 A	0 A to 8 A 0 A to 1.6 A
Power consumption per current circuit at rated current	Approx. 0.1 VA		
Thermal rating (protection and instrument transformers)	500 A for 1 s		
	150 A for 10 s		
	20 A continuously		
	25 A for 3 min		
	30 A for 2 min		
Dynamic load-carrying capacity	1250 A one half wave		

Voltage Input

All current, voltage, and power data are specified as RMS values.		
Rated frequency f_{rated}	50 Hz, 60 Hz	
Input and output modules	IO202/IO208/IO211/IO214	IO215
Measuring range	0 V to 200 V	0 V to 7.07 V
Input impedance	< 0.1 VA	< 0.01 VA
Thermal rating	230 V continuously	20 V continuously

Measuring-Transducer Inputs (via Module ANAI-CA-4EL)

Connector type	8-pin multiple contact strip
Differential current input channels	4
Measuring range	DC -24 mA to +24 mA
Fault	< 0.5 % of measuring range
Input impedance	140 Ω
Conversion principle	Delta-sigma (16 bit)
Permissible potential difference between channels	DC 20 V
Galvanic separation from ground/ housing	DC 700 V
Permissible overload	DC 100 mA continuously
Measurement repetition	200 ms

Measuring-Transducer Inputs (via Module ARC-CD-3FO)

Connector type	AVAGO AFBR-4526Z
Number of transceivers	3

Fiber type	Polymer Optical Fiber (POF) 1 mm
Receiver	
Maximum	-10 dBm ± 2 dBm
Minimum	-40 dBm ± 2 dBm
Spectrum	400 nm to 1100 nm
Attenuation	In the case of plastic optical fibers, you can expect a path attenuation of 0.2 dB/m Additional attenuation comes from the plug and sensor head.
Optical budget [1]	Minimal 25 dB
Analog sampling rate	16 kHz
ADC type	10-bit successive approximation
Transmitter	
Type	LED
Wavelength	λ = 650 nm
Transmit power	Minimum 0 dBm Maximum 2 dBm
Numerical aperture	0.5 [2]
Signal rate connection test	1 pulse per second
Pulse duration connection test	11 µs
Comment: [1] All values in combination with sensors approved by Siemens. [2] Numerical aperture (NA = sin θ (launch angle))	

High-Speed Measuring-Transducer Inputs, Voltage/Current (via IO210, IO212)

NOTE

Current and voltage may not be connected to a measuring-transducer input at the same time; only either current or voltage may be connected. Due to EMC, no line may be connected to an input that is not used (current or voltage).

Use shielded cables.

Table 12-1 High-Speed Measuring-Transducer Inputs, Voltage

Differential voltage input channels	8[27]
Measuring range	DC -10 V to +10 V
Fault	< 0.5 % of the measuring range
Input impedance	48 kΩ
Conversion principle	Delta-sigma (16 bit)
Permissible potential difference between channels	DC 3.5 kV
Galvanic separation from ground/ housing	DC 3.5 kV
Permissible overload	DC 20 V continuously DC 60 V continuously (IO210 MT3 terminal point C9)
Measurement repetition	62.5 µs

Table 12-2 High-Speed Measuring-Transducer Inputs, Current

Differential current input channels	8[28]

[27] The IO212 has 8 high-speed measuring-transducer inputs. They can be used either as a voltage or as a current input.
[28] The IO212 has 8 high-speed measuring-transducer inputs. They can be used either as a voltage or as a current input.

Measuring range	DC -20 mA to +20 mA
Fault	< 0.5 % of the measuring range
Input impedance, current	12 Ω
Conversion principle	Delta-sigma (16 bit)
Permissible potential difference between channels	DC 3.5 kV
Galvanic separation from ground/ housing	DC 3.5 kV
Permissible current overload	DC 100 mA continuously
Measurement repetition	62.5 µs

12.1.2 Supply Voltage

Integrated Power Supply			
For modular devices, the following printed circuit-board assemblies have a power supply: PS201 – Power supply of the base module and of the 1st device row PS203 – Voltage supply of 2nd device row CB202 – Plug in module assembly with integrated power supply, for example, to accommodate communication modules			
Permissible voltage ranges (PS201, PS203, CB202)	DC 19 V to DC 60 V	DC 48 V to DC 300 V AC 80 V to AC 265 V, 50 Hz/60 Hz	
Auxiliary rated voltage V_H (PS201, PS203, CB202)	DC 24 V/DC 48 V	DC 60 V/DC 110 V/DC 125 V/DC 220 V/ DC 250 V or AC 100 V/AC 115 V/AC 230 V, 50 Hz/60 Hz	
Permissible voltage ranges (PS101)	DC 19 V to DC 60 V	DC 48 V to 150 V	DC 88 V to DC 300 V AC 80 V to AC 265 V, 50 Hz/60 Hz
Auxiliary rated voltage V_H (PS101)	DC 24 V/DC 48 V	DC 60 V/DC 110 V/ DC 125 V	DC 110 V/ DC 125 V/ DC 220 V/DC 250 V or AC 100 V/AC 115 V/ AC 230 V, 50 Hz/60 Hz
Superimposed alternating voltage, peak-to-peak, IEC 60255-11		≤ 15% of the DC auxiliary rated voltage (applies only to direct voltage)	
Inrush current		≤ 18 A	
Recommended external protection		Miniature circuit breaker 6 A, characteristic C according to IEC 60898	
Internal fuse			
–	DC 24 V to DC 48 V	DC 60 V to DC 125 V	DC 24 V to DC 48 V AC 100 V to AC 230 V
PS101	4 A intert, AC 250 V, DC 150 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	2 A time-lag, AC 250 V, DC 300 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	
PS201, PS203, CB202	2 A time-lag, AC 250 V, DC 300 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20		
Power consumption (life relay active)			
–	DC	AC 230 V/50 Hz	AC 115 V/50 Hz

Integrated Power Supply			
1/3 base module, non-modular Without plug-in modules	7.0 W	16 VA	12.5 VA
1/3 base module, modular Without plug-in modules	13 W	33 VA	24 VA
1/6 expansion module	3 W	6 VA	6 VA
1/6 plug-in module assembly without plug-in modules (modules CB202)	3.5 W	14 VA	7 VA
Plug-in module for base module or plug-in module assembly (for example, communication module)	< 5 W	< 6 VA	< 6 VA
Stored-energy time for auxiliary voltage outage or short circuit, modular devices		For V ≥ DC 24 V ≥ 50 ms For V ≥ DC 110 V ≥ 50 ms For V ≥ AC 115 V ≥ 50 ms	
Stored-energy time for auxiliary voltage outage or short circuit, non-modular devices		For V ≥ DC 24 V ≥ 20 ms For V ≥ DC 60 V/DC 110 V ≥ 50 ms For V ≥ AC 115 V ≥ 200 ms	

12.1.3 Binary Inputs

Rated voltage range	DC 24 V to 250 V The binary inputs of SIPROTEC 5 are bipolar with the exception of the binary inputs on the IO230 and on the IO231.	
Current consumption, excited	Approx. DC 0.6 mA to 1.8 mA (independent of the operating voltage)	
Power consumption, max.	0.6 VA	
Pickup time	Approx. 3 ms	
Dropout time	Approx. 4 ms	
Switching thresholds	Adjustable with DIGSI 5	
	Range 1 for 24 V, 48 V, and 60 V Operating voltage	V_{low} ≤ DC 10 V V_{high} ≥ DC 19 V
	Range 2 for 110 V and 125 V Operating voltage	V_{low} ≤ DC 44 V V_{high} ≥ DC 88 V
	Range 3 for 220 V and 250 V Operating voltage	V_{low} ≤ DC 88 V V_{high} ≥ DC 176 V
Maximum permitted voltage	DC 300 V	
The binary inputs contain interference suppression capacitors. In order to ensure EMC, use the terminals shown in the terminal diagrams/connection diagrams to connect the binary inputs to the common potential.		

12.1.4 Relay Outputs

Standard Relay (Type S)

Switching capacity	On: 1000 W/VA Off: 30 VA; 40 W ohmic; 30 W/VA at L/R ≤ 40 ms
AC and DC contact voltage	250 V

Permissible current per contact (continuous)	5 A
Permissible current per contact (switching on and holding)	30 A for 1 s (make contact)
Short-time current across closed contact	250 A for 30 ms
Total permissible current for contacts connected to common potential	5 A
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	≤ 10 ms, typically 8 ms
Max. rated data of the output contacts in accordance with UL certification	DC 24 V, 8 A, General Purpose DC 48 V, 0.8 A, General Purpose DC 240 V, 0.1 A, General Purpose AC 240 V, 5 A, General Purpose AC 120 V, 1/3 hp AC 250 V, 1/2 hp B300 R300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V

Fast Relay (Type F)

Switching capacity	On: 1000 W/VA Off: 30 VA; 40 W ohmic; 30 W/VA at L/R ≤ 40 ms
AC and DC contact voltage	250 V
Permissible current per contact (continuous)	5 A
Permissible current per contact (switching on and holding)	30 A for 1 s (make contact)
Short-time current across closed contact	250 A for 30 ms
Total permissible current for contacts connected to common potential	5 A
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	Closing time, typical: 4 ms Opening time, typical: 2 ms ≤ 5 ms
Rated data of the output contacts in accordance with UL certification	AC 120 V, 8.5 A, General Purpose AC 277 V, 6 A, General Purpose AC 277 V, 0.7 hp AC 347 V, 4.5 A, General Purpose B300 R300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V
Supervision	2-channel activation with cyclic testing (only for make contact)

High-Speed Relay with Semiconductor Acceleration (Type HS)

Switching capacity	On/Off: 1000 W/VA
Contact voltage	AC 200 V, DC 250 V
Permissible current per contact (continuous)	5 A

Permissible current per contact (switching on and holding)	30 A for 1 s (make contact)
Short-time current across closed contact	250 A for 30 ms
Total permissible current for contacts connected to common potential	5 A
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used	Closing time, typical: 0.2 ms Opening time, typical: 6 ms Maximum: ≤ 9 ms
Rated data of the output contacts in accordance with UL certification	B150 Q300

Power Relay (for Direct Control of Motor Switches)

Switching capacity for permanent and periodic operation		
250 V/4.0 A 220 V/4.5 A 110 V/5.0 A 60 V/5.0 A 48 V/5.0 A 24 V/5.0 A	1000 W 1000 W 550 W 300 W 240 W 120 W	In order to prevent any damage, the external protection circuit must switch off the motor in case the rotor is blocked.
Turn on switching power for 30 s, recovery time until switching on again is 15 minutes. For short-term switching operations, an impulse/pause ratio of 3 % must be considered.		
100 V/9.0 A 60 V/10.0 A 48 V/10.0 A 24 V/10.0 A	1000 W 600 W 480 W 240 W	Continuous and inching operation is not permitted. In order to prevent any damage, the external protection circuit must switch off the motor in case the rotor is blocked.
AC and DC contact voltage		250 V
Permissible continuous current per contact		5 A
Permissible current per contact (switching on and holding)		30 A for 1 s
Short-time current across closed contact		250 A for 30 ms
Total permissible current for contacts connected to common potential		5 A
Switching time OOT (**O**utput **O**perating **T**ime) Additional delay of the output medium used		≤ 16 ms
Rated data of the output contacts in accordance with UL certification		DC 300 V, 10 A, Resistive DC 250 V, 1 hp motor - 30 s ON, 15 min OFF DC 110 V, 3/4 hp motor - 30 s ON, 15 min OFF DC 60 V, 1/2 hp motor - 30 s ON, 15 min OFF DC 48 V, 1/3 hp motor - 30 s ON, 15 min OFF DC 24 V, 1/6 hp motor - 30 s ON, 15 min OFF
Interference suppression capacitors across the contacts		4.7 nF, ± 20 %, AC 250 V
The power relays operate in interlocked mode, that is, only one relay of each switching pair picks up at a time thereby avoiding a power-supply short circuit.		

12.1.5 Design Data

Masses

	Device Size Weight of the Modular Devices				
Type of construction	1/3	1/2	2/3	5/6	1/1
Flush-mounting device	4.8 kg	8.1 kg	11.4 kg	14.7 kg	18.0 kg
Surface-mounted device with integrated on-site operation panel	7.8 kg	12.6 kg	17.4 kg	22.2 kg	27.0 kg
Surface-mounted device with detached on-site operation panel	5.1 kg	8.7 kg	12.3 kg	15.9 kg	19.5 kg

	Size	Weight
Detached on-site operation panel	1/3	1.9 kg
Detached on-site operation panel	1/6	1.1 kg

	Device Size Weight of the Non-Modular Devices 7xx82
Type of construction	1/3
Flush-mounting device	3.7 kg
Bracket for non-modular surface-mounting variant	1.9 kg

Dimensions of the Basic and 1/3 Modules

Type of Construction (Maximum Dimensions)	Width over all x Height over all x Depth [29](in Inches)
Flush-mounting device	150 mm x 268 mm x 229 mm (5.91 x 10.55 x 9.02)
Surface-mounted device with integrated on-site operation panel	150 mm x 314 mm x 337 mm (5.91 x 12.36 x 13.27)
Surface-mounted device with detached on-site operation panel	150 mm x 314 mm x 230 mm (5.91 x 12.36 x 9.06)

Dimensions of Device Rows

Type of Construction (Maximum Dimensions)	Width over all x Height over all x Depth [30](in Inches)				
Type of construction	1/3	1/2	2/3	5/6	1/1
Flush-mounting device	150 mm x 268 mm x 229 mm (5.91 x 10.55 x 9.02)	225 mm x 268 mm x 229 mm (8.86 x 10.55 x 9.02)	300 mm x 268 mm x 229 mm(11.81 x 10.55 x 9.02)	375 mm x 268 mm x 229 mm (14.76 x 10.55 x 9.02)	450 mm x 268 mm x 229 mm (17.72 x 10.55 x 9.02)
Surface-mounted device with integrated on-site operation panel	150 mm x 314 mm x 337 mm (5.91 x 12.36 x 13.27)	225 mm x 314 mm x 337 mm (8.86 x 12.36 x 13.27)	300 mm x 314 mm x 337 mm (11.81 x 12.36 x 13.27)	375 mm x 314 mm x 337 mm (14.76 x 12.36 x 13.27)	450 mm x 314 mm x 337 mm (17.72 x 12.36 x 13.27)

[29] Width and depth rounded to whole numbers in mm
[30] Width and depth rounded to whole numbers in mm

Type of Construction (Maximum Dimensions)	Width over all x Height over all x Depth [30](in Inches)				
Surface-mounted device with detached on-site operation panel	150 mm x 314 mm x 230 mm (5.91 x 12.36 x 9.06)	225 mm x 314 mm x 230 mm (8.86 x 12.36 x 9.06)	300 mm x 314 mm x 230 mm (11.81 x 12.36 x 9.06)	375 mm x 314 mm x 230 mm (14.76 x 12.36 x 9.06)	450 mm x 314 mm x 230 mm (17.72 x 12.36 x 9.06)

Expansion Module Dimensions

Type of Construction (Maximum Dimensions)	Width x Height x Depth [31] (in Inches)
Flush-mounting device	75 mm x 268 mm x 229 mm (2.95 x 10.55 x 9.02)
Surface-mounted device with integrated on-site operation panel	75 mm x 314 mm x 337 mm (2.95 x 12.36 x 13.27)
Surface-mounted device with detached on-site operation panel	75 mm x 314 mm x 230 mm (2.95 x 12.36 x 9.06)

Plug-In Module Dimensions

Type of Construction (Maximum Dimensions)	Width x Height x Depth (in Inches)
USART-Ax-xEL, ETH-Bx-xEL	61 mm x 45 mm x 120.5 mm (2.4 x 1.77 x 4.74)
USART-Ax-xFO, ETH-Bx-xFO (without protection cover)	61 mm x 45 mm x 132.5 mm (2.4 x 1.77 x 5.22)
ANAI-CA-4EL	61 mm x 45 mm x 119.5 mm (2.4 x 1.77 x 4.7)
ARC-CD-3FO	61 mm x 45 mm x 120.5 mm (2.4 x 1.77 x 4.74)

Minimum Bending Radii of the Connecting Cables Between the On-Site Operation Panel and the Base Module

Fiber-optic cable	R = 50 mm Pay attention to the length of the cable protection sleeve, which you must also include in calculations.
D-Sub cable	R = 50 mm (minimum bending radius)

Degree of Protection to IEC 60529

For equipment in the surface-mounting housing	IP50
For equipment in the flush-mounting housing	Front IP51 Back side of the modular devices IP50 Back side of the non-modular devices IP40
For operator protection	IP2x for current terminal (installed removed) IP1x for voltage terminal (removed/without cover) IP2x for voltage terminal (removed/with cover) IP2x for voltage terminal (installed)
Degree of pollution, IEC 60255-27	2
Maximum altitude above sea level	2000 m (6561.68 ft)

[30] Width and depth rounded to whole numbers in mm
[31] Width and depth rounded to whole numbers in mm

UL Note

Type 1 if mounted into a door or front cover of an enclosure. When expanding the device with the 2nd device row, then they must be mounted completely inside an enclosure.

Tightening Torques for Terminal Screws

Type of Line	Current Terminal	Voltage Terminal with Spring-Loaded Terminals	Voltage Terminal with Screw Connection
Litz wire with ring-type lug	2.7 Nm	No ring-type lug	No ring-type lug
Stranded wires with boot-lace ferrules or pin-type lugs	2.7 Nm	1.0 Nm	0.6 Nm
Solid conductor, bare (2 mm^2)	2.0 Nm	1.0 Nm	–



NOTE

Use copper cables only.

Torques for Other Screw Types

Screw Type	Torque
M4 x 20	1.2 Nm
M4 x 8	1.2 Nm
M2.5 x 6	0.39 Nm
Countersunk screw, M2.5 x 6	0.39 Nm
Countersunk screw, M2.5 x 8	0.39 Nm
Collar screw, M4 x 20	0.7 Nm

12.2 Protection Interface and Protection Topology

Setting Values

Mode	On Off	
PPS Synchronization	Telegr. and PPS Telegr. or PPS PPS synchronization off	
Blocking of the unbalanced runtimes	Yes No	
Maximum signal runtime threshold	0.1 ms to 30.0 ms	Increments of 0.1 ms
Maximum runtime difference	0.000 ms to 3.000 ms	Increments of 0.001 ms
Failure indication after	0.05 s to 2.00 s	Increments of 0.01 s
Failure indication after	0.0 s to 6.0 s	Increments of 0.1 s
Max. error rate/h	0.000 % to 100.000 %	Increments of 0.001 %
Max. error rate/min	0.000 % to 100.000 %	Increments of 0.001 %
PPS failure indication after	0.5 s to 60.0 s	Increments of 0.1 s

Transmission Rate

Direct connection:	
Transmission rate	2048 kbit/s
Connection via communication networks:	
Supported network interfaces	G703.1 with 64 kBit/s G703-T1 with 1.455 MBit/s G703-E1 with 2.048 MBit/s
	X.21 with 64 kBit/s or 128 kBit/s or 512 kBit/s
	Pilot wires with 128 kbit/s
Transmission rate	64 kBit/s at G703.1 1.455 MBit/s at G703-T1 2.048 MBit/s at G703-E1
	512 kBit/s or 128 kBit/s or 64 kBit/s at X.21
	128 kBit/s for pilot wires

Transmission Times

Priority 1		
Response time, total approx.		
For 2 ends	Minimum	8 ms
	Typical	10 ms
For 3 ends	Minimum	10 ms
	Typical	14 ms
For 6 ends	Minimum	15 ms
	Typical	18 ms
Dropout times, total approx.		
For 2 ends	Typical	20 ms
For 3 ends	Typical	20 ms
For 6 ends	Typical	26 ms

Priority 2		
Response time, total approx.		
For 2 ends	Minimum	9 ms
	Typical	16 ms
For 3 ends	Minimum	12 ms
	Typical	18 ms
For 6 ends	Minimum	17 ms
	Typical	23 ms
Dropout times, total approx.		
For 2 ends	Typical	24 ms
For 3 ends	Typical	25 ms
For 6 ends	Typical	32 ms

Priority 3[32]		
Response time, total approx.		
For 2 ends	Minimum	
	Typical	100 ms
For 3 ends	Minimum	
	Typical	150 ms
For 6 ends	Minimum	
	Typical	200 ms
Dropout times, total approx.		
For 2 ends	Typical	100 ms
For 3 ends	Typical	150 ms
For 6 ends	Typical	200 ms

[32] Times cannot be determined because the signals are transmitted in fragments.

12.3 Date and Time Synchronization

Date format	DD.MM.YYYY (Europe)
	MM/DD/YYYY (USA)
	YYYY-MM-DD (China)
Time source 1, time source 2	None
	IRIG-B 002(003) IRIG-B 006(007) IRIG-B 005(004) with extension according to IEEE C37.118-2005
	DCF77
	PI (protection interface)[33]
	SNTP
	IEC 60870-5-103
	DNP3
	IEEE 1588
Time zone 1, time zone 2	Local
	UTC
Failure indication after	0 s to 3600 s
Time zone and daylight saving time	Transfer of PC settings
	Manually setting the time zones
Time zone offset with respect to GMT	-720 min to 840 min
Switching over to daylight saving time	Active
	Inactive
Beginning of daylight saving time	Input: day and time
End of daylight saving time	Input: day and time
Offset daylight saving time	-120 to 120 [steps of 15]

[33] If provided

12.4 Analog-Units Function Group

20-mA Unit Ether. 7XV5674-0KK00-1AA1

Max. number of connected 20-mA units	4
Max. number of channels per 20-mA unit	12

20-mA Unit Serial 7XV5674-0KK30-1AA1 (RS485) and 7XV5674-0KK40-1AA1 (fiberglass)

Max. number of connected 20-mA units	4
Max. number of channels per 20-mA unit	12

RTD Unit (Ziehl TR1200) 7XV5662-6AD10

Max. number of connected RTD units	4
Max. number of sensors per RTD unit	12
Sensor type	Pt 100 as per EN 60751

RTD Unit (Ziehl TR1200 IP) 7XV5662-8AD10

Max. number of connected RTD units	4
Max. number of sensors per RTD unit	12
Sensor type	Pt 100 as per EN 60751; connection of Ni 100 and Ni 120 sensors possible. The measured values must be converted in the evaluation unit.

Temperature Measured Values

Unit of measurement for temperature	°C or °F, can be adjusted
Pt 100	-199 °C to 800 °C (-326 °F to 1472 °F)
Resolution	1 °C or 1 °F
Tolerance	±0.5 % of the measured value ±1 K

12.5 Overcurrent Protection, Phases

12.5.1 Stage with Definite-Time Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	–
Threshold value[34]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s
Pickup delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT [35] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

[34] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

[35] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value, no filter applied (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	2 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[36] (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1.5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [37]
Up to 50th harmonic, f_{rated} = 50 Hz	3% of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [38]
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [39]
Time delays	1 % of the setting value or 10 ms

[36] In case that the filter response exactly matches the user-defined gain factors
[37] In case that the user-defined gain factor is set below 3. The tolerance increases, if the gain factor is larger.
[38] 3 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.
[39] 3 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.5.2 Stage with Inverse-Time Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.00 to 15.00	Increments of 0.01
Pickup delay		0.00 s to 60.00 s	Increments of 0.01 s
Minimum time of the curve		0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

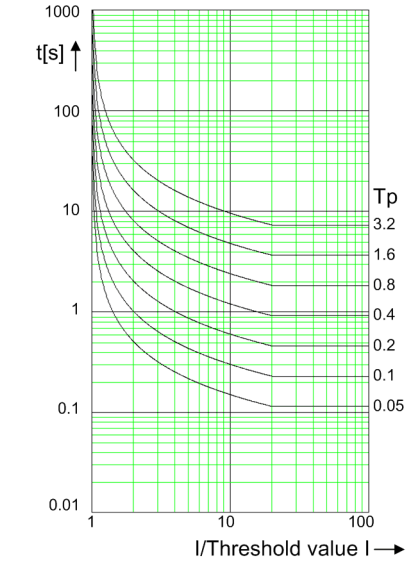
Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

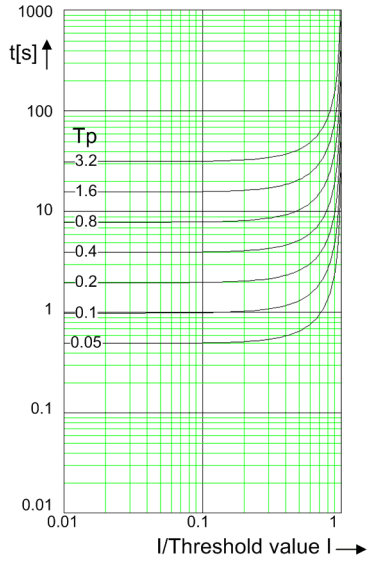
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

NORMAL INVERSE: Type A



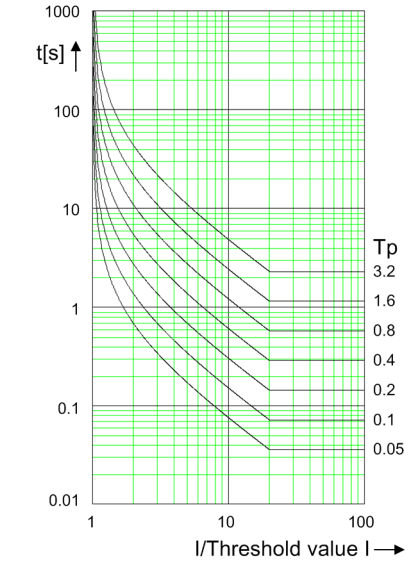
$$t = \frac{0.14}{(I/\text{Threshold value } I)^{0.02} - 1} \cdot T_p \ [s]$$

RESET NORMAL INVERSE: Type A



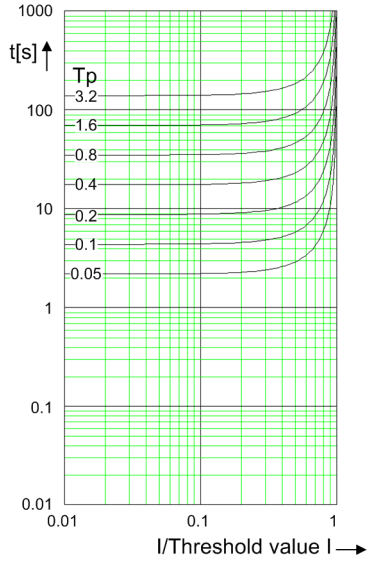
$$t = \frac{9.7}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

VERY INVERSE: Type B



$$t = \frac{13.5}{(I/\text{Threshold value } I)^{1} - 1} \cdot T_p \ [s]$$

RESET VERY INVERSE: Type B

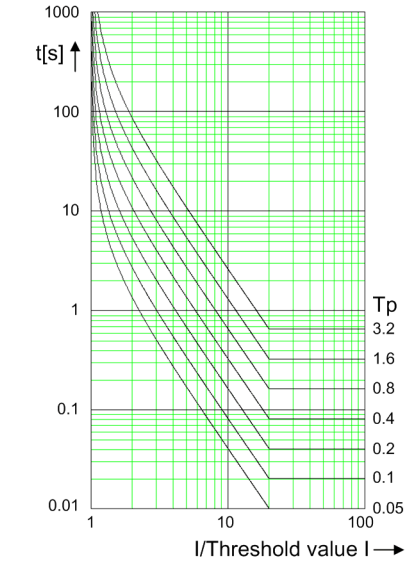


$$t = \frac{43.2}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

[dwocpki1-080213-01.tif, 1, en_US]

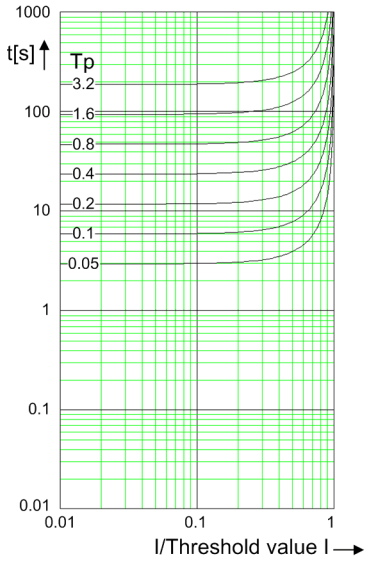
Figure 12-1 Operate Curves and Dropout-Time Characteristic Curves According to IEC

EXTREMELY INVERSE: Type C



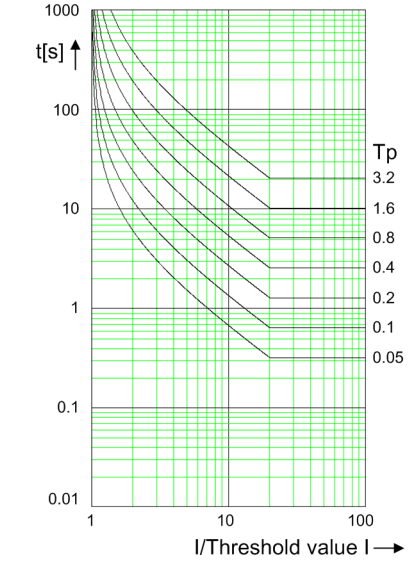
$$t = \frac{80}{(I/\text{Threshold value } I)^2 - 1} \cdot T_p \ [s]$$

RESET EXTREMELY INVERSE: Type C



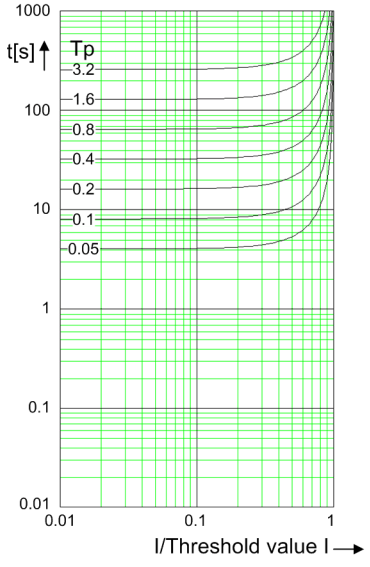
$$t = \frac{58.2}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

LONG-TIME INVERSE: Type B



$$t = \frac{120}{(I/\text{Threshold value } I)^1 - 1} \cdot T_p \ [s]$$

RESET LONG-TIME INVERSE: Type B



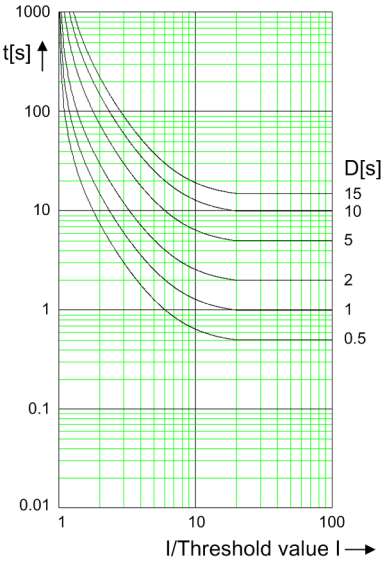
$$t = \frac{80}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

[dwocpki2-080213-01.tif, 1, en_US]

Figure 12-2 Operate Curves and Dropout-Time Characteristic Curves According to IEC

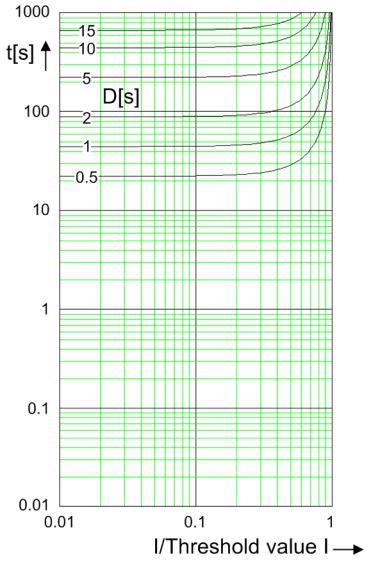
Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Inverse: Type C



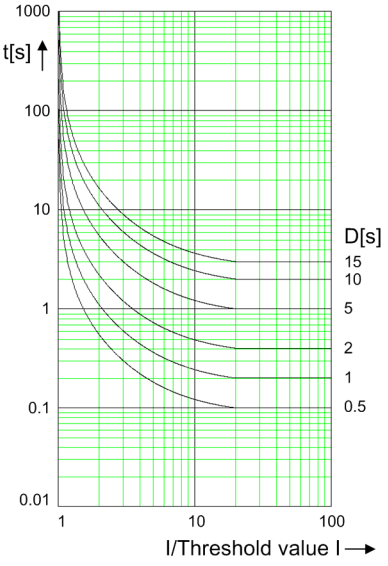
$$t = \left(\frac{44.6705}{\left(\text{I/Threshold value I} \right)^{2.0938} - 1} + 0.8983 \right) \cdot D \quad [s]$$

RESET INVERSE: Type C



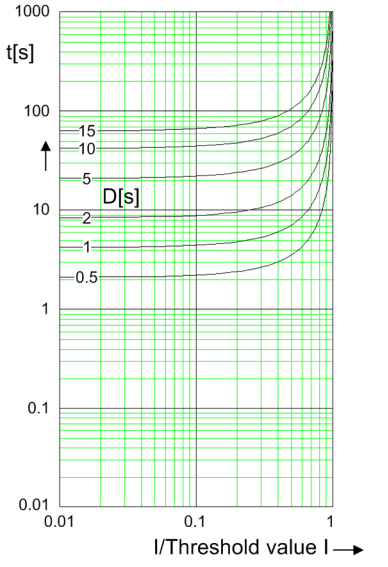
$$t = \frac{44}{1 - \left(\text{I/Threshold value I} \right)^{2.0938}} \cdot D \quad [s]$$

SHORT INVERSE



$$t = \left(\frac{1.3315}{\left(\text{I/Threshold value I} \right)^{1.2969} - 1} + 0.16965 \right) \cdot D \quad [s]$$

RESET SHORT INVERSE

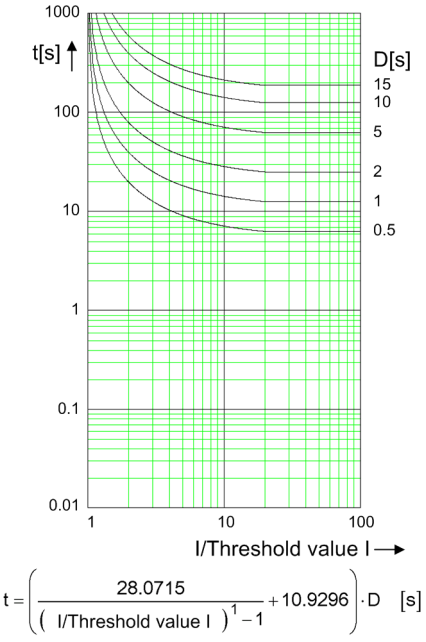


$$t = \frac{4.155}{1 - \left(\text{I/Threshold value I} \right)^{1.2969}} \cdot D \quad [s]$$

[dwocpka1-080213-01.tif, 2, en_US]

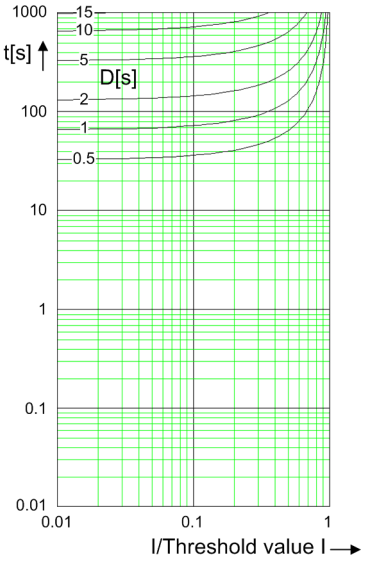
Figure 12-3 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

LONG INVERSE



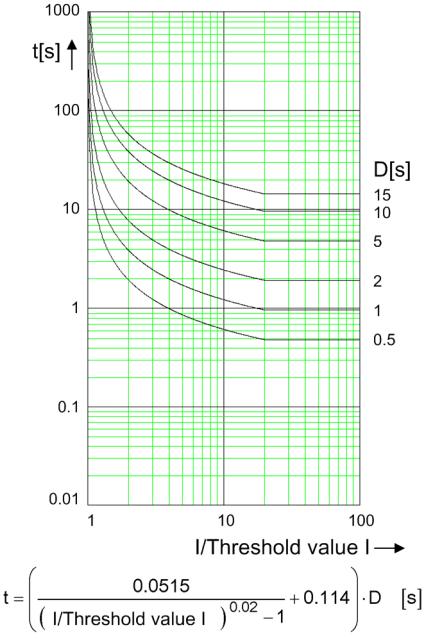
$$t = \left(\frac{28.0715}{\left(\text{I/Threshold value I} \right)^{1} - 1} + 10.9296 \right) \cdot D \quad [s]$$

RESET LONG INVERSE



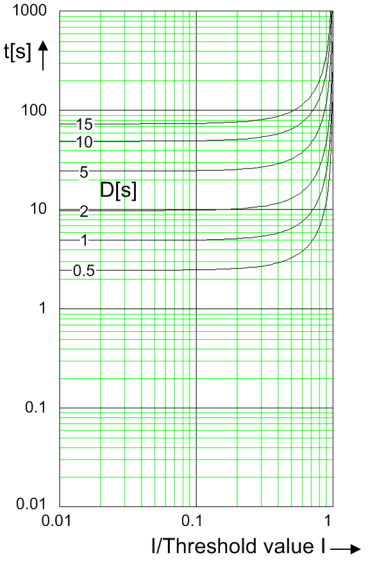
$$t = \frac{64.5}{1 - \left(\text{I/Threshold value I} \right)^{1}} \cdot D \quad [s]$$

MODERATELY INVERSE



$$t = \left(\frac{0.0515}{\left(\text{I/Threshold value I} \right)^{0.02} - 1} + 0.114 \right) \cdot D \quad [s]$$

RESET MODERATELY INVERSE

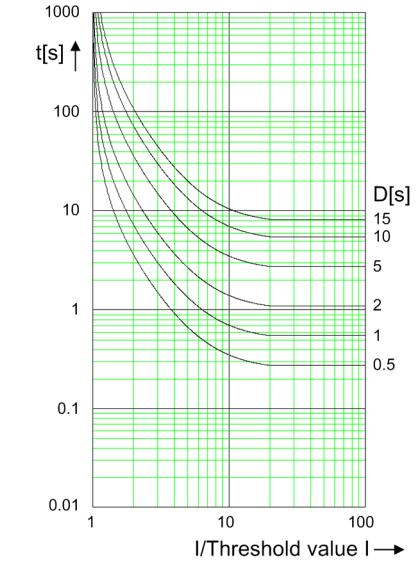


$$t = \frac{4.85}{1 - \left(\text{I/Threshold value I} \right)^{2}} \cdot D \quad [s]$$

[dwocpka2-080213-01.tif, 2, en_US]

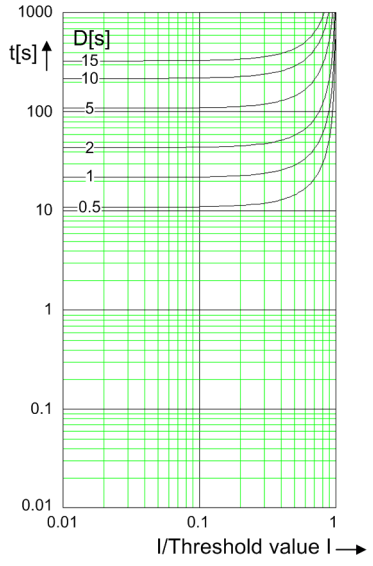
Figure 12-4 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

VERY INVERSE



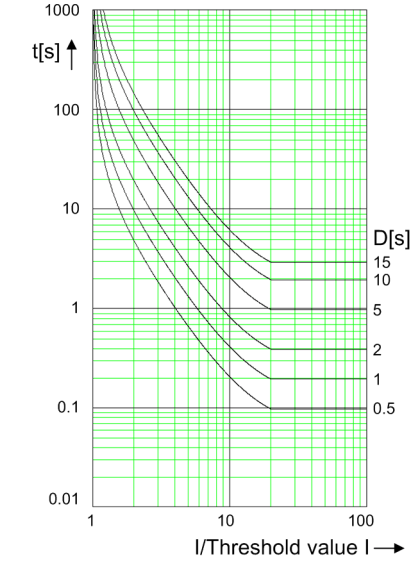
$$t = \left(\frac{19.61}{\left(\text{I/Threshold value I} \right)^2 - 1} + 0.491 \right) \cdot D \quad [s]$$

RESET VERY INVERSE



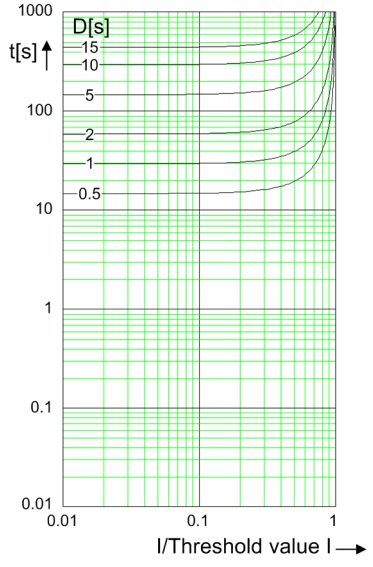
$$t = \frac{21.6}{1 - \left(\text{I/Threshold value I} \right)^2} \cdot D \quad [s]$$

EXTREMELY INVERSE



$$t = \left(\frac{28.2}{\left(\text{I/Threshold value I} \right)^2 - 1} + 0.1217 \right) \cdot D \quad [s]$$

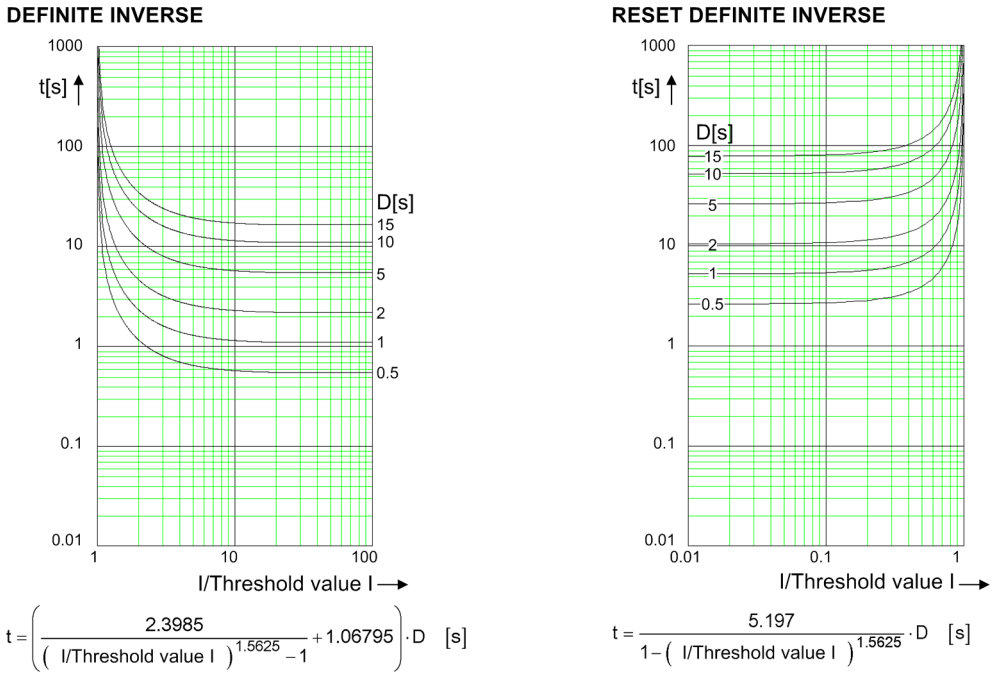
RESET EXTREMELY INVERSE



$$t = \frac{29.1}{1 - \left(\text{I/Threshold value I} \right)^2} \cdot D \quad [s]$$

[dwocpka3-080213-01.tif, 2, en_US]

Figure 12-5 Tripping Characteristic Curves and Dropout Characteristic Curves According to ANSI/IEEE



Note: IGnd threshold stands for ground fault instead ot the I threshold.

[dwocpka4-080213-01.tif, 2, en_US]

Figure 12-6 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value, no filter applied (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

Up to 50th harmonic, f_{rated} = 50 Hz	2 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[40] (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1.5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [41]
Up to 50th harmonic, f_{rated} = 50 Hz	3% of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [42]
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [43]
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.5.3 Stage with User-Defined Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–

[40] In case that the filter response exactly matches the user-defined gain factors
[41] In case that the user-defined gain factor is set below 3. The tolerance increases, if the gain factor is larger.
[42] 3 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.
[43] 3 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

Time multiplier	0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve	2 to 30	Increments of 1
X values of the operate curve	1.00 p.u. to 66.67 p.u.	Increments of 0.01 p.u.
Y values of the operate curve	0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve	2 to 30	Increments of 1
X values of the dropout characteristic curve	0.05 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve	0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value, no filter applied (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

Currents, method of measurement = RMS value with filter for the compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	2 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[44] (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1.5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [45]
Up to 50th harmonic, f_{rated} = 50 Hz	3% of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [46]
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [47]
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

[44] In case that the filter response exactly matches the user-defined gain factors
[45] In case that the user-defined gain factor is set below 3. The tolerance increases, if the gain factor is larger.
[46] 3 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.
[47] 3 In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

12.6 Voltage-Dependent Overcurrent Protection, Phases

Setting Values for All Stage Types

Method of measurement		Fundamental component RMS value	–
Overcurrent threshold value	For I_{rated} = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
Time delay		0.10 s to 60.00 s	Increments of 0.01 s

Setting Values for Inverse Time-Overcurrent Stages

Method of measurement	Fundamental component RMS value	–
Dropout ratio of undervoltage[48]	1.01 to 1.20	Increments of 0.01
Undervoltage threshold value[48]	0.300 V to 175.000 V	Increments of 0.001 V
Dropout	Disk emulation Instantaneous	–
Time multiplier	0.05 to 15.00	Increments of 0.01

Setting Values for Definite Time-Overcurrent Stages

Seal-in voltage	0.300 V to 175.000 V	Increments of 0.001 V
Phase-to-phase voltage	0.300 V to 175.000 V	Increments of 0.001 V
Negative-sequence voltage V2	0.300 V to 200.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Duration of V-seal-in time	0.10 s to 60.00 s	Increments of 0.01 s

Dropout for Inverse Time-Overcurrent Stages

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	
Current	95 % of 1.1 · threshold value
Voltage[48]	105 % of threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer [48]	150 mV sec.

Reset of the Integration Timer for Inverse Time-Overcurrent Stages

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

[48] The value is for the inverse time-overcurrent voltage-released stage.

Dropout for Definite Time-Overcurrent Stages

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with inrush-current detection	Approx. 10 ms

The operate curves and dropout-time characteristic curves according to IEC can be found in the chapter Technical Data under Inverse-Time Overcurrent Protection.

Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

The operate curves and dropout-time characteristic curves according to IEC can be found in the chapter Technical Data under Inverse-Time Overcurrent Protection.

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % part of harmonic in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Voltage	0.5 % of the setting value or 0.05 V
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.7 Overcurrent Protection, Ground

12.7.1 Stage with Definite-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[49]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[50] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

[49] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

[50] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

Tolerances

3I0 measured via I4[51], method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
3I0 measured via I4[52], method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.7.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[53]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.00 to 15.00	Increments of 0.01
Minimum time of the curve		0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

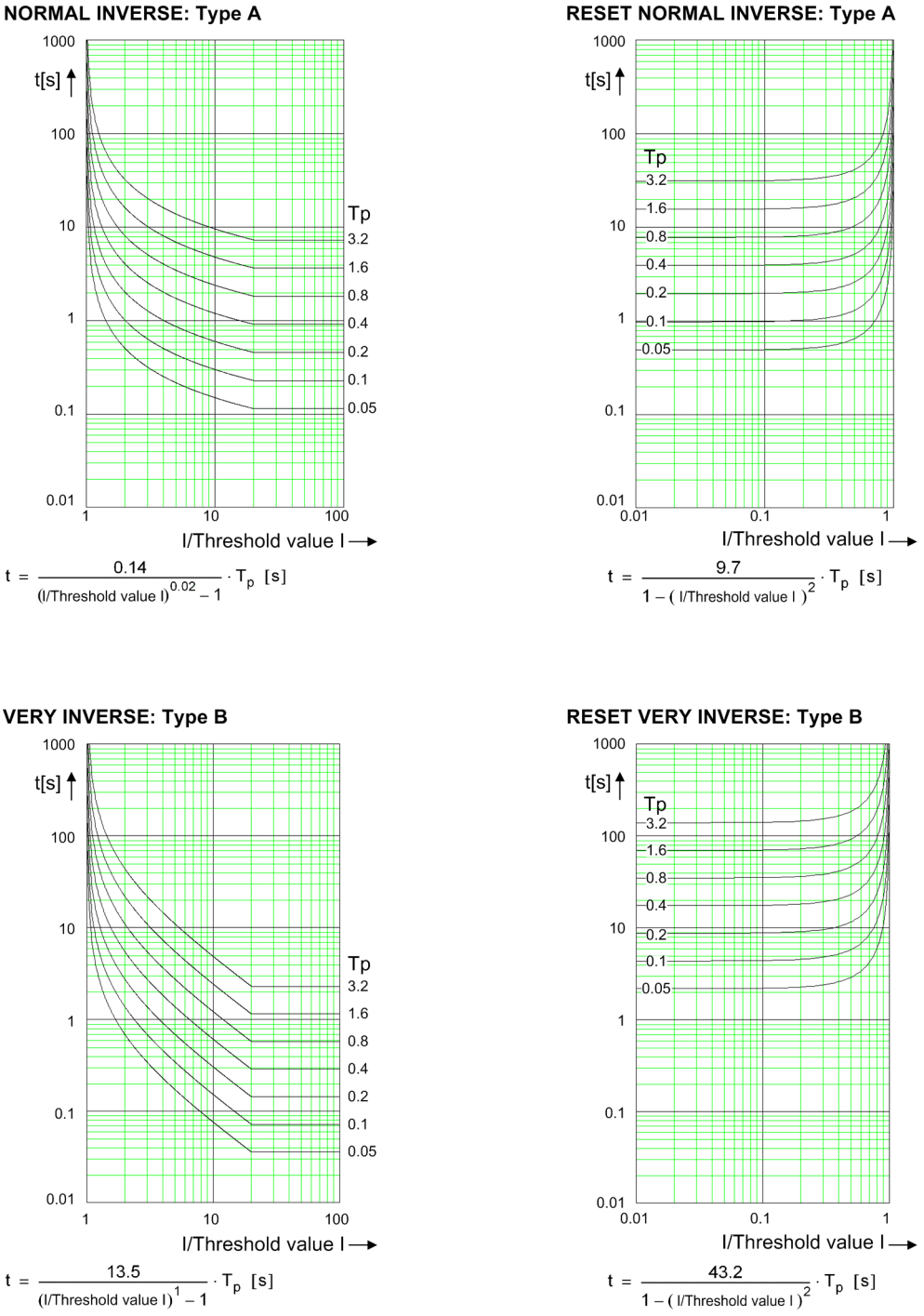
[51] Slightly expanded tolerances will occur during the calculation of 3I0, maximum factor of 2
[52] Slightly expanded tolerances will occur during the calculation of 3I0, maximum factor of 2
[53] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves According to IEC

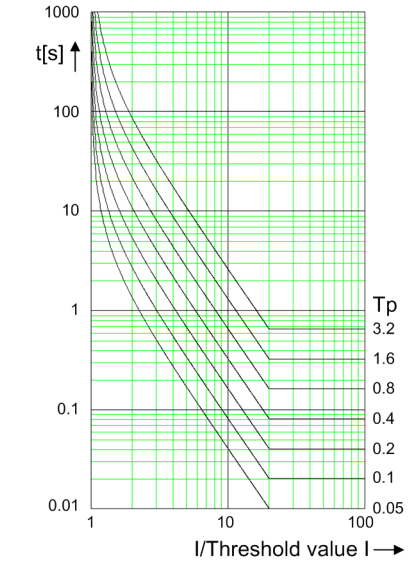
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms



[dwocpki1-080213-01.tif, 1, en_US]

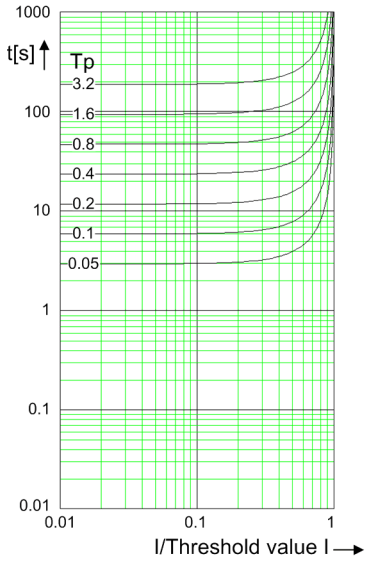
Figure 12-7 Operate Curves and Dropout-Time Characteristic Curves According to IEC

EXTREMELY INVERSE: Type C



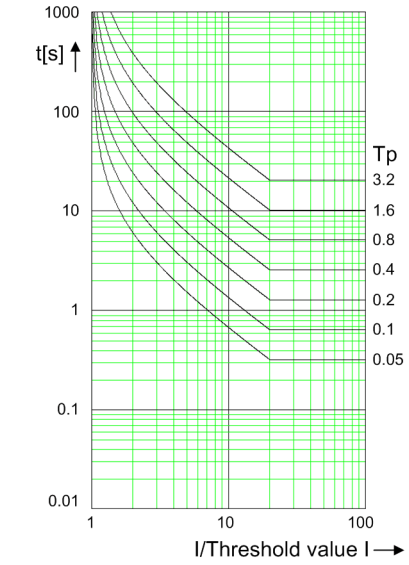
$$t = \frac{80}{(I/\text{Threshold value } I)^2 - 1} \cdot T_p \ [s]$$

RESET EXTREMELY INVERSE: Type C



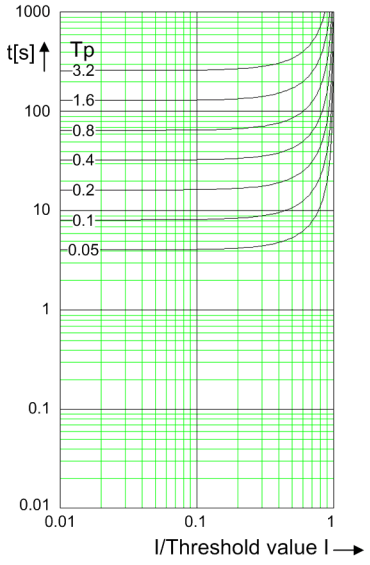
$$t = \frac{58.2}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

LONG-TIME INVERSE: Type B



$$t = \frac{120}{(I/\text{Threshold value } I)^1 - 1} \cdot T_p \ [s]$$

RESET LONG-TIME INVERSE: Type B



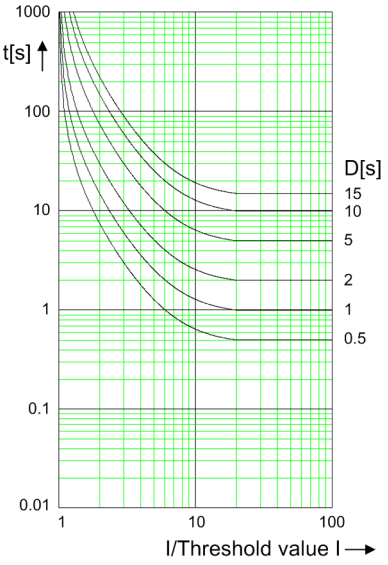
$$t = \frac{80}{1 - (I/\text{Threshold value } I)^2} \cdot T_p \ [s]$$

[dwocpki2-080213-01.tif, 1, en_US]

Figure 12-8 Operate Curves and Dropout-Time Characteristic Curves According to IEC

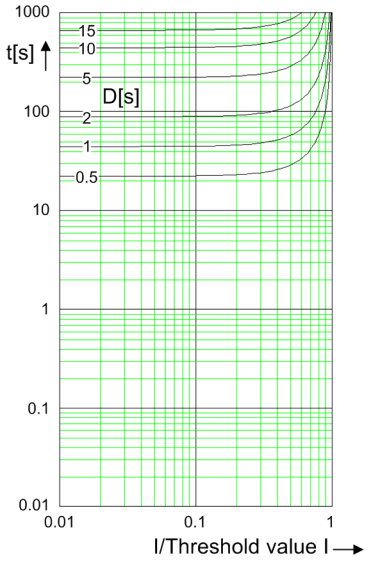
Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Inverse: Type C



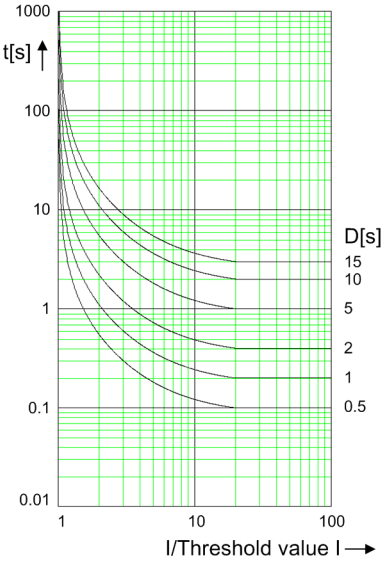
$$t = \left(\frac{44.6705}{\left(\text{I/Threshold value I} \right)^{2.0938} - 1} + 0.8983 \right) \cdot D \quad [s]$$

RESET INVERSE: Type C



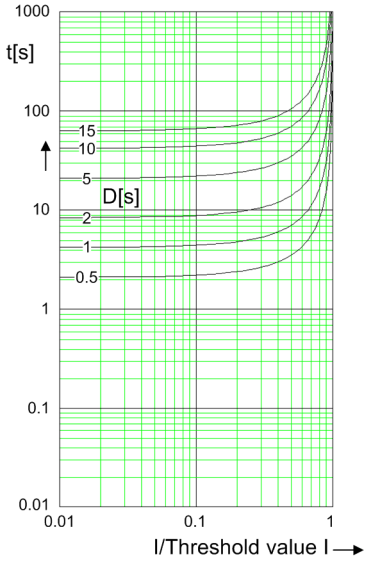
$$t = \frac{44}{1 - \left(\text{I/Threshold value I} \right)^{2.0938}} \cdot D \quad [s]$$

SHORT INVERSE



$$t = \left(\frac{1.3315}{\left(\text{I/Threshold value I} \right)^{1.2969} - 1} + 0.16965 \right) \cdot D \quad [s]$$

RESET SHORT INVERSE

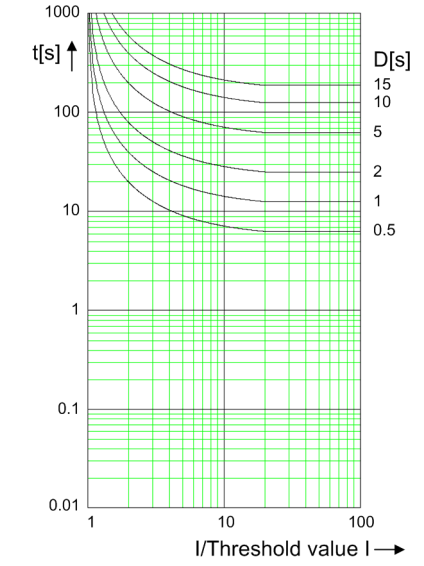


$$t = \frac{4.155}{1 - \left(\text{I/Threshold value I} \right)^{1.2969}} \cdot D \quad [s]$$

[dwocpka1-080213-01.tif, 2, en_US]

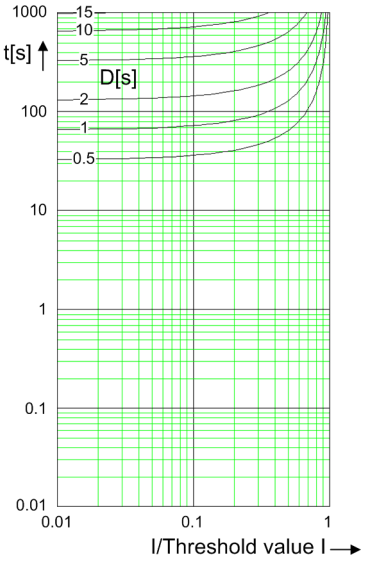
Figure 12-9 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

LONG INVERSE



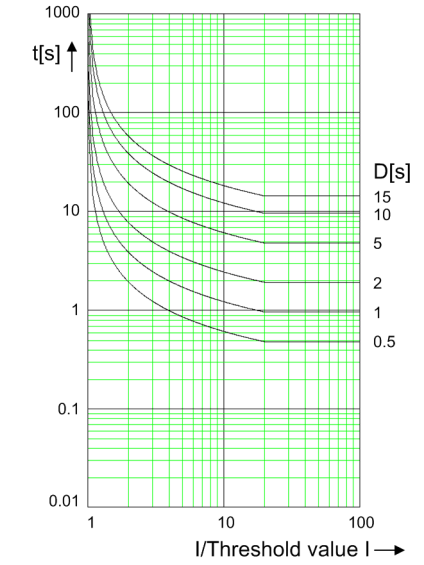
$$t = \left(\frac{28.0715}{\left(\text{I/Threshold value I} \right)^{1} - 1} + 10.9296 \right) \cdot D \quad [s]$$

RESET LONG INVERSE



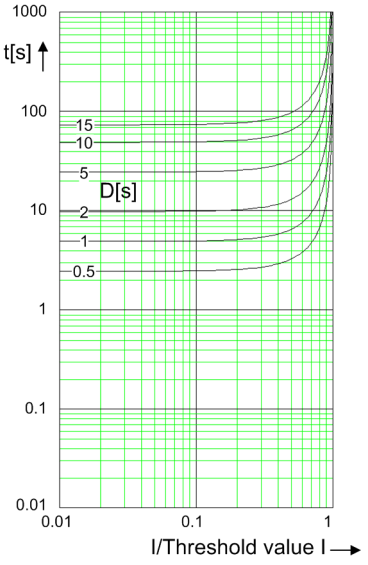
$$t = \frac{64.5}{1 - \left(\text{I/Threshold value I} \right)^{1}} \cdot D \quad [s]$$

MODERATELY INVERSE



$$t = \left(\frac{0.0515}{\left(\text{I/Threshold value I} \right)^{0.02} - 1} + 0.114 \right) \cdot D \quad [s]$$

RESET MODERATELY INVERSE

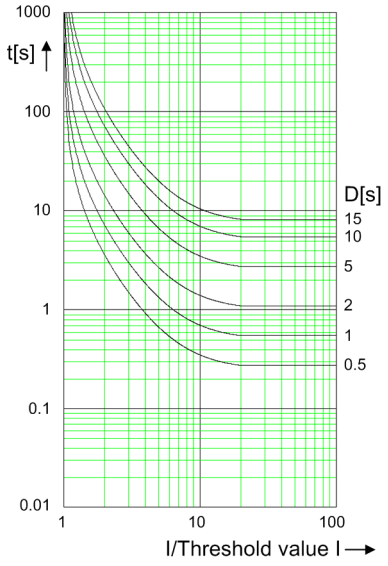


$$t = \frac{4.85}{1 - \left(\text{I/Threshold value I} \right)^{2}} \cdot D \quad [s]$$

[dwocpka2-080213-01.tif, 2, en_US]

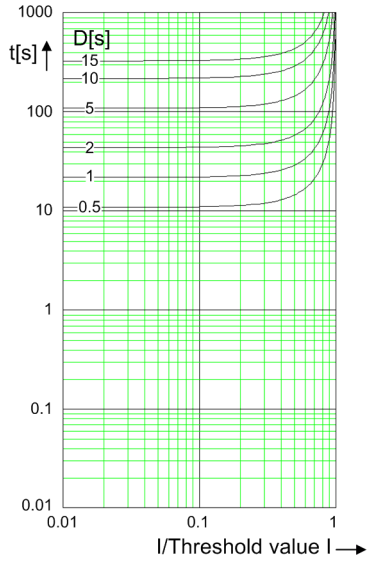
Figure 12-10 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

VERY INVERSE



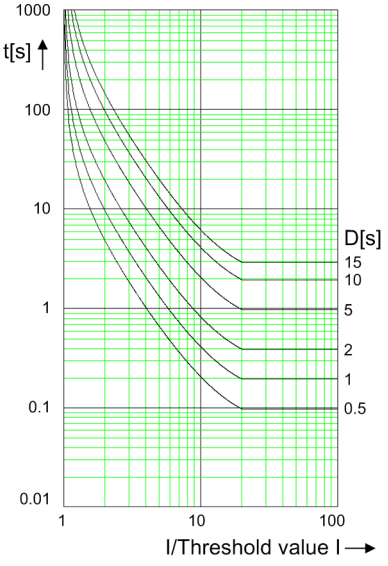
$$t = \left(\frac{19.61}{\left(\text{I/Threshold value I} \right)^2 - 1} + 0.491 \right) \cdot D \quad [s]$$

RESET VERY INVERSE



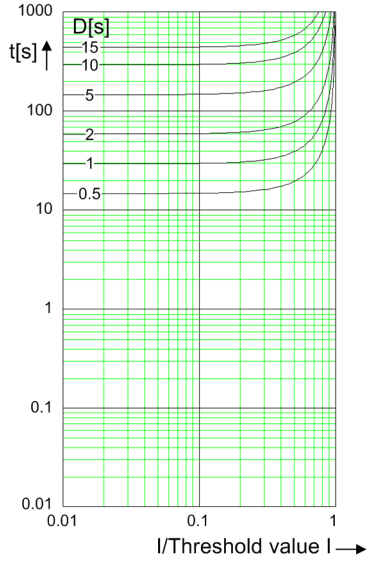
$$t = \frac{21.6}{1 - \left(\text{I/Threshold value I} \right)^2} \cdot D \quad [s]$$

EXTREMELY INVERSE



$$t = \left(\frac{28.2}{\left(\text{I/Threshold value I} \right)^2 - 1} + 0.1217 \right) \cdot D \quad [s]$$

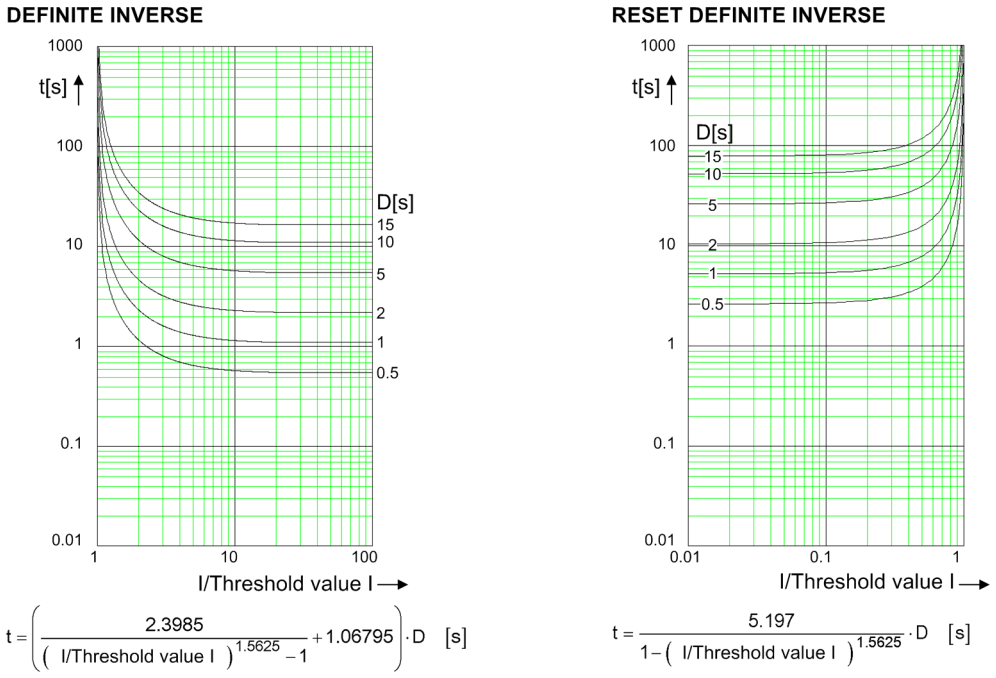
RESET EXTREMELY INVERSE



$$t = \frac{29.1}{1 - \left(\text{I/Threshold value I} \right)^2} \cdot D \quad [s]$$

[dwocpka3-080213-01.tif, 2, en_US]

Figure 12-11 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE



Note: IGnd threshold stands for ground fault instead ot the I threshold.

[dwocpka4-080213-01.tif, 2, en_US]

Figure 12-12 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

3I0 measured via I4[54], method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
3I0 measured via I4[55], method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

[54] Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2
[55] Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

Dropout time for 2 ≤ I/threshold value I ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.7.3 Stage with User-Defined Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.00 p.u. to 66.67 p. u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p. u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances

f < 10 Hz f > 80 Hz	Active

Tolerances

3I0 measured via I4[56], method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
3I0 measured via I4[57], method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

[56] Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2
[57] Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

12.8 Directional Overcurrent Protection, Phases

12.8.1 Stage with Definite-Time Characteristic Curve

Setting Values

Rotation angle of the reference voltage		-180° to +180°	Increments of 1°
Directional mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value[58]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Direction Determination

Type	With externally generated voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°
Dropout differential forward/reverse range	1°
Directional sensitivity	Unlimited for 1 and 2-phase short circuits Dynamically unlimited, stationary for 3-phase short circuits Approx. 13 V phase-to-phase

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT [59] at 50 Hz Approx. 22 ms + OOT at 60 Hz

[58] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

[59] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delay	1 % of the setting value or 10 ms
Direction-determination angle error	1 °

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.8.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Rotation angle of the reference voltage		-180° to +180°	Increments of 1°
Directional mode		Forward Backward	–
Method of measurement		Fundamental component RMS value	–
Threshold value[60]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–

[60] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

Time multiplier	0.00 to 15.00	Increments of 0.01
Minimum time of the curve	0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Normal inverse: type A	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-1*
Very inverse: type B	
Extremely inverse: type C	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-2*
Long-time inverse: type B	

Operate Curves and Dropout-Time Characteristic Curves according to ANSI/IEEE

Inverse: type C	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-3*
Short inverse	
Long inverse	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-4*
Moderately inverse	
Very inverse	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-5*
Extremely inverse	
Definite inverse	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve*, *Figure 12-6*

Direction Determination

Type	With externally generated voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°
Dropout differential forward/reverse range	1°
Directional sensitivity	Unlimited for 1 and 2-phase short circuits Dynamically unlimited, stationary for 3-phase short circuits Approx. 13 V phase-to-phase

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT [61] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for $2 \leq$ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.8.3 Stage with User-Defined Characteristic Curve

Setting Values

Rotation angle of the reference voltage	-180° to +180°	Increments of 1°
Directional mode	Forward Reverse	–
Method of measurement	Fundamental component RMS value	–

[61] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Threshold value[62]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Insatantaneous	-
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate characteristic curve		2 to 30	Increments of 1
X values of the operate curve		1.00 p.u. to 66.67 p.u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Direction Determination

Type	With externally generated voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°
Dropout differential forward/reverse range	1°
Directional sensitivity	Unlimited for 1 and 2-phase short circuits Dynamically unlimited, stationary for 3-phase short circuits Approx. 13 V phase-to-phase

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT [63] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

[62] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

[63] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for $2 \leq$ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.9 Directional Overcurrent Protection, Ground

12.9.1 Stage with Definite-Time Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances

10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.9.2 Stage with Inverse-Time Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Type of characteristic curve		Characteristic curves according to IEC and ANSI	
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.00 to 15.00	Increments of 0.01

Minimum time of the curve	0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Normal inverse: type A	Refer to the respective figure of the technical data for the non-dir-OC-ground function *12.7.2 Stage with Inverse-Time Characteristic Curve*
Very inverse: type B	
Extremely inverse: type C	
Long-time inverse: type B	

Operate Curves and Dropout-Time Characteristic Curves according to ANSI/IEEE

Inverse: type C	Refer to the respective figure of the technical data for the non-dir-OC-ground function *12.7.2 Stage with Inverse-Time Characteristic Curve*
Short inverse	
Long inverse	
Moderately inverse	
Very inverse	
Extremely inverse	
Definite inverse	

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.9.3 Stage with Inverse Time-Overcurrent Protection with Logarithmic-Inverse Characteristic Curve

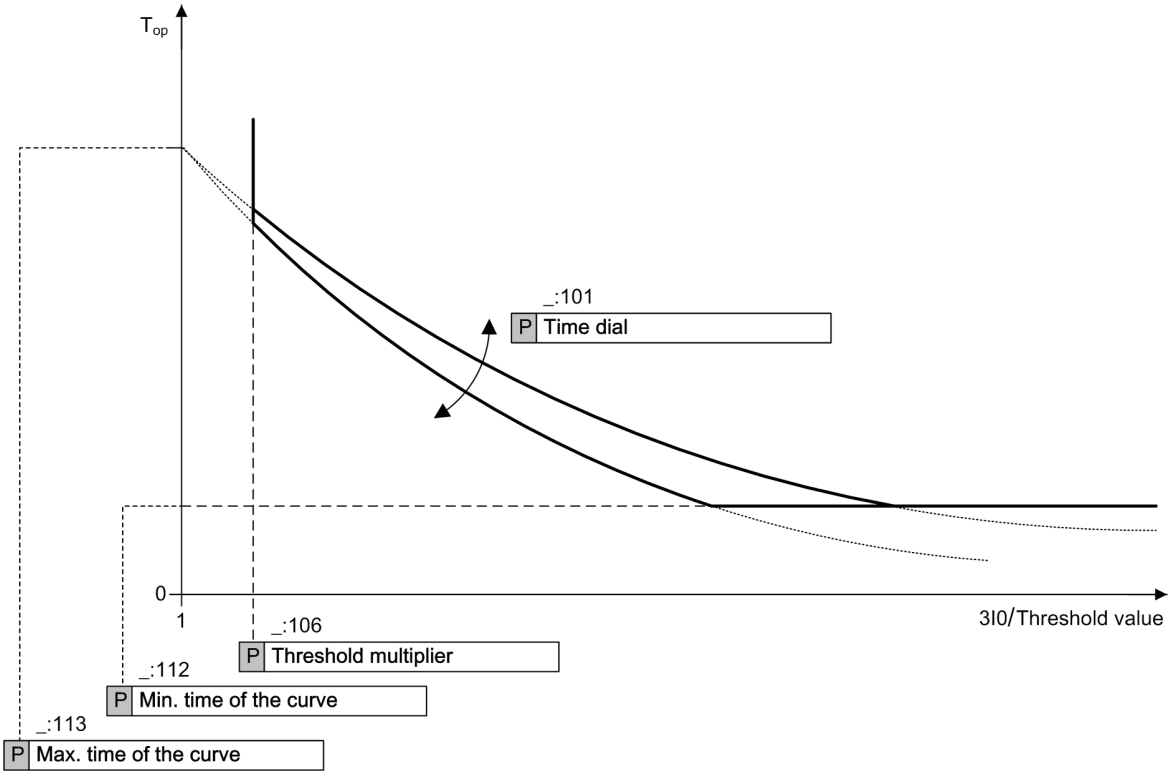
Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Characteristic curve: see *Figure 12-13*			
Threshold value multiplier		1.00 to 4.00	Increments of 0.01
Time multiplier		0.000 s to 60.000 s	Increments of 0.001 s
Minimum time of the characteristic curve		0.000 s to 60.000 s	Increments of 0.001 s
Maximum time of the characteristic curve		0.000 s to 60.000 s	Increments of 0.001 s

Additional time delay	0.000 s to 60.000 s	Increments of 0.001 s



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Figure 12-13 Operate Curve of Logarithmic Inverse-Time Characteristic

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances

10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Inverse-time operate time to logarithmic inverse-time characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Inverse-time dropout time to logarithmic inverse-time characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.9.4 Stage with Knee-Point Characteristic Curve

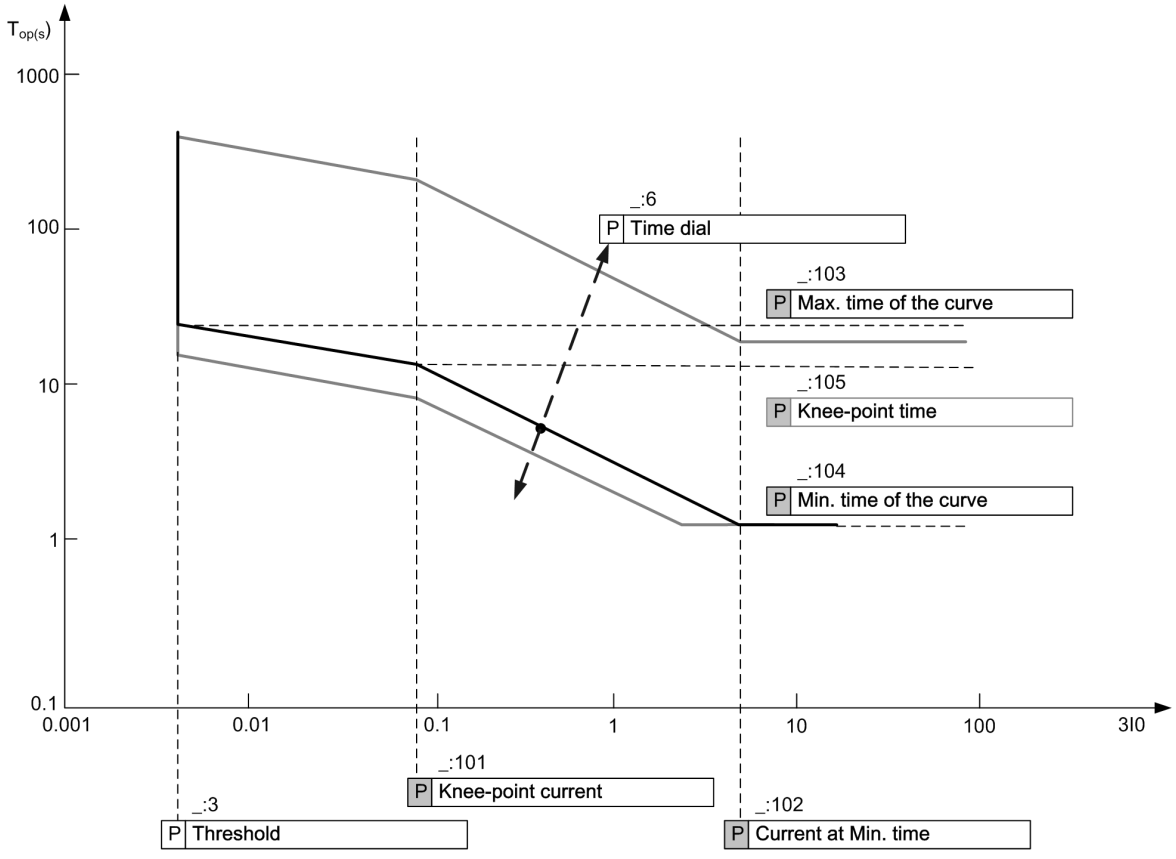
Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Characteristic curve: see *Figure 12-14*		
Minimum time of the characteristic curve	0.00 s to 30.00 s	Increments of 0.01 s
Knee-point time of the curve	0.00 s to 100.00 s	Increments of 0.01 s
Maximum time of the characteristic curve	0.00 s to 200.00 s	Increments of 0.01 s
Knee-point value	0.030 A to 35.000 A	Increments of 0.001 A
Current at minimum time of the curve	0.030 A to 35.000 A	Increments of 0.001 A
Time multiplier	0.05 to 1.50	Increments of 0.01



[dwdrloinkn-171013, 1, en_US]

Figure 12-14 Operate Curve of the Logarithmic Inverse Time with Knee-Point Characteristic (In the Example of **`Threshold = 0.004 A`**)

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Inverse-time operate time to logarithmic inverse time with knee-point characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Inverse-time dropout time to logarithmic inverse time with knee-point characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for $\tau > 100$ ms (with complete unbalance)	< 5 %

12.9.5 Stage with User-Defined Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01
X values of the operate curve		1.00 p. u. to 66.67 p. u.	Increments of 0.01 p. u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p. u. to 0.95 p. u.	Increments of 0.01 p. u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.10 Inrush-Current Detection

Setting Values

Operat.-range limit Imax	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Component of 2nd harmonic		10 % to 45 %	Increments of 1 %
Duration of the crossblock function		0.03 s to 200.00 s	Increments of 0.01 s

Times

Pickup times	Approx. 29 ms

Dropout Ratios

Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	0.95

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Current measurement I_{max}	1 % of the setting value or 5 mA
Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	1 % of the setting value for settings of $I_{2nd\ harm}/_{1st\ harm}$
Time delays	1 % of the setting value or 10 ms

12.11 Arc Protection

Setting Values

Threshold I>	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold 3I0>>	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
External trip initiation		yes no	
Operating mode		Light only Current and light	
Sensor		Point sensor Line sensor Custom	
Threshold Light		-28.00 dB to 0.00 dB	Increments of 0.01
Channel		Possible settings, application-dependent	

Dropout

The larger dropout differential (= **`| pickup threshold – dropout threshold |`**) of the following 2 criteria is used:

Dropout differential derived from the `Dropout ratio` parameter If this parameter is not available, a dropout ratio of 95 % applies to the overcurrent protection and a dropout ratio of 105 % applies to the undercurrent protection.	
Minimum absolute dropout differential	
Protection-class current transformers	15 mA sec. (I_{rated}= 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument transformers	0.5 mA sec. (I_{rated}= 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Shortest operate time Operating mode = light only	Approx. 2.6 ms + OOT[64]
Shortest operate time Operating mode = Current and light	Approx. 4.0 ms + OOT at 50 Hz Approx. 3.8 ms + OOT at 60 Hz

[64] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with a fast relay, see Chapter *12.1.4 Relay Outputs*

12.12 Instantaneous High-Current Tripping

Setting Values

Threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 50 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.50 to 0.90	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time for current > 2·√2·threshold value	Approx. 8 ms + OOT[65]

Tolerances

Response tolerance, current	5 % of setting value or 10 mA at I_{rated} = 1 A 5 % of setting value or 50 mA at I_{rated} = 5 A
Time delays	1 % of the setting value or 10 ms

[65] OOT (Output Operating Time) Additional delay of the output medium used, see Chap. *12.1.4 Relay Outputs*

12.13 Instantaneous Tripping at Switch onto Fault

Setting Values

Tripping delay	0.00 s to 60.00 s	Increments of 0.01 s

Tolerances

Times	< 1 % of the setting value or 10 ms

12.14 Overcurrent Protection, 1-Phase

12.14.1 Stage with Definite-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[66]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio (fixed)		0.95	–
Time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 15 ms + OOT[67] at 50 Hz Approx. 14 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT at 50 Hz Approx. 17 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

[66] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

[67] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.14.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[68]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout

[68] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 0.1 $I_{rated,sec}$.

Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

The tripping characteristic curves and dropout characteristic curves according to IEC can be found in the Technical Data chapter under Inverse Time-Overcurrent Protection.

Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

The tripping characteristic curves and dropout characteristic curves according to ANSI/IEEE can be found in the Technical Data chapter under Inverse Time-Overcurrent Protection.

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.14.3 Stage with User-Defined Characteristic Curve

Setting Values

Method of measurement	Fundamental component RMS value	–

Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.00 p.u. to 66.67 p. u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p. u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Frequency Operating Range

$0.9 \leq f/f_{rated} < 1.1$	According to specified tolerances
10 Hz $\leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80$ Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with less sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

12.15 Overcurrent Protection, 1-Phase (Fast Stage)

Setting Values

Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio (fixed)		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 8 ms + OOT[69]
Dropout time	Approx. 25 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Pickup tolerance, current	5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A)
Time delays	1 % of the setting value or 10 ms

[69] OOT (Output Operating Time) additional time delay of the output medium used, for example, 5 ms with fast relay

12.16 Non-Directional Intermittent Ground-Fault Protection

Setting Values

Threshold value 3I0> interm.	For current transformer type **protection** and I_{rated} = 1 A		0.030 A to 35.000 A	Increments of 0.001 A
	For current transformer type **protection** and I_{rated} = 5 A		0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Number of pickups until intermittent ground fault			2 to 10	Increments of 1
Pickup extension time			0.00 s to 10.00 s	Increments of 0.01 s
Sum of extended pickup times			0.00 s to 100.00 s	Increments of 0.01 s
Reset time			1.00 s to 600.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[70] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active with less sensitivity

[70] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Tolerances

Currents	-3I0 via protection-class current transformers: 1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
	-3I0 via sensitive current transformer: 1 % of setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A)
Times	1 % of the setting value or ± 10 ms

12.17 Directional Intermittent Ground-Fault Protection

Setting Values

Threshold value 3I0>	For current transformer type **protection** and I_{rated} = 1 A		0.030 A to 35.000 A	Increments of 0.001 A
	For current transformer type **protection** and I_{rated} = 5 A		0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Number of pulses until intermittent ground fault			2 to 10	Increments of 1
Pickup extension time			0.00 s to 10.00 s	Increments of 0.01 s
Sum of extended pickup times			0.00 s to 100.00 s	Increments of 0.01 s
Reset time			1.00 s to 600.00 s	Increments of 0.01 s
Number of pulses for operate			2 to 100	Increments of 1

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Pickup time	Approx. 30 ms + OOT[71] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active with less sensitivity

[71] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Tolerances

Currents	3I0 via protection-class current transformers: 1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
	3I0 via sensitive current transformer: 1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A)
Times	1 % of the setting value or ± 10 ms

12.18 Sensitive Ground-Fault Detection

12.18.1 General

Setting Values

Decay time V0			0.06 s to 0.20 s	Increments of 0.01 s
Dropout delay			0.00 s to 60.00 s	Increments of 0.01 s
Core balance current transformer current 1 Core balance current transformer current 2	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Core balance current transformer angle correction F1 Core balance current transformer angle correction F2			0.0° to 5.0°	Increments of 0.1°

Times

Pickup times	Approx. 25 ms + OOT[72] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Dropout times	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances [73]
$f < 10\ Hz$ $f > 80\ Hz$	Active with less sensitivity [74]

Tolerances

Currents	-3I0 via sensitive current transformer: 1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A, f_{rated} ± 10 %)
	-3I0 via protection-class current transformers: 1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A, f_{rated} ± 10 %)
Voltages	1 % of the setting value or 0.05 V
Times	1 % of the setting value or ±10 ms

[72] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays
[73] Transient ground-fault stage is inactive
[74] Transient ground-fault stage is inactive

Direction-calculation angle error[75]	≤ 1° at 3I0 > 5 mA, V0 = 0.6 V ≤ 2° at 3I0 ≤ 5 mA, V0 = 0.6 V

12.18.2 Directional 3I0 Stage with Cos φ or Sin φ Measurement

Setting Values

Direction method of measurement			cos φ sin φ	–
Threshold value 3I0> Minimum directional 3I0> for direction determination	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Threshold value V0>			0.300 V to 200.000 V	Increments of 0.001 V
Time delay of the direction determination			0.00 s to 60.00 s	Increments of 0.01 s
α1 constraint of the direction range α2 constraint of the direction range			1° to 15°	Increments of 1°
Angle correction φ			-45° to 45°	Increments of 1°
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[76] at 50 Hz Approx. 29 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

[75] Not applicable to *12.18.4 Directional 3I0 Stage with φ(V0,3I0) Measurement*
[76] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

12.18.3 Directional Transient Ground-Fault Stage

Setting Values

Threshold value 3I0>	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 1.600 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 8.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 1.600 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 8.000 A	Increments of 0.001 A
Threshold value V0>			0.300 V to 200.000 V	Increments of 0.001 V
Maximum operational V0			0.300 V to 340.000 V	Increments of 0.001 V
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 115 ms + OOT[77] at 50 Hz Approx. 112 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT at 50 Hz Approx. 15 ms + OOT at 60 Hz

[77] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.18.4 Directional 3I0 Stage with φ(V0,3I0) Measurement

Setting Values

Threshold value 3I0>	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Min. V0> for direction determination			0.300 V to 200.000 V	Increments of 0.001 V
Time delay of the direction determination			0.00 s to 60.00 s	Increments of 0.01 s
Rotation angle of the reference voltage			-180° to 180°	Increments of 1°
Forward range +/-			0° to 180°	Increments of 1°
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 23 ms + OOT[78] at 50 Hz Approx. 21 ms + OOT at 60 Hz
Extension of operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 21 ms + OOT at 50 Hz Approx. 20 ms + OOT at 60 Hz

Tolerances

Direction-calculation angle error	≤ 1° at 3I0 ≥ 10 mA, V0 = 0.6 V ≤ 2° at 2 mA < 3I0 < 10 mA, V0 = 0.6 V ≤ 3° at 3I0 ≤ 2 mA, V0 = 0.6 V

[78] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.18.5 Directional Y0 Stage with G0 or B0 Measurement (Admittance)

Setting Values

Direction method of measurement			B0 G0	–
Release Threshold value 3I0>	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type **sensitive** and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Threshold value V0>			0.300 V to 200.000 V	Increments of 0.001 V
Threshold value Y0>			0.10 mS to 100.00 mS	Increments of 0.01 mS
Time delay of direction determination			0.00 s to 60.00 s	Increments of 0.01 s
α1 constraint of direction range α2 constraint of direction range			1° to 15°	Increments of 1°
Angle correction φ			-45° to 45°	Increments of 1°
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[79] at 50 Hz Approx. 29 ms + OOT at 60 Hz
Extension of operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

[79] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Tolerances

Admittance	1 % of the setting value or 0.05 mS (I_{rated} = 1.6 A) or 0.25 mS (I_{rated} = 8 A), (f_{rated} = ± 10 %)

12.18.6 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage

Setting Values

Threshold value[80]	0.300 V to 200.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Pickup delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01
V< faulty ph-gnd vltg.	0.300 V to 200.000 V	Increments of 0.001 V
V> healthy ph-gnd. vltg.	0.300 V to 200.000 V	Increments of 0.001 V

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	
Standard filter, true RMS	Approx. 25 ms + OOT[81] at 50 Hz Approx. 22 ms + OOT at 60 Hz
2 cycle filters	Approx. 45 ms + OOT at 50 Hz Approx. 39 ms + OOT at 60 Hz
Dropout time	
Standard filter, true RMS	Approx. 20 ms + OOT at 50 Hz Approx. 16.6 ms + OOT at 60 Hz
2 cycle filters	Approx. 31.06 ms + OOT at 50 Hz Approx. 27.06 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

[80] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.
[81] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

12.18.7 Non-Directional 3I0 Stage

Setting Values

Method of Measurement			Fundamental component RMS value	
Threshold value 3I0>	Protection-class current transformers	For $I_{ph\text{-}rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For transformer type I-sensitive and $I_{N\text{-}rated}$ = 1 A	For $I_{ph\text{-}rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For transformer type I-sensitive and $I_{N\text{-}rated}$ = 5 A	For $I_{ph\text{-}rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph\text{-}rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Pickup delay			0.00 s to 60.00 s	Increments of 0.01 s
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[82] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

12.18.8 Non-Directional Y0 Stage

Setting Values

V0> threshold value	0.300 V to 200.000 V	Increments of 0.001 V
Threshold Y0>	0.10 mS to 100.00 mS	Increments of 0.01 mS

[82] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Pickup delay	0.00 s to 60.00 s	Increments of 0.01 s
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[83] at 50 Hz Approx. 29 ms + OOT at 60 Hz
Extension of operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

Tolerances

Admittance	1 % of the setting value or 0.05 mS (I_{rated} = 1.6 A) or 0.25 mS (I_{rated} = 8 A), (f_{rated} = ± 10 %)

[83] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.19 Undercurrent Protection

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value I<	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time	Approx. 25 ms + OOT[84] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Currents, method of measurement = fundamental component	1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % portion harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

[84] OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays, see Chapter Relay Outputs

Up to 50th harmonic, f_{rated} = 50 Hz	3 % of setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms

12.20 Negative-Sequence Protection

12.20.1 Stage with Definite-Time Characteristic Curve

Setting Values

Reference value for I_2 (I_{ref})		Rated object current $I_{rated, obj.}$ Positive-sequence current I_1	
Pickup value		5.0 % to 999.9 % I_2/I_{ref}	Increments of 0.1
Dropout ratio		0.40 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Release current (minimum current release)	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Maximum phase current (maximum current limiting)	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

- Dropout differential derived from the parameter **Dropout ratio**
- Dropout differential of 3 % of the object rated current

Times

Pickup time	Approx. 40 ms + OOT[85] at 50 Hz
	Approx. 35 ms + OOT at 60 Hz
Dropout time	Approx. 35 ms + OOT

Current Operating Range

Current range	At least one phase current ≥ setting value $I_{release}$
	All phase currents ≤ setting value $I_{ph, max}$

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

[85] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Tolerances

Pickup value	
$I_2/I_{rated, obj}$	Approx. 2 % of the setting value or 0.8 % of the absolute value
I_2/I_1	Approx. 2 % of the setting value or 4 % of the absolute value (I_1 > 50 mA (I_{rated} = 1 A) or 250 mA (I_{rated} = 5 A))
Time delays	1 % of the setting value or 10 ms

12.20.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Reference value for I_2 (I_{ref})		Rated object current $I_{rated,obj.}$ Positive-sequence current I_1	
Pickup value		5.0 % to 999.9 % I_2/I_{ref}	Increments of 0.1
Dropout		Disk emulation Instantaneous	
Time multiplier		0.05 to 15.00	Increments of 0.01
Release current (minimum current release)	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Maximum phase current (maximum current limiting)	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

- Dropout differential derived from the parameter **Dropout ratio**
- Dropout differential of 3 % of the object rated current

Times

Pickup time	Approx. 40 ms + OOT[86] at 50 Hz
	Approx. 35 ms + OOT at 60 Hz
Dropout time	Approx. 35 ms + OOT

Dropout Ratio

Disk emulation	Approx. 0.90 · threshold value
Instantaneous	Approx. 1.05 · threshold value Approx. 0.95 · pickup value

[86] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Operate and Dropout Characteristic Curves

You can select from the following operate and dropout characteristic curves:

Table 12-3 Standard Characteristic Curves to IEC

Normal inverse: type A	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve* , *Figure 12-1*
Very inverse: type B	
Extremely inverse: type C	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve* , *Figure 12-2*
Long-time inverse: type B	

Table 12-4 Standard Characteristic Curves to ANSI

Inverse: type C	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve* , *Figure 12-3*
Short inverse	
Long inverse	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve* , *Figure 12-4*
Moderately inverse	
Very inverse	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve* , *Figure 12-5*
Extremely inverse	
Definite inverse	See chapter *12.5.2 Stage with Inverse-Time Characteristic Curve* , *Figure 12-6*

Extension of the Operating Time

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

Current Operating Range

Current range	At least one phase current ≥ setting value $I_{release}$
	All phase currents ≤ setting value $I_{ph, max}$

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10 \text{ Hz} \le 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80 \text{ Hz}$	Slightly expanded tolerances
$f < 10 \text{ Hz}$ $f > 80 \text{ Hz}$	Inactive

Tolerances

Reference value = rated current	
Pickup value	Approx. 2 % of the setting value or 0.8 % of the absolute value
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the setting value or + 2 % of the current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the setting value or + 2 % of the current tolerance or 30 ms
Reference value = pos. seq. current	
Pickup value	Approx. 2 % of the setting value or 4 % of the absolute value (I1 > 50 mA (I_{rated} = 1 A) or 250 mA (I_{rated} = 5 A))

Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms

12.21 Directional Negative-Sequence Protection with Definite-Time Delay

Setting Values

Directional mode	Forward, backward, non-directional	
Stabilization with phase currents	0 % to 30 %	Increments of 1 %

Threshold value (pickup value) at $I_{N\text{-rated}}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
Threshold value (pickup value) at $I_{N\text{-rated}}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A

Extension time of the blocking after a 1-pole pause	0.00 s to 60.00 s	Increments of 0.01 s

Setting Values for Direction Determination

Minimum negative-sequence system voltage V2		0.150 V to 20.000 V	Increments of 0.001 V
Minimum negative-sequence system current I2	For I_{rated} = 1 A	0.030 A to 10.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 50.00 A	Increments of 0.01 A
Upper limit angle forward, β		0° to 360°	Increments of 1°
Lower limit angle forward, α		0° to 360°	Increments of 1°

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

- Dropout differential derived from the parameter **`Dropout ratio`**
- Dropout differential of 3 % of the object rated current

Times

Operate time with time delay = 0 ms	Approx. 40 ms + OOT[87] at 50 Hz Approx. 40 ms + OOT at 60 Hz
Dropout time	Approx. 39 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Threshold values:	
Negative-sequence voltage V2	1 % of the setting value or 0.5 V
Negative-sequence current I2	2 % of the setting value or 10 mA at I_{rated} = 1 A
	1 % of the setting value or 5 mA at I_{rated} = 5 A
Times:	
Independent time delays	1 % of the setting value or 10 ms

[87] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Limit angle in determining the direction	5°

12.22 Thermal Overload Protection, 3-Phase

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values/Increments for the Protection Stage

Threshold current warning	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold thermal warn.		50 % to 100 %	Increments of 1 %
Dropout threshold operate		50 % to 99 %	Increments of 1 %
Emerg. start T overtravel		0 s to 15 000 s	Increments of 10 s
K-factor acc. to IEC 60225-8		0.10 to 4.00	Increments of 0.01
Thermal time constant		10 s to 60 000 s	Increments of 1 s
Cooling time constant		10 s to 60 000 s	Increments of 1 s
Imax thermal	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Imin cooling	1 A @ 50 and 100 Irated	0.000 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.00 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.000 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.000 A to 8.000 A	Increments of 0.001 A
Temperature rise at Irated		40 K to 200 K	Increments of 1 K
Default temperature		-55°C to 55°C	Increments of 1°C
Minimal temperature		-55°C to 40°C	Increments of 1°C

Dropout Ratios

Tripping threshold (fixed at 100 %)	Dropout if value drops below operate indication dropout threshold
Thermal warning threshold	About 0.99 of the setting value
Current warning threshold	About 0.95 of the setting value

Frequency Range of the Input Signals

The function captures input signals up to the 50th harmonic.

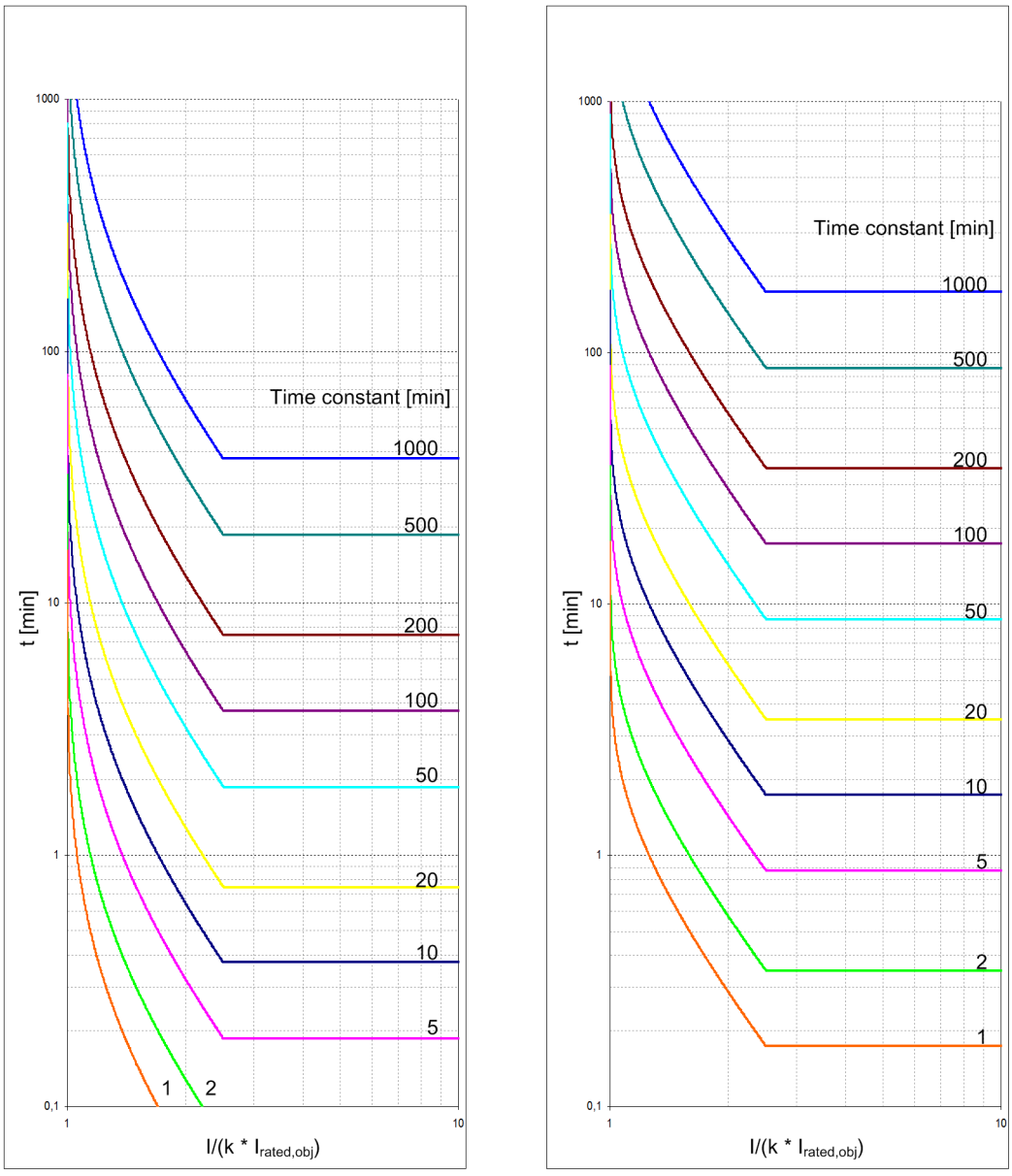
Tolerances

No filter applied (33 % harmonics, in relation to the fundamental component)		
With reference to $k \cdot I_{rated}$	Up to 30th harmonic	2 % or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), 2 % class acc. to IEC 60255-8
	Up to 50th harmonic, f_{rated} = 50 Hz	4 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 4 % class acc. to IEC 60255-8
	Up to 50th harmonic, f_{rated} = 60 Hz	5 % or 25 mA (I_{rated} = 1 A) or 125 mA (I_{rated} = 5 A), 5 % class acc. to IEC 60255-8
With the filter for compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)		
With reference to $k \cdot I_{rated}$	Up to 30th harmonic	2 % or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), 2 % class acc. to IEC 60255-8
	Up to 50th harmonic, f_{rated} = 50 Hz	3 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 3 % class acc. to IEC 60255-8
	Up to 50th harmonic, f_{rated} = 60 Hz	4 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 4 % class acc. to IEC 60255-8
With the filter for gain of harmonics including compensation of the amplitude attenuation[88] (33 % harmonics, in relation to the fundamental component)		
With reference to $k \cdot I_{rated}$	Up to 30th harmonic	2 % or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), 2 % class acc. to IEC 60255-8[89]
	Up to 50th harmonic, f_{rated} = 50 Hz	4 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 4 % class acc. to IEC 60255-8[90]
	Up to 50th harmonic, f_{rated} = 60 Hz	5 % or 25 mA (I_{rated} = 1 A) or 125 mA (I_{rated} = 5 A), 5 % class acc. to IEC 60255-8[90]
With reference to the operate time	Up to 30th harmonic	3 % or 1 s for $I/(k \cdot I_{rated}) > 1.25$, 3 % class acc. to IEC 60255-8

Operate Curve

Operate curve	$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj.}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj.}}\right)^2 - 1}$	
Where	t	Operate time
	τ_{th}	Time constant
	I	Current load current
	$I_{preload}$	Preload current
	k	Setting factor according to VDE 0435 part 3011 or IEC 60255-8 (K factor)
	$I_{rated, obj}$	Rated current of the protected object

[88] In case that the filter response exactly matches the user-defined gain factor.
[89] In case that the user-defined gain factor is set below 3. The tolerance is increased if the gain factor is larger.
[90] In case that the user-defined gain factor is set below 7. The tolerance is increased if the gain factor is larger.



With 80 % preload and with $I_{max, therm} = 2.5 * k * I_{rated}$

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - 1} \quad [min]$$

Without preload and with $I_{max, therm} = 2.5*k*I_{rated}$

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - 1} \quad [min]$$

[dwauslke-100611-01.tif, 1, en_US]

Figure 12-15 Operate Curve of Overload Protection

12.23 Thermal Overload Protection, User-Defined Characteristic Curve

Setting Values

Threshold current warning	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold thermal warn.		50 % to 100 %	Increments of 1 %
Dropout threshold operate		50 % to 99 %	Increments of 1 %
Emerg. start T overtravel		0 s to 15 000 s	Increments of 10 s
Imax thermal	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Imin cooling	1 A @ 50 and 100 Irated	0.000 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.00 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.000 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.000 A to 8.000 A	Increments of 0.001 A
Curve based on preload		1 % to 100 %	Increments of 1 %
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.10 p.u. to 20.00 p. u.	Increments of 0.0 p.u.
Y values of the operate curve		1.00 s to 20 000.00 s	Increments of 0.01 s

Dropout Ratios

Tripping threshold (fixed at 100 %)	Dropout if value drops below operate indication dropout threshold
Thermal warning threshold	About 0.99 of the setting value
Current warning threshold	About 0.95 of the setting value

Frequency Range of the Input Signals

The function captures input signals up to the 50th harmonic.

Tolerances

With reference to $k \cdot I_{rated}$	For I_{rated} = 1 A	2 % or 10 mA, class 2 % acc. to IEC 60255-8
	For I_{rated} = 5 A	2 % or 50 mA, class 2 % acc. to IEC 60255-8
With reference to operate time		3 % or 1 s, class 3 % acc. to IEC 60255-8 for $I/(k \cdot I_{rated}) > 1.25$

12.24 Unbalanced-Load Protection

Setting Values

Maximum continuously perm. I2	3.0 % to 30.0 % I2/ $I_{rated,machine}$	Increments of 0.1 %
Unbalanced load factor K	1.0 s to 100.0 s	Increments of 0.1 s
Warning delay	0.0 s to 60.0 s; ∞	Increments of 0.1 s
Cooling time thermal replica	0 s to 50 000 s	Increments of 1 s

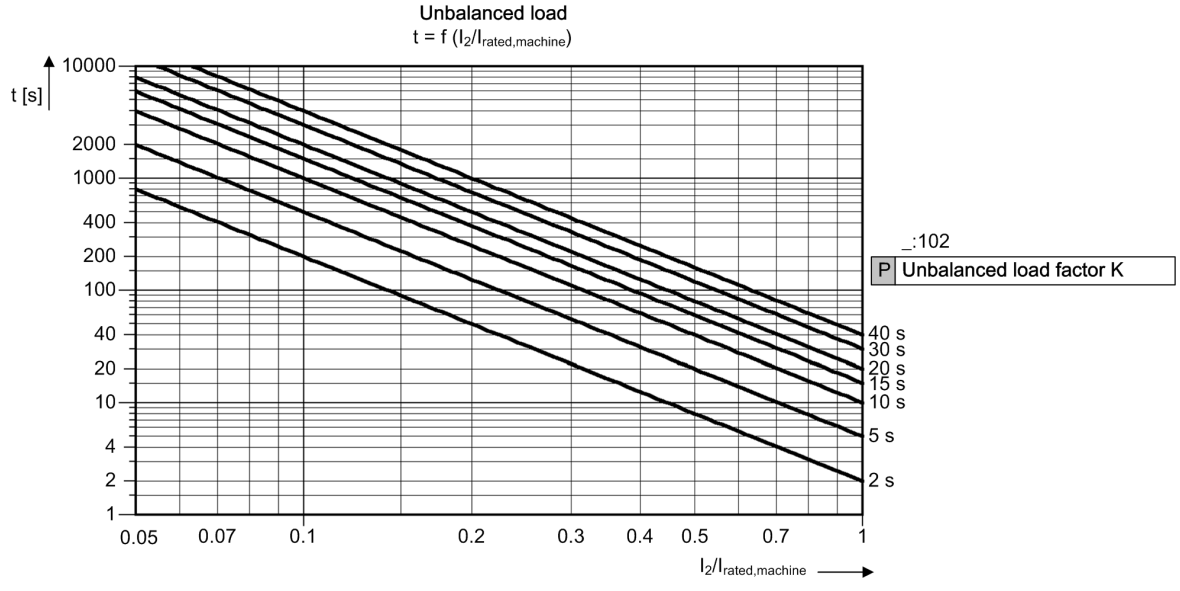
Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

- Dropout differential derived from a dropout ratio of 95 %
- Dropout differential of 3 % of the object rated current

Operate Characteristics

Characteristic of the thermal replica	$t_{I2\,Perm} = \frac{K}{(I_2/I_{rated,machine})^2}$	
Where:	t_{I2Perm}	Permissible application time of the negative-sequence current
	K	Unbalanced load factor K
	$I_2/I_{rated,machine}$	Unbalanced load (negative-sequence current/rated current of the machine)



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Figure 12-16 Thermal Characteristic for Unbalanced Load Protection

Times

Pickup time of the warning stage	Approx. 60 ms + OOT[91] at 50 Hz Approx. 50 ms + OOT at 60 Hz

[91] OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays

Dropout time	Approx. 50 ms or better

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Negative-sequence current I_2	Approx. 3 % of setting value or 0.030 A at I_{rated} = 1 A Approx. 3 % of setting value or 0.150 A at I_{rated} = 5 A
Warning delay	1 % of the setting value or 10 ms
Time for $2 \leq I_2/I_{2Perm} \leq 20$	5 % of reference (calculated) value or 100 ms ± (1 % current tolerance or 10 mA) at I_{rated} = 1 A 5 % of reference (calculated) value or 100 ms ± (1 % current tolerance or 50 mA) at I_{rated} = 5 A

Influencing Variables for the Thresholds

Harmonics	
– Up to 10 % 3rd harmonic	≤ 1 %
– Up to 10 % 5th harmonic	≤ 1 %

12.25 Current-Unbalance Protection for Capacitors, 3-Phase

Setting Values for the Function

Automatic compensation		Yes No	
Time between switch off and switch on		0.00 s to 60.00 s	Increments of 0.01 s
Normalization with Ic		Yes No	
Threshold of defective C-element	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Setting Values (Overcurrent-Protection Stage I>)

Measured value		compensated non-compensated	
$I_{unbal.}$	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
$I_{unbal.}$	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s

Setting Values (Counter Stage)

Type of counting groups	segregated sum	
Max. no. of def. elem. phs A	1 to 1000	Increments of 1
Max. no. of def. elem. phs B	1 to 1000	Increments of 1
Max. no. of def. elem. phs C	1 to 1000	Increments of 1
Operate delay	0.00 s to 10000.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[92] at 50 Hz Approx. 29 ms + OOT at 60 Hz

[92] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents I_c, $I_{unbal.}$ Protection-class current transformers	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents $I_{unbal.}$ Sensitive current transformer	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms

12.26 Current-Unbalance Protection for Capacitors, 1-Phase

Setting Values for the Function

Automatic compensation		Yes No	
Time between switch off and switch on		0.00 s to 60.00 s	Increments of 0.01 s
Normalization with Ic		Yes No	
Threshold of defective C-element	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Setting Values (Overcurrent-Protection Stage I>)

Current threshold $I_{unbal.}$	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.150 A to 175.000 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.005 A
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s
Measured value			compensated non-compensated

Setting Values (Counter Stage)

Type of counting groups		segregated sum
Type of counting phases		segregated sum
Max. no. of def. elem. phs A	1 to 1000	Increments of 1
Max. no. of def. elem. phs B	1 to 1000	Increments of 1
Max. no. of def. elem. phs C	1 to 1000	Increments of 1
Max. no. of def. elem.	1 to 1000	Increments of 1
Operate delay	0.00 s to 10000.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[93] at 50 Hz Approx. 29 ms + OOT at 60 Hz
Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents I_c, $I_{unbal.}$ Protection-class current transformers	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10%)
Currents $I_{unbal.}$ Sensitive current transformer	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A), (f_{rated} ± 10%)
Time delays	1 % of the setting value or 10 ms

[93] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.27 Voltage-Differential Protection for Capacitor Banks

Setting Values (General Functionality)

Voltage matching factor k	0.5000 to 2000.0000	Increments of 0.0001

Setting Values (Protection Stage V_{diff}>)

Threshold	0.005 p.u. to 1.000 p.u.[94]	Increments of 0.001 p.u.
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

Dropout ratio for sec. threshold > 3 V	95 %
Dropout differential for sec. threshold 0.3 V to 3 V	150 mV
Dropout ratio for sec. threshold 0.2 V to 0.3 V	50 %

Times

Operate time with time delay = 0 ms	Approx. 30 ms + OOT (Output Operating Time) at 50 Hz Approx. 27 ms + OOT (Output Operating Time) at 60 Hz
Dropout time	Approx. 20 ms + OOT (Output Operating Time) at 50 Hz Approx. 18 ms + OOT (Output Operating Time) at 60 Hz

Tolerances

Threshold ≥ 0.2 V	1 % of the setting value or 0.05 V (compensated)
Time delays	1 % of the setting value or 10 ms

Operating Range of the Secondary Differential Voltage

Operating Range of the secondary differential voltage	≥ 0.1 V (compensated)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

[94] Minimum secondary setting threshold = 0.2 V

12.28 Differential Protection for Capacitor Banks

Setting Values

Operate Curve			
Threshold value	$I/I_{ratedObj}$	0.05 to 2.00	Increments of 0.01
Gradient 1		0.00 to 0.80	Increments of 0.01
Intersection 1 Irest	$I/I_{ratedObj}$	0.00 to 5.00	Increments of 0.01
Gradient 2		0.25 to 0.95	Increments of 0.01
Intersection 2 Irest	$I/I_{ratedObj}$	1.00 to 20.00	Increments of 0.01
Startup Recognition			
Startup threshold value	$I/I_{ratedObj}$	0.1 to 2.0	Increments of 0.1
Characteristic-curve increase factor		1.0 to 5.0	Increments of 0.1
Maximum starting time		0.1 s to 180.0 s	Increments of 0.1 s
DC-Component Recognition			
Characteristic-curve increase factor DC		1.0 to 5.0	Increments of 0.1
Inrush-current detection			
Content 2nd harmonic		10 % to 45 %	Increments of 1 %
Duration of crossblk. 2. har.		0.00 s to 200.00 s or ∞	Increments of 0.01 s
Recognition of External Faults			
Additional stabilization threshold value	$I/I_{ratedObj}$	1.00 to 20.00	Increments of 0.01
Additional stabilization duration		0.00 s to 5.00 s or ∞	Increments of 0.01 s
Operate curve		See *Figure 12-17*	

Idiff Fast

Threshold value	$I/I_{ratedObj}$	0.5 to 35.0	Increments of 0.1
Tripping delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout Ratio

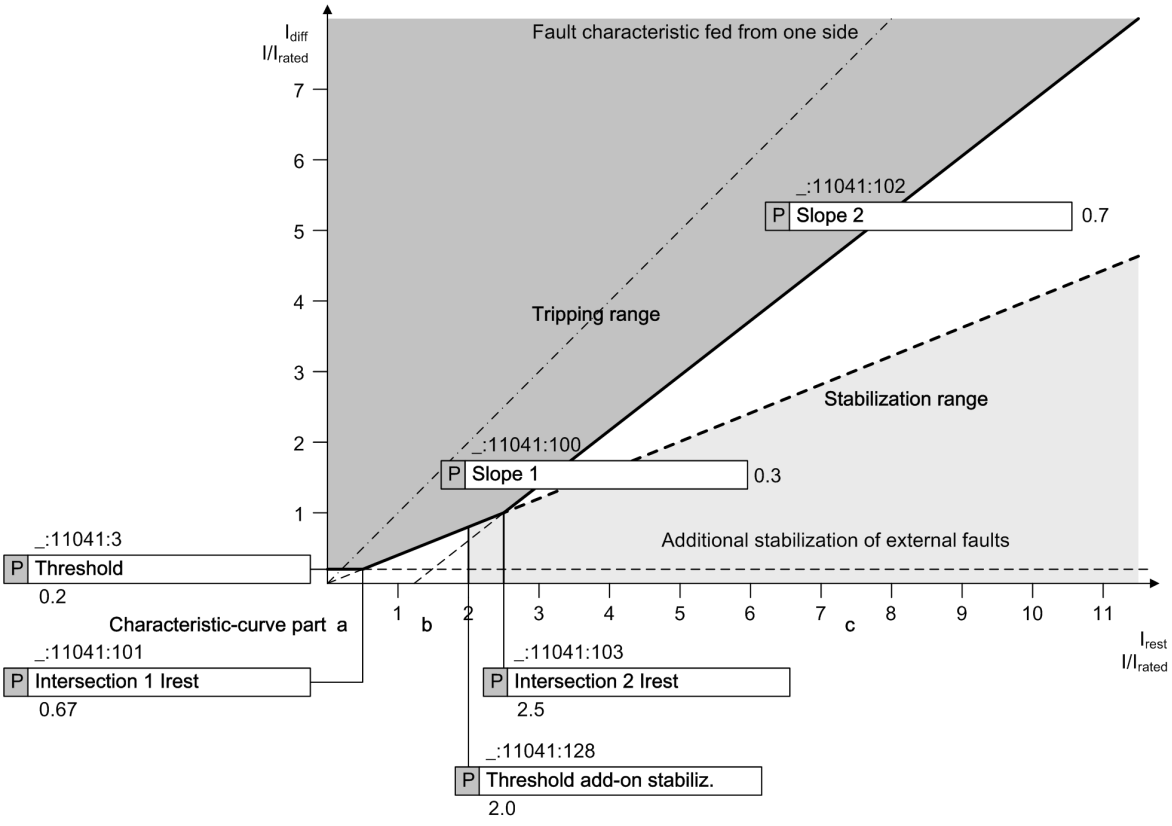
Idiff stage	Approx. 0.7
Idiff fast stage	Approx. 0.8

Response Tolerance

For preset characteristic-curve parameters; for 2 sides with one measuring point each	
Idiff stage and characteristic curve	2 % of the setting value
Idiff fast stage	2 % of the setting value

Time Delays

Idiff stage	0.00 s to 60.00 s	Increments of 0.01 s
Idiff fast stage	0.00 s to 60.00 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	



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Figure 12-17 Operate Curve of the Differential Protection

Operating Times

Operate times for infeed on one side		
Idiff stage, min	50 Hz 60 Hz	23 ms + OOT[95] 20 ms + OOT[1)]
Idiff fast stage, min	50 Hz 60 Hz	8 ms + OOT[1)] 8 ms + OOT[1)]
Dropout time, approx.	50 Hz 60 Hz	29 ms 26 ms

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

[95] Refer to protection functions, for example, Overcurrent protection

12.29 Overvoltage Protection with 3-Phase Voltage

Setting Values for Stage Type Definite Time-Overvoltage Protection

Measured value	Phase-to-phase Phase-to-ground	
Method of measurement	Fundamental component RMS value	
Pickup mode	1 out of 3 3 out of 3	
Pickup value[96]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 300.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Setting Values for Stage Type Inverse Time-Overvoltage Protection

Measured value	Phase-to-phase Phase-to-ground	
Method of measurement	Fundamental component RMS value	
Pickup mode	1 out of 3 3 out of 3	
Pickup value	0.300 V to 340.000 V	Increments of 0.001 V
Pickup factor	1.00 to 1.20	Increments of 0.01
Characteristic constant k	0.00 to 300.00	Increments of 0.01
Characteristic constant α	0.010 to 5.000	Increments of 0.001
Characteristic constant c	0.000 to 5.000	Increments of 0.001
Time multiplier	0.05 to 15.00	Increments of 0.01
Additional time delay	0.00 s to 60.00 s	Increments of 0.01 s
Reset time	0.00 s to 60.00 s	Increments of 0.01 s

Operate Curve for Stage Type Inverse Time-Overvoltage Protection

$$T_{op} = T_{inv} + T_{add}$$

Where

T_{op} Operate delay

T_{inv} Inverse-time delay

T_{add} Additional time delay (parameter **`Additional time delay`**)

$$T_{inv} = T_p \left(\frac{k}{\left(\frac{V}{V_{thresh}}\right)^{\alpha} - 1} + c \right) [s]$$

Where

T_{inv} Inverse-time delay

T_p Time multiplier (parameter **`Time dial`**)

V Measured voltage

[96] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.

V_{thresh}	Threshold value (parameter **Threshold**)
k	Curve constant k (parameter **Charact. constant k**)
α	Curve constant α (parameter **Charact. constant α**)
c	Curve constant c (parameter **Charact. constant c**)

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[97] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances for Stage Type Definite Time-Overvoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

Tolerances for Stage Type Inverse Time-Overvoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Operate time for $1.2 \leq$ V/V threshold value ≤ 20	5 % of the setting value or 30 ms
Reset time delay	1 % of the setting value or 10 ms

[97] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.30 Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage

Setting Values

Method of Measurement	RMS value Fundamental component Fundamental component over 2 cycle filters	
Block. on measuring-voltage outage	Yes No	
Determ. ph. aff. by grd. flt.	Yes No	
Threshold value[98]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Pickup delay	0.00 s to 320.00 s	Increments of 0.01 s
Dropout Ratio	0.90 to 0.99	Increments of 0.01
V< faulty ph-gnd vltg.	0.300 V to 200.000 V	Increments of 0.001 V
V> healthy ph-gnd. vltg.	0.300 V to 200.000 V	Increments of 0.001 V

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	
Standard filter, true RMS	Approx. 25 ms + OOT[99] at 50 Hz Approx. 22 ms + OOT at 60 Hz
2 cycle filters	Approx. 45 ms + OOT at 50 Hz Approx. 39 ms + OOT at 60 Hz
Dropout Time	
Standard filter, true RMS	Approx. 20 ms + OOT at 50 Hz Approx. 16.6 ms + OOT at 60 Hz
2 cycle filters	Approx. 31.06 ms + OOT at 50 Hz Approx. 27.06 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances

[98] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.
[99] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

f < 10 Hz f > 80 Hz	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

12.31 Overvoltage Protection with Positive-Sequence Voltage

Setting Values

Pickup value	0.300 V to 200.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[100] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

[100] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

12.32 Overvoltage Protection with Negative-Sequence Voltage

Setting Values for the Function

Measuring window	1 cycle to 10 cycles	Increments of 1 cycle

Setting Values

Pickup value of V2	0.300 V to 200.000 V	Increments of 0.001 V
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup times	55 ms to 210 ms + OOT [101] (depends on the measuring-window length) at 50 Hz 48 ms to 185 ms + OOT (depends on the measuring-window length) at 60 Hz
Dropout time	20 ms to 70 ms + OOT (depends on the measuring-window length)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Voltages	0.50 % of the setting value or 0.050 V
Time delays	1.00 % of the setting value or 10 ms

[101] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.33 Overvoltage Protection with Any Voltage

Setting Values

Measured value[102]	Measured phase-to-ground voltage V_A Measured phase-to-ground voltage V_B Measured phase-to-ground voltage V_C Measured phase-to-phase voltage V_{AB} Measured phase-to-phase voltage V_{BC} Measured phase-to-phase voltage V_{CA} Measured phase-to-phase voltage V_{AB} Measured phase-to-phase voltage V_{BC} Measured phase-to-phase voltage V_{CA} Calculated voltage V0	
Method of measurement	Fundamental component RMS value	
Pickup value[103]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[104] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V

[102] If the function **Overvoltage protection with any voltage** is used in a 1-phase function group, the measured-value parameter is not visible.
[103] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.
[104] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

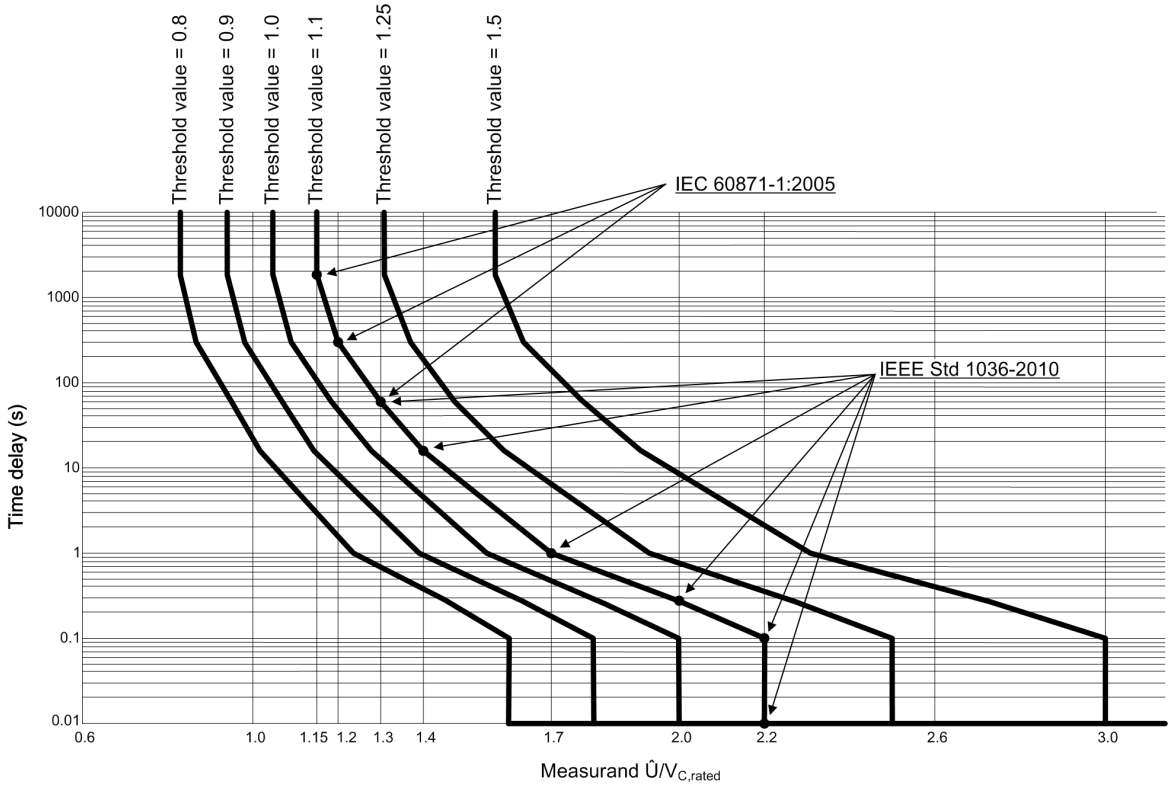
Time delays	1 % of the setting value or 10 ms

12.34 Peak Overvoltage Protection for Capacitors

Setting Values

Threshold value		
Inverse-time stage	0.80 to 3.00 p.u.	Increments of 0.01
Definite-time stage	0.80 to 10.00 p.u.	Increments of 0.01
User-defined characteristic curve	0.80 to 3.00 p.u.	Increments of 0.01
Tripping delay	0.01 s to 3600.00 s	Increments of 0.01 s
Dropout delay	0.00 s to 3600.00 s	Increments of 1.00 s
Down integration time	1 min to 1500 min	Increments of 1 min
Time multiplier	0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve	30	Increments of 1
X values of the operate curve	1.00 p.u. to 4.00 p.u.	Increments of 0.01 p.u.
Y values of the operate curve	0.00 s to 9999.99 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve	30	Increments of 1
X values of the dropout characteristic curve	0.01 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve	0.00 s to 9999.99 s	Increments of 0.01 s

Inverse-Time Characteristic Curve (IEC/IEEE)



[dw_pecinv-230813, 2, en_US]

Figure 12-18 Inverse-Time Characteristic Curve

The points on the characteristic curve defined in the standards result from a threshold setting of 1.1. These single points are connected via semi-logarithmic line segments.

Table 12-5 Peak Overvoltage Inverse-Time Characteristic (for Threshold Setting 1.1)

Measurand $\hat{U}/V_{c,rated}$	**Time Delay**	**Curve Point According to**
<1.15	∞ (no pickup)	Siemens definition
1.15	1800.00 s	IEC 60871-1:2005
1.2	300.00 s	IEC 60871-1:2005
1.3	60.00 s	IEC 60871-1:2005, IEEE Std 1036-2010
1.4	15.00 s	IEEE Std 1036-2010
1.7	1.00 s	IEEE Std 1036-2010
2	0.25 s	IEEE Std 1036-2010
2.2	0.1 s	IEEE Std 1036-2010
>2.2	0.01 s	IEEE Std 1036-2010

Times

Pickup time	Approx. 35 ms + OOT at 50 Hz[1] Approx. 25 ms + OOT at 60 Hz[1]
Dropout Time	Depending on settings
[1] OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays	

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Peak overvoltage (33 % harmonics, with reference to fundamental component)	
Up to 30th harmonic Up to 50th harmonic, f_{rated} = 50 Hz Up to 50th harmonic, f_{rated} = 60 Hz	1 % of the setting value or 0.005 p.u. (f_{rated} ± 10%) 3 % of the setting value or 0.02 p.u. (f_{rated} ± 10%) 4 % of the setting value or 0.02 p.u. (f_{rated} ± 10%)
Time delays	
Measured value of inverse-time stage	5 % of the setting value +1 % of the measured value or 30 ms
Measured value of definite-time stage	1 % of the setting value or 10 ms
Down integration time	5 % of the setting value or 30 ms

12.35 Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage

Setting Values for the Function

Measuring window	1 cycle to 10 cycles	Increments of 1 cycle
Minimum voltage V1	0.300 V to 60.000 V	Increments of 0.001 V

Setting Values for Stage Types

Pickup value of V2/V1	0.50 % to 100.00 %	Increments of 0.01 %
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup times	55 ms to 210 ms + OOT[105] (depends on the measuring-window length) at 50 Hz 48 ms to 190 ms + OOT (depends on the measuring-window length) at 60 Hz
Dropout times	22 ms to 55 ms + OOT (depends on the measuring-window length) at 50 Hz 18 ms to 45 ms + OOT (depends on the measuring-window length) at 60 Hz

Frequency Operating Range

0.9 f/f_{rated} to 1.1 f/f_{rated}	According to specified tolerances
10 Hz to 0.9 f/f_{rated} 1.1 f/f_{rated} to 80 Hz	Slightly expanded tolerances
$f < 10$ Hz $f > 80$ Hz	Inactive

Tolerances

Voltages	0.50 % of the setting value or 0.050 V
Time delays	1.00 % of the setting value or 10 ms

[105] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.36 Undervoltage Protection with 3-Phase Voltage

Setting Values for Stage Type Definite Time-Undervoltage Protection

Measured value		Phase-to-phase Phase-to-ground	
Method of measurement		Fundamental component RMS value	
Current-flow criterion		On Off	
Threshold value I>	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Pickup value[106]		0.300 V to 175.000 V	Increments of 0.001 V
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio		1.01 to 1.20	Increments of 0.01

Setting Values for Stage Type Inverse Time-Undervoltage Protection

Measured value		Phase-to-phase Phase-to-ground	
Method of measurement		Fundamental component RMS value	
Current-flow criterion		On Off	
Threshold value I>	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold		0.300 V to 175.000 V	Increments of 0.001 V
Pickup factor		0.80 to 1.00	Increments of 0.01
Characteristic constant k		0.00 to 300.00	Increments of 0.01
Characteristic constant α		0.010 to 5.000	Increments of 0.001
Characteristic constant c		0.000 to 5.000	Increments of 0.001
Time multiplier		0.05 to 15.00	Increments of 0.01
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s
Reset time		0.00 s to 60.00 s	Increments of 0.01 s

Operate Curve

$T_{op}=T_{Inv}+T_{add}$

Where:

T_{op} Operate delay

T_{Inv} Inverse-time delay

T_{add} Additional time delay (parameter **`Additional time delay`**)

[106] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.

$$T_{Inv} = T_p \left(\frac{k}{1 - \left(\frac{V}{V_{Thresh}} \right)^{\alpha}} + c \right) [s]$$

[fo_UVP3ph_inverse, 2, en_US]

Where

T_{Inv}	Inverse-time delay
T_p	Time multiplier (parameter **Time dial**)
V	Measured undervoltage
V_{Thresh}	Threshold value (parameter **Threshold**)
k	Curve constant k (parameter **Charact. constant k**)
α	Curve constant α (parameter **Charact. constant α**)
c	Curve constant c (parameter **Charact. constant c**)

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup time	Approx. 25 ms + OOT[107] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10 \text{ Hz} \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80 \text{ Hz}$	Slightly expanded tolerances
$f < 10 \text{ Hz}$ $f > 80 \text{ Hz}$	Inactive, maintained; Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

Tolerances for Stage Type Definite Time-Undervoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A, f_{rated} ± 10 %), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A, f_{rated} ± 10 %), valid for instrument transformers
Time delays	1 % of the setting value or 10 ms

[107] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

Tolerances for Stage Type Inverse Time-Undervoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A, f_{rated} ± 10 %), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A, f_{rated} ± 10 %), valid for instrument transformers
Operate time for $0 < V/V_{Thresh} < 0.9$	5 % of the setting value or 30 ms
Reset time delay	1 % of the setting value or 10 ms

12.37 Undervoltage Protection with Positive-Sequence Voltage

Setting Values

Measured value		Phase-to-phase Phase-to-ground	
Method of measurement		Fundamental component RMS value	
Current-flow criterion		On Off	
Threshold value I>	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Pickup value		0.300 V to 175.000 V	Increments of 0.001 V
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio		1.01 to 1.20	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time	Approx. 25 ms + OOT [108] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive, maintained; Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

Tolerances

Voltages	0.5 % of the setting value or 0.05 V

[108] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A, f_{rated} ± 10 %), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A, f_{rated} ± 10 %), valid for instrument transformers
Time delays	1 % of the setting value or 10 ms

12.38 Undervoltage Protection with Any Voltage

Setting Values

Measured value	Measured phase-to-ground voltage V_A Measured phase-to-ground voltage V_B Measured phase-to-ground voltage V_C Measured phase-to-phase voltage V_{AB} Measured phase-to-phase voltage V_{BC} Measured phase-to-phase voltage V_{CA} Calculated phase-to-phase voltage V_{AB} Calculated phase-to-phase voltage V_{BC} Calculated phase-to-phase voltage V_{CA} Calculated voltage V0	
Method of measurement	Fundamental component RMS value	
Pickup value[109]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	1.01 to 1.20	Increments of 0.01

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[110] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive, maintained; Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

[109] If you have selected the **method of measurement** = **RMS value**, do not set the threshold value under 10 V.
[110] OOT (Output Operating Time) additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*

12.39 Overfrequency Protection

Setting Values

Pickup values f>	40.00 Hz to 70.00 Hz	Increments of 0.01 Hz
Dropout differential	20 mHz to 2 000 mHz	Increments of 10 mHz
Time delay T	0.00 s to 600.00 s	Increments of 0.01 s
Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V

Times

Pickup times f>	Angle difference method	
	50 Hz	Approx. 70 ms + OOT[111]
	60 Hz	Approx. 60 ms + OOT
	Filtering method	
	50 Hz	Approx. 75 ms + OOT
	60 Hz	Approx. 75 ms + OOT
Dropout times f>	60 ms to 80 ms	

Dropout

The larger dropout differential (= **`| pickup value – dropout threshold |`**) of the following 2 criteria is used:

Dropout differential derived from the `Dropout ratio` parameter If this parameter is not available, a dropout ratio of 95 % applies to the overvoltage protection and a dropout ratio of 105 % applies to the undervoltage protection.	
Minimum absolute dropout differential	150 mV sec.

Operating Ranges

Voltage range	5 V to 230 V (phase-phase)	
Frequency range	Angle difference method	10 Hz to 80 Hz
	Filtering method	25 Hz to 80 Hz

Tolerances

Frequency f>	
f_{rated} - 0.20 Hz < f < f_{rated} + 0.20 Hz	± 5 mHz at V = V_{rated}
f_{rated} - 3.0 Hz < f < f_{rated} + 3.0 Hz	± 10 mHz at V = V_{rated}
Time delay T(f>)	1 % of the setting value or 10 ms
Minimum voltage	1 % of the setting value or 0.5 V

[111] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relay, see chapter *12.1.4 Relay Outputs*

12.40 Underfrequency Protection

Setting Values

Pickup values f<	40.00 Hz to 70.00 Hz	Increments of 0.01 Hz
Dropout differential	20 mHz to 2 000 mHz	Increments of 10 mHz
Time delay T	0.00 s to 600.00 s	Increments of 0.01 s
Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V

Times

Pickup times f<	Angle difference method	
	50 Hz 60 Hz	Approx. 70 ms + OOT[112] Approx. 60 ms + OOT
	Filtering method	
	50 Hz 60 Hz	Approx. 75 ms + OOT Approx. 75 ms + OOT
Dropout times f<	60 ms to 80 ms	

Dropout

The larger dropout differential (= **`| pickup value – dropout threshold |`**) of the following two criteria is used:

Dropout differential derived from the `Dropout ratio` parameter If this parameter is not available, a dropout ratio of 95 % applies to the overvoltage protection and a dropout ratio of 105 % applies to the undervoltage protection.	
Minimum absolute dropout differential	150 mV sec.

Operating Ranges

Voltage range	5 V to 230 V (phase-phase)	
Frequency range	Angle difference method	10 Hz to 80 Hz
	Filtering method	25 Hz to 80 Hz

Tolerances

Frequency f<	
f_{rated} - 0.20 Hz < f < f_{rated} + 0.20 Hz	± 5 mHz at V = V_{rated}
f_{rated} - 3.0 Hz < f < f_{rated} + 3.0 Hz	± 10 mHz at V = V_{rated}
Time delay T(f<)	1 % of the setting value or 10 ms
Minimum voltage	1 % of the setting value or 0.5 V

[112] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relay, see chapter *12.1.4 Relay Outputs*

12.41 Rate of Frequency Change Protection

Setting Values for the Function

Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V
Measuring window	2 periods to 5 periods	Increments of 1 period

Setting Values for Stage Types

Threshold	0.1 Hz/s to 20.0 Hz/s	Increments of 0.1 Hz/s
Dropout differential	0.02 Hz/s to 0.99 Hz/s	Increments of 0.01 Hz/s
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup time	Approx.165 ms to 225 ms (depends on measuring window length)
Dropout time	Approx.165 ms to 225 ms (depends on measuring window length)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Threshold, measuring window > 3 periods	Approx. 3 % or 0.06 Hz/s
Threshold, measuring window ≤ 3 periods	Approx. 5 % or 0.06 Hz/s
Minimum voltage	1 % of the setting value or 0.5 V
Time delays	1 % of the setting value or 10 ms

Functional Measured Value

Value	Description
df/dt	Calculated rate of frequency change

12.42 3-Phase Power Protection (P,Q)

Setting Values

Measured value	Positive sequence power Power of phase A Power of phase B Power of phase C	
Threshold value	-200.0 % to +200.0 %	Increments of 0.1
Tilt-power characteristic	-89.0° to +89.0°	Increments of 0.1°
Dropout delay time	0.00 s to 60.00 s	Increments of 0.01 s
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	Upper stage: 0.90 to 0.99 Lower stage: 1.01 to 1.10	Increments of 0.01 Increments of 0.01

Times

Pickup times	Approx. 55 ms + OOT[113] at 50 Hz Approx. 45 ms + OOT at 60 Hz
Dropout times	Approx. 55 ms + OOT at 50-Hz Approx. 45 ms + OOT at 60 Hz

Tolerances

Power	0.5 % S_{rated} ± 3 % of setting value (S_{rated}: rated apparent power)
Time delays	1 % of the setting value or 10 ms

Variables That Influence Pickup Values

Auxiliary DC voltage in the range $0.8 \leq V_{Aux}/V_{AuxRated} \leq 1.15$	≤ 1 %
Frequency in the range $0.95 \leq f/f_{rated} \leq 1.05$	≤ 1 %
Harmonics - Up to 10 % of 3rd harmonics - Up to 10 % of 5th harmonics	 ≤ 1 % ≤ 1 %

[113] OOT (Output Operating Time) additional delay of the output medium used, see Chapter *12.1.4 Relay Outputs*

12.43 Reverse-Power Protection

Setting Values

Reverse power $P_{reverse}$ (p.u.)	-0.30 % to -30.00 %	Increments of 0.01 %
Angle correction	-10.00 ° to 10.00 °	Increments of 0.01 °
Minimum voltage V1	0.300 V to 60.000 V	Increments of 0.001 V
Tripping delay	0.00 s to 60.00 s	0.00 s to 60.00 s
Tripping delay with quick stop	0.00 s to 60.00 s	0.00 s to 60.00 s
Dropout delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.40 to 0.99	Increments of 0.01

Times

Pickup times	Approx. 360 ms at f = 50 Hz Approx. 300 ms at f = 60 Hz
Dropout times	Approx. 360 ms at f = 50 Hz Approx. 300 ms at f = 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Reverse power	0.15 % S_{rated} or 5 % of the setting value when $Q < 0.5\ S_{rated}$
Time delays	1 % or 10 ms

12.44 Overexcitation Protection

Setting Values

Threshold value (characteristic curve dependent on pickup)		$\frac{U/U_{nenn}}{f/f_{nenn}}$	1.00 to 1.20	Increments of 0.01
Threshold value (characteristic curve independent on pickup)		$\frac{U/U_{nenn}}{f/f_{nenn}}$	1.00 to 1.40	Increments of 0.01
Time delay (warning delay and tripping delay)			0.00 s to 60.00 s	Increments of 0.01 s
Characteristic value pairs			2 to 30	
	Value ranges	V/f	1.00 p.u. to 10.00 p.u.	Increments of 0.01 p.u.
		t	0 s to 100 000 s	Increments of 1 s
Cooling time therm. replica			0 s to 100 000 s	Increments of 1 s

Functional Measured Values

Measured Value	Description
(_:2311:322) V/f	Value calculated from voltage and frequency.
(_:13591) Therm.charact.	Thermal tripping of the overexcitation protection. If the value reaches 100 %, tripping occurs.

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Operating Times

Operate times/dropout times		
Operate time at frequency	50 Hz	60 Hz
Minimum	33 ms + OOT[1]	30 ms + OOT[1][14]
Dropout time	10 ms + OOT[1]	10 ms + OOT[1]

Dropout Ratios

Warning, tripping (independent stage)	Approx. 0.98

Operate Curve

Thermal replica	For default setting refer to the following characteristic curve *Figure 12-19*

Tolerances

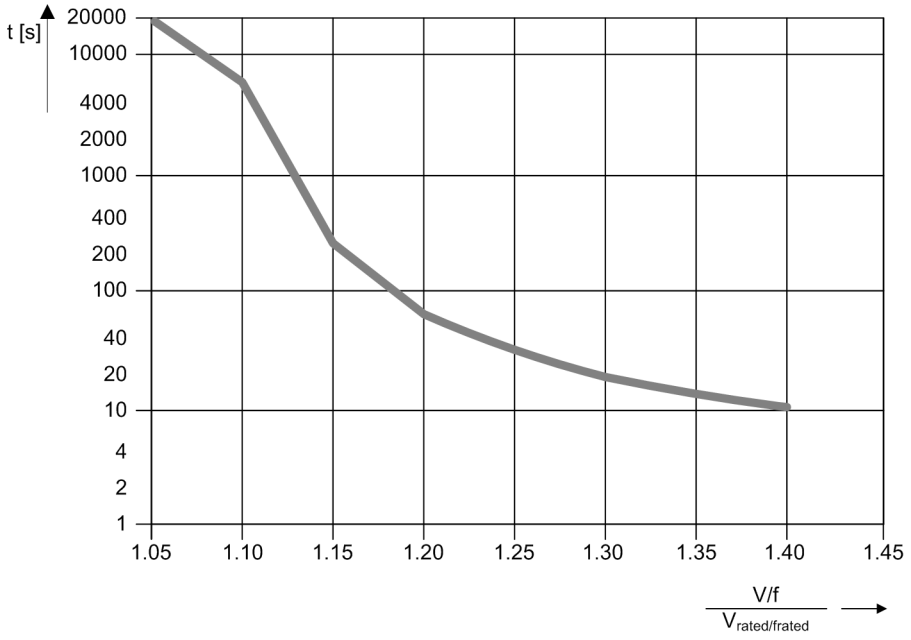
V/f pickup	2 % of the setting value
Time delays	1 % of the setting value or 10 ms (min. 1.5 periods)
Thermal replica	5 % based on V/f ± 600 ms

[114] Refer to protection functions, for example overcurrent protection

Voltage measurement accuracy	0.5 % of the setting value or 0.5 V in the range fn ± 10 %
Frequency measurement accuracy	1.0 % of the setting value or 1.0 Hz in the frequency range 10 Hz to 80 Hz

Influencing Quantities

Auxiliary direct voltage in the 0.8 range	≤ 1 %
Time delays	≤ 0.5 %/10 K
Thermal replica	≤ 1 %
Harmonics	
Up to 10 % of 3rd harmonic Up to 10 % of 5th harmonic	≤ 1 % ≤ 1 %



[dwrsasuf-070513-01.tif, 1, en_US]

Figure 12-19 Operate Curve from the Thermal Replica of the Overexcitation Protection (Default Setting)

12.45 Undervoltage-Controlled Reactive-Power Protection

Setting Values

Threshold value	Power Q	1.00 % to 200.00 %	Increments of 0.01 %
	Voltage of protection stage	3.000 to 175.000	Increments of 0.001 V
	Voltage of reclosure stage	3.000 V to 340.000 V	Increments of 0.001 V
Current I_1 release threshold	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s
Release time delay of reclosure stage		0.00 s to 3600.00 s	Increments of 0.01 s

Dropout Ratio

Protection stage	
Reactive-power flow Q	Approx. 0.95
Voltage	Approx. 1.05
Release current	Approx. 0.95

Reclosure stage	
Voltage	Approx. 0.95
Release current	Approx. 0.95

Times

Pickup time	Approx. 55 ms + OOT[115] at 50 Hz Approx. 45 ms + OOT at 60 Hz
Dropout time	Approx. 55 ms + OOT at 50 Hz Approx. 45 ms + OOT at 60 Hz

Tolerances

Current I_1	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Voltage	0.5 % of the setting value or 0.05 V
Power Q	0.5 % S_{rated} ± 3 % of the setting value (S_{rated}: rated apparent power)
Time delays	1 % of the setting value or 10 ms
Reclosure time delay	1 % of the setting value or 10 ms

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances

[115] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

f < 10 Hz f > 80 Hz	Active

12.46 Circuit-Breaker Failure Protection

Starting Conditions

For circuit-breaker failure protection	3-pole tripping internal or external[116]

Setting Values

Phase-current threshold values	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	1 A @ 50 Irated		
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	5 A @ 50 Irated		
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Sensitive threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	1 A @ 50 Irated		
	5 A @ 100 Irated	0.15 A to 175.00A	Increments of 0.01 A
	5 A @ 50 Irated		
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Supervision time of release signal		0.06 s to 1.00 s	Increments of 0.01 s
Time delays		0.05 s to 60.00 s	Increments of 0.001 s
Supervision time of binary inputs		0.05 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Circuit-Breaker Supervision

Position supervision via circuit-breaker auxiliary contacts	
For 3-pole CB tripping	1 input each for make contact and break contact



NOTE

The circuit-breaker failure protection can also work without the circuit-breaker auxiliary contacts stated.

Auxiliary contacts are required for circuit-breaker failure protection in cases where the current flow is absent or too low for tripping (for example with a transformer or a Buchholz protection).

[116] Via binary inputs

Times

Pickup time, in the case of an internal start Pickup time, in the case of an external start	< 1 ms < 5 ms
Typical dropout time	< 15 ms
Dropout time via circuit-breaker auxiliary-contact criterion	< 5 ms

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Threshold values, dropout thresholds	2 % of the setting value or 1 % of the rated current
Times	1 % of the setting value or 10 ms

12.47 Circuit-Breaker Restrike Protection

Setting Values

Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Monitoring duration		1.00 s to 600.00 s	Increments of 0.01 s
Position recognition delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s
Trip delay time		0.05 s to 60.00 s	Increments of 0.01 s
Retrip delay time		0.00 s to 60.00 s	Increments of 0.01 s
Minimum operate (trip) time		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= **| pickup value – dropout value |**) of the following 2 criteria applies:

Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Threshold	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Time delays	1 % of the setting value or 10 ms

12.48 Restricted Ground-Fault Protection

Setting Values

Threshold value[117]	0.05 A to 2.00 A	Increments of 0.01 A
Gradient	0.00 to 0.95	Increments of 0.01
Operate curve	See figure	
Pickup tolerance (for preset characteristic curve parameters; for 2 sides with 1 measuring point each)	2 %	
Tripping delay	0.00 s to 60.00 s or ∞ (no tripping)	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	

Functional Measured Values

Measured Value	Description
(_:306) I REF,operate	Operate quantity of the restricted ground-fault protection from the angle criterion
(_:307) I Angle,REF	Stabilizing value (angle) of the restricted ground-fault protection from the angle criterion
(_:311) I REF,Trip operate	Operate quantity of the restricted ground-fault protection when OFF
(_:312) I angle,REF operate	Stabilizing value of the restricted ground-fault protection when OFF
(_:301) I diff.	Differential current
(_:302) I restr.	Restraint current

Dropout Ratio

Threshold value	0.7

Dropout

The greater dropout differential (= **`| pickup value – dropout value |`**) of the following 2 criteria applies:

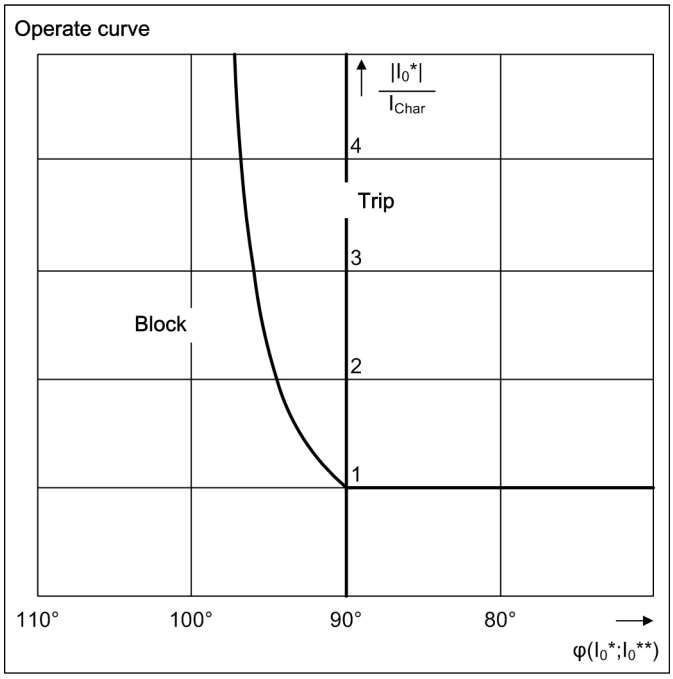
Dropout differential derived from the parameter `Dropout ratio` If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

7UT82/7UT85/7UT86/7UT87		
Frequency	50 Hz	60 Hz
	Operate time	Operate time

[117] The specified setting limit can be dynamically further limited, depending on the transformer adaptation factor, (for this refer to Chapter *6.41.4 Application and Setting Notes*).

At 1.5 · setting value threshold value	33 ms + OOT	32 ms + OOT
At 2.5 · setting value threshold value	27 ms + OOT	26 ms + OOT
Dropout time approx.	80 ms	67 ms



[dwausken-170712-01.tif, 1, en_US]

Figure 12-20 Restricted Ground-Fault Protection Operate Curve depending on the Phase Angle between II_0* and II_0** at $|II_0*| = |II_0**|$ (180° = External fault)

12.49 External Trip Initiation

Setting Values

Tripping delay	0.00 s to 60.00 s	Increments of 0.01 s

Times

Operate time with time delay = 0 ms - At initiation via binary input signal	Approx. 10 ms + OOT [118].

Tolerance

Sequence tolerance for delay times	1 % of the setting value or 10 ms

[118] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays, see chapter *12.1.4 Relay Outputs*

12.50 Automatic Reclosing

Function specifications	Cyclic automatic reclosing function Automatic reclosing function with adaptive dead time (ADT) Operation with External Automatic Reclosing Function	
Number of reclosings	Max. 8, per individual settings	
Type (depending on the order variation)	1-pole, 3-pole, or 1-/3-pole	
Operating mode of the automatic reclosing function	With trip command, without action time With trip command, with action time With pickup, without action time With pickup, with action time	
Reclaim time after reclosing	0.50 s to 300.00 s	Increments of 0.01 s
Blocking time after dynamic blocking	0.5 s	-
Blocking time after manual closure	0.00 s to 300.00 s	Increments of 0.01 s
Start supervision time	0.01 s to 300.00 s	Increments of 0.01 s
Circuit-breaker supervision time	0.01 s to 300.00 s	Increments of 0.01 s
Evolving-fault detection	With trip command with Pickup	
Reaction to evolving faults	Blocks automatic reclosing function Start, evolving fault, dead time	
Action times (separated for all cycles)	0.00 s to 300.00 s or oo (ineffective)	Increments of 0.01 s
Dead times after trip command (separated for all types and all cycles)	0.00 s to 1 800.00 s or oo (ineffective)	Increments of 0.01 s
Dead time after evolving-fault detection (separated for all cycles)	0.00 s to 1 800.00 s	Increments of 0.01 s
Synchrocheck after 3-pole dead time	None Internal External	
Transmission delay, inter close command	0.00 s to 300.00 s or oo (ineffective)	Increments of 0.01 s
Dead-line check/reduced dead time	Without Reduced dead time (VWE) Dead line checking	
Voltage supervision warning time	0.10 s to 30.00 s	Increments of 0.01 s
Limiting value for fault-free line	0.3 V to 340.0 V	Increments of 0.1 V
Limiting value for zero potential	0.3 V to 340.0 V	Increments of 0.1 V

12.51 Fault Locator

Setting Values

Reactance per unit length of the line per kilometer or per mile Line length for the correct output of the fault distance as a percentage of the line length The residual compensation factors in the setting format Kr and Kx or K0 and angle (K0)	
Consideration of the load current for 1-pole ground faults	Correction of the X value, for connection and disconnection

Fault Distance

Output of the fault distance (line length)	In Ω primary and secondary In km, miles or in percent. [119]

Tolerances

Measuring tolerances during sinusoidal measurands and error duration > 25 ms at 60 Hz or > 30 ms at 50 Hz	1.5 % from fault location at $V_K/V_{rated} \geq 0.01$ and one of the following scenarios: • Metal fault • Non-metallic fault for one-side infeed without load

[119] The output of the fault distance in km, miles and percent presupposes a homogenous line.

12.52 Temperature Supervision

Setting Values

Pickup value	-50 °C to 250 °C -58 °F to 482 °F	Increments of 1°C Increments of 1°F
Time delay	0 s to 60 s or ∞	Increments of 1 s

Dropout Conditions

Dropout differential	3 °C or 6 °F

Tolerances

Tripping delay	±1 % of the setting value or ±10 ms
Measured temperature value	±0.5 % of the setting value or ±1 °C or ±2 °F

12.53 Current-Jump Detection

Times

Pickup time	Approx. 10 ms + OOT[120] at 50 Hz Approx. 8 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Currents	3 % of setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), ($f_{rated} \pm 10$ %) for amplitude changes of sinusoidal measurands
Pulse time	1 % of the setting value or 10 ms

[120] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.54 Voltage-Jump Detection

Times

Pickup time	Approx. 10 ms + OOT[121] at 50 Hz Approx. 8 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive

Tolerances

Voltages	2 % of the setting value or 0.100 V for amplitude changes of sinusoidal measurands
Pulse time	1 % of the setting value or 10 ms

[121] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.55 Synchronization Function

Operating Modes

Synchrocheck
Switching synchronous systems
Switching asynchronous systems
De-energized switching
Direct closing command

Setting Values

Supervision/Delay times:		
Max. Duration of synchronization process	0.00 s to 3 600.00 s or ∞ (ineffective)	Increments of 0.01 s
Supervision time de-energized switching	0.00 s to 60.00 s	Increments of 0.01 s
Closure delay	0.00 s to 60.00 s	Increments of 0.01 s
Voltage threshold values:		
Upper voltage limit V_{max}	0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V
Lower voltage limit V_{min}	0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V
V<, for off-circuit conditions V>, for voltage present	0.300 V to 170.000 V (phase-to-phase) 0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V Increments of 0.001 V
Differential values, changeover thresholds asynchronous/synchronous:		
Voltage differences V2 > V1; V2 < V1	0.000 V to 170.000 V	Increments of 0.001 V
Frequency difference f2 > f1; f2 < f1	0.000 Hz to 2.000 Hz (synchronous) 0.000 Hz to 4.000 Hz (asynchronous)	Increments of 0.001 Hz
Angular difference α2 > α1; α2 < α1	0° to 90°	Increments of 1°
Δf threshold ASYN <-> SYN	0.010 Hz to 0.200 Hz	Increments of 0.001 Hz
Adjustments of the sides:		
Angle adjustment	0.0° to 360.0°	Increments of 0.1°
Voltage adjustment	0.500 to 2.000	Increments of 0.001
Circuit breaker		
Closing time of the circuit breaker	0.01 s to 0.60 s	Increments of 0.01 s

Dropout Ratio

Min./max. operating limit	1 % of the setting value
Voltage differential	10 % of the setting value or 0.5 V
De-energized/energized	5 % of the setting value
Frequency difference	3 mHz
Angular difference	0.1°

Measured Values of the Synchronization Function

Reference voltage V1 • Range • Tolerance at rated frequency	In kV primary, in V secondary or in % V_{rated} Display always as phase-to-phase voltage 10 % to 120 % of V_{rated} ≤ 1% of the measured value or 0.5% V_{rated}
Voltage to be synchronized V2 • Range • Tolerance at rated frequency	In kV primary, in V secondary or in % V_{rated} Display always as phase-to-phase voltage 10 % to 120 % of V_{rated} ≤ 1% of the measured value or 0.5% V_{rated}
Frequency of the voltage V1f1 • Range • Tolerance at rated frequency	f1 in Hz 25 Hz ≤ f ≤ 70 Hz 1 mHz
Frequency of the voltage V1f2 • Range • Tolerance at rated frequency	f2 in Hz 25 Hz ≤ f ≤ 70 Hz 1 mHz
Voltage difference V2-V1 • Range • Tolerance at rated frequency	In kV primary, in V secondary or in % V_{rated} Display always as phase-to-phase voltage in relation to side 1 10 % to 120 % of V_{rated} ≤ 1% of the measured value or 0.5% V_{rated}
Frequency difference f2-f1 • Range • Tolerance at rated frequency	In mHz f_{rated} ± 10 % 1 mHz
Angular difference λ2-λ1 • Range • Tolerance at rated frequency	In ° -180° to +180° 0.5°

Times

Measuring time, after switching on the variables	Approx. 80 ms

Operating Range

Voltage	20 V to 340 V
Frequency	f_{rated} -4 Hz ≤ f_{rated} ≤ f_{rated} +4 Hz

Tolerances

Tolerances of the voltage settings	2 % of the pickup value or 1 V
Voltage difference V2>V1; V2<V1	1 V
Frequency difference f2>f1; f2<f1	10 mHz
Angular difference α2>α1; α2<α1	1°
Tolerance of all time settings	10 ms
Max. phase displacement angle	5° for Δf ≤ 1 Hz 10° for Δf > 1 Hz

12.56 Voltage Controller

Setting Values

General Information		
I reference for % values	0.20 A to 100 000.00 A	Increments of 0.01 A
V reference for % values	0.20 kV to 1 200.00 kV	Increments of 0.01 kV
Volt. cont. 2W		
Target voltage 1	40.00 kV to 1 360.00 kV	Increments of 0.01 kV
Target voltage 2		
Target voltage 3		
Target voltage 4		
Volt. cont. 3W and GC		
Target voltage 1 w1	40.00 kV to 1 360.00 kV	Increments of 0.01 kV
Target voltage 2 w1		
Target voltage 3 w1		
Target voltage 4 w1		
Target voltage 1 w2		
Target voltage 2 w2		
Target voltage 3 w2		
Target voltage 4 w2		
Volt. cont. 2W, 3W, and GC		
Bandwidth	0.2 % to 10.0 %	Increments of 0.1 %
T1 delay	5 s to 600 s	Increments of 1 s
T1 Inverse Min	5 s to 100 s	Increments of 1 s
T2 delay	0 s to 100 s	Increments of 1 s
Fast step down limit	0.0 % to 50.0 %	Increments of 0.1 %
Fast step down T delay	0.0 s to 10.0 s	Increments of 0.1 s
Fast step up limit	-50.0 % to 0.0 %	Increments of -0.1 %
Fast step up T delay	0.0 s to 10.0 s	Increments of 0.1 s
Function monitoring	1 min to 120 min	Increments of 1 min
Line compensation LDC-Z		
Target voltage rising	0.0 % to 20.0 %	Increments of 0.1 %
Max load current	0.0 % to 500.0 %	Increments of 0.1 %
Line compensation LDC-X and R		
R line	0.0 Ω to 30.0 Ω	Increments of 0.1 Ω
X line	-30.0 Ω to 30.0 Ω	Increments of 0.1 Ω
Limiting values		
Vmin threshold	40.00 kV to 1 360.00 kV	Increments of 0.01 kV
Vmin time delay	0 s to 20 s	Increments of 1 s
Vmax threshold	40.00 kV to 1 360.00 kV	Increments of 0.01 kV
Vmax time delay	0 s to 20 s	Increments of 1 s
Blockings		
V< Threshold	40.00 kV to 1 360.00 kV	Increments of 0.01 kV
V< Time delay	0 s to 20 s	Increments of 1 s
I> Threshold	10 % to 500 %	Increments of 1 %
I> Time delay	0 s to 20 s	Increments of 1 s
I< Threshold	3 % to 100 %	Increments of 1 %

I< Time delay	0 s to 20 s	Increments of 1 s

Measured Values, Two-Winding Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
V act.	Current, measured positive-sequence voltage (referenced to phase-to-phase)	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	kV	V	Voltage difference referenced to the rated voltage of the controlled winding
I load	Current measured load current (positive-sequence system)	A	A	Load current referenced to the rated current of the winding
V max	Maximum positive-sequence voltage ever measured (referenced to phase-to-phase)	kV	V	Maximum voltage of the winding referenced to the rated voltage of the winding
V min	Minimum positive-sequence voltage ever measured (reference to phase-to-phase)	kV	V	Minimum voltage of the winding referenced to the rated voltage of the winding
V target	Calculated target voltage with consideration of Z compensation	kV	V	Target voltage of the winding referenced to the rated voltage of the winding

Measured Values, Three-Winding Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
Vact.w1	Actual voltage of winding 1	kV	V	Target voltage of the primary system referenced to the rated voltage
Vact.w2	Actual voltage of winding 2	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	kV	V	Voltage difference referenced to the rated voltage of the controlled winding
I load w1	Load current of winding 1	A	A	Load current referenced to the rated current of winding 1
I load w2	Load current of winding 2	A	A	Load current referenced to the rated current of winding 2
Vmax 1	Maximum voltage of winding 1	kV	V	Maximum voltage of winding 1 referenced to the rated voltage of winding 1
Vmax 2	Maximum voltage of winding 2	kV	V	Maximum voltage of winding 2 referenced to the rated voltage of winding 2
Vmin 1	Minimum voltage of winding 1	kV	V	Minimum voltage of winding 1 referenced to the rated voltage of winding 1
Vmin 2	Minimum voltage of winding 2	kV	V	Minimum voltage of winding 2 referenced to the rated voltage of winding 2
V tar.w1	Target voltage of winding 1	kV	V	Target voltage of winding 1 referenced to the rated voltage of winding 1

Measured Value	Description	Primary	Secondary	% Referenced to
V tar.w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

Measured Values Grid Coupling Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
Vact.w1	Actual voltage of winding 1	kV	V	Target voltage of the primary system referenced to the rated voltage
Vact.w2	Actual voltage of winding 2	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	kV	V	Voltage difference referenced to the rated voltage of the controlled winding
I load w1	Load current of winding 1	A	A	Load current referenced to the rated current of winding 1
I load w2	Load current of winding 2	A	A	Load current referenced to the rated current of winding 2
Vmax 1	Maximum voltage of winding 1	kV	V	Maximum voltage of winding 1 referenced to the rated voltage of winding 1
Vmax 2	Maximum voltage of winding 2	kV	V	Maximum voltage of winding 2 referenced to the rated voltage of winding 2
Vmin 1	Minimum voltage of winding 1	kV	V	Minimum voltage of winding 1 referenced to rated voltage of winding 1
Vmin 2	Minimum voltage of winding 2	kV	V	Minimum voltage of winding 2 referenced to rated voltage of winding 2
V tar.w1	Target voltage of winding 1	kV	V	Target voltage of winding 1 referenced to the rated voltage of winding 1
V tar.w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

Dropout Ratio

Threshold of the voltage limit	About 0.99 of the setting value
Threshold of the current limit	About 0.99 of the setting value

12.57 Current-Balance Supervision

Setting Values

Release threshold	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	1 A @ 50 Irated		
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	5 A @ 50 Irated		
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold value min/max		0.10 to 0.95	Increments of 0.01
Tripping delay		0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Overcurrent dropout ratio	About 0.97
Undercurrent dropout ratio	About 1.05

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.58 Voltage-Balance Supervision

Setting Values

Release threshold value	0,300 V to 170,000 V	Increments of 0.001 V
Threshold value min/max	0.58 to 0.95	Increments of 0.01
Tripping delay	0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Overvoltage dropout ratio	Approx. 0.97
Undervoltage dropout ratio	Approx. 1.05

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.59 Current-Sum Supervision

Setting Values

Slope of the characteristic curve		0.00 to 0.95	Increments of 0.01
Threshold	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Tripping delay		0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Dropout ratio	About 0.97

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.60 Voltage-Sum Supervision

Setting Values

Threshold value	0.300 V to 170.000 V	Increments of 0.001 V
Tripping delay	0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Dropout ratio	Approx. 0.97

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.61 Current Phase-Rotation Supervision

Setting Values

Tripping delay	0.00 s to 100.00 s	Increments of 0.01 s
Phase-rotation direction	A B C A C B	

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.62 Voltage Phase-Rotation Reversal

Setting Values

Tripping delay	0.00 s to 100.00 s	Increments of 0.01 s
Phase-rotation direction	A B C A C B	

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.63 Trip-Circuit Supervision

Setting Values

Number of monitored circuits per circuit-breaker function group	1 to 3	
Operating mode per circuit	With 1 binary input With 2 binary inputs	
Pickup and dropout time	About 1 s to 2 s	
Adjustable indication delay with 1 binary input	1.00 s to 600.00 s	Increments of 0.01 s
Adjustable indication delay with 2 binary inputs	1.00 s to 600.00 s	Increments of 0.01 s

12.64 Analog Channel Supervision via Fast Current Sum

Times

Pickup times	Approx. 2 ms (faster than the fastest protection function)
Dropout time	Approx. 100 ms

Blockings

Blocked functions	All functions that process the measured values from this current measuring point (for example, differential protection).

12.65 Measuring-Voltage Failure Detection

Setting Values

3ph.fail. - VA,VB,VC <		0.300 V to 340 000 V	Increments of 0.001 V
3ph.fail. - phs.curr.release	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
3ph.fail. - phs.curr. jump	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Asym.fail. - time delay		0.00 s to 30.00 s	Increments of 0.01 s
SO 3ph.fail. - time delay		0.00 s to 30.00 s	Increments of 0.01 s

Dropout

The larger dropout differential (= **`| pickup value – dropout threshold |`**) of the following 2 criteria is used:

Dropout differential derived from the `Dropout ratio` parameter If this parameter is not available, a dropout ratio of 95 % applies to the overvoltage protection and a dropout ratio of 105 % applies to the undervoltage protection.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup time	Approx. 10 ms + OOT[122] at 50 Hz Approx. 10 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Times

Use in function group **Line**	
Pickup time	Approx. 10 ms + OOT[123] at 50 Hz Approx. 9 ms + OOT at 60 Hz

Use in other function group types	
Pickup time	Approx. 20 ms + OOT[124] at 50 Hz Approx. 18 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances

[122] OOT (Output Operating Time) Additional delay of the output medium used, see chapter *12.1.4 Relay Outputs*
[123] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relays, see chapter *12.1.4 Relay Outputs*
[124] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relays, see chapter *12.1.4 Relay Outputs*

f < 10 Hz f > 80 Hz	Active

Tolerances

Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10%)
Voltages	0.5 % of the setting value or 0.5 V
Time delays	1 % of the setting value or 10 ms

12.66 Voltage-Transformer Circuit Breaker

Setting Values

Response time	0.000 s to 0.030 s	Increments of 0.001 s

12.67 Operational Measured Values and Statistical Values

The following applies to the tolerances of currents and voltages:

- The values apply both to the RMS values and the absolute value and phase angle of the fundamental components.
- The values were determined for pure sinusoidal signals – without harmonics.

Voltages

V_A, V_B, V_C Voltage range	V secondary < 200 V secondary
Secondary rated voltage Measuring range Frequency range	100 V to 125 V AC (0.8 to 2) · V_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range
V_{AB}, V_{BC}, V_{CA} Voltage range	V secondary < 200 V
Secondary rated voltage Measuring range Frequency range	100 V to 125 V AC (0.8 to 2) · V_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range

Currents, Instrument Transformers

I_A, I_B, I_C, $3I_0$ Current range	A secondary < 1.6 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A (0.1 to 1.6) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.15 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range

Currents, Protection-Class Current Transformer

I_A, I_B, I_C, $3I_0$ Current range	A secondary < 100 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A 0.1 to 25 A 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range

Currents, Protection-Class Current Transformer

I_A, I_B, I_C, $3I_0$ Current range	A secondary < 50 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A 0.1 to 25 A 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.15 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.6 % of the measured value in the above mentioned measuring range

Currents, Sensitive Ground-Current Transformer

$3I_0$ Current range	A secondary < 1.6 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A (0.1 to 1.6) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.15 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range

Phase Angle

ΦV	°
Frequency range	47.5 Hz to 52.5 Hz at f_{rated} = 50 Hz 57.5 Hz to 62.5 Hz at f_{rated} = 60 Hz

Tolerance ΦV	0.2 ° at rated voltage
ΦI	°
Frequency range	47.5 Hz to 52.5 Hz at f_{rated} = 50 Hz 57.5 Hz to 62.5 Hz at f_{rated} = 60 Hz
Tolerance ΦI	0.2 ° at rated current

Power Values

Active power P	W secondary
Measuring range Voltage range Current range Frequency range	|cosφ| ≥ 0.01 (0.8 to 1.2) · V_{rated} (0.1 to 2) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 69 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.5 % of the measured value in the above mentioned measuring range
Reactive power Q	var secondary
Measuring range Voltage range Current range Frequency range	|cosφ| ≥ 0.984 (0.8 to 1.2) · V_{rated} (0.1 to 2) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	1.0 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 69 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	1.5 % of the measured value in the above mentioned measuring range
Apparent power S	VA
Measuring range Voltage range Current range Frequency range	(0.01 to 2) · S_{rated} (0.8 to 1.2) · V_{rated} (0.01 to 2) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 69 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.5 % of the measured value in the above mentioned measuring range

Frequency

Frequency f	Hz

Range	f_{rated} - 0.20 Hz < f_{rated} + 0.20 Hz
Tolerance	± 5 mHz in the V_{rated} range
Range	f_{rated} - 3.00 Hz < f_{rated} + 3.00 Hz
Tolerance	± 10 mHz in the V_{rated} range
Frequency range (expanded)	25 Hz to 80 Hz; operational measured values 10 Hz to 80 Hz; functional measured values, system frequency
Tolerance	20 mHz in the range f_{rated} ± 10 % for rated values

Statistical Values of the Device

Device operating hours	h
Range	0 to 9 999 999 h
Tolerance	1 h

Statistical Values of the Circuit Breaker

Op.cnt. (operation counter)	
Range	0 to 999 999 999
Tolerance	None
∑**I Off** (sum of the primary currents switched off)	A, kA, MA, GA, TA, PA primary
Range	0 to 9.2 e+15
Operating hours	h
Range	0 to 9 999 999 h
Tolerance	1 h
Circuit breaker open hours	h
Range	0 to 9 999 999 h
Tolerance	1 h

Statistical Values of the Disconnector

Op.cnt. (operation counter)	
Range	0 to 999 999 999
Tolerance	None

12.68 Energy Values

Setting Values

Active energy W_p Reactive energy W_q	kWh, MWh, GWh kvarh, Mvarh, Gvarh
Range	≤ 2% for $I > 0.1\ I_{rated}$, $V > 0.1\ V_{rated}$ $\lvert\cos\varphi\rvert \geq 0.707$
Tolerance at rated frequency	1 %

12.69 Phasor Measurement Unit

Accuracy

As per IEEE Std C37.118.1a-2013

Synchrophasor Standard

IEEE Std C37.118.1-2011

12.70 Circuit-Breaker Wear Monitoring

Setting Values

Threshold value	ΣI^x-method stage	0 to 10 000 000	Increments of 1
	2P-method stage	0 to 10 000 000	Increments of 1
	I^2t-method stage	0.00 I/Ir*s to 21 400 000.00 I/Ir*s	Increments of 0.01
CB opening time		0.001 s to 0.500 s	Increments of 0.001 s
CB break time		0.001 s to 0.600 s	Increments of 0.001 s
CB make time		0.001 s to 0.600 s	Increments of 0.001 s
Exponent for the ΣI^x method		1.0 to 3.0	Increments of 0.1
Switching cycles at I_{rated}		100 to 1 000 000	Increments of 1
Rated short-circuit breaking current I_{sc}		10 to 100 000	Increments of 1
Switching cycles at I_{sc}		1 to 1000	Increments of 1
Level of warning 1		1 % to 100 %	Increments of 1 %
Level of warning 2		1 % to 100 %	Increments of 1 %
Operating current threshold	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Delay correction time		-0.050 s to 0.050 s	Increments of 0.001 s

Tolerances

Tolerance of the measured value make time	± 2 ms

12.71 CFC

Typical response times and maximum number of ticks of the CFC task levels:

Task Level	Time (in ms)	Ticks for Non-Modular Devices with CP100	Ticks for Modular Devices with CP200	Ticks for Modular Devices with CP300
Fast Event-Triggered	<1	500	500	1000
Event-Triggered	<10	12 367	12757	14702
Interlocking	<10	117 564 in total	121 537 in total	141 398 in total
Measurement	250			

The times describe the response time of a typical CFC chart at the respective task level. The maximum number of ticks applies to a typical load for the device based on the application template **Directional time-overcurrent protection, grounded electrical power system**. The maximum number can be lower in case of extensive protection applications.

The task level ***Measurement*** runs in cycles every 500 ms. All other task levels are event-triggered.

In order to estimate the tick consumption of a CFC chart, you can use the following formula:

$$T_{chart} = 5 \cdot n_{Inp} + 5 \cdot n_{Outp} + T_{TLev} + \sum_i T_{int} + \sum_j T_{Block}$$

where:

n_{Inp} Number of indications routed as input in the CFC chart

n_{Outp} Number of indications routed as output in the CFC chart

T_{TLev} 101 Ticks in Fast Event-Triggered Level
104 Ticks in Event-Triggered Level
54 Ticks in Measurement Level
74 Ticks in Interlocking Level

T_{int} Number of internal connections between 2 CFC blocks in one chart

T_{Block} Used ticks per CFC block (see Technical Data)

Table 12-6 Ticks of the Individual CFC Blocks

Element	Ticks
ABS_D	2.3
ABS_R	1.5
ACOS_R	6.9
ADD_D4	3.4
ADD_R4	3.3
ADD_XMV	6.4
ALARM	1.8
AND_SPS	1.1
AND10	2.9
APC_DEF	1.2
APC_EXE	1.0
APC_INFO	3.9
ASIN_R	1.3
ATAN_R	1.2
BLINK	1.3
BOOL_CNT	2.0
BOOL_INT	1.5

Element	Ticks
BSC_DEF	1.3
BSC_EXE	1.1
BSC_INFO	2,7
BUILD_ACD	2.9
BUILD_ACT	2.2
BUILD_BSC	1.2
BUILD_CMV	2.3
BUILD_DEL	2.1
BUILD_DPS	1.4
BUILD_ENS	1.3
BUILD_INS	0.5
BUILD_Q	0.8
BUILD_SPS	0.6
BUILD_WYE	3.2
BUILD_XMV	2.9
BUILDC_Q	3.0
CHART_STATE	5.9
CMP_DPS	1.5
CON_ACD	0.7
CON_ACT	0.5
CONNECT	0.4
COS_R	2.5
CTD	1.8
CTU	1.6
CTUD	2.3
DINT_REAL	3.0
DINT_UINT	3.0
DIV_D	2.9
DIV_R	1.6
DIV_XMV	2.2
DPC_DEF	0.4
DPC_EXE	0.4
DPC_INFO	1.1
DPC_OUT	1.3
DPS_SPS	1.0
DRAGI_R	1.7
EQ_D	1.0
EQ_R	1.9
EXP_R	1.5
EXPT_R	2.7
F_TRGM	0.3
F_TRIG	0.3
FF_D	0.9
FF_D_MEM	1.4
FF_RS	0.7
FF_RS_MEM	1.2
FF_SR	0.8

Element	Ticks
FF_SR_MEM	1.1
GE_D	0.9
GE_R	1.1
GT_D	0.9
GT_R	1.2
HOLD_D	1.1
HOLD_R	1.0
INC_INFO	0.9
LE_D	1.1
LE_R	1.1
LIML_R	1.5
LIMU_R	1.5
LN_R	3.3
LOG_R	1.2
LOOP	1.5
LT_D	0.9
LT_R	0.9
MAX_D	0.9
MAX_R	1.4
MEMORY_D	0.9
MEMORY_R	1.1
MIN_D	0.7
MIN_R	1.3
MOD_D	1.5
MUL_D4	2.5
MUL_R4	2.7
MUL_XMV	2.8
MUX_D	1.2
MUX_R	0.9
NAND10	3.5
NE_D	0.9
NE_R	0.9
NEG	1.2
NEG_SPS	0.8
NLC_LZ	7.1
NLC_XMV	4.4
NLC_ZP	3.0
NOR10	3.2
OR_DYN	1.1
OR_SPS	1.3
OR10	2.6
R_TRGM	0.4
R_TRIG	0.4
REAL_DINT	3.0
REAL_SXMV	3.0
SIN_R	0.8
SPC_DEF	0.4

Element	Ticks
SPC_EXE	0.4
SPC_INFO	0.4
SPC_OUT	0.4
SPLIT_ACD	3.4
SPLIT_ACT	1.0
SPLIT_BSC	1.3
SPLIT_CMV	2.2
SPLIT_DEL	2.0
SPLIT_DPS	1.0
SPLIT_INS	0.5
SPLIT_Q	0.7
SPLIT_SPS	0.8
SPLIT_WYE	2.6
SPLIT_XMV	2.1
SQRT_R	0.6
SUB_D	1.3
SUB_R	1.6
SUB_XMV	2.4
SUBST_B	1.0
SUBST_BQ	1.5
SUBST_D	1.0
SUBST_R	1.0
SUBST_XQ	1.4
SXMV_REAL	3.0
TAN_R	1.1
TLONG	2.2
TOF	1.0
TON	1.1
TT	2.5
TSHORT	1.9
UINT_DINT	3.0
XOR2	2,6

A Appendix

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A.1 Order Configurator and Order Options

Order Configurator

The order configurator assists you in the selection of SIPROTEC 5 products. The order configurator is a Web application that can be used with any browser. The order configurator can be used to configure complete devices or individual components, such as communication modules, expansion modules, or other accessories. At the end of the configuration process, the product code and a detailed presentation of the configuration result are provided. The product code unambiguously describes the selected product and also serves as an order number.

Ordering Options

The following ordering options are possible for SIPROTEC 5 products:

- Device
- Single part
- DIGSI 5
- Functional enhancement



NOTE

To order single parts in the order configurator, use the **Single part** link.

Individual parts are:

- Replacement base module
- Expansion module
- Plug-in module
- Sensors for arc protection
- Operation panel
- Terminal
- Accessories

A.2 Ordering Accessories

NOTE

To order terminals, terminal accessories, and mechanical accessories in the order configurator, use the **Single part** link.

Table A-1 Accessories

Group	Accessories
Terminal	Voltage terminal, terminal block, 14-pole
Terminal	Voltage input (power supply) Terminal block, 2-pole[125]
Terminal	Type A current terminal, 4 x protection (for modular devices)
Terminal	Type A current terminal, 3 x protection and 1 x measurement (for modular devices)
Terminal	Type A current terminal, 4 x measurement (for modular devices)
Terminal	Type B current terminal, 4 x protection (for non-modular devices)
Terminal	Type B current terminal, 3 x protection and 1 x measurement (for non-modular devices)
Terminal	2-pole cross connector for current terminal
Terminal	Terminal pair component IO110[125]
Terminal	Terminal kit only for IO230/231[125]
Terminal	2-pole cross connector for voltage terminal
Terminal	Cover for current terminal block
Terminal	Cover for voltage terminal block
Accessories	Cable, integrated operation panel 0.43 m
Accessories	Cable, detached operation panel 2.50 m
Accessories	Cable, detached operation panel 5.00 m
Accessories	Cable set COM link cable
Accessories	Cover plate for plug-in modules
Accessories	Set of angle brackets
Accessories	Labeling strips for LEDs/keypad
Accessories	Set of parts for mounting bracket 1/2
Accessories	Set of parts for mounting bracket 2/3
Accessories	Set of parts for mounting bracket 5/6
Accessories	Set of parts for mounting bracket 1/1
Accessories	Screw cover 1/3, type C11
Accessories	Screw cover 1/3, type C22
Accessories	Screw cover 1/6, type C21
Accessories	Bus termination plate
Accessories	Assembly frame for panel surface mounting for non-modular 7xx82 devices
Accessories	SDHC memory card for 7KE85

[125] Recommended tightening torque for fixing the terminal at the rear side: 0.3 Nm

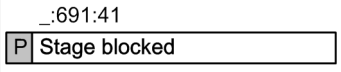
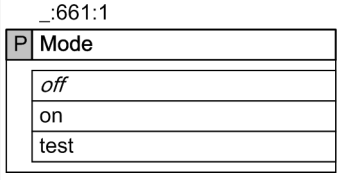
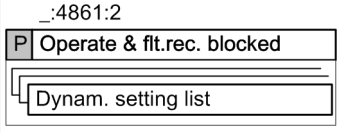
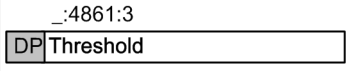
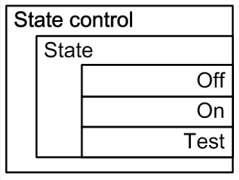
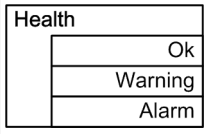
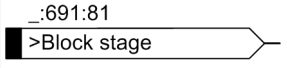
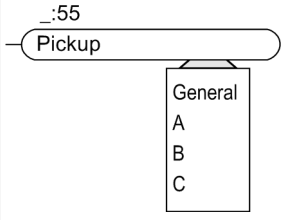
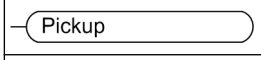
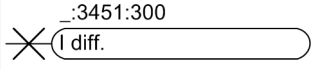
Group	Accessories
Accessories	Battery holder
Accessories	Connecting cable for 2nd row
Accessories	Arc push-buttons
Sensors for arc protection	Point sensor with line length of 3 m
Sensors for arc protection	Point sensor with line length of 4 m
Sensors for arc protection	Point sensor with line length of 5 m
Sensors for arc protection	Point sensor with line length of 10 m
Sensors for arc protection	Point sensor with line length of 15 m
Sensors for arc protection	Point sensor with line length of 20 m
Sensors for arc protection	Point sensor with line length of 35 m
Sensors for arc protection	Line sensor with line length of 5 m
Sensors for arc protection	Line sensor with line length of 10 m
Sensors for arc protection	Line sensor with line length of 20 m
Sensors for arc protection	Line sensor with line length of 30 m
Sensors for arc protection	Line sensor with line length of 40 m
Sensors for arc protection	Supply line for line sensors, length: 3 m
Sensors for arc protection	Supply line for line sensors, length: 5 m
Sensors for arc protection	Supply line for line sensors, length: 10 m

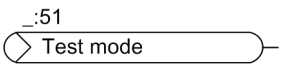
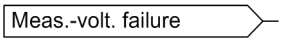
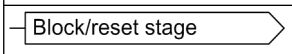
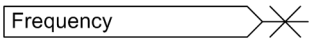
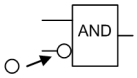
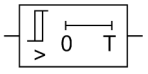
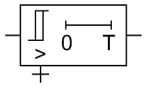
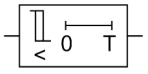
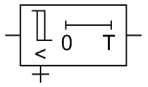
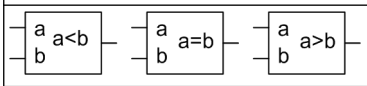
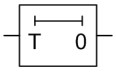
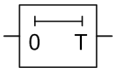
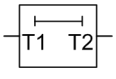
A.3 Typographic and Symbol Conventions

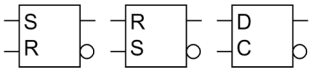
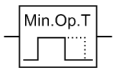
The following typefaces are used to characterize parameters in the text:

Mode	Parameter name
_:661:1	Parameter address _ stands for the address combination from function group:function 661, for example, stands for the address of the setting parameter
from	Parameter state

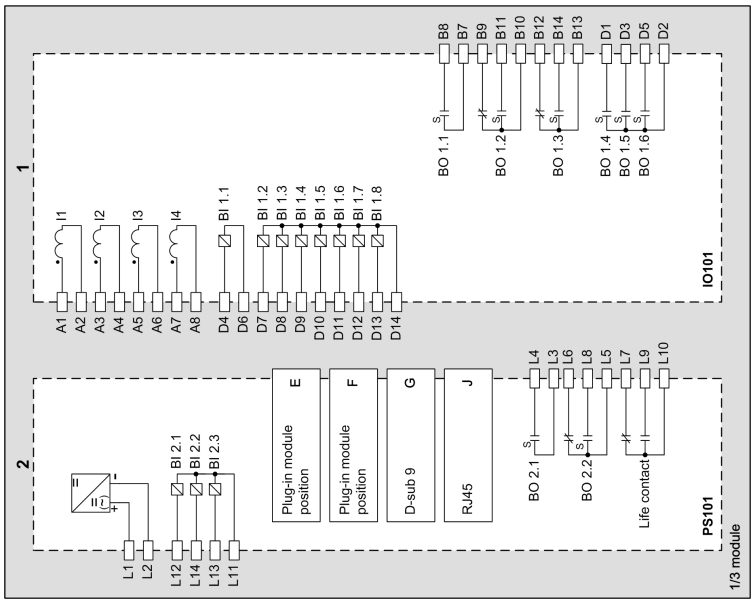
The following symbols are used in drawings:

Icon	Description
	Parameter
	Parameters with setting values The default setting is in the 1st position and displayed in italics
	Parameters with application-dependent setting values
	Dynamic settings:
	State logic
	Health of a function, stage, or function block
	External binary input signal with indication number
	External output signal with indication number and additional information
	External output signal without indication number
	Measured output value

Icon	Description
	Binary input signal derived from an external output signal
	Internal input signal
	Internal output signal
	Analog input signal
	Reset/Block a logic element
	AND gate
	OR gate
	XOR gate
	Negation
	Threshold stage exceeded
	Threshold stage exceeded with reset of input
	Threshold stage shortfall
	Threshold stage shortfall with reset of input
	Threshold stage exceeded with dropout delay
	Threshold stage exceeded with dropout delay and reset of input
	Threshold stage shortfall with Dropout delay
	Threshold stage shortfall with dropout delay and reset of input
	Comparators
	Pickup delay
	Dropout delay
	Pickup and dropout delay

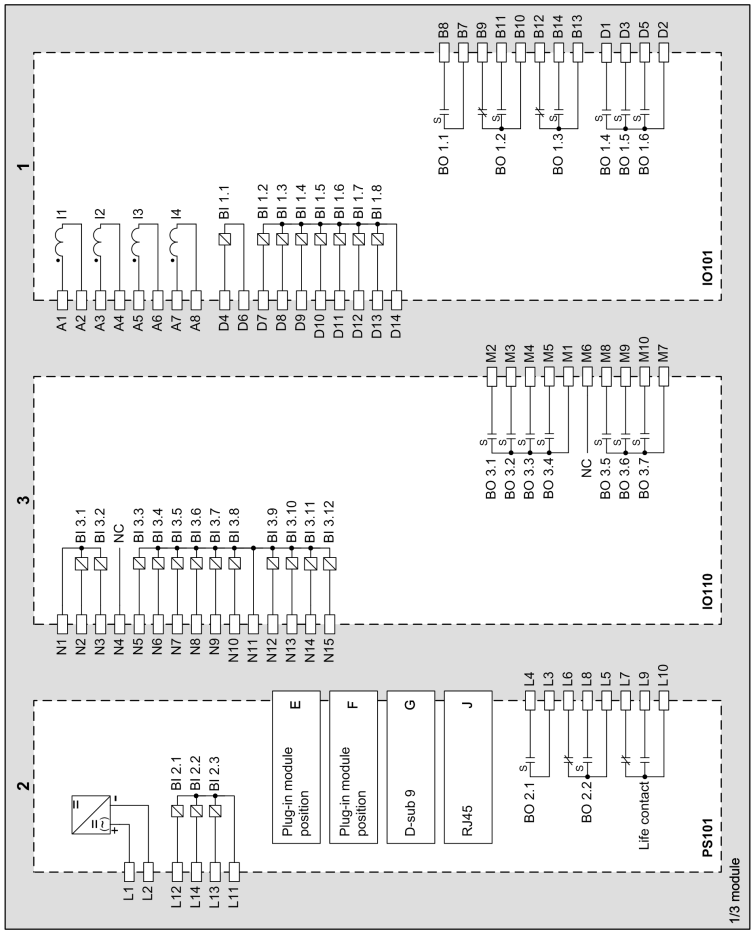
Icon	Description
	Trigger the pulse of duration T with a positive signal edge
	Trigger the pulse of duration T with a negative signal edge
	SR-Flip-Flop, RS-Flip-Flop, D-Flip-Flop
	Characteristic curve
	Minimum operate time

A.4 Standard Variants for 7SJ82



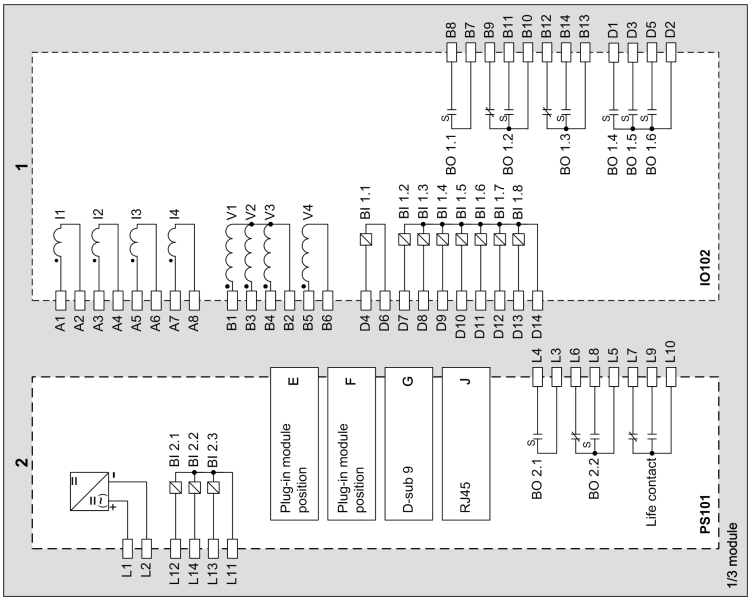
[sv82typ01-120913-01.tif, 1, en_US]

Figure A-1 Standard Variant Type U1



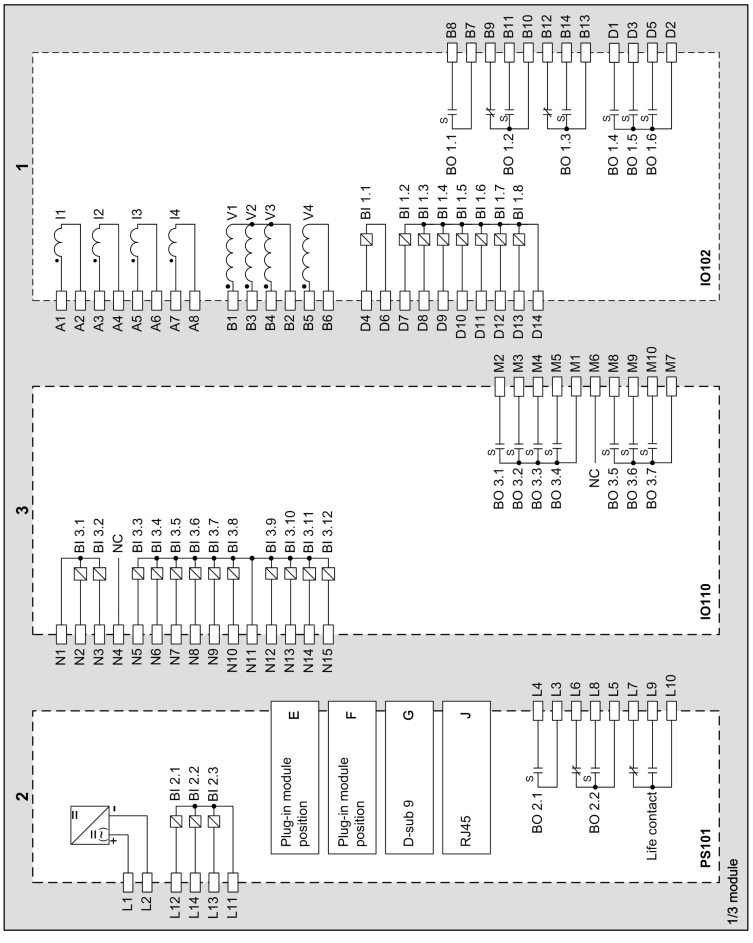
[sv82typ02-120913-01.tif, 1, en_US]

Figure A-2 Standard Variant Type U2



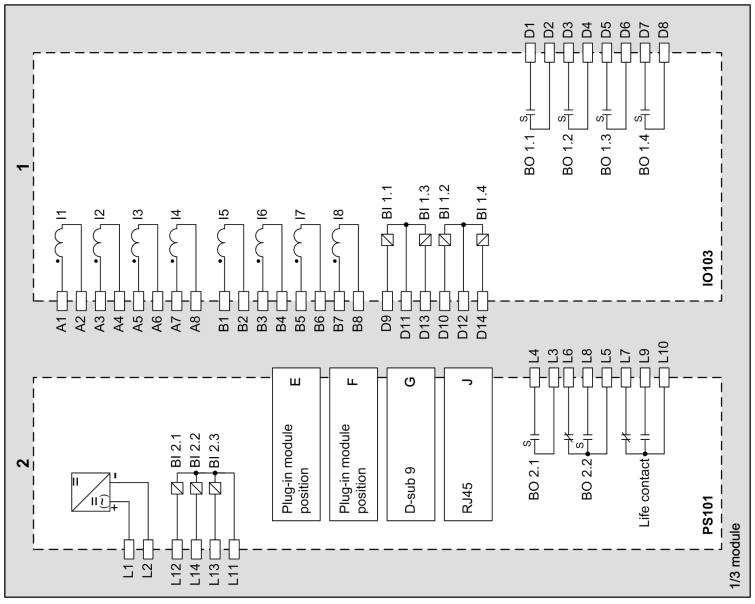
[sv82typ03-120913-01.tif, 1, en_US]

Figure A-3 Standard Variant Type U3



[sv82typ04-120913-01.tif, 1, en_US]

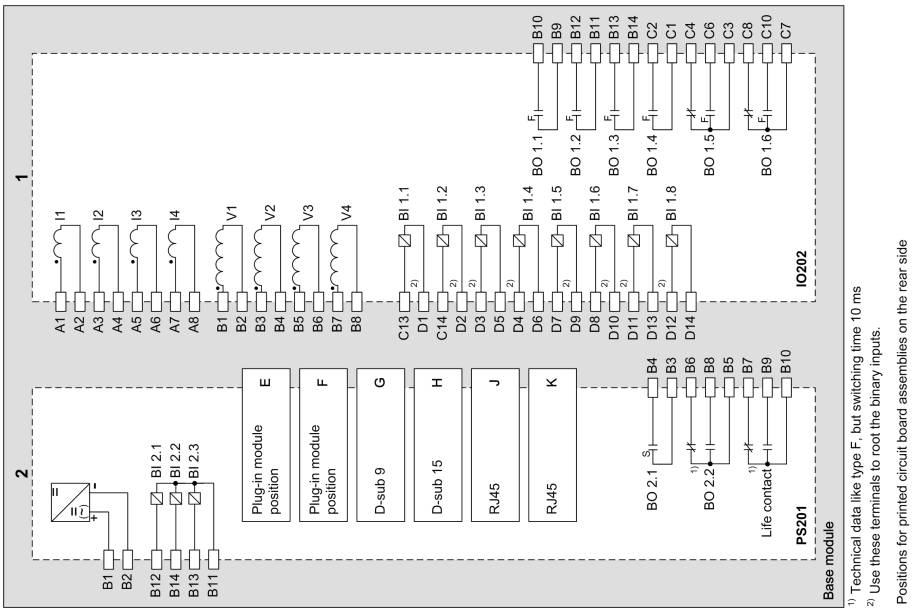
Figure A-4 Standard Variant Type U4



[svut82typ01-210114-01, 1, en_US]

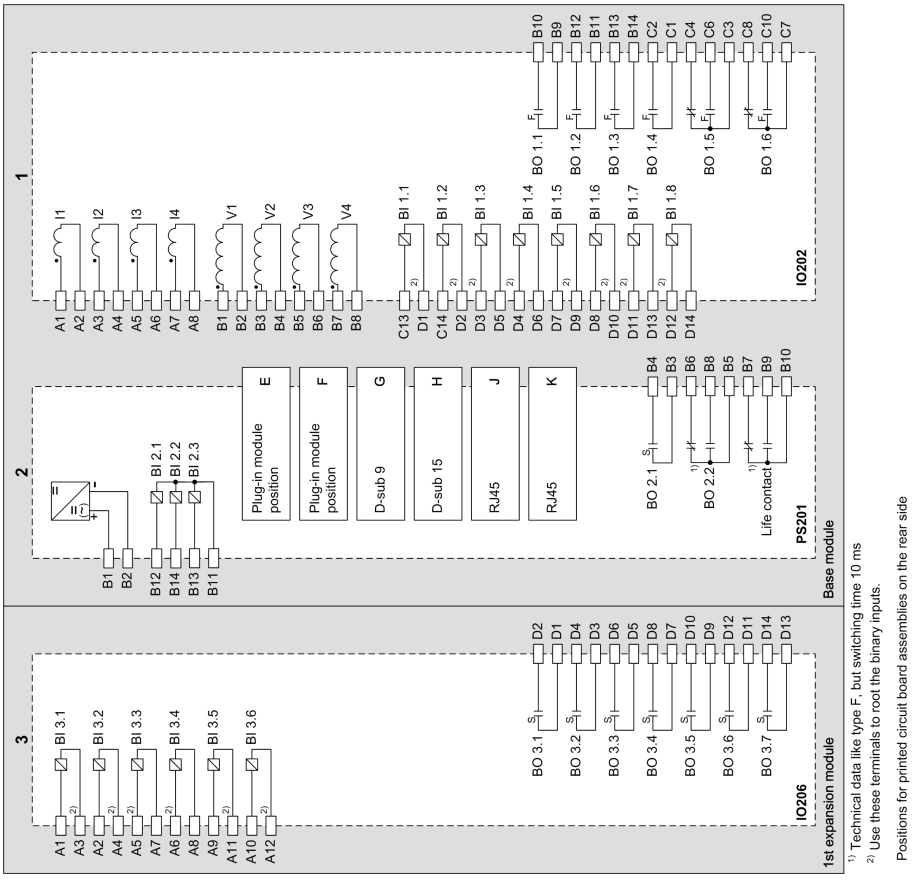
Figure A-5 Standard Variant Type U5

A.5 Standard Variants for 7SJ85



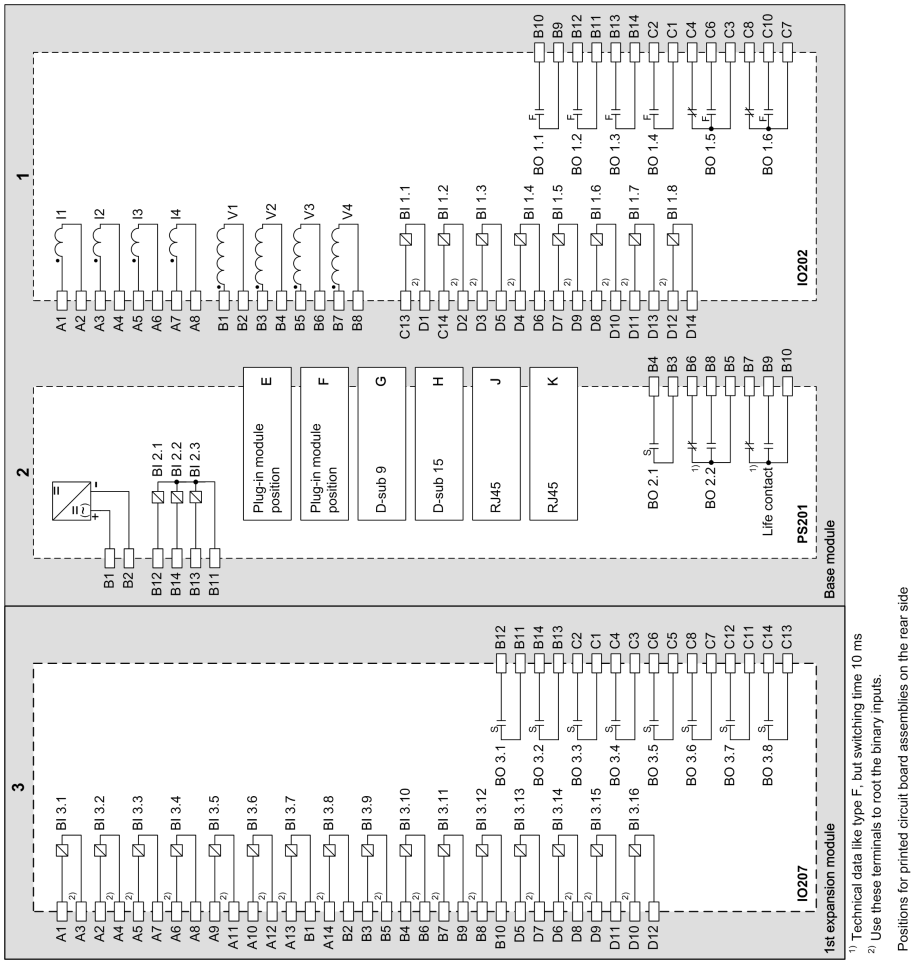
[svstyp01-191112-01.tif, 1, en_US]

Figure A-6 Standard Variant Type S1



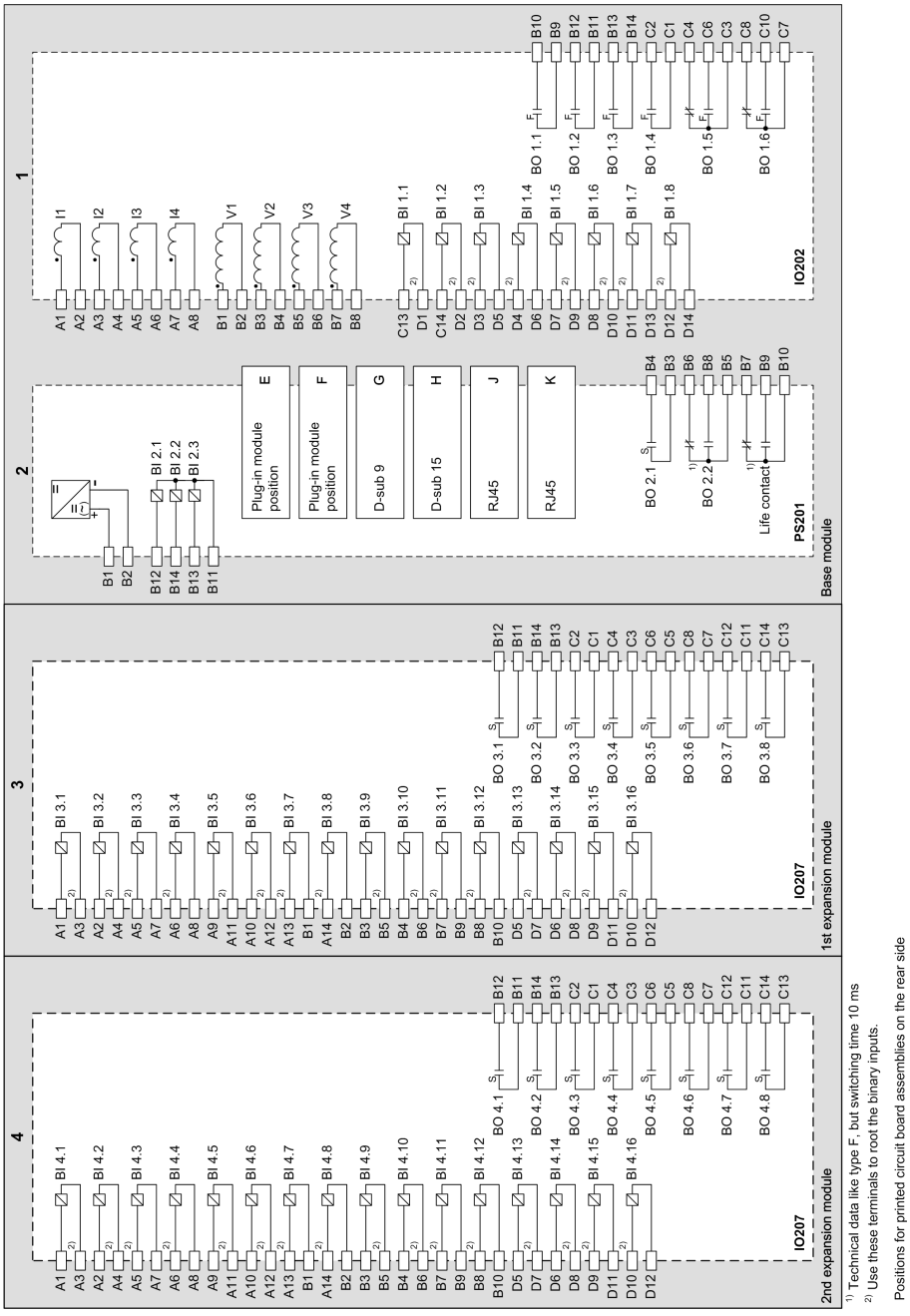
[svstyp02-191112-01.tif, 1, en_US]

Figure A-7 Standard Variant Type S2



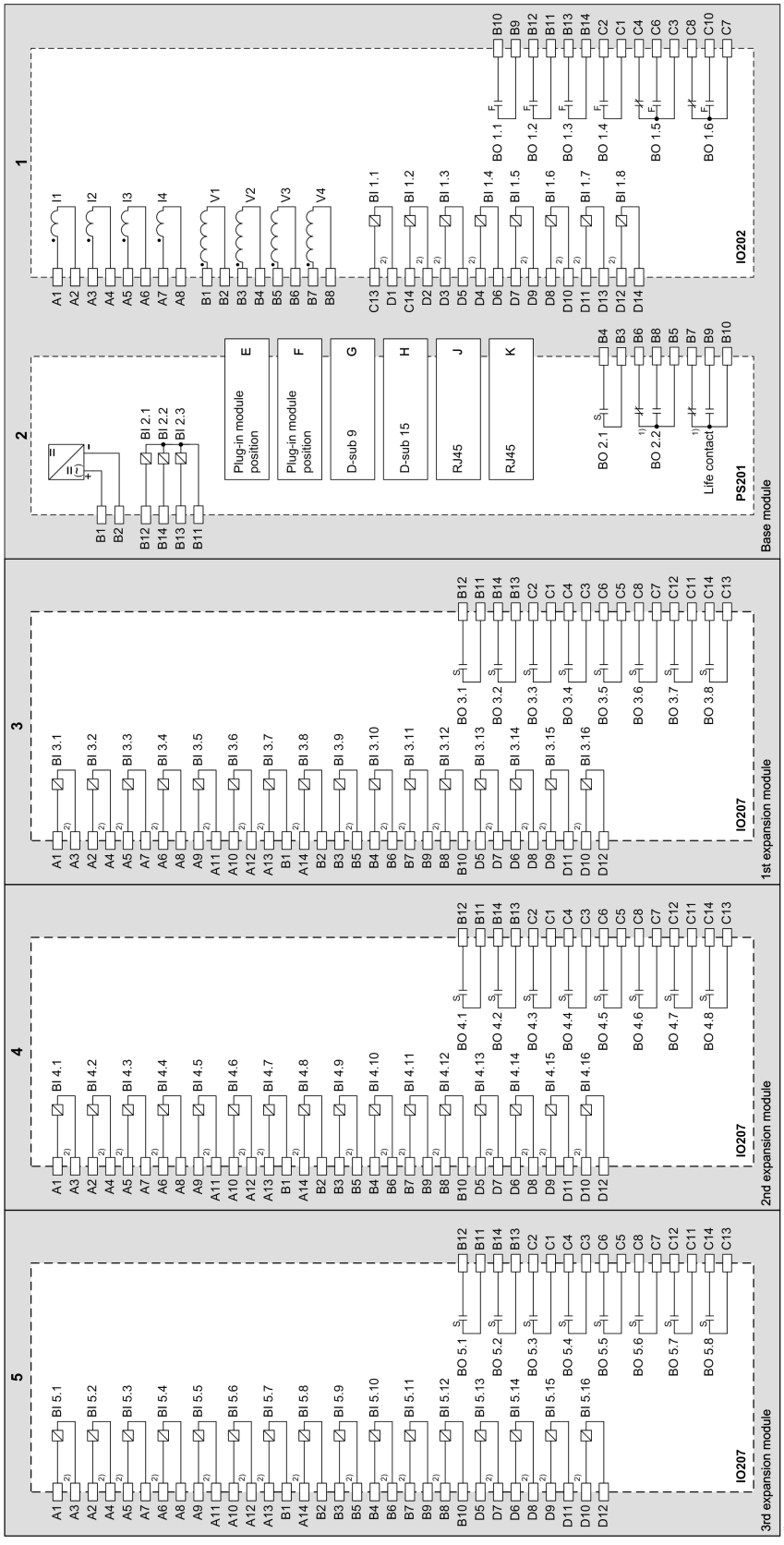
[svstyp03-191112-01.tif, 1, en_US]

Figure A-8 Standard Variant Type S3



[svstyp04-191112-01.tif, 1, en_US]

Figure A-9 Standard Variant Type S4



[svstyp05-191112-01.tif, 1, en_US]

Figure A-10 Standard Variant Type S5

A.6 Current Transformer Requirements

The requirements for phase current transformers are usually determined by the overcurrent protection, particularly by the high-current element settings. Besides, there is a minimum requirement based on experience.

The recommendations are given according to the standard IEC 60044-1.

The standards IEC 60044-6, BS 3938 and ANSI/IEEE C 57.13 are referred to for converting the requirement into the knee-point voltage and other transformer classes.

Accuracy Limiting Factors

Table A-2 Effective and Rated Accuracy Limiting Factor

Required minimum effective accuracy limiting factor	$K_{ALF'} = \frac{I \gg_{PU}}{I_{rated,\ prim}}$ but at least 20	
	with	
	$K_{ALF'}$	Minimum effective accuracy limiting factor
	$I>>_{PU}$	Primary pickup value of the high-current element
	$I_{rated,prim}$	Primary rated transformer current
Resulting rated accuracy limiting factor	$K_{ALF} = \frac{R_{BC} + R_{Ct}}{R_{BN} + R_{Ct}} \cdot K_{ALF'}$	
	with	
	K_{ALF}	Rated accuracy limiting factor
	R_{BC}	Connected burden (device and cables)
	R_{BN}	Rated burden
	R_{Ct}	Internal burden

Table A-3 Calculation Example According to IEC 60044–1

$I_{rated,sec}$ = 1 A $K_{ALF'}$ = 20 R_{BC} = 0.6 Ω (device and cables) R_{Ct} = 3 Ω R_{BN} = 5 Ω (5 VA)	$K_{ALF} = \frac{0.6 + 3}{5 + 3} \cdot 20 = 9$ K_{ALF} set to 10, so that: 5P10, 5 VA
with $I_{rated,sec}$ = Secondary rated transformer current	

Class Conversion

Table A-4 Conversion into Other Classes

British Standard BS 3938	$V_k = \frac{(R_{Ct} + R_{BN}) \cdot I_{rated,sec}}{1.3} \cdot K_{ALF}$
ANSI/IEEE C 57.13, class C	$V_{st\ max} = 20 \cdot I_{rated,sec} \cdot R_{BN} \cdot \frac{K_{ALF}}{20}$ $I_{rated,sec}$ = 5 A (typical value)

IEC 60044-6 (transient response), class TPS Classes TPX, TPY, TPZ	$V_{al} = K \cdot k_{SSC} \cdot (R_{Ct} + R_{BN}) \cdot I_{rated,sec}$ K≈ 1 $K_{SSC} \approx K_{ALF}$ You can find a calculation example in the above section Accuracy Limiting Factors with: $K_{SSC} \approx K_{ALF}$ T_P depending on power system and specified closing sequence	
	with	
	V_k	Knee-point voltage
	R_{Ct}	Internal burden
	R_{BN}	Rated burden
	$I_{rated,sec}$	Secondary rated transformer current
	K_{ALF}	Rated accuracy limiting factor
	$V_{s.t.max}$	Secondary terminal voltage at 20 $I_{rated,prim}$
	V_{al}	Secondary magnetization limit voltage
	K	Dimensioning factor
	K_{SSC}	Factor symmetric rated fault current
	T_P	Primary time constant

Cable Core Balance Current Transformer

The requirements to the cable core balance current transformer are determined by the function **Sensitive ground-fault detection**.
The recommendations are given according to the standards IEC 60044-1 and IEC 61869-2.

Table A-5 Requirements to the cable core balance current transformer according to IEC 60044-1 and IEC 61869-2

Transformation ratio, typical It may be necessary to select a different transformation ratio to suit the specific power system and thus the corresponding amount of the maximum ground fault current.	60 / 1
Accuracy limiting factor	FS = 10
Power	1 to 4 times the connected burden (device input plus infeeds)
Notes concerning the power: The burden of the sensitive ground-current input is very low (0.05 VA or 0.1 VA). Thus, an underburden of more than factor 4 is probable. In this case, clarify the suitability of the class accuracy concerning an important underburden with the transformer manufacturer. If necessary, request the accuracy for the range from 0 VA to the rated burden. This specification is then outside the standard, but in practice, it is possible in most cases. (Relevant standard: IEC 61869-2, Chapter 5.6.201.4 Extended burden range. There, the range 1 VA to rated burden is specified for rated burdens smaller than 15 VA.)	

Table A-6 Minimum Required Class Accuracy Depending on Neutral Grounding and Function Operating Principle

Neutral Point	**Isolated**	**Resonant-Grounded**	**High-Resistance Grounded**
Function directional	Class 1	Class 1	Class 1

Function non-directional	Class 3	Class 1	Class 3

NOTE

The class accuracy according to IEC 61869-2 below 5% I_{rated} (< 50 mA secondary) is not defined in general.

For very sensitive directional measurements, Siemens recommends the classes 0.5S or 0.1S that define the class accuracy via an extended current range (up to 1% I_{rated}) (see chapter 5.6.201.5, IEC 61869-2).

Another possibility is to correct the phase-angle error of the transformer on the device, if this error is known (see function description **Sensitive ground-fault detection**.

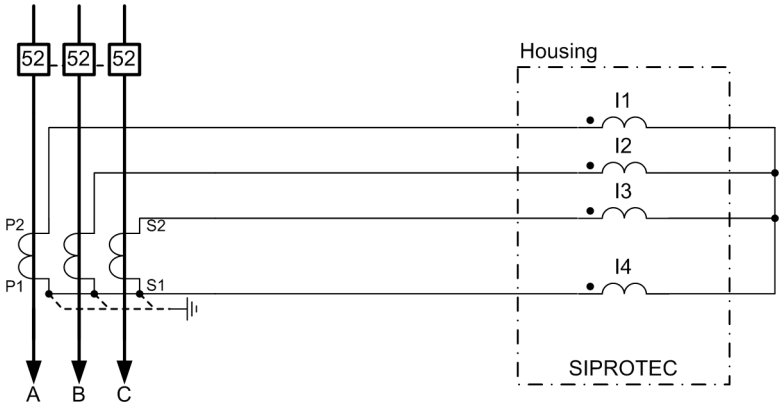
A.7 Connection Examples for Current Transformers



Current transformer 3-phase: connection = **3-phase**

[ti3leit1-070211-01.tif, 1, en_US]

Figure A-11 Connection to a 3-Wire Current Transformer (Residual Current to be Calculated)



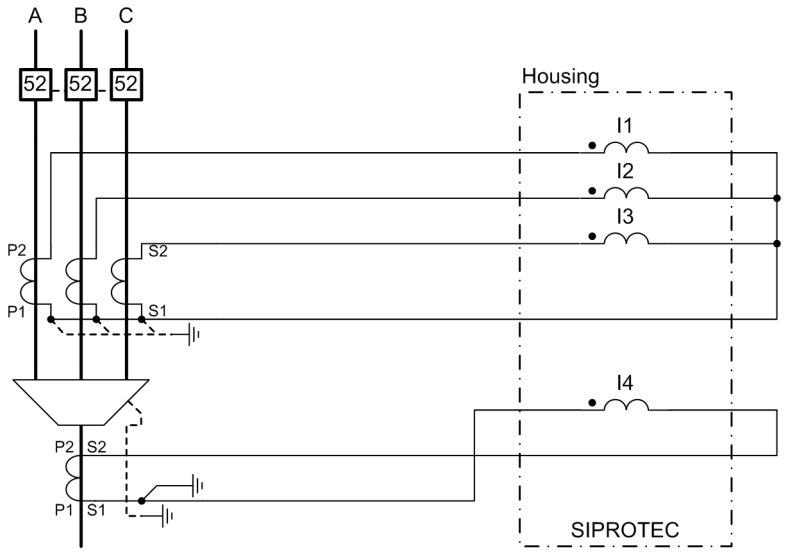
Current transformer 3-phase: connection = **3-phase + IN**

[tileite2-070211-01.tif, 1, en_US]

Figure A-12 Connection to a 3-Wire Current Transformer and Measured Zero-Sequence Current (Current in Common Return Path)

NOTE

The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 (I_N)!



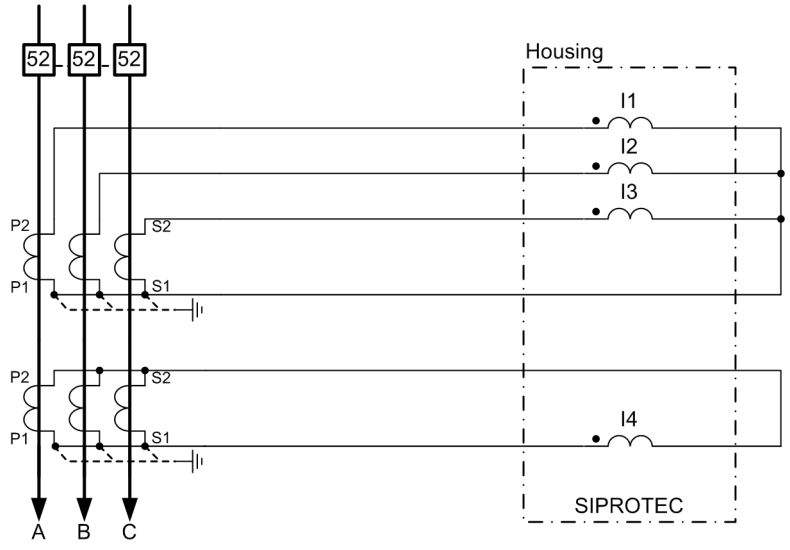
Current transformer 3-phase: connection = **3-phase + IN-separate**

[tileite3-260313-01.tif, 1, en_US]

Figure A-13 Connection to a 3-Wire Current Transformer and Cable Type Current Transformer for Sensitive Ground-Fault Detection

NOTE

The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N\text{-}sep}$)!



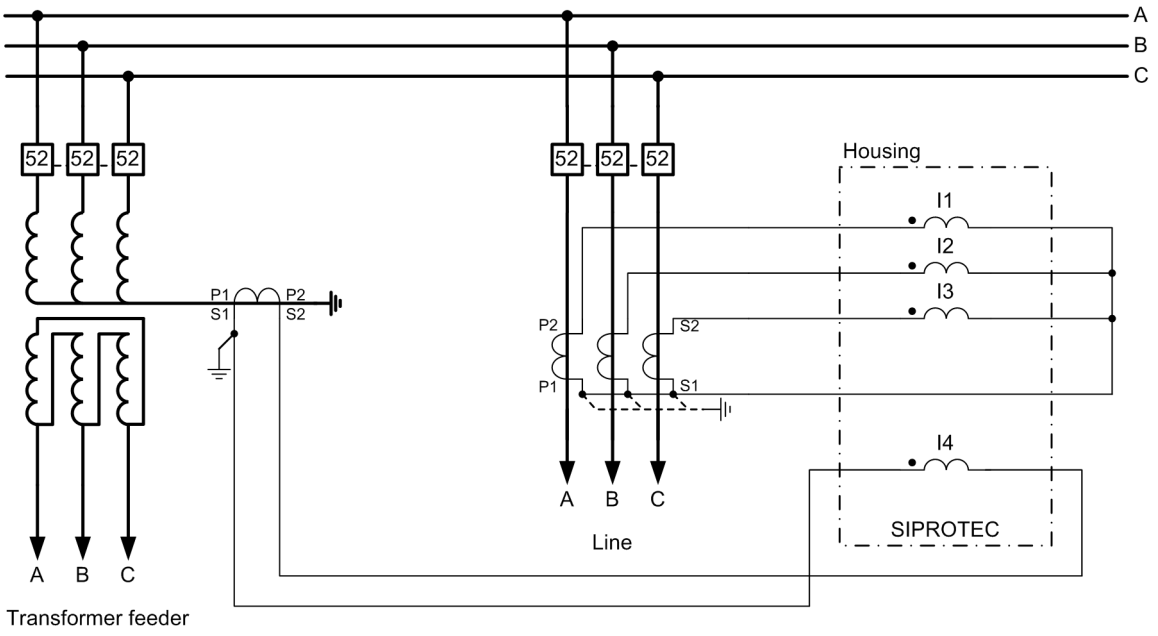
Current transformer 3-phase: connection = **3-phase + IN-separate**

[tileite4-260313-01.tif, 1, en_US]

Figure A-14 Connection to a 3-Wire Current Transformer and Measured Ground Current from a Complete Holmgreen Connection

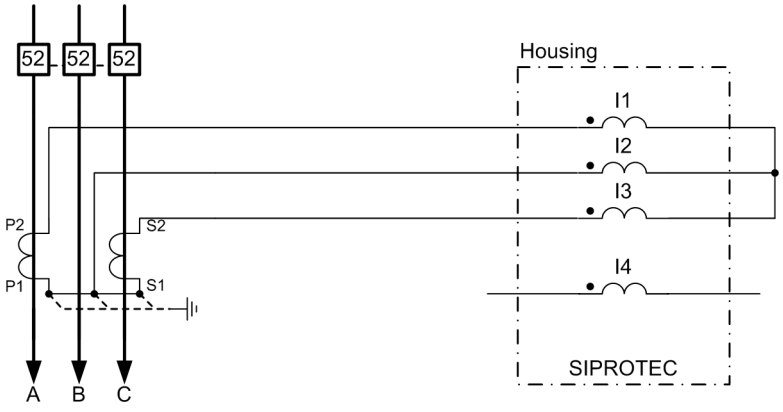
NOTE

The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N\text{-}sep}$)!



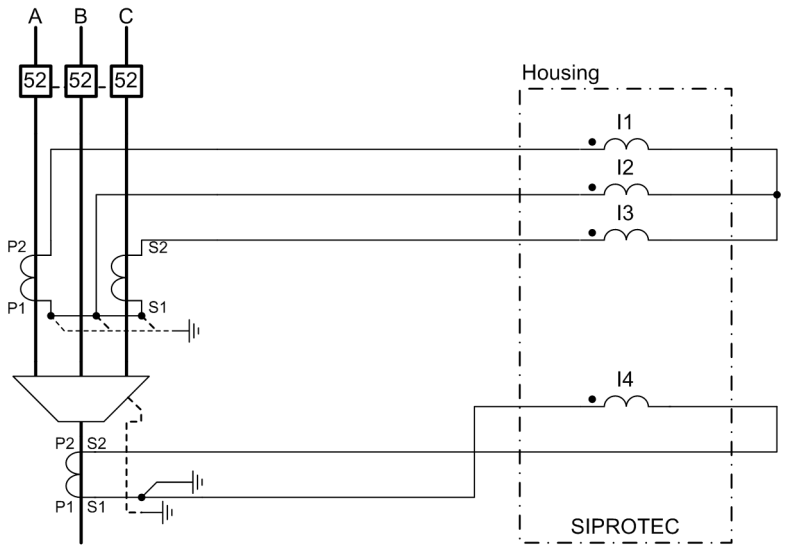
[tileite6-060313-01.tif, 1, en_US]

Figure A-15 Connection to a 3-Wire Current Transformer and Measured Ground Current via the Neutral-Point Current Transformer of a Grounded Power Transformer



[tileite7-070211-01.tif, 1, en_US]

Figure A-16 Connection to a 2-Wire Current Transformer - for Isolated or Resonant-Grounded Systems Only



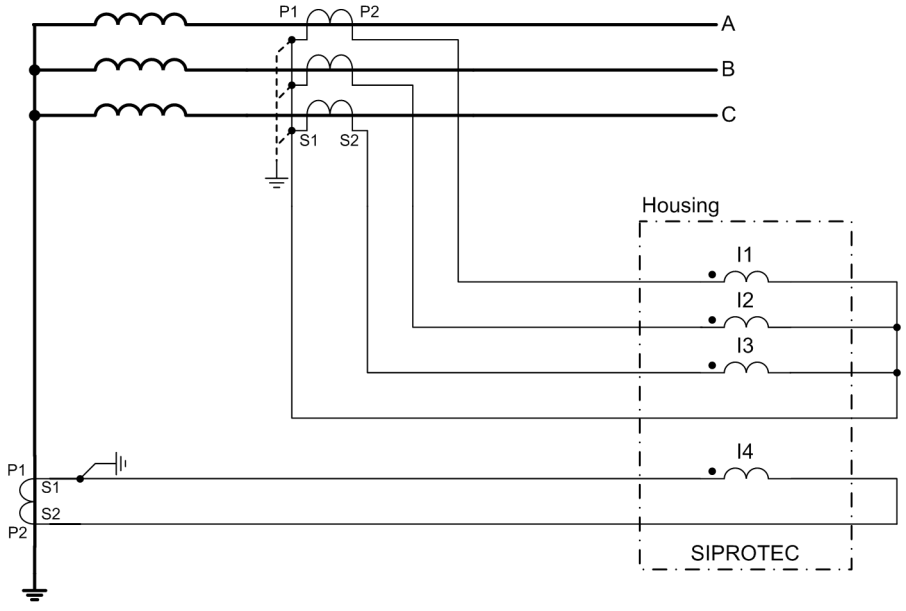
Current transformer 3-phase: connection = **3ph,2prim.CT + IN-sep**

[tileite8-260313-01.tif, 1, en_US]

Figure A-17 Connection to a 2-Wire Current Transformer and Cable Type Current Transformer for Sensitive Ground-Fault Detection - for Isolated or Resonant-Grounded Systems Only

NOTE

The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N\text{-}sep}$)!

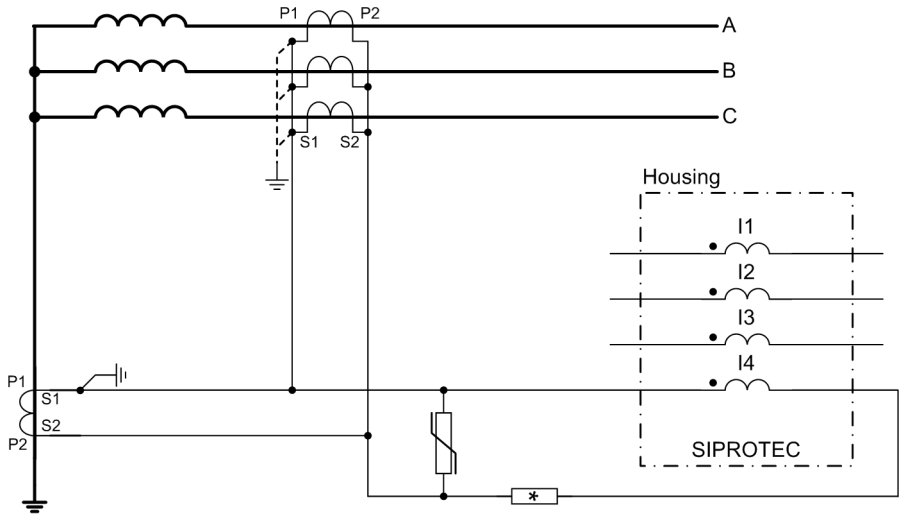


Current transformer 3-phase: connection = **3-phase**

Current transformer 1-phase: connection = **Ix**

[tileite9-260313-01.tif, 1, en_US]

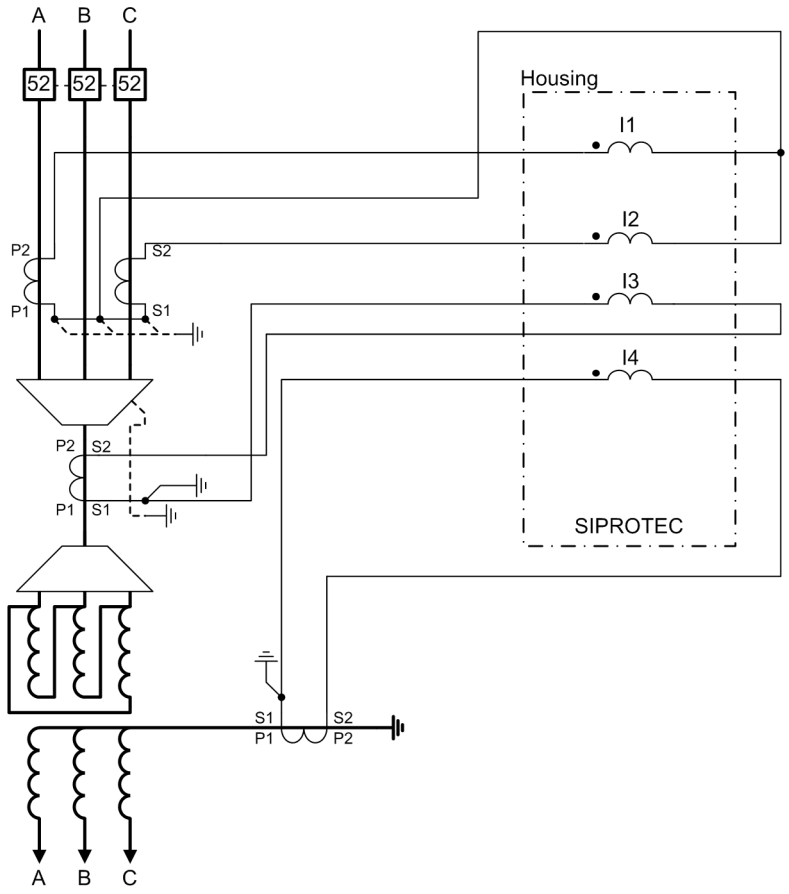
Figure A-18 Connection to a 3-Wire Current Transformer and an Additional Current Transformer in the Neutral Point of a Grounded Power Transformer



Current transformer 1-phase: connection = Ix

[tileit10-260313-01.tif, 1, en_US]

Figure A-19 Current Transformer Connection for High-Impedance Differential Protection (for Example, a Power Transformer, in Preparation)



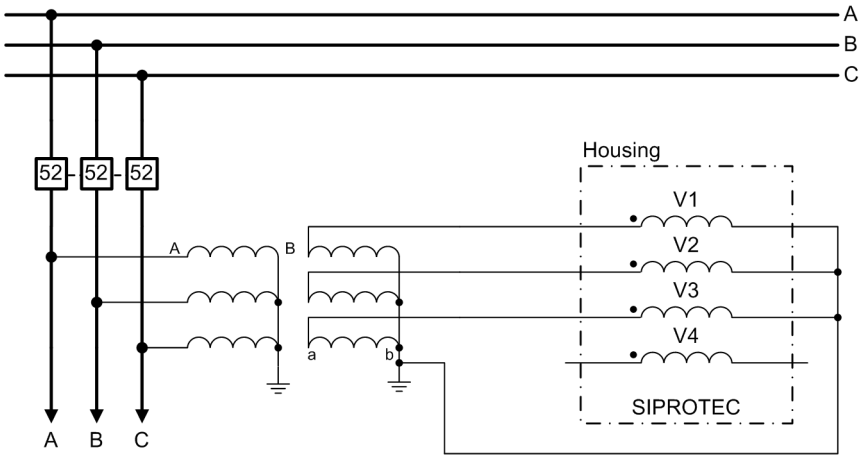
[tileit14-260313-10.tif, 2, en_US]

Figure A-20 Connection to a 2-Phase Current Transformer and Cable Type Current Transformer for Sensitive Ground-Fault Detection of the Line and Additional Sensitive Ground-Fault Detection via the Neutral-Point Current Transformer of a Grounded Power Transformer

NOTE

The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I3 ($I_{N\text{-}sep}$)!

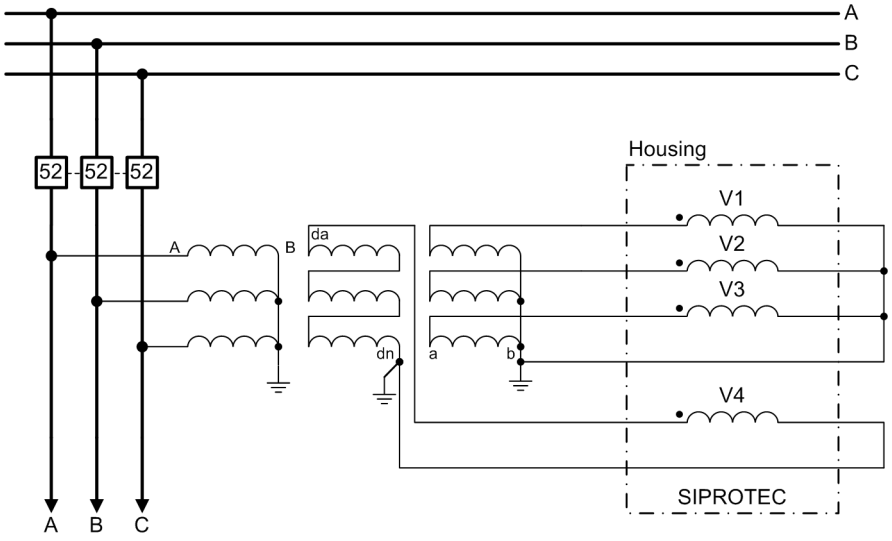
A.8 Connection Examples for Voltage Transformers for 7SJ85



Voltage transformer 3-phase: connection = 3 ph-to-gnd voltages

[tvvolta1-260313-01.tif, 1, en_US]

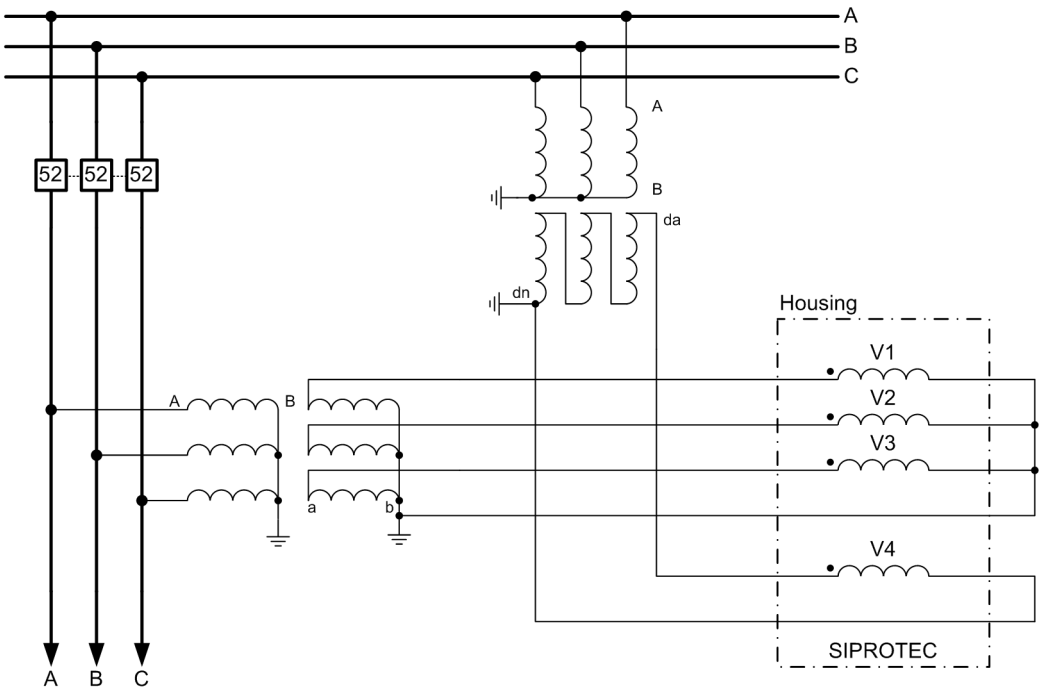
Figure A-21 Connection to 3 Star-Connected Voltage Transformers



Voltage transformer 3-phase: connection = 3 ph-to-gnd volt. + VN

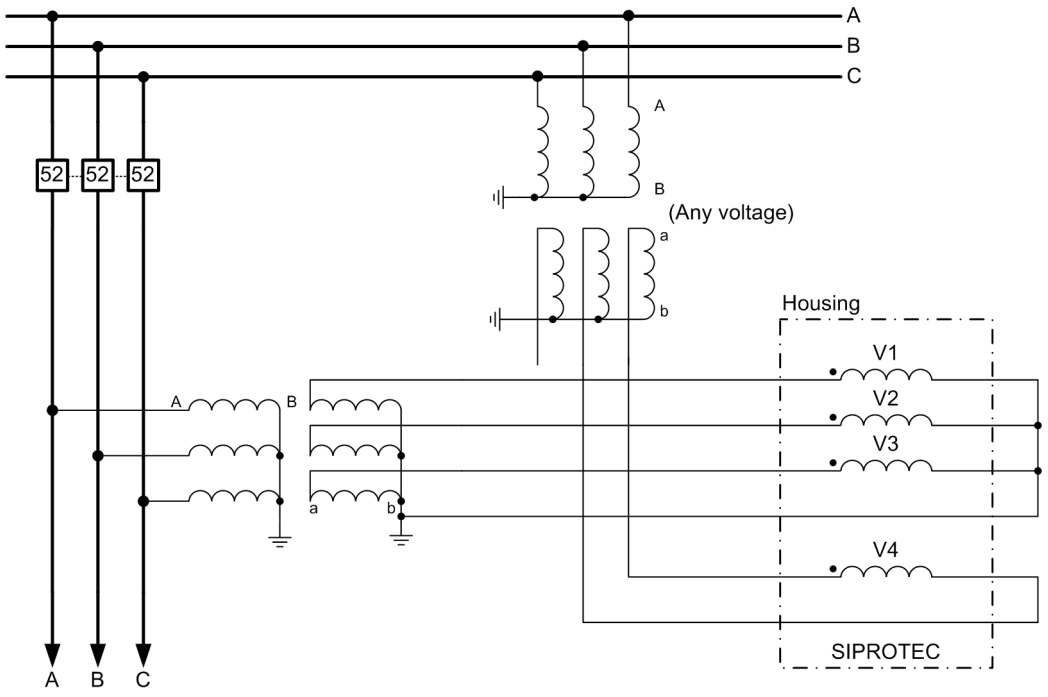
[tvvolta2-260313-01.tif, 1, en_US]

Figure A-22 Connection to 3 Star-Connected Voltage Transformers and to the Broken-Delta Winding



[tvvolta3-260313-01.tif, 1, en_US]

Figure A-23 Connection to 3 Star-Connected Voltage Transformers and to the Broken-Delta Winding of a Separate Voltage Transformer (for example, Busbar)

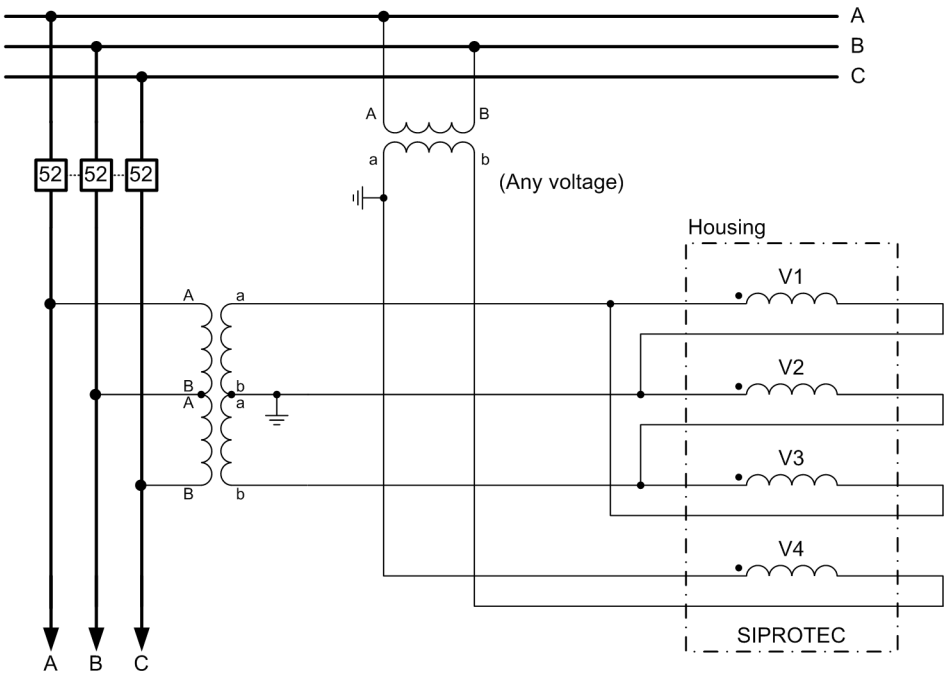


Voltage transformer 3-phase: connection = 3 ph-to-gnd voltages

Voltage transformer 1-phase: connection = VAB

[tvvolta4-260313-01.tif, 2, en_US]

Figure A-24 Connection to 3 Star-Connected Voltage Transformers and to the Phase-to-Phase Voltage of a Busbar Voltage Transformer (for Example, for Synchronization Applications)



Voltage transformer 3-phase: connection = **3 ph-to-ph voltages**

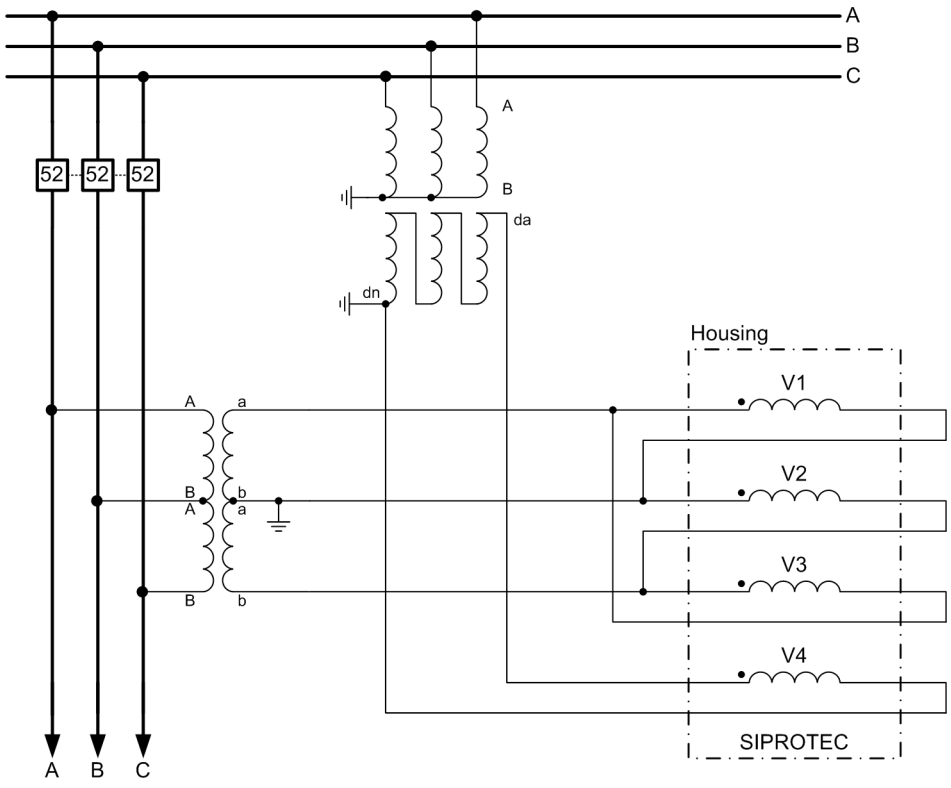
Voltage transformer 1-phase: connection = **VAB**

[tvvolta5-260313-01.tif, 1, en_US]

Figure A-25 Connection to V-Connected Voltage Transformer (Delta-Connected Device Input Transformer) and Connection to the Phase-to-Phase Voltage of a Busbar Voltage Transformer

NOTE

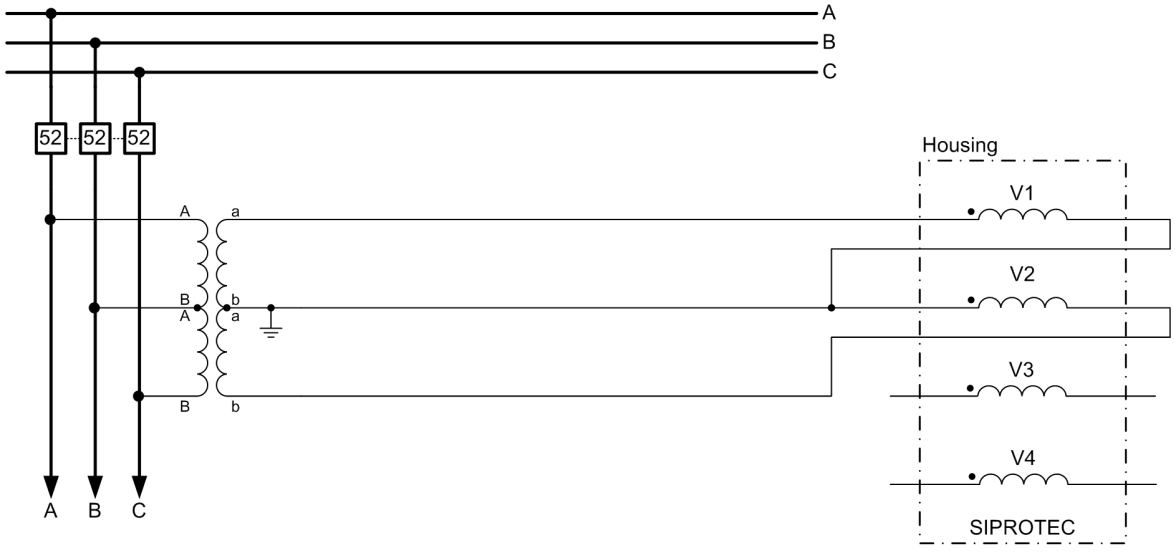
When using the connection type 3-phase-to-phase voltage, the zero-sequence voltage cannot be detected.



Voltage transformer 3-phase: connection = 3 ph-to-ph volt. + VN

[tvvolta6-260313-01.tif, 1, en_US]

Figure A-26 Connection to V-Connected Voltage Transformer (Delta-Connected Device Input Transformer) and Connection to the Broken-Delta Winding of a Busbar Voltage Transformer

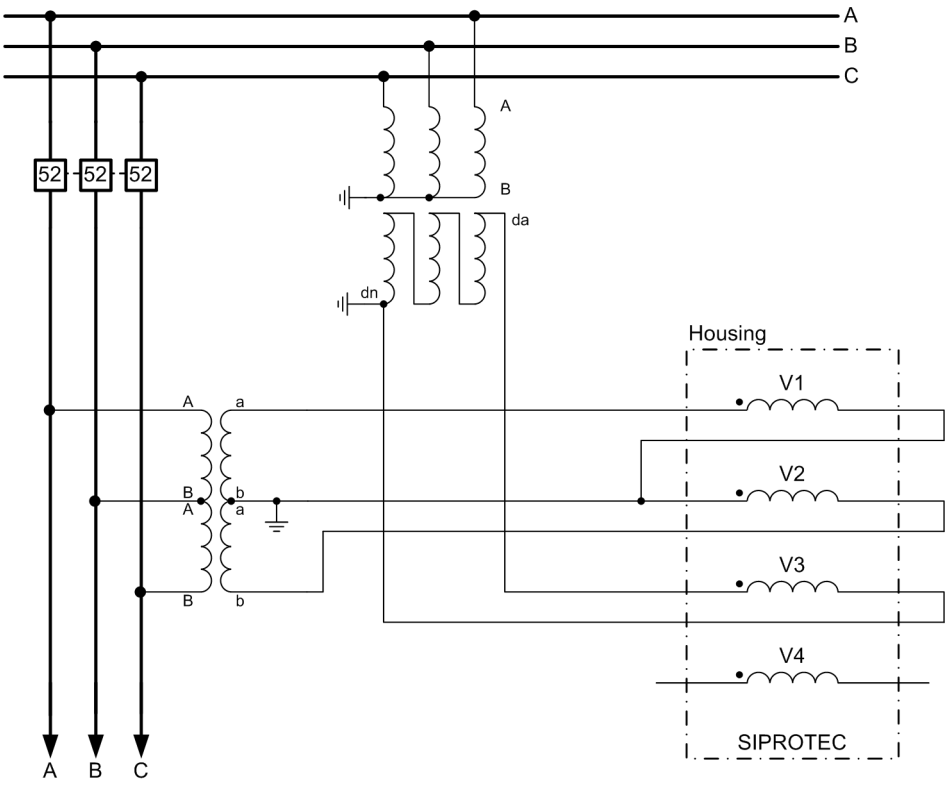


Voltage transformer 3-phase: connection = 2 ph-to-ph voltages

Phase voltages = VAB, VBC

[tvvol2ll-260313-01.tif, 2, en_US]

Figure A-27 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages)

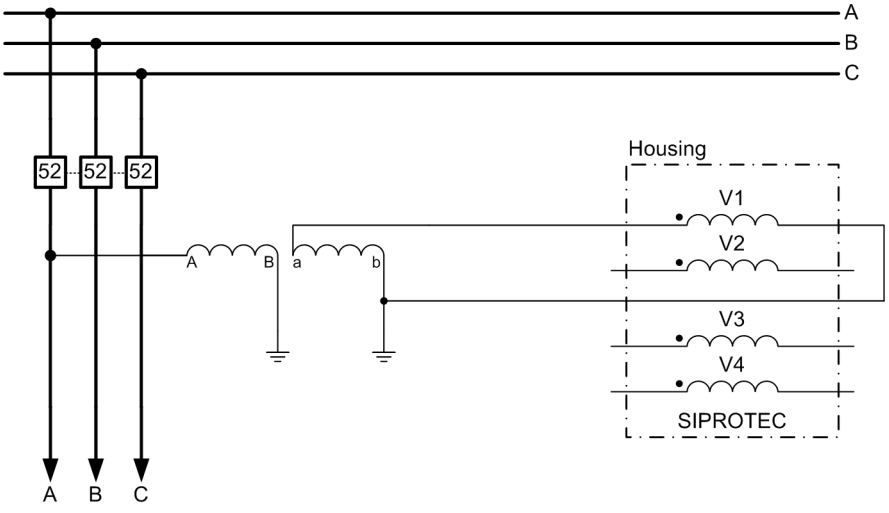


Voltage transformer 3-phase: connection = **2 ph-to-ph volt. + VN**

Phase voltages = VAB, VBC

[tvl2lluu-260313-01.tif, 2, en_US]

Figure A-28 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages) and Connection to the Broken-Delta Winding of a Busbar Voltage Transformer

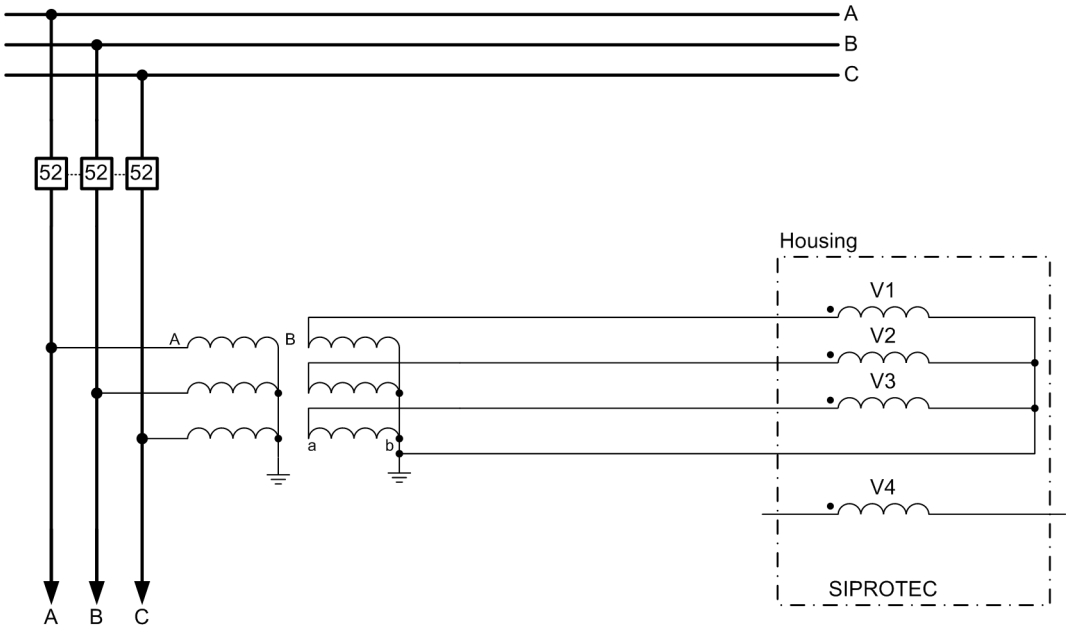


Voltage transformer 1-phase: connection = **VA**

[tvvolta7-260313-01.tif, 1, en_US]

Figure A-29 Connection to a 1-Pole Insulated Voltage Transformer (Phase-to-Ground Voltage)

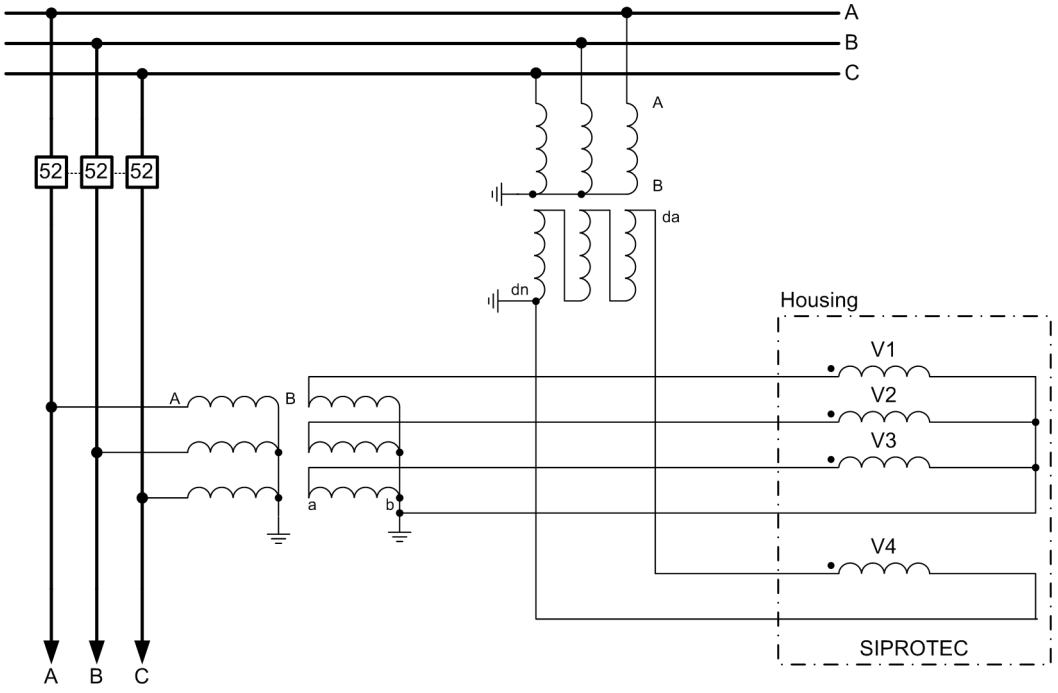
A.9 Connection Examples for Voltage Transformers for 7SJ82



Voltage transformer 3-phase: connection = 3 phase-to-ground volt.

[tvvolta3phVN-260313-01.vsd, 1, en_US]

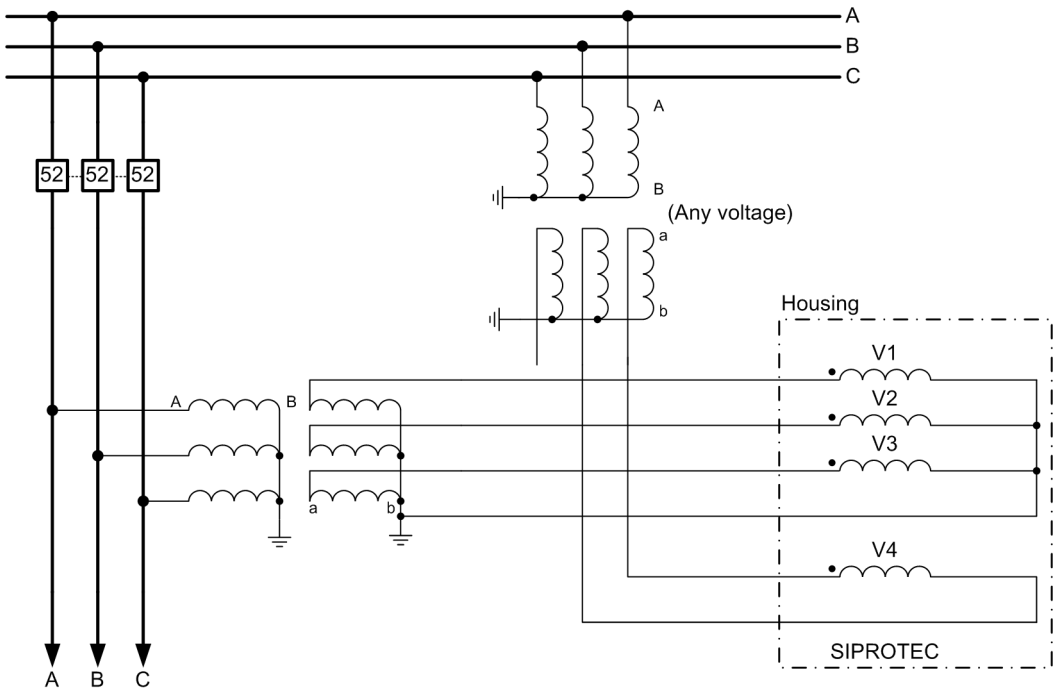
Figure A-30 Connection to 3 Star-Connected Voltage Transformers



Voltage transformer 3-phase: connection = 3 phase-to-ground volt. + VN

[tvvolta4light-260313-01.vsd, 1, en_US]

Figure A-31 Connection to 3 Star-Connected Voltage Transformers and to the Broken-Delta Winding of a Separate Voltage Transformer

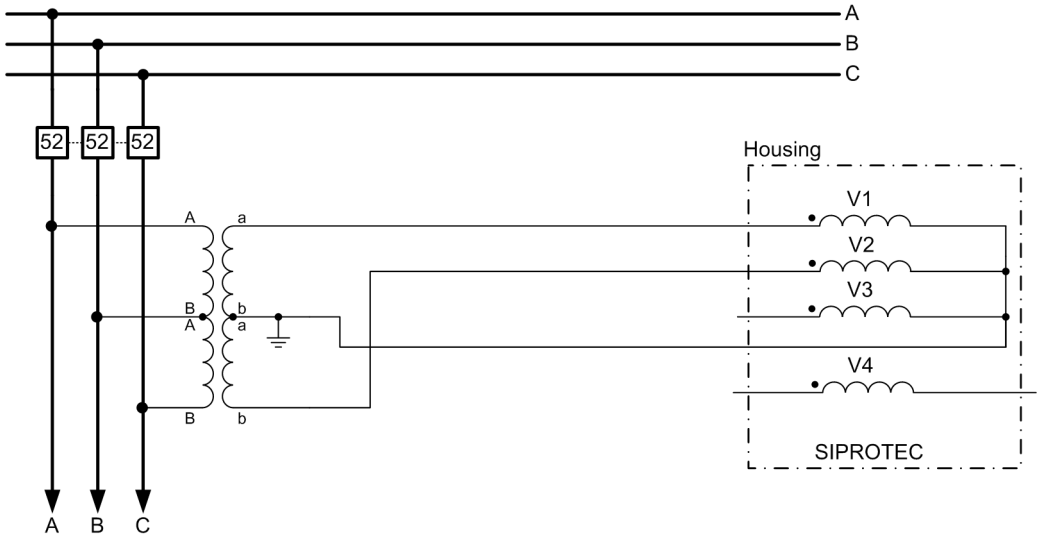


Voltage transformer 3-phase: connection = 3 ph-to-gnd voltages

Voltage transformer 1-phase: connection = VAB

[tvvolta4SJ82-260313-01.vsd, 1, en_US]

Figure A-32 Connection to 3 Star-Connected Voltage Transformers and to the Phase-to-Phase Voltage of a Busbar Voltage Transformer (for Example, for Synchronization Applications)

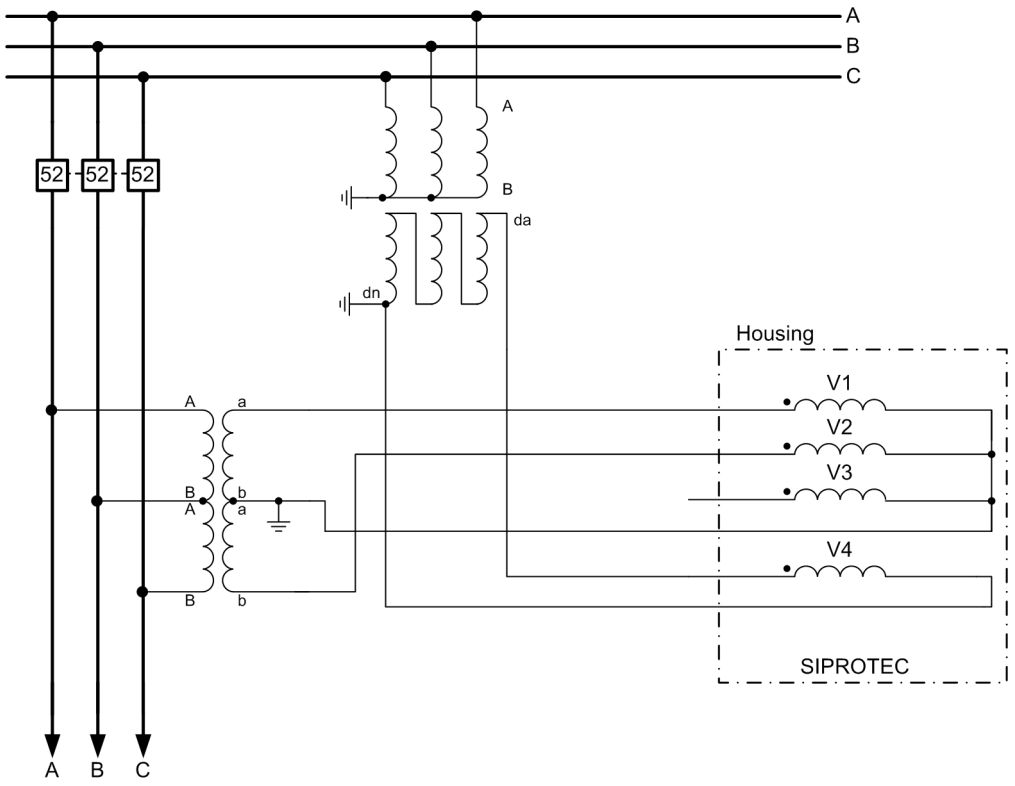


Voltage transformer 3-phase: connection = 2 ph-to-ph voltages

Phase voltages = VAB, VCB

[tvvol2ll82-260313-01.vsd, 1, en_US]

Figure A-33 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages)

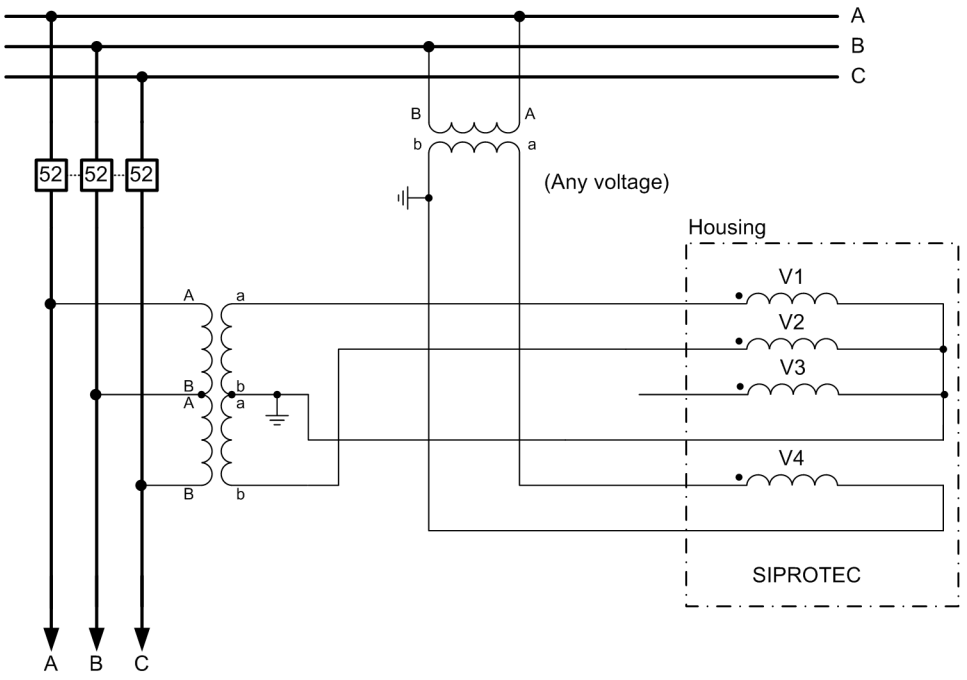


Voltage transformer 3-phase: connection = **2 ph-to-ph volt. + VN**

Phase voltages = VAB, VCB

[tvl2lluu82-260313-01.vsd, 1, en_US]

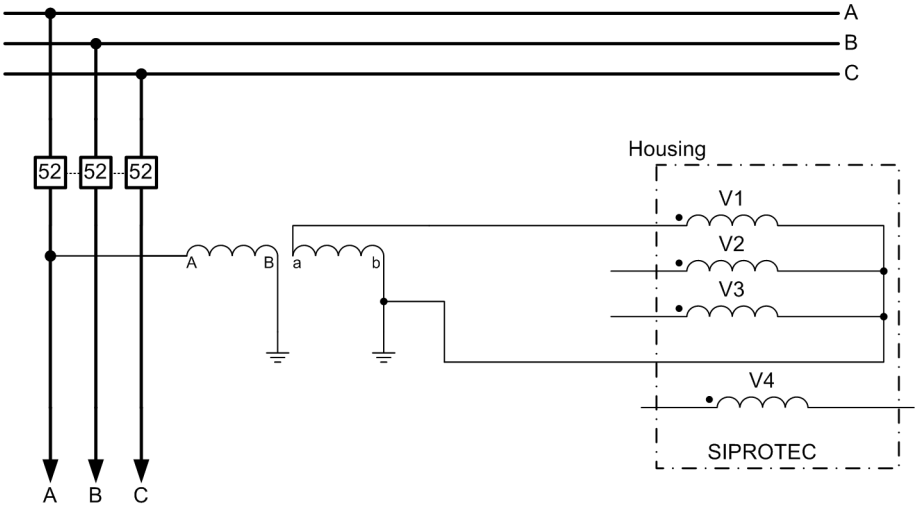
Figure A-34 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages) and Connection to the Broken-Delta Winding of a Busbar Voltage Transformer



Voltage transformer 3-phase: connection = 2 ph-to-ph voltages
Phase voltages = VAB, VCB
Voltage transformer 1-phase: connection = VAB

[tvvolta5SJ82-260313-01.vsd, 2, en_US]

Figure A-35 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages) and Connection to the Phase-to-Phase Voltage of a Busbar Voltage Transformer (for Example, for Synchronization Applications)



Voltage transformer 1-phase: connection = VA

[tvvolta7SJ82-260313-01.vsd, 1, en_US]

Figure A-36 Connection to a 1-Pole Insulated Voltage Transformer (Phase-to-Ground Voltage)

A.10 Prerouting 7SJ82/85 General

Meaning of the abbreviations in DIGSI, see *8.2.2.3 Connection Variants of the Circuit Breaker*.

Binary Inputs

Table A-7 Default Binary Inputs, Using the Example of Overcurrent Protection

Binary Input	Signal	Number	Signal Type	Configuration
BI1	Circuit breaker 1:Circuit break.:Position	201.4261.58	DPC	OH
BI2	Circuit breaker 1:Circuit break.:Position	201.4261.58	DPC	CH
BI3	Disconnector 1:Circuit break.:Position	601.5401.58	DPC	OH
BI4	Disconnector 1:Circuit break.:Position	601.5401.58	DPC	CH
BI5	Disconnector 2:Circuit break.:Position	602.5401.58	DPC	OH
BI6	Disconnector 2:Circuit break.:Position	602.5401.58	DPC	CH
BI7	Disconnector 3:Circuit break.:Position	603.5401.58	DPC	OH
BI8	Disconnector 3:Circuit break.:Position	603.5401.58	DPC	CH
BI9	Power system:Meas. point V-3ph 1:VT-miniature CB:>Open	11.941.2641.500	SPS	H

Binary Outputs

Table A-8 Default Output Relays, Using the Example of Overcurrent Protection

Binary Output	Signal	Number	Signal Type	Configuration
BO1	Circuit breaker 1:Circuit break.:Trip/open cmd.	201.4261.300	SPS	U
BO2	Circuit breaker 1:Circuit break.:Close command	201.4261.301	SPS	X
BO3	Disconnector 1:Disconnector:Open command	601.5401.300	SPS	X
BO4	Disconnector 1:Disconnector:Close command	601.5401.301	SPS	X
BO5	Disconnector 2:Disconnector:Open command	602.5401.300	SPS	X
BO6	Disconnector 2:Disconnector:Close command	602.5401.301	SPS	X
BO7	Disconnector 3:Disconnector:Open command	603.5401.300	SPS	X
BO8	Disconnector 3:Disconnector:Close command	603.5401.301	SPS	X

Function Keys

Table A-9 Default Setting Function Key Using the Example of Overcurrent Protection

Function Key	Signal	Number	Signal Type	Configuration
F-key1	Main menu:Logs:Operational log			X
F-key2	Main menu:Measurements:VI 3ph 1:Operational values			X
F-key3	Main menu:Logs:Fault log			X

Light-Emitting Diodes

Table A-10 Default LED Displays, Using the Example of Overcurrent Protection

LEDs	Signal	Number	Signal Type	Configuration
LED1	VI 3ph 1:Group indicat.:Pickup:phs A		SPS	NT
LED2	VI 3ph 1:Group indicat.:Pickup:phs B		SPS	NT
LED3	VI 3ph 1:Group indicat.:Pickup:phs C		SPS	NT
LED4	VI 3ph 1:Group indicat.:Pickup:phs gnd		SPS	NT
LED5	Circuit breaker 1:Circuit break.:Trip/ open cmd.	201.4261.300	SPS	L
LED15	Alarm handling:Group warning	5971.301	SPS	U
LED16	Device:Process mode inactive		SPS	U

A.11 Prerouting 7SJ82/85 Capacitor Bank Applications

Meaning of the abbreviations in DIGSI, see*8.2.2.3 Connection Variants of the Circuit Breaker*

Binary Inputs

Table A-11 Default Binary Inputs, Using the Example of Overcurrent Protection

Binary input	Signal	Number	Signal type	Configuration
BI1	Circuit breaker 1:Circuit break.:Position	201.4261.58	DPC	OH
BI2	Circuit breaker 1:Circuit break.:Position	201.4261.58	DPC	CH

Binary Outputs

Table A-12 Default Output Relays, Using the Example of Overcurrent Protection

Binary output	Signal	Number	Signal type	Configuration
BO1	Circuit breaker 1:Circuit break.:Trip/open cmd.	201.4261.300	SPS	U
BO2	Circuit breaker 1:Circuit break.:Close command	201.4261.301	SPS	X

Function Keys

Table A-13 Default Setting Function Key Using the Example of Overcurrent Protection

Function key	Signal	Number	Signal type	Configu-ration
F-key1	Main menu:Logs:Operational log			X
F-key2	Main menu:Measurements :Capacitor bank 1:Operational values			X
F-key3	Main menu:Logs:Fault log			X

Light-Emitting Diodes

Table A-14 Default LED Displays, Using the Example of Overcurrent Protection

LEDs	Signal	Number	Signal type	Configura-tion
LED1	Capacitor bank 1:Group indicat.:Pickup:phs A		SPS	NT
LED2	Capacitor bank 1:Group indicat.:Pickup:phs B		SPS	NT

LEDs	Signal	Number	Signal type	Configura-tion
LED3	Capacitor bank 1:Group indicat.:Pickup:phs C		SPS	NT
LED4	Capacitor bank 1:Group indicat.:Pickup:phs gnd		SPS	NT
LED5	Circuit breaker 1:Circuit break.:Trip/open cmd.	201.4261.300	SPS	L
LED15	Alarm handling:Group warning	5971.301	SPS	U
LED16	Device:Process mode inac-tive		SPS	U

Glossary

ACD

IEC 61850 data type: Directional protection activation information

ACK

Data transfer acknowledgment

ACT

IEC 61850 data type: Protection activation information

APC

Controllable analog set point information

ASDU

ASDU stands for Application Service Data Unit. An ASDU can consist of one or more identical information objects. A sequence of the same information elements, for example measured values, is identified by the address of the information object. The address of the information object defines the associated address of the first information element of the sequence. A consecutive number identifies the subsequent information elements. The number builds on this address in integral increments (+1).

BAC

Binary Controlled Analog Process Value

Back-up battery

The back-up battery ensures that specified data areas, flags, times and counters are kept retentive.

Bay Controller

Bay controllers are devices with control and monitoring functions without protection functions.

BCR

IEC 61850 data type: Binary counter reading

Best master clock algorithm

A PTP network contains communicating clocks. With the best master clock algorithm (BMC), the device indicating the most precise time is determined. This device is used as a reference clock and is designated as grandmaster. If the network topology is changed, the BMC algorithm is executed again on network segments that are possibly disconnected from the grandmaster. If a participating device is a master and a slave, it is called a boundary clock.

Big-endian

Big-endian and little-endian describe the order in which a sequence of bytes is stored. In big-endian systems, the most significant byte is stored at the lowest storage address. In little-endian systems, the most significant byte is stored at the highest storage address.

Binary Controlled Analog Process Value

The data type BAC represents a command with or without feedback. The BAC is used for example for the control of an arc suppression coil. The commands **Higher**, **Lower**, and **Stop** are possible. The feedback from the process is an analog value.

Binary Controlled Step Position

The data type BSC can, for example, be used to control a transformer tap changer. The commands **up**, **down** can be given.

Bit pattern indication

A bit pattern indication is a processing function, with the help of which adjacent numerical process information can be logged coherently and processed further in parallel via multiple inputs. The bit pattern indication can be selected as 1, 2, 3 or 4 bytes.

BMC

See best master clock algorithm

Boundary Clock

The Precision Time Protocol knows different types of clocks: an ordinary clock (abbreviation: OC), a boundary clock (BC), and a transparent clock (TC). The boundary clock transports time information over a network limit, for example, in a router connecting different switched networks: As a slave, the clock of the router receives the time information and transmits this further on as a master.

BRCB

Buffered Report Control Block

BSC

Binary Controlled Step Position

Buffered Report Control Block

Buffered Report Control Block (BRCB) is a form of report controlling. Internal events trigger the immediate sending of reports or saving of events for the transfer. Data values cannot therefore be lost on account of transport flow control conditions or connection interruptions. BRCB provides the functionality **SOE** (See Sequence of Events).

CB

Circuit breaker

CDC

Common Data Class

CFC

Continuous Function Chart

Chatter Blocking

A rapidly intermittent input (for example, owing to a relay contact fault) is disconnected after a parameterizable monitoring time and therefore cannot generate any more signal changes. The function prevents the system from overloading in the event of an error.

CID

Configured IED Description

CMV

Complex measured value

Combination Device

Combination devices are bay units with protection functions and with feeder mimic diagram.

Common Data Class

Generic term for a data class according to the IEC 61850 model.

Communication branch

A communication branch corresponds to the configuration of 1 to n participants communicating via a joint bus.

Configured IED Description

A Configured IED Description (CID) is a file for data exchange between the IED Configuration Tool and the IED itself.

Container

If an object contains other objects, this is referred to as a container. The object **Folder** for example is such a container.

Continuous Function Chart

The Continuous Function Chart (CFC) is a programming language. It is used for programmable logic controllers. The programming language Continuous Function Chart is not defined in the standard IEC 61131-3, but represents a current extension of IEC programming environments. CFC is a graphic programming language. Function blocks are linked to one another. This represents an essential difference from conventional programming languages, where sequences of commands are entered.

Control display

The control display becomes visible for devices with a large display after pressing the Control key. The diagram contains the switching devices to be controlled in the feeder. The control display serves for implementing switching operations. Specification of this diagram forms part of configuring.

Controllable Integer Status

The data type INC can be used to issue a command (to one or more relays, selectable under information routing) that is monitored via a whole number as feedback.

Controller

The controller initiates the IO data communication.

CRC

Cyclic redundancy check

Data type

The data type is a value set of a data object, together with the operations allowed on this value set. A data type contains a classification of a data element, such as the determination whether it consists of integers, letters, or similar.

Data unit

Information item with a joint transmission source. Abbreviation: DU = Data Unit

Data window

The right area of the project window visualizes the content of the area selected in the navigation window. The data window contains for example, indications or measured values of the information lists or the function selection for parameterization of the device.

DCF

Device Configuration File: Device parameterization

DCF77

The precise official time is determined in Germany by the Physikalisch-Technische Bundesanstalt PTB in Brunswick. The atomic clock unit of the PTB transmits this time via the long-wave time signal transmitter in Mainflingen near Frankfurt/Main. The emitted time signal can be received within a radius of approx. 1500 km from Frankfurt/Main.

DCP

Discovery and Basic Configuration Protocol

DDD

SIPROTEC 5 device driver (DIGSI 5 Device Driver)

DEL

Phase-to-phase related measurements of a 3-phase system

Device 5 Export Format

DEX5

Device Container

In the component view, all SIPROTEC devices are subordinate to an object of the device container type. This object is also a special object from the DIGSI-5 Manager. However, as there is no component view in the DIGSI 5 Manager, this object only becomes visible in conjunction with STEP 7.

DEX5

Device 5 Export Format

You can archive the data from an individual SIPROTEC 5 device in DEX5 format.

DHCP

Dynamic Host Configuration Protocol

DIGDNP

DIGSI 5 protocol settings for DNP3

File extension for a file generated by DIGSI for exporting the protocol configuration from DIGSI 5.

DIGMOD

DIGSI 5 protocol settings for Modbus TCP

File extension for a file generated by DIGSI for exporting the protocol configuration from DIGSI 5.

DIGSI 5 Display Pages

You can archive individual or all display pages of a SIPROTEC 5 device in DSP5 format. You can also use this format to exchange display pages between SIPROTEC 5 devices. The DSP5 format is based on XML.

DIGSI 5 protocol settings for DNP3

If the DNP3 protocol is configured for a system interface, you can export the protocol settings in DIGDNP format. The DIGDNP format is specially designed to transmit interface data from DIGSI 5 into the SICAM PAS substation automation system.

DIGSI 5 protocol settings for IEC 60870-5-103

If the IEC 60870-5-103 protocol is configured for a system interface, you can export the protocol settings in DIGT103 format. The DIGT103 format is specially designed to transmit interface data from DIGSI 5 into the SICAM PAS substation automation system.

DIGSI 5 protocol settings for IEC 60870-5-104

If the IEC 60870-5-104 protocol is configured for a system interface, you can export the protocol settings in DIGT104 format. The DIGT104 format is specially designed to transmit interface data from DIGSI 5 into the SICAM PAS substation automation system.

DIGSI 5 protocol settings for Modbus TCP

If the Modbus TCP protocol is configured for a system interface, you can export the protocol settings in DIGMOD format. The DIGMOD format is specially designed to transmit interface data from DIGSI 5 into the SICAM PAS substation automation system.

DIGSI 5 Test Sequences

You can archive individual or all test sequences of a SIPROTEC 5 device in SEQ5 format. You can also use this format to exchange test sequences between SIPROTEC 5 devices. The SEQ5 format is based on XML.

DIGSI

Configuration software for SIPROTEC

DIGT103

DIGSI 5 protocol settings for IEC 60870-5-103

File extension for a file generated by DIGSI for exporting the protocol configuration from DIGSI 5.

DIGT104

DIGSI 5 protocol settings for IEC 60870-5-104

File extension for a file generated by DIGSI for exporting the protocol configuration from DIGSI 5.

Discovery and Basic Configuration Protocol

The DCP protocol is used to detect devices without IP addresses and to assign addresses to these devices.

DNP3

DNP3 is a communications standard for telecontrol engineering. DNP3 is used as a general transmission protocol between control systems and substations and between bay devices and the systems control.

Double Command

Double commands (DPC – Double Point Control) are process outputs which visualize 4 process states at 2 outputs: 2 defined states (for example, On/Off) and 2 undefined states (for example, disturbed positions).

Double-point indication

Double-point indications (DPS – Double point status) are process indications which visualize 4 process states at 2 inputs: 3 defined states (for example, On/Off and disturbed position) and 1 undefined state (00).

DPC

IEC 61850 data type: Double Point Control

DPS

IEC 61850 data type: Double-point status

Drag and drop

Copying, moving, and linking function, used in graphic user interfaces. The mouse is used to highlight and hold objects and then move them from one data area to another.

DSP5

DIGSI 5 Display Pages

DU

Data unit

Dynamic Host Configuration Protocol

In order to configure PCs automatically, centralized and uniformly in a TCP/IP network, a dynamic assignment of IP addresses is used. DHCP is used. The system administrator determines how the IP addresses are to be assigned and specifies the time lapse over which they are assigned. DHCP is defined in the Internet standards RFC 2131 (03/97) and RFC 2241 (11/97).

For SIPROTEC 5, a device can also be assigned an IP address via DIGSI via DHCP.

ELCAD

Electrical CAD

Electrical CAD

You can import the topology information contained in an ELCAD file into a project and use it as the basis for a single-line configuration. The other information contained in the ELCAD file is not included in this process.

Electromagnetic Compatibility

Electromagnetic compatibility (EMC) means that an item of electrical equipment functions without error in a specified environment. The environment is not influenced in any impermissible way here.

ENC

Enumerated Status Controllable

ENS

Enumerated Status

ESD Protection

The ESD protection is the entirety of all means and measures for the protection of electrostatic-sensitive devices.

Far End Fault Indication

Far End Fault Indication (FEFI) is a special setting of switches. It is always only possible to log a line interruption on the receive line. If a line interruption is detected, the link status of the line is changed. The status change leads to deletion of the MAC address assigned to the port in the switch. However, outage of the receive line from the aspect of the switch can only be detected in the receiver, that is, by the switch. The receiver then immediately blocks the transmit line and signals the connection failure to the other device. The FEFI setting in the switch triggers detection of the error on the receive line of the switch.

FEFI

Far End Fault Indication

FG

Function group

Fleeting indication

Fleeting indications are single-point indications present for a very short time, in which only the coming of the process signal is logged and further processed time-correctly.

Floating

Floating means that a free potential not connected to ground is generated. Therefore no current flows through the body to ground in the event of touching.

Folder

This object type helps when structuring a project hierarchically.

Function group

Functions are brought together into function groups (FG). The assignment of functions to current and/or voltage transformers (assignment of functions to measuring points), the information exchange between the function groups via interfaces as well as the generation of group indications are important for this bringing together.

General interrogation

The state of all process inputs, of the status, and of the error image are scanned on system startup. This information is used to update the system-side process image. Likewise, the current process state can be interrogated after data loss with a general interrogation (GA).

General Station Description Mark-up Language

GSDML is an XML-based description language for creating a GSD file.

Generic Object-Oriented Substation Event

GOOSE. Protocol of IEC 61850 for communication between bay units.

GI

General interrogation

GIN

Generic Identification Number

GOOSE

Generic Object-Oriented Substation Event

Ground

The conductive ground whose electric potential can be set equal to 0 at every point. In the area of grounding conductors, the ground can have a potential diverging from 0. The term **reference ground** is also used for this situation.

Grounding

The grounding is the entirety of all means and measuring for grounding.

GSDML

General Station Description Mark-up Language

Hierarchy Level

In a structure with superordinate and subordinate objects, a hierarchy level is a level of equal-ranking objects.

High Availability Seamless Redundancy Protocol

Like PRP (Parallel Redundancy Protocol), HSR (High Availability Seamless Redundancy Protocol) is specified in IEC 62439-3. Both protocols offer redundancy without switching time.

The principal function can be found in the definition of PRP. With PRP, the same indication is sent via 2 separated networks. In contrast to this, in the case of HSR the indication is sent twice in the 2 directions of the ring. The recipient receives it correspondingly via 2 paths in the ring, takes the 1st message and discards the 2nd (see PRP).

Whereas NO indications are forwarded in the end device in the case of PRP, a switch function is installed in the HSR node. Thus, the HSR node forwards indication in the ring that are not directed at it.

In order to avoid circular messages in the ring, corresponding mechanisms are defined in the case of HSR.

SAN (Single Attached Node) end devices can only be connected with the aid of a REDBOX in the case of HSR. PRP systems and HSR systems can be coupled redundantly with 2 REDBOXES.

HMI

Human-Machine Interface

HSR

High Availability Seamless Redundancy Protocol

HV bay description

The HV project description file contains data concerning which bays are present within a ModPara project. The actual bay information is saved for each bay in an HV bay description file. Within the HV project description file, each bay receives an HV bay description file through a reference to the file name.

HV Project Description

If the configuring and parameterization of PCUs and submodules is completed with ModPara, all the data will be exported. The data is distributed to several files during this process. A file contains data on the basic project structure. This typically includes information on which bays are present within this project. This file is designated as an HV project description file.

ICD

IED Capability Description

IEC

International Electrotechnical Commission

IEC 60870-5-103

International standard protocol for communication with IEDs (especially protective equipment). Many protective relays, bay devices, bay controllers and measurement acquisition devices use the IEC 60870-5-103 protocol to communicate with the SICAM system.

IEC 60870-5-104

Internationally standardized telecontrol protocol. Transmission protocol based on IEC 60870-5-101 for the connection of the substation control level to the telecontrol center using TCP/IP via a Wide Area Network (WAN) connection.

IEC 60870-5-104 is also used for the communication with IEDs.

IEC 61850

IEC 61850 is an international standard for consistent communication in substations. This standard defines the communication amongst devices in substations and the related system requirements. All substation automation functions as well as engineering functions are supported. IEC 61850 can also be transferred to automation systems in other applications, for example, for the control and monitoring of distributed power generation.

IEC address

A unique IEC address must be assigned to each SIPROTEC device within an IEC bus. A total of 254 IEC addresses per IEC bus are available.

IEC communication branch

Within an IEC communication branch, the participants communicate on the basis of the protocol IEC 60870-5-103 via an IEC bus.

IED Capability Description

Data exchange from the IED configuration software (DIGSI) to the system configurator. This file describes the performance properties of an IED.

IEEE 1588

Time-synchronization protocol according to IEEE Std 1588-2008: Precision Clock Synchronization Protocol for Networked Measurement and Control Systems (IEEE 1588 v2) and IEEE Std C37.238-2011: IEEE Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications (Power Profile).

IID

Instantiated IED Description

INC

Controllable Integer Status

Initialization string

An initialization string consists of a series of modem-specific commands. If the modem is initialized, these commands are transferred to the modem. The commands can force definite settings for the modem, for example.

Input Data/Input Direction

Data is sent from the protocol slave to the protocol master.

INS

Integer Status

Instantiated IED Description

Files in IID format are ICD files adapted for the concrete application in the project. This format is mainly suitable for exchanging data between DIGSI 5 and an external system configurator or also a substation automation system such as SICAM PAS. The ICD format uses SCL as the description language for this purpose.

International Electrotechnical Commission

IEC

Internet protocol

An Internet protocol (IP) enables the connection of participants which are positioned in different networks.

IO

Input-Output

IO Provider Status

The provider (sender) of an IO data element uses this to signal the status (good/bad with error location).

IOPS

IO Provider Status

IP

Internet protocol

IPv4

Internet protocol version 4

ISC

Integer Step Controlled Position Information

LAN

Local Area Network

Link Address

The link address indicates the address of a SIPROTEC device.

Link Layer Discovery Protocol

The Link Layer Discovery Protocol supplies the basis for topology detection and for determination of the configuration.

List view

The right area of the project window displays the names and symbols of the objects which are within a container selected in the tree view. As the visualization is in the form of a list, this area is also referred to as list view.

LLDP

Link Layer Discovery Protocol

Local Area Network

A Local Area Network (LAN) is a regional, local PC network. The PCs are all equipped with a network interface card and work with one another via data exchange. The LAN requires an operating system on each PC and standardized data transport software. The operating systems can be different, as can the data transport software, but both must support a common transmission protocol (= TCP/IP protocols), so that all PCs can exchange data with one another.

LSB

Least Significant Bit

MAC address

The MAC address (Media Access Control) is the hardware address of each single system adaptor. With the MAC address, the device can be identified unambiguously in the system.

Management Information Base

A Management Information Base (MIB) is a database which saves information and statistics concerning each device in a network continuously. The performance of each device can be monitored with this information and statistics. In this way, it can also be ensured that all devices in the network function properly. MIBs are used with SNMP.

Manufacturing Message Specification

The standard Manufacturing Message Specification (MMS) serves for data exchange. The standard is used for the transmission protocols IEC 61850 and IEC 60870-6 TASE.2.

Measured Value

This data type provides a measured value that can be used as a CFC result, for instance.

Metered value

Metered values are a processing function, used to determine the total number of discrete similar events (counting pulses), for example, as integral over a time span. In the power supply utility field, electrical energy is often recorded as a metered value (energy import/delivery, energy transport).

MIB

Management Information Base

MICS

Model Implementation Conformance Statement

MMS

Manufacturing Message Specification

Modbus

The Modbus protocol is a communication protocol. It is based on a Master/Slave or Client/Server architecture.

Model Implementation Conformance Statement

Model Implementation Conformance Statement (see MICS)

The Model Implementation Conformance Statement describes in detail the standard data object models that are supported by the system or by the device.

Modem

Modem profiles for a modem connection are saved in this object type.

Modem Connection

This object type contains information on the two partners of a modem connection, local modem and remote modem.

Modem Profile

A modem profile comprises the name of the profile, a modem driver and optionally several initialization commands as well as a participant address. You can create multiple modem profiles for a physical modem. For this, link different initialization commands or participant addresses with a modem driver and its properties, and save these under various names.

Module

Self-contained unit at the device level. This can be a real module or a functional unit of the device.

MSB

Most Significant Bit

MV

Data type Measured Value

NACK

Negative acknowledgment

Navigation Window

Left area of the project window, which visualizes the names and symbols of all containers of a project in the form of a hierarchical tree structure.

Object

Each element of a project structure is designated as an object in DIGSI 5.

Object Property

Each object has properties. These can on the one hand be general properties that are common to several objects. Otherwise, an object can also have object-specific properties.

Offline

If there is no communication connection between a PC program (for example, configuration program) and a runtime application (for example, a PC application), the PC program is **offline**. The PC program executes in Offline mode.

Online

If there is a communication connection between a PC program (for example, configuration program) and a runtime application (for example, a PC application), the PC program is **online**. The PC program executes in Online mode.

Optical Switch Module

An Optical Switch Module (OSM) is a process for switching over switches in Ethernet networks that are ring-shaped in structure. OSM is a proprietary process from Siemens, which later became standard under the term MRP. OSM is integrated in the optical Ethernet module EN100-O. OSM is hardly used in IEC 61850 networks. RSTP is used there, this having become established as an international standard.

OSM

Optical Switch Module

Output data/Output direction

Data is sent from the protocol master to the protocol slave.

Parallel Redundancy Protocol

Parallel Redundancy Protocol (PRP) is a redundancy protocol for Ethernet networks that is specified in IEC 62439-3. Unlike conventional redundancy procedures, such as RSTP (Rapid Spanning Tree Protocol, IEEE 802.1D-2004), PRP offers uninterruptible switching, which avoids any down time in the event of a fault, and thus the highest availability.

PRP is based on the following approach: The redundancy procedure is generated in the end device itself. The principle is simple: The redundant end device has 2 Ethernet interfaces with the same address (DAN, Double Attached Node). Now, the same indication is sent twice, in the case of PRP (**parallel**) to 2 separate networks, and uniquely marks both with a sequence number. The recipient takes the information that it receives first, stores its ID based on the source address and the sequence number in a duplicate filter and thus recognizes the 2nd, redundant information. This redundant information is then discarded. If the 1st indication is missing, the 2nd indication with the same content comes via the other network. This redundancy avoids a switching procedure in the network and is thus interruption-free. The end device forwards no messages to the other network. Since the process is realized in the Ethernet layer (same MAC address), it is transparent and usable for all Ethernet payload protocols (IEC 61850, DNP, other TCP/IP based protocols). In addition, it is possible to use one of the 2 networks for the transmission of non-redundant messages.

There are 2 versions of PRP: PRP-0 and its successor PRP-1. Siemens implements PRP-1.

Parameterization

Comprehensive term for all setting work on the device. You can parameterize the protection functions with DIGSI 5 or sometimes also directly on the device.

Parameter set

The parameter set is the entirety of all parameters that can be set for a SIPROTEC device.

Participant address

A participant address consists of the name of the participant, the international dialing code, the local dialing code and the participant-specific telephone number.

PICS

Protocol Implementation Conformance Statement

PLC

See Programmable Logic Controller

PLC

Programmable Logic Controller

PROFIBUS

PROcess Feld BUS, German Process and Fieldbus standard (EN 50170). The standard specifies the functional, electrical and mechanical characteristics for a bit-serial fieldbus.

PROFIBUS Address

A unique PROFIBUS address must be assigned to each SIPROTEC device within a PROFIBUS network. A total of 254 PROFIBUS addresses per PROFIBUS network are available.

Profile_ID

A Profile_ID in combination with an API uniquely identifies the access and the behavior of an application.

PROFINET IO

PROFINET is an open Industrial Ethernet Standard from PROFIBUS for the automation.

Programmable Logic

The programmable logic is a function in Siemens devices or station controllers, enabling user-specific functionality in the form of a program. This logic component can be programmed by various methods: CFC (= Continuous Function Chart) is one of these. SFC (Sequential Function Chart) and ST (Structured Text) are others.

Programmable Logic Controller

Programmable logic controllers (PLC) are electronic controllers whose function is saved as a program in the control unit. The construction and wiring of the device do not therefore depend on the function of the control. The programmable logic controller has the structure of a computer; it consists of CPU with memory, installation/extension groups (for example, DI, AI, CO, CR), power supply (PS) and rack (with bus system). The peripherals and programming language are oriented towards the circumstances of the control system.

Programmable Logic Module

Modules are parts of the user program delimited by their function, structure and intended use.

Project

In terms of content, a project is the replication of a real energy supply system. In graphic terms, a project is represented as a number of objects which are incorporated in a hierarchical structure. Physically, a project consists of a series of directories and files containing project data.

Project tree

The Project tree is used to display a data structure. This data structure represents the content of the project and is created by a Generic Browser.

Protection communication

Protection communication includes all functionalities necessary for data exchange via the protection interface. Protection communication is created automatically during configuration of communication channels.

Protection Device

A protection device detects erroneous states in distribution networks, taking into account various criteria, such as error distance, error direction or fault direction, triggering a disconnection of the defective network section.

Protocol Implementation Conformance Statement

The performance properties of the system to be tested are summarized in the report on the conformity of implementation of a protocol (PICS = Protocol Implementation Conformance Statement).

PRP

Parallel Redundancy Protocol

Rapid Spanning Tree Protocol

The Rapid Spanning Tree Protocol (RSTP) is a standardized redundancy process with a short response time. In the Spanning Tree Protocol (STP protocol), structuring times in the multidigit second range apply in the case of a reorganization of the network structure. These times are reduced to several 100 milliseconds for RSTP.

Real Time

Real time

RedBox

Reduncancy box

The RedBox is used for the redundant connection of devices with only one interface to both the LAN A and the LAN B PRP network. The RedBox is a DAN (Double Attached Node) and operates as a proxy for the devices connected to it (VDANs). The RedBox has its own IP address in order to be able to configure, manage, and monitor it.

Relay Information by OMICRON

Files in RIO format can be used to exchange data between test systems from the OMICRON company and any other project-protection planning system. With DIGSI 5, you can export different settings from protection functions in RIO format, which the OMICRON test equipment 7VP15 can then continue to process. The relevant settings are described in the Test equipment manual.

RIO

Data format Relay Information by OMICRON

RSTP

Rapid Spanning Tree Protocol

SAN

Single Attached Node

A SAN is a non-redundant node in the PRP network. It is only connected with one port to one network (LAN A or LAN B). It can only communicate with nodes in the connected network. Via a RedBox, devices with only one connection can be redundantly connected to the 2 LAN A and LAN B networks. In order to obtain symmetrical LAN A and LAN B networks, Siemens recommends avoiding SANs and to connect the devices either via a RedBox or in a separate network without PRP support.

SBO

Select before operate

SC

See Single Command

SCD

See Substation Configuration Description

SCL

Substation Configuration Description Language

SED

System Exchange Description

SEQ

Data type Sequence

SEQ5

DIGSI 5 Test Sequences

Sequence of Events

Acronym: SOE. An ordered, time-stamped log of status changes at binary inputs (also referred to as state inputs). SOE is used to restore or analyze the performance, or an electrical power system itself, over a certain period of time.

Service Interface

Device interface for interfacing DIGSI 5 (for example, through a modem)

SICAM SAS

Substation Automation System – Modularly structured station control system, based on the substation controller SICAM SC and the SICAM WinCC operator control and monitoring system..

SICAM WinCC

The operator control and monitoring system SICAM WinCC graphically displays the state of your network. SICAM WinCC visualizes alarms and messages, archives the network data, provides the option of intervening manually in the process and manages the system rights of the individual employees.

SIM

Simulation data format for single/multiple devices

Simple Network Management Protocol

The Simple Network Management Protocol (SNMP) is an Internet standard protocol and serves for the administration of nodes in an IP network.

Simple Network Time Protocol

The Simple Network Time Protocol (SNTP) is a protocol for the synchronization of clocks via the Internet. With SNTP, client computers can synchronize their clocks via the Internet with a time server.

Simulation data format for single/multiple devices

You can export the simulation-related files of a SIPROTEC 5 device in the SIM format. This new functionality in DIGSI 5 provides the ability to export the simulation data and simulate all the devices in the DIGSI 5 project for test and commissioning needs. The simulation is achieved by importing the simulation file into a signal processing and automation system which will then simulate the device/devices with the process data as in a real-time system. This feature also ensures the testing of a device for various real-time system conditions.

Single Command

Single commands (SPC - Single Point Control) are process outputs which visualize 2 process states (for example, On/Off) at an output.

Single-line diagram

A single-line diagram (SLD) is a simplified electric overview of the switchgear. Only 1 phase is shown instead of all 3 phases of a line. Therefore, the diagram is called single-line.

Single-Line Editor

A Single-Line Editor contains a catalog of topological components to create a single-line diagram. The customer may use the single-line elements to configure the topological view of his substation.

Single-point indication

Single-point indications (SPS – Single point status) are process indications which visualize 2 process states (for example, On/Off) at an input.

SIPROTEC 5 device

This object type represents a real SIPROTEC device with all the contained setting values and process data.

SIPROTEC

The registered trademark SIPROTEC designates the product family of protection devices and fault recorders.

Slave device

A slave may only exchange data with a master after its has been requested to do so by this master. SIPROTEC devices work as slaves. A master computer controls a slave computer. A master computer can also control a peripheral device.

SLD

Single-line diagram

SLE

Single-Line Editor

SNMP

Simple Network Management Protocol

SNTP

Simple Network Time Protocol

SOE

Sequence of Events

SP

See Single-Point Indication

SPC

IEC 61850 data type: Single Point Control

SPS

IEC 61850 data type: Single point status

SSD

System Specification Description

ST

Structured Text file

Station Description

A station description is an IEC 61850-compliant file for data exchange between the system configurator and the IED configurator. The station description contains information on the network structure of a substation. The station description contains for example, information on the assignment of the devices to the primary equipment, as well as on the station-internal communication.

Structured Text file

You can import function charts (CFC) from DIGSI 4 in ST format. First, however, export your function charts from DIGSI 4.83 or higher.

Substation Configuration Description Language

A description language standardized in IEC 61850, SCL is based on XML. This description language allows all information relevant to an IEC 61850 substation to be documented consistently. This format is therefore suitable for exchanging IEC 61850-specific data between different applications, even if these come from different manufacturers. The described import checks are basically done for all SCL formats, not only for SCD imports.

System Exchange Description

Files in SED format can be used to exchange interface information between DIGSI 5 projects and thus between substations. To do this, the project extracts the data for the other projects from the file during import and writes its own data in the same file during export. The contents of an SED file are formulated in SCL.

System Specification Description

Files in SSD format contain the complete specification of a station automation system, including a single-line configuration of the station. The assignment of logical nodes from IEC 61850 to primary equipment can also be described in SSD files. This allows device requirements to be defined in the SSD file so that the devices can be used in the substation. The contents of an SED file are formulated in SCL.

TAI

Temps Atomique International - International Atomic Time

TC

Tap-position command – see Transformer Tap Position Command

TCP

Transmission Control Protocol

TEA-X

You can archive the data from individual SIPROTEC 5 devices or whole project in TEA-X format. This format is also suitable for data exchange between different applications, such as DIGSI 5 and Engineering Base (EB). The TEA-X format is based on XML.

Telephone book

Participant addresses for the modem connection are saved in this object type.

Time stamp

A time stamp is a value in a defined format. The time stamp assigns a time point to an event, for example, in a log file. Time stamps ensure that events can be found again.

Topological view

The Topological View is oriented to the objects of a system (for example, switch gear) and their relation to one another. The Topological View describes the structured layout of the system in hierarchical form. The Topological View does not assign the objects to the devices.

Transmission Control Protocol

The Transmission Control Protocol (TCP) is a transmission protocol for transport services in the Internet. TCP is based on IP and ensures connection of the participants during the data transmission. TCP ensures the correctness of the data and the correct sequence of the data packages.

Transparent Clock

The Precision Time Protocol knows different types of clocks: an ordinary clock (abbreviation: OC), a boundary clock (BC), and a transparent clock (TC). The transparent clock was added to the specification in 2008 and

improves the time-information transmission within a network by receiving PTP messages and transmitting them after modification (correction).

Tree view

The left area of the project window visualizes the names and symbols of all containers of a project in the form of a hierarchical tree structure. This area is referred to as a tree view.

Tunneling

Technology for connecting two networks via a third network, whereby the through traffic is completely isolated from the traffic of the third network.

UDP

User Datagram Protocol

Unbuffered Report Control Block

Unbuffered Report Control Block (URCB) is a form of report controlling. Internal events trigger the immediate sending of reports based on **best effort**. If no association exists or if the transport data flow is not fast enough, events can be lost.

URCB

Unbuffered Report Control Block

USART

Universal Synchronous/Asynchronous Receiver/Transmitter

User Datagram Protocol (UDP)

UDP is a protocol. The protocol is based on IP as TCP. In contrast to this, however, UDP works without a connection and does not have any safety mechanisms. The advantage of UDP in comparison to IP is the higher transmission rate.

UTC

Universal Time Coordinated

Vendor ID

Manufacturer-specific part of the device identification for PROFINET.

Virtual Device

A VD (virtual device) comprises all communication objects, as well as their properties and states, which a communication user can utilize in the form of services. A VD can be a physical device, a module of a device or a software module.

WYE

Phase-to-ground related measurements of a 3-phase system

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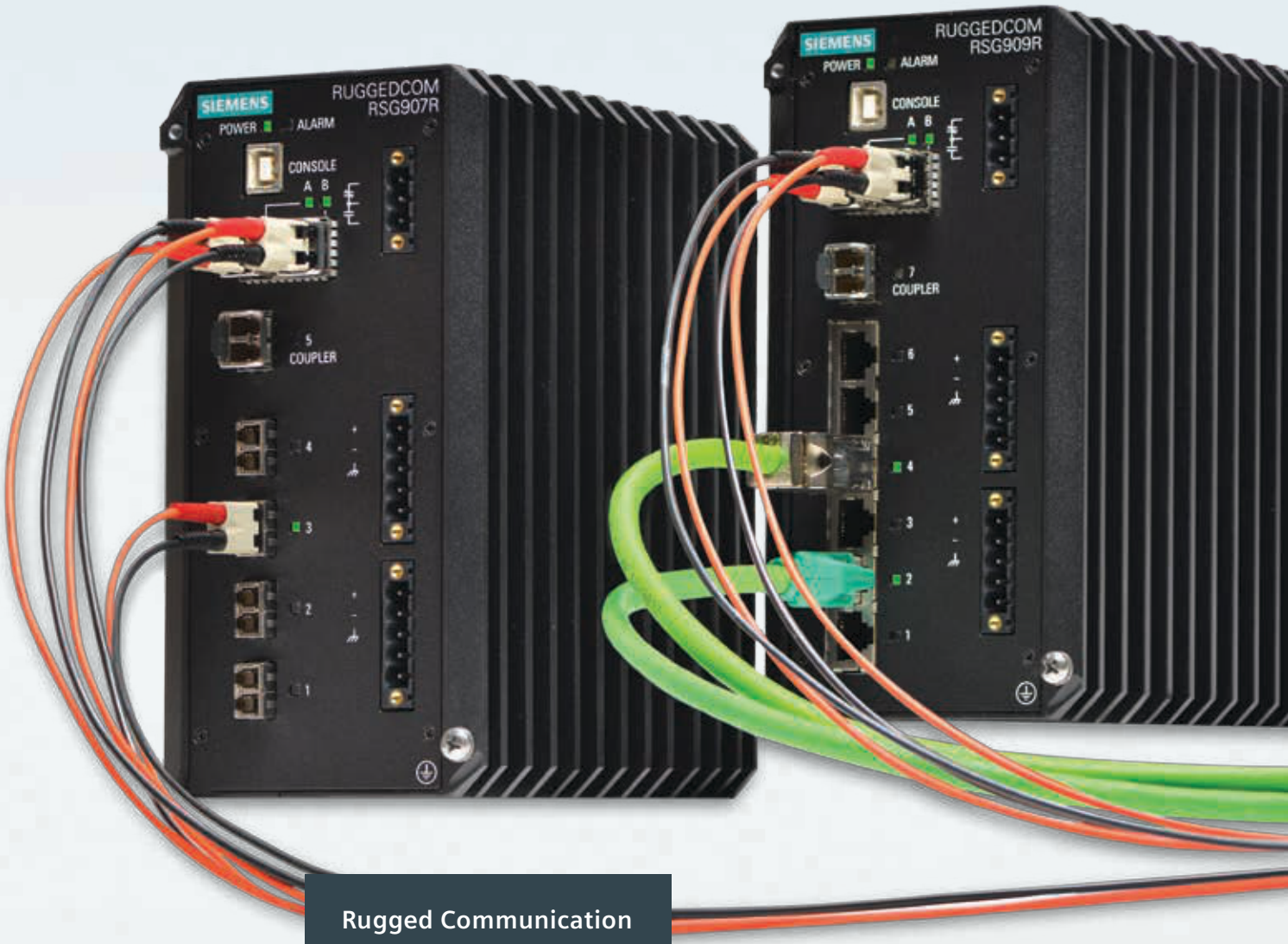
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SIEMENS

Ingenuity for life



Rugged Communication

RUGGEDCOM RSG907R & RSG909R

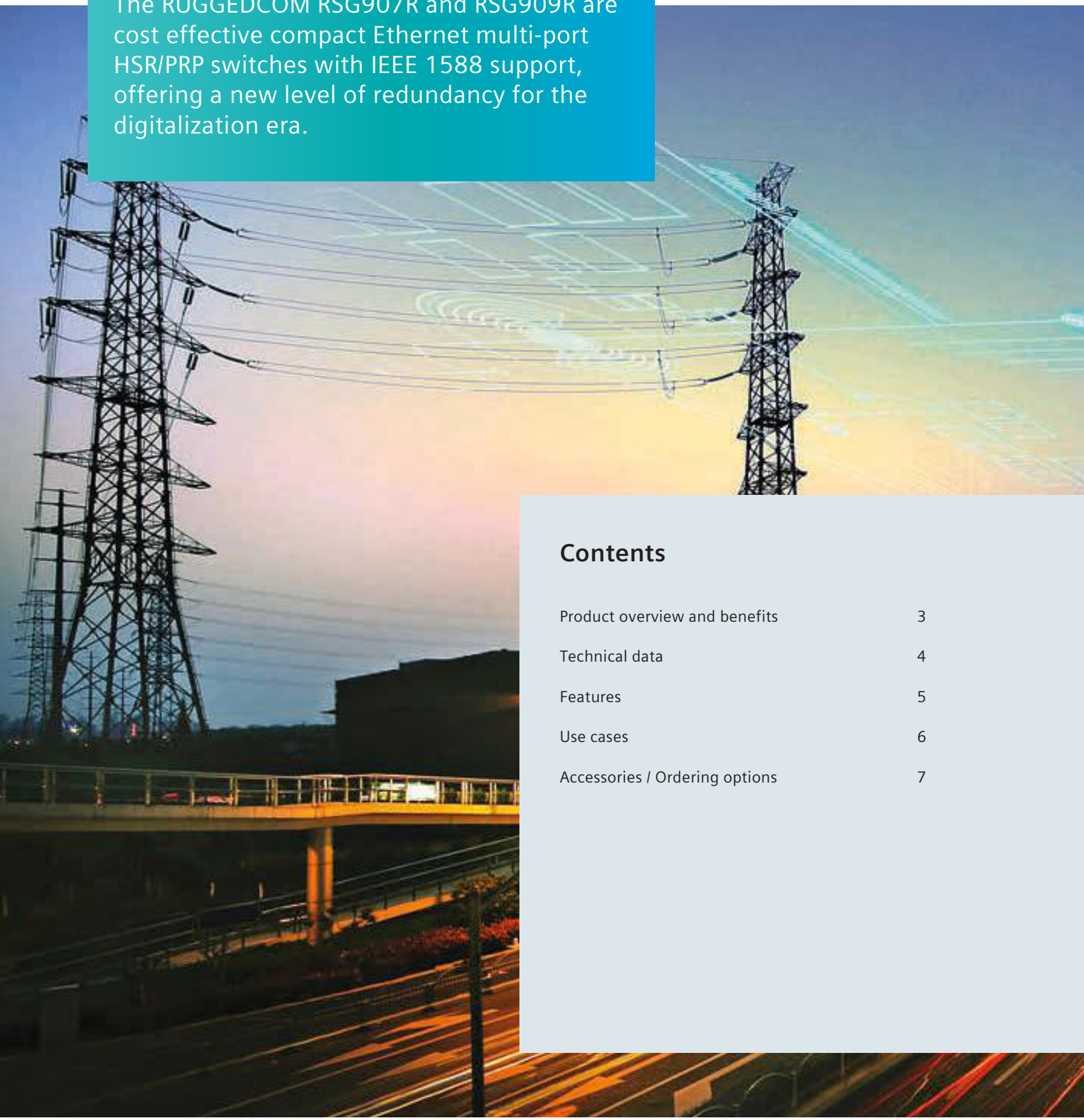
Compact multi-port IEEE 1588 switches with HSR and PRP support

Brochure

Edition 02/2018

usa.siemens.com/ruggedcom

The RUGGEDCOM RSG907R and RSG909R are cost effective compact Ethernet multi-port HSR/PRP switches with IEEE 1588 support, offering a new level of redundancy for the digitalization era.



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Product overview and benefits

The RUGGEDCOM RSG907R and RSG909R, two full Gigabit switches in a compact design, offering both HSR and PRP functionality to mitigate the risk of communication disruptions and downtime.
These rugged Gigabit switches are designed to operate in harsh environments with widely varying climatic and environmental conditions. Tested and certified to withstand extreme temperature, vibration and shock, the RUGGEDCOM RSG907R and RSG909R offer exceptional reliability for industrial applications such as electric utility substations, transportation systems and oil&gas.

The RUGGEDCOM RSG907R and RSG909R are ideal for applications that require high bandwidths and accommodate future network expansions. Three Redundant Network Access SFP ports providing ultimate flexibility in media and distance, with support for Gigabit bandwidth. The RSG907R connects up to 4 IEDs via 100BASE-FX fiber optics and RSG909R connects up to 6 IEDs via copper Ethernet on the Singly Attached Node ports.

Both products offer various network design options and cost savings through increased redundancy, reduced downtimes and high reliability.

HSR / PRP with Gigabit/s interfaces
Avoid revenue loss by mitigating the risk of communication disruptions and downtime with a redundant fault tolerant network supporting high bandwidth.

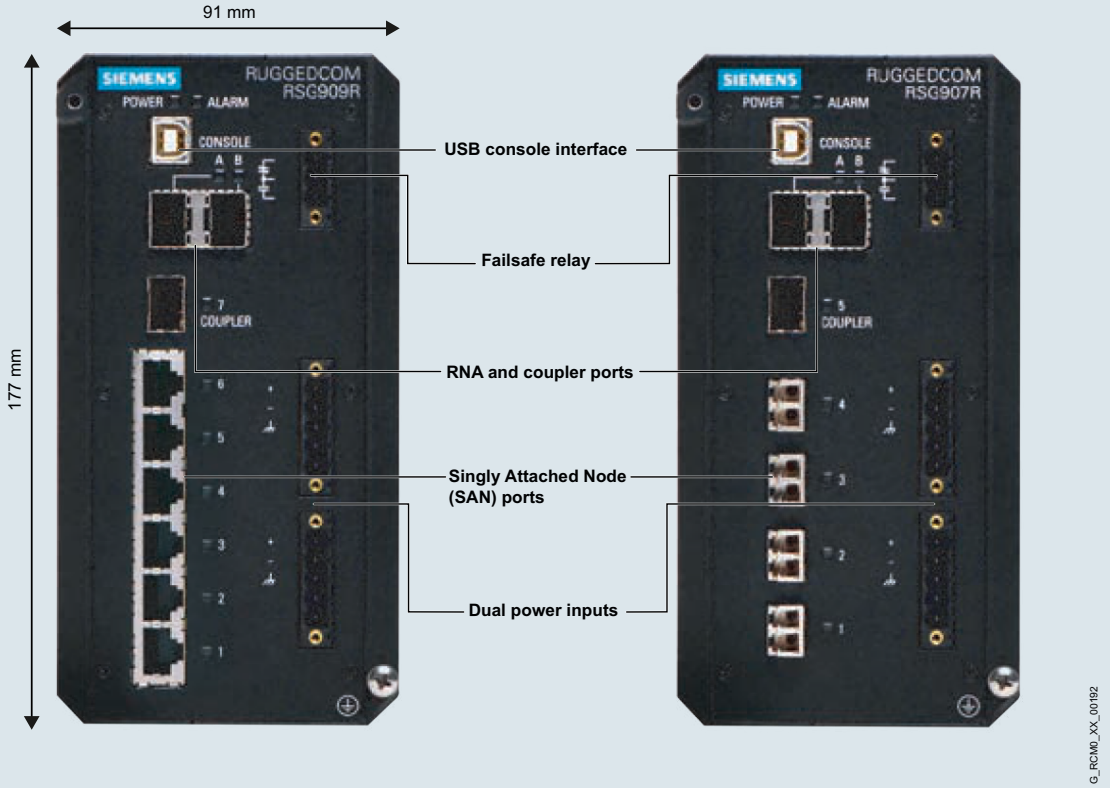
SFP RNA ports
SFP ports can be modified at any time allowing deployment flexibility for varying customer needs.

Power redundancy
Maintain continuous safe and reliable operations even during power failures, diminishing the risk of revenue and data loss.

Full fiber solution
Reduce failure rates due to increased immunity from electromagnetic phenomena.

IEEE 1588
The RSG907R and RSG909R enable the creation of a future proof network with support for IEEE 1588 time synchronisation.

Technical data



Technical data	RUGGEDCOM RSG907R	RUGGEDCOM RSG909R
Ethernet interfaces		
Ports	4 x 100BASE-FX + 3 x 1000 BASE-X (SFP)	6 x 10/100/1000BASE-T + 3 x 1000 BASE-X (SFP)
RNA uplinks (A / B) & coupler port	3 x 1 Gbit/s SFP ports	
Supported specifications	IEEE 1588	
Power supply characteristics		
Supported input voltage ranges	24/48 VDC (12 – 60 VDC) HI (85 – 264 VAC / 88 – 300 VDC)	
Mechanical specifications		
Dimensions (w x h x d) in mm	91 mm x 177 mm x 173 mm	
Weight	2.9 kg	
Mounting	DIN rail and panel mount	
Ambient conditions		
Operating temperature	-40° C to +85° C	
IP rating	IP40	
Other features		
IEEE 1588	Transparent Clock	

Features

Software
The RUGGEDCOM RSG907R and RSG909R both run on Rugged Operating System (ROS®) and deliver high performance switching.

ROS® supports the standard network technologies, such as Rapid Spanning Tree Protocol (RSTP), Multiple Spanning Tree Protocol (MSTP), Remote Monitoring (RMON), Simple Network Management Protocol (SNMP) and others, including proprietary protocol enhancements such as Siemens eRSTP (enhanced Rapid Spanning Tree Protocol) and Fast Root Failover (FRF).

Software features
- Quality of service (802.1p) for traffic prioritization
- NTP time synchronization (client and server)
- Smart power management for PoE interfaces
- Port rate and Broadcast Storm Limiting
- Port configuration, status, statistics, mirroring
- Simple Management interface through WebUI and console interface
- Single file configuration ensures easy installation and configuration control

HSR/PRP redundancy
The RUGGEDCOM RSG907R and RSG909R are multi-port Ethernet switches combined with an HSR/PRP redundancy box (RedBox) in a convenient compact design. IEEE 1588 function support enables the RUGGEDCOM RSG909R and the RSG907R to combine precision timing and network communication data on one network, reducing maintenance costs:
- Multi-port redundancy box allows for interconnection of up to 6 non-PRP or non-HSR end devices
- PRP/HSR coupling functionality to cover all types of redundant network topologies

Cyber security
Cyber security is an important issue in many industries where advanced automation and communications networks play a crucial role in mission critical applications and where high reliability is of paramount importance. Key RUGGEDCOM RSG907R and RSG909R features that address security issues at the local area network level include:

- Passwords – support for multiple access levels with separate credentials for each level
- SSH / SSL – extends capability of password protection to add encryption of passwords and data as they cross the network
- Enable / disable ports – capability to disable ports so unauthorized devices can't connect to unused ports
- SNMPv3 – encrypted authentication and access security
- HTTPS – for secure access to the web interface
- 802.1x – to ensure only permitted devices can connect to the device
- MAC address authentication – control access to devices that do not support RADIUS

Hardware
The RUGGEDCOM RSG907R and RSG909R have been specifically designed and certified for substation and distribution automation applications within electric power industry.

Power Supply
- Integrated power supply with redundant inputs
- Universal high voltage range: 88 – 300 VDC or 85 – 264 VAC
- Universal low voltage power supply range: 12 – 60 VDC

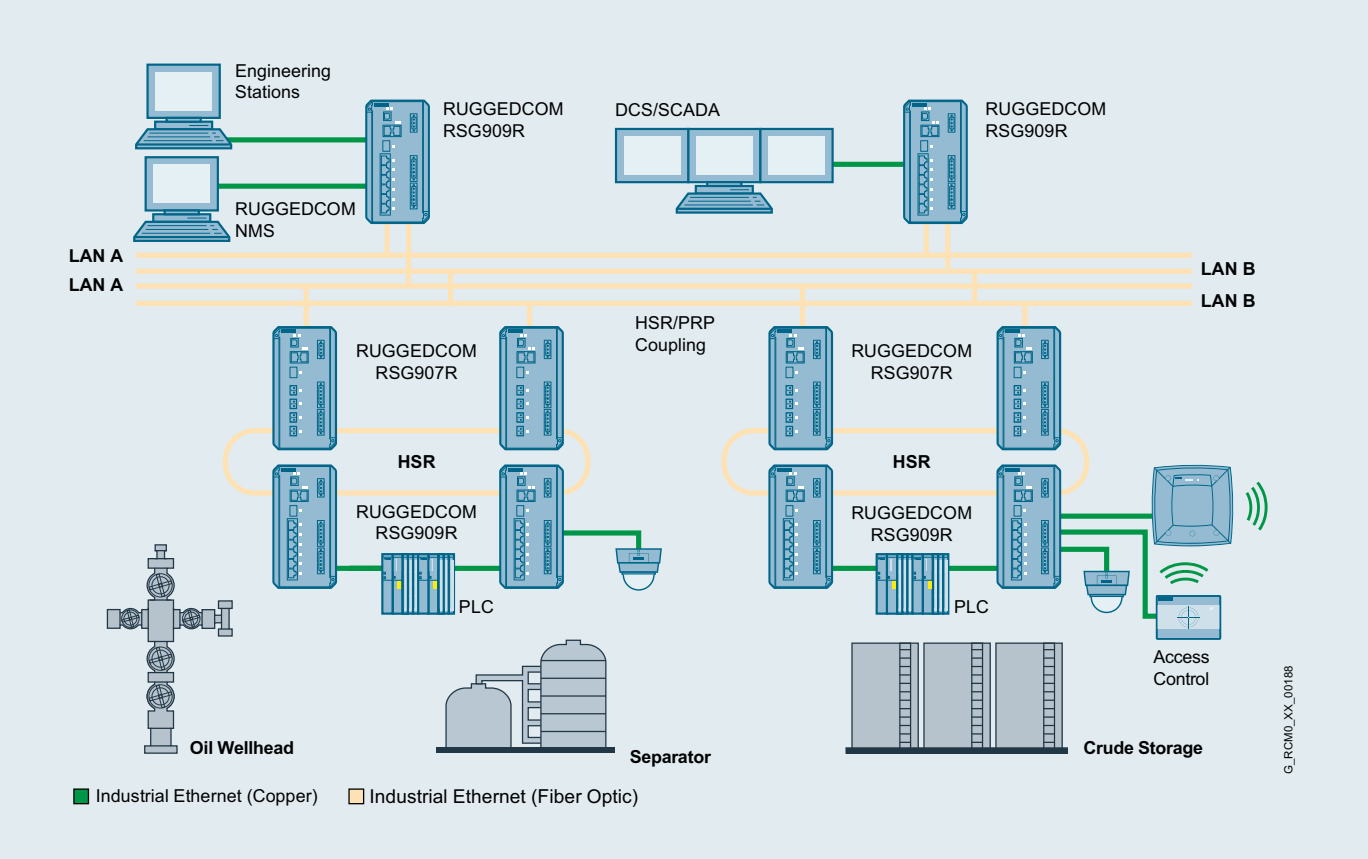
Configuration interface
The RUGGEDCOM RSG907R and RSG909R are equipped with a USB interface which enables easy in-field configuration and upgrading.

Harsh environments
As with all RUGGEDCOM products, Highly Accelerated Life Testing (HALT) has been used in the early stages of product development to detect any design or performance issues.

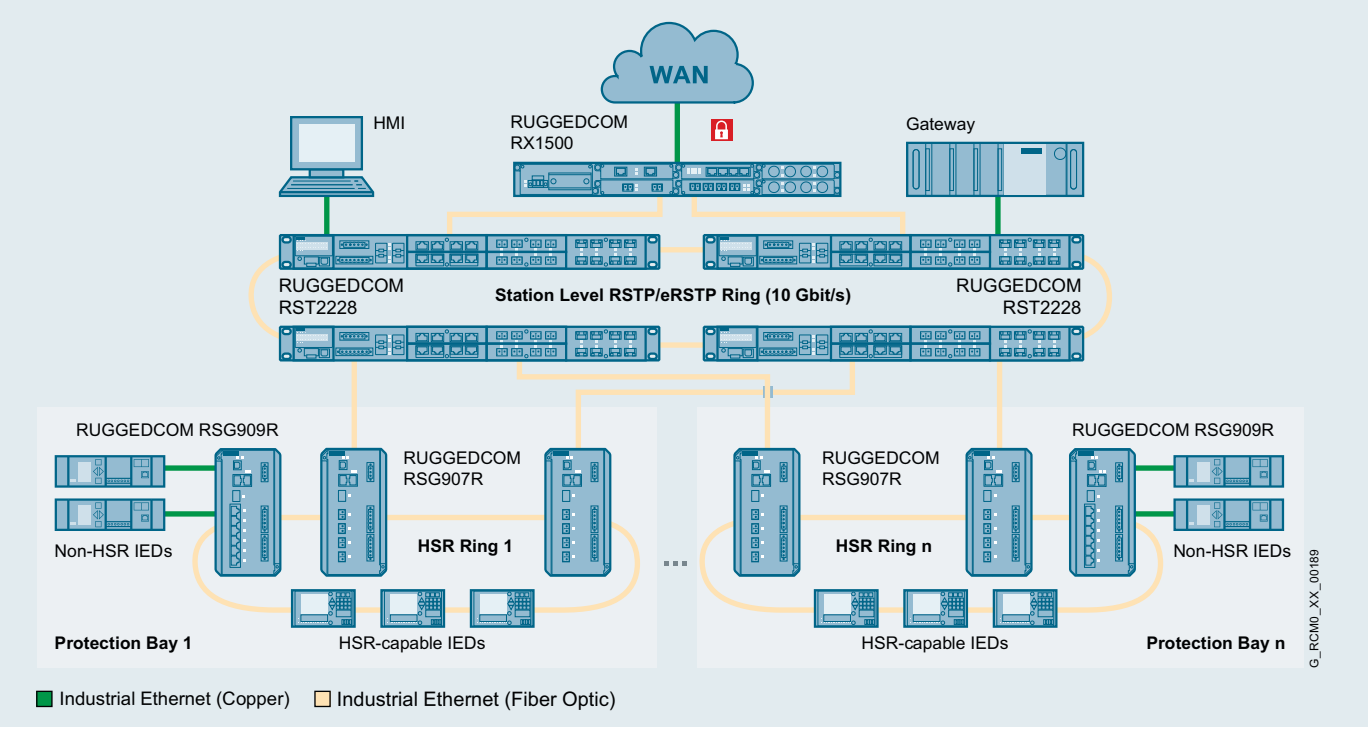
- Temperature: -40° C to +85° C (fanless)
- Safety: CSA/UL 60950
- Vibration: IEC 60255-21-1, Class 2
- Shock: IEC 60255-21-2, Class 2
- Humidity: IEC 60068-2-30, up to 95% relative humidity

Certifications
- IEC 61000-6-2 (industrial environments)
- IEC 61850-3 (electric substations)
- IEEE 1613 (electric substations)

Use cases



Multi-port Redundancy Box (Redbox) allowing for interconnection of up to 6 non-PRP or non-HSR end devices.



RSG907R/RSG909R switches terminating each HSR ring can be directly connected to RSTP network via their coupling ports.

Ordering options

Product	Article number							
RUGGEDCOM RSG909R	6GK6498-0RB00	.	.	N	.	–	Z	
RUGGEDCOM RSG907R	6GK6490-7RB00	.	.	N	.	–	Z	
Mounting kit								
DIN rail mounting kit		1						
DIN rail and panel mounting kit		3						
Power supply 1 + terminal block type								
24/48 VDC (12 – 60 VDC)			A					
HI (85 – 264 VAC / 88 – 300 VDC)			C					
Manufacturing modification								
Standard					0			
Conformal coating					1			

Examples	Order code
RUGGEDCOM RSG909R with high voltage power supply + DIN rail mounting kit + standard coating	6GK6498-0RB00-1AN0-Z
RUGGEDCOM RSG907R + DIN rail and panel mounting kit + conformal coating	6GK6490-7RB00-3AN1-Z

Accessories

Accessories	Description	Article number
USB Console cable	USB 2.0 A type to B type Cable Assembly 10 feet / 3 meters	6GK6000-8DT01-0AA0
Panel mounting kit	Allows wall and other lateral mounting possible, requires assembly and even mounting plane	6GK6000-8MR00-0AA1
Power cable without lugs	Power Cable with NA Plug for pluggable terminal blocks (6 ft.) for RUGGEDCOM products	6GK6000-8BB00-0AA0

Supported SFPs

Product name	Cable	Max. range	Temperature	Article number
SFP1132-1BX10R	SM, LC, Bi-Di	10 km	-40 - 85 °C	6GK6000-8FB51-0AA0
SFP1132-1BX10R	SM, LC, Bi-Di	10 km	-40 - 85 °C	6GK6000-8FB52-0AA0
SFP1132-1BX40R	SM, LC, Bi-Di	40 km	-40 - 85 °C	6GK6000-8FB53-0AA0
SFP132-1BX40T	SM, LC, Bi-Di	40 km	-40 - 85 °C	6GK6000-8FB54-0AA0
SFP1122-1SX	MM, LC	0.5 km	-40 - 85 °C	6GK6000-8FG51-0AA0
SFP1122-1SX2	MM, LC	2 km	-40 - 85 °C	6GK6000-8FE58-0AA0
SFP1132-1LX10	SM, LC	10 km	-40 - 85 °C	6GK6000-8FG52-0AA0
SFP1132-1LX25	SM, LC	25 km	-40 - 85 °C	6GK6000-8FG53-0AA0
SFP1132-1LX40	SM, LC	40 km	-40 - 85 °C	6GK6000-8FG57-0AA0
SFP1132-1LX70	SM, LC	70 m	-40 - 85 °C	6GK6000-8FG54-0AA0
SFP1132-1LX100	SM, LC	100 m	-40 - 85 °C	6GK6000-8FG55-0AA0
SFP1132-1LX115	SM, LC	115 km	-40 - 85 °C	6GK6000-8FE56-0AA0

* SM = Single-mode, MM = Multi-mode, Bi-Di = Bi Directional

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FastConnect™ Cabling System

Stringent demands are placed on the installation of cables in an industrial environment. Siemens offers FastConnect™, a system that fulfills all these requirements: on-site assembly – quick, easy and error-free. For more information, visit: **siemens.com/fastconnect**

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