# Base Load Power Hub (BLPH)

## Cable Sizing Calculation Report (including end of line minimum fault current clearance verification)

Document Number: 123A90-DDL-EL-RE-20151

Document Class: 2

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| 01 | 12/04/2024 | Accepted for Construction (AFC) | SPU | SPU - LMA | MDO |
| 00 | 19/10/2023 | Issue for Review (IFR) | NOSEGAL | NOCABOL | NOOYFOL |
| Rev. | Date | Description | Prepared | Reviewed | Approved |

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

## Revision / Change Log

| Rev. | Description |
|---|---|
| 00 | Issue for Review (IFR) |
| 01 | Accepted for Construction (AFC) |
| | |
| | |
| | |
| | |
| | |

## HOLDS LIST

| No. | Description |
|---|---|
| | |
| | |
| | |
| | |
| | |

# Table of contents


1 INTRODUCTION ..... 5
1.1 PROJECT OVERVIEW ..... 5
1.1.1 Project Location ..... 5
1.1.2 Project Concept ..... 6
2 DOCUMENT SCOPE ..... 8
2.1 REFERENCES ..... 8
2.2 DEFINITIONS AND ABBREVIATIONS ..... 9
3 CABLE SIZING ..... 10
3.1 METHOD ..... 10
3.2 CRITERIA ..... 10
3.3 POWER CABLES ..... 10
3.3.1 Type and length ..... 11
3.3.2 Cable installation and routing ..... 12
3.3.3 Cable ampacity calculation ..... 13
3.3.4 Electrical parameters ..... 15
3.4 LOAD FLOW ANALYSIS ..... 16
3.4.1 ETAP Study Assumptions ..... 16
3.4.2 LF Case 1 ..... 16
3.4.3 LF Case 2 ..... 16
3.4.4 LF Study Results ..... 17
3.5 SIZING OF NER CABLE ON TR-100AD1 ..... 19
3.6 SHORT CIRCUIT ANALYSIS ..... 19
3.6.1 ETAP Study Assumptions ..... 19
3.6.2 Study Cases ..... 19
3.6.3 SCC Case 1 – Maximum Short Circuit ..... 19
3.6.4 SCC Case 2 – Minimum Short Circuit Unbalance ..... 20
3.6.5 SCC Study Results ..... 21
4 CONCLUSION ..... 23



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

ATTACHMENTS ..... 24

## List of Figures

Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map ..... 5
Figure 2 - Wind Park Details ..... 6
Figure 3 – BLPH Concept ..... 7

## List of tables

Table 1 - Reference Documents ..... 8
Table 2 - Definitions and Abbreviations ..... 9
Table 3 - Type and length of power cables on BPLH ..... 11
Table 4 - Cable ampacity calculations for the power cables in BLPH ..... 14
Table 5 - Electrical parameters of power cables in BLPH ..... 15
Table 6: Cables Loading ..... 17
Table 7: Cables Voltage Drop ..... 18
Table 8: Short Circuit Capability Verification ..... 21
Table 9: Minimum Short Circuit Result ..... 22
Table 10 - Type and length of power cables on BPLH ..... 23

## List of Attachments

Attachment 1 Etap Report Load Flow Case 1
Attachment 2 Etap Report Load Flow Case 2
Attachment 3 Etap Report Short Circuit Study Case 1
Attachment 4 Etap Report Short Circuit Study Case 2
Attachment 5 Electrical parameters for Submarine HV cable
Attachment 6 Etap Single Line Diagram

# 1 INTRODUCTION

## 1.1 PROJECT OVERVIEW

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.

Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

### 1.1.1 Project Location

The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.




*Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map*




*Figure 2 - Wind Park Details*

The wind farm will consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile located on coordinates E 590719.1, N 5841602.3 is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed by Van Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

### 1.1.2 Project Concept

All components included in the BLPH will be integrated onshore on a topsides and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MW of power is exported to the electrical grid regardless of wind/solar availability.

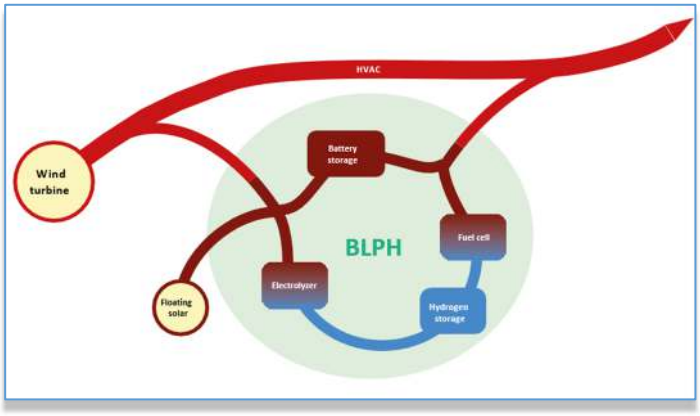



*Figure 3 – BLPH Concept*

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.

The purpose of the BLPH s to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

# 2 DOCUMENT SCOPE

The scope of this document is to present the method used in dimensioning the power cables in BLPH. The power cables are only those listed below:

- 66 kV power cables on BLPH
- 6.6 kV power cables on BLPH
- 0.4 kV cable between TR-200DE1 and LV switchgear

## 2.1 REFERENCES

| Doc. No. | Description |
|---|---|
| 123A90-DDL-EL-LIS-20148 Rev 00 | Electrical Power and Control Cable Schedule |
| 123A90-DDL-EL-LIS-20016 Rev. 2 | Electrical Load List & Balance (CCS Mode 'Import) |
| 123A90-PML-PM-TQ-00033 | Technical Query – Electrical data of WTG-57 |
| 123A90-DDL-EL-RE-20170 Rev. 0 | Electrical System Study Report – Load Flow |
| 123A90-DDL-EL-DG-20158 Rev. 1 | Overall Single Line Diagram |
| 144671-TKF-IAC-INS-SPE-0001 | Technical specification – 66 kV Al 3X400 CONF143350 specification (incl. Drain wire) |
| IEC-60092-352 (2005-09) | Electrical installations in ships – Part 352: Choice and installation of electrical cables |
| 2XS(FL)2Y HDPE High Voltage 36/60 (72.5) kV Cable | Cable catalogue for HV cable |
| 123A90-PML-PM-TQ-00033_REPLY | Technical Query N. 33 |
| IEC 61892-4 | Mobile and fixed offshore units - Electrical installations - Part 4: Cables |

*Table 1 - Reference Documents*

## 2.2 DEFINITIONS AND ABBREVIATIONS

| | |
|---|---|
| Al | Aluminium |
| BESS | Battery Energy Storage System |
| BLPH | Base Load Power Hub |
| Cu | Copper |
| COMPANY or Client (CPY): | Crosswind |
| CONTRACTOR (CTR): | ROSETTI MARINO S.p.A. |
| HV | High Voltage |
| LV | Low Voltage |
| N/A | Not Applicable |
| NER | Neutral Earthing Resistor |
| OCTC | Off Circuit Tap Changer |
| OLTC | On Load Tap Changer |
| PROJECT: | HOLLANDSE KUST NOORD WIND PARK Project |
| WTG | Wind Turbine Generator |
| XLPE | Cross-linked PolyEthylene |

*Table 2 - Definitions and Abbreviations*

# 3 CABLE SIZING

## 3.1 METHOD

Information on the type and length of the power cables are taken from 123A90-DDL-EL-LIS-20148 Rev 00. Routing of these cables are taken from project 3D model.

The electrical parameters of these cables are presented in Attachments 1, 2, 3.

Load flow analysis is performed for power cable sizing verification. The charging and discharging modes of operation are the critical operation modes, hence, load flow analysis on these two operation modes is presented in this report.

Short circuit analysis is performed for end of line minimum fault current clearance verification.

## 3.2 CRITERIA

The cable sizing should provide a minimum of 20% spare capacity for electrical loading.

During normal system operation and under steady state conditions, following shall be accomplished:

- Allowed voltage deviation: ±5% from the rated equipment voltage.

## 3.3 POWER CABLES

The electrical parameters of HV and LV power cables are based as follow:

- Electrical parameters for HV submarine cable – Attachment 5
- Electrical parameters for HV cables are as per Etap Library
- Electrical parameters for LV cable are as per Etap Library

### 3.3.1 Type and length

| Name in ETAP model | Between | Length (m) | Type |
|---|---|---|---|
| 66kV cable1 | HV switchgear and TR-100AD1 | 25 | 3X1X300mm$^2$ Cu/XLPE unarmoured |
| 66kV cable2 | 66 kV junction box and HV switchgear | 40 | 3X1X300mm$^2$ Cu/XLPE unarmoured |
| 66kV cable3 | 66 kV busbar at WTG-57 and 66kV junction box on BLPH.<br>*Ref. 123A90-PML-PM-TQ-00033* | 1240 | 1X3X400mm$^2$ Al/XLPE armoured |
| 6.6kV cable1 | 6.6 kV busbar and TR-100AD1 and incoming SG-100D1 (6.6kV) | 25 | 2X3X1X120mm$^2$ Cu/XLPE unarmoured |
| 6.6kV cable2 | SG-100D1 (6.6kV) and TR-200DE1 | 44 | 1X3X70mm$^2$ Cu/XLPE armoured |
| 6.6kV cable3 | SG-100D1 (6.6kV) and TA30 (Fuel Cell Package) | 78 | 1X3X70mm$^2$ Cu/XLPE armoured |
| 6.6kV cable4 | SG-100D1 (6.6kV) and T4 (Electrolyzer package) | 45 | 1X3X120mm$^2$ Cu/XLPE armoured |
| 6.6kV cable5 | SG-100D1 (6.6kV) and 18T1 (BESS Package) | 55 | 1X3X70mm$^2$ Cu/XLPE armoured |
| 6.6kV cable6 | SG-100D1 (6.6kV) and TR-200ED1 | 25 | 1X3X70mm$^2$ Cu/XLPE armoured |
| 0.4kV cable | LV at TR-200DE1 and LV switchgear (SG-200N1) | 10 | 5X3X1X300mm$^2$ Cu/EPR RFOU cable unarmoured |

*Table 3 - Type and length of power cables on BPLH*

Note: These cables are low smoke zero halogen types. All HV cables are assumed heavy duty screened (minimum 10 kA/s).

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

### 3.3.2 Cable installation and routing

Based on project 3D model, it is assumed that the cable routing in BLPH is on cable ladders supported on pipe rack. It is also assumed that each voltage level corresponds to one cable ladder. Further assumptions are listed below:

- From the HV switchgear room (B-100), 6 sets of 6.6 kV cables and 2 sets of 66 kV cables (on two separate cable ladders) are routed to the respective rooms. Due to space constraints, it is assumed that all 6.6 kV cables are routed on a single layer cable ladder, in trefoil formation.
- The 5 sets of LV cables (each set with three single core cables) plus 3 cables for neutral, are also assumed routed on a single layer cable ladder.
- 6.6 kV and LV cables are assumed installed in accordance with reference methods E and F in IEC 60092-352.

  The cable ladders for 6.6 kV, LV and HV cables are placed one above the other inside the containers and one beside the other along the pipe rack.

Correction factors as been calculated according to IEC 61892-4 - Mobile and fixed offshore units - Electrical installations - Part 4: Cables.

Overall correction factors are listed in chapter 3.3.3.

### 3.3.3 Cable ampacity calculation

There are different factors affecting the cable ampacity (no. of cables per phase, ambient air temperature, cable layout/routing etc.). Based on the assumed cable installation method, these correction factors are applied on the given cable ampacity from standard catalogues.

| Cable | Layout configuration | Cable ampacity per cable set in free air @ conductor temperature 90° C – IEC 61892-4 | Correction factor | | Allowable Ampacity - Derated |
|---|---|---|---|---|---|
| | | | Air temp. 25 °C | Cable installation | |
| 66kV cable1 | Single core cable in trefoil with screen bonded at both ends. | 601 A | 1.2 | 0.85 | 613.0 A |
| 66kV cable2 | Single core cables in trefoil with screen bonded at both ends. | 601 A | 1.2 | 0.85 | 613.0 A |
| 66kV cable3 | This is a subsea cable. The cable ampacity 574 A given in its datasheet is for subsea condition at seabed temperature 14.3 °C. When used in BLPH, the cable ampacity is corrected for the air temperature at 45 °C, and new cable ampacity is taken to be 459 A. | | | | |
| 6.6kV cable1 | Single core cables in trefoil with screen bonded at both ends. | 678 A | 1.2 | 0.85 | 691.56 A |
| 6.6kV cable2 | Multicore cable with screen bonded at both ends. | 242 A | 1.2 | 0.85 | 246.84 A |
| 6.6kV cable3 | Multicore cable with screen bonded at both ends. | 242 A | 1.2 | 0.85 | 246.84 A |
| 6.6kV cable4 | Multicore cable with screen bonded at both ends. | 339 A | 1.2 | 0.85 | 345.78 A |

| Cable | Layout configuration | Cable ampacity per cable set in free air @ conductor temperature 90° C – IEC 61892-4 | Correction factor | | Allowable Ampacity - Derated |
|---|---|---|---|---|---|
| | | | Air temp. 25 °C | Cable installation | |
| 6.6kV cable5 | Multicore cable with screen bonded at both ends. | 242 A | 1.2 | 0.85 | 246.84 A |
| 6.6kV cable6 | Multicore cable with screen bonded at both ends. | 242 A | 1.2 | 0.85 | 246.84 A |
| 0.4kV cable | Single core cables in trefoil with screen bonded at both ends. | 3005 A | 1.2 | 0.85 | 3065.1 A |

*Table 4 - Cable ampacity calculations for the power cables in BLPH*

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

### 3.3.4 Electrical parameters

Electrical parameters of these power cables are presented in the below:

| Parameters | Power cables | | | | |
|---|---|---|---|---|---|
| Voltage level | 66 kV | 66 kV | 6.6 kV | 6.6 kV | 0.4 kV |
| CSA | 1X3X400 $mm^2$ | 3X1X300 $mm^2$ | 1X3X120 $mm^2$ | 1X3X70 $mm^2$ | 3X1X300 $mm^2$ |
| Reference | 144671-TKF-IAC-INS-SPE-0001 | 0 | 0 2 | 0 2 | 0 2 |
| Positive/Negative sequence resistance at 90°C and 50 Hz per phase [Ohm/km] | 0.1018 | 0.0781 | 0.196 | 0.342 | 0.08 |
| Positive/Negative sequence reactance 50 Hz per phase [Ohm/km] | 0.0987 | 0.120 | 0.113 | 0.130 | 0.089 |
| Nominal capacitance per phase (to earth) [uF/km] | 0.29 | 0.205 | 0.445 | 0.350 | 0.590 |

*Table 5 - Electrical parameters of power cables in BLPH*

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

## 3.4 LOAD FLOW ANALYSIS

Purpose of load flow study is the calculation of maximum loading and voltage drop in the HV cables and in the main LV Cables, in order to check the correct sizing of the main equipment.

Case scenarios are defined to identify the worst conditions for cable loading and voltage drop. It's important to note that these scenarios differ from the typical operating case indicated in load balance, and they are only applicable to this specific study.

### 3.4.1 ETAP Study Assumptions

Calculation Method: Newton Raphson.

Initial Voltage Conditions: Bus Initial Voltages.

Update: Initial Bus Voltages, Transformers LTCs, Cable Load Amp.

Adjustments: Transformer Impedance Tolerance: 10% as per IEC Standard.

Note: where specific data are missing, ETAP typical values are used.

### 3.4.2 LF Case 1

- Generation Category: Normal.
- Loading Category: Normal.
- Load Diversity Factor: None.
- External Power Grid 20kV in service and considering maximum short circuit power.
- Resistance temperature correction: Global 90°C.
- BESS - A-85000 out of Service;
- Fuel-Cell - A-80000 out of Service;
- PV plant out of Service;
- Electrolyser A-20000 in Service;
- The LV loads stated as "continuous operation" in service and loaded according to load schedule usage factor.
- The LV loads stated as "stand-by operation" out of service.

### 3.4.3 LF Case 2

- Generation Category: Normal.
- Loading Category: Normal.
- Load Diversity Factor: None.
- External Power Grid 20kV in service and considering maximum short circuit power.

- Resistance temperature correction: Global 90°C.
- BESS - A-85000 in Service;
- Fuel-Cell - A-80000 in Service;
- PV plant in Service;
- Electrolyser A-20000 out of service;
- The LV loads stated as "continuous operation" in service and loaded according to load schedule usage factor.
- The LV loads stated as "stand-by operation" out of service.

### 3.4.4 LF Study Results

The following tables summarize the results of Load Flow calculations. Further details are available in the attached ETAP reports.

*Cables Loading*

| Cable ID | Voltage kV | Rated Ampacity [A] | CALCULATED OPERATING LOADING CONDITIONS | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | LF Case 1 | | | LF Case 2 | | |
| | | | [A] | % Loading | Check [YES/NO] | [A] | % Loading | Check [YES/NO] |
| 66kV_Cable1 | 66.00 | 613.00 | 37.57 | 6.13 | YES | 19.71 | 3.22 | YES |
| 66kV_Cable2 | 66.00 | 613.00 | 37.55 | 6.12 | YES | 19.74 | 3.22 | YES |
| 66kV_Cable3 | 66.00 | 459.20 | 37.51 | 8.17 | YES | 21.24 | 4.63 | YES |
| 0.4kV_cable | 0.40 | 2764.80 | 1350.75 | 48.86 | YES | 1347.67 | 48.74 | YES |
| 6.6kV_Cable1 | 6.60 | 691.60 | 363.86 | 52.61 | YES | 197.84 | 28.61 | YES |
| 6.6kV_Cable2 | 6.60 | 246.80 | 83.86 | 33.98 | YES | 83.67 | 33.90 | YES |
| 6.6kV_Cable3 | 6.60 | 246.80 | | | | 128.97 | 52.26 | YES |
| 6.6kV_Cable4 | 6.60 | 345.80 | 282.06 | 81.57 | NO | | | |
| 6.6kV_Cable5 | 6.60 | 246.80 | | | | 114.38 | 46.34 | YES |
| 6.6kV_Cable6 | 6.60 | 246.80 | | | | 41.49 | 16.81 | YES |

*Table 6: Cables Loading*

Regarding to 6.6kV_Cable4, the loading has been calculated on the electrolyser transformer rating since system load is not yet finalized. Considering that the transformer rating has margin on the system load the selected cable is considered acceptable even if the calculated margin is little lower than 20%.

| Cable ID | Voltage kV | Maximum Volatge Drop [%] | CALCULATED VoltAGE DROP IN THE OPERATING CONDITIONS | | | |
|---|---|---|---|---|---|---|
| | | | LF Case 1 | | LF Case 2 | |
| | | | % V Drop | Check [YES/NO] | % V Drop | Check [YES/NO] |
| 66kV_Cable1 | 66.00 | 5.00 | 0.01 | YES | 0.00 | YES |
| 66kV_Cable2 | 66.00 | 5.00 | 0.01 | YES | 0.00 | YES |
| 66kV_Cable3 | 66.00 | 5.00 | 0.51 | YES | 0.16 | YES |
| 0.4kV_cable | 0.40 | 5.00 | 0.88 | YES | 0.87 | YES |
| 6.6kV_Cable1 | 6.60 | 5.00 | 0.97 | YES | 0.29 | YES |
| 6.6kV_Cable2 | 6.60 | 5.00 | 0.32 | YES | 0.32 | YES |
| 6.6kV_Cable3 | 6.60 | 5.00 | | | 1.33 | YES |
| 6.6kV_Cable4 | 6.60 | 5.00 | 2.10 | YES | | |
| 6.6kV_Cable5 | 6.60 | 5.00 | | | 0.74 | YES |
| 6.6kV_Cable6 | 6.60 | 5.00 | | | 0.04 | YES |

*Table 7: Cables Voltage Drop*

## 3.5 SIZING OF NER CABLE ON TR-100AD1

The cable for Neutral Earthing Resistor (NER) for the secondary neutral of TR-100AD1 is dimensioned considering that NER shall limit the fault current to less than 400 A for maximum 10 seconds.

The minimum cross-section of the cable is calculated based on the maximum fault current (400 A) and the maximum limitation time (10 s), resulting in a value of 8.84 mm^2.

Therefore, a 1X70 mm^2 Copper/XLPE unarmoured cable is proposed.

## 3.6 SHORT CIRCUIT ANALYSIS

Purpose of short circuit study is the calculation of maximum expected 3-phase short circuit fault currents on network buses, in order to check adequacy of MV power Cables and the main LV power cable.

### 3.6.1 ETAP Study Assumptions

| | |
|---|---|
| SC Standard: | IEC |
| X/R for Peak kA Calculation Method: | method C |
| Pre-fault Voltage: | LF Case – Loading Category Design |
| cmax for Z adj. (V < 1000V) | 1.05% |
| Protect. Device Duty: | based on total bus fault current |

Note: where specific data are missing, ETAP typical values are used.

### 3.6.2 Study Cases

### 3.6.3 SCC Case 1 – Maximum Short Circuit

Short Circuit Currents have been calculated on the base of the IEC 61363 Standard for offshore.

- Generation Category: Normal.
- Loading Category: Normal.
- Load Diversity Factor: None.
- External Power Grid 20kV in service and considering minimum short circuit power.
- Resistance temperature correction: Global 20°C.
- BESS - A-85000 in Service;
- Fuel-Cell - A-80000 in Service;
- PV plant in Service;
- Electrolyser A-20000 out of service;
- The LV loads stated as "continuous operation" in service and loaded according to load schedule usage factor.

- The LV loads stated as "stand-by operation" out of service.

### 3.6.4 SCC Case 2 – Minimum Short Circuit Unbalance

Short Circuit Currents have been calculated on the base of the IEC 60909 Standard, because with IEC 61363 cannot calculate the unbalance current components.

- Generation Category: Normal.
- Loading Category: Normal.
- Load Diversity Factor: None.
- External Power Grid 20kV out of service (Island Condition).
- Resistance temperature correction: Global 90°C.
- BESS - A-85000 in Service;
- Fuel-Cell - A-80000 out of Service;
- PV plant out of Service;
- Electrolyser A-20000 out of service;
- The LV loads stated as "continuous operation" in service and loaded according to load schedule usage factor.
- The LV loads stated as "stand-by operation" out of service.

### 3.6.5 SCC Study Results

The following tables summarize the results of Short Circuit study calculations.

Further details are available in the attached ETAP reports.

*Short Circuit Capability Verification*

| Cable ID | Voltage kV | Crosssection [mm2] | SCC Max [kA] | Issc-max [kA] | Max Protection Clearing Time [s] | Check [YES/NO] |
|---|---|---|---|---|---|---|
| 66kV_Cable1 | 66.00 | 300.00 | 14.72 | 60.67 | 0.50 | YES |
| 66kV_Cable2 | 66.00 | 300.00 | 15.50 | 60.67 | 0.50 | YES |
| 66kV_Cable3 | 66.00 | 400.00 | 15.50 | 80.89 | 0.50 | YES |
| 0.4kV_cable | 0.40 | 300.00 | 32.17 | 42.90 | 1.00 | YES |
| 6.6kV_Cable1 | 6.60 | 120.00 | 8.45 | 24.27 | 0.50 | YES |
| 6.6kV_Cable2 | 6.60 | 70.00 | 8.45 | 14.16 | 0.50 | YES |
| 6.6kV_Cable3 | 6.60 | 70.00 | 8.45 | 14.16 | 0.50 | YES |
| 6.6kV_Cable4 | 6.60 | 120.00 | 8.45 | 24.27 | 0.50 | YES |
| 6.6kV_Cable5 | 6.60 | 70.00 | 8.45 | 14.16 | 0.50 | YES |
| 6.6kV_Cable6 | 6.60 | 70.00 | 8.45 | 14.16 | 0.50 | YES |

*Table 8: Short Circuit Capability Verification*

Issc-max has been calculated from the following formulae $I^2 \times t < K^2 \times S^2$, where $Iscc\text{-}max = K \times S / \sqrt{t}$

In the following table the minimum short circuit current calculated are presented:

| Bus ID | Voltage kV | MINIMUM SHORT CIRCUIT CURRENTS | | | | | |
|---|---|---|---|---|---|---|---|
| | | LLL | | | LG | | |
| | | Ik'' [kA] | Ip [kA] | Ik [kA] | Ik'' [kA] | Ip [kA] | Ik [kA] |
| SG-100D1 | 6.60 | 0.17 | 0.42 | 0.17 | 0.00 | 0.00 | 0.00 |
| SG-200N1 | 0.40 | 2.26 | 5.55 | 2.26 | 3.26 | 8.00 | 3.26 |
| **Bus ID** | **Voltage kV** | **MINIMUM SHORT CIRCUIT CURRENTS** | | | | | |
| | | LL | | | LLG | | |
| | | Ik'' [kA] | Ip [kA] | Ik [kA] | Ik'' [kA] | Ip [kA] | Ik [kA] |
| SG-100D1 | 6.60 | 0.15 | 0.37 | 0.15 | 0.15 | 0.37 | 0.15 |
| SG-200N1 | 0.40 | 1.96 | 4.80 | 1.96 | 3.53 | 8.66 | 3.53 |

*Table 9: Minimum Short Circuit Result*

# 4 CONCLUSION

Table 10 lists the power cables that have been dimensioned with a minimum of 20% spare capacity when in operation.

| Name in ETAP model | Between | Length (m) | Type |
|---|---|---|---|
| 66kV cable1 | HV switchgear and TR-100AD1 | 25 | 3X1X300mm² Cu/XLPE unarmoured |
| 66kV cable2 | 66 kV junction box and HV switchgear | 40 | 3X1X300mm² Cu/XLPE unarmoured |
| 66kV cable3 | 66 kV busbar at WTG-57 and junction box. | 1240 | 1X3X400mm² Al/XLPE armoured - Subsea cable |
| 6.6kV cable1 | 6.6 kV busbar and TR-100AD1 | 25 | 3X1X120mm² Cu/XLPE Unarmoured - 2 cable sets |
| 6.6k V cable2 | 6.6 kV busbar and TR-200DE1 | 44 | 3X1X70mm² Cu/XLPE unarmoured |
| 6.6k V cable3 | 6.6 kV busbar and TA30 | 78 | 1X3X70mm² Cu/XLPE armoured |
| 6.6k V cable4 | 6.6 kV busbar and T4 | 45 | 3X1X120mm² Cu/XLPE unarmoured |
| 6.6k V cable5 | 6.6 kV busbar and 18T1 | 55 | 1X3X70mm² Cu/XLPE armoured |
| 6.6k V cable6 | 6.6 kV busbar and TR-200ED1 | 25 | 1X3X70mm² Cu/XLPE armoured |
| 0.4kV cable | LV at TR-200DE1 and LV switchgear | 10 | 3X1X300mm² Cu/EPR RFOU cable unarmoured 5 cable sets |

*Table 10 - Type and length of power cables on BPLH*

Considering the minimum fault current results, two setting groups must be activated in the protection to protect the cables during several operating conditions (network connected to the grid and network in island condition). In island conditions, the 6.6kV overcurrent protection must be set with a high sensitivity to the fault and the trip must be constrained with the operation of undervoltage protection. This is necessary to protect all equipment and avoid spurious tripping.

# ATTACHMENTS

Attachment 1 Etap Report Load Flow Case 1

# Electrical Transient Analyzer Program

## Load Flow Analysis

Loading Category (5): CCS_Mode1_Import_Charging

Generation Category (5): CCS_Mode1_Import_Charging

Load Diversity Factor: None

| | Swing | V-Control | Load | Total |
|---|---|---|---|---|
| Number of Buses: | 1 | 0 | 18 | 19 |

| | XFMR2 | XFMR3 | Reactor | Line/Cable/ Busway | Impedance | Tie PD | Total |
|---|---|---|---|---|---|---|---|
| Number of Branches: | 2 | 0 | 0 | 16 | 0 | 0 | 18 |

| | |
|---|---|
| Method of Solution: | Adaptive Newton-Raphson Method |
| Maximum No. of Iteration: | 99 |
| Precision of Solution: | 0.0001000 |
| System Frequency: | 50.00 Hz |
| Unit System: | Metric |
| Project Filename: | BLPH-LV-SCstudy |
| Output Filename: | Z:\Studi\0351-0400\0396S_Crosswind\ETAP_15-Mar-2024\CS-LF_Case1.lfr |

## Adjustments

| Tolerance | Apply Adjustments | Individual /Global | Percent |
|---|---|---|---|
| Transformer Impedance: | Yes | Global | 10.0 |
| Reactor Impedance: | No | | |
| Overload Heater Resistance: | No | | |
| Transmission Line Length: | No | | |
| Cable / Busway Length: | No | | |

| Temperature Correction | Apply Adjustments | Individual /Global | Degree C |
|---|---|---|---|
| Transmission Line Resistance: | Yes | Global | 90 |
| Cable / Busway Resistance: | Yes | Global | 90 |

## Bus Input Data

| Bus | | | Initial Voltage | | Load | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Constant kVA | | Constant Z | | Constant I | | Generic | |
| ID | kV | Sub-sys | % Mag. | Ang. | MW | Mvar | MW | Mvar | MW | Mvar | MW | Mvar |
| Bus1 | 0.400 | 2 | 100.2 | -0.2 | 0.002 | 0.000 | | | | | | |
| Bus4 | 0.400 | 2 | 100.4 | -0.2 | | | | | | | | |
| Bus7 | 6.600 | 2 | 100.5 | 1.7 | | | | | | | | |
| Bus62 | 0.400 | 2 | 100.1 | -0.2 | 0.013 | 0.010 | | | | | | |
| Bus63 | 0.400 | 2 | 100.2 | -0.2 | 0.004 | 0.003 | | | | | | |
| Bus64 | 0.400 | 2 | 99.7 | -0.2 | 0.003 | 0.000 | | | | | | |
| Bus66 | 0.400 | 2 | 100.3 | -0.2 | | | | | | | | |
| Bus67 | 0.400 | 2 | 100.2 | -0.2 | | | | | | | | |
| Bus68 | 0.400 | 2 | 100.3 | -0.2 | | | | | | | | |
| Bus69 | 0.400 | 2 | 100.3 | -0.2 | | | | | | | | |
| Bus84 | 0.400 | 2 | 100.2 | -0.2 | 0.006 | 0.003 | | | | | | |
| Bus92 | 66.000 | 2 | 100.0 | 0.0 | | | | | | | | |
| Bus93 | 66.000 | 2 | 100.0 | 0.0 | | | | | | | | |
| Bus94 | 6.900 | 2 | 96.2 | 1.7 | | | | | | | | |
| Bus95 | 6.600 | 2 | 100.8 | -2.9 | | | 3.072 | 0.896 | | | | |
| HKN57 | 66.000 | 2 | 100.0 | 0.0 | | | | | | | | |
| HNA6-AFA70 | 66.000 | 2 | 100.0 | 0.0 | | | | | | | | |
| SG-100D1 | 6.600 | 2 | 100.6 | 1.7 | | | | | | | | |
| SG-200N1 | 0.400 | 2 | 100.3 | -0.2 | 0.008 | 0.004 | 0.779 | 0.427 | | | | |
| Total Number of Buses: 19 | | | | | 0.037 | 0.021 | 3.851 | 1.323 | 0.000 | 0.000 | 0.000 | 0.000 |

| Generation Bus | | | | Voltage | | Generation | | | Mvar Limits | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | kV | Type | Sub-sys | % Mag. | Angle | MW | Mvar | % PF | Max | Min |
| HKN57 | 66.000 | Swing | 2 | 100.0 | 0.0 | | | | | |
| | | | | | | 0.000 | 0.000 | | | |

## Line/Cable/Busway Input Data

**ohms or siemens/1000 m per Conductor (Cable) or per Phase (Line/Busway)**

| Line/Cable/Busway | | | Length | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ID | Library | Size | Adj. (m) | % Tol. | #/Phase | T (°C) | R | X | Y |
| 0.4kV_cable | 1.0NCUN1 | 300 | 10.0 | 0.0 | 5 | 90 | 0.080000 | 0.089000 | 0.0001854 |
| 6.6kV_Cable1 | 6.6NCUN1 | 120 | 25.0 | 0.0 | 2 | 90 | 0.196000 | 0.113000 | 0.0001400 |
| 6.6kV_Cable2 | 6.6NCUN1 | 70 | 44.0 | 0.0 | 1 | 90 | 0.342000 | 0.130000 | 0.0001100 |
| 6.6kV_Cable4 | 6.6NCUN1 | 120 | 45.0 | 0.0 | 1 | 90 | 0.196000 | 0.113000 | 0.0001400 |
| 66kV_Cable1 | 66NALS1 | 300 | 25.0 | 0.0 | 1 | 90 | 0.078100 | 0.120000 | 0.0000644 |
| 66kV_Cable2 | 66NALS1 | 300 | 40.0 | 0.0 | 1 | 90 | 0.078100 | 0.120000 | 0.0000644 |
| 66kV_Cable3 | 66NALS1 | 400 | 1240.0 | 0.0 | 1 | 90 | 0.101800 | 0.098700 | 0.0000911 |
| AC_UPS-F&G | 1.0MCUN4 | 35 | 40.0 | 0.0 | 1 | 90 | 0.669000 | 0.080000 | 0.0001015 |
| AC_UPS-PAS | 1.0MCUN4 | 35 | 40.0 | 0.0 | 1 | 90 | 0.669000 | 0.080000 | 0.0001015 |
| DB-L&SP-HV-MV | 1.0MCUN4 | 4.0 | 65.0 | 0.0 | 1 | 90 | 5.870000 | 0.093000 | 0.0000575 |
| DB-L&SP-LV- | 1.0MCUN4 | 4.0 | 20.0 | 0.0 | 1 | 90 | 5.870000 | 0.093000 | 0.0000575 |
| DB-L&SP-UPS- | 1.0MCUN4 | 4.0 | 47.0 | 0.0 | 1 | 90 | 5.870000 | 0.093000 | 0.0000575 |
| DB-L&SP.Inst. | 1.0MCUN4 | 4.0 | 45.0 | 0.0 | 1 | 90 | 5.870000 | 0.093000 | 0.0000575 |
| DB-L&SP_BoP | 1.0NCUN4 | 16 | 20.0 | 0.0 | 1 | 90 | 1.467000 | 0.080000 | 0.0000597 |
| DC_Batt_Swgr | 1.0MCUN4 | 16 | 65.0 | 0.0 | 1 | 90 | 1.460000 | 0.080000 | 0.0000971 |
| DC_UPS_Navaid | 1.0MCUN4 | 4.0 | 50.0 | 0.0 | 1 | 90 | 5.870000 | 0.093000 | 0.0000575 |

Line / Cable / Busway resistances are listed at the specified temperatures.

## 2-Winding Transformer Input Data

| Transformer | | Rating | | | | | Z Variation | | | % Tap Setting | | Adjusted | Phase Shift | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | Phase | MVA | Prim. kV | Sec. kV | % Z1 | X1/R1 | + 5% | - 5% | % Tol. | Prim. | Sec. | % Z | Type | Angle |
| TR-100AD1 | 3-Phase | 7.000 | 66.000 | 6.900 | 8.00 | 16.06 | 0 | 0 | 10.0 | 0 | 0 | 8.8000 | Dyn | 0.000 |
| TR-200DE1 | 3-Phase | 1.600 | 6.600 | 0.420 | 6.00 | 7.94 | 0 | 0 | 10.0 | 2.500 | 0 | 6.6000 | Dyn | 0.000 |

## 2-Winding Transformer Load Tap Changer (LTC) Settings

| Transformer | Connected Buses ("*" LTC Side) | | Transformer Load Tap Changer Setting | | | | | |
|---|---|---|---|---|---|---|---|---|
| ID | Primary Bus ID | Secondary Bus ID | % Min. Tap | % Max. Tap | % Step | Regulated Bus ID | % V | kV |
| TR-100AD1 | * Bus93 | Bus94 | -8.00 | 8.00 | 1.250 | SG-100D1 | 100.00 | 6.600 |

## Branch Connections

| CKT/Branch | | Connected Bus ID | | % Impedance, Pos. Seq., 100 MVA Base | | | |
|---|---|---|---|---|---|---|---|
| ID | Type | From Bus | To Bus | R | X | Z | Y |
| TR-100AD1 | 2W XFMR | Bus93 | Bus94 | 8.20 | 131.74 | 132.00 | |
| TR-200DE1 | 2W XFMR | Bus7 | Bus4 | 48.34 | 383.81 | 386.85 | |
| 0.4kV_cable | Cable | Bus4 | SG-200N1 | 8.30 | 9.23 | 12.41 | 0.0000018 |
| 6.6kV_Cable1 | Cable | Bus94 | SG-100D1 | 0.51 | 0.30 | 0.59 | 0.0003333 |
| 6.6kV_Cable2 | Cable | SG-100D1 | Bus7 | 3.16 | 1.20 | 3.38 | 0.0002304 |
| 6.6kV_Cable4 | Cable | SG-100D1 | Bus95 | 1.85 | 1.07 | 2.14 | 0.0002999 |
| 66kV_Cable1 | Cable | HNA6-AFA70 | Bus93 | 0.00 | 0.01 | 0.01 | 0.0070134 |
| 66kV_Cable2 | Cable | Bus92 | HNA6-AFA70 | 0.01 | 0.01 | 0.01 | 0.0112215 |
| 66kV_Cable3 | Cable | HKN57 | Bus92 | 0.29 | 0.28 | 0.40 | 0.4921036 |
| AC_UPS-F&G | Cable | SG-200N1 | Bus63 | 1387.96 | 165.97 | 1397.85 | 0.0000008 |
| AC_UPS-PAS | Cable | SG-200N1 | Bus62 | 1387.96 | 165.97 | 1397.85 | 0.0000008 |
| DB-L&SP-HV-MV | Cable | SG-200N1 | Bus67 | 19789.85 | 313.54 | 19792.34 | 0.0000007 |
| DB-L&SP-LV- | Cable | SG-200N1 | Bus68 | 6089.19 | 96.47 | 6089.95 | 0.0000002 |
| DB-L&SP-UPS- | Cable | SG-200N1 | Bus69 | 14309.59 | 226.71 | 14311.38 | 0.0000005 |
| DB-L&SP.Inst. | Cable | SG-200N1 | Bus66 | 13700.67 | 217.06 | 13702.39 | 0.0000005 |
| DB-L&SP_BoP | Cable | SG-200N1 | Bus84 | 1521.78 | 82.99 | 1524.04 | 0.0000002 |
| DC_Batt_Swgr | Cable | SG-200N1 | Bus1 | 4922.18 | 269.71 | 4929.56 | 0.0000012 |
| DC_UPS_Navaid | Cable | SG-200N1 | Bus64 | 15222.96 | 241.18 | 15224.87 | 0.0000006 |

## LOAD_FLOW_REPORT

| Bus | | Voltage | | Generation | | Load | | Load Flow | | | | | XFMR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | kV | % Mag. | Ang. | MW | Mvar | MW | Mvar | ID | MW | Mvar | Amp | %PF | %Tap |
| Bus1 | 0.400 | 100.475 | -4.9 | 0.000 | 0.000 | 0.002 | 0.000 | SG-200N1 | -0.002 | 0.000 | 2.3 | 100.0 | |
| Bus4 | 0.400 | 100.700 | -4.8 | 0.000 | 0.000 | 0.000 | 0.000 | SG-200N1 | 0.826 | 0.454 | 1350.7 | 87.6 | |
| | | | | | | | | Bus7 | -0.826 | -0.454 | 1350.7 | 87.6 | |
| Bus7 | 6.600 | 100.799 | -2.9 | 0.000 | 0.000 | 0.000 | 0.000 | SG-100D1 | -0.831 | -0.493 | 83.9 | 86.0 | |
| | | | | | | | | Bus4 | 0.831 | 0.493 | 83.9 | 86.0 | 2.500 |
| Bus62 | 0.400 | 100.334 | -4.8 | 0.000 | 0.000 | 0.013 | 0.010 | SG-200N1 | -0.013 | -0.010 | 23.2 | 80.0 | |
| Bus63 | 0.400 | 100.500 | -4.8 | 0.000 | 0.000 | 0.004 | 0.003 | SG-200N1 | -0.004 | -0.003 | 6.8 | 80.0 | |
| Bus64 | 0.400 | 99.988 | -4.9 | 0.000 | 0.000 | 0.003 | 0.000 | SG-200N1 | -0.003 | 0.000 | 4.6 | 100.0 | |
| Bus66 | 0.400 | 100.508 | -4.8 | 0.000 | 0.000 | 0.000 | 0.000 | SG-200N1 | 0.000 | 0.000 | 0.6 | 80.0 | |
| Bus67 | 0.400 | 100.481 | -4.8 | 0.000 | 0.000 | 0.000 | 0.000 | SG-200N1 | 0.000 | 0.000 | 0.6 | 80.0 | |
| Bus68 | 0.400 | 100.541 | -4.8 | 0.000 | 0.000 | 0.000 | 0.000 | SG-200N1 | 0.000 | 0.000 | 0.6 | 80.0 | |
| Bus69 | 0.400 | 100.505 | -4.8 | 0.000 | 0.000 | 0.000 | 0.000 | SG-200N1 | 0.000 | 0.000 | 0.6 | 80.0 | |
| Bus84 | 0.400 | 100.454 | -4.8 | 0.000 | 0.000 | 0.006 | 0.003 | SG-200N1 | -0.006 | -0.003 | 9.9 | 88.4 | |
| Bus92 | 66.000 | 99.985 | 0.0 | 0.000 | 0.000 | 0.000 | 0.000 | HNA6-AFA70 | 3.968 | 1.623 | 37.5 | 92.6 | |
| | | | | | | | | HKN57 | -3.968 | -1.623 | 37.5 | 92.6 | |
| Bus93 | 66.000 | 99.984 | 0.0 | 0.000 | 0.000 | 0.000 | 0.000 | HNA6-AFA70 | -3.968 | -1.641 | 37.6 | 92.4 | |
| | | | | | | | | Bus94 | 3.968 | 1.641 | 37.6 | 92.4 | 1.250 |
| Bus94 | 6.900 | 96.475 | -2.9 | 0.000 | 0.000 | 0.000 | 0.000 | SG-100D1 | 3.953 | 1.404 | 363.8 | 94.2 | |
| | | | | | | | | Bus93 | -3.953 | -1.404 | 363.8 | 94.2 | |
| Bus95 | 6.600 | 100.761 | -2.9 | 0.000 | 0.000 | 3.119 | 0.910 | SG-100D1 | -3.119 | -0.910 | 282.1 | 96.0 | |
| * HKN57 | 66.000 | 100.000 | 0.0 | 3.968 | 1.132 | 0.000 | 0.000 | Bus92 | 3.968 | 1.132 | 36.1 | 96.2 | |
| HNA6-AFA70 | 66.000 | 99.984 | 0.0 | 0.000 | 0.000 | 0.000 | 0.000 | Bus93 | 3.968 | 1.634 | 37.5 | 92.5 | |
| | | | | | | | | Bus92 | -3.968 | -1.634 | 37.5 | 92.5 | |
| SG-100D1 | 6.600 | 100.834 | -2.9 | 0.000 | 0.000 | 0.000 | 0.000 | Bus94 | -3.952 | -1.404 | 363.9 | 94.2 | |
| | | | | | | | | Bus7 | 0.831 | 0.493 | 83.9 | 86.0 | |
| | | | | | | | | Bus95 | 3.121 | 0.911 | 282.0 | 96.0 | |
| SG-200N1 | 0.400 | 100.568 | -4.9 | 0.000 | 0.000 | 0.796 | 0.436 | Bus4 | -0.825 | -0.453 | 1350.7 | 87.7 | |
| | | | | | | | | Bus63 | 0.004 | 0.003 | 6.8 | 80.0 | |
| | | | | | | | | Bus62 | 0.013 | 0.010 | 23.2 | 80.1 | |
| | | | | | | | | Bus67 | 0.000 | 0.000 | 0.6 | 80.1 | |
| | | | | | | | | Bus68 | 0.000 | 0.000 | 0.6 | 80.0 | |

| Bus | | Voltage | | Generation | | Load | | Load Flow | | | | | XFMR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | kV | % Mag. | Ang. | MW | Mvar | MW | Mvar | ID | MW | Mvar | Amp | %PF | %Tap |
| | | | | | | | | Bus69 | 0.000 | 0.000 | 0.6 | 80.1 | |
| | | | | | | | | Bus66 | 0.000 | 0.000 | 0.6 | 80.1 | |
| | | | | | | | | Bus84 | 0.006 | 0.003 | 9.9 | 88.4 | |
| | | | | | | | | Bus1 | 0.002 | 0.000 | 2.3 | 100.0 | |
| | | | | | | | | Bus64 | 0.003 | 0.000 | 4.6 | 100.0 | |

* Indicates a voltage regulated bus ( voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

## Bus Loading Summary Report

| Bus | | | Directly Connected Load | | | | | | | | Total Bus Load | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Constant kVA | | Constant Z | | Constant I | | Generic | | | | | Percent |
| ID | kV | Rated Amp | MW | Mvar | MW | Mvar | MW | Mvar | MW | Mvar | MVA | % PF | Amp | Loading |
| Bus1 | 0.400 | | 0.002 | | | | | | | | 0.002 | 100.0 | 2.3 | |
| Bus4 | 0.400 | | | | | | | | | | 0.942 | 87.6 | 1350.7 | |
| Bus7 | 6.600 | | | | | | | | | | 0.966 | 86.0 | 83.9 | |
| Bus62 | 0.400 | | 0.013 | 0.010 | | | | | | | 0.016 | 80.0 | 23.2 | |
| Bus63 | 0.400 | | 0.004 | 0.003 | | | | | | | 0.005 | 80.0 | 6.8 | |
| Bus64 | 0.400 | | 0.003 | | | | | | | | 0.003 | 100.0 | 4.6 | |
| Bus66 | 0.400 | | 0.000 | 0.000 | | | | | | | 0.000 | 80.0 | 0.6 | |
| Bus67 | 0.400 | | 0.000 | 0.000 | | | | | | | 0.000 | 80.0 | 0.6 | |
| Bus68 | 0.400 | | 0.000 | 0.000 | | | | | | | 0.000 | 80.0 | 0.6 | |
| Bus69 | 0.400 | | 0.000 | 0.000 | | | | | | | 0.000 | 80.0 | 0.6 | |
| Bus84 | 0.400 | | 0.006 | 0.003 | | | | | | | 0.007 | 88.4 | 9.9 | |
| Bus92 | 66.000 | | | | | | | | | | 4.287 | 92.6 | 37.5 | |
| Bus93 | 66.000 | | | | | | | | | | 4.294 | 92.4 | 37.6 | |
| Bus94 | 6.900 | | | | | | | | | | 4.195 | 94.2 | 363.8 | |
| Bus95 | 6.600 | | | | 3.119 | 0.910 | | | | | 3.249 | 96.0 | 282.1 | |
| HKN57 | 66.000 | 1250.0 | | | | | | | | | 4.127 | 96.2 | 36.1 | 2.9 |
| HNA6-AFA70 | 66.000 | 1250.0 | | | | | | | | | 4.291 | 92.5 | 37.5 | 3.0 |
| SG-100D1 | 6.600 | 630.0 | | | | | | | | | 4.194 | 94.2 | 363.9 | 57.8 |
| SG-200N1 | 0.400 | 2500.0 | 0.008 | 0.004 | 0.788 | 0.432 | | | | | 0.941 | 87.7 | 1350.7 | 54.0 |

* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).
# Indicates operating load of a bus exceeds the bus marginal limit (95.0% of the Continuous Ampere rating).

## Branch Loading Summary Report

| CKT / Branch | | Busway / Cable & Reactor | | | Transformer | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ampacity (Amp) | Loading Amp | | Capability (MVA) | Loading (input) | | Loading (output) | |
| ID | Type | | | % | | MVA | % | MVA | % |
| 0.4kV_cable | Cable | 2764.80 | 1350.75 | 48.86 | | | | | |
| 6.6kV_Cable1 | Cable | 691.60 | 363.86 | 52.61 | | | | | |
| 6.6kV_Cable2 | Cable | 246.80 | 83.86 | 33.98 | | | | | |
| 6.6kV_Cable4 | Cable | 345.80 | 282.06 | 81.57 | | | | | |
| 66kV_Cable1 | Cable | 613.00 | 37.57 | 6.13 | | | | | |
| 66kV_Cable2 | Cable | 613.00 | 37.55 | 6.12 | | | | | |
| 66kV_Cable3 | Cable | 459.20 | 37.51 | 8.17 | | | | | |
| AC_UPS-F&G | Cable | 136.89 | 6.77 | 4.94 | | | | | |
| AC_UPS-PAS | Cable | 136.89 | 23.19 | 16.94 | | | | | |
| DB-L&SP-HV-MV | Cable | 37.25 | 0.65 | 1.74 | | | | | |
| DB-L&SP-LV- | Cable | 37.25 | 0.65 | 1.74 | | | | | |
| DB-L&SP-UPS- | Cable | 37.25 | 0.65 | 1.74 | | | | | |
| DB-L&SP.Inst. | Cable | 37.25 | 0.65 | 1.74 | | | | | |
| DB-L&SP_BoP | Cable | 89.40 | 9.88 | 11.06 | | | | | |
| DC_Batt_Swgr | Cable | 89.40 | 2.26 | 2.52 | | | | | |
| DC_UPS_Navaid | Cable | 37.25 | 4.56 | 12.25 | | | | | |
| TR-100AD1 | Transformer | | | | 7.000 | 4.294 | 61.3 | 4.195 | 59.9 |
| TR-200DE1 | Transformer | | | | 1.600 | 0.966 | 60.4 | 0.942 | 58.9 |

* Indicates a branch with operating load exceeding the branch capability.

## Branch Losses Summary Report

| Branch ID | From-To Bus Flow | | To-From Bus Flow | | Losses | | % Bus Voltage | | Vd % Drop in Vmag |
|---|---|---|---|---|---|---|---|---|---|
| | MW | Mvar | MW | Mvar | kW | kvar | From | To | |
| 0.4kV_cable | 0.826 | 0.454 | -0.825 | -0.453 | 0.9 | 1.0 | 100.7 | 100.6 | 0.13 |
| 6.6kV_Cable1 | 3.953 | 1.404 | -3.952 | -1.404 | 1.0 | 0.3 | 96.5 | 100.8 | 0.03 |
| 6.6kV_Cable2 | -0.831 | -0.493 | 0.831 | 0.493 | 0.3 | -0.1 | 100.8 | 100.8 | 0.03 |
| 6.6kV_Cable4 | -3.119 | -0.910 | 3.121 | 0.911 | 2.1 | 0.9 | 100.8 | 100.8 | 0.07 |
| 66kV_Cable1 | -3.968 | -1.641 | 3.968 | 1.634 | 0.0 | -7.0 | 100.0 | 100.0 | 0.00 |
| 66kV_Cable2 | 3.968 | 1.623 | -3.968 | -1.634 | 0.0 | -11.2 | 100.0 | 100.0 | 0.00 |
| 66kV_Cable3 | -3.968 | -1.623 | 3.968 | 1.132 | 0.5 | -491.5 | 100.0 | 100.0 | 0.02 |
| AC_UPS-F&G | -0.004 | -0.003 | 0.004 | 0.003 | 0.0 | 0.0 | 100.5 | 100.6 | 0.07 |
| AC_UPS-PAS | -0.013 | -0.010 | 0.013 | 0.010 | 0.0 | 0.0 | 100.3 | 100.6 | 0.23 |
| DB-L&SP.Inst. | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 100.5 | 100.6 | 0.06 |
| DB-L&SP_BoP | -0.006 | -0.003 | 0.006 | 0.003 | 0.0 | 0.0 | 100.5 | 100.6 | 0.11 |
| DB-L&SP-HV-MV | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 100.5 | 100.6 | 0.09 |
| DB-L&SP-LV- | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 100.5 | 100.6 | 0.03 |
| DB-L&SP-UPS- | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 100.5 | 100.6 | 0.06 |
| DC_Batt_Swgr | -0.002 | 0.000 | 0.002 | 0.000 | 0.0 | 0.0 | 100.5 | 100.6 | 0.09 |
| DC_UPS_Navaid | -0.003 | 0.000 | 0.003 | 0.000 | 0.0 | 0.0 | 100.0 | 100.6 | 0.58 |
| TR-100AD1 | 3.968 | 1.641 | -3.953 | -1.404 | 14.8 | 237.2 | 100.0 | 96.5 | 3.51 |
| TR-200DE1 | -0.826 | -0.454 | 0.831 | 0.493 | 5.0 | 39.5 | 100.7 | 100.8 | 4.89 |
| | | | | | 24.6 | -230.9 | | | |

* This Transmission Line includes Series Capacitor.

## Alert Summary Report

### % Alert Settings

| | Critical | Marginal |
|---|---|---|
| **Loading** | | |
| Bus | 100.0 | 95.0 |
| Cable / Busway | 100.0 | 95.0 |
| Reactor | 100.0 | 95.0 |
| Line | 100.0 | 95.0 |
| Transformer | 100.0 | 95.0 |
| Panel | 100.0 | 95.0 |
| Protective Device | 100.0 | 95.0 |
| Generator | 100.0 | 95.0 |
| Inverter/Charger | 100.0 | 95.0 |
| **Bus Voltage** | | |
| OverVoltage | 105.0 | 102.0 |
| UnderVoltage | 95.0 | 98.0 |
| **Generator Excitation** | | |
| OverExcited (Q Max.) | 100.0 | 95.0 |
| UnderExcited (Q Min.) | 100.0 | |

## Marginal Report

| Device ID | Type | Condition | Rating/Limit | Unit | Operating | % Operating | Phase Type |
|---|---|---|---|---|---|---|---|
| Bus94 | Bus | Under Voltage | 6.900 | kV | 6.657 | 96.5 | 3-Phase |

## SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

| | MW | Mvar | MVA | % PF |
|---|---|---|---|---|
| Source (Swing Buses): | 3.968 | 1.132 | 4.127 | 96.17 Lagging |
| Source (Non-Swing Buses): | 0.000 | 0.000 | 0.000 | |
| Total Demand: | 3.968 | 1.132 | 4.127 | 96.17 Lagging |
| Total Motor Load: | 0.037 | 0.021 | 0.042 | 86.74 Lagging |
| Total Static Load: | 3.907 | 1.341 | 4.131 | 94.58 Lagging |
| Total Constant I Load: | 0.000 | 0.000 | 0.000 | |
| Total Generic Load: | 0.000 | 0.000 | 0.000 | |
| Apparent Losses: | 0.025 | -0.231 | | |
| System Mismatch: | 0.000 | 0.000 | | |

Number of Iterations: 3

Attachment 2 Etap Report Load Flow Case 2

# Electrical Transient Analyzer Program

## Load Flow Analysis

Loading Category (5): CCS_Mode1_Import_Charging

Generation Category (5): CCS_Mode1_Import_Charging

Load Diversity Factor: None

| | Swing | V-Control | Load | Total |
|---|---|---|---|---|
| Number of Buses: | 1 | 0 | 21 | 22 |

| | XFMR2 | XFMR3 | Reactor | Line/Cable/ Busway | Impedance | Tie PD | Total |
|---|---|---|---|---|---|---|---|
| Number of Branches: | 3 | 0 | 0 | 18 | 0 | 0 | 21 |

| | |
|---|---|
| Method of Solution: | Adaptive Newton-Raphson Method |
| Maximum No. of Iteration: | 99 |
| Precision of Solution: | 0.0001000 |
| System Frequency: | 50.00 Hz |
| Unit System: | Metric |
| Project Filename: | BLPH-LV-SCstudy |
| Output Filename: | Z:\Studi\0351-0400\0396S_Crosswind\ETAP_15-Mar-2024\CS-LF_Case2.lfr |

## Adjustments

| Tolerance | Apply Adjustments | Individual /Global | Percent |
|---|---|---|---|
| Transformer Impedance: | Yes | Global | 10.0 |
| Reactor Impedance: | No | | |
| Overload Heater Resistance: | No | | |
| Transmission Line Length: | No | | |
| Cable / Busway Length: | No | | |

| Temperature Correction | Apply Adjustments | Individual /Global | Degree C |
|---|---|---|---|
| Transmission Line Resistance: | Yes | Global | 90 |
| Cable / Busway Resistance: | Yes | Global | 90 |

## Bus Input Data

| Bus | | | Initial Voltage | | Load | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Constant kVA | | Constant Z | | Constant I | | Generic | |
| ID | kV | Sub-sys | % Mag. | Ang. | MW | Mvar | MW | Mvar | MW | Mvar | MW | Mvar |
| Bus1 | 0.400 | 2 | 100.5 | -4.9 | 0.002 | 0.000 | | | | | | |
| Bus4 | 0.400 | 2 | 100.7 | -4.8 | | | | | | | | |
| Bus7 | 6.600 | 2 | 100.8 | -2.9 | | | | | | | | |
| Bus62 | 0.400 | 2 | 100.3 | -4.8 | 0.013 | 0.010 | | | | | | |
| Bus63 | 0.400 | 2 | 100.5 | -4.8 | 0.004 | 0.003 | | | | | | |
| Bus64 | 0.400 | 2 | 100.0 | -4.9 | 0.003 | 0.000 | | | | | | |
| Bus66 | 0.400 | 2 | 100.5 | -4.8 | | | | | | | | |
| Bus67 | 0.400 | 2 | 100.5 | -4.8 | | | | | | | | |
| Bus68 | 0.400 | 2 | 100.5 | -4.8 | | | | | | | | |
| Bus69 | 0.400 | 2 | 100.5 | -4.8 | | | | | | | | |
| Bus84 | 0.400 | 2 | 100.5 | -4.8 | 0.006 | 0.003 | | | | | | |
| Bus92 | 66.000 | 2 | 100.0 | 0.0 | | | | | | | | |
| Bus93 | 66.000 | 2 | 100.0 | 0.0 | | | | | | | | |
| Bus94 | 6.900 | 2 | 96.5 | -2.9 | | | | | | | | |
| Bus96 | 6.600 | 2 | 100.6 | 1.7 | | | | | | | | |
| Bus97 | 6.600 | 2 | 100.6 | 1.7 | | | | | | | | |
| Bus98 | 0.800 | 2 | 101.2 | 5.2 | | | | | | | | |
| Bus99 | 6.600 | 2 | 100.7 | 1.7 | | | | | | | | |
| HKN57 | 66.000 | 2 | 100.0 | 0.0 | | | | | | | | |
| HNA6-AFA70 | 66.000 | 2 | 100.0 | 0.0 | | | | | | | | |
| SG-100D1 | 6.600 | 2 | 100.8 | -2.9 | | | | | | | | |
| SG-200N1 | 0.400 | 2 | 100.6 | -4.9 | 0.008 | 0.004 | 0.779 | 0.427 | | | | |
| Total Number of Buses: 22 | | | | | 0.037 | 0.021 | 0.779 | 0.427 | 0.000 | 0.000 | 0.000 | 0.000 |

| Generation Bus | | | | Voltage | | Generation | | | Mvar Limits | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | kV | Type | Sub-sys | % Mag. | Angle | MW | Mvar | % PF | Max | Min |
| Bus96 | 6.600 | Mvar/PF Control | 2 | 100.6 | 1.7 | 1.250 | 0.411 | 95.0 | | |
| Bus98 | 0.800 | Mvar/PF Control | 2 | 101.2 | 5.2 | 0.480 | 0.000 | 100.0 | | |
| Bus99 | 6.600 | Mvar/PF Control | 2 | 100.7 | 1.7 | 1.291 | 0.732 | 87.0 | | |
| HKN57 | 66.000 | Swing | 2 | 100.0 | 0.0 | | | | | |
| | | | | | | 3.021 | 1.143 | | | |

## Line/Cable/Busway Input Data

**ohms or siemens/1000 m per Conductor (Cable) or per Phase (Line/Busway)**

| Line/Cable/Busway ID | Library | Size | Length Adj. (m) | % Tol. | #/Phase | T (°C) | R | X | Y |
|---|---|---|---|---|---|---|---|---|---|
| 0.4kV_cable | 1.0NCUN1 | 300 | 10.0 | 0.0 | 5 | 90 | 0.080000 | 0.089000 | 0.0001854 |
| 6.6kV_Cable1 | 6.6NCUN1 | 120 | 25.0 | 0.0 | 2 | 90 | 0.196000 | 0.113000 | 0.0001400 |
| 6.6kV_Cable2 | 6.6NCUN1 | 70 | 44.0 | 0.0 | 1 | 90 | 0.342000 | 0.130000 | 0.0001100 |
| 6.6kV_Cable3 | 6.6NCUN1 | 70 | 78.0 | 0.0 | 1 | 90 | 0.342000 | 0.130000 | 0.0001100 |
| 6.6kV_Cable5 | 6.6NCUN1 | 70 | 55.0 | 0.0 | 1 | 90 | 0.342000 | 0.130000 | 0.0001100 |
| 6.6kV_Cable6 | 6.6NCUN1 | 70 | 25.0 | 0.0 | 1 | 90 | 0.342000 | 0.130000 | 0.0001100 |
| 66kV_Cable1 | 66NALS1 | 300 | 25.0 | 0.0 | 1 | 90 | 0.078100 | 0.120000 | 0.0000644 |
| 66kV_Cable2 | 66NALS1 | 300 | 40.0 | 0.0 | 1 | 90 | 0.078100 | 0.120000 | 0.0000644 |
| 66kV_Cable3 | 66NALS1 | 400 | 1240.0 | 0.0 | 1 | 90 | 0.101800 | 0.098700 | 0.0000911 |
| AC_UPS-F&G | 1.0MCUN4 | 35 | 40.0 | 0.0 | 1 | 90 | 0.669000 | 0.080000 | 0.0001015 |
| AC_UPS-PAS | 1.0MCUN4 | 35 | 40.0 | 0.0 | 1 | 90 | 0.669000 | 0.080000 | 0.0001015 |
| DB-L&SP-HV-MV | 1.0MCUN4 | 4.0 | 65.0 | 0.0 | 1 | 90 | 5.870000 | 0.093000 | 0.0000575 |
| DB-L&SP-LV- | 1.0MCUN4 | 4.0 | 20.0 | 0.0 | 1 | 90 | 5.870000 | 0.093000 | 0.0000575 |
| DB-L&SP-UPS- | 1.0MCUN4 | 4.0 | 47.0 | 0.0 | 1 | 90 | 5.870000 | 0.093000 | 0.0000575 |
| DB-L&SP.Inst. | 1.0MCUN4 | 4.0 | 45.0 | 0.0 | 1 | 90 | 5.870000 | 0.093000 | 0.0000575 |
| DB-L&SP_BoP | 1.0NCUN4 | 16 | 20.0 | 0.0 | 1 | 90 | 1.467000 | 0.080000 | 0.0000597 |
| DC_Batt_Swgr | 1.0MCUN4 | 16 | 65.0 | 0.0 | 1 | 90 | 1.460000 | 0.080000 | 0.0000971 |
| DC_UPS_Navaid | 1.0MCUN4 | 4.0 | 50.0 | 0.0 | 1 | 90 | 5.870000 | 0.093000 | 0.0000575 |

Line / Cable / Busway resistances are listed at the specified temperatures.

## 2-Winding Transformer Input Data

| Transformer | | Rating | | | | | Z Variation | | | % Tap Setting | | Adjusted | Phase Shift | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | Phase | MVA | Prim. kV | Sec. kV | % Z1 | X1/R1 | + 5% | - 5% | % Tol. | Prim. | Sec. | % Z | Type | Angle |
| TR-100AD1 | 3-Phase | 7.000 | 66.000 | 6.900 | 8.00 | 16.06 | 0 | 0 | 10.0 | 0 | 0 | 8.8000 | Dyn | 0.000 |
| TR-200DE1 | 3-Phase | 1.600 | 6.600 | 0.420 | 6.00 | 7.94 | 0 | 0 | 10.0 | 2.500 | 0 | 6.6000 | Dyn | 0.000 |
| TR-200ED1 | 3-Phase | 0.500 | 6.600 | 0.800 | 6.00 | 7.63 | 0 | 0 | 10.0 | 0 | 0 | 6.6000 | Dyn | 0.000 |

## 2-Winding Transformer Load Tap Changer (LTC) Settings

| Transformer | Connected Buses ("*" LTC Side) | | Transformer Load Tap Changer Setting | | | | | |
|---|---|---|---|---|---|---|---|---|
| ID | Primary Bus ID | Secondary Bus ID | % Min. Tap | % Max. Tap | % Step | Regulated Bus ID | % V | kV |
| TR-100AD1 | * Bus93 | Bus94 | -8.00 | 8.00 | 1.250 | SG-100D1 | 100.00 | 6.600 |

## Branch Connections

| CKT/Branch | | Connected Bus ID | | % Impedance, Pos. Seq., 100 MVA Base | | | |
|---|---|---|---|---|---|---|---|
| ID | Type | From Bus | To Bus | R | X | Z | Y |
| TR-100AD1 | 2W XFMR | Bus93 | Bus94 | 7.91 | 127.04 | 127.29 | |
| TR-200DE1 | 2W XFMR | Bus7 | Bus4 | 48.34 | 383.81 | 386.85 | |
| TR-200ED1 | 2W XFMR | Bus97 | Bus98 | 156.94 | 1197.47 | 1207.71 | |
| 0.4kV_cable | Cable | Bus4 | SG-200N1 | 8.30 | 9.23 | 12.41 | 0.0000018 |
| 6.6kV_Cable1 | Cable | Bus94 | SG-100D1 | 0.51 | 0.30 | 0.59 | 0.0003333 |
| 6.6kV_Cable2 | Cable | SG-100D1 | Bus7 | 3.16 | 1.20 | 3.38 | 0.0002304 |
| 6.6kV_Cable3 | Cable | SG-100D1 | Bus99 | 5.60 | 2.13 | 5.99 | 0.0004085 |
| 6.6kV_Cable5 | Cable | SG-100D1 | Bus96 | 3.95 | 1.50 | 4.23 | 0.0002880 |
| 6.6kV_Cable6 | Cable | SG-100D1 | Bus97 | 1.80 | 0.68 | 1.92 | 0.0001309 |
| 66kV_Cable1 | Cable | HNA6-AFA70 | Bus93 | 0.00 | 0.01 | 0.01 | 0.0070134 |
| 66kV_Cable2 | Cable | Bus92 | HNA6-AFA70 | 0.01 | 0.01 | 0.01 | 0.0112215 |
| 66kV_Cable3 | Cable | HKN57 | Bus92 | 0.29 | 0.28 | 0.40 | 0.4921036 |
| AC_UPS-F&G | Cable | SG-200N1 | Bus63 | 1387.96 | 165.97 | 1397.85 | 0.0000008 |
| AC_UPS-PAS | Cable | SG-200N1 | Bus62 | 1387.96 | 165.97 | 1397.85 | 0.0000008 |
| DB-L&SP-HV-MV | Cable | SG-200N1 | Bus67 | 19789.85 | 313.54 | 19792.34 | 0.0000007 |
| DB-L&SP-LV- | Cable | SG-200N1 | Bus68 | 6089.19 | 96.47 | 6089.95 | 0.0000002 |
| DB-L&SP-UPS- | Cable | SG-200N1 | Bus69 | 14309.59 | 226.71 | 14311.38 | 0.0000005 |
| DB-L&SP.Inst. | Cable | SG-200N1 | Bus66 | 13700.67 | 217.06 | 13702.39 | 0.0000005 |
| DB-L&SP_BoP | Cable | SG-200N1 | Bus84 | 1521.78 | 82.99 | 1524.04 | 0.0000002 |
| DC_Batt_Swgr | Cable | SG-200N1 | Bus1 | 4922.18 | 269.71 | 4929.56 | 0.0000012 |
| DC_UPS_Navaid | Cable | SG-200N1 | Bus64 | 15222.96 | 241.18 | 15224.87 | 0.0000006 |

## LOAD_FLOW_REPORT

| Bus | | Voltage | | Generation | | Load | | Load Flow | | | | | XFMR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | kV | % Mag. | Ang. | MW | Mvar | MW | Mvar | ID | MW | Mvar | Amp | %PF | %Tap |
| Bus1 | 0.400 | 100.223 | -0.2 | 0.000 | 0.000 | 0.002 | 0.000 | SG-200N1 | -0.002 | 0.000 | 2.3 | 100.0 | |
| Bus4 | 0.400 | 100.448 | -0.2 | 0.000 | 0.000 | 0.000 | 0.000 | SG-200N1 | 0.822 | 0.452 | 1347.7 | 87.6 | |
| | | | | | | | | Bus7 | -0.822 | -0.452 | 1347.7 | 87.6 | |
| Bus7 | 6.600 | 100.547 | 1.7 | 0.000 | 0.000 | 0.000 | 0.000 | SG-100D1 | -0.827 | -0.491 | 83.7 | 86.0 | |
| | | | | | | | | Bus4 | 0.827 | 0.491 | 83.7 | 86.0 | 2.500 |
| Bus62 | 0.400 | 100.081 | -0.2 | 0.000 | 0.000 | 0.013 | 0.010 | SG-200N1 | -0.013 | -0.010 | 23.2 | 80.0 | |
| Bus63 | 0.400 | 100.248 | -0.2 | 0.000 | 0.000 | 0.004 | 0.003 | SG-200N1 | -0.004 | -0.003 | 6.8 | 80.0 | |
| Bus64 | 0.400 | 99.735 | -0.2 | 0.000 | 0.000 | 0.003 | 0.000 | SG-200N1 | -0.003 | 0.000 | 4.6 | 100.0 | |
| Bus66 | 0.400 | 100.256 | -0.2 | 0.000 | 0.000 | 0.000 | 0.000 | SG-200N1 | 0.000 | 0.000 | 0.6 | 80.0 | |
| Bus67 | 0.400 | 100.229 | -0.2 | 0.000 | 0.000 | 0.000 | 0.000 | SG-200N1 | 0.000 | 0.000 | 0.6 | 80.0 | |
| Bus68 | 0.400 | 100.290 | -0.2 | 0.000 | 0.000 | 0.000 | 0.000 | SG-200N1 | 0.000 | 0.000 | 0.6 | 80.0 | |
| Bus69 | 0.400 | 100.254 | -0.2 | 0.000 | 0.000 | 0.000 | 0.000 | SG-200N1 | 0.000 | 0.000 | 0.6 | 80.0 | |
| Bus84 | 0.400 | 100.202 | -0.2 | 0.000 | 0.000 | 0.006 | 0.003 | SG-200N1 | -0.006 | -0.003 | 9.9 | 88.4 | |
| Bus92 | 66.000 | 100.009 | 0.0 | 0.000 | 0.000 | 0.000 | 0.000 | HNA6-AFA70 | -2.183 | -0.571 | 19.7 | 96.7 | |
| | | | | | | | | HKN57 | 2.183 | 0.571 | 19.7 | 96.7 | |
| Bus93 | 66.000 | 100.009 | 0.0 | 0.000 | 0.000 | 0.000 | 0.000 | HNA6-AFA70 | 2.183 | 0.553 | 19.7 | 96.9 | |
| | | | | | | | | Bus94 | -2.183 | -0.553 | 19.7 | 96.9 | 5.000 |
| Bus94 | 6.900 | 96.195 | 1.7 | 0.000 | 0.000 | 0.000 | 0.000 | SG-100D1 | -2.188 | -0.623 | 197.8 | 96.2 | |
| | | | | | | | | Bus93 | 2.188 | 0.623 | 197.8 | 96.2 | |
| Bus96 | 6.600 | 100.642 | 1.7 | 1.250 | 0.411 | 0.000 | 0.000 | SG-100D1 | 1.250 | 0.411 | 114.4 | 95.0 | |
| Bus97 | 6.600 | 100.591 | 1.7 | 0.000 | 0.000 | 0.000 | 0.000 | SG-100D1 | 0.476 | -0.029 | 41.5 | -99.8 | |
| | | | | | | | | Bus98 | -0.476 | 0.029 | 41.5 | -99.8 | |
| Bus98 | 0.800 | 101.213 | 5.2 | 0.480 | 0.000 | 0.000 | 0.000 | Bus97 | 0.480 | 0.000 | 342.3 | 100.0 | |
| Bus99 | 6.600 | 100.677 | 1.7 | 1.291 | 0.732 | 0.000 | 0.000 | SG-100D1 | 1.291 | 0.732 | 129.0 | 87.0 | |
| * HKN57 | 66.000 | 100.000 | 0.0 | -2.183 | -1.063 | 0.000 | 0.000 | Bus92 | -2.183 | -1.063 | 21.2 | 89.9 | |
| HNA6-AFA70 | 66.000 | 100.009 | 0.0 | 0.000 | 0.000 | 0.000 | 0.000 | Bus93 | -2.183 | -0.560 | 19.7 | 96.9 | |
| | | | | | | | | Bus92 | 2.183 | 0.560 | 19.7 | 96.9 | |
| SG-100D1 | 6.600 | 100.582 | 1.7 | 0.000 | 0.000 | 0.000 | 0.000 | Bus94 | 2.188 | 0.623 | 197.8 | 96.2 | |
| | | | | | | | | Bus7 | 0.827 | 0.491 | 83.7 | 86.0 | |
| | | | | | | | | Bus99 | -1.290 | -0.732 | 129.0 | 87.0 | |
| | | | | | | | | Bus96 | -1.249 | -0.411 | 114.4 | 95.0 | |

| Bus | | Voltage | | Generation | | Load | | Load Flow | | | | | XFMR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | kV | % Mag. | Ang. | MW | Mvar | MW | Mvar | ID | MW | Mvar | Amp | %PF | %Tap |
| | | | | | | | | Bus97 | -0.476 | 0.029 | 41.5 | -99.8 | |
| SG-200N1 | 0.400 | 100.316 | -0.2 | 0.000 | 0.000 | 0.792 | 0.434 | Bus4 | -0.821 | -0.451 | 1347.7 | 87.7 | |
| | | | | | | | | Bus63 | 0.004 | 0.003 | 6.8 | 80.0 | |
| | | | | | | | | Bus62 | 0.013 | 0.010 | 23.2 | 80.1 | |
| | | | | | | | | Bus67 | 0.000 | 0.000 | 0.6 | 80.1 | |
| | | | | | | | | Bus68 | 0.000 | 0.000 | 0.6 | 80.0 | |
| | | | | | | | | Bus69 | 0.000 | 0.000 | 0.6 | 80.1 | |
| | | | | | | | | Bus66 | 0.000 | 0.000 | 0.6 | 80.1 | |
| | | | | | | | | Bus84 | 0.006 | 0.003 | 9.9 | 88.4 | |
| | | | | | | | | Bus1 | 0.002 | 0.000 | 2.3 | 100.0 | |
| | | | | | | | | Bus64 | 0.003 | 0.000 | 4.6 | 100.0 | |

* Indicates a voltage regulated bus ( voltage controlled or swing type machine connected to it)

\# Indicates a bus with a load mismatch of more than 0.1 MVA

## Bus Loading Summary Report

| Bus | | | Directly Connected Load | | | | | | | | Total Bus Load | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Constant kVA | | Constant Z | | Constant I | | Generic | | | | | Percent |
| ID | kV | Rated Amp | MW | Mvar | MW | Mvar | MW | Mvar | MW | Mvar | MVA | % PF | Amp | Loading |
| Bus1 | 0.400 | | 0.002 | | | | | | | | 0.002 | 100.0 | 2.3 | |
| Bus4 | 0.400 | | | | | | | | | | 0.938 | 87.6 | 1347.7 | |
| Bus7 | 6.600 | | | | | | | | | | 0.962 | 86.0 | 83.7 | |
| Bus62 | 0.400 | | 0.013 | 0.010 | | | | | | | 0.016 | 80.0 | 23.2 | |
| Bus63 | 0.400 | | 0.004 | 0.003 | | | | | | | 0.005 | 80.0 | 6.8 | |
| Bus64 | 0.400 | | 0.003 | | | | | | | | 0.003 | 100.0 | 4.6 | |
| Bus66 | 0.400 | | 0.000 | 0.000 | | | | | | | 0.000 | 80.0 | 0.6 | |
| Bus67 | 0.400 | | 0.000 | 0.000 | | | | | | | 0.000 | 80.0 | 0.6 | |
| Bus68 | 0.400 | | 0.000 | 0.000 | | | | | | | 0.000 | 80.0 | 0.6 | |
| Bus69 | 0.400 | | 0.000 | 0.000 | | | | | | | 0.000 | 80.0 | 0.6 | |
| Bus84 | 0.400 | | 0.006 | 0.003 | | | | | | | 0.007 | 88.4 | 9.9 | |
| Bus92 | 66.000 | | | | | | | | | | 2.257 | 96.7 | 19.7 | |
| Bus93 | 66.000 | | | | | | | | | | 2.252 | 96.9 | 19.7 | |
| Bus94 | 6.900 | | | | | | | | | | 2.274 | 96.2 | 197.8 | |
| Bus96 | 6.600 | | | | | | | | | | 1.316 | 95.0 | 114.4 | |
| Bus97 | 6.600 | | | | | | | | | | 0.477 | 99.8 | 41.5 | |
| Bus98 | 0.800 | | | | | | | | | | 0.480 | 100.0 | 342.3 | |
| Bus99 | 6.600 | | | | | | | | | | 1.484 | 87.0 | 129.0 | |
| HKN57 | 66.000 | 1250.0 | | | | | | | | | 2.428 | 89.9 | 21.2 | 1.7 |
| HNA6-AFA70 | 66.000 | 1250.0 | | | | | | | | | 2.254 | 96.9 | 19.7 | 1.6 |
| SG-100D1 | 6.600 | 630.0 | | | | | | | | | 3.224 | 93.5 | 280.4 | 44.5 |
| SG-200N1 | 0.400 | 2500.0 | 0.008 | 0.004 | 0.784 | 0.430 | | | | | 0.937 | 87.7 | 1347.7 | 53.9 |

* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).
# Indicates operating load of a bus exceeds the bus marginal limit (95.0% of the Continuous Ampere rating).

## Branch Loading Summary Report

| CKT / Branch | | Busway / Cable & Reactor | | | Transformer | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ampacity | Loading | | Capability | Loading (input) | | Loading (output) | |
| ID | Type | (Amp) | Amp | % | (MVA) | MVA | % | MVA | % |
| 0.4kV_cable | Cable | 2764.80 | 1347.67 | 48.74 | | | | | |
| 6.6kV_Cable1 | Cable | 691.60 | 197.84 | 28.61 | | | | | |
| 6.6kV_Cable2 | Cable | 246.80 | 83.67 | 33.90 | | | | | |
| 6.6kV_Cable3 | Cable | 246.80 | 128.97 | 52.26 | | | | | |
| 6.6kV_Cable5 | Cable | 246.80 | 114.38 | 46.34 | | | | | |
| 6.6kV_Cable6 | Cable | 246.80 | 41.49 | 16.81 | | | | | |
| 66kV_Cable1 | Cable | 613.00 | 19.71 | 3.22 | | | | | |
| 66kV_Cable2 | Cable | 613.00 | 19.74 | 3.22 | | | | | |
| 66kV_Cable3 | Cable | 459.20 | 21.24 | 4.63 | | | | | |
| AC_UPS-F&G | Cable | 136.89 | 6.79 | 4.96 | | | | | |
| AC_UPS-PAS | Cable | 136.89 | 23.25 | 16.98 | | | | | |
| DB-L&SP-HV-MV | Cable | 37.25 | 0.65 | 1.74 | | | | | |
| DB-L&SP-LV- | Cable | 37.25 | 0.65 | 1.74 | | | | | |
| DB-L&SP-UPS- | Cable | 37.25 | 0.65 | 1.74 | | | | | |
| DB-L&SP.Inst. | Cable | 37.25 | 0.65 | 1.74 | | | | | |
| DB-L&SP_BoP | Cable | 89.40 | 9.91 | 11.08 | | | | | |
| DC_Batt_Swgr | Cable | 89.40 | 2.26 | 2.53 | | | | | |
| DC_UPS_Navaid | Cable | 37.25 | 4.57 | 12.28 | | | | | |
| TR-100AD1 | Transformer | | | | 7.000 | 2.274 | 32.5 | 2.252 | 32.2 |
| TR-200DE1 | Transformer | | | | 1.600 | 0.962 | 60.1 | 0.938 | 58.6 |
| TR-200ED1 | Transformer | | | | 0.500 | 0.480 | 96.0 | 0.477 | 95.4 |

* Indicates a branch with operating load exceeding the branch capability.

## Branch Losses Summary Report

| Branch ID | From-To Bus Flow | | To-From Bus Flow | | Losses | | % Bus Voltage | | Vd % Drop in Vmag |
|---|---|---|---|---|---|---|---|---|---|
| | MW | Mvar | MW | Mvar | kW | kvar | From | To | |
| 0.4kV_cable | 0.822 | 0.452 | -0.821 | -0.451 | 0.9 | 1.0 | 100.4 | 100.3 | 0.13 |
| 6.6kV_Cable1 | -2.188 | -0.623 | 2.188 | 0.623 | 0.3 | -0.1 | 96.2 | 100.6 | 0.01 |
| 6.6kV_Cable2 | -0.827 | -0.491 | 0.827 | 0.491 | 0.3 | -0.1 | 100.5 | 100.6 | 0.03 |
| 6.6kV_Cable3 | 1.291 | 0.732 | -1.290 | -0.732 | 1.3 | 0.1 | 100.7 | 100.6 | 0.10 |
| 6.6kV_Cable5 | 1.250 | 0.411 | -1.249 | -0.411 | 0.7 | 0.0 | 100.6 | 100.6 | 0.06 |
| 6.6kV_Cable6 | 0.476 | -0.029 | -0.476 | 0.029 | 0.0 | -0.1 | 100.6 | 100.6 | 0.01 |
| 66kV_Cable1 | 2.183 | 0.553 | -2.183 | -0.560 | 0.0 | -7.0 | 100.0 | 100.0 | 0.00 |
| 66kV_Cable2 | -2.183 | -0.571 | 2.183 | 0.560 | 0.0 | -11.2 | 100.0 | 100.0 | 0.00 |
| 66kV_Cable3 | 2.183 | 0.571 | -2.183 | -1.063 | 0.2 | -492.0 | 100.0 | 100.0 | 0.01 |
| AC_UPS-F&G | -0.004 | -0.003 | 0.004 | 0.003 | 0.0 | 0.0 | 100.2 | 100.3 | 0.07 |
| AC_UPS-PAS | -0.013 | -0.010 | 0.013 | 0.010 | 0.0 | 0.0 | 100.1 | 100.3 | 0.23 |
| DB-L&SP.Inst. | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 100.3 | 100.3 | 0.06 |
| DB-L&SP_BoP | -0.006 | -0.003 | 0.006 | 0.003 | 0.0 | 0.0 | 100.2 | 100.3 | 0.11 |
| DB-L&SP-HV-MV | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 100.2 | 100.3 | 0.09 |
| DB-L&SP-LV- | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 100.3 | 100.3 | 0.03 |
| DB-L&SP-UPS- | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 100.3 | 100.3 | 0.06 |
| DC_Batt_Swgr | -0.002 | 0.000 | 0.002 | 0.000 | 0.0 | 0.0 | 100.2 | 100.3 | 0.09 |
| DC_UPS_Navaid | -0.003 | 0.000 | 0.003 | 0.000 | 0.0 | 0.0 | 99.7 | 100.3 | 0.58 |
| TR-100AD1 | -2.183 | -0.553 | 2.188 | 0.623 | 4.4 | 70.1 | 100.0 | 96.2 | 3.81 |
| TR-200DE1 | -0.822 | -0.452 | 0.827 | 0.491 | 5.0 | 39.3 | 100.4 | 100.5 | 4.88 |
| TR-200ED1 | -0.476 | 0.029 | 0.480 | 0.000 | 3.9 | 29.4 | 100.6 | 101.2 | 0.62 |
| | | | | | 17.0 | -370.5 | | | |

* This Transmission Line includes Series Capacitor.

## Alert Summary Report

### % Alert Settings

| | Critical | Marginal |
|---|---|---|
| **Loading** | | |
| Bus | 100.0 | 95.0 |
| Cable / Busway | 100.0 | 95.0 |
| Reactor | 100.0 | 95.0 |
| Line | 100.0 | 95.0 |
| Transformer | 100.0 | 95.0 |
| Panel | 100.0 | 95.0 |
| Protective Device | 100.0 | 95.0 |
| Generator | 100.0 | 95.0 |
| Inverter/Charger | 100.0 | 95.0 |
| **Bus Voltage** | | |
| OverVoltage | 105.0 | 102.0 |
| UnderVoltage | 95.0 | 98.0 |
| **Generator Excitation** | | |
| OverExcited (Q Max.) | 100.0 | 95.0 |
| UnderExcited (Q Min.) | 100.0 | |

## Marginal Report

| Device ID | Type | Condition | Rating/Limit | Unit | Operating | % Operating | Phase Type |
|---|---|---|---|---|---|---|---|
| Bus94 | Bus | Under Voltage | 6.900 | kV | 6.637 | 96.2 | 3-Phase |
| TR-200ED1 | Transformer | Overload | 0.500 | MVA | 0.480 | 96.0 | 3-Phase |

## SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

| | MW | Mvar | MVA | % PF |
|---|---|---|---|---|
| Source (Swing Buses): | -2.183 | -1.063 | 2.428 | 89.91 Lagging |
| Source (Non-Swing Buses): | 3.021 | 1.143 | 3.230 | 93.53 Lagging |
| Total Demand: | 0.838 | 0.080 | 0.842 | 99.54 Lagging |
| Total Motor Load: | 0.037 | 0.021 | 0.042 | 86.74 Lagging |
| Total Static Load: | 0.784 | 0.430 | 0.894 | 87.70 Lagging |
| Total Constant I Load: | 0.000 | 0.000 | 0.000 | |
| Total Generic Load: | 0.000 | 0.000 | 0.000 | |
| Apparent Losses: | 0.017 | -0.371 | | |
| System Mismatch: | 0.000 | 0.000 | | |

Number of Iterations: 3

Attachment 3 Etap Report Short Circuit Study Case 1

# Electrical Transient Analyzer Program

## Short-Circuit Analysis

### IEC 61363 Standard

### 3-Phase Instantaneous Fault Currents

| | Swing | V-Control | Load | Total |
|---|---|---|---|---|
| Number of Buses: | 1 | 0 | 21 | 22 |

| | XFMR2 | XFMR3 | Reactor | Line/Cable/ Busway | Impedance | Tie PD | Total |
|---|---|---|---|---|---|---|---|
| Number of Branches: | 3 | 0 | 0 | 18 | 0 | 0 | 21 |

| | Synchronous Generator | Power Grid | Synchronous Motor | Induction Machines | Lumped Load | Inverter | Total |
|---|---|---|---|---|---|---|---|
| Number of Machines: | 0 | 4 | 0 | 0 | 10 | 0 | 14 |

| | |
|---|---|
| System Frequency: | 50.00 |
| Unit System: | Metric |
| Project Filename: | BLPH-LV-SCstudy |
| Output Filename: | Z:\Studi\0351-0400\0396S_Crosswind\ETAP_15-Mar-2024\CS-SCC_Case-1.SI3S |

## Adjustments

| Tolerance | Apply Adjustments | Individual /Global | Percent |
|---|---|---|---|
| Transformer Impedance: | Yes | Global | 10.0 |
| Reactor Impedance: | Yes | Individual | |
| Overload Heater Resistance: | No | | |
| Transmission Line Length: | No | | |
| Cable / Busway Length: | No | | |

| Temperature Correction | Apply Adjustments | Individual /Global | Degree C |
|---|---|---|---|
| Transmission Line Resistance: | Yes | Global | 20 |
| Cable / Busway Resistance: | Yes | Global | 20 |

## Bus Input Data

| Bus | | | | | Initial Voltage | |
|---|---|---|---|---|---|---|
| ID | Type | Nom. kV | Base kV | Sub-sys | %Mag. | Ang. |
| Bus1 | Load | 0.400 | 0.439 | 1 | 100.22 | -0.25 |
| Bus4 | Load | 0.400 | 0.439 | 1 | 100.45 | -0.22 |
| Bus7 | Load | 6.600 | 6.900 | 1 | 100.55 | 1.69 |
| Bus62 | Load | 0.400 | 0.439 | 1 | 100.08 | -0.17 |
| Bus63 | Load | 0.400 | 0.439 | 1 | 100.25 | -0.22 |
| Bus64 | Load | 0.400 | 0.439 | 1 | 99.74 | -0.25 |
| Bus66 | Load | 0.400 | 0.439 | 1 | 100.26 | -0.22 |
| Bus67 | Load | 0.400 | 0.439 | 1 | 100.23 | -0.21 |
| Bus68 | Load | 0.400 | 0.439 | 1 | 100.29 | -0.23 |
| Bus69 | Load | 0.400 | 0.439 | 1 | 100.25 | -0.22 |
| Bus84 | Load | 0.400 | 0.439 | 1 | 100.20 | -0.21 |
| Bus92 | Load | 66.000 | 66.000 | 1 | 100.01 | 0.00 |
| Bus93 | Load | 66.000 | 66.000 | 1 | 100.01 | 0.00 |
| Bus94 | Load | 6.900 | 6.900 | 1 | 96.20 | 1.69 |
| Bus96 | Load | 6.600 | 6.900 | 1 | 100.64 | 1.69 |
| Bus97 | Load | 6.600 | 6.900 | 1 | 100.59 | 1.69 |
| Bus98 | Load | 0.800 | 0.836 | 1 | 101.21 | 5.23 |
| Bus99 | Load | 6.600 | 6.900 | 1 | 100.68 | 1.68 |
| HKN57 | SWNG | 66.000 | 66.000 | 1 | 100.00 | 0.00 |
| HNA6-AFA70 | Load | 66.000 | 66.000 | 1 | 100.01 | 0.00 |
| SG-100D1 | Load | 6.600 | 6.900 | 1 | 100.58 | 1.69 |
| SG-200N1 | Load | 0.400 | 0.439 | 1 | 100.32 | -0.24 |

22 Buses Total

All voltages reported by ETAP are in % of bus Nominal kV.
Base kV values of buses are calculated and used internally by ETAP.

## Line/Cable/Busway Input Data

| Line/Cable/Busway | | | | | | | ohms or siemens/1000 m per Conductor (Cable) or per Phase (Line/Busway) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Length | | | | | | |
| ID | Library | Size | Adj. (m) | % Tol. | #/Phase | T (°C) | R | X | Y |
| 0.4kV_cable | 1.0NCUN1 | 300 | 10.0 | 0 | 5 | 20 | 0.06274 | 0.08900 | 0.0001854 |
| 6.6kV_Cable1 | 6.6NCUN1 | 120 | 25.0 | 0 | 2 | 20 | 0.15372 | 0.11300 | 0.0001400 |
| 6.6kV_Cable2 | 6.6NCUN1 | 70 | 44.0 | 0 | 1 | 20 | 0.26822 | 0.13000 | 0.0001100 |
| 6.6kV_Cable3 | 6.6NCUN1 | 70 | 78.0 | 0 | 1 | 20 | 0.26822 | 0.13000 | 0.0001100 |
| 6.6kV_Cable5 | 6.6NCUN1 | 70 | 55.0 | 0 | 1 | 20 | 0.26822 | 0.13000 | 0.0001100 |
| 6.6kV_Cable6 | 6.6NCUN1 | 70 | 25.0 | 0 | 1 | 20 | 0.26822 | 0.13000 | 0.0001100 |
| 66kV_Cable1 | 66NALS1 | 300 | 25.0 | 0 | 1 | 20 | 0.06091 | 0.12000 | 0.0000644 |
| 66kV_Cable2 | 66NALS1 | 300 | 40.0 | 0 | 1 | 20 | 0.06091 | 0.12000 | 0.0000644 |
| 66kV_Cable3 | 66NALS1 | 400 | 1240.0 | 0 | 1 | 20 | 0.07940 | 0.09870 | 0.0000911 |
| AC_UPS-F&G | 1.0MCUN4 | 35 | 40.0 | 0 | 1 | 20 | 0.52469 | 0.08000 | 0.0001015 |
| AC_UPS-PAS | 1.0MCUN4 | 35 | 40.0 | 0 | 1 | 20 | 0.52469 | 0.08000 | 0.0001015 |
| DB-L&SP-HV-MV | 1.0MCUN4 | 4.0 | 65.0 | 0 | 1 | 20 | 4.60374 | 0.09300 | 0.0000575 |
| DB-L&SP-LV- | 1.0MCUN4 | 4.0 | 20.0 | 0 | 1 | 20 | 4.60374 | 0.09300 | 0.0000575 |
| DB-L&SP-UPS- | 1.0MCUN4 | 4.0 | 47.0 | 0 | 1 | 20 | 4.60374 | 0.09300 | 0.0000575 |
| DB-L&SP.Inst. | 1.0MCUN4 | 4.0 | 45.0 | 0 | 1 | 20 | 4.60374 | 0.09300 | 0.0000575 |
| DB-L&SP_BoP | 1.0NCUN4 | 16 | 20.0 | 0 | 1 | 20 | 1.15054 | 0.08000 | 0.0000597 |
| DC_Batt_Swgr | 1.0MCUN4 | 16 | 65.0 | 0 | 1 | 20 | 1.14505 | 0.08000 | 0.0000971 |
| DC_UPS_Navaid | 1.0MCUN4 | 4.0 | 50.0 | 0 | 1 | 20 | 4.60374 | 0.09300 | 0.0000575 |

Line / Cable / Busway resistances are listed at the specified temperatures.

## 2-Winding Transformer Input Data

| Transformer | Rating | | | | | Z Variation | | | % Tap Setting | | Adjusted |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | MVA | Prim. kV | Sec. kV | % Z | X/R | + 5% | - 5% | % Tol. | Prim. | Sec. | % Z |
| TR-100AD1 | 7.000 | 66.000 | 6.900 | 8.00 | 16.06 | 0 | 0 | -10.0 | 5.000 | 0 | 7.2000 |
| TR-200DE1 | 1.600 | 6.600 | 0.420 | 6.00 | 7.94 | 0 | 0 | -10.0 | 2.500 | 0 | 5.4000 |
| TR-200ED1 | 0.500 | 6.600 | 0.800 | 6.00 | 7.63 | 0 | 0 | -10.0 | 0 | 0 | 5.4000 |

## Branch Connections

| CKT/Branch | | Connected Bus ID | | % Impedance, Pos. Seq., 100 MVAb | | | |
|---|---|---|---|---|---|---|---|
| ID | Type | From Bus | To Bus | R | X | Z | Y |
| TR-100AD1 | 2W XFMR | Bus93 | Bus94 | 6.39 | 102.66 | 102.86 | |
| TR-200DE1 | 2W XFMR | Bus7 | Bus4 | 38.59 | 306.37 | 308.79 | |
| TR-200ED1 | 2W XFMR | Bus97 | Bus98 | 128.41 | 979.75 | 988.13 | |
| 0.4kV_cable | Cable | Bus4 | SG-200N1 | 6.51 | 9.23 | 11.30 | 0.0000018 |
| 6.6kV_Cable1 | Cable | Bus94 | SG-100D1 | 0.40 | 0.30 | 0.50 | 0.0003333 |
| 6.6kV_Cable2 | Cable | SG-100D1 | Bus7 | 2.48 | 1.20 | 2.75 | 0.0002304 |
| 6.6kV_Cable3 | Cable | SG-100D1 | Bus99 | 4.39 | 2.13 | 4.88 | 0.0004085 |
| 6.6kV_Cable5 | Cable | SG-100D1 | Bus96 | 3.10 | 1.50 | 3.44 | 0.0002880 |
| 6.6kV_Cable6 | Cable | SG-100D1 | Bus97 | 1.41 | 0.68 | 1.57 | 0.0001309 |
| 66kV_Cable1 | Cable | HNA6-AFA70 | Bus93 | 0.00 | 0.01 | 0.01 | 0.0070134 |
| 66kV_Cable2 | Cable | Bus92 | HNA6-AFA70 | 0.01 | 0.01 | 0.01 | 0.0112215 |
| 66kV_Cable3 | Cable | HKN57 | Bus92 | 0.23 | 0.28 | 0.36 | 0.4921036 |
| AC_UPS-F&G | Cable | SG-200N1 | Bus63 | 1088.55 | 165.97 | 1101.14 | 0.0000008 |
| AC_UPS-PAS | Cable | SG-200N1 | Bus62 | 1088.55 | 165.97 | 1101.14 | 0.0000008 |
| DB-L&SP-HV-MV | Cable | SG-200N1 | Bus67 | 15520.85 | 313.54 | 15524.02 | 0.0000007 |
| DB-L&SP-LV- | Cable | SG-200N1 | Bus68 | 4775.65 | 96.47 | 4776.62 | 0.0000002 |
| DB-L&SP-UPS- | Cable | SG-200N1 | Bus69 | 11222.77 | 226.71 | 11225.06 | 0.0000005 |
| DB-L&SP.Inst. | Cable | SG-200N1 | Bus66 | 10745.21 | 217.06 | 10747.40 | 0.0000005 |
| DB-L&SP_BoP | Cable | SG-200N1 | Bus84 | 1193.51 | 82.99 | 1196.39 | 0.0000002 |
| DC_Batt_Swgr | Cable | SG-200N1 | Bus1 | 3860.38 | 269.71 | 3869.79 | 0.0000012 |
| DC_UPS_Navaid | Cable | SG-200N1 | Bus64 | 11939.12 | 241.18 | 11941.55 | 0.0000006 |

## Power Grid Input Data

| Power Grid | Connected Bus | Rating | | % Impedance 100 MVA Base | | | Time Constant |
|---|---|---|---|---|---|---|---|
| ID | ID | MVASC | kV | R | X" | R/X" | Tdc |
| A-80000 | Bus99 | 2.230 | 6.600 | 446.20499 | 4462.04980 | 0.10 | 0.0318 |
| A-85000 | Bus96 | 1.970 | 6.600 | 505.09500 | 5050.95020 | 0.10 | 0.0318 |
| SCC_Max | HKN57 | 1771.888 | 66.000 | 0.56157 | 5.61569 | 0.10 | 0.0318 |
| SG-200D2 | Bus98 | 0.500 | 0.800 | 1990.07422 | 19900.74414 | 0.10 | 0.0318 |

Total Connected Power Grids ( = 4 ): 1776.588 MVA

## Lumped Load Input Data

| Load | Lumped Load | | | | | | Motor Loads | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rating | | | | % Load | | Loading | | % Imp. (Machine Base) | | | Time Constant | | |
| ID | kVA | kV | Amp | % PF | MTR | STAT | kW | kvar | R | X" | R/X" | Td' | Tdc | MW/PP |
| AC_UPS_F&G | 12.5 | 0.400 | 18.04 | 80.00 | 100 | 0 | 3.77 | 2.83 | 6.46 | 15.37 | 0.42 | .2000 | 0.01 | 0.01 |
| AC_UPS_PAS | 32.5 | 0.400 | 46.91 | 80.00 | 100 | 0 | 12.90 | 9.67 | 6.46 | 15.37 | 0.42 | .2000 | 0.01 | 0.03 |
| BL_SG-200N1 | 982.4 | 0.400 | 1417.97 | 87.70 | 1 | 99 | 7.87 | 4.31 | 6.46 | 15.37 | 0.42 | .2000 | 0.01 | 0.01 |
| DB-L&SP-BoP | 37.3 | 0.400 | 53.84 | 88.40 | 100 | 0 | 6.08 | 3.22 | 6.46 | 15.37 | 0.42 | .2000 | 0.01 | 0.03 |
| DB-L&SP-HVMV | 1.7 | 0.400 | 2.45 | 80.00 | 100 | 0 | 0.36 | 0.27 | 6.46 | 15.37 | 0.42 | .2000 | 0.01 | 0.00 |
| DB-L&SP-Inst. | 1.7 | 0.400 | 2.45 | 80.00 | 100 | 0 | 0.36 | 0.27 | 6.46 | 15.37 | 0.42 | .2000 | 0.01 | 0.00 |
| DB-L&SP-LV | 1.7 | 0.400 | 2.45 | 80.00 | 100 | 0 | 0.36 | 0.27 | 6.46 | 15.37 | 0.42 | .2000 | 0.01 | 0.00 |
| DB-L&SP-UPS | 1.7 | 0.400 | 2.45 | 80.00 | 100 | 0 | 0.36 | 0.27 | 6.46 | 15.37 | 0.42 | .2000 | 0.01 | 0.00 |
| DC-Battery-System_SWGR | 11.5 | 0.400 | 16.60 | 100.00 | 100 | 0 | 1.57 | 0.00 | 6.46 | 15.37 | 0.42 | .2000 | 0.01 | 0.01 |
| NAVAID_System | 3.2 | 0.400 | 4.56 | 100.00 | 100 | 0 | 3.16 | 0.00 | 6.46 | 15.37 | 0.42 | .2000 | 0.01 | 0.00 |

Total Connected Lumped Loads ( = 10 ): 1086.2 kVA

## SHORT-CIRCUIT REPORT

3-Phase fault at bus : **Bus4**

Nominal kV = 0.400

i = total fault current,
Idc = dc component,
ienv = top envelope of current-wave,
Iac(rms) = rms value of ac component,
Idc(%) = percentage value of dc component

| t (s) | t (cycle) | i (kA) | Idc (kA) | ienv (kA) | Iac (kA, rms) | Idc (%) |
|---|---|---|---|---|---|---|
| 0.000 | 0.00 | -0.231 | 46.511 | 93.252 | 33.051 | 99.51 |
| 0.001 | 0.05 | 0.256 | 44.704 | 91.439 | 33.047 | 95.65 |
| 0.002 | 0.10 | 5.172 | 42.978 | 89.707 | 33.042 | 91.97 |
| 0.003 | 0.15 | 13.862 | 41.328 | 88.051 | 33.038 | 88.46 |
| 0.004 | 0.20 | 25.309 | 39.750 | 86.466 | 33.033 | 85.09 |
| 0.005 | 0.25 | 38.232 | 38.239 | 84.949 | 33.029 | 81.86 |
| 0.006 | 0.30 | 51.216 | 36.792 | 83.496 | 33.025 | 78.78 |
| 0.007 | 0.35 | 62.845 | 35.405 | 82.103 | 33.020 | 75.82 |
| 0.008 | 0.40 | 71.843 | 34.075 | 80.767 | 33.016 | 72.98 |
| 0.009 | 0.45 | 77.196 | 32.800 | 79.485 | 33.012 | 70.26 |
| 0.010 | 0.50 | 78.255 | 31.575 | 78.255 | 33.007 | 67.64 |
| 0.011 | 0.55 | 74.794 | 30.400 | 77.074 | 33.003 | 65.13 |
| 0.012 | 0.60 | 67.036 | 29.272 | 75.939 | 32.999 | 62.72 |
| 0.013 | 0.65 | 55.629 | 28.188 | 74.849 | 32.995 | 60.41 |
| 0.014 | 0.70 | 41.581 | 27.146 | 73.801 | 32.990 | 58.18 |
| 0.015 | 0.75 | 26.165 | 26.144 | 72.794 | 32.986 | 56.04 |
| 0.016 | 0.80 | 10.789 | 25.182 | 71.825 | 32.982 | 53.99 |
| 0.017 | 0.85 | -3.138 | 24.256 | 70.894 | 32.978 | 52.01 |
| 0.018 | 0.90 | -14.346 | 23.366 | 69.997 | 32.974 | 50.11 |
| 0.019 | 0.95 | -21.827 | 22.509 | 69.135 | 32.970 | 48.28 |
| 0.020 | 1.00 | -24.936 | 21.685 | 68.305 | 32.966 | 46.51 |
| 0.021 | 1.05 | -23.450 | 20.892 | 67.506 | 32.961 | 44.82 |
| 0.022 | 1.10 | -17.596 | 20.128 | 66.737 | 32.957 | 43.19 |
| 0.023 | 1.15 | -8.024 | 19.394 | 65.997 | 32.953 | 41.61 |
| 0.024 | 1.20 | 4.256 | 18.686 | 65.284 | 32.949 | 40.10 |
| 0.025 | 1.25 | 17.972 | 18.006 | 64.597 | 32.945 | 38.65 |
| 0.026 | 1.30 | 31.713 | 17.350 | 63.936 | 32.941 | 37.24 |
| 0.027 | 1.35 | 44.069 | 16.719 | 63.299 | 32.938 | 35.89 |
| 0.028 | 1.40 | 53.769 | 16.111 | 62.686 | 32.934 | 34.59 |
| 0.029 | 1.45 | 59.803 | 15.525 | 62.095 | 32.930 | 33.34 |
| 0.030 | 1.50 | 61.525 | 14.961 | 61.525 | 32.926 | 32.13 |
| 0.031 | 1.55 | 58.710 | 14.418 | 60.976 | 32.922 | 30.97 |
| 0.032 | 1.60 | 51.582 | 13.894 | 60.448 | 32.918 | 29.85 |
| 0.033 | 1.65 | 40.786 | 13.390 | 59.938 | 32.914 | 28.77 |
| 0.034 | 1.70 | 27.329 | 12.905 | 59.447 | 32.910 | 27.73 |
| 0.035 | 1.75 | 12.483 | 12.437 | 58.974 | 32.907 | 26.72 |
| 0.036 | 1.80 | -2.348 | 11.986 | 58.518 | 32.903 | 25.76 |
| 0.037 | 1.85 | -15.757 | 11.552 | 58.078 | 32.899 | 24.83 |
| 0.038 | 1.90 | -26.474 | 11.133 | 57.655 | 32.895 | 23.93 |
| 0.039 | 1.95 | -33.493 | 10.730 | 57.246 | 32.892 | 23.07 |
| 0.040 | 2.00 | -36.169 | 10.342 | 56.853 | 32.888 | 22.24 |
| 0.041 | 2.05 | -34.278 | 9.968 | 56.473 | 32.884 | 21.43 |
| 0.042 | 2.10 | -28.044 | 9.607 | 56.107 | 32.881 | 20.66 |
| 0.043 | 2.15 | -18.114 | 9.259 | 55.754 | 32.877 | 19.91 |
| 0.044 | 2.20 | -5.495 | 8.924 | 55.414 | 32.873 | 19.20 |
| 0.045 | 2.25 | 8.544 | 8.602 | 55.086 | 32.870 | 18.50 |
| 0.046 | 2.30 | 22.598 | 8.291 | 54.770 | 32.866 | 17.84 |
| 0.047 | 2.35 | 35.260 | 7.991 | 54.466 | 32.863 | 17.19 |
| 0.048 | 2.40 | 45.261 | 7.702 | 54.172 | 32.859 | 16.57 |
| 0.049 | 2.45 | 51.595 | 7.424 | 53.888 | 32.856 | 15.98 |
| 0.050 | 2.50 | 53.615 | 7.155 | 53.615 | 32.852 | 15.40 |
| 0.051 | 2.55 | 51.098 | 6.897 | 53.351 | 32.849 | 14.85 |
| 0.052 | 2.60 | 44.265 | 6.647 | 53.097 | 32.845 | 14.31 |
| 0.053 | 2.65 | 33.761 | 6.407 | 52.852 | 32.842 | 13.80 |
| 0.054 | 2.70 | 20.591 | 6.176 | 52.616 | 32.838 | 13.30 |
| 0.055 | 2.75 | 6.021 | 5.953 | 52.388 | 32.835 | 12.82 |
| 0.056 | 2.80 | -8.544 | 5.738 | 52.168 | 32.831 | 12.36 |
| 0.057 | 2.85 | -21.701 | 5.531 | 51.956 | 32.828 | 11.91 |
| 0.058 | 2.90 | -32.182 | 5.331 | 51.752 | 32.825 | 11.48 |
| 0.059 | 2.95 | -38.983 | 5.138 | 51.554 | 32.821 | 11.07 |
| 0.060 | 3.00 | -41.458 | 4.953 | 51.364 | 32.818 | 10.67 |
| 0.061 | 3.05 | -39.384 | 4.774 | 51.181 | 32.814 | 10.29 |
| 0.062 | 3.10 | -32.983 | 4.602 | 51.004 | 32.811 | 9.92 |
| 0.063 | 3.15 | -22.898 | 4.436 | 50.833 | 32.808 | 9.56 |
| 0.064 | 3.20 | -10.135 | 4.276 | 50.668 | 32.805 | 9.22 |
| 0.065 | 3.25 | 4.042 | 4.121 | 50.509 | 32.801 | 8.88 |
| 0.066 | 3.30 | 18.230 | 3.973 | 50.356 | 32.798 | 8.56 |
| 0.067 | 3.35 | 31.024 | 3.829 | 50.208 | 32.795 | 8.26 |
| 0.068 | 3.40 | 41.160 | 3.691 | 50.065 | 32.792 | 7.96 |
| 0.069 | 3.45 | 47.632 | 3.558 | 49.928 | 32.788 | 7.67 |
| 0.070 | 3.50 | 49.795 | 3.429 | 49.795 | 32.785 | 7.40 |
| 0.071 | 3.55 | 47.424 | 3.306 | 49.667 | 32.782 | 7.13 |

(Cont.)

3-Phase fault at bus : **Bus4**

Nominal kV = 0.400

i = total fault current,
Idc = dc component,
ienv = top envelope of current-wave,
Iac(rms) = rms value of ac component,
Idc(%) = percentage value of dc component

| t (s) | t (cycle) | i (kA) | Idc (kA) | ienv (kA) | Iac (kA, rms) | Idc (%) |
|---|---|---|---|---|---|---|
| 0.072 | 3.60 | 40.740 | 3.187 | 49.543 | 32.779 | 6.87 |
| 0.073 | 3.65 | 30.387 | 3.072 | 49.424 | 32.776 | 6.63 |
| 0.074 | 3.70 | 17.367 | 2.961 | 49.308 | 32.773 | 6.39 |
| 0.075 | 3.75 | 2.943 | 2.854 | 49.197 | 32.770 | 6.16 |
| 0.076 | 3.80 | -11.483 | 2.751 | 49.090 | 32.766 | 5.94 |
| 0.077 | 3.85 | -24.509 | 2.652 | 48.986 | 32.763 | 5.72 |
| 0.078 | 3.90 | -34.871 | 2.556 | 48.886 | 32.760 | 5.52 |
| 0.079 | 3.95 | -41.566 | 2.464 | 48.790 | 32.757 | 5.32 |
| 0.080 | 4.00 | -43.946 | 2.375 | 48.697 | 32.754 | 5.13 |
| 0.081 | 4.05 | -41.790 | 2.290 | 48.607 | 32.751 | 4.94 |
| 0.082 | 4.10 | -35.317 | 2.207 | 48.520 | 32.748 | 4.77 |
| 0.083 | 4.15 | -25.170 | 2.127 | 48.436 | 32.745 | 4.59 |
| 0.084 | 4.20 | -12.351 | 2.051 | 48.355 | 32.742 | 4.43 |
| 0.085 | 4.25 | 1.878 | 1.977 | 48.277 | 32.739 | 4.27 |
| 0.086 | 4.30 | 16.117 | 1.906 | 48.202 | 32.736 | 4.12 |
| 0.087 | 4.35 | 28.965 | 1.837 | 48.129 | 32.733 | 3.97 |
| 0.088 | 4.40 | 39.159 | 1.771 | 48.059 | 32.731 | 3.83 |
| 0.089 | 4.45 | 45.694 | 1.707 | 47.991 | 32.728 | 3.69 |
| 0.090 | 4.50 | 47.925 | 1.645 | 47.925 | 32.725 | 3.56 |
| 0.091 | 4.55 | 45.629 | 1.586 | 47.862 | 32.722 | 3.43 |
| 0.092 | 4.60 | 39.025 | 1.529 | 47.801 | 32.719 | 3.30 |
| 0.093 | 4.65 | 28.755 | 1.474 | 47.742 | 32.716 | 3.19 |
| 0.094 | 4.70 | 15.819 | 1.421 | 47.685 | 32.713 | 3.07 |
| 0.095 | 4.75 | 1.477 | 1.370 | 47.629 | 32.711 | 2.96 |
| 0.096 | 4.80 | -12.870 | 1.320 | 47.576 | 32.708 | 2.85 |
| 0.097 | 4.85 | -25.825 | 1.273 | 47.525 | 32.705 | 2.75 |
| 0.098 | 4.90 | -36.124 | 1.227 | 47.475 | 32.702 | 2.65 |
| 0.099 | 4.95 | -42.764 | 1.183 | 47.427 | 32.700 | 2.56 |
| 0.100 | 5.00 | -45.100 | 1.140 | 47.380 | 32.697 | 2.47 |
| 0.101 | 5.05 | -42.909 | 1.099 | 47.335 | 32.694 | 2.38 |

| t (s) | t (cycle) | i (kA) | Idc (kA) | ienv (kA) | Iac (kA, rms) | Idc (%) |
|---|---|---|---|---|---|---|

3-Phase fault at bus : **HKN57**

Nominal kV = 66.000

i = total fault current,
Idc = dc component,
ienv = top envelope of current-wave,
Iac(rms) = rms value of ac component,
Idc(%) = percentage value of dc component

| t (s) | t (cycle) | i (kA) | Idc (kA) | ienv (kA) | Iac (kA, rms) | Idc (%) |
|---|---|---|---|---|---|---|
| 0.000 | 0.00 | -0.001 | 21.985 | 43.971 | 15.546 | 100.00 |
| 0.001 | 0.05 | 0.395 | 21.304 | 43.290 | 15.546 | 96.90 |
| 0.002 | 0.10 | 2.858 | 20.645 | 42.630 | 15.546 | 93.90 |
| 0.003 | 0.15 | 7.083 | 20.006 | 41.991 | 15.546 | 90.99 |
| 0.004 | 0.20 | 12.592 | 19.386 | 41.372 | 15.546 | 88.18 |
| 0.005 | 0.25 | 18.786 | 18.786 | 40.772 | 15.546 | 85.45 |
| 0.006 | 0.30 | 24.999 | 18.205 | 40.191 | 15.546 | 82.80 |
| 0.007 | 0.35 | 30.565 | 17.642 | 39.627 | 15.546 | 80.24 |
| 0.008 | 0.40 | 34.883 | 17.096 | 39.081 | 15.546 | 77.76 |
| 0.009 | 0.45 | 37.476 | 16.567 | 38.552 | 15.546 | 75.35 |
| 0.010 | 0.50 | 38.040 | 16.054 | 38.040 | 15.546 | 73.02 |
| 0.011 | 0.55 | 36.467 | 15.558 | 37.543 | 15.546 | 70.76 |
| 0.012 | 0.60 | 32.863 | 15.076 | 37.062 | 15.546 | 68.57 |
| 0.013 | 0.65 | 27.533 | 14.610 | 36.595 | 15.546 | 66.45 |
| 0.014 | 0.70 | 20.952 | 14.158 | 36.143 | 15.546 | 64.40 |
| 0.015 | 0.75 | 13.720 | 13.720 | 35.706 | 15.546 | 62.41 |
| 0.016 | 0.80 | 6.502 | 13.296 | 35.281 | 15.546 | 60.48 |
| 0.017 | 0.85 | -0.038 | 12.885 | 34.870 | 15.546 | 58.61 |
| 0.018 | 0.90 | -5.300 | 12.486 | 34.471 | 15.546 | 56.79 |
| 0.019 | 0.95 | -8.809 | 12.100 | 34.085 | 15.546 | 55.04 |
| 0.020 | 1.00 | -10.260 | 11.726 | 33.711 | 15.546 | 53.33 |
| 0.021 | 1.05 | -9.546 | 11.363 | 33.348 | 15.546 | 51.68 |
| 0.022 | 1.10 | -6.775 | 11.011 | 32.997 | 15.546 | 50.09 |
| 0.023 | 1.15 | -2.252 | 10.671 | 32.656 | 15.546 | 48.54 |
| 0.024 | 1.20 | 3.547 | 10.341 | 32.326 | 15.546 | 47.04 |
| 0.025 | 1.25 | 10.021 | 10.021 | 32.006 | 15.546 | 45.58 |
| 0.026 | 1.30 | 16.505 | 9.711 | 31.696 | 15.546 | 44.17 |
| 0.027 | 1.35 | 22.333 | 9.411 | 31.396 | 15.546 | 42.81 |
| 0.028 | 1.40 | 26.906 | 9.120 | 31.105 | 15.546 | 41.48 |
| 0.029 | 1.45 | 29.747 | 8.838 | 30.823 | 15.546 | 40.20 |
| 0.030 | 1.50 | 30.549 | 8.564 | 30.549 | 15.546 | 38.96 |
| 0.031 | 1.55 | 29.208 | 8.300 | 30.284 | 15.546 | 37.75 |
| 0.032 | 1.60 | 25.829 | 8.043 | 30.028 | 15.546 | 36.58 |
| 0.033 | 1.65 | 20.717 | 7.794 | 29.779 | 15.546 | 35.45 |
| 0.034 | 1.70 | 14.347 | 7.553 | 29.538 | 15.546 | 34.36 |
| 0.035 | 1.75 | 7.320 | 7.319 | 29.304 | 15.546 | 33.29 |
| 0.036 | 1.80 | 0.300 | 7.093 | 29.078 | 15.546 | 32.26 |
| 0.037 | 1.85 | -6.048 | 6.874 | 28.858 | 15.546 | 31.27 |
| 0.038 | 1.90 | -11.125 | 6.661 | 28.646 | 15.546 | 30.30 |
| 0.039 | 1.95 | -14.453 | 6.455 | 28.440 | 15.545 | 29.36 |
| 0.040 | 2.00 | -15.729 | 6.256 | 28.240 | 15.545 | 28.45 |
| 0.041 | 2.05 | -14.847 | 6.062 | 28.047 | 15.545 | 27.57 |
| 0.042 | 2.10 | -11.911 | 5.875 | 27.859 | 15.545 | 26.72 |
| 0.043 | 2.15 | -7.229 | 5.693 | 27.677 | 15.545 | 25.90 |
| 0.044 | 2.20 | -1.277 | 5.517 | 27.501 | 15.545 | 25.09 |
| 0.045 | 2.25 | 5.346 | 5.346 | 27.331 | 15.545 | 24.32 |
| 0.046 | 2.30 | 11.974 | 5.181 | 27.165 | 15.545 | 23.57 |
| 0.047 | 2.35 | 17.943 | 5.021 | 27.005 | 15.545 | 22.84 |
| 0.048 | 2.40 | 22.651 | 4.865 | 26.850 | 15.545 | 22.13 |
| 0.049 | 2.45 | 25.623 | 4.715 | 26.699 | 15.545 | 21.45 |
| 0.050 | 2.50 | 26.554 | 4.569 | 26.554 | 15.545 | 20.78 |
| 0.051 | 2.55 | 25.336 | 4.428 | 26.412 | 15.545 | 20.14 |
| 0.052 | 2.60 | 22.077 | 4.291 | 26.275 | 15.545 | 19.52 |
| 0.053 | 2.65 | 17.081 | 4.158 | 26.143 | 15.545 | 18.91 |
| 0.054 | 2.70 | 10.823 | 4.030 | 26.014 | 15.545 | 18.33 |
| 0.055 | 2.75 | 3.905 | 3.905 | 25.889 | 15.545 | 17.76 |
| 0.056 | 2.80 | -3.009 | 3.784 | 25.768 | 15.545 | 17.21 |
| 0.057 | 2.85 | -9.254 | 3.667 | 25.651 | 15.545 | 16.68 |
| 0.058 | 2.90 | -14.232 | 3.554 | 25.538 | 15.545 | 16.17 |
| 0.059 | 2.95 | -17.464 | 3.444 | 25.428 | 15.545 | 15.67 |
| 0.060 | 3.00 | -18.647 | 3.337 | 25.322 | 15.545 | 15.18 |
| 0.061 | 3.05 | -17.674 | 3.234 | 25.218 | 15.545 | 14.71 |
| 0.062 | 3.10 | -14.651 | 3.134 | 25.118 | 15.545 | 14.26 |
| 0.063 | 3.15 | -9.885 | 3.037 | 25.021 | 15.545 | 13.82 |
| 0.064 | 3.20 | -3.850 | 2.943 | 24.927 | 15.545 | 13.39 |
| 0.065 | 3.25 | 2.852 | 2.852 | 24.836 | 15.545 | 12.97 |
| 0.066 | 3.30 | 9.557 | 2.764 | 24.748 | 15.545 | 12.57 |
| 0.067 | 3.35 | 15.600 | 2.679 | 24.663 | 15.545 | 12.18 |
| 0.068 | 3.40 | 20.381 | 2.596 | 24.580 | 15.545 | 11.81 |
| 0.069 | 3.45 | 23.423 | 2.516 | 24.499 | 15.545 | 11.44 |
| 0.070 | 3.50 | 24.422 | 2.438 | 24.422 | 15.545 | 11.09 |
| 0.071 | 3.55 | 23.270 | 2.362 | 24.346 | 15.545 | 10.75 |
| 0.072 | 3.60 | 20.075 | 2.289 | 24.273 | 15.545 | 10.41 |
| 0.073 | 3.65 | 15.141 | 2.219 | 24.202 | 15.545 | 10.09 |
| 0.074 | 3.70 | 8.944 | 2.150 | 24.134 | 15.545 | 9.78 |
| 0.075 | 3.75 | 2.084 | 2.083 | 24.067 | 15.545 | 9.48 |
| 0.076 | 3.80 | -4.774 | 2.019 | 24.003 | 15.545 | 9.18 |
| 0.077 | 3.85 | -10.965 | 1.957 | 23.940 | 15.545 | 8.90 |

(Cont.)

3-Phase fault at bus : **HKN57**

Nominal kV = 66.000

i = total fault current,
Idc = dc component,
ienv = top envelope of current-wave,
Iac(rms) = rms value of ac component,
Idc(%) = percentage value of dc component

| t (s) | t (cycle) | i (kA) | Idc (kA) | ienv (kA) | Iac (kA, rms) | Idc (%) |
|---|---|---|---|---|---|---|
| 0.078 | 3.90 | -15.889 | 1.896 | 23.880 | 15.545 | 8.62 |
| 0.079 | 3.95 | -19.070 | 1.837 | 23.821 | 15.545 | 8.36 |
| 0.080 | 4.00 | -20.203 | 1.781 | 23.764 | 15.545 | 8.10 |
| 0.081 | 4.05 | -19.182 | 1.726 | 23.709 | 15.545 | 7.85 |
| 0.082 | 4.10 | -16.113 | 1.672 | 23.656 | 15.545 | 7.61 |
| 0.083 | 4.15 | -11.302 | 1.620 | 23.604 | 15.545 | 7.37 |
| 0.084 | 4.20 | -5.223 | 1.570 | 23.554 | 15.545 | 7.14 |
| 0.085 | 4.25 | 1.521 | 1.522 | 23.505 | 15.545 | 6.92 |
| 0.086 | 4.30 | 8.268 | 1.475 | 23.458 | 15.545 | 6.71 |
| 0.087 | 4.35 | 14.350 | 1.429 | 23.413 | 15.545 | 6.50 |
| 0.088 | 4.40 | 19.170 | 1.385 | 23.368 | 15.545 | 6.30 |
| 0.089 | 4.45 | 22.249 | 1.342 | 23.326 | 15.545 | 6.10 |
| 0.090 | 4.50 | 23.284 | 1.301 | 23.284 | 15.545 | 5.92 |
| 0.091 | 4.55 | 22.168 | 1.260 | 23.244 | 15.545 | 5.73 |
| 0.092 | 4.60 | 19.007 | 1.221 | 23.205 | 15.545 | 5.56 |
| 0.093 | 4.65 | 14.106 | 1.184 | 23.167 | 15.545 | 5.38 |
| 0.094 | 4.70 | 7.941 | 1.147 | 23.130 | 15.545 | 5.22 |
| 0.095 | 4.75 | 1.112 | 1.112 | 23.095 | 15.545 | 5.06 |
| 0.096 | 4.80 | -5.716 | 1.077 | 23.060 | 15.545 | 4.90 |
| 0.097 | 4.85 | -11.877 | 1.044 | 23.027 | 15.545 | 4.75 |
| 0.098 | 4.90 | -16.773 | 1.012 | 22.995 | 15.545 | 4.60 |
| 0.099 | 4.95 | -19.927 | 0.980 | 22.964 | 15.545 | 4.46 |
| 0.100 | 5.00 | -21.033 | 0.950 | 22.933 | 15.545 | 4.32 |
| 0.101 | 5.05 | -19.987 | 0.921 | 22.904 | 15.544 | 4.19 |

| t (s) | t (cycle) | i (kA) | Idc (kA) | ienv (kA) | Iac (kA, rms) | Idc (%) |
|---|---|---|---|---|---|---|

3-Phase fault at bus : **HNA6-AFA70**

Nominal kV = 66.000

i = total fault current,
Idc = dc component,
ienv = top envelope of current-wave,
Iac(rms) = rms value of ac component,
Idc(%) = percentage value of dc component

| t (s) | t (cycle) | i (kA) | Idc (kA) | ienv (kA) | Iac (kA, rms) | Idc (%) |
|---|---|---|---|---|---|---|
| 0.000 | 0.00 | -0.001 | 20.821 | 41.643 | 14.724 | 99.99 |
| 0.001 | 0.05 | 0.158 | 19.961 | 40.783 | 14.723 | 95.86 |
| 0.002 | 0.10 | 2.291 | 19.136 | 39.959 | 14.723 | 91.90 |
| 0.003 | 0.15 | 6.107 | 18.346 | 39.168 | 14.723 | 88.11 |
| 0.004 | 0.20 | 11.154 | 17.588 | 38.411 | 14.723 | 84.47 |
| 0.005 | 0.25 | 16.862 | 16.862 | 37.684 | 14.723 | 80.98 |
| 0.006 | 0.30 | 22.600 | 16.166 | 36.988 | 14.723 | 77.64 |
| 0.007 | 0.35 | 27.737 | 15.499 | 36.320 | 14.723 | 74.43 |
| 0.008 | 0.40 | 31.704 | 14.859 | 35.681 | 14.723 | 71.36 |
| 0.009 | 0.45 | 34.048 | 14.245 | 35.067 | 14.723 | 68.41 |
| 0.010 | 0.50 | 34.479 | 13.657 | 34.479 | 14.723 | 65.59 |
| 0.011 | 0.55 | 32.896 | 13.093 | 33.915 | 14.723 | 62.88 |
| 0.012 | 0.60 | 29.398 | 12.553 | 33.375 | 14.723 | 60.29 |
| 0.013 | 0.65 | 24.274 | 12.035 | 32.857 | 14.723 | 57.80 |
| 0.014 | 0.70 | 17.972 | 11.538 | 32.360 | 14.723 | 55.41 |
| 0.015 | 0.75 | 11.062 | 11.062 | 31.883 | 14.723 | 53.13 |
| 0.016 | 0.80 | 4.171 | 10.605 | 31.427 | 14.723 | 50.93 |
| 0.017 | 0.85 | -2.071 | 10.168 | 30.989 | 14.723 | 48.83 |
| 0.018 | 0.90 | -7.097 | 9.748 | 30.570 | 14.723 | 46.82 |
| 0.019 | 0.95 | -10.457 | 9.346 | 30.167 | 14.723 | 44.88 |
| 0.020 | 1.00 | -11.862 | 8.960 | 29.781 | 14.723 | 43.03 |
| 0.021 | 1.05 | -11.212 | 8.590 | 29.412 | 14.723 | 41.26 |
| 0.022 | 1.10 | -8.609 | 8.236 | 29.057 | 14.723 | 39.55 |
| 0.023 | 1.15 | -4.343 | 7.896 | 28.717 | 14.723 | 37.92 |
| 0.024 | 1.20 | 1.136 | 7.570 | 28.391 | 14.723 | 36.36 |
| 0.025 | 1.25 | 7.257 | 7.258 | 28.079 | 14.723 | 34.86 |
| 0.026 | 1.30 | 13.392 | 6.958 | 27.780 | 14.723 | 33.42 |
| 0.027 | 1.35 | 18.909 | 6.671 | 27.492 | 14.723 | 32.04 |
| 0.028 | 1.40 | 23.240 | 6.396 | 27.217 | 14.723 | 30.72 |
| 0.029 | 1.45 | 25.934 | 6.132 | 26.953 | 14.723 | 29.45 |
| 0.030 | 1.50 | 26.700 | 5.879 | 26.700 | 14.723 | 28.23 |
| 0.031 | 1.55 | 25.439 | 5.636 | 26.458 | 14.723 | 27.07 |
| 0.032 | 1.60 | 22.249 | 5.404 | 26.225 | 14.723 | 25.95 |
| 0.033 | 1.65 | 17.419 | 5.181 | 26.002 | 14.723 | 24.88 |
| 0.034 | 1.70 | 11.401 | 4.967 | 25.788 | 14.723 | 23.86 |
| 0.035 | 1.75 | 4.762 | 4.762 | 25.583 | 14.723 | 22.87 |
| 0.036 | 1.80 | -1.868 | 4.566 | 25.387 | 14.723 | 21.93 |
| 0.037 | 1.85 | -7.861 | 4.377 | 25.198 | 14.723 | 21.02 |
| 0.038 | 1.90 | -12.648 | 4.197 | 25.018 | 14.723 | 20.16 |
| 0.039 | 1.95 | -15.778 | 4.024 | 24.845 | 14.723 | 19.32 |
| 0.040 | 2.00 | -16.963 | 3.858 | 24.679 | 14.723 | 18.53 |
| 0.041 | 2.05 | -16.104 | 3.698 | 24.519 | 14.723 | 17.76 |
| 0.042 | 2.10 | -13.299 | 3.546 | 24.367 | 14.723 | 17.03 |
| 0.043 | 2.15 | -8.839 | 3.400 | 24.221 | 14.723 | 16.33 |
| 0.044 | 2.20 | -3.175 | 3.259 | 24.080 | 14.723 | 15.65 |
| 0.045 | 2.25 | 3.125 | 3.125 | 23.946 | 14.723 | 15.01 |
| 0.046 | 2.30 | 9.430 | 2.996 | 23.817 | 14.723 | 14.39 |
| 0.047 | 2.35 | 15.110 | 2.872 | 23.693 | 14.723 | 13.80 |
| 0.048 | 2.40 | 19.598 | 2.754 | 23.575 | 14.723 | 13.23 |
| 0.049 | 2.45 | 22.442 | 2.640 | 23.461 | 14.723 | 12.68 |
| 0.050 | 2.50 | 23.352 | 2.531 | 23.352 | 14.723 | 12.16 |
| 0.051 | 2.55 | 22.229 | 2.427 | 23.248 | 14.722 | 11.66 |
| 0.052 | 2.60 | 19.171 | 2.327 | 23.148 | 14.722 | 11.18 |
| 0.053 | 2.65 | 14.469 | 2.231 | 23.052 | 14.722 | 10.71 |
| 0.054 | 2.70 | 8.573 | 2.139 | 22.960 | 14.722 | 10.27 |
| 0.055 | 2.75 | 2.051 | 2.051 | 22.871 | 14.722 | 9.85 |
| 0.056 | 2.80 | -4.468 | 1.966 | 22.787 | 14.722 | 9.44 |
| 0.057 | 2.85 | -10.353 | 1.885 | 22.706 | 14.722 | 9.05 |
| 0.058 | 2.90 | -15.037 | 1.807 | 22.628 | 14.722 | 8.68 |
| 0.059 | 2.95 | -18.069 | 1.733 | 22.553 | 14.722 | 8.32 |
| 0.060 | 3.00 | -19.159 | 1.661 | 22.482 | 14.722 | 7.98 |
| 0.061 | 3.05 | -18.209 | 1.593 | 22.413 | 14.722 | 7.65 |
| 0.062 | 3.10 | -15.317 | 1.527 | 22.348 | 14.722 | 7.33 |
| 0.063 | 3.15 | -10.774 | 1.464 | 22.285 | 14.722 | 7.03 |
| 0.064 | 3.20 | -5.030 | 1.404 | 22.224 | 14.722 | 6.74 |
| 0.065 | 3.25 | 1.346 | 1.346 | 22.166 | 14.722 | 6.46 |
| 0.066 | 3.30 | 7.724 | 1.290 | 22.111 | 14.722 | 6.20 |
| 0.067 | 3.35 | 13.475 | 1.237 | 22.058 | 14.722 | 5.94 |
| 0.068 | 3.40 | 18.030 | 1.186 | 22.006 | 14.722 | 5.70 |
| 0.069 | 3.45 | 20.938 | 1.137 | 21.958 | 14.722 | 5.46 |
| 0.070 | 3.50 | 21.911 | 1.090 | 21.911 | 14.722 | 5.24 |
| 0.071 | 3.55 | 20.847 | 1.045 | 21.866 | 14.722 | 5.02 |
| 0.072 | 3.60 | 17.846 | 1.002 | 21.823 | 14.722 | 4.81 |
| 0.073 | 3.65 | 13.199 | 0.961 | 21.781 | 14.722 | 4.62 |
| 0.074 | 3.70 | 7.355 | 0.921 | 21.742 | 14.722 | 4.43 |
| 0.075 | 3.75 | 0.884 | 0.883 | 21.704 | 14.722 | 4.24 |
| 0.076 | 3.80 | -5.586 | 0.847 | 21.667 | 14.722 | 4.07 |
| 0.077 | 3.85 | -11.425 | 0.812 | 21.632 | 14.722 | 3.90 |

(Cont.)

3-Phase fault at bus : **HNA6-AFA70**

Nominal kV = 66.000

i = total fault current,
Idc = dc component,
ienv = top envelope of current-wave,
Iac(rms) = rms value of ac component,
Idc(%) = percentage value of dc component

| t (s) | t (cycle) | i (kA) | Idc (kA) | ienv (kA) | Iac (kA, rms) | Idc (%) |
|---|---|---|---|---|---|---|
| 0.078 | 3.90 | -16.065 | 0.779 | 21.599 | 14.722 | 3.74 |
| 0.079 | 3.95 | -19.055 | 0.746 | 21.567 | 14.722 | 3.59 |
| 0.080 | 4.00 | -20.104 | 0.716 | 21.536 | 14.722 | 3.44 |
| 0.081 | 4.05 | -19.115 | 0.686 | 21.506 | 14.722 | 3.30 |
| 0.082 | 4.10 | -16.186 | 0.658 | 21.478 | 14.722 | 3.16 |
| 0.083 | 4.15 | -11.607 | 0.631 | 21.451 | 14.722 | 3.03 |
| 0.084 | 4.20 | -5.829 | 0.605 | 21.425 | 14.722 | 2.90 |
| 0.085 | 4.25 | 0.579 | 0.580 | 21.400 | 14.722 | 2.78 |
| 0.086 | 4.30 | 6.989 | 0.556 | 21.376 | 14.722 | 2.67 |
| 0.087 | 4.35 | 12.770 | 0.533 | 21.353 | 14.722 | 2.56 |
| 0.088 | 4.40 | 17.354 | 0.511 | 21.331 | 14.722 | 2.45 |
| 0.089 | 4.45 | 20.291 | 0.490 | 21.310 | 14.722 | 2.35 |
| 0.090 | 4.50 | 21.290 | 0.470 | 21.290 | 14.722 | 2.26 |
| 0.091 | 4.55 | 20.251 | 0.450 | 21.270 | 14.722 | 2.16 |
| 0.092 | 4.60 | 17.276 | 0.432 | 21.252 | 14.722 | 2.07 |
| 0.093 | 4.65 | 12.652 | 0.414 | 21.234 | 14.722 | 1.99 |
| 0.094 | 4.70 | 6.831 | 0.397 | 21.217 | 14.722 | 1.91 |
| 0.095 | 4.75 | 0.381 | 0.381 | 21.200 | 14.722 | 1.83 |
| 0.096 | 4.80 | -6.068 | 0.365 | 21.185 | 14.722 | 1.75 |
| 0.097 | 4.85 | -11.887 | 0.350 | 21.170 | 14.722 | 1.68 |
| 0.098 | 4.90 | -16.508 | 0.336 | 21.155 | 14.722 | 1.61 |
| 0.099 | 4.95 | -19.479 | 0.322 | 21.141 | 14.722 | 1.55 |
| 0.100 | 5.00 | -20.511 | 0.308 | 21.128 | 14.722 | 1.48 |
| 0.101 | 5.05 | -19.505 | 0.296 | 21.115 | 14.722 | 1.42 |

| t (s) | t (cycle) | i (kA) | Idc (kA) | ienv (kA) | Iac (kA, rms) | Idc (%) |
|---|---|---|---|---|---|---|

3-Phase fault at bus : **SG-100D1**

Nominal kV = 6.600

i = total fault current,
Idc = dc component,
ienv = top envelope of current-wave,
Iac(rms) = rms value of ac component,
Idc(%) = percentage value of dc component

| t (s) | t (cycle) | i (kA) | Idc (kA) | ienv (kA) | Iac (kA, rms) | Idc (%) |
|---|---|---|---|---|---|---|
| 0.000 | 0.00 | -0.009 | 11.643 | 23.295 | 8.239 | 99.92 |
| 0.001 | 0.05 | 0.295 | 11.377 | 23.029 | 8.239 | 97.64 |
| 0.002 | 0.10 | 1.691 | 11.118 | 22.769 | 8.239 | 95.42 |
| 0.003 | 0.15 | 4.017 | 10.865 | 22.516 | 8.239 | 93.25 |
| 0.004 | 0.20 | 7.018 | 10.619 | 22.270 | 8.238 | 91.14 |
| 0.005 | 0.25 | 10.379 | 10.379 | 22.029 | 8.238 | 89.09 |
| 0.006 | 0.30 | 13.744 | 10.145 | 21.795 | 8.238 | 87.08 |
| 0.007 | 0.35 | 16.764 | 9.917 | 21.566 | 8.237 | 85.13 |
| 0.008 | 0.40 | 19.118 | 9.694 | 21.343 | 8.237 | 83.22 |
| 0.009 | 0.45 | 20.555 | 9.477 | 21.126 | 8.237 | 81.36 |
| 0.010 | 0.50 | 20.913 | 9.265 | 20.913 | 8.237 | 79.54 |
| 0.011 | 0.55 | 20.136 | 9.058 | 20.706 | 8.236 | 77.76 |
| 0.012 | 0.60 | 18.280 | 8.856 | 20.503 | 8.236 | 76.03 |
| 0.013 | 0.65 | 15.505 | 8.658 | 20.306 | 8.236 | 74.34 |
| 0.014 | 0.70 | 12.066 | 8.465 | 20.112 | 8.236 | 72.68 |
| 0.015 | 0.75 | 8.279 | 8.277 | 19.924 | 8.235 | 71.07 |
| 0.016 | 0.80 | 4.496 | 8.093 | 19.739 | 8.235 | 69.49 |
| 0.017 | 0.85 | 1.069 | 7.913 | 19.559 | 8.235 | 67.95 |
| 0.018 | 0.90 | -1.683 | 7.738 | 19.383 | 8.235 | 66.44 |
| 0.019 | 0.95 | -3.508 | 7.566 | 19.211 | 8.234 | 64.97 |
| 0.020 | 1.00 | -4.246 | 7.399 | 19.043 | 8.234 | 63.53 |
| 0.021 | 1.05 | -3.841 | 7.235 | 18.879 | 8.234 | 62.13 |
| 0.022 | 1.10 | -2.347 | 7.075 | 18.719 | 8.234 | 60.76 |
| 0.023 | 1.15 | 0.072 | 6.918 | 18.562 | 8.233 | 59.41 |
| 0.024 | 1.20 | 3.165 | 6.765 | 18.409 | 8.233 | 58.10 |
| 0.025 | 1.25 | 6.613 | 6.615 | 18.259 | 8.233 | 56.82 |
| 0.026 | 1.30 | 10.065 | 6.469 | 18.112 | 8.233 | 55.56 |
| 0.027 | 1.35 | 13.168 | 6.326 | 17.969 | 8.232 | 54.34 |
| 0.028 | 1.40 | 15.604 | 6.187 | 17.829 | 8.232 | 53.14 |
| 0.029 | 1.45 | 17.121 | 6.050 | 17.692 | 8.232 | 51.97 |
| 0.030 | 1.50 | 17.558 | 5.917 | 17.558 | 8.232 | 50.82 |
| 0.031 | 1.55 | 16.858 | 5.786 | 17.427 | 8.232 | 49.70 |
| 0.032 | 1.60 | 15.078 | 5.659 | 17.299 | 8.231 | 48.61 |
| 0.033 | 1.65 | 12.378 | 5.534 | 17.174 | 8.231 | 47.54 |
| 0.034 | 1.70 | 9.012 | 5.412 | 17.052 | 8.231 | 46.49 |
| 0.035 | 1.75 | 5.296 | 5.293 | 16.932 | 8.231 | 45.47 |
| 0.036 | 1.80 | 1.582 | 5.176 | 16.815 | 8.230 | 44.47 |
| 0.037 | 1.85 | -1.777 | 5.062 | 16.701 | 8.230 | 43.49 |
| 0.038 | 1.90 | -4.464 | 4.950 | 16.589 | 8.230 | 42.53 |
| 0.039 | 1.95 | -6.226 | 4.841 | 16.480 | 8.230 | 41.60 |
| 0.040 | 2.00 | -6.903 | 4.735 | 16.373 | 8.230 | 40.68 |
| 0.041 | 2.05 | -6.439 | 4.631 | 16.269 | 8.229 | 39.79 |
| 0.042 | 2.10 | -4.889 | 4.529 | 16.166 | 8.229 | 38.91 |
| 0.043 | 2.15 | -2.414 | 4.429 | 16.066 | 8.229 | 38.06 |
| 0.044 | 2.20 | 0.732 | 4.332 | 15.969 | 8.229 | 37.22 |
| 0.045 | 2.25 | 4.232 | 4.236 | 15.873 | 8.228 | 36.41 |
| 0.046 | 2.30 | 7.735 | 4.143 | 15.780 | 8.228 | 35.61 |
| 0.047 | 2.35 | 10.888 | 4.052 | 15.688 | 8.228 | 34.82 |
| 0.048 | 2.40 | 13.374 | 3.963 | 15.599 | 8.228 | 34.06 |
| 0.049 | 2.45 | 14.941 | 3.876 | 15.511 | 8.228 | 33.31 |
| 0.050 | 2.50 | 15.426 | 3.791 | 15.426 | 8.227 | 32.58 |
| 0.051 | 2.55 | 14.774 | 3.707 | 15.342 | 8.227 | 31.87 |
| 0.052 | 2.60 | 13.041 | 3.626 | 15.261 | 8.227 | 31.17 |
| 0.053 | 2.65 | 10.389 | 3.546 | 15.181 | 8.227 | 30.48 |
| 0.054 | 2.70 | 7.068 | 3.468 | 15.103 | 8.227 | 29.81 |
| 0.055 | 2.75 | 3.397 | 3.392 | 15.026 | 8.226 | 29.16 |
| 0.056 | 2.80 | -0.272 | 3.318 | 14.951 | 8.226 | 28.52 |
| 0.057 | 2.85 | -3.589 | 3.245 | 14.878 | 8.226 | 27.89 |
| 0.058 | 2.90 | -6.234 | 3.174 | 14.807 | 8.226 | 27.28 |
| 0.059 | 2.95 | -7.958 | 3.104 | 14.737 | 8.225 | 26.68 |
| 0.060 | 3.00 | -8.596 | 3.036 | 14.668 | 8.225 | 26.10 |
| 0.061 | 3.05 | -8.095 | 2.969 | 14.601 | 8.225 | 25.53 |
| 0.062 | 3.10 | -6.509 | 2.904 | 14.536 | 8.225 | 24.97 |
| 0.063 | 3.15 | -4.001 | 2.840 | 14.472 | 8.225 | 24.42 |
| 0.064 | 3.20 | -0.821 | 2.778 | 14.409 | 8.224 | 23.89 |
| 0.065 | 3.25 | 2.711 | 2.717 | 14.348 | 8.224 | 23.36 |
| 0.066 | 3.30 | 6.246 | 2.658 | 14.288 | 8.224 | 22.85 |
| 0.067 | 3.35 | 9.431 | 2.599 | 14.230 | 8.224 | 22.35 |
| 0.068 | 3.40 | 11.948 | 2.542 | 14.172 | 8.224 | 21.86 |
| 0.069 | 3.45 | 13.545 | 2.487 | 14.116 | 8.224 | 21.38 |
| 0.070 | 3.50 | 14.062 | 2.432 | 14.062 | 8.223 | 20.91 |
| 0.071 | 3.55 | 13.441 | 2.379 | 14.008 | 8.223 | 20.46 |
| 0.072 | 3.60 | 11.738 | 2.327 | 13.956 | 8.223 | 20.01 |
| 0.073 | 3.65 | 9.116 | 2.276 | 13.904 | 8.223 | 19.57 |
| 0.074 | 3.70 | 5.825 | 2.226 | 13.854 | 8.223 | 19.14 |
| 0.075 | 3.75 | 2.184 | 2.177 | 13.805 | 8.222 | 18.72 |
| 0.076 | 3.80 | -1.458 | 2.129 | 13.757 | 8.222 | 18.31 |
| 0.077 | 3.85 | -4.747 | 2.083 | 13.710 | 8.222 | 17.91 |

(Cont.)

3-Phase fault at bus : **SG-100D1**

Nominal kV = 6.600

i = total fault current,
Idc = dc component,
ienv = top envelope of current-wave,
Iac(rms) = rms value of ac component,
Idc(%) = percentage value of dc component

| t (s) | t (cycle) | i (kA) | Idc (kA) | ienv (kA) | Iac (kA, rms) | Idc (%) |
|---|---|---|---|---|---|---|
| 0.078 | 3.90 | -7.366 | 2.037 | 13.664 | 8.222 | 17.52 |
| 0.079 | 3.95 | -9.064 | 1.992 | 13.620 | 8.222 | 17.14 |
| 0.080 | 4.00 | -9.678 | 1.949 | 13.576 | 8.221 | 16.76 |
| 0.081 | 4.05 | -9.154 | 1.906 | 13.533 | 8.221 | 16.39 |
| 0.082 | 4.10 | -7.546 | 1.864 | 13.491 | 8.221 | 16.04 |
| 0.083 | 4.15 | -5.016 | 1.824 | 13.450 | 8.221 | 15.69 |
| 0.084 | 4.20 | -1.816 | 1.784 | 13.410 | 8.221 | 15.34 |
| 0.085 | 4.25 | 1.738 | 1.745 | 13.370 | 8.221 | 15.01 |
| 0.086 | 4.30 | 5.292 | 1.706 | 13.332 | 8.220 | 14.68 |
| 0.087 | 4.35 | 8.496 | 1.669 | 13.294 | 8.220 | 14.36 |
| 0.088 | 4.40 | 11.033 | 1.633 | 13.257 | 8.220 | 14.04 |
| 0.089 | 4.45 | 12.650 | 1.597 | 13.222 | 8.220 | 13.74 |
| 0.090 | 4.50 | 13.186 | 1.562 | 13.186 | 8.220 | 13.44 |
| 0.091 | 4.55 | 12.585 | 1.528 | 13.152 | 8.219 | 13.14 |
| 0.092 | 4.60 | 10.903 | 1.494 | 13.118 | 8.219 | 12.86 |
| 0.093 | 4.65 | 8.300 | 1.462 | 13.085 | 8.219 | 12.58 |
| 0.094 | 4.70 | 5.029 | 1.430 | 13.053 | 8.219 | 12.30 |
| 0.095 | 4.75 | 1.406 | 1.398 | 13.022 | 8.219 | 12.03 |
| 0.096 | 4.80 | -2.216 | 1.368 | 12.991 | 8.219 | 11.77 |
| 0.097 | 4.85 | -5.487 | 1.338 | 12.961 | 8.218 | 11.51 |
| 0.098 | 4.90 | -8.089 | 1.309 | 12.931 | 8.218 | 11.26 |
| 0.099 | 4.95 | -9.771 | 1.280 | 12.902 | 8.218 | 11.01 |
| 0.100 | 5.00 | -10.370 | 1.252 | 12.874 | 8.218 | 10.77 |
| 0.101 | 5.05 | -9.831 | 1.225 | 12.846 | 8.218 | 10.54 |

| t (s) | t (cycle) | i (kA) | Idc (kA) | ienv (kA) | Iac (kA, rms) | Idc (%) |
|---|---|---|---|---|---|---|

3-Phase fault at bus : **SG-200N1**

Nominal kV = 0.400

i = total fault current,
Idc = dc component,
ienv = top envelope of current-wave,
Iac(rms) = rms value of ac component,
Idc(%) = percentage value of dc component

| t (s) | t (cycle) | i (kA) | Idc (kA) | ienv (kA) | Iac (kA, rms) | Idc (%) |
|---|---|---|---|---|---|---|
| 0.000 | 0.00 | -0.252 | 45.424 | 91.101 | 32.298 | 99.45 |
| 0.001 | 0.05 | 0.049 | 43.485 | 89.155 | 32.294 | 95.21 |
| 0.002 | 0.10 | 4.693 | 41.638 | 87.301 | 32.289 | 91.18 |
| 0.003 | 0.15 | 13.038 | 39.878 | 85.535 | 32.285 | 87.34 |
| 0.004 | 0.20 | 24.088 | 38.200 | 83.851 | 32.280 | 83.68 |
| 0.005 | 0.25 | 36.592 | 36.599 | 82.244 | 32.276 | 80.18 |
| 0.006 | 0.30 | 49.166 | 35.071 | 80.710 | 32.271 | 76.84 |
| 0.007 | 0.35 | 60.426 | 33.612 | 79.244 | 32.267 | 73.66 |
| 0.008 | 0.40 | 69.124 | 32.218 | 77.844 | 32.263 | 70.61 |
| 0.009 | 0.45 | 74.269 | 30.886 | 76.506 | 32.258 | 67.70 |
| 0.010 | 0.50 | 75.226 | 29.612 | 75.226 | 32.254 | 64.92 |
| 0.011 | 0.55 | 71.774 | 28.394 | 74.002 | 32.250 | 62.26 |
| 0.012 | 0.60 | 64.130 | 27.228 | 72.830 | 32.245 | 59.71 |
| 0.013 | 0.65 | 52.927 | 26.113 | 71.709 | 32.241 | 57.27 |
| 0.014 | 0.70 | 39.151 | 25.045 | 70.635 | 32.237 | 54.94 |
| 0.015 | 0.75 | 24.042 | 24.023 | 69.607 | 32.233 | 52.70 |
| 0.016 | 0.80 | 8.979 | 23.044 | 68.622 | 32.229 | 50.56 |
| 0.017 | 0.85 | -4.662 | 22.106 | 67.679 | 32.224 | 48.51 |
| 0.018 | 0.90 | -15.642 | 21.208 | 66.775 | 32.220 | 46.54 |
| 0.019 | 0.95 | -22.976 | 20.347 | 65.908 | 32.216 | 44.66 |
| 0.020 | 1.00 | -26.032 | 19.523 | 65.077 | 32.212 | 42.86 |
| 0.021 | 1.05 | -24.596 | 18.732 | 64.281 | 32.208 | 41.13 |
| 0.022 | 1.10 | -18.888 | 17.974 | 63.517 | 32.204 | 39.47 |
| 0.023 | 1.15 | -9.542 | 17.248 | 62.785 | 32.200 | 37.88 |
| 0.024 | 1.20 | 2.452 | 16.551 | 62.083 | 32.196 | 36.35 |
| 0.025 | 1.25 | 15.851 | 15.883 | 61.409 | 32.192 | 34.89 |
| 0.026 | 1.30 | 29.278 | 15.242 | 60.763 | 32.188 | 33.48 |
| 0.027 | 1.35 | 41.354 | 14.628 | 60.143 | 32.184 | 32.14 |
| 0.028 | 1.40 | 50.836 | 14.039 | 59.548 | 32.180 | 30.85 |
| 0.029 | 1.45 | 56.739 | 13.474 | 58.977 | 32.176 | 29.61 |
| 0.030 | 1.50 | 58.430 | 12.931 | 58.430 | 32.172 | 28.42 |
| 0.031 | 1.55 | 55.689 | 12.411 | 57.904 | 32.168 | 27.28 |
| 0.032 | 1.60 | 48.736 | 11.912 | 57.399 | 32.164 | 26.19 |
| 0.033 | 1.65 | 38.200 | 11.433 | 56.915 | 32.161 | 25.14 |
| 0.034 | 1.70 | 25.067 | 10.974 | 56.450 | 32.157 | 24.13 |
| 0.035 | 1.75 | 10.576 | 10.533 | 56.004 | 32.153 | 23.16 |
| 0.036 | 1.80 | -3.897 | 10.110 | 55.576 | 32.149 | 22.24 |
| 0.037 | 1.85 | -16.980 | 9.705 | 55.165 | 32.145 | 21.35 |
| 0.038 | 1.90 | -27.431 | 9.315 | 54.770 | 32.142 | 20.49 |
| 0.039 | 1.95 | -34.269 | 8.941 | 54.391 | 32.138 | 19.67 |
| 0.040 | 2.00 | -36.862 | 8.583 | 54.027 | 32.134 | 18.89 |
| 0.041 | 2.05 | -34.992 | 8.239 | 53.678 | 32.130 | 18.13 |
| 0.042 | 2.10 | -28.879 | 7.908 | 53.342 | 32.127 | 17.41 |
| 0.043 | 2.15 | -19.153 | 7.591 | 53.020 | 32.123 | 16.71 |
| 0.044 | 2.20 | -6.800 | 7.287 | 52.711 | 32.119 | 16.04 |
| 0.045 | 2.25 | 6.941 | 6.995 | 52.414 | 32.116 | 15.40 |
| 0.046 | 2.30 | 20.696 | 6.715 | 52.128 | 32.112 | 14.79 |
| 0.047 | 2.35 | 33.091 | 6.446 | 51.854 | 32.109 | 14.20 |
| 0.048 | 2.40 | 42.886 | 6.188 | 51.591 | 32.105 | 13.63 |
| 0.049 | 2.45 | 49.098 | 5.940 | 51.338 | 32.102 | 13.08 |
| 0.050 | 2.50 | 51.095 | 5.702 | 51.095 | 32.098 | 12.56 |
| 0.051 | 2.55 | 48.659 | 5.474 | 50.862 | 32.095 | 12.06 |
| 0.052 | 2.60 | 42.007 | 5.254 | 50.638 | 32.091 | 11.58 |
| 0.053 | 2.65 | 31.768 | 5.044 | 50.423 | 32.088 | 11.12 |
| 0.054 | 2.70 | 18.924 | 4.842 | 50.216 | 32.084 | 10.67 |
| 0.055 | 2.75 | 4.713 | 4.648 | 50.017 | 32.081 | 10.25 |
| 0.056 | 2.80 | -9.493 | 4.462 | 49.826 | 32.077 | 9.84 |
| 0.057 | 2.85 | -22.324 | 4.284 | 49.643 | 32.074 | 9.44 |
| 0.058 | 2.90 | -32.540 | 4.112 | 49.467 | 32.070 | 9.07 |
| 0.059 | 2.95 | -39.161 | 3.948 | 49.298 | 32.067 | 8.71 |
| 0.060 | 3.00 | -41.555 | 3.790 | 49.135 | 32.064 | 8.36 |
| 0.061 | 3.05 | -39.504 | 3.638 | 48.979 | 32.060 | 8.02 |
| 0.062 | 3.10 | -33.226 | 3.493 | 48.828 | 32.057 | 7.70 |
| 0.063 | 3.15 | -23.350 | 3.353 | 48.684 | 32.054 | 7.40 |
| 0.064 | 3.20 | -10.858 | 3.219 | 48.545 | 32.050 | 7.10 |
| 0.065 | 3.25 | 3.016 | 3.090 | 48.412 | 32.047 | 6.82 |
| 0.066 | 3.30 | 16.899 | 2.967 | 48.284 | 32.044 | 6.55 |
| 0.067 | 3.35 | 29.420 | 2.848 | 48.160 | 32.041 | 6.29 |
| 0.068 | 3.40 | 39.343 | 2.734 | 48.042 | 32.037 | 6.03 |
| 0.069 | 3.45 | 45.686 | 2.625 | 47.928 | 32.034 | 5.79 |
| 0.070 | 3.50 | 47.819 | 2.520 | 47.819 | 32.031 | 5.56 |
| 0.071 | 3.55 | 45.521 | 2.419 | 47.713 | 32.028 | 5.34 |
| 0.072 | 3.60 | 39.010 | 2.323 | 47.612 | 32.025 | 5.13 |
| 0.073 | 3.65 | 28.914 | 2.230 | 47.515 | 32.021 | 4.92 |
| 0.074 | 3.70 | 16.212 | 2.141 | 47.421 | 32.018 | 4.73 |
| 0.075 | 3.75 | 2.139 | 2.055 | 47.331 | 32.015 | 4.54 |
| 0.076 | 3.80 | -11.936 | 1.973 | 47.245 | 32.012 | 4.36 |
| 0.077 | 3.85 | -24.644 | 1.894 | 47.162 | 32.009 | 4.18 |

(Cont.)

3-Phase fault at bus : **SG-200N1**

Nominal kV = 0.400

i = total fault current,
Idc = dc component,
ienv = top envelope of current-wave,
Iac(rms) = rms value of ac component,
Idc(%) = percentage value of dc component

| t (s) | t (cycle) | i (kA) | Idc (kA) | ienv (kA) | Iac (kA, rms) | Idc (%) |
|---|---|---|---|---|---|---|
| 0.078 | 3.90 | -34.749 | 1.818 | 47.082 | 32.006 | 4.02 |
| 0.079 | 3.95 | -41.271 | 1.746 | 47.005 | 32.003 | 3.86 |
| 0.080 | 4.00 | -43.579 | 1.676 | 46.931 | 32.000 | 3.70 |
| 0.081 | 4.05 | -41.454 | 1.609 | 46.859 | 31.997 | 3.56 |
| 0.082 | 4.10 | -35.113 | 1.545 | 46.791 | 31.994 | 3.41 |
| 0.083 | 4.15 | -25.183 | 1.483 | 46.725 | 31.991 | 3.28 |
| 0.084 | 4.20 | -12.643 | 1.424 | 46.661 | 31.988 | 3.15 |
| 0.085 | 4.25 | 1.274 | 1.367 | 46.600 | 31.985 | 3.02 |
| 0.086 | 4.30 | 15.199 | 1.312 | 46.542 | 31.982 | 2.90 |
| 0.087 | 4.35 | 27.766 | 1.260 | 46.485 | 31.979 | 2.79 |
| 0.088 | 4.40 | 37.738 | 1.210 | 46.431 | 31.976 | 2.67 |
| 0.089 | 4.45 | 44.135 | 1.161 | 46.378 | 31.973 | 2.57 |
| 0.090 | 4.50 | 46.328 | 1.115 | 46.328 | 31.970 | 2.47 |
| 0.091 | 4.55 | 44.097 | 1.070 | 46.279 | 31.967 | 2.37 |
| 0.092 | 4.60 | 37.657 | 1.028 | 46.232 | 31.965 | 2.27 |
| 0.093 | 4.65 | 27.636 | 0.987 | 46.187 | 31.962 | 2.18 |
| 0.094 | 4.70 | 15.010 | 0.947 | 46.144 | 31.959 | 2.10 |
| 0.095 | 4.75 | 1.011 | 0.909 | 46.102 | 31.956 | 2.01 |
| 0.096 | 4.80 | -12.993 | 0.873 | 46.062 | 31.953 | 1.93 |
| 0.097 | 4.85 | -25.637 | 0.838 | 46.023 | 31.950 | 1.86 |
| 0.098 | 4.90 | -35.686 | 0.805 | 45.986 | 31.948 | 1.78 |
| 0.099 | 4.95 | -42.161 | 0.773 | 45.950 | 31.945 | 1.71 |
| 0.100 | 5.00 | -44.431 | 0.742 | 45.915 | 31.942 | 1.64 |
| 0.101 | 5.05 | -42.279 | 0.712 | 45.881 | 31.939 | 1.58 |

| t (s) | t (cycle) | i (kA) | Idc (kA) | ienv (kA) | Iac (kA, rms) | Idc (%) |
|---|---|---|---|---|---|---|

## Short-Circuit Summary Report

3-Phase Fault Currents

| Bus | | Device | | Device Capacity (kA) | | | | Short-Circuit Current (kA) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Making | | | | | | | |
| ID | kV | ID | Type | Peak | Ib sym | Ib asym | Idc | ip | Ib sym | Ib asym | Idc |
| Bus4 | 0.400 | Bus4 | Bus | | | | | 78.255 | | | |
| HKN57 | 66.000 | HKN57 | SwtchGear | 78.750 | | | | 38.040 | | | |
| | 66.000 | CB1 | CB | 78.750 | 31.500 | 32.387 | 7.529 | 38.040 | 15.545 | 15.646 | 1.781 |
| | 66.000 | CB2 | CB | 78.750 | 31.500 | 32.387 | 7.529 | 38.040 | 15.545 | 15.646 | 1.781 |
| HNA6-AFA70 | 66.000 | HNA6-AFA70 | SwtchGear | 78.750 | | | | 34.479 | | | |
| | 66.000 | CB3 | CB | 78.750 | 31.500 | 32.387 | 7.529 | 34.479 | 14.722 | 14.739 | 0.716 |
| | 66.000 | CB4 | CB | 78.750 | 31.500 | 32.387 | 7.529 | 34.479 | 14.722 | 14.739 | 0.716 |
| SG-100D1 | 6.600 | SG-100D1 | SwtchGear | 62.500 | | | | 20.913 | | | |
| | 6.600 | CB6 | CB | 62.500 | 25.000 | 25.704 | 5.976 | 20.913 | 8.221 | 8.449 | 1.949 |
| | 6.600 | CB8 | CB | 62.500 | 25.000 | 25.704 | 5.976 | 20.913 | 8.221 | 8.449 | 1.949 |
| | 6.600 | CB9 | CB | 62.500 | 25.000 | 25.704 | 5.976 | 20.913 | 8.221 | 8.449 | 1.949 |
| | 6.600 | CB12 | CB | 62.500 | 25.000 | 25.704 | 5.976 | 20.913 | 8.221 | 8.449 | 1.949 |
| | 6.600 | CB10 | CB | 62.500 | 25.000 | 25.704 | 5.976 | 20.913 | 8.221 | 8.449 | 1.949 |
| SG-200N1 | 0.400 | SG-200N1 | SwtchGear | 105.000 | | | | 75.226 | | | |
| | 0.400 | CB14 | CB | 105.000 | 50.000 | 50.383 | | 75.226 | 32.172 | 34.674 | 12.931 |
| | 0.400 | CB7 | CB | 105.000 | 50.000 | 50.383 | | 75.226 | 32.172 | 34.674 | 12.931 |
| | 0.400 | CB16 | CB | 105.000 | 50.000 | 50.383 | | 75.226 | 32.172 | 34.674 | 12.931 |
| | 0.400 | CB18 | CB | 105.000 | 50.000 | 50.383 | | 75.226 | 32.172 | 34.674 | 12.931 |
| | 0.400 | CB19 | CB | 105.000 | 50.000 | 50.383 | | 75.226 | 32.172 | 34.674 | 12.931 |
| | 0.400 | CB21 | CB | 105.000 | 50.000 | 50.383 | | 75.226 | 32.172 | 34.674 | 12.931 |
| | 0.400 | CB22 | CB | 105.000 | 50.000 | 50.383 | | 75.226 | 32.172 | 34.674 | 12.931 |
| | 0.400 | CB23 | CB | 105.000 | 50.000 | 50.383 | | 75.226 | 32.172 | 34.674 | 12.931 |
| | 0.400 | CB25 | CB | 105.000 | 50.000 | 50.383 | | 75.226 | 32.172 | 34.674 | 12.931 |
| | 0.400 | CB27 | CB | 105.000 | 50.000 | 50.383 | | 75.226 | 32.172 | 34.674 | 12.931 |
| | 0.400 | CB29 | CB | 105.000 | 50.000 | 50.383 | | 75.226 | 32.172 | 34.674 | 12.931 |

LV circuit breaker duty determined based on service rating.

* Indicates a device with calculated duty exceeding the device capability.

\# Indicates a device with calculated duty exceeding the device marginal limit. ( 95 % times device capability)

Attachment 4 Etap Report Short Circuit Study Case 2

# Electrical Transient Analyzer Program

## Short-Circuit Analysis

### IEC 60909 Standard

### 3-Phase, LG, LL, & LLG Fault Currents

| | Swing | V-Control | Load | Total |
|---|---|---|---|---|
| Number of Buses: | 1 | 0 | 13 | 14 |

| | XFMR2 | XFMR3 | Reactor | Line/Cable/ Busway | Impedance | Tie PD | Total |
|---|---|---|---|---|---|---|---|
| Number of Branches: | 1 | 0 | 0 | 12 | 0 | 0 | 13 |

| | Synchronous Generator | Power Grid | Synchronous Motor | Induction Machines | Lumped Load | Inverter | Total |
|---|---|---|---|---|---|---|---|
| Number of Machines: | 0 | 1 | 0 | 0 | 0 | 0 | 1 |

| | |
|---|---|
| System Frequency: | 50.00 |
| Unit System: | Metric |
| Project Filename: | BLPH-LV-SCstudy |
| Output Filename: | Z:\Studi\0351-0400\0396S_Crosswind\ETAP_15-Mar-2024\CS-SCC_Case-2.SI2S |

## Adjustments

| Tolerance | Apply Adjustments | Individual /Global | Percent |
|---|---|---|---|
| Transformer Impedance: | Yes | Global | 10.0 |
| Reactor Impedance: | Yes | Individual | |
| Overload Heater Resistance: | No | | |
| Transmission Line Length: | No | | |
| Cable / Busway Length: | No | | |

| Temperature Correction | Apply Adjustments | Individual /Global | Degree C |
|---|---|---|---|
| Transmission Line Resistance: | Yes | Global | 90 |
| Cable / Busway Resistance: | Yes | Global | 90 |

## Bus Input Data

| Bus | | | | | Initial Voltage | |
|---|---|---|---|---|---|---|
| ID | Type | Nom. kV | Base kV | Sub-sys | %Mag. | Ang. |
| Bus1 | Load | 0.400 | 0.420 | 2 | 100.22 | 30.00 |
| Bus4 | Load | 0.400 | 0.420 | 2 | 100.45 | 30.00 |
| Bus7 | Load | 6.600 | 6.600 | 2 | 100.55 | 1.69 |
| Bus62 | Load | 0.400 | 0.420 | 2 | 100.08 | 30.00 |
| Bus63 | Load | 0.400 | 0.420 | 2 | 100.25 | 30.00 |
| Bus64 | Load | 0.400 | 0.420 | 2 | 99.74 | 30.00 |
| Bus66 | Load | 0.400 | 0.420 | 2 | 100.26 | 30.00 |
| Bus67 | Load | 0.400 | 0.420 | 2 | 100.23 | 30.00 |
| Bus68 | Load | 0.400 | 0.420 | 2 | 100.29 | 30.00 |
| Bus69 | Load | 0.400 | 0.420 | 2 | 100.25 | 30.00 |
| Bus84 | Load | 0.400 | 0.420 | 2 | 100.20 | 30.00 |
| Bus96 | SWNG | 6.600 | 6.600 | 2 | 100.00 | 0.00 |
| SG-100D1 | Load | 6.600 | 6.600 | 2 | 100.58 | 1.69 |
| SG-200N1 | Load | 0.400 | 0.420 | 2 | 100.32 | 30.00 |

14 Buses Total

All voltages reported by ETAP are in % of bus Nominal kV.
Base kV values of buses are calculated and used internally by ETAP.

## Line/Cable/Busway Input Data

**ohms or siemens per 1000 m per Conductor (Cable) or per Phase (Line/Busway)**

| Line/Cable/Busway | | | Length | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | Library | Size | Adj. (m) | % Tol. | #/Phase | T (°C) | R1 | X1 | Y1 | R0 | X0 | Y0 |
| 0.4kV_cable | 1.0NCUN1 | 300 | 10.0 | 0.0 | 5 | 90 | 0.08 | 0.089 | 0.0001854 | 0.1272 | 0.22606 | 0.0001854 |
| 6.6kV_Cable2 | 6.6NCUN1 | 70 | 44.0 | 0.0 | 1 | 90 | 0.342 | 0.13 | 0.00011 | 0.68 | 0.0632 | |
| 6.6kV_Cable5 | 6.6NCUN1 | 70 | 55.0 | 0.0 | 1 | 90 | 0.342 | 0.13 | 0.00011 | 0.68 | 0.0632 | |
| AC_UPS-F&G | 1.0MCUN4 | 35 | 40.0 | 0.0 | 1 | 90 | 0.669 | 0.08 | 0.0001015 | 2.1073999 | 0.1968 | |
| AC_UPS-PAS | 1.0MCUN4 | 35 | 40.0 | 0.0 | 1 | 90 | 0.669 | 0.08 | 0.0001015 | 2.1073999 | 0.1968 | |
| DB-L&SP-HV-MV | 1.0MCUN4 | 4.0 | 65.0 | 0.0 | 1 | 90 | 5.8699999 | 0.093 | 0.0000575 | 18.4909992 | 0.22878 | |
| DB-L&SP-LV- | 1.0MCUN4 | 4.0 | 20.0 | 0.0 | 1 | 90 | 5.8699999 | 0.093 | 0.0000575 | 18.4909992 | 0.22878 | |
| DB-L&SP-UPS- | 1.0MCUN4 | 4.0 | 47.0 | 0.0 | 1 | 90 | 5.8699999 | 0.093 | 0.0000575 | 18.4909992 | 0.22878 | |
| DB-L&SP.Inst. | 1.0MCUN4 | 4.0 | 45.0 | 0.0 | 1 | 90 | 5.8699999 | 0.093 | 0.0000575 | 18.4909992 | 0.22878 | |
| DB-L&SP_BoP | 1.0NCUN4 | 16 | 20.0 | 0.0 | 1 | 90 | 1.467 | 0.08 | 0.0000597 | 5.868 | 0.32 | |
| DC_Batt_Swgr | 1.0MCUN4 | 16 | 65.0 | 0.0 | 1 | 90 | 1.46 | 0.08 | 0.0000971 | 4.599 | 0.1968 | |
| DC_UPS_Navaid | 1.0MCUN4 | 4.0 | 50.0 | 0.0 | 1 | 90 | 5.8699999 | 0.093 | 0.0000575 | 18.4909992 | 0.22878 | |

Line / Cable / Busway resistances are listed at the specified temperatures.

## 2-Winding Transformer Input Data

| Transformer | Rating | | | | | Z Variation | | | % Tap Setting | | Adjusted | Phase Shift | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | MVA | Prim. kV | Sec. kV | % Z | X/R | + 5% | - 5% | % Tol. | Prim. | Sec. | % Z | Type | Angle |
| TR-200DE1 | 1.600 | 6.600 | 0.420 | 6.00 | 7.94 | 0 | 0 | 10.0 | 2.500 | 0 | 6.60 | Dyn | -30.00 |

## 2-Winding Transformer Grounding Input Data

| Transformer | Rating | | | Conn. | Grounding | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Primary | | | | Secondary | | | |
| ID | MVA | Prim. kV | Sec. kV | Type | Type | kV | Amp | ohm | Type | kV | Amp | ohm |
| TR-200DE1 | 1.600 | 6.600 | 0.420 | D/Y | | | | | Solid | | | |

## Branch Connections

| CKT/Branch | | Connected Bus ID | | % Impedance, Pos. Seq., 100 MVAb | | | |
|---|---|---|---|---|---|---|---|
| ID | Type | From Bus | To Bus | R | X | Z | Y |
| TR-200DE1 | 2W XFMR | Bus7 | Bus4 | 51.54 | 409.27 | 412.50 | |
| 0.4kV_cable | Cable | Bus4 | SG-200N1 | 9.07 | 10.09 | 13.57 | 0.0000016 |
| 6.6kV_Cable2 | Cable | SG-100D1 | Bus7 | 3.45 | 1.31 | 3.70 | 0.0002108 |
| 6.6kV_Cable5 | Cable | SG-100D1 | Bus96 | 4.32 | 1.64 | 4.62 | 0.0002635 |
| AC_UPS-F&G | Cable | SG-200N1 | Bus63 | 1517.01 | 181.41 | 1527.81 | 0.0000007 |
| AC_UPS-PAS | Cable | SG-200N1 | Bus62 | 1517.01 | 181.41 | 1527.81 | 0.0000007 |
| DB-L&SP-HV-MV | Cable | SG-200N1 | Bus67 | 21629.82 | 342.69 | 21632.53 | 0.0000007 |
| DB-L&SP-LV- | Cable | SG-200N1 | Bus68 | 6655.33 | 105.44 | 6656.16 | 0.0000002 |
| DB-L&SP-UPS- | Cable | SG-200N1 | Bus69 | 15640.02 | 247.79 | 15641.99 | 0.0000005 |
| DB-L&SP.Inst. | Cable | SG-200N1 | Bus66 | 14974.49 | 237.24 | 14976.37 | 0.0000005 |
| DB-L&SP_BoP | Cable | SG-200N1 | Bus84 | 1663.27 | 90.70 | 1665.74 | 0.0000002 |
| DC_Batt_Swgr | Cable | SG-200N1 | Bus1 | 5379.82 | 294.78 | 5387.89 | 0.0000011 |
| DC_UPS_Navaid | Cable | SG-200N1 | Bus64 | 16638.32 | 263.61 | 16640.41 | 0.0000005 |

## Power Grid Input Data

| | | Rating | | % Impedance 100 MVA Base | | | Grounding |
|---|---|---|---|---|---|---|---|
| Power Grid ID | Connected Bus ID | MVASC | kV | R | X" | R/X" | Type |
| A-85000 | Bus96 | 1.970 | 6.600 | 505.09500 | 5050.95020 | 0.10 | Delta |

Total Connected Power Grids ( = 1 ): 1.970 MVA

## SHORT- CIRCUIT REPORT

Fault at bus: **Bus4**
Nominal kV = 0.400
Voltage c Factor = 0.95 (Minimum If)

| Contribution | | 3-Phase Fault | | Line-To-Ground Fault | | | | | Positive & Zero Sequence Impedances Looking into "From Bus" | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From Bus | To Bus | % V | kA | % Voltage at From Bus | | | kA Symm. rms | | % Impedance on 100 MVA base | | | |
| ID | ID | From Bus | Symm. rms | Va | Vb | Vc | Ia | 3I0 | R1 | X1 | R0 | X0 |
| Bus4 | Total | 0.00 | 2.265 | 0.00 | 82.32 | 82.54 | 3.274 | 3.274 | 5.64E+002 | 5.46E+003 | 5.15E+001 | 4.09E+002 |
| SG-200N1 | Bus4 | 0.00 | 0.000 | 0.00 | 82.32 | 82.54 | 0.000 | 0.000 | | | | |
| Bus7 | Bus4 | 6.80 | 2.265 | 46.21 | 45.85 | 90.48 | 3.274 | 3.274 * | 5.64E+002 | 5.46E+003 | 5.15E+001 | 4.09E+002 |
| Bus63 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.32 | 82.54 | 0.000 | 0.000 | | | | |
| Bus62 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.32 | 82.54 | 0.000 | 0.000 | | | | |
| Bus67 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.32 | 82.54 | 0.000 | 0.000 | | | | |
| Bus68 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.32 | 82.54 | 0.000 | 0.000 | | | | |
| Bus69 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.32 | 82.54 | 0.000 | 0.000 | | | | |
| Bus66 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.32 | 82.54 | 0.000 | 0.000 | | | | |
| Bus84 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.32 | 82.54 | 0.000 | 0.000 | | | | |
| Bus1 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.32 | 82.54 | 0.000 | 0.000 | | | | |
| Bus64 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.32 | 82.54 | 0.000 | 0.000 | | | | |
| SG-100D1 | Bus7 | 6.82 | 0.144 | 46.26 | 45.81 | 90.48 | 0.120 | 0.000 | 2.29E+003 | 4.60E+003 | | |

| | | 3-Phase | L-G | L-L | L-L-G |
|---|---|---|---|---|---|
| Initial Symmetrical Current (kA, rms) | : | 2.265 | 3.274 | 1.961 | 3.550 |
| Peak Current (kA), Method C | : | 5.569 | 8.051 | 4.823 | 8.729 |
| Breaking Current (kA, rms, symm) | : | | 3.274 | 1.961 | 3.550 |
| Steady State Current (kA, rms) | : | 2.265 | 3.274 | 1.961 | 3.550 |

\# Indicates a fault current contribution from a three-winding transformer.
* Indicates a zero sequence fault current contribution (3I0) from a grounded Delta- Y transformer.

Fault at bus: **SG-100D1**
Nominal kV = 6.600
Voltage c Factor = 1.00 (Minimum If)

| Contribution | | 3-Phase Fault | | Line-To-Ground Fault | | | | | Positive & Zero Sequence Impedances Looking into "From Bus" | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From Bus | To Bus | % V | kA | % Voltage at From Bus | | | kA Symm. rms | | % Impedance on 100 MVA base | | | |
| ID | ID | From Bus | Symm. rms | Va | Vb | Vc | Ia | 3I0 | R1 | X1 | R0 | X0 |
| SG-100D1 | Total | 0.00 | 0.172 | 0.00 | 173.21 | 173.21 | 0.000 | 0.000 | 5.09E+002 | 5.05E+003 | | |
| Bus7 | SG-100D1 | 0.00 | 0.000 | 0.00 | 173.21 | 173.21 | 0.000 | 0.000 | | | | |
| Bus96 | SG-100D1 | 0.09 | 0.172 | 0.00 | 173.21 | 173.21 | 0.000 | 0.000 | 5.09E+002 | 5.05E+003 | | |
| Bus4 | Bus7 | 0.00 | 0.000 | 105.00 | 105.00 | 105.00 | 0.000 | 0.000 | | | | |
| A-85000 | Bus96 | 100.00 | 0.172 | 0.00 | 173.21 | 173.21 | 0.000 | 0.000 | 5.05E+002 | 5.05E+003 | | |

| | | 3-Phase | L-G | L-L | L-L-G |
|---|---|---|---|---|---|
| Initial Symmetrical Current (kA, rms) | : | 0.172 | 0.000 | 0.149 | 0.149 |
| Peak Current (kA), Method C | : | 0.425 | 0.000 | 0.368 | 0.368 |
| Breaking Current (kA, rms, symm) | : | | 0.000 | 0.149 | 0.149 |
| Steady State Current (kA, rms) | : | 0.172 | 0.000 | 0.149 | 0.149 |

\# Indicates a fault current contribution from a three-winding transformer.
* Indicates a zero sequence fault current contribution (3I0) from a grounded Delta- Y transformer.

Fault at bus: **SG-200N1**
Nominal kV = 0.400
Voltage c Factor = 0.95 (Minimum If)

| Contribution | | 3-Phase Fault | | Line-To-Ground Fault | | | | | Positive & Zero Sequence Impedances Looking into "From Bus" | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From Bus | To Bus | % V | kA | % Voltage at From Bus | | | kA Symm. rms | | % Impedance on 100 MVA base | | | |
| ID | ID | From Bus | Symm. rms | Va | Vb | Vc | Ia | 3I0 | R1 | X1 | R0 | X0 |
| SG-200N1 | Total | 0.00 | 2.260 | 0.00 | 82.21 | 82.70 | 3.260 | 3.260 | 5.73E+002 | 5.47E+003 | 6.60E+001 | 4.35E+002 |
| Bus4 | SG-200N1 | 0.23 | 2.260 | 0.47 | 82.23 | 82.66 | 3.260 | 3.260 | 5.73E+002 | 5.47E+003 | 6.60E+001 | 4.35E+002 |
| Bus63 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.21 | 82.70 | 0.000 | 0.000 | | | | |
| Bus62 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.21 | 82.70 | 0.000 | 0.000 | | | | |
| Bus67 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.21 | 82.70 | 0.000 | 0.000 | | | | |
| Bus68 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.21 | 82.70 | 0.000 | 0.000 | | | | |
| Bus69 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.21 | 82.70 | 0.000 | 0.000 | | | | |
| Bus66 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.21 | 82.70 | 0.000 | 0.000 | | | | |
| Bus84 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.21 | 82.70 | 0.000 | 0.000 | | | | |
| Bus1 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.21 | 82.70 | 0.000 | 0.000 | | | | |
| Bus64 | SG-200N1 | 0.00 | 0.000 | 0.00 | 82.21 | 82.70 | 0.000 | 0.000 | | | | |
| Bus7 | Bus4 | 6.97 | 2.260 | 46.43 | 45.74 | 90.48 | 3.260 | 3.260 * | 5.64E+002 | 5.46E+003 | 5.15E+001 | 4.09E+002 |

| | | 3-Phase | L-G | L-L | L-L-G |
|---|---|---|---|---|---|
| Initial Symmetrical Current (kA, rms) | : | 2.260 | 3.260 | 1.957 | 3.528 |
| Peak Current (kA), Method C | : | 5.547 | 8.002 | 4.804 | 8.660 |
| Breaking Current (kA, rms, symm) | : | | 3.260 | 1.957 | 3.528 |
| Steady State Current (kA, rms) | : | 2.260 | 3.260 | 1.957 | 3.528 |

\# Indicates a fault current contribution from a three-winding transformer.
* Indicates a zero sequence fault current contribution (3I0) from a grounded Delta- Y transformer.

## Short-Circuit Summary Report

3-Phase, LG, LL, LLG Fault Currents

| Bus | | 3-Phase Fault | | | Line-to-Ground Fault | | | | Line-to-Line Fault | | | | *Line-to-Line-to-Ground | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | kV | I"k | ip | Ik | I"k | ip | Ib | Ik | I"k | ip | Ib | Ik | I"k | ip | Ib | Ik |
| Bus4 | 0.400 | 2.265 | 5.569 | 2.265 | 3.274 | 8.051 | 3.274 | 3.274 | 1.961 | 4.823 | 1.961 | 1.961 | 3.550 | 8.729 | 3.550 | 3.550 |
| SG-100D1 | 6.600 | 0.172 | 0.425 | 0.172 | 0.000 | 0.000 | 0.000 | 0.000 | 0.149 | 0.368 | 0.149 | 0.149 | 0.149 | 0.368 | 0.149 | 0.149 |
| SG-200N1 | 0.400 | 2.260 | 5.547 | 2.260 | 3.260 | 8.002 | 3.260 | 3.260 | 1.957 | 4.804 | 1.957 | 1.957 | 3.528 | 8.660 | 3.528 | 3.528 |

All fault currents are in rms kA. Current ip is calculated using Method C.

* LLG fault current is the larger of the two faulted line currents.

## Sequence Impedance Summary Report

| Bus | | Positive Seq. Imp. (ohm) | | | Negative Seq. Imp. (ohm) | | | Zero Seq. Imp. (ohm) | | | Fault Zf (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | kV | Resistance | Reactance | Impedance | Resistance | Reactance | Impedance | Resistance | Reactance | Impedance | Resistance | Reactance | Impedance |
| Bus4 | 0.400 | 0.00996 | 0.09637 | 0.09688 | 0.00996 | 0.09637 | 0.09688 | 0.00091 | 0.00722 | 0.00728 | 0.00000 | 0.00000 | 0.00000 |
| SG-100D1 | 6.600 | 2.21900 | 22.00909 | 22.12067 | 2.21900 | 22.00909 | 22.12067 | | | | 0.00000 | 0.00000 | 0.00000 |
| SG-200N1 | 0.400 | 0.01012 | 0.09655 | 0.09708 | 0.01012 | 0.09655 | 0.09708 | 0.00116 | 0.00767 | 0.00776 | 0.00000 | 0.00000 | 0.00000 |

## Branch (earth-fault factor) Summary Report

| Bus | | EFF/Ke (LG) | EFF/Ke (LLG) |
|---|---|---|---|
| ID | kV | | |
| Bus4 | 0.400 | 0.75 | 0.17 |
| SG-100D1 | 6.600 | 1.73 | 1.50 |
| SG-200N1 | 0.400 | 0.75 | 0.18 |

Attachment 5 Electrical parameters for Submarine HV cable

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

# Technical Specification

## Hollandse Kust Noord

## 66kV Al 3x400 CONF143350 specification (incl. drain wire)

# Document details

| | |
|---|---|
| Publication date | 10-3-2022 |
| TKF Revision | C15 |
| Document name | 50718-TSN-OF0261989 |
| Employer | Crosswind |
| Customer | Van Oord Offshore Wind bv |
| Customer proj. ref. | 14.4671 |
| Customer doc ref. | 144671-TKF-IAC-INS-SPE-0001 |

# Document status history & authorization

| State | Updater | Verifier | Date of change | Revision | Revision comment |
|---|---|---|---|---|---|
| Under editing | Bart Dwars | Dion Gigengack | 09 Mar 22 | S15 | update of revision table |
| Waiting for internal approval | Bart Dwars | Bart Dwars | 09 Mar 22 | P16 | - |
| Internally approved | Bart Dwars | Bart Dwars | 09 Mar 22 | C14 | approved |
| For review at customer | Cindy Kruse | Cindy Kruse | 10 Mar 22 | C15 | For revieew to customer |
| - | - | - | - | - | - |
| - | - | - | - | - | - |
| - | - | - | - | - | - |

# Table of Contents

Document details ..... 2
Document status history & authorization ..... 2
1. Abbreviations ..... 4
2. Reference and Standards ..... 5
3. Introduction ..... 6
4. Project Design Parameters ..... 7
5. Cable data sheet ..... 8
5.1 Cross-sectional drawing ..... 8
5.2 General ..... 8
5.3 Cable construction ..... 9
5.4 Cable Electrical Parameters ..... 11
5.5 Cable Mechanical Parameters ..... 12
5.6 Cable Bending Stiffness vs bending Radius ..... 13
5.7 Cable curvature tension vs bending Radius ..... 15
5.8 Cable Drain wire ..... 15



CONFIDENTIAL
All rights reserved. All data, knowledge and information provided in this letter is strictly confidential. Passing on or copying of this document, use and communication of its contents are not permitted without prior written authorization from B.V. Twentsche Kabelfabriek. As a result of our continuous innovative development program, we reserve the right to carry through technical changes with similar or improved functional product specifications. No rights may be derived from the contents of this letter.

## Version History (No. of Submittals to VOOW)

| (VOOW) Rev. no. | Purpose | Description of (if any) Updated/Modified Sections |
|---|---|---|
| 0 | First submittal | Initial version of document |
| 1 | Second submittal | Updated with comments according to transmittal 144671-VO-TKF-TR-0012 13-08-2021 16:43 |
| 2 | Third submittal | Updated single core information |
| 3 | Fourth submittal | Updated with comments according to transmittal 144671-VO-TKF-TR-0018 02-09-2021 17:42 |
| 4 | Fifth submittal | Updated based on comments according to 144671-TKF-IAC-INS-SPE-0001-66kV Al 3x400 CONF143350 specification (incl. drain wire)-DRS from 08-10-2021 |
| 5 | Sixth submittal | Updated in accordance with 144671-TKF-IAC-INS-SPE-0001 66kV Al 3x400 CONF142760 specification (incl. drain wire) CRS |
| | | |
| | | |



CONFIDENTIAL
All rights reserved. All data, knowledge and information provided in this letter is strictly confidential. Passing on or copying of this document, use and communication of its contents are not permitted without prior written authorization from B.V. Twentsche Kabelfabriek. As a result of our continuous innovative development program, we reserve the right to carry through technical changes with similar or improved functional product specifications. No rights may be derived from the contents of this letter.

# 1. Abbreviations

The abbreviations as used in the text are to be interpreted as defined below:

| | |
|---|---|
| - AC | Alternated Current |
| - AL | Aluminium |
| - BARGE | Flat-bottomed boat |
| - CPS | Cable Protection System |
| - CLV | Cable Laying Vessel |
| - CSA | Cross Sectional Area |
| - Cu | Copper |
| - CIGRE | International Council on Large Electric Systems |
| - DC | Direct Current |
| - DOB | Depth Of Burial |
| - DOC | Depth Of Cover |
| - EN | European Standard |
| - EMPLOYER | VOOW – Van Oord Offshore Wind |
| - HD | Harmonization Document |
| - kA | Kilo Ampere |
| - kV | Kilo Volt |
| - kN | Kilo Newton |
| - HDPE | High density Polyethylene |
| - HOS | Hang-Off System |
| - Hz | Hertz (Electrical system frequency) |
| - FAT | Factory Acceptance Test |
| - IEC | International Electrotechnical Commission |
| - ISO | International Organization for Standardization |
| - OSS | Offshore Substation |
| - ITP | Inspection and Test Plan |
| - MBR | Minimum Bending Radius |
| - MVA | MegaVoltAmpere |
| - MW | MegaWatt |
| - kV | Kilo Volt |
| - SAT | Site Acceptance Test |
| - SM | Single Mode |
| - SWA | Steel wire armouring |
| - SoS | Scope of Supply |
| - SoW | Scope of Work |
| - SC | Semi Conductive |
| - SUPPLIER | BV Twentsche Kabelfabriek (TKF) |
| - PROJECT | Hollandse Kust Noord |
| - OF | Optical Fibre |
| - TJ | Transition Joint |
| - TB | Technical Brochure |
| - WTG | Wind Turbine Generator |
| - LWT | Longitudinal Water Tightness |
| - LAT | Lowest Astronomical Tide |
| - RWT | Radial Water Tightness |
| - PP | Poly Propylene |
| - UV | Ultra Violet |
| - XLPE | Cross-linked Polyethylene |


CONFIDENTIAL
All rights reserved. All data, knowledge and information provided in this letter is strictly confidential. Passing on or copying of this document, use and communication of its contents are not permitted without prior written authorization from B.V. Twentsche Kabelfabriek. As a result of our continuous innovative development program, we reserve the right to carry through technical changes with similar or improved functional product specifications. No rights may be derived from the contents of this letter.

# 2. Reference and Standards

1. HKN-A.01.00_App5_Annex_3_HKN-.03.01_Design_and_supply_of_infield_cables_V5IEC
2. 14.4671 VOOW - ITT IAC CR Rev.2 2021-04-19
3. IEC 60840 Power Cables with Extruded Insulation and their Accessories for Rated Voltages above 30 kV (Um= 36 kV) up to 150 kV (Um = 170 kV) – Test Methods and requirements
4. IEC 60228 Conductors of Insulated Cables.
5. IEC 60287 Electric cables - Calculation of the current rating
6. IEC 60229 Tests on extruded over sheaths with a special protective function
7. ITU-T G.657 Characteristics of a bending-loss insensitive single-mode optical fibre and cable
8. ITU-T G.652 D Characteristics of a single-mode optical fibre and cable
9. ITU-T G.650.1 Definitions and test methods for linear, deterministic attributes of single-mode fibre and cable
10. CIGRE Technical Brochure 490 Recommendations for Testing of Long AC Submarine Cables with Extruded Insulation for System Voltage above 30 (36) to 500 (550) kV. (replaces CIGRE 189-1)
11. CIGRE Technical Brochure 623 Recommendations for Mechanical Testing of Submarine Cables. (UM=7.2 KV) up to 60 KV (UM = 72.5 KV).

member of the TKH Group

CONFIDENTIAL
All rights reserved. All data, knowledge and information provided in this letter is strictly confidential. Passing on or copying of this document, use and communication of its contents are not permitted without prior written authorization from B.V. Twentsche Kabelfabriek. As a result of our continuous innovative development program, we reserve the right to carry through technical changes with similar or improved functional product specifications. No rights may be derived from the contents of this letter.

# 3. Introduction

The Hollandse Kust (noord) Wind Farm Zone (HKNWFZ) is located 10 Nautical Miles off the west coast of the Netherlands. There has been one Wind Farm Site designated in the HKNWFZ: Hollandse Kust (noord) Wind Farm Site (HKNWFS), see Figure 1-1. The total surface area (including maintenance and safety zones) of the HKNWFS is approximately 125 [km2]. HKNWFS will accommodate sixty-nine (69) SG 11.0-200 DD turbines of 11.0 [MW] plus one (1) optional innovation position, resulting in a total capacity of approx. 760 [MW].
The HKNWFS crosses several existing telecom cables and pipelines. The existing Princess Amalia Wind Farm (120 [MW]) lies within the HKNWFZ.




Figure 3-1: Hollandse Kust (Noord) project area

The Hollandse Kust Noord (HKN) wind farm consists of 69 wind turbines with 12 strings (open loops), 1 optional innovative foundation (HKN 70) and 1 OSS. Between the wind turbines the array cable connection is based on 66 [kV] 3x400 [mm2 ] Al cables, 66 [kV] 3x630 [mm2 ] Al cables and 66 [kV] 3x800 [mm2 ]. Water depths range from -26.5 m to -18 m (LAT).


CONFIDENTIAL
All rights reserved. All data, knowledge and information provided in this letter is strictly confidential. Passing on or copying of this document, use and communication of its contents are not permitted without prior written authorization from B.V. Twentsche Kabelfabriek. As a result of our continuous innovative development program, we reserve the right to carry through technical changes with similar or improved functional product specifications. No rights may be derived from the contents of this letter.

# 4. Project Design Parameters

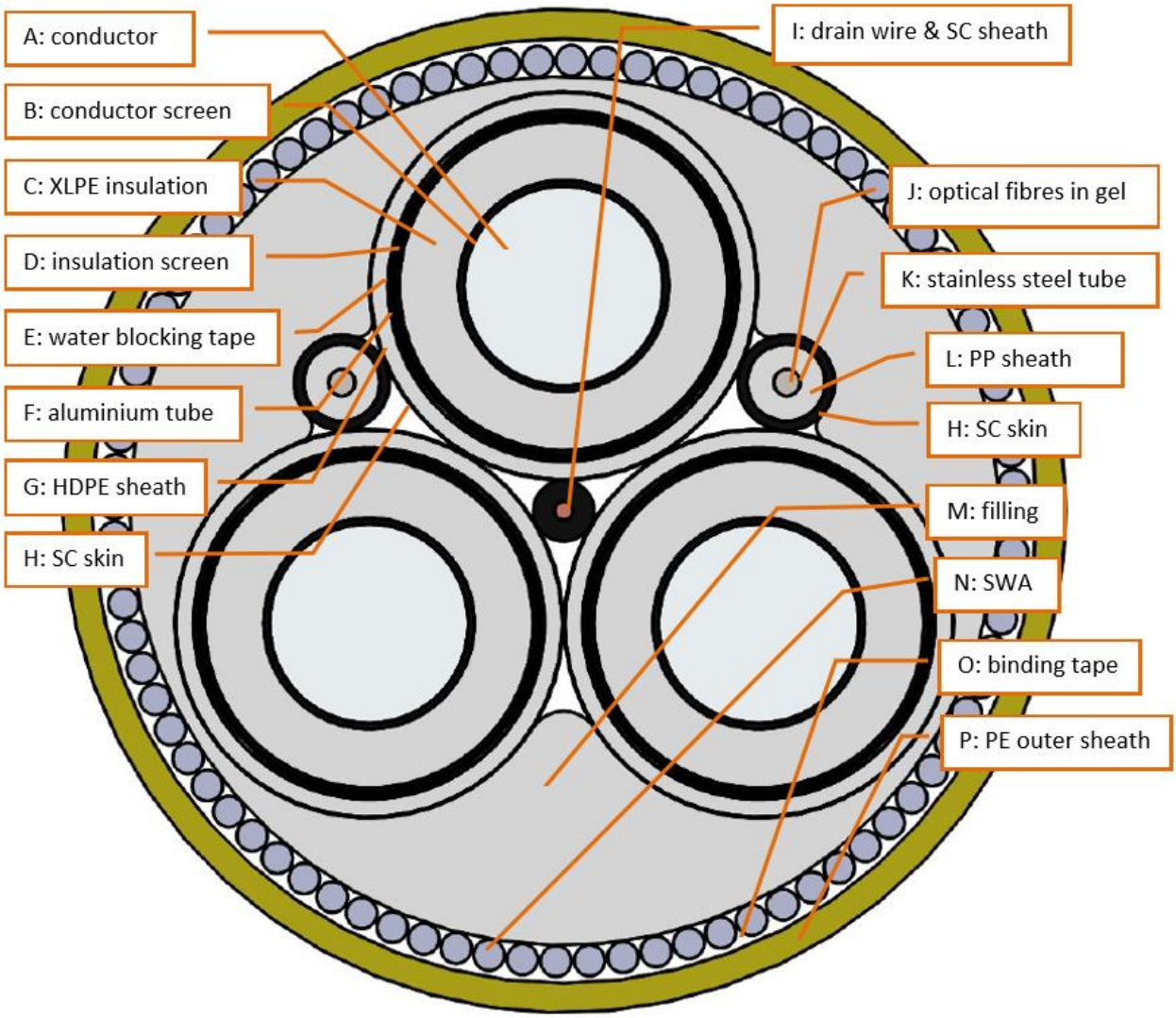
| Parameter | Value |
|---|---|
| Cable Type | Three-Core Composite Cable |
| Conductor Material | Aluminium |
| Conductor Insulation | XLPE |
| Metallic Screen | Aluminium welded sheath |
| Nominal Voltage phase to phase [kV] | 66 |
| Maximum rated continuous phase-to phase operating voltage [kV] | 72.5 |
| Rated nominal power per WTG | 11.55 MW |
| Rated nominal current (Ir) (IEC 60287) per WTG | 112.3 Amperes<br>Based on 11.55MW & power factor (cos φ) = ±0.9 |
| Rated max short-circuit current 3 phase | 800mm2: 21.2 kA at OSS<br>630mm2: 20.5 kA at HKN 36<br>400mm2: 19.8 kA at HKN 37 |
| Bonding of metal sheaths (including drain wires and stainless steel tube of fibre optic cable) and armouring wires of the Infield cable | The sheaths of the individual cores as well as the armouring shall be properly earthed at both Infield Cable ends (solid bonding) |
| Single phase short circuit current | 7.9 kA for duration 0.6 second (400 mm2 AL)<br>8.0 kA for duration 0.6 second (630 mm2 AL)<br>8.1 kA for duration 0.6 second (800 mm2 AL) |
| Rated voltage phase to phase (U) | 66 kV |
| Rated voltage phase to ground (Uo) | 38 kV |
| Maximum voltage in system (Um) | 72.5 kV |
| The operating frequency | 50 Hz |
| Basic Impulse Level | 325 kV |



CONFIDENTIAL
All rights reserved. All data, knowledge and information provided in this letter is strictly confidential. Passing on or copying of this document, use and communication of its contents are not permitted without prior written authorization from B.V. Twentsche Kabelfabriek. As a result of our continuous innovative development program, we reserve the right to carry through technical changes with similar or improved functional product specifications. No rights may be derived from the contents of this letter.

# 5. Cable data sheet

## 5.1 Cross-sectional drawing




Below are the 3x1x400 mm2 general, electrical and mechanical parameters presented:

## 5.2 General

| Information | Specifications | Unit |
|---|---|---|
| TKF article number | 304402 | |
| Article class | Subsea cable | |
| Type | AL/XLPE/Al/SWA/PE 38/66 (72.5) kV | |
| Description | 3 x 1 x 400 Al + 2 x 36 SM | |
| Net Weight (dry) | 253 | N/m |
| Weight under water | 115 | N/m |


CONFIDENTIAL
All rights reserved. All data, knowledge and information provided in this letter is strictly confidential. Passing on or copying of this document, use and communication of its contents are not permitted without prior written authorization from B.V. Twentsche Kabelfabriek. As a result of our continuous innovative development program, we reserve the right to carry through technical changes with similar or improved functional product specifications. No rights may be derived from the contents of this letter.

| | | |
|---|---|---|
| Marking power core | {Length} m TKF 1 x 400 mm² Al 38/66 (72.5) kV {Production order number} {Year} {phase number in white} | |
| Marking outer sheath | {Length} m TKF - 38/66 (72.5)kV - 3 x 1 x 400 Al + 2 x 36 SM-FO IEC60840 { Production order number } {Year} SUBSEA | |

## 5.3 Cable construction

| Cable Construction | Specifications | Unit |
|---|---|---|
| Standardization | IEC 60840, CIGRE TB 490, CIGRE TB 623 | |
| Number of cores | 3 | pc |
| Number of FO cables | 2 | pc |
| **Single Power cores** | | |
| Nominal cross section conductor | 400 | $mm^2$ |
| Conductor material | Aluminium (1050) | |
| Conductor weight | 2 | Kg/m |
| Shape of conductor | Round | |
| Conductor category | IEC 60228, Class 2 compacted | |
| Nominal earth screen cross section | 68.6 | mm2 |
| Core insulation | XLPE | |
| Earth screen construction | Welded aluminium sheath (smooth) | |
| Longitudinal water blocking conductors | YES (SC compound) | |
| Longitudinal water blocking screen | YES (SC water blocking tape) | |
| Conductor diameter | 24.7±0.5 | mm |
| Nominal conductor screen thickness | 0.8 | mm |
| Nominal diameter conductor screen | 26.3±1 | mm |
| Nominal Insulation thickness | 8 | mm |
| Diameter over insulation | 42.3±1 | mm |
| Nominal insulation screen thickness | 0.5 | mm |
| Nominal diameter insulation screen | 43.3±1 | mm |
| Diameter over SC water blocking tape | 43.9±1 | mm |
| Nominal thickness metal sheath (1050 aluminium) | 0.5 | mm |
| Nominal diameter metal sheath | 44.9±1 | mm |
| Inner sheath thickness (total of adhesive ,HDPE and SC skin) | 3 | mm |
| Screen weight per m | 0.19 | kg/m |



CONFIDENTIAL
All rights reserved. All data, knowledge and information provided in this letter is strictly confidential. Passing on or copying of this document, use and communication of its contents are not permitted without prior written authorization from B.V. Twentsche Kabelfabriek. As a result of our continuous innovative development program, we reserve the right to carry through technical changes with similar or improved functional product specifications. No rights may be derived from the contents of this letter.

| | | |
|---|---|---|
| Inner sheath material | LDPE(glue)/HDPE/LDPE(SC) | |
| SC skin thickness | 0.2 | mm |
| Nominal diameter power core | 50.7±1 | mm |
| Weight of single core in air | 2.8 | Kg/m |
| Weight of single core in water | 0.73 | Kg/m |
| **Fibre optic cables** | | |
| Type fibre optic element | 1 x 316L tube, 36 x SM | |
| Material tube | Stainless steel 316 (1.4401) | |
| Diameter fibre optic cable | 13 | mm |
| Mass of FOC | 48 | Kg/km |
| **Assembled 3 core cable** | | |
| Number of FO cables | 2 | |
| Lay-up configuration | S-lay | |
| Lay length power cores | 1199 | mm |
| Lay-up loss of power cores | 1.2 | % |
| Lay-up loss of optical fibre cable | 1.4 | % |
| Thickness polymeric bedding layer | 2 | mm |
| Filling material between cores, type of material, solid or lose | Polymer, solid | |
| Thickness armouring | 4.2 | mm |
| Number of armour wires | 79 | |
| Lay length armour wires | 2064 | mm |
| Armouring weight per m | 7.6 | kg/m |
| Steel type | Grade 34 +Z275 class A | |
| Material outer sheath | PE | |
| UV resistant (outer sheath) | YES | |
| Outer sheath thickness | 4 | mm |
| Outer diameter approx. | 132±3 | mm |
| Maximum stack height | 5 | m |
| Aluminium weight of single Power core (nominal) | 1.2 | Kg/m |
| Copper weight (nominal) | 0.04 | Kg/m |
| Steel weight (nominal) | 8.7 | Kg/m |
| Weight of cable in air | 25.9 | Kg/m |



CONFIDENTIAL
All rights reserved. All data, knowledge and information provided in this letter is strictly confidential. Passing on or copying of this document, use and communication of its contents are not permitted without prior written authorization from B.V. Twentsche Kabelfabriek. As a result of our continuous innovative development program, we reserve the right to carry through technical changes with similar or improved functional product specifications. No rights may be derived from the contents of this letter.

| | | |
|---|---|---|
| Weight of cable in water | 11.9 | Kg/m |

## 5.4 Cable Electrical Parameters

| Technical characteristics (electrical) | Specifications | Unit |
|---|---|---|
| Nominal voltage $U_0$ | 38 | kV |
| Nominal voltage U | 66 | kV |
| Nominal voltage $U_{max}$ | 72.5 | kV |
| Frequency | 50 | Hz |
| Basic impulse level | 325 | kV |
| Mutual capacitance (Nominal) | 0.29 | µF/km |
| Maximum conductor temperature | 90 | °C |
| Conductor AC resistance @ 90°C Conductor temp (maximum)[1] | 101.7 | mΩ/km |
| Conductor DC resistance @ 20°C (maximum)[1] | 77.8 | mΩ/km |
| Metal sheath DC resistance @ 20°C (maximum)[1] | 418.5 | mΩ/km |
| Max. short-circuit temperature conductor | 250 | °C |
| Max. short-circuit temperature metal sheath | 180 | °C |
| Max conductor short circuit current for 1 second (adiabatic) | 38.3 | kA |
| Max conductor short circuit current for 1 second (non-adiabatic) | 38.8 | kA |
| Max screen short-circuit current for 0.6 second (non-adiabatic, $T^{start}$ 78 degrees C) | 8.5 | kA |
| Impedance at 50Hz at 90°C-modules | 157 | mΩ/km |
| Impedance at 50Hz at 90°C-angle | 49.7 | ° |
| Charging current per phase at rated voltage | 3.5 | A/km |
| Dielectric loss factor of XLPE insulation (95-100ºC) | ≤10 x $10^{-4}$ | |
| Inductance of conductor | 0.382 | mH/km |
| Inductance of earth screen | 0.165 | mH/km |
| Positive sequence impedance at 20°C, split into real and imaginary part, X + j*Y | 80.4<br>98.7 | mΩ /km |
| Negative sequence impedance at 20°C, split into real and imaginary part, X + j*Y | 80.4<br>98.7 | mΩ /km |
| Positive sequence impedance at 50°C, split into real and imaginary part, X + j*Y | 89.5<br>98.7 | mΩ /km |
| Negative sequence impedance at 50°C, split into real and imaginary part, X + j*Y | 89.5<br>98.7 | mΩ /km |

CONFIDENTIAL
All rights reserved. All data, knowledge and information provided in this letter is strictly confidential. Passing on or copying of this document, use and communication of its contents are not permitted without prior written authorization from B.V. Twentsche Kabelfabriek. As a result of our continuous innovative development program, we reserve the right to carry through technical changes with similar or improved functional product specifications. No rights may be derived from the contents of this letter.

| | | |
|---|---|---|
| Positive sequence impedance at 90°C, split into real and imaginary part, X + j*Y | 101.8<br>98.7 | mΩ /km |
| Negative sequence impedance at 90°C, split into real and imaginary part, X + j*Y | 101.8<br>98.7 | mΩ /km |
| Zero sequence impedance at 20°C, split into real and imaginary part, X + j*Y | 353.6<br>542.9 | mΩ /km |
| Zero sequence impedance at 20°C, split into real and imaginary part, X + j*Y current path earth screen + armour wires | 201.5<br>161.3 | mΩ /km |
| Zero sequence impedance at 90°C, split into real and imaginary part, X + j*Y current path earth screen + armour wires | 253.2<br>161.3 | mΩ /km |
| Dielectric losses (DC) at 66kV (Insulation losses) | 0.1341 | W/m |
| Maximum cable ampacity [3] | 574 | A |
| Conductor losses at 100% max cable ampacity [3] | 33.5 | W/m |
| Sheath losses at 100% max cable ampacity [3] | 2.4 | W/m |
| Armour losses at 100% max cable ampacity [3] | 14.1 | W/m |
| Electrical stress at inner semi-con at U0 [2] | 6.08 | kV/mm |
| Electrical stress at outer semi-con at U0 [2] | 3.78 | kV/mm |

1. Resistance is applicable to complete array cable where lay loss factor was accounted for
2. Electrical stress calculated based on nominal dimensions of the insulation
3. Cable buried in seabed under DOB of 2 meter with 0.6m seabed dynamics, seabed temperature 14.3ºC, thermal resistivity of 0.6, losses calculation based on IEC60287

## 5.5 Cable Mechanical Parameters

| Technical characteristics (mechanical) | Specifications | Unit |
|---|---|---|
| Minimum coiling radius | 6 | m |
| Minimum coiling height | 18 | m |
| Minimum bending radius of single core cable during installation (with tension) | 0.9 | m |
| Minimum bending radius cores cleated | 0.9 | m |
| Minimum bending radius cores temporary storage | 0.9 | m |
| Minimum bending radius cores during production on the lay-up drum | 0.9 | m |
| Minimum bending radius during installation | 1.8 | m |
| Minimum bending radius after installation | 1.56 | m |
| Minimum bending radius of three-core armoured subsea cable during storage (drum/carrousel) | 1.56 | m |
| Elastic torsion stiffness (calculated) | 19.04 | kN.m2/rad |
| Elastic bending stiffness (calculated) | 6.94 | $kNm^2$ |

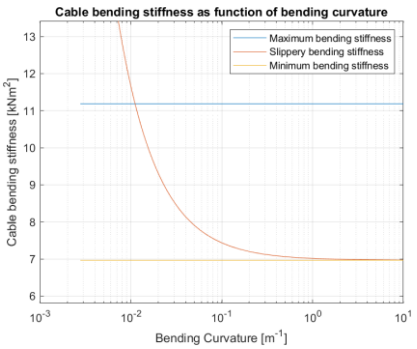
member of the TKH Group
CONFIDENTIAL
All rights reserved. All data, knowledge and information provided in this letter is strictly confidential. Passing on or copying of this document, use and communication of its contents are not permitted without prior written authorization from B.V. Twentsche Kabelfabriek. As a result of our continuous innovative development program, we reserve the right to carry through technical changes with similar or improved functional product specifications. No rights may be derived from the contents of this letter.

| | | |
|---|---|---|
| specific gravity | 1.89 | |
| SWL (Max straight cable tension) | 186 | kN |
| Nominal permanent tensile strength | 17.14 | kN |
| MBL (ultimate Tensile Strength) | 452.2 | kN |
| Maximum allowed pulling force, straight pull (Safe Working Load) for power core | 102.5 | kN |
| Maximum permissible tension in the conductor without joints | 21 | kN |
| Maximum water ingress under project conditions for conductor metal sheath and FO cable | 10 | meter |
| Maximum tension at MBR during installation | 85 | kN |
| Axial stiffness (based on not fixated situation) | 165 | MN |
| Maximum axial straight compression | 30 | kN |
| Crush load (Cigre 623, 6.3) | 500 | kN/m |
| Crush load for long term stacking (Cigre 623, 6.4) | 167 | kN/m |
| Sidewall force (Cigre 623, 6.5 distributed contact) | 47 | kN/m |
| Minimum installation temperature | -10 | °C |

## 5.6 Cable Bending Stiffness vs bending Radius

The graph below shows the relation between the cable bending stiffness at different bending radii. These parameters should take into account for cable installation.

member of the TKH Group
CONFIDENTIAL
All rights reserved. All data, knowledge and information provided in this letter is strictly confidential. Passing on or copying of this document, use and communication of its contents are not permitted without prior written authorization from B.V. Twentsche Kabelfabriek. As a result of our continuous innovative development program, we reserve the right to carry through technical changes with similar or improved functional product specifications. No rights may be derived from the contents of this letter.

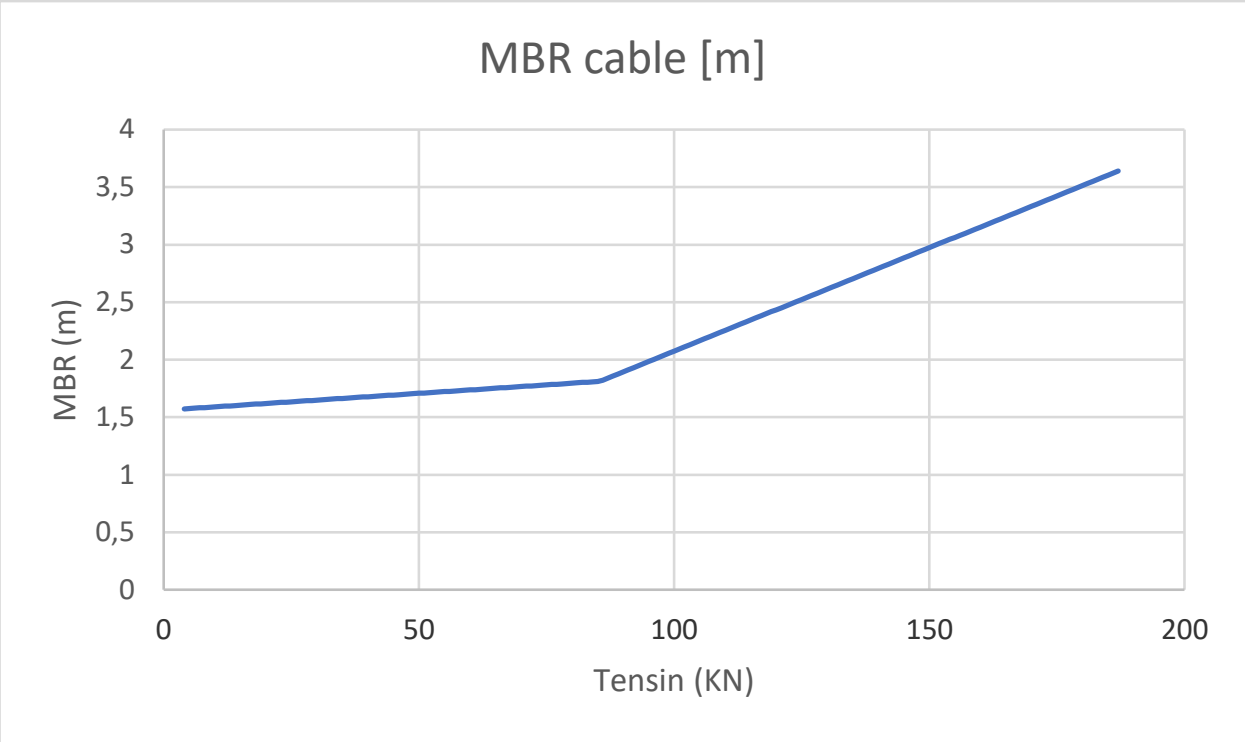





CONFIDENTIAL
All rights reserved. All data, knowledge and information provided in this letter is strictly confidential. Passing on or copying of this document, use and communication of its contents are not permitted without prior written authorization from B.V. Twentsche Kabelfabriek. As a result of our continuous innovative development program, we reserve the right to carry through technical changes with similar or improved functional product specifications. No rights may be derived from the contents of this letter.

## 5.7 Cable curvature tension vs bending Radius

The Curvature -Tension relation for 400 mm2 cable is presented in the following figure.

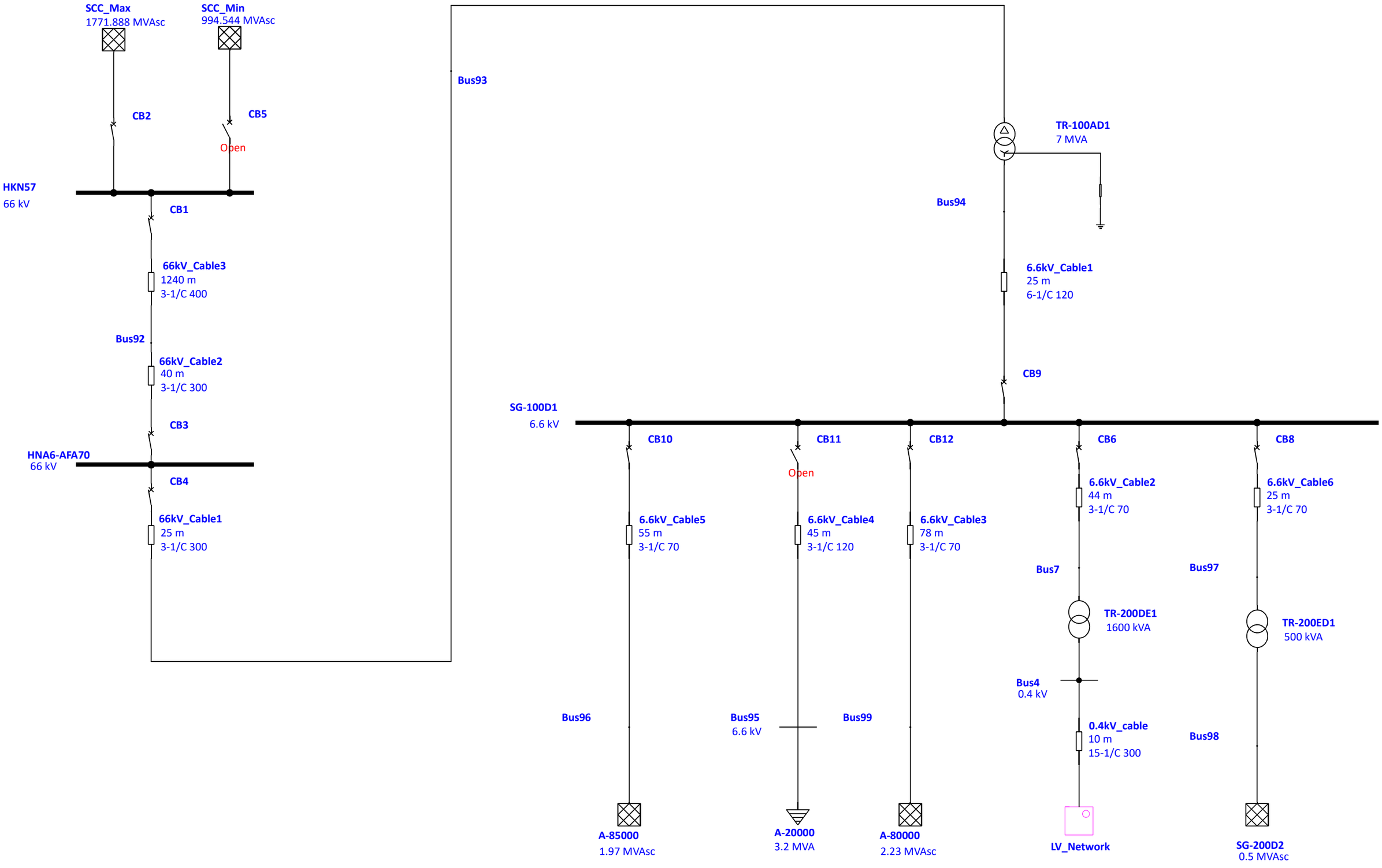



## 5.8 Cable Drain wire

| Construction | Specification | Unit |
|---|---|---|
| Nominal cross section | 4 | $mm^2$ |
| Conductor material | Copper | |
| Core insulation | Semi conductive HDPE | |
| Colour of outer sheath | Black | |
| **Cable construction details** | | |
| Conductor Diameter | 2.5 | mm |
| Outer sheath thickness | 3.4 | mm |
| Outer diameter | 9.2 | mm |
| MBR and MBR during and after installation | 0.25 | m |
| **Electrical Parameter** | | |
| Electrical resistance @ 20°C DC – core | 4.61 (from IEC 60228 ) | Ω /km |


CONFIDENTIAL
All rights reserved. All data, knowledge and information provided in this letter is strictly confidential. Passing on or copying of this document, use and communication of its contents are not permitted without prior written authorization from B.V. Twentsche Kabelfabriek. As a result of our continuous innovative development program, we reserve the right to carry through technical changes with similar or improved functional product specifications. No rights may be derived from the contents of this letter.

Attachment 6 Etap Single Line Diagram


SCC_Max
1771.888 MVAsc
SCC_Min
994.544 MVAsc
CB2
CB5
Open
HKN57
66 kV
CB1
66kV_Cable3
1240 m
3-1/C 400
Bus92
66kV_Cable2
40 m
3-1/C 300
CB3
HNA6-AFA70
66 kV
CB4
66kV_Cable1
25 m
3-1/C 300
Bus93
TR-100AD1
7 MVA
Bus94
6.6kV_Cable1
25 m
6-1/C 120
CB9
SG-100D1
6.6 kV
CB10
CB11
CB12
CB6
CB8
Open
6.6kV_Cable5
55 m
3-1/C 70
6.6kV_Cable4
45 m
3-1/C 120
6.6kV_Cable3
78 m
3-1/C 70
6.6kV_Cable2
44 m
3-1/C 70
6.6kV_Cable6
25 m
3-1/C 70
Bus7
Bus97
TR-200DE1
1600 kVA
TR-200ED1
500 kVA
Bus4
0.4 kV
0.4kV_cable
10 m
15-1/C 300
Bus98
Bus96
Bus95
6.6 kV
Bus99
A-85000
1.97 MVAsc
A-20000
3.2 MVA
A-80000
2.23 MVAsc
LV_Network
SG-200D2
0.5 MVAsc