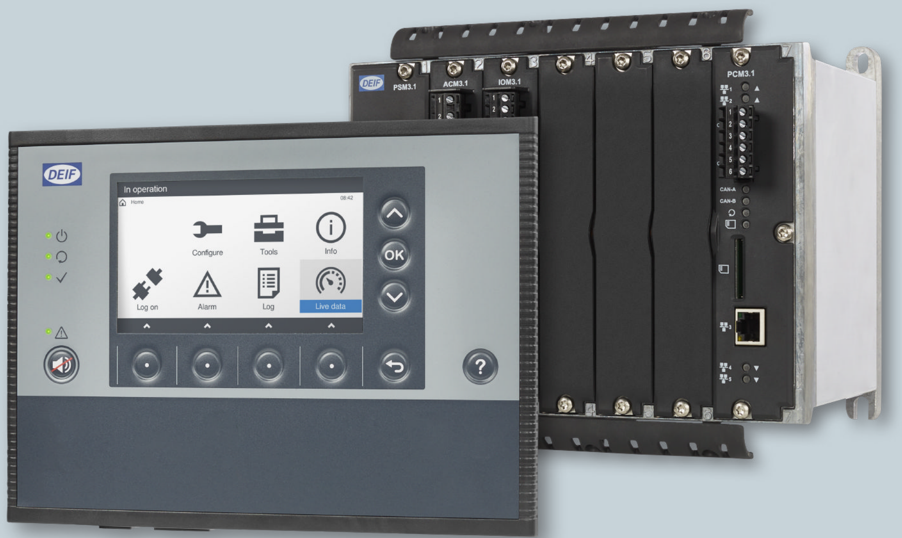
-power in control

# DESIGNER'S HANDBOOK

## Generator Protection Unit
## GPU 300





DEIF A/S · Frisenborgvej 33 · DK-7800 Skive
Tel.: +45 9614 9614 · Fax: +45 9614 9615
Info@deif.com · www.deif.com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## 1. Introduction



## 2. Product principles



## 3. Controller

## 5. AC configuration and nominal settings



## 6. Breaker

# 1. Introduction

## 1.1 About the Designer's handbook

### 1.1.1 General purpose

This is the designer's handbook for DEIF's Generator Protection Unit, GPU 300. The designer's handbook provides information required to design and configure GPU 300 controllers.

**DANGER!**
**Read this manual before designing the system. Failure to do this could result in human injury or damage to the equipment.**

### 1.1.2 Intended users of the Designer's handbook

The Designer's handbook is primarily for the person who designs the control system, electrical system, and communication system where the controllers are installed. This includes drawing the system drawings, setting the controller parameters, and selecting and setting up the protections and functions.

The Designer's handbook can also be used during commissioning to check the design drawings and the controller parameters. Operators may find the Designer's handbook useful for understanding the system and for troubleshooting.

### 1.1.3 Symbols and conventions in the Designer's handbook

The **Designer's handbook** uses the following symbols and conventions.

#### Inputs and outputs

Most of the controller inputs and outputs are configurable. You can assign functions to inputs or outputs by using either the display unit or PICUS. To assign a function, under **Configure > Input/output**, select a hardware module, then select a set of terminals to configure.

#### Parameters

You can select and change the parameters by using either the display unit or PICUS, under **Configure > Parameters**.

#### Functions

As far as possible, the Designer's handbook descriptions are based on functions. This means that the relevant input and output functions, and parameters are grouped together in each function description. There are no separate, general lists of input functions, output functions, and parameters.

#### Multi-function parameters and IOs

Some parameters and inputs/outputs can be used by more than one function. Search the **whole** Designer's handbook to see the impact of a change.

**Parameter used by more than one function example**

For a controller, **Configure > Parameters > Generator > Nominal settings > Voltage** is the genset *Nominal voltage*. The *Nominal voltage* is the basis for all the voltage alarms.

### General names

Square brackets [ ] are used to create general names. General names are used to avoid repeating the same function description.

> **Use of square brackets examples**
>
> *[Controlled equipment]* represents the *Generator* for a controller.
>
> *[Hardware module]* represents the relevant controller hardware module.
>
> *[Breaker]* represents the *Generator breaker* for a controller.

### Numbered possibilities

The hash symbol # is used when there are several numbered possibilities, to avoid repeating the same function description for each numbered possibility.

> **Use of hash # example**
>
> *NEL ID #*: # represents 1 to 3. That is, you can configure up to three non-essential loads.

## 1.1.4 Recommended design process

DEIF recommends the following design process:

1. Make a list of the functions required for the controller.
   - For each function, list the required controller inputs and outputs.
2. Order the controller from DEIF.
   - Ensure that the controller has terminals available for all the required inputs and outputs.
3. Install the controller with a power supply and Ethernet communication.
4. Using PICUS, connect to the controller and do the following:
   a. Under **Configure > IO**, assign the required input and output functions.
   b. Under **Configure > Parameters**, starting with the AC and nominal settings, configure the parameters.
   c. Under **Configure > CustomLogic**, create additional functions if required.
   d. Under **Tools > Backups**, make a backup of the configuration.

## 1.1.5 Software version

This **Designer's handbook** corresponds to the following software versions.

**Table 1.1** Software versions

| Software | Details | Version |
|---|---|---|
| PCM APPL | Controller application | GPU 1.0.x |
| DU APPL | Display unit application | GPU 1.0.x |
| PICUS | Utility software | 1.0.0.x |

### 1.1.6 Technical support

You can read about service and support options on the DEIF website, www.deif.com. You can also find contact details on the DEIF website.

You have the following options if you need technical support:

- Help: The display unit includes context-sensitive help.
- Technical documentation: Download all the product technical documentation from the DEIF website: www.deif.com/documentation
- Training: DEIF regularly offers training courses at the DEIF offices worldwide.
- Support: DEIF offers 24-hour support. See www.deif.com for contact details. There may be a DEIF subsidiary located near you. You can also e-mail support@deif.com.
- Service: DEIF engineers can help with design, commissioning, operating and optimisation.

### 1.1.7 List of technical documentation for GPU 300

| Document | Contents |
|---|---|
| Data sheet | • Controller application, functions, hardware and protections<br>• Technical specifications<br>• Hardware modules, display unit, and accessories<br>• Ordering information |
| Quick start guide | • Mounting<br>• Connecting wiring<br>• PICUS (PC software)<br>◦ Download and install<br>◦ Controller configuration<br>• Display unit overview |
| Designer's handbook | • Controller principles and functions<br>• Alarms<br>• AC configuration and nominal settings<br>• Breaker<br>• Hardware characteristics<br>• PICUS parameters, alarms and passwords<br>• Modbus |
| Installation instructions | • Tools and materials<br>• Mounting<br>• Minimum wiring for the controller<br>• Wiring for hardware module terminals<br>• Wiring for controller functions<br>• Wiring communication<br>• Wiring the display unit |

| Document | Contents |
|---|---|
| Commissioning guidelines | • Tools, software and information required<br>• Controller and equipment checks<br>• Testing<br>• Troubleshooting |
| Operator's manual | • Controller equipment<br>• Operating the controller<br>• Alarms and log<br>• Using the display unit<br>• Troubleshooting and maintenance |
| PICUS manual | Using PICUS and CustomLogic |

## 1.2 Warnings and safety

### 1.2.1 Safety during installation and operation

Installing and operating the equipment may require work with dangerous currents and voltages. The installation must only be carried out by authorised personnel who understand the risks involved in working with electrical equipment.

**DANGER!**
**Hazardous live currents and voltages. Do not touch any terminals, especially the AC measurement inputs and the relay terminals. Touching the terminals could lead to injury or death.**

### 1.2.2 Controller power supply

If the controller has no power supply, it is OFF and does not provide any protection to the system. The controller cannot enforce any trip, block, or latch when it is off. All the controller relays de-energise.

The controller must have a reliable power supply, which must include a backup power supply. In addition, the switchboard design must ensure that the system is sufficiently protected if the controller power supply fails.

### 1.2.3 Factory settings

The controller is delivered pre-programmed from the factory with a set of default settings. These settings are based on typical values and may not be correct for your system. You must therefore check all parameters before using the controller.

### 1.2.4 Electrostatic discharge

You must protect the equipment terminals from static discharge during handling, including installation and dismounting. Once the equipment is correctly installed and the frame ground is connected, it is no longer necessary to protect the terminals from static discharge.

### 1.2.5 Shelving and taking alarms out of service

**DANGER!**
**Shelved and out of service alarms are completely disabled. These alarms cannot be activated by the operating conditions, and provide NO protection. Note: Shelving or taking out of service also automatically acknowledges the alarm and resets the latch.**

It is possible to shelve and/or take selected alarms out of service. However, only qualified personnel should shelve and/or take alarms out of service. This must be done carefully, and only as a temporary measure, for example, during commissioning.

### 1.2.6 Do not manually override active alarm actions

**DANGER!**
**Do not use switchboard or manual control to override the alarm action of an active alarm.**

An alarm may be active because it is latched, or because the alarm condition is still present. If the alarm action is manually overridden, a latched alarm does not do its alarm action again. In this situation, the latched alarm does not provide protection.

**Latched *Over-current* alarm example**

The controller trips a breaker because of over-current. The operator then manually (that is, not using the controller) closes the breaker while the *Over-current* alarm is still latched.

If another over-current situation arises, the controller **does not trip the breaker again**. The controller regards the original *Over-current* latched alarm as still active, and does not provide protection.

### 1.2.7 Do not use unsupported hardware modules

**CAUTION**
Only use the hardware modules that are listed in the controller data sheet. Unsupported hardware modules can make the controller malfunction.

## 1.3 Legal information

### 1.3.1 Third party equipment

DEIF takes no responsibility for the installation or operation of any third party equipment, including the **genset**. Contact the **genset company** if you have any doubt about how to install or operate the genset.

### 1.3.2 Warranty

**CAUTION**
The rack may only be opened to remove, replace, and/or add a hardware module. The procedure in the **Installation instructions** must be followed. If the rack is opened for any other reason, and/or the procedure is not followed, then the warranty is void.

**CAUTION**
If the display unit is opened, then the warranty is void.

### 1.3.3 Open source software

This product contains open source software licensed under, for example, the GNU General Public License (GNU GPL) and GNU Lesser Public License (GNU LGPL). The source code for this software can be obtained by contacting DEIF at support@deif.com. DEIF reserves the right to charge for the cost of the service.

### 1.3.4 Trademarks

DEIF, power in control and the DEIF logo are trademarks of DEIF A/S.

Modbus is a registered trademark of Schneider Automation Inc.

Windows is a registered trademark of Microsoft Corporation in the United States and other countries.

All trademarks are the properties of their respective owners.

### 1.3.5 Copyright



### 1.3.6 Disclaimer

DEIF A/S reserves the right to change any of the contents of this document without prior notice.

The English version of this document always contains the most recent and up-to-date information about the product. DEIF does not take responsibility for the accuracy of translations, and translations might not be updated at the same time as the English document. If there is a discrepancy, the English version prevails.

# 2. Product principles

## 2.1 Description

### 2.1.1 Overall description

The GPU 300 Generator Protection Unit is designed for marine use. Each controller contains all the functions that are needed to protect electrical equipment with a breaker, for example, a diesel generator, a busbar, or a motor.

Each controller includes processor technology and high-speed internal communication to provide fast protection functions.

The controller design is modular. Processor, communication, measurement, and input-output hardware modules may be replaced or added in the field. The controller automatically recognises the new hardware modules.

The controller display unit colour graphic screen allows fast access to live data. The operator can use the screen to manage alarms. With the right authorisation, the operator can also check and/or change the IO and parameter configuration. The light indicators of the display unit are visible over a long distance. The display processor can display all languages.

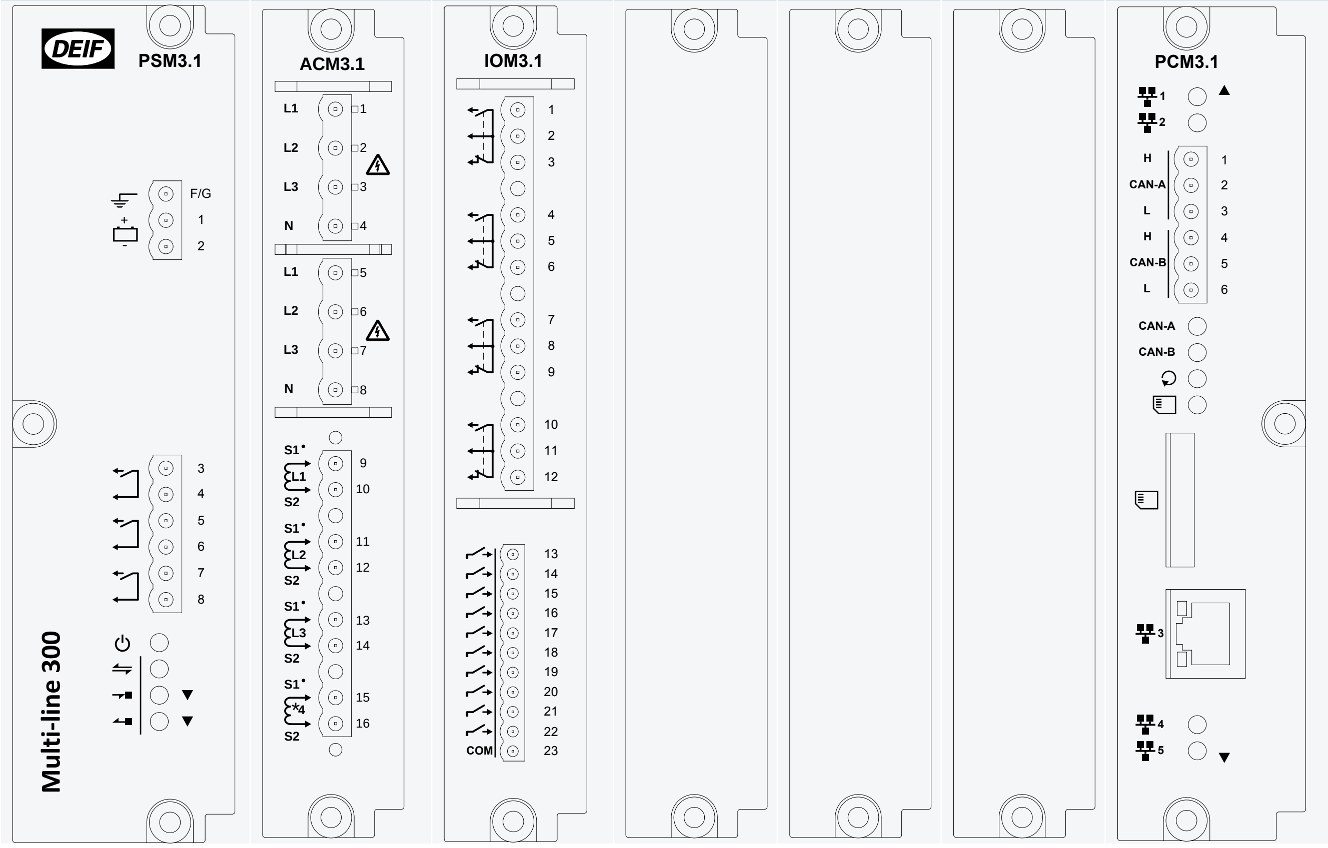
PICUS is a proprietary, free PC software interface to the controller. Use PICUS to configure the inputs, outputs and parameters for each controller.

### 2.1.2 Hardware configuration

The controller minimum hardware is described below. Up to three additional IOM3.1 hardware modules can be ordered, and installed in the empty slots. Spare hardware modules may also be ordered for installation in the field.

**Table 2.1** Default hardware configuration

| Slot 1 | Slot 2 | Slot 3 | Slot 4 | Slot 5 | Slot 6 | Slot 7 |
|---|---|---|---|---|---|---|
| PSM3.1 | ACM3.1 | IOM3.1 | Blind module | Blind module | Blind module | PCM3.1 |
| Power supply module | Alternating current module | Input output module | | | | Processor and communication module |



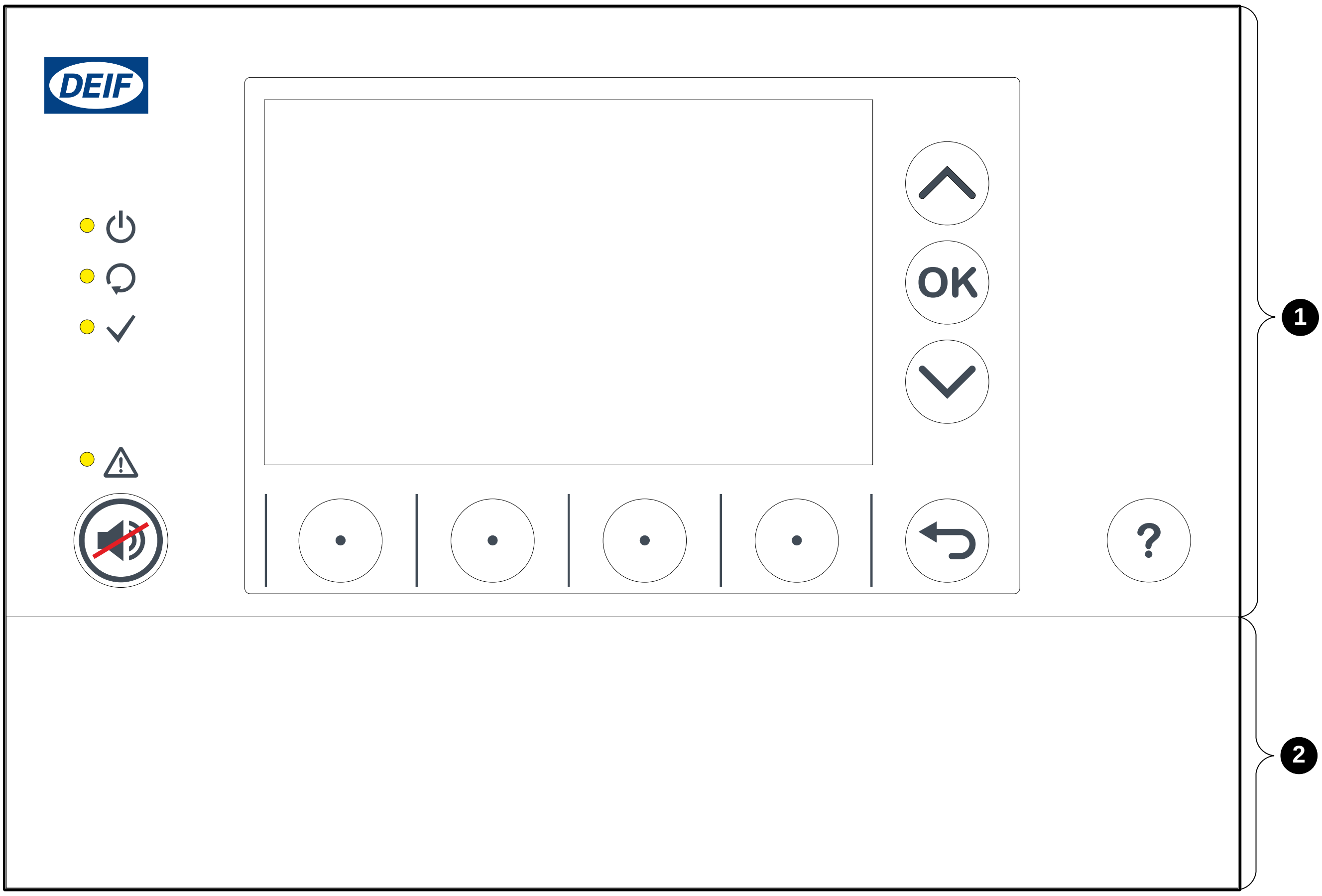

| | |
|---|---|
| **Weight** | Controller and display unit: 3180 g (7.0 lb)<br>Controller (including the default hardware modules): 2345 g (5.2 lb)<br>Display unit: 835 g (1.8 lb)<br>Ethernet cable: ±110 g (4 oz) |

## 2.1.3 Display unit options

The LEDs are shown in yellow on the display unit folios below.

### Default display unit

**Figure 2.1** Default: DU 300 (folio without AC detection LEDs)

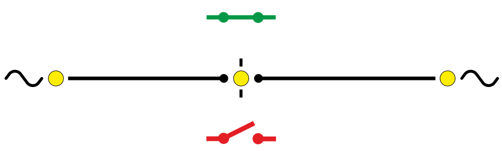



| No. | |
|---|---|
| 1 | Top part (Same for all display units) |
| 2 | Bottom strip (Default bottom strip shown) |

| | Functions |
|---|---|
| **Default display unit** | No LEDs for generator, breaker and busbar status |

### With LEDs

**Figure 2.2** Optional: DU 300 (folio with AC detection LEDs)



| | Functions |
|---|---|
| **Display unit with LEDs** | LEDs for generator, busbar and breaker status |

# 2.2 Principles

## 2.2.1 Understanding the controller versatility

The controller has configurable hardware, which in turn has configurable inputs and outputs. The controller gets information from the measurements, the inputs, and the network. The controller sends out information using the outputs, and the network.

### Configurable hardware

The controller has a default configuration. Hardware modules (IOM3.1) can be added. The controller software automatically detects the hardware in the rack. After you assign a function to an input or output, you can assign parameters to that function.

Most of the controller inputs and outputs can be assigned any function. Functions are **not** restricted to specific hardware modules.

The configuration information is attached to the rack, and not to the module hardware. If you change the sequence of the same type of hardware modules in the rack (for example, swap two IOM3.1), you can lose the hardware configuration information.

### Variety of input and output types

The controllers often allow the same function to use any one of a number of alternative types of inputs and/or outputs. This makes the controllers versatile and compatible with a wide range of equipment and systems.

### Information flow

The following drawing gives an overview of the ways that information can flow between a controller and the genset it controls. Information flow to the display unit, another controller, a PLC, and the switchboard is also shown.

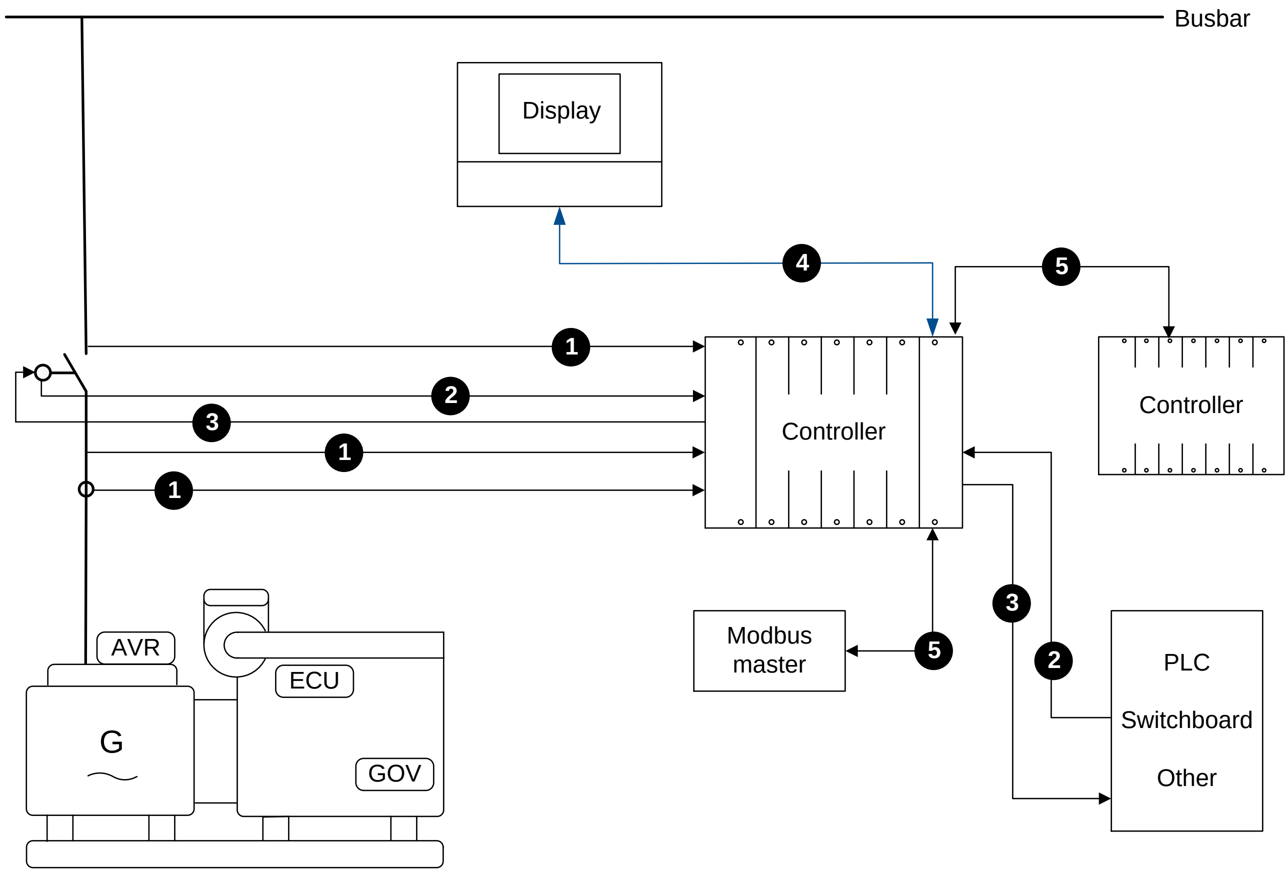



**Table 2.2** Example of information flow to and from a controller

| Point | Type | Description | Uses |
|---|---|---|---|
| 1 | AC measurements | The controller measures the AC voltage and current from the genset and the voltage on the busbar. | Protection, synchronisation, and logging. |
| 2 | Digital inputs | Digital measurement devices on the breaker can be connected to the controller. The controller can also receive digital inputs from the genset, a PLC, the switchboard, and other sources. | A wide variety of purposes, including protection, user inputs, various levels of alarms, and logging. |
| 3 | Digital outputs | The controller can activate digital outputs connected to the breaker, genset, a PLC, the switchboard (for example, for lights and counters), and other equipment. | A wide variety of purposes, including protections, status and alarm indicators, and as input to a PLC. |
| 4 | DEIF network | The DEIF equipment communicates with other DEIF equipment using this network. | Send commands and configuration changes from the display unit to the controller, and information from the controller to the display unit. |
| 5 | Ethernet network | The DEIF equipment communicates with other equipment using this network. | Check network redundancy. Send and receive Modbus data. |

## 2.2.2 Controller unpowered

A controller is unpowered if it loses power, for example, because its power supply is disconnected. When the controller is unpowered, none of its protections and functions are active.

An unpowered controller does not communicate with the rest of the network, and is invisible to the rest of the network.

### Effect of the unpowered controller hardware

Network links through the unpowered controller are broken.

All relays return to their de-energised hardware condition. For example, on IOM3.1 there is a changeover switch on terminals 1 to 3. If the controller loses power, then there will be an open circuit between terminals 1 and 2 (the normally open terminals of the changeover switch), and a closed circuit between terminals 2 and 3.

**INFO**
Even though a controller relay may be configured as normally energised, it is also de-energised if the controller loses power.

**CAUTION**
Class societies require an independent backup power supply for the controller, to avoid having an unpowered controller.

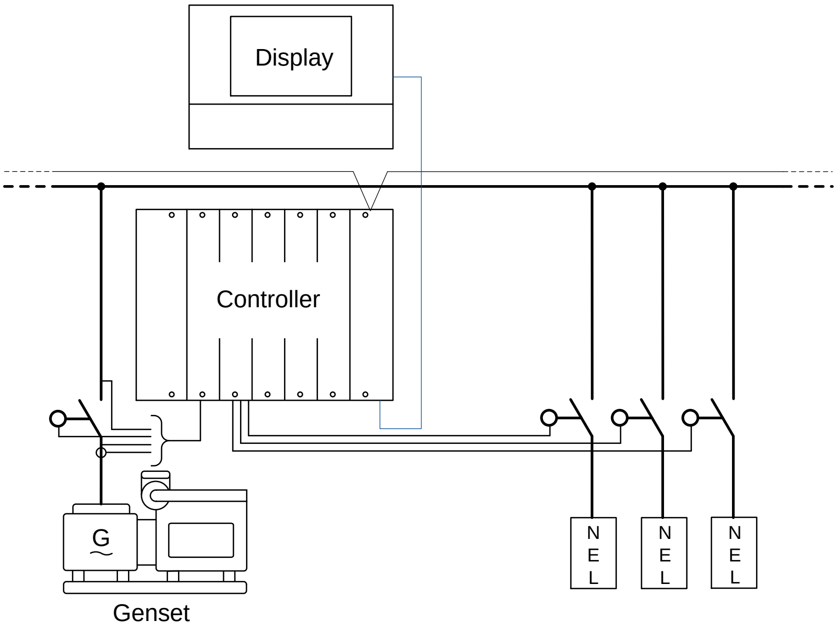
# 3. Controller

## 3.1 Overview

### 3.1.1 Application

The controller protects a generator breaker. Each controller can be connected to up to three non-essential load groups (NEL).

**Figure 3.1** Example of a controller application, with optional non-essential loads




### 3.1.2 Controller functions

| | Functions |
|---|---|
| **Breaker** | • Breaker trip and alarms<br>• Synchronisation check<br>• Breaker close (external command)<br>• Breaker position detection |
| **Counters** | • Active power (kW)<br>• Reactive power (kvarh)<br>• Running hours<br>• Breaker trips |
| **CustomLogic** | • User-friendly logic configuration tool, based on ladder logic and function blocks<br>• Selectable input events and output commands |

| | Functions |
|---|---|
| **Communication** | • Ethernet network<br>• Supports Internet Protocol version 6 (IPv6) and Internet Protocol version 4 (IPv4)<br>• Connects the controller to:<br>◦ Controller display unit<br>◦ PICUS<br>◦ Modbus<br>• Password protection<br>◦ Customisable permission levels |
| **Modular design** | • Compact, all-in-one controller<br>• Includes all necessary 3-phase measurements<br>• Remove, replace, or add extra hardware modules on-site<br>• Configurable inputs and outputs |
| **Plug & play system setup** | • Display unit with a 5-inch colour graphic display<br>◦ Live data monitoring and alarm management<br>◦ Input, output, and parameter configuration<br>◦ Context-sensitive help<br>• Automatic network configuration<br>• Default configuration for standard application<br>• Default configuration of hardware modules |
| **Redundancy** | • Configurable terminals<br>• Ethernet network ring connection |
| **Advanced troubleshooting** | • Controller hardware self-test<br>• Event and alarm log, with real-time clock<br>• Access to 24-hour service and support |
| **PICUS** | • Free-of-charge PC software<br>• Set up permissions<br>• Configure controller inputs, outputs, and parameters<br>• See live data<br>• Controller software updates |
| **Documentation** | • Free download at www.deif.com<br>◦ Data sheet<br>◦ Quick start guide<br>◦ Designer's handbook<br>◦ Installation instructions<br>◦ Commissioning guidelines<br>◦ Operator's manual<br>◦ PICUS manual<br>◦ Modbus table<br>• Context-sensitive help in the display unit |

# 3.2 Controller principles

## 3.2.1 Nominal settings

The controller nominal settings are used in a number of key functions. For example, many protection settings are based on a percentage of the nominal settings.

### Generator nominal settings

Configure these nominal settings under **Configure > Parameters > Generator > Nominal settings**.

**Table 3.1** Controller nominal settings

| Nominal setting | Range | Default | Notes |
|---|---|---|---|
| Voltage (V) | 10 V to 160 kV | 400 V | The phase-to-phase* nominal AC voltage for the genset. |
| Current (I) | 0 A to 9 kA | 867 A | The maximum current flow in one phase (that is, L1, L2 or L3) from the genset during normal operation. |
| Frequency (f) | 48 to 62 Hz | 50 Hz | The system nominal frequency, typically either 50 Hz or 60 Hz. All the controllers in the system should have the same nominal frequency. |
| Power (P) | 1 kW to 0.9 GW | 480 kW | The nominal active power may be on the genset nameplate. |
| Apparent power (S) | 1 kVA to 1 GVA | 530 kVA | The nominal apparent power should be on the genset nameplate. |
| Power factor (PF) | 0.6 to 1 | 0.9 | The power factor should be on the genset nameplate. |

Note: *The nominal voltage is always phase-to-phase, even when phase-to-neutral measurements are chosen.

Configure this under **Configure > Parameters > Generator > Nominal settings > Calculation method**:

**Table 3.2** Nominal setting calculation method

| Parameter | Range | Default |
|---|---|---|
| Reactive power (Q) nominal | Q nominal calculated<br>Q nominal = P nominal<br>Q nominal = S nominal | Q nominal calculated |
| P or S nominal | No calculation<br>P nominal calculated<br>S nominal calculated | No calculation |

See **AC configuration and nominal settings**, **Nominal power calculations** for more information.

### Busbar nominal settings

Configure these nominal settings under **Configure > Parameters > Busbar > Nominal settings**.

**Table 3.3** Controller nominal settings

| Nominal setting | Range | Default | Notes |
|---|---|---|---|
| Voltage (V) | 10 V to 160 kV | 400 V | The phase-to-phase nominal voltage for the busbar. If there are no transformers between the genset and the busbar, the nominal voltage for the busbar will be the same as the nominal voltage for the genset. |
| Frequency (f) | 48 to 62 Hz | 50 Hz | The system nominal frequency, typically either 50 Hz or 60 Hz. This should be the same as the genset nominal frequency, and all the controllers in the system should have the same nominal frequency. |

**4th current nominal settings**

Configure these nominal settings under **Configure > Parameters > 4th current > Nominal settings > Current (I4)**.

**Table 3.4** Controller nominal settings

| Nominal setting | Range | Default | Notes |
|---|---|---|---|
| Nominal (4th) | 0 V to 9000 A | 867 A | The nominal current flow at the measurement position.<br><br>For *Earth inverse time over-current*, this is the ground current measurement. For *Neutral inverse time over-current*, this is the neutral phase current measurement. |

### 3.2.2 AC configuration

The **AC configuration and nominal settings** chapter describes the AC configuration in general.

The following table shows how the general AC configuration description applies to the controller.

**Table 3.5** AC configuration for the controller

| Controller name | General name |
|---|---|
| Generator | [Controlled equipment] |
| Busbar | [Busbar] |

## 3.3 Synchronisation

### 3.3.1 Introduction

A number of power sources can supply power to the same busbar. These power sources must be synchronised in order to safely connect them. Synchronisation consists of matching the voltage, frequency and phases of the power sources. The sources must be synchronised before they can be connected by closing a breaker.

This chapter gives an overview of the different synchronisation settings of the controller. The controller uses these settings to determine if it is safe to active a relay to send a signal to close the breaker between the power source and the busbar.

## 3.3.2 General synchronisation parameters

Configure the synchronisation parameters under **Configure > Parameters > Synchronisation > Settings > Frequency window**.

| Name | Range | Default | Notes |
|---|---|---|---|
| Delta frequency min. | -0.5 to 0.3 Hz | -0.1 Hz | For the synchronisation check function: Add *Delta frequency min.* to the busbar frequency, for the **minimum** frequency of the synchronising generator.<br><br>If this value is too low, there can be reverse power when the breaker closes. |
| Delta frequency max. | 0.0 to 0.5 Hz | 0.3 Hz | For the synchronisation check function: Add *Delta frequency max.* to the busbar frequency, for the **maximum** frequency of the synchronising generator.<br><br>*Delta frequency max.* must always be higher than *Delta frequency min.* |

**Frequency window example**

Busbar frequency: **50.1 Hz**
Delta frequency min.: **-0.1 Hz**
Delta frequency max.: **0.3 Hz**

The generator frequency must be between **50.0 Hz** and **50.4 Hz** for the synchronisation check function.

Configure the synchronisation parameters under **Configure > Parameters > Synchronisation > Settings > Voltage window**.

| Name | Range | Default | Notes |
|---|---|---|---|
| Delta voltage min. | 2 to 10 % of nominal voltage | 5 % | The maximum that the voltage of the generator may be below the voltage of the busbar for the synchronisation check function. |
| Delta voltage max. | 2 to 10 % of nominal voltage | 5 % | The maximum that the voltage of the synchronising generator may be above the voltage of the busbar for the synchronisation check function. |

## 3.3.3 Dynamic synchronisation

During dynamic synchronisation, the synchronising genset can run at a slightly different frequency to the busbar. This difference is called the *slip frequency*. Dynamic synchronisation is recommended where fast synchronisation is required, and where the synchronising genset is able to take load when the breaker closes.

The synchronising genset is typically run with a positive slip frequency. That is, the synchronising genset runs at a slightly higher frequency than the busbar. This is to avoid a reverse power trip after synchronisation.

This type of synchronisation is relatively fast because of the minimum and maximum frequency differences. The frequency does not have to be the same as the busbar frequency. As long as the frequency difference is within the limits and the phase angles are matched, the controller can send the close breaker signal.

**INFO**
Dynamic synchronisation is recommended where fast synchronisation is required, and where the incoming genset is able to take load when the breaker closes.

### Inputs and outputs

This function uses the controller AC measurements, and breaker configuration.

### Parameters

Configure the synchronisation parameters under **Configure > Parameters > Synchronisation > Settings > Type**.

**Table 3.6** Dynamic synchronisation parameters

| Name | Range | Default | Notes |
|---|---|---|---|
| Sync. type | Dynamic, Static | Dynamic | *Dynamic* must be selected. |
| Breaker close time | 40 to 300 ms | 50 ms | The time between when the close breaker signal is sent and when the breaker actually closes. |

### How it works

The two power sources are the three-phase electricity from the generator and the three-phase electricity at the busbar. Synchronising the power sources minimises the phase angle difference between them.

For example: The genset is running at 1503 RPM (about 50.1 Hz). The busbar frequency is 50.0 Hz. This gives the genset a positive slip frequency of 50.1 Hz - 50.0 Hz = 0.1 Hz. If the slip frequency is less than the value configured in parameter *Delta frequency max.*, and more than *Delta frequency min.*, the controller can activate a relay to send a close breaker signal when the power sources are synchronised.

In this example, the difference in the phase angle between the genset and the busbar gets smaller and smaller. When difference in the phase angle is near zero, the controller will send the breaker close signal based on the *Breaker closing time*. In this way, the breaker physically closes when the genset is exactly synchronised with the busbar.

When the generator is running with a positive slip frequency of 0.1 Hz relative to the busbar, the two systems will be synchronised every 10 seconds:

$$T_{sync} = 1 / (f_{sync\ genset} - f_{online\ genset}) = 1 / (50.1\ \text{Hz} - 50.0\ \text{Hz}) = 10\ \text{s}$$

### Close breaker signal

The controller always calculates when to send the close breaker signal to get the best possible synchronisation of the power sources. The close breaker signal is sent just before the power sources are synchronised. The close breaker signal is timed so that the breaker is closed when the difference in the phase angle of the L1 vectors is zero.

The timing of the close breaker signal depends on the *Breaker close time* and the slip frequency.

For example, if the response time of the circuit breaker ($t_{CB}$) is 250 ms, and the slip frequency ($f_{slip}$) is 0.1 Hz:

$$degrees_{CLOSE} = 360\ \text{degrees} \times t_{CB} \times f_{slip} = 360\ \text{degrees} \times 0.25\ \text{s} \times 0.1\ \text{Hz} = 9\ \text{degrees}$$

In this example, the controller will start the close breaker signal when the difference between the phase angles of the sources is 9 degrees.

## 3.3.4 Static synchronisation

During static synchronisation, the synchronising genset has to run very close to the same speed as the busbar. The aim is to let the genset run at exactly the same frequency as the busbar, with the phase angles between the three-phase system of the generator and the three-phase system of the busbar matching exactly. Static synchronisation is most suited to systems with a very stable busbar frequency, and is therefore rarely used in marine applications.

Static synchronisation is recommended where a slip frequency is not acceptable.

**Static synchronisation application example**

Use static synchronisation during commissioning, to synchronise the genset to the busbar while the breaker closing is disabled. The commissioning engineer can then measure the voltages across the breaker, as a safety check.

### Inputs and outputs

This function uses the controller AC measurements, and breaker configuration.

### Parameters

Configure the synchronisation parameters under **Configure > Parameters > Synchronisation > Settings > Type**.

**Table 3.7** Static synchronisation parameters

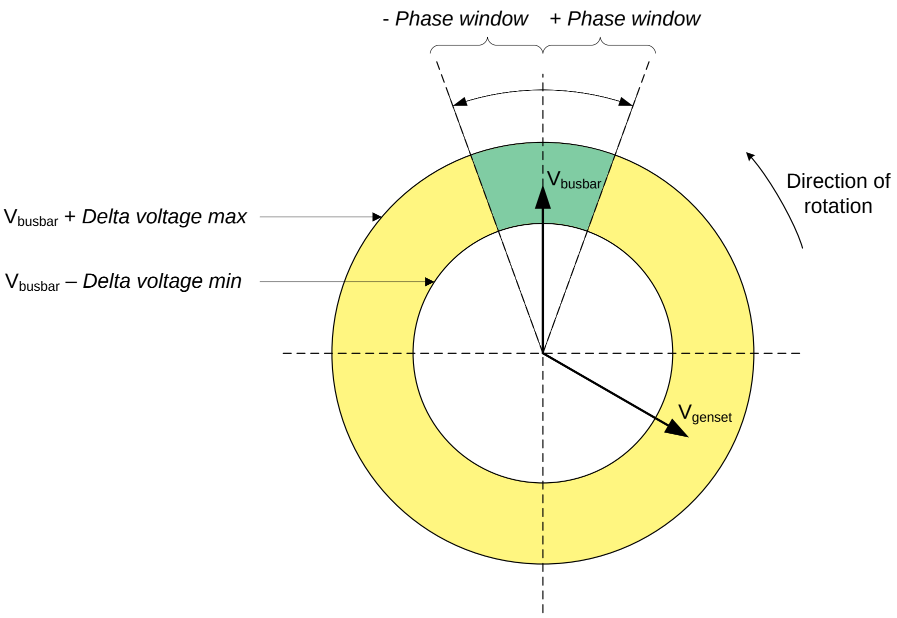
| Name | Range | Default | Notes |
|---|---|---|---|
| Sync. type | Dynamic, Static | Dynamic | *Static* must be selected. Note that the factory default is *Dynamic*. |
| Phase window | 0.0 to 45.0 deg | 5.0 deg | The maximum phase angle difference allowed for synchronisation. |
| Minimum time in phase window | 0.1 s to 15 min | 1.0 s | To close the breaker, the measurements must show that the controller will be able to keep the phase angle difference within the phase window for this minimum time. |
| Breaker close time | 40 to 300 ms | 50 ms | The time between when the close breaker signal is sent and when the breaker actually closes. |

### How it works

*Generator breaker* > *Control* > *Close* is activated when phase angle difference between phase L1 of the synchronising generator and the busbar is within the *Phase window* (after the *Minimum time in phase window* timer has run out). The voltage differences must also be within the configured range (*Delta voltage min.* and *Delta voltage max.*). This is shown in the following drawing. In addition, the frequency differences must be within the configured range (*Delta frequency min.* and *Delta frequency max.*).

The response time of the breaker is not relevant when using static synchronisation, because the slip frequency should be either very small or zero.

**Figure 3.2** Voltage and phase angle difference for static synchronisation




### Load distribution after synchronisation

The difference between the frequencies of the sources is low. The load distribution therefore does not change much when the breaker closes.

## 3.3.5 Synchronisation check

The *Sync. check OK* (synchronisation check OK) function activates a relay whenever the AC measurements on both sides of the breaker are within the specified synchronisation settings. The function activates the relay regardless of the current alarm state of the controller. When the controller detects that the AC measurements are no longer within the specified synchronisation settings, the *Sync. check OK* function deactivates the relay.

**DANGER!**
**Do not wire the relay with the *Sync. check OK* function to close the breaker. Use *Generator breaker* > *Command* > *Close* instead.**

**CAUTION**
The *Sync. check OK* function does not check whether it is okay to close the breaker. It does not take the breaker close time into account either.

### Inputs and outputs

This function uses the controller AC measurements.

Assign the synchronisation check output under **Configure > Input/output**. Select the hardware module, then select the input/output to configure.

**Table 3.8** Hardware required in addition to the minimum standard controller wiring

| Function | IO | Type | Details |
|---|---|---|---|
| Synchronisation > Sync. check OK | Digital output | Continuous | The controller activates this relay when the synchronisation measured across the breaker is within the range defined by the parameters. |

**Parameters**

Configure the synchronisation parameters under **Configure > Parameters > Synchronisation > Settings > Type**.

**Table 3.9** Synchronisation settings parameters

| Name | Range | Default | Notes |
|---|---|---|---|
| Sync. behaviour | Synchronise and close breaker, Sync. check (signal when in sync.) | Synchronise and close breaker | Only visible if *Sync. check OK* and the breaker *Close* digital outputs are configured at the same time.<br><br>**Synchronise and close breaker**: The *Synchronise and close* function is enabled. The controller will not activate the *Sync. check OK* relay.<br><br>**Sync. check (signal when in sync.)**: The *Sync. check OK* function is enabled and the controller will activate the *Sync. check OK* relay when the busbars are synchronised. The controller will not activate the *Close* breaker relay. |

**Alarms**

Configure the synchronisation alarm parameters under **Configure > Parameters > Synchronisation > Alarms**.

See **Breaker**, **Breaker protections, Vector mismatch** for more information.

# 3.4 Generator breaker

## 3.4.1 Introduction

The generator breaker (GB) connects the generator to the busbar. The controller includes a synchronisation check function for this breaker. The generator breaker is an important part of the system safety, and trips to protect the generator from busbar problems. The generator breaker also trips to prevent genset problems from disturbing the busbar.

See the **Breaker** chapter for more information on the breaker. This includes the inputs and output functions and the parameters to configure. For this controller, replace *[Breaker]* with *Generator breaker*.

### 3.4.2 Synchronise and close breaker

A digital input can be configured to give a command to the controller to close the breaker when synchronised. The controller continuously checks whether the busbars on both sides of the breaker are synchronised. The controller immediately activates the close breaker relay when the busbars are synchronised. When the breaker closes, or if the *Breaker closing failure* alarm is triggered, or if the *Deactivate breaker close* digital input is activated, the command is reset.

#### Inputs and outputs

This function uses the controller AC measurements.

Assign the synchronise and close breaker input under **Configure > Input/output**. Select the hardware module, then select the input/output to configure.

**Table 3.10** Hardware required in addition to the minimum standard controller wiring

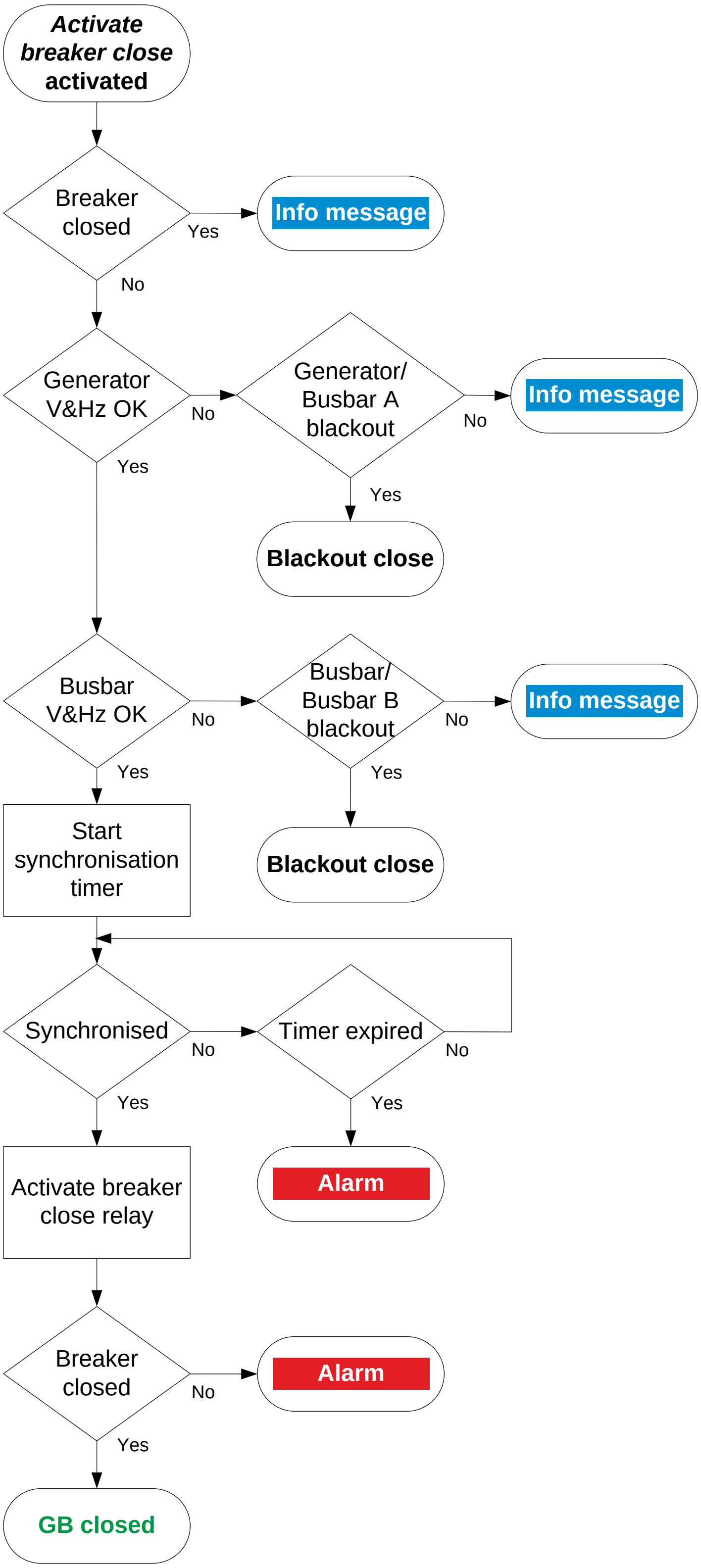
| Function | IO | Type | Details |
|---|---|---|---|
| Generator breaker > Activate breaker close | Digital input | Pulse | After the input is activated, the controller sends a close breaker command to the breaker when it detects that the breaker is synchronised. |
| Generator breaker > Deactivate breaker close | Digital input | Pulse | When the input is activated, the *Activate breaker close* input is cancelled. If the breaker is already closed when the input is activated, the input has no effect. |

#### How it works

When the *Activate breaker close* digital input is activated, the controller checks if both sides of the busbar are synchronised. The controller does not perform any actions to synchronise the busbars. When the controller detects that the busbars are synchronised, the controller sends a close breaker command.

The operator can activate the *Deactivate breaker close* digital input at any time before the breaker closes to cancel the close procedure. If the breaker is closed, the *Deactivate breaker close* digital input does not open the breaker.

## Synchronise and close breaker flowchart




1. When the breaker close relay is activated, the controller checks whether the generator breaker is closed. If the generator breaker is already closed, the sequence stops, and an info message is shown.
2. The controller checks the generator voltage and frequency.
   - If a blackout is detected at the generator (Busbar A), the controller starts the *Blackout close* sequence.
   - If the voltage and frequency are not OK, but there is no blackout, then the controller cancels the close command and displays an info message.
   - If the voltage and frequency are OK, the sequence continues.
3. The controller checks the busbar voltage and frequency.
   - If a blackout is detected at the busbar (Busbar B), the controller starts the *Blackout close* sequence.
   - If the voltage and frequency are not OK, but there is no blackout, then the controller cancels the close command and displays an info message.
   - If the voltage and frequency are OK, the sequence continues.
4. The controller starts a synchronisation timer and checks if the busbars are synchronised.
   - When the busbars are synchronised, the controller activates the *Generator breaker* > *Control* > *Close* output to close the breaker.
   - If the busbars do not synchronise within the time allowed, the controller activates a *GB synchronisation failure* alarm.
5. The controller checks whether the generator breaker has closed.
   - If the generator breaker has closed, the generator breaker close sequence has been completed successfully.
   - If the generator breaker has not closed the *GB closing failure* alarm is activated.

### 3.4.3 Blackout close

The *Blackout close* function sets the action the controller takes when a dead busbar is detected and *Activate breaker close* is activated. If the parameter is not set to *Off*, the breaker is closed without synchronising across the breaker.

**DANGER!**
**Incorrect parameter settings for the connected equipment can lead to equipment damage or loss of life.**

#### Blackout conditions

A blackout is present if the following conditions is met:

- The phase-to-phase voltage is less than 10 % of the nominal voltage ($V_{L-L}$ < 10 % of $V_{nom}$).
  - This percentage is fixed.

#### Conditions that prevent blackout close

If any of the following conditions are present, the controller will not start the blackout close:

- The breaker position is unknown.
- There is a short circuit.
  - A digital input with the function *[Breaker]* > *Feedback* > *Short circuit* was activated.
- There is a blocking alarm.
  - The alarm action determines whether the alarm is a blocking alarm.
- The live busbar is not OK.
  - A measurement failure is detected on one or more of the phases of the busbar.

#### Parameters

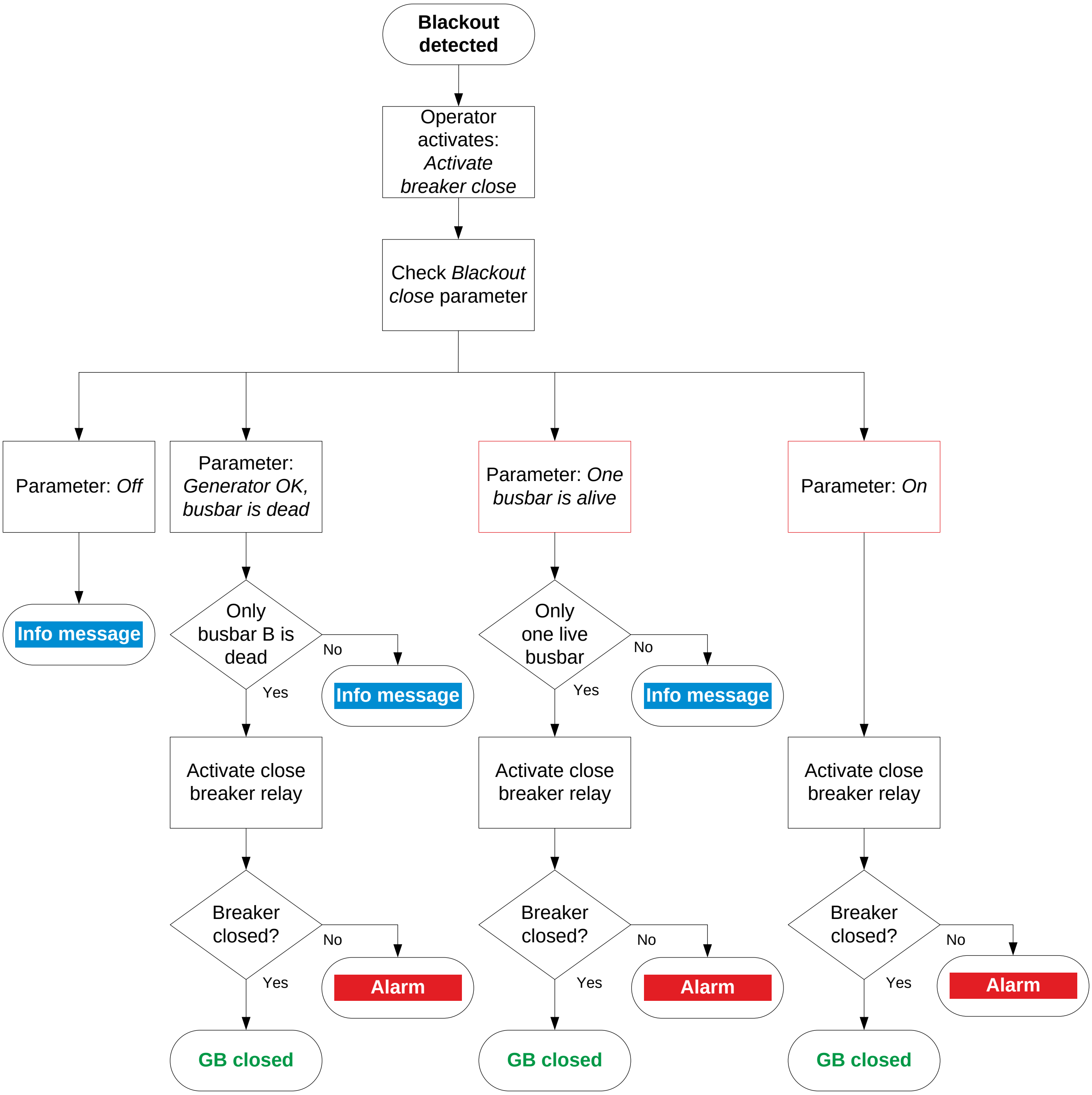
Configure the synchronisation parameters under **Configure > Parameters > Breakers > Generator breaker**.

**Table 3.11** Blackout close parameters

| Name | Range | Default | Notes |
|---|---|---|---|
| Blackout close | Off; Generator OK, busbar is dead; One busbar is alive*; On* | Off | These actions are only taken if the *Activate breaker close* digital input is activated, and a blackout is detected.<br><br>**Off**: The controller will not activate the close breaker relay if a blackout is detected at the [Controlled equipment] or at the [Busbar].<br><br>**Generator OK, busbar is dead**: The controller activates the close breaker relay if a blackout is detected at the [Busbar] and the busbar at the [Controlled equipment] is stable. If a blackout is detected at the [Controlled equipment], or at the [Controlled equipment] and at the [Busbar], then the controller does not activate the close breaker relay.<br><br>**One busbar is alive***: The controller activates the close breaker relay if a blackout is detected at the [Controlled equipment], or at [Busbar]. The live busbar must be stable. If a blackout is detected at both the [Controlled equipment] and at [Busbar], then the controller does not activate the close breaker relay.<br><br>**On***: The controller activates the close breaker relay if a blackout is detected at the [Controlled equipment] and/or at the [Busbar]. |

*Note: These options must only be selected if the controller is connected to a bus tie breaker.

### Blackout close flowchart




1. When there is a blackout, the operator has to activate the *Activate breaker close* digital input. When the controller detects that one or both of the busbars have a frequency and voltage that are not in range, the blackout close procedure starts.
2. The controller checks the setting of the *Blackout close* parameter.
   a. If the parameter is set to *Off*, the controller takes does not close the breaker. An info message is shown and the procedure ends.

   b. If the parameter is set to *Generator OK, busbar is dead*, the controller checks if the blackout was detected only at the [Busbar].
      - If the blackout was only detected at the [Busbar], then the controller activates the close breaker relay.
      - If the blackout was only detected at the [Controlled equipment] or on both sides of the breaker, then the controller shows and info message and the procedure ends.

   c. If the parameter is set to *Only one live busbar*, then the controller checks if the blackout was detected only at the [Controlled equipment] busbar, or only at the [Busbar].
      - If the blackout was only detected at the [Controlled equipment], or only at the [Busbar], then the controller activates the close breaker relay.
      - If the blackout was detected on both sides of the breaker, then the controller shows and info message and the procedure ends.

   d. If the parameter is set to *On*, then the controller activates the close breaker relay.

3. The controller checks whether the generator breaker has closed.
   - If the generator breaker has closed, the generator breaker close sequence has been completed successfully.
   - If the generator breaker has not closed the GB closing failure alarm is activated.

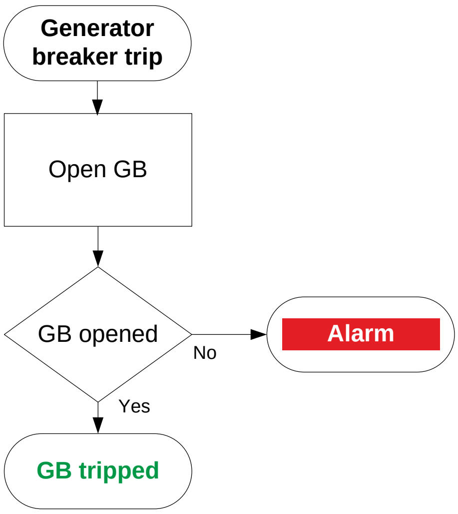
### 3.4.4 Generator breaker trip flowchart

The controller automatically trips the generator breaker (GB) for this alarm action:

- Trip generator breaker

The generator breaker also trips if the controller's *Emergency stop* input is deactivated.

**Table 3.12** Generator breaker trip flowchart




1. When a trip is required, the controller activates the *Generator breaker* > *Control* > *Open* output to open the breaker.
2. The controller checks whether the breaker has opened:
   - If the breaker has opened, the trip is successful.
   - If the breaker has not opened, the controller activates the *GB opening failure* alarm.

## 3.5 Controller alarms

### 3.5.1 Protections

**INFO**
These protections are in addition to the AC protections.

| | Protections | Alarms |
|---|---|---|
| **Breaker** | GB opening failure | 1 |
| | GB closing failure | 1 |
| | GB position failure | 1 |
| | GB tripped (external) | 1 |
| | GB short circuit | 1 |
| | GB configuration failure | 1 |
| **Synchronisation check** | Phase sequence error terminal A (generator) | 1 |
| | Phase sequence error terminal B (busbar) | 1 |
| | Vector mismatch | 1 |
| | Voltage or frequency not OK | 1 |
| | GB synchronisation failure | 1 |
| **Inputs** | Digital inputs | 1 customised alarm per input |
| | Emergency stop | 1 |
| **Non-essential load (NEL)** | NEL over-current | 1 × 3 NELs |
| | NEL under-frequency | 1 × 3 NELs |
| | NEL overload | 2 × 3 NELs |
| | NEL reactive overload | 1 × 3 NELs |
| **ACM measurement error*** | Generator L1-L2-L3 wire break | 1 |
| | Busbar L1-L2-L3 wire break | 1 |
| | Generator L1 wire break | 1 |
| | Generator L2 wire break | 1 |
| | Generator L3 wire break | 1 |
| | Busbar L1 wire break | 1 |
| | Busbar L2 wire break | 1 |
| | Busbar L3 wire break | 1 |
| **Network** | Ethernet redundancy broken | 1 |
| | Modbus communication timeout | 1 |
| **Hardware alarms** | System not OK | 1 |
| | Controller temperature too high | 1 |
| | PCM clock battery failure | 1 |
| | PSM 1 supply voltage high | 1 |
| | PSM 1 supply voltage low | 1 |
| | SW mismatch on hardware module(s) | 1 |
| | Required IO card(s) not found | 1 |

*Note: These protections can only be active when the breaker is closed.

### 3.5.2 Breaker alarms

The **Breaker** chapter describes breaker handling and alarms in general.

The following table shows where to configure these alarms for the controller, as well as which general alarm corresponds to each controller alarm.

**Table 3.13** Breaker alarm names for the controller (Parameter menu)

| Controller alarm | Configure > Parameters > | General name |
|---|---|---|
| Vector mismatch | Breakers > Generator breaker > Vector mismatch | Vector mismatch |
| GB opening failure | Breakers > Generator breaker > Opening failure | Breaker opening failure |
| GB closing failure | Breakers > Generator breaker > Closing failure | Breaker closing failure |
| GB position failure | Breakers > Generator breaker > Position failure | Breaker position failure |
| GB short circuit | Breakers > Generator breaker > Short circuit | Breaker short circuit |
| GB configuration failure | - | Breaker configuration failure |
| Phase sequence error terminal A | AC configuration > Generator > Phase sequence error | Phase sequence error |
| Phase sequence error terminal B | AC configuration > Busbar > Phase sequence error | Phase sequence error |

### 3.5.3 AC alarms

The **AC configuration and nominal settings** chapter describes AC alarms in general.

The following table shows where to configure these alarms for the controller, as well as which general alarm corresponds to each controller alarm.

**Table 3.14** AC alarm names for the controller

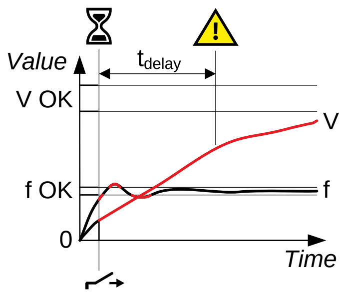
| Controller alarm | Configure > Parameters > | General name |
|---|---|---|
| Generator over-voltage 1 or 2 | Generator > Voltage protections > Over-voltage 1 or 2 | Over-voltage |
| Generator under-voltage 1 or 2 | Generator > Voltage protections > Under-voltage 1 or 2 | Under-voltage |
| Generator voltage unbalance | Generator > Voltage protections > Voltage unbalance | Voltage unbalance |
| Generator over-current 1 or 2 | Generator > Current protections > Over-current 1 or 2 | Over-current |
| Fast over-current 1 or 2 | Generator > Current protections > Fast over-current 1 or 2 | Fast over-current |
| Current unbalance (average calc.) | Generator > Current protections > Current unbalance (average calc) | Current unbalance (average calc) |
| Current unbalance (nominal calc.) | Generator > Current protections > Current unbalance (nominal calc) | Current unbalance (nominal calc) |
| Inverse time over-current | Generator > Current protections > Inverse time over-current | Inverse time over-current |

| Controller alarm | Configure > Parameters > | General name |
|---|---|---|
| Non-directional earth current | Generator > Current protections > Non-directional earth current | Non-directional earth current |
| Generator over-frequency 1 or 2 | Generator > Frequency protections > Over-frequency 1 or 2 | Over-frequency |
| Generator under-frequency 1 or 2 | Generator > Frequency protections > Under-frequency 1 or 2 | Under-frequency |
| Overload 1 or 2 | Generator > Power protections > Overload 1 or 2 | Overload |
| Reverse power 1 or 2 | Generator > Power protections > Reverse power 1 or 2 | Reverse power |
| Reactive power export 1 or 2 | Generator > Reactive power protections > Reactive power export 1 or 2 | Reactive power export |
| Reactive power import 1 or 2 | Generator > Reactive power protections > Reactive power import 1 or 2 | Reactive power import |
| Busbar over-voltage 1 or 2 | Busbar > Voltage protections > Over-voltage 1 or 2 | Busbar over-voltage |
| Busbar under-voltage 1 or 2 | Busbar > Voltage protections > Under-voltage 1 or 2 | Busbar under-voltage |
| Busbar voltage unbalance | Busbar > Voltage protections > Voltage unbalance | Busbar voltage unbalance |
| Busbar over-frequency 1 or 2 | Busbar > Frequency protections > Over-frequency 1 or 2 | Busbar over-frequency |
| Busbar under-frequency 1 or 2 | Busbar > Frequency protections > Under-frequency 1 or 2 | Busbar under-frequency |

### 3.5.4 Voltage or frequency not OK

This alarm alerts the operator that the voltage or frequency is not in the required range within the specified period after the *Activate breaker close* digital input is activated.

The alarm response is based on the voltage and frequency from the generator.




See **Configure > Parameters > AC configuration > [Controlled equipment]**. The parameters that the alarm is based on are under **Voltage and frequency OK**. The alarm is configured under **Voltage or frequency not OK**.

The alarm action is always *Warning*.

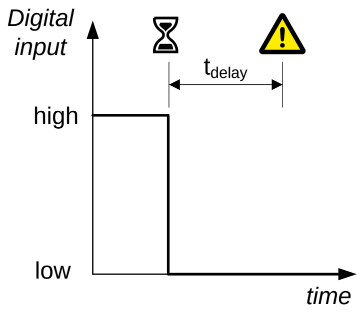
**Table 3.15** Default parameters

| Parameter | Range | Default |
|---|---|---|
| Delay | 1 s to 1 h | 30 s |
| Enable | Not enabled, Enabled | Enabled |
| Inhibit | | Generator breaker closed |

## 3.5.5 Emergency stop

You can configure one of the controller's digital inputs as the emergency stop.

When this input is present, the alarm is always enabled. You cannot see or change the alarm parameters. The delay is 1 second. The alarm action is *Trip breaker*, latch enabled.




Assign the *Emergency stop* input under **Configure > Input/output**. Select the hardware module, then select the input to configure.

| Function | IO | Type | Details |
|---|---|---|---|
| Alarm > Emergency stop | Digital input | Continuous | Wire the emergency stop digital input so that it is normally activated. If the emergency stop digital input is not activated for longer than the delay, then controller activates the *Emergency stop* alarm. |

**CAUTION**
The *Emergency stop* is part of the safety chain, and this digital input function should only be used to inform the controller of the emergency stop. The parameters are configured here for this digital input to trip the breaker as a backup. However, the controller's emergency stop input cannot be used as the system's only emergency stop. For example, if the controller is unpowered, it cannot respond to the emergency stop digital input.

# 4. Alarms

## 4.1 Introduction

### 4.1.1 Overview of alarm processing

The controller protections prevent unwanted, damaging, or dangerous situations from occurring. The alarm handling is an adaptation of the ISA 18.2 standard. You can configure many of the protection's alarm parameters to suit your design and operational needs.

Most of the protections are **Enabled** by default in the controller. You can enable or disable certain alarms and configure their alarm settings (typically the *Set point* and *Delay*) as required.

The alarm parameters, states, and operator actions are described in the following sections.

**CAUTION**
Improper configuration of the alarm parameters can result in unwanted operational conditions and possible damage to equipment or injury to personnel.

**INFO**
Some of the protections are not configurable, as the system must maintain a basic level of protection.

See **Alarm handling**, **Overview of alarm handling** in this chapter for more information regarding the ISA 18.2 alarm states and handling.

### Alarm process

The controller detects an *Alarm condition*.

Check whether the alarm is disabled.

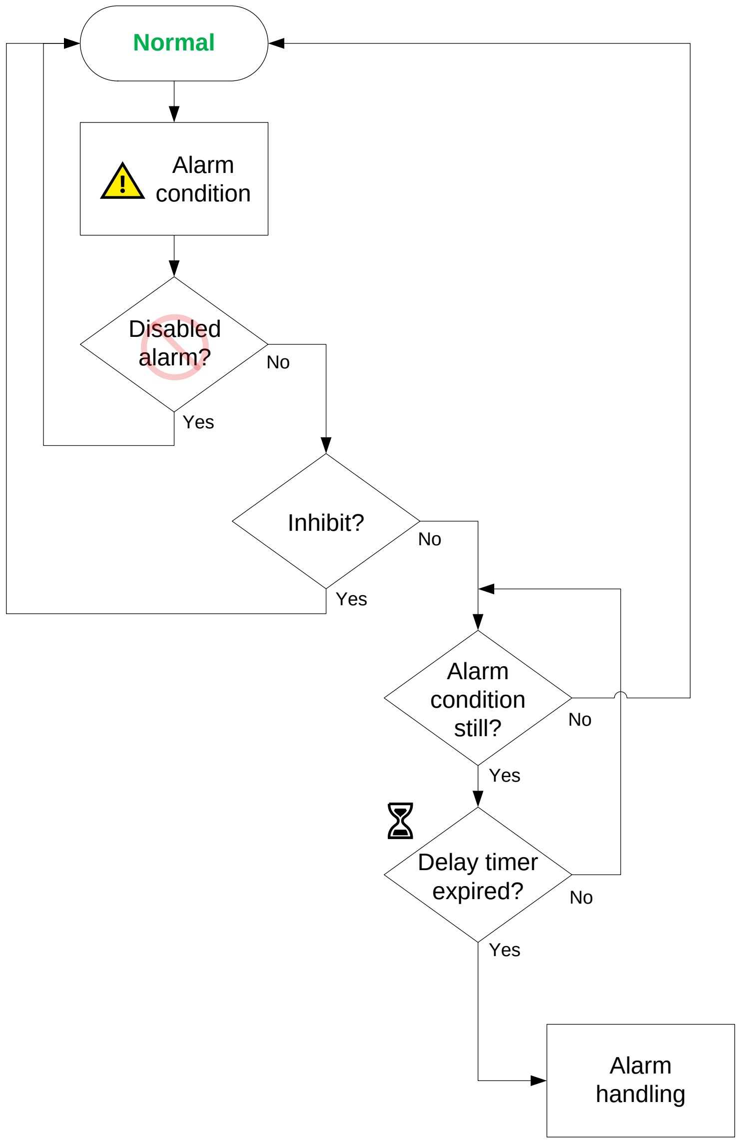
Check whether the alarm has an active inhibit.

Check whether the *Alarm condition* is still present.

The alarm is not activated until the delay timer has expired.

Check whether the *Alarm condition* is still present.

The alarm is activated and included in the alarm list.




When an alarm condition is met (typically, the operating value reaches the *Set point*), then the controller starts the *Time delay*. During this period the controller checks whether the *Alarm condition* is still present. If not, the alarm returns to normal.

- If the *Alarm condition* continues after the *Time delay* has expired:
  - The alarm protection becomes active in the system.
  - The alarm requires action and acknowledgement.
- If the *Alarm condition* clears after the *Time delay* has expired:
  - The associated alarm protection does not become active, unless a *Latch* is present on the alarm.
  - The alarm requires acknowledgement.

The alarm results in both a visual and audible indication (subject to design of the system) for the operator. The system controls the alarm states as necessary based upon the operational conditions. Some alarms can be configured to be automatically acknowledged.

**INFO**
On user-configurable alarms, *Auto acknowledge* is **Not enabled** by default. *Auto acknowledge* can be useful during commissioning and troubleshooting. However, DEIF does not recommend *Auto acknowledge* during normal operation.

During operation the system continues to monitor the *Alarm condition(s)* and moves alarms between different states as necessary. Operator action can also move the alarm(s) to other states.

See **Alarm handling,** later in this chapter for more information.

### Alarm latch

An additional layer of protection can be added by using a *Latch* on most alarms.

When a *Latch* is enabled on an alarm, an extra confirmation must be made by the operator, before the alarm can be cleared. The alarm protection remains active, even if the *Alarm condition* clears, until the operator resets the latched alarm.

**INFO**
A latched alarm can only be reset after both the alarm has been acknowledged and the *Alarm condition* has cleared.

Acknowledging the alarm does not *Reset* the alarm latch.

- An acknowledged alarm, that has no latch enabled, clears from the alarms list if the alarm condition clears.
- An acknowledged alarm, that has a latch enabled, does not clear from the alarms list even if the alarm condition clears.
  - The operator must *Reset* (unlatch) the alarm to clear the alarm from the alarms list.
  - The alarm protection remains active until the alarm is reset.

See **Alarm handling, Latch reset** later in this chapter for more information on the operator action.

### Operator actions

Operators can perform different actions to change the alarm state. Typically acknowledging an alarm. The operator actions are described in more detail in the **Alarm handling** section in this chapter.

**INFO**
Operator actions can be done by using the display unit, PICUS, digital inputs and/or CustomLogic (if configured).

## 4.1.2 Customising alarms

You can customise the alarms for your system by configuring the alarm parameters. The parameters that you can configure are restricted for some alarms.

See **Alarm parameters** for more information about parameter settings.

**INFO**
You can also create custom alarms for the input/output configurations for the controller terminals.

### Limitations

There are a few limitations to the customising of alarm parameters. These are stated below.

**Table 4.1** Alarm parameters that cannot be customised

| Not customisable | Notes |
|---|---|
| Additional protections | The list of alarm protections are fixed, and you cannot add more protections.<br><br>If a protection is not available, you can set it up in CustomLogic. However, it will not be part of the alarm list, or the alarm management system. |
| Certain protections | Some protections cannot be disabled. For example, the *GB opening failure* alarm is always enabled. |
| Certain alarm actions | You cannot change certain alarm actions. For example, the *Emergency stop* alarm always trips the breaker. |
| Additional alarm actions | You cannot create additional alarm actions. You can only choose alarm actions from the list of alarm actions.<br><br>You can set up responses to operating values or conditions in CustomLogic, but these will not be available as alarm actions to the alarms. |
| Change the *Trigger level* for certain alarms | Most alarms have a fixed *Trigger level*. For example, *Busbar over-voltage* is always a *High* alarm, while *Busbar under-frequency* is always a *Low* alarm. |

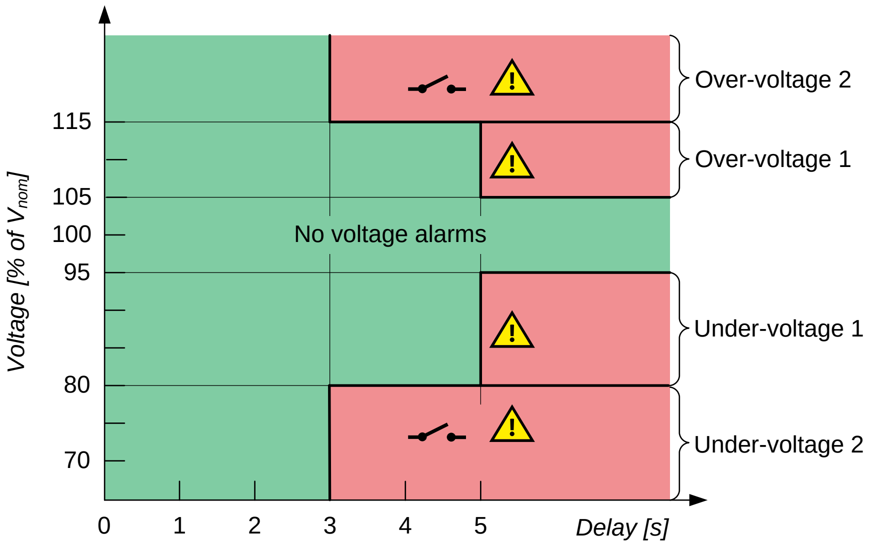
## 4.1.3 Alarm levels

Alarm levels refers to configuring a number of alarms for one reference value. For each alarm level, the *Set point*, *Time delay*, *Action* and other parameters are configured.

### Example of alarm levels

The following graph shows the busbar voltage alarms that are present by default, that is, *Busbar over-voltage 1*, *Busbar over-voltage 2*, *Busbar under-voltage 1* and *Busbar under-voltage 2*.

**Figure 4.1** Example of alarm levels for busbar voltage




If the operation is in the green area, the controller does not activate any busbar voltage alarms.

In the example, an over-voltage *Warning* alarm is activated if the busbar voltage has been over 105 % of the busbar's nominal voltage for 5 seconds. If the busbar voltage is over 115 % of $V_{nom}$ for more than 3 seconds, the controller activates the *Trip breaker* alarm action. Both alarms will be active if the busbar voltage is over 115 % of $V_{nom}$ for more than 5 seconds. The alarm action *Trip breaker* has a higher priority than *Warning*.

The graph shows two protection levels for under-voltage. In the example, if the busbar voltage is under 95 % of $V_{nom}$ for more than 5 seconds, a *Warning* is activated. If the busbar voltage is under 80 % of $V_{nom}$ for more than 3 seconds, the *Trip breaker* alarm action is activated.

### 4.1.4 Operate time

The operate time is the total time that the controller takes to respond to a change in the operating conditions. The operate time is a controller characteristic, and not a configurable parameter.

The controller operate time is listed for each AC protection. The operate time starts when the AC conditions change so that the alarm set point is exceeded. The operate time is completed when the controller has changed its output(s) accordingly.

Operate time = measurement time + calculation time + time to change the controller output(s)

For example, the operate time may be "< 100 ms". This means that the controller protection responds to the change in the alternating current conditions within 100 ms.

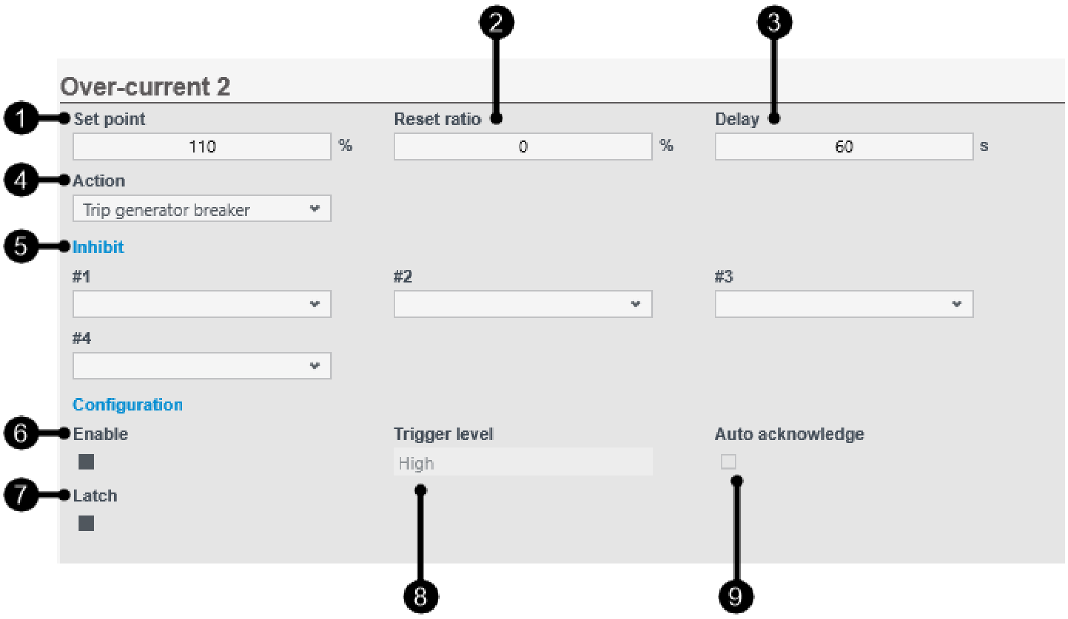
**INFO**
The operate times do not include any provision for the time delay configured for the AC protection. For example, over-voltage has an operate time of < 100 ms, but the default time delay for *Over-voltage 1* is 5 seconds. The *Over-voltage 1* alarm action is therefore between 5.0 and 5.1 seconds after the alarm set point is exceeded.

# 4.2 Alarm parameters

## 4.2.1 Overview of alarm parameters

You can configure alarms by adjusting the parameters in the controller. Each alarm parameter is explained in detail in the following sections. Some alarm settings are not configurable and these are not shown for some alarms.

**Figure 4.2** Typical alarm parameters in PICUS




| # | Parameter | Range | Notes |
|---|---|---|---|
| 1 | Set point | Varies | The setting at which the alarm is triggered.<br>Must be considered with *Trigger level* setting. |
| 2 | Reset ratio | 0 to 20 % | Applied during reset |
| 3 | Delay | 0 s to1 h | Delay before the alarm becomes active |
| 4 | Action | Varies | Action to be taken |
| 5 | Inhibit(s) #1 to #32 | Varies | Inhibit(s), that if active, can inhibit the alarm from becoming active.<br><br>Note that there are only four fields for inhibits in PICUS. |
| 6 | Enable | Not enabled, Enabled | If the alarm is enabled or not enabled in the controller |
| 7 | Latch | Not enabled, Enabled | If **Enabled** the alarm is latched when it occurs and requires both acknowledgement and reset (unlatch) to clear. |
| 8 | Trigger level (fixed)* | High, Low | Whether the alarm is triggered at a **High** or **Low** setting. |
| 9 | Auto acknowledge | Not enabled, Enabled | If **Enabled** the alarm is automatically acknowledged when it occurs. |

*Note: *Trigger level* is typically fixed and cannot be changed. However, the set point for *Directional over-current* determines the *Trigger level*. In addition, you can configure I/O alarms with a **High** or **Low** *Trigger level*.

### 4.2.2 Set point

The *Set point* is the reference value that is compared by the controller to decide whether the *Alarm condition* is present in the system.

When the operating value, that the alarm is based on, reaches the *Set point*, the controller starts the *Time delay* (if applicable) for the alarm. The *Set point* is often a percentage of the controller's nominal setting.

**INFO**
Most alarms require a *Set point* to be configured.

For example, the *Set point* for the *Over-current 1* alarm can be 100 %. This means that the current from the equipment must be 100 % (or more) of the nominal current to activate the alarm.

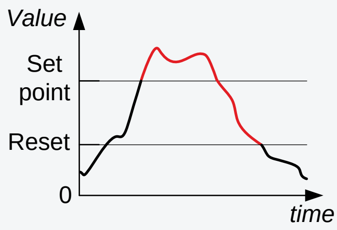
### 4.2.3 Reset ratio

The *Reset ratio* prevents the operating value from being too close to the alarm *Set point* when the alarm is reset. The *Reset ratio* makes the system more stable by imposing hysteresis on the alarm *Set point*. The *Reset ratio* is a percentage that is subtracted from the set point of high alarms (and added to the *Set point* of low alarms).

A *Reset ratio* can only be used where the alarm is based on an analogue value.

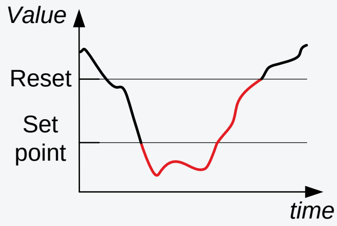
**High alarm example**

Consider an *Over-current* alarm with a *Set point* of 100 % of nominal current and a *Reset ratio* of 3 %. The over-current alarm cannot be reset until the operating value falls below 97 % of nominal current. The red line in the following figure shows that the alarm is activated when the value exceeds the *Set point*. The alarm is only deactivated when the value drops below the reset value.




**Low alarm example**

Consider an *Under-frequency 1* alarm with a *Set point* of 95.0 % of the nominal frequency and a *Reset ratio* of 1.0 %. The alarm is only reset when the operating value is above 96.0 % of the nominal frequency.




### 4.2.4 Action

The alarm *Action* is the response that you allocate to the *Alarm condition*. Each alarm must be assigned one alarm *Action*. The controllers are delivered with pre-defined alarm actions. You can change the alarm *Action* for most alarms.

Alarm actions are used to assign a set of responses for each alarm. Each alarm *Action* consists of a group of actions that the system takes when the alarm conditions are met. Alarm actions also act as a type of alarm categorisation. Minor alarm situations may be assigned warnings, while a critical situation may trip the breaker.

The alarm actions are effective as long as the operating value exceeds the alarm *Set point* (including the *Reset ratio* if configured) or the alarm is latched.

The description of the common alarm actions follows.

**Table 4.2** Alarm actions

| Action | Priority | Effect |
|---|---|---|
| Warning | Low | A warning alarm is activated. |
| Trip generator breaker | High | The controller trips the genset breaker. |

### Priority of alarm action

It is possible for two or more alarm actions to be active for the same equipment at the same time. In these cases, the controller performs the alarm *Action* with the highest priority. A later alarm *Action* with a lower priority does not change the controller's execution of the earlier alarm *Action* with the higher priority. Similarly, if a higher priority alarm *Action* is activated after a lower priority alarm *Action*, the controller performs the high priority alarm *Action*.

## 4.2.5 Delay

When the alarm *Set point* is exceeded and a *Delay* is configured for the alarm, the controller starts the timer for the alarm. If the operational value stops exceeding the *Set point*, the timer is stopped and reset. If the value exceeds the alarm *Set point* for the whole of the *Delay*, the controller activates the alarm.

The following graphs show how the *Delay* works.

**Figure 4.3** Delay for a high alarm based on an analogue operating value

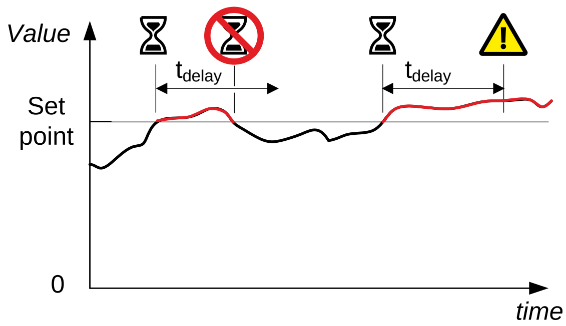
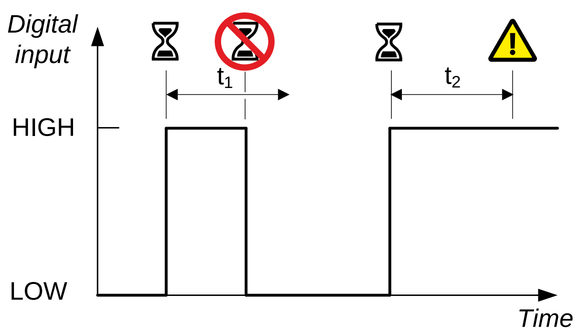



**Figure 4.4** Delay for a high alarm based on a digital input



**INFO**
The total delay before the alarm *Action* is activated is the *Operate time* for the protection plus the *Delay* parameter.

### 4.2.6 Inhibit

Inhibits stop the alarm *Action* when the inhibit conditions are active. When an inhibit is active, the controller does not activate the alarm *Action*, even if all the other alarm conditions are met. Inhibits are automatic and are not controlled by the operator.

**INFO**
Inhibited alarms are not shown in the alarm list.

The controllers are delivered with the appropriate default inhibits for each alarm. You can remove these inhibits, and/or add more inhibits. In addition to the default inhibits, you can also configure three customisable I/O inhibits for selection.

See **Customised inhibits** for more information.

For example, for generator under-voltage, the inhibits *Genset breaker closed* is selected. This means that if the generator breaker is closed, the generator under-voltage alarm is disabled (since the busbar under-voltage alarm(s) will provide protection in this situation).

In addition to the default inhibits available, some alarms include permanent inhibit conditions. These inhibits are not configurable, and are described under the alarm that uses them.

**INFO**
For some protections, inhibits are not applicable. The controller will not allow you to select any inhibits for these alarms.

The controller includes the following inhibits:

**Table 4.3** Controller inhibits

| Inhibit | Disables the alarm when ... |
|---|---|
| Generator breaker closed | The *Generator breaker* > *Feedback* > *Closed* digital input is activated. |
| Generator breaker open | The *Generator breaker* > *Feedback* > *Open* digital input is activated. |
| Generator voltage present | The generator voltage is above 10 % of the nominal voltage. |
| Generator voltage not present | The generator voltage is below 10 % of the nominal voltage. |
| Generator frequency present | The generator frequency is above 10 % of the nominal frequency. |
| Generator frequency not present | The generator frequency is below 10 % of the nominal frequency. |
| ACM wire break | All these conditions are met:<br>• The generator breaker is closed<br>• Voltage is detected by one set of ACM voltage measurements<br>• No voltage is detected on a phase, or on all three phases for the other set of ACM voltage measurements |

| Inhibit | Disables the alarm when ... |
|---|---|
| Inhibit 1 | The *Inhibits > Activate inhibit 1* digital input is activated. |
| Inhibit 2 | The *Inhibits > Activate inhibit 2* digital input is activated. |
| Inhibit 3 | The *Inhibits > Activate inhibit 3* digital input is activated. |

### 4.2.7 Enable

Some alarms can be **Not enabled** or **Enabled**, according to your requirements.

If the alarm is **Not enabled**, it does not respond to changes in the operating values, and is never activated.

If the alarm is **Enabled**, it is activated when the alarm *Set point* and *Delay* are exceeded. However, if the conditions for one or more inhibits are met, then the alarm and its *Action* are inhibited, and not activated.

### 4.2.8 Trigger level

If the reference value must be higher than the *Set point* to activate the alarm, a **High** *Trigger level* is selected in the alarm configuration.

Similarly, if the reference value must be lower than the *Set point* to activate the alarm, a **Low** *Trigger level* is selected in the alarm configuration.

**INFO**
For most alarms the *Trigger level* is set and cannot be changed. Custom I/O alarms can be configured for **High** or **Low** setting of the *Trigger level*.

### 4.2.9 Auto acknowledge

When *Auto acknowledge* is selected, the alarm is immediately marked as acknowledged in the alarm display when the alarm is activated.

**INFO**
The alarm only remains displayed in the alarm list, if the alarm has no latch configured and the reference value falls back below the *Set point* and *Reset ratio* (if applicable).

Alarms that have a *Latch* configured, even if automatically acknowledged, still require unlatching by the operator.

### 4.2.10 Latch

You can configure a *Latch* on any alarm. When an alarm with a *Latch* is activated, the alarm *Action* remains in force until the alarm is acknowledged and then reset (unlatched). Alarm latching provides an extra layer of safety.

**CAUTION**
Enabling a *Latch* on an alarm is not enough for safety protection. To be effective, the alarm must also be **Enabled**, and the alarm *Action* must be effective against the unsafe situation. For example, a *Latch* on an alarm with the action **Warning** offers little extra protection.

# 4.3 Customised inhibits

## 4.3.1 Configuring customised inhibits

In addition to the default inhibits, you can also configure three custom digital input inhibits (*Inhibit 1*, *Inhibit 2* and *Inhibit 3*).

**INFO**
Each controller can have a maximum of three customised inhibits configured.

### Inputs

Assign the inhibit function under **Configure > Input/output**. Select the hardware module, then select the input to configure.

**Table 4.4** Hardware required in addition to the minimum standard controller wiring

| Function | IO | Type | Details |
|---|---|---|---|
| Inhibits > Activate inhibit #, where # is 1 to 3 | Digital input | Continuous | When the digital input is activated, then the controller applies *Inhibit #*, where # is 1 to 3. |

**INFO**
If you use CustomLogic, you do not have to wire up a digital input, and assign the *Activate inhibit #* function to the input.

### Parameters

Select the customised inhibit under **Configure > Parameters > [Alarm] > Inhibit > #[number]**, where [Alarm] represents any alarm, and [number] represents the number of the inhibit field.

**Table 4.5** Inhibit parameters

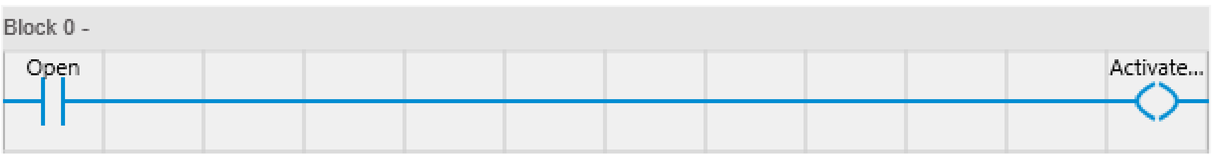
| Range | Notes |
|---|---|
| The controller inhibits, plus *Inhibit #*, where # is 1 to 3 | If you select *Inhibit #*, and the digital inhibit *Activate inhibit #* is activated, then the controller inhibits the alarm. |

### Using CustomLogic to activate a customised inhibit

You can use CustomLogic to activate a customised inhibit when a condition is met.

In this example CustomLogic is configured to *Activate inhibit 2* when the *Breaker* > *Inputs* > *Feedback* > *Open* is activated.

1. Under **Configure > CustomLogic > Logic creator**, create a **New** *Project* with one *Section* and one *Block*.
2. Add a **Normally open contact** and a **Normally open coil** to the logic grid and connect them to each other.




3. Select the *normally open contact*. Set the function to **Breaker > Inputs > Feedback > Open**.
4. Select the *normally open coil*.
   a. Set the function to **Inhibits > Activate inhibit 2**.

5. Select **Write** from the right side panel.
6. Under **Configure > Parameters > Utility > CustomLogic**, select *Enable* and then **Write**.

For this controller, all the alarms that include *Inhibit 2* will now be inhibited when the *Breaker* > *Inputs* > *Feedback* > *Open* is activated.

See **CustomLogic** in the **PICUS manual** for more information.

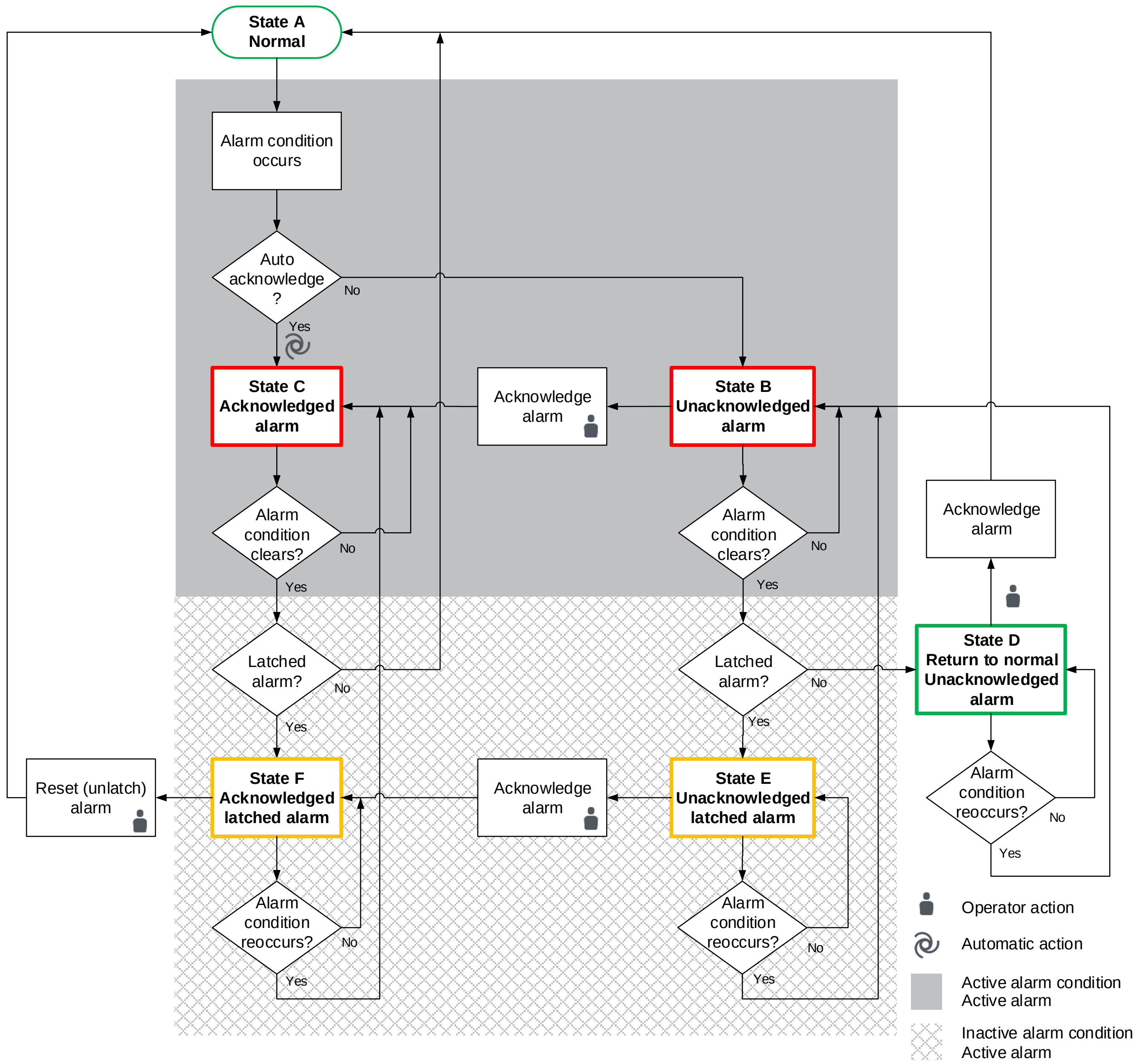
# 4.4 Alarm handling

## 4.4.1 Overview of alarm handling

When an *Alarm condition* occurs the controller automatically creates an active alarm in the system (subject to inhibits). The active alarm is handled by automatic and operator actions. The system only returns to a fully normal state (A) when the *Alarm condition* is inactive, the alarm has been acknowledged, and if applicable, the alarm has been reset (unlatched). While the alarm condition is **Active**, the alarm state remains in state B or C.

The following diagram shows the typical alarm handling process. The three additional special states G *Shelve*, H *Inhibited*, and I *Out of service* are not shown in this diagram.

**Figure 4.5** Alarm processing states (excluding state G, H and I)




**INFO**

For alarms configured with a *Latch*, the alarm remains **Active** even if the *Alarm condition* has become **Inactive**. The alarm requires acknowledgement and resetting (unlatch) by the operator before the alarm protection can be cleared and return to normal. This provides an additional layer of protection.

**Table 4.6** Alarm states

| Alarm state | Description | Alarm condition* | Alarm** |
|---|---|---|---|
| A | Normal operating condition | No | Inactive |
| B | Unacknowledged alarm | Yes | Active |

| Alarm state | Description | Alarm condition* | Alarm** |
| --- | --- | --- | --- |
| C | Acknowledged alarm | Yes | Active |
| D | Unacknowledged alarm | No | Inactive |
| E | Unacknowledged latched alarm | No | Active |
| F | Acknowledged latched alarm | No | Active |

* Note: The alarm condition that triggers the alarm, typically the *Set point,* may be present *Yes* or not present *No*.

**Note: Any alarm may be **Active** or **Inactive** in the system. If active the alarm *Action* is also active.

**INFO**
Inhibited, shelved, or out of service alarm states force the alarm protection to be **Inactive** in the system, even if the *Alarm condition* is still present.

### Automatic actions

The controller's alarm handling system can perform the following automatic actions:

- Horn/siren output
- Inhibit
- Auto acknowledge
- Control alarm state

See **Horn outputs**, later in this chapter for more information on the alarm horn outputs.

### Operator alarm actions

An operator can perform the following alarm actions:

- Acknowledge
- Shelve
- Out of service
- Latch reset
- Silence alarm horn/siren

**INFO**
Alarm actions are controlled by the group and user permissions.

## 4.4.2 Acknowledge

Alarms that have no *Auto acknowledge* require acknowledging by operator action. The operator must take action regarding the alarm condition. The operator can mark the alarm as *acknowledged*.

**INFO**
Acknowledging an alarm does not make the alarm *Action* **inactive** unless the alarm condition has cleared.

**Table 4.7** Acknowledgement status and operator actions

| Acknowledged? | Latch? | Alarm condition? | Alarm action* | Required operator actions |
|---|---|---|---|---|
| Unacknowledged | Latch | Active | Active | • The alarm condition must be corrected.<br>• The alarm must be acknowledged.<br>• The alarm must be reset (unlatched). |
| | | Inactive | Active | • The alarm must be acknowledged.<br>• The alarm must be reset (unlatched). |
| | No latch | Active | Active | • The alarm condition must be corrected.<br>• The alarm must be acknowledged. |
| | | Inactive | Inactive | • The alarm must be acknowledged. |
| Acknowledged | Latch | Active | Active | • The alarm condition must be corrected.<br>• The alarm must be reset (unlatched). |
| | | Inactive | Active | • The alarm condition must be corrected.<br>• The alarm must be reset (unlatched). |
| | No latch | Active | Active | • The alarm condition must be corrected. |
| | | Inactive | Inactive | • No further action is required. |

*Note: Alarm action is controlled automatically by the controller.

Inhibited, shelved, and out of service alarms all have an inactive alarm *Action*.

### Inputs

You can assign these functions inputs under **Configure > Input/output**. Select the hardware module, then select the input to configure.

**Table 4.8** Optional hardware

| Function | IO | Type | Details |
|---|---|---|---|
| Alarm > Acknowledge all alarms | Digital input | Pulse | When this input is activated, the controller acknowledges all its alarms. |

## 4.4.3 Shelve

The operator can shelve each alarm for a period of time, during any alarm state (except if the alarm is already *Out of service*).

If an unacknowledged alarm is shelved, the alarm is automatically acknowledged. If a latched alarm is shelved, the latch on the alarm is reset. While the alarm is shelved, the alarm action is not active.

When the period expires, the alarm is automatically unshelved. Alternatively, an operator can manually unshelve the alarm. The alarm then responds as normal to alarm conditions.

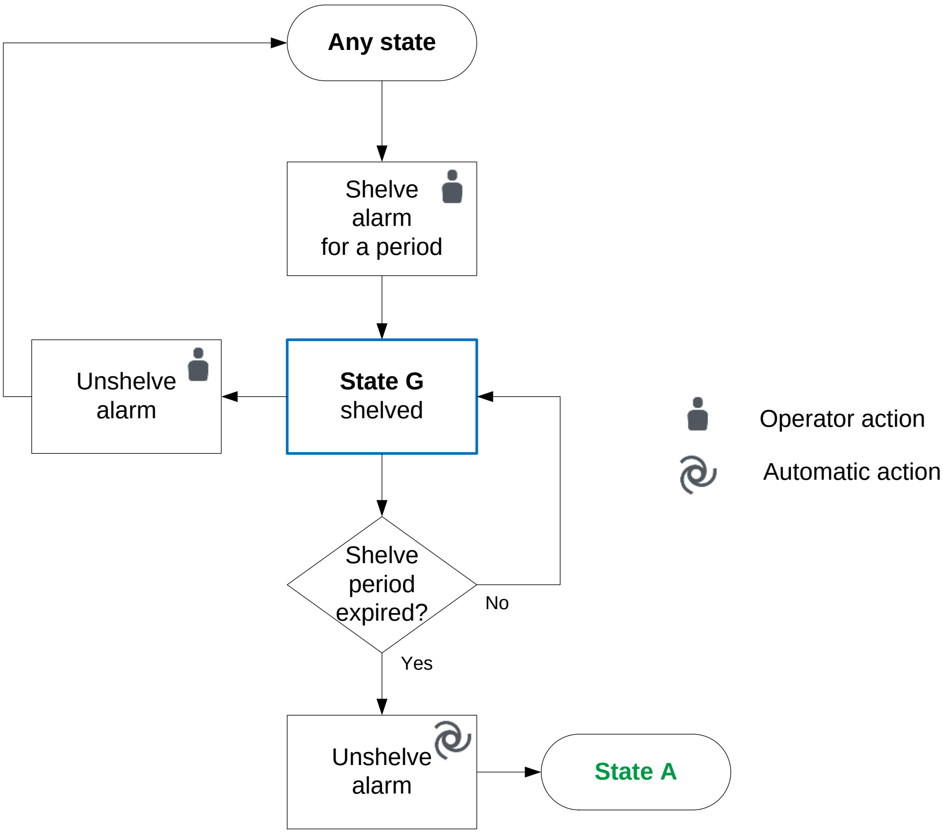
**DANGER!**
**Shelving certain alarms can disable critical protections. In addition, shelving automatically acknowledges the alarm and resets the latch.**

Operator shelves the alarm.

Operator unshelves the alarm.

Check whether the shelve period has expired.

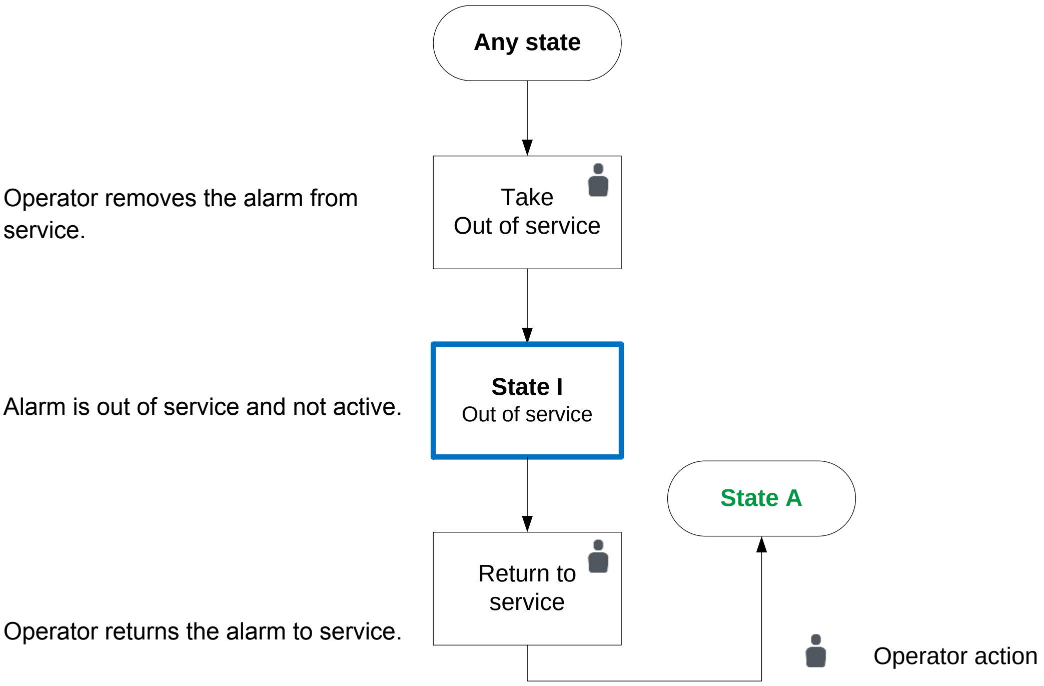
The controller automatically unshelves the alarm after the period expires.




### 4.4.4 Out of service

You can take any alarm *Out of service*, during any alarm state (except if the alarm is already *Shelved*). When an alarm is *Out of service*, the alarm is suspended indefinitely.

**DANGER!**
**Taking certain alarms *Out of service* can disable critical protections. In addition, taking *Out of service* automatically acknowledges the alarm and resets the latch.**




## 4.4.5 Latch reset

You can enable a *Latch* on most alarms. When an alarm with a *Latch* is activated, the alarm *Action* remains in force after the *Alarm condition* clears. The latched alarm then requires acknowledgement and resetting to clear the alarm *Action*.

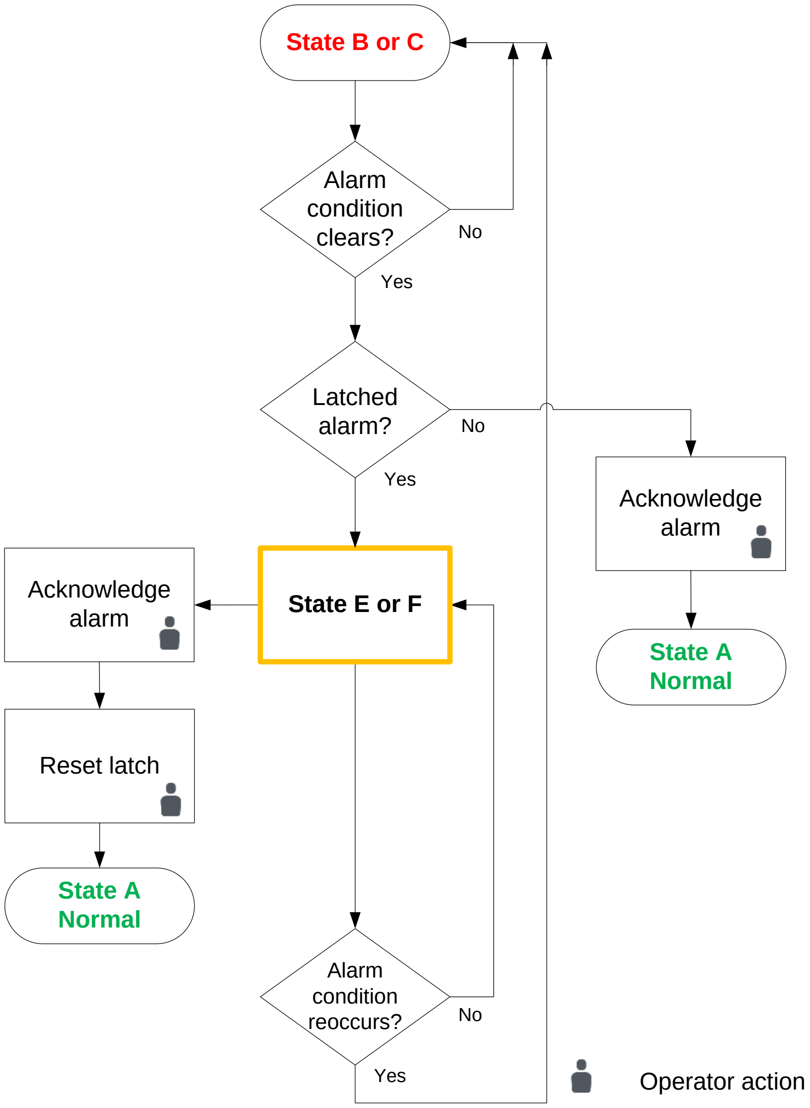
**INFO**
Alarm latching can provide an extra layer of safety for the system.

The controller checks the *Alarm condition*.

The controller checks whether the alarm has a *Latch* enabled.

The latched alarm can be reset after acknowledgment by the operator.

If the alarm condition reoccurs, the alarm is activated again.




## Input

You can assign a function to reset latched alarms to an input under **Configure > Input/output**. Select the hardware module, then select the input to configure.

**Table 4.9** Optional hardware

| Function | IO | Type | Details |
|---|---|---|---|
| Alarm > Reset all latched alarms | Digital input | Pulse | The controller resets all its latched alarms (that are ready to be reset) when this input is activated. |

# 4.5 Alarm test and status

## 4.5.1 Alarm test

The alarm test activates all the controller alarms AND all their alarm actions. You can use the alarm test function to test the controller alarms, for example, during commissioning.

**DANGER!**
**DO NOT use the alarm test during normal operation. Alarm actions include tripping breakers.**

### Parameters

Configure these parameters under **Configure > Parameters > Utility > Alarm test**.

**Table 4.10** Alarm test parameters

| Parameter | Range | Default | Notes |
|---|---|---|---|
| Enable alarm test | Not enabled, Enabled | Not enabled | **Not enabled**: The alarm test function is deactivated.<br><br>**Enabled**: The alarm test starts as soon as the parameter change is written to the controller. All the controller's enabled alarms and their alarm actions are activated. The alarms appear on the display and in the alarm list. |
| Test type | All alarms, Enabled alarms | Enabled alarms | **All alarms**: All the controller's alarms appear on the display and in the alarm list.<br><br>**Enabled alarms**: All the enabled alarms appear on the display and in the alarm list. |

### Before the test

Make sure that you are ready for the consequences of the test, for example, a blackout. If the test consequences are not acceptable, do not use the alarm test function.

Be aware that it may take you some time to get the system back to normal after an alarm test.

### During the test

When the test is *Enabled*, the alarms appear on the display and in the alarm list, and are recorded in the log.

If an alarm is acknowledged during the test, then the alarm is removed from the alarm list, and the alarm action stops. This allows you to test the link to the alarm system.

**Latches**: The test resets all alarm latches. Alarms with latches may simply be acknowledged during the test (that is, it is not necessary to reset the latches during the alarm test).

**Shelved alarms**: The alarm test unshelves these alarms, and they remain unshelved after the test.

**Out of service alarms**: The alarm test returns these alarms to service. These alarms remain in service after the test.

### After the test

When the test is *Not enabled*, the test alarms disappear from the display and the alarm list, and the alarm actions are stopped. However, all the test alarms remain in the log.

## 4.5.2 Alarm status digital outputs

You can configure a digital output with a function for an alarm status. The controller activates the digital output if the alarm status is present.

Assign the function to a digital output under **Configure > Input/output**. Select a hardware module with a digital output, then select the output to configure.

**Table 4.11** Alarm status functions

| Function | IO | Type | Details |
|---|---|---|---|
| Alarm > Status OK | Digital output | Continuous | Activated if the power supply to PSM3.1 is OK, and all of the controller hardware module self-checks were OK.<br><br>*Status OK* is always configured on terminals 3 and 4 of PCM3.1. *Status OK* can also be configured on any other digital output terminals.<br><br>This digital output has a safety function. The controller deactivates this output if there is a problem with the controller. |
| Alarm > Any alarm | Digital output | Continuous | Activated if there are any active alarms in the controller. Active alarms include unacknowledged alarms, but exclude alarms that are shelved or out of service. |
| Alarm > Any unacknowledged alarm | Digital output | Continuous | Activated if there are any unacknowledged alarms in the controller. |
| Alarm > Any latched alarm | Digital output | Continuous | Activated if there are any active alarms with active latches in the controller. |
| Alarm > Any shelved alarm | Digital output | Continuous | Activated if there are any shelved alarms in the controller. |
| Alarm > Any out of service alarm | Digital output | Continuous | Activated if any alarms in the controller are out of service. |
| Alarm > Any warning alarm | Digital output | Continuous | Activated if there is any warning alarm active in the controller. |
| Alarm > Any GB trip alarm | Digital output | Continuous | Activated if there is any active alarm in the controller with the alarm action *Trip generator breaker*. |

### Applications

A digital output with an alarm status may be wired to a switchboard light, to help the operator. For example, you can configure a relay with the *Alarm > Any latched alarm* function, and wire it to a light on the switchboard. When there are any alarms with active latches, the light is lit. The operator then knows that there are alarms that must be checked and unlatched.

### Alarm test

The alarm test activates these outputs. Acknowledging the test alarms deactivates the outputs.

# 4.6 Horn outputs

## 4.6.1 Horn output function

Any of the controller's configurable digital outputs can be configured as horn outputs. These horn outputs are typically connected to an acoustic alarm or visual indicator.

The controller alarm system is in full control of the horn outputs. Other systems, including CustomLogic, cannot control the horn outputs. If a digital output is configured as a horn output, it cannot be configured for anything else.

You can configure up to three horn output functions, and the parameter settings for each of these functions. By adjusting the parameters, each horn output function can be configured as one of four different types of horn output:

- Simple horn
- Simple horn with acknowledgement
- Siren
- Siren with acknowledgement

The horn outputs are only activated when an alarm condition becomes active in the system.

An operator can silence the horn output by pressing **Horn silence** on the display unit.

See **Silencing alarms** for more information.

### Output

Assign the horn output function under **Configure > Input/output**. Select the hardware module, then select the output to configure.

**Table 4.12** Hardware required in addition to the minimum standard controller wiring

| Function | IO | Type | Details |
|---|---|---|---|
| Alarm > Horn #, where # is 1 to 3 | Digital output | Continuous (performance depends on the output parameter) | The controller activates the horn output based on whether alarms are active and/or acknowledged, according to the selected parameters. |

### Parameters

**INFO**
You must configure the horn output function to see the parameters.

Configure the horn output parameters under **Configure > Parameters > Alarm horn > Horn #**.

**Table 4.13** Default horn output parameters

| Parameter | Range | Default | Notes |
|---|---|---|---|
| Reset when new alarm | Not enabled, Enabled | Not enabled | **Not enabled**: New alarms have no effect on the horn output.<br><br>**Enabled**: When a new alarm is activated, then the timers for *Minimum down time* and *Minimum up time* restart. This gives a wailing effect for new alarms. |
| Minimum down time | 0 s to 1 h | 1 s | Only relevant if *Reset when new alarm* is **Enabled**. See the examples for more information. |
| Minimum up time | 0 s to 1 h | 10 s | Only relevant if *Reset when new alarm* is **Enabled**. See the examples for more information. |
| De-energise when all alarms are ack'ed | Not enabled, Enabled | Not enabled | **Not enabled**: Alarm acknowledgement has no effect on the horn output.<br><br>**Enabled**: When all active alarms are acknowledged, then the horn output is deactivated. |

### Simple horn

The horn output is activated when one or more alarms are active.

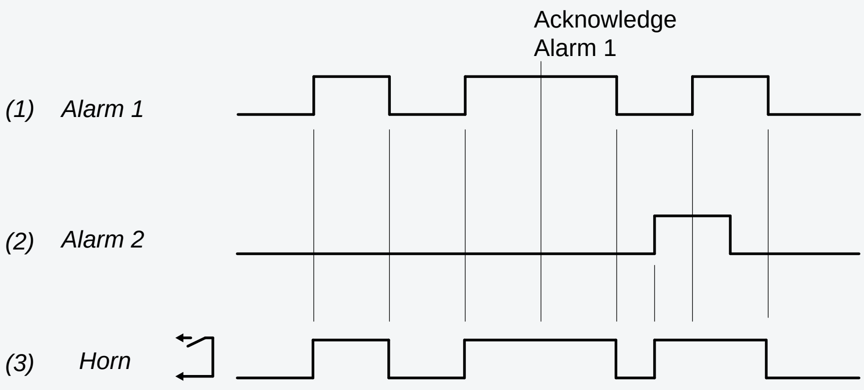
The horn output is deactivated when there are no active alarms.

**Table 4.14** Simple horn parameters

| Parameter | Default | Notes |
|---|---|---|
| Reset when new alarm | Not enabled | |
| Minimum down time | 0 s | No effect on the output. |
| Minimum up time | 0 s | No effect on the output. |
| De-energise when all alarms are ack'ed | Not enabled | |

**INFO**
Acknowledging alarms (or not acknowledging alarms) has no effect on this horn output.

**Simple horn example**




### Simple horn with acknowledge

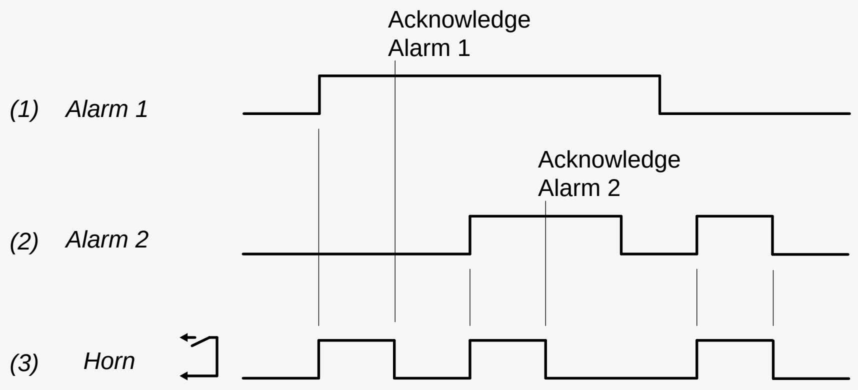
The horn output is activated when one or more alarms are active.

The horn output is deactivated when all alarms are acknowledged, even if there are still active alarms. The horn output is also deactivated when there are no active alarms.

**Table 4.15** Simple horn with acknowledge parameters

| Parameter | Default | Notes |
|---|---|---|
| Reset when new alarm | Not enabled | |
| Minimum down time | 0 s | No effect on the output. |
| Minimum up time | 0 s | No effect on the output. |
| De-energise when all alarms are ack'ed | Enabled | When all active alarms are acknowledged, the horn output is deactivated.<br><br>If there are no latched alarms, the horn output is also deactivated when all the alarms do not exceed their set points, regardless of the acknowledgement status of the alarms. |

**Simple horn with acknowledge example**




The horn output is deactivated when both alarms are acknowledged (even though both alarms are still active).

### Siren

The horn output is activated when one or more alarms are active.

The horn output is deactivated when there are no active alarms.

The horn output is affected when a new alarm becomes active. To alert the operator to the new alarm, the horn output is deactivated for the time in the *Minimum down time* parameter, and then activated again. If the horn output is connected to a siren, this gives a wailing effect every time there is a new alarm.

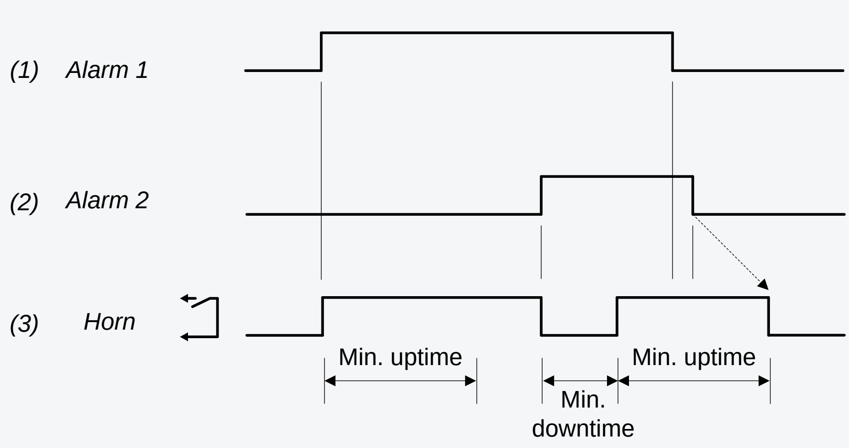
Each time the horn output is activated, the horn output must remain activated for the time in the *Minimum up time* parameter. This stops multiple new alarms from deactivating the horn output.

**Table 4.16** Siren parameters

| Parameter | Default | Notes |
|---|---|---|
| Reset when new alarm | Enabled | |
| Minimum down time | 0 s to 1 h | Required |
| Minimum up time | 0 s to 1 h | Required |
| De-energise when all alarms are ack'ed | Not enabled | |

**INFO**
Acknowledging alarms (or not acknowledging alarms) has no effect on the horn output.

**Siren example**




The horn output is deactivated for the *Minimum down time* when *Alarm 2* becomes active. To fulfil the *Minimum up time* requirement, the horn output remains active for a short time after both alarms become inactive.

### Siren with acknowledge

The horn output is activated when one or more alarms are active.

The horn output is deactivated when there are no active alarms. The horn output is also deactivated when all alarms are acknowledged, even if there are still active alarms.

The horn output is affected when a new alarm is activated. To alert the operator to the new alarm, the horn output is deactivated for the time in the *Minimum down time* parameter, and then activated again. If the horn output is connected to a siren, this gives a wailing effect every time there is a new alarm.

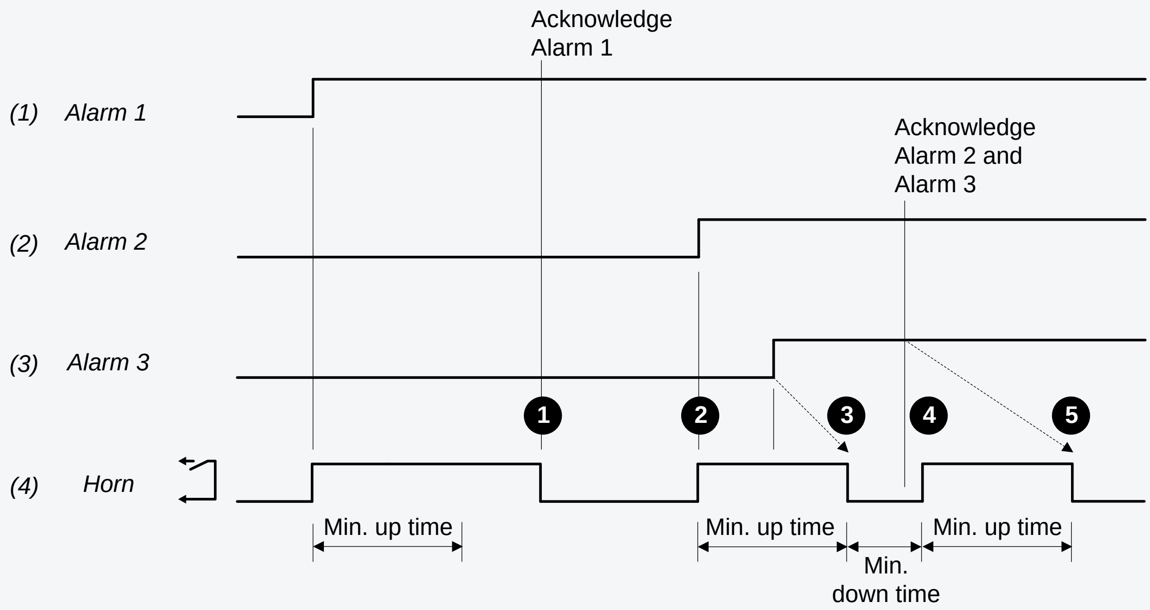
There is no *Minimum down time* when all the alarms are acknowledged.

Each time the horn output is activated, the horn output must remain activated for the time in the *Minimum up time* parameter, to stop multiple new alarms from deactivating the horn output. The horn output will also be activated for the time in the *Minimum up time* parameter even if all alarms are acknowledged.

**Table 4.17** Siren with acknowledge parameters

| Parameter | Default | Notes |
|---|---|---|
| Reset when new alarm | Enabled | |
| Minimum down time | 0 s to 1 h | Required |
| Minimum up time | 0 s to 1 h | Required |
| De-energise when all alarms are ack'ed | Enabled | When all active alarms are acknowledged, the horn output is deactivated.<br><br>If there are no latched alarms, the horn output is also deactivated when all the alarms do not exceed their set points, regardless of the acknowledgement status of the alarms. |

**Siren with acknowledge example**



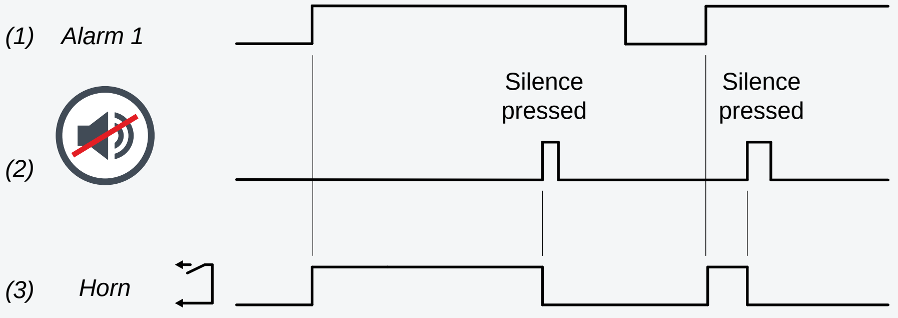

1. The horn output is deactivated when alarm 1 is acknowledged. There is no *Minimum down time* when the alarms are acknowledged.
2. Alarm 2 becomes active, and shortly after that, alarm 3 become active. For alarm 2, the horn output remains activated for the *Minimum up time*.
3. The horn output is then deactivated for the *Minimum down time* for alarm 3.
4. All alarms are acknowledged during the *Minimum down time* for alarm 3. After the *Minimum down time* for alarm 3, the horn output is activated for the *Minimum up time*, to complete the horn output for alarm 3.
5. The horn output is deactivated after the *Minimum up time*, since all alarms are acknowledged.

## 4.6.2 Silencing alarms

When the operator presses **Horn silence**  on the display unit, the controller immediately deactivates all horn outputs.

**Horn silence**  does NOT have any other effect on the alarm system. If a new alarm is activated after the push-button is pressed, then the horn output restarts.

**Effect of the horn silence push-button example**




**INFO**

**Horn silence** on the display unit does not affect the acknowledgement status of any alarms.

# 4.7 Non-essential loads

## 4.7.1 Non-essential load trip (NEL) function

Non-essential load trip (NEL) groups are tripped to protect the busbar against imminent blackout. The NEL can be configured to trip (that is, disconnect) if over-current, low busbar frequency, overload and/or reactive overload is measured by a controller.

Each non-essential load (NEL) trip is a function with a warning alarm. The trip is active until the measurement that activated the alarm returns to normal (unless the alarm is latched; then the trip remains active until the latch is reset). The operator can then reconnect the non-essential load.

For NEL trip alarms, you can only set the set point and the delay. You cannot assign other alarm actions or use inhibits.

Up to three non-essential loads (NEL) can be defined per controller. The NELs are tripped individually, that is, a trip of NEL 1 does not directly influence NEL 2 or NEL 3. Inhibits are used to prevent an NEL trip when the breaker to the busbar is open.

The order in which the non-essential loads trip depend on the associated reference value, set point and delay. The convention is to trip NEL 1 first and NEL 3 last.

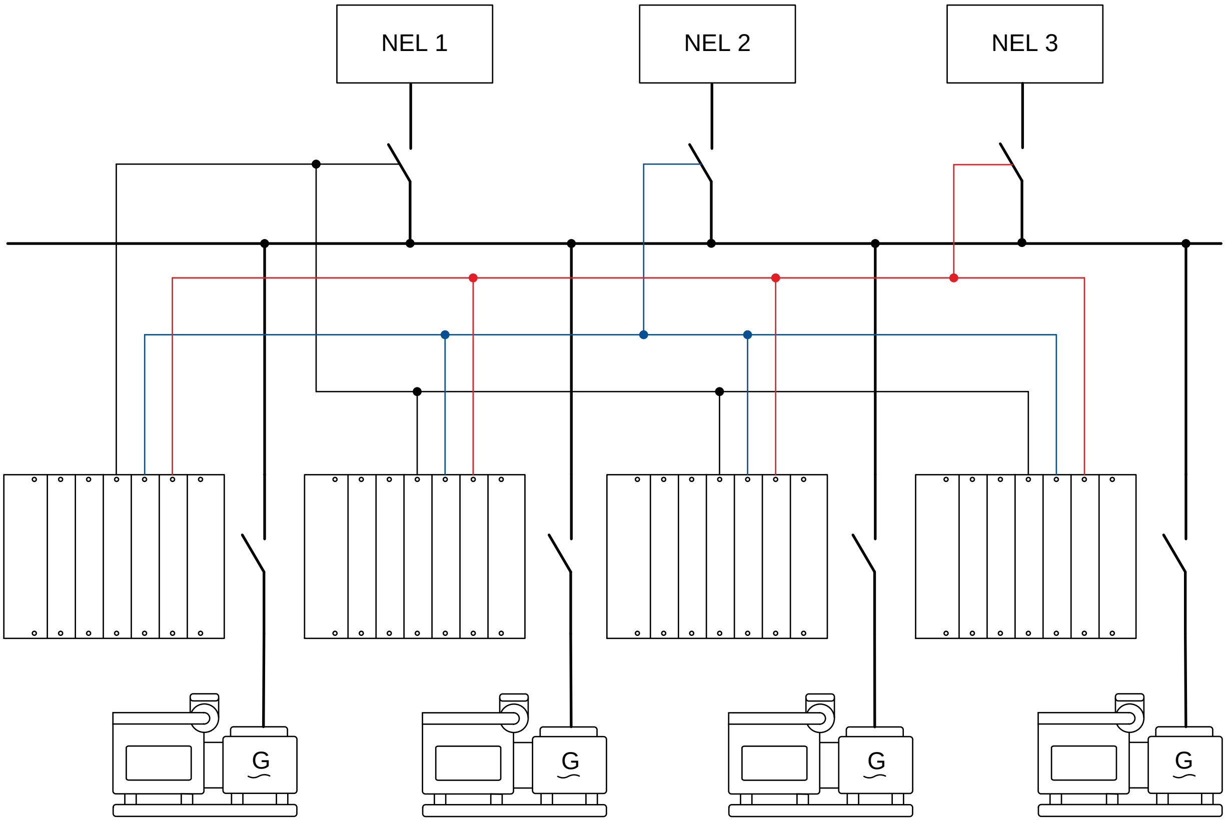
The NEL trip relay is activated when one or more of the NEL alarms is activated. It remains active whenever there is at least one NEL alarm, even if the original NEL alarm is deactivated.

The NEL trips are always active if the controller has power.

**INFO**
In this description, # represents the *NEL ID*.

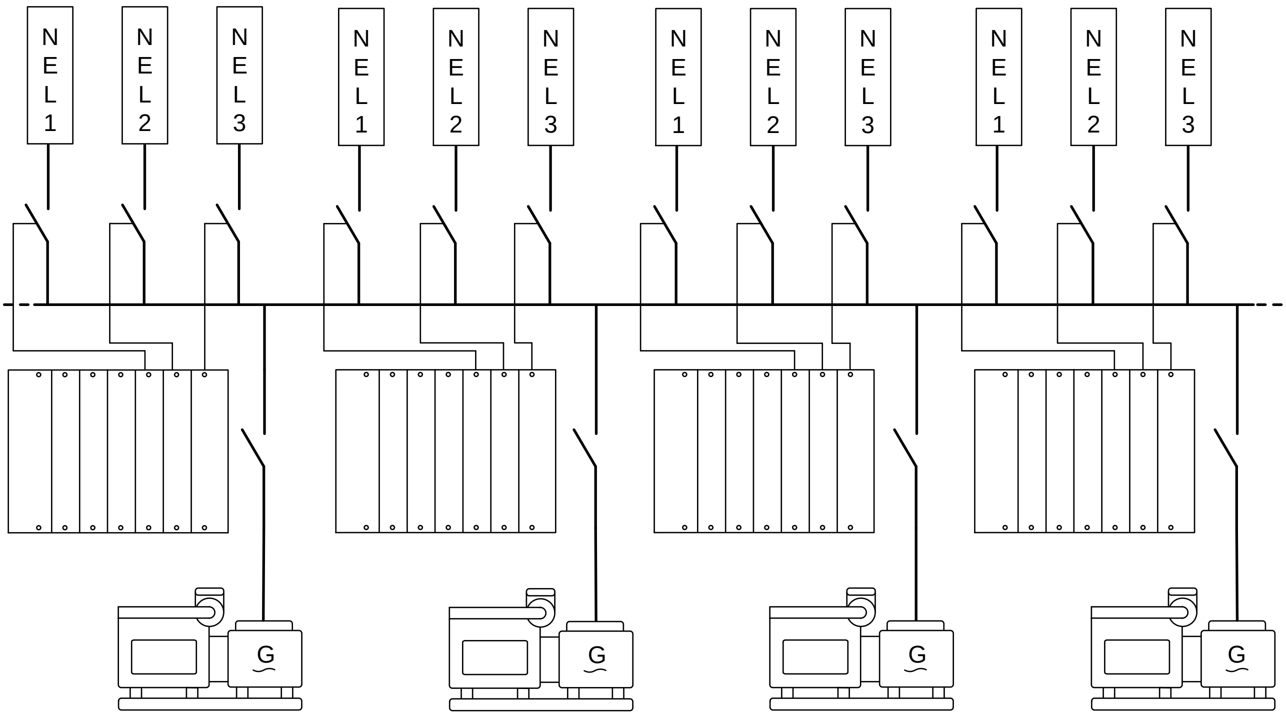
## Wiring examples

**Figure 4.6** Example of three non-essential loads that are connected for full redundancy




For redundancy and secure operation, DEIF strongly recommends that all controller NEL trip settings are identical.

**Figure 4.7** Example of 12 non-essential loads that are connected with no redundancy




DEIF recommends that you connect each non-essential load to each controller, so that any controller can trip the non-essential loads. As a minimum, each non-essential load should be connected to at least two controllers. However, it is possible to connect each controller to up to three non-essential loads, with no interaction from the other controllers.

### Inputs and outputs

Assign the non-essential load inputs and outputs under **Configure > Input/output** for each controller. Select the hardware module, then select the input/output to configure.

**Table 4.18** Hardware required in addition to the minimum standard controller wiring

| Function | IO | Type | Details |
|---|---|---|---|
| Non-essential load trip > Non-essential load trip # | Digital output | Continuous | The controller activates the output when a non-essential load alarm is activated.<br><br>The digital output will be activated as long as at least one NEL alarm is active. That is, if the operating value no longer exceeds the set point, the digital output is normally deactivated. However, if an NEL alarm has a latch, the digital output will not be deactivated until latch is reset. |

### Parameters

The non-essential load parameter is only visible when the *Non-essential load trip #* function is configured.

Configure this parameter under **Configure > Parameters > Non-essential load trip > Trip # > Settings**.

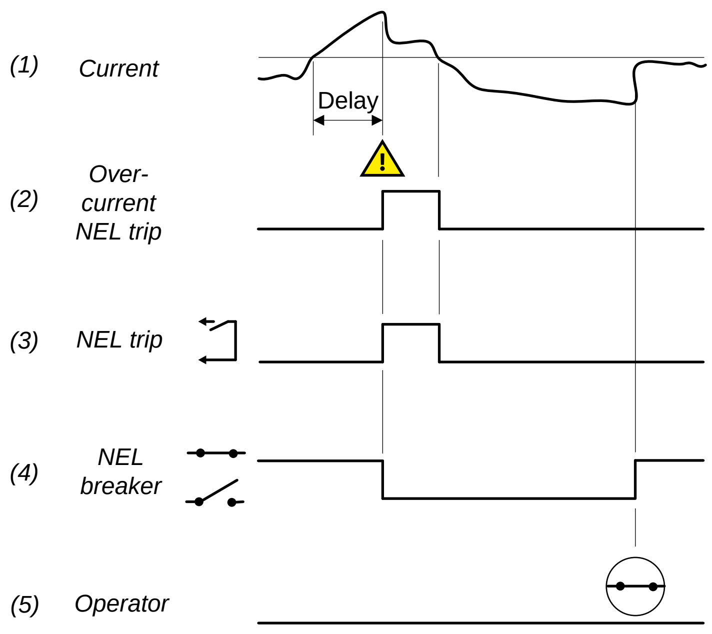
**Table 4.19** Non-essential load parameter

| Parameter | Range | Default | Notes |
|---|---|---|---|
| Trip when breaker trips | Not enabled, Enabled | Not enabled | **Not enabled**: Controller breaker trips have no direct effect on the non-essential load trips.<br><br>**Enabled**: Whenever the controller breaker trips, then the controller also activates the *Non-essential load trip #* output. The NEL trip remains active as long as the breaker trip is active. |

The parameters for each alarm are given in the following sections.

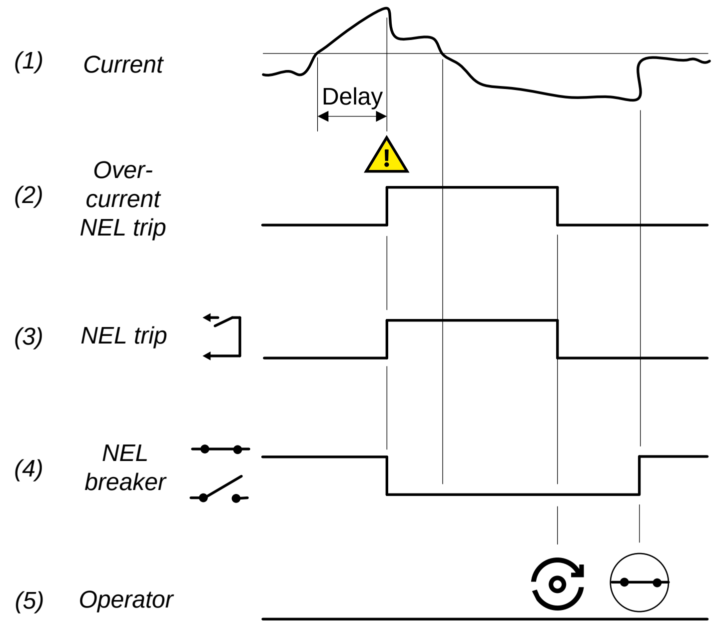
### How the NEL function works

**Table 4.20** Sequence diagram example with over-current NEL trip, without a latch




1. **Current**: The current fluctuates based on the demand. When the current exceeds the set point, the alarm's delay timer starts. If the current is over the set point for the delay time, the alarm is activated and the NEL breaker trips. In response, the current drops.
2. **Over-current NEL trip**: The controller activates the NEL trip when the operating value is above the set point for the delay time.
   - The alarm is deactivated when the alarm value returns to normal.
3. **NEL trip**: *Non-essential load trip > Non-essential load trip #* (digital output): The controller activates this output when an NEL alarm is activated. The output is deactivated when all the NEL alarm values return to normal.
4. **NEL breaker**: The NEL breaker disconnects the NEL when the controller activates the NEL trip output. The operator has to close the breaker to reconnect the NEL.
5. **Operator**: Operator intervention is required to reconnect the NEL.

**Table 4.21** Sequence diagram example with over-current NEL trip with a latch



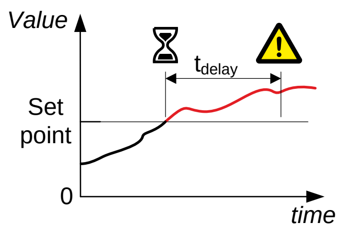

1. **Current**: See the previous example.
2. **Over-current NEL trip**: The controller activates the NEL trip when the operating value is above the set point for the delay time.
   - The alarm is reset when the latch is reset.
3. **NEL trip**: *Non-essential load trip* > *Non-essential load trip #* (digital output): The controller activates this output when an NEL alarm is activated. The output is deactivated when all the NEL alarm values are normal, and all latches are reset.
4. **NEL breaker**: The NEL breaker disconnects the NEL when the controller activates the NEL trip output. The operator has to close the breaker to reconnect the NEL.
5. **Operator**: Operator intervention is required to reset the latch and reconnect the NEL.

## 4.7.2 Over-current NEL trip

These non-essential load trips (NELs) are for over-current protection. The over-current trip may, for example, be activated by inductive loads and an unstable power factor (PF < 0.7), which increase the current.

The trip response is based on the highest of the three phase current true RMS values from the controlled equipment, as measured by the controller.

By default, up to three NEL trips are available.




Configure the parameters under **Configure > Parameters > Non-essential load trip > Trip #** > **Over-current**.

**Table 4.22** Default parameters

| Parameter | Range | Over-current NEL trip 1 | Over-current NEL trip 2 | Over-current NEL trip 3 |
|---|---|---|---|---|
| Set point | 50 to 200 % of nominal current | 100 % | 100 % | 100 % |
| Delay | 0.1 s to 1 h | 5.0 s | 8.0 s | 10.0 s |
| Enable | Not enabled, Enabled | Not enabled | Not enabled | Not enabled |
| Action* | | Warning | Warning | Warning |

*Note: The NEL function also trips NEL #. You cannot reconnect the NEL until the alarm is deactivated.

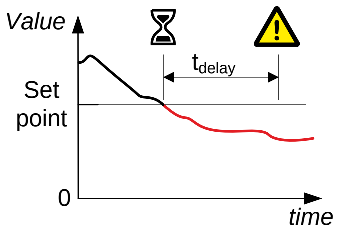
Inhibits: The trips are inhibited if the breaker to the busbar is open.

## 4.7.3 Busbar under-frequency NEL trip

These NEL trips are for busbar under-frequency protection.

The trip response is based on the fundamental frequency of the 3-phase voltage from the busbar, as measured by the controller.

By default, three trips are available for this protection.




Configure the parameters under **Configure > Parameters > Non-essential load trip > Trip # > Under-frequency** .

**Table 4.23** Default parameters

| Parameter | Range | Busbar under-frequency NEL trip 1 | Busbar under-frequency NEL trip 2 | Busbar under-frequency NEL trip 3 |
|---|---|---|---|---|
| Set point | 70 to 100 % of nominal frequency | 95 % | 95 % | 95 % |
| Delay | 0.1 s to 1 h | 5.0 s | 8.0 s | 10.0 s |
| Enable | Not enabled, Enabled | Not enabled | Not enabled | Not enabled |
| Action* | | Warning | Warning | Warning |

*Note: The NEL function also trips NEL #. You cannot reconnect the NEL until the alarm is deactivated.

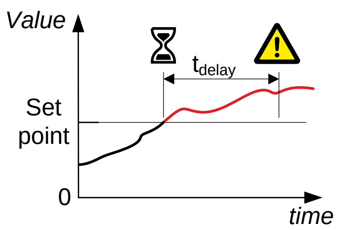
Inhibits: There are no default inhibits for these trips.

## 4.7.4 Overload NEL trip

These non-essential load trips (NEL) are for overload protection. Tripping the NEL groups reduces the active power load at the busbar, and thus reduce the load percentage on all the running gensets. This can prevent a possible blackout at the busbar due to overloading the running gensets.

The alarm response is based on the true RMS value of 3-phase active power supplied by the controlled equipment, as measured by the controller.

By default, six trips are available for this protection. You can configure **Overload 1** for three overload trips, and **Overload 2** for three fast overload trips.




Configure the parameters under **Configure > Parameters > Non-essential load trip > Trip #** > **Overload 1**.

**Table 4.24** Default overload NEL trip parameters

| Parameter | Range | Overload 1 NEL trip 1 | Overload 1 NEL trip 2 | Overload 1 NEL trip 3 |
|---|---|---|---|---|
| Set point | 10 to 200 % of nominal power | 100 % | 100 % | 100 % |
| Time delay | 0.1 s to 1 h | 5.0 s | 8.0 s | 10.0 s |

| Parameter | Range | Overload 1 NEL trip 1 | Overload 1 NEL trip 2 | Overload 1 NEL trip 3 |
|---|---|---|---|---|
| Enable | Not enabled, Enabled | Not enabled | Not enabled | Not enabled |
| Action* | | Warning | Warning | Warning |

*Note: The NEL function also trips NEL #. You cannot reconnect the NEL until the alarm is deactivated.

Configure the parameters under **Configure > Parameters > Non-essential load trip > Trip #** > **Overload 2**.

**Table 4.25** Default fast overload NEL trip parameters

| Parameter | Range | Overload 2 NEL trip 1 | Overload 2 NEL trip 2 | Overload 2 NEL trip 3 |
|---|---|---|---|---|
| Set point | 10 to 200 % of nominal power | 110 % | 110 % | 110 % |
| Time delay | 0.1 s to 100 s | 1.0 s | 1.0 s | 1.0 s |
| Enable | Not enabled, Enabled | Not enabled | Not enabled | Not enabled |
| Action* | | Warning | Warning | Warning |

*Note: The NEL function also trips NEL #. You cannot reconnect the NEL until the alarm is deactivated.

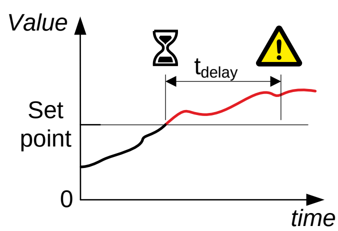
Inhibits: The trips are inhibited if the breaker to the busbar is open.

## 4.7.5 Reactive overload NEL trip

These non-essential load trips (NELs) are for reactive overload protection. Tripping the NELs reduces the reactive power load at the busbar, and thus reduce the load percentage on all the running gensets. This can prevent a possible blackout at the busbar due to overloading the running gensets.

The alarm response is based on the true RMS value of 3-phase reactive power supplied by the controlled equipment, as measured by the controller.

By default, three trips, one for each NEL configured to a controller, are available for this protection.




Configure the parameters under **Configure > Parameters > Non-essential load trip > Trip #** > **Reactive overload**.

**Table 4.26** Default reactive overload NEL trip parameters

| Parameter | Range | Reactive overload NEL trip 1 | Reactive overload NEL trip 2 | Reactive overload NEL trip 3 |
|---|---|---|---|---|
| Set point | 10 to 200 % of nominal reactive power | 110 % | 110 % | 110 % |
| Time delay | 0.1 s to 1 h | 5.0 s | 8.0 s | 10.0 s |
| Enable | Not enabled, Enabled | Not enabled | Not enabled | Not enabled |
| Action* | | Warning | Warning | Warning |

*Note: The NEL function also trips NEL #. You cannot reconnect the NEL until the alarm is deactivated.

Inhibits: The trips are inhibited if the breaker to the busbar is open.

# 4.8 Input alarms

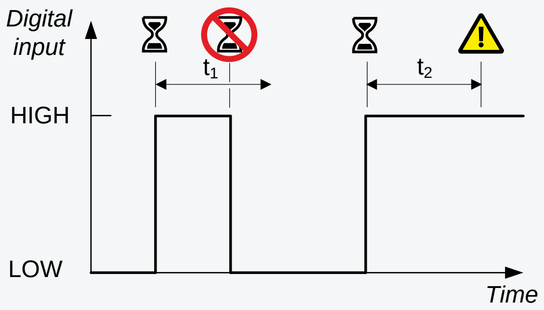
## 4.8.1 Digital input (DI) alarms

You can configure custom alarms for any of the controller module's digital inputs (DI). When the digital input (DI) is triggered the alarm becomes active in the system and the controller does the associated alarm action.

**HIGH input trigger example**

Select "High" for the alarm trigger level.

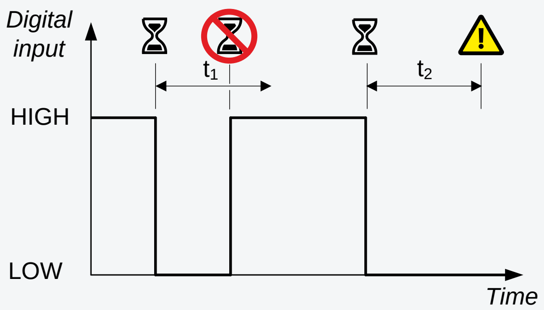
By default, a digital input (DI) is normally open, and the alarm is activated if the digital input is closed for longer than the *Time delay*.




**LOW input trigger example**

Alternatively, configure the digital input (DI) so that the alarm is activated if the digital input is open for longer than the *Time delay*.

Select "Low" for the alarm trigger level.




The custom alarm can be configured with typical alarm parameter settings.

Configure the alarm under **Configure > Input/output > [Hardware module] > DI > Alarms**

**Table 4.27** Custom alarm (DI) parameters

| Parameter | Range | Default | Notes |
|---|---|---|---|
| Title | Text | - | Name for the alarm |
| Trigger level | Low, High | - | Whether the alarm is trigged at **High** or **Low**. |
| Auto acknowledge | Not enabled, Enabled | Not enabled | |
| Latch | Not enabled, Enabled | Not enabled | |
| Time delay | 0 s to 1 h | 10 | Select the unit for the time delay from a list. By default no unit is selected. |

| Parameter | Range | Default | Notes |
|---|---|---|---|
| Action | Selectable list. | - | |
| Inhibit(s) | Selectable list. | - | |

# 4.9 Miscellaneous alarms

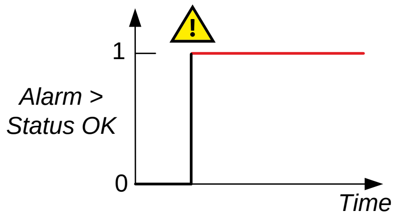
## 4.9.1 System not OK

This alarm communicates that there is a problem with one of the hardware modules in the controller.

The system is okay if all of the following conditions are met:

- All the modules in the rack are sending an OK signal.
- All the modules in the rack have a software version that is compatible with the controller application software.
- All the modules required for the controller type are present in the rack.
- The alternating current module has received all the required settings (wiring mode, nominal settings, and so on) at start-up.
- The controller software has started and is running OK.

By default the *Status OK* alarm output is configured to terminals 3 and 4 of the power supply module of the controller. This configuration cannot be removed or changed.




The alarm action is *Warning*, and the alarm is always enabled. You cannot see or change the alarm parameters.

See **Alarm status digital outputs** for more information about the configuration of the *Status OK* alarm output.

## 4.9.2 Required IO card(s) not found

This alarm communicates that some of the default hardware modules for the controller type were not found.

If one or more default controller hardware modules are missing, then this alarm is activated on start-up. The controller also activates the *System not OK* alarm. The alarm parameters are not visible in PICUS.

## 4.9.3 Software mismatch on hardware module(s)

This alarm is activated if any of the hardware modules in the controller have a software version installed that differs from the expected version. This alarm activates the *System not OK* alarm. The alarm parameters are not visible in PICUS.

**INFO**
This alarm is only activated if you install a replacement hardware module in the controller. Update the controller software to fix the problem.

# 5. AC configuration and nominal settings

## 5.1 AC configuration

### 5.1.1 System

You can configure the system's AC configuration under **Configure > Parameters > AC configuration > System**.

**Phase configuration: AC configuration**
Configure this parameter under **Configure > Parameters > AC configuration > System > Phase configuration**.

You must set this parameter if the AC configuration is not three-phase.

| Parameter | Range | Default | Notes |
|---|---|---|---|
| **AC configuration** | Three phase, Split-phase L1-L3, Split-phase L1-2, Single-phase L1 | Three phase | **Three phase**: The wiring for three-phase AC configuration, is shown in the **Installation instructions**.<br><br>**Split-phase L1-L3**: The waveforms are offset by a half-cycle (180 degrees) from the neutral wire. This is sometimes called L1-N-L3, or single-phase in the USA.<br><br>**Split-phase L1-L2**: The waveforms are offset by a half-cycle (180 degrees) from the neutral wire. This is sometimes called L1-N-L2, or single-phase in the USA.<br><br>**Single-phase L1**: Select this option if the generator and busbar are single-phase. You must use the L1 terminal for the voltage and current measurements. Do not use the L2 or L3 terminals. The current measurement on the neutral phase (N) is optional.<br><br>Some of the controller protections are irrelevant in a single-phase configuration (for example, *Current unbalance*, *Voltage unbalance* and *Phase sequence*). |

See **Wiring for controller functions**, **AC measurement wiring**, **System AC configuration** in the **Installation instructions** for examples of single-phase L1 wiring, and split-phase L1-L2 wiring.

**Phase configuration: AC setup**
Configure this parameter under **Configure > Parameters > AC configuration > System > Phase configuration**.

You must set this parameter if you do not want the AC measurements that the controller uses for the alarms to be phase-to-phase. This parameter determines whether the controller uses phase-to-phase or phase-to-neutral voltages.

Measurements from the neutral line can be present for phase-to-phase measurements.

| Parameter | Range | Default | Notes |
|---|---|---|---|
| **AC setup** | Phase-phase, Phase-neutral | Phase-phase | **Phase-phase**: The controller uses the phase-to-phase voltages for the alarms (that is, L1-L2, L2-L3, and L3-L1). See the **Installation instructions** for a wiring examples for a phase-to-phase AC configuration.<br><br>**Phase-neutral**: The controller uses the phase-to-neutral voltages for the alarms (that is, L1-N, L2-N, and L3-N). Measurements from the neutral line must be present in a phase-to-neutral system.<br><br>If you select *Single-phase L1*, you must also select *Phase-neutral*. |

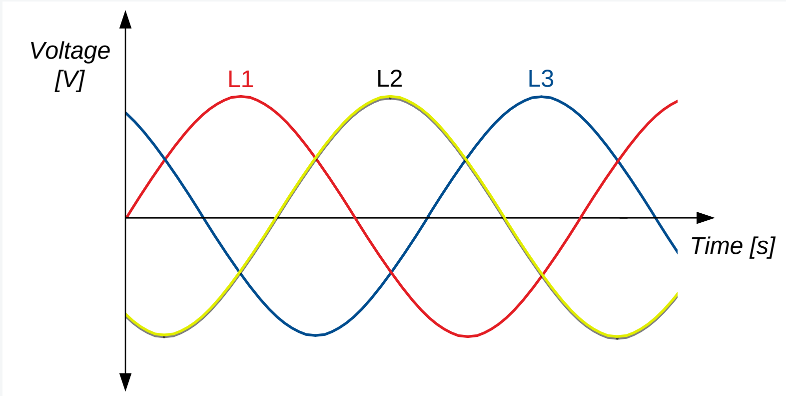
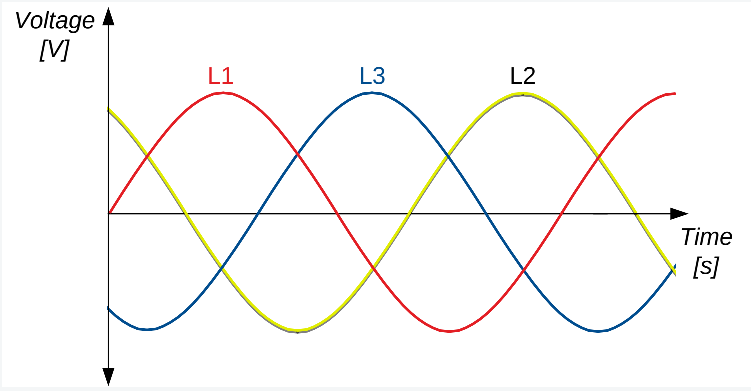
See **Wiring for controller functions**, **AC measurement wiring**, **System AC configuration** in the **Installation instructions** for an example of wiring required for the phase-to-neutral voltage measurements.

**INFO**
This parameter does not affect the nominal voltages. The nominal voltages are always phase-to-phase voltages.

### Phase direction: AC phase rotation

Configure this parameter under **Configure > Parameters > AC configuration > System > Phase direction**.

You must set this parameter if the AC phase rotation is not L1-L2-L3.

| Parameter | Range | Default | Notes |
|---|---|---|---|
| AC phase rotation | L1-L2-L3, L1-L3-L2 | L1-L2-L3 | **L1-L2-L3**: The global standard phase rotation is L1-L2-L3. Using an alternative wiring can lead to confusion, fatal accidents and serious damage to equipment.<br><br>**L1-L3-L2**: DEIF does not recommend that you wire the system L1-L3-L2, due to the potential for confusion. However, this parameter allows the controller to function correctly even though the generator is wired L1-L3-L2.<br> |

**DANGER!**
**Never attempt to connect gensets to the same busbar if they do not have the same phase rotation.**

**DANGER!**
**Do not use this parameter to attempt to correct for incorrect wiring of the controller's AC measurement terminals. Rewire the terminals correctly.**

## 5.1.2 [Controlled equipment] and [Busbar]

For GPU 300, most applications involve the protection of a generator and generator breaker. "Generator" is the [Controlled equipment] and "Busbar" is [Busbar] for the AC configuration.

However, it is also possible to use a GPU 300 to control other types of breaker. The AC configuration names remain "Generator" and "Busbar". The table below shows how these relate for other types of breaker.

| Application | [Controlled equipment] | [Busbar] |
|---|---|---|
| Generator | Generator | Busbar |
| Shaft generator | Generator | Busbar |
| Shore connection | Shore busbar | Ship busbar |
| Bus tie breaker | Busbar A | Busbar B |
| Motor | Motor | Busbar |

## 5.1.3 Generator AC configuration

You can configure the controlled equipment's AC configuration.

### Voltage transformer

Configure these parameters under **Configure > Parameters > AC configuration > Generator > Voltage transformer**.

You must set these parameters if there is a voltage transformer on the controlled equipment's voltage measurement.

If *Primary*:*Secondary* ratio is 1, the controller uses the voltage measurement without any correction for a voltage transformer.

The controller does not need information about the voltage transformer type (for example, open delta, star-delta, and so on).

| Parameter | Range | Default | Notes |
|---|---|---|---|
| Primary | 10 V to 160 kV | 400 V | Use the controlled equipment nominal voltage. |
| Secondary | 17 to 690 V | 400 V | The voltage on the controller side of the voltage transformer.<br><br>Note: The phase angle must be the same on the high and low voltage sides of the generator voltage measurement transformer.<br>Note: The minimum normal operating voltage for the controller is 100 V. However, this range starts at 17 V to allow switchboard tests. |

See **Wiring for controller functions**, **AC measurement wiring**, **Generator AC configuration** in the **Installation instructions** for an example of generator voltage transformer wiring.

### Current transformer

Configure these parameters under **Configure > Parameters > AC configuration > Generator > Current transformer**.

You must set these parameters if there is a current transformer on the controlled equipment's current measurement. These parameters only apply to the current measurements on L1, L2 and L3.

| Parameter | Range | Default | Notes |
|---|---|---|---|
| Primary | 5 to 9000 A | 1000 A | Use the controlled equipment's nominal current. |
| Secondary | 1 or 5 A | 1 A | The current on the controller side of the current transformer. You can select either 1 A or 5 A. |

See the **Installation instructions** for examples of generator current transformer wiring.

### Voltage and frequency OK

Configure these parameters under **Configure > Parameters > AC configuration > Generator > Voltage and frequency OK**.

The controller normally uses these parameters to calculate whether the voltage and frequency from the controlled equipment measurements are OK, for the synchronisation check.

| Parameter | Range | Default | Notes |
|---|---|---|---|
| Frequency and voltage OK | 0 s to 1 h | 2 s | If the voltage and frequency are OK for this time in seconds, then the equipment's LED becomes steady green. |
| Minimum OK voltage | 90 to 100 % | 95 % | The voltage must be above this voltage (as a percent of nominal voltage) for the synchronisation check. |
| Maximum OK voltage | 100 to 110 % | 105 % | The voltage must be below this voltage (as a percent of nominal voltage) for the synchronisation check. |
| Minimum OK frequency | 90 to 100 % | 99 % | The frequency must above this frequency (as a percent of nominal frequency) for the synchronisation check. |
| Maximum OK frequency | 100 to 110 % | 101 % | The frequency must below this frequency (as a percent of nominal frequency) for the synchronisation check. |

See **Synchronisation check** for more information.

## 5.1.4 Busbar AC configuration

You can configure the busbar's AC configuration.

### Voltage transformer

Configure these parameters under **Configure > Parameters > AC configuration > Busbar > Voltage transformer**.

You must set these parameters if there are voltage transformers on the busbar voltage measurement.

If *Primary*:*Secondary* ratio is 1, the controller uses the voltage measurement without any correction for a voltage transformer.

The controller does not need information about the voltage transformer type (for example, open delta, star-delta, and so on).

| Parameter | Range | Default | Notes |
|---|---|---|---|
| Primary | 10 V to 160 kV | 400 V | The busbar nominal voltage. |
| Secondary | 17 to 690 V | 400 V | The voltage on the controller side of the voltage transformer.<br><br>Note: The phase angle must be the same on the high and low voltage sides of the busbar voltage measurement transformer.<br>Note: The minimum normal operating voltage for the controller is 100 V. However, this range starts at 17 V to allow switchboard tests. |

See **Wiring for controller functions**, **Busbar AC configuration** in the **Installation instructions** for an example of busbar voltage transformer wiring.

### Voltage and frequency OK

Configure these parameters under **Configure > Parameters > AC configuration > Busbar > Voltage and frequency OK**.

The controller uses these parameters to calculate whether the voltage and frequency from the busbar measurements are OK.

| Parameter | Range | Default | Notes |
|---|---|---|---|
| Frequency and voltage OK | 0 to 1 h | 0 s | If the busbar voltage and frequency are OK for this time in seconds, then the busbar LED becomes steady green. The busbar LED must be steady green (that is, not flashing) for the synchronisation check. |
| Minimum OK voltage | 90 to 100 % | 95 % | The voltage must be above this voltage (as a percent of nominal voltage) for the synchronisation check. |
| Maximum OK voltage | 100 to 110 % | 105 % | The voltage must be below this voltage (as a percent of nominal voltage) for the synchronisation check. |
| Minimum OK frequency | 90 to 100 % | 98 % | The frequency must above this frequency (as a percent of nominal frequency) for the synchronisation check. |
| Maximum OK frequency | 100 to 110 % | 102 % | The frequency must below this frequency (as a percent of nominal frequency) for the synchronisation check. |

### Blackout detection

Configure this parameter under **Configure > Parameters > AC configuration > [Busbar] > Blackout detection**.

| Parameter | Range | Default | Notes |
|---|---|---|---|
| Blackout delay | 0 to 1 h | 0 s | After detecting the blackout, the controller does not respond unless the blackout is still present after this time. |

## 5.1.5 4th current AC configuration

You can configure the 4th current's AC configuration.

### Current transformer (I4)

Configure these parameters under **Configure > Parameters > AC configuration > 4th current input > Current transformer (I4)**.

You must set these parameters if there is a current transformer on the 4th current measurement. These parameters only apply to the current measurements at the 4th current measurement position.

| Parameter | Range | Default | Notes |
|---|---|---|---|
| Primary | 5 to 9000 A | 1000 A | Use the measurement position's nominal current. |
| Secondary | 1 or 5 A | 1 A | The current on the controller side of the current transformer. You can select either 1 A or 5 A. |

See the **Installation instructions** for examples of 4th current transformer wiring.

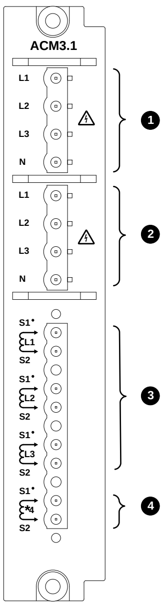
# 5.2 Nominal settings

## 5.2.1 General information on nominal settings

The controller nominal settings are used in a number of key functions. For example, many protection settings are based on a percentage of the nominal settings.

The nominal settings for the controller are mainly the alternating current (AC) settings. See the controller description for more information on the nominal settings.

This is how the AC measurements on the ACM3.1 module relate to the controller:




1. Busbar voltage measurements
2. Generator voltage measurements
3. Generator current measurements
4. Configurable current measurement

## 5.2.2 Nominal power calculations

Configure the controller nominal power calculations under **Configure > Parameters > [Controlled equipment] > Nominal settings > Calculation method**.

### Reactive power (Q) nominal

Some alarms and regulators use the nominal reactive power (Q). However, Q is not defined in the controller's nominal settings. The controller therefore always calculates Q. You can select the method that the controller uses here.

**Table 5.1** Calculation method

| Parameter | Range | Default | Notes |
|---|---|---|---|
| Reactive power (Q) nominal | See notes | Q nominal calculated | **Q nominal calculated**: The controller calculates Q nominal based on S nominal and the power factor.<br><br>**Q nominal = P nominal**: The controller uses the nominal power as the nominal reactive power.<br><br>**Q nominal = S nominal**: The controller uses the nominal apparent power as the nominal reactive power. |

**INFO**
If PF nominal = 1, then *Q nominal calculated* will be 0. Select *Q nominal = P nominal*, or *Q nominal = S nominal* if *Q nominal* must not be 0.

**INFO**
The set points for the reactive power import and reactive power export alarms are based on Q nominal. If Q nominal = 0, then these alarms will always be activated, unless they are configured as *Not enabled*.

**P or S nominal**

**Table 5.2** Calculation method

| Parameter | Range | Default | Notes |
|---|---|---|---|
| P or S nominal | See notes | No calculation | **No calculation**: *P nominal* has the value entered in the Power (P) nominal parameter. *S nominal* has the value entered in the Apparent power (S) nominal parameter.<br><br>**P nominal calculated**: The controller uses the nominal apparent power (S) and nominal power factor (PF) to calculate the nominal power.<br><br>**S nominal calculated**: The controller uses the nominal power (P) and the nominal power factor (PF) to calculate the nominal apparent power. |

# 5.3 Generator AC protections

## 5.3.1 Information about protections

This section describes the AC protections based on the controller's measurements on the generator side of the breaker.

For the controller, [Controlled equipment] is *Generator*, and [Breaker] is *GB*.

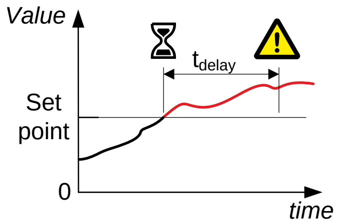
The controller includes the following alternating current (AC) protections, according to IEEE Std. C37.2-1996 (R2008).

The protections comply with the protection functionality in IEC 61850-5 and IEC 61850-7-4, but not the communication requirements of IEC 61850. The protection names in the following tables are derived from the specification that provides the most accurate description of the protection.

## 5.3.2 Over-voltage (ANSI 59)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Over-voltage | U>, U>> | 59 | PTOV | < 100 ms |

The alarm response is based on the highest phase-to-phase voltage, or the highest phase-to-neutral voltage, from the generator, as measured by the controller. The phase-to-phase voltage is the default. The phase-to-neutral voltage is used if selected under **Configure > Parameters > AC configuration > System > Phase configuration > AC setup**.




Configure the parameters under **Configure > Parameters > Generator > Voltage protections > Over-voltage**.

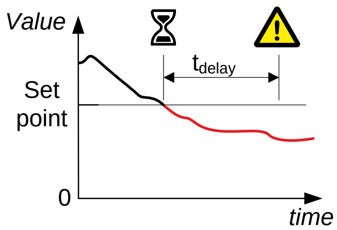
**Table 5.3** Default parameters

| Parameter | Range | Over-voltage 1 | Over-voltage 2 |
|---|---|---|---|
| Set point | 80 to 120 % of nominal voltage | 105 % | 115 % |
| Time delay | 0.00 s to 1 h | 5.00 s | 1.00 s |
| Enable | Not enabled, Enabled | Not enabled | Not enabled |
| Action | | Warning | Warning |
| Inhibit | | Generator breaker closed | Generator breaker closed |

## 5.3.3 Under-voltage (ANSI 27)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Under-voltage | U<, U<< | 27 | PTUV | < 100 ms |

The alarm response is based on the lowest phase-to-phase voltage, or the lowest phase-to-neutral voltage, from the generator, as measured by the controller. The phase-to-phase voltage is the default. The phase-to-neutral voltage is used if selected under **Configure > Parameters > AC configuration > System > Phase configuration > AC setup**.




Configure the parameters under **Configure > Parameters > Generator > Voltage protections > Under-voltage**.

**Table 5.4** Default parameters

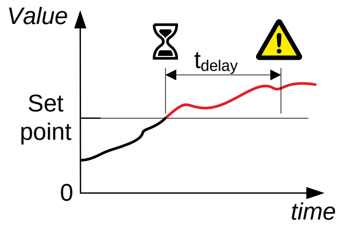
| Parameter | Range | Under-voltage 1 | Under-voltage 2 |
|---|---|---|---|
| Set point | 50 to 100 % of nominal voltage | 95 % | 80 % |
| Delay | 0.00 s to 1 h | 5.00 s | 3.00 s |
| Enable | Not enabled, Enabled | Enabled | Enabled |
| Action | | Warning | Warning |
| Inhibits | | Generator breaker closed | Generator breaker closed |

## 5.3.4 Voltage unbalance (ANSI 47)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Voltage unbalance (voltage asymmetry) | UUB> | 47 | - | < 200 ms |

The alarm response is based on the highest difference between any of the three phase-to-phase voltage or phase-to-neutral true RMS values and the average voltage, as measured by the controller. The phase-to-phase voltage is the default. The phase-to-neutral voltage is used if selected under **Configure > Parameters > AC configuration > System > Phase configuration > AC setup**.

If phase-to-phase voltages are used, the controller calculates the average phase-to-phase voltage. The controller then calculates the difference between each phase-to-phase voltage and the average voltage. Finally, the controller divides the maximum difference by the average voltage to get the voltage unbalance.




Configure the parameters under **Configure > Parameters > Generator > Voltage protections > Voltage unbalance**.

**Table 5.5** Default parameters

| Parameter | Range | Voltage unbalance |
|---|---|---|
| Set point | 0 to 50 % | 10 % |
| Delay | 0.1 s to 1 h | 10.00 s |
| Enable | Not enabled, Enabled | Enabled |
| Alarm action | | Warning |
| Inhibits | | ACM wire break |

**Voltage unbalance example**

A genset has a nominal voltage of 230 V. The L1-L2 voltage is 235 V, the L2-L3 voltage is 225 V, and the L3-L1 voltage is 210 V.

The average voltage is 223.3 V. The difference between the phase-to-phase voltage and the average is 12.7 V for L1-L2, 2.7 V for L2-L3 and 13.3 V for L3-L1.

The voltage unbalance is 13.3 V/223.3 V = 0.06 = 6.0 %.

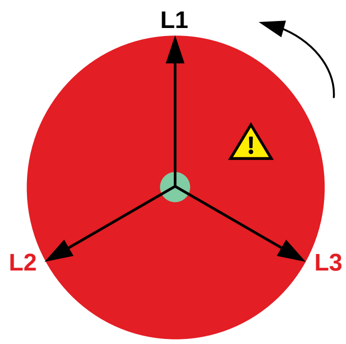
## 5.3.5 Negative sequence voltage (ANSI 60)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Negative sequence voltage | | 60 | PNSC | < 200 ms |

Negative sequence voltages arise when the virtual representation of the phase rotation for an unbalanced system appears negative.

Negative sequence voltages can occur where there are single phase loads, unbalanced line short circuits and open conductors, and/or unbalanced phase-to-phase or phase-to-neutral loads.

The alarm response is based on the sum of the phase voltages, with a correction for the phase angle, as measured from the generator.




Configure the parameters under **Configure > Parameters > Generator > Voltage protections > Negative sequence voltage**.

**Table 5.6** Default parameters

| Parameter | Range | Negative sequence voltage |
|---|---|---|
| Set point | 1 to 100 % of nominal voltage | 5 % |
| Time delay | 0.1 s to 1 h | 0.5 s |
| Enable | Not enabled, Enabled | Not enabled |
| Action | | Warning |

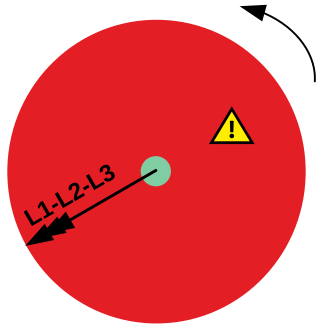
## 5.3.6 Zero sequence voltage (ANSI 59Uo)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Zero sequence voltage | | 59Uo | PZOV | < 200 ms |

Zero sequence voltages arise when the phases rotation is positive, but the vector zero value (star point) is displaced. This zero sequence voltage protection can be used instead of using zero voltage measurement or summation transformers (zero sequence transformers).

This protection is used for detecting earth faults.

The alarm response is based on the sum of the phase voltages, as measured from the generator.




Configure the parameters under **Configure > Parameters > Generator > Voltage protections > Zero sequence voltage**.

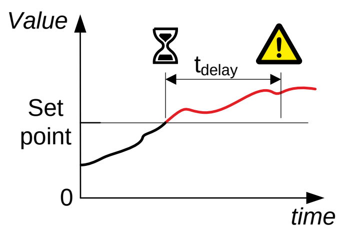
**Table 5.7** Default parameters

| Parameter | Range | Zero sequence voltage |
|---|---|---|
| Set point | 1 to 100 % of nominal voltage | 5 % |
| Time delay | 0.1 s to 1 h | 0.5 s |
| Enable | Not enabled, Enabled | Not enabled |
| Action | | Warning |

## 5.3.7 Over-current (ANSI 50TD)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Over-current | 3I>, 3I>> | 50TD | PTOC | < 100 ms |

The alarm response is based on the highest of the three line current true RMS values from the controlled equipment, as measured by the controller.




Configure the parameters under **Configure > Parameters > Generator > Current protections > Over-current**.

**Table 5.8** Default parameters

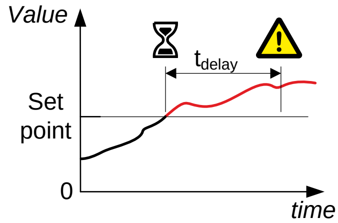
| Parameter | Range | Over-current 1 | Over-current 2 |
|---|---|---|---|
| Set point | 50 to 200 % of nominal current | 100 % | 110 % |
| Delay | 0.00 s to 1 h | 20 s | 60 s |
| Enable | Not enabled, Enabled | Enabled | Enabled |
| Alarm action | | Warning | Trip generator breaker |

## 5.3.8 Fast over-current (ANSI 50/50TD)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Fast over-current | 3I>>> | 50/50TD* | PIOC* | < 50 ms |

*Note: ANSI **50** and IEC 61850-5 **PIOC** apply when the *Delay* parameter is 0 s.

The alarm response is based on the highest of all three line current true RMS values from the controlled equipment, as measured by the controller.




Configure the parameters under **Configure > Parameters > Generator > Current protections > Fast over-current**.

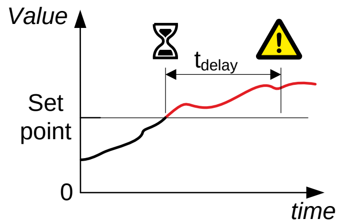
**Table 5.9** Default parameters

| Parameter | Range | Fast over-current 1 | Fast over-current 2 |
|---|---|---|---|
| Set point | 80 to 350 % of nominal current | 200 % | 300 % |
| Delay | 0.00 s to 1 h | 0.00 s | 0.00 s |
| Enable | Not enabled, Enabled | Not enabled | Not enabled |
| Action | | Trip breaker | Trip breaker |

## 5.3.9 Current unbalance (ANSI 46)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Current unbalance | IUB> | 46 | - | < 200 ms |

The alarm response is based on the highest difference between any of the three phase current true RMS values, as measured by the controller. You can choose either the *Average method* (ANSI) or the *Nominal method* to calculate the *Current unbalance*. See the description and examples below.




Configure the parameters under **Configure > Parameters > Generator > Current protections > Current unbalance (average calc)** or **(nominal calc)**.

**Table 5.10** Default parameters

| Parameter | Range | Current unbalance (average calc.) | Current unbalance (nominal calc.) |
|---|---|---|---|
| Set point | 0 to 100 % | 30 % | 30 % |
| Delay | 0.10 s to 1 h | 10.00 s | 10.00 s |
| Enable | Not enabled, enabled | Enabled | Enabled |
| Action | | Warning | Warning |

### Average method

The *Average method* uses the ANSI standard calculation method to determine current unbalance. The controller calculates the average current for the three phases. The controller then calculates the difference between each phase current and the average current. Finally, the controller divides the maximum difference by the average current to get the current unbalance. See the example below.

**Average method example**

A genset has a nominal current of 100 A. The L1 current is 80 A, the L2 current is 90 A, and the L3 current is 60 A.

The average current is 76.7 A. The difference between the phase current and the average is 3.3 A for L1, 13.3 A for L2 and 16.7 A for L3.

The current unbalance is therefore 16.7 A / 76.7 A = 0.22 = 22 %.

### Nominal method

The controller calculates the difference between the phase with the highest current, and the phase with the lowest current. Finally, the controller divides the difference by the nominal current to get the current unbalance. See the example below.

**Nominal method example**

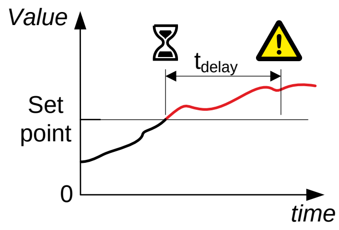
A genset has a nominal current of 100 A. The L1 current is 80 A, the L2 current is 90 A, and the L3 current is 60 A.

The current unbalance is (90 A - 60 A) / 100 A = 0.3 = 30 %.

## 5.3.10 Directional over-current (ANSI 67)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Directional over-current | | 67 | PTOC | < 100 ms |

The alarm response is based on the highest (in a specific direction) of the three line current true RMS values from the generator, as measured by the controller.




Configure the parameters under **Configure > Parameters > Generator > Current protections > Directional over-current #**, where # is 1 or 2.

**Table 5.11** Default parameters

| Parameter | Range | Directional over-current 1 | Directional over-current 2 |
|---|---|---|---|
| Set point | -200 to 200 % of nominal current | 110 % | 130 % |
| Delay | 0.00 s to 1 h | 0.10 s | 0.10 s |
| Enable | Not enabled, Enabled | Not enabled | Not enabled |
| Action | | Warning | Warning |

**INFO**
For a positive set point, the alarm trigger level is *High*. When a negative set point is written to the controller, then the controller automatically changes the alarm trigger level to *Low*.

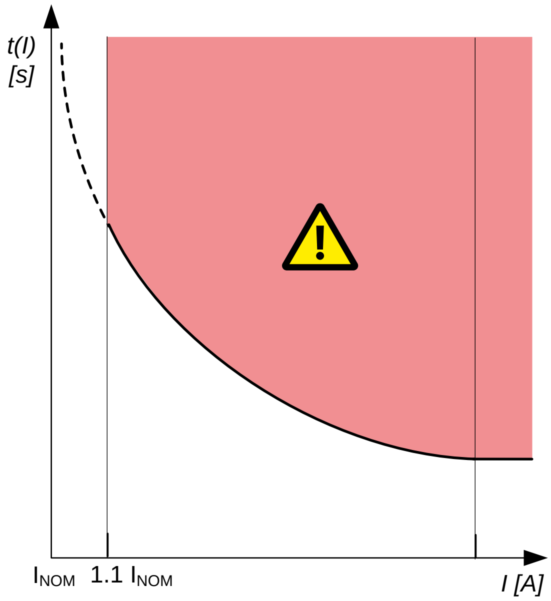
## 5.3.11 Inverse time over-current (ANSI 51)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Inverse time over-current | It> | 51 | PTOC | - |

This is an inverse time over-current alarm.

The alarm response is based on the highest of all three line current true RMS values, according to IEC 60255 part 151, as measured by the controller.

The alarm response time depends on an approximated integral of the current measurement over time. The integral is only updated when the measurement is above the activation threshold. See the description below for more details.




### Inverse time over-current calculation method

The controller uses this equation from IEC 60255 to calculate the time that the current measurement may be over the set point before the inverse time over-current alarm is activated:

$$t(G) = TMS\left(\frac{k}{\left(\frac{G}{G_S}\right)^{\alpha}-1}+c\right)$$

where:

| | |
|---|---|
| t(G) | Theoretical operating time constant value of G, in seconds |
| k, c and α | Constants for the selected curve (*k* and *c* in seconds, *α* (alpha) has no unit) |
| G | Measured value, that is, $I_{phase}$ |
| $G_S$ | Alarm set point ($G_S = I_{nom}$ * LIM) |
| TMS | Time multiplier setting |

### Parameters

Configure the parameters under **Configure > Parameters > Generator > Current protections > Inverse time over-current**.

**Table 5.12** Three-phase inverse time over-current alarm default parameters

| Parameter | Range | Inverse time over-current |
|---|---|---|
| Curve | See the table below | IEC Inverse |
| Limit (the set point, also known as LIM) | 50 to 200 % of nominal current | 110 % |

| Parameter | Range | Inverse time over-current |
|---|---|---|
| Time multiplier setting (TMS) | 0.01 to 100.0 | 1.0 |
| k (only used if custom curve is selected) | 0.001 s to 2 min | 0.14 s |
| c (only used if custom curve is selected) | 0.000 s to 1 min | 0 s |
| alpha (α, or a) (only used if custom curve is selected) | 0.001 to 1 | 0.02 |
| Enable | Not enabled, Enabled | Enabled |
| Alarm action | | Trip breaker |

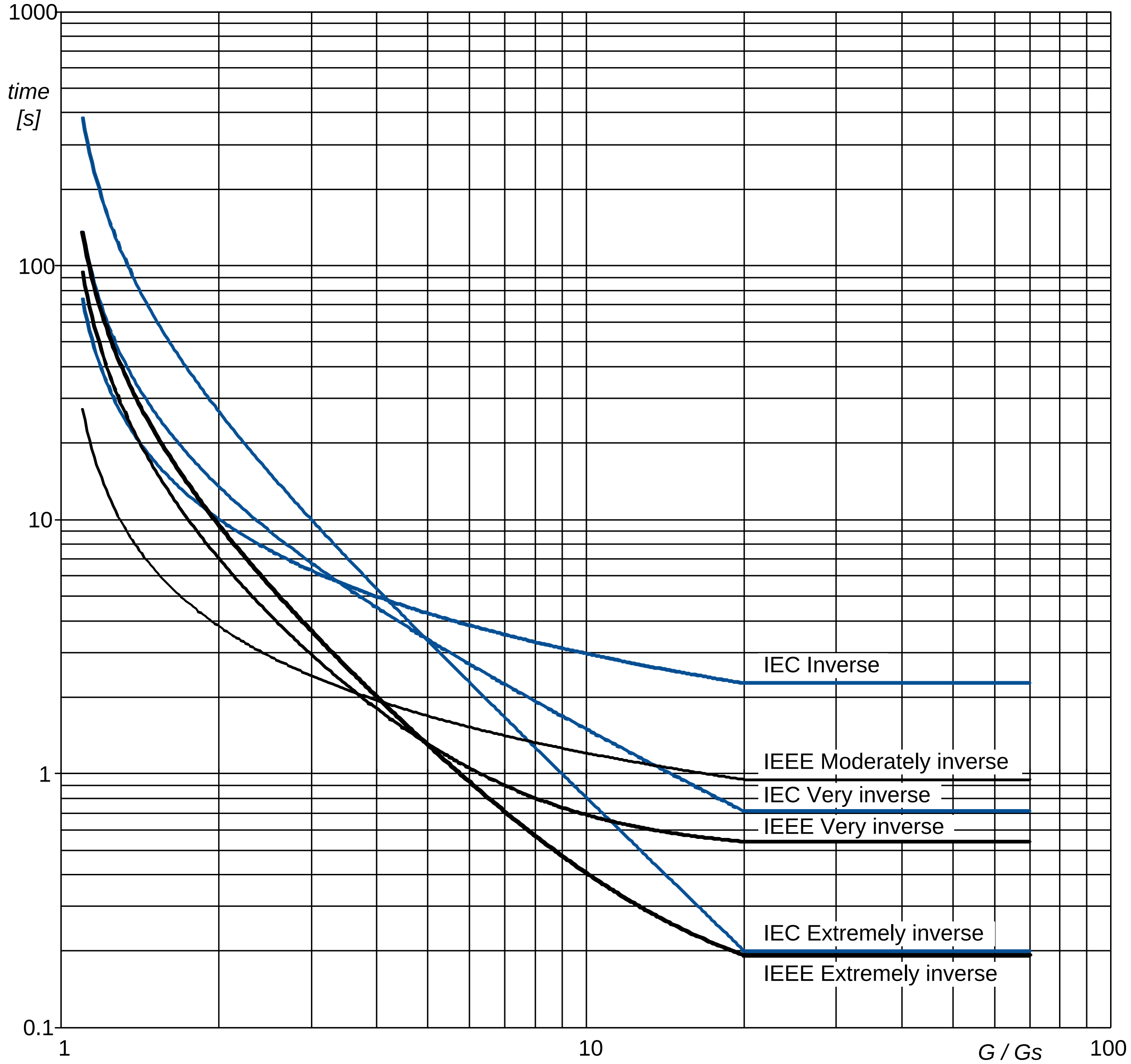
### Standard inverse time over-current curves

The controller includes these standard inverse time over-current curves, in accordance with IEC 60255.

**Table 5.13** Parameters for the inverse time over-current curves

| Curve name | k | c | alpha (α, or a) |
|---|---|---|---|
| IEC Inverse | 0.14 s | 0 s | 0.02 |
| IEC Very Inverse | 13.5 s | 0 s | 1 |
| IEC Extremely Inverse | 80 s | 0 s | 2 |
| IEEE Moderately Inverse | 0.0515 s | 0.114 s | 0.02 |
| IEEE Very Inverse | 19.61 s | 0.491 s | 2 |
| IEEE Extremely Inverse | 28.2 s | 0.1217 s | 2 |
| Custom | Customisable | Customisable | Customisable |

**Figure 5.1** Standard curve shapes for inverse time over-current, with time multiplier setting (TMS) = 1

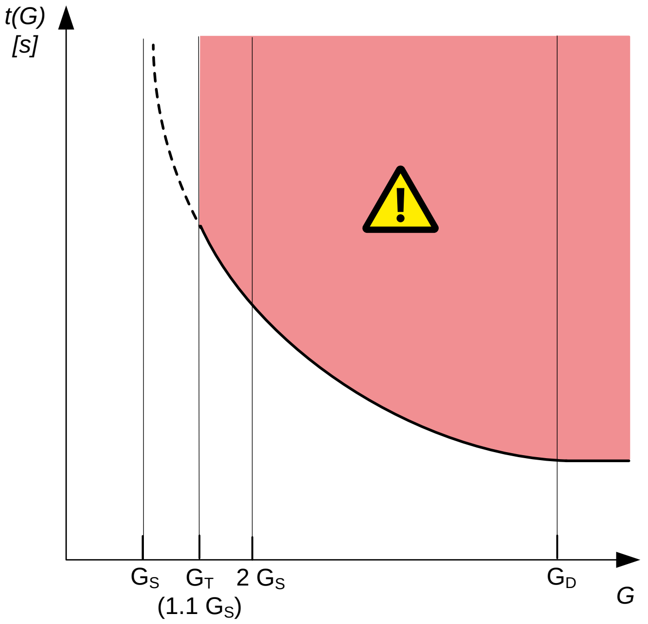



### Definite time characteristic

$G_D$ is the point where the alarm shifts from an inverse curve to a definite time characteristic, as the following graph shows. That is, after this point, the curve is flat, and a current increase does not have any effect on the alarm response time. In IEC60255, this point is defined as $G_D = 20 \times G_S$.

In this controller, if the rated secondary current of the current measurement transformer is **1 A** (that is, the current transformer rating is -/1 A), then $\mathbf{G_D = 17.5 \times G_S}$ for this protection. However, if the rated secondary current of the current transformer is **5 A** (that is, -/5 A), then $\mathbf{G_D = 3.5 \times G_S}$.

**Figure 5.2** Inverse time over-current time characteristic graph




**INFO**
If the performance of the inverse time over-current protection is important, DEIF recommends using a current transformer that is rated for a 1 A secondary current (that is, -/1 A).

### 5.3.12 Negative sequence current (ANSI 46)

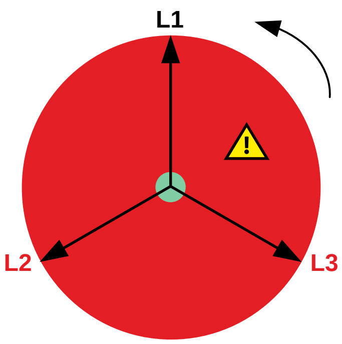
| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Negative sequence current | | 46 | PUBC | < 200 ms |

Negative sequence currents arise when the virtual representation of the phase rotation for an unbalanced system appears negative.

Negative sequence currents can occur where there are single phase loads, unbalanced line short circuits and open conductors, and/or unbalanced phase-phase or phase-neutral loads.

This protection is used to prevent the generator from overheating. Negative sequence currents produce a magnetic field in the generator counter-rotating to the rotor. This field crosses the rotor at twice the rotor velocity, inducing double-frequency currents in the field system and in the rotor body.

The alarm response is based on the sum of the phase currents, with a correction for the phase angle, from the generator, as measured by the controller.



Configure the parameters under **Configure > Parameters > Generator > Current protections > Negative sequence current**.

**Table 5.14** Default parameters

| Parameter | Range | Negative sequence current |
|---|---|---|
| Set point | 1 to 100 % of nominal voltage | 20 % |
| Time delay | 0.1 s to 1 h | 0.50 s |
| Enable | Not enabled, Enabled | Not enabled |
| Action | | Warning |

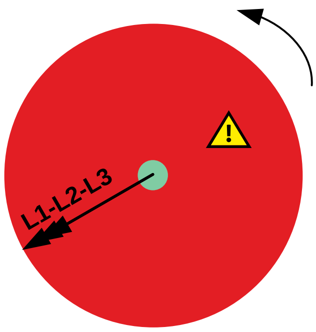
## 5.3.13 Zero sequence current (ANSI 51Io)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Zero sequence current | | 51Io | PTOC | < 200 ms |

Zero sequence currents arise when the phases rotation is positive, but the vector zero value (star point) is displaced.

This protection is used for detecting earth faults.

The alarm response is based on the sum of the phase currents from the generator, as measured by the controller.




Configure the parameters under **Configure > Parameters > Generator > Current protections > Zero sequence current**.

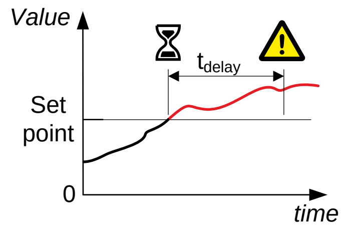
**Table 5.15** Default parameters

| Parameter | Range | Zero sequence current |
|---|---|---|
| Set point | 0 to 100 % of nominal voltage | 20 % |
| Time delay | 0.1 s to 1 h | 0.50 s |
| Enable | Not enabled, Enabled | Not enabled |
| Action | | Warning |

## 5.3.14 Over-frequency (ANSI 81O)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Over-frequency | f>, f>> | 81O | PTOF | < 100 ms |

The alarm response is based on the fundamental frequency of the Line 1-N voltage from the generator, as measured by the controller.




Configure the parameters under **Configure > Parameters > Generator > Frequency protections > Over-frequency**.

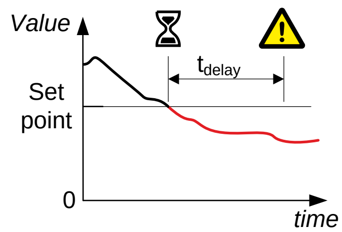
**Table 5.16** Default parameters

| Parameter | Range | Over-frequency 1 | Over-frequency 2 |
|---|---|---|---|
| Set point | 80 to 120 % of nominal frequency | 105 % | 107 % |
| Delay | 0.00 s to 1 h | 5.00 s | 3.00 s |
| Enable | Not enabled, Enabled | Enabled | Enabled |
| Action | | Warning | Warning |
| Inhibit | | Generator breaker closed | Generator breaker closed |

## 5.3.15 Under-frequency (ANSI 81U)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Under-frequency | f<, f<< | 81U | PTUF | < 100 ms |

The alarm response is based on the fundamental frequency of the Line 1-N voltage from the generator, as measured by the controller.




Configure the parameters under **Configure > Parameters > Generator > Frequency protections > Under-frequency**.

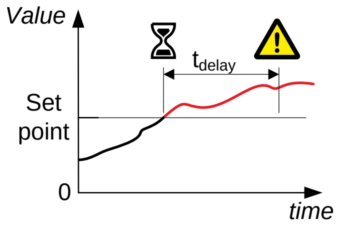
**Table 5.17** Default parameters

| Parameter | Range | Under-frequency 1 | Under-frequency 2 |
|---|---|---|---|
| Set point | 80 to 100 % of nominal frequency | 95 % | 93 % |
| Delay | 0.00 s to 1 h | 5.00 s | 3.00 s |
| Enable | Not enabled, Enabled | Enabled | Enabled |
| Alarm action | | Warning | Warning |
| Inhibits | | Generator breaker closed | Generator breaker closed |

## 5.3.16 Overload (ANSI 32)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Overload | P>, P>> | 32 | PDOP | < 100 ms |

The alarm response is based on the sum of the 3-phase active power values for Line 1, Line 2 and Line 3, from the generator, as measured by the controller.




Configure the parameters under **Configure > Parameters > Generator > Power protections > Overload**.

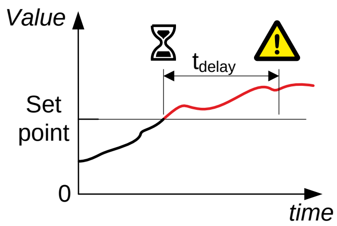
**Table 5.18** Default parameters

| Parameter | Range | Overload 1 | Overload 2 |
|---|---|---|---|
| Set point | 0 to 200 % of nominal power | 95 % | 110 % |
| Delay | 0.00 s to 1 h | 30.00 s | 30.00 s |
| Enable | Not enabled, Enabled | Enabled | Enabled |
| Alarm action | | Warning | Trip breaker |

## 5.3.17 Reverse power (ANSI 32R)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Reverse power | P<, P<< | 32R | PDRP | < 100 ms |

The alarm response is based on the sum of the active power values for Line 1, Line 2 and Line 3, to the generator, as measured by the controller.




Configure the parameters under **Configure > Parameters > Generator > Power protections > Reverse power**.

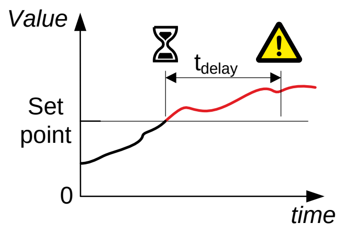
**Table 5.19** Default parameters

| Parameter | Range | Reverse power 1 | Reverse power 2 |
|---|---|---|---|
| Set point | 0 to 200 % of nominal power | 8.0 % | 15.0 % |
| Delay | 0.00 s to 1 h | 5.00 s | 2.00 s |
| Enable | Not enabled, Enabled | Enabled | Enabled |
| Action | | Trip generator breaker | Trip generator breaker |

## 5.3.18 Reactive power export (ANSI 40O)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Reactive power export (over-excitation) | Q>, Q>> | 40O | POEX | < 100 ms |

The alarm response is based on the reactive power (Q) from the controlled equipment, as measured and calculated by the controller.




Configure the parameters under **Configure > Parameters > [Controlled equipment] > Reactive power protections > Reactive power export**.

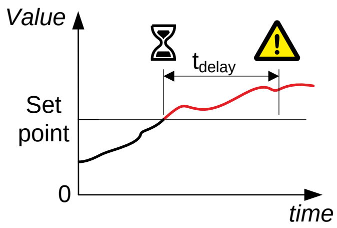
**Table 5.20** Default parameters

| Parameter | Range | Reactive power export 1 | Reactive power export 2 |
|---|---|---|---|
| Set point | 0 to 100 % of nominal reactive power | 60 % | 75 % |
| Delay | 0.00 s to 1 h | 10.00 s | 5.00 s |
| Enable | Not enabled, Enabled | Not enabled | Not enabled |
| Action | | Warning | Warning |

## 5.3.19 Reactive power import (ANSI 40U)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Reactive power import (loss of excitation/ under-excitation) | Q<, Q<< | 40U | PUEX | < 100 ms |

The alarm response is based on the reactive power (Q) to the controlled equipment, as measured and calculated by the controller.




Configure the parameters under **Configure > Parameters > [Controlled equipment] > Reactive power protections > Reactive power import**.

**Table 5.21** Default parameters

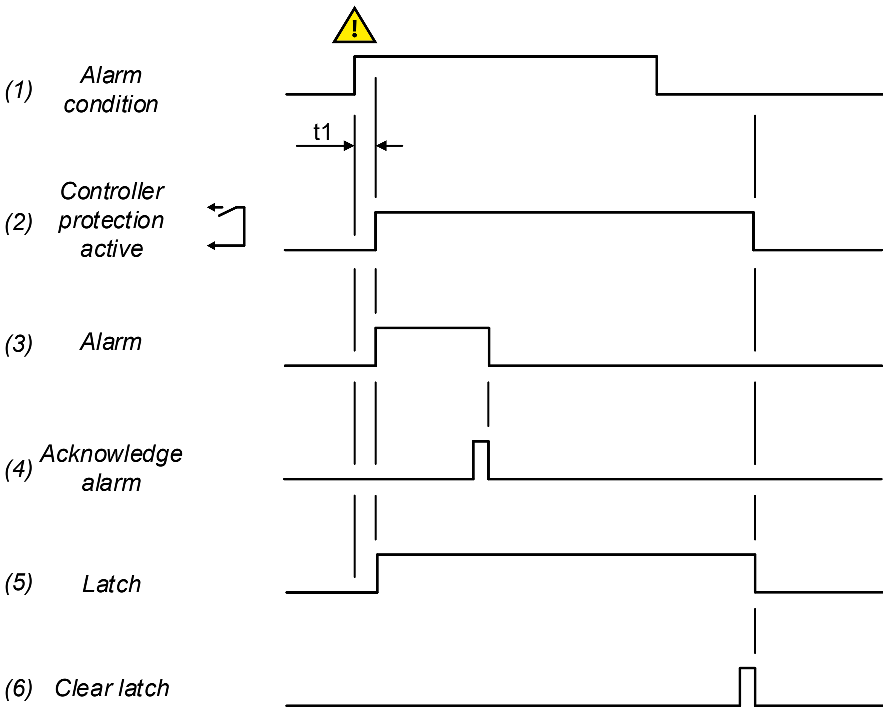
| Parameter | Range | Reactive power import 1 | Reactive power import 2 |
|---|---|---|---|
| Set point | 0 to 150 % of nominal reactive power (Q) | 50 % | 70 % |
| Delay | 0.00 s to 1 h | 10.00 s | 5.00 s |
| Enable | Not enabled, Enabled | Not enabled | Not enabled |
| Action | | Warning | Warning |

## 5.3.20 Lockout relay (ANSI 86)

The lockout relay ensures that the alarm action continues for an alarm, until the lockout relay is reset. The controller can function as a lockout relay for alarm conditions which have the *Latch* parameter enabled. The protection is in effect until the alarm condition is cleared, the alarm acknowledged and the latch is reset.

The lockout relay applies to all latched alarms, and does not activate a specific alarm or have any inhibits.

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Lockout relay | | 86 | | Dependent on protection |




1. **Alarm condition**: When an alarm condition occurs, an alarm dependent delay timer activates. If the alarm condition occurs for longer than the delay timer, the protection activates.
2. **Controller protection**: If a latch is enabled for the protection, the latch activates when the controller protection activates. The protection will remain active until the latch is reset, even if the alarm condition clears.
3. **Alarm**: The alarm output, for example an alarm horn, remains active until the alarm is acknowledged. When the alarm is acknowledged the protection remains active if a latch is enabled.
4. **Acknowledge alarm**: The alarm can be acknowledged while the alarm condition is still active, or when the alarm condition has cleared. If a latch is active and the alarm is acknowledged after the alarm condition has cleared, the protection will remain active.
5. **Alarm latch**: If a latch is enabled for the alarm, the alarm latch will activate when the controller protection activates. While the latch is active, the alarm protection will also be active.
6. **Clear alarm latch**: The alarm latch can only be removed once the alarm condition is no longer active and the alarm is acknowledged. The protection will remain active until the latch is cleared.

For most alarms, a latch can be *Enabled* as a parameter under **Configure > Parameters > [Alarm] > Latch**.

**CAUTION**
If the controller is unpowered, the controller relays will de-energise.

**CAUTION**
Alarms that are **latched** will not trip the breaker again if the breaker is closed manually by the operator.

### Optional: Configuring an external lockout relay

An external lockout relay with manual reset functionality can be connected to a digital output. The digital output activates if a specific alarm condition is triggered by the controller. For example: Under **Configure > Input/output** a digital output can be configured to activate if *Any latched alarm* is present. When the digital output is activated, the lockout relay connected to it is also activated. If the alarm condition is cleared on the controller, an operator must manually reset the lockout relay.

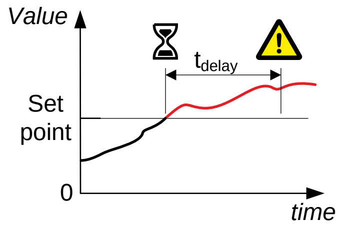
**INFO**
When the controller is connected to an external lockout relay, the controller interfaces with the lockout relay. When the controller interfaces with an external lockout relay, the controller is not seen as the lockout relay for the system.

# 5.4 Busbar AC protections

## 5.4.1 Busbar over-voltage (ANSI 59)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Over-voltage | U>, U>> | 59 | PTOV | < 50 ms |

The alarm response is based on highest phase-to-phase voltage, or the highest phase-to-neutral voltage, from the busbar, as measured by the controller.




Configure the parameters under **Configure > Parameters > Busbar > Voltage protections > Over-voltage**.

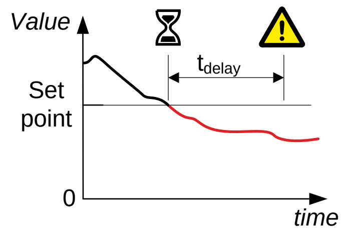
**Table 5.22** Default parameters

| Parameter | Range | Busbar over-voltage 1 | Busbar over-voltage 2 |
|---|---|---|---|
| Set point | 90 to 120 % of nominal voltage | 105 % | 115 % |
| Delay | 0.00 s to 1 h | 5.00 s | 3.00 s |
| Enable | Not enabled, Enabled | Enabled | Enabled |
| Action | | Warning | Trip generator breaker |
| Inhibit | | Generator breaker open | Generator breaker open |

## 5.4.2 Busbar under-voltage (ANSI 27)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Under-voltage | U<, U<< | 27 | PTUV | < 50 ms |

The alarm response is based on the lowest phase-to-phase voltage, or the lowest phase-to-neutral voltage, from the busbar, as measured by the controller.




Configure the parameters under **Configure > Parameters > Busbar > Voltage protections > Under-voltage**.

**Table 5.23** Default parameters

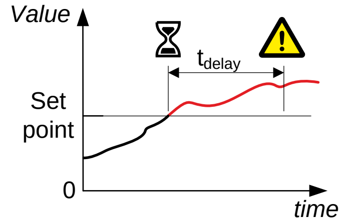
| Parameter | Range | Busbar under-voltage 1 | Busbar under-voltage 2 |
|---|---|---|---|
| Set point | 50 to 100 % of nominal voltage | 95 % | 80 % |
| Delay | 0.00 s to 1 h | 5.00 s | 3.00 s |
| Enable | Not enabled, Enabled | Enabled | Enabled |
| Action | | Warning | Trip generator breaker |
| Inhibit | | Generator breaker open, ACM wire break | Generator breaker open, ACM wire break |

## 5.4.3 Busbar voltage unbalance (ANSI 47)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Voltage unbalance (voltage asymmetry) | UUB> | 47 | - | < 200 ms |

The alarm response is based on the highest difference between any of the three busbar phase-to-phase voltage or phase-to-neutral true RMS values and the average voltage, as measured by the controller. The phase-to-phase voltage is the default. The phase-to-neutral voltage is used if selected under **Configure > Parameters > AC configuration > System > Phase configuration > AC setup**.

If phase-to-phase voltages are used, the controller calculates the average phase-to-phase voltage. The controller then calculates the difference between each phase-to-phase voltage and the average voltage. Finally, the controller divides the maximum difference by the average voltage to get the voltage unbalance. See the example.




Configure the parameters under **Configure > Parameters > Busbar > Voltage protections > Voltage unbalance**.

**Table 5.24** Default parameters

| Parameter | Range | Busbar voltage unbalance |
|---|---|---|
| Set point | 0 to 50 % of nominal voltage | 10 % |
| Delay | 0.1 s to 1 h | 10.0 s |
| Enable | Not enabled, Enabled | Enabled |

| Parameter | Range | Busbar voltage unbalance |
|---|---|---|
| Action | | Warning |
| Inhibit | | ACM wire break |

**Busbar voltage unbalance example**

The busbar has a nominal voltage of 230 V. The L1-L2 voltage is 235 V, the L2-L3 voltage is 225 V, and the L3-L1 voltage is 210 V.

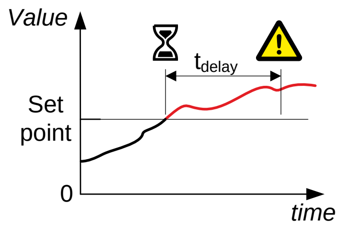
The average voltage is 223.3 V. The difference between the phase-to-phase voltage and the average is 12.7 V for L1-L2, 2.7 V for L2-L3 and 13.3 V for L3-L1.

The busbar voltage unbalance is 13.3 V / 223.3 V = 0.06 = 6 %

## 5.4.4 Busbar over-frequency (ANSI 81O)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Over-frequency | f>, f>> | 81O | PTOF | < 50 ms |

The alarm response is based on the fundamental frequency of the Line 1-N voltage from the busbar, as measured by the controller.




Configure the parameters under **Configure > Parameters > Busbar > Frequency protections > Over-frequency**.

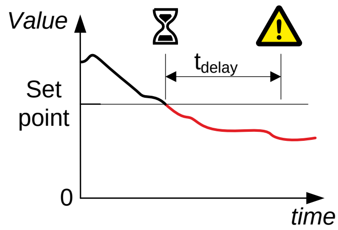
**Table 5.25** Default parameters

| Parameter | Range | Busbar over-frequency 1 | Busbar over-frequency 2 |
|---|---|---|---|
| Set point | 100 to 130 % of nominal frequency | 105 % | 110 % |
| Delay | 0.00 s to 1 h | 5.00 s | 8.00 s |
| Enable | Not enabled, Enabled | Enabled | Enabled |
| Alarm action | | Warning | Trip generator breaker |
| Inhibit | | Generator breaker open | Generator breaker open |

### 5.4.5 Busbar under-frequency (ANSI 81U)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Under-frequency | f<, f<< | 81U | PTUF | < 50 ms |

The alarm response is based on the fundamental frequency of the Line 1-N voltage from the busbar, as measured by the controller.




Configure the parameters under **Configure > Parameters > Busbar > Frequency protections > Under-frequency**.

**Table 5.26** Default parameters

| Parameter | Range | Busbar under-frequency 1 | Busbar under-frequency 2 |
|---|---|---|---|
| Set point | 80 to 100 % of nominal frequency | 96 % | 93 % |
| Delay | 0.00 s to 1 h | 10.00 s | 5.00 s |
| Enable | Not enabled, Enabled | Enabled | Enabled |
| Action | | Warning | Trip generator breaker |
| Inhibit | | Generator breaker open, ACM wire break | Generator breaker open, ACM wire break |

## 5.5 Other AC protections

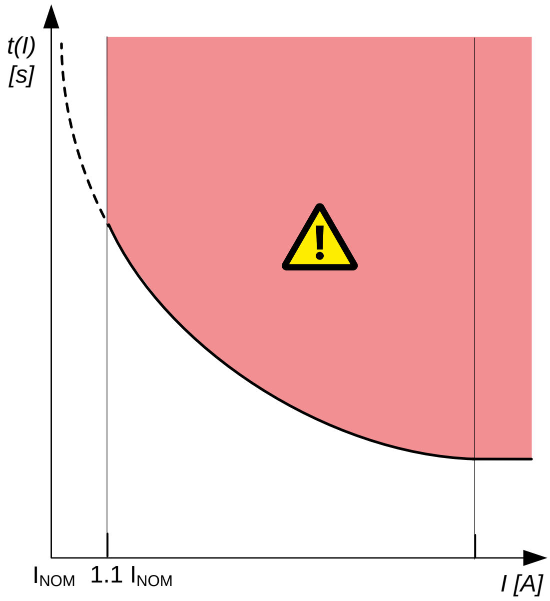
### 5.5.1 Earth inverse time over-current (ANSI 51G)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Earth inverse time over-current | | 51G | | - |

This is the inverse time over-current alarm for the ground current measurement.

The alarm response is based on the ground current, as measured by the 4th current measurement. A 128 tap FIR low pass filter is applied. The busbar frequency, as measured by the controller (f0), is used as the cutoff frequency. The filter has 0 dB attenuation at f0, and 33 dB attenuation at 3 × f0.

The alarm response time depends on an approximated integral of the current measurement over time. The integral is only updated when the measurement is above the activation threshold.




## Wiring

You must wire the 4th current measurement on ACM3.1 (terminals 15,16) to measure the ground current.

**INFO**
The *Earth inverse time over-current* and *Neutral inverse time over-current* alarms each require the 4th current measurement. You therefore cannot have both of these protections at the same time.

## Parameters

Configure the parameters under **Configure > Parameters > 4th current input > Current protections > Earth inverse time over-current**.

**Table 5.27** Default parameters

| Parameter | Range | Earth inverse time over-current |
|---|---|---|
| Curve | See the reference | IEC Inverse |
| Limit (the set point, also known as LIM) | 2 to 200 % of nominal current (4th current input) | 10 % |
| Time multiplier setting (TMS) | 0.01 to 100.0 | 1.0 |
| k (only used if custom curve is selected) | 0.001 s to 2 min | 0.14 s |
| c (only used if custom curve is selected) | 0 s to 1 min | 0 s |
| alpha (α, or a) (only used if custom curve is selected) | 0.001 to 1 | 0.02 |
| Enable | Not enabled, Enabled | Enabled |
| Alarm action | | Trip breaker |

See **Generator AC protections**, **Inverse time over-current** for the calculation method, the standard curves, and information about the definite time characteristic.

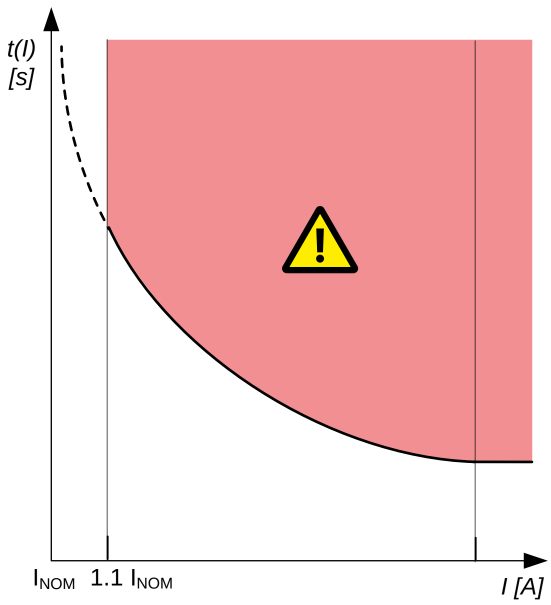
### 5.5.2 Neutral inverse time over-current (ANSI 51N)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | IEC 61850 | Operate time |
|---|---|---|---|---|
| Neutral inverse time over-current | | 51N | | - |

This is the inverse time over-current alarm for the neutral current measurement.

The alarm response is based on the unfiltered (except for anti-aliasing) neutral current, as measured by the 4th current measurement.

The alarm response time depends on an approximated integral of the current measurement over time. The integral is only updated when the measurement is above the activation threshold.




**Wiring**

You must wire the 4th current measurement on ACM3.1 (terminals 15,16) to measure the neutral current.

See **Wiring for controller functions**, **System AC configuration** in the **Installation instructions** for an example of how to wire the neutral current measurement.

**INFO**

The *Earth inverse time over-current* and *Neutral inverse time over-current* alarms each require the 4th current measurement. You therefore cannot have both of these protections at the same time.

**Parameters**

Configure the parameters under **Configure > Parameters > 4th current input > Current protections > Neutral inverse time over-current**.

**Table 5.28** Default parameters

| Parameter | Range | Neutral inverse time over-current |
|---|---|---|
| Curve | See the reference | IEC Inverse |
| Limit (the set point, also known as LIM) | 2 to 200 % of nominal current (4th current input) | 30 % |
| Time multiplier setting (TMS) | 0.01 to 100.0 | 1.0 |

| Parameter | Range | Neutral inverse time over-current |
|---|---|---|
| k (only used if custom curve is selected) | 0.001 s to 2 min | 0.14 s |
| c (only used if custom curve is selected) | 0 s to 1 min | 0 s |
| alpha (α, or a) (only used if custom curve is selected) | 0.001 to 1 | 0.02 |
| Enable | Not enabled, Enabled | Enabled |
| Alarm action | | Trip breaker |

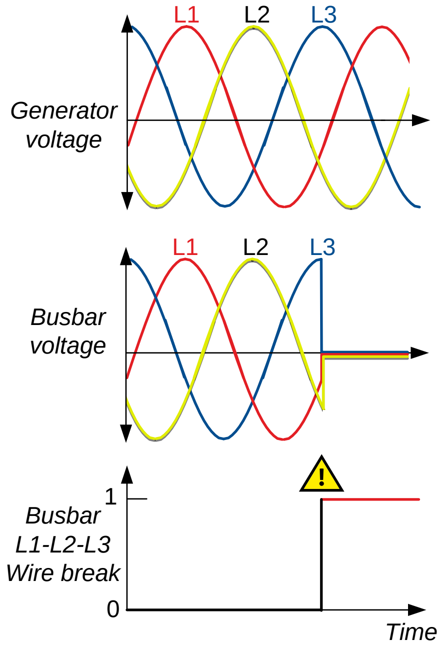
See **Generator AC protections**, **Inverse time over-current** for the calculation method, the standard curves, and information about the definite time characteristic.

# 5.6 ACM voltage measurement errors

## 5.6.1 Generator/Busbar L1-L2-L3 wire break

These alarms alert the operator to a voltage measurement failure:

- *Generator L1-L2-L3 wire break*
- *Busbar L1-L2-L3 wire break*




The controller only activates the alarm when all of these conditions are met:

- The generator breaker is closed
- Voltage is detected by one set of ACM voltage measurements
- No voltage is detected on all three phases for the other set of ACM voltage measurements

**Parameters**

**Configure > Parameters > AC configuration > Generator > Multiple phase wire break**

**Configure > Parameters > AC configuration > Busbar > Multiple phase wire break**

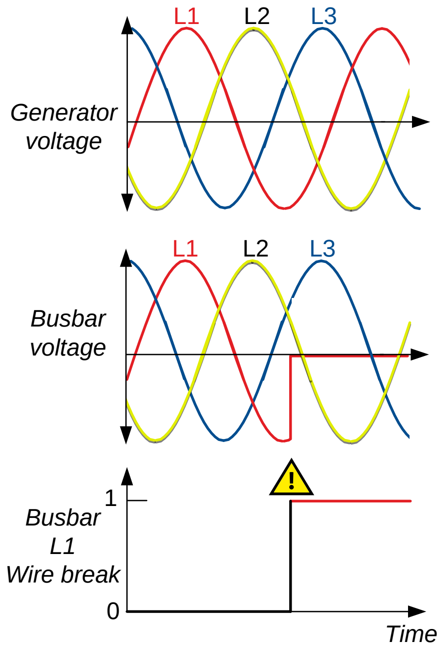
**Table 5.29** Default parameters

| Parameter | Range | Default |
|---|---|---|
| Enable | Not enabled, enabled | Enabled |
| Alarm action | | Warning, Latch enabled |

## 5.6.2 Generator/Busbar L# wire break

These alarms alert the operator to a measurement failure on a phase:

- *Generator L1 wire break*
- *Generator L2 wire break*
- *Generator L3 wire break*
- *Busbar L1 wire break*
- *Busbar L2 wire break*
- *Busbar L3 wire break*




The controller only activates the alarm when all of these conditions are met:

- The generator breaker is closed
- Voltage is detected by one set of ACM voltage measurements
- No voltage is detected on one of the phases for the other set of ACM voltage measurements

### Parameters

**Configure > Parameters > AC configuration > Generator > L# wire break**

**Configure > Parameters > AC configuration > Busbar > L# wire break**

**Table 5.30** Default parameters

| Parameter | Range | Default |
|---|---|---|
| Enable | Not enabled, enabled | Enabled |
| Alarm action | | Warning, Latch enabled |

# 6. Breaker

## 6.1 Configuring the breaker

### 6.1.1 Pulse breaker

A pulse breaker closes or opens in response to a pulse from the controller.

#### Wiring examples

See **Wiring for controller functions**, **Breaker wiring** in the **Installation instructions** for an example of pulse breaker wiring.

#### Inputs and outputs

Assign the breaker inputs and outputs under **Configure > Input/output**. Select the hardware module, then select the input/output to configure.

**Table 6.1** Breaker configuration

| Function | IO | Type | Details |
|---|---|---|---|
| Generator breaker > Control > Close | Digital output | Pulse | The controller activates the *Close* output to close the breaker. |
| Generator breaker > Control > Open | Digital output | Pulse | The controller activates the *Open* output to close the breaker. |
| Generator breaker > Feedback > Closed | Digital input | Continuous | The feedback ensures that the controller knows when the breaker is closed. |
| Generator breaker > Feedback > Open | Digital input | Continuous | The feedback ensures that the controller knows when the breaker is open. |
| Generator breaker > Feedback > Short circuit | Digital input | Continuous | Required for short circuit detection, when the breaker is tripped independently due to a short circuit. One input is required for each breaker.<br><br>The breaker activates this input when it detects a short circuit. The controller then activates the *GB short circuit* alarm. |

The following inputs and outputs are not part of the breaker configuration and are optional. They can be used for commands to the controller.

**Table 6.2** Breaker commands

| Function | IO | Type | Details |
|---|---|---|---|
| Generator breaker > Activate breaker close | Digital input | Pulse | After the input is activated, the controller sends a close breaker command to the breaker when it detects that the breaker is synchronised. |
| Generator breaker > Deactivate breaker close | Digital input | Pulse | When the input is activated, the *Activate breaker close* input is cancelled. If the breaker is already closed when the input is activated, the input has no effect. |
| Generator breaker > Command > Block close | Digital input | Continuous | The controller does not allow the breaker to close while this input is active. |

### Parameters

Configure the parameters under **Configure > Parameters > Breakers > Generator breaker > Configuration**.

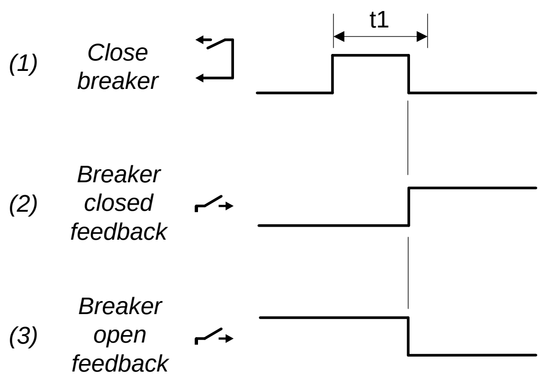
**Table 6.3** Parameters

| Parameter | Range | Default | Notes |
|---|---|---|---|
| Breaker type | Various breakers | Pulse breaker | **Pulse breaker**: This breaker requires a pulse signal to close, and a different pulse signal to open. |
| Pulse time ON | 0.0 to 10.0 s | 1.0 s | The length of the synchronisation pulse (that is, the amount of time that the *Generator breaker* > *Control* > *Close* or *Generator breaker* > *Control* > *Open* output is activated). |

### Sequence diagram

The following sequence diagrams show the sequences for closing and opening for a pulse breaker.

**Table 6.4** Closing a pulse breaker

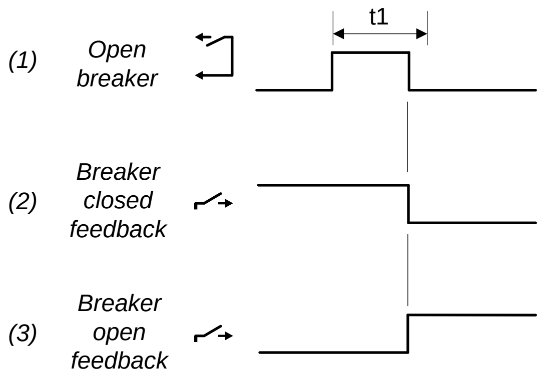



t1 Pulse on (*Parameters* > *Breakers* > *Generator breaker* > *Pulse time ON*)

To close a pulse breaker:

1. **Close breaker**: *Generator breaker* > *Control* > *Close* (digital output). The controller activates this output until there is breaker closed feedback, or for the *Pulse time ON*.
2. **Breaker closed feedback**: *Generator breaker* > *Feedback* > *Closed* (digital input). This input is activated when the breaker closes.
3. **Breaker open feedback**: *Generator breaker* > *Feedback* > *Open* (digital input). This input is deactivated when the breaker closes.

**Table 6.5** Opening a pulse breaker




t1 Pulse on (*Parameters > Breakers > Generator breaker > Pulse time ON*)

To open a pulse breaker:

1. **Open breaker**: *Generator breaker > Control > Open* (digital output). The controller activates this output until there is breaker open feedback, or for the *Pulse time ON*.
2. **Breaker closed feedback**: *Generator breaker > Feedback > Closed* (digital input). This input is deactivated when the breaker opens.
3. **Breaker open feedback**: *Generator breaker > Feedback > Open* (digital input). This input is activated when the breaker opens.

## 6.1.2 Compact breaker

To close a compact breaker, the controller sends a close pulse, followed by a pause, and then a spring-loading pulse.

### Wiring examples

See **Wiring for controller functions**, **Breaker wiring** in the **Installation instructions** for an example of compact breaker wiring.

### Inputs and outputs

Assign the breaker inputs and outputs under **Configure > Input/output**. Select the hardware module, then select the input/output to configure.

**Table 6.6** Breaker configuration

| Function | IO | Type | Details |
|---|---|---|---|
| Generator breaker > Control > Close | Digital output | Pulse | The controller activates the *Close* output to close the breaker. |
| Generator breaker > Control > Open | Digital output | Pulse | The controller activates the *Open* output to open the breaker. |
| Generator breaker > Feedback > Closed | Digital input | Continuous | The feedback ensures that the controller knows when the breaker is closed. |
| Generator breaker > Feedback > Open | Digital input | Continuous | The feedback ensures that the controller knows when the breaker is open. |
| Generator breaker > Feedback > Short circuit | Digital input | Continuous | Required for short circuit detection, when the breaker is tripped independently due to a short circuit. One input is required for each breaker.<br><br>The breaker activates this input when it detects a short circuit. The controller then activates the *GB short circuit* alarm. |
| Generator breaker > Feedback > Spring-loaded | Digital input | Pulse | Optional. The breaker sends this pulse when it is spring-loaded. There is also a timer for spring-loading. |

The following inputs and outputs are not part of the breaker configuration and are all optional.

**Table 6.7** Breaker commands

| Function | IO | Type | Details |
|---|---|---|---|
| Generator breaker > Activate breaker close | Digital input | Pulse | After the input is activated, the controller sends a close breaker command to the breaker when it detects that the breaker is synchronised. |
| Generator breaker > Deactivate breaker close | Digital input | Pulse | When the input is activated, the *Activate breaker close* input is cancelled. If the breaker is already closed when the input is activated, the input has no effect. |
| Generator breaker > Command > Block close | Digital input | Continuous | The controller does not allow the breaker to close while this input is active. |

### Parameters

Configure the parameters under **Configure > Parameters > Breakers > Generator breaker** > **Configuration**.

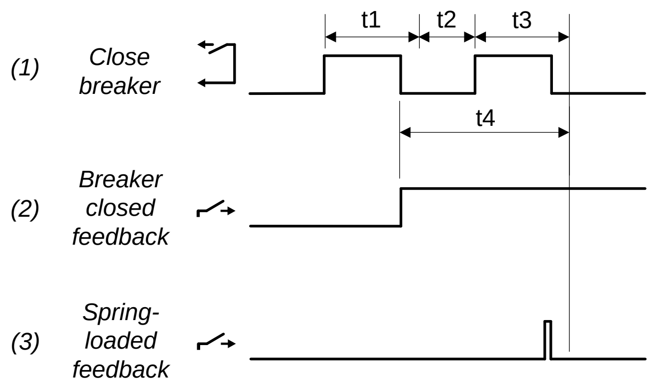
**Table 6.8** Parameters

| Parameter | Range | Default | Notes |
|---|---|---|---|
| Breaker type | Various breakers | Set to *Compact breaker* | **Compact breaker**: This is a type of pulse breaker. In addition, a compact breaker has a spring-loaded opening mechanism, which must be allowed to charge. |
| Pulse time ON | 0.0 to 10.0 s | 1.0 s | The length of the synchronisation pulse (that is, the amount of time that the *Generator breaker* > *Control* > *Close* output is activated). |
| Pulse time OFF | 0.0 to 10.0 s | 0.5 s | The controller will not send another pulse until after this time has elapsed. |
| Spring-load time | 0.0 to 30.0 s | 1.0 s | After the breaker closes, the controller activates the *Close* output for the *Spring-load time*. |

### Sequence diagrams

The sequence diagram below shows the sequence for closing a compact breaker.

**Table 6.9** Closing a compact breaker

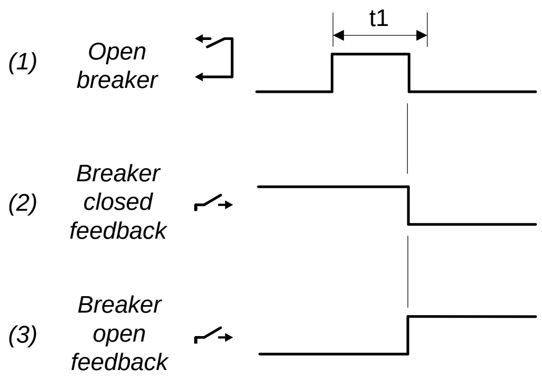



| | |
|---|---|
| t1 | Pulse on (*Parameters* > *Breakers* > *Generator breaker* > *Pulse time ON*) |
| t2 | Pulse off (*Parameters* > *Breakers* > *Generator breaker* > *Pulse time OFF*) |
| t3 | Spring-load time (*Parameters* > *Breakers* > *Generator breaker* > *Spring-load time*) |
| t4 | No controller breaker operations |

To close a compact breaker:

1. **Close breaker**: *Generator breaker > Control > Close* (digital output). The controller activates this output for the *Pulse time ON*, then deactivates it for the *Pulse time OFF*, then activates it again for the *Spring-load time*.
2. **Breaker closed feedback**: *Generator breaker > Feedback > Closed* (digital input). This input is activated when the breaker closes.
3. **Optional: Spring-loaded feedback**: *Generator breaker > Feedback > Spring-loaded* (digital input). This input is activated when the breaker is spring-loaded.

**Table 6.10** Opening a compact breaker




t1 Pulse on (*Parameters > Breakers > Generator breaker > Pulse time ON*)

To open a compact breaker:

1. **Open breaker**: *Generator breaker > Control > Open* (digital output). The controller activates this output until there is breaker open feedback, or for the *Pulse time ON*.
2. **Breaker closed feedback**: *Generator breaker > Feedback > Closed* (digital input). This input is deactivated when the breaker opens.
3. **Breaker open feedback**: *Generator breaker > Feedback > Open* (digital input). This input is activated when the breaker opens.

## 6.1.3 Continuous breaker

**CAUTION**
Due to class requirements, this breaker type is not suitable for marine use. This is because, if the controller failed, then the breaker would open and the ship would lose power.

A continuous breaker only closes and stays closed if there is a continuous close signal.

### Wiring examples

See **Wiring for controller functions**, **Breaker wiring** in the **Installation instructions** for an example of continuous breaker wiring.

### Inputs and outputs

Assign the breaker inputs and outputs under **Configure > Input/output**. Select the hardware module, then select the input/output to configure.

**Table 6.11** Breaker configuration

| Function | IO | Type | Details |
|---|---|---|---|
| Generator breaker > Control > Close | Digital output | Continuous | Optional if there is an *Open* output. The controller activates the *Close* output to close the breaker. To open the breaker, the controller deactivates the *Close* output. |
| Generator breaker > Control > Open | Digital output | Continuous | Optional if there is a *Close* output. If configured, the controller activates the *Open* output when the breaker must open. The controller deactivates the *Open* output when the breaker must close. |

| Function | IO | Type | Details |
|---|---|---|---|
| Generator breaker > Feedback > Closed | Digital input | Continuous | Optional* if there is an *Open* feedback. The feedback ensures that the controller knows when the breaker is closed. |
| Generator breaker > Feedback > Open | Digital input | Continuous | Optional* if there is a *Closed* feedback. The feedback ensures that the controller knows when the breaker is open. |
| Generator breaker > Feedback > Short circuit | Digital input | Continuous | Required for short circuit detection, when the breaker is tripped independently due to a short circuit. One input is required for each breaker.<br><br>The breaker activates this input when it detects a short circuit. The controller then activates the *GB short circuit* alarm. |

*Note: Both of these feedbacks are required for marine applications.

The following inputs and outputs are not part of the breaker configuration and are all optional.

**Table 6.12** Breaker commands

| Function | IO | Type | Details |
|---|---|---|---|
| Generator breaker > Activate breaker close | Digital input | Pulse | After the input is activated, the controller sends a close breaker command to the breaker when it detects that the breaker is synchronised. |
| Generator breaker > Deactivate breaker close | Digital input | Pulse | When the input is activated, the *Activate breaker close* input is cancelled. If the breaker is already closed when the input is activated, the input has no effect. |
| Generator breaker > Command > Block close | Digital input | Continuous | The controller does not allow the breaker to close while this input is active. |

### Parameters

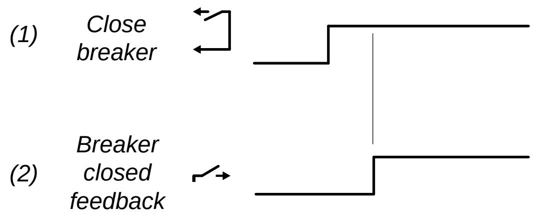
Configure the parameters under **Configure > Parameters > Breakers > Generator breaker** > **Configuration**.

**Table 6.13** Parameters

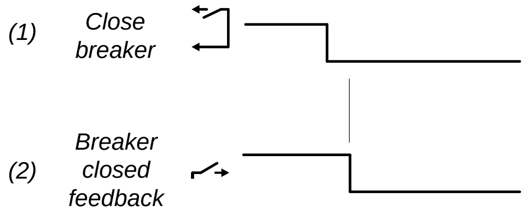
| Parameter | Range | Default | Notes |
|---|---|---|---|
| Breaker type | Various breakers | Set to *Continuous breaker* | **Continuous breaker**: This breaker receives a continuous signal to close. If this signal stops, the breaker opens. A single digital output (relay) can therefore be configured to control this breaker.<br><br>Due to class requirements, this breaker type is not suitable for marine use. This is because the ship would lose power if the controller failed. |

### Sequence diagrams

The sequence diagrams below show the sequences for closing and opening for a continuous breaker.




1. **Close breaker**: *Generator breaker* > *Control* > *Close* (digital output). The controller activates this output to close the breaker.
2. **Breaker closed feedback**: *Generator breaker* > *Feedback* > *Closed* (digital input). This input is activated when the breaker is closed.




1. **Close breaker**: *Generator breaker* > *Control* > *Close* (digital output). The controller deactivates this output to open the breaker.
2. **Breaker closed feedback**: *Generator breaker* > *Feedback* > *Closed* (digital input). This input is deactivated when the breaker is opens.

## 6.1.4 Breaker state outputs

You can configure outputs for the breaker state.

### Inputs and outputs

Assign the breaker state outputs under **Configure > Input/output**. Select the hardware module, then select the output to configure.

The outputs are not part of the breaker configuration and are optional.

**Table 6.14** Breaker states

| Function | IO | Type | Details |
|---|---|---|---|
| Generator breaker > State > Is open | Digital output | Continuous | Activated when the breaker is open. |
| Generator breaker > State > Is closed | Digital output | Continuous | Activated when the breaker is closed. |
| Generator breaker > State > Is synchronising | Digital output | Continuous | Activated when synchronisation is active (so that the breaker can be closed). |

### Application

A digital output with a breaker state may be wired to a switchboard light, to help the operator.

For example, a digital output may have the *Generator breaker* > *State* > *Is open* function. A switchboard light is lit when the breaker is open.

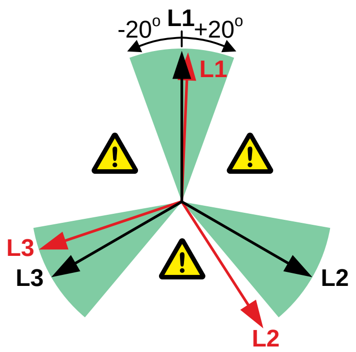
# 6.2 Breaker protections

## 6.2.1 Vector mismatch

This alarm alerts the operator to a vector mismatch.

The alarm is based on the difference between the phase angles on either side of the breaker, as measured by the controller. The alarm is activated when synchronisation is ON and the difference in the phase angles is more than the set point.

On the diagram to the right, the vector diagram for the busbar is black, and the mismatch that is allowed by default is green. The vector diagram for the controlled equipment is red. L2 is outside the allowed mismatch.




Configure the parameters under **Configure > Parameters > Synchronisation > Alarms > Vector mismatch**.

**Table 6.15** Default parameters

| Parameter | Range | Default |
|---|---|---|
| Set point | 1 to 20 degrees | 20 degrees |
| Delay | 5 s to 1 min | 10 s<br><br>DEIF recommends that this delay is lower than the *GB synchronisation failure* delay. |
| Enabled/Not enabled | Enabled/Not enabled | Enabled |
| Alarm action | | Warning |

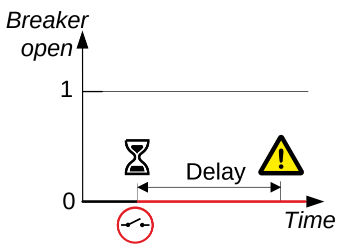
### Frequency-based inhibit

The *Vector mismatch* alarm is inhibited outside of the synchronisation window. That is, it is inhibited if the frequency from the controlled equipment is more than the *Delta frequency min.* below the busbar frequency, or the *Delta frequency max.* above the busbar frequency. These parameters are defined under **Synchronisation > Settings**.

## 6.2.2 Breaker opening failure

This alarm alerts the operator to a breaker open failure if a breaker open feedback is present.

The alarm is based on the breaker feedback signal, which is a digital input to the controller. The alarm timer starts when the controller sends the signal to open the breaker. The alarm is activated if the breaker feedback does not change from *Closed* to *Open* within the delay time.




Configure the parameters under **Configure > Parameters > Breakers > Generator breaker > Opening failure**. The alarm is always enabled.

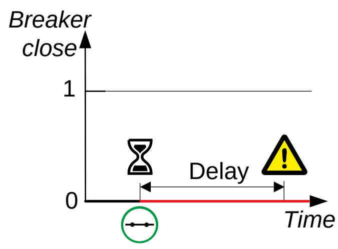
**Table 6.16** Default parameters

| Parameter | Range | Default |
|---|---|---|
| Delay | 0.1 to 5.0 s | 2.0 s |
| Alarm action | | Warning, Latch enabled |

## 6.2.3 Breaker closing failure

This alarm is for breaker closing failure.

The alarm is based on the breaker feedback signal, which is a digital input to the controller. The alarm timer starts when the controller sends the signal to close the breaker. The alarm is activated if the breaker feedback signal does not change from *Open* to *Closed* within the delay time.




Configure the parameters under **Configure > Parameters > Breakers > [Breaker] > Closing failure**. This alarm is always enabled.

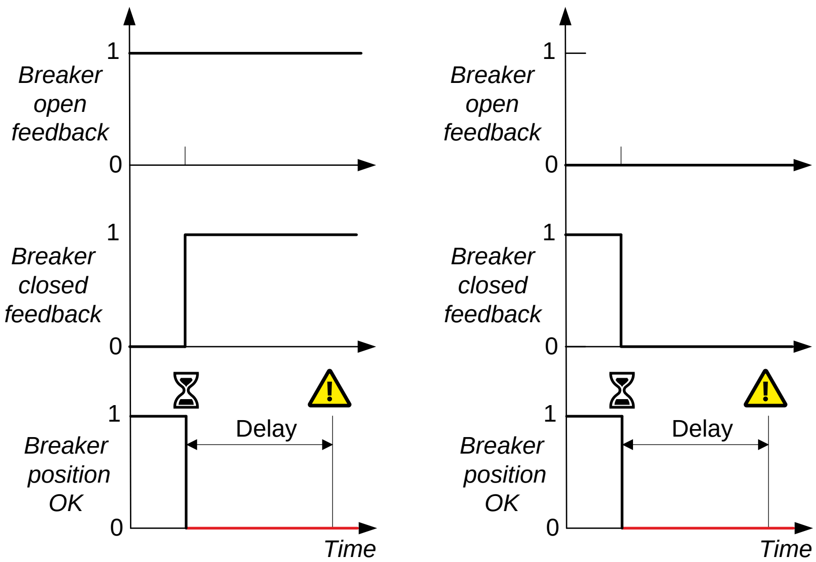
**Table 6.17** Default parameters

| Parameter | Range | Default |
|---|---|---|
| Delay | 0.1 to 5.0 s | 2.0 s |
| Alarm action | | Trip breaker, Latch enabled |

## 6.2.4 Breaker position failure

This alarm is for breaker position failure. The alarm is present where both open and closed feedback are configured.

The alarm is based on the breaker feedback signals, which are digital inputs to the controller. The alarm is activated if the breaker *Closed* and *Open* feedbacks are both missing for longer than the delay time. The alarm is also activated if the breaker *Closed* and *Open* feedbacks are both present for longer than the delay time.



Configure the parameters under **Configure > Parameters > Breakers > Generator breaker > Position failure**.

This alarm is always enabled. The alarm action is *Warning, Latch enabled*.

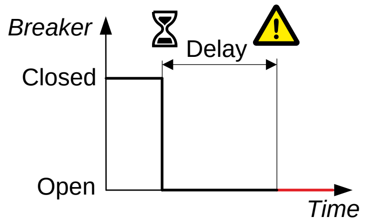
**Table 6.18** Default parameters

| Parameter | Range | Default |
| --- | --- | --- |
| Delay | 0.1 to 5.0 s | 1.0 s |

## 6.2.5 Breaker trip (external)

This alarm alerts the operator to an externally-initiated breaker trip.

The alarm is activated if the controller did not send an open signal, but the breaker feedback shows that the breaker is open.




Configure the parameters under **Configure > Parameters > Breakers > [Breaker] > Tripped (external)**.

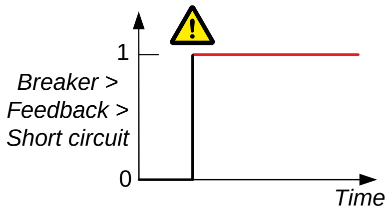
The delay is always 0.1 s.

**Table 6.19** Default parameters

| Parameter | Range | Default |
| --- | --- | --- |
| Enable | Not enabled, Enabled | Enabled |
| Alarm action | | Trip breaker, Latch enabled |

## 6.2.6 Breaker short circuit

The alarm is based on the digital input with the *Breaker* > *Feedback* > *Short circuit* function (wired to the breaker's short circuit feedback).




Configure the parameters under **Configure > Parameters > Breakers > [Breaker] > Short circuit**.

**Table 6.20** Default parameters

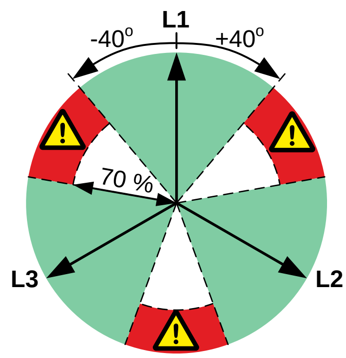
| Parameter | Range | Default |
|---|---|---|
| Enable | Not enabled, Enabled | Enabled |
| Alarm action | | Trip breaker, Latch enabled |

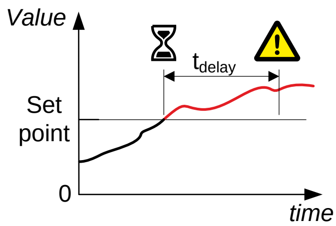
## 6.2.7 Phase sequence error

This alarm is for phase sequence error protection.

The controller continuously checks the line voltage vectors on either side of the breaker against the orientation defined in the controller. If the voltage is more than the detection voltage, and the phase angle differs from the expected angle by more than ±40°, the alarm is activated. This means that the alarm will also detect if the phase rotation is different from the direction of rotation defined in the controller.

There are two alarms for each controller. These alarms correspond to the controller's AC measurements. There is one alarm for the voltage from the [Controlled equipment] (terminal A), and another alarm for the voltage on the [Busbar] (terminal B).




Configure the parameters under **Configure > Parameters > AC configuration > [Controlled equipment] / [Busbar] > Phase sequence error**.

**Table 6.21** Default parameters

| Parameter | Range | Default |
|---|---|---|
| Detection voltage | 30 to 90 % of nominal controlled equipment/busbar voltage | 70 % |
| Delay | 1 to 10 s | 1 s |
| Action | | Warning |
| Enable | Not enabled, Enabled | Enabled |

## 6.2.8 Breaker configuration failure

This alarm blocks breaker operation if the breaker is not properly configured.

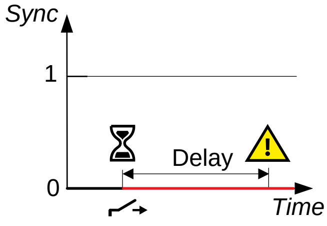
The alarm is activated when digital inputs are not configured for one or both breaker feedback functions (*Generator breaker > Feedback > Open* and *Generator breaker > Feedback > Closed*) . The breaker open relay (*Generator breaker > Control > Open*) must also be configured.

This alarm is always enabled, and has the alarm action *Warning*. You cannot change the parameters for this alarm.

## 6.2.9 Breaker synchronisation failure

This alarm alerts the operator to a breaker synchronisation failure.

The alarm is based on the synchronisation of the generator to the busbar, as measured by the controller. The controller activates the alarm if the generator and busbar are not synchronised within the delay time.




Configure the parameters under **Configure > Parameters > Breakers > Generator breaker > Synchronisation failure**.

The alarm action is always *Warning*.

**Table 6.22** Default parameters

| Parameter | Range | Default |
|---|---|---|
| Delay | 30 s to 5 min | 1 min |
| Enable | Not enabled, Enabled | Enabled |
| Latch | Not enabled, Enabled | Enabled |

# 7. Hardware characteristics

## 7.1 Overview

### 7.1.1 Introduction

This chapter provides details on the hardware characteristics for each hardware module, and for each set of terminals.

Some terminal types are common to a number of different hardware modules. To minimise repetition, the general terminal types are described under **General characteristics**.

#### Technical specifications

See the **Data sheet** for detailed technical specifications for the terminals.

#### Configuring the inputs and outputs

For information on how to configure the inputs and outputs, see the **PICUS manual** if you are using PICUS, and see the **Operator's manual** if you are using the display unit.

#### Terminal wiring

See the **Installation instructions** for the terminal wiring options.

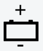
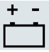
## 7.2 General characteristics

### 7.2.1 Frame ground characteristics

| Symbol | Hardware modules |
|---|---|
|  | PSM3.1<br>DU 300 |

The frame ground is required by classification societies. Among other things, it protects the equipment against lightning.

## 7.2.2 Power supply characteristics

| Symbol | Hardware modules |
|---|---|
|  | PSM3.1 |
|  | DU 300 |

The power supply is connected to these terminals.

**Backup power**
The DEIF equipment does not contain a backup power supply. The power supply source must therefore include the power backup needed.

**Start current**
When the power supply is connected, the start current may briefly exceed the current that corresponds to the maximum power on the data sheet.

Battery-powered systems are normally robust with respect to start current, and the start current is not a problem.

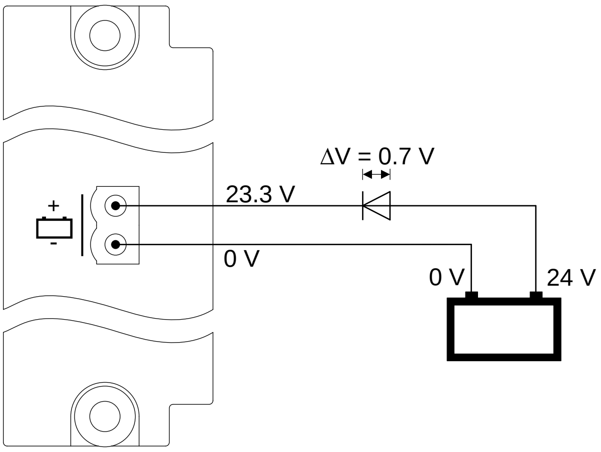
For other types of power supply, for example, an AC-to-DC supply, the start current may be a problem. The minimum rating for the power supply current limiter is therefore included on the data sheet.

**Reverse polarity**
The power supply is protected against reverse polarity. That is, if the power supply terminals are switched, the DEIF equipment will not be damaged. However, the DEIF equipment will not be able to operate until the power supply has been connected correctly.

**Diode compensation**
Diode compensation is available in PSM3.1. Set the parameter under **Configure > Parameters > Power Supply > PSM 1**.

| Parameter | Range | Default | Notes |
|---|---|---|---|
| Diode offset | 0 to 1 V | 0 V | This parameter corrects the power supply measurement values used for the supply voltage alarms. Use the parameter to compensate for a small decrease in voltage over the diode. |

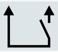
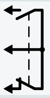
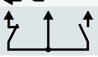
**Figure 7.1** Example of a voltage decrease over a diode




### Heat emission

For the heat emission from the equipment, use the maximum power consumption for the power supply (or power supplies).

## 7.2.3 Relay output characteristics

| Symbol | Hardware modules |
|---|---|
|  | PSM3.1 |
|  | DU 300 (terminals 6,7) |
|  | IOM3.1 |
|  | DU 300 (terminals 3,4,5) |

The controller can use relay outputs for many purposes. Examples: Activate alarm devices, open and close breakers, and genset speed and voltage regulation.

### Configuration

All relay outputs are configurable, except for PSM3.1 terminals 3,4 (*Status OK*) and the DU 300 relays. A controller can have a number of relay outputs.

You can assign a digital output function or configure an alarm for each relay output.

You can also program customised relay output functions using **CustomLogic**.

### Controller types and single-line diagram

The controller type determines which digital output functions are available.

To see certain digital output functions, you must include the corresponding equipment in the single-line diagram.

### Relay state

The relay state (whether it is open or closed) depends on the relay hardware, the coil state and the function (or alarm) state. The following table shows how these combine to give the relay state.

**Table 7.1** Relay state

| Hardware | Coil configuration | Function (or alarm) | Relay state |
|---|---|---|---|
| Normally open | Normally de-energised | Not activated | Open |
| Normally open | Normally de-energised | Activated | Closed |
| Normally open | Normally energised | Not activated | Closed |
| Normally open | Normally energised | Activated | Open |
| Normally closed | Normally de-energised | Not activated | Closed |
| Normally closed | Normally de-energised | Activated | Open |
| Normally closed | Normally energised | Not activated | Open |
| Normally closed | Normally energised | Activated | Closed |

The effect of the relay hardware, the coil state and the function (or alarm) state is also shown below under **Coil state**.

**CAUTION**
Incorrect connection of the relay, or incorrect configuration of the relay function, will cause incorrect operation.

### Relay hardware

The relay hardware can be normally open or normally closed. The relay hardware returns to its normal state when the controller has no power. The relay hardware type is shown on the hardware module faceplate.

Normally open relay hardware:

- All PSM3.1 relays
- IOM3.1 terminals 1,2
- IOM3.1 terminals 4,5
- IOM3.1 terminals 7,8
- IOM3.1 terminals 10,11

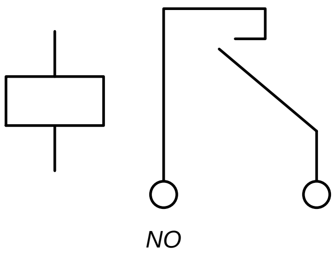
Normally closed relay hardware:

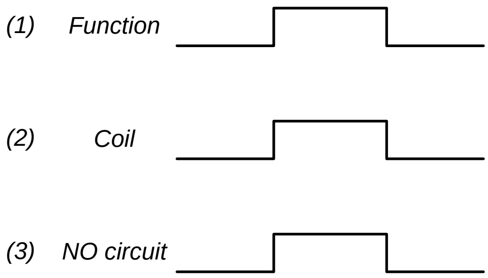
- IOM3.1 terminals 3,2
- IOM3.1 terminals 6,5
- IOM3.1 terminals 9,8
- IOM3.1 terminals 12,11

### Coil state

You can configure the normal coil state in the display unit or PICUS. Under **Configure > Input/output**, select the terminals, then select *Normally de-energised* (the default) or *Normally energised* for the *Coil state*.

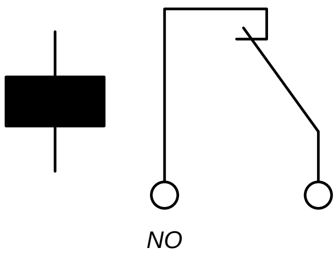
**Table 7.2** Relay, normally de-energised coil

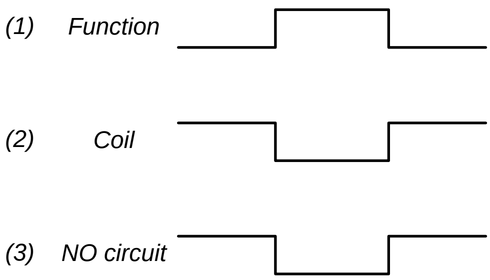



1. **Function**: The digital output function assigned to the terminals. The controller software activates the function. For example: *Breaker > Command > Close*.
2. **Coil**: The controller energises the relay coil when the function is activated.
3. **Normally open circuit**: The normally open circuit closes when the coil is energised.

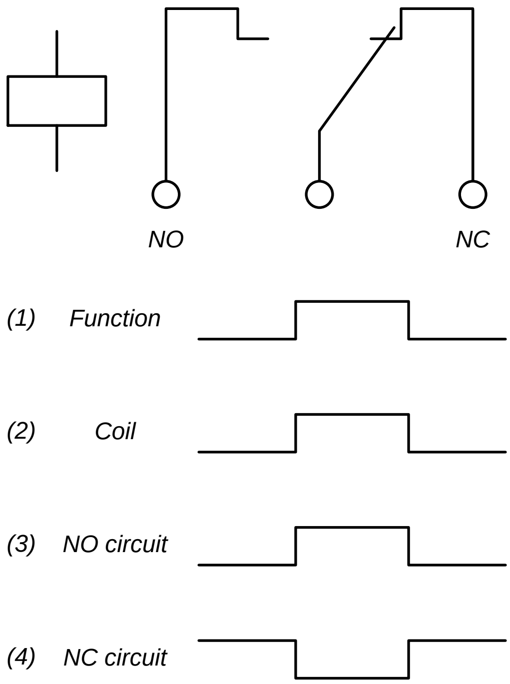
**Table 7.3** Relay, normally energised coil



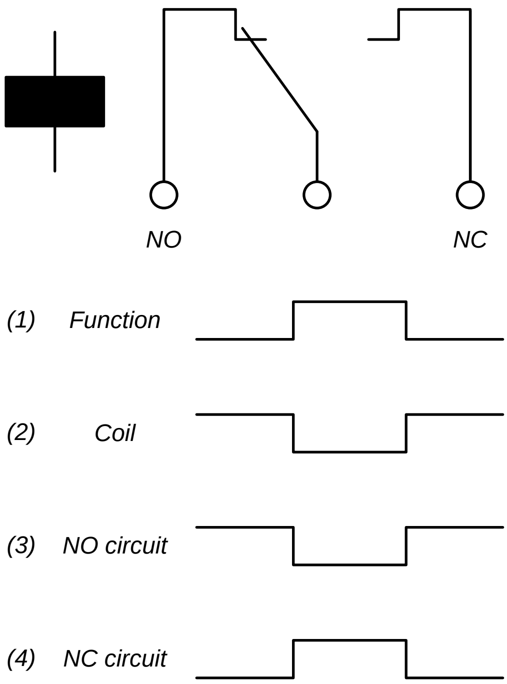

1. **Function**: The digital output function assigned to the terminals. The controller software activates the function. For example: *Breaker > Command > Close*.
2. **Coil**: The controller de-energises the relay coil when the function is activated.
3. **Normally open circuit**: The normally open circuit opens when the coil is de-energised.

**Table 7.4** Changeover relay, normally de-energised coil



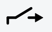

1. **Function**: The digital output function assigned to the terminals. The controller software activates the function. For example: *Breaker* > *Command* > *Close*.
2. **Coil**: The controller energises the relay coil when the function is activated.
3. **Normally open circuit**: The normally open circuit closes when the coil is energised.
4. **Normally closed circuit**: The normally closed circuit opens when the coil is energised.

**Table 7.5** Changeover relay, normally energised coil




1. **Function**: The digital output function assigned to the terminals. The controller software activates the function. For example: *Breaker* > *Command* > *Close*.
2. **Coil**: The controller de-energises the relay coil when the function is activated.
3. **Normally open circuit**: The normally open circuit opens when the coil is de-energised.
4. **Normally closed circuit**: The normally closed circuit closes when the coil is de-energised.

### 7.2.4 Digital input characteristics

| Symbol | Hardware modules |
|---|---|
|  | IOM3.1 |

The controller can use digital inputs for many purposes. Examples: Command buttons, breaker feedback, and alarms.

**Polarity**
The digital input is a bi-directional input. The wiring to the input and common terminals may be changed around without affecting its operation.

Each set of digital inputs (that is, each set of digital inputs that share a common terminal) must share the same reference polarity (high or low). However, different sets of digital input terminals can have different reference polarities.

In general, the controller activates the associated digital input function for a HIGH digital input. However, for the *Emergency stop* safety function, the controller activates the digital input function for a LOW digital input.

**Configuration**
All digital inputs are configurable. A controller can have a number of digital inputs.

You can assign a digital input function and/or configure an alarm for each digital input.

You can also program customised digital input functions using **CustomLogic**.

**Controller types and single-line diagram**
The controller type determines which digital input functions are available.

To see certain digital input functions, you must include the corresponding equipment in the single-line diagram.

**Controller operation**
Some of the digital input functions are only applicable in certain controller modes. If the controller is in another mode, it ignores the digital input.

## 7.3 Power Supply Module PSM3.1

### 7.3.1 Power supply module PSM3.1

The power supply module provides power to all the hardware modules in the rack. The rack status and alarms activate the PSM's three relay outputs. There are two ports for internal communication with other racks (future use).

PSM3.1 manages the hardware module self-checks for the rack and includes a self-check status LED. The power supply terminals include circuit protection against load dump transients and JEM177 surge transients (rugged design). These terminals also include battery voltage measurement.

**Table 7.6** PSM3.1 terminals

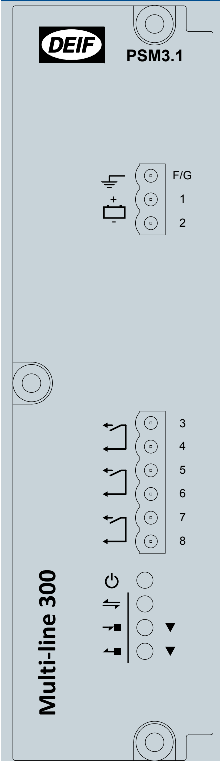
| Module | Count | Symbol | Type | Name |
|---|---|---|---|---|
|  | 1 | | Ground | Frame ground |
| | 1 | | 12 or 24 V | Power supply |
| | 3 | | Relay output | Status OK (fixed), and configurable |
| | 2 | | Internal communication (RJ45) | DEIF internal communication connections (Reserved for future use to connect several extension racks.)<br>(The LEDs are on the front of the hardware module. The connections are at the bottom of the hardware module.) |

**Table 7.7** PSM3.1 technical specifications

| Category | Specification |
|---|---|
| **Controller power supply** | Input voltage: 12 or 24 V DC nominal (8 to 36 V DC continuously)<br>UL/cUL Listed: 10 to 32.5 V DC<br>0 V DC for 50 ms when coming from at least 8 V DC (cranking dropout)<br>Consumption: Typical 20 W, maximum 35 W<br><br>The power supply inputs are internally protected by a 12 A fuse (not replaceable) (fuse size determined by load dump requirements).<br>Voltage withstand: ±36 V DC<br>Load dump protected by TVS diodes.<br><br>Start current<br>• Power supply current limiter<br>◦ 24 V: 4 A minimum<br>◦ 12 V: 8 A minimum<br>• Battery: No limit |
| **Relay outputs** | Relay type: Solid state<br>Electrical rating and UL/cUL Listed: 30 V DC and 1 A, resistive<br>Voltage withstand: ±36 V DC |

| Category | Specification |
|---|---|
| **Terminal connections** | **Frame ground and power supply**: Terminals: Standard 45° plug, 2.5 $mm^2$<br>Wiring: 1.5 to 2.5 $mm^2$ (12 to 16 AWG), multi-stranded<br><br>**Other connections**: Terminals: Standard 45° plug, 2.5 $mm^2$<br>Wiring: 0.5 to 2.5 $mm^2$ (12 to 22 AWG), multi-stranded |
| **Communication connections** | DEIF internal communication: RJ45. Use an Ethernet cable that meets or exceeds the SF/UTP CAT5e specifications. |
| **Torques and terminals** | Module faceplate screws: 0.5 N·m (4.4 lb-in)<br><br>Connection of wiring to terminals: 0.5 N·m (4.4 lb-in)<br>UL/cUL Listed: Wiring must be minimum 90 °C (194 °F) copper conductors only. |
| **Galvanic isolation** | Between power supply and other I/Os: 600 V, 50 Hz for 60 s<br>Between relay groups and other I/Os: 600 V, 50 Hz for 60 s<br>Between internal communication ports and other I/Os: 600 V, 50 Hz for 60 s |
| **Protection** | Unmounted: No protection rating<br>Mounted in rack: IP20 according to IEC/EN 60529 |
| **Size** | L 43.3 mm × H 162 mm × D 150 mm (1.5 in × 6.4 in × 5.9 in) |
| **Weight** | 331 g (0.7 lb) |

## 7.3.2 PSM3.1 terminal overview

| Terminal | Symbol | Name | Type | Function |
|---|---|---|---|---|
| F/G | | F/G | Ground | Frame ground |
| 1 | | + | 12 or 24 V DC (nominal) | Power supply |
| 2 | | - | 0 V DC | |
| 3 | | Normally open | Relay output (30 V DC and 1 A) | Alarm > Status OK (fixed)* |
| 4 | | Common | | |
| 5 | | Normally open | | Alarm > Horn 1, or configurable |
| 6 | | Common | | |
| 7 | | Normally open | | Alarm > Any alarm, or configurable |
| 8 | | Common | | |

* The first relay (terminals 3, 4) is reserved for the *Alarm > Status OK* output and cannot be reconfigured.

**Table 7.8** PSM3.1 Internal communication connections

| Connection | Symbol | Type | Name |
|---|---|---|---|
| Bottom of rack, front | | Internal communication input | Internal communication input connection for future use to connect several extension racks. |
| Bottom of rack, back | | Internal communication output | Internal communication output connection for future use to connect several extension racks. |

**INFO**
Internal communication connections are for future use to connect several extension racks together. These are not to be used for the Ethernet DEIF network connections.

### 7.3.3 Frame ground characteristics

See **Hardware characteristics**, **General characteristics**, **Frame ground characteristics**.

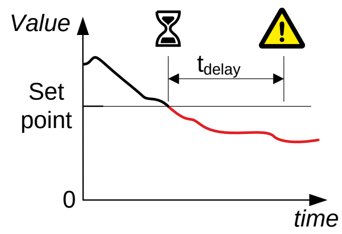
### 7.3.4 Power supply characteristics

See **Hardware characteristics**, **General characteristics**, **Power supply characteristics**.

### 7.3.5 PSM 1 supply voltage low alarm

This default alarm is for power supply voltage protection.

The alarm is based on the power supply voltage measured by the PSM. The alarm is activated when the power supply voltage is less than the set point for the delay time.




Configure the parameters under **Configure > Parameters > Power supply > PSM 1 > Low voltage alarm**.

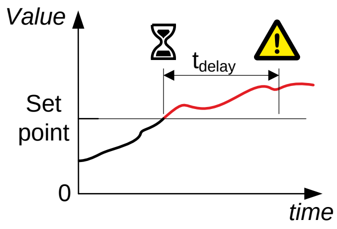
**Table 7.9** Default parameters

| Parameter | Range | PSM 1 supply voltage low |
|---|---|---|
| Set point | 8.0 to 32.0 V DC | 18.0 V DC |
| Delay | 0 s to 1 h | 1.0 s |
| Enable | Not enabled, Enabled | Enabled |
| Alarm action | | Warning |

### 7.3.6 PSM 1 supply voltage high alarm

This default alarm is for power supply voltage protection.

The alarm is based on the power supply voltage measured by the PSM. The alarm is activated when the power supply voltage exceeds the set point for the delay time.




Configure the parameters under **Configure > Parameters > Power supply > PSM 1 > High voltage alarm**.

**Table 7.10** Default parameters

| Parameter | Range | PSM 1 supply voltage high |
|---|---|---|
| Set point | 12.0 to 36.0 V DC | 30.0 V DC |
| Delay | 0 s to 1 h | 1.0 s |
| Enable | Not enabled, Enabled | Enabled |
| Alarm action | | Warning |

### 7.3.7 Relay output characteristics

The first relay output (terminals 3,4) on PSM3.1 is reserved for the *Status OK* function. You cannot change the function for this relay.

The two other relay outputs on PSM3.1 are configurable (that is, terminals 5,6 and terminals 7,8 can be assigned any function).

See **Hardware characteristics**, **General characteristics**, **Relay output characteristics** for more information.

## 7.4 Alternating Current Module ACM3.1

### 7.4.1 Alternating current module ACM3.1

The alternating current module measures the voltage and current on one side of a breaker, and the voltage on the other side. The hardware module responds when the measurements exceed the AC alarm parameters. ACM3.1 uses the AC measurements to check the synchronisation before the breaker closes.

ACM3.1 provides robust frequency detection in environments with electrical noise. ACM3.1 allows extended measurement bandwidth up to 40 times the nominal frequency. ACM3.1 includes a configurable 4th current measurement.

By default, ACM3.1 measures 3-phase systems. Alternatively, split-phase (1-phase, 3-wire, for example, L1-N-L2) or single-phase (1-phase, 2-wire, for example, L1-N) can be selected.

**Table 7.11** ACM3.1 terminals

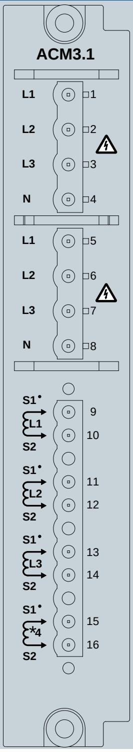
| Module | Count | Symbol | Type | Name |
|---|---|---|---|---|
|   | 2 × (L1, L2, L3 and N) | L1/L2/L3/N | Voltage | 3-phase voltage measurements |
| | 1 × (L1, L2, L3 and 4th) |   | Current | 3-phase current measurement<br><br>4th current measurement |

**Table 7.12** ACM3.1 technical specifications

| Category | Specification |
|---|---|
| **Voltage measurements** | Nominal value: 100 to 690 V AC phase-to-phase<br>Measurement range: 2 to 897 V AC phase-to-phase<br>Accuracy: Class 0.2<br>Phase angle accuracy: 0.1° (within nominal voltage range **and** nominal frequency range)<br>Altitude derating from 2,000 to 4,000 m (6,562 to 13,123 ft): 100 to 480 V AC phase-to-phase<br>UL/cUL Listed: 100 to 600 V AC phase-to-phase<br>Load on external voltage transformer: Maximum 0.2 VA/phase<br>Voltage withstand: 1.2 × Nominal voltage continuously; 1.3 × Nominal voltage for 10 s |
| **Current measurements** | Nominal value: 1 or 5 A AC from current transformer<br>Measurement range: 0.02 to 17.5 A AC from current transformer; Truncation level: 11 mA<br>Accuracy: Class 0.2<br>Earth current: 18 dB attenuation of third harmonic of the nominal frequency<br>UL/cUL Listed: From listed or R/C (XOWD2.8) current transformers 1 or 5 A<br>Load on external current transformer: Maximum 0.3 VA/phase<br>Current withstand: 10 A continuously; 17.5 A for 60 s; 100 A for 10 s; 250 A for 1 s |
| **Frequency measurements** | Nominal value: 50 Hz or 60 Hz<br>Measurement range: 35 to 78 Hz<br>Accuracy: Class 0.1 of nominal value (35 to 78 Hz) (-40 to 70 °C) (-40 to 158 °F)<br>Class 0.02 of nominal value (40 to 70 Hz) (15 to 30 °C) (59 to 86 °F) |
| **Power measurements** | Accuracy: Class 0.5 |

| Category | Specification |
|---|---|
| **Accuracy and temperature** | Unless otherwise specified for the above measurements:<br>Nominal range: -40 to 70 °C (-40 to 158 °F)<br>Reference range: 15 to 30 °C (59 to 86 °F)<br>Accuracy: Measurement type specific within reference range.<br>Additional 0.2 % error of full scale per 10 °C (18 °F) outside reference range.<br><br>Example: The accuracy for Power (P) at 70 °C (158 °F) is 0.5 % + 4 x 0.2 % = 1.3 %. |
| **Torques and terminals** | Module faceplate screws: 0.5 N·m (4.4 lb-in)<br><br>Secure the current measurement terminal block to the module faceplate: 0.5 N·m (4.4 lb-in)<br><br>Connection of wiring to terminals: 0.5 N·m (4.4 lb-in)<br>UL/cUL Listed: Wiring must be minimum 90 °C (194 °F) copper conductors only. |
| **Terminal connections** | AC voltage and current terminals: Standard 45° plugs, 2.5 $mm^2$<br>Wiring: 2.5 $mm^2$ (13 AWG), multi-stranded |
| **Galvanic isolation** | Between AC voltage and other I/Os: 3310 V, 50 Hz for 60 s<br>Between AC current and other I/Os: 2210 V, 50 Hz for 60 s |
| **Protection** | Unmounted: No protection rating<br>Mounted in rack: IP20 according to IEC/EN 60529 |
| **Size** | L 28 mm × H 162 mm × D 150 mm (1.1 in × 6.4 in × 5.9 in) |
| **Weight** | 232 g (0.5 lb) |

## 7.4.2 ACM3.1 terminal overview

| Terminal | Symbol | Name | Type | Function |
|---|---|---|---|---|
| 1 | L1 | L1 voltage | Voltage<br>100 to 690 V AC phase-to-phase (nominal) | [Busbar] L1 |
| 2 | L2 | L2 voltage | | [Busbar] L2 |
| 3 | L3 | L3 voltage | | [Busbar] L3 |
| 4 | N | N voltage | | [Busbar] N |
| 5 | L1 | L1 voltage | Voltage<br>100 to 690 V AC phase-to-phase (nominal) | [Controlled equipment] L1 |
| 6 | L2 | L2 voltage | | [Controlled equipment] L2 |
| 7 | L3 | L3 voltage | | [Controlled equipment] L3 |
| 8 | N | N voltage | | [Controlled equipment] N |
| 9 | S1 • | Current in (European: S1; US: •) | Current<br>1 or 5 A AC (nominal) | [Controlled equipment] L1 |
| 10 | S2 | Current out (European: S2) | | |
| 11 | S1 • | Current in (European: S1; US: •) | Current<br>1 or 5 A AC (nominal) | [Controlled equipment] L2 |
| 12 | S2 | Current out (European: S2) | | |
| 13 | S1 • | Current in (European: S1; US: •) | Current<br>1 or 5 A AC (nominal) | [Controlled equipment] L3 |
| 14 | S2 | Current out (European: S2) | | |

| Terminal | Symbol | Name | Type | Function |
|---|---|---|---|---|
| 15 | S1• | Current in (European: S1; US: •) | Current<br>1 or 5 A AC (nominal) | [Controlled equipment] N, or configurable |
| 16 | S2 | Current out (European: S2) | | |

**CAUTION**
Only wire the neutral terminal if it is available on both the [Busbar] and [Controlled equipment]. If neutral is only wired on one side of the equipment it causes a difference in the reference of a star connection. The difference causes an error during synchronisation.

### 7.4.3 Voltage measurement characteristics

The ACM has two sets of terminals for voltage measurement. The first set of terminals (1 to 4) measure the voltage on the busbar. The second set of terminals (5 to 8) measure the voltage from the equipment that the controller controls. The ACM uses these measurements for logging, alarms and protective functions. For power functions, the second set of voltage measurements (terminals 5 to 8) and the current measurements (terminals 9 to 16) from the ACM are used together.

You do not have to connect and measure the neutral phases (terminals 4 and 8). However, DEIF recommends that the neutral phases are measured if they are available.

### 7.4.4 Current measurement characteristics

The ACM measures the current, then uses these measurements for logging, alarms and protective functions. For power functions, the second set of voltage measurements (terminals 5 to 8) and the current measurements (terminals 9 to 16) from the ACM are used together.

You do not have to connect and measure the fourth current (terminals 15,16). However, DEIF recommends that the neutral phase is measured if it is available.

## 7.5 Input output module IOM3.1

### 7.5.1 Input output module IOM3.1

The input output module has four changeover relay outputs, and 10 digital inputs. These IOs are all configurable.

**Table 7.13** IOM3.1 terminals

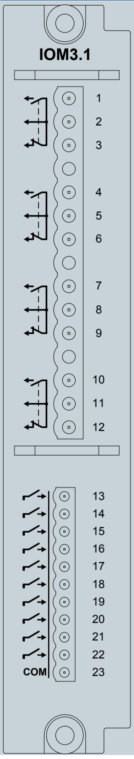
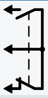
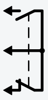
| Module | Count | Symbol | Type | Name |
|---|---|---|---|---|
|   | 4 |  | Relay output | Configurable |
| | 10 |  | Digital input | Configurable |

**Table 7.14** IOM3.1 technical specifications

| Category | Specification |
|---|---|
| **Relay outputs**  | Relay type: Electromechanical<br>Electrical rating and UL/cUL Listed: 250 V AC or 30 V DC, and 6 A, resistive; B300, pilot duty (B300 is a power limit specification for inductive loads)<br>Altitude derating from 3,000 to 4,000 m (9,842 to 13,123 ft): Maximum 150 V AC phase-to-phase<br>Voltage withstand: 250 V AC |
| **Digital inputs**  | Bi-directional input<br>ON: 8 to 36 V DC<br>OFF: 0 to 2 V DC<br>Minimum pulse length: 50 ms<br>Impedance: 4.7 kΩ<br>Voltage withstand: ±36 V DC |
| **Terminal connections** | **Relay outputs**: Terminals: Standard 45° plug, 2.5 $mm^2$<br>Wiring: 0.5 to 2.5 $mm^2$ (12 to 22 AWG), multi-stranded<br><br>**Digital inputs**: Terminals: Standard 45° plug, 1.5 $mm^2$<br>Wiring: 0.5 to 1.5 $mm^2$ (16 to 28 AWG), multi-stranded |

| Category | Specification |
|---|---|
| **Torques and terminals** | Module faceplate screws: 0.5 N·m (4.4 lb-in)<br><br>Connection of wiring to relay output terminals: 0.5 N·m (4.4 lb-in)<br>Connection of wiring to digital input terminals: 0.25 N·m (2.2 lb-in)<br><br>UL/cUL Listed: Wiring must be minimum 90 ºC (194 °F) copper conductors only. |
| **Galvanic isolation** | Between relay groups and other I/Os: 2210 V, 50 Hz for 60 s<br>Between digital input groups and other I/Os: 600 V, 50 Hz for 60 s |
| **Protection** | Unmounted: No protection rating<br>Mounted in rack: IP20 according to IEC/EN 60529 |
| **Size** | L 28 mm × H 162 mm × D 150 mm (1.1 in × 6.4 in × 5.9 in) |
| **Weight** | 196 g (0.4 lb) |

## 7.5.2 IOM3.1 terminal overview

| Terminal | Symbol | Name | Type |
|---|---|---|---|
| 1 | | Normally open | Relay output (250 V AC or 30 V DC, and 6 A) |
| 2 | | Common | |
| 3 | | Normally closed | |
| 4 | | Normally open | |
| 5 | | Common | |
| 6 | | Normally closed | |
| 7 | | Normally open | |
| 8 | | Common | |
| 9 | | Normally closed | |
| 10 | | Normally open | |
| 11 | | Common | |
| 12 | | Normally closed | |
| 13 | | Bi-directional input | Digital input (OFF: 0 to 2 V DC, ON: 8 to 36 V DC, Impedance: 4.7 kΩ) |
| 14 | | Bi-directional input | |
| 15 | | Bi-directional input | |
| 16 | | Bi-directional input | |
| 17 | | Bi-directional input | |
| 18 | | Bi-directional input | |
| 19 | | Bi-directional input | |
| 20 | | Bi-directional input | |
| 21 | | Bi-directional input | |
| 22 | | Bi-directional input | |
| 23 | COM | | Digital input common |

### 7.5.3 Changeover relay output characteristics

The relay is a changeover switch.

See **Hardware characteristics**, **General characteristics**, **Relay output characteristics** for more information.

### 7.5.4 Digital input characteristics

See **Hardware characteristics**, **General characteristics**, **Digital input characteristics**.

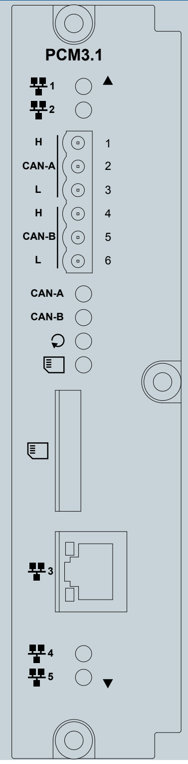
## 7.6 Processor and Communication Module PCM3.1

### 7.6.1 Processor and communication module PCM3.1

The processor and communication module has the controller's main microprocessor, which contains and runs the controller application software. It includes the Ethernet switch to manage the controller Ethernet connections, with five 100BASE-TX Ethernet connections. It also has two sets of CAN bus terminals and houses the SD card (future use).

PCM3.1 includes external memory (the SD card) for alarm logging, trending, black box recording, and installing application software (future use).

**Table 7.15** PCM3.1 terminals

| Module | Count | Symbol | Type | Name |
|---|---|---|---|---|
|   | 5 |  | Ethernet (RJ45) | DEIF network<br>(The LEDs are on the front of the hardware module. Two of the connections are at the top of the hardware module, one on the front, and two at the bottom.) |
| | 2 | H, CAN-A, L<br>H, CAN-B, L | CAN bus connection | CAN bus (future use for engine communication) |
| | 1 |  | SD card* | External memory (future use) |

*Note: To meet the temperature and EMC specifications, you must order this SD card from DEIF.

**Table 7.16** PCM3.1 technical specifications

| Category | Specification |
|---|---|
| **CAN terminals** | Voltage withstand: ±24 V DC |
| **Galvanic isolation** | Between CAN A and other I/Os: 600 V, 50 Hz for 60 s<br>Between CAN B and other I/Os: 600 V, 50 Hz for 60 s<br>Between Ethernet ports and other I/Os: 600 V, 50 Hz for 60 s |
| **Battery** | CR2430 3V rated for operation at -40 to 85 °C (-40 to 185 °F). This battery can be changed. **Not** a standard CR2430 battery. |
| **Battery life** | Design life of the timekeeping battery is 10 years. This is reduced if the ambient temperature is over 40 °C (104 °F). |
| **Communication connections** | CAN communication terminals: Standard 45° plug, 1.5 mm$^2$<br>Wiring: 0.5 to 1.5 mm$^2$ (16 to 28 AWG), multi-stranded<br><br>DEIF network: RJ45. Use an Ethernet cable that meets or exceeds the SF/UTP CAT5e specifications. 100BASE-TX. |
| **Torques and terminals** | Module faceplate screws: 0.5 N·m (4.4 lb-in)<br>Connection of wiring to terminals: 0.5 N·m (4.4 lb-in)<br>UL/cUL Listed: Wiring must be minimum 90 °C (194 °F) copper conductors only. |
| **Protection** | Unmounted: No protection rating<br>Mounted in rack: IP20 according to IEC/EN 60529 |

| Category | Specification |
|---|---|
| **Size** | L 36.8 mm × H 162 mm × D 150 mm (1.4 in × 6.4 in × 5.9 in) |
| **Weight** | 214 g (0.5 lb) |

## 7.6.2 PCM3.1 terminal overview

| Terminal | Symbol | Type | Name |
|---|---|---|---|
| 1 | H | CAN high | CAN bus A (Future use for engine communication) |
| 2 | CAN-A | CAN signal ground | |
| 3 | L | CAN low | |
| 4 | H | CAN high | CAN bus B (Future use for engine communication) |
| 5 | CAN-B | CAN signal ground | |
| 6 | L | CAN low | |

**Table 7.17** PCM3.1 Recommended Ethernet connections

| Connection | Symbol | Type | Name |
|---|---|---|---|
| 1 | | RJ45 | DEIF network to another controller |
| 2 | | RJ45 | DEIF network to another controller |
| 3 | | RJ45 | Service PC |
| 4 | | RJ45 | Display unit |
| 5 | | RJ45 | DEIF network |

The Ethernet connections listed above are the recommended defaults, to help troubleshooting. The Ethernet ports are in fact fully interchangeable.

**INFO**
Only one display unit may be connected to each controller rack. DEIF recommends mounting the display unit close to the controller rack.

## 7.6.3 Controller temperature too high

This is a built-in alarm for the controller internal temperature, as measured on PCM3.1. The alarm is triggered when the controller internal temperature is higher than 80 °C (176 °F). The alarm parameters are not visible in PICUS.

**INFO**
If the controller operates at internal temperatures higher than 80 °C (176 °F), the performance and the lifetime of the controller is reduced.

## 7.6.4 PCM3.1 Internal battery

PCM3.1 includes an internal battery for timekeeping during a power supply failure. If there is no power supplied to the controller or the PCM module, the controller uses the battery power for its internal clock.

During normal operation, the controller power supply powers the internal clock.

If both the power supply and internal battery fail, the controller internal clock time is lost.

For normal operation at a temperature under 40 °C, the battery should last 10 years before it needs replacing.

If the internal battery fails, there is an alarm.

See **Processor and communication module PCM3.1**, **PCM3.1 technical specifications** in the **Data sheet** for more information about the type of battery.

See **Maintenance**, **Changing the battery** in the **Operator's manual** for information about changing the battery.

### 7.6.5 PCM clock battery failure alarm

The *PCM clock battery failure* alarm is activated when the battery in PCM3.1 needs to be replaced. You cannot see or change the alarm parameters.

See **Changing the battery** in the **Operator's manual**.

## 7.7 Display unit DU 300

### 7.7.1 Display unit DU 300

The display unit is the operator's interface to the controller. It allows the operator to use up to 20 push-buttons to set up, operate and supervise the controller. The display unit includes up to 15 tricolour (red, yellow, green), wide angle, high visibility light indicators to show the system status.

The 5-inch (diagonal measurement) colour graphic display shows real-time operating information. The 800 by 480 pixel display supports 24-bit RGB colour and all languages with UTF-8 fonts. It is anti-reflection and has a configurable dimmer function.

For communication, the display unit has two 100BASE-TX connections, and can be placed up to 100 m from the controller rack.

The power supply terminals include circuit protection against load dump transients and JEM177 surge transients (rugged design).

The display unit specifications apply to all controller types. However, the display unit front folio depends on the controller type. The front folio details are included in the description for each controller type.

**Figure 7.2** Line drawing of the back of DU 300 with the terminal positions

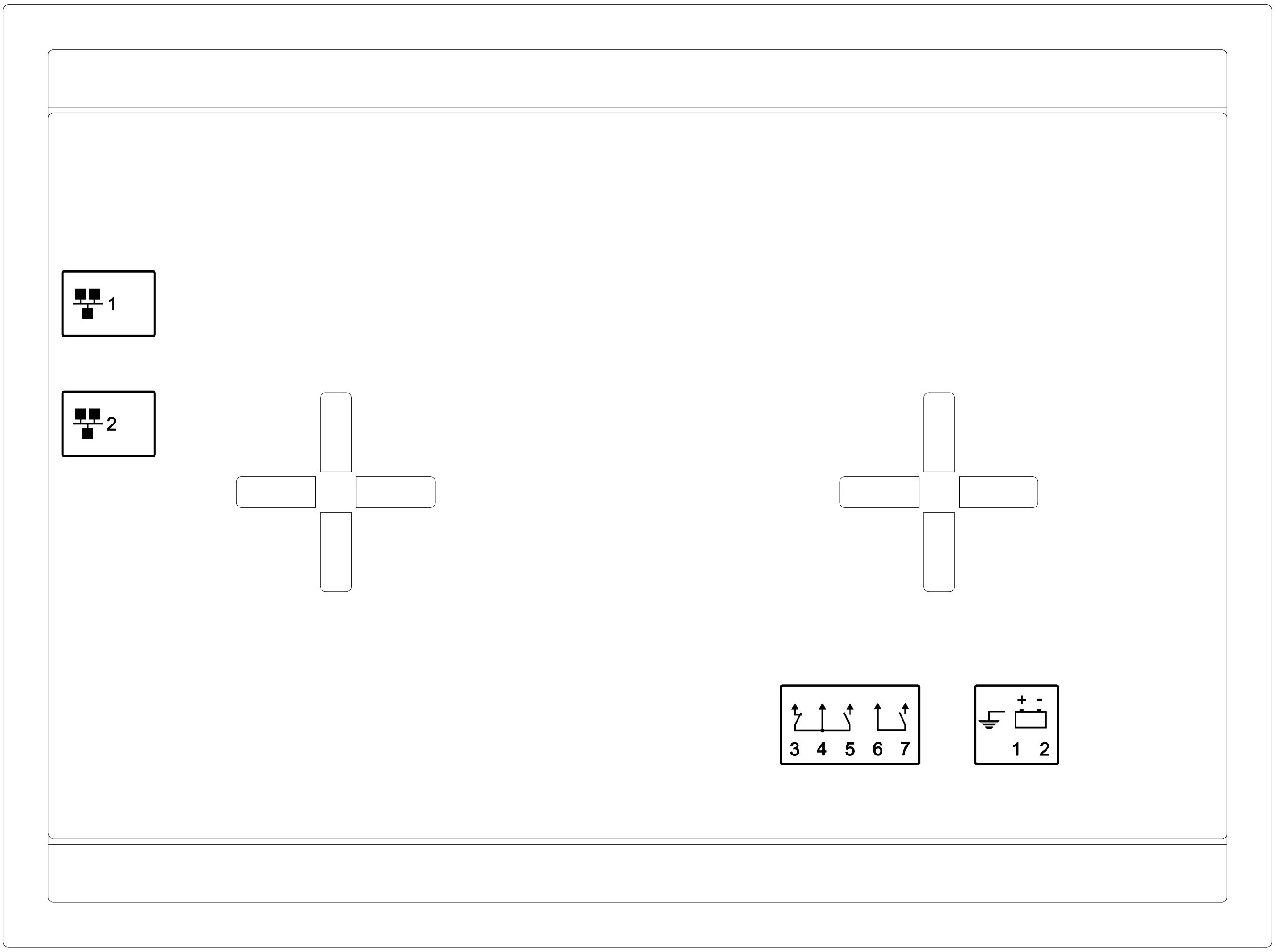



**Table 7.18** DU 300 terminals

| Count | Symbol | Type | Name |
|---|---|---|---|
| 1 | | Ground | Frame ground |
| 1 | | 12 or 24 V DC | Power supply |
| 1 | | Relay output | For future use |
| 1 | | Relay output | Display status OK |
| 2 | | Ethernet (RJ45) | DEIF network |

**Figure 7.3** Display unit with dimensions in mm (followed by approximate dimensions in inches), first-angle projection

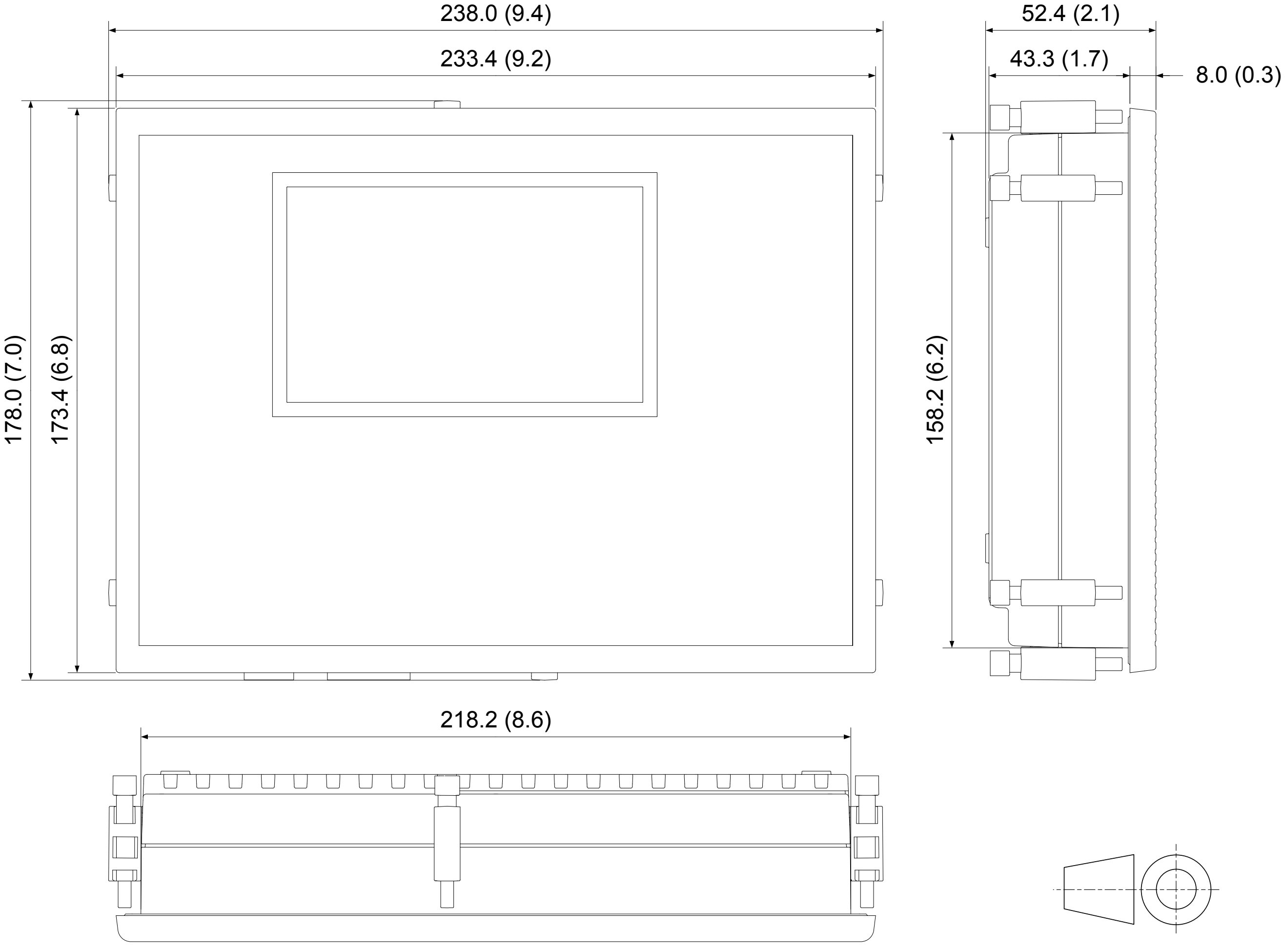



**Table 7.19** DU 300 technical specifications

| Category | Specification |
|---|---|
| **Protection** | From the front: IP65 according to IEC/EN 60529<br>From the back: IP20 according to IEC/EN 60529 |
| **UL/cUL Listed** | Type Complete Device, Open Type 1 |

| Category | Specification |
|---|---|
| **Power supply** | Input voltage: 12 or 24 V DC nominal (8 to 36 V DC continuously)<br>UL/cUL Listed: 10 to 32.5 V DC<br>0 V DC for 50 ms when coming from at least 8 V DC (cranking dropout)<br>Consumption: Maximum 12 W<br><br>The power supply inputs are internally protected by a 12 A slow-blow fuse (not replaceable) (fuse size determined by load dump requirements).<br>Voltage withstand: ±36 V DC<br>Load dump protected by TVS diodes.<br><br>Start current<br>• Power supply current limiter<br>◦ 24 V: 2.1 A minimum<br>◦ 12 V: 4.2 A minimum<br>• Battery: No limit |
| **Relay output** | Relay type: Electromechanical<br>Electrical rating and UL/cUL Listed: 30 V DC and 1 A, resistive<br>Voltage withstand: ±36 V DC |
| **Relay output** | Relay type: Solid state<br>Electrical rating and UL/cUL Listed: 30 V DC and 1 A, resistive<br>Voltage withstand: ±36 V DC |
| **Terminal connections** | **Frame ground and power supply**: Terminals: Standard plug, 2.5 $mm^2$<br>Wiring: 1.5 to 2.5 $mm^2$ (12 to 16 AWG), multi-stranded<br><br>**Other connections**: Terminals: Standard plug, 2.5 $mm^2$<br>Wiring: 0.5 to 2.5 $mm^2$ (12 to 22 AWG), multi-stranded |
| **Communication connections** | DEIF network: RJ45. Use an Ethernet cable that meets or exceeds the SF/UTP CAT5e specifications. 100BASE-TX. |
| **Torques and terminals** | Display unit fixing screw clamps: 0.15 N·m (1.3 lb-in)<br><br>Connection of wiring to terminals: 0.5 N·m (4.4 lb-in)<br>UL/cUL Listed: Wiring must be minimum 90 °C (194 °F) copper conductors only. |
| **Galvanic isolation** | Between power supply, relay groups, and network plugs: 600 V, 50 Hz for 60 s |
| **Mounting** | Panel mount, using six fixing screw clamps (included)<br>Minimum panel plate thickness: 2.0 mm<br>Maximum panel plate thickness: 5.0 mm<br><br>UL/cUL Listed: For use on a flat surface of a type 1 enclosure<br>UL/cUL Listed: To be installed in accordance with the NEC (US) or the CEC (Canada) |
| **Cable organisation** | 4 cable tie slots for cable strain relief (4 mm (0.16 in) wide) |
| **Size** | L 235 mm × H 175 mm × D 52 mm (9.3 in × 6.9 in × 2.0 in) (outer frame)<br>Panel cutout: L 220 mm × H 160 mm (8.7 in × 6.3 in) |
| **Accessory (included)** | Ethernet cable: Shielded patch cable SF/UTP CAT5e, 2 metres long |
| **Weight** | Display unit: 835 g (1.8 lb)<br>Ethernet cable: ±110 g (4 oz) |

### 7.7.2 Display unit terminal overview

**Figure 7.4** Back of display unit DU 300, with the terminal positions

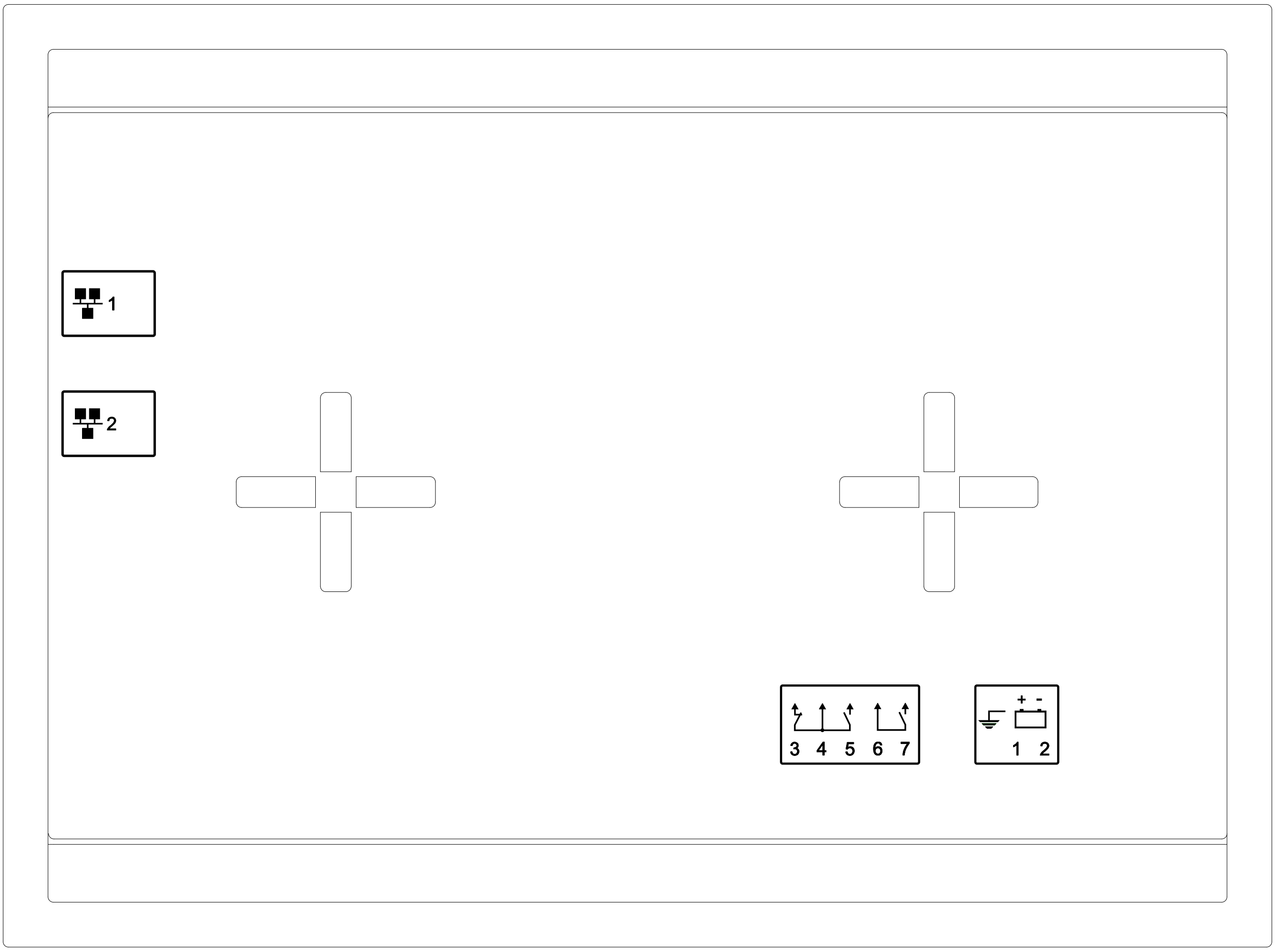



**Table 7.20** Display unit electrical terminals

| Terminal | Symbol | Type | Name |
|---|---|---|---|
| F/G | ⏚ | Ground | Frame ground |
| 1 | + - (battery) | 12 or 24 V DC (nominal) | Power supply (+) |
| 2 | | 0 V DC | Power supply (-) |
| 3 | (relay) | Relay output (30 V DC and 1 A) | Future use |
| 4 | | | |
| 5 | | | |
| 6 | (relay) | Relay output (30 V DC and 1 A) | Status OK (+) |
| 7 | | | Status OK (-) |

**Table 7.21** Display unit Ethernet connections

| Connection | Symbol | Type | Name |
|---|---|---|---|
| 1 | | RJ45 | DEIF network Ethernet connection to controller (default connection) |
| 2 | | RJ45 | Ethernet future use for additional display units. |

**CAUTION**
The first time a display unit is connected to a controller, it is paired to that controller. If you later disconnect the display unit and connect it to a different controller, then the display continues to be paired to the original controller (if the display unit power is not disrupted). DEIF therefore recommends that you disconnect the display unit power, connect the Ethernet cable to the required controller, and then reconnect the display unit power.

## 7.7.3 Frame ground characteristics

See **Hardware characteristics**, **General characteristics**, **Frame ground characteristics**.

## 7.7.4 Power supply characteristics

See **Hardware characteristics**, **General characteristics**, **Power supply characteristics**.

## 7.7.5 Relay output characteristics

### Changeover relay, terminals 3,4,5

For future use. You cannot configure this relay.

### Status OK relay, terminals 6,7

The relay output on terminals 6,7 is used for the display unit *Status OK*. If the display unit loses communication with the controller, then the display unit activates the relay.

You cannot change the relay configuration. The relay is always de-energised when the communication is OK.

See **Hardware characteristics**, **General characteristics**, **Relay output characteristics** for more information.

# 7.8 DEIF Ethernet network

## 7.8.1 Communication

**Table 7.22** DEIF network characteristics

| Category | Details |
|---|---|
| **Specifications** | • Supports Internet Protocol version 6 (IPv6) and Internet Protocol version 4 (IPv4) |
| **Functions** | • Authentication (non-DEIF equipment cannot disrupt communication)<br>• Connects the controller to:<br>◦ Controller display unit<br>◦ PICUS<br>◦ Modbus |

## 7.8.2 Communication information

Use the **Display unit** to configure communication under **Tools > Communication**.

Configure the communication settings for a controller using the directly connected display unit.

By default, the controller uses IPv6 addressing. You can also configure IPv4 if required.

**INFO**
For the new settings to take effect after selecting IPv4, you must restart the controller. Disconnect, then reconnect the power supply.

**Table 7.23** Configurable communication settings

| Setting | Range | Default | Notes |
|---|---|---|---|
| Label | Text | No default | |
| IP address mode | Static, Auto | Auto | Select *Static* to specify an IPv4 address. |
| IPv4 address | 0.0.0.0 to 255.255.255.255* | No default | Static IPv4 address for the controller. |
| Netmask | 0.0.0.0 to 255.255.255.255* | No default | Depends on IPv4 address. |
| Gateway | 0.0.0.0 to 255.255.255.255* | No default | |

*Note: This is the range of addresses that you can select. The range of addresses that you can actually use depends on your network design. In addition, some addresses in this range are reserved.

See **Using the display unit**, **Configure communication** in the **Operator's manual** for more information regarding how to configure the settings with the display unit.

## 7.8.3 Restrictions

### Ethernet restrictions

- The Ethernet cables must not be longer than 100 metres, point-to-point.
- The Ethernet cables must meet or exceed the SF/UTP CAT5e specification.

**INFO**
For marine applications, you can use a marine-approved managed switch to connect the DEIF network to your own network. The switch must support and be enabled for Rapid Spanning Tree Protocol (RSTP), otherwise there will be a network failure.

## 7.8.4 Ethernet redundancy broken

This alarm applies to the DEIF network connection between controller PCM modules. The alarm is activated when there is no redundant communication between the controllers.

Configure the alarm parameters under **Configure > Parameters > Utility > Network**.

**Table 7.24** Default parameters

| Parameter | Range | Default |
|---|---|---|
| Enable | Not enabled, Enabled | Enabled |
| Auto acknowledge | Not enabled, Enabled | Enabled |

# 8. PICUS

## 8.1 Overview

### 8.1.1 Using PICUS

PICUS is computer software that provides an interface to DEIF's ML 300 controllers.

See the **PICUS manual** for a full description of how to use PICUS.

### 8.1.2 Parameter store delayed alarm

The controller activates this alarm if an operator and/or external equipment is changing the controller parameters too rapidly. For example, a programming error on a PLC can create a storm of Modbus changes. The settings are not stored, to protect the controller's internal memory.

The alarm is always enabled. You cannot see or change the alarm parameters.

## 8.2 Log

### 8.2.1 Introduction

The controller stores a maximum of 2000 log entries. When the log is full, the controller discards the excess log entries using *first in, first out*.

See the **PICUS manual** for a full description of the event log.

## 8.3 Date and time

### 8.3.1 Setting the date and time

You can set the date and time in each controller.

# 8.4 Permissions and passwords

## 8.4.1 Introduction

Access to the controllers' configuration and functionality is protected with user permission access. The controller is supplied with a number of default *Groups*, *Users* and *Passwords*.

See **Default permissions** for more information about the default users and passwords.

**INFO**
Only users with the correct permission may access, configure, or update the configuration.

### Permission structure

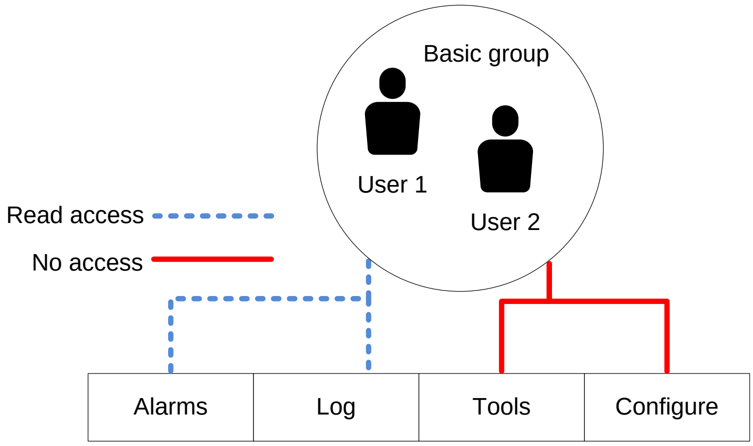
The permissions structure allows the creation and maintenance of **users** and **groups** within each controller configuration. These are stored locally on each controller, and therefore each controller can store its own set of user permissions and groups.

Each **user** is a member of a **group**. The **group** gives the **user** permissions to associated features or functions of the controller.

When a **user** is assigned to a **group**, they inherit the permissions for that **group**.

In the following diagram, you can see the permissions that **User 1** and **User 2** have to the controller. Both **User 1** and **User 2** are members of a basic permission group, and they inherit the permissions from that specific group.

**Figure 8.3** Simple permission example




In the diagram, **User 1** and **User 2** are members of the **Basic group**. They have read access to the **Alarms**, and **Log**, but they have no access to the **Tools** or **Configure** functions.

Permissions access enables you to easily control which user can access which function. This provides a layer of control for the operation of the controller.

**INFO**
In order to benefit fully from the permissions structure, you need to set up your **users** and **groups** with careful consideration.

**CAUTION**
You can only access the user permissions option if you are a member of a group that has access to that function.

## 8.4.2 Group settings

For **Groups**, the permissions consists of three parts:

- *Group settings*
- *Group permissions*
- *Permission area settings*

A permission group has a number of permission areas and in turn the permission area has a number of area settings.

### Group settings

The *Group settings* contain the general information about the permission group.

**Table 8.1** Group settings

| Setting | Type | Notes |
|---|---|---|
| Name | Required | |
| Owner | Optional | |
| Date of creation | Automatic | System created |
| Users in group | Automatic | List of users assigned to this group |
| Notes | Optional | |

### Group permissions

The group permissions grant or remove access to each of the different areas in the software.

**Table 8.2** Group permissions

| Setting | Notes |
|---|---|
| Read access | Allows settings to be read from the controller. |
| Read/write access | Allows settings to be read or written back to the controller. |
| No access | Allows no access for the function or setting. |
| Mixed access | Where permissions are different at different levels within the permission area.<br>Assigned automatically by system. |

### Permission area settings

The permission area settings allow different permission configurations for the tasks within each of the different areas of the software.

**Table 8.3** Software areas and tasks

| Software area | Tasks |
|---|---|
| Alarms* | • Acknowledge<br>• Reset all latches<br>• Remove from service<br>• Shelve |
| Log | Historical log |
| Tools | • Communication<br>• Units<br>• Date and time<br>• Report<br>• Backups<br>• Advanced<br>  ◦ Firmware<br>  ◦ Permissions |
| Configure | • Input/output<br>• Parameters<br>• CustomLogic |

**Configuring mixed access for *Tools* tasks example**

You could configure a **Group** that allows *Read/write access* to **Tools**. Then, you edit the **Tools** permission area, and set **Date and time** to be *No access*. When you save the changes, the controller automatically assigns the **Tools** permission *Mixed access*.

## 8.4.3 User settings

The following information is stored for each of the *Users* on the controller.

**Table 8.4** User settings

| Setting | Type | Notes |
|---|---|---|
| User name | Required | Minimum 2 characters. |
| Organisation | Optional | |
| Group | Required | Selectable from list. |
| Mobile number | Optional | |
| Direct number | Optional | |
| Email (primary) | Optional | |
| Email (secondary) | Optional | |
| Notes | Optional | |
| Password | Required | Minimum 8 characters. |

## 8.4.4 Default permissions

**CAUTION**
Ensure that all default passwords are changed to reduce any security risk to the operation. Additionally, it is recommended to adjust or edit the *group* and *user* permissions according to your own operational needs.

### Default groups and users

The controller is supplied with a number of default *groups*, *users* and *passwords*. These provide initial access to the controller.

**Table 8.5** Default groups, users, and passwords

| User | Password | Group |
|---|---|---|
| Operator* | 00000000 | Operators |
| Service | 00000002 | Service engineers |
| Designer | 00000003 | Designers |
| Admin | 00000004 | Administrators |

# 9. CustomLogic

## 9.1 Overview

### 9.1.1 Using CustomLogic

CustomLogic is used in PICUS to create and configure customised logical operations for use in the system. These functions are built using ladder logic elements and can include interaction with external equipment, or more advanced logic interfaces.

**Activating controller outputs**
CustomLogic cannot directly activate controller outputs that are configured for controller functions. For example, CustomLogic cannot activate the *Generator breaker* > *Control* > *Open* digital output.

However, CustomLogic can activate external commands, for example, *Generator breaker* > *Command* > *Activate breaker close*. The CustomLogic command has the same effect as, for example, the *Generator breaker* > *Command* > *Activate breaker close* digital input.

See the **PICUS manual** for more information.

### 9.1.2 CustomLogic reset on save

If you make a change to the CustomLogic and then save the change to the controller, all the CustomLogic states and timers are reset.

# 10.Modbus

## 10.1 Modbus in GPU 300

### 10.1.1 Overview

Modbus is generally accepted as the standard communication protocol between intelligent industrial devices. This means that the Modbus protocol is used as a standard method to represent and communicate data in intelligent industrial devices.

The controller includes a built-in client for Modbus TCP/IP. The Modbus TCP/IP client allows external devices to communicate with the controller using the Modbus TCP/IP communication protocol. For example: A PLC can send commands to the controller over using the Modbus TCP/IP protocol. Or a PLC can request that specific data is read from the controller, such as the settings for the nominal AC configuration.

This document will only describe the information required to communicate with the controller using the Modbus TCP/IP protocol. For more information about Modbus in general and the Modbus TCP/IP protocol refer to the documentation freely available at http://www.modbus.org.

Refer to the Modbus tables, available for download at www.deif.com, to see how the controller data is mapped to the Modbus addresses.

**INFO**
All values in this chapter are decimal values, unless specifically stated that a value is hexadecimal.

### 10.1.2 Warnings

**DANGER!**
**The DEIF controllers do not include a firewall or other Internet security measures. It is the customer's own responsibility to protect the network. The controller provides no access restrictions (for example group and user permissions) when accessed through Modbus TCP. If the controllers are connected to a network connection outside of the controller network, the controller can be accessed and configured through Modbus TCP by anyone connected to the network.**

**DANGER!**
**All controller settings can be accessed and modified through Modbus TCP. This includes disabling critical controller protections by changing settings and alarms. Use the Modbus tables provided by DEIF to ensure that you do not disable critical protections.**

## 10.2 Modbus implementation in GPU 300

### 10.2.1 Modbus TCP protocol

The controller uses the Modbus TCP protocol to communicate with an external device over the Modbus network and through the internet. The communication protocol uses static IPv4 addresses to send information. Dynamic IPv4 addresses (created by a dynamic host configuration protocol server (DHCP server)) and IPv6 addresses are not supported by the controller for Modbus communication purposes.

See **Getting started with PICUS**, **Ethernet connection**, **Configure communication** in the **PICUS manual** for more information to configure the controller communication information.

## 10.2.2 Modbus communication port

The controller uses port 502 (standard for Modbus TCP protocol) for TCP communication. This port cannot be changed in the controller.

Each controller can process up to 10 communication requests at a single time.

## 10.2.3 Controller identifier

The Modbus TCP protocol will always use the controller IPv4 address to identify the controller the server wants to communicate with. However, some Modbus communication tools will still require/automatically add a Modbus ID, also known as a unit identifier, for the unit the server is communicating with. For these cases the controller accepts Modbus IDs from 1 to 247. This is the case for all ML 300 controllers in the network that communicate using the Modbus TCP protocol.

## 10.2.4 Data handling

**CAUTION**
Always consult the Modbus tables provided by DEIF to ensure you are referencing the correct Modbus address for the function that you are executing.

### Endian

To ensure the correct data is retrieved from the controller, the request from the Modbus server must match the data type of the selected address. The data types are fixed in the controller, and are indicated in the Modbus table for each address in the *Holding register* and *Input register*.

**Address data type example**

In the *Holding register*, the data stored in Modbus address 34452, the NEL 1 over-current UTC shelved time information, is of the ABCD data type. This means that the data located in this address is stored with the most significant byte and the most significant word placed first.

### Sign

In general, the integer data (16-bit and 32-bit) that is accessed from the controller through Modbus TCP are signed integer values.

### Scaling

Data in the *Holding register* and *Input register* of the Modbus table is scaled according to the formula:

$$\text{Actual value} = \text{Value in register} * 10^{-\text{Scaling}}$$

**Modbus data scaling example**

The Modbus address 20119 in the *Holding register* contains the set point value for the *PSM1 High voltage alarm*. The scaling for this address is 1.

This means that when a value of 305 is read from the controller, the actual value is:
Actual value = Value in register * $10^{-Scaling}$ = 305 * $10^{-1}$ = 305 * 0.1 = 30.5 V

To write a value of 30 V to the controller using Modbus the value that should be written to the register is:
Value in register = Actual value / $10^{-Scaling}$ = 30.0 / $10^{-1}$ = 300

# 10.3 Modbus tables

## 10.3.1 Download Modbus tables

You can download the Modbus table for the controller from the product page at www.deif.com.

Steps:

1. Go to www.deif.com.
2. Type the product name in the search bar and submit your search.
3. Select the controller from the search results.
4. Select **Modbus tables** under **Download documentation** on the product page.
5. Select the Modbus table from the list of documentation and confirm the storage location.

## 10.3.2 Modbus table overview

The Modbus tables are stored in a Microsoft® Excel file that contains five spreadsheets with Modbus data. The table below gives a short description of each of the spreadsheets in the file.

**Table 10.1** Modbus table spreadsheet overview

| Spreadsheet name | Description |
|---|---|
| Overview | This spreadsheet contains an overview of the other four spreadsheets. The information includes a description of each function group listed in the tables spreadsheets, and an explanation of the table headings. |
| Discrete output coil | You can read or write information to the addresses that are listed in this spreadsheet. Use Modbus function code 01 to read the whether a coil is on or off. Use Modbus function code 05 or 15 to toggle the coil value. Addresses that are read only on this spreadsheet will return a 0 value when a confirmation is returned after trying to write to the read only address. |
| Discrete input contact | You only can read information from the addresses that are listed in this spreadsheet. Use Modbus function code 02 to read the whether the contact is on or off. |

| Spreadsheet name | Description |
|---|---|
| Output holding register | You can read or write information to the addresses that are listed in this spreadsheet. Use Modbus function code 03 to read the information stored at the requested Modbus address(es). Use Modbus function code 06 or 16 to write information to the Modbus address(es). Addresses that are read only on this spreadsheet will return a 0 value when a confirmation is returned after trying to write to the read only address. |
| Input register | You only can read information from the addresses that are listed in this spreadsheet. Use Modbus function code 04 to read the information stored at the requested Modbus address(es). |

# 10.4 Setting up Modbus

## 10.4.1 Setting up Modbus TCP/IP communication

In order to communicate with a controller through Modbus TCP the following conditions must be met:

- The device interfacing with the controller must be connected to the controller Ethernet connections on the controller communication module (For example PCM3.1).
- The controller must have a unique IPv4 address which is active.
- Modbus TCP communication software must be installed on the device communicating with the controller.

See **Wiring the communication** in the Installation instructions for more information about how to wire the Ethernet connection to the controller.

# 10.5 Modbus alarm

## 10.5.1 Modbus communication timeout

The controller activates this alarm if there are no Modbus requests within the delay time.

Configure the parameters under **Configure > Parameters > Utility > Network > Modbus communication timeout**.

**Table 10.2** Default parameters

| Parameter | Range | Default |
|---|---|---|
| Delay | 0.1 to 3600 s | 10 s |
| Enable | Not enabled, Enabled | Not enabled |
| Action | | Warning |

# 11.Glossary

## 11.1 Terms and abbreviations

| Term | Abbreviation | Explanation |
|---|---|---|
| Action | | The pre-defined set of actions that an alarm initiates. Also known as fail class. |
| Alarm levels | | The number of alarms that can be assigned to an operating value. For example, the Over-current protection by default has two alarm levels. |
| Alarm monitoring system | AMS | Third party equipment used to monitor the controller system's alarms, for example, by using Modbus TCP/IP communication. |
| Alternating current | AC | |
| Alternating current module 3.1 | ACM3.1 | A replaceable PCB with voltage and current measurement inputs. Used in the DEIF controller. |
| American National Standards Institute | ANSI | |
| American wire gauge | AWG | A standardised wire gauge system, also known as the Brown & Sharpe wire gauge. |
| Apparent power | S | The 3-phase apparent power, measured in kVA. |
| Automatic voltage regulator | AVR | Regulates the genset voltage. The AVR is third-party equipment. The AVR can have a fixed voltage set point. Alternatively, the DEIF controller can control the AVR. |
| Bi-directional input | | The wiring to a controller's digital input and common terminals may be swapped around without affecting the input's operation. |
| Blind module | | A hardware module that consists of only a module faceplate. These are installed over empty slots, to protect the controller electronics. |
| Breaker | | A mechanical switching device that closes to connect the generator to the busbar. The breaker opens to disconnect the generator. |
| Busbar | | The copper conductors which connect the power sources to the power consumers. Represented on the single-line diagram as the line that connects all the power sources and power consumers. If the bus tie breaker is open, there are two separate and independent busbar sections. Similarly, if the bus tie breaker is closed, there is only one busbar. |
| Canadian Electrical Code | CEC | A standard published for the installation and maintenance of electrical equipment in Canada. |
| Commissioning | | The careful and systematic process that takes place after installation and before the system is handed over to the operator. Commissioning must include checking and adjusting the controller. |
| Common terminal | COM | This is generally connected to either a power source, or the supply return. See the wiring examples for more information. |
| Configuration | | Assigning input and output functions to terminals, and setting parameters, so that the controller is suitable for the application where it is installed. |
| Conformité Européenne | CE | The product meets the legal requirements described in the applicable directive(s). All products with CE marking have free access to markets in the European Economic Area (EEA). |
| Connected | | A generator is connected to the system if it is running, synchronised with the busbar, and its breaker is closed. |
| Controller | GPU | GPU 300, DEIF's Generator Protection Unit. |

| Term | Abbreviation | Explanation |
|---|---|---|
| Current transformer | CT | |
| CustomLogic | | The ladder logic system included in the controller software, which can be configured for customised responses to measured or calculated values. |
| Digital input | DI | Terminals on a controller hardware module that the controller uses to measure a digital input. A pre-configured digital input function or alarm can be assigned to the input. |
| Digital output | DO | Terminals on a controller hardware module that the controller uses to send a digital output. A pre-configured digital output function can be assigned to the output. |
| Direct current | DC | |
| Electromagnetic compatibility | EMC | An equipment characteristic relating to the equipment's performance in the presence of electromagnetic interference, as well as its emission of electromagnetic interference. |
| Electromagnetic interference | EMI | The radiation emitted by the equipment as well as radiation that can affect the performance of equipment. |
| Electrostatic discharge | ESD | |
| European Norm | EN | Standards issued by the European Committee for Standardisation (also known as Comité Européen de Normalisation). |
| Firmware | | Software that is installed in the controller. This software enables the controller to: process inputs and outputs, display operating data, keep track of the quipment status, and so on. |
| Generator breaker | GB | The breaker between a genset and the busbar. The controller can control a generator breaker. |
| Ground | | A connection between the equipment and earth. For marine applications, a ground is a connection to the ship's frame. |
| | GOST | Regional standards maintained by the Euro-Asian Council for Standardization, Metrology and Certification. |
| Horn output | | The controller's digital output(s) that can be connected to a horn, a siren, lights, or other equipment. This alerts the operator that one or more alarms are activated. |
| Hysteresis | | An offset added to prevent rapid switching when a value is near the control point. |
| Ingress Protection Rating, or International Protection Rating | IP | The degree of protection against solids and water provided by mechanical casings and electrical enclosures. |
| Inhibit | | A pre-defined condition that inhibits the alarm action. For example, for the inhibit ACM wire break, if the controller detects a wire break on the voltage measurements, the voltage unbalance alarm is prevented from occurring. Inhibited alarms are not shown in the alarm display. |
| Input output module 3.1 | IOM3.1 | A replaceable PCB, with four relay outputs, and 10 digital inputs. Used in the DEIF controller. |
| Institute of Electrical and Electronics Engineers | IEEE | |
| International Association of Classification Societies | IACS | |
| International Electrotechnical Commission | IEC | |

| Term | Abbreviation | Explanation |
|---|---|---|
| International Organization for Standardization | ISO | |
| Internet Protocol version 4 | IPv4 | A protocol for communication across networks. IPv4 currently routes the most traffic on the Internet, but will gradually be replaced by IPv6. |
| Internet Protocol version 6 | IPv6 | A protocol for communication across networks. Among other things, IPv6 has a much larger address space than IPv4. |
| | JEM-TR177 | Japan Electrical Manufacturers Association's noise standard. |
| Latch | | An extra layer of protection that keeps the alarm action activated. When the alarm is not active and acknowledged, it can be unlatched. |
| Light emitting diode | LED | Used to show the controller and equipment status and alarms. |
| Liquid crystal display | LCD | The screen of the display unit. The information displayed varies, depending on the equipment operation and the operator input. |
| Mean Time Between Failures | MTBF | |
| Mean Time To Failure | MTTF | |
| Module | | A standardised, replaceable printed circuit board that is mounted in the rack. For example, PSM3.1 is a hardware module that supplies power to the rest of the rack. |
| Multi-line 300 | ML 300 | A DEIF product platform. GPU 300 is part of ML 300. |
| National Electrical Code | NEC | A standard for the safe installation of electrical wiring and equipment in the United States. |
| Network time protocol | NTP | Used to synchronise the time of a computer client or server to another server or reference time source. |
| Neutral | N | The neutral line in a three-phase electrical system. |
| Nominal setting | nom or NOM | Defines the expected voltage and frequency for the system, along with each power source's maximum load and current. Many of the controller's alarms are based on percentages of the nominal settings. |
| Non-essential load | NEL | A load that is not critical to the system. These may be disconnected by the controller in the event of over-load, over-current, or busbar under-current. |
| Operate time | | The time that the controller takes to measure, calculate, and change the controller output. For each alarm, the reaction time is based on the minimum setting for the time delay. |
| Out of service | | A state that an alarm can be assigned to by an operator. Out of service alarms are inactive alarms. Out of service alarms do not automatically return to service and require operator action. |
| Parameter | | A value, or set point, used to determine the controller's operation. Parameters include nominal values, the configuration options for the configurable inputs and outputs, and alarm settings. The same set of parameters can be uploaded to several controllers. |
| Personal computer | PC | Used to run the PICUS software. For example, a laptop computer. |
| Phase L1 | L1 | The power line for one phase of a three-phase electrical system. Corresponds to R in Germany, Red in the UK and Pacific, Red in New Zealand, Black in the USA, and U on electrical machine terminals. The above colour codes are for guidance only. If uncertain perform a phase measurement. |

| Term | Abbreviation | Explanation |
|---|---|---|
| Phase L2 | L2 | The power line for one phase of a three-phase electrical system. Corresponds to S in Germany, Yellow in the UK and Pacific, White in New Zealand, Red in the USA, and V on electrical machine terminals. The above colour codes are for guidance only. If uncertain perform a phase measurement. |
| Phase L3 | L3 | The power line for one phase of a three-phase electrical system. Corresponds to T in Germany, Blue in the UK and Pacific, Blue in New Zealand, Blue in the USA, and W on electrical machine terminals. The above colour codes are for guidance only. If uncertain perform a phase measurement. |
| Power | P | The 3-phase active power, measured in kW. |
| Power factor | PF | The 3-phase power factor. |
| Power in Control Utility Software | PICUS | The DEIF utility software, used to design, configure, troubleshoot and monitor a system. |
| Power supply module 3.1 | PSM3.1 | A replaceable PCB that powers the controller. This module includes three relay outputs for status signals. Used in the DEIF controller. |
| Printed circuit board | PCB | Supports and electrically connects components. |
| Processor and communication module 3.1 | PCM3.1 | A replaceable PCB, which contains the controller processor, as well as the CAN bus connections and Ethernet communication connections. Used in the DEIF controller. |
| Programmable logic controller | PLC | A digital computer used for the automation of electromechanical processes. |
| Proportional integral derivative | PID | A feedback controller. |
| Rack | | An aluminium box with a rack system that houses the hardware modules. Each controller consists of a rack and a number of hardware modules. |
| Rapid spanning tree protocol | RSTP | An improved network protocol that builds logical loop-free topologies for ethernet networks. |
| Reactive power | Q | The 3-phase reactive power, measured in kvar. |
| Root mean squared | RMS | Refers to the mean magnitude of a sinusoidal wave. For example, RMS V refers to the mean AC voltage. |
| SD card | | External memory (future use) |
| Shelve | | A temporary state that an alarm can be assigned to by an operator. Shelved alarms are inactive alarms, but only for a selected period by the operator. When the period of time expires, the alarm is automatically unshelved by the system restoring the alarm to the previous alarm state. Alarm conditions are checked again. |
| Single-phase | | A system where the load is connected between one of the phases and the neutral. Note: Single-phase does NOT mean a 3-wire single-phase distribution system, where the waveforms are offset by a half-cycle (180 degrees) from the neutral wire. |
| Supervisory control and data acquisition system | SCADA | |
| Switchboard | | The cabinet where the power sources are connected to the power consumers. See Busbar too. |
| Third-party equipment | | Equipment other than the DEIF controller. For example: The genset, the genset engine control system, the wiring, the busbars, and the switchboard. |
| Time | t | |
| Time delay | | An alarm must exceed its set point continuously for the period in its Time delay parameter before the alarm is activated. |

| Term | Abbreviation | Explanation |
|---|---|---|
| Transmission control protocol/internet protocol | TCP/IP | |
| Trip | | An emergency or fast opening of a breaker. No attempt is made to de-load the breaker before it opens. |
| United States of America | US, USA | |
| Universal serial bus | USB | Communication protocol. |
| | UL 94 | A plastics flammability standard released by Underwriters Laboratories of the USA. |
| Voltage | V | Electrical potential difference. U is used as an abbreviation for voltage in most of Europe, Russia and China. |
| Voltage and frequency | V & Hz | For certain controller actions, both the voltage and frequency must be within the specified range. For example, for busbar OK, or to start synchronising a genset to the busbar. |
| Voltage transformer | VT | |

# 11.2 Units

The table below lists the units used in the documentation, as well as the US units where these are different. In the documentation, the US units are given in brackets, for example, 80 °C (176 °F).

**Table 11.1** Units used in the documentation

| Unit | Name | Measures | US unit | US name | Conversion | Alternative units |
|---|---|---|---|---|---|---|
| A | ampere | Current | | | | |
| bar | bar | Pressure | psi | pounds per square inch | 1 bar = 14.5 psi | 1 bar = 0.980665 atmosphere (atm)<br><br>1 bar = 100,000 Pascal (Pa) |
| ºC | degrees Celsius | Temperature | ºF | Fahrenheit | T[ºC] = (T[ºF] - 32 º) × 5 / 9 | T[ºC] = T[Kelvin (K)] - 273.15 |
| dB | decibel | Noise or interference (a logarithmic scale) | | | | |
| g | gram | Weight | oz | ounce | 1 g = 0.03527 oz | |
| *g* | gravitational force | Gravity, $g$ = 9.8 m/s$^2$ | ft/s$^2$ | | $g$ = 32.2 ft/s$^2$ | |
| h | hour | Time | | | | |
| Hz | hertz | Frequency (cycles per second) | | | | |
| kg | kilogram | Weight | lb | pound | 1 kg = 2.205 lb | |
| kPa | kilopascal | Pressure | psi | pounds per square inch | 1 kPa = 0.145 psi | |
| m | metre | Length | ft | foot (or feet) | 1 m = 3.28 ft | |

| Unit | Name | Measures | US unit | US name | Conversion | Alternative units |
|---|---|---|---|---|---|---|
| mA | milliampere | Current | | | | |
| min | minute | Time | | | | |
| mm | millimetre | Length | in | inch | 1 mm = 0.0394 in | |
| ms | millisecond | Time | | | | |
| N·m | newton metre | Torque | lb-in | pound-force inch | 1 N·m = 8.85 lb-in | |
| RPM | revolutions per minute | Frequency of rotation (rotational speed) | | | | |
| s | second | Time | | | | |
| V | volt | Voltage | | | | |
| V AC | volt (alternating current) | Voltage (alternating current) | | | | |
| V DC | volt (direct current) | Voltage (direct current) | | | | |
| W | watt | Power | | | | |
| Ω | ohm | Resistance | | | | |

# 11.3 Symbols

## 11.3.1 Symbols for notes

### Safety notes

**DANGER!**
**This highlights dangerous situations. If the guidelines are not followed, these situations could result in death, serious personal injury, and equipment damage or destruction.**

**CAUTION**
This highlights potentially dangerous situations. If the guidelines are not followed, these situations could result in personal injury or damaged equipment.

### General notes

**INFO**
This highlights general information.

This highlights where to find more information.

**Example heading**

This highlights examples.

### 11.3.2 Mathematical symbols

| Abbreviation | Symbolises | Example |
|---|---|---|
| + | Addition | 2 + 3 = 5 |
| - | Subtraction | 5 - 2 = 3 |
| x | Multiplication (numbers) | 2 × 3 = 6 |
| / | Division | 15 / 3 = 5 |
| · | Multiplication (units) | 5 N·m = 5 Newton metres |
| Σ | Summation | Σ Nominal power for connected gensets = 1000 kW + 1500 kW + 500 kW = 3000 kW |

### 11.3.3 Drawing symbols

The drawings use EU symbols. The US alternative is shown where applicable.

**Table 11.2** Electrical symbols

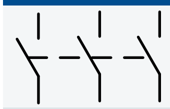
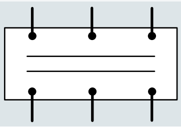
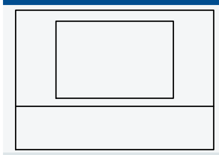
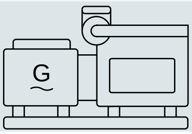
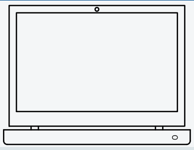
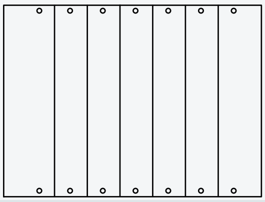
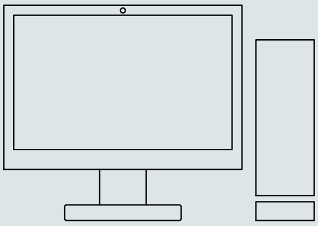
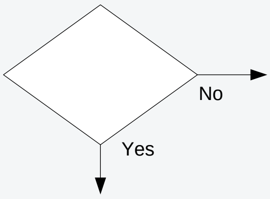
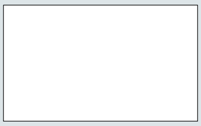
| Symbol | Symbol name |
|---|---|
|  | 3-phase breaker |
| • | Connector dot |
|  | Current transformer (S1 and · show "current in"; S2 shows "current out") |
|  | Single-line diagram closed breaker |
|  | Single-line diagram open breaker |
|  | Voltage transformer. This is a general voltage transformer, without any information about the transformer connections. These could for example be: open delta, star-star, closed delta, and so on. |

**Table 11.3** Icons used in drawings

| Symbol | Symbol name |
|---|---|
|  | Display unit DU 300 |
|  | Genset |

| Symbol | Symbol name |
|---|---|
|  | Laptop |
|  | Non-essential load |
|  | Rack R7 |
|  | Server or desktop PC |

## 11.3.4 Flowchart symbols

| Symbol | Symbol name |
|---|---|
|  | Decision |
|  | Process |
|  | Start or end |

### 11.3.5 Module faceplate symbols

**Table 11.4** Terminals

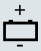
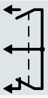
| Symbol | Symbol name |
|---|---|
|  | Frame ground |
|  | Power supply |
| L1, L2, L3 and N | Three-phase voltage measurements |
|  | Current transformer |
| COM | Common |
|  | Digital input |
|  | Relay output (normally open) |
|  | Relay output (changeover relay, with normally open and normally closed terminals) |
| H, CAN-#, L | CAN bus connection |

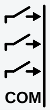
**Table 11.5** LEDs

| Symbol | Symbol name |
|---|---|
| CAN-# | CAN bus |
|  | DEIF network |
|  | Internal communication in |
|  | Internal communication out |
|  | Internal communication status |
|  | Power supply status (PSM) |
|  | System status (PCM) |

**Table 11.6** Other

| Symbol | Symbol name |
|---|---|
| ▲ | RJ45 connections at the top of the hardware module |
| ▼ | RJ45 connections at the bottom of the hardware module |
|  | SD card |

**Table 11.7** Terminal sets

| Example | Explanation |
|---|---|
|   | The vertical line to the right of the symbols shows terminal sets. In the example, the digital inputs have the same common. |