# iE 250

Core

## Designer's handbook

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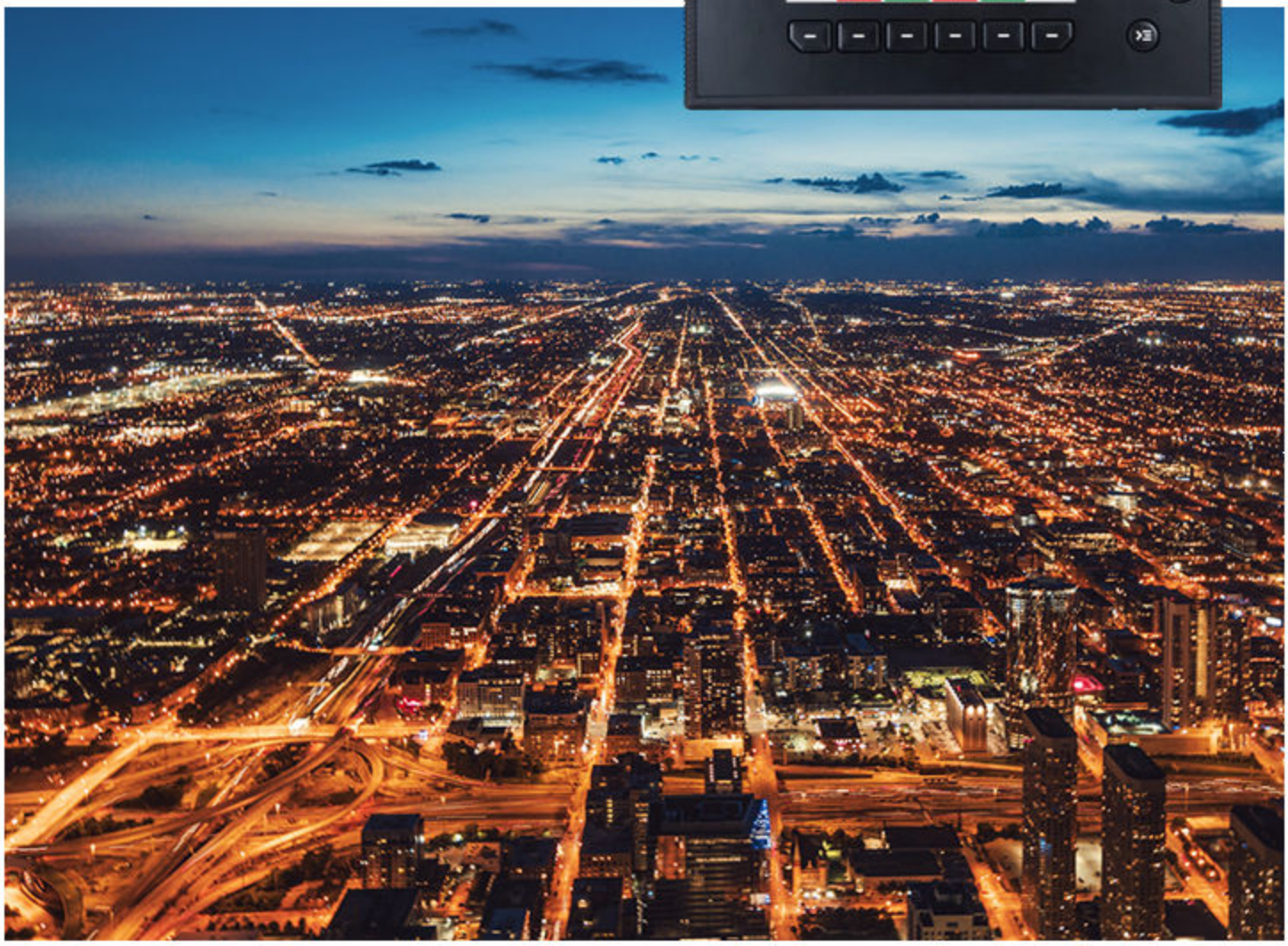

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# 1. About the Designer's handbook

## 1.1 Intended users of the Designer's handbook

The Designer's handbook is intended for the designer of the system where the controllers are installed. It 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.

## 1.2 Symbols and conventions

### Symbols for hazard statements

**DANGER!**

**This shows dangerous situations.**

If the guidelines are not followed, these situations will result in death, serious personal injury, and equipment damage or destruction.

**WARNING**

**This shows potentially dangerous situations.**

If the guidelines are not followed, these situations could result in death, serious personal injury, and equipment damage or destruction.

**CAUTION**

**This shows low level risk situation.**

If the guidelines are not followed, these situations could result in minor or moderate injury.

**NOTICE**

**This shows an important notice**

Make sure to read this information.

### Symbols for general notes

**NOTE** This shows general information.

**More information**
This shows where you can find more information.

**Example**

This shows an example.

**How to ...**
This shows a link to a video for help and guidance.

## Functions

The Designer's handbook descriptions are based on functions. Each function description includes the associated input and output functions, and parameters.

## Function or parameter path notation

A function or parameter path is stated in this document as follows:

`Generator > Nominal settings > Nominal settings 1 > Voltage (V)`

The above path is for the `Voltage (V)` parameter under `Nominal settings 1` for the `Generator`.

## Inputs and outputs

The controller has configurable inputs and outputs. You can assign functions to inputs or outputs with either the display or PICUS. These functions are assigned to a hardware module and set of corresponding terminals. Only functions applicable for the type of terminal are listed. If an ECU is configured in Fieldbus, you can also see ECU functions.

## Parameters

Parameters can be configured with either the display or PICUS.

Parameter visibility may depend on the hardware or input/output configuration.

## Multi-function parameters and I/Os

Some parameters and inputs or outputs can be used by more than one function.

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

For a **GENSET** controller:

`Generator > Nominal settings > Nominal settings 1 > Voltage (V)`

This parameter is for the genset *Nominal voltage* for the first set of nominal settings. The *Nominal voltage* is the basis for all of 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**

*[A-side]* represents the *Generator* for a **GENSET** controller.

*[Hardware module]* represents the relevant controller hardware module.

*[Breaker]* represents the *Generator breaker* for a **GENSET** controller.

### Numbers

The hash symbol # is used when there are several numbered possibilities.

**Example**

*Nominal settings #*

Where the # could be 1 to 4.

## 1.3 Software versions

The information in this document relates to software versions:

| Software | Details | Version |
|---|---|---|
| iE 250 Core<br>iE 250 Power management | Controller application | 2.0.18.x |
| CODESYS libraries | CODESYS | 2.0.18.x |
| PICUS | PC software | 1.0.27.x |

## 1.4 Need more information?

Get direct access to the resources that you need by using the links below.

**DEIF website**
Official DEIF homepage.

**Give feedback**
Help improve our documentation with your feedback.

**Support**
Self-help resources and how to contact DEIF for assistance.

**Documentation**
**iE 250** documentation.

**Product**
**iE 250** product page.

**How to...**
Learn how to use this product.

## 1.5 CAD drawings

**DWG Drawings**

DWG **iE 250** Front-mounted with MIO
www.deif.com/rtd/ie250fmm/dwg

DWG **iE 250** Base-mounted with MIO
www.deif.com/rtd/ie250bmm/dwg

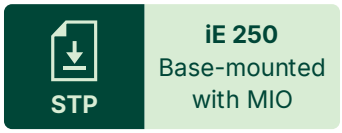
DWG **iE 250** Base-mounted without MIO
www.deif.com/rtd/ie250bm/dwg

DWG **iE 7** Display

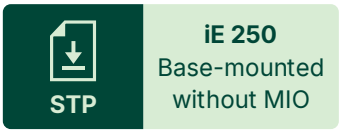
www.deif.com/rtd/ie7/dwg

**STP STEP-file**

www.deif.com/rtd/ie250fmm/stp




www.deif.com/rtd/ie250bmm/stp



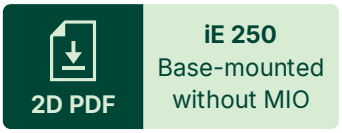

www.deif.com/rtd/ie250bm/stp

www.deif.com/rtd/ie7/stp

**2D PDF**

www.deif.com/rtd/ie250fmm/2dpdf

www.deif.com/rtd/ie250bmm/2dpdf




www.deif.com/rtd/ie250bm/2dpdf

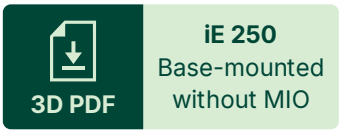
www.deif.com/rtd/ie7/2dpdf

**3D PDF**

To view a 3D PDF you must enable multimedia and 3D content in your PDF viewer.

www.deif.com/rtd/ie250fmm/3dpdf

www.deif.com/rtd/ie250bmm/3dpdf




www.deif.com/rtd/ie250bm/3dpdf

www.deif.com/rtd/ie7/3dpdf

## 1.6 Warnings and safety

### Safety during installation and operation

When you install and operate the equipment, you may have to 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 or any relay terminals, as this could lead to injury or death.

## Controller power supply

It is recommended that the controller has both a reliable power supply and a backup power supply. The switchboard design must ensure sufficient protection of the system, if the controller power supply fails.

## Connect the controller (or extension rack) protective earth

**DANGER!**

**Failure to ground**

Failure to ground the controller (or extension rack) could lead to injury or death.

You must ground the controller (or extension rack) to a protective earth.

## 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.

## PLC design and testing

The controllers require an operator, a PLC, CustomLogic, and/or CODESYS to control the system. The controllers do not do system calculations or system power management. Each controller simply follows the commands that it receives. The controllers do not evaluate whether the commands are appropriate for the system state.

**CAUTION**

**Incorrect PLC commands**

The PLC must be programmed correctly and thoroughly tested, to ensure safety, and avoid situations where the PLC gives the controllers incorrect commands and set points.

The PLC is supplied by a third-party. DEIF is not responsible for the PLC design and testing.

**Regulation set point example**

The controller does not evaluate whether regulation set points are appropriate. The controller simply attempts to regulate to achieve the set point. If the operating value exceeds an alarm set point, then the controller activates the alarm action.

## Electrostatic discharge

If the modules are not installed in the controller, protect the module from electrostatic discharge. While the controller is open for the installation of modules, you must also protect the inside of the controller from electrostatic discharge.

Electrostatic discharge during installation can damage the modules and the inside of the controller.

## 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. Shelving or taking out of service also automatically acknowledges the alarm and resets the latch.

You can 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.

## Do not circumvent active alarm actions

**DANGER!**

**Circumventing a latched alarm action**

If the alarm action is circumvented, a latched alarm does NOT provide any protection.

Do not circumvent the alarm action of an active alarm. An alarm may be active because it is latched, or because the alarm condition is still present.

**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.

## Do not use unsupported hardware modules

Only use the hardware modules that are listed in the Technical specifications.

## Remote-controlled starts

The gensets can be started by remote signals (for example, by sending a Modbus signal, or using PICUS). To avoid personal injury, the genset design, the layout, and maintenance procedures must take this into account.

## 1.7 Legal information

### Third party equipment

DEIF takes no responsibility for installation or operation of any third party equipment. In no event shall DEIF be liable for any loss of profits, revenues, indirect, special, incidental, consequential, or other similar damages arising out of or in connection with any incorrect installation or operation of any third party equipment.

### Warranty

**NOTICE**

**Warranty**

The warranty will be lost if the warranty seals are broken.

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# 2. System principles

## 2.1 About the controllers

### 2.1.1 About the controller types

The iE 250 is a versatile and modular-designed controller for land. Its design enables you to tailor the installation to your needs.

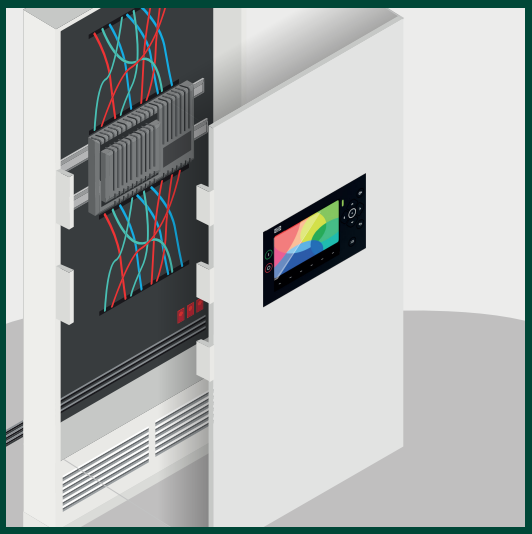
Available hardware versions:

- **iE 250 (7")**: Front-mounted version with 7" touchscreen.
- **iE 250 (Base)**: Base-mounted version for DIN rail or fixed (180° rotated) mounting in back panel.

Front-mounted controller with combined display

iE 250 (7″)

Base-mounted controller with or without display



iE 250 (Base)

iE 7 display

An extensive range of control, protection and supervision features. Applications range from generator control and protection to engineered energy management solutions with our market-leading fuel optimisation technology.

The supported features depend on the software licence installed.

Each controller is assigned a type from the factory. You can see the type of controller on the single-line application drawing.

| Controller type | Controls and protects |
|---|---|
| Single genset controller | • A prime mover, generator, generator breaker, mains connection, and mains breaker<br>• A prime mover, generator, generator breaker, and mains connection<br>• A prime mover, generator, and generator breaker |
| Genset controller | A prime mover, generator, and generator breaker. |

| Controller type | Controls and protects |
|---|---|
| Mains controller | • A mains connection, and mains breaker.<br>• A mains connection, mains breaker, and a tie breaker. |
| Bus tie breaker controller | A bus tie breaker. |

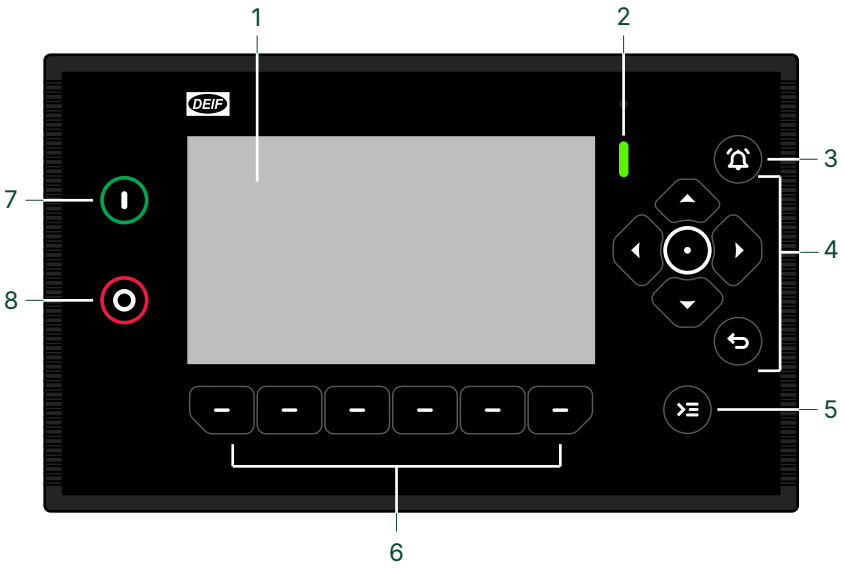
### 2.1.2 Software licences

The supported features depend on the software licence installed.

The standard license is the **Core** licence synchronising and load share, and support.

### 2.1.3 Display layout

The base-mounted controller can run with or without a display, but we recommend that you use an iE 7 display. The display is the operator's interface to the controller.




| No. | Item | Notes |
|---|---|---|
| 1 | Display screen | 7" colour touch screen. |
| 2 | Status LED | Multi-colour LED for status indication. |
| 3 | Notification centre button | Silences the alarm horn (deactivates the output), and opens the **Notification centre**, which shows alarms and events. |
| 4 | Navigation buttons | Up, down, left, and right arrows. |
| | Enter button | Confirms the selection. |
| | Back button | • Returns to the previous page<br>• Shows the menu.<br>• Hold: Change to Dashboard |
| 5 | Control centre button | Opens the **Control centre**. |
| 6 | Configurable buttons | Buttons can be activated either by pressing the physical button or the soft key on the screen. * |
| 7 | Start button | In manual or local operation, it starts the asset. |
| 8 | Stop button ** | In manual or local operation, it stops the asset. |

**NOTE** * Dashboard pages can be created, copied and modified, to assign different functions to the buttons (with PICUS and the Display designer).
** Double press to override cooldown process. Press again to cancel **Idle run**, if configured.

## 2.2 Application as a system

### 2.2.1 Single-line application drawing

The system is defined by the application drawing created with PICUS:

- How many controllers
- What type of controllers

- How they are connected

Additional breaker settings, measurements, and feedbacks can also be configured.

You can create up to 4 different application drawings.

If there is more than one application, the active application can be selected by setting the parameter:

```
System > Plant > Active application
```

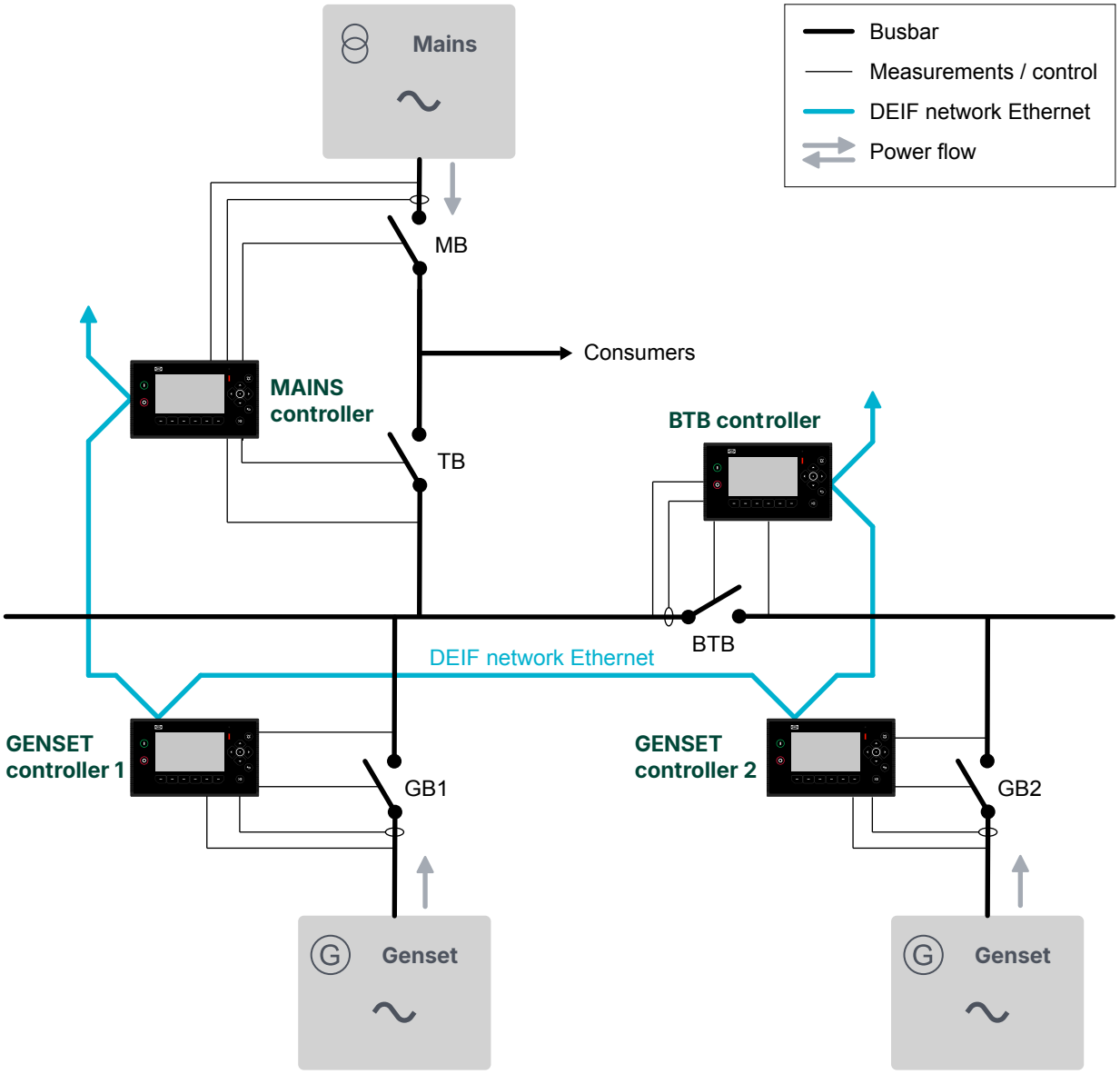
The application drawing is created in PICUS and must be written to all connected controllers in the same system. If different applications are detected in the system, the controller activates an alarm.

**More information**
See the PICUS manual for how to configure and write the Application drawing.

## 2.2.2 Applications

The complete system is easily monitored and controlled from PICUS through a graphical supervision page. The values that are presented in the intuitive and easy-to-use user interface include the running status, hours in operation, breaker status, condition of mains and busbars, and fuel consumption.

**Example application with Load sharing**




## 2.2.3 Application selector

The application licence can be changed by using the Application selector parameter. You can only change to a licence that is already present and activated on your controller. If the licence selected is not present and active on the controller, the Licence error alarm is activated. A Factory reset always returns the controller to the original licence.

**DANGER!**

**Controller must not be in operation**

The controller must not be in operation or controlling any equipment when you change Application licence.

Make the controller safe for commissioning to avoid equipment damage, personal injury, or unexpected critical system operations.

**System > Application selector**

| Parameter | Range |
|---|---|
| Application selector | • Core<br>• Power management |

## 2.2.4 Change controller type

You can change the type of controller from the single-line application drawing. Remove the existing controller and replace it with a new controller type with the same Controller ID. This feature requires the necessary permission in order to access it.

The controller must be either safe for commissioning:

1. Any controlled equipment must be stopped.
2. All breakers must be open.

or

1. The controller is in emulation mode.

Changing the controller type resets the default I/O configuration. The I/O configuration must checked and reconfigured as necessary after changing the controller type. It is recommended to take a backup of your settings before changing the controller type.

**NOTICE**

**Configuration reset**

When a controller changes type, all of the controller's existing configuration is deleted, this also includes the log. The IP address configuration and permissions (both users and groups) are not deleted.

It is recommended to take a backup of your controller before changing controller type if you require the settings.

**More information**
See **Application** in the PICUS manual for how to create the single-line application drawing.

## 2.2.5 Maximum number of controllers

There can be up to a total of 64 controllers per **DEIF network Ethernet**. That is, you can assign up to 64 unique **Controller ID** numbers out of a possible range of 64.

A system can consist of several controllers in the same **DEIF network**. It is also possible to include other controllers (using Modbus communication) in the system.

| Types | Possible | Notes |
|---|---|---|
| **SINGLE** genset controller | 0 to 1 | If there is a **SINGLE** genset controller, there cannot be any other controllers in the plant. |
| **GENSET** controller | 1 to 64 | |
| **MAINS** controller | 0 to 64 | |
| **BUS TIE breaker** controller | 0 to 63 | |

**NOTE** For Core applications, you can use any combination of iE 250 Core and iE 350 Core controllers.

# 2.3 Control and modes

## 2.3.1 About the controller mode

The iE controllers operate in a controller mode. This mode decides which actions may be taken or how the controller reacts to operational situations.

Controller modes:

- **LOCAL mode**
  - The operator can start, stop, connect and disconnect the asset. The controller automatically synchronises before closing a breaker, and automatically de-loads before opening a breaker. Remote commands for sequences are ignored.
- **REMOTE mode**
  - REMOTE mode uses command start sequences from digital inputs, PICUS, Modbus, CustomLogic, and/or CODESYS. Display push-buttons for sequences are ignored.
- **NO REG - No regulation mode**
  - Regulation is not controlled by the controller and must be done manually or externally.
- **TEST - Test mode**
  - The test sequence starts when an operator selects the test mode.

## 2.3.2 Local control

While in local control, the operator can use the display for breaker open and close (as well as engine start and stop for a **GENSET** controller).

### Inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Local > Mode > Local control` | Digital input | Pulse | If the controller is in remote control, the controller is placed in local control when this input is activated. This input has the same effect as pressing the local push-button on the display. |
| `Local > Mode > Under local control` | Digital output | Continuous | Activated if the controller is in local control. |

## 2.3.3 Remote control

While in remote control, the display ignores the push-buttons for breaker open and close (as well as engine start and stop for a **GENSET** controller).

### Inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Local > Mode > Remote control` | Digital input | Pulse | If the controller is in local control, the controller is placed in remote control when this input is activated. This input has the same effect as pressing the remote push-button on the display. |
| `Local > Mode > Under remote control` | Digital output | Continuous | Activated if the controller is in remote control. |

## 2.3.4 Command sources

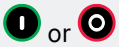
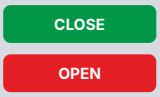
You can prohibit certain command sources from use in the system. For example, you could restrict the display function for the start or stop of the engine. Command sources can be configured as parameter settings or dynamically controlled with CustomLogic or Modbus.

You can configure different restrictions for when in either LOCAL or REMOTE mode.

### Parameters

You can use parameters to enable or disable the display command sources.

**`Local > Command sources > Active [mode] sources *`**

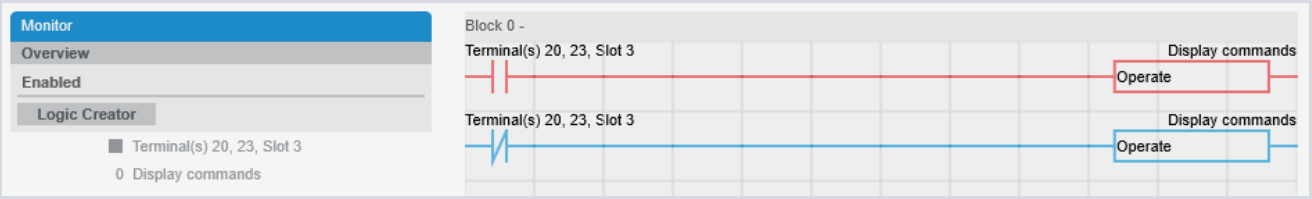
| Parameter | Range | Push-button | Notes |
|---|---|---|---|
| `PICUS commands` | Not enabled, Enabled | - | Allow or prohibit PICUS commands. |
| `Modbus commands` | Not enabled, Enabled | - | Allow or prohibit Modbus commands. |
| `I/O commands` | Not enabled, Enabled | - | Allow or prohibit I/O commands to be used. |
| `CustomLogic commands` | Not enabled, Enabled | - | Allow or prohibit CustomLogic commands to be used. |
| `CODESYS commands` | Not enabled, Enabled | - | Allow or prohibit CODESYS commands to be used. |
| `Display commands` | Remote/Local mode | - | **Remote**: The controller only responds to remote signals.<br>**Local**: The controller only responds to operator inputs using the display unit. |
| | Mute alarm | - | Allow or prohibit the operator to mute alarms. |
| | Start/stop engine |  | Allow or prohibit the operator to start or stop the engine or power source. |
| | Open/close [Equipment] breaker |  | Allow or prohibit the operator to open or close the breaker(s). |

**NOTE** * Where **[mode]** is either local or remote.

### Dynamic control

You can use a CustomLogic function to dynamically enable or not enable the command source parameter by setting the value. The value is represented as a bits value.

**Example CustomLogic project**




In this example, a **GENSET** controller has a digital input is associated with an OPERATE block for the function *Display commands*. The value set in the OPERATE block relates to value for the command source.

When the digital input is not active the OPERATE value is set to 0. No push-buttons can be used.
When the digital input is active the OPERATE value is set to 1. All push-buttons can be used.

To enable the commands set the OPERATE value to 1.
To not enable the commands set the OPERATE value to 0.

### Display commands

The display commands are controlled by the bit value, which depends on the type of controller.

**GENSET controllers**

| Command | Bit | OPERATE value |
|---|---|---|
| Remote/Local | 0 | 1 |
| Mute alarm | 1 | 2 |
| Start/stop engine | 2 | 4 |
| Open/close breaker | 3 | 8 |

**SINGLE genset controllers**

| Command | Bit | OPERATE value |
|---|---|---|
| Remote/Local | 0 | 1 |
| Mute alarm | 1 | 2 |
| Start/stop engine | 2 | 4 |
| Open/close breaker | 3 | 8 |
| Open/close mains breaker * | 4 | 16 |

**NOTE** * Only on the **SINGLE genset** with mains breaker controller.

**BUS TIE breaker and MAINS controllers**

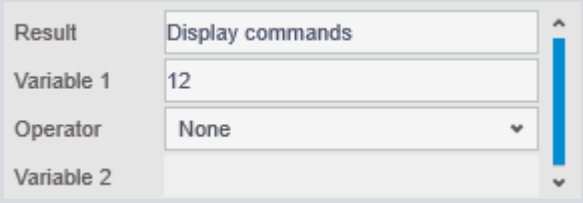
| Command | Bit | OPERATE value |
|---|---|---|
| [Mode] | 0 | 1 |
| Mute alarm | 1 | 2 |
| Open/close breaker | 2 | 4 |

**Example 1**

In this example, we enable only the *Start/stop engine*, and *Open/close breaker* push-buttons on a **GENSET** controller.

| Command | Bit | OPERATE value |
|---|---|---|
| Start/stop engine | 2 | 4 |
| Open/close breaker | 3 | 8 |

Bit 2 + Bit 3 = 4 + 8 = OPERATE value 12




## 2.3.5 Controller unpowered

### Power status and system behaviour

A controller is considered unpowered when it loses electrical power, for example, if the power supply is disconnected. When a controller is unpowered, the controller protections and functions are inactive.

An unpowered controller:

- Does not communicate with other system components
- Is not recognised by the system
- Is invisible to the system

When a controller detects that another controller in the system is unpowered, the controller activates the following alarms:

- *Missing controller ID #*
- *Missing any controller*

# 2.4 Controller functions

## 2.4.1 Control and command structure

The controllers communicate with each other using the Ethernet connections between controllers. This is a virtual network referred to as the **DEIF network Ethernet**. The Ethernet connections can also be used by other systems, such as SCADA or alarm systems.

### Example: Commands to start sequences

The controller can receive external commands to start controller sequences. For example, a controller in remote control can respond to an external command to close the breaker. If the controller is in local control, then the controller displays an information message and ignores the external command.

An external command can only start a sequence if all the conditions are met, and the controller mode allows the external command to start the sequence.

The controller provides several different ways in which to start the same sequence.

### Commands to start sequences

| Command | Default mode | Example |
|---|---|---|
| Using Modbus communication, an operator, a SCADA system, a controller with CODESYS installed, or a PLC sets a Modbus address in the function group Command to **1** (True). | Remote | A PLC has a Modbus connection to the required controller. The PLC writes 1 (True) to Modbus address 1000 in the discrete output coil using the Modbus function code 05 or 15.<br><br>The controller gets the command, and starts the sequence to start the genset. |
| A digital input, which is assigned an external command function, is activated. | Remote | A button on the switchboard is wired to a digital input of the controller rack. These terminals are assigned the `Engine > Command > Start engine` function.<br><br>The operator presses the button on the switchboard, to activate the digital input.<br><br>The controller detects that the digital input is activated, and starts the sequence to start the genset. |
| The operator selects a virtual display push-button on the **Supervision** page in PICUS. | Remote | The operator presses the controller **Start** button on the **Supervision** page in PICUS.<br><br>The controller gets the command over the DEIF network, and starts the sequence to start the genset. |
| CustomLogic activates an external command function. | Remote | A function is programmed in CustomLogic. The CustomLogic rung has the conditions that need to be met. There is a **Normally open coil** with the function `Engine > Command > Start engine` at the end of the rung. |

| Command | Default mode | Example |
|---|---|---|
| | | The conditions are met, and CustomLogic activates the function.<br><br>The controller detects that the function is activated, and starts the sequence to start the genset. |
| The operator presses a push-button on the display. | Local | The operator presses the **Start** button on the display unit.<br><br>The controller gets the command over the **DEIF network Ethernet**, and starts the sequence to start the genset. |

The controller ignores the command and displays an information message if the controller cannot execute the command. For example, if a controller is in local control, it ignores a remote *Start engine* command. The controller displays the information message *Not under remote control*.

## 2.4.2 Controller input and output functions

Each type of controller has a default configuration. 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 controllers allow the same function to use a number of alternative types of inputs and/or outputs. This makes the controllers very versatile and compatible with a wide range of assets and systems.

For example, a generator breaker close can be initiated by the operator for a **GENSET** controller in local mode. Alternatively, if the **GENSET** controller is in remote mode, a digital input, CustomLogic, CODESYS, or an external system using a Modbus command can initiate the generator breaker close.

## 2.4.3 Input source precedence

Each controller can receive inputs from a number of sources.

### Digital input functions

Digital input functions can be activated by wiring connected to hardware, Modbus and/or CustomLogic coils.

Guidelines for digital input functions:

1. If a digital input function is assigned to hardware, you cannot assign that function to a CustomLogic coil (that is, a normally open or normally closed coil).
2. If a digital input function is assigned to a CustomLogic coil, you cannot assign that function to hardware.
   - If you try to assign a digital input that is already assigned to a CustomLogic coil to hardware, it may seem possible. However, if you refresh the hardware view, you will see that the input has not been assigned.
3. If a digital input function is assigned to CODESYS, the function will not be available in the hardware. If the function has already been assigned to the hardware, an alarm will occur.
4. For pulse functions:
   a. If there is a command from Modbus, then the controller can activate the function. This is true even if the function is assigned to hardware.
   b. The controller always responds to the most recent input, without considering the source.
5. For continuous functions:
   a. If the function is assigned to hardware: If Modbus sends a command, then the command is not allowed and has no effect.
   b. If the function is not assigned to hardware: If Modbus and CustomLogic send conflicting signals, then the controller uses the CustomLogic signal.

Commands from display have the same precedence as wiring connected to hardware.

### Analogue input functions

Analogue input functions can receive inputs from wiring connected to hardware, Modbus, CustomLogic coils, and/or CODESYS.

Guidelines for analogue input functions:

1. If the analogue input function is assigned to hardware, Modbus can only read the input value. Modbus, CustomLogic, and CODESYS cannot modify the input value.
2. If the analogue input function is not assigned to hardware, Modbus, CustomLogic, and CODESYS can modify the input value.
3. If Modbus, CustomLogic, and/or CODESYS send conflicting signals, then the controller uses the CustomLogic or CODESYS signal.

## 2.4.4 Alive function

To confirm that the controller is operational, a digital output can be configured to activate for a specified amount of time in a time period. If the signal does not repeat within the defined time period, then the controller is no longer operational.

### Digital output (optional)

| Function | I/O | Type | Details |
|---|---|---|---|
| `Local > Alive > Alive` | Digital output | Pulse | The output is set to high for the *Duty cycle* time each *Period*.<br><br>For example, if the *Duty cycle* is set to 50 % and the *Period* is set to 2 s, then the output is high for 1 s and low for 1 s. This signal repeats while the controller is operational. |

### Parameters

**`Local > Alive > Alive configuration`**

| Parameter | Range | Comment |
|---|---|---|
| `Duty cycle` | 0.0 to 100.0 % | The percentage of the *Period* that the signal is high.<br><br>If the *Duty cycle* is set to 0 %, then the I/O output is always low.<br><br>If the *Duty cycle* is set to 100 %, the output is always high. |
| `Period` | 0.10 to 60.00 s | The time between the start of a high signal to the start of the next high signal. |

# 2.5 Nominal settings

## 2.5.1 About the nominal settings

The controller nominal settings are used in a number of key functions. These include load sharing and protections. Many protection settings are based on a percentage of the nominal settings.

Each controller can store four sets of nominal settings. You can easily change the active set of nominal settings by changing the parameter, using a digital input, analogue input, or an external source (for example, Modbus).

Always check that the conditions are safe to change the nominal settings. Changing nominal settings while a genset is running with a load could lead to unexpected actions. For example, the generator breaker can trip due to an under frequency alarm when changing the nominal frequency from 50 Hz to 60 Hz.

The nominal settings for the controller are mainly the alternating current (AC) settings. Changing the nominal settings set also changes the engine nominal speed, and analogue governor and AVR offsets.

**More information**
See **each controller type** for the controller's nominal setting parameters.

### Input and output functions

| Function | I/O | Type | Details |
|---|---|---|---|
| `Local > Nominal settings > Controller nominal setting > Nominal settings #*` | Digital input | Pulse | The controller changes the active nominal setting group to the nominal setting group assigned to the digital input. |
| `Local > Nominal settings > Controller nominal setting > Nominal settings # selected*` | Digital output | Continuous | Activated if the active nominal setting group is the same as the nominal setting group configured to the output. |
| `Local > Nominal settings > Controller nominal setting > Nominal settings #*` | Analogue input | Supervised binary input | The controller changes the active nominal setting group to the nominal setting group assigned to the analogue input. The input signal is treated by the controller as a pulse signal. |
| `Local > Nominal settings > Controller nominal setting > Nominal setting selected` | Analogue output | 0 to 3 | The controller outputs a number correlating to the active nominal setting group. Where *Nominal setting 1* is zero. |

**NOTE** * # is 1 to 4.

### Parameters

**`Local > Nominal settings > Controller nominal setting`**

| Parameter | Range | Notes |
|---|---|---|
| `Selection` | • Nominal settings 1<br>• Nominal settings 2<br>• Nominal settings 3<br>• Nominal settings 4 | The selected nominal setting group for the controller.<br><br>Changing the nominal setting group using a digital input, analogue input, or external command changes this parameter. |

## 2.5.2 Nominal power calculations

### 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.

**`[A-side] > Nominal settings > Nominal settings #* > Calculation method`**

| Parameter | Range | Notes |
|---|---|---|
| `Reactive power (Q) nominal` | • Q nominal calculated<br>• Q nominal = P nominal<br>• Q nominal = S nominal | **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. |
| `P or S nominal` | • No calculation<br>• P nominal calculated<br>• S nominal calculated | **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. |

| Parameter | Range | Notes |
|---|---|---|
| | | **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. |

**NOTE** * # is 1 to 4.

### 2.5.3 Power transformer

You can use a step-up or step-down power transformer.

#### Parameters

**`Power transformer > Nominal settings # *`**

| Parameter | Range | Notes |
|---|---|---|
| `Winding nominal voltage source` | • Use nominal voltages<br>• User defined | **Use nominal voltages**: The controller uses the nominal voltage settings.<br><br>**User defined**: The controller uses the values configured below for voltage settings. |
| `[B-side] side winding nominal voltage` ** | 10.0 V AC to 1.5 MV AC | Voltage on the B-side. |
| `[A-side] side winding nominal voltage` ** | 10.0 V AC to 1.5 MV AC | Voltage on the A-side. |
| `Phase shift` | -180.0 to 180.0° | Phase shift value in degrees (°) |

**NOTE** * # is 1 to 4.
** These parameters are only visible if `Winding nominal voltage source` is set as `User defined` and written to the controller.

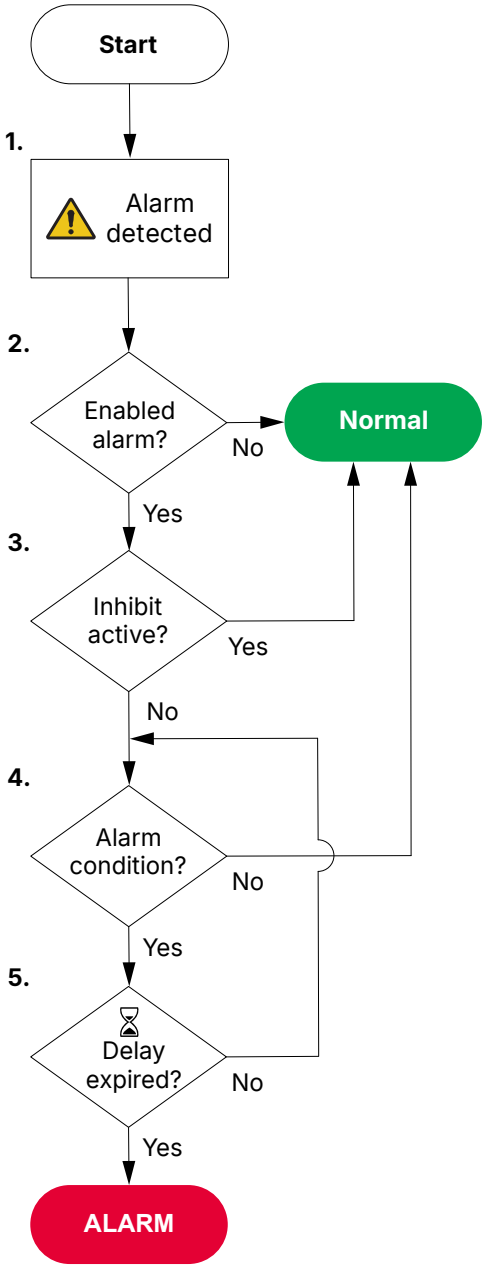
## 2.6 Alarms and protections

### 2.6.1 How alarm processing works

The controller alarms prevent unwanted, damaging, or dangerous situations from occurring. The alarm handling is an adaptation of the ISA 18.2 standard. You can configure alarm parameters to suit your design and operational needs. To protect the system, you can not change the configuration for some alarms.

Some of the alarms 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.

An alarm is detected when the **Alarm condition** is met (typically, the operating value reaches the *Set point*), the controller starts the *Time delay*. During this period the controller checks whether the **Alarm condition** remains active. If the **Alarm condition** is not longer active, the alarm is not activated. If the **Alarm condition** continues after the time delay has expired the **Alarm action** is activated.




1. The controller detects an **Alarm condition**.
2. The controller checks if the alarm is enabled:
   - If the alarm is not enabled the controller ignores the alarm.
3. The controller checks if the alarm has an active inhibit.
   - If the alarm has an active inhibit the controller ignores the alarm.
4. The controller checks if the **Alarm condition** is still active:
   - If the **Alarm condition** is no longer active the controller ignores the alarm.
5. While the **Alarm condition** is active, the controller checks if the *Time delay* has expired:
   - If the **Alarm condition** is no longer active before the *Time delay* expires, the controller ignores the alarm.
   - If the **Alarm condition** continues and the *Time delay* expires, the controller activates the alarm and the **Alarm action.**

The alarm results in both a visual and audible indication (subject to design of your 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. *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.

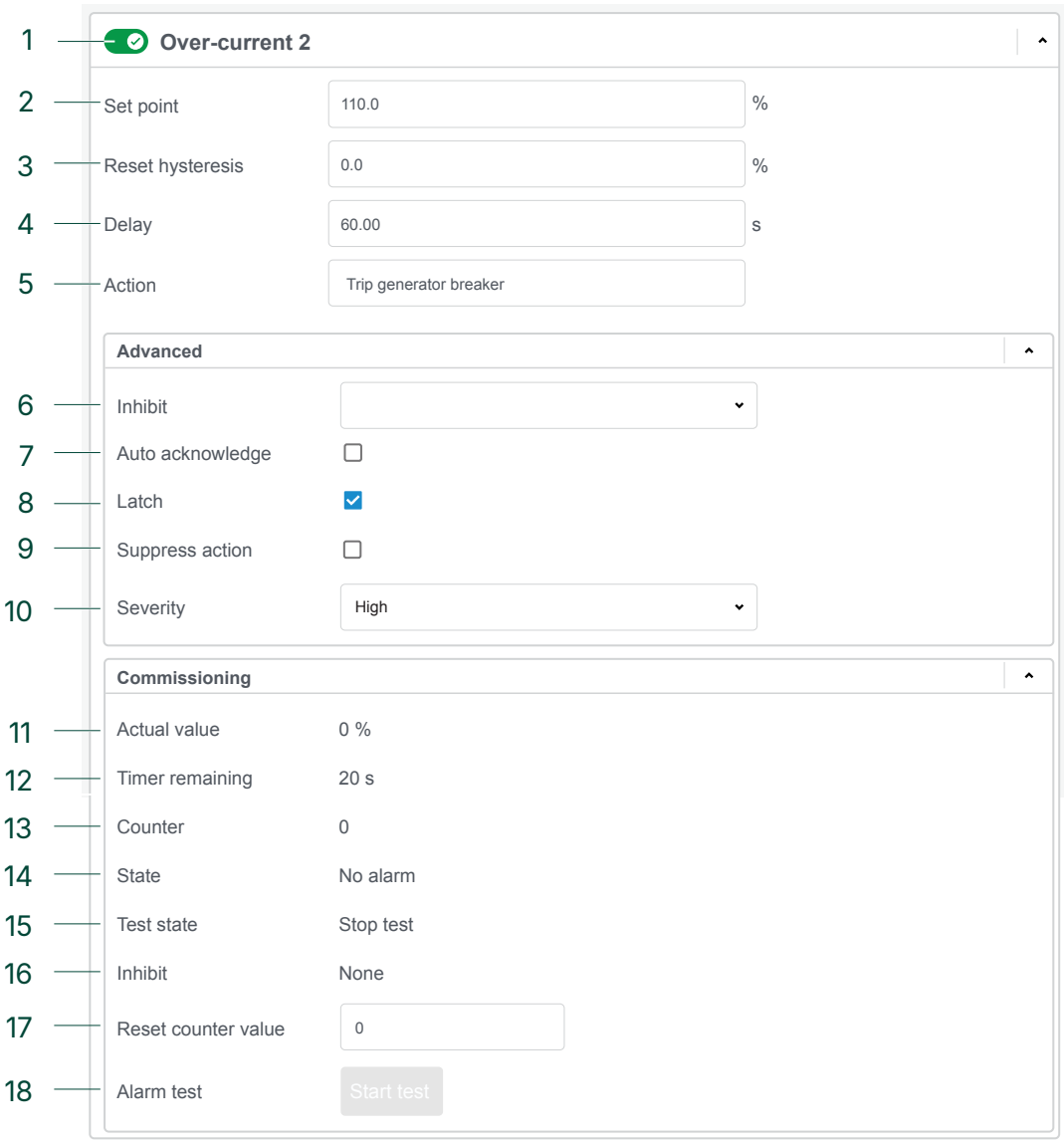
**CAUTION**

**Incorrect alarm configuration**

Incorrect configuration of the alarm parameters could result in unwanted operational conditions and possible injury to personnel or damage to the equipment.

## 2.6.2 Alarm parameters

The alarm settings are configured as parameter settings in the controller. Some alarm settings are not configurable.




| # | Parameter | Range | Notes |
|---|---|---|---|
| 1 | `Enable` | Not enabled, Enabled | Enabled alarms activate in the system if the **Alarm condition** occurs. |
| 2 | `Set point` | | The setting at which the alarm activates. |
| 3 | `Reset hysteresis` | Varies | See **Reset hysteresis** for more information. |
| 4 | `Delay` | Varies | A time delay before the **Alarm action** becomes active. |
| 5 | `Action` | Varies | The **Alarm action** to be taken. |
| 6 | `Inhibit(s) 1 to 32` | Varies | Inhibit(s), that if active, can inhibit the alarm from becoming active. |
| 7 | `Auto acknowledge` | Not enabled, Enabled | If **Enabled** the alarm is automatically acknowledged when it occurs. * |
| 8 | `Latch` | Not enabled, Enabled | If **Enabled** the alarm is latched when it occurs and requires both acknowledgement and reset (unlatch) to clear the **Alarm action**. |
| 9 | `Suppress action` | Not enabled, Enabled | If **Enabled** the alarm action is suppressed. The alarm message will appear in the alarm list. |

| # | Parameter | Range | Notes |
|---|---|---|---|
| 10 | `Severity` | High<br>Medium<br>Low | Use severity to mark the alarms with Red (High), Orange (Medium), or Yellow (Low) on the display unit.<br><br>This has no effect on how alarms processing, priority, or any actions taken. |
| 11 | Actual value | | The value of the operating value for the alarm. |
| 12 | Timer remaining | | The time remaining on the alarm timer. |
| 13 | Counter | | The number of times that the alarm has been activated. |
| 14 | State | | The alarm state. |
| 15 | Test state | | The test state. |
| 16 | Inhibit | | List of the alarm inhibits that are active. |
| 17 | `Reset counter value` | | Set or reset the alarm counter value. |
| 18 | `Alarm test` | Start test, Stop test | Select **Start test** to start an alarm test. Starting an alarm test also activates the alarm action.<br><br>Select **Stop test** to stop the alarm test. |

### 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. 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 asset must be 100 % (or more) of the nominal current to activate the alarm.

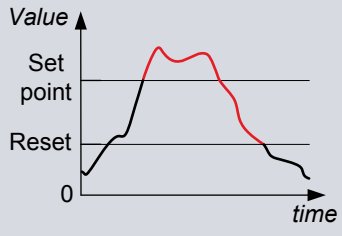
### Reset hysteresis

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

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

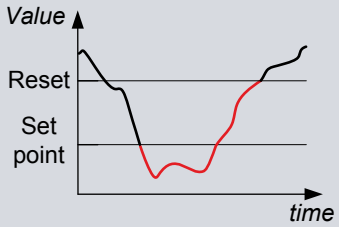
**Overspeed example**

An *Overspeed* alarm with a *Set point* of 110 % of nominal speed and a *Reset hysteresis* of 10 %. The alarm cannot be reset until the operating value falls below 100 % of nominal speed. The red line in the 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.



**Under-speed example**

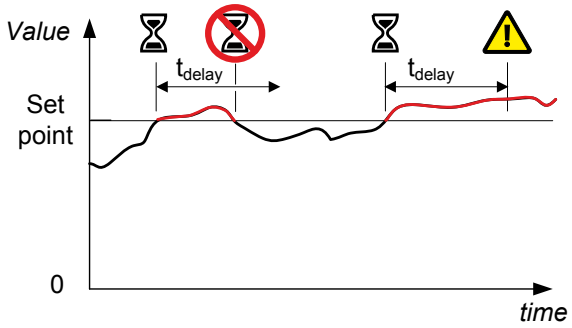
An *Under-speed* alarm with a *Set point* of 80 % of the nominal speed and a *Reset hysteresis* of 5.0 %. The alarm is only reset when the operating value is above 85.0 % of the nominal speed.



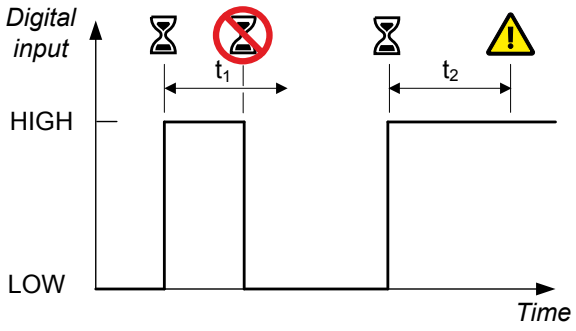

### Delay

When the alarm *Set point* is exceeded and an alarm *Delay* is configured, 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.

### Delay for a high alarm based on an analogue operating value




### Delay for a high alarm based on a digital input




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

### Trigger level

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

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*.

### Auto acknowledge

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

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

### Action

The **Alarm action** is the response that you allocate to the **Alarm condition.** Each alarm can only 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 condition** is met. **Alarm actions** act as a type of alarm categorisation. Minor alarm situations may be assigned warnings, while a critical situation may trip the breaker and shutdown the genset.

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

### Priority of alarm action

If two or more alarm actions are active for the same asset at the same time, 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 more severe **Alarm action** is activated after a less severe **Alarm action**, the controller performs the more severe **Alarm action**.

**Alarm action priority example**

One alarm activates *Trip generator breaker and stop engine*, and at the same time another alarm activates *Trip generator breaker and shutdown engine*. *Trip generator breaker and stop engine* includes a cooldown period, while *Trip generator breaker and shutdown engine* does not. The controller shuts down the engine without cooling, regardless of the order of the alarms.

### Inhibits

Inhibits stop the **Alarm action**. 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.

If an inhibit with active conditions is created for an active, unacknowledged alarm (with or without a latch), then the alarm state changes to an inactive, unacknowledged alarm (with or without a latch). The alarm must be acknowledged (and unlatched) before it is removed from the alarm list.

Inhibited alarms are not shown in the alarm list, unless they have occurred and are unacknowledged before they were inhibited.

The controller types are delivered with 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.

**More information**
See Customised inhibits for how to configure customisable I/O inhibits.

For example, for a **GENSET** controller, for generator under-voltage, the inhibits *Engine not running* is selected. This means that if the genset is either starting up, or if there is no running detection, the generator under-voltage alarm is disabled.

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.

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

### Suppress action

For all controller types, an alarm action is suppressed when *Suppress action* is **Enabled** for the alarm, and the function `Alarm system > Additional functions > Suppress alarm action` is activated by a digital input, PICUS, Modbus, and/or CustomLogic.

If the **Alarm action** is suppressed, when the alarm is activated, the alarm is shown in the alarm handling system, but the **Alarm action** is only *Warning*.

### Severity

You can configure the *Severity* for each alarm, to make sure that the most severe alarms are the most prominent to the operator. By default, all alarms have a **High** severity.

### 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.

For example, you can create a low oil pressure alarm with a latch and a *Trip generator breaker and shutdown engine* alarm action. Then, if there is low oil pressure, the controller trips the breaker and stops the engine. The engine remains stopped and will not be able to start until the alarm is reset.

**NOTICE**

**Effective action with latch**

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.

### 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.

Do not change an active alarm to **Not enabled.** If you change an active alarm to **Not enabled** the **Alarm action** continues. The **Alarm action** cannot be reset until after the alarm is enabled again.

**NOTE** * Some alarms settings are not configurable. You can not configure some alarms, as the system must maintain a basic level of protection.

### Alarm test

The alarm test activates the alarm and its **Alarm action**. You can use the alarm test parameter to test individual alarms, for example, during commissioning.

Alarm tests of individual alarms can be stopped one at a time using the parameter, or at the same time using the *Stop test* button on the **Alarms** page in PICUS.

### Additional alarm information

The additional alarm information provides information about the state of the alarm. This information can be useful during commissioning and trouble shooting.

| Information | Notes |
|---|---|
| Reset counter value | Changes the *Counter* parameter value to the selected value. |

## 2.6.3 Operate time

The operate time is the total time that the controller takes to respond to a change in the operating conditions. A part of the operate time is determined by the controller hardware characteristics. The rest of the operate time can be adjusted by changing configurable controller parameters.

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 accordingly.

```
Operate time = measurement time + calculation time + time to change the controller output +
                                                delay
```

**Operate time example**

The over-voltage protection has an operate time of **< 100 ms** listed on the data sheet. For *Over-voltage 1*, you can configure a delay from 0.00 to 3600.00 s.

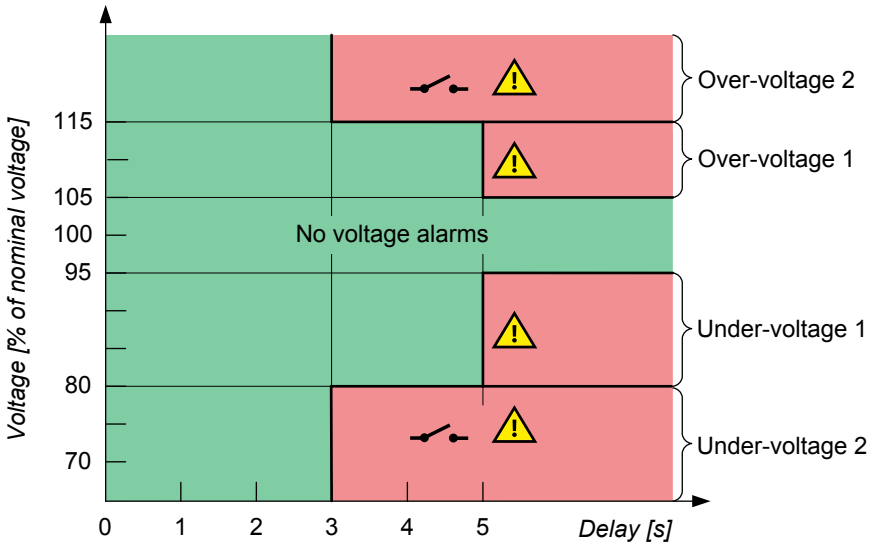
If the delay is **5.00 s**, the controller does the *Over-voltage 1* alarm action **5.10 s** after the alarm *set point* is exceeded.

## 2.6.4 Alarm levels

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

### Example of alarm levels

This example shows the B-side 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*.



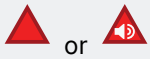
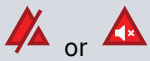
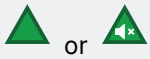
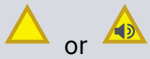
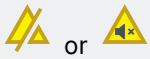

If the operation is in the green area, the controller does not activate any busbar voltage alarms.

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 the nominal voltage 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 the nominal voltage for more than 5 seconds. The alarm action *Trip [Breaker]* has a higher priority than *Warning*.

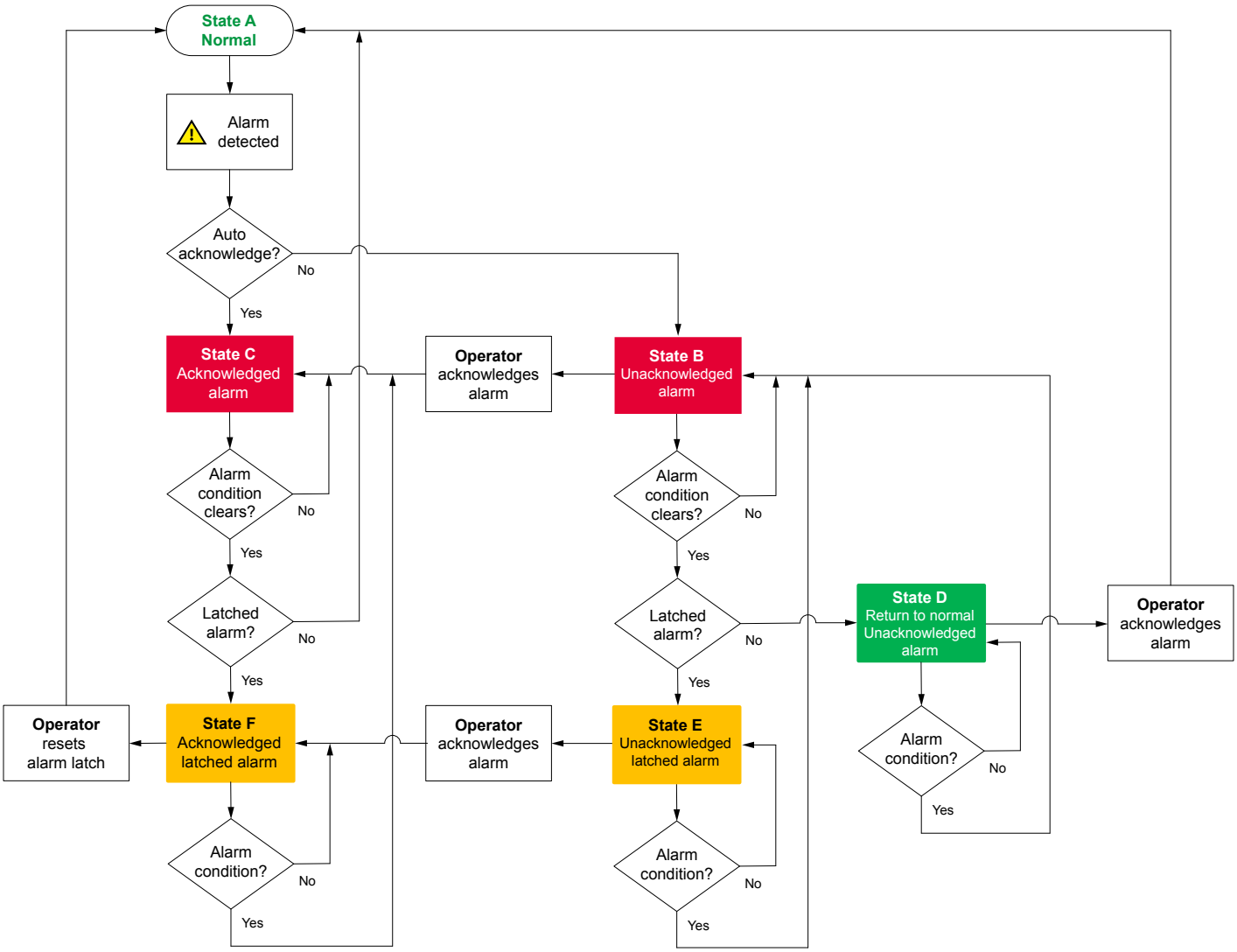
The graph shows two protection levels for under-voltage. In the example, if the busbar voltage is under 95 % of the nominal voltage for more than 5 seconds, a *Warning* is activated. If the busbar voltage is under 80 % of the nominal voltage for more than 3 seconds, the *Trip [Breaker]* **Alarm action** is activated.

## 2.6.5 Alarm processing states

Alarms can be active in the system in different states:

| State | Symbol | Alarm condition | Alarm action | Acknowledge | Notes |
|---|---|---|---|---|---|
| State A | - | Not active | Not active | - | Normal state<br>• The alarm is not active in the system. |
| State B |  | Active | Active | Unacknowledged | Unacknowledged alarm<br>• An alarm condition occurred.<br>• An alarm action is active.<br>• An alarm requires acknowledgement.<br>• An alarm requires action to clear the alarm condition. |
| State C |  | Active | Active | Acknowledged | Acknowledged alarm<br>• An alarm condition occurred.<br>• An alarm action is active.<br>• An alarm is acknowledged.<br>• An alarm requires action to clear the alarm condition. |
| State D |  | Not active | Not active | Unacknowledged | Normal state but unacknowledged<br>• An alarm condition occurred, but was cleared.<br>• An alarm action is inactive.<br>• An alarm requires acknowledgement. |
| State E |  | Not active | Active | Unacknowledged | Unacknowledged latched alarm<br>• An alarm condition has cleared.<br>• An alarm action is active.<br>• An alarm requires acknowledgement.<br>• An alarm latch requires reset. |
| State F |  | Not active | Active | Acknowledged | Acknowledged latched alarm<br>• An alarm condition has cleared.<br>• An alarm action is active.<br>• An alarm is acknowledged.<br>• An alarm latch requires reset. |
| State G | | Active or Not active | Not active | - | Shelved alarm<br>• An alarm is shelved for a period of time.<br>• An alarm returns automatically after the period has expired. |
| State H | | Active or Not active | Not active | - | An alarm is inhibited to occur. |
| State I | | Active or Not active | Not active | - | Out of service alarm<br>• An alarm is marked *out of service* for an indefinite period.<br>• An alarm does not return automatically and must be returned to service manually. |

The three special **Shelve** (Stage G), **Inhibited** (Stage H), and **Out of service** (State I) are not shown in this diagram.




**NOTE** Alarms configured with a *Latch* continue to have the **Alarm action** active even if the **Alarm condition** is no longer active. The alarm requires first acknowledgement and then reset by an operator before the alarm can be cleared and return to normal.

**Inhibited**, **Shelved**, or **Out of service** alarms are forced to be not active in the system, even if the **Alarm condition** is present.

## 2.6.6 Alarm actions

The controller controls the following automatic actions:

- Horn/siren output
- Inhibits alarms (if applicable)
- Auto-acknowledges alarms (if configured)
- Controls the alarm state
- Suppress action (if configured)

### Operator alarm actions *

An operator controls the following alarm actions:

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

**NOTE** * The actions an operator can use are controlled by the group and user permissions granted to their login.

### 2.6.7 Common alarm actions

| **Warning** | |
|---|---|
| Controller types | All |
| Priority | Low |
| Effect | The controller activates a warning alarm. |

| **Block [Breaker]** | |
|---|---|
| Controller types | All |
| Priority | - |
| Effect | **Breaker closing is blocked**: If the breaker is open, the controller will not close it. (If the breaker is closed, this **Alarm action** does not open the breaker.) |

| **Trip [Breaker]** | |
|---|---|
| Controller types | All |
| Priority | High |
| Effect | The controller trips the [Breaker] (that is, without de-loading). |

| **Trip generator breaker and stop engine** | |
|---|---|
| Controller types | **SINGLE genset** and **GENSET** controllers |
| Priority | High |
| Effect | The controller trips the genset breaker (that is, without de-loading). After the cooldown period, the controller stops the engine. |

| **Trip generator breaker and shutdown engine** | |
|---|---|
| Controller types | **SINGLE genset** and **GENSET** controllers |
| Priority | Highest |
| Effect | The controller trips the genset breaker (that is, without de-loading). The controller shuts down the engine, **without** a cooldown period. |

### 2.6.8 Acknowledge an alarm

Alarms must be acknowledged. The operator must take action regarding the **Alarm condition**. The operator can mark the alarm as *acknowledged*. Alarms that have *Auto-acknowledge* do not require acknowledge by operator action.

**NOTICE**

**Active alarm action**

Acknowledging an alarm has no influence on the alarm *Action*.

**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*.

**Digital inputs**

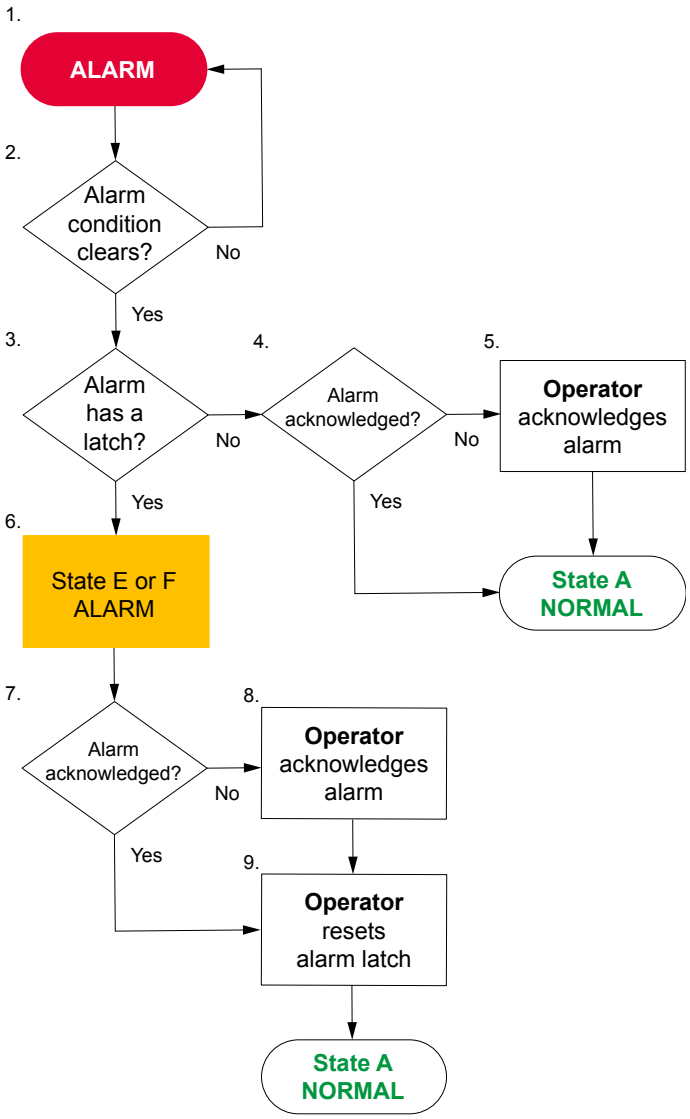
| Function | I/O | Type | Details |
|---|---|---|---|
| `Alarm system > Command > Acknowledge all alarms` | Digital input | Pulse | When this input is activated, the controller acknowledges all its alarms. |

## 2.6.9 Alarm latch and reset

An additional layer of protection can be added by using a *Latch* on most alarms. When a *Latch* is **Enabled** on an alarm, there is an extra confirmation that must be made by the operator, before the alarm can be cleared. The **Alarm action** remains active, even if the **Alarm condition** clears, until the operator resets the latched alarm.

A latched alarm can only be reset by an operator after both the alarm has been acknowledged and the **Alarm condition** has cleared. Acknowledging the alarm does not *Reset* the alarm latch.

For example, you can configure a low oil pressure alarm with a latch enabled, with a *Trip generator breaker and shutdown engine* alarm action and an *Engine not running* inhibit. If there is low oil pressure, the controller trips the breaker and shuts down the engine. The engine remains stopped and will not be able to start until the operator acknowledges the alarm AND resets the latch.




1. An alarm activates in the system as either:
   - Unacknowledged (**State B**)
   - Acknowledged (**State C**) *
2. The controller checks if the **Alarm condition** has cleared.
   - If the **Alarm condition** continues, the **Alarm action** remains active.
3. The controller checks if the alarm has a latch configured:
   - If the alarm has a latch configured, the controller continues from step 6.
4. The controller checks if the alarm is acknowledged:
   - If the alarm is acknowledged the alarm returns to normal **State A**.
5. The operator acknowledges the alarm. After the acknowledgement the alarm returns to normal **State A**.
6. A latched alarm in the system is either:
   - Unacknowledged (**State E**)
   - Acknowledged (**State F**)
7. The controller checks if the alarm is acknowledged:
   - If the alarm is acknowledged, the controller continues from step 9.
8. The operator acknowledges the alarm, and the alarm the latch can then be reset.
9. The operator resets the latch on the alarm, and the alarm returns to normal **State A**.

**NOTE** * The alarm may have *Auto-acknowledge* configured. *Auto-acknowledge* can be useful during commissioning and troubleshooting. However, DEIF does not recommend the use of *Auto acknowledge* during normal operation.

### Digital input (optional)

| Function | I/O | Type | Details |
|---|---|---|---|
| `Alarm system > Command > Reset all latched alarms` | Digital input | Pulse | The controller resets all latched alarms (that are ready to be reset) when this input is activated. |

## 2.6.10 Shelve an alarm

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

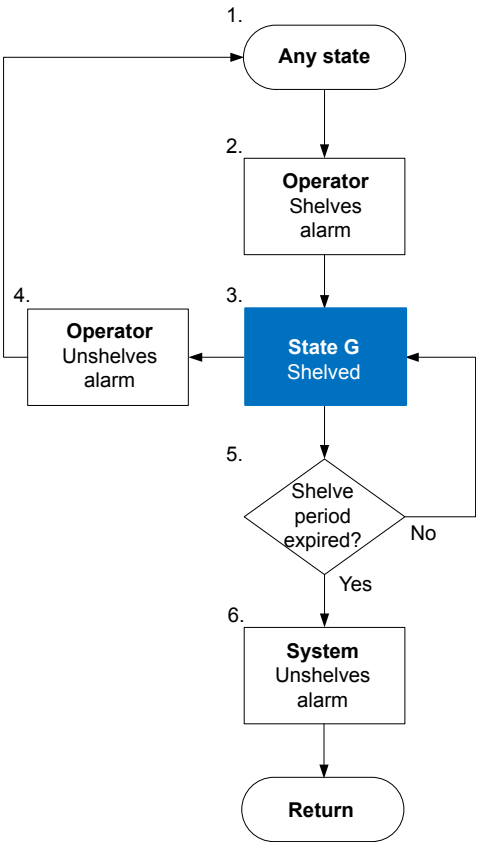
If an unacknowledged alarm is shelved, the alarm is automatically acknowledged. If a latched alarm is shelved, the latch on the alarm is reset. While the alarm is shelved, the alarm action is not active.

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.

**CAUTION**

**Shelved alarms**

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




1. The alarm can be in any state.
2. The operator shelves the alarm for a specific period of time.
3. The alarm is now shelved (**State G**).
4. The operator unshelves the alarm, the alarm returns back to its original state.
5. The controller checks if the shelve period has expired:
   - If the shelve period has not expired, the alarm remains as shelved.
6. The system unshelves the alarm if the shelve period has expired.

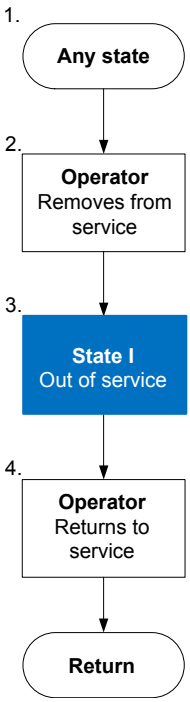
## 2.6.11 Out of service an alarm

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.

**CAUTION**

**Out of service alarms**

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




1. The alarm can be in any state.
2. The operator removes the alarm from service.
3. The alarm is now out of service (**State I**).
4. The operator returns the alarm to service, the alarm returns back to its original state.

**NOTE** The system does not automatically return an *Out of service* alarm, an operator must perform this action.

## 2.6.12 Alarm test

An alarm test activates the controller alarms and all their **Alarm actions**. You can activate alarm tests from the PICUS **Alarms** page, or by starting an alarm test for an individual alarm using the alarm's **Alarm test** parameter.

**CAUTION**

**Do not use during normal operation**

DO NOT use the alarm test during normal operation. The alarm actions can trip all the breakers, and create a blackout.

**More information**
See **Alarms** in the **PICUS manual** for the alarm test buttons available on the **Alarms** page in PICUS.

### Before the test

Make sure that a blackout is acceptable, before you 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. Test alarms appear in green text on the display, and are marked with a grey dot in the **T** column in the PICUS alarm list.

If an alarm was acknowledged before the test, the alarm status changes to unacknowledged during the alarm test.

If an alarm is acknowledged during the test, the alarm remains on the alarm list, and the alarm action continues until the alarm test stops.

- **Latched alarms**: Alarms with latches can be acknowledged and the latches reset manually during the test. If an alarm latch is reset during the test, then the alarm is removed from the alarm list, and the alarm action stops.
- **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 tested alarms remain active until they are acknowledged and, if required, their latches are removed. The alarms are rechecked, and reactivated if the alarm conditions are still present. All the test alarms remain in the log, and are indicated with a grey dot in the **T** column.

Alarms that were acknowledged before the alarm test are still acknowledged when the alarm test stops.

## 2.6.13 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.

### Applications

A digital output with an alarm status may be wired to a switchboard light, to help the operator. For example, you can configure an output with the `Alarm system > State > 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.

## 2.6.14 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.

You can also create custom alarms for the input/output configurations for both analogue and digital terminals.

### Limitations on alarm parameters that cannot be customised

| Not customisable | Notes |
|---|---|
| Additional alarms | The list of alarms is fixed, and you cannot add more alarms.<br><br>If an alarm 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 alarms | Some alarms cannot be disabled. For example, the *Phase sequence error* protection (which prevents synchronisation when the phase sequence is not the same on either side of the breaker) is always *Enabled*. |
| Certain alarm actions | You cannot change certain alarm actions. For example, for *Voltage or frequency not OK*, the action is always *Block*, to stop the breaker from closing. |
| 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. |
| Inhibits that are not configured for the controller type | You cannot add more inhibits to the list of inhibits available for selection for the controller type. For example, you cannot select the *Tie breaker closed* inhibit, as this is not applicable to the **GENSET** controller.<br><br>However, there are three custom inhibits for each controller. You can activate a custom inhibit using a digital input, Modbus, and/or CustomLogic. |
| 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. |

### 2.6.15 Customised inhibits

In addition to the default inhibits, you can also use three custom inhibit functions (*Inhibit 1*, *Inhibit 2* and *Inhibit 3*). You can activate a custom inhibit using a digital input, PICUS, Modbus, CustomLogic, and/or CODESYS.

#### Digital input

| Function | I/O | Type | Details |
|---|---|---|---|
| `Alarm system > Inhibits > Activate inhibit #` * | Digital input | Continuous | When the digital input is activated, then the controller applies *Inhibit #* * |

**NOTE** * # is 1 to 3.

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:

`[Alarm] > Inhibit > #[number]`

Where `[Alarm]` represents any alarm, and `[number]` represents the number of the inhibit field.

#### Inhibit parameters

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

### 2.6.16 Additional functions

#### Suppress action inhibit

It can be useful to use a digital input function to suppress the alarm action for certain alarms. You can activate the function using a digital input, PICUS, Modbus, CustomLogic, and/or CODESYS.

#### Digital input

| Function | I/O | Type | Details |
|---|---|---|---|
| `Alarm system > Additional functions > Suppress alarm action` | Digital input | Continuous | When the digital input is activated, then the controller suppresses all the alarms with *Suppress action* enabled. |

#### Group alarm

It can be useful to use a digital input function for a group of controllers. You can activate the function using a digital input, PICUS, Modbus, CustomLogic, and/or CODESYS.

#### Digital input

| Function | I/O | Type | Details |
|---|---|---|---|
| `Alarm system > Additional functions > Group alarm` | Digital input | Pulse | When the digital input is activated, then the controller activates the group alarm in all the controllers in the group. |

## 2.7 Modbus

The controller includes a built-in Modbus TCP/IP server. The Modbus TCP/IP server allows external devices to communicate with the controller using the Modbus TCP/IP communication protocol.

For example:

- A PLC can request that specific data is read from the controller, such as the settings for the nominal AC configuration.
- A PLC can send commands to the controller using the Modbus TCP/IP protocol.

**More information**
See Modbus server manual for information on using the Modbus in the controller.

# 2.8 Engine interface communication

## 2.8.1 How it works

The controller can receive information from an ECU using CAN bus communication. The information can be used as input for the controller functions. The controller also uses the information as display values, alarms, and as values to be transmitted through Modbus.

Most of the engine communication protocols are based on the SAE J1939 standard. J1939 is a very large standard, and most of it is irrelevant to engine communication. The controller supports only relevant parts of J1939, as described in Generic J1939.

The ECU is wired to the CAN bus communication to the controller, and the ECU is added using the Fieldbus configuration.

**More information**
See the Engine interface communication manual for how to wire and configure an ECU to the controller.

**More information**
See the PICUS manual for how to configure Fieldbus and select the ECU protocol.

Once added to your controller, the ECU can be accessed from PICUS or the display as an additional hardware selection. For example, you can configure the ECU input or output settings, functions, or alarms. You can also include the ECU on the I/O status page to see the status of the analogue inputs, or see the ECU on Live data. Alarms (DM1) and logs (DM2) can also be accessed.

### Not supported engines

If you have an engine that is not supported in the software, contact DEIF.

## 2.8.2 ECU power configuration function

This configures how the controller expects the ECU to be powered. The ECU can be powered by:

- The engine run coil digital output
- The ECU power digital output function (see below)
- Externally powered

The ECU must be configured in the Fieldbus configuration for the functions and alarms to be shown.

### Digital output

| Function | Type | Details |
|---|---|---|
| `Engine > Controls > ECU power` | Continuous | Connect this to the ECU power control. |

**Parameter**

**`Communication > Fieldbus > CAN bus > ECU > ECU Power configuration`**

| Range | Comment |
|---|---|
| Auto<br>Always ON | **Auto**: The controller expects either the engine run coil or ECU power digital output. If neither of these are configured it is expected to be always on.<br>**Always ON**: The controller expects the ECU is powered externally and is always powered on. |

### 2.8.3 ECU reset input function

Some ECUs need to be reset after they have run for a number of hours. If the ECU reset input function is enabled, when the controller gets a signal from the ECU, the controller disconnects the power to the ECU (if the engine is not running).

**Digital input**

| Function | Type |
|---|---|
| `Engine > ECU > ECU reset input` | Pulse |

### 2.8.4 Other EIC information

**More information**
See **Engine communication** in the **GENSET** chapter for inputs, outputs, parameters, and alarms.

## 2.9 Custom parameters

You can configure up to 50 custom parameters for use in CustomLogic, CODESYS applications or Modbus.

Configure custom parameters under `Custom parameters`.

**`Custom parameter # *`**

| Parameter | Range | Comment |
|---|---|---|
| `Enable #` | Not enabled, Enabled | **Not enabled**: The parameter is not used.<br><br>**Enabled**: The parameter can be used in a CustomLogic project. |
| `Integer #` | - 2147483647 to 2147483647 | The range for the integer value to be stored. |
| `Float #` | - 2147480000.0000 to 2147480000.0000 | The range for the float value to be stored. |

**NOTE** * # is the parameter number from 0 to 49.

## 2.10 CustomLogic

### 2.10.1 Use 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.

**More information**
See **CustomLogic** in the PICUS manual for how to use CustomLogic.

## 2.10.2 Enable CustomLogic

**`Local > CustomLogic > Configuration`**

| Parameter | Range | Comment |
|---|---|---|
| `Enable` | Not enabled, Enabled | **Not enabled**: The controller ignores the CustomLogic projects. The inputs and outputs remain assigned to CustomLogic and cannot be used elsewhere.<br><br>**Enabled**: The controller executes the CustomLogic project. |

## 2.10.3 Digital inputs and outputs (optional)

| Function | I/O | Type | Details |
|---|---|---|---|
| `Local > CustomLogic > Inputs > Custom digital input` * | Digital input | Pulse/ continuous | If this input is activated, then the controller activates the corresponding CustomLogic digital input function.<br><br>The controller can execute the logic in a CustomLogic Project once every 200 milliseconds. If an input signal is not available for at least 200 milliseconds there is a risk that the input signal will not be detected by the controller. |
| `Local > CustomLogic > Outputs > Custom digital output` * | Digital output | Pulse/ continuous | If CustomLogic activates the digital output function, then the controller activates the digital output. |
| `Local > CustomLogic > State > Is enabled` | Digital output | Continuous | If the parameter `Local > CustomLogic > Configuration > Enable` is **Enabled**, then the controller activates this output. |

**NOTE** * There are 20 available CustomLogic digital inputs or outputs.

## 2.10.4 Activate controller outputs

CustomLogic cannot directly activate controller outputs that are configured for controller functions. For example, CustomLogic cannot activate the `Breakers > [Breaker] > Controls > [*B] open` digital output.

However, CustomLogic can activate external commands, for example, the `[Breaker] > Open` command. The CustomLogic command has the same effect as, for example, the `Breakers > [Breaker] > Command > [*B] open` digital input. The controller only follows the external command if the controller is in Manual mode or remote control.

## 2.10.5 CustomLogic and Modbus

Each controller has 80 Modbus signals that can be assigned to contacts and coils.

When a Modbus signal is assigned to a contact, the contact can be activated and deactivated using the correct Modbus address for the signal number.

When a Modbus signal is assigned to a coil, the state of the coil can be read using the correct Modbus address for the signal number. It is not possible to use a Modbus interface to write a value to a Modbus signal that has been assigned to a coil.

## 2.10.6 Constraints

### 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.

# 2.11 Date and time

## 2.11.1 About date and time settings

The date and time can be set manually from PICUS or the display.

The time is stored locally on each controller, and automatically synchronised between all DEIF controllers connected in the same network. The alarms, logs, and display unit use the time.

### Time master

The time master's time is synchronised to all the other controllers. The synchronisation is achieved by using a Network Time Protocol (NTP) client and server system. The controller that has been powered ON for the longest time on the Ethernet network is the time master. When a new controller is added to the network, it fetches the time from the time master in the network.

If two Ethernet networks with DEIF controllers are joined, then the time from the network with the controller that has been powered on for the longest is used.

If the time master fails, the controllers in the network determine which controller has been ON the longest. The controller that has been on the longest, then becomes the new time master.

### Synchronisation interval and performance

Each controller checks the time from the time master at regular intervals. The frequency of these checks adapts to the synchronisation quality. If the synchronisation is poor, then the controller uses shorter intervals between checks.

The time difference can initially be a few seconds. This is adjusted down over time. The time synchronisation can take some time (for example, 30 minutes) to synchronise the controllers.

**`Configure > Time settings`**

| Setting | Range | Notes |
|---|---|---|
| Date format | • YYYY-MM-DD<br>• YY-MM-DD<br>• DD-MM-YYYY<br>• DD-MM-YY<br>• MM-DD-YYYY<br>• MM-DD-YY | |
| Date | 2018-01-01 to 2100-12-31 | |
| Time zone | Selectable list | The adjustment for daylight saving is based on the time zone, and is automatically applied by the controller.<br><br>Daylight savings is not applied to the controller when you select the **Etc/UTC** time zone. |
| Time format | • 12 hour<br>• 24 hour | The *AM/PM* selector for *Time* is only visible when *12 hour* is selected. |
| Time | • 00:00:00 to 23:59:59<br>• 12:00:00 AM to 11:59:59 PM | |

**NOTE** If a setting is changed on any controller in the network, the new setting is synchronised to all controllers in the network.

### 2.11.2 Set the time manually

Use the `Configure > Time settings` page in PICUS or the display to set the time manually.

When you change the time on any controller in the network, the new time is shared with all the controllers in the network through the time master.

## 2.12 Event and system logs

Each controller records both system activity and operational or user events.

**More information**
See Activity logs in Cybersecurity for details on the *Event log* and *Live system log*.

## 2.13 Test functions

### 2.13.1 Emulation

With emulation you can run your controllers in a virtual operating mode. During emulation you can simulate various real-world actions, such as starting or stopping the genset without actually having any genset connected. You can also test and configure your controller, and mimic inputs or outputs that are configured.

**More information**
See **Emulation** in the PICUS manual for how to use and configure the emulation feature.

### 2.13.2 Lamp test

The lamp test lights all the LEDs on the display. The test cycles through the LED colours for the time configured in the lamp test parameters.

During the lamp test a message box is shown on the display.

**Digital inputs (optional)**

| Function | I/O | Type | Details |
|---|---|---|---|
| `Test functions > Lamp test > Start lamp test` | Digital input | Pulse | Activating this input has the same effect as enabling the lamp test *Activate* parameter. |
| `Test functions > Lamp test > Stop lamp test` | Digital input | Pulse | If this input is activated while a lamp test is in progress, the controller stops the lamp test. |

### Parameters

**`Test functions > Lamp test`**

| Parameter | Range | Comment |
|---|---|---|
| `Activate` | Not enabled, Enabled | **Not enabled**: There is no lamp test.<br><br>**Enabled**: When the parameter is saved, the lamp test starts. After the lamp test, the controller automatically changes the parameter to *Not enabled*.<br><br>Alternatively, you can start the lamp test from the display unit (**Tools > Advanced > Lamp test**) or a digital input (see above). |
| `Duration` | 1 s to 1 h | The time for the lamp test. |
| `Color cycle time` | 1 s to 1 h | The time that each colour is lit. The colour cycle is green, yellow, red. The color cycle repeats for the duration of the lamp test.<br><br>For the default settings, the lamp test will cycle through all the colours twice. |

## 2.14 CODESYS (optional)

You can extend your controller's application with a CODESYS license.

CODESYS is a widely adopted IEC 61131-3 programming environment that enables powerful, flexible, and scalable control system development. You can use instruction lists, structured text, ladder diagrams, function block design, and sequential function charts. Use the CODESYS Visualisation to even create your own HMI visualisations for your project.

With CODESYS, you can create and integrate your own CODESYS project with the controller's application. This both extends the logic and operation of your system, and eliminates the need for an additional external and expensive PLC.

By using CODESYS, you gain a reliable and efficient development platform that aligns perfectly with our product's capabilities.

**More information**
See the CODESYS Integration manual for information about using CODESYS with the controller.

# 3. Cybersecurity

## 3.1 About Cybersecurity

While DEIF has taken great attention to security and has designed the product to be a secure product, we recommend adopting Information Technology (IT) and Operational Technology (OT) security best practices when connecting the controller to a network.

To minimise the risk of data security breaches we recommend:

- Change the administrator (User: admin) password the first time that you log in to the controller.
- Only connect to trusted networks and avoid public networks and the Internet.
- Use additional security layers like a VPN for remote access.
- Ensure interfaces that are not used are disabled or made unavailable to non-authorised individuals.
- Restrict physical access to authorised only persons.

**Admin password**

To ensure security, change the administrator (User: admin) password the first time that you log in to the controller.

## 3.2 Permissions

### 3.2.1 About permissions

The controllers' configuration and functionality is protected with permission access. Only users with the correct permission may access, configure, or update the configuration or controller settings.

**Permission structure**

The permissions consist of **Roles** and **Users** in each controller configuration. These are stored locally on each controller, or can be written to all connected and logged in controllers.

Each **user** is a member of a **role**. The **role** gives the **user** permissions to associated features or functions of the controller. You can also remove access from a user as required.

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.

**NOTICE**

**Permissions access**

You can only access the user permissions option if you are a member of a role that has access to that function.

### 3.2.2 Role settings

Role settings include both **Role information** and **Role permissions**.

**Role information**

The **Role information** contains the name and automatically recorded changelog.

| Setting | Type | Format | Notes |
|---|---|---|---|
| Name | Manual | Text | The Role name. |
| Created | Automatic | Date | Date the role was created. |

| Setting | Type | Format | Notes |
|---|---|---|---|
| Changed | Automatic | Date | Date the role was changed. |
| Editor | Automatic | Text | The user who created or changed the role. |

### Role permissions

The **Role permissions** allow or remove access to features in the software.

Parent permissions are required for any child permissions. For example, to allow access to the feature **Emulation** (a child), the role must also have access to **Application** (the Parent). If you remove a parent permission, all child permissions are automatically removed.

Some features can be configured for **Read** and/or **Write** access. With **Read** only access the user cannot write or update any information. **Read** access is mandatory if you allow **Write** access.

| Feature permissions | |
|---|---|
| Live Data | Live Data |
| Application | Plant configuration<br>Emulation<br>Supervision |
| Alarms | Alarms<br>Alarm acknowledge<br>Alarm reset latch<br>Alarm out of service<br>Alarm shelve |
| Log | Event log<br>Engine interface J1939 DM2<br>Engine interface J1939 DM2 clear |
| I/O status | I/O status |
| Tools | Print setup<br>Backup restore<br>Backup<br>Restore<br>Restore configuration<br>Trending<br>Regulator status<br>Alarm test<br>Firmware<br>User management<br>Role management |
| Configure | Date and time<br>Communication<br>Input/output configuration<br>Parameters<br>Counters<br>CustomLogic<br>Modbus<br>Fieldbus configuration<br>Fieldbus supervision<br>Dashboard configuration<br>Header configuration |
| Not assigned a category | Feature toggle |

| Feature permissions | |
|---|---|
| | Notification configuration |

### 3.2.3 User settings

| Setting | Type | Notes |
|---|---|---|
| User name | Required | Minimum 2 characters. |
| Organisation | Optional | |
| Roles | Required | Selectable from list. |
| Mobile number | Optional | |
| Direct number | Optional | |
| Email (primary) | Optional | |
| Email (secondary) | Optional | |
| Password | Required | Minimum 8 characters and must comply with password verification. |

### 3.2.4 Default user

The default administration user is **admin**. Use the **admin** user to access and configure the WebConfig. To use a different user, that user must have the **Provisioner** role.

| User | Password | Role |
|---|---|---|
| admin | admin | Administrator for the system. |

**NOTICE**

**Secure your system**

Ensure that all default passwords are changed to reduce the security risk to your system. Additionally, it is recommended to adjust or edit the role and user permissions according to your own operational needs.

**NOTICE**

**Lost passwords**

Lost passwords cannot be recovered. If you have lost your password you can not configure your controller or system.

If you have lost your password, then you must use the Factory reset and reconfigure your controller by using your recovery backup.

### 3.2.5 Password strength verification

All created and modified passwords are subject to password strength verification.

Entered passwords must:

- Have a minimum length of 8 characters or more.
- Not include repeated words or substrings (for example "abcabcabc").
- Not be listed on known vulnerable passwords (for example "12345678", "password").

## 3.3 Network communication

### 3.3.1 Ethernet port configuration

The default is to use DHCP to obtain the IP address, subnet, netmask and DNS servers. If you use a manually configured (static) IP, be careful to make sure that the selected values match the network to which the controller is connected.

| Service | Protocol | Port | Direction | Notes |
|---|---|---|---|---|
| Web configuration | HTTPS (TCP) | 80 | Inbound | Opened and re-directed to port 443. |
| Web configuration | HTTPS (TCP) | 443 | Inbound | Opened to allow communication with PICUS. |
| Modbus server | TCP | 502 | Inbound | Opened to allow Modbus TCP communication. |

In addition, the controller may use the following ports for application and PLC communication:

| Service | Protocol | Port | Direction | Notes |
|---|---|---|---|---|
| Network time synchronisation | UDP | 123 | | NTP client |
| | | 503 | | |
| CODESYS Gateway Protocol | | 1217 | | |
| Programming and client interface of the CODESYS Control runtime system | | 1740 | | |
| | | 1741 | | |
| | | 1742 | | |
| | | 1743 | | |
| Websocket port for Fast Live Data (FLD). Used for WebUI/ browser | | 4321 | | |
| OPC UA | TCP | 4840 | | If OPC UA is enabled. |
| Multicast DNS (mDNS) | UDP | 5353 | | Used for device discovery. |
| CODESYS WebVisualization | | 8000 | | Redirects to 8443 |
| TLS encrypted port for CODESYS WebVisualization | | 8443 | | |
| Programming and client interface of the CODESYS Control runtime system | | 11740 | | |
| Power Management System (PMS) - bottom ring | MRP | 12345 | | |
| Application broadcast - bottom ring | MRP | 12346 | | |
| PMS - top ring | MRP | 12347 | | |
| Application broadcast - top ring | MRP | 12348 | | |
| Ring protocol - bottom ring | MRP | 12350 | | |
| Inter Controller Communication - bottom ring | MRP | 12351 | | |
| Ring protocol - top ring | MRP | 12352 | | |

### 3.3.2 Untrusted networks

Connections to untrusted networks may require additional equipment and/or security counter-measures that are not included in the product.

## 3.4 CODESYS

If you have a CODESYS license you must connect to the controller and log in using the CODESYS IDE. You can then create a user account and set the password.

## 3.5 Activity logs

### 3.5.1 About activity logs

Each controller records activity of both the system and operational events.

These are recorded in logs:

- Event log
- Live system log

### 3.5.2 Event log

This can be accessed with PICUS or the display.

All activities that require a user login are logged with the username. The user can also use the controller for some actions without logging in (for example, selecting breaker open). These actions are logged without a username.

The controller stores a maximum of 2000 event log entries. When the log is full, the controller discards the excess log entries using first in, first out.

If an ECU has been configured, you can also switch to see the DM2 logs.

**More information**
See the PICUS manual or Operator's manual for how to view the Event log.

### 3.5.3 System log

This can only be accessed with WebConfig and the **admin** user.

The *Live system log* records all different system-related events that occur. These logs can be useful for cybersecurity control, troubleshooting issues, and also for product support.

These logs include:

- System events and journal.
- Connected session access with WebConfig.
- CODESYS related information.

**Download logs**
You can select and download the system logs directly from the controller as text files.

1. Select **Download** from **Logs**.
2. Select the **Duration** (period) you want to download.
   - This can be **Latest**, **Day**, **Week**, or **All**.
3. Select the **Type** of log to download.
   - This can be **SYSLOG**.

4. Select **Download** to create a ZIP archive with the log files included.
5. Locate your browser's download location to access the ZIP archive.

### SYSLOG

The system log (SYSLOG) archive includes:

- Authentication journal.
  - *Connected sessions with WebConfig.*
- Reliability log.
  - *Operational values and performance information.*
- System journal.
  - *System operations.*

# 4. Busbar sections and load sharing

This chapter is only relevant when there is at least one bus tie breaker in the application. The bus tie breaker(s) can be controlled by a BUS TIE breaker controller and/or externally controlled.

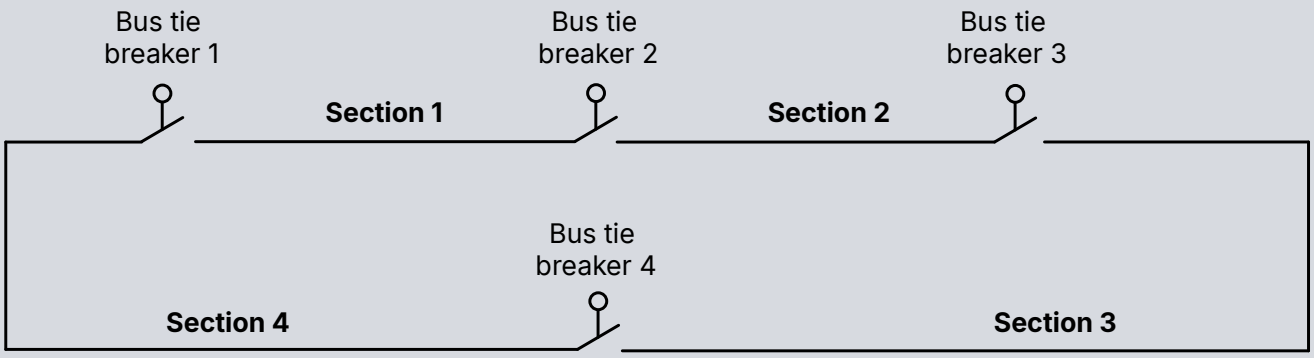
## 4.1 About busbar sections

### 4.1.1 Dynamic busbar sections

The bus tie breakers create busbar sections. The bus tie breakers can be externally controlled, or controlled by a BUS TIE breaker controller.

The busbar sections are dynamic. That is, the sections change whenever bus tie breakers are opened or closed.

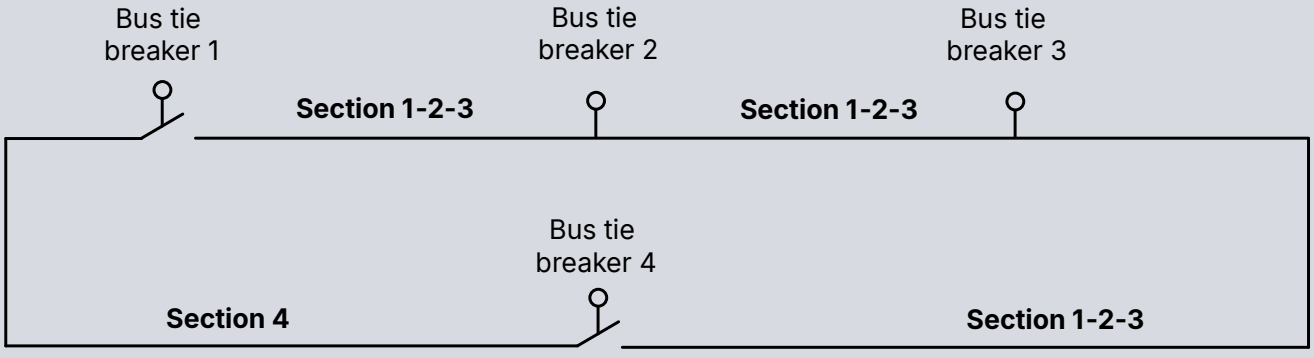
**Example of busbar sections**




When the breaker(s) are open, each busbar section is independent from the other section(s). The controllers in the section can share the load in that section.

If the breaker(s) are closed, then the connected busbar sections together form one busbar section, as shown in the example below. The controllers in the connected busbar section can share the load for the combined busbar section.

**Example of busbar sections created by closing two bus tie breakers**




The busbar sections are numbered here to make it easier to understand sections. However, busbar section numbers are not used in PICUS.

## 4.1.2 Externally controlled bus tie breaker

The externally controlled bus tie breaker function allows an externally controlled bus tie breaker to be present. This breaker is opened or closed by the operator. The DEIF controllers only receive position feedback from the breaker, and do not control it.

### Additional equipment

You should install a check sync relay or a paralleling relay in the switchboard, to check the synchronisation before closing, for example, the DEIF CSQ-3 or HAS.

### Wiring example

**More information**
See **Breaker wiring** in the **Installation instructions** for an example of external breaker wiring.

### Digital inputs

Only 1 feedback is needed as a minimum for the feedback.

| Function | I/O | Type | Details |
|---|---|---|---|
| `Breakers > [External breaker] > Feedback > [B #] closed` * | Digital input | Continuous | The feedback ensures that the controller system knows when the external breaker is closed. |
| `Breakers > [External breaker] > Feedback > [B #] open` * | Digital input | Continuous | The feedback ensures that the controller system knows when the external breaker is open. |

### Digital outputs (optional)

| Function | I/O | Type | Details |
|---|---|---|---|
| `Breakers > [External breaker] > State > [B #] is open` * | Digital output | Continuous | Activated when the breaker is open. |
| `Breakers > [External breaker] > State > [B #] is closed` * | Digital output | Continuous | Activated when the breaker is closed. |

**NOTE** * # represents the external breaker number. Up to 4 external breakers can be assigned to a controller.

### How to use the externally controlled bus tie breaker

To close the externally controlled bus tie breaker, the operator, CODESYS, or PLC must synchronise the busbar sections and then close the breaker.

### Alarm

**More information**
See External breaker # position failure for more information about this alarm.

## 4.1.3 Ring busbar connection

BUS TIE breaker controllers and/or externally controlled bus tie breakers can be installed in system with a ring busbar.

A ring busbar connection is only allowed if there are at least two bus tie breakers in the single-line application drawing. These bus tie breakers can be controlled by BUS TIE breaker controllers and/or externally controlled.

## 4.1.4 Black busbar negotiation

Two (or more) controllers can receive a breaker close command at the same time to connect to a black busbar. However, the controller system ensure that only one connects at a time.

# 4.2 In parallel

## 4.2.1 Genset in parallel

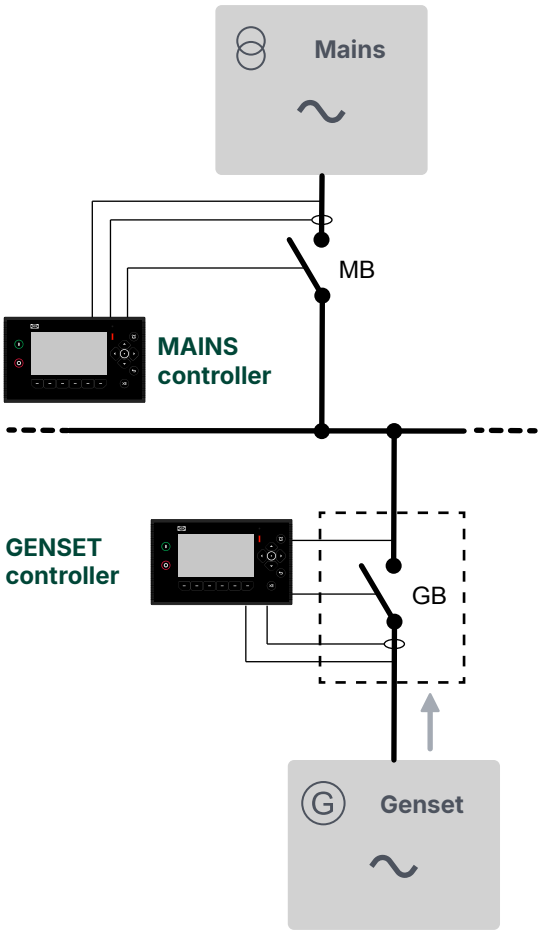
The controllers work together to determine whether there are any gensets connected to the busbar section. The determination includes the relevant breaker states and AC measurements.

### Inhibits

The *Genset in parallel* and *Genset not in parallel* inhibits are used by MAINS controllers. The MAINS controller receives information from the GENSET controllers. The relevant measurements are in the dashed line box in the diagram.

If there is at least one genset and one mains connected to the same busbar section, then the *Genset in parallel* inhibit is activated.

If there are no gensets connected to the busbar section, then the *Genset not in parallel* inhibit is activated.




## 4.2.2 Mains in parallel

The controllers work together to determine whether there are any mains connected to the same busbar section. The determination includes the relevant breaker states and AC measurements.

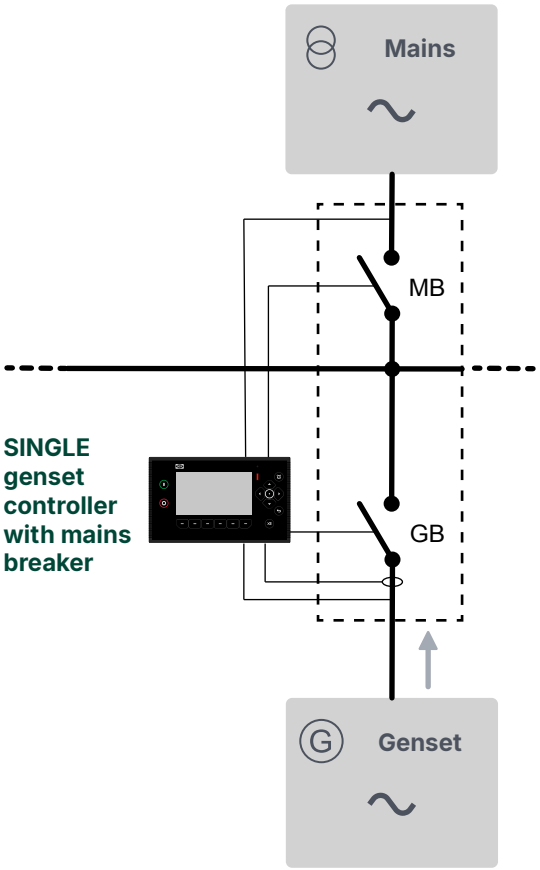
### Inhibits

The *Mains in parallel* and *Mains not in parallel* inhibits are used by the SINGLE genset and GENSET controllers. The relevant measurements are in the dashed line boxes in the diagrams.

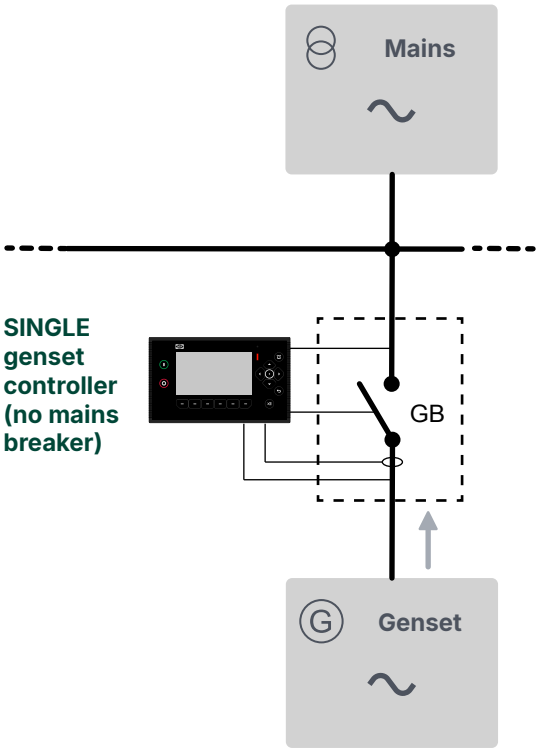
If there is at least one genset and one mains connected to the same busbar section, then the *MAINS in parallel* inhibit is activated.

If there are no mains connected to the busbar section, then the *MAINS not in parallel* inhibit is activated.

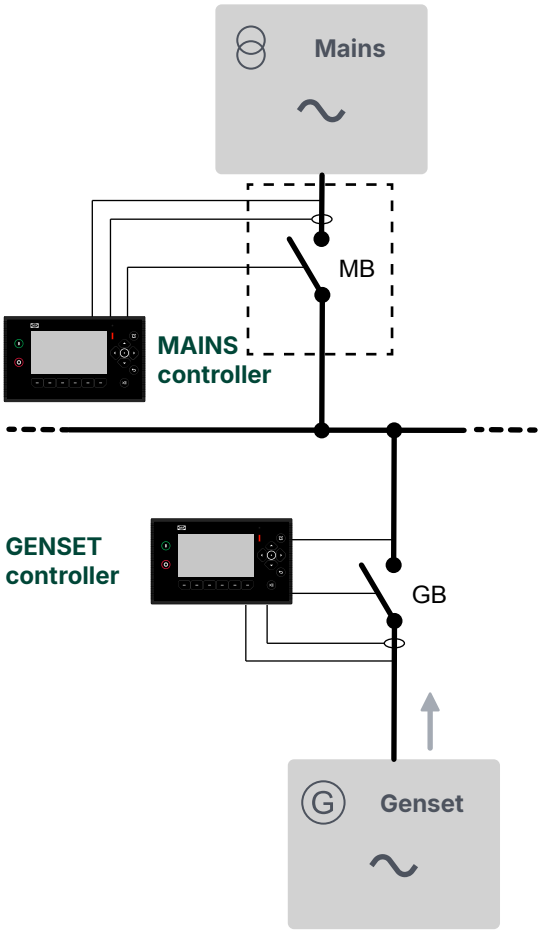
The *SINGLE genset - With mains breaker* controller considers the states of the *Generator breaker* and *Mains breaker*, along with the AC measurements.




The *SINGLE genset - No mains breaker* controller considers the state of the *Generator breaker* along with the AC measurements.



The GENSET controller considers the state of the *Mains breaker* along with the mains AC measurements.




**Regulation**

If there is a mains is connected to the section, the controllers cannot change the frequency and voltage of the section.

## 4.3 Busbar section load sharing

### 4.3.1 Busbar section characteristics

The busbar sections have the following effect:

- **GENSET** controllers can load share with other **GENSET** controller(s) in the same busbar section.
  - **GENSET** controllers do not attempt to load share with **GENSET** controllers in different busbar sections.
- **GENSET** controllers with external set point (network) activated automatically respond to the set point(s) from controllers in the same busbar section.
  - The **GENSET** controllers respond to set point(s) from the **MAINS** and/or **BUS TIE breaker** controllers in the busbar section.
  - The **GENSET** controllers ignore set points from outside the section.
  - For **BUS TIE breaker** controllers, separate set points are sent to busbar A and to busbar B.

### 4.3.2 DEIF network load sharing

The controllers can share the load (both active power (P) and reactive power (Q)) over the DEIF network.

Load sharing over the DEIF network occurs when the load sharing mode is activated in all of the **GENSET** controllers that must share the load. The load sharing mode can be activated using digital inputs, Modbus and/or CustomLogic.

The load is shared equally between the **GENSET** controllers in the same section with load sharing mode activated. The gensets each run at the same percentage of nominal load. This allows differently sized gensets to share the load.

**NOTE** Only DEIF controllers can be used for load sharing over the DEIF network. No other vendors' controllers can be used for load sharing over the DEIF network.

**More information**
See **Power load sharing** and **Reactive power load sharing** in the **Regulation** chapter for load sharing inputs, outputs, and parameters.

### Hardware

| Name | Type | Details |
|---|---|---|
| DEIF network | Ethernet | The DEIF network can be used for equal load sharing (active and/or reactive power). |
| GOV control | Various | Required for active power load sharing. |
| AVR control | Various | Required for reactive power sharing. |

### Example

**Equal load sharing example**

A 1000 kW genset is supplying a load of 900 kW. A 500 kW genset is then connected to the same section. Load sharing is activated in both **GENSET** controllers.

Together, the gensets run at 900 kW / (1000 kW + 500 kW) = 0.6 = 60 % of their nominal load. Therefore, the 1000 kW genset supplies 600 kW, and the 500 kW genset supplies 300 kW.

### Alarms that can affect network load sharing

Genset and generator breaker problems can affect load sharing. For example, GB position failure, and a variety of other **GENSET** controller alarms can affect load sharing.

The following alarms can affect the DEIF network load sharing:

- External breaker # position failure
- Any bus tie breaker position failure
- Missing all controllers
- Missing controller ID #
- Missing any controller
- Controller ID not configured
- Duplicate controller ID
- Single-line missing / none active
- Different single-line configurations
- Controller not part of system

If any of these alarms are present, load sharing can be unpredictable. You must therefore find and correct the cause.

### Manual regulation

If the regulator is in manual or deactivated, then that controller does not automatically control load, and therefore it cannot participate in load sharing.

## 4.4 Load sharing alarms

### 4.4.1 P load sharing failure

This alarm is for genset active power load sharing failure.

The alarm is based on the absolute value of the difference between the measured value and the internal controller set point, as a percentage of the genset nominal power.

The controller activates the alarm if the difference between the reference and measured values is outside the activation range for longer than the delay.

This alarm is not activated when the deviation of the error swings in and out of the activation range above and below the set point. This is because this alarm is only activated when the deviation of the error stays either above or below the activation range for the delay time.

**Regulators > GOV > Monitoring > P load sharing failure**

| Parameter | Range |
|---|---|
| Set point | 0.0 to 50.0 % regulation deviation |
| Delay | 0 s to 1 h |

## 4.4.2 Q load sharing failure

This alarm is for genset reactive power load sharing failure.

The alarm is based on the absolute value of the difference between the measured value and the internal controller set point, as a percentage of the genset nominal reactive power.

The controller activates the alarm if the difference between the reference and measured values is outside the activation range for a time longer than the delay.

This alarm is not activated when the deviation of the error swings in and out of the activation range above and below the set point. This is because this alarm is only activated when the deviation of the error stays either above or below the activation range for the delay time.

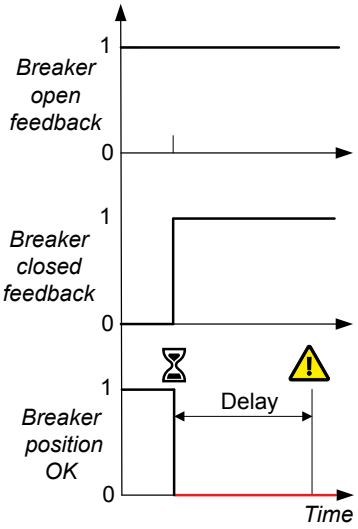
**Regulators > AVR > Monitoring > Q load sharing failure**

| Parameter | Range |
|---|---|
| Set point | 0.0 to 50.0 % regulation deviation |
| Delay | 0 s to 1 h |

## 4.4.3 External breaker # position failure

This alarm is for an externally controlled breaker position failure.

The alarm is based on the externally controlled 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.



**Breakers > [Breaker] feedback monitoring > Position failure**

The parameter is only visible if there is an external breaker is on the single-line application drawing. This alarm is always enabled. The alarm action is *Warning, Latch enabled*.

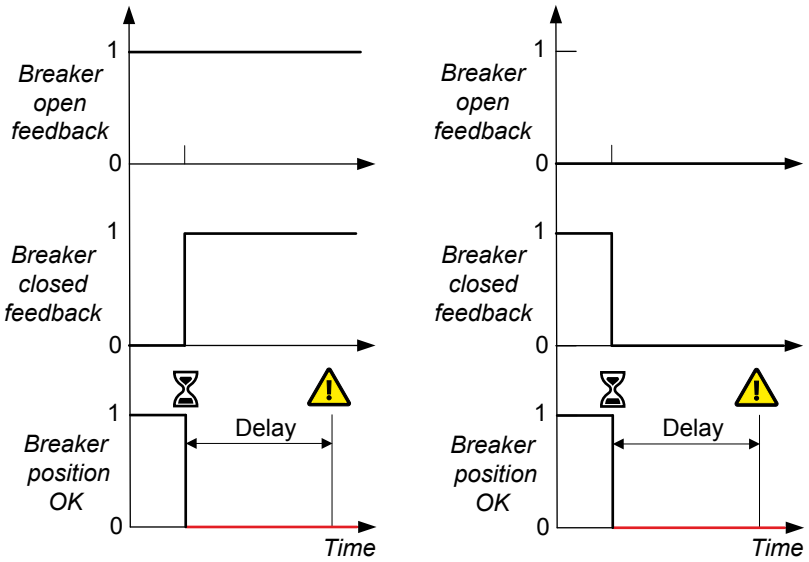
| Parameter | Range |
|---|---|
| Delay | 0.1 s to 5.0 s |

## 4.4.4 Any bus tie breaker position failure

This alarm is for any bus tie breaker position failure.

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.

The alarm is activated in ALL of the controllers in the sections connected to the bus tie breaker.




**System > Monitoring > Any bus tie breaker position failure**

This alarm is always enabled.

### Effect of redundant breaker feedback

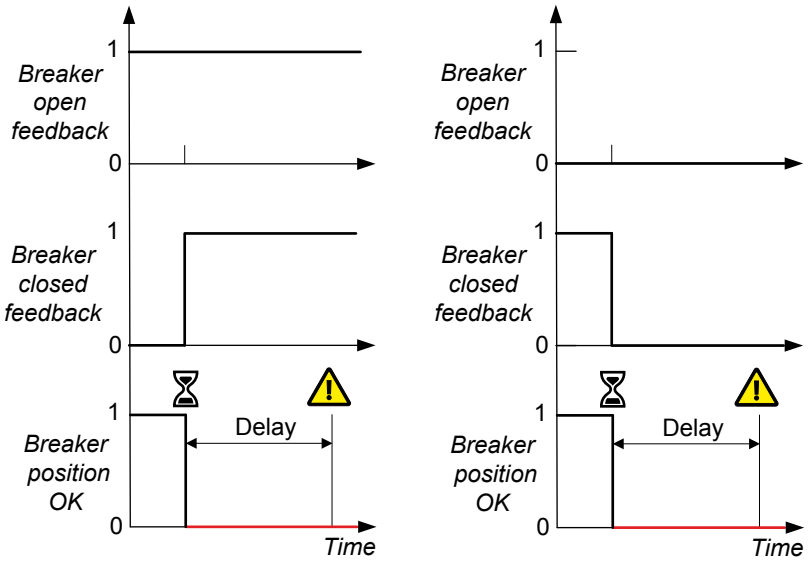
If redundant breaker feedback is configured for the bus tie breaker, then this alarm only activates when a bus breaker position failure is detected on each breaker feedback.

## 4.4.5 Any mains breaker position failure

This alarm is for any mains breaker position failure.

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.

The alarm is activated in ALL of the controllers in the sections connected to the mains breaker.



**System > Monitoring > Any mains breaker position failure**

This alarm is always enabled.

| Parameter | Range | Default |
|---|---|---|
| Alarm action | | Warning |

### Effect of redundant breaker feedback

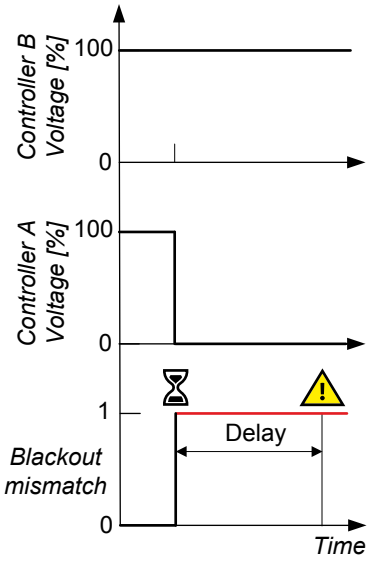
If redundant breaker feedback is configured for the mains breaker, then this alarm only activates when a mains breaker position failure is detected on each breaker feedback.

## 4.5 Network alarms

### 4.5.1 Blackout detection mismatch

This alarm communicates that not all controllers in the section detected the blackout.

The alarm is based on the blackout detection for all the controllers in the section. The alarm is activated when one or more controllers detect a blackout, while one or more controllers in the same section do not detect a blackout, and this continues for longer than the delay time.




**System > Monitoring > Blackout detection mismatch**

| Parameter | Range |
|---|---|
| Delay | 0.0 s to 1 h |

### 4.5.2 Missing all controllers

This alarm communicates a network failure.

The alarm is based on the network between the controllers included in the single-line application drawing. The alarm is activated when the controller cannot communicate over the network with any other controllers. If this alarm is activated, the *Missing controller ID #* alarms are not activated.

**System > Monitoring > Missing all controllers**

This alarm is always enabled.

### 4.5.3 Missing controller ID #

This alarm communicates a communication failure with one or more controllers in the single-line application drawing.

The alarm is activated when a controller is present on the single-line application drawing, but the controller displaying the alarm cannot communicate with it.

The alarm is always enabled, and the alarm action is *Warning*. The alarm parameters are not visible.

### 4.5.4 Duplicate controller ID

This alarm communicates that there is another controller with the same *Controller ID* in the network.

The alarm is based on the network between the controllers included in the single-line application drawing. The alarm is activated when the controller detects another controller with the same *Controller ID* as itself.

**`System > Monitoring > Duplicate controller ID`**

This alarm is always enabled.

### 4.5.5 Single-line missing/none active

This alarm communicates that the single-line application drawing cannot be read from the controller, or that no single-line application drawing is configured for the controller.

The alarm is always enabled and the action is *Warning*. The alarm parameters are not visible.

### 4.5.6 Different single-line configurations

This alarm communicates that different single-line application drawings are present on one or more controllers in the system.

This alarm is activated when a single-line application drawing is written to a controller, but not *Broadcast* to the remaining controllers. The alarm is always enabled, and the action is *Warning*. The alarm parameters are not visible.

### 4.5.7 Controller not part of system

This alarm occurs if the controller has a *Controller ID* that is not included in the single-line application drawing. Check or configure the system under **Application**.

The alarm is always *Enabled*, and the action is *Warning*. The alarm parameters are not visible.

#### Stand-alone applications

You must also create a single-line application drawing if the controller is in a stand-alone application. The single-line application drawing then has only that controller.

### 4.5.8 Missing any controller

This alarm occurs if a controller in the application single-line application drawing is missing from the network.

**`System > Monitoring > Missing any controller`**

This alarm is always enabled.

### 4.5.9 DEIF network redundancy broken

This alarm applies to the DEIF network connection between the controller PCM modules. The alarm is activated when there is no redundant communication between the controllers. This alarm is based on the single-line application drawing and the application communication. That is, all of the controllers in the network must be included in the single-line application drawing.

**Communication > DEIF network > DEIF network redundancy broken**

**NOTE** This alarm must either be *Enabled* for all the controllers in the system, or *Not enabled* for all the controllers in the system.

## 4.5.10 DEIF network top ring redundancy broken

This alarm only applies to top ring topology in a configuration using CODESYS. This alarm applies to the DEIF network connection between the controller PCM modules in a top ring configuration. The alarm is activated when there is no redundant communication for the top ring connections between each group of connected controllers. This alarm only applies to top ring topology in a configuration using CODESYS.

**Communication > DEIF network > DEIF network top ring redundancy broken**

**NOTE** This alarm must either be *Enabled* for all the controllers in the system, or *Not enabled* for all the controllers in the system.

**More information**
See the **Multi-line 300 CODESYS guidelines** for more information about the network restrictions when using a top ring network configuration.

## 4.5.11 DEIF network fork detected

The DEIF network can be connected as a chain, a ring, or a star.

If a controller has more than 2 DEIF network connections, then the network is forked (or branched), and the controller activates this alarm. If you are trying to connect the network as a ring, this alarm can be helpful for identifying which controller(s) have star connections.

**Communication > DEIF network > DEIF network fork detected**

## 4.5.12 DEIF network has only one connection

For redundancy, the DEIF network should be connected as a ring. That is, each controller should have two DEIF network connections. This alarm is activated if the controller had two DEIF network connections, but now has only one DEIF network connection.

**Communication > DEIF network > DEIF network has only one connection**

# 5. AC configuration

## 5.1 AC configuration

**Phase configuration: AC configuration**

This parameter must be the same for all the controllers in the system.

**`[A-side] > AC setup > Phase configuration`**

| Parameter | Range | Notes |
|---|---|---|
| `AC configuration` | • Three-phase<br>• Three-phase (2 CT, L1-L3)<br>• Three-phase (L1-L2, CT L1)<br>• Split-phase L1-L3<br>• Split-phase L1-L2<br>• Split-phase L2-L3<br>• Single-phase L1<br>• Single-phase L2<br>• Single-phase L3 | **Three-phase**: The A-side and B-side are three-phase, and there are current measurements on all three phases. Voltage and current measurement on the neutral phase (N) is optional.<br><br>**Three-phase (2 CT, L1-L3)**: The A-side and B-side are three-phase. However, the controller only uses the current measurements on L1 and L3. Voltage and current measurement on the neutral phase (N) is optional.<br><br>**Three-phase (L1-L2, CT L1)**: The A-side and B-side are three-phase. However, the controller only uses the voltage measurements from L1 and L2, and the current measurement on L1.<br><br>**Split-phase L1-L3**: The waveforms are offset by a half-cycle (180 degrees) from the neutral wire. This is sometimes called 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 single-phase in the USA.<br><br>**Split-phase L2-L3** The waveforms are offset by a half-cycle (180 degrees) from the neutral wire. This is sometimes called single-phase in the USA.<br><br>**Single-phase L1**: The A-side and B-side are single-phase. Use the L1 terminal for the voltage and current measurements (not the L2 or L3 terminals). The current measurement on the neutral phase (N) is optional.<br><br>**Single-phase L2**: The A-side and B-side are single-phase. Use the L2 terminal for the voltage and current measurements (not the L1 or L3 terminals). The current measurement on the neutral phase (N) is optional.<br><br>**Single-phase L3**: The A-side and B-side are single-phase. Use the L3 terminal for the voltage and current measurements (not the L1 or L2 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*). |

**More information**

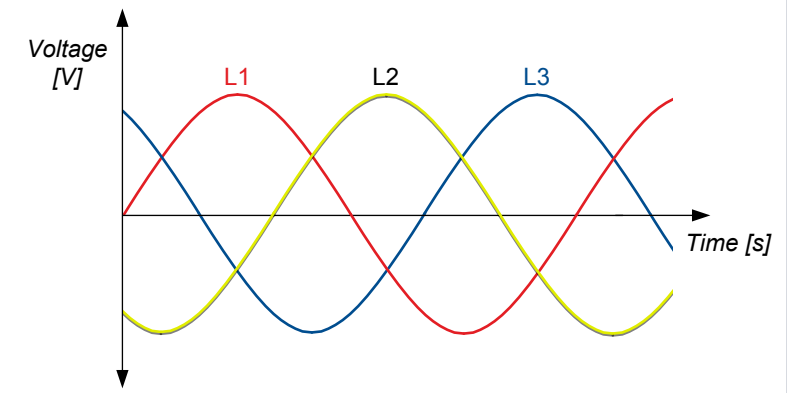
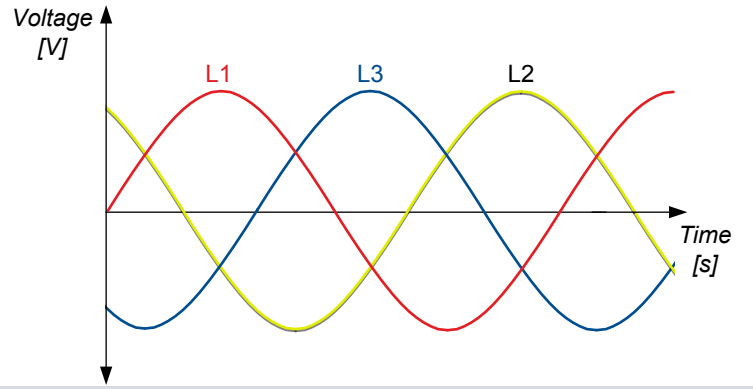
See **System AC configuration** in the **Installation instructions** for examples of three-phase, single-phase wiring, and split-phase wiring.

### Phase direction: AC phase rotation

Set this parameter if the AC phase rotation is not L1-L2-L3.

This parameter must be the same in all the controllers in the system.

**`[A-side] > AC setup > Phase direction`**

| Parameter | Range | Notes |
|---|---|---|
| `AC setup` | • L1-L2-L3<br>• L1-L3-L2 | **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><br>**L1-L3-L2**: We do 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>  <br> |

**DANGER!**

**Different phase rotation**

Never attempt to connect assets to the same busbar if they do not have the same phase rotation.

**CAUTION**

**Incorrect parameter use**

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

### Voltage measurement

By default, the controller uses the phase-to-phase voltages for alarms. For relevant AC protections, you can use the `AC setup` parameter, to select phase-to-neutral voltages instead. Note that the nominal voltages are always phase-to-phase voltages.

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

`Phase-neutral`: Measurements from the neutral line must be present in a phase-to-neutral system. If you select *Single-phase L1* (or *L2* or *L3*), you must also select *Phase-neutral* in the voltage protections.

## 5.1.1 [A-side] and [B-side] for each controller type

The names used for [A-side] and [B-side] for the AC configuration of each controller type:

| Controller type | [A-side] (MIO terminals 78 to 81) | [B-side] (MIO terminals 83 to 86) |
|---|---|---|
| **SINGLE genset** | Generator | Mains |
| **GENSET** | Generator | Busbar |
| **MAINS** | Mains | Busbar |
| **BUS TIE breaker** | Busbar A | Busbar B |

## 5.1.2 [A-side] AC configuration

### Voltage transformer

Set these parameters for the voltage transformer on the [A-side]'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-star, and so on).

**`[A-side] > AC setup > Voltage transformer`**

| Parameter | Range | Notes |
|---|---|---|
| `Primary` | 10 V to 1500 kV AC | The voltage transformer primary side (asset side) value. |
| `Secondary` | 17 to 690 V AC | The voltage transformer secondary side (controller side) value.<br>**NOTE** Phase shift is not allowed in the voltage transformer. The phase must be the same on the high and low voltage sides of the voltage measurement transformer.<br>**NOTE** The minimum normal operating voltage for the controller is 100 V. |

**More information**
See **[A-side] AC configuration** in the **Installation instructions** for an example of generator voltage transformer wiring.

### Current transformer

**CAUTION**

**Current transformer changes**

Changing the current transformer settings changes the protection range for all the protections that depend on the current measurements. This includes power protections.

If you change the current transformer values and the set points for the over-current and fast over-current protections are out of the set point range, then the **Protection set point out of range** alarm activates. The alarm action is warning, and cannot be configured.

You must set these parameters for the current transformer on the current measurement. These parameters only apply to the current measurements on L1, L2 and L3.

**[A-side] > AC setup > Current transformer**

| Parameter | Range | Notes |
|---|---|---|
| Primary | 5 to 9000 A | The current transformer primary side (asset side) nominal current. |
| Secondary | 1 or 5 A | The current transformer secondary side (controller side) nominal current. You can select either 1 A or 5 A. |

### Voltage and frequency OK

The controller uses these parameters to calculate whether the voltage and frequency from the [A-side] measurements are OK, so that the breaker can close.

**[A-side] > AC setup > Voltage and frequency OK**

| Parameter | Range | Notes |
|---|---|---|
| Voltage and frequency OK | 0.0 s to 1 h | If the voltage and frequency are OK for this time in seconds, then the equipment's LED becomes steady green. The breaker is not allowed to close before the LED is steady green (that is, not flashing). |
| Minimum OK voltage | 70 to 100 % | The voltage must be above this voltage (as a percent of nominal voltage) for the breaker to start to synchronise and close. |
| Maximum OK voltage | 100 to 120 % | The voltage must be below this voltage (as a percent of nominal voltage) for the breaker to start to synchronise and close. |
| Minimum OK frequency | 70.00 to 100.00 % | The frequency must above this frequency (as a percent of nominal frequency) for the breaker to start to synchronise and close. |
| Maximum OK frequency | 100.00 to 110.00 % | The frequency must below this frequency (as a percent of nominal frequency) for the breaker to start to synchronise and close. |

### Voltage and frequency OK (blackout)

For the **SINGLE genset**, **GENSET**, or **MAINS** controllers.

During a blackout, the controller uses these parameters to calculate whether the voltage and frequency from the generator measurements are OK, so that the breaker can close.

**[A-side] > AC setup > Voltage and frequency OK (blackout)**

| Parameter | Range | Notes |
|---|---|---|
| Voltage and frequency OK | 0.0 s to 1 h | If the voltage and frequency from the [A-side] are OK for this time in seconds, then the asset's LED becomes steady green. The breaker is not allowed to close before the LED is steady green (that is, not flashing). |
| Minimum OK voltage | 70 to 100 % | The voltage must be above this voltage (as a percent of nominal voltage) for the breaker to start to synchronise and close. |
| Maximum OK voltage | 100 to 120 % | The voltage must be below this voltage (as a percent of nominal voltage) for the breaker to start to synchronise and close. |
| Minimum OK frequency | 70.00 to 100.00 % | The frequency must above this frequency (as a percent of nominal frequency) for the breaker to start to synchronise and close. |
| Maximum OK frequency | 100.00 to 110.00 % | The frequency must below this frequency (as a percent of nominal frequency) for the breaker to start to synchronise and close. |

### Voltage or frequency not OK

For the **SINGLE genset** and **GENSET** controller.

**`[A-side] > AC setup > Voltage or frequency not OK`**

| Parameter | Range | Notes |
|---|---|---|
| `Delay` | 1 s to 1 h | If no inhibits are activated, then, if the voltage or frequency are not okay, this alarm is activated after the delay. |

## 5.1.3 [B-side] AC configuration

### Voltage transformer

Set these parameters if there are voltage transformers on the B-side 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).

**`[B-side] > AC setup > Voltage transformer`**

| Parameter | Range | Notes |
|---|---|---|
| `Primary` | 10 V to 1500 kV AC | The voltage transformer primary side value. |
| `Secondary` | 17 to 690 V AC | The voltage transformer secondary side (controller side) value.<br><br>Note: No phase shift is allowed in the voltage transformer. That is, the phase must be the same on the high and low voltage sides of the B-side voltage measurement transformer.<br>Note: The minimum normal operating voltage for the controller is 100 V. |

**More information**
See **[B-side] AC configuration** in the **Installation instructions** for an example of B-side voltage transformer wiring.

### Blackout detection

**`[B-side] > AC setup > Blackout detection`**

| Parameter | Range | Notes |
|---|---|---|
| `Blackout delay` | 0.0 s to 3600.0 s | The controller does not allow the breaker to blackout close, or any other blackout actions, unless blackout is still present after this time. All the *Blackout delay* timers in the section must run out before any controller can allow a blackout close. |

### Voltage and frequency OK

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

**`[B-side] > AC setup > Voltage and frequency OK`**

| Parameter | Range | Notes |
|---|---|---|
| `Voltage and frequency OK` | 0.0 s to 3600.0 s | If the B-side voltage and frequency are OK for this time in seconds, then the B-side LED becomes steady green. The breaker is not allowed to close before the B-side LED is steady green (that is, not flashing). |
| `Minimum OK voltage` | 70 to 100 % | The voltage must be above this voltage (as a percent of nominal voltage) for the breaker to start to synchronise and close. |

| Parameter | Range | Notes |
|---|---|---|
| Maximum OK voltage | 100 to 120 % | The voltage must be below this voltage (as a percent of nominal voltage) for the breaker to start to synchronise and close. |
| Minimum OK frequency | 70.00 to 100.00 % | The frequency must above this frequency (as a percent of nominal frequency) for the breaker to start to synchronise and close. |
| Maximum OK frequency | 100.00 to 110.00 % | The frequency must below this frequency (as a percent of nominal frequency) for the breaker to start to synchronise and close. |

### 5.1.4 Voltage and frequency as digital outputs

For the [A-side] and the [B-side], you can configure digital outputs with functions for *Voltage and frequency OK* and *No voltage and frequency*. These functions are based on the AC measurements and parameters, and can be useful for troubleshooting.

#### Digital output functions

| Function | I/O | Type | Details |
|---|---|---|---|
| [A-side] > State > Voltage and frequency OK | Digital output | Continuous | Activated if the voltage and frequency from the A-side are within the range specified in:<br><br>Configure > Parameters > [A-side] > AC setup > Voltage and frequency OK |
| [A-side] > State > No voltage and frequency | Digital output | Continuous | Activated if the phase-to-phase voltage from the A-side is less than 10 % of the nominal voltage. |
| [B-side] > State > Voltage and frequency OK | Digital output | Continuous | Activated if the voltage and frequency at the [B-side] are within the range specified in:<br><br>Configure > Parameters > [B-side] > AC setup > Voltage and frequency OK |
| [A-side] > State > No voltage and frequency | Digital output | Continuous | Activated if the phase-to-phase voltage at the [B-side] is less than 10 % of the nominal voltage. |

### 5.1.5 4th current input configuration

#### Nominal current

**Local > 4th current input > Nominal settings > Nominal settings #* > Current (I4)**

| Parameter | Range | Notes |
|---|---|---|
| Nominal | 1.0 to 9000.0 A | The maximum 4th current flow during normal operation. |

**NOTE** * # is 1 to 4.

#### Current transformer

Set these parameters if there is a current transformer on the 4th current input measurement.

**Local > 4th current input > Current transformer (I4)**

| Parameter | Range | Notes |
|---|---|---|
| Primary | 5 to 9000 A | The current transformer primary side (measurement side) nominal current. |
| Secondary | 1 or 5 A | The current transformer secondary side (controller side) nominal current. Select either 1 A or 5 A. |

**More information**
See the **Installation instructions** for examples of 4th current input wiring for the neutral phase.

## 5.2 AC measurement filters

### 5.2.1 About AC measurement filters

You can configure average filtering on the primary AC measurements for smooth measurement readout on noisy or oscillating systems.

The AC filtered measurements are used on the values shown in Live data, CustomLogic, Modbus, CODESYS (if installed) and other shown operational values. The internal calculations and protections continue to use the actual values.

AC measurement filters can be configured as:

- **No filter**: Always show the actual value.
- **Averaged (200 ms)**: Show a value averaged over 200 ms.
- **Averaged (800 ms)**: Show a value averaged over 800 ms.

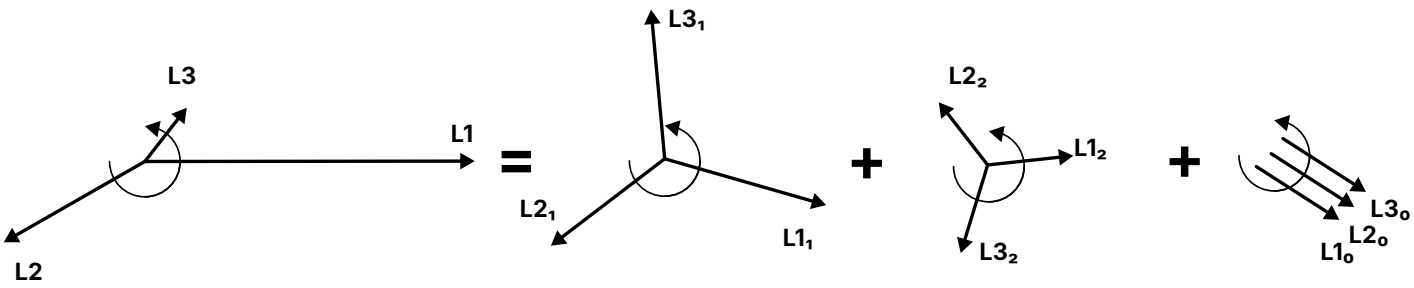
### 5.2.2 AC measurement filters

**`Local > AC measurement filters > Primary AC measurements`**

| Parameter | Range |
|---|---|
| `Voltage` | No filter, Averaged (200 ms), Averaged (800 ms) |
| `Current` | No filter, Averaged (200 ms), Averaged (800 ms) |
| `Active power` | No filter, Averaged (200 ms), Averaged (800 ms) |
| `Reactive power` | No filter, Averaged (200 ms), Averaged (800 ms) |
| `Apparent power` | No filter, Averaged (200 ms), Averaged (800 ms) |
| `Power factor and cos phi` | No filter, Averaged (200 ms), Averaged (800 ms) |
| `Frequency from voltage` | No filter, Averaged (200 ms), Averaged (800 ms) |
| `Frequency from current` | No filter, Averaged (200 ms), Averaged (800 ms) |

## 5.3 Symmetrical components

Any rotating set of voltage or current phasors for a three-phase system can be expressed as a positive sequence set, a negative sequence set, and a zero sequence set. These symmetrical components offer a simplified approach to analyse AC systems, especially for unbalanced load or fault conditions.




Initial phasors | Positive sequence | Negative sequence | Zero sequence

**Positive sequence**
The positive sequence is a balanced (equal magnitude and 120° apart) set of three phasors, rotating with the normal phase rotation.

### Negative sequence

The negative sequence set is a balanced set of three phasors, rotating with a negative phase sequence.

### Zero sequence

The rotating phasors of the zero sequence set are aligned in phase and magnitude.

## 5.4 AC measurements as analogue outputs

### 5.4.1 About AC measurements as analogue outputs

You can configure an analogue output with the function for an alternating current (AC) operating value. This value may be measured directly or calculated from the AC measurements. The controller then adjusts the analogue output to reflect the AC operating value.

### Applications

An analogue output with a function for an alternating current (AC) operating value may be wired to a switchboard instrument, to help the operator. For example, the total kW from a generator can be displayed.

Alternatively, an analogue output may be wired to a switchboard instrument, to help troubleshooting. For example, the voltage unbalance between two phases (*Busbar | L-L unbalanced [V]*) can be displayed.

### 5.4.2 [A-side] AC measurements

### Function names

The [A-side] AC measurement function names follow these formats:

```
[A-side] > [Physical quantity] > [Asset] | [Measurement] [[unit]].
```

### [A-side] AC measurement function names for each controller type

| Controller type | [A-side] | [Asset] |
|---|---|---|
| **SINGLE genset** | Generator | Generator |
| **GENSET** | Generator | Generator |
| **MAINS** | Mains | Mains |
| **BUS TIE breaker** | Busbar A | Busbar A |

### [A-side] voltage analogue output functions

**`[A-side] > Voltage (V)`**

| Function | Details |
|---|---|
| `[Asset] \| L1-N [V AC]` | The controller outputs the L1-N voltage from the A-side. |
| `[Asset] \| L2-N [V AC]` | The controller outputs the L2-N voltage from the A-side. |
| `[Asset] \| L3-N [V AC]` | The controller outputs the L3-N voltage from the A-side. |
| `[Asset] \| N [V AC]` | The controller outputs the N voltage from the A-side, relative to the star point. |
| `[Asset] \| L-N min. [V AC]` | The controller outputs the lowest L-N voltage (that is, for the phase with the lowest L-N voltage). |
| `[Asset] \| L-N max. [V AC]` | The controller outputs the highest L-N voltage (that is, for the phase with the highest L-N voltage). |
| `[Asset] \| L-N unbalanced [V AC]` | The controller outputs the L-N unbalanced voltage from the A-side, relative to the neutral. |

| Function | Details |
|---|---|
| [Asset] \| L1-L2 [V AC] | The controller outputs the L1-L2 voltage from the A-side. |
| [Asset] \| L2-L3 [V AC] | The controller outputs the L2-L3 voltage from the A-side. |
| [Asset] \| L3-L1 [V AC] | The controller outputs the L3-L1 voltage from the A-side. |
| [Asset] \| L-L min. [V AC] | The controller outputs the lowest L-L voltage (that is, for the phases with the lowest L-L voltage). |
| [Asset] \| L-L max. [V AC] | The controller outputs the highest L-L voltage (that is, for the phases with the highest L-L voltage) from the A-side. |
| [Asset] \| L-L unbalanced [V AC] | The controller outputs the L-L unbalanced voltage between the phases of the A-side. |
| [Asset] \| Positive sequence [V AC] | The controller outputs the magnitude of the positive sequence voltage. |
| [Asset] \| Negative sequence [V AC] | The controller outputs the magnitude of the negative sequence voltage. |
| [Asset] \| Zero sequence [V AC] | The controller outputs the magnitude of the zero sequence voltage from the A-side. |

### [A-side] frequency analogue output functions

**[A-side] > Frequency (f) (from voltage)**

| Function | Details |
|---|---|
| [Asset] \| L1 [Hz] | The controller outputs the L1 frequency (based on the voltage measurement). |
| [Asset] \| L2 [Hz] | The controller outputs the L2 frequency (based on the voltage measurement). |
| [Asset] \| L3 [Hz] | The controller outputs the L3 frequency (based on the voltage measurement). |
| [Asset] \| Min. [Hz] | The controller outputs the frequency of the phase with the lowest frequency (based on the voltage measurement). |
| [Asset] \| Max. [Hz] | The controller outputs the frequency of the phase with the highest frequency (based on the voltage measurement). |

**[A-side] > Frequency (f) (from current)**

| Function | Details |
|---|---|
| [Asset] \| L1 [Hz] | The controller outputs the L1 frequency (based on the current measurement). |
| [Asset] \| L2 [Hz] | The controller outputs the L2 frequency (based on the current measurement). |
| [Asset] \| L3 [Hz] | The controller outputs the L3 frequency (based on the current measurement). |
| [Asset] \| Min. [Hz] | The controller outputs the frequency of the phase with the lowest frequency (based on the current measurement). |
| [Asset] \| Max. [Hz] | The controller outputs the frequency of the phase with the highest frequency (based on the current measurement). |

### [A-side] current analogue output functions

**[A-side] > Current (I)**

| Function | Details |
|---|---|
| [Asset] \| L1 [A] | The controller outputs the L1 current from the A-side. |
| [Asset] \| L2 [A] | The controller outputs the L2 current from the A-side. |
| [Asset] \| L3 [A] | The controller outputs the L3 current from the A-side. |

| Function | Details |
|---|---|
| [Asset] \| N [A] | The controller outputs the N current from the A-side, relative to the star point. |
| [Asset] \| Min. [A] | The controller outputs the lowest phase current. |
| [Asset] \| Max. [A] | The controller outputs the highest phase current. |
| [Asset] \| Unbalanced nominal [A] | The controller outputs the unbalanced current from the A-side, calculated using the nominal method. |
| [Asset] \| Unbalanced average [A] | The controller outputs the unbalanced current from the A-side, calculated using the average method. |
| [Asset] \| Positive sequence [A] | The controller outputs the magnitude of the positive sequence current. |
| [Asset] \| Negative sequence [A] | The controller outputs the magnitude of the negative sequence current. |
| [Asset] \| Zero sequence [A] | The controller outputs the magnitude of the zero sequence current from the A-side. |

### [A-side] power analogue output functions

**[A-side] > Power (P)**

| Function | Details |
|---|---|
| [Asset] \| L1 [kW] | The controller outputs the L1 power. |
| [Asset] \| L2 [kW] | The controller outputs the L2 power. |
| [Asset] \| L3 [kW] | The controller outputs the L3 power. |
| [Asset] \| Min. [kW] | The controller outputs the power of the phase with the lowest power. |
| [Asset] \| Max. [kW] | The controller outputs the power of the phase with the highest power. |
| [Asset] \| Total [kW] | The controller outputs the total power. |
| [Asset] \| Total [%] | The controller outputs the total power, as a percentage of the A-side's nominal power. |
| [Asset] \| Available [kW] | The controller outputs the available power for the A-side in kW. Available power = Nominal power - Total power |
| [Asset] \| Available [%] | The controller outputs the available power for the A-side, as a percentage of the A-side's nominal power. Available power = Nominal power - Total power |

### [A-side] reactive power analogue output functions

**[A-side] > Reactive power (Q)**

| Function | Details |
|---|---|
| [Asset] \| L1 [kvar] | The controller outputs the L1 reactive power. |
| [Asset] \| L2 [kvar] | The controller outputs the L2 reactive power. |
| [Asset] \| L3 [kvar] | The controller outputs the L3 reactive power. |
| [Asset] \| Min. [kvar] | The controller outputs the reactive power of the phase with the lowest reactive power. |
| [Asset] \| Max. [kvar] | The controller outputs the reactive power of the phase with the highest reactive power. |
| [Asset] \| Total [kvar] | The controller outputs the total reactive power. |
| [Asset] \| Total [%] | The controller outputs the total reactive power, as a percentage of the A-side's nominal reactive power. |
| [Asset] \| Available [kvar] | The controller outputs the available reactive power for the A-side in kvar. Available reactive power = Nominal reactive power - Total reactive power |
| [Asset] \| Available [%] | The controller outputs the available reactive power for the A-side, as a percentage of the A-side's nominal reactive power. Available reactive power = Nominal reactive power - Total reactive power |

### [A-side] apparent power analogue output functions

**[A-side] > Apparent power (S)**

| Function | Details |
|---|---|
| [Asset] \| L1 [kVA] | The controller outputs the L1 apparent power. |
| [Asset] \| L2 [kVA] | The controller outputs the L2 apparent power. |
| [Asset] \| L3 [kVA] | The controller outputs the L3 apparent power. |
| [Asset] \| Min. [kVA] | The controller outputs the apparent power of the phase with the lowest apparent power. |
| [Asset] \| Max. [kVA] | The controller outputs the apparent power of the phase with the highest apparent power. |
| [Asset] \| Total [kVA] | The controller outputs the total apparent power. |
| [Asset] \| Total [%] | The controller outputs the total apparent power, as a percentage of the A-side's nominal apparent power. |
| [Asset] \| Available [kVA] | The controller outputs the available apparent power for the A-side in kVA. Available apparent power = Nominal apparent power - Total apparent power |
| [Asset] \| Available [%] | The controller outputs the available apparent power for the A-side, as a percentage of the A-side's nominal apparent power. Available apparent power = Nominal apparent power - Total apparent power |

### [A-side] power factor analogue output functions

**[A-side] > Power factor (PF)**

| Function | Details |
|---|---|
| [Asset] \| cos phi | The controller outputs the power factor, calculated as cos phi. |
| [Asset] \| Power factor | The controller outputs the power factor. |

### [A-side] phase angle analogue output functions

**[A-side] > Phase angle**

| Function | Details |
|---|---|
| [Asset] \| Phase angle L1-L2 [°] | The controller outputs the phase angle between L1 and L2. |
| [Asset] \| Phase angle L2-L3 [°] | The controller outputs the phase angle between L2 and L3. |
| [Asset] \| Phase angle L3-L1 [°] | The controller outputs the phase angle between L3 and L1. |
| [Asset] \| A-B phase angle L1 [°] | The controller outputs the phase angle between L1 of the A-side and L1 of the B-side. |
| [Asset] \| A-B phase angle L2 [°] | The controller outputs the phase angle between L2 of the A-side and L2 of the B-side. |
| [Asset] \| A-B phase angle L3 [°] | The controller outputs the phase angle between L3 of the A-side and L3 of the B-side. |

## 5.4.3 [B-side] AC measurements

### Function names

The B-side AC measurement function names follow these formats:

```
[B-side] > [Physical quantity] > [Asset] | [Measurement] [[unit]].
```

**Example**

| | |
|---|---|
| | Busbar B > Apparent power (S) > Busbar B \| Total [kVA] |

### [B-side] AC measurement function names for each controller type

| Controller type | [B-side] | [Asset] |
|---|---|---|
| **SINGLE genset** | Mains | Mains |
| **GENSET** | Busbar | Busbar |
| **MAINS** | Busbar | Busbar |
| **BUS TIE breaker** | Busbar B | Busbar B |

### [B-side] voltage analogue output functions

**[B-side] > Voltage (V)**

| Function | Details |
|---|---|
| [Asset] \| L1-N [V AC] | The controller outputs the L1-N voltage from the B-side. |
| [Asset] \| L2-N [V AC] | The controller outputs the L2-N voltage from the B-side. |
| [Asset] \| L3-N [V AC] | The controller outputs the L3-N voltage from the B-side. |
| [Asset] \| N [V AC] | The controller outputs the N voltage from the B-side. |
| [Asset] \| L-N min. [V AC] | The controller outputs the lowest L-N voltage (that is, for the phase with the lowest L-N voltage). |
| [Asset] \| L-N max. [V AC] | The controller outputs the highest L-N voltage (that is, for the phase with the highest L-N voltage). |
| [Asset] \| L-N unbalanced [V AC] | The controller outputs the L-N unbalanced voltage. |
| [Asset] \| L1-L2 [V AC] | The controller outputs the L1-L2 voltage from the B-side. |
| [Asset] \| L2-L3 [V AC] | The controller outputs the L2-L3 voltage from the B-side. |
| [Asset] \| L3-L1 [V AC] | The controller outputs the L3-L1 voltage from the B-side |
| [Asset] \| L-L min. [V AC] | The controller outputs the lowest L-L voltage (that is, for the phases with the lowest L-L voltage). |
| [Asset] \| L-L max. [V AC] | The controller outputs the highest L-L voltage (that is, for the phases with the highest L-L voltage). |
| [Asset] \| L-L unbalanced [V AC] | The controller outputs the L-L unbalanced voltage. |
| [Asset] \| Positive sequence [V AC] | The controller outputs the magnitude of the positive sequence voltage. |
| [Asset] \| Negative sequence [V AC] | The controller outputs the magnitude of the negative sequence voltage. |
| [Asset] \| Zero sequence [V AC] | The controller outputs the magnitude of the zero sequence voltage. |

### [B-side] frequency analogue output functions

**[B-side] > Frequency (f) (from voltage)**

| Function | Details |
|---|---|
| [Asset] \| L1 [Hz] | The controller outputs the L1 frequency (based on the voltage measurement). |
| [Asset] \| L2 [Hz] | The controller outputs the L2 frequency (based on the voltage measurement). |
| [Asset] \| L3 [Hz] | The controller outputs the L3 frequency (based on the voltage measurement). |
| [Asset] \| Min. [Hz] | The controller outputs the frequency of the phase with the lowest frequency (based on the voltage measurement). |
| [Asset] \| Max. [Hz] | The controller outputs the frequency of the phase with the highest frequency (based on the voltage measurement). |

### [B-side] phase angle analogue output functions

`[B-side] > Phase angle`

| Function | Details |
|---|---|
| `[Asset] \| Phase angle L1-L2 [°]` | The controller outputs the phase angle between L1 and L2. |
| `[Asset] \| Phase angle L2-L3 [°]` | The controller outputs the phase angle between L2 and L3. |
| `[Asset] \| Phase angle L3-L1 [°]` | The controller outputs the phase angle between L3 and L1. |

## 5.4.4 4th current input

Assign the AC measurement function to an analogue output.

### Analogue outputs

| Function | Details |
|---|---|
| `Local > 4th current input > Current (I) > L4 [A]` | The controller outputs the 4th current (based on the 4th current measurement). |
| `Local > 4th current input > Frequency (f) > L4 [Hz]` | The controller outputs the 4th frequency (based on the 4th current measurement). |
| `Local > 4th current input > Power (P) > L4 [kW]` | The controller outputs the 4th power (based on the 4th current measurement and the [B-side] L1 voltage). |
| `Local > 4th current input > Reactive power (Q) > L4 [kvar]` | The controller outputs the 4th reactive power (based on the 4th current measurement and the [B-side] voltage). |
| `Local > 4th current input > Apparent power (S) > L4 [kVA]` | The controller outputs the 4th apparent power (based on the 4th current measurement and the [B-side] voltage). |
| `Local > 4th current input > Power factor (PF) > L4 \| cos phi` | The controller outputs the power factor, calculated as cos phi (based on the 4th current measurement and the [B-side] voltage). |
| `Local > 4th current input > Power factor (PF) > L4 \| Power factor` | The controller outputs the power factor (based on the 4th current measurement and the [B-side] voltage). |
| `Local > 4th current input > Phase angle > L4 [°]` | The controller outputs the phase angle between the 4th current measurement and the [B-side] L1 voltage measurement. |

# 5.5 A-side AC protections

## 5.5.1 About AC protections

This section describes the AC protections based on the controller's measurements on the [A-side] of the breaker.

| Controller type | [A-side] | [Breaker] |
|---|---|---|
| **SINGLE genset** | Genset | GB and MB |
| **GENSET** | Genset | GB |
| **MAINS** | Mains | MB and TB* |
| **BUS TIE breaker** | Busbar A | BTB |

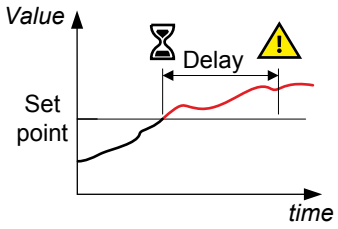
**NOTE** * TB is only for a **MAINS** controller with a tie breaker.

The controllers include the following alternating current (AC) protections, according to IEEE Std. C37.2™-2022.

## 5.5.2 [A-side] over-voltage (ANSI 59)

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

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



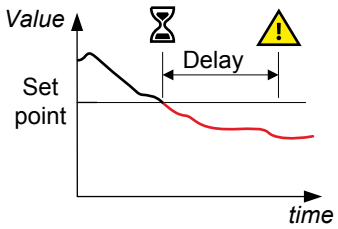

**[A-side] > Voltage protections > Over-voltage #**

| Parameter | Range |
|---|---|
| AC setup | Phase-phase, Phase-neutral |
| Set point | 80.0 to 120.0 % of nominal voltage |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.00 s to 2 h |

## 5.5.3 [A-side] under-voltage (ANSI 27)

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

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




**[A-side] > Voltage protections > Under-voltage #**

| Parameter | Range |
|---|---|
| AC setup | Phase-phase, Phase-neutral |
| Set point | 10.0 to 100.0 % of nominal voltage |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.00 s to 2 h |

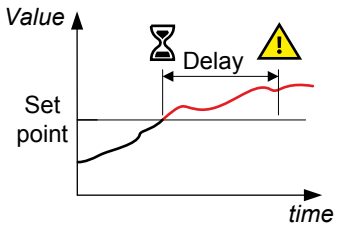
## 5.5.4 [A-side] voltage unbalance (ANSI 47)

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

**NOTE** * This operate time includes the minimum user-defined delay of 100 ms.

The method is based on the ANSI C84.1-2016 calculation method to determine voltage unbalance. The alarm response is based on the highest difference between any of the three A-side phase-to-phase voltage or phase-to-neutral true RMS values and the average voltage, as measured by the controller.

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.




**[A-side] > Voltage protections > Voltage unbalance**

| Parameter | Range |
|---|---|
| AC setup | Phase-phase, Phase-neutral |
| Set point | 0.0 to 50.0 % |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.10 s to 2 h |

**Voltage unbalance example**

A **GENSET** controller controls a genset with 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 %.

## 5.5.5 Positive sequence under-voltage (ANSI 27D)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Positive sequence under-voltage | $U_1<$ | 27D | < 60 ms |

The alarm response is based on the voltage state of the positive sequence voltage part of the voltage phasors of the A-side. The positive sequence represents the symmetrical part of the system. For more information, see Symmetrical components.

The positive sequence under-voltage alarm protects, for example, generators from running at a voltage that is too low.

### Parameters

**[A-side] > Voltage protections > Positive sequence under-voltage**

| Parameter | Range |
|---|---|
| Set point | 10.0 to 110.0 % of nominal voltage |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.02 s to 2 h |

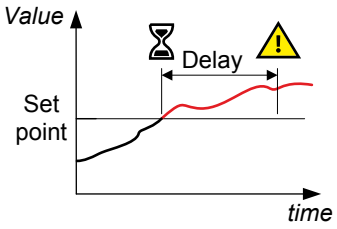
## 5.5.6 Negative sequence over-voltage (ANSI 47)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Negative sequence voltage | $U_2>$ | 47 | < 200 ms * |

**NOTE** * This operate time includes the minimum user-defined delay of 100 ms.

The alarm response is based on the voltage state of the negative sequence voltage part of the voltage phasors of the A-side. For more information, see Symmetrical components.

Negative sequence voltage typically occurs due to unbalanced loads, or a broken conductor. The negative sequence over-voltage protection protects against unbalanced voltage conditions.




**[A-side] > Voltage protections > Negative sequence voltage**

| Parameter | Range |
|---|---|
| Set point | 1.0 to 100.0 % of nominal voltage |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.10 s to 2 h |

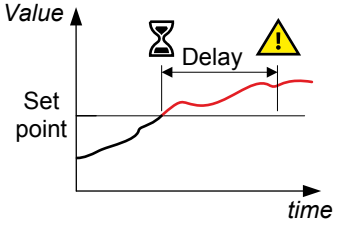
## 5.5.7 Zero sequence over-voltage (ANSI 59$U_0$)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Zero sequence voltage | $U_0$ | 59$U_0$ | < 200 ms * |

**NOTE** * This operate time includes the minimum user-defined delay of 100 ms.

The alarm response is based on the voltage state of the zero sequence voltage part of the voltage phasors of the A-side. For more information, see Symmetrical components.

Zero sequence voltage typically occurs due to earth faults or unbalanced loads. The detection of any zero sequence voltage depends on the controller measuring relative to earth or neutral. That is, the controller's neutral voltage terminal (N) must be connected to earth or neutral.



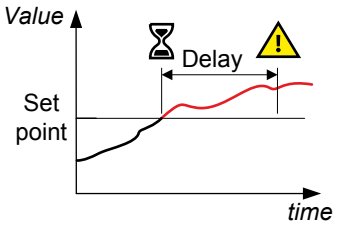

**[A-side] > Voltage protections > Zero sequence voltage**

| Parameter | Range |
|---|---|
| Set point | 0.0 to 100.0 % of nominal voltage |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.10 s to 2 h |

## 5.5.8 Over-current (ANSI 50TD)

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

The alarm response is based on the highest phase current true RMS values from the A-side, as measured by the controller.




**[A-side] > Current protections > Over-current #**

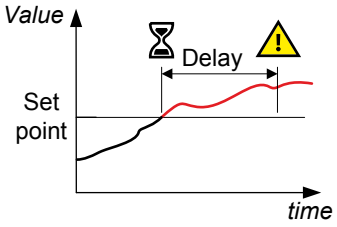
| Parameter | Range |
|---|---|
| Set point | Variable. Depends on current transformer settings. |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.00 s to 2 h |

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

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

**NOTE** * ANSI **50** applies when the *Delay* parameter is 0 s.

The alarm response is based on the highest phase current true RMS values from the A-side, as measured by the controller.




**[A-side] > Current protections > Fast over-current #**

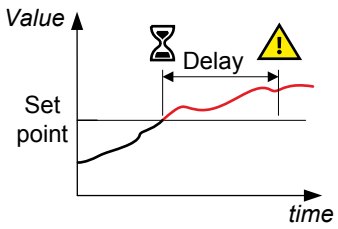
| Parameter | Range |
|---|---|
| Set point | Variable. Depends on current transformer settings. |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.00 s to 2 h |

## 5.5.10 Current unbalance (ANSI 46)

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

**NOTE** * This operate time includes the minimum user-defined delay of 100 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*.




**[A-side] > Current protections > Current unbalance ([average/nominal] calc.)**

| Parameter | Range |
|---|---|
| Set point | 0.0 to 100.0 % |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.10 s to 2 h |

### Average method

The *Average method* is based on the ANSI C84.1-2016 calculation method to determine ***voltage*** 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.

**Average method example**

A **GENSET** controller controls a genset with 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.

**Nominal method example**

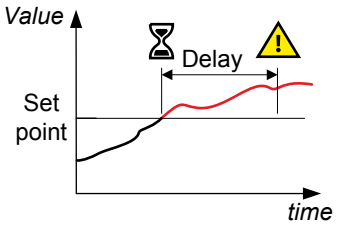
A **GENSET** controller controls a genset with a nominal current of 100 A. The L1 current is 80 A, the L2 current is 90 A, and the L3 current is 60 A.

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

## 5.5.11 Directional over-current (ANSI 67)

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

The alarm response is based on the highest phase current true RMS value, with the direction from the active power from the A-side, as measured by the controller.




**[A-side] > Current protections > Directional over-current #**

| Parameter | Range |
|---|---|
| Set point | Variable. Depends on current transformer settings. |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.00 s to 2 h |

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*.

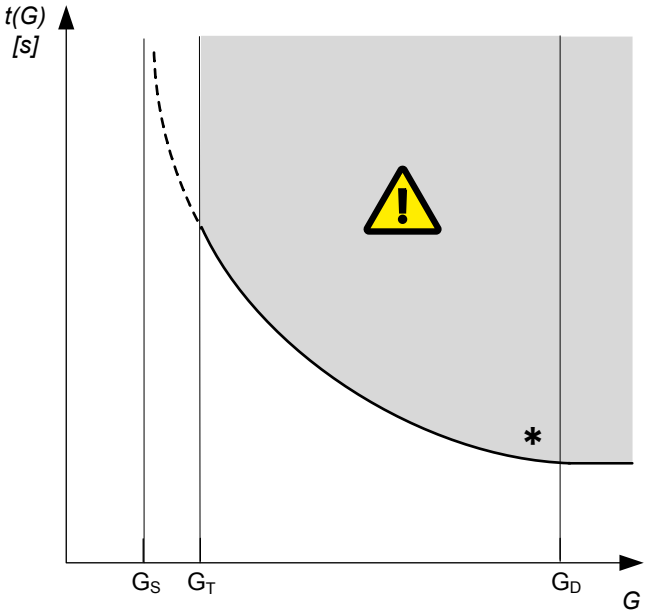
## 5.5.12 Inverse time over-current (ANSI 51)

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

The inverse time-over current protection is based on IEC 60255-151:2009. The alarm response is based on the highest phase current true RMS values, 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 (indicated in the diagram to the right by the value $G_T$). See the description below for more details.

Note: The diagram on the right is a simplified representation of this alarm and does not show the integral over time.




### Inverse time over-current calculation method

The controller uses this equation from IEC 60255-151 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, highest phase current true RMS value ($I_{phase}$) |
| $G_S$ | Alarm set point ($G_S$ = $I_{nom}$ * LIM / 100 %) |
| TMS | Time multiplier setting |

### Parameters

**[A-side] > Current protections > Inverse time over-current**

| Parameter | Range |
|---|---|
| Curve | See the table below |
| Limit (the set point, also known as LIM) | 2.0 to 200.0 % of nominal current |
| Time multiplier setting (TMS) | 0.01 to 100.00 |
| Threshold ($G_T$) | 1.000 to 1.300 |
| k * | 0.001 s to 2 min |
| c * | 0.000 s to 1 min |
| alpha (α, or a) * | 0.001 to 60.000 |

**NOTE** * Only used if *Custom characteristic* is selected.

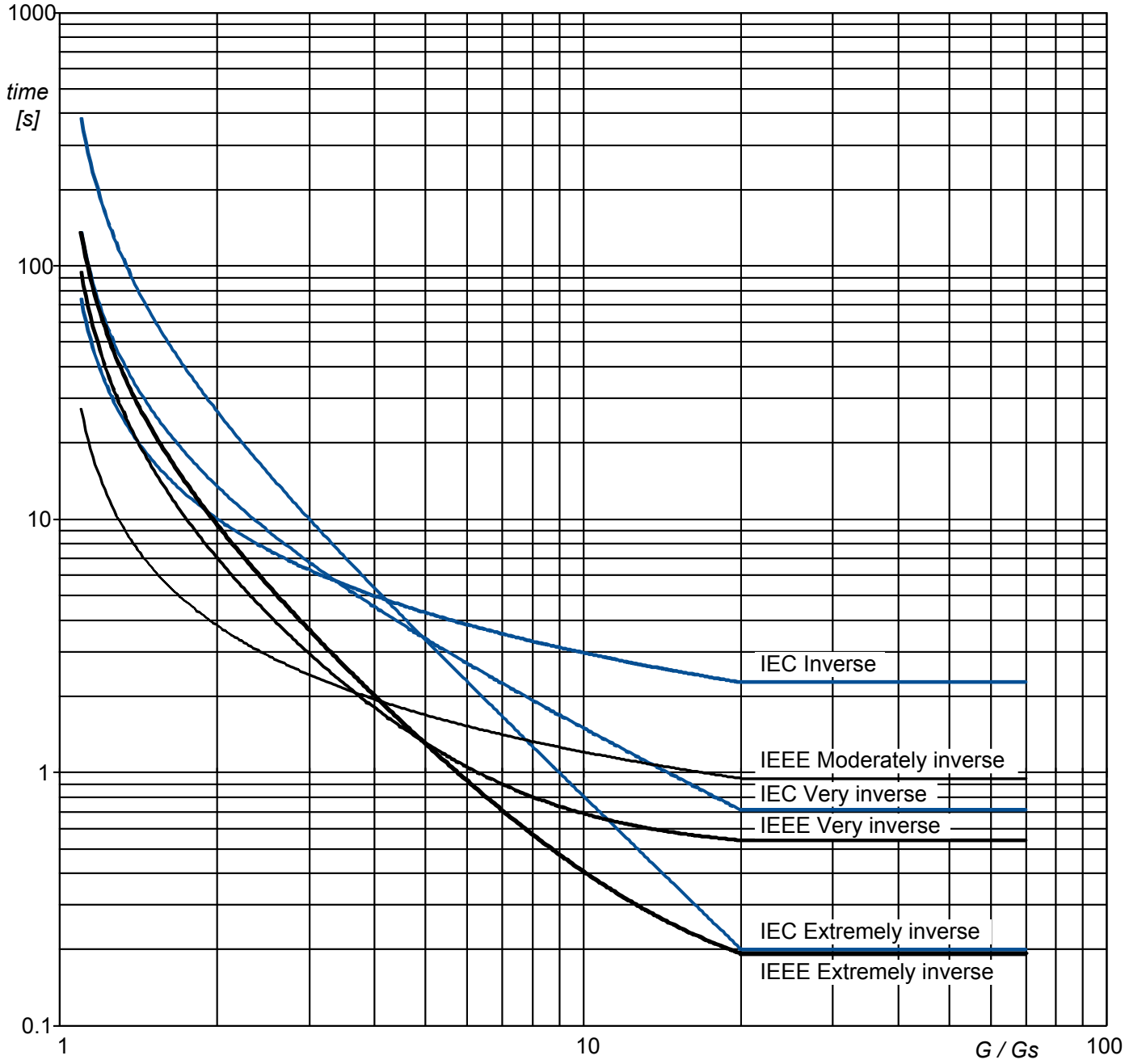
### Standard inverse time over-current curves

The controller includes these standard inverse time over-current curves, in accordance with IEC 60255-151.

**Table 5.1** 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 characteristic | Customisable | Customisable | Customisable |

**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 IEC 60255-151, this point is defined as $G_D = 20 \times G_S$.

The current measurement range (see the data sheet) can limit the controller's ability to follow the characteristic at higher currents. See the * on the simplified representation diagram above.

In this controller, the maximum current measurement is 20 A. If the rated secondary current of the current measurement transformer is **1 A** (that is, the current transformer rating is -/1 A), then $\mathbf{G_D = 20 \times I_{CT\ primary}}$ for this protection. However, if the rated secondary current of the current transformer is **5 A** (that is, -/5 A), then $\mathbf{G_D = 4 \times I_{CT\ primary}}$ .

**Influence of the CT primary current rating on $G_D$ example**

A current transformer has a primary rating of 500 A and a secondary rating of 5 A. The nominal current of the system is 350 A, and the three-phase inverse time over-current alarm *Limit* is 100 %.

| | |
|---|---|
| | $G_D$ of the inverse time over-current characteristic graph according to IEC 60255-151 is 7000 A.<br>• $G_D = 20 \times G_S = 20 \times (I_{nom} \times (Limit / 100)) = 20 \times (350 \times (1 / 1)) = 7000$ A<br><br>However, the highest $G_D$ value where measurements can be made is 2000 A.<br>• Because the secondary current rating is 5 A, the formula to calculate the measurable $G_D$ is $G_D = 4 \times I_{CT\ primary}$.<br>• $G_D = 4 \times I_{CT\ primary} = 4 \times 500 = 2000$ A |

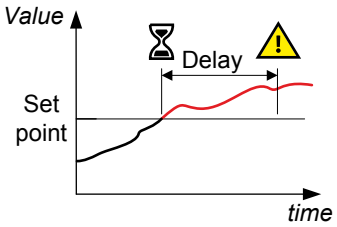
If the time performance at higher currents of the inverse time over-current protection is important, DEIF recommends using a current transformer that is rated for a 1 A secondary current (that is, -/1 A).

## 5.5.13 Negative sequence over-current (ANSI 46)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Negative sequence current | $I_2>$ | 46 | < 200 ms * |

**NOTE** * This operate time includes the minimum user-defined delay of 100 ms.

The alarm response is based on the current state of the negative sequence current part of the current phasors of the A-side. For more information, see Symmetrical components.




Negative sequence current typically occurs due to asymmetrical faults, unbalanced loads, or broken conductors.

Negative sequence current in the stator of a synchronous generator induces a double frequency current in the rotor. This increases the risk of overheating the generator.

**`[A-side] > Current protections > Negative sequence current`**

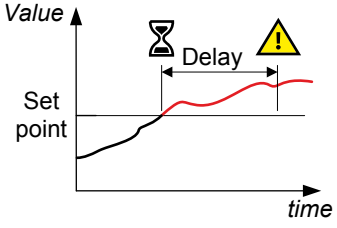
| Parameter | Range |
|---|---|
| `Set point` | 1.0 to 100.0 % of nominal current |
| `Reset hysteresis` | 0.0 to 20.0 % |
| `Delay` | 0.10 s to 2 h |

## 5.5.14 Zero sequence over-current (ANSI $51I_0$)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Zero sequence current | $I_0>$ | $51I_0$ | < 200 ms * |

**NOTE** * This operate time includes the minimum user-defined delay of 100 ms.

The alarm response is based on the current state of the zero sequence current part of the current phasors of the A-side. For more information, see Symmetrical components.




Zero sequence current typically occurs due to earth faults in earthed power systems, or unbalanced loads in four-wire systems (that is, systems with a distributed neutral).

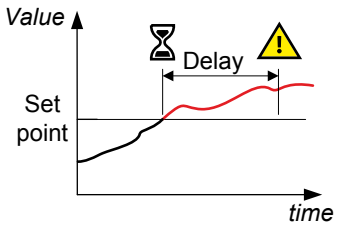
**[A-side] > Current protections > Zero sequence current**

| Parameter | Range |
|---|---|
| Set point | 0.0 to 100.0 % of nominal current |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.10 s to 2 h |

## 5.5.15 [A-side] over-frequency (ANSI 81O)

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

The alarm response is based on the lowest fundamental frequency (based on phase voltage), from the A-side. This ensures that the alarm only activates when all of the phase frequencies are above the set point.



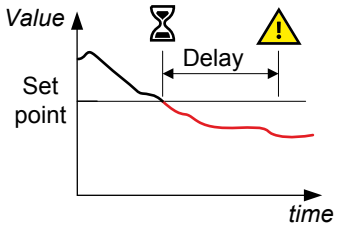

**[A-side] > Frequency protections > Over-frequency #**

| Parameter | Range |
|---|---|
| Set point | 80.0 to 120.0 % of nominal frequency |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.00 s to 2 h |

## 5.5.16 [A-side] under-frequency (ANSI 81U)

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

The alarm response is based on the highest fundamental frequency (based on phase voltage), from the A-side. This ensures that the alarm only activates when all of the phase frequencies are below the set point.



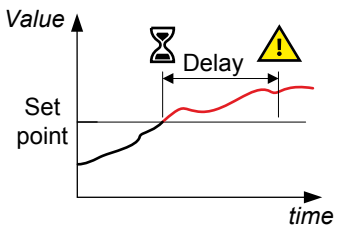

**[A-side] > Frequency protections > Under-frequency #**

| Parameter | Range |
|---|---|
| Set point | 80.0 to 100.0 % of nominal frequency |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.00 s to 2 h |

## 5.5.17 Overload (power export) (ANSI 32)

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

The alarm response is based on the total active power from the A-side, as measured by the controller.




**[A-side] > Power protections > Overload* #**

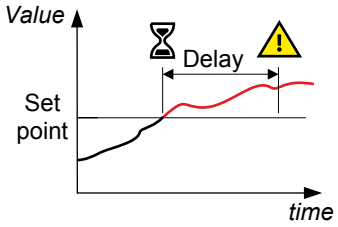
| Parameter | Range |
|---|---|
| Set point | 0.0 to 200.0 % of nominal power |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.00 s to 2 h |

**NOTE** * For a BUS TIE breaker controller, this is **Power export**.

## 5.5.18 Reverse power (power import) (ANSI 32R)

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

The alarm response is based on the total active power to the A-side, as measured by the controller.




**[A-side] > Power protections > Reverse power* #**

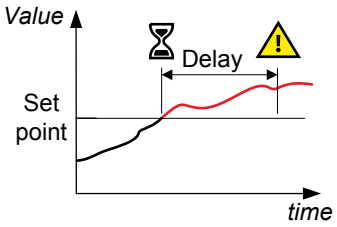
| Parameter | Range |
|---|---|
| Set point | 0.0 to 200.0 % of nominal power |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.00 s to 2 h |

**NOTE** * For a BUS TIE breaker controller, this is **Power import**.

## 5.5.19 Reactive power export (ANSI 40O)

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

The alarm response is based on the total reactive power (Q) from the A-side, as measured and calculated by the controller.



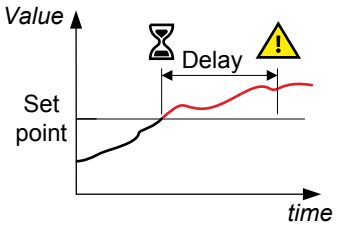

**[A-side] > Reactive power protections > Reactive power export #**

| Parameter | Range |
|---|---|
| Set point | 0.0 to 100.0 % of nominal reactive power |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.00 s to 2 h |

## 5.5.20 Reactive power import (ANSI 40U)

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

The alarm response is based on the total reactive power (Q) to the A-side, as measured and calculated by the controller.




**[A-side] > Reactive power protections > Reactive power import #**

| Parameter | Range |
|---|---|
| Set point | 0.0 to 150.0 % of nominal reactive power (Q) |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.00 s to 2 h |

## 5.5.21 Active synchroniser (ANSI 25A)

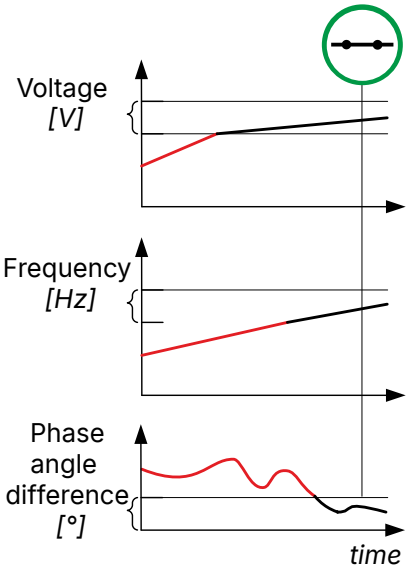
| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Active synchroniser (including blackout close) | - | 25A | - |

For all breakers, the active synchroniser ensures that the voltages, frequencies, and phase are within the allowed limits before the controller closes the breaker.

The active synchroniser can allow blackout close. That is, if the configured conditions are met and equipment is trying to close a breaker to a busbar that does not have voltage, the breaker can be allowed to close without synchronisation.

The synchronisation is based on the frequency difference, the voltage difference, and the phase across the breaker, as measured by the controller.

The active synchroniser on does not have an alarm or inhibits. However, if the controller cannot synchronise within the time allowed, there will be a sync failure alarm.




The active synchroniser is based on the parameters under:

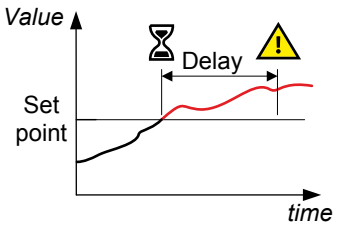
`Breakers > [Breaker] configuration > Synchronisation setting`

# 5.6 B-side AC protections

## 5.6.1 [B-side] over-voltage (ANSI 59)

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

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



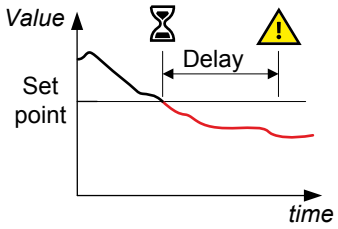

**`[B-side] > Voltage protections > Over-voltage #`**

| Parameter | Range |
|---|---|
| `AC setup` | Phase-phase, Phase-neutral |
| `Set point` | 90.0 to 120.0 % of nominal voltage |
| `Reset hysteresis` | 0.0 to 20.0 % |
| `Delay` | 0.00 s to 2 h |

## 5.6.2 [B-side] under-voltage (ANSI 27)

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

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




**[B-side] > Voltage protections > Under-voltage #**

| Parameter | Range |
|---|---|
| AC setup | Phase-phase, Phase-neutral |
| Set point | 90.0 to 120.0 % of nominal voltage |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.00 s to 2 h |

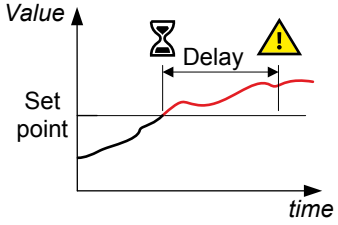
## 5.6.3 [B-side] voltage unbalance (ANSI 47)

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

**NOTE** * This operate time includes the minimum user-defined delay of 100 ms.

The method is based on the ANSI C84.1-2016 calculation method to determine voltage unbalance. The alarm response is based on the highest difference between any of the three B-side phase-to-phase voltage or phase-to-neutral true RMS values and the average voltage, as measured by the controller.

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.




**[B-side] > Voltage protections > Voltage unbalance**

| Parameter | Range |
|---|---|
| AC setup | Phase-phase, Phase-neutral |
| Set point | 0.0 to 50.0 % of nominal voltage |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.10 s to 2 h |

**B-side voltage unbalance example**

The B-side 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 B-side voltage unbalance is 13.3 V / 223.3 V = 0.06 = 6 %

## 5.6.4 [B-side] positive sequence under-voltage (ANSI 27D)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Positive sequence under-voltage | $U_1<$ | 27D | < 60 ms |

The alarm response is based on the voltage state on the positive sequence voltage part of the voltage phasors of the B-side. The positive sequence represents the symmetrical part of the system. For more information, see Symmetrical components.

The positive sequence under-voltage alarm protects, for example, generators from running at a voltage that is too low.

**`[B-side] > Voltage protections > Positive sequence under-voltage`**

| Parameter | Range |
|---|---|
| `Set point` | 10.0 to 110.0 % |
| `Reset hysteresis` | 0.0 to 20.0 % |
| `Delay` | 0.02 s to 2 h |

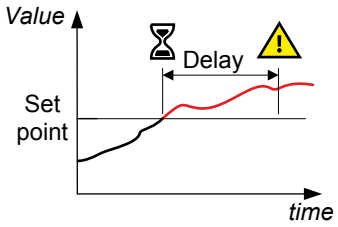
## 5.6.5 [B-side] negative sequence over-voltage (ANSI 47)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Negative sequence voltage | $U_2>$ | 47 | < 200 ms * |

**NOTE** * This operate time includes the minimum user-defined delay of 100 ms.

The alarm response is based on the voltage state of the negative sequence voltage part of the voltage phasors of the B-side. For more information, see Symmetrical components.

Negative sequence voltage typically occurs due to unbalanced loads, or a broken conductor. The negative sequence over-voltage protection protects against unbalanced voltage conditions.




**`[B-side] > Voltage protections > Negative sequence voltage`**

| Parameter | Range |
|---|---|
| `Set point` | 1.0 to 100.0 % of nominal voltage |
| `Reset hysteresis` | 0.0 to 20.0 % |
| `Delay` | 0.10 s to 2 h |

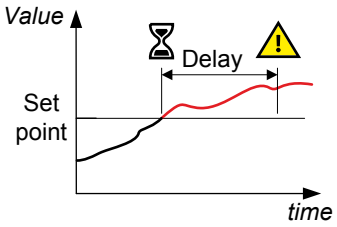
## 5.6.6 [B-side] zero sequence over-voltage (ANSI $59U_0$)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Zero sequence voltage | $U_0$ | $59U_0$ | < 200 ms * |

**NOTE** * This operate time includes the minimum user-defined delay of 100 ms.

The alarm response is based on the voltage state of the zero sequence voltage part of the voltage phasors of the B-side. For more information, see Symmetrical components.

Zero sequence voltage typically occurs due to earth faults or unbalanced loads. The detection of any zero sequence voltage depends on the controller measuring relative to earth or neutral. That is, the controller's neutral voltage terminal (N) must be connected to earth or neutral.



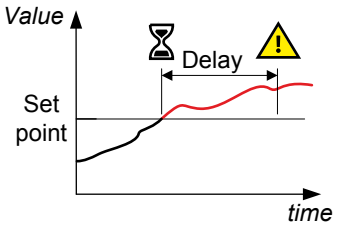

**[B-side] > Voltage protections > Zero sequence voltage**

| Parameter | Range |
|---|---|
| Set point | 0.0 to 100.0 % of nominal voltage |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.10 s to 2 h |

## 5.6.7 [B-side] over-frequency (ANSI 81O)

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

The alarm response is based on the lowest fundamental frequency (based on phase voltage), from the B-side. This ensures that the alarm only activates when all of the phase frequencies are above the set point.



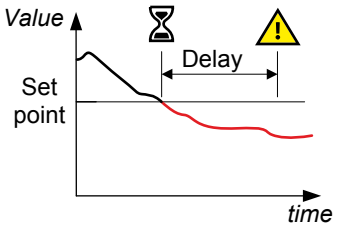

**[B-side] > Frequency protections > Over-frequency #**

| Parameter | Range |
|---|---|
| Set point | 100.0 to 130.0 % of nominal frequency |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.00 s to 2 h |

## 5.6.8 [B-side] under-frequency (ANSI 81U)

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

The alarm response is based on the highest fundamental frequency (based on phase voltage), from the B-side. This ensures that the alarm only activates when all of the phase frequencies are below the set point.



**[B-side] > Frequency protections > Under-frequency #**

| Parameter | Range |
|---|---|
| Set point | 80.0 to 100.0 % of nominal frequency |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.00 s to 2 h |

# 5.7 A-side or B-side AC protections

## 5.7.1 Vector shift (ANSI 78)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Vector shift | dφ/dt | 78 | < 40 ms |

Vector shifts arise when a mains failure occurs while a generator is running parallel with the mains.

Vector shifts can occur because the stator magnetic field lags behind the rotor magnetic field. When a mains failure occurs, the phase angle between the stator and rotor magnetic fields changes. This change in the phase angle, is also known as a vector shift.

The alarm response is based on the change in the phase angle that occurred due to the mains failure. The alarm response can be based on the change in an individual phase, or on the change in all the phases.

In grids where fast automatic reconnection attempts are expected, this protection opens the breaker to prevent damaging failures.

Fast changes in frequency can also activate this alarm. Too sensitive configuration can lead to too many unwanted detections of vector shift.

**Figure 5.1** Vector shift causes the instantaneous phase angle change (Δφ)

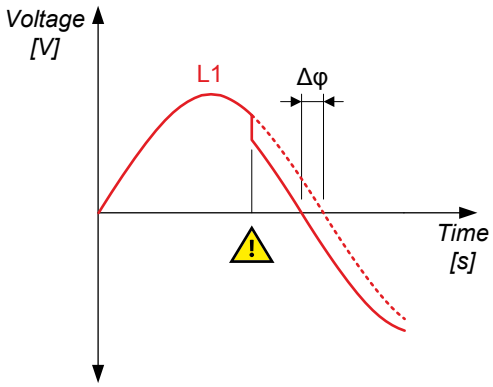



**Figure 5.2** Vector shift in phase L1 only

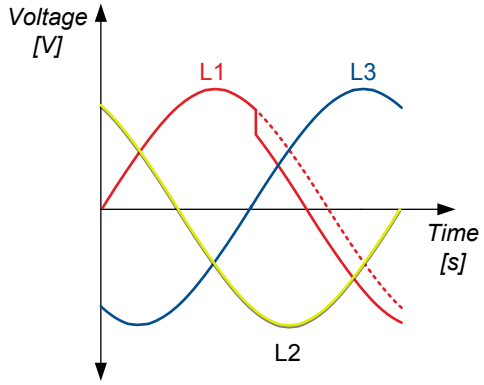
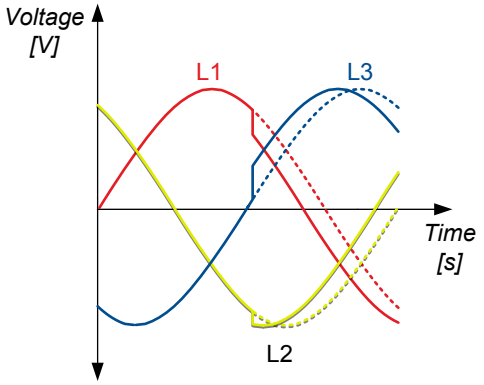



**Figure 5.3** Vector shift in all phases



**[B-side] > Additional protections > Vector shift**

| Parameter | Range |
|---|---|
| AC setup | [B-side], [A-side] |
| Vector shift select | Individual phases, All phases |
| Set point | 1 to 90° |

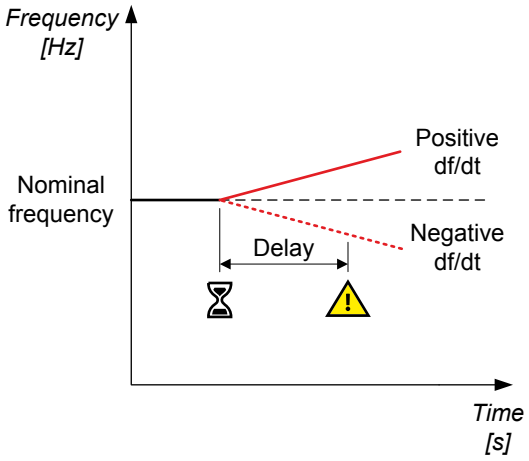
## 5.7.2 Rate of change of frequency (ANSI 81R)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| ROCOF (df/dt) | df/dt | 81R | < 200 ms (12 half periods) |

When a mains failure occurs, the measured frequency can change within a short period of time. This is because the generators can be either instantly overloaded or instantly de-loaded. In grids where fast automatic reconnection attempts are expected, this protection opens the breaker to prevent damaging failures.

If the generator overloads instantly, then it slows down. The generator frequency greatly decreases in a short amount of time. Similarly, if the generator de-loads instantly, it speeds up. The generator frequency increases greatly in a short amount of time.

The alarm response is based on the rate of change of the measured frequency. The rate of change in frequency is based on the zero crossings. A new ROCOF value is calculated for each crossing (up and down), based on values from a configurable number of half periods (*Measurement half period*) preceding this. The ROCOF protection compares this resulting value to the set points (*Positive df/dt set point* and *Negative df/dt set point*). The protection allows the user to configure a *Delay*.




**[B-side] > Additional protections > ROCOF (df/dt)**

| Parameter | Range |
|---|---|
| AC setup | [B-side], [A-side] |
| Measurement half period | 8 to 20 half periods |
| Positive df/dt set point | 0.200 to 10.000 Hz/s |
| Negative df/dt set point | -10.000 to -0.200 Hz/s |
| Delay | 0.0 to 0.5 s |

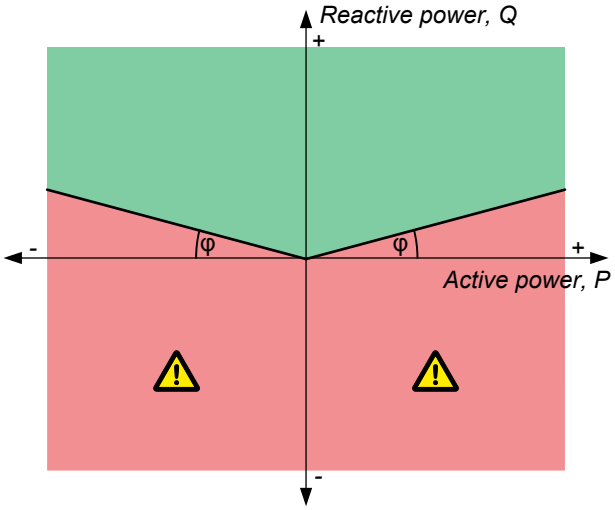
## 5.7.3 Low voltage low reactive power

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Low voltage low reactive power | U< Q< | 27Q | < 250 ms |

The low voltage low reactive power protection (also called QU-protection) is activated when all of the following conditions are met within the delay:

- One voltage measurement is below the *Set point*.
- The feed-in current must be greater than the *V< and Q< I min* set point.
- The angle value is greater than the *V< and Q< angle min* set point.

The alarm response is based on the direction of the reactive power (Q) from the A-side or B-side, all the phase currents, and the voltage as measured and calculated by the controller.



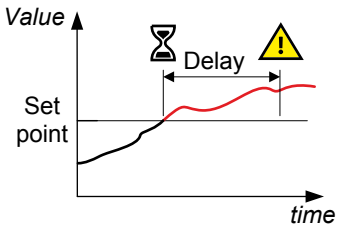

**[A-side or B-side] > Additional protections > V< and Q< #**

| Parameter | Range |
|---|---|
| AC setup | • Phase-phase [B-side]<br>• Phase-neutral [B-side]<br>• Phase-phase [A-side]<br>• Phase-neutral [A-side] |
| I min | 0.0 to 100.0 % |
| Angle min | 0.00 to 10.00° |
| Set point | 0.0 to 100.0 % of nominal reactive power |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.00 s to 120.10 s |

## 5.7.4 Average over-voltage (ANSI 59AVG)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Average over-voltage | | 59AVG | - |

The alarm response is based on the highest average phase-to-phase voltage, or the highest average phase-to-neutral voltage, from the B-side or A-side, averaged during the calculation time.




The average voltage calculation is based on the power quality approach in EN 61000-4-30. The root mean squared (RMS) voltage is measured and aggregated for 10 periods at 50 Hz nominal frequency (this is 12 periods at 60 Hz). This result is then aggregated 15 times (that is, for a 3-second average). Finally, the 3-second averages are aggregated over the aggregate time.

For this protection, the average voltage is measured and calculated over a minimum of 30 seconds, and updated every 3 seconds.

**[B-side or A-side] > Additional protections > Average over-voltage #**

| Parameter | Range |
|---|---|
| AC setup | • Phase-phase [B-side] |

| Parameter | Range |
|---|---|
| | • Phase-neutral [B-side]<br>• Phase-phase [A-side]<br>• Phase-neutral [A-side] |
| V> aggregate time | 30 s to 15 min* |
| Set point | 90.0 to 120.0 % of nominal voltage |
| Reset hysteresis | 0.0 to 20.0 % |
| Delay | 0.00 s to 1 h |

**NOTE** * The selected value is rounded down to the nearest multiple of 3 seconds. For example, if the *V> aggregate time* is set to 38 seconds, the controller uses an aggregate time of 36 seconds.

The calculations are reset if the parameters are changed, or if there is any gap in the measurement.

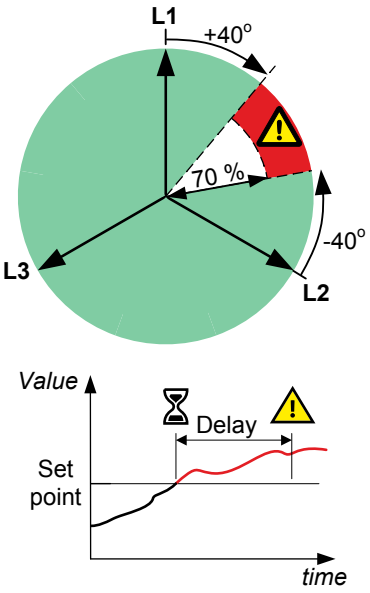
## 5.8 Other AC protections

### 5.8.1 Phase sequence error

The controller continuously checks the L1 and L2 line voltage phasors on either side of the breaker against the orientation defined in the controller (see AC configuration). If the voltage is more than the detection voltage, and the phase differs from expected 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 [A-side], and another alarm for the voltage on the [B-side].

The alarm action is *Trip [Breaker]* and cannot be changed.




**[A-side] > AC setup > Phase sequence error**

| Parameter | Range |
|---|---|
| Detection voltage * | 30 to 90 % of nominal A-side voltage |
| Delay | 1 to 10 s |

**NOTE** * The alarm is inhibited if the voltage is below the set point.

**[B-side] > AC setup > Phase sequence error**

| Parameter | Range |
|---|---|
| Detection voltage * | 30 to 90 % of nominal B-side voltage |
| Delay | 1 to 10 s |

**NOTE** * The alarm is inhibited if the voltage is below this set point.

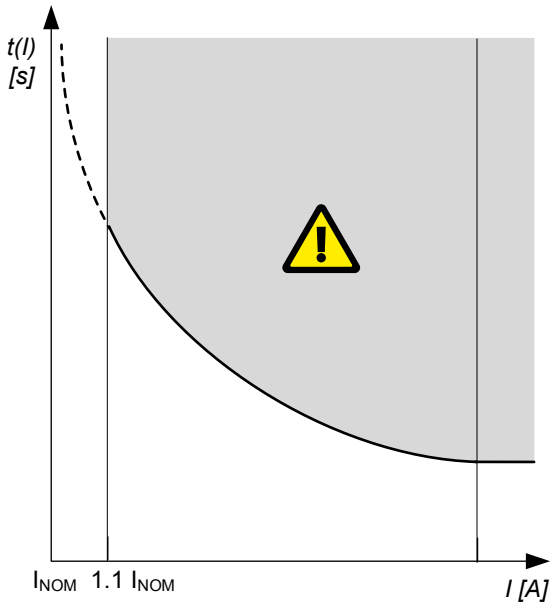
## 5.8.2 Earth inverse time over-current (ANSI 51G)

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

The alarm response is based on the earth current, as measured by the 4th current measurement filtered to attenuate the third harmonic (at least 18 dB; a 128 tap FIR low pass filter is applied). The A-side frequency, as measured by the controller (f), 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.

Note: The diagram on the right is a simplified representation of this alarm. The diagram does not show the integral over time.




### Wiring

You must wire the 4th current measurement on MIO2.1 (terminals 70,71) to measure the earth current.

**More information**
See **I4 current** in the **Installation instructions** for an example of how to wire the earth current measurement.

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

**`Local > 4th current input > Earth inverse time over-current`**

| Parameter | Range |
|---|---|
| `Curve` | See below |
| `Limit` (the set point, also known as LIM) | 2.0 to 200.0 % of nominal current (4th current input) |
| `Time multiplier setting` (TMS) | 0.01 to 100.00 |
| `Threshold` | 1.000 to 1.300 |
| `k` * | 0.001 s to 2 min |
| `c` * | 0.000 s to 1 min |
| `alpha (α, or a)` * | 0.001 s to 1 min |

**NOTE** * Only used if custom curve is selected.

**More information**
See Inverse time over-current (ANSI 51) for the calculation method, the standard curves, and information about the definite time characteristic.

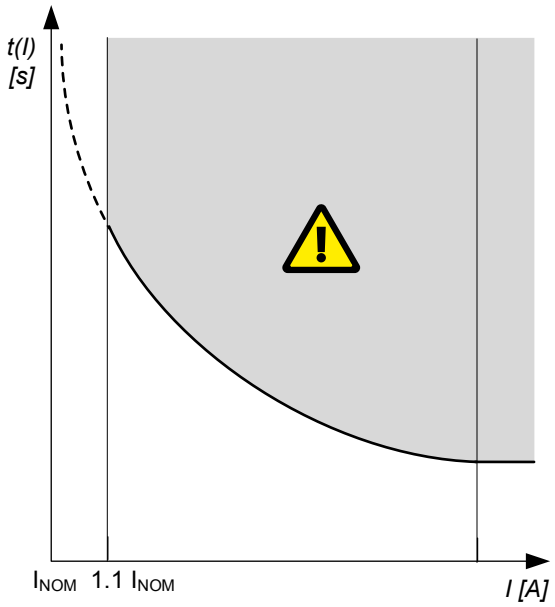
## 5.8.3 Neutral inverse time over-current (ANSI 51N)

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

The alarm response is based on the RMS 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.

Note: The diagram on the right is a simplified representation of this alarm. The diagram does not show the integral over time.




### Wiring

You must wire the 4th current measurement on MIO2.1 (terminals 70,71) to measure the ground current.

**More information**
See **I4 current** in the **Installation instructions** for an example of how to wire the neutral current measurement.

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

**`Local > 4th current input > Neutral inverse time over-current`**

| Parameter | Range |
|---|---|
| `Curve` | See below |
| `Limit` (the set point, also known as LIM) | 2.0 to 200.0 % of nominal current (4th current input) |
| `Time multiplier setting` (TMS) | 0.01 to 100.00 |
| `Threshold` | 1.000 to 1.300 |
| `k` * | 0.001 s to 2 min |
| `c` * | 0.000 s to 1 min |
| `alpha (α, or a)` * | 0.001 s to 1 min |

**NOTE** * Only used if custom curve is selected.

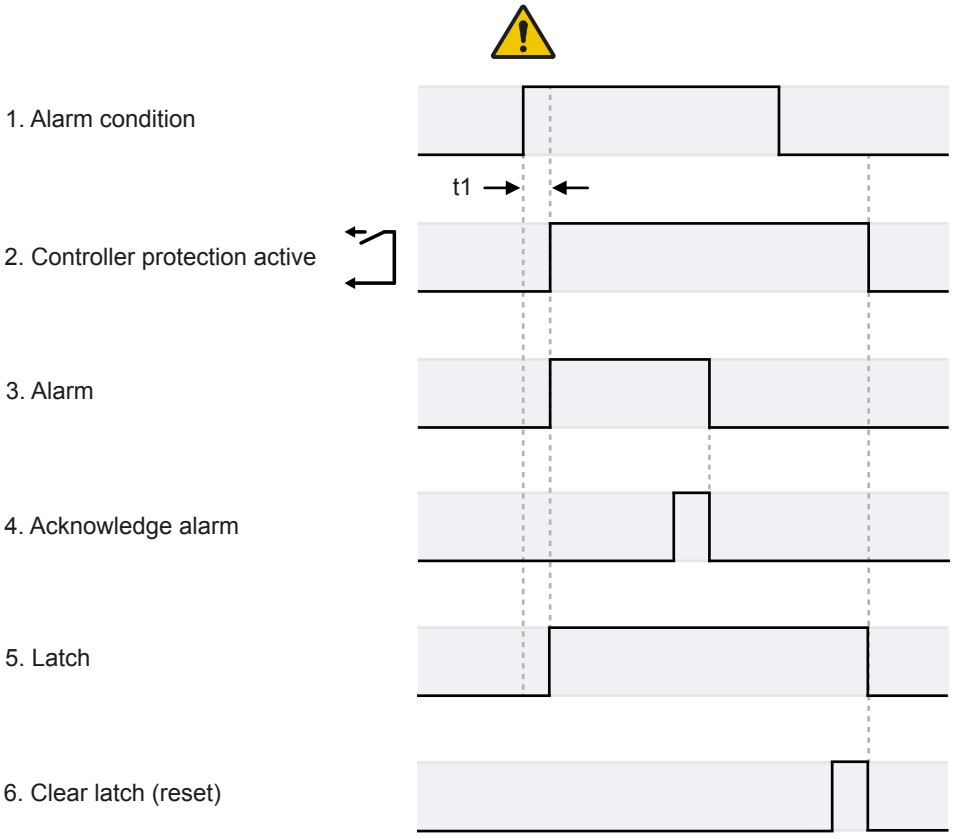
**More information**
See Inverse time over-current (ANSI 51) for the calculation method, the standard curves, and information about the definite time characteristic.

## 5.8.4 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) | 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 (t1), the protection activates.
2. **Controller protection active**
   - 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. **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 latch (reset)**

- 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 `[Alarm location] > [Alarm] > Latch`

`[Alarm location]` is the location of the alarm parameters, for example, `Busbar > Voltage protections`.

`[Alarm]` is the alarm name.

| NOTICE |
| --- |
| **Not powered controller opens digital outputs**<br>If the controller is not powered, the controller opens the digital outputs. |

| NOTICE |
| --- |
| **Latched alarms do not trip breaker again if breaker manually operated**<br>Alarms that are latched do 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.

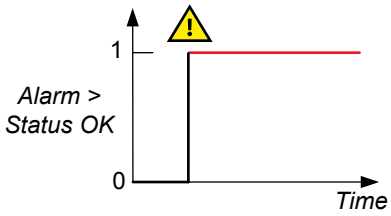
When the controller is connected to an external lockout relay, the controller interfaces with the lockout relay. When the controller interfaces with an external lockout relay, the controller is not seen as the lockout relay for the system.

# 6. Alarms and protections

## 6.1 General system alarms

### 6.1.1 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 software.
- All the modules required for a specific 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.

  **More information**
  See **Fieldbus troubleshooting** in the PICUS manual for EtherCAT connection errors and extension rack problems.
- The controller software has started and is running OK.

By default, the *Status OK* alarm output is configured to terminals 7 and 10 on the controller.

**`Local > Monitoring > System not OK`**

This alarm is always enabled.

**More information**
See Alarm status digital outputs for how the *Status OK* alarm is configured.

### 6.1.2 Critical process error

The alarm communicates that the controller's critical communication and/or processing are disrupted.

The alarm action is *Warning* and the alarm is always enabled. The controller also activates the *System not OK* alarm. The alarm parameters are not visible.

It is unlikely that customers will see this alarm. If you do see this alarm take the following actions:

1. Restart the controller.
2. If restarting does not help, update the controller software to the latest version.
3. Contact DEIF.

### 6.1.3 Configuration update delayed

The controller activates this alarm if an operator and/or external equipment is changing the controller configuration too quickly. For example, a programming error on a PLC can create a storm of Modbus changes.

To protect the controller's internal memory, the excess configuration changes are not stored immediately. The delay can be up to 10 minutes. If the controller loses power during this time, the changes may be lost.

The alarm is always enabled. The alarm action is *Warning*. The alarm is automatically acknowledged when the configuration changes are stored. The alarm parameters are not visible.

### 6.1.4 Not under remote control

This alarm communicates that the controller is not under remote control (that is, the controller is under local control).

**`Local > Mode > Not under remote control`**

| Parameter | Range |
|---|---|
| `Delay` | 0.0 s to 1 h |

### 6.1.5 AC protections not running

This alarm communicates that there is a problem with the AC protections and/or that the controller has an EtherCAT connection problem. The alarm parameters are not visible.

**More information**
See **Fieldbus troubleshooting** in the PICUS manual for EtherCAT connection errors and extension rack problems.

### 6.1.6 Fieldbus connection missing

This alarm is for the internal communication between the controller and its extension units. If there is a redundancy connection, this alarm communicates that an Ethernet connection is missing or broken.

The alarm is always enabled, and the alarm action is *Warning*. The alarm parameters are not visible.

### 6.1.7 Fieldbus conflict

This alarm is for the internal communication between the controller and its extension units. If there is a hardware change or hardware failure, this alarm communicates that the hardware configuration does not match the previous hardware configuration.

The alarm is always enabled, and the alarm action is *Block*. The alarm parameters are not visible.

Use `Configure > Fieldbus configuration` in PICUS to correct the hardware configuration.

### 6.1.8 Controller ID not configured

This alarm communicates that the user has never configured the *Controller ID*.

The alarm is always enabled and the action is *Warning*. The alarm parameters are not visible.

### 6.1.9 Trip AVR output not configured

This alarm communicates that there is an alarm configured that has a *Trip AVR* alarm action, but the *Trip AVR* output is not configured.

The alarm is always enabled and the action is *Warning*. The alarm parameters are not visible.

The *Trip AVR* digital output can be configured under `Generator > AVR > Trip AVR` on the Input/output page. Alternatively the output can be configured using Modbus.

### 6.1.10 NTP server not connected

The alarms *NTP server 1 not connected*, *NTP server 2 not connected*, or *No NTP server(s) connected* are activated when the NTP server(s) are configured, but the controller did not connect to the server(s) within 10 minutes after the

configuration is written to the controller. These alarms are triggered if the controller network cannot access the NTP server(s), or if the NTP server(s) are not set up correctly.

Configure the parameters for these alarms under `Communication > NTP`. The alarm action is always *Warning* and cannot be changed.

### 6.1.11 NTP server no response

The alarms *NTP server 1 no response*, *NTP server 2 no response*, or *No NTP server time synchronisation* are activated when the controller was successfully connected to NTP server(s), but the server(s) did not respond to the controller for up to 22 minutes.

Configure the parameters for these alarms under `Communication > NTP`. The alarm action is *Warning* and cannot be changed.

### 6.1.12 Licence error

This alarm communicates that the controller's Application licence is not valid.

The alarm action is *Block* and the alarm is always enabled. The controller also activates the *System not OK* alarm. The alarm parameters are not visible.

It is unlikely that customers will see this alarm. If you do see this alarm take the following actions:

1. Restart the controller to see if the alarm clears.
2. If restarting does not help, check that the Application selector parameter is not configured to a licence not present or active on your controller.
   - You can use WebConfig and Licence manager to check the licences installed.
3. Contact DEIF for assistance.

### 6.1.13 Live power detected (emulation)

This alarm informs the operator that live power was detected during emulation.

The controller activates this alarm if `Test functions > Emulation > Emulation active` is *Enabled* and live power is detected on MIO2.1.

The alarm is always enabled. You cannot see or change the alarm parameters.

### 6.1.14 Emulation disabled (live power)

This alarm informs the operator that emulation has been disabled (because live power was detected during emulation).

The controller activates this alarm if `Test functions > Emulation > Emulation active` is *Enabled* and live power is detected on MIO2.1. The alarm changes the emulation parameter to *Not enabled* on all controllers in the system.

The alarm is always enabled. You cannot see or change the alarm parameters.

## 6.2 Custom input alarms

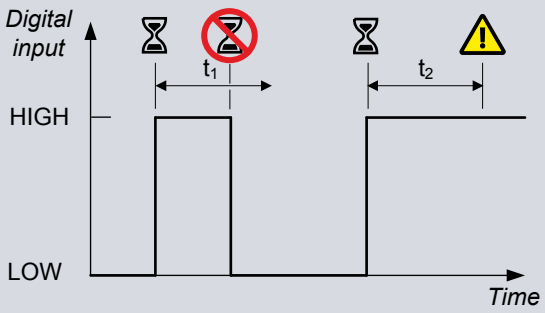
### 6.2.1 Digital input (DI) alarms

You can configure custom alarms for any of the controller 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.

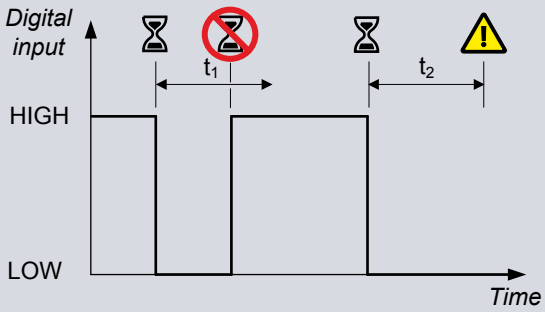
By default, a digital input (DI) is normally low, and the alarm is activated if the digital input is high for longer than the *Time delay*.




**LOW input trigger example**

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

Select *Low* for the alarm trigger level.




**`Input/output > [Hardware module] > DI > Alarms`**

| Parameter | Range | Notes |
|---|---|---|
| `Name` | Text | Name for the alarm |
| `Trigger level` | Low, High | Whether the alarm is triggered at **High** or **Low**. |
| `Delay` | 0 s to 1 h | |

## 6.2.2 Analogue input (AI) alarms

You can configure custom alarms for the controller analogue inputs (AI). When the analogue input alarm set point is exceeded for longer than the delay time, then the alarm becomes active in the system and the controller does the associated alarm action.

Configure the analogue input (AI) sensor setup (including the scale) before creating an alarm for the input. The configuration of the analogue input determines the configuration of the alarm. For example, the analogue input can be configured as a 0 to 20 mA current input that corresponds to a percentage. The analogue input alarm is then configured for a certain percentage set point.

**More information**
See Analogue input characteristics and configuration for how to configure sensor failure alarms.

**`Input/output > [Hardware module] > AI > Alarms`**

| Parameter | Range | Notes |
|---|---|---|
| `Name` | Text | Name for the alarm |
| `Trigger level` | Low, High | Whether the alarm is triggered at **High** or **Low**. |
| `Delay` | 0 s to 1 h | |
| `Set point` | Varies | Depends upon selected input scale unit |
| `Reset hysteresis` | Varies | Depends upon selected input scale unit |

**Low oil pressure analogue input alarm example**

Configure the analogue input for the oil pressure sensor under **[Hardware module] > AI > Sensor setup**. In this example, the sensor provides a 4 to 20 mA signal, which corresponds linearly to 0 to 10 bar.

Configure the sensor as follows:
Sensor = *0 to 25 mA*
Units = *bar*
Select an unused *Custom input scale #*.
Input (mA), Minimum = *4*, Maximum = *20*
Output (bar), Minimum = *0*, Maximum = *10*
Create two points for the curve: *4 mA and 0 bar*; and *20 mA and 10 bar*.

Configure the alarm as follows:
Name = *Low oil pressure*
Trigger level = *Low*
Enable = *Enabled*
Delay = *0.1 seconds*
Set point = *1 bar*
Action = *Trip generator breaker and shutdown engine*
Inhibit = *Engine not running*

If the engine is running, but the oil pressure falls below 1 bar (this corresponds to an analogue input of less than 5.6 mA) for more than 0.1 seconds, then the alarm is activated. The controller trips the breaker and shuts down the engine.

## 6.3 General hardware module alarms

### 6.3.1 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. The alarm action is *Warning*. The alarm parameters are not visible.

**NOTE** This alarm is only activated if you install a replacement hardware module in the controller. The new module can have different software to the rest of the controller. Reinstall or update the controller firmware to fix the problem. This alarm activates the *System not OK* alarm.

### 6.3.2 Required hardware card(s) not found

This alarm communicates that some of the default hardware modules for the controller type were not found. The alarm action is *Warning*. The controller also activates the *System not OK* alarm. The alarm parameters are not visible.

If one or more default controller hardware modules are missing, then this alarm is activated on start-up.

### 6.3.3 Card issue detected

This alarm is for issues with a hardware module. If an issue is detected with a hardware module, the alarm is activated. This indicates that there is a problem with a hardware module.

The alarm is always enabled, and the alarm action is *Warning*. The alarm parameters are not visible.

The value in the Event log shows which hardware module has an issue. It could be a hardware defect.

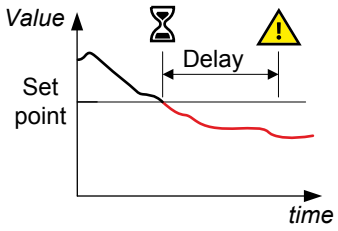
Contact DEIF product support for assistance and help identify the hardware issue. This may require a replacement hardware module.

# 6.4 Controller

## 6.4.1 PCM2.1 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 controller. The alarm is activated when the power supply voltage is less than the set point for the delay time.



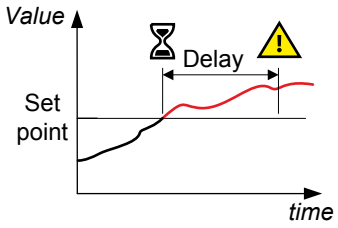

**`Hardware > PCM2.1 > Low voltage alarm`**

| Parameter | Range |
|---|---|
| `Set point` | 8.0 to 32.0 V DC |
| `Delay` | 0 s to 1 h |

## 6.4.2 PCM2.1 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 controller. The alarm is activated when the power supply voltage exceeds the set point for the delay time.




**`Hardware > PCM2.1 > High voltage alarm`**

| Parameter | Range |
|---|---|
| `Set point` | 12.0 to 36.0 V DC |
| `Delay` | 0 s to 1 h |

## 6.4.3 Controller temperature too high

This is a built-in alarm for the controller internal temperature, as measured on the controller. The alarm is triggered when the controller internal temperature is higher than 80 °C (176 °F). The alarm action is *Warning*. The alarm parameters are not visible.

If the controller operates at internal temperatures higher than 80 °C (176 °F), the performance and the lifetime of the controller is significantly reduced.

## 6.4.4 Clock battery failure alarm

The *Clock battery failure* alarm is activated when the battery in controller needs to be replaced. The alarm action is *Warning*. The alarm parameters are not visible.

## 6.4.5 Network and communication alarms

### 6.4.5.1 Data loss from a controller

This alarm is for data loss detected from a controller. If there is more than 5% data loss for over 60 seconds, the alarm is activated. This can indicate a bad network or an overloaded controller.

The alarm is always enabled, and the alarm action is *Warning*. The alarm parameters are visible.

It is recommended to run network diagnostics of the network if this alarm is activated.

**System > Monitoring > Data loss from a controller**

| Parameter | Range |
|---|---|
| Set point | 0 to 100.0 % |
| Delay | 0.0 s to 1 h |

## 6.4.5.2 Data loss on DEIF network

This alarm is for data loss detected on the DEIF network. If there is more than 5% data loss for over 60 seconds, the alarm is activated. This can indicate a bad network or an overloaded controller.

The alarm is always enabled, and the alarm action is *Warning*. The alarm parameters are visible.

It is recommended to run network diagnostics of the network if this alarm is activated.

**System > Monitoring > Data loss on DEIF network**

| Parameter | Range |
|---|---|
| Set point | 0 to 100.0 % |
| Delay | 0.0 s to 1 h |

## 6.4.5.3 Unknown traffic on DEIF network

This alarm is for unknown traffic detected from on the DEIF network. If there is unknown data detected on the network, the alarm is activated without delay. This can indicate non-DEIF equipment sending data that may affect the DEIF communication.

The alarm is always enabled, and the alarm action is *Warning*. The alarm parameters are not visible.

It is recommended to check both cable wiring and remove any non-DEIF equipment from the network if this alarm is activated.

## 6.4.5.4 High traffic on DEIF network

The alarm is used to detect potential foreign noise or unwanted data traffic on the DEIF communication ring. If interference is suspected, the alarm can be enabled for diagnostic purposes. The alarm is disabled by default. When enabled, the alarm action is *Warning*, and the alarm parameters are visible.

**NOTE** This alarm is not intended to be active during normal operation.

### Operational guidelines when the alarm is enabled

To reduce communication load on the DEIF network when the alarm is active:

- Operate with only the minimum number of controllers required.
- Avoid actions that generate unnecessary communication, such as opening or closing breakers.

During normal system operation, natural communication between controllers may cause the alarm to activate when enabled. Such activation is expected and does not necessarily indicate a fault.

**System > Monitoring > High traffic on DEIF network**

| Parameter | Range |
|---|---|
| Set point | 100.0 to 500.0 % |
| Delay | 0.0 s to 1 h |

# 6.5 Measurement Input Output module MIO2.1

## 6.5.1 Relay # wire break alarms

These alarms are for MIO2.1 configured digital output channels. The wire break monitoring is only active when the digital output is open.

**Hardware > MIO2.1 > Relay # supervision ***

| Parameter | Range |
|---|---|
| Delay | 0.0 s to 1 h |

**NOTE** * # is 9 to 16.

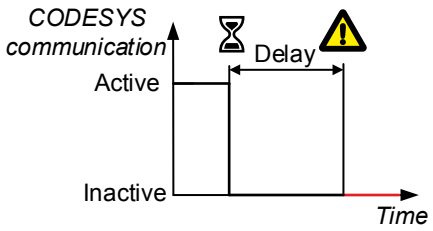
# 6.6 CODESYS alarms

## 6.6.1 CODESYS application not OK

This alarm alerts the operator that there is a communication problem between CODESYS and the controller.

If communication between CODESYS and the controller was active and became inactive, the delay timer starts. If the communication does not become active within the delay period, the alarm is triggered.

Controller types: This alarm is present in all controllers that have CODESYS installed.




**CODESYS > Monitoring > Application not OK**

| Parameter | Range |
|---|---|
| Startup time | 0 to 600 s |
| Delay | 0.00 s to 5 min |

## 6.6.2 CODESYS configuration conflict

If the same input/output function is configured in CODESYS and the controller *at the same time*, this alarm is triggered.

The conflict sets the **Link_OK** output on the controller function block in the program to **FALSE**.

Controller types: This alarm is present in all controllers that have CODESYS installed.

**CODESYS > Monitoring > I/O config conflict**

This alarm is always enabled.

To clear the alarm, you can either:

- Remove the conflicting function from the CODESYS project, and update the CODESYS application on the controller.
- Remove the conflicting function from the controller, and perform a warm reset of the CODESYS application.

# 6.7 Event logging

## 6.7.1 App logging failure

This alarm is for detection of any corrupted information detected in the log. If there is any detected corrupted data in the application log, the alarm is activated.

The alarm is always enabled, and the alarm action is *Warning*. The alarm parameters are not visible.

In the unlikely event this alarm occurs, contact DEIF product support for assistance.

## 6.7.2 Event logging failure

This alarm is for detection of any corrupted information detected in the log. If there is any detected corrupted data in the event log, the alarm is activated.

The alarm is always enabled, and the alarm action is *Warning*. The alarm parameters are not visible.

In the unlikely event this alarm occurs, contact DEIF product support for assistance.

# 7. Breakers, synchronisation and de-loading

## 7.1 About

### 7.1.1 How it works

A number of power sources can supply power to the same busbar. To connect to a live busbar, these power sources must be synchronised in order to safely connect them. Synchronisation consists of matching the voltage, frequency and phases on both sides of the breaker that must be closed.

The **SINGLE genset** and **GENSET** controllers can adjust the frequency and phase of the genset(s) by regulating their governors.

The **SINGLE genset** and **GENSET** controllers can adjust the voltage of the genset(s) by regulating their AVRs.

Each controller type monitors the voltage, frequency and phase across its breaker. If the measurements are within the configured limits, the controller can activate the `Breakers > [Breaker] > Controls > [*B] close` output.

**More information**
See Regulation for information on the regulation of the gensets.
See **each controller type** for information on each controller's breaker sequences.

### 7.1.2 Regulation required for synchronisation

#### SINGLE genset controller

In REMOTE and LOCAL mode, when a **SINGLE genset** controller gets a *Close generator breaker* command, the controller ignores the selected regulator mode and external set points. The controller automatically uses the voltage and frequency regulation parameters to synchronise the genset to the busbar. For static synchronisation, the controller also uses the phase regulation parameters.

When a **SINGLE genset** with mains breaker controller gets a *Close mains breaker* command, the controller automatically uses the voltage and frequency parameters to synchronise the genset to the mains. For static synchronisation, the controller also uses the phase regulation parameters.

If the controller is in NO REG mode, the controller does not regulate the genset. The operator can however manually synchronise the genset.

#### GENSET controller

In REMOTE and LOCAL mode, when a **GENSET** controller gets a *Close breaker* command, the controller ignores the selected regulator mode and external set points. The controller automatically uses the voltage and frequency regulation parameters to synchronise the genset to the busbar. For static synchronisation, the controller also uses the phase regulation parameters.

If the controller is in NO REG mode, the controller does not regulate the genset. The operator can however manually synchronise the genset.

#### MAINS and BUS TIE breaker controllers

**MAINS** and **BUS TIE breaker** controllers do not regulate.

When one of these controllers gets a *Close breaker* command, it broadcasts over the network the voltage and frequency that it requires to synchronise. In response, the **GENSET** controller(s) in the same section then regulate according to the set point.

### 7.1.3 Regulation required for de-loading

Regardless of the type of regulation, when the de-loading requirements are met (within the time available for de-loading), the controller automatically opens the breaker.

#### SINGLE genset controllers

When a **SINGLE genset** controller gets a *Open generator breaker* command, the controller ignores the selected regulator mode and external set points. The controller automatically uses the fixed power ramp down and parameters for regulation to de-load the genset. However, if manual regulation is active, the operator can de-load the genset, but the controller does not automatically de-load the genset. If regulation is off, the controller does not de-load the genset and trips the breaker.

When a **SINGLE genset** with mains breaker controller gets a *Open mains breaker* command, and there is a mains power measurement, the controller ignores the selected regulator mode and external set points. The controller automatically de-loads the mains if a mains power measurement is available. However, if manual regulation is active, the operator can de-load the mains, but the controller does not automatically de-load the mains. If regulation is off, or if there is no mains power measurement, the controller does not de-load the mains and trips the breaker.

**`Breakers > Generator breaker configuration > De-load last breaker`**

| Parameter | Range | Comment |
|---|---|---|
| Load share | Not enabled, Enabled | **Enabled**: The last breaker can be de-loaded when the regulation mode is power load sharing. |
| Fixed frequency | Not enabled, Enabled | **Enabled**: The last breaker can be de-loaded when the regulation mode is fixed frequency. |

#### GENSET controllers

When a **GENSET** controller gets a *Open breaker* command, the controller ignores the selected regulator mode and external set points. The controller automatically uses the fixed power ramp down and parameters for regulation to de-load the genset. However, if manual regulation is active, the operator can de-load the genset, but the controller does not automatically de-load the genset. If regulation is off, the controller does not de-load the genset and trips the breaker.

#### MAINS and BUS TIE breaker controllers

**MAINS** and **BUS TIE breaker** controllers do not regulate.

When one of these controllers gets an *Open breaker* command, it broadcasts over the network the active and reactive power set point that it requires to de-load. In response, the **GENSET** controller(s) in the same section that have External set point(network) activated then regulate according to the network set point (and their power ramps).

When one of these controllers gets an *Open breaker* command, it broadcasts over the network the active and reactive power set point that it requires to de-load. In response, the **GENSET** controller(s) in the same section that have active regulation then regulate according to the set point (and their power ramps). However, if manual regulation is active, the operator can de-load the breaker, but the controller does not automatically de-load the breaker. If there is no regulation available in the connecting section(s), the controller trips the breaker.

#### Reactive power de-loading

To ensure stability, by default the regulation uses a Fixed cos phi set point during the active power de-loading. When the active power is close to the open point, the controller changes the cos phi set point to 1.0. Alternatively, you can select Reactive power curve.

**More information**
See the reactive power ramp down in AVR regulation function in the Regulation chapter.

## 7.2 Synchronisation in each controller mode

### 7.2.1 Synchronisation in LOCAL mode

If the controller is under local control, to start synchronisation, the operator must press the push-button **Close breaker** CLOSE on the display. The controller automatically closes the breaker if the synchronisation meets the requirements within the time allowed.

### 7.2.2 Synchronisation in REMOTE mode

If the controller is under remote control, to start synchronisation, the controller must receive an external command (for example, from a digital input, PICUS, Modbus, CustomLogic, CODESYS, or a PLC). The controller monitors the synchronisation, and automatically closes the breaker if the synchronisation meets the requirements within the time allowed.

### 7.2.3 Synchronisation in NO REG mode

In NO REG mode, the operator can do the synchronisation manually.

Regardless of the regulation, if the synchronisation requirements are met (within the time available for synchronisation), the controller automatically closes the breaker.

#### Manual regulation in NO REG mode using controller inputs

The switchboard manual regulation buttons can be connected to digital inputs on the controller, and configured with the following functions:

- `Regulators > GOV > Manual > Manual GOV increase`
- `Regulators > GOV > Manual > Manual GOV decrease`
- `Regulators > AVR > Manual > Manual AVR increase`
- `Regulators > AVR > Manual > Manual AVR decrease`

During manual regulation, when the operator presses the buttons, the controller adjusts the governor and/or AVR output.

During manual regulation to synchronise, the controller status text may be *Manual regulation* rather than *Synchronising [*B]*. However, if the breaker close command is still active and the synchronisation requirements are met, the controller automatically closes the breaker.

## 7.3 Configuring breakers

### 7.3.1 Breaker commands

#### Digital inputs (optional)

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

| Function | I/O | Type | Details |
|---|---|---|---|
| `Breakers > [Breaker] > Command > [*B] open` | Digital input | Pulse | This input has the same effect as pressing the *Breaker open* on the display. |
| `Breakers > [Breaker] > Command > [*B] close` | Digital input | Pulse | This input has the same effect as pressing the *Breaker close* on the display. |

| Function | I/O | Type | Details |
|---|---|---|---|
| `Breakers > [Breaker] > Command > Block [*B] close` | Digital input | Continuous | The controller does not allow the breaker to close while this input is active. |
| `Breakers > [Breaker] > Command > [*B] open without de-loading` | Digital input | Pulse | If the controller is under remote control, then activating this digital input opens the breaker without de-loading the breaker. |

### 7.3.2 Pulse breaker

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

#### Wiring examples

**More information**
See **Breaker wiring** in the **Installation instructions** for an example of pulse breaker wiring.

#### Inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Breakers > [Breaker] > Controls > [*B] close` | Digital output | Pulse | The controller activates the *[*B] close* output to close the breaker. |
| `Breakers > [Breaker] > Controls > [*B] open` | Digital output | Pulse | The controller activates the *[*B] open* output to open the breaker. |
| `Breakers > [Breaker] > Controls > [*B] trip` | Digital output | Continuous | The controller activates the *Trip* output when an alarm with a trip breaker action activates.<br><br>The output remains active until all alarms with a trip breaker action are resolved. |
| `Breakers > [Breaker] > Feedback > [*B] open` | Digital input | Continuous | Wire this feedback from the breaker, to inform the controller when the breaker is open. |
| `Breakers > [Breaker] > Feedback > [*B] closed` | Digital input | Continuous | Wire this feedback from the breaker, to inform the controller when the breaker is closed. |
| `Breakers > [Breaker] > Feedback > [*B] short circuit` | Digital input | Continuous | Optional: Wire this feedback from the breaker, to inform the controller if a short circuit occurs. |

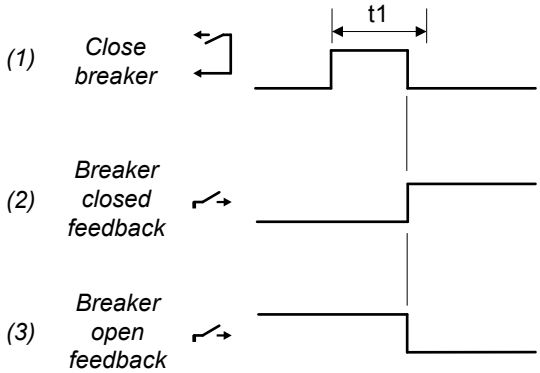
#### Parameters

**`Breakers > [Breaker] configuration > Configuration`**

| Parameter | Range | Notes |
|---|---|---|
| `Breaker type` | • Pulse breaker<br>• Compact breaker<br>• Continuous breaker | This breaker requires a pulse signal to close, and a different pulse signal to open. |
| `Pulse time ON` | 0.0 to 60.0 s | The length of the breaker close pulse (that is, the maximum amount of time that the `Breakers > [Breaker] > Control > [*B] close` output is activated).<br><br>If the controller receives breaker closed feedback within this time, the controller stops activating the breaker close output. |
| `Open point (de-loading)` | 1.0 to 20.0 % of nominal power | The breaker is de-loaded when the power flowing through the breaker is less than this set point. The nominal power is the nominal power of the [A-side]. |

### Sequence diagram

**Table 7.1** Closing a pulse breaker

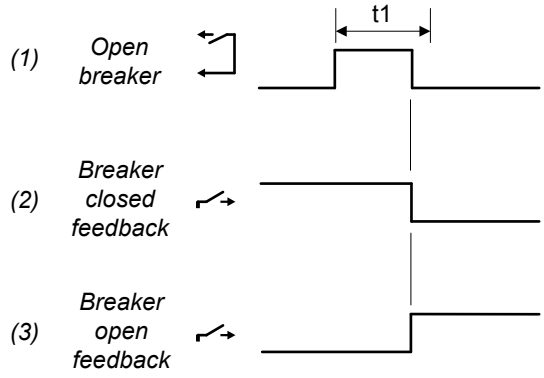



t1 Pulse on (`Parameters > Breakers > [Breaker] > Pulse time ON`)

To close a pulse breaker:

1. **Close breaker**: `Breakers > [Breaker] > Controls > [*B] close` (digital output). The controller activates this output until there is breaker closed feedback, or for the *Pulse time ON*.
2. **Breaker closed feedback**: `Breakers > [Breaker] > Feedback > [*B] closed` (digital input). This input is activated when the breaker is closed.
3. **Breaker open feedback**: `Breakers > [Breaker] > Feedback > [*B] open` (digital input). This input is deactivated when the breaker is closed.

**Table 7.2** Opening a pulse breaker

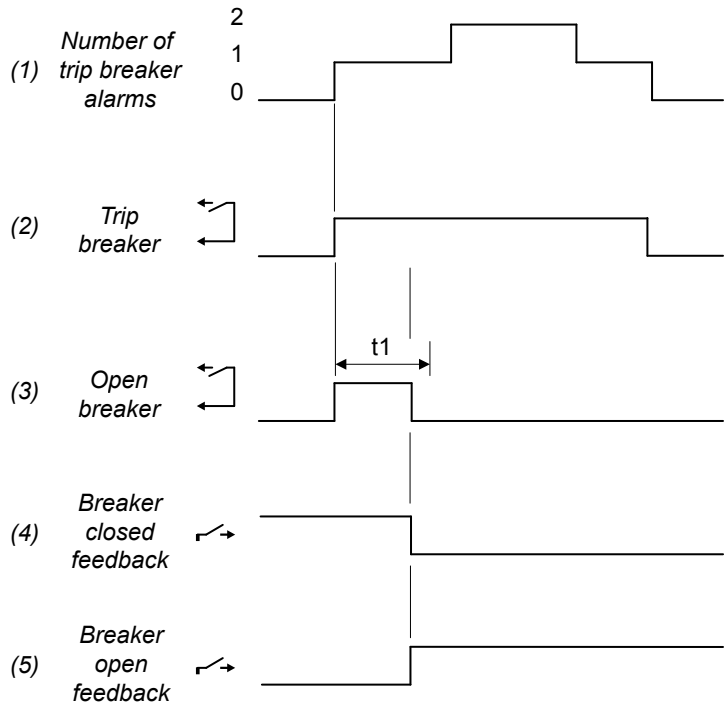



t1 Pulse on (`Parameters > Breakers > [Breaker] > Pulse time ON`)

To open a pulse breaker:

1. **Open breaker**: `Breakers > [Breaker] > Controls > [*B] open` (digital output). The controller activates this output until there is breaker open feedback, or for the *Pulse time ON*.
2. **Breaker closed feedback**: `Breakers > [Breaker] > Feedback > [*B] closed` (digital input). This input is deactivated when the breaker is opened.
3. **Breaker open feedback**: `Breakers > [Breaker] > Feedback > [*B] open` (digital input). This input is activated when the breaker is opened.

**Table 7.3** Trip a pulse breaker




t1 Pulse on (`Parameters > Breakers > [Breaker] > Pulse time ON`)

To trip a pulse breaker:

1. **Number of trip breaker alarms**: The number of active alarms with a *Trip [breaker]* (or similar) alarm action.
2. **Trip breaker**: `Breakers > [Breaker] > Controls > [*B] trip` (digital output). The controller activates this output until all alarms with a *Trip [breaker]* (or similar) alarm action are not active.
3. **Open breaker**: `Breakers > [Breaker] > Controls > [*B] open` (digital output). The controller activates this output until there is breaker open feedback, or for the *Pulse time ON*.
4. **Breaker closed feedback**: `Breakers > [Breaker] > Feedback > [*B] closed` (digital input). This input is deactivated when the breaker is opened.
5. **Breaker open feedback**: `Breakers > [Breaker] > Feedback > [*B] open` (digital input). This input is activated when the breaker is opened.

## 7.3.3 Compact breaker

To close a compact breaker, the controller sends an open pulse to load the spring, followed by a pause, and then a close pulse.

### Wiring examples

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

### Inputs and outputs

| Function | IO | Type | Details |
|---|---|---|---|
| `Breakers > [Breaker] > Controls > [*B] close` | Digital output | Pulse | When the power sources are synchronised, the controller activates the *[*B] close* output to close the breaker. |
| `Breakers > [Breaker] > Controls > [*B] open` | Digital output | Pulse | The controller activates the *[*B] open* output to open the breaker. The controller also activates the *[*B] open* output to spring-load the breaker. |
| `Breakers > [Breaker] > Controls > [*B] trip` | Digital output | Continuous | The controller activates the *Trip* output when an alarm with a trip breaker action activates.<br><br>The output remains active until all alarms with a trip breaker action are resolved. |
| `Breakers > [Breaker] > Feedback > [*B] closed` | Digital input | Continuous | Wire this feedback from the breaker, to inform the controller when the breaker is closed. |
| `Breakers > [Breaker] > Feedback > [*B] open` | Digital input | Continuous | Wire this feedback from the breaker, to inform the controller when the breaker is open. |

| Function | IO | Type | Details |
|---|---|---|---|
| `Breakers > [Breaker] > Feedback > [*B] spring loaded` | Digital input | Pulse | Optional. The breaker sends this pulse when it is spring loaded. There is also a timer for spring loading. |
| `Breakers > [Breaker] > Feedback > ['B] short circuit` | Digital input | Continous | Optional: Wire this feedback from the breaker, to inform the controller if a short circuit occurs. |

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

| Function | IO | Type | Details |
|---|---|---|---|
| `Breaker > [Breaker] > Command > [*B] open` | Digital input | Pulse | This input has the same effect as pressing the *Breaker open* button on the display unit. |
| `Breaker > [Breaker] > Command > [*B] close` | Digital input | Pulse | This input has the same effect as pressing the *Breaker close* button on the display unit. |
| `Breaker > [Breaker] > Command > Block [*B] close` | Digital input | Continuous | The controller does not allow the breaker to close while this input is active. |

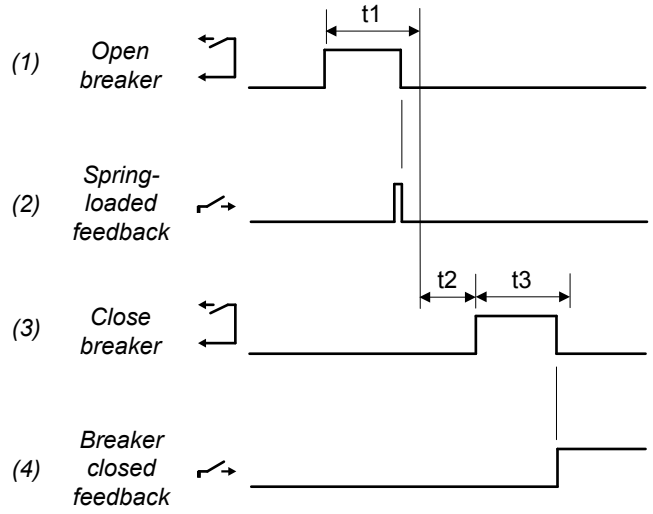
### Parameters

**`Breakers > [Breaker] configuration > Configuration`**

| Parameter | Range | Notes |
|---|---|---|
| `Breaker type` | • Pulse breaker<br>• Compact breaker<br>• Continuous 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 before the compact breaker is allowed to close.<br><br>To see the compact breaker parameters, you must change the breaker type, then write the change to the controller, and refresh. |
| `Pulse time ON` | 0.0 to 60.0 s | The length of the synchronisation pulse (that is, the maximum amount of time that the *Breakers > [Breaker] > Controls > [*B] close* output is activated).<br><br>If the controller receives breaker closed feedback within this time, the controller stops activating the breaker close output. |
| `Pulse time OFF` | 0.0 to 10.0 s | During the close sequence, after spring-loading, the controller will not send the *[*B] close* pulse until after this time has elapsed. |
| `Spring load time` | 0.0 to 30.0 s | At the start of the close sequence, for spring loading, the controller activates the *[*B] open* output for the *Spring load time*. |
| `Open point (de-loading)` | 1.0 to 20.0 % of nominal power | The breaker is de-loaded when the power flowing through the breaker is less than this set point. The nominal power is the nominal power of the [A-side]. |

## Sequence diagrams

**Table 7.4** Closing a compact breaker




t1 Spring load time (`Breakers > [Breaker] configuration > Spring load time`)

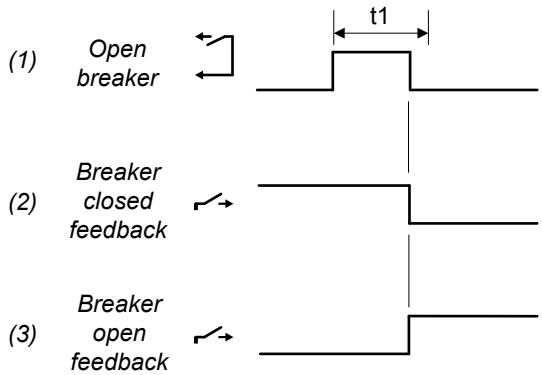
t2 Wait after spring-loading (`Breakers > [Breaker] > Pulse time OFF`)

t3 Pulse on (`Breakers > [Breaker] > Pulse time ON`)

To close a compact breaker:

1. **Open breaker**: `Breakers > [Breaker] > Controls > [*B] open` (digital output). To spring load the breaker, the controller activates this output until there is spring loaded feedback, or for the *Spring load time*. After the breaker is spring loaded, the controller waits for the *Pulse time OFF*.
2. **Optional: Spring loaded feedback**: `Breakers > [Breaker] > Feedback > [*B] spring loaded` (digital input). This input is activated when the breaker is spring loaded.
3. **Close breaker**: `Breakers > [Breaker] > Controls > [*B] close` (digital output). The controller activates this output until there is breaker open feedback, or for the *Pulse time ON*.
4. **Breaker closed feedback**: `Breakers > [Breaker] > Feedback > [*B] closed` (digital input). This input is activated when the breaker is closed.

**Table 7.5** Opening a compact breaker

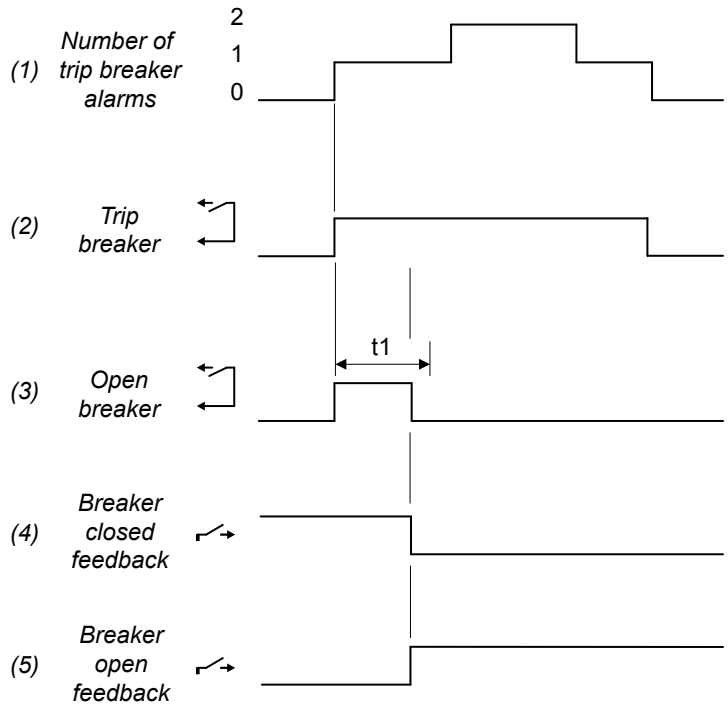



t1 Pulse on (`Breakers > [Breaker] > Pulse time ON`)

To open a compact breaker:

1. **Open breaker**: `Breakers > [Breaker] > Controls > [*B] open` (digital output). The controller activates this output until there is breaker open feedback, or for the *Pulse time ON*.
2. **Breaker closed feedback**: `Breakers > [Breaker] > Feedback > [*B] closed` (digital input). This input is deactivated when the breaker is opened.
3. **Breaker open feedback**: `Breakers > [Breaker] > Feedback > [*B] open` (digital input). This input is activated when the breaker is opened.

**Table 7.6** Trip a compact breaker




t1 Pulse on (`Breakers > [Breaker] > Pulse time ON`)

To trip a pulse breaker:

1. **Number of trip breaker alarms**: The number of active alarms with a *Trip [breaker]* (or similar) alarm action.
2. **Trip breaker**: `Breakers > [Breaker] > Controls > [*B] trip` (digital output). The controller activates this output until all alarms with a *Trip [breaker]* (or similar) alarm action are not active.
3. **Open breaker**: `Breakers > [Breaker] > Controls > [*B] open` (digital output). The controller activates this output until there is breaker open feedback, or for the *Pulse time ON*.
4. **Breaker closed feedback**: `Breakers > [Breaker] > Feedback > [*B] closed` (digital input). This input is deactivated when the breaker is opened.
5. **Breaker open feedback**: `Breakers > [Breaker] > Feedback > [*B] open` (digital input). This input is activated when the breaker is opened.

## 7.3.4 Continuous breaker

You can configure a continuous breaker to use a open breaker signal, an close breaker signal, or an open and a close breaker signal to open and close the breaker. Configuring both an open and a close breaker signal for a continuous breaker ensures that synchronisation is precise and that AC protections meet the required operation times.

### Wiring examples

**More information**
See **Breaker wiring** in the **Installation instructions** for an example of continuous breaker wiring.

### Inputs and outputs

For a continuous breaker, DEIF recommends installing both of the breaker control relays to ensure precise synchronisation and AC protection operate times.

| Function | I/O | Type | Details |
|---|---|---|---|
| `Breakers > [Breaker] > Controls > [*B] close` | Digital output | Continuous | The controller activates the *Close* output to close the breaker. To open the breaker, the controller deactivates the *Close* output. The *Close* relay ensures precise synchronisation. |
| `Breakers > [Breaker] > Controls > [*B] open` | Digital output | Continuous | The controller activates the *Open* output when the breaker must open. The controller deactivates the *Open* output when the breaker must close. The *Open* relay ensures the AC protection operate times. |
| `Breakers > [Breaker] > Controls > [*B] trip` | Digital output | Continuous | The controller activates the *Trip* output when an alarm with a trip breaker action activates.<br><br>The output remains active until all alarms with a trip breaker action are resolved. |
| `Breakers > [Breaker] > Feedback > [*B] closed` | Digital input | Continuous | Wire this feedback from the breaker to inform the controller when the breaker is closed. * |

| Function | I/O | Type | Details |
|---|---|---|---|
| `Breakers > [Breaker] > Feedback > [*B] open` | Digital input | Continuous | Wire this feedback from the breaker to inform the controller when the breaker is open. * |
| `Breakers > [Breaker] > Feedback > [*B] short circuit` | Digital input | Continuous | Optional. Wire this feedback from the breaker if a short circuit occurs. |

**NOTE** * There must be at least one breaker feedback.

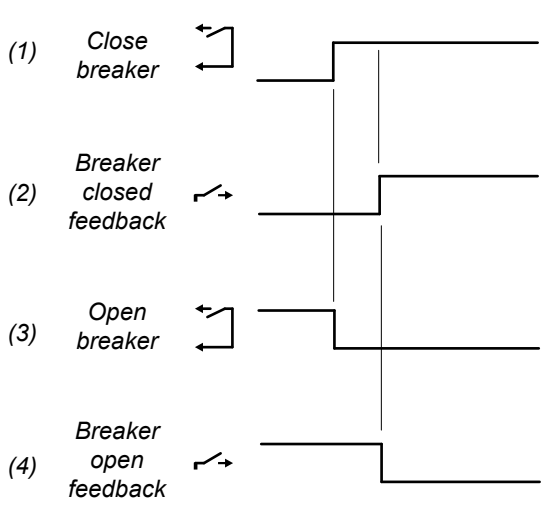
### Parameters

**`Breakers > [Breaker] configuration > Configuration`**

| Parameter | Range | Notes |
|---|---|---|
| `Breaker type` | • Pulse breaker<br>• Compact breaker<br>• Continuous breaker | **Continuous breaker:** This breaker receives a continuous signal to close if **[B*] close**, or the **[B*] close** and **[B*] open** functions are configured. If this signal stops, the breaker opens.<br><br>If only the **[B*] open** is configured, the breaker receives a continuous signal to open. If this signal stops, the breaker synchronises and closes. |
| `Open point (de-loading)` | 1.0 to 20.0 % of nominal power | The breaker is de-loaded when the power flowing through the breaker is less than this set point. The nominal power is the nominal power of the [A-side]. |

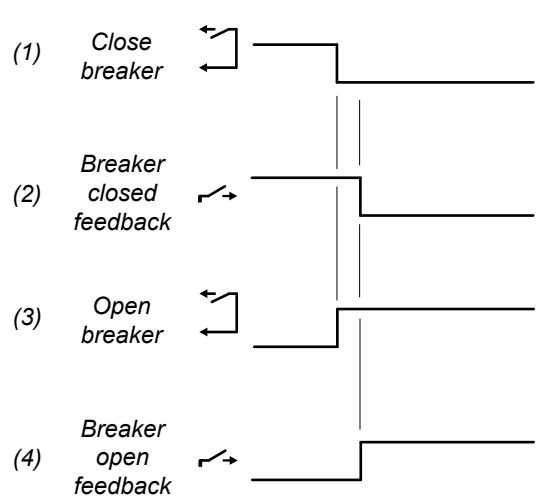
### Sequence diagrams

**Table 7.7** Closing a continuous breaker



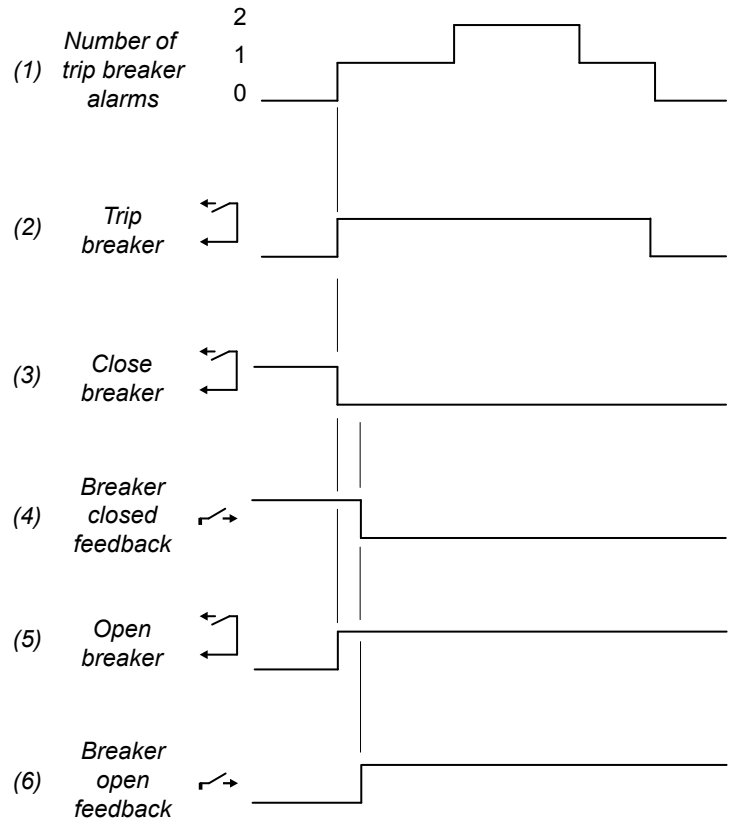

1. **Close breaker**: `Breakers > [Breaker] > Controls > [*B] close` (digital output). The controller activates this output to close the breaker.
2. **Breaker closed feedback**: `Breakers > [Breaker] > Feedback > [*B] closed` (digital input). This input is activated when the breaker is closed.
3. **Open breaker**: `Breakers > [Breaker] > Controls > [*B] open` (digital output). The controller deactivates this output to close the breaker.
4. **Breaker open feedback**: `Breakers > [Breaker] > Feedback > [*B] closed` (digital input). This input is deactivated when the breaker is closed.

**Table 7.8** Opening a continuous breaker




1. **Close breaker**: `Breakers > [Breaker] > Controls > [*B] close` (digital output). The controller deactivates this output to open the breaker.
2. **Breaker closed feedback**: `Breakers > [Breaker] > Feedback > [*B] closed` (digital input). This input is deactivated when the breaker is opened.
3. **Open breaker**: `Breakers > [Breaker] > Controls > [*B] open` (digital output). The controller activates this output to open the breaker.
4. **Breaker open feedback**: `Breakers > [Breaker] > Feedback > [*B] open` (digital input). This input is activated when the breaker is opened.

**Table 7.9** Trip a continuous breaker




1. **Number of trip breaker alarms**: The number of active alarms with a *Trip [breaker]* (or similar) alarm action.
2. **Trip breaker**: `Breakers > [Breaker] > Controls > [*B] trip` (digital output). The controller activates this output until all alarms with a *Trip [breaker]* (or similar) alarm action are not active.
3. **Close breaker**: `Breakers > [Breaker] > Controls > [*B] close` (digital output). The controller deactivates this output to open the breaker.
4. **Breaker closed feedback**: `Breakers > [Breaker] > Feedback > [*B] closed` (digital input). This input is deactivated when the breaker is opened.
5. **Open breaker**: `Breakers > [Breaker] > Controls > [*B] open` (digital output). The controller activates this output to open the breaker.
6. **Breaker open feedback**: `Breakers > [Breaker] > Feedback > [*B] open` (digital input). This input is activated when the breaker is opened.

## 7.3.5 Redundant breaker feedback

Redundant breaker feedback can be configured on bus tie breaker controllers and externally controlled breakers.

### Wiring examples

**More information**
See **Breaker wiring** in the **Installation instructions** for an example of redundant breaker feedback wiring.

### Digital inputs

The redundant breaker feedback inputs are only visible if a redundant breaker feedback was configured to the controller.

| Function | I/O | Type | Details |
|---|---|---|---|
| `Breakers > [BTB/External breaker #] > Feedback > [BTB/External breaker] # open` * | Digital input | Continuous | Wire this feedback from the breaker, to inform the controller when the breaker is open. |
| `Breakers > [BTB/External breaker #] > Feedback > [BTB/External breaker] # closed` * | Digital input | Continuous | Wire this feedback from the breaker, to inform the controller when the breaker is closed. |

**NOTE** * # is the number of the breaker with its redundant breaker feedback assigned to the controller.

### 7.3.6 Breaker state outputs

#### Digital outputs (optional)

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

| Function | I/O | Type | Details |
|---|---|---|---|
| `Breakers > [Breaker] > State > [*B] is open` | Digital output | Continuous | Activated when the breaker is open. |
| `Breakers > [Breaker] > State > [*B] is closed` | Digital output | Continuous | Activated when the breaker is closed. |
| `Breakers > [Breaker] > State > [*B] is synchronising` | Digital output | Continuous | Activated when the system is synchronising the breaker. |
| `Breakers > [Breaker] > State > [*B] is de-loading` | Digital output | Continuous | Activated when the system is de-loading the breaker. |
| `Breakers > [Breaker] > State > [*B] is preparing` | Digital output | Continuous | Only for compact breakers.<br><br>Activated when the system is loading the spring on a compact breaker. |

#### Application

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

For example, for a **MAINS** controller, a digital output may have the `Mains breaker > State > MB is deloading` function. A switchboard light is lit when the controller system is de-loading the mains breaker.

## 7.4 Synchronisation functions

### 7.4.1 Dynamic synchronisation

During dynamic synchronisation, the synchronising genset can run at a slightly different speed to the genset(s) on the busbar. This speed 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 speed than the genset(s) on the busbar. This is to ensure that the synchronising genset starts to deliver power immediately after synchronisation, and thereby avoid a reverse power situation.

This type of synchronisation is relatively fast because of the minimum and maximum frequency differences. Synchronisation is possible while the controller is still regulating the frequency towards the set point. 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 phases are matched, the controller can send the close breaker signal.

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

### Parameters

**`Breakers > [Breaker] configuration > Synchronisation setting`**

| Name | Range | Notes |
|---|---|---|
| `Sync. type` | Dynamic, Static, Automatic * | *Dynamic or Automatic* * must be selected. |
| `Delta frequency min.` | -2.00 to 2.00 Hz | For synchronisation: 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.` | -2.00 to 2.00 Hz | For synchronisation: 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*. |
| `Delta voltage min.` | 2.0 to 10.0 % of nominal voltage | The maximum that the voltage of the synchronising generator may be below the voltage of the busbar for the breaker to close. |
| `Delta voltage max.` | 2.0 to 10.0 % of nominal voltage | The maximum that the voltage of the synchronising generator may be above the voltage of the busbar for the breaker to close. |
| `Breaker close time` | 40 to 300 ms | The time between when the close breaker signal is sent and when the breaker actually closes. |

**NOTE** * Automatic is only available on **MAINS** and **BUS TIE breaker** controllers. The controller checks the information for the busbar section connected to the breaker. If the section can be regulated, the controller uses dynamic synchronisation. Otherwise the controller uses static synchronisation. See Mains breaker synchronisation and Bus tie breaker synchronisation for more details.

**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 synchronisation.

### Slip frequency

The slip frequency target is calculated as follows:

Slip frequency = (*Delta frequency min.* + *Delta frequency max.*)/2

**Slip frequency example**

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

The slip frequency is **0.1 Hz**.

When the dynamic synchronisation starts, the frequency control function regulates the synchronising genset frequency towards the following set point:

$f_{set\ point} = f_{busbar}$ + Slip frequency

**Slip frequency bad example**

Delta frequency min.: **-0.3 Hz**
Delta frequency max.: **0.3 Hz**

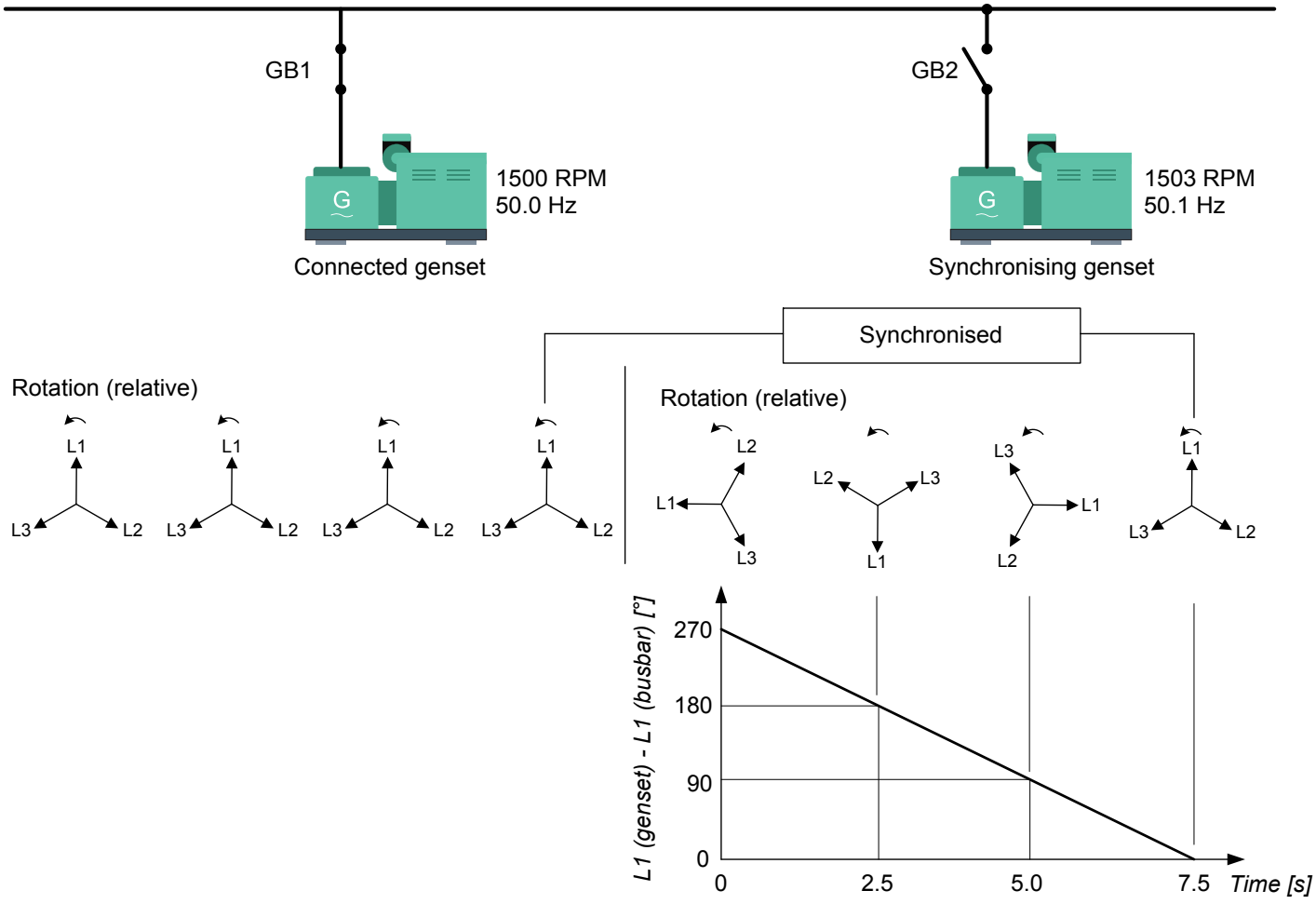
The slip frequency is **0.0 Hz**. There is a risk that there will be a long synchronisation time, because there is no change in the phase difference.

### Speed up for slip frequency under 0.3 Hz

If the slip frequency is under 0.3 Hz, the controller automatically changes the slip frequency target until the phase difference is 30 degrees. This cannot be configured or disabled.

### Dynamic synchronisation principle

The dynamic synchronisation principle is shown in the following example.




The power sources are the connected gensets and the synchronising genset. Synchronisation minimises the phase difference between the power sources.

In this example, the synchronising genset is running at 1503 RPM (about 50.1 Hz). The connected genset is running at 1500 RPM (50.0 Hz). This gives the synchronising genset a positive slip frequency of 50.1 Hz - 50.0 Hz = 0.1 Hz. If the slip frequency is less than *Delta frequency max.*, and more than *Delta frequency min.*, then the controller can close the breaker when the power sources are synchronised (subject to the voltages also being within the required limits).

In the example above, the difference in the phase between the synchronising genset and the busbar gets smaller and smaller. When the difference in the phases is near zero, the controller will send the breaker close signal based on the *Breaker closing time* (this is not shown in the example). In this way, the breaker physically closes when the genset and the busbar phases are exactly aligned.

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

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

The phases for both three-phase systems rotate. However, in this example, the phasors for the busbar are shown as stationary to simplify the explanation. This is because we are only interested in the phase difference.

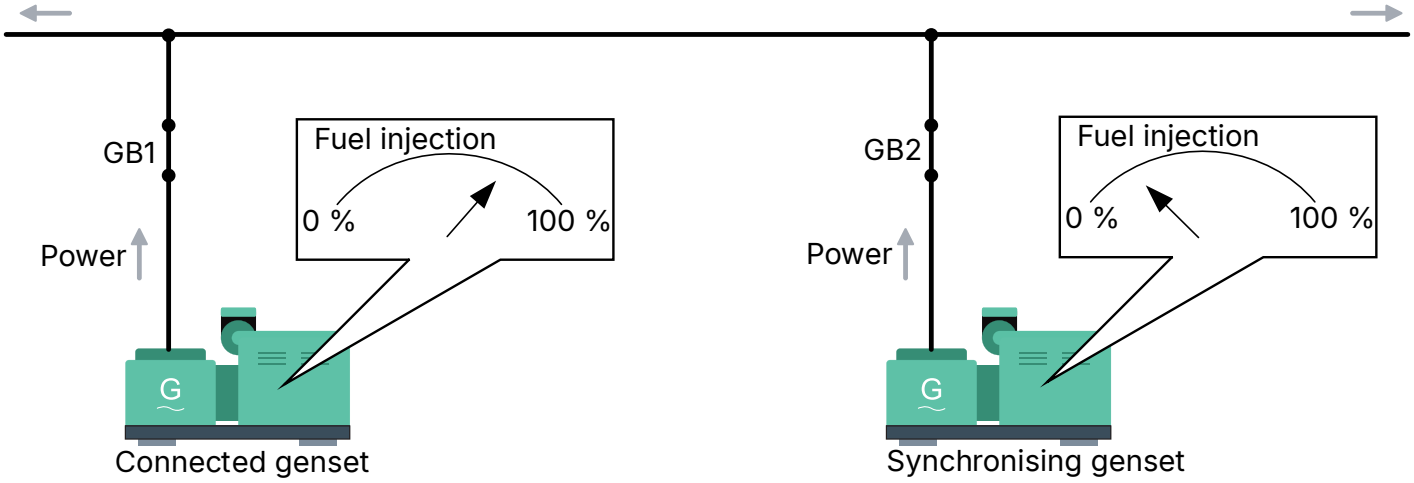
### Load distribution after synchronisation

When the breaker closes, the synchronising genset will take some of the load if it had a positive slip frequency. A negative slip frequency will lead to reverse power in the synchronising genset.

The proportion of the load that the synchronising genset takes depends on the frequency difference, and the prime mover characteristics.

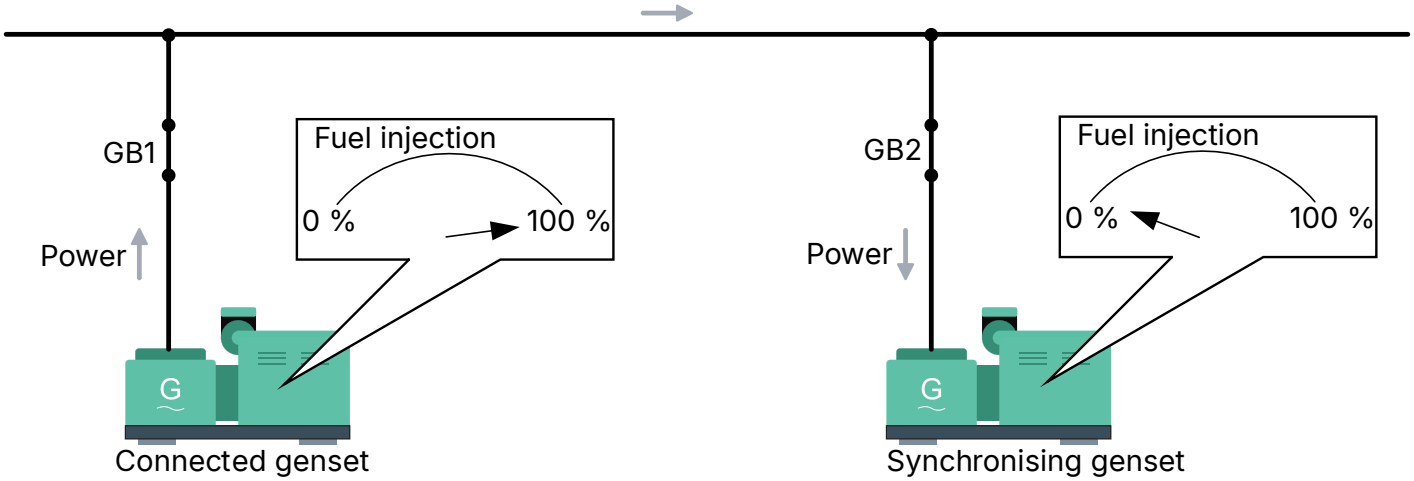
The following example shows that at a given *positive* slip frequency, the synchronising genset will *export* power to the load after the breaker closes.

**Example of load distribution after synchronisation with a positive slip frequency**




The following example shows that at a given *negative* slip frequency, the synchronising genset will *receive* power from the connected genset when the breaker closes. This can cause a reverse power trip.

**Example of load distribution after synchronisation with a negative slip frequency**




**NOTE** To avoid trips caused by reverse power, configure the synchronisation parameters for a positive slip frequency.

### 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 phases of the L1 phasors is zero.

The timing of the close breaker signal depends on the *Breaker closing 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 activates the close breaker output 9 degrees before the phases are aligned.

## 7.4.2 Static synchronisation

During static synchronisation, the synchronising genset runs very close to the same speed as the generator on the busbar. The aim is to let the gensets run at exactly the same speed, with the phases of the A-side and the B-side matching exactly. Static synchronisation is most suited to systems with a very stable frequency.

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

Static synchronisation should only be used with an analogue output (that is, not relay outputs).

Static synchronisation cannot be performed in non-regulating controller types where regulation is required.

**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, regulators, and breaker configuration.

### Digital input

You can use a parameter to configure the synchronisation type as *Static synchronisation*. If you need to change the synchronisation type, you can assign a digital input to select static synchronisation.

| Function | I/O | Type | Details |
|---|---|---|---|
| `Breakers > [Breaker] > Command > [*B] static synchronisation` | Digital input | Continuous | **Activated**: The controller uses static synchronisation.<br><br>**Deactivated**: The controller uses the synchronisation defined in the *Sync. type* parameter. |

**Static synchronisation digital input examples**

A system has several bus tie breakers and a ring busbar. The bus tie breakers are configured for dynamic synchronisation. However, to close the last breaker in the ring, the controller must use static synchronisation.

A system has two connections to the same mains supply. The mains breakers are configured for dynamic synchronisation. To connect the second mains breaker, the controller must use static synchronisation.

For both of these examples, you do not need the digital input if you configure the *Sync. type* as *Automatic*.

### Parameters

**`Breakers > [Breaker] configuration > Synchronisation setting`**

| Name | Range | Notes |
|---|---|---|
| `Sync. type` | • Dynamic<br>• Static<br>• Automatic * | *Static* or Automatic * must be selected. To see the static synchronisation parameters, write the change to the controller, and refresh. |
| `Delta frequency min.` | -2.00 to 2.00 Hz | For synchronisation: Add *Delta frequency min.* to the B-side frequency, for the **minimum** frequency of the synchronising generator.<br><br>This value must be negative for static synchronisation. |
| `Delta frequency max.` | -2.00 to 2.00 Hz | For synchronisation: Add *Delta frequency max.* to the B-side frequency, for the **maximum** frequency of the synchronising generator.<br><br>*Delta frequency max.* must always be higher than *Delta frequency min*. |
| `Delta voltage min.` | 2.0 to 10.0 % of nominal voltage | The maximum that the voltage of the synchronising generator may be below the voltage of the busbar for the breaker to close. |
| `Delta voltage max.` | 2.0 to 10.0 % of nominal voltage | The maximum that the voltage of the synchronising generator may be above the voltage of the busbar for the breaker to close. |
| `Breaker close time` | 40 to 300 ms | The time between when the close breaker signal is sent and when the breaker actually closes. This is not used for static synchronisation. |
| `Phase window` | 0.0 to 45.0° | The maximum phase difference allowed for synchronisation. |
| Minimum time in phase window | 0.1 s to 15 min | To close the breaker, the measurements must show that the controller will be able to keep the phase difference within the phase window for this minimum time. |

**NOTE** * *Automatic* is only available on **MAINS** and **BUS TIE breaker** controllers. The controller checks the information for the busbar section connected to the breaker. If the section can be regulated, the controller uses dynamic synchronisation. Otherwise the controller uses static synchronisation. See **Mains breaker synchronisation** and **Bus tie breaker synchronisation** for more details.

**Frequency window example**

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

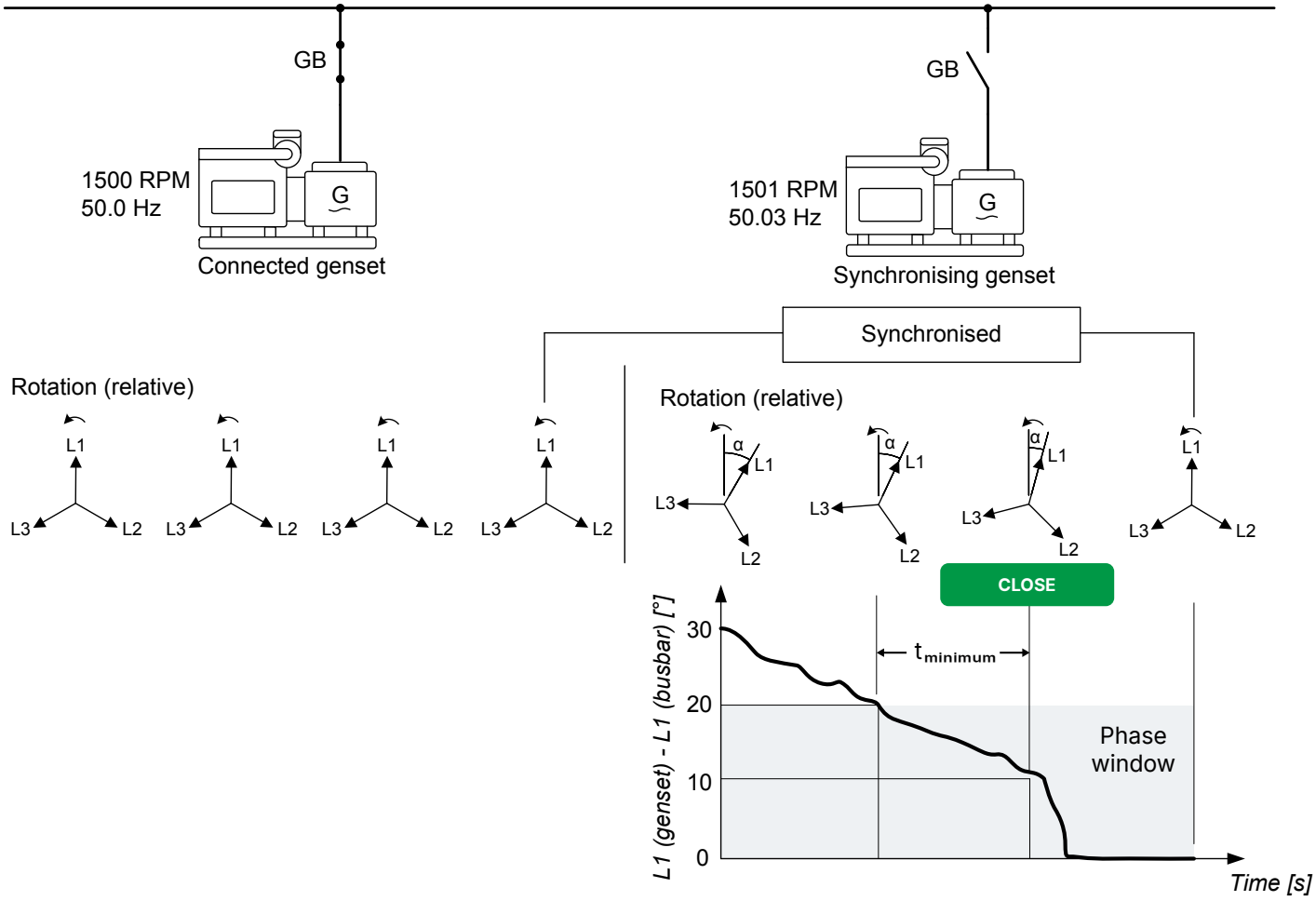
| | |
|---|---|
| | The generator frequency must be between **50.0 Hz** and **50.4 Hz** for synchronisation. |

**NOTE** For static synchronisation, on average, the frequencies need to be nearly identical.

### Static synchronisation principle, with phasor diagrams

The static synchronisation principle is shown below. Phase regulation for synchronisation reduces the phase difference to meet the static synchronisation requirements.

**Figure 7.1** Static synchronisation principle




### Phase regulation for synchronisation

When static synchronisation is started, if the frequency difference is outside the frequency window, the frequency regulation regulates the synchronising genset frequency towards the busbar frequency.

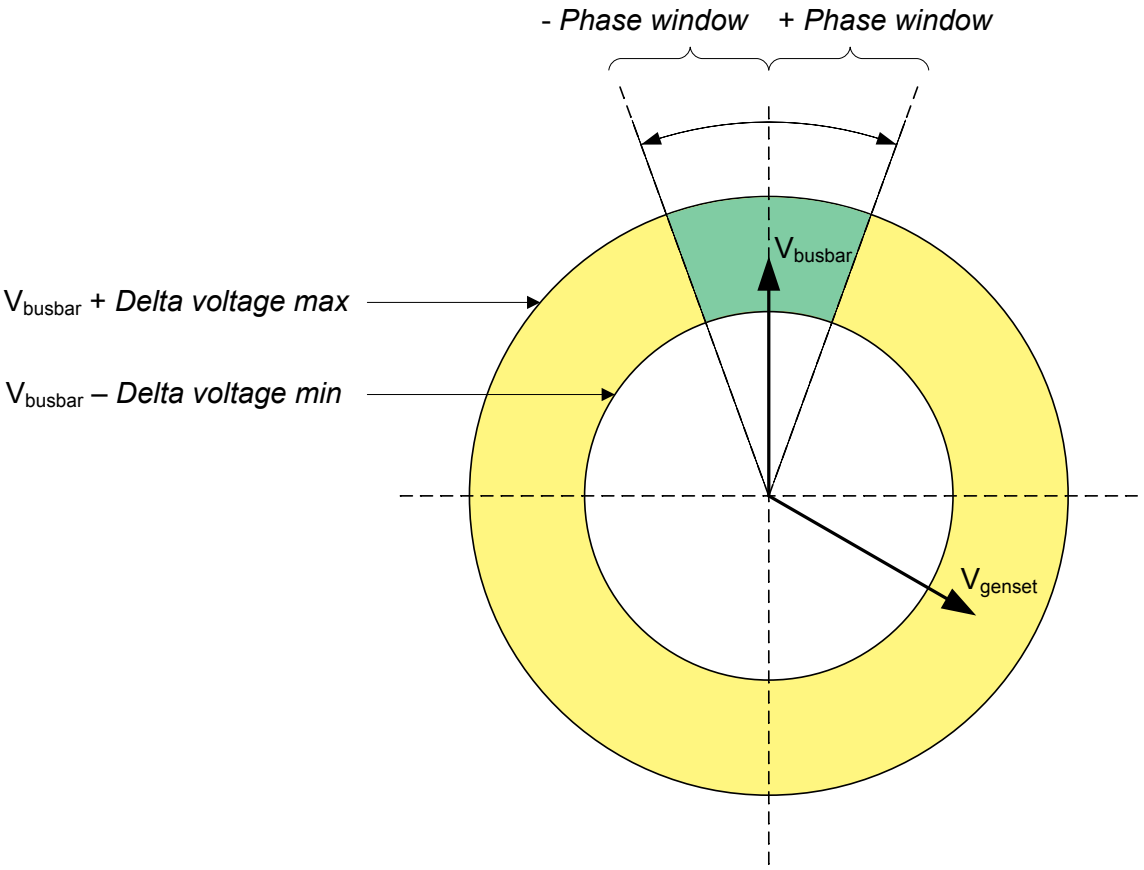
When the genset-busbar difference is 200 mHz, the phase synchronisation function takes over. The phase regulator for synchronisation aims to minimise the angle between the synchronising genset and the busbar.

### Close breaker signal

The output `Breaker > [Breaker] > Controls > [*B] Close` is activated when the phase difference between the synchronising generator and the busbar is kept within the *Phase window* while the *Minimum time in phase window* timer runs. 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.

**Figure 7.2** Voltage and phase difference for static synchronisation




### Load distribution after synchronisation

The difference between the frequencies of A-side and B-side is low. The load distribution therefore does not change much when the breaker closes.

## 7.4.3 Regulator parameters for synchronisation

During synchronisation the controller regulates the governor to change the frequency or phase. These settings are only used during synchronisation, and can be configured to optimise the synchronisation speed for the system.

If the controller can regulate the AVR, it also regulates the voltage. Note that there are no special parameters for voltage regulation for synchronisation.

### Analogue synchronisation parameters

**`Regulators > GOV > Analogue > Frequency synchronisation`**

| Parameter | Range | Notes |
|---|---|---|
| `Kp` | 0.00 to 60.00 | The PID gain for the regulator. |
| `Ti` | 0.00 s to 1 min | The PID control integral time.<br><br>To turn off the integral component, set Ti to 0. This might cause unexpected regulator behaviour. |
| `Td` | 0.00 to 2.00 s | The PID control derivative. |

**`Regulators > GOV > Analogue > Phase synchronisation`**

The phase synchronisation parameters are only used when static synchronisation is selected.

| Parameter | Range | Notes |
|---|---|---|
| Kp | 0.00 to 60.00 | The PID gain for the regulator. |
| Ti | 0.00 s to 1 min | The PID control integral time.<br><br>To turn off the integral component, set Ti to 0. This might cause unexpected regulator behaviour. |
| Td | 0.00 to 2.00 s | The PID control derivative. |

### Relay synchronisation parameters

**Regulators > GOV > Relay configuration > Frequency synchronisation**

| Parameter | Range | Notes |
|---|---|---|
| Kp | 0.0 to 1000.0 | The gain for the regulator. |

**Regulators > GOV > Relay configuration > Phase synchronisation**

Note: When static synchronisation is required, DEIF does not recommend using digital outputs to regulate the governor. The phase synchronisation parameter is only used when static synchronisation is selected.

| Parameter | Range | Notes |
|---|---|---|
| Kp | 0.0 to 1000.0 | The gain for the regulator. |

## 7.4.4 Synchronisation status outputs

Synchronisation status outputs are available in Modbus, CustomLogic and CODESYS.

### Outputs

For CustomLogic contacts, access the synchronisation status outputs under `Functions > Breakers > [Breaker] > Outputs > Sync. status`. These outputs are all optional.

### Synchronisation status

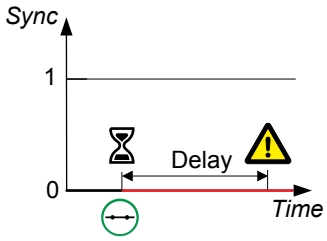
| Function | Type | Details |
|---|---|---|
| Delta frequency above max. | Continuous | Activated when the [A-side] side frequency is above the sum of the [B-side] side frequency and *Delta frequency max.** |
| Delta frequency below min. | Continuous | Activated when the [A-side] side frequency is below the sum of the [B-side] side frequency and *Delta frequency min.** |
| Delta voltage above max. | Continuous | Activated when the [A-side] side voltage is above the sum of the [B-side] side voltage and *Delta voltage max.** |
| Delta voltage below min. | Continuous | Activated when the [A-side] side voltage is below the sum of the [B-side] side voltage and *Delta voltage min.** |
| Vector mismatch | Continuous | Activated when the difference in phase angles on either side of the breaker is outside the *Vector mismatch* alarm set point. However, this function does not use a low frequency inhibit. Also, the vector mismatch detection is active all the time (and is not affected by the breaker state). |
| Phase angle outside window | Continuous | Activated when the phase angle difference is outside the *Phase window** (only available for *Static* or *Automatic* synchronisation). |

# 7.5 Synchronisation and breaker alarms

## 7.5.1 Breaker synchronisation failure

This alarm alerts the operator about a breaker synchronisation failure.

The alarm is based on the synchronisation of the A-side to the B-side, as measured by the controller. The alarm is activated if the controller has not been able to synchronise within the delay time.




**Breakers > [Breaker] monitoring > Synchronisation failure**

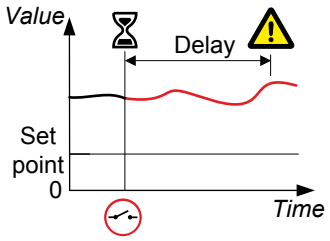
| Parameter | Range |
|---|---|
| Delay | 30.0 s to 5 min |

## 7.5.2 De-load failure

This alarm alerts the operator to breaker de-load failure.

The alarm is based on the load across the breaker, as measured by the controller. When the controller internal set point has ramped down to the breaker open point, the timer starts. The controller activates the alarm if the load across the breaker is not reduced to the *Open point (de-loading)* within the delay time.

The *Open point (de-loading)* is configured under **Breakers > [Breaker] configuration > Configuration**.

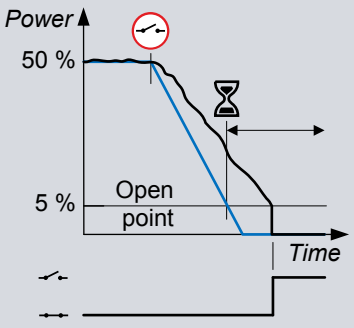



**Breakers > [Breaker] monitoring > De-load failure**

| Parameter | Range |
|---|---|
| Delay | 0.0 s to 1 h |

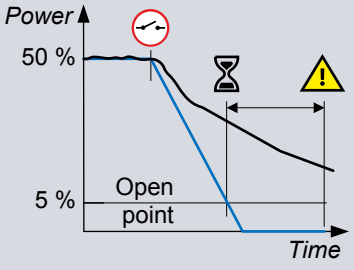
**Effect of de-load ramp example**

The genset is running at 50 % of nominal power. The breaker open point is 5 % of nominal power. The graph shows the power set point in blue, and the genset power in black. The breaker opens in time, and there is no de-load error.




**Effect of slow de-loading example**

The genset is running at 50 % of nominal power. The breaker open point is 5 % of nominal power. The graph shows the power set point in blue, and the genset power in black. The de-loading is a lot slower than the power set point ramp down. The breaker does not open in time, and there is a de-load error alarm.



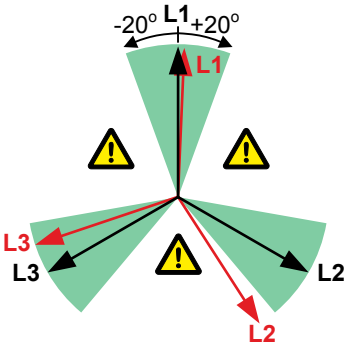
**More information**
See Regulation for more information about de-loading.

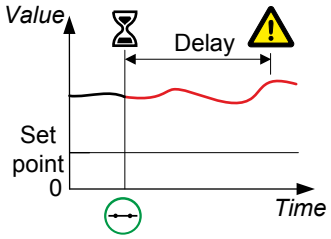
## 7.5.3 Vector mismatch

This alarm alerts the operator to a vector mismatch during synchronisation.

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

On the diagram to the right, the phasor diagram for the B-side is black, and the mismatch that is allowed by default is green. The phasor diagram for the A-side is red. L2 is outside the allowed window.




**Breakers > [Breaker] monitoring > Vector mismatch**

| Parameter | Range |
|---|---|
| Set point | 1 to 20° |
| Delay | 5.0 s to 1 min* |

**NOTE** * DEIF recommends that this delay is lower than the genset *Breaker synchronisation failure* delay.

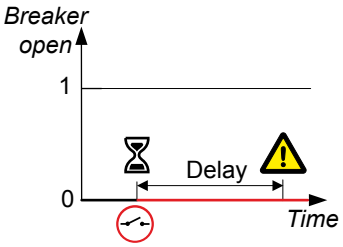
### Frequency-based inhibit

The *Vector mismatch* alarm is inhibited outside of the synchronisation window. That is, it is inhibited if the frequency from the A-side is more than the *Delta frequency min.* below the B-side frequency, or the *Delta frequency max.* above the B-side frequency. These parameters are defined under **Synchronisation settings**.

## 7.5.4 Breaker opening failure

This alarm alerts the operator to a breaker open failure.

The alarm is based on the breaker feedback signal(s) (a digital input, or two digital inputs) 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.




The alarm is always enabled when at least one breaker feedback is configured. The alarm always has the *Latch enabled*.

If no breaker feedback is configured in the **Input/output** for the breaker, then the alarm parameters are not visible.

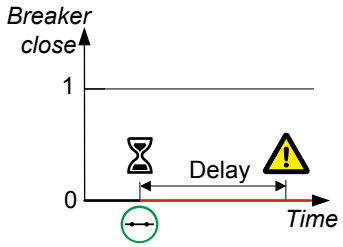
**Breakers > [Breaker] monitoring > Opening failure**

| Parameter | Range |
|---|---|
| Delay | 0.1 to 60.0 s |

## 7.5.5 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.




This alarm is always enabled when at least one breaker feedback is configured for the breaker. The alarm always has the *Latch enabled*.

If no breaker feedback is configured in the **Input/output** for the breaker, then the alarm parameters are not visible.

**`Breakers > [Breaker] monitoring > Closing failure`**

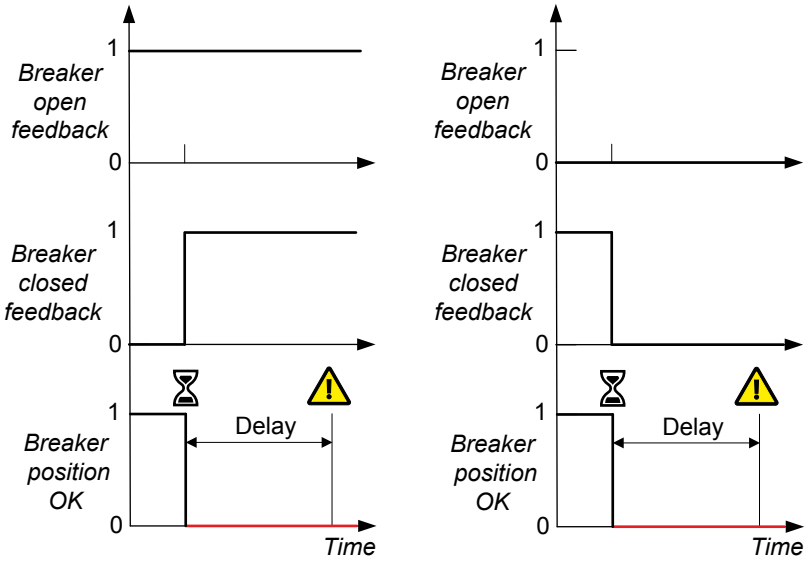
| Parameter | Range |
|---|---|
| `Delay` | 0.1 to 60.0 s |

## 7.5.6 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.

When both breaker feedback functions are configured for the breaker, the alarm is always *Enabled* and has the *Latch enabled*.




If only one or no breaker feedbacks are configured in the **Input/output** for the breaker, then the alarm parameters are not visible.

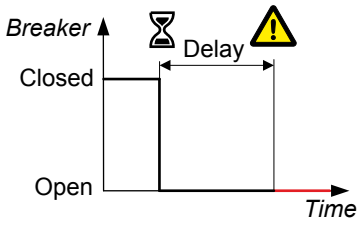
**`Breakers > [Breaker] monitoring > Position failure`**

| Parameter | Range |
|---|---|
| `Delay` | 0.1 to 5.0 s |

## 7.5.7 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.

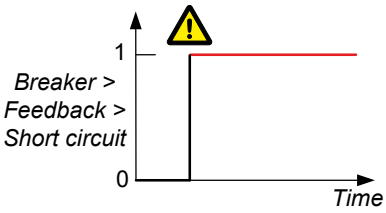



**`Breakers > [Breaker] monitoring > Tripped (external)`**

By default, the alarm has the *Latch enabled*. The delay is always 0.1 s.

## 7.5.8 Breaker short circuit

The alarm response is based on the digital input with the *Breakers > Feedback > [*B] short circuit* function (see below). This digital input is typically wired to the breaker's short circuit feedback output.




### Parameter

**`Breakers > [Breaker] monitoring > Short circuit`**

### Digital input

| Function | I/O | Type | Details |
|---|---|---|---|
| `Breakers > [Breaker] > Feedback > [*B] 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>• The breaker activates this input when it detects a short circuit. The controller then activates the *[Breaker] short circuit* alarm. |

## 7.5.9 Breaker configuration failure

This alarm blocks breaker operation if the breaker is not properly configured. The alarm is activated if a breaker is present on the single-line application drawing, but the **Input/output** functions that are required for the breaker type are not fully configured.

This alarm is always enabled, and has the alarm action *Block* with *Latch enabled*. You cannot see or change the parameters for this alarm.

# 8. Regulation

## 8.1 About regulation

### 8.1.1 How it works

The **SINGLE genset** and **GENSET** controllers can use analogue and/or relay control functions for regulation.

There are seven governor regulation modes and six automatic voltage regulator (AVR) regulation modes (including manual regulation) that can be selected on the controller to control the genset regulators. These modes can be activated by configuring the activation function to a digital input, or by using CustomLogic, or by sending the activation signal over Modbus. To change from one regulation mode to another regulation mode, select the new regulation mode using your configured activation function.

All the input and output information in this chapter is written from the DEIF controller point of view, except if clearly stated otherwise.

#### Overview of analogue control

Analogue control generally achieves finer control results than relay control. Analogue control also allows the controller to use a pulse width modulation (PWM) output, for governors and automatic voltage regulators that support this as an input (as an alternative to an analogue input to the governor or AVR). DEIF recommends that you use the full capability of analogue control in situations which require precision, such as static synchronisation.

#### Overview of relay control

Relay control is not able to produce the same precision as a well-tuned analogue controller. However, setting up relay control is simpler. To extend the life of relays, the controller has a range around the reference where the controller does not send regulation pulses to the governor or automatic voltage regulator. This range is called the regulation deadband. Analogue regulation does not have a deadband area, which contributes to more accurate regulation of the governor or AVR.

### 8.1.2 Analogue regulation

**More information**
See Analogue outputs for how to configure the analogue output(s) and PWM.

#### Configuring analogue outputs

Assign the analogue output regulation function(s) to the analogue output terminals under `Configure > Input/output`.

- `Regulators > GOV > GOV output [%]`
- `Regulators > AVR > AVR output [%]`

Configure the parameter to *Analogue* (where *[Regulator]* is *Governor* or *AVR*).

**`Regulators > [Regulator] general configuration > Regulator output`**

| Parameter | Range |
|---|---|
| Output type | • Analogue / ECU (for GOV)<br>• Analogue / DVR (for AVR)<br>• Relay |

#### Configuring pulse width modulation

Some governors require a pulse width modulation (PWM) input. The controller converts the analogue output to a PWM signal for the PWM terminals.

Connect the governor to the controller's PWM terminals.

Assign the `Regulators > GOV > GOV output [%]` function to the PWM terminals.

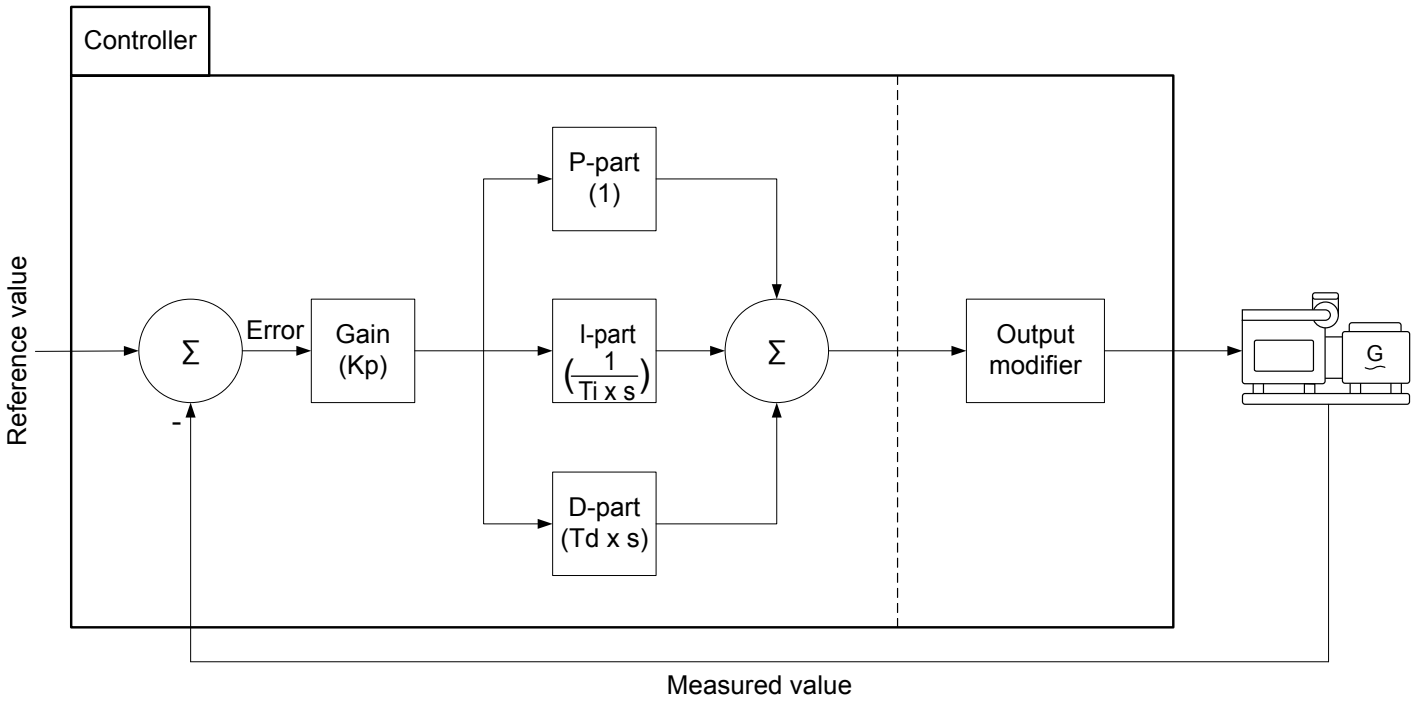
**More information**
See Pulse width modulation (PWM) output characteristics for the relationship between duty cycles and the PWM output.

### Analogue PID controller

A schematic of the analogue PID controller is given below. Analogue control works as follows:

1. The controller measures the operating value(s).
2. The controller deducts the measured value from the reference value to determine the error (also known as the deviation).
3. The error is the input for the PID controller. The controller sends the PID controller output to the output modifier.
4. The output modifier converts the output from the PID controller as required for the governor or AVR.
5. The governor or AVR then regulate the genset fuel or excitation.

**Figure 8.1** Simplified overview of the analogue PID controller




### PID control

The PID controller consists of three parts.

| Part | Contribution (Laplace domain) | Configurable parameters |
|---|---|---|
| Proportional part | 1 | Kp |
| Integral part | 1 / ( Ti x s ) | Kp, Ti |
| Derivative part | Td x s | Kp, Td |

### Gain

The gain (*Kp*) determines the magnitude of the signal.

The same gain (*Kp*) is applied to **each part** of the analogue controller. That is, increasing the gain not only increases the proportional part, but also increases the integral part and the derivative part.

### Proportional part

The proportional part contributes the gain × error to the PID output.

Gain (*Kp*) is the only term in the proportional part of the controller. That is, the contribution of the proportional part of the controller is directly proportional to the calculated error. For example, if *Kp* is 15 and the calculated error is +0.02, the proportional contribution is +0.30.

A high *Kp* makes the system respond strongly to the error. However, the response can be too large, and can lead to long settling times. A high *Kp* may make operation unstable.

A low *Kp* makes the system respond more weakly to the error. A low *Kp* can reduce the settling time. However, the response can be too small, and therefore ineffective.

### Integral part

The integral part eliminates the steady-state error.

The integral part is determined by:

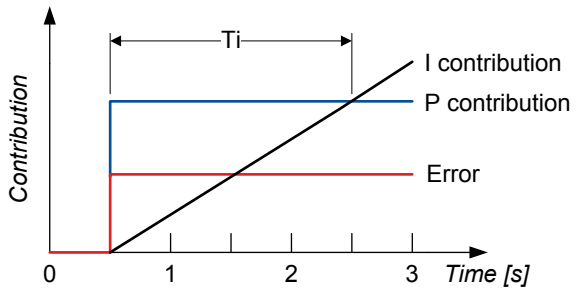
- The gain × error
- The integration time (*Ti*)
- The error history

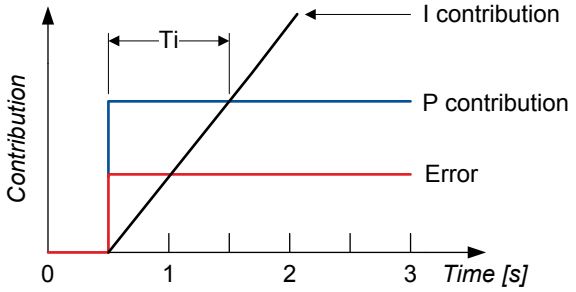
*Ti* is the time it takes for the contribution of the integral part to be equal to the contribution of the proportional part. If *Ti* is reduced, the contribution of the integral part is increased.

Do not set *Ti* too low. This can make the operation unstable (the effect is similar to a very high gain).

The figures below show the effect of *Ti* (a constant error is used to simplify the example).

When the system is far away from the reference point the integral part will have a large contribution to the correction. When the system is close to the reference value, the integral part can have a small contribution to the correction.




The integral contribution results from integrating the error.

Set *Ti* to zero to turn off the integral part.

### Derivative part

The derivative part stabilises operation, allowing higher gain and lower integral action times. The derivative part can improve the settling time.

The derivative part is determined by:

- The amplified error
- The derivative time (*Td*)
- The current rate of change of the error

The derivative part uses the current rate of change over *Td* to predict the future error. If *Td* is higher than the optimal time, the settling time can be very long. For very high values, the system might not be able to settle at the reference value (the effect is similar to a very high gain).

From experience, the derivative part can improve regulation during load sharing, power regulation and static synchronisation, when the parameter is properly tuned.

Use the derivative part if the situation requires very precise regulation (for example, static synchronisation). If the derivative part is used, it is important to tune it properly.

Set *Td* to zero to turn off the derivative part.

### 8.1.3 Relay regulation

Relay control uses the *[Regulator] increase* and *[Regulator] decrease* relays to increase or decrease the control signal, based on the output of the controller (where [Regulator] is either GOV, or AVR).

Droop must be enabled on the governor and/or AVR when you use relay regulation. If droop is not enabled on the governor and/or AVR, it is difficult to maintain a stable operation mode.

#### Configuring digital outputs

To use relay outputs to interface with the governor or AVR, assign the digital output regulation functions.

Configure the parameter to *Relay* (where *[Regulator]* is *Governor* or *AVR*).

**`Regulators > [Regulator] > General configuration > Regulator output`**

| Parameter | Range |
|---|---|
| Output type | • Off<br>• Analogue / ECU (for GOV)<br>• Analogue / DVR (for AVR)<br>• Relay |

#### Relay regulation ranges

The controller determines whether the output should be increased or decreased by comparing the measured value to the reference. The controller determines how far the deviation (also known as the error) is from the reference, multiplies it by the gain, and selects the output range. The output can be in one of three ranges, which are summarised in the table below:

| Range | Relay position | Notes |
|---|---|---|
| Constant range | Closed or intermittent open/close | See the diagrams below.<br><br>The measured value is far away from the reference value. The *[Regulator] increase* * or *[Regulator] decrease* * relay is activated for the maximum time allowed by the *Period time* and the *Maximum ON time* percentage. If the measured value is still far away after the maximum time was reached, then the relay is reactivated after the *Period time* is reached.<br><br>See point 1 on the figures below for an example where the *Maximum ON time* is set to 100 %. |
| Variable range | Intermittent open/close | The measured value is approaching the reference value, but is not in the deadband range yet. The *[Regulator] increase* * or *[Regulator] decrease* * relay pulses. The signal from the relay is thus intermittent.<br><br>The length of the pulse is dependent on the distance from the reference value, the period time and the controller gain, *Kp*. If the measured value is further away from the reference |

| Range | Relay position | Notes |
|---|---|---|
| | | value, the controller uses a longer pulse. If the measured value is closer to the reference value, the controller uses a shorter pulse. You can define the minimum pulse width.<br><br>See points 2, 3, 4 and 5 on the figures below. |
| Deadband range | Open | The measured value is so close to the reference value that it is within the deadband percentage of the reference value. The deadband is specific to the control type that is active, and you can define the deadband value. The *[Regulator] increase* * and *[Regulator] decrease* * relays remain deactivated continuously.<br><br>See point 6 on the figures below. |

**NOTE** * [Regulator] is either GOV, or AVR.

If the output is in either the constant or the variable range, the controller activates the configured relay (governor increase or decrease, or AVR increase or decrease) for the required time. The figures below show how the time decreases from the value set for *Period time* to the value set for *Minimum ON time* as the measured value gets closer to the reference for high *Kp* values and low *Kp* values. The *Maximum ON time* parameter is set to 100 %.

**Figure 8.2** Up and down relay on time for different errors (deviations from the reference)

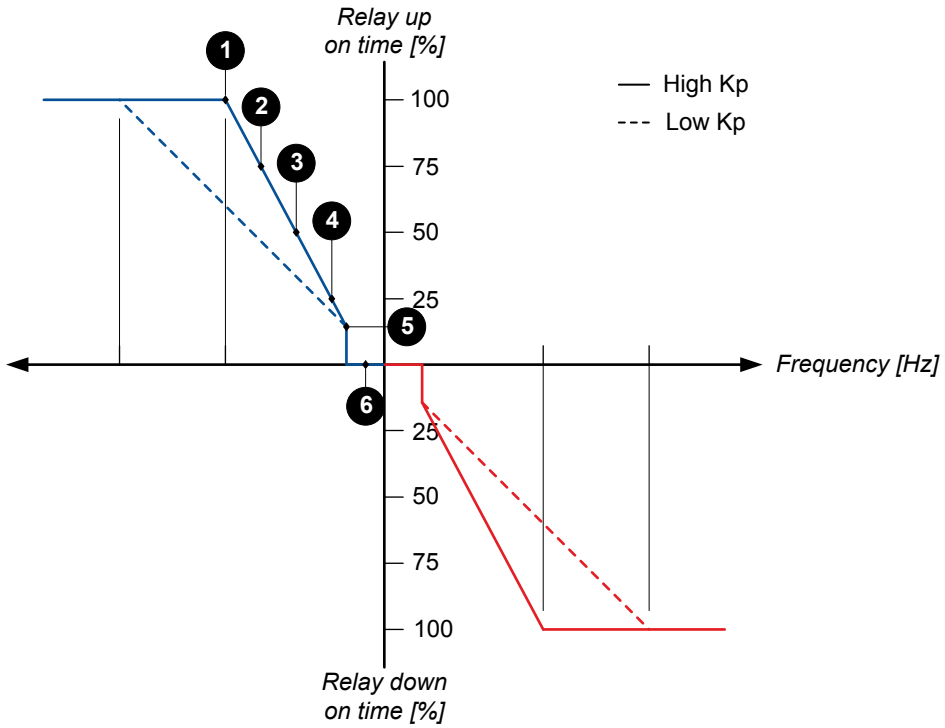
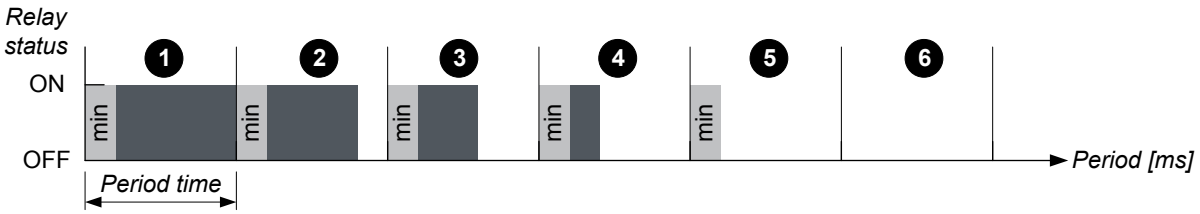



**Figure 8.3** Relay action (based on measurements at the end of the period time)




## Pulse properties

A relay regulator output has these main properties:

- Period time
- Minimum ON time
- Maximum ON time

The *Period time* defines the time from the start time of one pulse to the start time of the next pulse.

The *Minimum ON time* sets the minimum amount of time a relay is allowed to be closed. This should be similar to the minimum time required for the system to respond to the output signal.

The *Maximum ON time* sets the maximum amount of time a relay is allowed to be closed when the regulation is in the constant range. The parameter is a percentage of the *Period time*.

The pulse length is never shorter than the *Minimum ON time*. If the *Maximum ON time* is 100 %, when the pulse length is equal to or greater than the period time, the output is constant. The error where this shift occurs depends on *Kp* and the period time. As *Kp* increases, the variable range decreases. As *Kp* decreases, the variable range increases.

### 8.1.4 Droop

The droop percentage for a genset governor is a measure of how much the engine speed changes when there is a change in the genset power output. Similarly, for a genset AVR, the droop percentage shows the relationship between the generator voltage and the reactive power output.

Regulation of a genset using frequency droop or voltage droop might be required under certain system conditions. For example, when the controller cannot interface with all the controllers in the system.

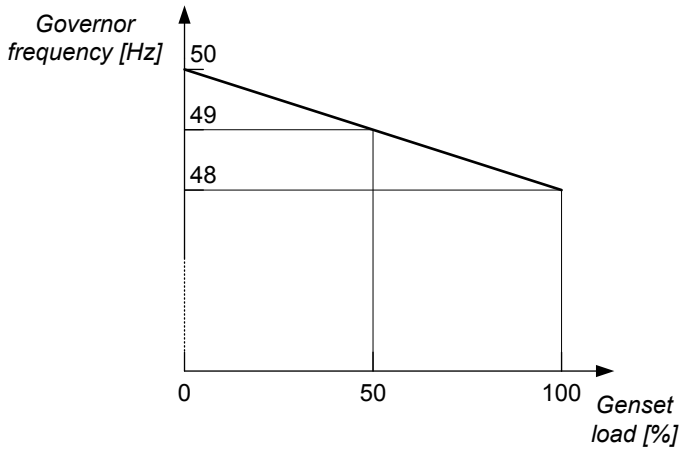
**Droop definitions**

| Droop name | Description |
|---|---|
| Governor or AVR droop | The droop setting of the governor or AVR.<br><br>The governor droop and AVR droop is always present when it is activated in the governor or AVR. |
| Controller droop | The droop setting in the controller. This refers to the *Frequency droop* parameter, the *Voltage droop* parameter, or both parameters.<br><br>The controller droop setting is only active when the frequency droop and/or voltage droop is the selected regulation mode. When the regulation mode is present, the controller regulates the governor and/or AVR to follow the droop curve, based on the emulated droop from the controller. |
| Frequency droop | This droop value is related to the engine speed. Since engine speed and the generator frequency are proportional, you can also use the generator frequency to calculate frequency droop (governor droop). |
| Voltage droop | The droop value that is related to the generator voltage (AVR droop). |

When the controller is in *Frequency droop* or *Voltage droop* regulation mode, the regulation of the governor and AVR emulates a situation where the load sharing is controlled by the droop. For example, when there is a higher load, the controller regulates the governor to get a slightly lower frequency. The droop setting in the controller does not change the actual droop in the governor or AVR.

The genset frequency follows the frequency of the busbar when more than one power generating assets or mains is connected to the busbar. The power output is related to the frequency by the droop curve when droop is activated in the governor, or when frequency droop is the active regulation mode in the controller. When the load on the busbar changes (for example, when a load is added or removed), all the gensets that are connected to the busbar that are in droop mode will adjust their power output according to the droop curve at the busbar frequency. If the gensets have the same droop value, then the load is shared equally between the gensets.

**Figure 8.4** Example of a frequency droop curve for a genset with 4% frequency droop

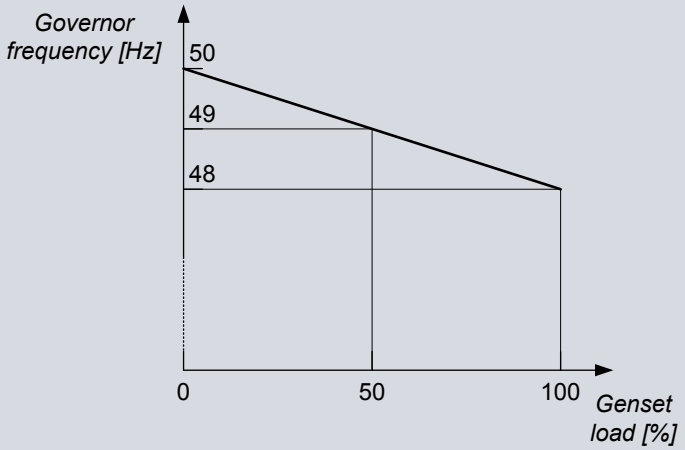



The reactive power output is related to the voltage by the voltage droop curve when droop is activated in the AVR, or when voltage droop is the active regulation mode on the controller. The reactive power load during voltage droop is shared in a similar way as active power is shared during frequency droop.

**Gensets with the same droop setting example**

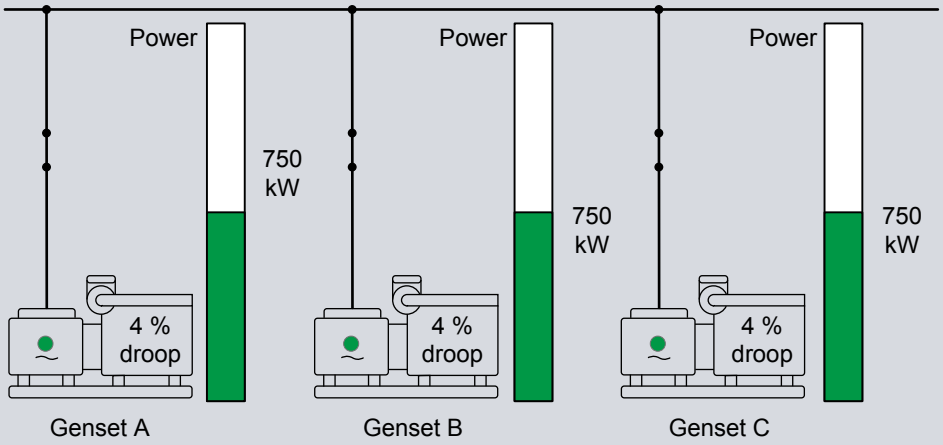
Gensets A, B and C have a nominal power of 1500 kW each and operate at a nominal frequency of 50 Hz. Each genset has a 4 % controller droop. The droop curve for each genset is the same, and is shown in the figure below.

**Figure 8.5** Droop curve for gensets A, B and C




All of the gensets are connected to the busbar and are running frequency droop as the active regulation mode. When the load on the busbar increases to 2250 kW, the gensets are able to share the load equally because they have the same droop. The new frequency of the busbar and the gensets is 49 Hz (50 Hz × (1 - 0.04 × 750 kW / 1500 kW) = 49 Hz).

At a total load of 2250 kW, the system runs at 49 Hz. Gensets A, B and C each supply 750 kW (50 % of nominal power).

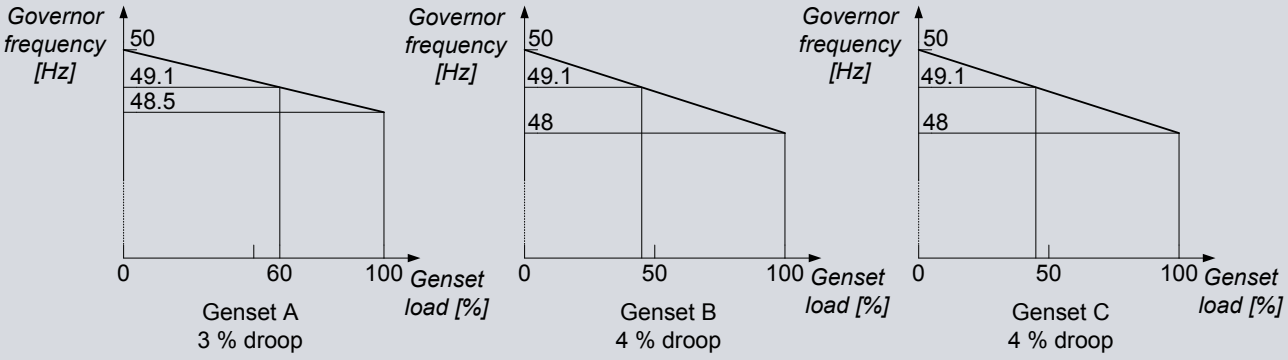



If the gensets that are connected to the same busbar section have different droop settings, the genset(s) with a lower droop will be loaded more. When the droop curve for one or more gensets are different from the other gensets on the busbar, the gensets take a different proportion of the load due to the different droop curves.

**Gensets with different droop settings example**

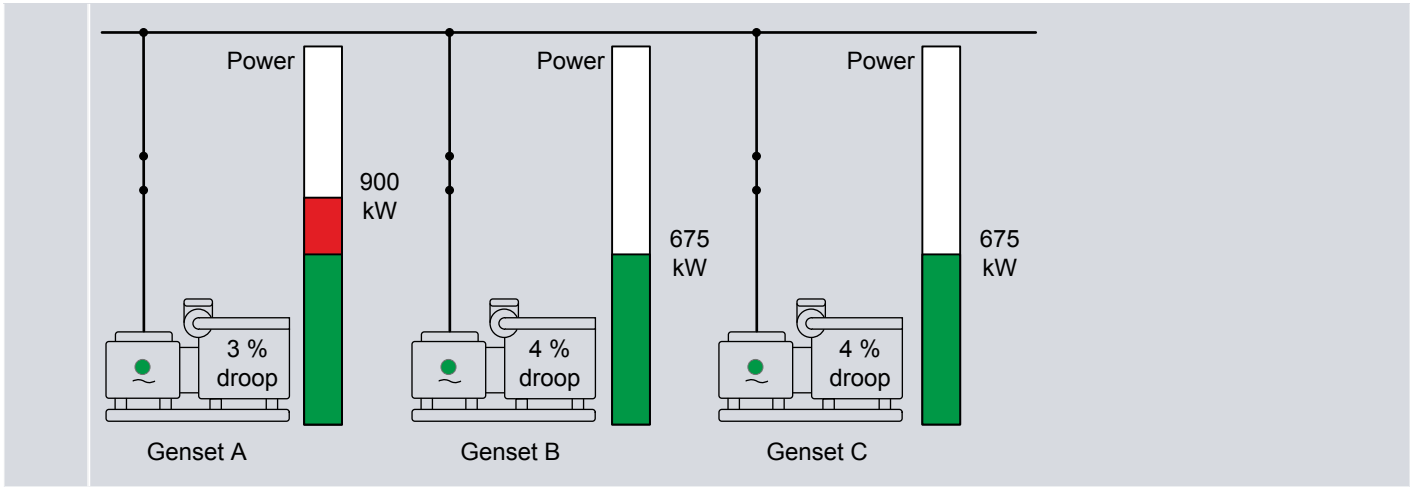
Gensets A, B and C have a nominal power of 1500 kW each and operate at a nominal frequency of 50 Hz. Genset A has a 3 % droop and gensets B and C each have a 4 % droop.

**Figure 8.6** Droop curves for gensets A, B and C




All of the gensets are connected to the busbar and are running frequency droop as the active regulation mode. When the load on the busbar increases to 2250 kW, the load is not shared equally between the gensets. The new frequency on the busbar is 49.1 Hz. Because all the generators on the busbar operate at the same frequency, Genset A takes more of the load than gensets B and C.

At a total load of 2250 kW, the system runs at 49.1 Hz. Genset A supplies 900 kW (60 % of nominal power), while Gensets B and C each supply 675 kW (45 % of their nominal power).




**More information**
See Frequency droop and Voltage droop for information about these regulation modes.

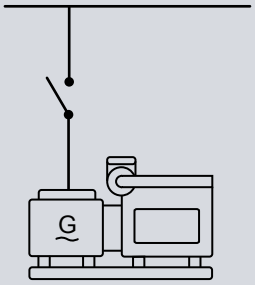
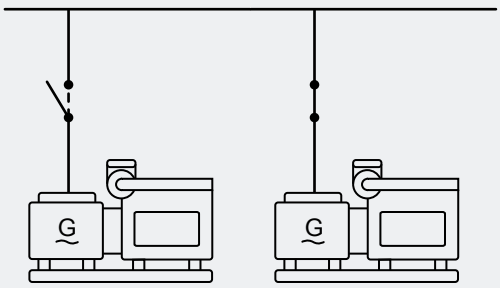
## 8.1.5 Regulation rules

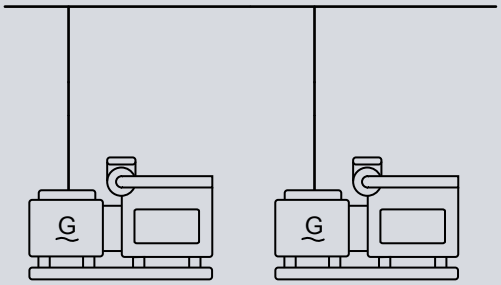
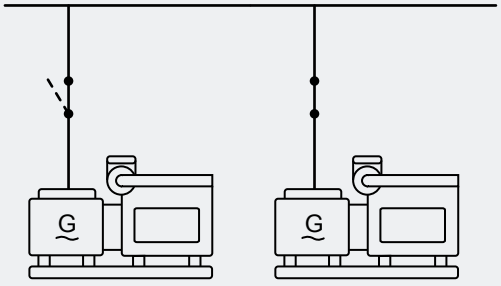
The controller regulates the genset as follows:

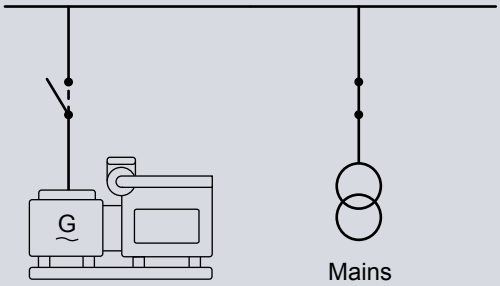
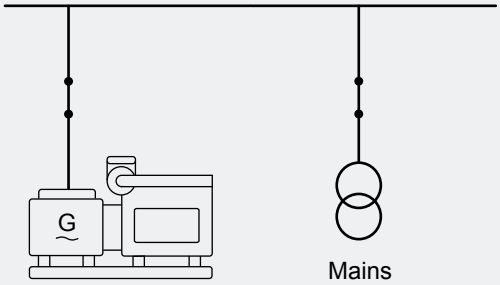
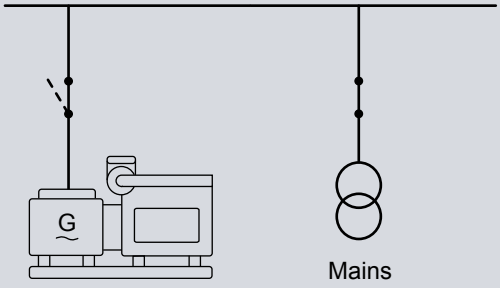
- **Not connected**: According to the selected regulation mode and inputs.
- **Synchronising**: The controller synchronises the genset to the busbar. The regulation mode and other inputs are ignored.
- **Connected**: According to the selected regulation mode and inputs.

During regulation of the system, the guidelines for the controller mode selection should be followed. The suggested regulation mode in the table is always for the asset on the left side of the busbar in the image.

**Suggested regulation modes**

| Condition | | Suggested governor mode | Suggested AVR mode | Set point source |
|---|---|---|---|---|
|   | The generator breaker is open and the genset is running.<br><br>This can be a stand-alone genset, or a genset in a system. | • Fixed frequency (Recommended)<br>• Fixed RPM (Recommended for asynchronous gensets)<br>• Power load share<br>• Frequency droop | • Fixed voltage (Recommended)<br>• Reactive power load share<br>• Voltage droop | • Genset nominal frequency<br>• Genset nominal voltage |
|   | The generator breaker is open and the **GENSET** controller receives a close breaker command. | • Before sending command to close breaker:<br>◦ Fixed frequency (Recommended)<br>◦ Fixed RPM (Recommended for asynchronous gensets) | • Before sending command to close breaker:<br>◦ Fixed voltage (Recommended)<br>◦ Reactive power load share<br>◦ Voltage droop<br>• No mode selection required while synchronising | |

| Condition | | Suggested governor mode | Suggested AVR mode | Set point source |
|---|---|---|---|---|
| | The controller sends commands to synchronise genset to the busbar frequency and voltage. | ◦ Power load share<br>◦ Frequency droop<br>• No mode selection required while synchronising | | |
|  | The genset is connected to the busbar without mains and is producing power.<br><br>The genset can be one genset connected to the busbar, or a genset running parallel to another power producing component (except mains) on the busbar. | • Power load share (Recommended)<br>• Fixed power<br>• Frequency droop | • Reactive power load share (Recommended)<br>• Fixed reactive power<br>• Fixed cos phi<br>• Voltage droop | • Controller set point<br>• External set point<br>◦ Modbus<br>◦ Analogue |
|  | The genset is running parallel to another power producing component on the busbar (except mains). The **GENSET** controller receives a open breaker command.<br><br>The controller sends | • Before sending command to open breaker:<br>◦ Power load share (Recommended)<br>◦ Fixed power<br>◦ Frequency droop<br>• No mode selection required while de-loading | • Before sending command to open breaker:<br>◦ Reactive power load share (Recommended)<br>◦ Fixed reactive power<br>◦ Fixed cos phi<br>◦ Voltage droop<br>• No mode selection required while de-loading | |

| Condition | | Suggested governor mode | Suggested AVR mode | Set point source |
|---|---|---|---|---|
| | commands to de-load the generator breaker. | | | |
|  | The generator breaker is open and the **GENSET** controller receives a close breaker command.<br><br>The controller sends commands to synchronise genset to the busbar frequency and voltage. | • Before sending command to close breaker:<br>◦ Fixed frequency (Recommended)<br>◦ Fixed RPM (Recommended for asynchronous gensets)<br>◦ Power load share<br>◦ Frequency droop<br>• No mode selection required while synchronising | • Before sending command to close breaker:<br>◦ Fixed voltage (Recommended)<br>◦ Reactive power load share<br>◦ Voltage droop<br>• No mode selection required while synchronising | |
|  | The genset is running parallel to mains and is producing power.<br><br>The genset can be part of a system of power producing components on the busbar that are running parallel to mains. | • Fixed power (Recommended)<br>• Frequency droop | • Fixed reactive power (Recommended)<br>• Fixed cos phi (Recommended)<br>• Voltage droop | • Controller set point<br>• External set point<br>◦ Modbus<br>◦ Analogue |
|  | The genset is running parallel to mains. The **GENSET** controller receives a open breaker command. | • Before sending command to open breaker:<br>◦ Fixed power (Recommended)<br>◦ Frequency droop<br>• No mode selection required while de-loading | • Before sending command to open breaker:<br>◦ Fixed reactive power (Recommended)<br>◦ Fixed cos phi (Recommended)<br>◦ Voltage droop | |

| Condition | | Suggested governor mode | Suggested AVR mode | Set point source |
|---|---|---|---|---|
| | The controller sends commands to de-load the generator breaker. | | • No mode selection required while de-loading | |

### 8.1.6 Freeze regulation

You can use the *Freeze regulator* digital input to override the regulation settings on a genset. The *Freeze regulator* command stops regulation on the governor and the AVR when it is activated.

**Digital input**

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > Common > Freeze regulator` | Digital input | Continuous | The operator activates this input to override any regulation settings on the governor and the AVR. |

When the *Freeze regulation* input is active the Regulator status screen on the display will show *No regulation*.

## 8.2 Governor regulation modes

### 8.2.1 How it works

The genset regulation system consists of a number of regulation modes for the governor. Each regulator processes the input information and calculates the regulation to reach the required operating value. The resulting value is then modified according to the governor interface, and sent to the governor.

**NOTICE**

**Parameters require input/output configuration**

To see the parameters, you must have a governor configured in the controller with *Input/output* (relay output or analogue output).

When a generator breaker is closed and a governor regulator is configured, the operator, CustomLogic, CODESYS or PLC must select a regulation mode. If no mode is selected, then the *Governor regulator mode not selected* alarm activates informing the operator that no regulation mode is selected.

While the generator breaker is closed, the operator, CustomLogic, CODESYS or PLC can change the regulation mode by activating a different regulation mode. When a new regulation mode is selected, the previous regulation mode is deactivated automatically. If multiple regulation modes are written to the controller at almost the same time, the mode that was received last will be the new active mode.

In some cases the operator might want to deactivate regulation. This can be done with the *Deactivate regulation* functions.

### 8.2.2 Deactivate regulation

When the genset is running, it is recommended to always have a regulation mode selected. It is possible to change the regulation mode from one regulation mode to another without deactivating the current regulation mode first. In some special cases you might want to deactivate the controller regulation mode.

When the **Deactivate regulation** governor regulation mode is selected, the current regulation mode is deactivated and the governor regulation status is *No regulation*. While no governor regulation mode is selected, the controller does not send any regulation signals to the governor. It is also not possible to send manual regulation signals to the governor through the controller inputs (**Manual GOV increase** and **Manual GOV decrease**). This means that the genset has the same frequency and power production (if governor droop is active) as before the regulation mode was deactivated, unless the changes are directly caused by the genset.

When no regulation mode is selected, the controller does not activate the **Frequency synchronisation, Phase synchronisation** or **RPM synchronisation** regulation modes when the breaker close signal, or breaker open signal is activated on the controller.

### Digital input

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > GOV > Modes > Deactivate regulation` | Digital input | Pulse | The operator activates this input to deactivate the current governor regulation mode. |

## 8.2.3 Fixed frequency

If a genset is running with an open generator breaker, then the controller uses fixed frequency regulation to keep the frequency at the nominal set point.

If a genset is operating as a stand-alone genset, the operator, CustomLogic, CODESYS or PLC can select fixed frequency regulation, so that the controller uses the nominal frequency as the regulation set point.

Alternatively the fixed frequency set point can be determined by an analogue input, CustomLogic, Modbus, or CODESYS.

**More information**
See External communication how the fixed frequency set point is configured using an analogue input or Modbus.

### Digital inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > GOV > Modes > Activate fixed frequency` | Digital input | Pulse | The operator activates this input to activate fixed frequency regulation. |
| `Regulators > GOV > Modes > Deactivate fixed frequency` | Digital input | Pulse | The operator activates this input to deactivate fixed frequency regulation. |
| `Regulators > GOV > Modes > Deactivate regulation` | Digital input | Pulse | Disables any active governor regulation mode. |
| `Regulators > GOV > State > Fixed frequency regulation is selected` | Digital output | Continuous | The relay activates when fixed frequency regulation is selected. |
| `Regulators > GOV > State > Fixed frequency regulation is active` | Digital output | Continuous | The relay activates when fixed frequency regulation is active. |

### Analogue governor output frequency parameters

The frequency regulation parameters define analogue regulation when the controller regulates the frequency.

**`Regulators > GOV analogue configuration > Frequency regulation`**

| Parameter | Range | Notes |
|---|---|---|
| `Kp` | 0 to 60 | The PID gain for the regulator. |
| `Ti` | 0 s to 1 min | The PID control integral time. |
| `Td` | 0 to 2 s | The PID control derivative. |

### Relay governor output frequency parameters

The frequency regulation parameters define relay regulation when the controller regulates the frequency.

**`Regulators > GOV > Relay configuration > Frequency regulation`**

| Parameter | Range | Notes |
|---|---|---|
| `Kp` | 0 to 100 | This is the gain for the regulator. |
| `Deadband` | 0.2 to 10 % | The deadband for the regulator, as a percentage of the nominal frequency. |

## 8.2.4 Fixed power

If a genset is connected to the busbar along with other power generating equipment, the controller can use fixed power (that is, active power) regulation to ensure that the genset provides a constant amount of power to the busbar regardless of the busbar frequency. The genset that is under fixed power regulation will provide a constant amount of power to the busbar, regardless of the frequency on the busbar. This means that there must be other power generating equipment on the busbar, to regulate the frequency of the busbar.

If only one genset is connected to a busbar without any other power generating equipment, then fixed power regulation is not possible. In this situation changing the goevrnor output only changes the frequency of the genset, and not the power.

The controller also uses fixed power regulation when ramping up the power of a genset (increasing the load), or when ramping down the power of a genset (decreasing the load).

If multiple gensets are connected to the same busbar section, the controller can regulate its genset to provide fixed power. Connected gensets automatically run at the same engine speed. Therefore, decreasing the fuel to the genset automatically decreases the power that it provides, and increases the load on the other power generating equipment. Increasing the fuel to the genset automatically increases the power that it provides, and decreases the load on the other power generating equipment.

If more than one genset is connected to the busbar, then the total load on the busbar must be greater than the fixed power set point. To ensure that the busbar frequency is stable, you must have more gensets under load sharing regulation than fixed power regulation.

Alternatively the fixed power set point can be determined by an analogue input, CustomLogic, Modbus, or CODESYS.

**More information**
See External communication how the fixed power set point is configured using an analogue input or Modbus.

### Digital inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > GOV > Modes > Activate fixed power` | Digital input | Pulse | The operator activates this input to activate fixed power regulation. |
| `Regulators > GOV > Modes > Deactivate fixed power` | Digital input | Pulse | The operator activates this input to deactivate fixed power regulation. |
| `Regulators > GOV > Active power offset > Active power offset 1` | Digital input | Continuous | The operator activates this input to add the **Offset 1** value for fixed power to the fix power set point. |
| `Regulators > GOV > Active power offset > Active power offset 2` | Digital input | Continuous | The operator activates this input to add the **Offset 2** value for fixed power to the fix power set point. |
| `Regulators > GOV > Active power offset > Active power offset 3` | Digital input | Continuous | The operator activates this input to add the **Offset 3** value for fixed power to the fix power set point. |

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > GOV > Modes > Deactivate regulation` | Digital input | Pulse | Disables any active governor regulation mode. |
| `Regulators > GOV > State > Fixed power regulation is selected` | Digital output | Continuous | The relay activates when fixed power regulation is selected. |
| `Regulators > GOV > State > Fixed power regulation is active` | Digital output | Continuous | The relay activates when fixed power regulation is active. |

### Parameters

**`Regulators > GOV > Regulation set points > Fixed power`**

| Parameter | Range | Notes |
|---|---|---|
| `Set point` | -100 to 100 % | The regulation set point for fixed power, as a percentage of the genset's nominal power. |
| `Offset 1` | -100.0 to 100.0 % | This value is added to the fixed power set point when the **Active power offset 1** digital input is activated. |
| `Offset 2` | -100.0 to 100.0 % | This value is added to the fixed power set point when the **Active power offset 2** digital input is activated. |
| `Offset 3` | -100.0 to 100.0 % | This value is added to the fixed power set point when the **Active power offset 3** digital input is activated. |
| `Limit 1` | -300.00 to 300.00 % | This value is the upper or lower limit for the power set point for fixed power regulation.<br><br>It does not matter whether **Limit 1** is higher or lower than **Limit 2** when the controller determines the set point range. |
| `Limit 2` | -300.00 to 300.00 % | This value is the upper or lower limit for the power set point for fixed power regulation.<br><br>It does not matter whether **Limit 2** is higher or lower than **Limit 1** when the controller determines the set point range. |

**Adding offsets to the fixed power set point example**

A genset that is running parallel to other gensets is under fixed power regulation. The fixed power set point is 30 % of the nominal genset power. **Offset 1** is set to -5 %, **Offset 2** is set to 5 %, and **Offset 3** is set to 10 %.

1. **Active power offset 1** is activated. The fixed power set point changes from 30 % to 25 %.
   - New set point = Current set point + offset = 30 % + (-5 %) = 25 %
2. **Active power offset 1** is deactivated. The fixed power set point changes from 25 % to 30 %.
   - New set point = Current set point - offset = 25 % - (-5 %) = 30 %
3. **Active power offset 2** and **Active power offset 3** are activated. The fixed power set point changes from 30 % to 45 %.
   - New set point = Current set point + offset 2 + offset 3 = 30 % + 5 % + 10 % = 45 %

**Limiting the fixed power set point example**

A genset that is running parallel to other gensets is under fixed power regulation. The fixed power set point is 30 % of the nominal genset power. **Offset 1** is set to 20 %, **Offset 2** is set to 30 %, and **Offset 3** is set to 40 %. **Limit 1** is set to 2 % and **Limit 2** is set to 100 %.

If **Active power offset 1**, **Active power offset 2** and **Active power offset 3** are activated at the same time, then the calculated set point is 120 % of nominal genset power. But this value is higher than **Limit 2**. The power set point is 100 %, because the calculated value is outside of the set point range that is determined by **Limit 1** and **Limit 2**.

**Limit 1** is changed to 80 % and **Limit 2** is changed to 40 % and all other parameters remain the same as earlier in the example. The set point range is 40 % to 80 %.

1. The genset has a fixed power set point of 40 % when no offsets are activated. This is because the **Set point** (30 %) is lower than the lower limit (**Limit 2** = 40 %).
   - Because the **Set point** (30 %) is lower than the set point range, the set point is adjusted to the lower limit of the range (**Limit 2** = 40 %).
2. If **Active power offset 1** is activated, the set point changes from 40 % to 50 %.
   - New set point = current set point + offset = 30 % +20 % = 50 %.
   - The new set point is within the set point range, and is not adjusted by **Limit 1** and **Limit 2**.
3. If **Active power offset 1** and **Active power offset 3** are activated at the same time, then the fixed power set point is 80 %.
   - New set point = current set point + offset 1 + offset 3 = 30 % + 20 % + 40 % = 90 %
   - The new set point is not inside the set point range. The set point is adjusted to the upper limit of the range (**Limit 1** = 80 %).

### Analogue governor output power parameters

The power regulation parameters define analogue regulation when the controller regulates the governor to change the genset active power output.

**`Regulators > GOV > Analogue > Power regulation`**

| Parameter | Range | Notes |
|---|---|---|
| `Kp` | 0 to 60 | The PID gain for the regulator. |
| `Ti` | 0 s to 1 min | The PID control integral time. |
| `Td` | 0 to 2 s | The PID control derivative. |

### Relay governor output power parameters

The power regulation parameters define relay regulation when the controller regulates the governor to change the genset active power output.

**`Regulators > GOV > Relay configuration > Power regulation`**

| Parameter | Range | Notes |
|---|---|---|
| `Kp` | 0 to 100 | This is the gain for the regulator. |
| `Deadband` | 0.2 to 10.0 % | The deadband for the regulator, as a percentage of the nominal power. |

## 8.2.5 Frequency droop

If a genset is connected to the busbar, with or without other power generating assets connected to the same busbar section, the controller can use frequency droop to regulate the genset frequency/power.

This setting does not provide optimal regulation of the genset, and should only be used if there is a specific design reason for its use.

During frequency droop regulation the controller regulates the governor output to follow the droop setting of the controller.

**More information**
See Droop for the relationship between the controller droop and the governor droop.

### Digital inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > GOV > Modes > Activate frequency droop` | Digital input | Pulse | The operator activates this input to activate frequency droop regulation. |
| `Regulators > GOV > Modes > Deactivate frequency droop` | Digital input | Pulse | The operator activates this input to deactivate frequency droop regulation. |
| `Regulators > GOV > Modes > Deactivate regulation` | Digital input | Pulse | Disables any active governor regulation mode. |
| `Regulators > GOV > State > Frequency droop regulation is selected` | Digital output | Continuous | The relay activates when frequency droop regulation is selected. |
| `Regulators > GOV > State > Frequency droop regulation is active` | Digital output | Continuous | The relay activates when frequency droop regulation is active. |

### Parameters

**`Regulators > GOV > Analogue > Frequency droop`**

| Parameter | Range | Notes |
|---|---|---|
| `Droop` | 0.0 to 10.0 % | The droop percentage that the controller is regulating towards. The controller droop does not have to be the same as the genset's governor droop.<br><br>A high droop setting results in high frequency deviations from nominal frequency.<br><br>A too low droop setting results in not adding the necessary stability to the system. |

**`Regulators > GOV > Relay configuration > Frequency droop`**

| Parameter | Range | Notes |
|---|---|---|
| `Droop` | 0.0 to 10.0 % | The droop percentage that the controller is regulating towards. The controller droop does not have to be the same as the genset's governor droop.<br><br>A high droop setting results in high frequency deviations from nominal frequency.<br><br>A too low droop setting results in not adding the necessary stability to the system. |

The droop setting for an analogue regulator is not linked to the droop setting for a relay regulator. This means that if you change from an analogue output to a relay output (or from a relay output to an analogue output), you must check the droop setting and correct it if required.

## 8.2.6 Power load sharing

During power (kW) load sharing, the controller uses the nominal frequency as a reference to regulate the governor output to the genset. The nominal frequency reference can be adjusted by contributing a weighted amount of the power set point to the reference value.

Power (kW) load sharing can be used in a system where more than one genset is connected to the same busbar section. At least two of these gensets must have power load sharing regulation mode activated in order to share the load between them.

All gensets on the same busbar section that have power load sharing active, will share an equal percentage of the load.

**More information**
See Busbar sections and load sharing.

### Digital inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > GOV > Modes > Activate power load sharing` | Digital input | Continuous | The operator activates this input to activate power load sharing. |
| `Regulators > GOV > Modes > Deactivate regulation` | Digital input | Pulse | Disables any active governor regulation mode. |
| `Regulators > GOV > State > Power load sharing is selected` | Digital output | Continuous | The relay activates when active power load sharing (kW) is selected. |
| `Regulators > GOV > State > Power load sharing is active` | Digital output | Continuous | The relay activates when active power load sharing (kW) is active. |

### Analogue governor output power load sharing parameters

The power load sharing parameters define analogue regulation when the controller regulates the genset active power output for load sharing.

**`Regulators > GOV > Analogue > Power load sharing regulation`**

| Parameter | Range | Notes |
|---|---|---|
| `Kp` | 0 to 60 | The PID gain for the regulator. |
| `Ti` | 0 s to 1 min | The PID control integral time. |
| `Td` | 0 to 2 s | The PID control derivative. |
| `P weight` | 0 to 100 % | If P weight is 100 %, the controller uses the power and frequency set points equally during load sharing regulation. If P weight is 0 %, the controller ignores the power set point during load sharing regulation.<br><br>DEIF recommends that you start with the default value, and then, if necessary, adjust this parameter. If *P weight* is too low, the load sharing will not be effective and the load will float between the controllers. If *P weight* is too high, the frequency regulation will be too slow, for example, when a big load connects. |

### Relay governor output power load sharing parameters

The power load sharing parameters define relay regulation when the controller regulates the genset active power output for load sharing.

**`Regulators > GOV > Relay configuration > Power load sharing regulation`**

| Parameter | Range | Notes |
|---|---|---|
| `Kp` | 0 to 100 | This is the gain for the regulator. |
| `f deadband` | 0.2 to 10 % | The frequency deadband for the regulator, as a percentage of nominal frequency.<br><br>The default deadband is ± 1 %. That is, for a genset with a nominal frequency of 50 Hz, the deadband is 1 Hz. When the controller frequency set point is 50 Hz, the regulator will not control the frequency if it is between 49.5 and 50.5 Hz. |
| `P deadband` | 0.2 to 10 % | The power deadband for the regulator, as a percentage of nominal power.<br><br>The default deadband is ± 2 %. That is, for a genset with a nominal power of 100 kW, the deadband is 4 kW. When the controller power set point is 50 kW, the regulator will not control the power if it is between 48 and 52 kW. |
| `P weight` | 0 to 100 % | If P weight is 100 %, the controller uses the power and frequency set points equally during load sharing regulation. If P weight is 0 %, the controller ignores the power set point during load sharing regulation. |

| Parameter | Range | Notes |
|---|---|---|
| | | DEIF recommends that you start with the default value, and then, if necessary, adjust this parameter. If *P weight* is too low, the load sharing will not be effective and the load will float between the controllers. If *P weight* is too high, the frequency regulation will be too slow, for example, when a big load connects. |

## 8.2.7 Manual regulation

When *Manual regulation* is the active regulation mode, the operator controls the governor output manually. The operator can increase or decrease governor output of the genset using digital inputs (if configured) or Modbus. During *Manual regulation*, both the synchronisation and the de-loading must also be manually controlled.

### Digital inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > GOV > Modes > Activate manual regulation` | Digital input | Pulse | The operator activates this input to activate manual regulation. |
| `Regulators > GOV > Modes > Deactivate manual regulation` | Digital input | Pulse | The operator activates this input to deactivate manual regulation. |
| `Regulators > GOV > Manual > Manual GOV increase` | Digital input | Continuous | When this input is activated during *Manual regulation*, the controller increases the output to the governor. This affects the `Regulators > GOV > Control > GOV increase` digital output, or the `Regulator > GOV > Control > GOV output [%]` analogue output.<br><br>Set the percentage change of the governor analogue output value per second for manual analogue regulation under `Regulators > GOV analogue configuration > Manual slope`. |
| `Regulators > GOV > Manual > Manual GOV decrease` | Digital input | Continuous | When this input is activated during *Manual regulation*, the controller decreases the output to the governor. This affects the `Regulators > GOV > Control > GOV decrease` digital output, or the `Regulator > GOV > Control > GOV output [%]` analogue output.<br><br>Set the percentage change of the governor analogue output value per second for manual analogue regulation under `Regulators > GOV analogue configuration > Manual slope`. |
| `Regulators > GOV > Modes > Deactivate regulation` | Digital input | Pulse | Disables any active governor regulation mode. |
| `Regulators > GOV > State > Manual GOV regulation is active` | Digital output | Continuous | The relay activates when *Manual regulation* is the active governor regulation mode. |

### Parameters

**`Regulators > GOV > Analogue > Manual slope`**

This parameter is only visible if a governor analogue output is configured.

| Parameter | Range | Notes |
|---|---|---|
| Manual GOV slope | 0 to 200 %/s | The controller increases or decreases the *GOV output [%]* analogue output by this amount when the *Manual GOV increase* or *Manual GOV decrease* digital inputs are activated. |

**Regulators > GOV > Relay configuration > Manual configuration**

These parameters adjust the controller's relay control output when the selected regulation mode is **Manual regulation**.

| Parameter | Range | Notes |
|---|---|---|
| Period time | 40 ms to 1 h | You can make the governor response faster by decreasing the *Period time*. However, if the rest of the system is slow anyway, you can reduce the wear on the relays by increasing the *Period time*.<br><br>Although a relay controller is capable of fast responses, the *Period time* should be similar to the response of the system to extend the relay life. |
| Minimum ON time | 40 ms to 1 h | The *Minimum ON time* must be long enough to ensure that the governor can detect the shortest pulse that the controller sends to it. You can increase the *Minimum ON time* to force a slow system to respond more to the controller's regulation.<br><br>If the controller needs to increase the governor output, the *GOV increase* digital output is activated for at least the *Minimum ON time*. While the controller is increasing the governor output, the *GOV decrease* digital output is not activated.<br><br>If the controller needs to decrease the governor output, the *GOV decrease* digital output is activated for at least the *Minimum ON time*. While the controller is decreasing the governor output, the *GOV increase* digital output is not activated. |

## 8.2.8 Frequency synchronisation

### Analogue governor output frequency synchronisation parameters

The frequency synchronisation parameters define analogue regulation when the controller regulates the frequency for breaker synchronisation.

**Regulators > GOV analogue configuration > Frequency synchronisation**

| Parameter | Range | Notes |
|---|---|---|
| Kp | 0 to 60 | The PID gain for the regulator. |
| Ti | 0 s to 1 min | The PID control integral time. |
| Td | 0 to 2 s | The PID control derivative. |

### Relay governor output frequency synchronisation parameters

The frequency synchronisation parameter defines relay regulation when the controller regulates the frequency for breaker synchronisation.

**Regulators > GOV > Relay configuration > Frequency synchronisation**

| Parameter | Range | Notes |
|---|---|---|
| Kp | 0 to 100 | This is the gain for the regulator. |

## 8.2.9 Phase synchronisation

The controller uses the phase synchronisation parameters to synchronise the phase angle of a synchronous prime mover to the phase angle of the busbar during static synchronisation. These regulation parameters are used automatically when the

controller receives the *Close breaker* command and any regulation mode (except **Manual regulation**) is active on the controller.

### Analogue governor output phase synchronisation parameters

The phase synchronisation parameters define analogue regulation when the controller regulates the phase angle for breaker static synchronisation.

**`Regulators > GOV > Analogue > Phase synchronisation`**

| Parameter | Range | Notes |
|---|---|---|
| `Kp` | 0 to 60 | The PID gain for the regulator. |
| `Ti` | 0 s to 1 min | The PID control integral time. |
| `Td` | 0 to 2 s | The PID control derivative. |

### Relay governor output phase synchronisation parameters

The phase synchronisation parameter defines relay regulation when the controller regulates the phase angle for breaker static synchronisation.

**`Regulators > GOV > Relay configuration > Phase synchronisation`**

| Parameter | Range | Notes |
|---|---|---|
| `Kp` | 0 to 100 | This is the gain for the regulator. |

## 8.3 AVR regulation modes

### 8.3.1 How it works

The genset regulation system consists of a number of basic control modes for the AVR. Each controller processes the input information and calculates what action the genset should take to reach the required operating value. The calculated value is then modified according to the AVR interface, and sent to the AVR.

**NOTICE**

**Parameters require output configuration**

To see the parameters, you must have an AVR configured in the controller with relay outputs or analogue output and no governor mode is active.

When a generator breaker is closed and an AVR regulator is configured, the operator, CustomLogic, CODESYS or PLC must select a regulation mode. If no mode is selected, then the *Regulation mode not selected* alarm activates (if enabled) informing the operator that no regulation mode is selected.

While the generator breaker is closed, the operator, CustomLogic, CODESYS or PLC can change the regulation mode by activating a different regulation mode. When a new regulation mode is selected, the previous regulation mode is deactivated automatically. If multiple regulation modes are written to the controller at almost the same time, the mode that was received last will be the new active mode.

In some cases the operator might want to deactivate the regulation mode. To do this the operator must activate the *Deactivate* digital input.

**NOTICE**

**Genset start and regulation mode**

The controller does not automatically select a regulation mode when the genset is started.

## 8.3.2 Deactivate regulation

When the genset is running, it is recommended to always have a regulation mode selected. It is possible to change the regulation mode from one regulation mode to another without deactivating the current regulation mode first. In some special cases you might want to deactivate the controller regulation mode.

When the **Deactivate regulation** AVR regulation mode is selected, the current regulation mode is deactivated and the AVR regulation status is *No regulation mode selected*. While no AVR regulation mode is selected, the controller does not send any regulation signals to the AVR. It is also not possible to send manual regulation signals to the AVR through the controller inputs (**Manual AVR increase** and **Manual AVR decrease**). This means that the genset has the same voltage and reactive power production (if AVR droop is active) as before the regulation mode was deactivated, unless the changes are directly caused by the genset.

### Digital input

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > AVR > Modes > Deactivate regulation` | Digital input | Pulse | The operator activates this input to deactivate the current AVR regulation mode. |

## 8.3.3 Fixed voltage

The controller can regulate and maintain the genset voltage at its nominal voltage by sending a signal to the AVR to adjust the exciter current.

When the genset is not connected to the busbar and fixed voltage is selected, the controller regulates the voltage to the genset nominal voltage. During synchronisation the controller regulates the voltage to the busbar voltage. If a genset is already connected to a load, the controller matches the generator voltages before closing an additional generator breaker.

Alternatively the fixed voltage set point can be determined by an analogue input, CustomLogic, Modbus, or CODESYS.

**More information**

See External communication how the fixed voltage set point is configured using an analogue input or Modbus.

### Digital inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > AVR > Modes > Activate fixed voltage` | Digital input | Pulse | The operator activates this input to activate fixed voltage regulation. |
| `Regulators > AVR > Modes > Deactivate fixed voltage` | Digital input | Pulse | The operator activates this input to deactivate fixed voltage regulation. |
| `Regulators > GOV > Modes > Deactivate regulation` | Digital input | Pulse | Disables any active governor regulation mode. |
| `Regulators > AVR > State > Fixed voltage is active` | Digital output | Continuous | The relay activates when fixed voltage regulation is active. |

### Analogue AVR output voltage parameters

The voltage regulation parameters define analogue regulation when the controller regulates the voltage.

**Regulators > AVR > Analogue > Voltage regulation**

| Parameter | Range | Notes |
|---|---|---|
| Kp | 0 to 60 | The PID gain for the regulator. |
| Ti | 0 s to 1 min | The PID control integral time. |
| Td | 0 to 2 s | The PID control derivative. |

### Relay AVR output voltage parameters

The voltage regulation parameters define relay regulation when the controller regulates the voltage.

**Regulators > AVR > Relay configuration > Voltage regulation**

| Parameter | Range | Notes |
|---|---|---|
| Kp | 0 to 100 | This is the gain for the regulator. |
| Deadband | 0 to 10 % | The deadband for the regulator, as a percentage of the nominal voltage. |

## 8.3.4 Fixed reactive power

If a genset is connected to the busbar along with other power generating equipment or mains, the controller can use fixed reactive power regulation to ensure that the genset provides a constant amount of reactive power to the busbar regardless of the active power produced by the genset. The controller can regulate and maintain the reactive power (kvar) of the genset at its set point by sending a signal to the AVR to adjust the exciter current. This changes the phase angle between the current and the voltage, hereby regulating the reactive power.

If a genset is connected to the busbar along with other power generating equipment, the controller can use fixed reactive power regulation to ensure that the genset provides a constant amount of reactive power to the busbar.

The controller also uses fixed reactive power regulation when ramping up the reactive power of a genset (increasing the load), or when ramping down the reactive power of a genset (decreasing the load).

If multiple gensets are connected to the same busbar section, the controller can regulate its genset to provide fixed reactive power. Connected gensets automatically run at the same voltage. Therefore, decreasing the excitation in the generator automatically decreases the reactive power that it provides, and increases the load on the other power generating equipment. Increasing the excitation in the generator automatically increases the reactive power that it provides, and decreases the load on the other power generating equipment.

**NOTICE**

**Genset forced to deliver fixed reactive power**

By forcing a genset to deliver a fixed reactive power, the other gensets will have to compensate for this genset's fixed position. This might cause the other gensets to produce too much capacitive or inductive reactive power.

Alternatively the fixed reactive power set point can be determined by an analogue input, CustomLogic, Modbus, or CODESYS.

**More information**

See External communication how the fixed reactive power set point is configured using an analogue input or Modbus.

### Digital inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > AVR > Modes > Activate fixed reactive power` | Digital input | Pulse | The operator activates this input to activate fixed reactive power regulation. |
| `Regulators > AVR > Modes > Deactivate fixed reactive power` | Digital input | Pulse | The operator activates this input to deactivate fixed reactive power regulation. |
| `Regulators > AVR > Reactive power offset > Cos phi/Reactive power offset 1` | Digital input | Continuous | The operator activates this input to add the **Offset 1** value for fixed reactive power or fixed cos phi to the set point. |
| `Regulators > AVR > Reactive power offset > Cos phi/Reactive power offset 2` | Digital input | Continuous | The operator activates this input to add the **Offset 2** value for fixed reactive power or fixed cos phi to the set point. |
| `Regulators > AVR > Reactive power offset > Cos phi/Reactive power offset 3` | Digital input | Continuous | The operator activates this input to add the **Offset 3** value for fixed reactive power or fixed cos phi to the set point. |
| `Regulators > AVR > Modes > Deactivate regulation` | Digital input | Pulse | Disables any active AVR regulation mode. |
| `Regulators > AVR > State > Fixed reactive power is active` | Digital output | Continuous | The relay activates when fixed reactive power regulation is active. |

### Parameters

**`Regulators > AVR > Regulation set points > Fixed reactive power`**

| Parameter | Range | Notes |
|---|---|---|
| `Set point` | -100 to 100 % | The regulation set point for fixed reactive power, as a percentage of the genset's nominal reactive power.<br><br>The genset's nominal reactive power is calculated by the controller.<br>📖 See **AC configuration and nominal settings, Nominal settings, Nominal power calculations** for more information about how the controller calculates the nominal reactive power. |
| `Set point` | Inductive, Capacitive | If the generator production requires reactive power from the system, it is a capacitive production with a leading cos phi value.<br><br>If the generator production supplies reactive power to the system, it is an inductive production with a lagging cos phi value. |
| `Set point adjustment` | Preferred, Locked | Preferred: The set point will remain at the fixed set point, but in certain situations, for example during de-load of another breaker, the produced power is allowed to change.<br><br>Locked: The controller will always regulate to the selected set point. |
| `Offset 1` | 0 to 100 % | This value is added to the fixed reactive power set point when the **Reactive power offset 1** digital input is activated. |
| `Offset 1` | Inductive, Capacitive | Select whether the offset has a lagging cos phi value (inductive), or a leading cos phi value (capacitive).<br><br>If the offset has the same value (inductive or capacitive) as the set point, then the offset is added to the set point. If the offset has a different value (inductive or capacitive) as the set point, then the offset is subtracted from the set point. |
| `Offset 2` | 0 to 100 % | This value is added to the fixed reactive power set point when the **Reactive power offset 2** digital input is activated. |

| Parameter | Range | Notes |
|---|---|---|
| Offset 2 | Inductive, Capacitive | Select whether the offset has a lagging cos phi value (inductive), or a leading cos phi value (capacitive).<br><br>If the offset has the same value (inductive or capacitive) as the set point, then the offset is added to the set point. If the offset has a different value (inductive or capacitive) as the set point, then the offset is subtracted from the set point. |
| Offset 3 | 0 to 100 % | This value is added to the fixed reactive power set point when the **Reactive power offset 3** digital input is activated. |
| Offset 3 | Inductive, Capacitive | Select whether the offset has a lagging cos phi value (inductive), or a leading cos phi value (capacitive).<br><br>If the offset has the same value (inductive or capacitive) as the set point, then the offset is added to the set point. If the offset has a different value (inductive or capacitive) as the set point, then the offset is subtracted from the set point. |
| Limit 1 | -300 to 300 % | This value is the upper or lower limit for the reactive power set point for fixed reactive power regulation.<br><br>It does not matter whether **Limit 1** is higher or lower than **Limit 2** when the controller determines the set point range. |
| Limit 2 | -300 to 300 % | This value is the upper or lower limit for the reactive power set point for fixed reactive power regulation.<br><br>It does not matter whether **Limit 2** is higher or lower than **Limit 1** when the controller determines the set point range. |

**Adding offsets to the fixed reactive power set point example**

A genset that is running parallel to mains is under fixed reactive power regulation. The fixed reactive power set point is 30 % of the nominal reactive power. **Offset 1** is set to 5 %, **Offset 2** is set to 10 %, and **Offset 3** is set to 15 %. The set point and all the offsets are set to *Inductive*.

1. **Reactive power offset 1** is activated. The fixed reactive power set point changes from 30 % inductive to 35 % inductive.
   - New set point = Current set point + offset = 30 % + 5 % = 35 %
2. **Reactive power offset 1** is deactivated. The fixed reactive power set point changes from 35 % inductive to 30 % inductive.
   - New set point = Current set point - offset = 35 % - 5 % = 30 %
3. **Reactive power offset 2** and **Reactive power offset 3** are activated. The fixed reactive power set point changes from 30 % inductive to 55 % inductive.
   - New set point = Current set point + offset 2 + offset 3 = 30 % + 10 % + 15 % = 55 %

**Offset 1** changes to 5 % *Capacitive*.

**Reactive power offset 1** is activated. The fixed reactive power set point changes from 30 % inductive to 25 % inductive.

- New set point = Current set point - offset = 30 % - 5 % = 25 %
- The offset is subtracted from the set point because the set point is an inductive value and the offset is a capacitive value.

**Limiting the fixed reactive power set point example**

A genset that is running parallel to mains is under fixed reactive power regulation. The fixed reactive power set point is 30 % of the nominal reactive power. **Offset 1** is set to 20 %, **Offset 2** is set to 30 %, and **Offset 3** is set to 40 %. **Limit 1** is set to 2 % and **Limit 2** is set to 100 %. The set point and all the offsets are set to *Inductive*.

If **Reactive power offset 1**, **Reactive power offset 2** and **Reactive power offset 3** are activated at the same time, then the calculated set point is 120 % (inductive) of nominal reactive power. But this value is higher than **Limit 2**. The reactive power set point is 100 % (inductive), because the calculated value is outside of the set point range that is determined by **Limit 1** and **Limit 2**.

**Limit 1** is changed to 80 % and **Limit 2** is changed to 40 % and all other parameters remain the same as earlier in the example. The set point range is 40 % to 80 %.

1. The genset has a fixed reactive power set point of 40 % when no offsets are activated. This is because the **Set point** (30 %) is lower than the lower limit (**Limit 2** = 40 %).
   - Because the **Set point** (30 %) is lower than the set point range, the set point is adjusted to the lower limit of the range (**Limit 2** = 40 %).
2. If **Active power offset 1** is activated, the set point changes from 40 % inductive to 50 % inductive.
   - New set point = current set point + offset = 30 % +20 % = 50 %.
   - The new set point is within the set point range, and is not adjusted by **Limit 1** and **Limit 2**.
3. If **Active power offset 1** and **Active power offset 3** are activated at the same time, then the fixed reactive power set point is 80 % inductive.
   - New set point = current set point + offset 1 + offset 3 = 30 % + 20 % + 40 % = 90 %
   - The new set point is not inside the set point range. The set point is adjusted to the upper limit of the range (**Limit 1** = 80 %).

### Analogue AVR output reactive power parameters

The reactive power regulation parameters define analogue regulation when the controller regulates the genset reactive power output.

**`Regulators > AVR > Analogue > Reactive power regulation`**

| Parameter | Range | Notes |
|---|---|---|
| `Kp` | 0 to 60 | The PID gain for the regulator. |
| `Ti` | 0 s to 1 min | The PID control integral time. |
| `Td` | 0 to 2 s | The PID control derivative. |

### Relay AVR output reactive power parameters

The reactive power regulation parameters define relay regulation when the controller regulates the genset reactive power output.

**`Regulators > AVR > Relay configuration > Reactive power regulation`**

| Parameter | Range | Notes |
|---|---|---|
| `Kp` | 0 to 100 | This is the gain for the regulator. |
| `Deadband` | 0 to 10 % | The deadband for the regulator, as a percentage of the nominal reactive power. |

## 8.3.5 Fixed cos phi

The controller can send regulation signals to the genset's AVR to keep the genset's cos phi value at the controller set point. When fixed cos phi is the active regulation mode, the controller sends signals to the AVR to adjust the exciter current when the cos phi value changes due to loads that were added to or removed from the busbar. By keeping the cos phi value at a fixed value, the reactive power is regulated according to the amount of active power being produced by the genset.

**NOTICE**

**Genset forced to deliver fixed reactive power**

By forcing a genset to deliver a fixed reactive power instead of using fixed cos phi regulation, the other gensets will have to compensate for this genset's fixed position. This might cause the other gensets to produce too much capacitive or inductive reactive power.

Alternatively the fixed cos phi set point can be determined by an analogue input, CustomLogic, Modbus, or CODESYS.

The fixed cos phi mode will only be used when multiple gensets are connected to the same busbar section. If only one genset is connected, then the cos phi value is decided by the system and regulation will not work.

**More information**
See External communication how the fixed cos phi set point is configured using an analogue input or Modbus.

### Digital inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > AVR > Modes > Activate fixed cos phi` | Digital input | Pulse | The operator activates this input to activate fixed cos phi regulation. |
| `Regulators > AVR > Modes > Deactivate fixed cos phi` | Digital input | Pulse | The operator activates this input to deactivate fixed cos phi regulation. |
| `Regulators > AVR > Cos phi / reactive power offset > Cos phi/ Reactive power offset 1` | Digital input | Continuous | The operator activates this input to add the **Offset 1** value for fixed reactive power or fixed cos phi to the set point. |
| `Regulators > AVR > Cos phi / reactive power offset > Cos phi/ Reactive power offset 2` | Digital input | Continuous | The operator activates this input to add the **Offset 2** value for fixed reactive power or fixed cos phi to the set point. |
| `Regulators > AVR > Cos phi / reactive power offset > Cos phi/ Reactive power offset 3` | Digital input | Continuous | The operator activates this input to add the **Offset 3** value for fixed reactive power or fixed cos phi to the set point. |
| `Regulators > AVR > Modes > Deactivate regulation` | Digital input | Pulse | Disables any active AVR regulation mode. |
| `Regulators > AVR > State > Fixed cos phi is active` | Digital output | Continuous | The relay activates when fixed cos phi regulation is active. |

### Parameters

**`Regulators > AVR > Regulation set points > Fixed cos phi`**

| Parameter | Range | Notes |
|---|---|---|
| `Set point` | Inductive, Capacitive | If the generator production requires reactive power from the system, it is a capacitive production with a leading cos phi value.<br><br>If the generator production supplies reactive power to the system, it is an inductive production with a lagging cos phi value. |

**`Regulators > AVR > Regulation set points > Fixed cos phi offset`**

| Parameter | Range | Notes |
|---|---|---|
| `Offset [1 to 3]` | 0.0000 to 1.0000 | This value is added to the cos phi set point when the fixed cos phi **Offset [1 to 3]** digital input is activated. |
| `Offset [1 to 3]` | Inductive, Capacitive | Select whether the offset has a lagging cos phi value (inductive), or a leading cos phi value (capacitive). |

| Parameter | Range | Notes |
|---|---|---|
| | | If the offset has the same value (inductive or capacitive) as the set point, then the offset is subtracted from the set point. If the offset has a different value (inductive or capacitive) to the set point, then the offset is added to the set point. |

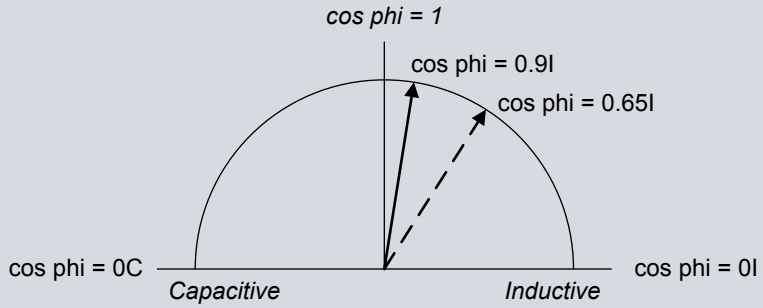
**`Regulators > AVR > Regulation set points > Fixed cos phi limit`**

| Parameter | Range | Notes |
|---|---|---|
| `Limit [1 to 2]` | 0.0000 to 1.0000 | This value is the upper or lower limit for the cos phi set point for fixed cos phi regulation.<br><br>It does not matter whether **Limit 1** is higher or lower than **Limit 2** when the controller determines the set point range. |
| `Limit [1 to 2]` | Inductive, Capacitive | Select whether the limit has a lagging cos phi value (inductive), or a leading cos phi value (capacitive). |

### Examples

The examples below demonstrate how the cos phi offset is added to the set point.

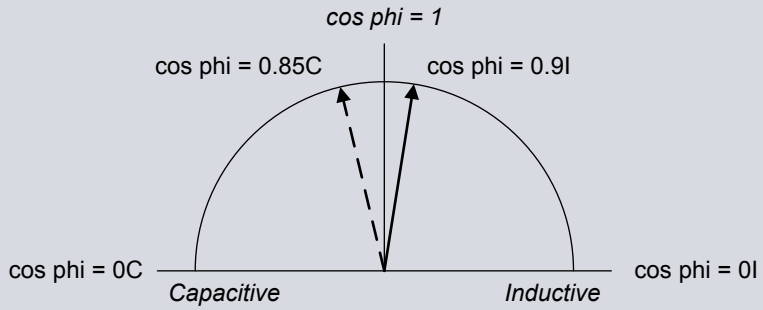
**Adding an inductive cos phi offset to an inductive cos phi set point example**




The cos phi *Set point* is set to the default value of 0.9 inductive. *Offset 1* is set to 0.25 inductive. The set point range (determined by Limit 1 and Limit 2) is not taken into account for this example.

When the *Cos phi/Reactive power offset 1* digital input is activated the cos phi set point changes to 0.9I +0.25I = 0.65 inductive.

**Adding a capacitive cos phi offset to an inductive cos phi set point example**




The cos phi *Set point* is set to the default value of 0.9 inductive. *Offset 1* is set to 0.25 capacitive. The set point range (determined by Limit 1 and Limit 2) is not taken into account for this example.

When the *Cos phi/Reactive power offset 1* digital input is activated the cos phi set point changes to 0.9I +0.25C = 0.85 capacitive.

### 8.3.6 Voltage droop

If a genset is connected to the busbar, with or without other power generating assets connected to the same busbar section, the controller can use voltage droop to regulate the genset voltage/reactive power.

This setting does not provide optimal regulation of the genset, and should only be used if there is a specific design reason for its use. For example, another genset that cannot communicate with the controller is connected to the same busbar section.

During voltage droop regulation the controller regulates the AVR output to follow the droop setting of the controller.

**More information**
See Droop for the relationship between the controller droop and the AVR droop.

#### Parameters

**`Regulators > AVR > [Analogue or Relay configuration] > Voltage droop`**

| Parameter | Range | Notes |
|---|---|---|
| `Droop` | 0.0 to 10.0 % | The droop percentage that the controller emulates. The controller droop does not have to be the same as the genset's AVR droop.<br><br>A high droop setting results in high voltage/reactive power deviations from nominal voltage.<br><br>A too low droop setting results in not adding the necessary stability to the system. |

The droop setting for an analogue regulator is not linked to the droop setting for a relay regulator. This means that if you change from an analogue output to a relay output (or from a relay output to an analogue output), you must check the droop setting and correct it if required.

### 8.3.7 Reactive power load sharing

During reactive power (kvar) load sharing, the controller uses the nominal voltage as a reference to regulate the AVR output to the genset. The nominal voltage reference can be adjusted by contributing a weighted amount of the reactive power set point to the reference value.

Reactive power load sharing can be used in a system where more than one genset is connected to the same busbar section. At least two of these gensets must have reactive power load sharing activated in order to share the load between them.

All gensets on the same busbar section that have reactive power load sharing active, will share an equal percentage of the load.

**More information**
See Busbar sections and load sharing.

#### Digital inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > AVR > Modes > Activate reactive power load sharing` | Digital input | Continuous | The operator activates this input to activate reactive power load sharing. |
| `Regulators > AVR > Modes > Deactivate regulation` | Digital input | Pulse | The input disables any active AVR regulation mode. |

| Function | I/O | Type | Details |
|---|---|---|---|
| Regulators > AVR > State > Reactive power load sharing is selected | Digital output | Continuous | The relay activates when reactive power load sharing (kW) is selected. |
| Regulators > AVR > State > Reactive power load sharing is active | Digital output | Continuous | The relay activates when reactive power load sharing (kW) is active. |

### Analogue AVR output reactive power load sharing parameters

The reactive power load sharing parameters define analogue regulation when the controller regulates the AVR to change the genset reactive power output for load sharing.

**Regulators > AVR > Analogue > Reactive power load sharing regulation**

| Parameter | Range | Notes |
|---|---|---|
| Kp | 0.00 to 60.00 | The PID gain for the regulator. |
| Ti | 0.00 s to 1 min | The PID control integral time.<br><br>To turn off the integral component, set Ti to 0. This might cause unexpected regulator behaviour. |
| Td | 0.00 to 2.00 s | The PID control derivative. |
| Q weight | 0.0 to 100.0 % | If Q weight is 100 %, the controller uses the reactive power and voltage set points equally during load sharing regulation. If Q weight is 0 %, the controller ignores the reactive power set point during load sharing regulation.<br><br>DEIF recommends that you start with the default value, and then, if necessary, adjust this parameter. If Q weight is too low, the reactive power load sharing will not be effective and the load will float between the controllers. If Q weight is too high, the voltage regulation will be too slow, for example, when a new heavy consumer connects. |

### Relay AVR output reactive power load sharing parameters

The reactive power load sharing parameters define relay regulation when the controller regulates the AVR to change the genset reactive power output for load sharing.

**Regulators > AVR > Relay configuration > Reactive power load sharing regulation**

| Parameter | Range | Notes |
|---|---|---|
| Kp | 0 to 100 | This is the gain for the regulator. |
| V deadband | 0.0 to 10.0 % | The voltage deadband for the regulator, as a percentage of the nominal voltage. |
| Q deadband | 0.0 to 10.0 % | The reactive power deadband for the regulator, as a percentage of the nominal reactive power. |
| Q weight | 0.0 to 100.0 % | If Q weight is 100 %, the controller uses the reactive power and voltage set points equally during load sharing regulation. If Q weight is 0 %, the controller ignores the reactive power set point during load sharing regulation.<br><br>DEIF recommends that you start with the default value, and then, if necessary, adjust this parameter. If Q weight is too low, the reactive power load sharing will not be effective and the load will float between the controllers. If Q weight is too high, the voltage regulation will be too slow, for example, when a new heavy consumer connects. |

## 8.3.8 Manual regulation

When *Manual regulation* is the active regulation mode, the operator controls and operates the equipment from the switchboard. The operator can increase or decrease voltage output of the genset using digital inputs (if configured) or Modbus.

### Digital inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > AVR > Modes > Activate manual regulation` | Digital input | Pulse | The operator activates this input to activate manual regulation. |
| `Regulators > AVR > Modes > Deactivate manual regulation` | Digital input | Pulse | The operator activates this input to deactivate manual regulation. |
| `Regulators > AVR > Manual > Manual AVR increase` | Digital input | Continuous | This input only has an effect when *Manual regulation* is the selected regulation mode.<br><br>When this input is activated, the controller increases the output to the AVR. This affects the `Regulators > AVR > Control > AVR increase` digital output, or the `Regulator > AVR > Control > AVR output [%]` analogue output.<br><br>Set the percentage change of the AVR voltage per second for manual analogue regulation under `Regulators > AVR analogue configuration > Manual slope`. |
| `Regulators > AVR > Manual > Manual AVR decrease` | Digital input | Continuous | This input only has an effect when *Manual regulation* is the selected regulation mode.<br><br>When this input is activated, the controller decreases the output to the AVR. This affects the `Regulators > AVR > Control > AVR decrease` digital output, or the `Regulator > AVR > Control > AVR output [%]` analogue output.<br><br>Set the percentage change of the AVR voltage per second under `Regulators > AVR analogue configuration > Manual slope`. |
| `Regulators > AVR > Modes > Deactivate regulation` | Digital input | Pulse | Disables any active AVR regulation mode. |
| `Regulators > AVR > State > Manual AVR regulation is active` | Digital output | Continuous | The relay activates when *Manual regulation* is the active AVR regulation mode. |

### Parameters

**`Regulators > AVR > Analogue > Manual slope`**

This parameter is only visible if an AVR analogue output is configured.

| Parameter | Range | Notes |
|---|---|---|
| `Manual AVR slope` | 0.0 to 200.0 %/s | The controller increases or decreases the *AVR output [%]* analogue output by this amount when the *Manual AVR increase* or *Manual AVR decrease* digital inputs are activated. |

**`Regulators > AVR > Relay configuration > Manual configuration`**

These parameters adjust the controller's relay control output.

| Parameter | Range | Notes |
|---|---|---|
| Period time | 40 ms to 1 h | You can make the AVR response faster by decreasing the *Period time*. However, if the rest of the system is slow anyway, then decreasing the *Period time* will provide no additional benefits.<br><br>Although a relay controller is capable of fast responses, it is recommended to set the *Period time* to be similar to the response of the system. |
| Minimum ON time | 40 ms to 1 h | The *Minimum ON time* must be long enough to ensure that the AVR can detect the shortest pulse that the controller sends to it. You can increase the *Minimum ON time* to force a slow system to respond to the controller's regulation.<br><br>If the controller needs to increase the AVR output, the *AVR increase* digital output is activated for at least the *Minimum ON time*. While the controller is increasing the AVR output, the *AVR decrease* digital output is not activated.<br><br>If the controller needs to decrease the AVR output, the *AVR decrease* digital output is activated for at least the *Minimum ON time*. While the controller is decreasing the AVR output, the *AVR increase* digital output is not activated. |

# 8.4 External communication

## 8.4.1 How it works

For certain actions and in some regulation modes it is possible to for the controller to receive its set point from an external source. This source can for example be an analogue input, or a set point from CustomLogic, Modbus, or CODESYS (if installed).

**NOTICE**

**Parameters require input/output configuration**

The parameters are only visible, if a governor and/or AVR is configured in the controller *Input/output* (relay output or analogue output).

## 8.4.2 External set points

You can use set point values from an external source, for example analogue inputs or Modbus, instead of using the controller internal set points.

Configure the external set point digital input functions on the **GENSET** controller. When the functions are active, the controller ignores the internal set points configured in the parameters and uses the set points it receives from the external source.

Inputs from external set points must come from the same source. That is, either from analogue inputs or from Modbus. If an analogue input is configured for an external set point and Modbus communication is available, then the controller will always receive its external set point value from the analogue input. The Modbus address for that external set point becomes a read-only value, which is equal to the value of the analogue input for that set point.

### Inputs and outputs

Use the digital inputs and output in the table below to activate, deactivate, and to see the activation status of the external set point. The analogue inputs are used to send the external set point value to the controller. When an external communication input is assigned to an analogue input, it is not possible to send the assigned external communication set point to the controller with another communication method (for example, Modbus).

These inputs and outputs are only visible if a regulation output (either relay or analogue) is configured.

| Function | I/O | Type | Details |
|---|---|---|---|
| Regulators > [Regulator]* > External set points > Activate external set point | Digital input | Pulse | When activated, the controller sends regulation signals according to the external set points settings. These set points overwrite the controller's internal set points. |
| Regulators > [Regulator]* > External set points > Deactivate external set point | Digital input | Pulse | When activated, the controller stops sending regulation signals according to the external set point settings. The controller uses the internal set points to regulate the genset. |
| Regulators > [Regulator]* > State > External set point is selected | Digital output | Continuous | Optional. The relay activates when regulation from an external set point is selected. |
| Regulators > [Regulator]* > State > External set point is active | Digital output | Continuous | Optional. The relay activates when regulation from and external set point is active. |
| Regulators > GOV > Frequency offset [%] | Analogue input | | When configured, the controller receives the frequency offset value from this analogue input. This offset is added or subtracted from the nominal frequency. $f_{new} = f_{nom} + (f_{nom} \times \text{Frequency offset})$ |
| Regulators > GOV > Power set point [%] | Analogue input | | When configured, the controller receives the active power set point from this analogue input. The internal controller value for the active power set point is ignored. |
| Regulators > AVR > Voltage offset [%] | Analogue input | | When configured, the controller receives the voltage offset value from this analogue input. The offset is added or subtracted from the nominal voltage. $V_{new} = V_{nom} + (V_{nom} \times \text{Voltage offset})$ |
| Regulators > AVR > Reactive power set point [%] | Analogue input | | When configured, the controller receives the reactive power set point from this analogue input. The internal controller value for the reactive power set point is ignored. |
| Regulators > AVR > Cos phi set point | Analogue input | | When configured, the controller receives the cos phi set point from this analogue input. The internal controller value for the cos phi set point is ignored. |

**NOTE** * [Regulator] is either Governor or AVR, depending on which regulator is configured for the controller.

It is also possible activate and deactivate the controller mode, including the external communication modes, using CustomLogic, Modbus, or CODESYS. This is only possible if the function has not been assigned to a digital input in PICUS.

**More information**
See **Discrete output coil (01; 05; 15)** in the **Modbus tables** for more information about the Modbus functions and their properties.

### Modbus parameters

The parameters are not visible in the controller or PICUS. To configure these parameters, you must have a Modbus interface to the controller.

| Parameter | Modbus address | Modbus function codes | Valid Modbus range | Scaling ($10^{-x}$) | Unit | Comment |
|---|---|---|---|---|---|---|
| Regulators > Governor > Frequency offset | 8008 | 03; 06; 16 | -100 to 100 | 1 | % | If the operator activates *Activate external set point*, the frequency offset is determined by the value set in Modbus. |

| Parameter | Modbus address | Modbus function codes | Valid Modbus range | Scaling ($10^{-x}$) | Unit | Comment |
|---|---|---|---|---|---|---|
| | | | | | | The value entered is the percentage of the nominal frequency that is added to or subtracted from the nominal frequency to determine the new set point. |
| `Regulators > Governor > Power set point` | 8009 | 03; 06; 16 | 0 to 100 | 0 | % | If the operator activates *Activate external set point*, the power set point is determined by the value set in Modbus. |
| `Regulators > AVR > Voltage offset` | 8010 | 03; 06; 16 | -100 to 100 | 1 | % | If the operator activates *Activate external set point*, the voltage offset is determined by the value set in Modbus.<br><br>The value entered is the percentage of the nominal voltage that is added to or subtracted from the nominal voltage to determine the new set point. |
| `Regulators > AVR > Reactive power set point` | 8011 | 03; 06; 16 | 0 to 100 | 0 | % | If the operator activates *Activate external set point*, the reactive power set point is determined by the value set in Modbus. |
| `Regulators > AVR > cos phi set point` | 8012 | 03; 06; 16 | 60 to 100 | 2 | - | If the operator activates *Activate external set point*, the cos phi set point is determined by the value set in Modbus. |

**More information**
See **Holding register (03;06;16)** in the **Modbus tables** for more information about the Modbus functions and their properties.

## 8.5 Governor

### 8.5.1 Governor regulation function

A governor is external equipment used to control the engine speed for the genset. During frequency regulation, when the speed drops below the required speed, the governor increases the fuel supply to the engine which increases the engine speed. Similarly, by decreasing the fuel supply, the engine speed also decreases. The frequency of the genset is directly related to engine speed and the number of poles in the generator.

The governor must allow external adjustment (digital inputs or analogue input), to let the **GENSET** controller bias the governor internal set point.

**Digital inputs**

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > GOV > Command > Activate ramp 1` | Digital input | Pulse | The operator activates this input to use curve 1 during power ramp up and power ramp down.<br><br>If ramp 2 was selected as the active ramping method when you activate ramp 1, the ramping method is immediately changed to ramp 1. |
| `Regulators > GOV > Command > Activate ramp 2` | Digital input | Pulse | The operator activates this input to use curve 2 during power ramp up and power ramp down. |

| Function | I/O | Type | Details |
|---|---|---|---|
| | | | If ramp 1 was selected as the active ramping method when you activate ramp 2, the ramping method is immediately changed to ramp 2. |
| `Regulators > GOV > Command > Pause ramping` | Digital input | Continuous | The operator activates this input to pause the power ramp up or power ramp down process.<br><br>When the power ramp up or power ramp down is paused, the operator can deactivate this input to unpause the process. |

### Parameters for governor general configuration

The governor general configuration settings apply to all the controller's governor regulation outputs (for example, relay, analogue, pulse width modulation, and so on).

### Regulator output

If a governor analogue regulation output and both governor relay regulation outputs are configured, then one output must be selected as the output that sends feedback to the governor.

**`Regulators > GOV > General configuration`**

| Parameter | Range | Notes |
|---|---|---|
| `Regulator output` | • Off<br>• Relay<br>• Analogue / ECU | **Off:** The controller does not attempt to regulate the governor, and ignores any configured hardware.<br><br>**Relay:** The controller uses the relay outputs to regulate the governor (only visible if both relays for the governor regulation are configured).<br><br>**Analogue / ECU**: The controller uses an analogue output or engine interface communication (to the engine control unit) to regulate the governor. This option is only visible if a governor analogue regulator output and/or EIC is configured. |

### Regulation delay

This parameter sets the time the controller waits before starting to regulate the genset. The delay time starts after the running feedback confirms that the genset is running. It is not desirable to start regulation exactly when running feedback is achieved. Frequency and voltage are still low compared to the nominal value at this point. The regulation delay is intended to delay regulation until the frequency and voltage have stabilised at their preset values. This prevents regulation overshoot at start-up.

**`Regulators > GOV > General configuration`**

| Parameter | Range | Notes |
|---|---|---|
| `Regulator delay` | 0 s to 2.75 h | The controller waits for the amount of time specified by this parameter, before regulating the genset.<br>This time can for example be used to set the regulation mode. |

### Parameters for governor regulation set point

The governor regulation set point settings apply to all the controller's governor regulation outputs (for example, relay, analogue, pulse width modulation, and so on).

### Active power ramp up

This parameter defines the speed of the ramp up of the genset active power when the genset is connected to a busbar or when the fixed power set point changes. The ramping functionality ramps the regulation set points to follow the configurable curve towards the final set point. This reduces the mechanical strain on the genset when the breaker closes and the genset starts to supply power to the system. Limiting the power ramp up speed also increases the system stability.

The parameter consists of two curves. Each curve can consist of 2 to 10 coordinates for the time and the percentage of the genset nominal power.

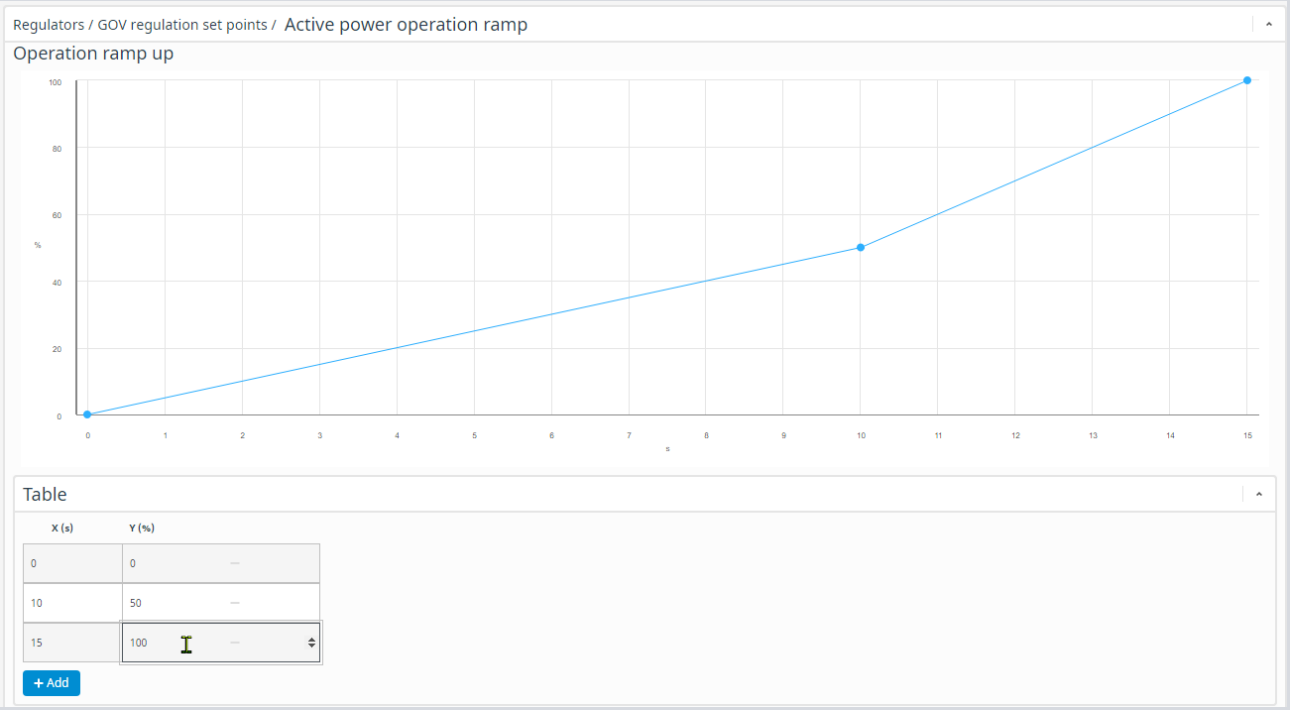
**`Regulators > GOV > Regulation set points > Active power ramp up`**

| Parameter | Range | Notes |
|---|---|---|
| `[s]` | 0 to 3600 s | The time coordinate for the active power ramp up curve. |
| `[%]` | 0 to 100 % | The percentage of nominal active power of the genset coordinate for the active power ramp up curve. |

**Active power ramp up example**

You want a 100 kW genset to ramp up to 50 % of its nominal power at 5 %/s, and 10%/s between 50 % and a 100 % of its nominal power. This means that it will take at least 15 seconds to ramp up the genset load from 0 kW to 100 kW.

The coordinates for the primary power ramp up curve are: (0 s; 0 %), (10 s; 50 %) and (15 s; 100 %).




This means that the controller regulates the genset to follow a slope of 5 kW/s for the first 50 % of the genset's nominal power. And the controller regulates the genset to follow a slope of 10 kW/s between 50 % and a 100 % of the genset's nominal power.

If the genset load is 0 kW, and 50 kW is required from the genset, it takes at least 10 seconds to ramp up the genset load.
If the genset load is 0 kW, and 70 kW is required from the genset, it takes at least 12 seconds to ramp up the genset load.

### Active power ramp down

This parameter defines the speed of the ramp down of the genset active power when the fixed power set point changes or when the genset disconnects from the busbar. This reduces the mechanical strain on the genset and breaker when the breaker opens and the genset stops supplying power to the system. Limiting the power ramp down speed also increases the system stability.

The parameter consists of two curves. Each curve can consist of 2 to 10 coordinates for the time and the percentage of the genset nominal power.

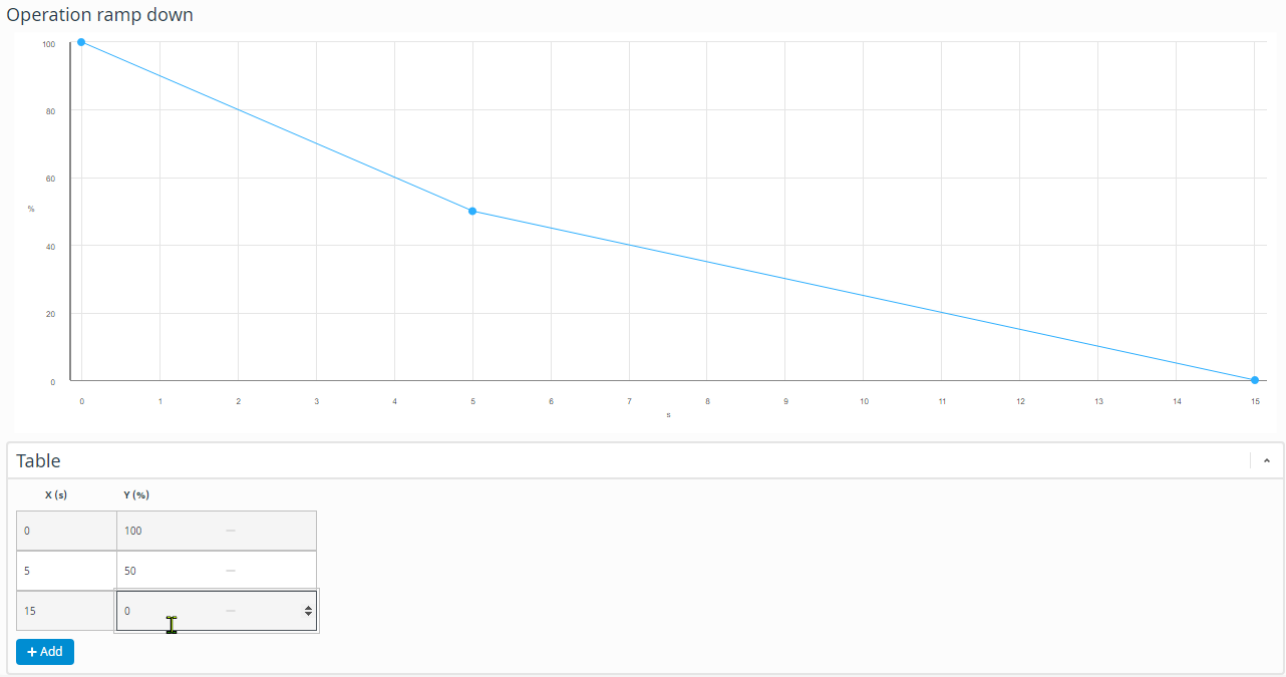
**Regulators > GOV > Regulation set points > Active power ramp down**

| Parameter | Range | Notes |
|---|---|---|
| [s] | 0 to 3600 s | The time coordinate for the power ramp down curve. |
| [%] | 0 to 100 % | The percentage of nominal power of the genset coordinate for the power ramp down curve. |

**Power ramp down example**

You want a 100 kW genset to ramp down to 50 % of its nominal power at 10 %/s, and 5%/s between 50 % and a 0 % of its nominal power. This means that it will take at least 15 seconds to ramp down the genset load from 1000 kW to 0 kW.

The coordinates for the primary power ramp up curve are: (0 s; 100 %), (5 s; 50 %) and (15 s; 0 %).




This means that the controller regulates the genset to follow a slope of 10 kW/s between 100 % and 50 % of the genset's nominal power. And the controller regulates the genset to follow a slope of 5 kW/s between 50 % and a 0 % of the genset's nominal power.

If the genset load is 50 kW, and 0 kW is required from the genset, it takes at least 10 seconds to ramp down the genset load.
If the genset load is 70 kW, and 0 kW is required from the genset, it takes at least 12 seconds to ramp down the genset load.

## 8.5.2 Governor analogue regulation function

You can configure an analogue output on the controller to regulate the governor. You can also set a number of parameters for the governor analogue regulation function.

### Inputs and Outputs

| Function | I/O | Units | Details |
|---|---|---|---|
| Regulators > GOV > Command > Reset GOV to offset | Digital input | Pulse | When the operator activates this digital input, the analogue output is reset to the GOV output offset value. |
| Regulators > GOV > GOV output [%] | Analogue output | -100 to 100 % | The controller adjusts this output to regulate the governor. |

| Function | I/O | Units | Details |
|---|---|---|---|
| | | | DEIF recommends that you use the full range of the output, that is from -100 % to 100 %, when you configure the output. |

**NOTE** The setup and parameters for governor regulation using pulse width modulation (PWM) is exactly the same as for an analogue output.

**More information**
See **Input/Output** in the **PICUS manual** for how to configure an analogue output.

### Parameters

To see the governor analogue control parameters, you must assign the function to an analogue output.

When you start and/or run a genset, you might want to adjust the starting point for analogue regulation. This is done by changing the output offset.

**`Regulators > GOV > Analogue > Offset`**

| Parameter | Range | Notes |
|---|---|---|
| `GOV output offset 1`<br>`GOV output offset 2`<br>`GOV output offset 3`<br>`GOV output offset 4` | -100.0 to 100.0 % | The offset is added to the GOV analogue output. The number of the offset relates to the nominal settings set. If you select *Nominal settings 1*, then the controller uses *GOV output offset 1*. The nominal settings set also determine the values of other nominal settings and engine RPM.<br><br>When the genset starts, it starts from the offset value, allowing the genset to reach the set point quickly. Ideally, the governor should be tuned so that if there is no signal, the genset runs at its nominal frequency if there is no load. However, if this is not possible, *GOV output offset* allows you to compensate the output to the governor.<br><br>To set this parameter, start with *GOV output offset* = 0 %. Change the offset value in small increments to fine tune the frequency output of the genset. When you reach the desired genset frequency output, the offset is tuned. |

## 8.5.3 Governor relay regulation function

You can configure relay outputs on the controller to regulate the governor. You can also set a number of parameters for the governor relay regulation function.

### Digital outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > GOV > Controls > GOV increase` | Digital output | Variable-length pulse | The controller activates this output to regulate the governor to increase the engine speed or power. |
| `Regulators > GOV > Controls > GOV decrease` | Digital output | Variable-length pulse | The controller activates this output to regulate the governor to decrease the engine speed or power. |

### Parameters

These parameters are only visible, if you assign the functions to digital outputs.

**Regulators > GOV > Relay configuration > Automatic configuration**

| Parameter | Range | Notes |
|---|---|---|
| Period time | 250 ms to 32.5 s | You can make the governor response faster by decreasing the *Period time*. However, if the rest of the system is slow anyway, you can reduce the wear on the relays by increasing the *Period time*.<br><br>Although a relay controller is capable of fast responses, the *Period time* should be similar to the response of the system to extend the relay life. |
| Minimum ON time | 10 ms to 6.5 s | The Minimum ON time must be long enough to ensure that the governor can detect the shortest pulse that the controller sends to it. You can increase the Minimum ON time to force a slow system to respond more to the controller's regulation.<br><br>If the controller needs to increase the governor output, the GOV increase digital output is activated for at least the Minimum ON time. While the controller is increasing the governor output, the GOV decrease digital output is not activated.<br><br>If the controller needs to decrease the governor output, the GOV decrease digital output is activated for at least the Minimum ON time. While the controller is decreasing the governor output, the GOV increase digital output is not activated. |
| Maximum ON time | 0.00 to 100.00 % | You can decrease the Maximum ON time to force a fast system to respond less to the controller's regulation.<br><br>If the controller needs to increase the governor output, the GOV increase digital output is activated for no longer than the Maximum ON time. While the controller is increasing the governor output, the GOV decrease digital output is not activated.<br><br>If the controller needs to decrease the governor output, the GOV decrease digital output is activated for no longer than the Maximum ON time. While the controller is decreasing the governor output, the GOV increase digital output is not activated. |

# 8.6 Automatic voltage regulator

## 8.6.1 AVR regulation function

An AVR is used to control the excitation of the genset. When the current to the exciter is increased, the magnetic field of the exciter also increases. During voltage regulation, this increases the voltage output from the genset. Similarly, by decreasing the current to the exciter, the voltage output from the genset is decreased. Reactive power is adjusted in the attempt to increase or decrease voltage.

The AVR must be prepared for external adjustment (digital inputs or analogue input), to let the genset controller bias the AVR internal set point.

The sections below describe the input and output setup and common input parameters for the automatic voltage regulator (AVR).

### Optional digital input

If there is a shaft generator, shore connection or bus tie breaker in the system, the network external set points must be configured for the genset controllers. The network external set point is required to synchronise and de-load shaft generators, shore connections and bus tie breakers. The Modbus external set points are optional.

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > AVR > Command > Pause ramping` | Digital input | Continuous | The operator activates this input to pause the voltage ramp up or voltage ramp down process.<br><br>When the voltage ramp up or voltage ramp down in paused, the operator can deactivate this input to unpause the process. |

### Parameters

The `AVR general configuration` and `AVR regulation set point` settings apply to all the controller's AVR regulation outputs (for example, relay or analogue).

These parameters are only visible, if you configure an AVR output function.

**`Regulators > AVR > General configuration > Regulator output`**

If a governor analogue regulation output and both governor relay regulation outputs are configured, then one output must be selected as the output that sends feedback to the governor.

| Parameter | Range | Notes |
|---|---|---|
| `Regulator output` | • Off<br>• Relay<br>• Analogue | **Off:** The controller does not attempt to regulate the AVR, and ignores any configured hardware.<br><br>**Relay:** The controller uses the configured relay outputs to regulate the AVR (only visible if both relays for governor regulation are configured).<br><br>**Analogue:** The controller uses the configured analogue output to regulate the governor (only visible if a governor analogue regulator output is configured). |

**`Regulators > AVR > General configuration > Regulator delay`**

This parameter sets the time the controller waits before starting to regulate the genset. The delay time starts after the running feedback confirms that the genset is running. It is not desirable to start regulation exactly when running feedback is achieved. Frequency and voltage are at this point, still low compared to nominal value. The regulation delay is intended to delay regulation until the governor and AVR have settled frequency and voltage on their preset values. This prevents regulation overshoot at start-up.

| Parameter | Range | Notes |
|---|---|---|
| `Regulator delay` | 0.0 s to 1 h | The controller waits for the amount of time specified by this parameter, before regulating the genset.<br><br>This time can for example be used to set the regulation mode. |

**`Regulators > AVR > Regulation set points > Reactive power ramp up`**

These parameters are only visible, if you configure an AVR output function.

This parameter limits the speed of the ramp up of the genset reactive power when the genset is connected to a busbar or when the fixed reactive power set point changes. This reduces the mechanical strain on the generator when the breaker closes and the generator starts to supply reactive power to the system. Limiting the reactive power ramp up speed also increases the system stability.

In Island regulation mode for power load sharing, the power ramp up is only used an initial power ramp up to the load share set point during initial connection. Afterwards the ramp is not used.

The curve can consist of 2 to 10 coordinates for the time and the percentage of the genset nominal reactive power.

| Parameter | Range | Notes |
|---|---|---|
| [s] | 0 to 3600 s | The time coordinate for the reactive power ramp up curve. |
| [%] | 0 to 100 % | The percentage of nominal reactive power of the genset coordinate for the reactive power ramp up curve. |

**Reactive power ramp up using reactive power curve example**

You want a 100 kvar genset to ramp up to 50 % of its nominal reactive power at 5 %/s, and 10%/s between 50 % and a 100 % of its nominal reactive power. This means that it will take at least 15 seconds to ramp up the genset reactive power from 0 kvar to 100 kvar.

The coordinates for the primary power ramp up curve are: (0 s; 0 %), (10 s; 50 %) and (15 s; 100 %).

This means that the controller regulates the genset to ensure that the reactive power ramp up does not exceed 5 kvar/s for the first 50 % of the genset's nominal reactive power. And the controller regulates the genset to ensure that the reactive power ramp up does not exceed 10 kvar/s between 50 % and a 100 % of the genset's nominal reactive power.

If the genset reactive power is 0 kvar, and 50 kvar is required from the genset, it takes at least 10 seconds to ramp up the genset reactive power.
If the genset reactive power is 0 kvar, and 70 kvar is required from the genset, it takes at least 12 seconds to ramp up the genset reactive power.

**Regulators > AVR > Regulation set points > Reactive power ramp down**

This parameter limits the speed of the ramp down of the genset reactive power when the fixed reactive power set point changes or when the genset disconnects from the busbar. This reduces the mechanical strain on the generator and breaker when the breaker opens and the generator stops supplying reactive power to the system. Limiting the reactive power ramp up speed also increases the system stability.

The curve can consist of 2 to 10 coordinates for the time and the percentage of the genset nominal reactive power.

| Parameter | Range | Notes |
|---|---|---|
| Cos phi reset point | 0 to 100 % | When **Fixed cos phi** is selected as the ramping method, and the active power reaches the **Cos phi reset point**, the controller stops using a fixed cos phi value for the remainder of the ramping down of the reactive power.<br><br>When the active power reaches the **Cos phi reset point**, the cos phi value is regulated to 1 in the remaining de-load time.<br><br>The **Cos phi reset point** is a percentage of the active power before the breaker open point. |
| [s] | 0 to 3600 s | The time coordinate for the reactive power ramp down curve. |
| [%] | 0 to 100 % | The percentage of nominal reactive power of the genset coordinate for the reactive power ramp down curve. |

The cos phi value at the start of the breaker de-load sequence is maintained until the active power reaches the cos phi reset point. During the breaker de-load sequence the controller does not use the cos phi set point (internal or external) as the fixed cos phi value.

**Reactive power ramp down example**

You want a 100 kvar genset to ramp down to 50 % of its nominal reactive power at 10 %/s, and 5 %/s between 50 % and a 0 % of its nominal reactive power. This means that it will take at least 15 seconds to ramp down the genset reactive power from 100 kvar to 0 kvar.

The coordinates for the power ramp up curve are: (0 s; 100 %), (5 s; 50 %) and (15 s; 0 %).

This means that the controller regulates the genset to ensure that the reactive power ramp down does not exceed 10 kvar/s between 100 % and 50 % of the genset's nominal reactive power. And the controller regulates the genset to ensure that the reactive power ramp down does not exceed 5 kvar/s between 50 % and a 0 % of the genset's nominal reactive power.

If the genset reactive power is 50 kvar, and 0 kvar is required from the genset, it takes at least 10 seconds to ramp down the genset reactive power.
If the genset reactive power is 70 kvar, and 0 kvar is required from the genset, it takes at least 12 seconds to ramp down the genset reactive power.

**Cos phi reset point example**

A 100 kW genset ramps down from 80 % of its nominal active power and 0.92 inductive cos phi to the breaker open point at 5 %/s (default ramp down curve). This means that it will take 15 seconds to reach breaker open point.

The cos phi reset point is 5 % before the open point. In this example the cos phi value will be regulated to 1 between 14.25 and 15 seconds. The reactive power will respond accordingly. The resultant ramp down can be seen in the image below:

## 8.6.2 AVR analogue regulation function

You can configure an analogue output on the controller to regulate the AVR. You can also set a number of parameters for the AVR analogue regulation function.

### Inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > AVR > Command > Reset AVR to offset` | Digital input | Pulse | When the operator activates this digital input, the output is set to the offset value. |
| `Regulators > AVR > AVR output [%]` | Analogue output | - | The controller adjusts this output to regulate the AVR. |

**NOTE** The setup and parameters for AVR regulation using pulse width modulation (PWM) is exactly the same as for an analogue output.

### Parameters

To see the AVR analogue control parameters, you must assign the `Regulators > AVR > AVR output [%]` function to an analogue output (that is, AO or PWM).

When you start and/or run a genset, you might want to adjust the starting point for analogue regulation. This is done by changing the output offset.

**`Regulators > AVR > Analogue > Offset`**

| Parameter | Range | Notes |
|---|---|---|
| `AVR output offset 1`<br>`AVR output offset 2`<br>`AVR output offset 3`<br>`AVR output offset 4` | -100.0 to 100.0 % | The offset is added to the AVR analogue output. The number of the offset relates to the nominal settings set. If you select *Nominal settings 1*, then the controller uses *AVR output offset 1*. The nominal settings set also determine the values of other nominal settings and engine RPM.<br><br>When the genset is started, it will start from the offset value, allowing the genset to reach the set point quickly. Ideally, the AVR should be tuned so that if there is no signal, the genset runs at its nominal voltage if there is no load. However, if this is not possible, AVR output offset allows you to compensate the output to the AVR.<br><br>To set this parameter, start with *AVR output offset* = 0 %. Change the offset value in small increments to fine tune the voltage output of the genset. When you reach the desired genset voltage output, the offset is tuned. |

## 8.6.3 AVR relay regulation parameters

You can configure relay outputs on the controller to regulate the AVR. You can also set a number of parameters for the AVR relay regulation function.

### Digital outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Regulators > AVR > Controls > AVR increase` | Digital output | Variable-length pulse | The controller activates this output to send a signal to the AVR to increase the voltage or reactive power. |
| `Regulators > AVR > Controls > AVR decrease` | Digital output | Variable-length pulse | The controller activates this output to send a signal to the AVR to decrease the voltage or reactive power. |

### Parameters

These parameters adjust the controller's relay control output. To see these parameters, you must assign the functions to digital outputs.

**`Regulators > AVR > Relay configuration > Automatic configuration`**

| Parameter | Range | Notes |
|---|---|---|
| `Period time` | 50 ms to 15 s | You can make the AVR response faster by decreasing the *Period time*. However, if the rest of the system is slow anyway, then decreasing the *Period time* will provide no additional benefits.<br><br>Although a relay controller is capable of fast responses, it is recommended to set the *Period time* to be similar to the response of the system. |
| `Minimum ON time` | 10 ms to 3 s | The *Minimum ON time* must be long enough to ensure that the AVR can detect the shortest pulse that the controller sends to it. You can increase the *Minimum ON time* to force a slow system to respond to the controller's regulation.<br><br>If the controller needs to increase the AVR output, the AVR increase digital output is activated for at least the Minimum ON time. While the controller is increasing the AVR output, the AVR decrease digital output is not activated. |

| Parameter | Range | Notes |
|---|---|---|
| | | If the controller needs to decrease the AVR output, the AVR decrease digital output is activated for at least the Minimum ON time. While the controller is decreasing the AVR output, the AVR increase digital output is not activated. |
| `Maximum ON time` | 0 to 100 % | You can decrease the Maximum ON time to force a fast system to respond less to the controller's regulation.<br><br>If the controller needs to increase the AVR output, the AVR increase digital output is activated for at least the Minimum ON time. While the controller is increasing the AVR output, the AVR decrease digital output is not activated.<br><br>If the controller needs to decrease the AVR output, the AVR decrease digital output is activated for at least the Minimum ON time. While the controller is decreasing the AVR output, the AVR increase digital output is not activated. |

# 8.7 Configuration alarms

## 8.7.1 GOV relay setup incomplete

The alarm is based on the **Input/output** configuration of the controller. The controller activates the alarm when only one of the following digital outputs is configured:

- `Regulators > GOV > Control > GOV increase`
- `Regulators > GOV > Control > GOV decrease`

The alarm action is *Warning* and the alarm remains active until the configuration is corrected.

The alarm is always enabled. The alarm parameters are not visible.

## 8.7.2 AVR relay setup incomplete

The alarm is based on the **Input/output** configuration of the controller. The controller activates the alarm when only one of the following digital outputs are configured:

- `Regulators > AVR > Control > AVR increase`
- `Regulators > AVR > Control > AVR decrease`

The alarm action is *Warning* and the alarm remains active until the configuration is corrected.

The alarm is always enabled. The alarm parameters are not visible.

# 8.8 Regulation alarms

## 8.8.1 GOV regulation error

This alarm shows when there is an error with the governor controlled regulation.

The alarm is based on the difference between the measured value and the required set point, as a percentage of the set point. The larger the set point, the more the measured value is allowed to differ from the set point.

The alarm activates if the measured value is outside of the permitted range for longer than the delay.

This alarm is not activated when the genset frequency swings in and out of the permitted range above and below the set point. This is because this alarm only activates when the measured value is constantly above the upper limit, or constantly below the lower limit for the entire delay period.

### Parameters

Do not set the alarm set point lower than the deadband percentage for relay regulation. Doing so might activate the alarm in an area where regulation is not possible.

**`Regulators > GOV > Monitoring > Regulation error`**

| Parameter | Range |
|---|---|
| `Set point` (absolute value) | 1.0 to 100.0 % regulation deviation |
| `Delay` | 10 s to 1 h |

**Alarm deviation examples**

1. The controller is trying to control the genset to run at 50 Hz, and the measured frequency is 49.5 Hz.
   - The deviation from the set point is $|(49.5\ \text{Hz} - 50\ \text{Hz})| / 50\ \text{Hz} = 0.01 = 1\ \%$.
   - The deviation is less than the alarm set point, and the alarm is not activated.
2. The controller is trying to control the genset to run at 60 Hz and the measured speed is 62 Hz.
   - The deviation from the set point is $|(62\ \text{Hz} - 60\ \text{Hz})| / 60\ \text{Hz} = 0.03 = 3.3\ \%$.
   - The deviation is less than the alarm set point, and the alarm is not activated.
3. The controller is controlling 1500 kW genset, and is running fixed power regulation with a set point of 1000 kW. The measured power is 600 kW.
   - The deviation from the set point is $|(600\ \text{kW} - 1000\ \text{kW})| / 1000\ \text{kW} = 0.4 = 40\ \%$
   - The deviation is more than the alarm set point. If the measured power is stays below 700 kW for longer than the delay, then the alarm activates.

## 8.8.2 AVR regulation error

This alarm shows when there is an error with the AVR controlled regulation.

The alarm is based on the difference between the measured value and the required set point, as a percentage of the set point. The larger the set point, the more the measured value is allowed to differ from the set point.

The alarm activates if the measured value is outside of the permitted range for longer than the delay.

This alarm is not activated when the genset voltage swings in and out of the permitted range above and below the set point. This is because this alarm only activates when the measured value is constantly above the upper limit, or constantly below the lower limit for the entire delay period.

### Parameters

Do not set the alarm set point lower than the deadband percentage for relay regulation. Doing so might activate the alarm in an area where regulation is not possible.

**`Regulators > AVR > Monitoring > Regulation error`**

| Parameter | Range |
|---|---|
| `Set point` (absolute value) | 1.0 to 100.0 % regulation deviation |
| `Delay` | 10 s to 1 h |

**Alarm deviation examples**

1. The controller is running fixed voltage regulation with a set point of 400 V, and the measured voltage is 250 V.
   - The deviation from the set point is $|(250\ \text{V} - 400\ \text{V})| / 400\ \text{V} \times 100 = 38\ \%$.
   - The deviation is more than the alarm set point. If the measured power is stays below 280 V for longer than the delay, then the alarm activates.

2. The controller is running fixed reactive power regulation with a set point of 0 % of nominal reactive power, and the measured value is 2 % of nominal reactive power.
   - The deviation from the set point is 2 %.
   - The deviation is less than the alarm set point, and the alarm is not activated.
3. The controller is running fixed cos phi regulation with a set point of 0.9 I, and the measured value is 0.95 C.
   - The deviation from the set point is $|(0.95\ C - 0.9\ I)| / 0.9\ I \times 100 = 17\ \%$.
   - The deviation is less than the alarm set point, and the alarm is not activated.

## 8.8.3 GOV regulation mode not selected

This alarm can only be activated if a governor output is configured.

When the genset is running and the generator breaker is closed, a governor regulation mode must be selected when the controller is not under switchboard control.

The regulation mode can be one of the following:

- Fixed frequency
- Fixed power
- Power load sharing
- Frequency droop
- Manual regulation

If a regulation mode is not selected within the alarm delay, the alarm is activated. While no governor regulation mode is selected, no regulation will take place.

### Parameters

**`Regulators > GOV > Monitoring > Regulation mode not selected`**

| Parameter | Range |
|---|---|
| `Delay` | 0 s to 1 h |

## 8.8.4 AVR regulator mode not selected

This alarm can only be activated if an AVR output is configured.

When the genset is running and the generator breaker is closed, an AVR regulation mode must be selected when the controller is not under switchboard control.

The regulation mode can be one of the following:

- Fixed voltage
- Fixed reactive power
- Fixed cos phi
- Reactive power load sharing
- Voltage droop
- Manual regulation

If a regulation mode is not selected within the alarm delay, the alarm is activated. While no AVR regulation mode is selected, no regulation will take place.

### Parameters

**Regulators > AVR > Monitoring > Regulation mode not selected**

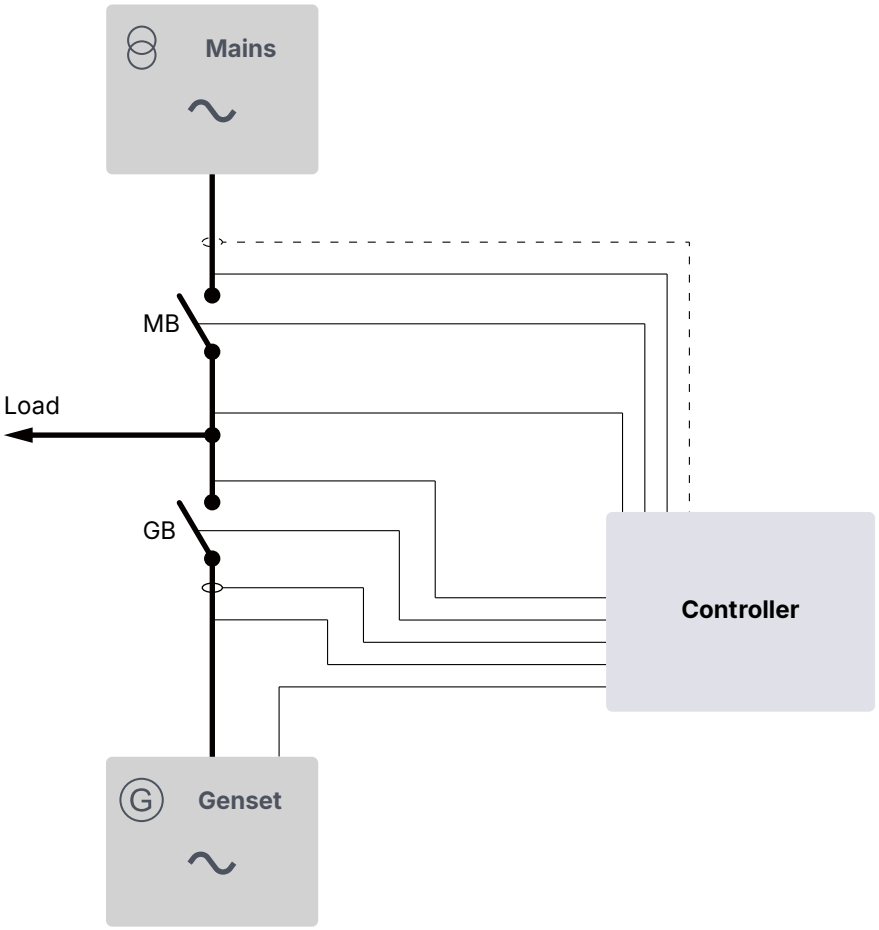
| Parameter | Range |
|---|---|
| Delay | 0 s to 1 h |

# 9. SINGLE genset controller

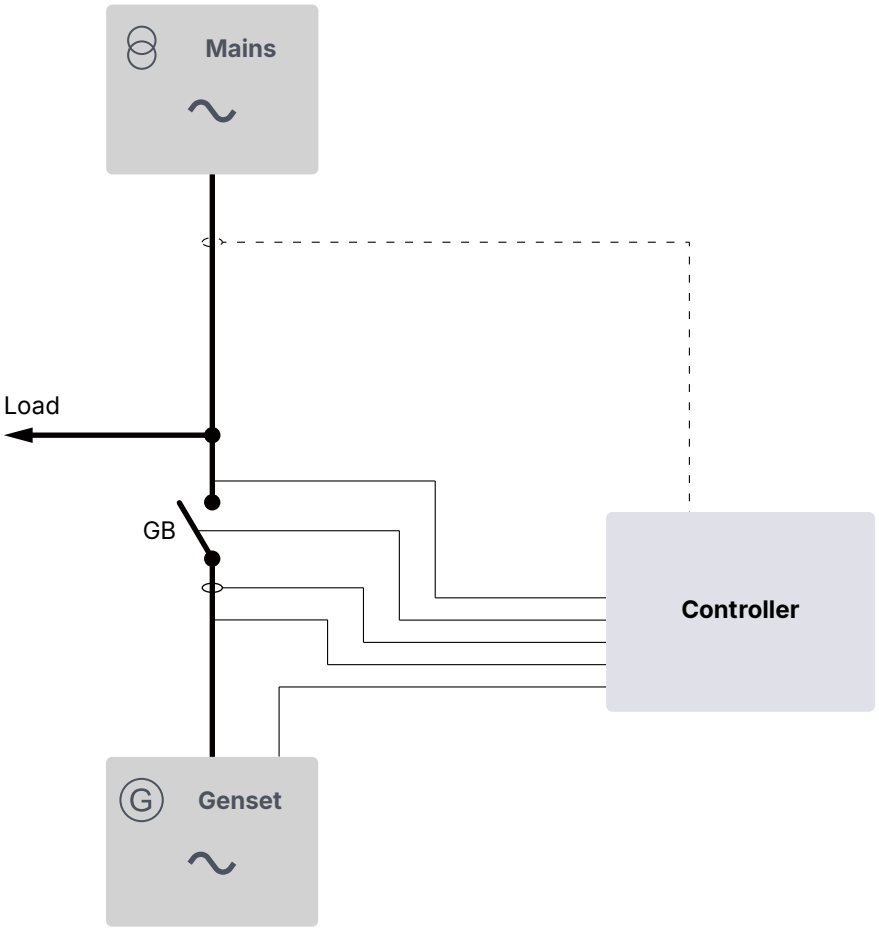
## 9.1 About the SINGLE genset controller

A **SINGLE genset** controller controls and protects a prime mover and generator, the breaker (GB), with or without a mains breaker (MB) to a load point. There are no other controllers on the single-line application drawing.

**Example application with mains breaker**



**Example application with no mains breaker**




## 9.1.1 SINGLE genset controller functions

| | Functions |
|---|---|
| **Pre-programmed sequences** | • Genset start sequence and genset stop sequence<br>  ◦ Running detection (Multiple feedback options: Frequency, MPU/W/NPN/PNP (RPM), Digital input, Oil pressure)<br>  ◦ Run coil and/or stop coil for engine control<br>  ◦ Temperature-dependent cooldown<br>• Breaker sequences<br>  ◦ Generator breaker close sequence (with synchronisation)<br>  ◦ Generator breaker open sequence (with de-loading)<br>  ◦ Mains breaker close sequence (with synchronisation) *<br>  ◦ Mains breaker open sequence (with de-loading) *<br>• Generator breaker blackout close (black busbar negotiation) |
| **Genset regulation** | • PID regulators for analogue outputs<br>• P regulators for relay outputs<br>  ◦ *Relay period time* and *Minimum ON time* configurable<br>• Set point selection<br>  ◦ Select mode or external set point, using digital input, PICUS, Modbus, CustomLogic, and/or CODESYS<br>• Governor modes<br>  ◦ Fixed frequency<br>  ◦ Fixed active power<br>  ◦ Frequency droop (controller regulation emulates droop) |

| | Functions |
|---|---|
| | ◦ Fixed RPM<br>◦ External set point: Frequency offset, or Power set point<br>◦ Manual<br>◦ Off<br>• AVR modes<br>◦ Fixed voltage<br>◦ Fixed reactive power<br>◦ Fixed cos phi<br>◦ Voltage droop (controller regulation emulates droop)<br>◦ External set point: Voltage offset, Reactive power set point, or cos phi set point<br>◦ Manual<br>◦ Off<br>• Configurable power ramp up, power ramp down<br>• Temperature-dependent power derate settings (3 sets) |
| **Mains** | • Configurable supervision<br>• Mains power measurement from 4th current measurement, or analogue input |
| **4th current** | • Measure power from/to the mains, or for earth or neutral protections * |
| **Counters** | • Counters, to edit or reset<br>◦ Start attempts<br>◦ Running time (total and trip)<br>◦ Generator breaker operations and trips<br>◦ Mains breaker operations and trips *<br>◦ Energy export to system (active and reactive)<br>◦ External breaker operations<br>• Energy counters with configurable digital outputs (for external counters)<br>◦ Energy export to system (active and reactive) |
| **Other functions** | • Asynchronous generator (optional)<br>• Priming sequence |

**NOTE** * Only in a **SINGLE genset** controller with mains breaker.

# 9.2 SINGLE genset controller principles

## 9.2.1 Genset nominal settings

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

**`Engine > Nominal settings > Nominal settings # *`**

| Parameter | Range | Comment |
|---|---|---|
| `Nominal RPM` | 100 to 50000 RPM | When an MPU/W/NPN/PNP is used to measure the engine speed, then the nominal engine speed is used for the overspeed and underspeed alarms. |

**NOTE** * # is 1 to 4.

**Generator > Nominal settings > Nominal settings # ***

| Nominal setting | Range | Notes |
|---|---|---|
| Voltage (V) | 10 V to 150 kV | The phase-to-phase ** nominal AC voltage for the genset. |
| Current (I) | 1.0 A to 9 kA | The maximum current flow in one phase (that is, L1, L2 or L3) from the genset during normal operation. |
| Frequency (f) | 20.00 to 100.00 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) | 1.0 kW to 0.9 GW | The nominal active power may be on the genset or prime mover nameplate. |
| Apparent power (S) | 1.0 kVA to 1 GVA | The nominal apparent power should be on the genset or generator nameplate. |
| Power factor (PF) | 0.6000 to 1.0000 | The power factor should be on the genset or generator nameplate. |

**NOTE** * # is 1 to 4.
**NOTE** ** In a single-phase set up the nominal AC voltage is phase-to-neutral.

### Calculation method

**Generator > Nominal settings > Nominal settings # > Calculation method ***

| Calculation method | Options |
|---|---|
| Reactive power (Q) nominal | Q nominal calculated<br>Q nominal = P nominal<br>Q nominal = S nominal |
| P or S nominal | No calculation<br>P nominal calculated<br>S nominal calculated |

**NOTE** * # is 1 to 4.

**More information**
See **Nominal power calculations** for more information.

## 9.2.2 Mains nominal settings

**Mains > Nominal settings > Nominal settings # ***

| Nominal setting | Range | Notes |
|---|---|---|
| Voltage (V) > Nominal value source | User defined<br>Use generator nominal voltage | **User defined**: If this is selected, after the parameters are written, a field appears where you can set the nominal voltage. |
| Calculation method > Reactive power (Q) nominal | Q nominal calculated<br>Q nominal = P nominal<br>Q nominal = S nominal | **Q nominal calculated**: The controller uses the nominal settings to calculate the nominal reactive power (nominal Q) for the mains connection. |
| Calculation method > P or S nominal | No calculation<br>P nominal calculated<br>S nominal calculated | **P nominal calcuated**: The controller calculates the nominal active power (nominal P), and ignores any entered values.<br>**S nominal calculated**: The controller calculated the nominal apparent power (nominal S), and ignores any entered values. |
| Power (P) > Nominal | 1.0 kW to 900 MW | Configure the value according to the mains connection. Set the value to ensure the mains connection over-power protection is triggered at the correct time. |

| Nominal setting | Range | Notes |
|---|---|---|
| `Apparent power (S) > Nominal` | 1.0 kVA to 1 GVA | Mains connection apparent power. |
| `Power factor (PF) > Nominal` | 0.6000 to 1.0000 | Mains connection power factor. |

**NOTE** * # is 1 to 4.

**More information**
See Nominal power calculations.

## 9.3 Genset principles

### 9.3.1 Run coil or stop coil

The engine start and stop functions are suitable for genset start systems with either a run coil or a stop coil. A set of controller digital output terminals must be connected to and configured for either the run coil output, or the stop coil output.

**Run coil and stop coil outputs**

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Controls > Run coil` | Digital output | Continuous | If all power to the controller is lost, then the genset stops.<br><br>Required if there is no *Stop coil*. |
| `Engine > Controls > Stop coil` | Digital output | Continuous | If all power to the controller is lost, then the genset keeps running.<br><br>Required if there is no *Run coil*. |

### 9.3.2 Ready for operation

The genset is ready for operation when the following conditions are met:

- There are no alarms blocking the start.
- If configured, the *Start enable* digital input is activated.

### 9.3.3 Running detection

The controller can be configured to receive engine running feedback from a variety of measurements. There can be more than one running feedback measurement.

*Running detection* is a state calculated by the controller, and used by a number of functions. It is either OFF or ON. If any running feedback measurements show that the engine is running, then *Running detection* is ON.

**Inputs and outputs**

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Feedback > Digital running detection` | Digital input | Continuous | Optional. External equipment activates the digital input when the engine is running. |

The controller can also use the following inputs for running feedback.

| Function | I/O | Type | Details |
|---|---|---|---|
| Frequency | Generator voltage measurements | Continuous | Always present. The controller uses the generator voltage measurements to calculate the frequency. The controller then compares the frequency with the detection set point.<br><br>Note: The controller cannot measure the frequency at very low voltages. See the **Data sheet** for the measurement range. The voltage must also be at least 10 % of nominal for the controller to use the frequency for running detection. For safety, DEIF recommends that you install at least one other running detection input. |
| MPU | HSDI | Continuous | Optional. The MPU input is connected to an MPU mounted on the engine. |
| W | HSDI | Continuous | Optional. The W input is connected to the battery recharging generator and measures the engine speed. Alternatively, the W input can be connected to an NPN/PNP sensor. |
| `Engine > Measurements > Lube oil > Engine oil pressure [bar]` | Analogue input | Pressure in bar | Optional. This set of analogue input terminals are connected to a transducer for the engine oil pressure. |

### Parameters

**`Engine > Running detection > MPU setup`**

| Parameter | Range | Comment |
|---|---|---|
| `Number of MPU teeth` | 1 to 10000 | The controller uses the number of teeth to calculate the engine speed from the MPU/W/NPN/PNP measurement signal. |

**`Engine > Running detection > Feedback type`**

| Parameter | Range | Comment |
|---|---|---|
| `Primary running feedback` | The available running feedbacks (depends on hardware) | Select one of the inputs as the primary running feedback.<br><br>If the *Primary running feedback* does not detect running, but any other running feedback detects running, then the controller activates the *Primary running feedback failure* alarm. |

**`Engine > Running detection > RPM running detection`**

| Parameter | Range | Comment |
|---|---|---|
| `RPM` | 0.0 to 50000.0 RPM | Running detection is ON when the engine speed measured by the MPU/W/NPN/PNP input is above this set point. |
| `Use engine speed` | Not enabled, Enabled | **Not enabled:** The MPU/W/NPN/PNP measurement is ignored and not used for running detection.<br>**Enabled:** The MPU/W/NPN/PNP measurement is used as a running detection input. |

**`Engine > Running detection > Frequency running detection`**

| Parameter | Range | Comment |
|---|---|---|
| `Frequency` | 10.0 to 100.0 Hz | Running detection is ON when the frequency measured by the generator voltage measurements is above this set point.<br><br>For example: For a 60 Hz system, you can use a detection set point of 45 Hz. |

**Engine > Running detection > Oil pressure running detection**

| Parameter | Range | Comment |
|---|---|---|
| Oil pressure * | 0.0 to 10.0 bar | Running detection is ON when the engine oil pressure is above this set point. |
| Use oil pressure * | Not enabled, Enabled | **Not enabled:** The engine oil pressure is ignored and not used for running detection.<br>**Enabled:** The engine oil pressure is used as a running detection input. |

**NOTE** * This parameter is only visible if the analogue input is configured.

### Frequency running detection hysteresis

For stable operation, running detection has a fixed 2 Hz hysteresis.

**Frequency running detection hysteresis examples**

**Example 1**: The detection set point for frequency is 32 Hz. When the frequency rises above 32 Hz, running detection changes to ON. However, the frequency has to drop below 30 Hz for running detection to change to OFF.

**Example 2**: The detection set point for frequency is 45 Hz. When the frequency rises above 45 Hz, running detection changes to ON. However, the frequency has to drop below 43 Hz for running detection to change to OFF.

### MPU/W input running detection hysteresis

For stable operation, running detection has a fixed 5 % hysteresis on the genset RPM.

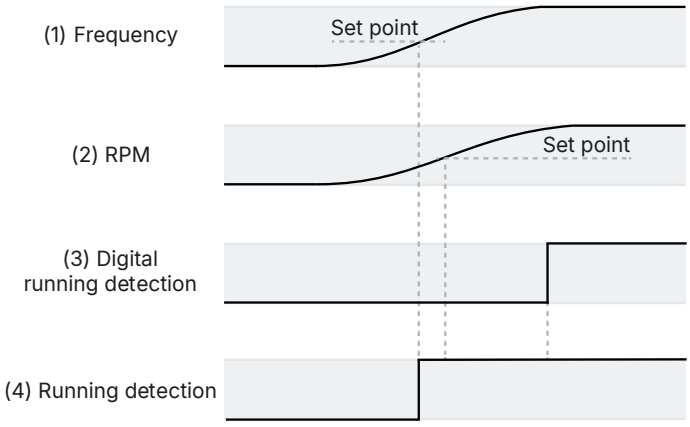
### Oil pressure running detection hysteresis

For stable operation, running detection has a fixed 5 % hysteresis on the oil pressure.

### Example: Running detection ON

The following sequence diagram is an example of how *Running detection* changes during an engine start. *Running detection* changes from OFF to ON when **one** running feedback detects that the engine is running.

### Running detection ON sequence diagram

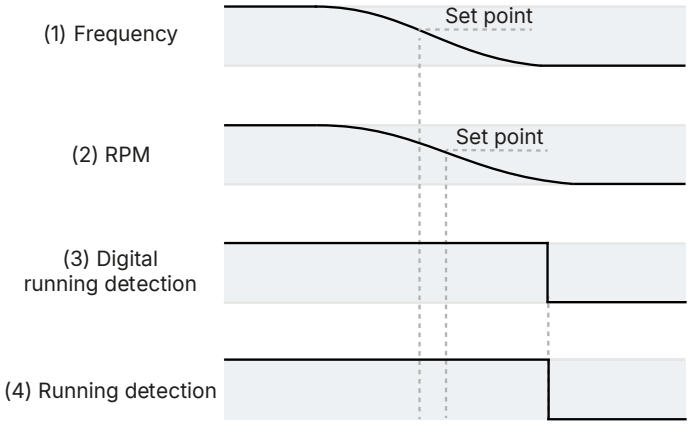



1. **Frequency**: The engine starts and the frequency rises above the set point.
2. **RPM**: (MPU/W/NPN/PNP input). The engine starts and the RPM rises above the set point.
3. **Digital running detection**: *Engine > Feedback > Digital running detection* (digital input). In the example, the response of this input is slower than the other running detection inputs.
4. **Running detection**: Running detection changes from OFF to ON when any running feedback (in this case, the frequency) rises above the *Detection set point*.

### Example: Running detection OFF

The following sequence diagram is an example of how *Running detection* changes during an engine stop. *Running detection* changes from ON to OFF when **none** of the running feedbacks detect that the engine is running.

### Running detection OFF sequence diagram




1. **Frequency**: The engine slows down and the frequency drops to 2 Hz below the set point.
2. **RPM**: (MPU/W/NPN/PNP input). The engine slows down and the RPM drops to 5 % below the set point.
3. **Digital running detection**: *Engine > Feedback > Digital running detection* (digital input). In the example, the response of this input is slower than the other running detection inputs.
4. **Running detection**: Running detection changes from ON to OFF when none of the running feedbacks detect that the engine is running.

### Risks when using only frequency for running detection

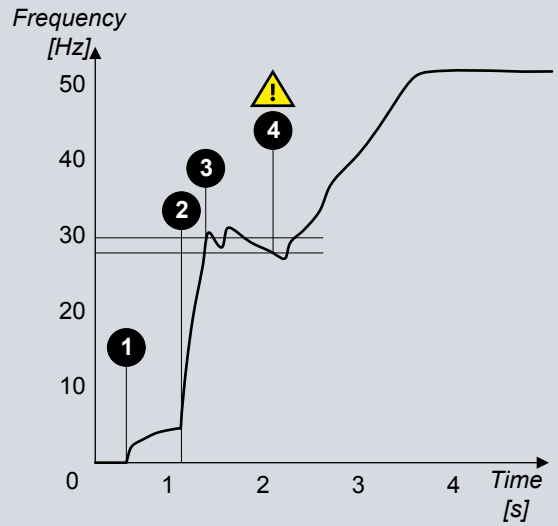
It is possible to only use frequency for running detection. However, using only frequency for running detection increases the risk of not detecting that the genset is running.

The software only uses the frequency measurements when the voltage is at least 10 % of the nominal voltage. This could cause trouble, since the voltage does not necessarily increase linearly with speed (this depends on the AVR).

If the frequency curve for the genset start up has a dip around the detection set point, the controller can interpret the dip as no running detection, and stop the genset. Increasing or decreasing the set point away from the dip would solve this problem.

**Frequency running detection example**

A genset start up frequency curve is given below.



1. Crank begins.
2. Fuel in.
3. If the running detection set point is 30 Hz, running detection is ON.
4. If the running detection set point is 30 Hz, the frequency drops 2 Hz below the set point, and running detection from frequency is OFF.
   - If there are no other running detection inputs, the controller immediately deactivates the run coil and/or activates the stop coil.

### 9.3.4 Regulation

The **SINGLE genset** controller can regulate both a governor (GOV) and an AVR.

**More information**
See Regulation for how regulation works.

## 9.4 Engine start

### 9.4.1 Engine start function

The controller software includes a pre-programmed engine start sequence. For the engine's start function, you must configure these inputs and outputs, and parameters.

If a parameter needs an input or output to be configured, then that parameter is not visible until an input or output is configured with the relevant function.

**More information**
See [Controller] protections for the engine start protections, and how to configure them.

#### Controller modes

Under remote and local control, the controller uses these inputs and outputs, and parameters to start the genset.

When the operator starts the genset under switchboard control, the controller is not involved. These sequences do not apply to starting a genset under switchboard control.

#### Inputs and outputs

#### Required engine start output

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Controls > Crank` | Digital output | Continuous | Connect this output to the engine crank. |

#### Optional engine start inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Command > Start enable` | Digital input | Continuous | Optional. If this input is configured, it must be activated for the engine start sequence to start. |
| `Engine > Controls > Start prepare` | Digital output | Continuous | Optional. The *Start prepare* digital output may, for example, be wired to start a pump, so that the engine oil pressure can build up before cranking. Note that *Start prepare* does not have any provision for feedback. The *Start prepare* function is only a timer, and does not check whether, for example, the pump start was successful.<br><br>The *Start prepare* digital output is not needed if the third party engine controller ensures that all start prepare conditions are okay before activating the *Start enable* digital input. |

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Controls > Idle run` | Digital output | Continuous | Optional. Connect this output to the engine idle run if supported. Not all engines support this feature. |
| `Engine > Idle run > End idle start` | Digital input | Pulse | Optional. The operator or another system can activate this input to request the controller to end the engine start idle run. |
| `Engine > Function > Remove start (release crank relay)` | Digital input | Pulse | Optional. The engine controller activates this input. In response, the GENSET controller deactivates the *Crank* output, although the *Crank on* timer continues to run.<br><br>This input is useful when only frequency is used for *Running detection*, but the genset frequency increases slowly, and the crank must be removed before there is *Running detection*. Even when this input is activated, the start sequence tries to detect that the engine is running for the whole of the *Crank on* time. |

### Optional engine start commands

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Command > Start engine` | Digital input | Pulse | Optional. When the controller is under remote control, the operator or another system can activate this input to request the controller to start the engine. |
| `Engine > Command > Block engine start` | Digital input | Continuous | Optional. The operator or another system can activate this input so that the controller cannot start the engine. The input blocks the start in both remote and local control. |
| `Engine > Command > Start engine and close generator breaker` | Digital input | Pulse | Optional. When the controller is under remote control, the operator or another system can activate this input to request the controller to start the engine and then synchronise and close the breaker. |

### Required parameters

**`Engine > Start sequence > Crank`**

| Parameter | Range | Comment |
|---|---|---|
| `Crank on` | 1.0 s to 3 min | For the *Crank on* part of the start sequence, the controller activates the *Crank* output for this period. |
| `Crank off` | 1.0 to 99.0 s | If there is no running detection during *Crank on*, then the controller deactivates the *Crank* output for this period. |
| `Disengage crank` | 1 to 2000 RPM | The controller deactivates the *Crank* output when the engine speed reaches this set point, although the *Crank on* timer continues to run. This parameter only has an effect if an engine speed measurement (for example, an MPU/W/NPN/PNP) is configured.<br><br>Even when *Disengage crank* is used, the start sequence tries to detect that the engine is running for the whole of the *Crank on* time. |

**`Engine > Start sequence > Start attempts`**

This parameter limits the wear on the genset from too many start attempts.

| Parameter | Range | Comment |
|---|---|---|
| `Normal` | 1 to 100 | This is the maximum number of start attempts if the digital input `Alarm system > Additional functions > Suppress alarm action` is not active. |

| Parameter | Range | Comment |
|---|---|---|
| | | If the genset does not start after these attempts, the *Start failure* alarm is activated. |
| `Suppress alarm action` | 1 to 10 | This is the maximum number of start attempts if the digital input `Alarm system > Additional functions > Suppress alarm action` is active.<br><br>If the genset does not start after these attempts, the *Start failure* alarm is activated. |

**`Engine > Running detection > Engine ready`**

| Parameter | Range | Comment |
|---|---|---|
| `Delay` | 1.0 s to 5 min | After *Running detection* is ON, the engine must run for this period before the breaker close sequence can start. |

### Parameters (optional)

**`Engine > Start sequence > Start prepare`**

You must configure the `Engine > Controls > Start prepare` digital output to see these parameters.

| Parameter | Range | Comment |
|---|---|---|
| `Start prepare` | 0.0 s to 10 min | Optional. If the start conditions are OK, the controller activates the *Start prepare* output for this time. When the *Start prepare* timer expires, the controller activates the *Crank* output. See **Start prepare** in the **Engine start sequence**. |
| `Extended start prepare` | 0.0 s to 10 min | Optional. The controller keeps the *Start prepare output* activated for this time during cranking. |

**`Engine > Start sequence > Run coil`**

You must configure the `Engine > Controls > Run coil` digital output to see these parameters.

| Parameter | Range | Comment |
|---|---|---|
| `Run coil before crank` | 0.0 s to 10 min | Optional. The controller activates the *Run coil* output for this time before the *Crank* output is activated. |
| `During start attempts` | Pulse, Continuous | **Pulse**: If the start attempt fails, the controller deactivates the *Crank* output and the *Run coil*.<br><br>**Continuous**: If the start attempt fails, the controller deactivates the *Crank* output. However, the *Run coil* remains activated until the maximum number of start attempts is reached. |

**`Engine > Start sequence > Stop coil`**

You must configure the `Engine > Controls > Stop coil` digital output to see these parameters.

| Parameter | Range | Comment |
|---|---|---|
| `During crank off` | Activated, Not activated | **Activated**: The stop coil is activated during the start sequence if there is no running detection and the crank is off.<br><br>**Not activated**: The stop coil is not activated during the start sequence if there is no running detection and the crank is off. |

### Idle run start (optional)

You must configure the `Engine > Controls > Idle run` digital output to see these parameters.

You can configure an idle run start period for the engine. This allows the engine to warm-up before running at nominal speed.

If this is configured, the controller will activate the digital output `Engine > Controls > Idle run` before starting the engine. The controller then waits for one of the engine conditions (coolant temperature, oil temperature, external input condition, or the maximum timer) to be fulfilled before increasing to nominal speed.

During the idle run start period, the operator can override the period and press **Start** on the display, the controller then cancels the idle run start period and increases to nominal speed.

Additionally, during the idle run start period, the operator can press **Stop** to abort the engine start sequence and run the engine stop sequence.

### Optional idle run start parameters

**`Engine > Idle run start > Idle run`**

| Parameter | Range | Comment |
|---|---|---|
| `Enable` | Not enabled, Enabled | Enables the engine to idle run until a condition is true before changing to nominal speed. |
| `Extended inhibit` | 0 s to 60 min | This extends the inhibit period after the idle run is complete, so that while the engine is changing to nominal speed, certain alarms are not activated. |

**`Engine > Idle run start > Minimum`**

| Parameter | Range | Comment |
|---|---|---|
| `Use` | Not enabled, Enabled | Uses minimum set point to determine if the engine is ready to increase to nominal speed. |
| `Delay` | 0 s to 999 min | This is the minimum time the idle run start is active. * |

**NOTE** * The minimum period can be overridden by pressing **Start** to cancel the idle run start period and increases to nominal speed.

**`Engine > Idle run start > Coolant temperature`**

| Parameter | Range | Comment |
|---|---|---|
| `Use` | Not enabled, Enabled | Uses coolant temperature set point to determine if the engine is ready to increase to nominal speed. |
| `Set point` | - 50 to 200 °C | The temperature the engine coolant must reach before ending the idle run start. |

**`Engine > Idle run start > Oil temperature`**

| Parameter | Range | Comment |
|---|---|---|
| `Use` | Not enabled, Enabled | Uses oil temperature set point to determine if the engine is ready to increase to nominal speed. |
| `Set point` | - 50 to 200 °C | The temperature the engine oil must reach before ending the idle run start. |

**`Engine > Idle run start > External condition`**

| Parameter | Range | Comment |
|---|---|---|
| `Use` | Not enabled, Enabled | Uses the external condition to determine if the engine is ready to increase to nominal speed. |

| Parameter | Range | Comment |
|---|---|---|
| | | The external condition is configured with the digital input `Engine > Idle run > End idle run start`, or with CustomLogic or CODESYS. |

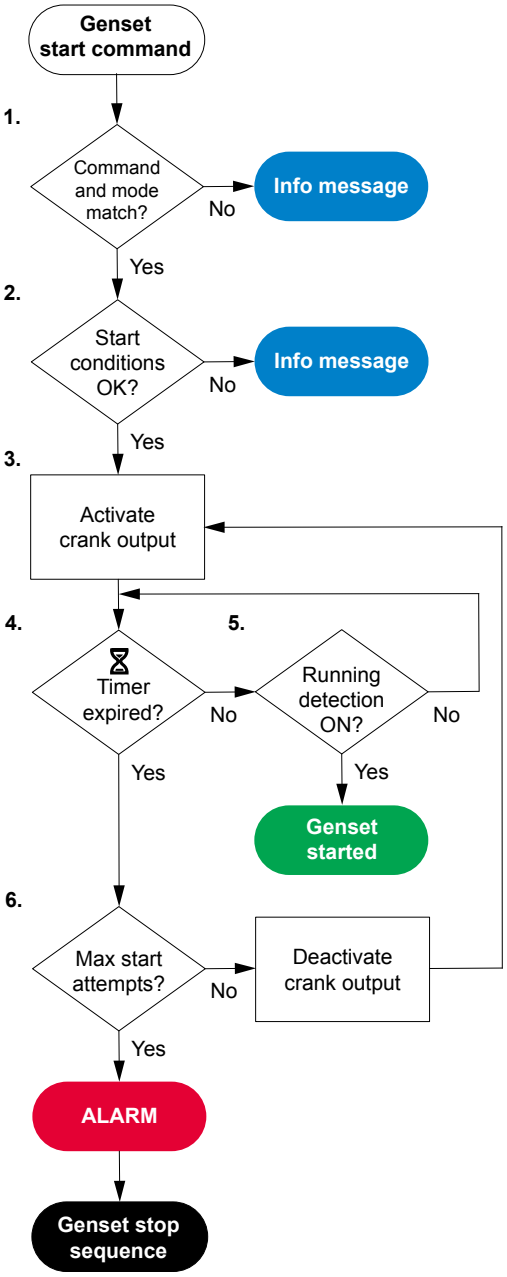
**`Engine > Idle run start > Maximum`**

| Parameter | Range | Comment |
|---|---|---|
| `Use` | Not enabled, Enabled | Uses maximum set point to determine if the engine is ready to increase to nominal speed. |
| `Delay` | 1 s to 120 min | This is the maximum time the idle run start can operate. |

## 9.4.2 Engine start flowchart

The following flowchart shows the sequence that the controller uses to start a genset. The engine start sequences are described in detail in the sections that follow.

**Table 9.1** Engine start flowchart *




1. **Command and mode match**: The controller checks that the command source and the controller mode match:
   - In REMOTE mode, the command to start the genset can come from a digital input, PICUS, Modbus, CustomLogic, and/or CODESYS.
   - In LOCAL mode, the operator can press the push-button **Start** on the display unit. The controller ignores all other commands.
2. **Start conditions OK**: The controller checks whether the start conditions are OK:
   - If configured, the *Start enable* digital input is activated.
   - There are no active or unacknowledged alarms to prevent the genset start. These alarm actions prevent a genset start:
     - *Block GB*
     - *Trip generator breaker and stop engine*
     - *Trip generator breaker and shutdown engine*
3. **Crank output activated**: If all the start conditions are OK, the controller activates the *Crank* output and a timer.
4. **Running detection ON**: While the start timer runs, the controller checks whether *Running detection* is ON.
   - When the controller detects that the genset is running, the genset start is complete.
5. **Crank on timer expired**: If *Running detection* is OFF after the *Crank on* timer runs out, the controller checks the number of start attempts:
   - If the maximum number of start attempts has not been reached, the controller attempts to start the genset again.
   - If the maximum number of start attempts has been reached, the controller activates the *Start failure* alarm and stops the engine.

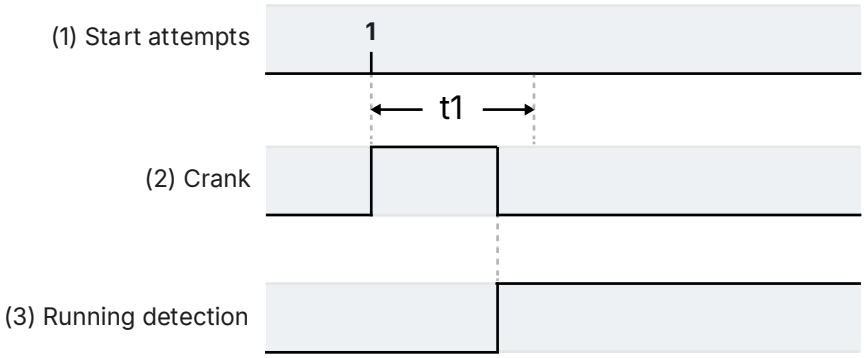
**NOTE** * The optional *Start prepare* function is not shown here.

## 9.4.3 Engine start sequence

### Engine start sequence for a stop coil system

In this example, the `Engine > Start sequence > Stop coil > During crank off` parameter is *Activated*. The engine speed (RPM measurement) and/or the *Remove start (release crank relay)* digital input do not disengage the crank before there is *Running detection*.

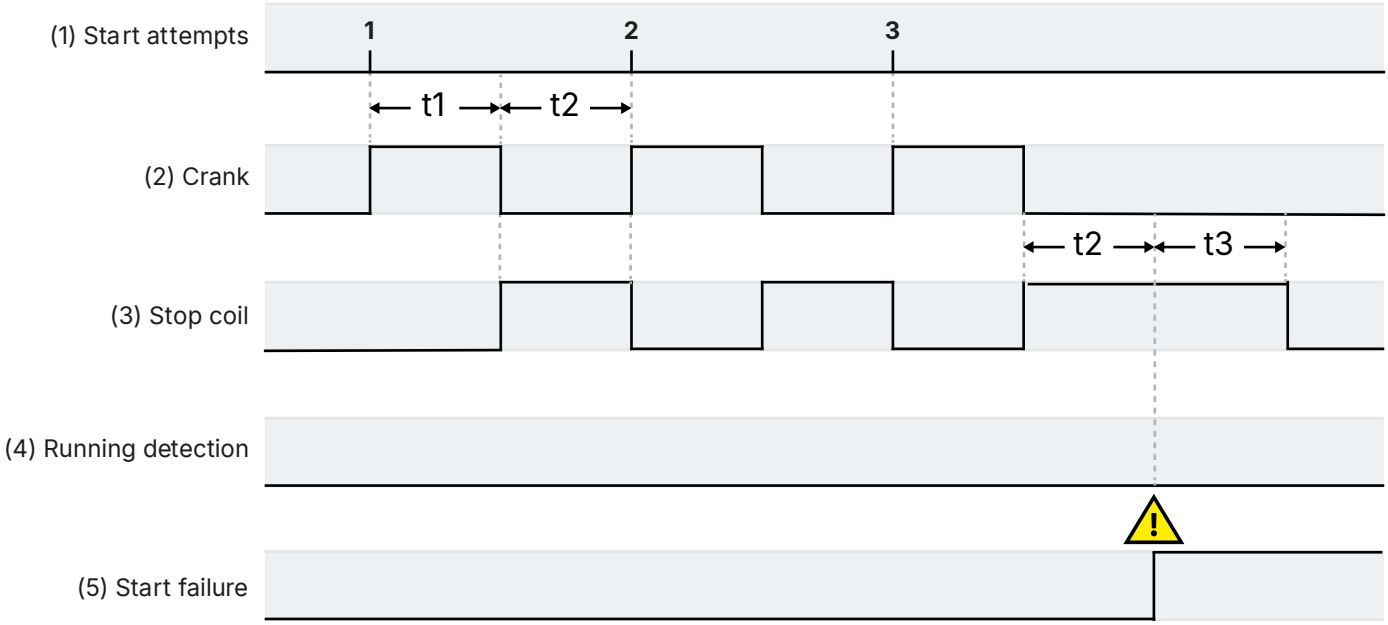
### Successful engine start sequence for a stop coil system




t1 = Crank on (`Parameters > Engine > Start sequence > Crank > Crank on`)

1. **Start attempts**: The engine starts during the first start attempt.
2. **Crank**: `Engine > Controls > Crank` (digital output). The controller activates the *Crank* output. If *Running detection* changes from OFF to ON, cranking stops.
3. **Running detection**. The engine is regarded as started when *Running detection* is ON.

### Failure of engine start sequence for a stop coil system




t1 Crank on (`Parameters > Engine > Start sequence > Crank > Crank on`)

t2 Crank off (`Parameters > Engine > Start sequence > Crank > Crank off`)

t3 Extended stop (`Parameters > Engine > Stop sequence > Extended stop`) (optional)

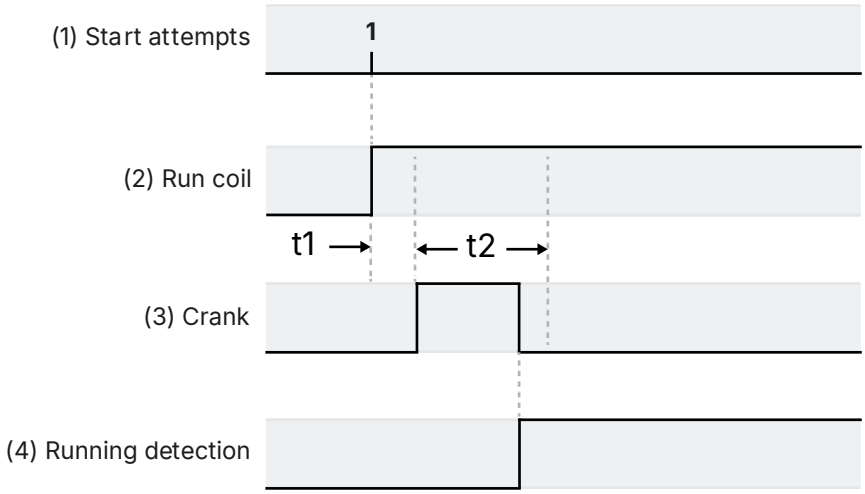
Failure of engine start sequence for a stop coil system:

1. **Start attempts**: `Parameters > Engine > Start sequence > Start attempts > Normal` = 3.
2. **Crank**: `Engine > Crank` (digital output). The controller activates the *Crank* output for the *Crank on* time, and deactivates it for *Crank off* time.
3. **Stop coil**: *Engine > Stop coil* (digital output). If *Running detection* is OFF after the *Crank on* time, then the controller activates the *Stop coil* for the time in the *Crank off* parameter. If all start attempts fail, the controller also activates the *Stop coil* for the time in *Extended stop > Stop coil activated*. This ensures that the engine is stopped if the engine start was not detected. The engine cannot be started during the *Extended stop > Stop coil activated* time.
4. **Running detection**. There is no running detection.
5. **Start failure**. The controller activates the *Start failure* alarm after the last unsuccessful start attempt.

### Engine start sequence for a run coil system

In this example, the `Engine > Start sequence > Run coil > During start attempts` parameter is set to *Follow crank*. The engine speed (RPM measurement) and/or the *Remove start (release crank relay)* digital input do not disengage the crank before there is *Running detection*.

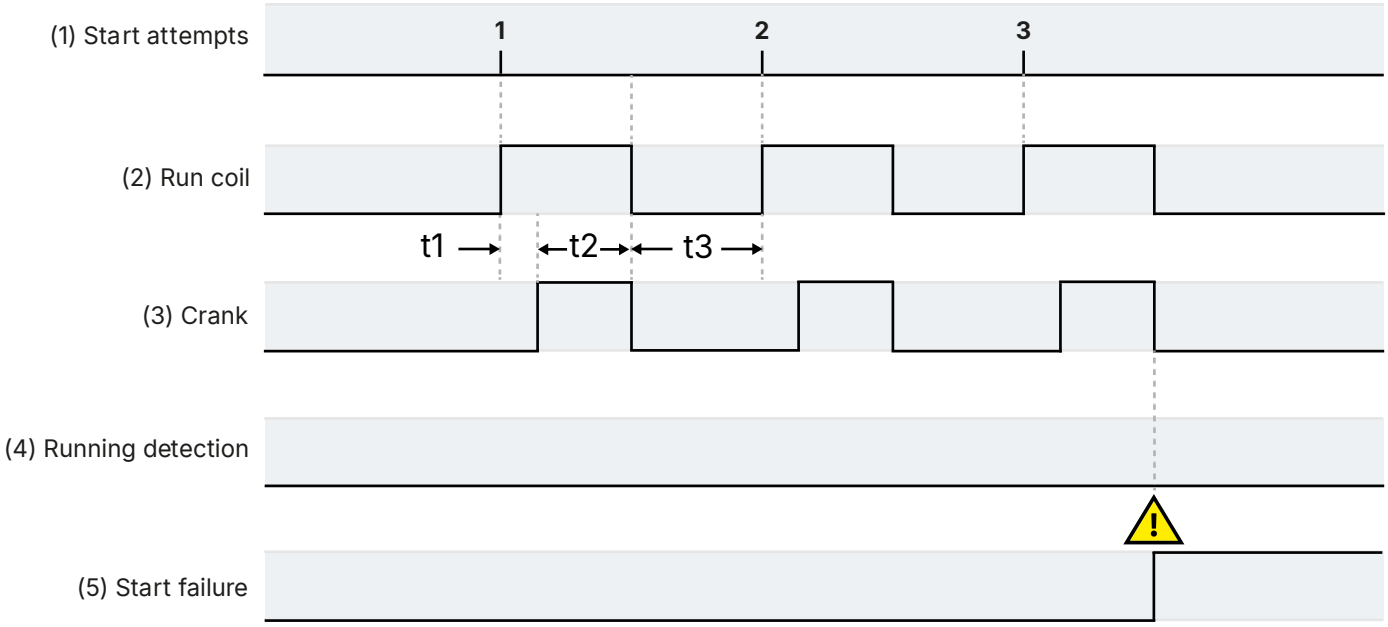
### Successful engine start sequence for a run coil system




t1 = Run coil before crank (optional)
t2 = Crank on (`Parameters > Engine > Start sequence > Crank > Crank on`)

1. **Start attempts**: The engine starts during the first start attempt.
2. **Run coil**: `Engine > Run coil` (digital output). The controller activates the *Run coil* at the time in the *Run coil before crank* parameter. If *Running detection* is ON, the engine is regarded as started, and the *Run coil* remains activated.
3. **Crank**: `Engine > Crank` (digital output). The controller activates the *Crank* output. If *Running detection* changes from OFF to ON, cranking stops.
4. **Running detection**. The engine is regarded as started when *Running detection* is ON.

### Failure of engine start sequence for a run coil system



t1 Run coil before crank (optional)

t2 Crank on (`Parameters > Engine > Start sequence > Crank > Crank on`)

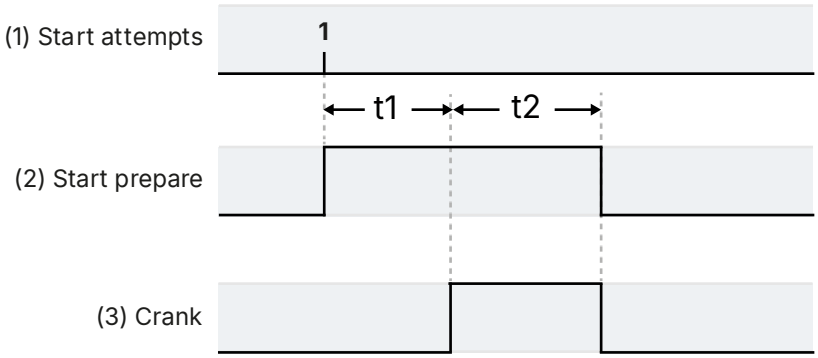
t3 Crank off (`Parameters > Engine > Start sequence > Crank > Crank off`)

1. **Start attempts**: `Parameters > Engine > Start sequence > Start attempts > Normal` = 3.
2. **Run coil**: `Engine > Controls > Run coil` (digital output). The controller activates the *Run coil* at the time in the *Run coil before crank* parameter. If *Running detection* is still OFF after cranking, the controller deactivates the *Run coil* for the time in the *Crank off* parameter. This ensures that the engine is stopped if the engine start was not detected. The engine cannot be started during the *Crank off* time.
3. **Crank**: `Engine > Controls > Crank` (digital output). The controller activates the *Crank* output for the *Crank on* time, and deactivates it for *Crank off* time.
4. **Running detection**. There is no running detection.
5. **Start failure**. The controller activates the *Start failure* alarm after the last unsuccessful start attempt.

### Optional start prepare

You can use the optional `Engine > Controls > Start prepare` digital output with a stop coil or a run coil system.

### Successful engine start sequence with start prepare




t1 = Start prepare (`Parameters > Engine > Start sequence > Start prepare > Start prepare`)

t2 = Extended start prepare (`Parameters > Engine > Start sequence > Start prepare > Extended start prepare`)

1. **Start attempts**
2. **Start prepare**: `Engine > Controls > Start prepare` (digital output) (optional).
   a. At the start of each start sequence, the controller activates the *Start prepare* output for the time in the *Start prepare* parameter (**t1**). All other engine start outputs (that is, *Stop coil*, *Crank* ) are not activated during this time.
   b. If there is an *Extended start prepare* time (**t2**), then the *Start prepare* output remains activated for this time during cranking. If cranking stops before the extended start prepare timer stops, then the controller deactivates the *Start prepare* output.
3. **Crank**: `Engine > Controls > Crank` (digital output). After the *Start prepare* time, the controller activates the *Crank* output.

## 9.4.4 Interruption of the start sequence

These actions interrupt the engine start sequence:

- The *Emergency stop* is activated (that is, the digital input is deactivated) (for example, from the operator, or a PLC).
- There is a *Stop engine* command.
  - For example: In LOCAL mode, the operator pushes the push-button **Stop** on the display unit.
- The following alarm actions:

- *Trip generator breaker and stop engine*
- *Trip generator breaker and shutdown engine*

The *Block* alarm action will not interrupt the genset start sequence after it has begun. However, the *Block* alarm action prevents a new genset start sequence from starting.

When the start sequence is interrupted, the controller does the following:

- Deactivates the *Crank* output.
- Activates the *Stop coil* output (if present). Alternatively, deactivates the *Run coil* output (if present).
- Deactivates the *Start prepare* output (if present).

There is no cooldown period when the engine start sequence is interrupted.

If *Running detection* is ON, the controller regards the engine as started. When the engine has started, the actions listed here do not interrupt the engine start sequence, but result in a engine stop instead. The engine stop normally includes the cooldown period configured in the controller. However, for a shutdown, there is no cooldown period.

# 9.5 Engine stop

## 9.5.1 Engine stop function

For a normal genset stop, the controller ensures that the genset runs for a cooldown period before stopping. If a shutdown alarm action shuts down the genset, there is no cooldown period. You can also configure an idle run stop period before the engine shuts down.

The controller software includes pre-programmed genset stop sequences. For the engine's stop function, you must configure these inputs and outputs, and parameters.

Parameters that need a hardware function are not visible until the function is assigned to an input or output.

**More information**
See GENSET controller alarms for more information on how the engine stop alarms work, and how to configure them.

### Controller modes

Under remote and local control, the controller uses these inputs and outputs, and parameters to stop the genset.

When the operator stops the genset under switchboard control, the controller is not involved. These sequences do not apply to stopping a genset under switchboard control.

### Optional inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Command > Stop engine` | Digital input | Pulse | Optional. When the controller is under remote control, the operator or another system can activate this input to request the controller to stop the engine. |
| `Engine > Controls > Idle run` | Digital output | Continuous | Optional. Connect this output to the engine idle run if supported. Not all engines support this feature.<br><br>This digital output is needed to use either idle run start and/or idle run stop. |
| `Engine > Idle run > End idle stop` | Digital input | Pulse | Optional. The operator or another system can activate this input to request the controller to end the engine stop idle run. |

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Command > Open generator breaker and stop engine` | Digital input | Pulse | Optional. When the controller is under remote control, the operator or another system can activate this input to request the controller to de-load and open the breaker, and then stop the engine. |
| `Engine > Cooldown > Coolant water [C]` | Analogue input | Units = °C | Optional. This input measures the engine water temperature, and is used for temperature-dependent cooldown. |

### Parameters

**`Engine > Stop sequence > Cooldown`**

| Parameter | Range | Comment |
|---|---|---|
| `Cooldown time` * | 0 s to 165 min | This is the cooldown time if the digital input `Alarm system > Additional functions > Suppress alarm action` is not active.<br><br>After the engine stop signal or command, the engine runs for this period before the controller activates the *Stop coil* (or deactivates the *Run coil*). |
| `Suppress alarm action` * | 1 s to 3 h | This is the cooldown time if the digital input `Alarm system > Additional functions > Suppress alarm action` is active.<br><br>After the engine stop signal or command, the engine runs for this period before the controller activates the *Stop coil* (or deactivates the *Run coil*). |
| `Temperature threshold` | 0 to 150 °C | Optional. The engine cooldown stops if the engine coolant water temperature reaches this threshold before the cooldown timer expires. |

**NOTE** * If the digital input `Alarm system > Additional functions > Suppress alarm action` is active, the *Suppress alarm action* value is used instead of the *Cooldown time* value.

**`Engine > Stop sequence > Extended stop`**

| Parameter | Range | Comment |
|---|---|---|
| `Extended stop` | 1.0 to 99.0 s | The *Stop coil* remains activated for this period after *Running detection* is OFF. During this period a new start attempt is not possible. |

### Optional idle run stop

You can optionally configure an idle run stop period for the engine, allowing the engine to cool-down after taking load.

If this is configured, the controller will activate the digital output `Engine > Controls > Idle run` before stopping the engine. The controller then waits for one of the engine conditions (coolant temperature, oil temperature, external input condition, or the maximum timer) to be fulfilled before stopping the engine.

During the idle run stop period, the operator can override the period and press **Stop** on the display, the controller then cancels the idle run stop period and stops the engine.

Additionally, during the idle run stop period, the operator can press **Start** to abort the engine stop sequence and run the engine start sequence.

Optional. You must configure the `Engine > Controls > Idle run` digital output to see these parameters.

### Optional parameters

**`Engine > Idle run stop > Idle run`**

| Parameter | Range | Comment |
|---|---|---|
| `Enable` | Not enabled, Enabled | Enables the engine to idle run until a condition is true before stopping the engine. |

**`Engine > Idle run stop > Minimum`**

| Parameter | Range | Comment |
|---|---|---|
| `Use` | Not enabled, Enabled | Uses minimum set point to determine if the engine is ready to stop. |
| `Delay` | 0 s to 999 min | This is the minimum time the idle run stop is active. |

**`Engine > Idle run stop > Coolant temperature`**

| Parameter | Range | Comment |
|---|---|---|
| `Use` | Not enabled, Enabled | Uses coolant temperature set point to determine if the engine is ready to stop. |
| `Set point` | - 50 to 200 °C | The temperature the engine coolant must reach before ending the idle run stop. |

**`Engine > Idle run stop > Oil temperature`**

| Parameter | Range | Comment |
|---|---|---|
| `Use` | Not enabled, Enabled | Uses oil temperature set point to determine if the engine is ready to stop. |
| `Set point` | - 50 to 200 °C | The temperature the engine oil must reach before ending the idle run stop. |

**`Engine > Idle run stop > External condition`**

| Parameter | Range | Comment |
|---|---|---|
| `Use` | Not enabled, Enabled | Uses the external condition to determine if the engine is ready to stop.<br><br>The external condition is configured with the digital input `Engine > Idle run > End idle run stop`, or with CustomLogic or CODESYS. |

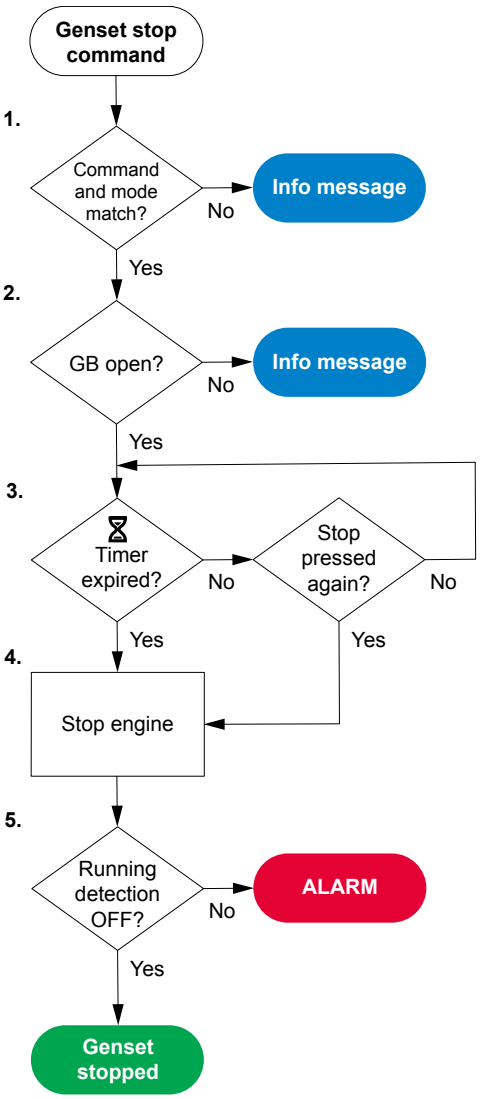
**`Engine > Idle run stop > Maximum`**

| Parameter | Range | Comment |
|---|---|---|
| `Use` | Not enabled, Enabled | Uses maximum set point to determine if the engine is ready to stop. |
| `Delay` | 1 s to 120 min | This is the maximum time the idle run stop can operate. |

## 9.5.2 Engine stop flowchart

The following flowchart shows how the controller normally stops a genset. An engine shutdown is described later.

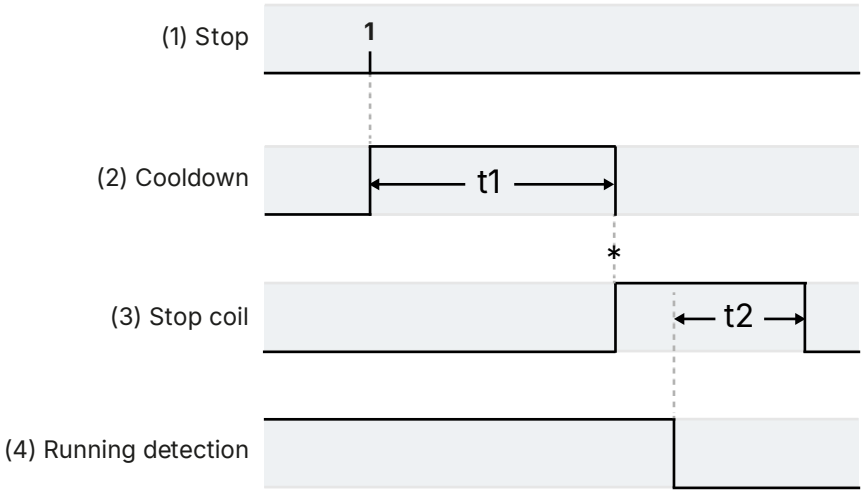
**Table 9.2** Engine stop flowchart



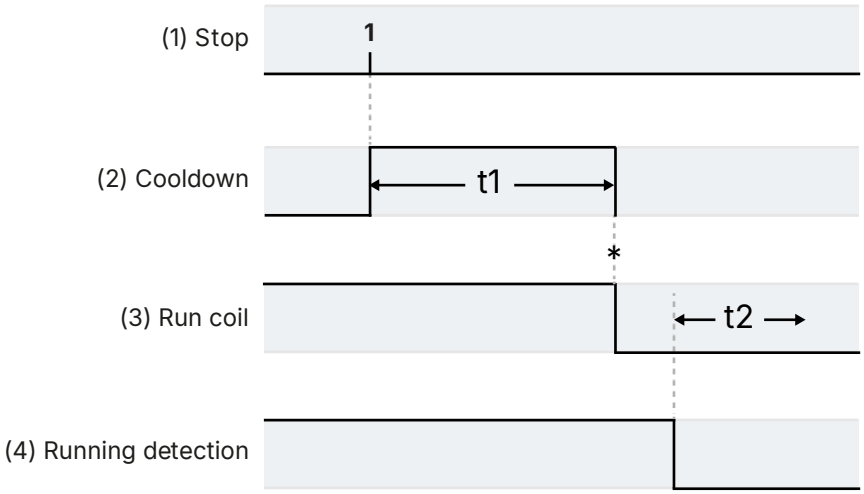

1. **Command and mode match**: The controller checks that the command source and the controller mode match:
   - In REMOTE mode, the command to stop the genset can come from a digital input, PICUS, Modbus, CustomLogic, and/or CODESYS.
   - In LOCAL mode, The operator can press the push-button **Stop** on the display unit. The controller ignores all other commands.
2. **GB open**: The controller checks whether the genset breaker is open. If the genset breaker is not open, the controller cancels the stop sequence and the display unit shows an info message.
3. **Cooldown timer expired**: The genset runs without load for the cooldown time. The controller checks whether the cooldown timer has expired or the stop button was pressed again.
   - If the cooldown timer has not expired, but the engine stop button was pressed again, the controller stops the cooldown.
4. **Stop engine**: To stop the engine:
   - Stop coil system: The controller activates the *Stop coil* output.
   - Run coil system: The controller deactivates the *Run coil* output.
5. **Running detection OFF**: The controller checks whether the engine has stopped.
   - If *Running detection* is ON, the controller activates an alarm.
   - If *Running detection* is OFF, the engine has stopped and the stop sequence has been completed successfully.

## 9.5.3 Engine stop sequence

### Engine stop sequence for a stop coil system



### Engine stop sequence for a run coil system




t1 Cooldown (`Parameters > Engine > Stop sequence > Cooldown > Cooldown time`)

t2 Extended stop (`Parameters > Engine > Stop sequence > Extended stop > Extended stop`)

* Up to this point, the engine can be restarted immediately, without completing the stop sequence.

1. **Stop**. The stop command can come from the controller, an operator, or an external source. See Engine stop flowchart.
2. **Cooldown** (optional). The controller allows the genset to run for the time configured. There is no cooldown for shutdowns, an emergency stop, or an operator stop by pressing the engine stop push-button again. Temperature-dependent cooldown is also possible (see below).
3. **Stop engine**:
   - **Stop coil**: `Engine > Controls > Stop coil` (digital output). The controller activates the stop coil digital output until running feedback is OFF. The controller then keeps the stop coil activated for the time in the (optional) *Extended stop* parameter.
   - **Run coil**: `Engine > Controls > Run coil` (digital output). The controller deactivates the run coil digital output after the cooldown period. The genset cannot restart during the time in the (optional) *Extended stop* parameter.
4. **Running detection**. When the running detection is OFF, the controller regards the engine as stopped.

### Temperature-dependent cooldown

Temperature-dependent cooldown stops the engine cooldown when the engine coolant water temperature reaches the configured threshold before the cooldown timer expires. The cooldown can be shorter than when just a timer is used, which reduces fuel use. Configure the cooldown threshold under `Engine > Stop sequence > Cooldown > Temperature threshold`.

### Analogue input for cooldown

| Function | I/O |
|---|---|
| `Engine > Measurements > Coolant > Engine coolant water [°C]` | Analogue input |

**NOTE** You must configure the analogue input function to see the parameters.

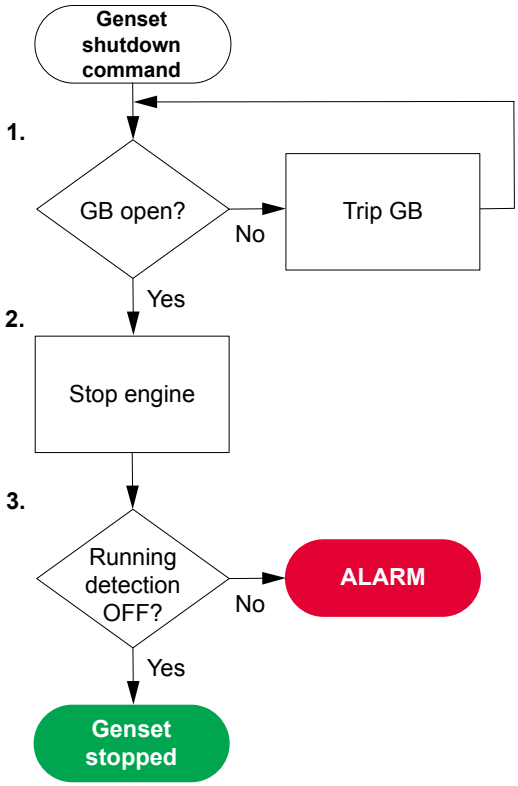
## 9.5.4 Engine shutdown flowchart

The engine is shut down for the following alarm action:

- Trip generator breaker and shutdown engine

The engine is also shutdown if the controller's *Emergency stop* input is deactivated.

### Engine shutdown flowchart




1. **GB open**: The controller checks whether the generator breaker is open. If not, the controller trips the generator breaker.
2. **Stop engine**: The controller shuts down the engine:
   - Stop coil system: The controller activates the *Stop coil* output.
   - Run coil system: The controller deactivates the *Run coil* output.
3. **Running detection OFF**: If *Running detection* is still ON after the time allowed, the controller activates the *Stop failure* alarm.

**NOTE** The controller does not require the engine stop conditions to be met for an engine shutdown. Similarly, there is no cooldown time for an engine shutdown.

## 9.6 Generator breaker

### 9.6.1 How it works

The generator breaker (GB) connects the genset to the busbar. The genset must be running, and synchronised with the busbar, for the generator breaker to close. The generator breaker is an important part of the system safety, and trips to protect the genset from problems on the busbar. The generator breaker also trips to stop genset problems from disturbing the busbar.

#### General breaker information

**More information**
See the **Breakers, synchronisation and de-loading** chapter for more information on synchronisation and breakers. This includes the inputs and output functions and the parameters to configure.

*[Breaker]* refers to *Generator breaker*. The breaker abbreviation (*[*B]*) is *GB*.

#### Synchronisation

When the generator breaker close button is pressed, if the controller has an active regulation mode, it ignores the regulation mode and automatically regulates the genset to synchronise. When the generator breaker is closed, the controller returns to its previous regulation mode.

If the controller(s) regulation is off or under *Manual regulation*, the controller does not automatically regulate the genset to synchronise. The genset can be synchronised manually while the synchronisation timer is running if the controller is under *Manual regulation*.

Regardless of the regulation, if the synchronisation requirements are met (within the time available for synchronisation), the controller automatically closes the breaker.

#### De-loading

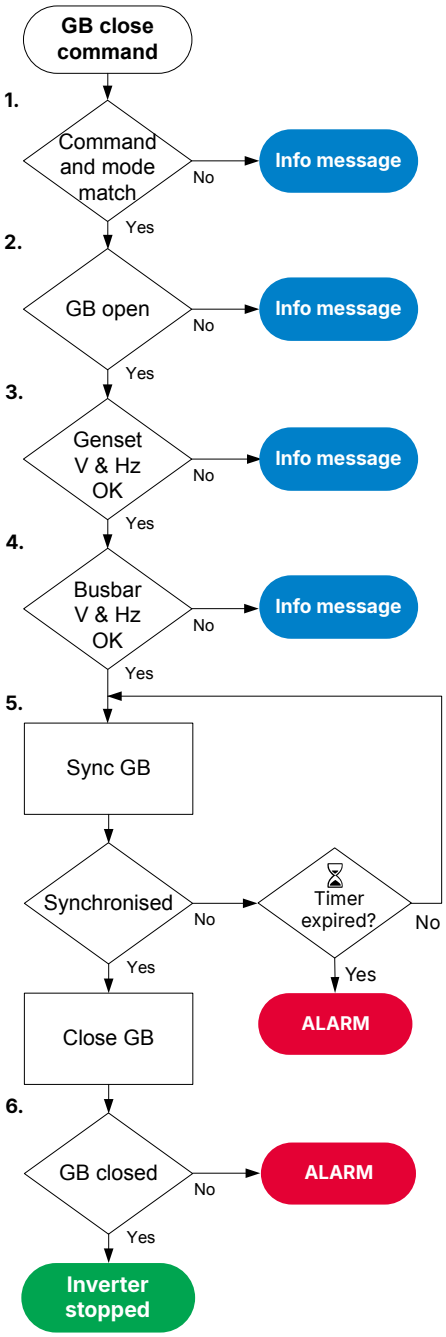
When the generator breaker open button is pressed, the controller checks whether the genset has an active regulation mode. If regulation is off, the controller trips the breaker (without de-loading).

If regulation is possible, the controller ignores its regulation mode and tries to de-load and open the breaker. The generator breaker must be de-loaded manually while the de-load timer is running if the controllers is under *Manual regulation*. When the generator breaker is open, the controller returns to its previous regulation mode.

## 9.6.2 Generator breaker close flowchart

The following flowchart shows the sequence that the controller normally uses to close the generator breaker.

**Table 9.3** Generator breaker close flowchart




1. **Command and mode match**: The controller checks that the command source and the controller mode match:
   - In REMOTE mode, the command to close the breaker can come from a digital input, PICUS, Modbus, CustomLogic, and/or CODESYS.
   - In LOCAL mode, the operator can press the push-button **Close breaker** CLOSE on the display unit. The controller ignores all other commands.
2. **GB open**: The controller checks whether the generator breaker is open. If the generator breaker is already closed, the sequence stops, and an info message is shown.
3. **Genset V & Hz OK**: The controller checks whether the voltage and frequency from the genset are within the allowed range*. If these are not in the range, then the controller cancels the close command and displays an info message.
4. **Busbar V & Hz OK**: The controller checks whether the voltage and frequency on the busbar are within range*. If these are not in the range, then the controller cancels the close command and displays an info message.
5. **Sync GB**: If the controller has an active regulation mode, it tries to synchronise the genset to the busbar.
   - When the genset and busbar are synchronised, the controller activates the *Breakers > Generator breaker > Control > GB close* output to close the breaker.
   - If the genset and busbar do not synchronise within the time allowed, the controller activates a *GB synchronisation failure* alarm.
6. **GB closed**: 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 controller activates the *GB closing failure* alarm.

*Note: See **Configure > Parameters > [A-side] / [B-side] > AC setup > Voltage and frequency OK** for these ranges.

### 9.6.3 Generator breaker blackout close flowchart

The *Blackout close* function sets the action that the controller allows when a dead busbar is detected. If the parameter is not *Off*, then an operator or a remote input can close the breaker directly to the black busbar.

**DANGER!**

**Incorrect blackout close parameters**

Incorrect blackout close parameter settings can lead to equipment damage or loss of life.

#### Blackout conditions

A blackout is present if 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 allow the blackout close:

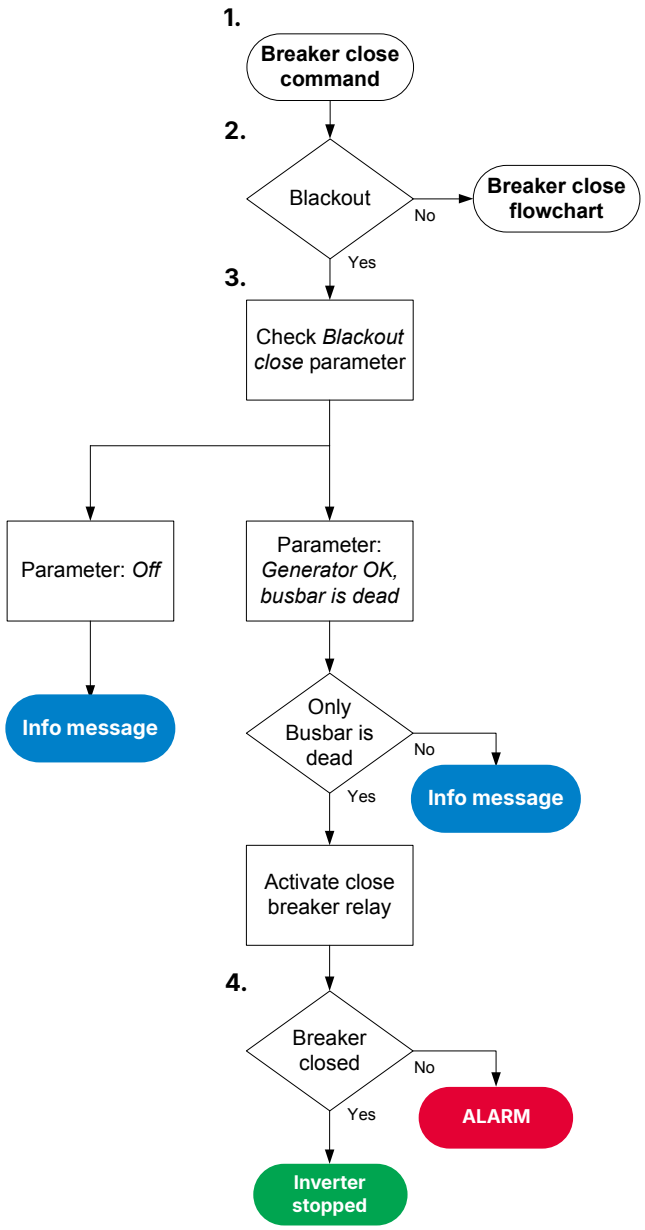
- The breaker position is unknown.
- There is a short circuit.
  - A digital input with the function *Breakers > Generator breaker > Feedback > GB short circuit* was activated.
- There is a blocking alarm.
  - The alarm action determines whether the alarm is a blocking alarm.
- The busbar and/or generator AC measurements are not OK.
  - A measurement failure is detected on one or more of the phases.

#### Blackout close parameters

**`Breakers > Generator breaker configuration`**

| Name | Range | Default | Notes |
|---|---|---|---|
| `Blackout close` | • Off<br>• Generator OK, busbar is dead | Generator OK, busbar is dead | **Off**: The controller will never activate the close breaker relay if any blackout is detected.<br><br>**Generator OK, busbar is dead**: If a blackout is detected at the Busbar and the Generator is stable, then the controller allows the breaker to close. |

**Table 9.4** Blackout close flowchart




1. **Breaker close command**: An operator or a remote command attempts to close the breaker.
2. **Blackout**: The controller detects a blackout on one or both of the busbars, and the conditions for blackout close are met.
3. **Check *Blackout close* parameter**:
   a. **Off**: The controller does not allow the breaker to close. The controller shows an info message, and the sequence ends.
   b. **Generator OK, busbar is dead**: The controller checks whether the blackout was detected only at the Busbar.
      - *Blackout only at the Busbar*: The controller activates the close breaker relay.
      - *Blackout only at the Generator or on both sides of the breaker*: The controller shows an info message and the sequence ends.
4. **Breaker closed**: The controller checks whether the generator breaker has closed.
   - If the generator breaker has closed, the blackout close sequence has been completed successfully.
   - If the generator breaker has not closed the controller activates the *GB closing failure* alarm.

**NOTICE**

**Breaker close position**

For a generator breaker blackout close, the controller does not check the position of any other breakers in the system. It only checks that the busbar is dead. Black busbar negotiation will however ensure that two breakers do not close simultaneously.

## 9.6.4 Generator breaker open flowchart

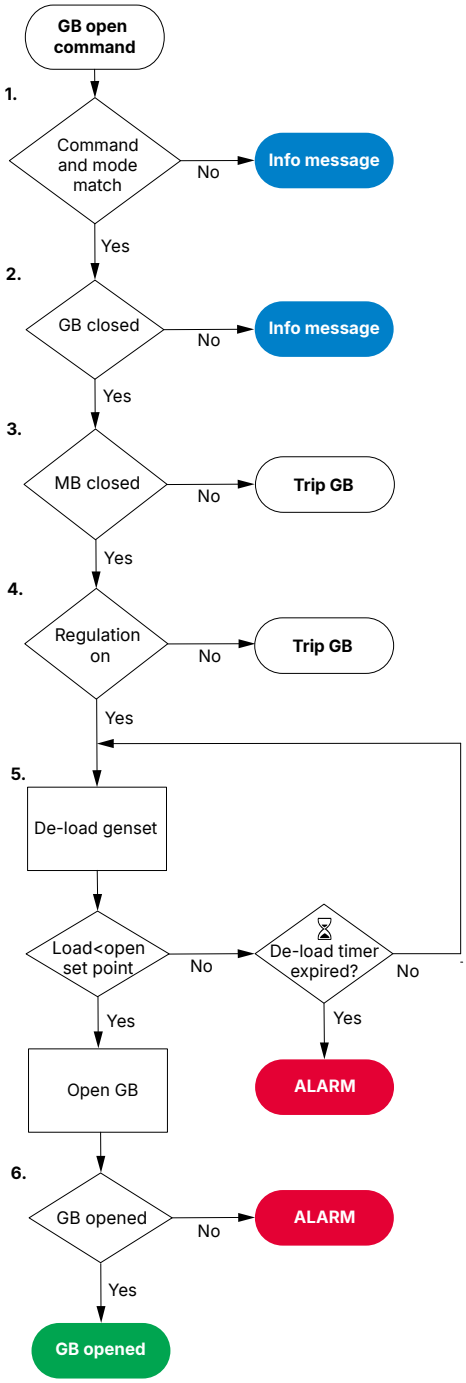
The following flowchart shows the sequence that the controller normally uses to open the generator breaker when the **SINGLE genset** controller controls both a generator breaker and a mains breaker.

**More information**
If the **SINGLE genset** controller does not control a mains breaker, see the Generator breaker open flowchart under **GENSET** controller.

The alarm action *Block* does not open a closed breaker, although it stops an open breaker from closing. If the controller or an operator sends a GB open command while *Block* is active, the controller uses this sequence.

The sequence to trip the generator breaker is described in another flowchart.

**Table 9.5** Generator breaker open flowchart for single genset with mains breaker




1. **Command and mode match**: The controller checks that the command source and the controller mode match:
   - In REMOTE mode, the command to open the genset breaker can come from a digital input, PICUS, Modbus, CustomLogic, and/or CODESYS.
   - In LOCAL mode, the operator can press the push-button **Open breaker** OPEN on the display unit. The controller ignores all other commands.
2. **GB closed**: The controller checks whether the generator breaker is closed. If the generator breaker is open, the sequence ends.
3. **MB closed**: The controller checks whether the mains breaker is closed.
   - If the mains breaker is open, the controller trips the generator breaker, without de-loading.
4. **Regulation on**: The controller checks whether regulation is on.
   - If regulation is off, the controller trips the breaker.
   - If regulation is on, the controller tries to de-load the breaker.
   - If regulation is manual, an operator can manually de-load the breaker.
5. **De-load genset**: The controller adjusts the regulation to de-load the genset:
   - When the load is less than the set point for the breaker to open, the controller activates the `Breakers > Generator breaker > Control > GB open` output.
   - If the controller cannot de-load the breaker before the de-load timer expires, the controller activates the *GB de-load failure* alarm. The controller continues to try to de-load the breaker.
6. **GB opened**: The controller checks whether the generator breaker has opened:
   - If the generator breaker has opened, the generator breaker open sequence has been completed successfully.
   - If the generator breaker has not opened, the controller activates the *GB opening failure* alarm.

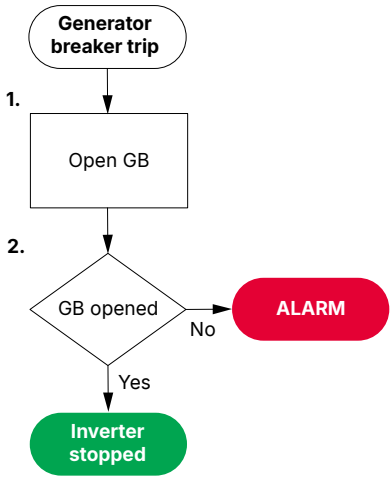
### 9.6.5 Generator breaker trip flowchart

The controller automatically trips the generator breaker (GB) for these alarm actions:

- Trip generator breaker
- Trip generator breaker and stop engine
- Trip generator breaker and shutdown engine

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

The controller does not require the genset stop conditions to be met for a breaker trip. Similarly, the breaker is not de-loaded for a trip.




1. **Open GB**: When a trip is required, the controller activates the `Breakers > Generator breaker > Controls > GB open` output to open the breaker.
2. **GB opened**: 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.

## 9.7 Mains breaker

### 9.7.1 How it works

The mains breaker (MB) connects the mains to the busbar. For the mains breaker to close, the mains must be live, and the busbar must be synchronised with the mains. The mains breaker is an important part of the system safety, and trips to protect the busbar from mains problems. The mains breaker also trips to stop busbar problems from disturbing the mains.

#### General breaker information

**More information**
See the **Breakers, synchronisation and de-loading** chapter for more information on synchronisation and breakers. This includes the inputs and output functions and the parameters to configure.

For the mains breaker of a **SINGLE genset** with mains breaker controller, the breaker abbreviation (*[*B]*) is *MB*. *[Breaker]* refers to *Mains breaker*.

The mains breaker open flowchart and the mains breaker blackout close flowchart for the **SINGLE genset** controller are given in this section.

#### Synchronisation

When the mains breaker close button is pressed, if the controller has an active regulation mode, it ignores the regulation mode and automatically regulates the genset to synchronise. When the mains breaker is closed, the controller returns to its previous regulation mode.

If the controller(s) regulation is off or under *Manual regulation*, the controller does not automatically regulate the genset to synchronise. The genset can be synchronised manually while the synchronisation timer is running if the controller is under *Manual regulation*.

Regardless of the regulation, if the synchronisation requirements are met (within the time available for synchronisation), the controller automatically closes the breaker.

**De-loading**

When the mains breaker open button is pressed, all of the following are required for de-loading:

- The genset must be connected.
- The genset must have an active regulation mode or be under *Manual regulation*.
- There must be a mains power measurement.

If de-loading is not possible, the controller trips the mains breaker (without de-loading).

If regulation is possible, the controller ignores its regulation mode and tries to de-load and open the breaker. The mains breaker must be de-loaded manually while the de-load timer is running if the controllers is under *Manual regulation*. When the mains breaker is open, the controller returns to its previous regulation mode.

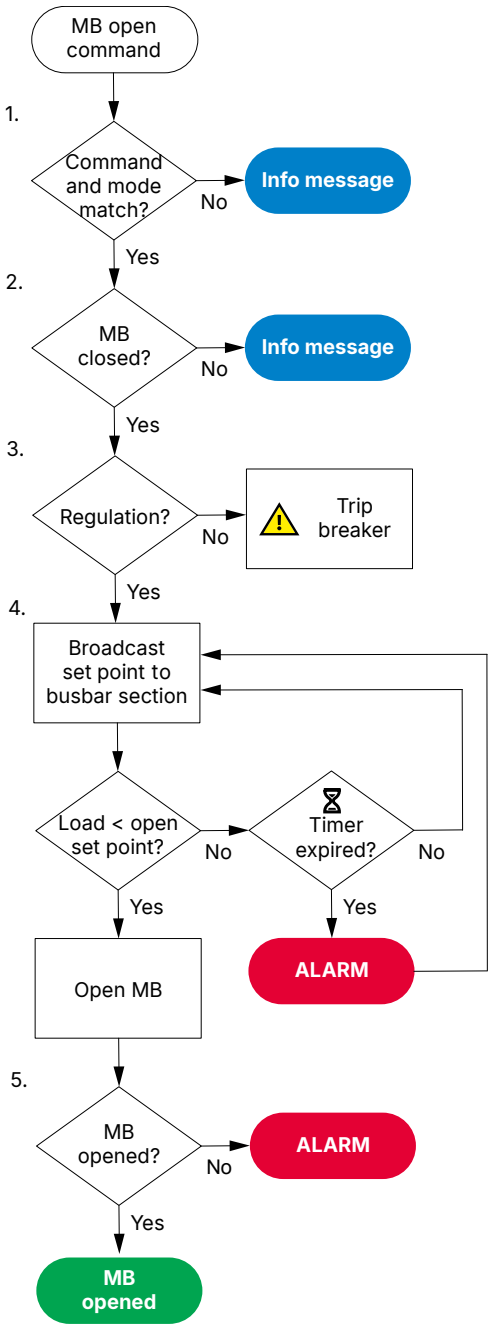
### 9.7.2 Mains breaker open flowchart

The following flowchart shows the sequence that the controller normally uses to open the mains breaker.

The alarm action *Block mains breaker* does not open a closed breaker, although it stops an open breaker from closing. If the controller or an operator sends an MB open command while *Block mains breaker* is active, the controller uses this sequence.

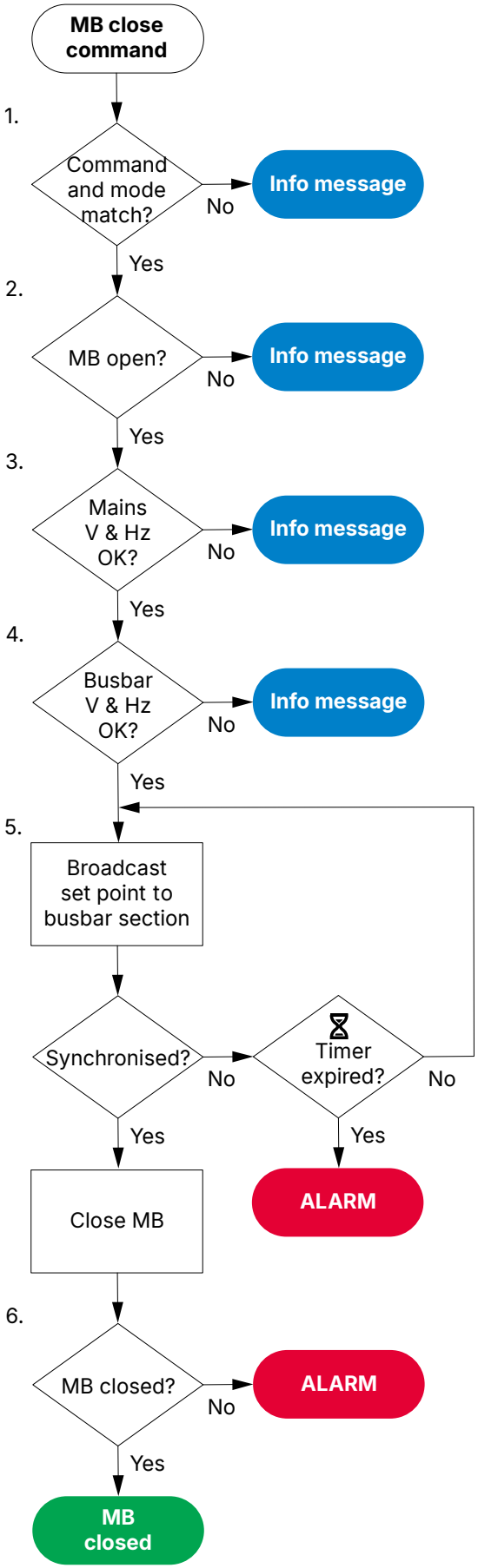
The sequence to trip the mains breaker is described in another flowchart.

**Table 9.6** Mains breaker (MB) open flowchart




1. **Command and mode match**: The controller checks that the command source and the controller mode match:
   - In REMOTE mode, the command to open the genset breaker can come from a digital input, PICUS, Modbus, CustomLogic, and/or CODESYS.
   - In LOCAL mode, the operator can press the push-button **Open breaker** OPEN on the display unit. The controller ignores all other commands.
2. **MB closed**: The controller checks whether the breaker is closed. If the breaker is open, the sequence ends.
3. **De-load possible**: The controller checks de-loading is possible.
   - If de-loading is not possible, the controller trips the breaker.
   - If de-loading is possible, the controller tries to de-load the breaker.
4. **Genset de-loads mains breaker**: The controller regulates the genset.
   - When the load is less than the set point for the breaker to open, the controller activates the *Breakers > Mains breaker > Control > MB open* output.
   - If the controller cannot de-load the breaker before the de-load timer expires, the controller activates the *MB de-load failure* alarm. The controller continues to try to de-load the breaker.
5. **MB opened**: The controller checks whether the breaker has opened:
   - If the breaker has opened, the mains breaker open sequence has been completed successfully.
   - If the breaker has not opened, the controller activates the *MB opening failure* alarm.

### 9.7.3 Mains breaker close flowchart




1. **Command and mode match**: The controller checks that the command source and the controller mode match:
   - In REMOTE mode, the command to close the breaker can come from a digital input, PICUS, Modbus, CustomLogic, and/or CODESYS.
   - In LOCAL mode, the operator can press the push-button **Close breaker** CLOSE on the display unit. The controller ignores all other commands.
2. **MB open**: The controller checks whether the breaker is open. If the breaker is already closed, the sequence stops, and an info message is shown.
3. **Mains V & Hz OK**: The controller checks whether the voltage and frequency are within the allowed range*. If these are not in the range, then the controller cancels the close command and displays an info message.
4. **Busbar V & Hz OK**: Subject to the *Blackout close* parameter:
   - The controller checks whether the voltage and frequency on the busbar are within range*. If these are not in the range, then the controller cancels the close command and displays an information message.
5. **Broadcast set point to busbar section**: The controller broadcasts the required set point on the busbar section.
   - If the mains and busbar are synchronised, the controller activates the `Breakers > Mains breaker > Controls > MB close` output to close the breaker.
   - If the mains and busbar do not synchronise within the time allowed, the controller activates an *MB synchronisation failure* alarm.
6. **MB closed**: The controller checks whether the breaker has closed.
   - If the breaker has closed, the breaker close sequence has been completed successfully.
   - If the breaker has not closed, the controller activates the *MB closing failure* alarm.

**NOTE** * See `[Source] / [Busbar] > AC setup > Voltage and frequency OK` for these ranges.

## 9.7.4 Busbar blackout MB close flowchart

The mains breaker (MB) can close if the mains is live and there is a blackout on the busbar (that is, the genset is not connected). This is hard coded, and there are no other blackout close options for the mains breaker of a **SINGLE genset** controller.

### Blackout conditions

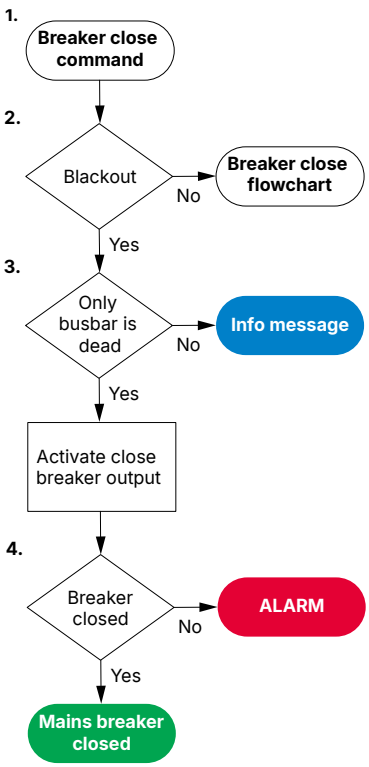
A blackout is present if the phase-to-phase voltage is less than 10 % of the nominal voltage ($V_{L-L}$ < 10 % of $V_{nom}$). This percentage is fixed.

### Conditions that prevent blackout close

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

- The breaker position is unknown.
- There is a short circuit.
  - A digital input with the function `Breakers > Generator breaker > Feedback > GB short circuit` was activated.
- There is a blocking alarm.
  - The alarm action determines whether the alarm is a blocking alarm.
- The mains and/or generator AC measurements are not OK.
  - A measurement failure is detected on one or more of the phases.

**Table 9.7** Blackout close flowchart




1. **Breaker close command**: An operator or a remote command attempts to close the mains breaker.
2. **Blackout**: The controller detects a blackout, and the conditions for blackout close are met.
3. **Only busbar is dead**: The controller checks whether the blackout is only on the busbar between the genset and the mains.
   - *Blackout only on the busbar*: The controller activates the close main breaker output.
4. **Breaker closed**: The controller checks whether the mains breaker has closed.
   - If the mains breaker has closed, the blackout close sequence has been completed successfully.
   - If the mains breaker has not closed the controller activates the *MB closing failure* alarm.

# 9.8 Other SINGLE genset controller functions

## 9.8.1 Engine communication

The controller supports J1939 communication with engines, as well as some proprietary protocols.

**More information**
See **Omni Engine interface communication** for the details for each engine type.

### Inputs and outputs

You can use controller inputs and outputs for the ECU.

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > ECU > Measurement list filter - available` | Digital input | Pulse | |
| `Engine > ECU > Measurement list filter - clear` | Digital input | Pulse | |
| `Engine > ECU > Log request (DM2)` | Digital input | Pulse | After this input is activated, the controller requests the DM2 log from the ECU. |
| `Engine > ECU > Log clear (DM2)` | Digital input | Pulse | After this input is activated, the controller requests the ECU to clear the DM2 log. |
| `Engine > ECU > ECU reset input` | Digital input | Pulse | After this input is activated, the controller requests the ECU to reset. |
| `Engine > Controls > ECU power` | Digital output | Continuous | You can use this output so that the ECU is only powered on when the engine needs to run. |
| `Engine > ECU > ...` | Analogue outputs | Various | Over 100 ECU outputs are available as analogue outputs. These can be connected to switchboard instruments for troubleshooting. |

### Parameters for controls

**`Engine > ECU > Controls > Speed control (TSC1 / Custom)`**

| Parameter | Range | Notes |
|---|---|---|
| `Source address` | 0 to 255 | EIC speed/Torque control source address. |

**`Engine > ECU > Controls > Cab message (CM1 / Custom)`**

| Parameter | Range | Notes |
|---|---|---|
| `Source address` | 0 to 255 | Selection of EIC J1939 CAB message 1 source address. The controller telegrams for DPF regeneration use this source address. |

**`Engine > ECU > Controls > CAN controls`**

| Parameter | Range | Notes |
|---|---|---|
| `Enable` | Not enabled, Enabled | **Enable**: Enable writing commands to the ECU. |

**`Engine > ECU > Controls > Droop`**

| Parameter | Range | Notes |
|---|---|---|
| `Droop settings` | None<br>Engine Control Unit (ECU)<br>Emulated droop | **None**: The controller does not use droop.<br>**Engine control unit (ECU)**: The controller sends the specified droop value to the ECU. |

| Parameter | Range | Notes |
|---|---|---|
| | | **Emulated droop**: The controller emulates the specified droop. |
| `Droop value` | 0.0 to 25.0 % | The specified droop. |

**`Engine > ECU > Controls > Reset`**

| Parameter | Range | Notes |
|---|---|---|
| `Power off timer` | 1 to 300 s | The controller uses this timer with the digital output `Engine > Controls > ECU power`. This can be wired to turn the ECU power off. |

### Parameters for diagnostic alarms

**`Engine > ECU > Diagnostic alarms > ECU Red stop lamp`**

**`Engine > ECU > Diagnostic alarms > ECU Amber warning lamp`**

**`Engine > ECU > Diagnostic alarms > ECU Protect lamp`**

**`Engine > ECU > Diagnostic alarms > ECU Malfunction indicator lamp`**

### Parameters for DPF controls

**`Engine > ECU > DPF controls > Controls`**

| Parameter | Range | Notes |
|---|---|---|
| `Aftertreatment Regeneration Inhibit Switch` | Not enabled, Enabled | **Enabled**: The regeneration is inhibited. |
| `Aftertreatment Regeneration Force Switch` | Automatic, Forced | **Automatic**: The ECU automatically regenerates the DPF filter as required.<br>**Forced**: Forces the regeneration of the DPF filter. |

### Parameters for specific manufacturers

**`Engine > ECU > Manufacture specific`**

| Parameter | Range | Notes |
|---|---|---|
| `Shutdown override > Enable` | Not enabled, Enabled | |
| `Parameters > Speed control` | Standard J1939, [Manufacturer specific] | If the manufacturer has a proprietary speed control, you can select it here. |

## 9.8.2 Temperature-dependent power derating

The temperature-dependent power derating function reduces the genset nominal load by reducing the genset nominal power used by fixed power. The derating function can be configured for up to three temperature measurements.

Temperature-dependent power derating does not affect protections.

### Analogue inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Power derate > Derate # temperature [C]` * | Analogue input | The measurement must be in °C. | This can measure any temperature, for example, the engine cooling water. |
| `Engine > Power derate > Temperature > Derate # temperature [C]` * | Analogue output | - | Optional. You can connect this output to a switchboard instrument to monitor the analogue input. |

**NOTE** * # is 1 to 3.

### Parameters

The analogue input(s) must be configured to see the power derate parameter and curve.

**`Engine > Power derate > Temperature > Derate # *`**

| Parameter | Range | Comment |
|---|---|---|
| `Enable derate` | Not enabled, Enabled | **Not enabled**: Fixed power uses the genset nominal power, no matter what the derate temperature is.<br><br>**Enabled**: The controller uses the power derating curve to derate the power within the configured range. See below. |
| `Setup` | | Use this section to set up the power derate curve. |

**NOTE** * # is 1 to 3.

## 9.8.3 Percentage-dependent power derating

The percentage-dependent power derating function reduces the genset nominal load by reducing the genset nominal power.

### Input and output

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Power derate > Percentage > Derate percentage [%]` | Analogue input | The measurement must be in %. | |
| `Engine > Power derate > Percentage > Derate percentage [%]` | Analogue output | - | Optional. You can connect this output to a switchboard instrument to monitor the analogue input. |

### Parameters

**`Engine > Power derate > Percentage`**

The analogue input must be configured to see the power derate parameter.

| Parameter | Range | Comment |
|---|---|---|
| `Enable derate` | Not enabled, Enabled | **Not enabled**: The controller uses the genset nominal power, no matter what the derate percentage is.<br><br>**Enabled**: The controller uses the analogue input to derate the nominal power. |

## 9.8.4 Priming

The priming function activates an output at regular intervals while the engine is not running. Priming is not active while the engine is starting or stopping. For example, priming can be used for an engine heater or lube oil pump. For the priming function, you must configure the following output and parameters.

### Digital output

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Controls > Priming` | Digital output | Continuous | Optional. Use this output to prime the engine at regular intervals. |

### Parameters

**`Engine > Maintenance > Priming`**

To see these parameters, you must assign the *Priming* function to a digital output.

| Parameter | Range | Comment |
|---|---|---|
| `Enable` | Not enabled, Enabled | **Not enabled**: The controller does not activate the *Priming* output.<br><br>**Enabled**: After the engine stops, the controller activates the *Priming* output for the period configured under *ON timer*. The controller then deactivates the output for the period configured under *OFF timer*. The on and off cycle repeats until the engine starts. |
| `ON timer` | 0.0 s to 1 h | The priming period. |
| `OFF timer` | 0.0 s to 1 h | The interval between each priming. |

## 9.8.5 Engine operating values as analogue inputs

In addition to analogue inputs described previously, you can use these analogue inputs to communicate engine operating values to the controller.

### Analogue inputs

| Function | I/O |
|---|---|
| `Engine > Measurements > Coolant > Engine coolant temperature [°C]` | Analogue input |
| `Engine > Measurements > Coolant > Engine coolant level [%]` | Analogue input |
| `Engine > Measurements > Lube oil > Engine oil temperature [°C]` | Analogue input |
| `Engine > Measurements > Lube oil > Engine oil pressure [bar]` | Analogue input |

## 9.8.6 Engine operating values as analogue outputs

You can configure an analogue output with a function for an engine operating value. The controller then adjusts the analogue output to reflect the engine operating value.

### Analogue outputs

| Function | I/O | Units | Details |
|---|---|---|---|
| `Engine > Measurements > Coolant > Engine coolant water [C]` | Analogue output | -50 to 200 °C | The controller outputs the engine coolant water temperature. |
| `Engine > Measurements > Coolant > Engine coolant level [%]` | Analogue output | 0 to 100 % | The controller outputs the engine coolant level. |
| `Engine > Measurements > Coolant > Analogue input > Engine coolant water [C]` | Analogue output | -50 to 200 °C | The controller outputs the engine coolant water temperature. For this function to work, there must be an analogue input to the controller with the engine coolant water temperature. |
| `Engine > Measurements > Coolant > Analogue input > Engine coolant level [%]` | Analogue output | 0 to 100 % | The controller outputs the engine coolant level. For this function to work, there must be an analogue input to the controller with the engine coolant level. |
| `Engine > Measurements > Lube oil > Engine oil pressure [bar]` | Analogue output | 0 to 10 bar | The controller outputs the engine oil pressure. |

| Function | I/O | Units | Details |
|---|---|---|---|
| Engine > Measurements > Lube oil > Engine oil temperature [C] | Analogue output | -50 to 200 °C | The controller outputs the engine oil temperature. |
| Engine > Measurements > Lube oil > Analogue input > Engine oil temperature [C] | Analogue output | -50 to 200 °C | The controller outputs the engine oil temperature. For this function to work, there must be an analogue input to the controller with the engine oil temperature. |
| Engine > Measurements > Lube oil > Analogue input > Engine oil pressure [bar] | Analogue output | 0 to 10 bar | The controller outputs the engine oil pressure. For this function to work, there must be an analogue input to the controller with the engine oil pressure. |
| Engine > Measurements > Speed > Engine speed [RPM] | Analogue output | 0 to 20,000 RPM | The controller outputs the engine speed. |
| Engine > Measurements > Speed > Analogue input > Engine MPU [RPM] | Analogue output | 0 to 20,000 RPM | The controller outputs the engine speed. For this function to work, there must be an active MPU/W/NPN/PNP input to the controller with the engine speed. |
| Engine > Power derate > Temperature > Derate [1 to 3] temperature [C] | Analogue output | -50 to 200 °C | The controller outputs the derate temperature. |
| Engine > Power derate > Percentage > Derate percentage [%] | Analogue output | 0 to 100 % | The controller outputs the derate percentage. |
| Engine > Service timers > Hours until total running hours notification [h] | Analogue output | | The controller outputs the hours until the total running hours timer runs out. |
| Engine > Service timers > Hours until trip running hours notification [h] | Analogue output | | The controller outputs the hours until the trip running hours timer runs out. |

### Applications

An analogue output with an engine operating value may be wired to a switchboard instrument, to help the operator with troubleshooting. For example, the engine speed measured by the MPU can be displayed.

## 9.8.7 Fuel pump

To keep the level in a tank in the required range, you can use the controller's inputs and outputs to control a pump.

**More information**
See **Fuel pump** in the **GENSET controller** chapter for details.

## 9.8.8 Engine states as digital outputs

You can configure a digital output with a function for an engine state. The controller activates the digital output if the engine state is present. These can be useful for troubleshooting.

### Digital outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| Engine > State > Running | Digital output | Continuous | Activated if there is running detection for the engine. |
| Engine > State > Not running | Digital output | Continuous | Activated if there is no running detection for the engine. |

| Function | I/O | Type | Details |
|---|---|---|---|
| Engine > State > Not ready to start | Digital output | Continuous | Activated if there is any condition that would block the controller from starting the engine. |
| Engine > State > Ready to start | Digital output | Continuous | Activated if there are no conditions that would block the controller from starting the engine. |
| Engine > State > Starting | Digital output | Continuous | Activated while the controller works through the pre-programmed start sequence. |
| Engine > State > Cooldown | Digital output | Continuous | Activated while the controller cooldown timer is running. |
| Engine > State > Stopping | Digital output | Continuous | Activated while the engine is stopping. |
| Engine > State > Extended stop | Digital output | Continuous | Activated while the engine extended stop is active. |

### 9.8.9 Digital AVR

The controller can work with a digital AVR.

**More information**
See **Digital AVR** in the **GENSET controller** chapter for details.

### 9.8.10 Close before excitation

You can configure the controller to start up the genset with the excitation switched off.

**More information**
See **Close before excitation** in the **GENSET controller** chapter for details.

### 9.8.11 Mains power measurement

If the controller knows the mains power, it attempts to de-load the mains breaker before opening it. The mains power can be calculated from the 4th current measurement, or the controller can use an analogue input function for mains power.

If the mains power is unknown, the controller trips the mains breaker when a command is given to open the mains breaker.

#### Analogue inputs

You can use an external transducer for the mains power measurement by assigning a function to an analogue input.

| Function | I/O | Units | Details |
|---|---|---|---|
| Mains > Analogue > P total [kW] | Analogue input | kW | The analogue input is the active power at the mains breaker. |
| Mains > Analogue > Q total [kvar] | Analogue input | kvar | The analogue input is the reactive power at the mains breaker. |
| Mains > Analogue > S total [kVA] | Analogue input | kVA | The analogue input is the apparent power at the mains breaker. |

The controller can handle both positive power values (that is, from the mains), and negative power values (that is, to the mains).

### Parameters

**`Mains > AC setup > Mains power measurement`**

| Parameter | Range | Notes |
|---|---|---|
| `Current source` | • None<br>• I4<br>• Analogue input | **None**: No measurement of mains power. The controller does not attempt to de-load the mains breaker.<br><br>**I4**: The controller uses the 4th current measurement to calculate the mains power.<br><br>**Analogue input**: The controller uses an analogue input to measure the mains power. |

## 9.8.12 Counters

You can view, edit and reset all the counters on the display unit under **Configure > Counters**. The counters include:

- Start attempts
- Total running hours and minutes
- Trip running hours and minutes
- Generator breaker operations and trips
- Mains breaker operations and trips
- Power export (active and reactive)

Running hours trip works like a car trip meter. For example, you can use this counter to track the running hours since the last maintenance.

### Energy counter outputs

For each energy counter, you can configure a digital output to send a pulse every time a certain amount of energy is transferred.

### Digital outputs

You must configure the digital output function to see the parameters.

| Function | I/O | Type | Details |
|---|---|---|---|
| `Generator > Production counters > Active energy export pulse` | Digital output | Pulse | |
| `Generator > Production counters > Reactive energy export pulse` | Digital output | Pulse | |

### Parameters

**`Generator > Production counters > Active energy export`**

| Parameter | Range | Comment |
|---|---|---|
| `Pulse every` | 1 kWh to 10 MWh | The value when a digital output sends a pulse. |
| `Pulse length` | 0.1 s to 1 h | The length of the pulse that is sent. This value should be long enough so the pulse can be registered by the external counter. |

**`Generator > Production counters > Reactive energy export`**

| Parameter | Range | Comment |
|---|---|---|
| `Pulse every` | 1 kvarh to 10 Mvarh | The value when a digital output sends a pulse. |
| `Pulse length` | 0.1 s to 1 h | The length of the pulse that is sent. This value should be long enough so the pulse can be registered by the external counter. |

**Table 9.8** Energy counter function and corresponding parameter full names

| [Counter pulse] | [Counter] |
|---|---|
| Active energy export pulse | Active energy export |
| Reactive energy export pulse | Reactive energy export |

**Application example for an energy counter output**

1. Connect the digital output to an external counter.
2. Configure the digital output using the display unit or PICUS to *Active energy export pulse*.
3. Configure the *Pulse every* parameter to the value where you would like to send a pulse. For example, 100 kWh.
4. Configure the *Pulse length* to the required length of the pulse for your external counter. For example, 1 second.

With the example setup the controller sends a 1 second pulse to the external counter for each 100 kWh the controller logs.

## 9.8.13 Mains supervision

You can set up parameters for mains supervision. If there is a mains error (voltage or frequency outside the configured limits), then the controller can activate an alarm to open the breaker (to protect the asset). The controller can also show the mains status using digital outputs.

### Parameters

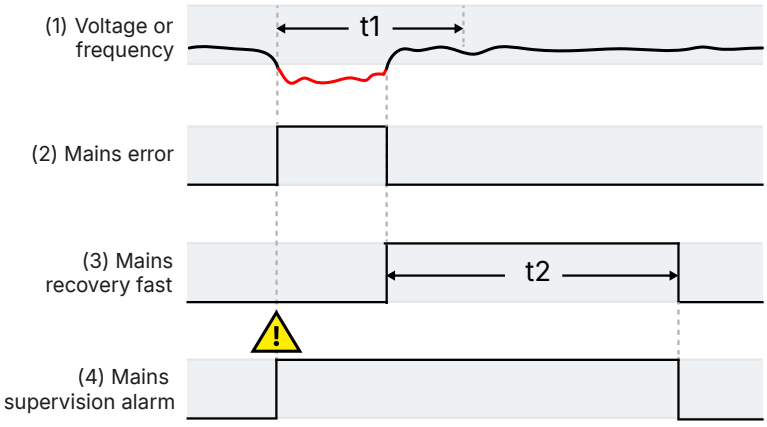
**`Mains > AC setup > Supervision selector`**

| Parameter | Range | Notes |
|---|---|---|
| `Enable supervision` | Not enabled, Enabled | **Not enabled**: No mains supervision.<br><br>**Enabled**: The controller can activate the mains supervision alarm. The mains supervision digital outputs show the mains supervision status. |
| `Recovery selector time` | 0.1 s to 1 h | If the mains error lasts for less than this time, then *Recovery time fast* is used. If the error lasts for longer than this time, then *Recovery time slow* is used. |
| `Recovery time fast` | 0.1 s to 1 h | This is used if the mains error stops within the *Recovery selector time*. The timer starts when the mains error stops. |
| `Recovery time slow` | 0.1 s to 1 h | This is used if the mains error does not stop within the *Recovery selector time*. The timer starts when the mains error stops. |
| `Voltage low` | 80.0 to 100.0 % of nominal voltage | There is a mains error if the mains voltage is below this level. |
| `Voltage high` | 100.0 to 120.0 % of nominal voltage | There is a mains error if the mains voltage is above this level. |
| `Frequency low` | 90.0 to 100.0 % of nominal frequency | There is a mains error if the mains frequency is below this level. |
| `Frequency high` | 100.0 to 110.0 % of nominal frequency | There is a mains error if the mains frequency is above this level. |

### How it works

These sequence diagrams are examples of how mains supervision works.

### Recovery time fast mains error

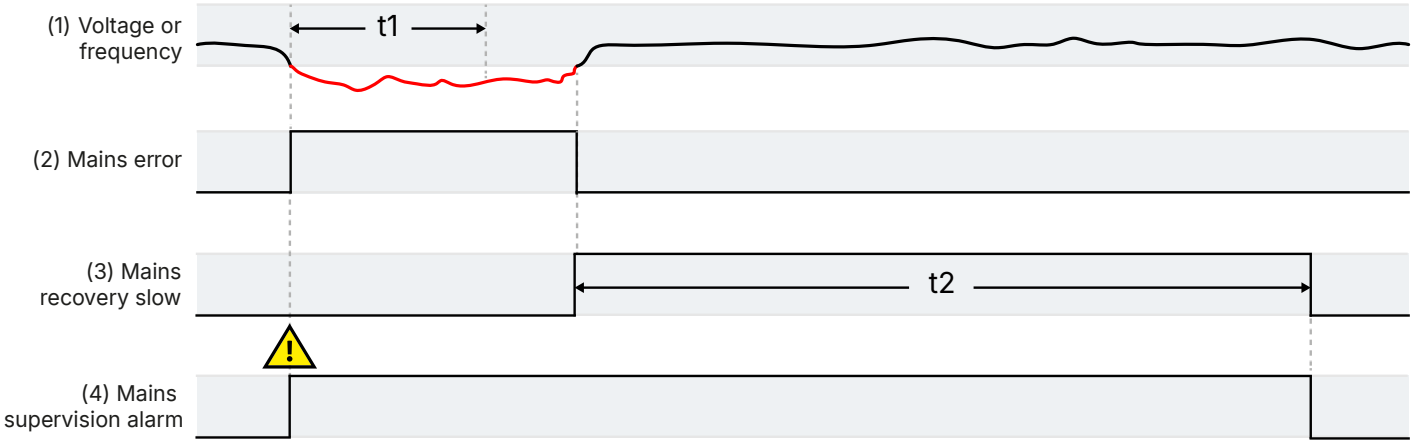



t1 = Recovery selector time (`Mains > AC setup > Supervision selector > Recovery selector time`)

t2 = Recovery time fast (`Mains > AC setup > Supervision selector > Recovery time fast`)

1. **Voltage or frequency**: The mains voltage or frequency is outside the configured limits for less than the *Recovery selector time*. The controller therefore uses the *Recovery time fast*.
2. **Mains error**: `Mains > Supervision > Mains error` (digital output) (optional). The controller activates this digital output while the mains voltage or frequency is outside the configured limits.
3. **Mains recovery fast**: `Mains > Supervision > Mains recovery fast` (digital output) (optional). The controller activates this digital output while the *Recovery time fast* timer is running.
4. **Mains supervision alarm**. The controller activates this alarm while there is a mains error, and while the recovery timer is running.

### Recovery time slow mains error




t1 = Recovery selector time (`Mains > AC setup > Supervision selector > Recovery selector time`)

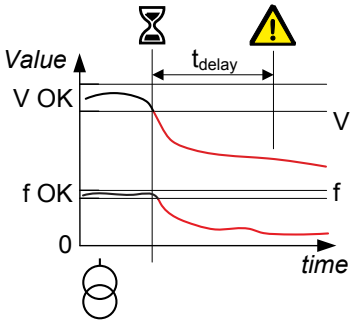
t2 = Recovery time slow (`Mains > AC setup > Supervision selector > Recovery time slow`)

1. **Voltage or frequency**: The mains voltage or frequency is outside the configured limits for more than the *Recovery selector time*. The controller therefore uses the *Recovery time slow*.
2. **Mains error**: `Mains > Supervision > Mains error` (digital output) (optional). The controller activates this digital output while the mains voltage or frequency is outside the configured limits.
3. **Mains recovery slow**: `Mains > Supervision > Mains recovery slow` (digital output) (optional). The controller activates this digital output while the *Recovery time slow* timer is running.
4. **Mains supervision alarm**. The controller activates this alarm while there is a mains error, and while the recovery timer is running.

### 9.8.14 Mains supervision alarm

The controller activates this alarm if the mains voltage or frequency is outside the range configured under `Mains > AC setup > Supervision selector`.

The alarm remains activated for the recovery time.




**`Mains > AC setup > Supervision alarm`**

### 9.8.15 Mains supervision status as digital outputs

You can configure digital outputs with functions for the mains supervision status. The controller activates the digital output when the mains supervision state is activated. These outputs can be useful for troubleshooting.

#### Digital outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Mains > Supervision > Mains error` | Digital output | Continuous | Activated when there is a mains error. |
| `Mains > Supervision > Mains recovery fast` | Digital output | Continuous | Activated during the fast recovery period. |
| `Mains > Supervision > Mains recovery slow` | Digital output | Continuous | Activated during the slow recovery period. |

## 9.9 Asynchronous generator

### 9.9.1 How it works

By default the **SINGLE genset** and **GENSET** controllers are configured for synchronous generators, but the controllers can also be configured for asynchronous generators. When you configure the controller as an asynchronous generator controller, AVR regulation is not available.

#### Parameters

**`Generator > AC setup > Generator type`**

| Parameter | Range | Notes |
|---|---|---|
| `Generator type` | Synchronous, Asynchronous | **Asynchronous**: A generator that is not energised while the breaker is open. The controller uses RPM synchronisation for this generator type.<br><br>**Synchronous**: The generator is excited while the breaker is open. The controller uses frequency synchronisation for this generator type. |

#### Generator speed

An asynchronous generator must have a generator speed measurement. That is, an MPU, W, NPN or PNP speed measurement is requirement. The speed measurement and number of teeth must be correct.

#### Generator nominal speed

The generator nominal speed is very important for an asynchronous generator (`Engine > Nominal settings > Nominal RPM`). The controller uses the generator nominal speed for the RPM synchronisation calculations.

**DANGER!**

**Generator nominal speed**

At zero load, the generator nominal speed must correspond to the nominal frequency.

## 9.9.2 Breaker setup

When you configure the controller as an asynchronous generator controller, the breaker synchronisation is based on RPM synchronisation.

### Parameters

**`Breakers > Generator breaker configuration > Synchronisation settings`**

| Name | Range | Notes |
|---|---|---|
| `Delta speed min.` | -10 % to 10 % of the nominal speed (adjusted for the busbar frequency) | The maximum that the speed of the genset may be below the frequency of the busbar for the breaker to close. |
| `Delta speed max.` | -10 % to 10 % of the nominal speed (adjusted for the busbar frequency) | The maximum that the speed of the genset may be above the frequency of the busbar for the breaker to close. |

**Asynchronous generator speed and frequency example**

An asynchronous generator has a nominal speed of 1500 RPM. The busbar nominal frequency is 50 Hz. The *Delta speed min.* is -2 %, and the *Delta speed max.* is 5 %. The actual busbar frequency is 52 Hz.

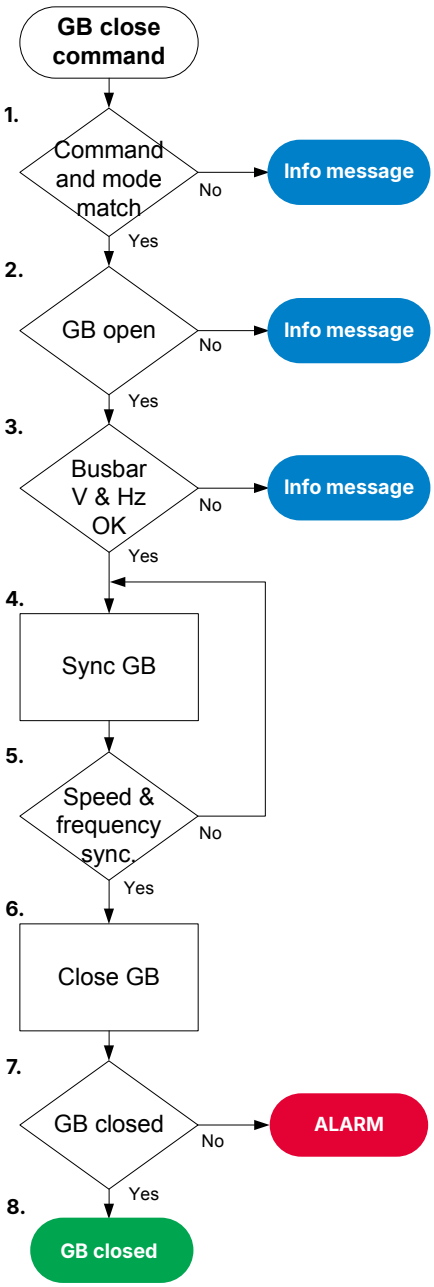
The generator speed that corresponds to the actual busbar frequency is 1500 RPM x 52 Hz / 50 Hz = 1560 RPM. The minimum generator speed for synchronisation is 1560 x (100 - 2) / 100 = 1529 RPM. The maximum generator speed for synchronisation is 1560 x (100 + 5) / 100 = 1638 RPM.

The breaker cannot close if the *Delta speed min.* is more than the *Delta speed max.*

## 9.9.3 Asynchronous generator breaker close flowchart

The flowchart below shows the sequence that the controller normally uses to close the generator breaker for an asynchronous genset.

**Table 9.9** Asynchronous generator breaker close flowchart




1. **Command and mode match**: The controller checks that the command source and the controller mode match:
   - In REMOTE mode, the command to close the breaker can come from a digital input, PICUS, Modbus, CustomLogic, and/or CODESYS.
   - In LOCAL mode, the operator can press the push-button **Close breaker** CLOSE on the display unit. The controller ignores all other commands.
2. **GB open**: The controller checks whether the generator breaker is open. If the generator breaker is already closed, the sequence stops, and an info message is shown.
3. **Busbar V & Hz OK**: The controller checks whether the voltage and frequency on the busbar are within range. If these are not within range, then the controller cancels the close command and displays an info message.
4. **Sync GB**: If the controller has an active regulation mode, it tries to synchronise the speed of the genset to match the frequency of the busbar.
5. **Speed & frequency sync.**: The controller checks whether the busbar frequency and generator speed are synchronised.
   - There is no timer or automatic cancellation - the controller keeps checking until there is synchronisation, or until the *GB close* command is cancelled.
6. **Close GB**: When the genset and the busbar are synchronised, the controller activates the *Breakers > Generator breaker > Control > GB close* output to close the breaker.
7. **GB closed**: The controller checks whether the generator breaker has closed.
   - If the generator breaker has not closed, the controller activates the *GB closing failure* alarm.
8. If the generator breaker is closed, then the asynchronous generator breaker close sequence has been completed successfully.

## 9.9.4 No synchronisation signal for asynchronous generator

The controller cannot match the generator speed to the busbar frequency if there is no signal from the RPM measurement. The controller activates this alarm if the engine is running (that is, there is running detection) and it does not get input from the RPM measurement within the delay time.

This alarm is only available on **SINGLE genset** and **GENSET** controllers, where the generator type is configured as an asynchronous generator.

**Parameters**

**`Breakers > Generator breaker monitoring > No synchronisation signal`**

| Parameter | Range |
|---|---|
| `Delay` | 0.1 s to 300 s |

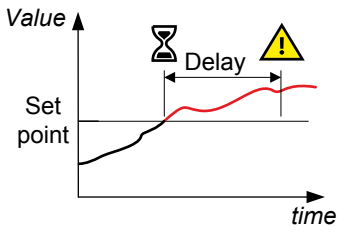
### 9.9.5 Asynchronous over-voltage

This protection is activated if the generator has a voltage above remnant level while the breaker is open. The voltage could be present because the generator is not an asynchronous generator.

For an asynchronous generator, there is no voltage in the generator when the generator breaker is open.

The alarm set point is a percentage of the nominal voltage of the generator.

This alarm is only available on **SINGLE genset** and **GENSET** controllers, where the generator type is *Asynchronous*.




**Parameters**

**`Generator > Voltage protections > Asynchronous over-voltage`**

| Parameter | Range |
|---|---|
| `Set point` | 1 % to 80 % of nominal voltage |
| `Delay` | 0.0 s to 1 min |

## 9.10 SINGLE genset controller protections

### 9.10.1 Protections

**NOTE** These protections are in addition to the AC protections and general protections for iE 250 controllers.

**Protections for the SINGLE genset controller**

| | Protections | Alarms |
|---|---|---|
| **Engine** | Emergency stop | 1 |
| | Overspeed (2 alarms) | 2 |
| | Under-speed (2 alarms) | 2 |
| | Power ramp up error | 1 |
| | Power ramp down error | 1 |
| | Crank failure | 1 |
| | Primary running feedback failure | 1 |
| | Start failure | 1 |
| | Stop failure | 1 |
| | Engine stopped (external) | 1 |
| | Engine started (external) | 1 |
| | Start enable removed during start | 1 |
| | Total running hours notification | 1 |
| | Trip running hours notification | 1 |
| **Generator** | Voltage or frequency not OK | 1 |
| **Mains** | Mains supervision alarm | 1 |
| **Regulation** | GOV regulation mode not selected | 1 |
| | GOV relay setup incomplete | 1 |
| | P load sharing failure | 1 |
| | AVR regulation mode not selected | 1 |
| | AVR relay setup incomplete | 1 |
| | Q load sharing failure | 1 |
| **Asynchronous generator** (optional) | Asynchronous generator over-voltage | 1 |
| | No synchronisation signal for asynchronous generator | 1 |

## 9.10.2 Alarm actions

The controller has the following alarm actions:

- Warning
- Block generator breaker
- Block mains breaker*
- Trip generator breaker
- Trip mains breaker*
- Trip generator and mains breakers*
- Trip generator breaker and stop engine
- Trip generator breaker and shutdown engine

**NOTE** * Not available in a SINGLE genset controller with no mains breaker.

## 9.10.3 Inhibits

The controller includes the following inhibits:

**Controller inhibits**

| Inhibit | Disables the alarm when ... |
|---|---|
| Engine running | *Running detection* is ON. |
| Engine not running | *Running detection* is OFF. |
| Engine stopping | The engine is in the stop sequence. |
| Idle run active | The engine is idling. |
| Generator breaker closed | Based on the breaker feedbacks and validation, the generator breaker is closed.* |
| Generator breaker open | Based on the breaker feedbacks and validation, the generator breaker is open.* |
| Mains breaker closed** | Based on the breaker feedbacks and validation, the mains breaker is closed.* |
| Mains breaker open** | Based on the breaker feedbacks and validation, the mains breaker is open.* |
| Generator voltage present | The generator voltage is above 10 % of the nominal voltage. |
| No generator voltage | The generator voltage is below 10 % of the nominal voltage. |
| Generator frequency present | The generator frequency is above 10 % of the nominal frequency. |
| No generator frequency | The generator frequency is below 10 % of the nominal frequency. |
| Mains in parallel | The busbar section is connected to the mains. |
| Mains not in parallel | The busbar section is not connected to a mains. |
| Inhibit 1 | A digital input, PICUS, Modbus, CustomLogic, or CODESYS activated *Inhibits > Activate inhibit 1*. |
| Inhibit 2 | A digital input, PICUS, Modbus, CustomLogic, or CODESYS activated *Inhibits > Activate inhibit 2*. |
| Inhibit 3 | A digital input, PICUS, Modbus, CustomLogic, or CODESYS activated *Inhibits > Activate inhibit 3*. |

**NOTE** * There is no inhibit if there is breaker feedback failure.
**NOTE** ** Not available in the *SINGLE genset - No mains breaker* controller.

In addition to these inhibits, the *SINGLE genset - No mains breaker* has an *ACM wire break* inhibit.

## 9.10.4 Breaker alarms

**More information**
The **Breakers, synchronisation and de-loading** chapter describes breaker handling and alarms in general.

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

**Generator breaker alarm names for the SINGLE genset controller**

| SINGLE genset alarm | Configure > Parameters > | General name |
|---|---|---|
| GB synchronisation failure | Breakers > Generator breaker monitoring > Synchronisation failure | Breaker synchronisation failure |
| GB de-load failure | Breakers > Generator breaker monitoring > De-load failure | Breaker de-load failure |
| Vector mismatch | Breakers > Generator breaker monitoring > Vector mismatch | Vector mismatch |
| GB opening failure | Breakers > Generator breaker monitoring > Opening failure | Breaker opening failure |

| SINGLE genset alarm | Configure > Parameters > | General name |
|---|---|---|
| GB closing failure | Breakers > Generator breaker monitoring > Closing failure | Breaker closing failure |
| GB position failure | Breakers > Generator breaker monitoring > Position failure | Breaker position failure |
| GB trip (external) | Breakers > Generator breaker monitoring > Tripped (external) | Breaker trip (external) |
| GB short circuit | Breakers > Generator breaker monitoring > Short circuit | Breaker short circuit |
| GB configuration failure | - | Breaker configuration failure |
| Phase sequence error genset | Generator > AC setup > Phase sequence error | Phase sequence error |

**Mains breaker alarm names for the SINGLE genset controller**

| SINGLE genset alarm | Configure > Parameters > | General name |
|---|---|---|
| MB synchronisation failure* | Breakers > Mains breaker monitoring > Synchronisation failure | Breaker synchronisation failure |
| MB de-load failure* | Breakers > Mains breaker monitoring > De-load failure | Breaker de-load failure |
| Vector mismatch* | Breakers > Mains breaker monitoring > Vector mismatch | Vector mismatch |
| MB opening failure* | Breakers > Mains breaker monitoring > Opening failure | Breaker opening failure |
| MB closing failure* | Breakers > Mains breaker monitoring > Closing failure | Breaker closing failure |
| MB position failure* | Breakers > Mains breaker monitoring > Position failure | Breaker position failure |
| MB trip (external)* | Breakers > Mains breaker monitoring > Tripped (external) | Breaker trip (external) |
| MB short circuit* | Breakers > Mains breaker monitoring > Short circuit | Breaker short circuit |
| MB configuration failure* | - | Breaker configuration failure |
| Phase sequence error mains | Mains > AC setup > Phase sequence error | Phase sequence error |

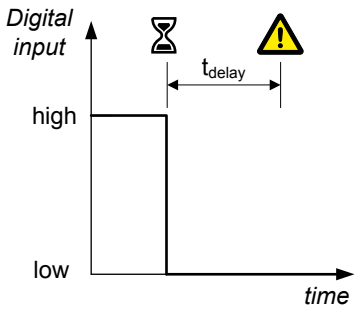
**NOTE** * Not available in the SINGLE genset controller with no mains breaker.

## 9.10.5 AC alarms

**More information**
See the **Data sheet** for the AC alarms for this controller type. See the **AC configuration** chapter for descriptions of the AC protections.

## 9.10.6 Emergency stop

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



| Function | I/O | Type | Details |
|---|---|---|---|
| Alarm system > Additional functions > 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, then the controller activates the emergency stop function and the *Emergency stop* alarm. |

**CAUTION**

**The Emergency stop is part of the safety chain**

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. 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.

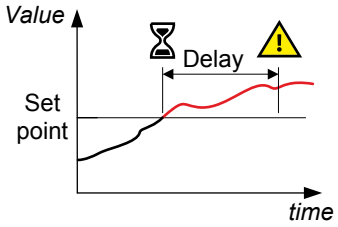
**Engine > Emergency stop > Emergency stop**

| Parameter | Range |
|---|---|
| Delay | 0.0 s to 1 min |

## 9.10.7 Overspeed

These two alarms are for overspeed protection.

The alarm response is based on the genset speed, as measured by the MPU/W/NPN/PNP input.




**Engine > Protections > Speed > Overspeed # ***

In addition to these overspeed alarms, one of the controller's digital inputs can be connected to hardware that detects overspeed. A customised alarm for overspeed can then be configured on that digital input.

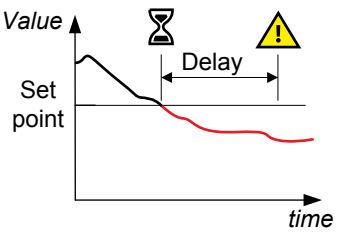
| Parameter | Range |
|---|---|
| Set point | 10.0 to 150.0 % of nominal speed |
| Delay | 0.0 s to 3 min |

**NOTE** * # is 1 or 2.

## 9.10.8 Underspeed

This alarm alerts the operator that a genset is running too slowly.

The alarm response is based on the engine speed as a percentage of the nominal speed. If the engine speed drops below the set point for the delay time, then the alarm is activated.



**Engine > Protections > Speed > Under-speed # ***

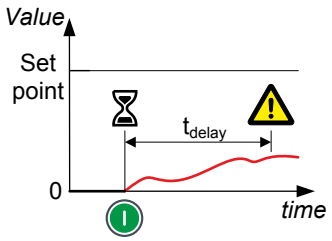
| Parameter | Range |
|---|---|
| Set point (lower than) | 0.0 to 100.0 % of nominal speed |
| Delay | 0.0 s to 3 min |

**NOTE** * # is 1 or 2.

## 9.10.9 Crank failure

The alarm response is based on the MPU/W/NPN/PNP input. This alarm is only available if the magnetic pickup (MPU) has been chosen as the primary running feedback.

The timer starts when cranking starts (that is, when the *Crank* output is activated). The alarm is activated if the set point has not been reached within the delay time.




**Engine > Start sequence > Crank failure**

| Parameter | Range |
|---|---|
| Set point (lower than) | 1.0 to 400.0 RPM |
| Delay | 0.0 to 20.0 s |

## 9.10.10 Oil pressure

This alarm is activated if the oil pressure exceeds the set point.

**Engine > Protections > Pressure > Oil pressure # ***

| Parameter | Range |
|---|---|
| Set point | 0.0 to 10.0 bar |
| Delay | 0.0 s to 3 min |

**NOTE** * # is 1 or 2.

## 9.10.11 Oil temperature

This alarm is activated if the oil temperature exceeds the set point.

**Engine > Protections > Temperature > Oil temperature # ***

| Parameter | Range |
|---|---|
| Set point | 0.0 to 200.0 °C |
| Delay | 0.0 s to 3 min |

**NOTE** * # is 1 or 2.

## 9.10.12 Coolant temperature

This alarm is activated if the coolant temperature exceeds the set point.

**Engine > Protections > Temperature > Coolant temperature # ***

| Parameter | Range |
|---|---|
| Set point | 0.0 to 200.0 °C |
| Delay | 0.0 s to 3 min |

**NOTE** * # is 1 to 3.

## 9.10.13 Coolant level

This alarm is activated if the coolant level is under the set point.

**Engine > Protections > Level > Coolant level # ***

| Parameter | Range |
|---|---|
| Set point | 0.0 to 100.0 % |
| Delay | 0.0 s to 3 min |

**NOTE** * # is 1 to 3.

## 9.10.14 Running detection not reached

This alarm is activated if the running detection level is not reached.

**Engine > Start sequence > Running detection not reached**

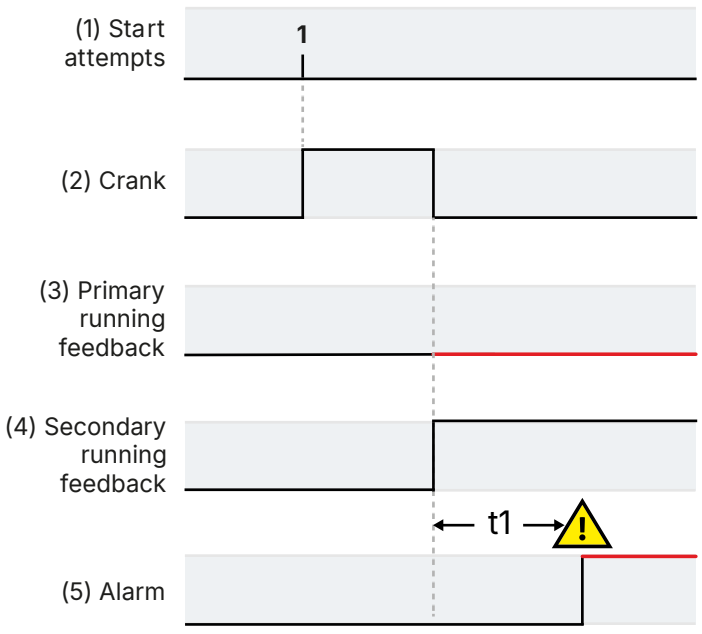
| Parameter | Range |
|---|---|
| Run detection not reached | 1 s to 20 min |

## 9.10.15 Primary running feedback failure

This alarm is for genset running feedback failure. This alarm is only available if more than one running feedback is present. The alarm is activated if running is detected on any of the secondary running feedbacks but not on the primary running feedback.

The sequence diagram on the right shows how the primary running feedback failure alarm works.

1. **Start attempt**: The controller gets a start signal.
2. **Crank**: The controller activates the *Crank* output.
3. **Primary running feedback**: If the primary running feedback has failed, it does not detect the genset start.
4. **Secondary running feedback**: The secondary running feedback detects the genset start. The crank stops after running is detected. The alarm timer starts when running is detected on the secondary running feedback, but not on the primary running feedback.
5. **Alarm**: If the primary running feedback does not detect that the genset has started within the delay time (t1), the *Primary running feedback failure* alarm is activated.




**Engine > Running detection > Primary running feedback failure**

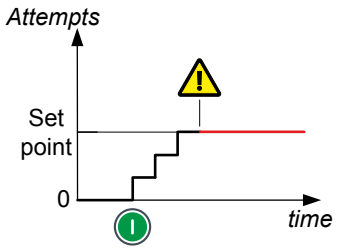
This alarm is always *Enabled*.

| Parameter | Range |
|---|---|
| Delay | 0.0 s to 3 min |

## 9.10.16 Start failure

This alarm is for genset start failure.

If the genset has not started after the maximum number of start attempts are completed, the controller activates this alarm.




**Engine > Start sequence > Start failure**

## 9.10.17 Start enable removed during start

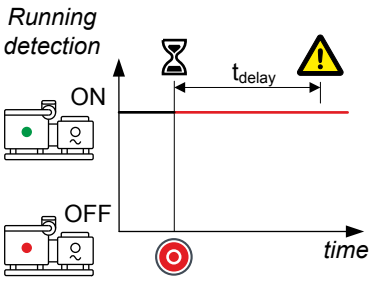
The alarm response is based on the engine start-up sequence. This alarm is activated if the engine start-up procedure is interrupted by the loss of the *Start enable* input before the engine has started.

**Engine > Start sequence > Start enable remove during start**

## 9.10.18 Stop failure

This alarm is for genset stop failure.

The controller attempts to stop the genset by activating the *Stop coil* output (if present) or alternatively, by deactivating the *Run coil* output (if present). If *Running detection* is still ON after the delay time, the controller activates this alarm.



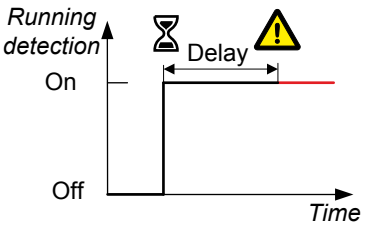

**Engine > Stop sequence > Stop failure**

| Parameter | Range |
|---|---|
| Delay | 10.0 s to 2 min |

## 9.10.19 Engine started (external)

This alarm is to alert the operator to an externally-initiated engine start.

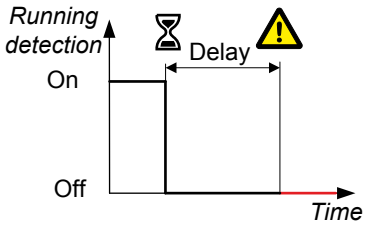
The alarm is activated if the controller did not initiate an engine start, but *Running detection* shows that the engine is running.



## 9.10.20 Engine stopped (external)

This alarm alerts the operator to an externally-initiated engine stop.

The alarm is activated if the controller did not initiate an engine stop, but *Running detection* shows that the engine has stopped.



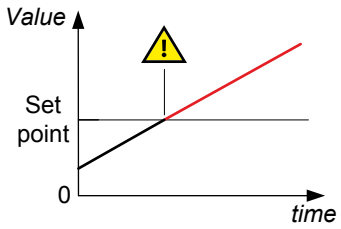

**Engine > Stop sequence > Externally stopped**

| Parameter | Range |
|---|---|
| Delay | 1 to 1200 s |

## 9.10.21 Running hours notification

This alarm notifies the operator when the total running hours exceeds the set point.

The alarm response is based on the *Total running hours* counter.




**Engine > Maintenance > Service timer > Service timer # ***

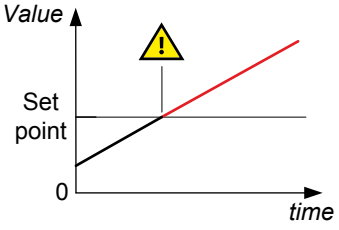
| Parameter | Range |
|---|---|
| Set point | 0 to 9000 h |

**NOTE** * # is 1 to 4.

## 9.10.22 Trip running hours notification

This alarm notifies the operator when the trip running hours exceeds the set point.

The alarm response is based on the *Trip running hours* counter.




**Engine > Maintenance > Running hours trip**

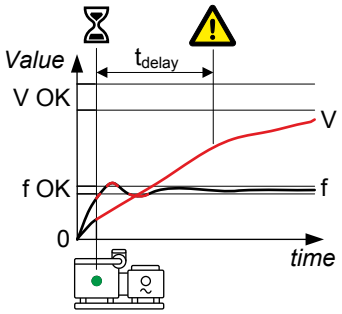
| Parameter | Range |
|---|---|
| Set point | 0 to 1,000,000 hours |

## 9.10.23 Voltage or frequency not OK

This alarm alerts the operator that the voltage or frequency is not in the required operation range within a specified time after running detection is active.

A delay timer starts when running detection activates. If the voltage and frequency are not in the required operation ranges when the delay timer expires the alarm activates.

The alarm response is based on the voltage and frequency from the A-side.




**[A-side] > AC setup > Voltage or frequency not OK**

The alarm action is always *Block*.

| Parameter | Range |
|---|---|
| Delay | 1 s to 1 h |

## 9.10.24 Magnetic pickup wire break

This alarm is activated if there is a magnetic pickup wire break.

**Engine > Running detection > Magnetic pickup wire break**

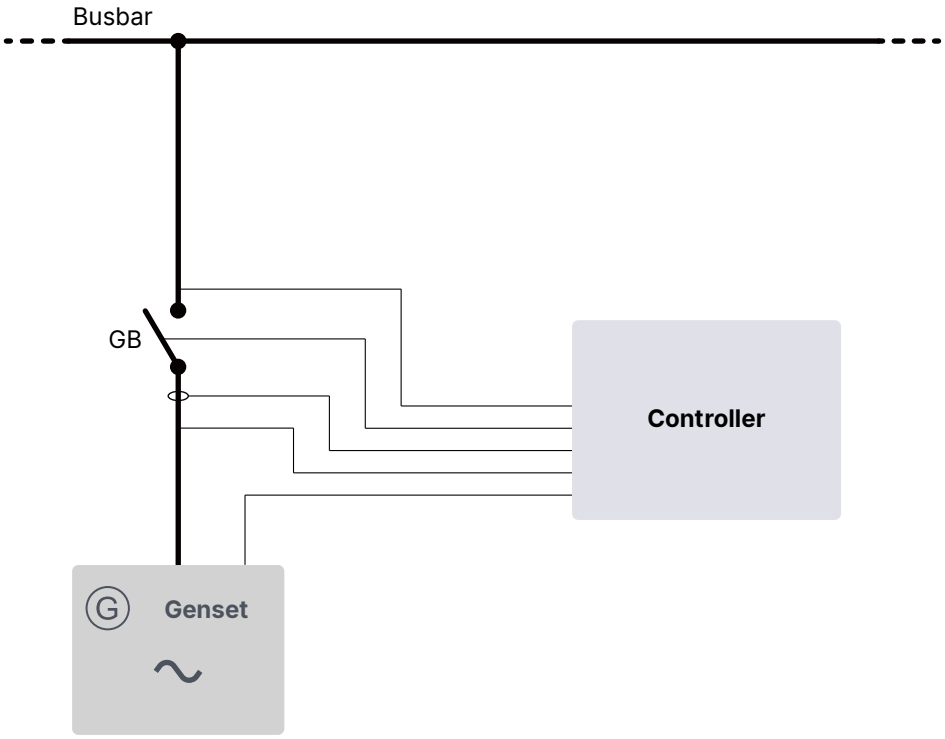
| Parameter | Range |
|---|---|
| Delay | 1 s to 1 h |

# 10. GENSET controller

## 10.1 About the GENSET controller

A **GENSET** controller controls and protects a prime mover (for example, a diesel engine) and generator, as well as the generator breaker. A system can include a number of **GENSET** controllers.

**Example application**




### 10.1.1 Functions

| | Functions |
|---|---|
| **Pre-programmed sequences** | • Genset start and stop sequences<br>• Breaker sequences<br>• Generator breaker blackout close |
| **Regulation** | • PID regulators for analogue outputs<br>• P regulators for relay outputs<br>• Set point selection using digital input, Modbus, CustomLogic, or CODESYS<br>• Governor<br>  ◦ Active power load sharing<br>  ◦ Fixed frequency<br>  ◦ Fixed active power<br>  ◦ Frequency droop<br>  ◦ Fixed RPM<br>  ◦ External set point: Frequency offset, or Power set point<br>  ◦ Manual<br>  ◦ Off<br>• AVR<br>  ◦ Reactive power load sharing<br>  ◦ Fixed voltage |

| | Functions |
|---|---|
| | ◦ Fixed reactive power<br>◦ Fixed cos phi<br>◦ Voltage droop<br>◦ External set point: Frequency offset, or Power set point<br>◦ Manual<br>◦ Off<br>• Configurable power ramp up/down<br>• Three sets of temperature-dependent power derate settings |
| **4th current** | • Measurement for earth or neutral protections |
| **Control modes** | • Local mode<br>◦ Generator start/stop with the start/stop push-buttons<br>◦ The breaker is controlled by the close/open push-buttons<br>• Remote mode<br>◦ Generator and breaker controlled from a PLC (or integrated CODESYS) combined with parameter settings |
| **Other functions** | • Asynchronous generator (optional)<br>• Priming sequence |

# 10.2 GENSET controller principles

## 10.2.1 Genset applications

The GENSET controllers described in this chapter work together in the application. Each GENSET controller only controls a genset and a generator breaker.

For an application with only one genset, you can use a SINGLE genset controller. The SINGLE genset controller can also control a mains connection.

**More information**
See the **SINGLE genset controller** chapter.

## 10.2.2 GENSET controller 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.

**`Engine > Nominal settings > Nominal settings # *`**

| Parameter | Range | Comment |
|---|---|---|
| `Nominal RPM` | 100 to 50000 RPM | When an MPU/W/NPN/PNP is used to measure the engine speed, then the nominal engine speed is used for the overspeed and underspeed alarms. |

**NOTE** * # is 1 to 4.

### Generator nominal settings

**`Generator > Nominal settings > Nominal settings # *`**

| Nominal setting | Range | Notes |
|---|---|---|
| `Voltage (V)` | 10.0 V AC to 1.5 MV AC | The phase-to-phase ** nominal AC voltage for the genset. |
| `Current (I)` | 1.0 A to 9 kA | The maximum current flow in one phase (that is, L1, L2 or L3) from the genset during normal operation. |
| `Frequency (f)` | 20.00 to 100.00 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)` | | The nominal active power may be on the genset nameplate. |
| `Apparent power (S)` | 1.0 kVA to 1 GVA | The nominal apparent power should be on the genset or generator nameplate. |
| `Power factor (PF)` | 0.6000 to 1.0000 | The power factor should be on the genset or generator nameplate. |

**NOTE** * # is 1 to 4.
**NOTE** ** In a single-phase set up the nominal AC voltage is phase-to-neutral.

**`Generator > Nominal settings > Nominal settings # > Calculation method *`**

| Calculation method | Options |
|---|---|
| `Reactive power (Q) nominal` | Q nominal calculated<br>Q nominal = P nominal<br>Q nominal = S nominal |
| `P or S nominal` | No calculation<br>P nominal calculated<br>S nominal calculated |

**NOTE** * # is 1 to 4.

**More information**
See Nominal power calculations for how these are used.

### Busbar nominal settings

**`Busbar > Nominal settings > Nominal settings # > Voltage (V) *`**

| Nominal setting | Range | Notes |
|---|---|---|
| `Nominal value source` | Use generator nominal voltage<br>User defined | **Use generator nominal voltage:**<br>• The phase-to-phase nominal voltage for the busbar is the same as the generator nominal voltage.<br>**User defined:**<br>• You can configure the phase-to-phase nominal voltage for the busbar. |
| `Voltage (V)` ** | 10.0 V AC to 1.5 MV AC | 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. |

**NOTE** * # is 1 to 4.
**NOTE** ** The `Nominal value source` must be configured as `User defined` and written to the controller, for the nominal voltage setting to be visible.

## 10.2.3 Run coil or stop coil

The engine start and stop functions are suitable for genset start systems with either a run coil or a stop coil. A set of controller digital output terminals must be connected to and configured for either the run coil output, or the stop coil output.

### Run coil and stop coil outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Controls > Run coil` | Digital output | Continuous | If all power to the controller is lost, then the genset stops.<br><br>Required if there is no *Stop coil*. |
| `Engine > Controls > Stop coil` | Digital output | Continuous | If all power to the controller is lost, then the genset keeps running.<br><br>Required if there is no *Run coil*. |

## 10.2.4 Running detection

The controller can be configured to receive engine running feedback from a variety of measurements. There can be more than one running feedback measurement.

*Running detection* is a state calculated by the controller, and used by a number of functions. It is either OFF or ON. If any running feedback measurements show that the engine is running, then *Running detection* is ON.

### Inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Feedback > Digital running detection` | Digital input | Continuous | Optional. External equipment activates the digital input when the engine is running. |

The controller can also use the following inputs for running feedback.

| Function | I/O | Type | Details |
|---|---|---|---|
| Frequency | Generator voltage measurements | Continuous | Always present. The controller uses the generator voltage measurements to calculate the frequency. The controller then compares the frequency with the detection set point.<br><br>Note: The controller cannot measure the frequency at very low voltages. See the **Data sheet** for the measurement range. The voltage must also be at least 10 % of nominal for the controller to use the frequency for running detection. For safety, DEIF recommends that you install at least one other running detection input. |
| MPU | HSDI | Continuous | Optional. The MPU input is connected to an MPU mounted on the engine. |
| W | HSDI | Continuous | Optional. The W input is connected to the battery recharging generator and measures the engine speed. Alternatively, the W input can be connected to an NPN/PNP sensor. |
| `Engine > Measurements > Lube oil > Engine oil pressure [bar]` | Analogue input | Pressure in bar | Optional. This set of analogue input terminals are connected to a transducer for the engine oil pressure. |

### Parameters

**`Engine > Running detection > MPU setup`**

| Parameter | Range | Comment |
|---|---|---|
| `Number of MPU teeth` | 1 to 10000 | The controller uses the number of teeth to calculate the engine speed from the MPU/W/NPN/PNP measurement signal. |

**Engine > Running detection > Feedback type**

| Parameter | Range | Comment |
|---|---|---|
| Primary running feedback | The available running feedbacks (depends on hardware) | Select one of the inputs as the primary running feedback.<br><br>If the *Primary running feedback* does not detect running, but any other running feedback detects running, then the controller activates the *Primary running feedback failure* alarm. |

**Engine > Running detection > RPM running detection**

| Parameter | Range | Comment |
|---|---|---|
| RPM | 0.0 to 50000.0 RPM | Running detection is ON when the engine speed measured by the MPU/W/NPN/PNP input is above this set point. |
| Use engine speed | Not enabled, Enabled | **Not enabled:** The MPU/W/NPN/PNP measurement is ignored and not used for running detection.<br>**Enabled:** The MPU/W/NPN/PNP measurement is used as a running detection input. |

**Engine > Running detection > Frequency running detection**

| Parameter | Range | Comment |
|---|---|---|
| Frequency | 10.0 to 100.0 Hz | Running detection is ON when the frequency measured by the generator voltage measurements is above this set point.<br><br>For example: For a 60 Hz system, you can use a detection set point of 45 Hz. |

**Engine > Running detection > Oil pressure running detection**

| Parameter | Range | Comment |
|---|---|---|
| Oil pressure * | 0.0 to 10.0 bar | Running detection is ON when the engine oil pressure is above this set point. |
| Use oil pressure * | Not enabled, Enabled | **Not enabled:** The engine oil pressure is ignored and not used for running detection.<br>**Enabled:** The engine oil pressure is used as a running detection input. |

**NOTE** * This parameter is only visible if the analogue input is configured.

### Frequency running detection hysteresis

For stable operation, running detection has a fixed 2 Hz hysteresis.

**Frequency running detection hysteresis examples**

**Example 1**: The detection set point for frequency is 32 Hz. When the frequency rises above 32 Hz, running detection changes to ON. However, the frequency has to drop below 30 Hz for running detection to change to OFF.

**Example 2**: The detection set point for frequency is 45 Hz. When the frequency rises above 45 Hz, running detection changes to ON. However, the frequency has to drop below 43 Hz for running detection to change to OFF.

### MPU/W input running detection hysteresis

For stable operation, running detection has a fixed 5 % hysteresis on the genset RPM.

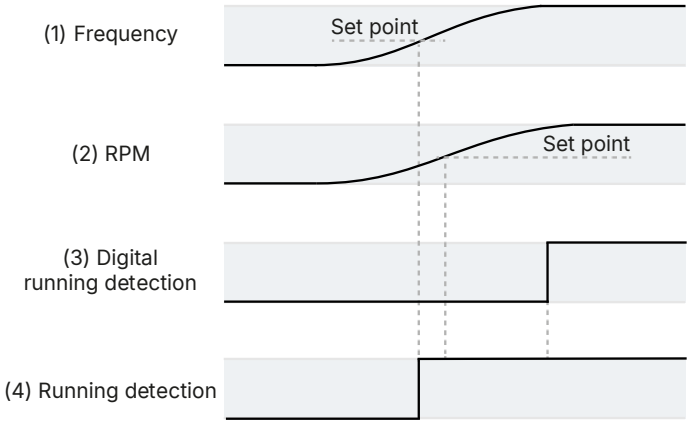
### Oil pressure running detection hysteresis

For stable operation, running detection has a fixed 5 % hysteresis on the oil pressure.

### Example: Running detection ON

The following sequence diagram is an example of how *Running detection* changes during an engine start. *Running detection* changes from OFF to ON when **one** running feedback detects that the engine is running.

### Running detection ON sequence diagram

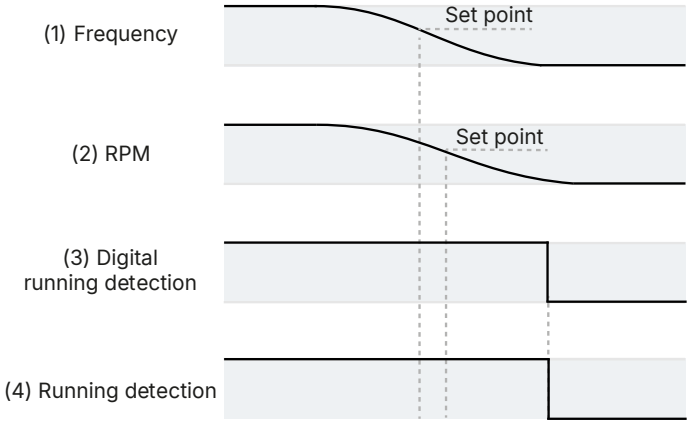



1. **Frequency**: The engine starts and the frequency rises above the set point.
2. **RPM**: (MPU/W/NPN/PNP input). The engine starts and the RPM rises above the set point.
3. **Digital running detection**: *Engine > Feedback > Digital running detection* (digital input). In the example, the response of this input is slower than the other running detection inputs.
4. **Running detection**: Running detection changes from OFF to ON when any running feedback (in this case, the frequency) rises above the *Detection set point*.

### Example: Running detection OFF

The following sequence diagram is an example of how *Running detection* changes during an engine stop. *Running detection* changes from ON to OFF when **none** of the running feedbacks detect that the engine is running.

### Running detection OFF sequence diagram




1. **Frequency**: The engine slows down and the frequency drops to 2 Hz below the set point.
2. **RPM**: (MPU/W/NPN/PNP input). The engine slows down and the RPM drops to 5 % below the set point.
3. **Digital running detection**: *Engine > Feedback > Digital running detection* (digital input). In the example, the response of this input is slower than the other running detection inputs.
4. **Running detection**: Running detection changes from ON to OFF when none of the running feedbacks detect that the engine is running.

### Risks when using only frequency for running detection

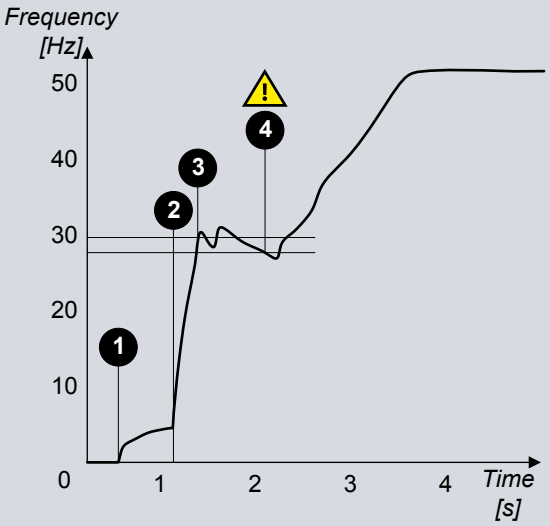
It is possible to only use frequency for running detection. However, using only frequency for running detection increases the risk of not detecting that the genset is running.

The software only uses the frequency measurements when the voltage is at least 10 % of the nominal voltage. This could cause trouble, since the voltage does not necessarily increase linearly with speed (this depends on the AVR).

If the frequency curve for the genset start up has a dip around the detection set point, the controller can interpret the dip as no running detection, and stop the genset. Increasing or decreasing the set point away from the dip would solve this problem.

**Frequency running detection example**

A genset start up frequency curve is given below.




1. Crank begins.
2. Fuel in.
3. If the running detection set point is 30 Hz, running detection is ON.
4. If the running detection set point is 30 Hz, the frequency drops 2 Hz below the set point, and running detection from frequency is OFF.
   - If there are no other running detection inputs, the controller immediately deactivates the run coil and/or activates the stop coil.

## 10.2.5 Regulation

The GENSET controller can regulate both a governor (GOV) and an AVR.

**More information**
See Regulation for how regulation works.

## 10.2.6 Load sharing

When gensets operate in parallel, they supply power to the same busbar. The controllers communicate over the DEIF network to ensure load sharing.

## 10.2.7 Ready for operation

The genset associated with a **GENSET** controller is ready for operation when the following conditions are met:

- There are no alarms blocking the start.
- If configured, the *Start enable* digital input is activated.
- The controller is not in switchboard control.

### 10.2.8 AC configuration

How the general AC configuration description applies to the **GENSET** controller:

| GENSET | General name |
|---|---|
| Generator | [A-side] |
| Busbar | [B-side] |

**More information**
The AC configuration and nominal settings for general information about AC configuration.

### 10.2.9 Breaker configuration

For the **GENSET** controller, replace [Breaker] with "Generator breaker" in the descriptions.

**More information**
See Breakers, synchronisation and de-loading for how to configure breakers.

## 10.3 Engine start

### 10.3.1 Engine start function

The controller software includes a pre-programmed engine start sequence. For the engine's start function, you must configure these inputs and outputs, and parameters.

If a parameter needs an input or output to be configured, then that parameter is not visible until an input or output is configured with the relevant function.

**More information**
See [Controller] protections for the engine start protections, and how to configure them.

#### Controller modes

Under remote and local control, the controller uses these inputs and outputs, and parameters to start the genset.

When the operator starts the genset under switchboard control, the controller is not involved. These sequences do not apply to starting a genset under switchboard control.

#### Inputs and outputs

#### Required engine start output

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Controls > Crank` | Digital output | Continuous | Connect this output to the engine crank. |

#### Optional engine start inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Command > Start enable` | Digital input | Continuous | Optional. If this input is configured, it must be activated for the engine start sequence to start. |
| `Engine > Controls > Start prepare` | Digital output | Continuous | Optional. The *Start prepare* digital output may, for example, be wired to start a pump, so that the engine oil pressure can build up before cranking. Note that *Start prepare* does not have any provision for feedback. The *Start prepare* function is only a timer, and does not check whether, for example, the pump start was successful. |

| Function | I/O | Type | Details |
|---|---|---|---|
| | | | The *Start prepare* digital output is not needed if the third party engine controller ensures that all start prepare conditions are okay before activating the *Start enable* digital input. |
| `Engine > Controls > Idle run` | Digital output | Continuous | Optional. Connect this output to the engine idle run if supported. Not all engines support this feature. |
| `Engine > Idle run > End idle start` | Digital input | Pulse | Optional. The operator or another system can activate this input to request the controller to end the engine start idle run. |
| `Engine > Function > Remove start (release crank relay)` | Digital input | Pulse | Optional. The engine controller activates this input. In response, the GENSET controller deactivates the *Crank* output, although the *Crank on* timer continues to run.<br><br>This input is useful when only frequency is used for *Running detection*, but the genset frequency increases slowly, and the crank must be removed before there is *Running detection*. Even when this input is activated, the start sequence tries to detect that the engine is running for the whole of the *Crank on* time. |

### Optional engine start commands

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Command > Start engine` | Digital input | Pulse | Optional. When the controller is under remote control, the operator or another system can activate this input to request the controller to start the engine. |
| `Engine > Command > Block engine start` | Digital input | Continuous | Optional. The operator or another system can activate this input so that the controller cannot start the engine. The input blocks the start in both remote and local control. |
| `Engine > Command > Start engine and close generator breaker` | Digital input | Pulse | Optional. When the controller is under remote control, the operator or another system can activate this input to request the controller to start the engine and then synchronise and close the breaker. |

### Required parameters

**`Engine > Start sequence > Crank`**

| Parameter | Range | Comment |
|---|---|---|
| `Crank on` | 1.0 s to 3 min | For the *Crank on* part of the start sequence, the controller activates the *Crank* output for this period. |
| `Crank off` | 1.0 to 99.0 s | If there is no running detection during *Crank on*, then the controller deactivates the *Crank* output for this period. |
| `Disengage crank` | 1 to 2000 RPM | The controller deactivates the *Crank* output when the engine speed reaches this set point, although the *Crank on* timer continues to run. This parameter only has an effect if an engine speed measurement (for example, an MPU/W/NPN/PNP) is configured.<br><br>Even when *Disengage crank* is used, the start sequence tries to detect that the engine is running for the whole of the *Crank on* time. |

**`Engine > Start sequence > Start attempts`**

This parameter limits the wear on the genset from too many start attempts.

| Parameter | Range | Comment |
|---|---|---|
| `Normal` | 1 to 100 | This is the maximum number of start attempts if the digital input `Alarm system > Additional functions > Suppress alarm action` is not active.<br><br>If the genset does not start after these attempts, the *Start failure* alarm is activated. |
| `Suppress alarm action` | 1 to 10 | This is the maximum number of start attempts if the digital input `Alarm system > Additional functions > Suppress alarm action` is active.<br><br>If the genset does not start after these attempts, the *Start failure* alarm is activated. |

**`Engine > Running detection > Engine ready`**

| Parameter | Range | Comment |
|---|---|---|
| `Delay` | 1.0 s to 5 min | After *Running detection* is ON, the engine must run for this period before the breaker close sequence can start. |

### Parameters (optional)

**`Engine > Start sequence > Start prepare`**

You must configure the `Engine > Controls > Start prepare` digital output to see these parameters.

| Parameter | Range | Comment |
|---|---|---|
| `Start prepare` | 0.0 s to 10 min | Optional. If the start conditions are OK, the controller activates the *Start prepare* output for this time. When the *Start prepare* timer expires, the controller activates the *Crank* output. See **Start prepare** in the **Engine start sequence**. |
| `Extended start prepare` | 0.0 s to 10 min | Optional. The controller keeps the *Start prepare output* activated for this time during cranking. |

**`Engine > Start sequence > Run coil`**

You must configure the `Engine > Controls > Run coil` digital output to see these parameters.

| Parameter | Range | Comment |
|---|---|---|
| `Run coil before crank` | 0.0 s to 10 min | Optional. The controller activates the *Run coil* output for this time before the *Crank* output is activated. |
| `During start attempts` | Pulse, Continuous | **Pulse**: If the start attempt fails, the controller deactivates the *Crank* output and the *Run coil*.<br><br>**Continuous**: If the start attempt fails, the controller deactivates the *Crank* output. However, the *Run coil* remains activated until the maximum number of start attempts is reached. |

**`Engine > Start sequence > Stop coil`**

You must configure the `Engine > Controls > Stop coil` digital output to see these parameters.

| Parameter | Range | Comment |
|---|---|---|
| `During crank off` | Activated, Not activated | **Activated**: The stop coil is activated during the start sequence if there is no running detection and the crank is off.<br><br>**Not activated**: The stop coil is not activated during the start sequence if there is no running detection and the crank is off. |

### Idle run start (optional)

You must configure the `Engine > Controls > Idle run` digital output to see these parameters.

You can configure an idle run start period for the engine. This allows the engine to warm-up before running at nominal speed.

If this is configured, the controller will activate the digital output `Engine > Controls > Idle run` before starting the engine. The controller then waits for one of the engine conditions (coolant temperature, oil temperature, external input condition, or the maximum timer) to be fulfilled before increasing to nominal speed.

During the idle run start period, the operator can override the period and press **Start** on the display, the controller then cancels the idle run start period and increases to nominal speed.

Additionally, during the idle run start period, the operator can press **Stop** to abort the engine start sequence and run the engine stop sequence.

### Optional idle run start parameters

**`Engine > Idle run start > Idle run`**

| Parameter | Range | Comment |
|---|---|---|
| `Enable` | Not enabled, Enabled | Enables the engine to idle run until a condition is true before changing to nominal speed. |
| `Extended inhibit` | 0 s to 60 min | This extends the inhibit period after the idle run is complete, so that while the engine is changing to nominal speed, certain alarms are not activated. |

**`Engine > Idle run start > Minimum`**

| Parameter | Range | Comment |
|---|---|---|
| `Use` | Not enabled, Enabled | Uses minimum set point to determine if the engine is ready to increase to nominal speed. |
| `Delay` | 0 s to 999 min | This is the minimum time the idle run start is active. * |

**NOTE** * The minimum period can be overridden by pressing **Start** to cancel the idle run start period and increases to nominal speed.

**`Engine > Idle run start > Coolant temperature`**

| Parameter | Range | Comment |
|---|---|---|
| `Use` | Not enabled, Enabled | Uses coolant temperature set point to determine if the engine is ready to increase to nominal speed. |
| `Set point` | - 50 to 200 °C | The temperature the engine coolant must reach before ending the idle run start. |

**`Engine > Idle run start > Oil temperature`**

| Parameter | Range | Comment |
|---|---|---|
| `Use` | Not enabled, Enabled | Uses oil temperature set point to determine if the engine is ready to increase to nominal speed. |
| `Set point` | - 50 to 200 °C | The temperature the engine oil must reach before ending the idle run start. |

**Engine > Idle run start > External condition**

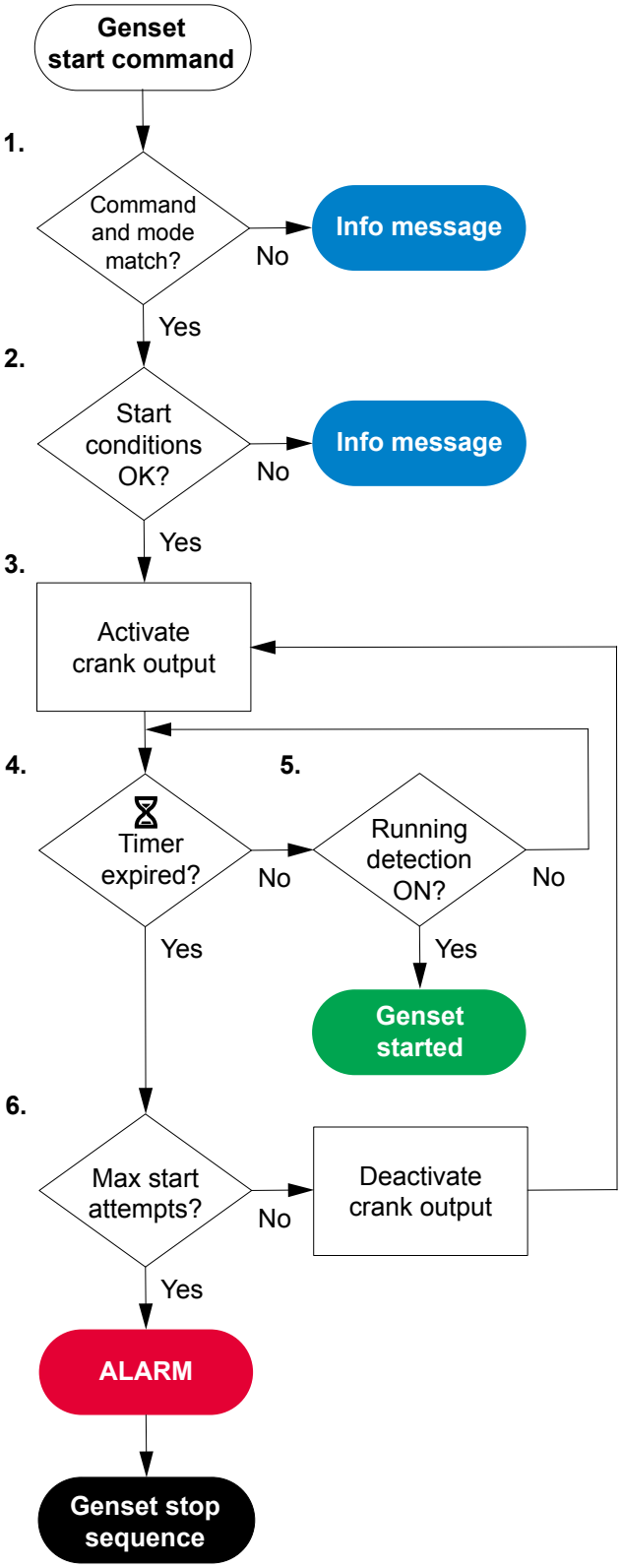
| Parameter | Range | Comment |
|---|---|---|
| Use | Not enabled, Enabled | Uses the external condition to determine if the engine is ready to increase to nominal speed.<br><br>The external condition is configured with the digital input Engine > Idle run > End idle run start , or with CustomLogic or CODESYS. |

**Engine > Idle run start > Maximum**

| Parameter | Range | Comment |
|---|---|---|
| Use | Not enabled, Enabled | Uses maximum set point to determine if the engine is ready to increase to nominal speed. |
| Delay | 1 s to 120 min | This is the maximum time the idle run start can operate. |

## 10.3.2 Engine start flowchart

Both *Start prepare* and *Idle run start* functions are not included on this diagram.



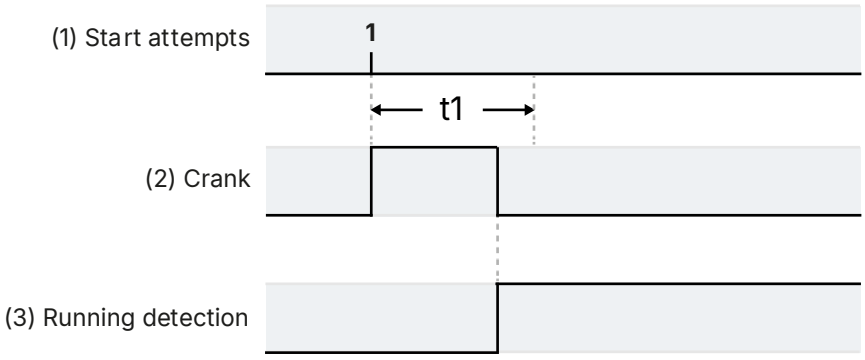

1. **Command and mode match:** The controller checks that the command source and the controller mode match.
2. **Start conditions OK:** The controller checks whether the start conditions are OK:
   - If configured, the *Start enable* digital input is activated.
   - There are no active or unacknowledged alarms to prevent the genset start. These alarm actions prevent a genset start:
     - *Block GB*
     - *Trip generator breaker and stop engine*
     - *Trip generator breaker and AVR and stop engine*
     - *Trip generator breaker and shutdown engine*
     - *Trip generator breaker and AVR and shutdown engine*
3. **Crank output activated:** If all the start conditions are OK, the controller activates the *Crank* output and a timer.
4. **Crank on timer expired:** If *Running detection* is OFF after the *Crank on* timer runs out, the controller checks the number of start attempts:
   - If the maximum number of start attempts has not been reached, the controller attempts to start the genset again.
   - If the maximum number of start attempts has been reached, the controller activates the *Start failure* alarm and stops the engine.
   - **Running detection ON:** While the start timer runs, the controller checks whether *Running detection* is ON.
     - When the controller detects that the genset is running, the genset start is complete.
5. **Maximum start attempts:** The controller checks the number of start attempts:
   - If the maximum number of start attempts has not been reached, the controller attempts to start the genset again.
   - If the maximum number of start attempts has been reached, the controller activates the *Start failure* alarm and stops the engine.

## 10.3.3 Engine start sequence

### Engine start sequence for a stop coil system

In this example, the `Engine > Start sequence > Stop coil > During crank off` parameter is *Activated*. The engine speed (RPM measurement) and/or the *Remove start (release crank relay)* digital input do not disengage the crank before there is *Running detection*.

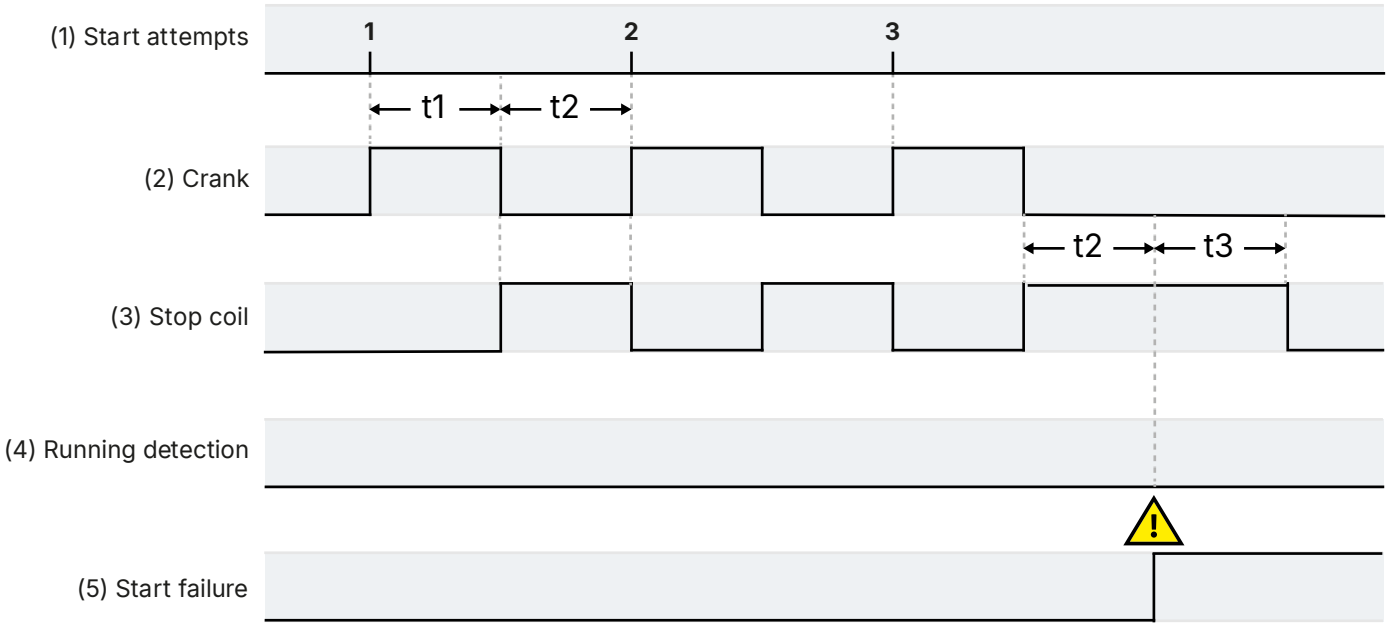
### Successful engine start sequence for a stop coil system




t1 = Crank on (`Parameters > Engine > Start sequence > Crank > Crank on`)

1. **Start attempts**: The engine starts during the first start attempt.
2. **Crank**: `Engine > Controls > Crank` (digital output). The controller activates the *Crank* output. If *Running detection* changes from OFF to ON, cranking stops.
3. **Running detection**. The engine is regarded as started when *Running detection* is ON.

### Failure of engine start sequence for a stop coil system




| | |
|---|---|
| t1 | Crank on (`Parameters > Engine > Start sequence > Crank > Crank on`) |
| t2 | Crank off (`Parameters > Engine > Start sequence > Crank > Crank off`) |
| t3 | Extended stop (`Parameters > Engine > Stop sequence > Extended stop`) (optional) |

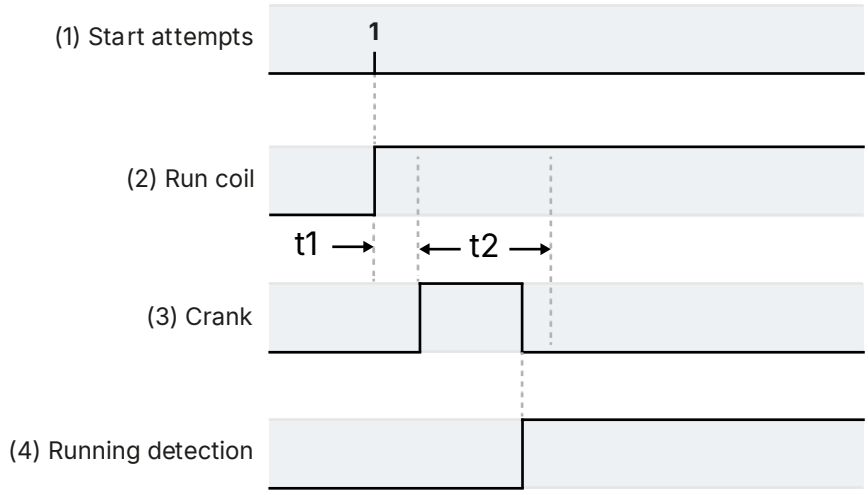
Failure of engine start sequence for a stop coil system:

1. **Start attempts**: `Parameters > Engine > Start sequence > Start attempts > Normal` = 3.
2. **Crank**: `Engine > Crank` (digital output). The controller activates the *Crank* output for the *Crank on* time, and deactivates it for *Crank off* time.
3. **Stop coil**: *Engine > Stop coil* (digital output). If *Running detection* is OFF after the *Crank on* time, then the controller activates the *Stop coil* for the time in the *Crank off* parameter. If all start attempts fail, the controller also activates the *Stop coil* for the time in *Extended stop > Stop coil activated*. This ensures that the engine is stopped if the engine start was not detected. The engine cannot be started during the *Extended stop > Stop coil activated* time.
4. **Running detection**. There is no running detection.
5. **Start failure**. The controller activates the *Start failure* alarm after the last unsuccessful start attempt.

### Engine start sequence for a run coil system

In this example, the `Engine > Start sequence > Run coil > During start attempts` parameter is set to *Follow crank*. The engine speed (RPM measurement) and/or the *Remove start (release crank relay)* digital input do not disengage the crank before there is *Running detection*.

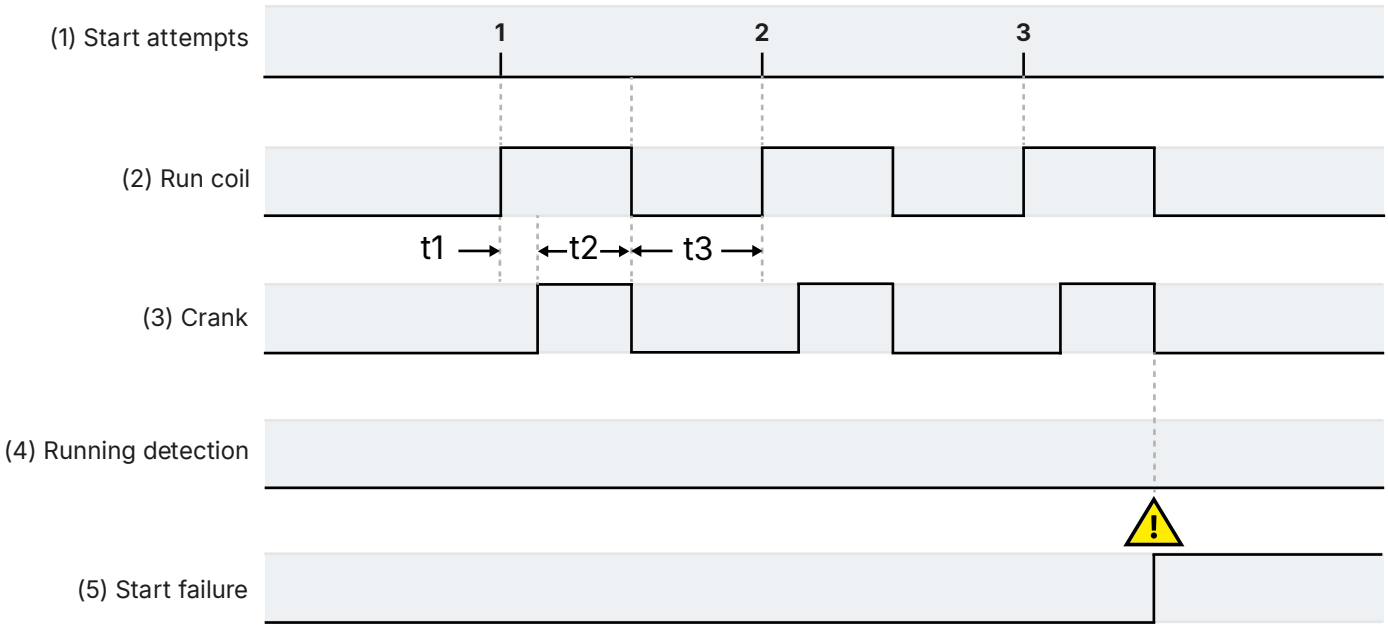
### Successful engine start sequence for a run coil system




t1 = Run coil before crank (optional)
t2 = Crank on (`Parameters > Engine > Start sequence > Crank > Crank on`)

1. **Start attempts**: The engine starts during the first start attempt.
2. **Run coil**: `Engine > Run coil` (digital output). The controller activates the *Run coil* at the time in the *Run coil before crank* parameter. If *Running detection* is ON, the engine is regarded as started, and the *Run coil* remains activated.
3. **Crank**: `Engine > Crank` (digital output). The controller activates the *Crank* output. If *Running detection* changes from OFF to ON, cranking stops.
4. **Running detection**. The engine is regarded as started when *Running detection* is ON.

### Failure of engine start sequence for a run coil system




t1 Run coil before crank (optional)

t2 Crank on (`Parameters > Engine > Start sequence > Crank > Crank on`)

t3 Crank off (`Parameters > Engine > Start sequence > Crank > Crank off`)

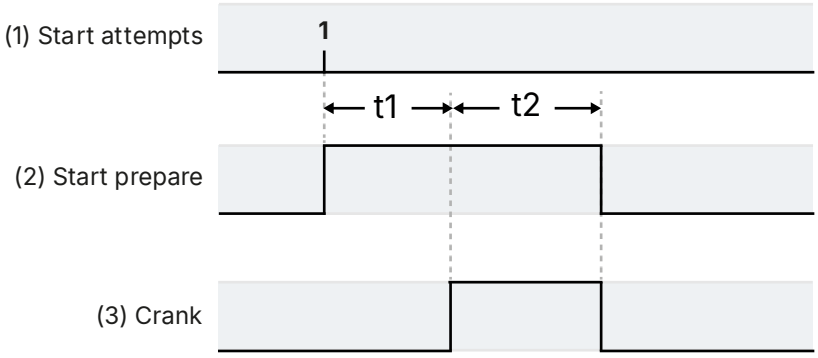
1. **Start attempts**: `Parameters > Engine > Start sequence > Start attempts > Normal` = 3.
2. **Run coil**: `Engine > Controls > Run coil` (digital output). The controller activates the *Run coil* at the time in the *Run coil before crank* parameter. If *Running detection* is still OFF after cranking, the controller deactivates the *Run coil* for the time in the *Crank off* parameter. This ensures that the engine is stopped if the engine start was not detected. The engine cannot be started during the *Crank off* time.

3. **Crank**: `Engine > Controls > Crank` (digital output). The controller activates the *Crank* output for the *Crank on* time, and deactivates it for *Crank off* time.
4. **Running detection**. There is no running detection.
5. **Start failure**. The controller activates the *Start failure* alarm after the last unsuccessful start attempt.

### Optional start prepare

You can use the optional `Engine > Controls > Start prepare` digital output with a stop coil or a run coil system.

### Successful engine start sequence with start prepare




t1 = Start prepare (`Parameters > Engine > Start sequence > Start prepare > Start prepare`)

t2 = Extended start prepare (`Parameters > Engine > Start sequence > Start prepare > Extended start prepare`)

1. **Start attempts**
2. **Start prepare**: `Engine > Controls > Start prepare` (digital output) (optional).
   a. At the start of each start sequence, the controller activates the *Start prepare* output for the time in the *Start prepare* parameter (**t1**). All other engine start outputs (that is, *Stop coil*, *Crank* ) are not activated during this time.
   b. If there is an *Extended start prepare* time (**t2**), then the *Start prepare* output remains activated for this time during cranking. If cranking stops before the extended start prepare timer stops, then the controller deactivates the *Start prepare* output.
3. **Crank**: `Engine > Controls > Crank` (digital output). After the *Start prepare* time, the controller activates the *Crank* output.

## 10.3.4 Interruption of the start sequence

These actions interrupt the engine start sequence:

- The *Emergency stop* digital input is activated (for example, from the operator, or a PLC).
- There is a *Stop engine* command. For example: Under local control, the operator pushes the push-button **Stop** on the display unit.
- The following alarm actions:
  - *Trip generator breaker and stop engine*
  - *Trip generator breaker and shutdown engine*

When the start sequence is interrupted, the controller does the following:

- Deactivates the *Crank* output.
- Deactivates the *Run coil* output (if present).
- Activates the *Stop coil* output (if present).
- Deactivates the *Start prepare* output (if present).

There is no cooldown period when the engine start sequence is interrupted.

**NOTE** If *Running detection* is ON, the controller regards the engine as started. When the engine has started, the actions listed here do not interrupt the engine start sequence, but result in a engine stop instead. The engine stop normally includes the cooldown period configured in the controller. However, for a shutdown, there is no cooldown period.

# 10.4 Engine stop

## 10.4.1 Engine stop function

For a normal genset stop, the controller ensures that the genset runs for a cooldown period before stopping. If a shutdown alarm action shuts down the genset, there is no cooldown period. You can also configure an idle run stop period before the engine shuts down.

The controller software includes pre-programmed genset stop sequences. For the engine's stop function, you must configure these inputs and outputs, and parameters.

Parameters that need a hardware function are not visible until the function is assigned to an input or output.

**More information**
See GENSET controller alarms for more information on how the engine stop alarms work, and how to configure them.

### Controller modes

Under remote and local control, the controller uses these inputs and outputs, and parameters to stop the genset.

When the operator stops the genset under switchboard control, the controller is not involved. These sequences do not apply to stopping a genset under switchboard control.

### Optional inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Command > Stop engine` | Digital input | Pulse | Optional. When the controller is under remote control, the operator or another system can activate this input to request the controller to stop the engine. |
| `Engine > Controls > Idle run` | Digital output | Continuous | Optional. Connect this output to the engine idle run if supported. Not all engines support this feature.<br><br>This digital output is needed to use either idle run start and/or idle run stop. |
| `Engine > Idle run > End idle stop` | Digital input | Pulse | Optional. The operator or another system can activate this input to request the controller to end the engine stop idle run. |
| `Engine > Command > Open generator breaker and stop engine` | Digital input | Pulse | Optional. When the controller is under remote control, the operator or another system can activate this input to request the controller to de-load and open the breaker, and then stop the engine. |
| `Engine > Cooldown > Coolant water [C]` | Analogue input | Units = °C | Optional. This input measures the engine water temperature, and is used for temperature-dependent cooldown. |

### Parameters

**`Engine > Stop sequence > Cooldown`**

| Parameter | Range | Comment |
|---|---|---|
| `Cooldown time` * | 0 s to 165 min | This is the cooldown time if the digital input `Alarm system > Additional functions > Suppress alarm action` is not active. |

| Parameter | Range | Comment |
|---|---|---|
| | | After the engine stop signal or command, the engine runs for this period before the controller activates the *Stop coil* (or deactivates the *Run coil*). |
| `Suppress alarm action` * | 1 s to 3 h | This is the cooldown time if the digital input `Alarm system > Additional functions > Suppress alarm action` is active.<br><br>After the engine stop signal or command, the engine runs for this period before the controller activates the *Stop coil* (or deactivates the *Run coil*). |
| `Temperature threshold` | 0 to 150 °C | Optional. The engine cooldown stops if the engine coolant water temperature reaches this threshold before the cooldown timer expires. |

**NOTE** * If the digital input `Alarm system > Additional functions > Suppress alarm action` is active, the *Suppress alarm action* value is used instead of the *Cooldown time* value.

**`Engine > Stop sequence > Extended stop`**

| Parameter | Range | Comment |
|---|---|---|
| `Extended stop` | 1.0 to 99.0 s | The *Stop coil* remains activated for this period after *Running detection* is OFF. During this period a new start attempt is not possible. |

### Optional idle run stop

You can optionally configure an idle run stop period for the engine, allowing the engine to cool-down after taking load.

If this is configured, the controller will activate the digital output `Engine > Controls > Idle run` before stopping the engine. The controller then waits for one of the engine conditions (coolant temperature, oil temperature, external input condition, or the maximum timer) to be fulfilled before stopping the engine.

During the idle run stop period, the operator can override the period and press **Stop** on the display, the controller then cancels the idle run stop period and stops the engine.

Additionally, during the idle run stop period, the operator can press **Start** to abort the engine stop sequence and run the engine start sequence.

Optional. You must configure the `Engine > Controls > Idle run` digital output to see these parameters.

### Optional parameters

**`Engine > Idle run stop > Idle run`**

| Parameter | Range | Comment |
|---|---|---|
| `Enable` | Not enabled, Enabled | Enables the engine to idle run until a condition is true before stopping the engine. |

**`Engine > Idle run stop > Minimum`**

| Parameter | Range | Comment |
|---|---|---|
| `Use` | Not enabled, Enabled | Uses minimum set point to determine if the engine is ready to stop. |
| `Delay` | 0 s to 999 min | This is the minimum time the idle run stop is active. |

**`Engine > Idle run stop > Coolant temperature`**

| Parameter | Range | Comment |
|---|---|---|
| `Use` | Not enabled, Enabled | Uses coolant temperature set point to determine if the engine is ready to stop. |
| `Set point` | - 50 to 200 °C | The temperature the engine coolant must reach before ending the idle run stop. |

**Engine > Idle run stop > Oil temperature**

| Parameter | Range | Comment |
|---|---|---|
| Use | Not enabled, Enabled | Uses oil temperature set point to determine if the engine is ready to stop. |
| Set point | - 50 to 200 °C | The temperature the engine oil must reach before ending the idle run stop. |

**Engine > Idle run stop > External condition**

| Parameter | Range | Comment |
|---|---|---|
| Use | Not enabled, Enabled | Uses the external condition to determine if the engine is ready to stop.<br><br>The external condition is configured with the digital input Engine > Idle run > End idle run stop, or with CustomLogic or CODESYS. |

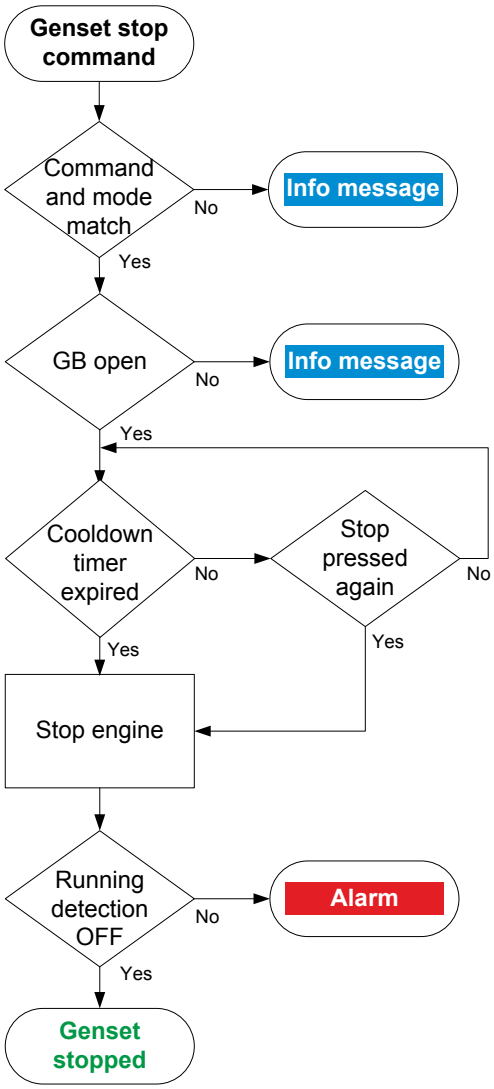
**Engine > Idle run stop > Maximum**

| Parameter | Range | Comment |
|---|---|---|
| Use | Not enabled, Enabled | Uses maximum set point to determine if the engine is ready to stop. |
| Delay | 1 s to 120 min | This is the maximum time the idle run stop can operate. |

## 10.4.2 Engine stop flowchart

The following flowchart shows how the controller normally stops a genset. An engine shutdown is described later.

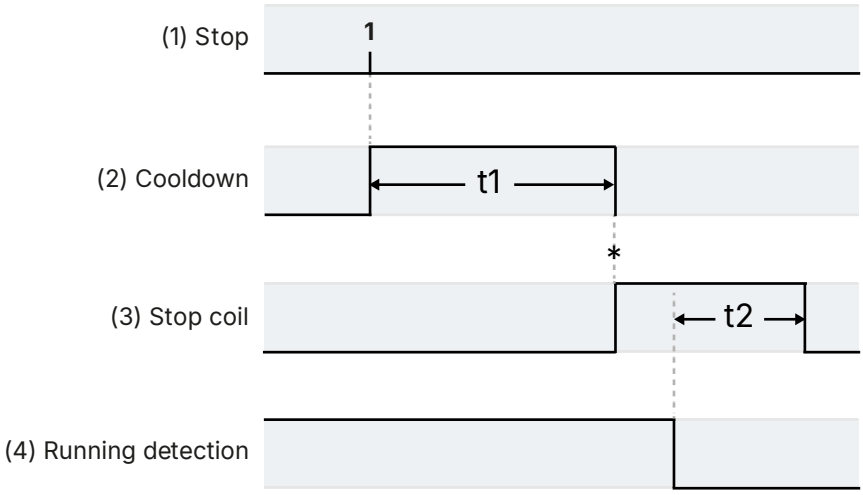
*Idle run stop* function is not included on this diagram.



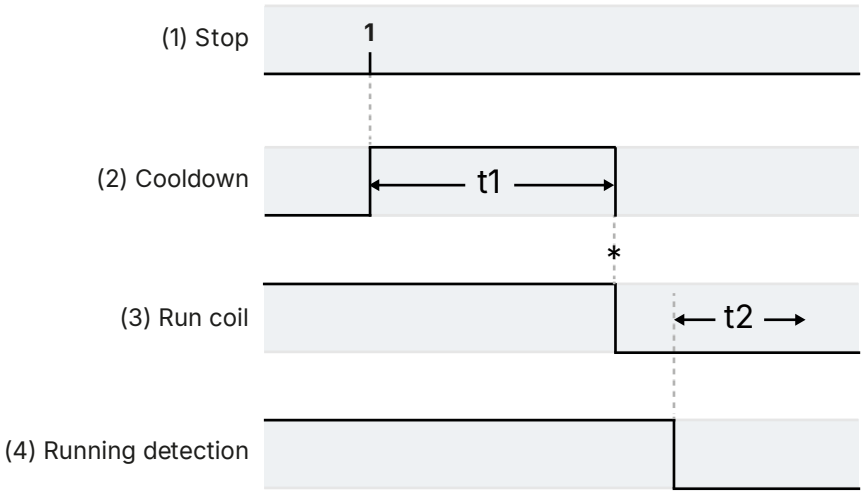

1. **Command and mode match:** The controller checks that the command source and the controller mode match.
2. **GB open:** The controller checks whether the genset breaker is open. If the genset breaker is not open, the controller cancels the stop sequence and the display unit shows an info message.
3. **Cooldown timer expired:** The genset runs without load for the cooldown time. The controller checks whether the cooldown timer has expired or the stop button was pressed again.
   - If the cooldown timer has not expired, but the engine stop button was pressed again, the controller stops the cooldown.
4. **Stop engine:** To stop the engine:
   - Stop coil system: The controller activates the *Stop coil* output.
   - Run coil system: The controller deactivates the *Run coil* output.
5. **Running detection OFF:** The controller checks whether the engine has stopped.
   - If *Running detection* is ON, the controller activates an alarm.
   - If *Running detection* is OFF, the engine has stopped and the stop sequence has been completed successfully.

## 10.4.3 Engine stop sequence

### Engine stop sequence for a stop coil system



### Engine stop sequence for a run coil system




t1 Cooldown (`Parameters > Engine > Stop sequence > Cooldown > Cooldown time`)

t2 Extended stop (`Parameters > Engine > Stop sequence > Extended stop > Extended stop`)

* Up to this point, the engine can be restarted immediately, without completing the stop sequence.

1. **Stop**. The stop command can come from the controller, an operator, or an external source. See Engine stop flowchart.
2. **Cooldown** (optional). The controller allows the genset to run for the time configured. There is no cooldown for shutdowns, an emergency stop, or an operator stop by pressing the engine stop push-button again. Temperature-dependent cooldown is also possible (see below).
3. **Stop engine**:
   - **Stop coil**: `Engine > Controls > Stop coil` (digital output). The controller activates the stop coil digital output until running feedback is OFF. The controller then keeps the stop coil activated for the time in the (optional) *Extended stop* parameter.
   - **Run coil**: `Engine > Controls > Run coil` (digital output). The controller deactivates the run coil digital output after the cooldown period. The genset cannot restart during the time in the (optional) *Extended stop* parameter.
4. **Running detection**. When the running detection is OFF, the controller regards the engine as stopped.

### Temperature-dependent cooldown

Temperature-dependent cooldown stops the engine cooldown when the engine coolant water temperature reaches the configured threshold before the cooldown timer expires. The cooldown can be shorter than when just a timer is used, which reduces fuel use. Configure the cooldown threshold under `Engine > Stop sequence > Cooldown > Temperature threshold`.

### Analogue input for cooldown

| Function | I/O |
|---|---|
| `Engine > Measurements > Coolant > Engine coolant water [°C]` | Analogue input |

**NOTE** You must configure the analogue input function to see the parameters.

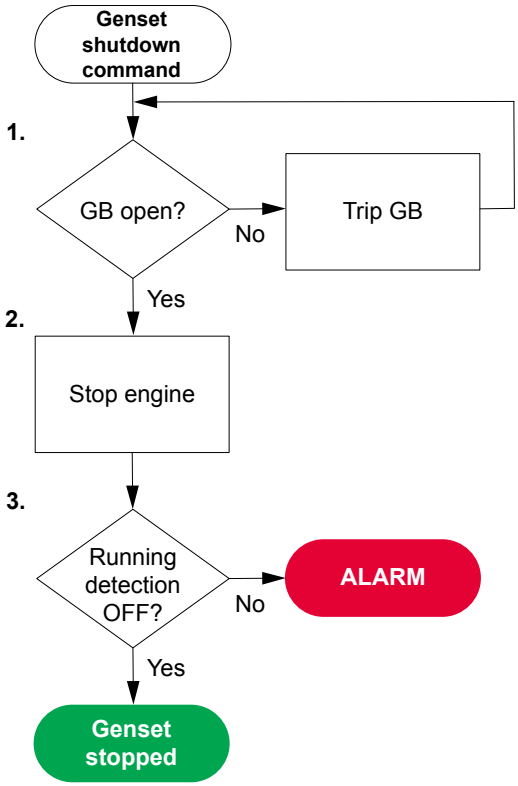
## 10.4.4 Engine shutdown flowchart

The engine is shut down for the following alarm action:

- Trip generator breaker and shutdown engine

The engine is also shutdown if the controller's *Emergency stop* input is deactivated.

### Engine shutdown flowchart




1. **GB open**: The controller checks whether the generator breaker is open. If not, the controller trips the generator breaker.
2. **Stop engine**: The controller shuts down the engine:
   - Stop coil system: The controller activates the *Stop coil* output.
   - Run coil system: The controller deactivates the *Run coil* output.
3. **Running detection OFF**: If *Running detection* is still ON after the time allowed, the controller activates the *Stop failure* alarm.

**NOTE** The controller does not require the engine stop conditions to be met for an engine shutdown. Similarly, there is no cooldown time for an engine shutdown.

## 10.5 Generator breaker

### 10.5.1 How it works

The generator breaker (GB) connects the genset to the busbar. The genset must be running, and synchronised with the busbar, for the generator breaker to close. The generator breaker is an important part of the system safety, and trips to protect the genset from problems on the busbar. The generator breaker also trips to stop genset problems from disturbing the busbar.

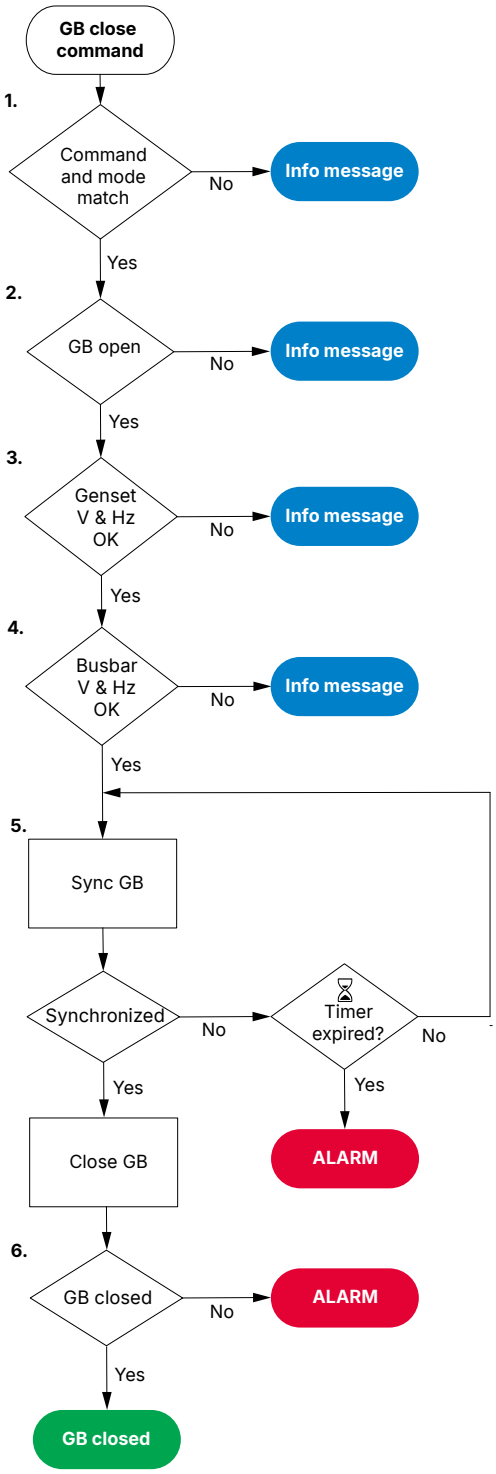
#### General breaker information

**More information**
See Breakers, synchronisation and de-loading for how synchronisation and breakers work. This includes the inputs and output functions and the parameters to configure.

*[Breaker]* refers to *Generator breaker*. The breaker abbreviation (*[*B]*) is *GB*.

### 10.5.2 Generator breaker close flowchart

**More information**
See Generator breaker blackout close flowchart for how to allow the genset to connect to a dead busbar.




1. **Command and mode match:** The controller checks that the command source and the controller mode match.
2. **GB open:** The controller checks whether the generator breaker is open. If the generator breaker is already closed, the sequence stops, and an info message is shown.
3. **Genset V & Hz OK:** The controller checks whether the voltage and frequency from the genset are within the allowed range*. If these are not in the range, then the controller cancels the close command and displays an info message.
4. **Busbar V & Hz OK:** The controller checks whether the voltage and frequency on the busbar are within range*. If these are not in the range, then the controller cancels the close command and displays an info message.
5. **Sync GB:** The controller tries to synchronise the genset to the busbar.
   - When the genset and busbar are synchronised, the controller activates the *Breakers > Generator breaker > Controls > GB close* output to close the breaker.
   - If the genset and busbar do not synchronise within the time allowed, the controller activates a *GB synchronisation failure* alarm.
6. **GB closed:** 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 controller activates the *GB closing failure* alarm.

**NOTE** * See `Parameters > [A-side] / [B-side] AC setup > Voltage and frequency OK` for these ranges.

## 10.5.3 Generator breaker blackout close flowchart

The *Blackout close* function sets the action that the controller allows when a dead busbar is detected. If the parameter is not *Off*, then an operator or a remote input can close the breaker directly to the black busbar.

**DANGER!**

**Incorrect settings**

Incorrect blackout close parameter settings can lead to equipment damage or loss of life.

### Blackout conditions

A blackout is present if 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 allow the blackout close:

- The breaker position is unknown.
- There is a short circuit.
  - A digital input with the function `Breakers > Generator breaker > Feedback > GB short circuit` was activated.
- There is a blocking alarm.
  - The alarm action determines whether the alarm is a blocking alarm.
- The busbar and/or generator AC measurements are not OK.
  - A measurement failure is detected on one or more of the phases.

### Parameters

**`Breakers > Generator breaker configuration`**

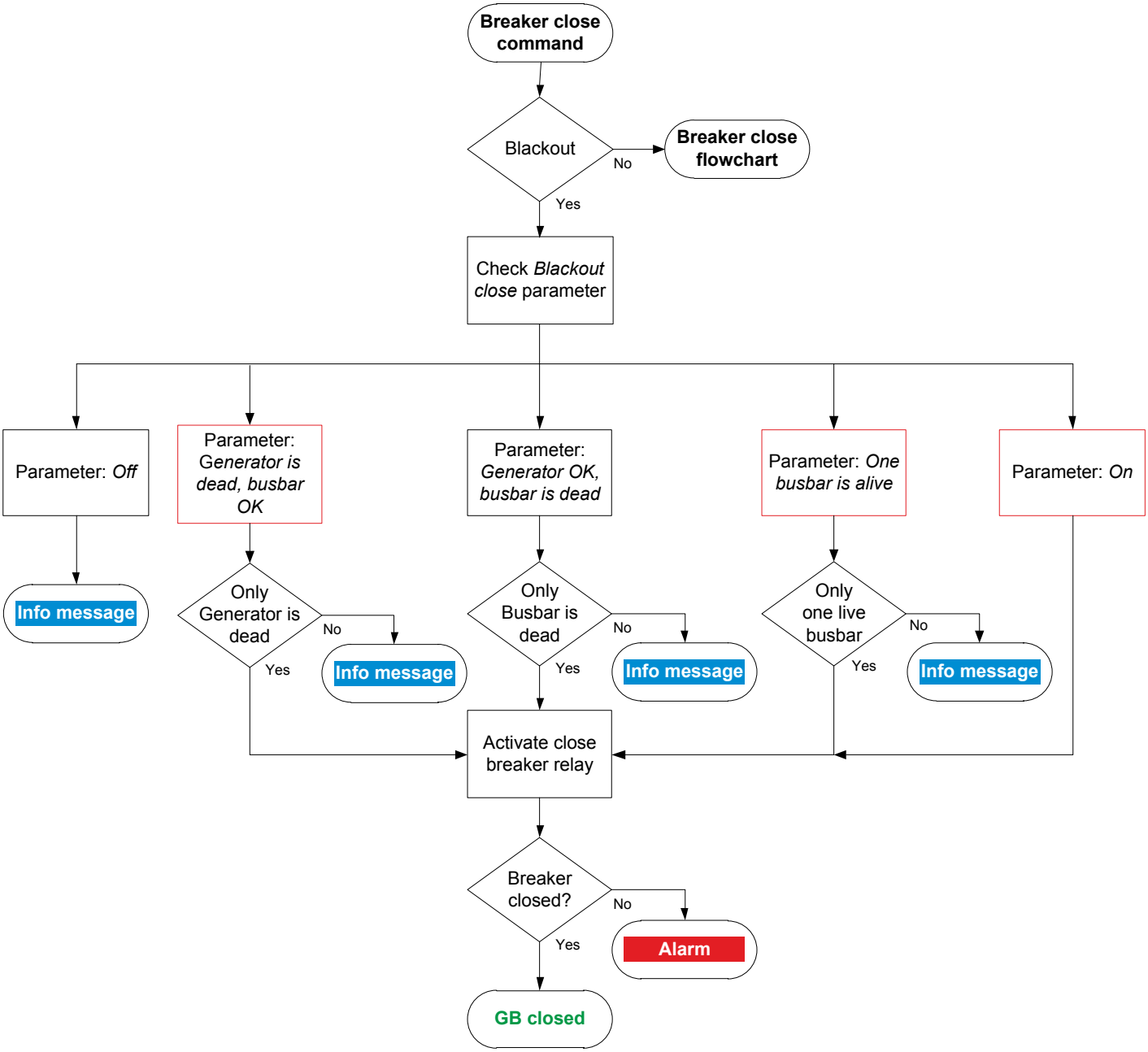
| Name | Range | Notes |
|---|---|---|
| `Blackout close` | • Blackout close is OFF<br>• Generator is dead, busbar OK<br>• Generator OK, busbar is dead<br>• One busbar is alive<br>• On | **Blackout close is OFF**: The controller will never activate the close breaker relay if any blackout is detected.<br><br>**Generator is dead, busbar OK** *: If a blackout is detected at the Generator, but the Busbar is stable, then the controller allows the breaker to close.<br><br>**Generator OK, busbar is dead**: If a blackout is detected at the Busbar and the Generator is stable, then the controller allows the breaker to close.<br><br>**One busbar is alive** *: If a blackout is detected at the Generator or the Busbar, and the live busbar is stable, then the controller allows the breaker to close.<br><br>**On** *: If a blackout is detected at the Generator and/or at the Busbar, then the controller allows the breaker to close. |

**CAUTION**

**Protection of system**

The system must be adequately protected if you use the (*) options for genset applications.

### Blackout close flowchart




1. **Breaker close command:** An operator or a remote command attempts to close the breaker.
2. **Blackout:** The controller detects a blackout on one or both of the busbars, and the conditions for blackout close are met.
3. **Check *Blackout close* parameter:**
   a. **Off**: The controller does not allow the breaker to close. The controller shows an info message, and the sequence ends.
   b. **Generator is dead, busbar OK**: The controller checks whether the blackout was detected only at the Generator.
      - *Blackout only at the Generator*: The controller activates the close breaker relay.
      - *Blackout was only at the Busbar or on both sides of the breaker*: The controller shows an info message, and the sequence ends.
   c. **Generator OK, busbar is dead**: The controller checks whether the blackout was detected only at the Busbar.
      - *Blackout only at the Busbar*: The controller activates the close breaker relay.
      - *Blackout only at the Generator or on both sides of the breaker*: The controller shows an info message and the sequence ends.
   d. **One busbar is alive:** The controller checks if the blackout was detected only at the Generator, or only at the Busbar.
      - *Blackout only at the Generator, or only at the Busbar*: The controller activates the close breaker relay.
      - *Blackout on both sides of the breaker*: The controller shows an info message and the sequence ends.

e. **On**: If there is a blackout on either/both busbars, the controller activates the close breaker relay.

4. **Breaker closed:** The controller checks whether the generator breaker has closed.
   - If the generator breaker has closed, the blackout close sequence has been completed successfully.
   - If the generator breaker has not closed the controller activates the *GB closing failure* alarm.

### 10.5.4 Generator breaker open flowchart

The alarm action *Block* does not open a closed breaker, although it stops an open breaker from closing. If the controller or an operator sends a GB open command while *Block* is active, the controller uses this sequence.

The sequence to trip the generator breaker is described in another flowchart.

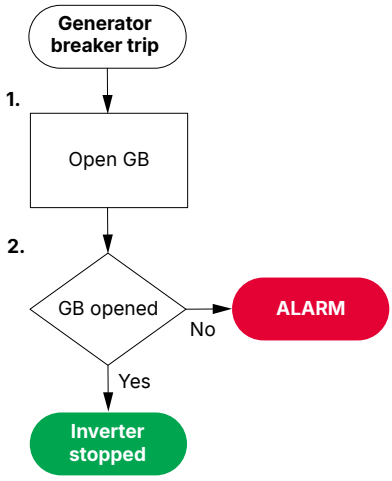
### 10.5.5 Generator breaker trip flowchart

The controller automatically trips the generator breaker (GB) for these alarm actions:

- Trip generator breaker
- Trip generator breaker and stop engine
- Trip generator breaker and shutdown engine

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

The controller does not require the genset stop conditions to be met for a breaker trip. Similarly, the breaker is not de-loaded for a trip.




1. **Open GB**: When a trip is required, the controller activates the `Breakers > Generator breaker > Controls > GB open` output to open the breaker.
2. **GB opened**: 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.

## 10.6 Digital AVR

The controller can work with a digital AVR (see the **Data sheet** for details). Select the DAVR and configure the source address on the **Fieldbus configuration** page in PICUS.

**More information**
See **Fieldbus configuration** in the **PICUS manual**.

You can then use the following parameters in the controller to configure the digital AVR.

**Generator > Digital AVR > AC setup > Selection**

| Parameter | Range |
|---|---|
| AC configuration | Use the controller AC settings, 2-phase (W-U), 2-phase (V-W), 3-phase (U-V-W) |

**Generator > Digital AVR > AC setup > Voltage transformer**

| Parameter | Range |
|---|---|
| Enable VT | Not enabled, Enabled |

**Generator > Digital AVR > AC setup > Generator**

| Parameter | Range |
|---|---|
| Primary | 400.0 to 32000.0 V |
| Secondary | 50.0 to 600.0 V |

**Generator > Digital AVR > AC setup > Busbar**

| Parameter | Range |
|---|---|
| Primary | 400.0 to 32000.0 V |
| Secondary | 50.0 to 600.0 V |

**Generator > Digital AVR > Settings > Start on threshold**

| Parameter | Range |
|---|---|
| Start on threshold PWM | 0.0 to 100.0 % |
| Start on threshold activation | 0.0 to 100.0 % |

**Generator > Digital AVR > Settings > Soft start**

| Parameter | Range |
|---|---|
| Soft-start ramp | 0.1 to 120.0 s |

**Generator > Digital AVR > Settings > Reset soft start**

| Parameter | Range |
|---|---|
| Minimum frequency threshold | 6.0 to 500.0 Hz |
| Minimum VBus threshold | 0.0 to 450.0 V |

**Generator > Digital AVR > Settings > Dry alternator**

| Parameter | Range |
|---|---|
| Excitation reference for dry alternator | 0.0 to 20.0 A |

**Generator > Digital AVR > Settings > Bias**

| Parameter | Range |
|---|---|
| Bias scale | 1.0 to 50.0 % |
| Analogue bias input type | 0 to 10 V, +- 10 V, 4 to 20 mA |
| Regulation selection | Analogue, CAN bias |

**Generator > Digital AVR > Settings > PID**

| Parameter | Range |
|---|---|
| PID gain factor | 1.0 to 200.0 |

**Generator > Digital AVR > Settings > Droop**

| Parameter | Range |
|---|---|
| Reactive droop compensation | 0.0 to 10.0 % |
| Voltage droop compensation | 0.0 to 10.0 % |
| Droop type | Off, Reactive droop compensation, Voltage line droop compensation |

**Generator > Digital AVR > Settings > Controls**

| Parameter | Range |
|---|---|
| Write all settings | Not selected, Selected |
| Controls | Not enabled, Enabled |
| Reset all DVC alarms | Not selected, Selected |
| Digital AVR modes | Genset mode, Dry alternator, Ventilator mode |

**Generator > Digital AVR > Current limitation > Selection**

| Parameter | Range |
|---|---|
| Current limitation type | Off, Magnetisation, Inductive motor |

**Generator > Digital AVR > Current limitation > Magnetisation**

| Parameter | Range |
|---|---|
| Current limitation transformer | 0.0 to 300.0 % |

**Generator > Digital AVR > Current limitation > Inductive motor starting**

| Parameter | Range |
|---|---|
| Current limitation induction motor | 0.0 to 300.0 % |

**Generator > Digital AVR > Operation modes > Selection**

| Parameter | Range |
|---|---|
| SVR and LAM configuration | Off, SVR, SVR + LAM |

**Generator > Digital AVR > Operation modes > U/f variable slope**

| Parameter | Range |
|---|---|
| Knee set point | 70.0 to 100.0 % |
| U/f variable slope | 0.5 to 5.0 |

**Generator > Digital AVR > Operation modes > Load acceptance module**

| Parameter | Range |
|---|---|
| Adjust LAM | 70.0 to 100.0 % |
| LAM duration | 0.0 to 10000.0 ms |

**Generator > Digital AVR > Operation modes > Soft voltage recovery**

| Parameter | Range |
|---|---|
| Soft voltage recovery | 0.01 to 3.00 s/% |

### 10.6.1 Digital AVR outputs

The controller analogue outputs can be configured to show a range of digital AVR values. See the functions available under Generator > Digital AVR > LED and Generator > Digital AVR > Measurements.

### 10.6.2 Digital AVR alarms

You can enable the following alarms. They are based on operating values from the digital AVR.

**Generator > Digital AVR > Alarms > Over-voltage**

**Generator > Digital AVR > Alarms > Under-voltage**

**Generator > Digital AVR > Alarms > Over-frequency**

**Generator > Digital AVR > Alarms > Under-frequency**

**Generator > Digital AVR > Alarms > Open diode**

**Generator > Digital AVR > Alarms > Shorted diode**

**Generator > Digital AVR > Alarms > Reverse kW**

**Generator > Digital AVR > Alarms > Reverse kvar**

**Generator > Digital AVR > Alarms > Pt100 # alarm ***

**Generator > Digital AVR > Alarms > Pt100 # fault ***

**Generator > Digital AVR > Alarms > PTC # fault ***

**Generator > Digital AVR > Alarms > Sensing lost**

**Generator > Digital AVR > Alarms > Unbalanced voltage**

**Generator > Digital AVR > Alarms > Unbalanced current**

**Generator > Digital AVR > Alarms > Short circuit**

**Generator > Digital AVR > Alarms > IGBT overheat**

**Generator > Digital AVR > Alarms > Motor start**

**Generator > Digital AVR > Alarms > PWR bridge overload**

**Generator > Digital AVR > Alarms > Power supply**

**Generator > Digital AVR > Alarms > CAN supply**

**Generator > Digital AVR > Alarms > Pt100 # open short fault status ***

**Generator > Digital AVR > Alarms > AIN # wire break fault status ***

**Generator > Digital AVR > Alarms > AOUT # overload wire break fault status ***

**Generator > Digital AVR > Alarms > DOUT overload fault status**

**NOTE** * # is 1 to 5.

## 10.7 Other GENSET controller functions

### 10.7.1 Engine communication

The controller supports J1939 communication with engines, as well as some proprietary protocols.

**More information**
See **Omni Engine interface communication** for the details for each engine type.

### Inputs and outputs

You can use controller inputs and outputs for the ECU.

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > ECU > Measurement list filter - available` | Digital input | Pulse | |
| `Engine > ECU > Measurement list filter - clear` | Digital input | Pulse | |
| `Engine > ECU > Log request (DM2)` | Digital input | Pulse | After this input is activated, the controller requests the DM2 log from the ECU. |
| `Engine > ECU > Log clear (DM2)` | Digital input | Pulse | After this input is activated, the controller requests the ECU to clear the DM2 log. |
| `Engine > ECU > ECU reset input` | Digital input | Pulse | After this input is activated, the controller requests the ECU to reset. |
| `Engine > Controls > ECU power` | Digital output | Continuous | You can use this output so that the ECU is only powered on when the engine needs to run. |
| `Engine > ECU > ...` | Analogue outputs | Various | Over 100 ECU outputs are available as analogue outputs. These can be connected to switchboard instruments for troubleshooting. |

### Parameters for controls

**`Engine > ECU > Controls > Speed control (TSC1 / Custom)`**

| Parameter | Range | Notes |
|---|---|---|
| `Source address` | 0 to 255 | EIC speed/Torque control source address. |

**`Engine > ECU > Controls > Cab message (CM1 / Custom)`**

| Parameter | Range | Notes |
|---|---|---|
| `Source address` | 0 to 255 | Selection of EIC J1939 CAB message 1 source address. The controller telegrams for DPF regeneration use this source address. |

**`Engine > ECU > Controls > CAN controls`**

| Parameter | Range | Notes |
|---|---|---|
| `Enable` | Not enabled, Enabled | **Enable**: Enable writing commands to the ECU. |

**`Engine > ECU > Controls > Droop`**

| Parameter | Range | Notes |
|---|---|---|
| `Droop settings` | None<br>Engine Control Unit (ECU)<br>Emulated droop | **None**: The controller does not use droop.<br>**Engine control unit (ECU)**: The controller sends the specified droop value to the ECU.<br>**Emulated droop**: The controller emulates the specified droop. |
| `Droop value` | 0.0 to 25.0 % | The specified droop. |

**Engine > ECU > Controls > Reset**

| Parameter | Range | Notes |
|---|---|---|
| Power off timer | 1 to 300 s | The controller uses this timer with the digital output Engine > Controls > ECU power. This can be wired to turn the ECU power off. |

### Parameters for diagnostic alarms

**Engine > ECU > Diagnostic alarms > ECU Red stop lamp**

**Engine > ECU > Diagnostic alarms > ECU Amber warning lamp**

**Engine > ECU > Diagnostic alarms > ECU Protect lamp**

**Engine > ECU > Diagnostic alarms > ECU Malfunction indicator lamp**

### Parameters for DPF controls

**Engine > ECU > DPF controls > Controls**

| Parameter | Range | Notes |
|---|---|---|
| Aftertreatment Regeneration Inhibit Switch | Not enabled, Enabled | **Enabled**: The regeneration is inhibited. |
| Aftertreatment Regeneration Force Switch | Automatic, Forced | **Automatic**: The ECU automatically regenerates the DPF filter as required.<br>**Forced**: Forces the regeneration of the DPF filter. |

### Parameters for specific manufacturers

**Engine > ECU > Manufacture specific**

| Parameter | Range | Notes |
|---|---|---|
| Shutdown override > Enable | Not enabled, Enabled | |
| Parameters > Speed control | Standard J1939, [Manufacturer specific] | If the manufacturer has a proprietary speed control, you can select it here. |

## 10.7.2 Asynchronous generator

**More information**
See Asynchronous generator in **SINGLE genset** controller.

## 10.7.3 Priming

The priming function activates an output at regular intervals while the engine is not running. Priming is not active while the engine is starting or stopping. For example, priming can be used for an engine heater or lube oil pump. For the priming function, you must configure the following output and parameters.

### Digital output

| Function | I/O | Type | Details |
|---|---|---|---|
| Engine > Controls > Priming | Digital output | Continuous | Optional. Use this output to prime the engine at regular intervals. |

### Parameters

**Engine > Maintenance > Priming**

To see these parameters, you must assign the *Priming* function to a digital output.

| Parameter | Range | Comment |
|---|---|---|
| Enable | Not enabled, Enabled | **Not enabled**: The controller does not activate the *Priming* output. |

| Parameter | Range | Comment |
|---|---|---|
| | | **Enabled**: After the engine stops, the controller activates the *Priming* output for the period configured under *ON timer*. The controller then deactivates the output for the period configured under *OFF timer*. The on and off cycle repeats until the engine starts. |
| `ON timer` | 0.0 s to 1 h | The priming period. |
| `OFF timer` | 0.0 s to 1 h | The interval between each priming. |

## 10.7.4 Temperature-dependent power derating

The temperature-dependent power derating function reduces the genset nominal load by reducing the genset nominal power used by load sharing. The derating function can be configured for up to three temperature measurements.

### Input and output

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Power derate > Temperature > Derate # temperature [C]` * | Analogue input | The measurement must be in °C. | This can measure any temperature, for example, the engine cooling water. |
| `Engine > Power derate > Temperature > Derate # temperature [C]` * | Analogue output | - | Optional. You can connect this output to a switchboard instrument to monitor the analogue input. |

**NOTE** * # is 1 to 3.

### Parameters

**`Engine > Power derate > Temperature > Derate # *`**

The analogue input(s) must be configured to see the power derate parameter and curve.

| Parameter | Range | Comment |
|---|---|---|
| `Enable derate` | Not enabled, Enabled | **Not enabled**: The load sharing uses the genset nominal power, no matter what the derate temperature is.<br><br>**Enabled**: The controller uses the power derating curve to derate the power for load sharing within the configured range. See **How it works**. |
| `Setup` | | Use this section to set up the power derate curve. |

**NOTE** * # is 1 to 3.

### How it works

You can create a customised curve for each temperature input.

Power derate affects load sharing and fixed power regulation, since these are based on a percentage of nominal power.

The derating does **not** affect the alarms.

**Temperature-dependent power derating example**

There are two 1000 kW gensets in the system. For genset A, the power derate curve is 100 % until 80 °C, then linearly down to 70 % at 100 °C. Genset B does not have power derating.

The genset A temperature is 90 °C. The system load is 1480 kW.

| | |
|---|---|
| | The derated nominal power for genset A is 85 % of the nominal power, that is, 850 kW. The total genset nominal power is 1850 kW.<br><br>For equal load sharing, each genset runs at 1480 kW / 1850 kW × 100 % = 80 % of their nominal load. Genset A runs at 680 kW, and genset B runs at 800 kW. |

## 10.7.5 Percentage-dependent power derating

The percentage-dependent power derating function reduces the genset nominal load by reducing the genset nominal power used by load sharing.

### Input and output

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > Power derate > Percentage > Derate percentage [%]` | Analogue input | The measurement must be in %. | |
| `Engine > Power derate > Percentage > Derate percentage [%]` | Analogue output | - | Optional. You can connect this output to a switchboard instrument to monitor the analogue input. |

### Parameters

**`Engine > Power derate > Percentage`**

The analogue input must be configured to see the power derate parameter.

| Parameter | Range | Default | Comment |
|---|---|---|---|
| `Enable derate` | Not enabled, Enabled | Not enabled | **Not enabled**: The load sharing uses the genset nominal power, no matter what the derate percentage is.<br><br>**Enabled**: The controller uses the analogue input to derate the power for load sharing. |

## 10.7.6 Fuel pump

The fuel pump logic is used to start and stop the fuel supply pump to keep the fuel in the service tank at the required level. To see the fuel pump parameters, you must first configure the fuel pump digital output and the fuel level analogue input.

### Inputs and outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Auxiliary > Fuel pump > Fuel pump` | Digital output | Continuous | Controller output to activate the fuel pump when the fuel level is below the start limit, until the fuel level is above the stop limit. |
| `Auxiliary > Fuel pump > Fuel level [%]` | Analogue input | - | The level in the fuel tank. |
| `Auxiliary > Fuel pump > Activate fuel pump logic` | Digital input | Pulse | Optional. External signal to activate the controller's fuel pump function. If this function is not assigned to a digital input, the fuel pump function is always active. |
| `Auxiliary > Fuel pump > Deactivate fuel pump logic` | Digital input | Pulse | Optional. External signal to deactivate the controller's fuel pump function. |

| Function | I/O | Type | Details |
|---|---|---|---|
| Auxiliary > Fuel pump > Fuel level [%] | Analogue output | - | Optional. You can connect this to a switchboard instrument for troubleshooting. |
| Auxiliary > Fuel pump > Analogue input > Fuel level [%] | Analogue output | - | Optional. You can connect this to a switchboard instrument for troubleshooting. |

**Auxiliary > Fuel pump > Fuel pump settings**

| Name | Range | Details |
|---|---|---|
| Pump ON set point | 0 to 100 % | Fuel level to activate the output, to start the fuel transfer pump. |
| Pump ON delay | 0.0 s to 1 h | The fuel level must be below the pump on set point for this time before the controller activates the output to start the pump. |
| Pump OFF set point | 0 to 100 % | Fuel level to deactivate the output, to stop the fuel transfer pump. |
| Pump OFF delay | 0.0 s to 1 h | The fuel level must be above the pump off set point for this time before the controller deactivates the output to stop the pump. |

**Auxiliary > Fuel pump > Fuel fill alarm**

| Name | Range | Details |
|---|---|---|
| Delay | 1 s to 5 min | When the fuel pump is running, the fuel level must increase by 2 % within this delay, otherwise the controller activates the alarm. |

## 10.7.7 Engine operating values as analogue inputs

In addition to analogue inputs described previously, you can use these analogue inputs to communicate engine operating values to the controller.

### Analogue inputs

| Function | I/O |
|---|---|
| Engine > Measurements > Coolant > Engine coolant temperature [°C] | Analogue input |
| Engine > Measurements > Coolant > Engine coolant level [%] | Analogue input |
| Engine > Measurements > Lube oil > Engine oil temperature [°C] | Analogue input |
| Engine > Measurements > Lube oil > Engine oil pressure [bar] | Analogue input |

## 10.7.8 Engine operating values as analogue outputs

You can configure an analogue output with a function for an engine operating value. The controller then adjusts the analogue output to reflect the engine operating value.

### Analogue outputs

| Function | I/O | Units | Details |
|---|---|---|---|
| Engine > Measurements > Coolant > Engine coolant water [C] | Analogue output | -50 to 200 °C | The controller outputs the engine coolant water temperature. |
| Engine > Measurements > Coolant > Engine coolant level [%] | Analogue output | 0 to 100 % | The controller outputs the engine coolant level. |
| Engine > Measurements > Coolant > Analogue input > Engine coolant water [C] | Analogue output | -50 to 200 °C | The controller outputs the engine coolant water temperature. For this function to work, there must be an analogue input to the |

| Function | I/O | Units | Details |
|---|---|---|---|
| | | | controller with the engine coolant water temperature. |
| `Engine > Measurements > Coolant > Analogue input > Engine coolant level [%]` | Analogue output | 0 to 100 % | The controller outputs the engine coolant level. For this function to work, there must be an analogue input to the controller with the engine coolant level. |
| `Engine > Measurements > Lube oil > Engine oil pressure [bar]` | Analogue output | 0 to 10 bar | The controller outputs the engine oil pressure. |
| `Engine > Measurements > Lube oil > Engine oil temperature [C]` | Analogue output | -50 to 200 °C | The controller outputs the engine oil temperature. |
| `Engine > Measurements > Lube oil > Analogue input > Engine oil temperature [C]` | Analogue output | -50 to 200 °C | The controller outputs the engine oil temperature. For this function to work, there must be an analogue input to the controller with the engine oil temperature. |
| `Engine > Measurements > Lube oil > Analogue input > Engine oil pressure [bar]` | Analogue output | 0 to 10 bar | The controller outputs the engine oil pressure. For this function to work, there must be an analogue input to the controller with the engine oil pressure. |
| `Engine > Measurements > Speed > Engine speed [RPM]` | Analogue output | 0 to 20,000 RPM | The controller outputs the engine speed. |
| `Engine > Measurements > Speed > Analogue input > Engine MPU [RPM]` | Analogue output | 0 to 20,000 RPM | The controller outputs the engine speed. For this function to work, there must be an active MPU/W/NPN/PNP input to the controller with the engine speed. |
| `Engine > Power derate > Temperature > Derate [1 to 3] temperature [C]` | Analogue output | -50 to 200 °C | The controller outputs the derate temperature. |
| `Engine > Power derate > Percentage > Derate percentage [%]` | Analogue output | 0 to 100 % | The controller outputs the derate percentage. |
| `Engine > Service timers > Hours until total running hours notification [h]` | Analogue output | | The controller outputs the hours until the total running hours timer runs out. |
| `Engine > Service timers > Hours until trip running hours notification [h]` | Analogue output | | The controller outputs the hours until the trip running hours timer runs out. |

### Applications

An analogue output with an engine operating value may be wired to a switchboard instrument, to help the operator with troubleshooting. For example, the engine speed measured by the MPU can be displayed.

## 10.7.9 Engine states as digital outputs

You can configure a digital output with a function for an engine state. The controller activates the digital output if the engine state is present. These can be useful for troubleshooting.

### Digital outputs

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > State > Running` | Digital output | Continuous | Activated if there is running detection for the engine. |
| `Engine > State > Not running` | Digital output | Continuous | Activated if there is no running detection for the engine. |

| Function | I/O | Type | Details |
|---|---|---|---|
| `Engine > State > Not ready to start` | Digital output | Continuous | Activated if there is any condition that would block the controller from starting the engine. |
| `Engine > State > Ready to start` | Digital output | Continuous | Activated if there are no conditions that would block the controller from starting the engine. |
| `Engine > State > Starting` | Digital output | Continuous | Activated while the controller works through the pre-programmed start sequence. |
| `Engine > State > Cooldown` | Digital output | Continuous | Activated while the controller cooldown timer is running. |
| `Engine > State > Stopping` | Digital output | Continuous | Activated while the engine is stopping. |
| `Engine > State > Extended stop` | Digital output | Continuous | Activated while the engine extended stop is active. |

## 10.7.10 Counters

You can view, edit and reset all the counters on the display unit under `Configure > Counters`.

The counters include:

- Start attempts
- Total running hours and minutes
- Trip running hours and minutes
- Generator breaker operations and trips
- Energy export (active and reactive)

Running hours trip works like a car trip meter. For example, you can use this counter to track the running hours since the last maintenance.

### Energy counter outputs

For each energy counter, you can configure a digital output to send a pulse every time a certain amount of energy is transferred.

### Digital outputs

You must configure the digital output function to see the parameters.

| Function | I/O | Type |
|---|---|---|
| `Generator > Production counters > Active energy export pulse` | Digital output | Pulse |
| `Generator > Production counters > Reactive energy export pulse` | Digital output | Pulse |

### Parameters

**`Generator > Production counters > Active energy export`**

| Parameter | Range | Comment |
|---|---|---|
| `Pulse every` | 1 kWh to 10 MWh | The value when a digital output sends a pulse. |
| `Pulse length` | 0.1 s to 1 h | The length of the pulse that is sent. This value should be long enough so the pulse can be registered by the external counter. |

**Generator > Production counters > Reactive energy export**

| Parameter | Range | Comment |
|---|---|---|
| Pulse every | 1 kvarh to 10 Mvarh | The value when a digital output sends a pulse. |
| Pulse length | 0.1 s to 1 h | The length of the pulse that is sent. This value should be long enough so the pulse can be registered by the external counter. |

### Energy counter function and corresponding parameter full names

| [Counter pulse] | [Counter] |
|---|---|
| Active energy export pulse | Active energy export |
| Reactive energy export pulse | Reactive energy export |

**Application example for an energy counter output**

1. Connect the digital output to an external counter.
2. Configure the digital output using the display unit or PICUS to *Active energy export pulse*.
3. Configure the *Pulse every* parameter to the value where you would like to send a pulse. For example, 100 kWh.
4. Configure the *Pulse length* to the required length of the pulse for your external counter. For example, 1 second.

With the example setup the controller sends a 1 second pulse to the external counter for each 100 kWh the controller logs.

## 10.7.11 Trip AVR

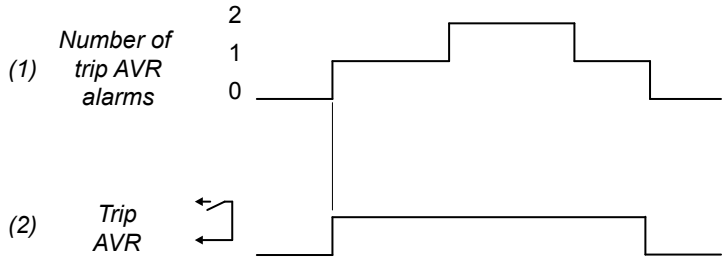
The *Trip AVR* output ensures that excitation is stopped when an alarm activates with a *Trip AVR* alarm action. In cases where there is high voltage present, stopping the excitation reduce the time required to stop an engine in case of an emergency.

The *Trip AVR* output and alarm action does not initiate a breaker trip. To trip the breaker and the AVR, digital outputs for both actions must be configured and the correct alarm action must selected. For example, the *Trip breaker + AVR* alarm action.

### Digital output

| Function | I/O | Type | Details |
|---|---|---|---|
| `[A-side] > AVR > Trip AVR` | Digital output | Continuous | When this output is configured it is possible to assign alarm actions that trip the AVR.<br>When an alarm with a *Trip AVR* action activates, the *Trip AVR* digital output activates and stays activated until all alarms with a *Trip AVR* action are resolved.<br>When the output is active, the controller pauses AVR regulation. |

### Trip AVR sequence diagram




To trip the AVR:

1. **Number of trip AVR alarms**: The number of active alarms with a *Trip AVR* (or similar) alarm action.
2. **Trip AVR**: `[A-side] > AVR > Trip AVR` (digital output). The controller activates this output until all alarms with a *Trip AVR* (or similar) alarm action are not active.

# 10.8 GENSET controller alarms

## 10.8.1 GENSET controller alarms

These alarms are in addition to the AC protections and general alarms for the controllers.

**Alarms for the GENSET controller**

| | Alarms |
|---|---|
| **Engine** | Emergency stop |
| | Overspeed (2 alarms) |
| | Under-speed (2 alarms) |
| | Crank failure |
| | Primary running feedback failure |
| | Start failure |
| | Stop failure |
| | Engine stop (external) |
| | Engine start (external) |
| | Start enable removed during start |
| | Total running hours notification |
| | Trip running hours notification |
| | Magnetic pickup wire break |
| **Generator** | Voltage or frequency not OK |
| **Regulation** | GOV regulation error |
| | GOV regulation mode not selected |
| | GOV relay setup incomplete |
| | AVR regulation error |
| | AVR regulation mode not selected |
| | AVR relay setup incomplete |
| **Non-essential load (NEL)** | • Up to 3 non-essential loads per controller<br>• Can connect each controller to the same 3 non-essential load breakers |
| | NEL # over-current (1 alarm for each non-essential load) |
| | NEL # under-frequency (1 alarm for each non-essential load) |
| | NEL # overload 1 and 2 (2 alarms for each non-essential load) |
| | NEL # reactive overload (1 alarm for each non-essential load) |
| **Other** | Trip AVR output not configured |

## 10.8.2 Alarm actions

The controller has the following alarm actions:

- Warning
- Block generator breaker
- Trip generator breaker
- Trip generator breaker and stop engine
- Trip generator breaker and shutdown engine

- Trip AVR *
- Trip generator breaker + AVR *
- Trip generator breaker + AVR + stop engine *
- Trip generator breaker + AVR + shutdown engine *

**NOTE** * These alarm actions are only available if the *Trip AVR* digital output is configured.

### 10.8.3 Inhibits

| Inhibit | Disables the alarm when ... |
|---|---|
| Engine running | *Digital running detection* is ON. |
| Engine not running | *Digital running detection* is OFF. |
| Generator breaker closed | The `Breakers > Generator breaker > Feedback > GB closed` digital input is activated. |
| Generator breaker open | The `Breakers > Generator breaker > Feedback > GB open` digital input is activated. |
| Generator voltage present | The generator voltage is above 10 % of the nominal voltage. |
| No generator voltage | The generator voltage is below 10 % of the nominal voltage. |
| Generator frequency present | The generator frequency is above 10 % of the nominal frequency. |
| No generator frequency | The generator frequency is below 10 % of the nominal frequency. |
| Engine stopping | The engine is in the stop sequence. |
| Idle run active | The engine idle run is active. |
| Mains in parallel | A mains is connected to the system. |
| Mains not in parallel | No mains is connected to the system. |
| 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 1 | The `Alarm system > Inhibits > Activate inhibit 1` digital input is activated. |
| Inhibit 2 | The `Alarm system > Inhibits > Activate inhibit 2` digital input is activated. |
| Inhibit 3 | The `Alarm system > Inhibits > Activate inhibit 3` digital input is activated. |

### 10.8.4 Breaker alarms

**More information**
See Breakers, synchronisation and de-loading for breaker handling and alarms in general.

| GENSET alarm | Parameters | General name |
|---|---|---|
| GB synchronisation failure | `Breakers > Generator breaker monitoring > Synchronisation failure` | Breaker synchronisation failure |
| GB de-load failure | `Breakers > Generator breaker monitoring > De-load failure` | Breaker de-load failure |
| Vector mismatch | `Breakers > Generator breaker monitoring > Vector mismatch` | Vector mismatch |

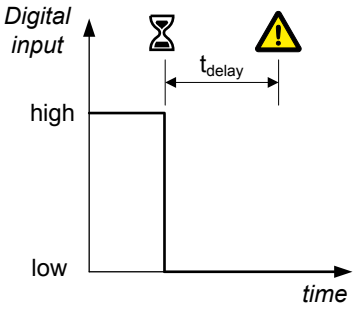
| GENSET alarm | Parameters | General name |
|---|---|---|
| GB opening failure | `Breakers > Generator breaker monitoring > Opening failure` | Breaker opening failure |
| GB closing failure | `Breakers > Generator breaker monitoring > Closing failure` | Breaker closing failure |
| GB position failure | `Breakers > Generator breaker monitoring > Position failure` | Breaker position failure |
| GB trip (external) | `Breakers > Generator breaker monitoring > Tripped (external)` | Breaker trip (external) |
| GB short circuit | `Breakers > Generator breaker monitoring > Short circuit` | Breaker short circuit |
| GB configuration failure | - | Breaker configuration failure |
| Generator phase sequence error | `Generator > AC setup > Phase sequence error` | Phase sequence error |
| Busbar phase sequence error | `Busbar > AC setup > Phase sequence error` | Phase sequence error |

## 10.8.5 AC alarms

**More information**
See the **Data sheet** for the AC alarms for this controller type. See the **AC configuration** chapter for descriptions of the AC protections.

## 10.8.6 Emergency stop

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




| Function | I/O | Type | Details |
|---|---|---|---|
| `Alarm system > Additional functions > 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, then the controller activates the emergency stop function and the *Emergency stop* alarm. |

**CAUTION**

**The Emergency stop is part of the safety chain**

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. 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.

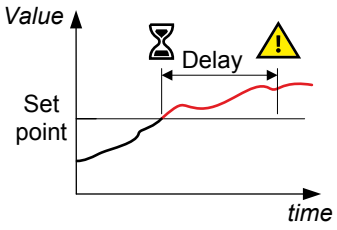
**Engine > Emergency stop > Emergency stop**

| Parameter | Range |
|---|---|
| Delay | 0.0 s to 1 min |

## 10.8.7 Overspeed

These two alarms are for overspeed protection.

The alarm response is based on the genset speed, as measured by the MPU/W/NPN/PNP input.




**Engine > Protections > Speed > Overspeed # ***

In addition to these overspeed alarms, one of the controller's digital inputs can be connected to hardware that detects overspeed. A customised alarm for overspeed can then be configured on that digital input.

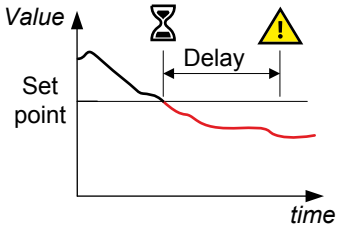
| Parameter | Range |
|---|---|
| Set point | 10.0 to 150.0 % of nominal speed |
| Delay | 0.0 s to 3 min |

**NOTE** * # is 1 or 2.

## 10.8.8 Underspeed

This alarm alerts the operator that a genset is running too slowly.

The alarm response is based on the engine speed as a percentage of the nominal speed. If the engine speed drops below the set point for the delay time, then the alarm is activated.




**Engine > Protections > Speed > Under-speed # ***

| Parameter | Range |
|---|---|
| Set point (lower than) | 0.0 to 100.0 % of nominal speed |
| Delay | 0.0 s to 3 min |

**NOTE** * # is 1 or 2.

## 10.8.9 Oil pressure

This alarm is activated if the oil pressure exceeds the set point.

**Engine > Protections > Pressure > Oil pressure # ***

| Parameter | Range |
|---|---|
| Set point | 0.0 to 10.0 bar |
| Delay | 0.0 s to 3 min |

**NOTE** * # is 1 or 2.

## 10.8.10 Oil temperature

This alarm is activated if the oil temperature exceeds the set point.

**Engine > Protections > Temperature > Oil temperature # ***

| Parameter | Range |
|---|---|
| Set point | 0.0 to 200.0 °C |
| Delay | 0.0 s to 3 min |

**NOTE** * # is 1 or 2.

## 10.8.11 Coolant temperature

This alarm is activated if the coolant temperature exceeds the set point.

**Engine > Protections > Temperature > Coolant temperature # ***

| Parameter | Range |
|---|---|
| Set point | 0.0 to 200.0 °C |
| Delay | 0.0 s to 3 min |

**NOTE** * # is 1 to 3.

## 10.8.12 Coolant level

This alarm is activated if the coolant level is under the set point.

**Engine > Protections > Level > Coolant level # ***

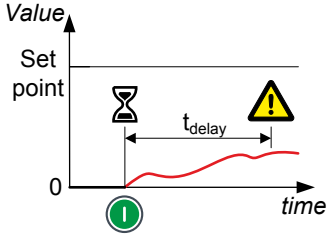
| Parameter | Range |
|---|---|
| Set point | 0.0 to 100.0 % |
| Delay | 0.0 s to 3 min |

**NOTE** * # is 1 to 3.

## 10.8.13 Crank failure

The alarm response is based on the MPU/W/NPN/PNP input. This alarm is only available if the magnetic pickup (MPU) has been chosen as the primary running feedback.

The timer starts when cranking starts (that is, when the *Crank* output is activated). The alarm is activated if the set point has not been reached within the delay time.



**Engine > Start sequence > Crank failure**

| Parameter | Range |
|---|---|
| Set point (lower than) | 1.0 to 400.0 RPM |
| Delay | 0.0 to 20.0 s |

## 10.8.14 Running detection not reached

This alarm is activated if the running detection level is not reached.

**Engine > Start sequence > Running detection not reached**

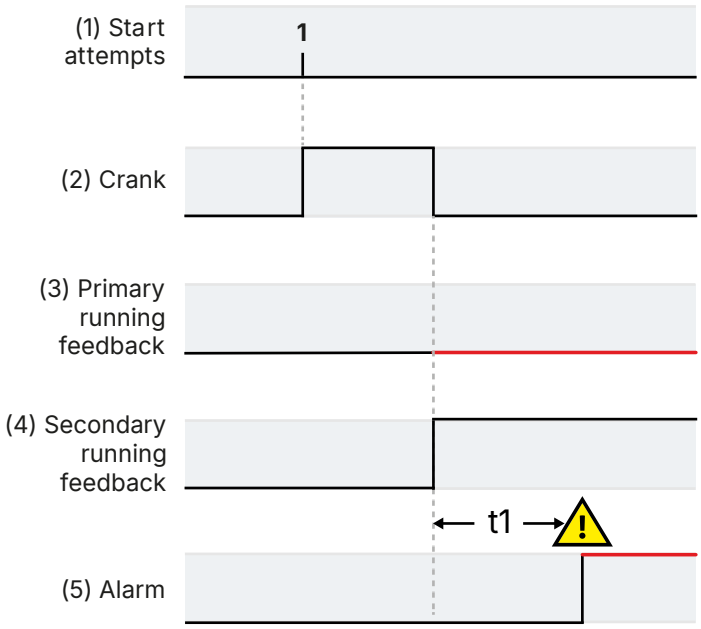
| Parameter | Range |
|---|---|
| Run detection not reached | 1 s to 20 min |

## 10.8.15 Primary running feedback failure

This alarm is for genset running feedback failure. This alarm is only available if more than one running feedback is present. The alarm is activated if running is detected on any of the secondary running feedbacks but not on the primary running feedback.

The sequence diagram on the right shows how the primary running feedback failure alarm works.

1. **Start attempt**: The controller gets a start signal.
2. **Crank**: The controller activates the *Crank* output.
3. **Primary running feedback**: If the primary running feedback has failed, it does not detect the genset start.
4. **Secondary running feedback**: The secondary running feedback detects the genset start. The crank stops after running is detected. The alarm timer starts when running is detected on the secondary running feedback, but not on the primary running feedback.
5. **Alarm**: If the primary running feedback does not detect that the genset has started within the delay time (t1), the *Primary running feedback failure* alarm is activated.




**Engine > Running detection > Primary running feedback failure**

This alarm is always *Enabled*.

| Parameter | Range |
|---|---|
| Delay | 0.0 s to 3 min |

## 10.8.16 Magnetic pickup wire break

This alarm is activated if there is a magnetic pickup wire break.

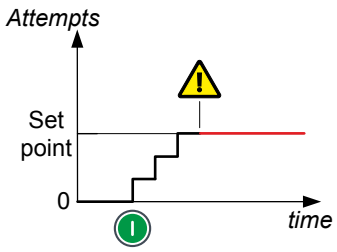
**Engine > Running detection > Magnetic pickup wire break**

| Parameter | Range |
|---|---|
| Delay | 1 s to 1 h |

## 10.8.17 Start failure

This alarm is for genset start failure.

If the genset has not started after the maximum number of start attempts are completed, the controller activates this alarm.




**Engine > Start sequence > Start failure**

## 10.8.18 Start enable removed during start

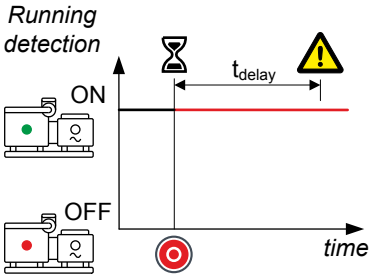
The alarm response is based on the engine start-up sequence. This alarm is activated if the engine start-up procedure is interrupted by the loss of the *Start enable* input before the engine has started.

**Engine > Start sequence > Start enable remove during start**

## 10.8.19 Stop failure

This alarm is for genset stop failure.

The controller attempts to stop the genset by activating the *Stop coil* output (if present) or alternatively, by deactivating the *Run coil* output (if present). If *Running detection* is still ON after the delay time, the controller activates this alarm.



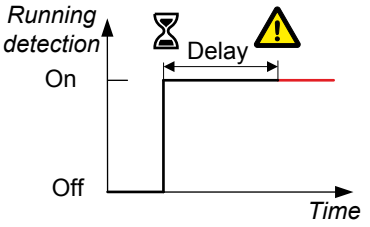

**Engine > Stop sequence > Stop failure**

| Parameter | Range |
|---|---|
| Delay | 10.0 s to 2 min |

## 10.8.20 Engine started (external)

This alarm is to alert the operator to an externally-initiated engine start.

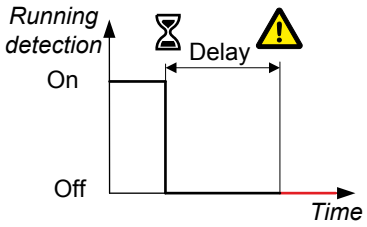
The alarm is activated if the controller did not initiate an engine start, but *Running detection* shows that the engine is running.



## 10.8.21 Engine stopped (external)

This alarm alerts the operator to an externally-initiated engine stop.

The alarm is activated if the controller did not initiate an engine stop, but *Running detection* shows that the engine has stopped.



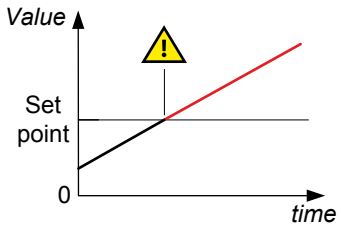

**Engine > Stop sequence > Externally stopped**

| Parameter | Range |
|---|---|
| Delay | 1 to 1200 s |

## 10.8.22 Running hours notification

This alarm notifies the operator when the total running hours exceeds the set point.

The alarm response is based on the *Total running hours* counter.




**Engine > Maintenance > Service timer > Service timer # ***

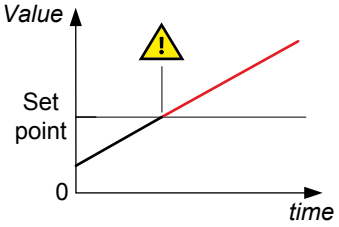
| Parameter | Range |
|---|---|
| Set point | 0 to 9000 h |

**NOTE** * # is 1 to 4.

## 10.8.23 Trip running hours notification

This alarm notifies the operator when the trip running hours exceeds the set point.

The alarm response is based on the *Trip running hours* counter.




**Engine > Maintenance > Running hours trip**

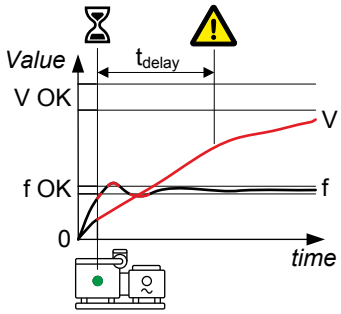
| Parameter | Range |
|---|---|
| Set point | 0 to 1,000,000 hours |

## 10.8.24 Voltage or frequency not OK

This alarm alerts the operator that the voltage or frequency is not in the required operation range within a specified time after running detection is active.

A delay timer starts when running detection activates. If the voltage and frequency are not in the required operation ranges when the delay timer expires the alarm activates.

The alarm response is based on the voltage and frequency from the A-side.




**`[A-side] > AC setup > Voltage or frequency not OK`**

The alarm action is always *Block*.

| Parameter | Range |
|---|---|
| `Delay` | 1 s to 1 h |

## 10.8.25 Other GENSET controller alarms

The following alarms are also included on the **GENSET** controller:

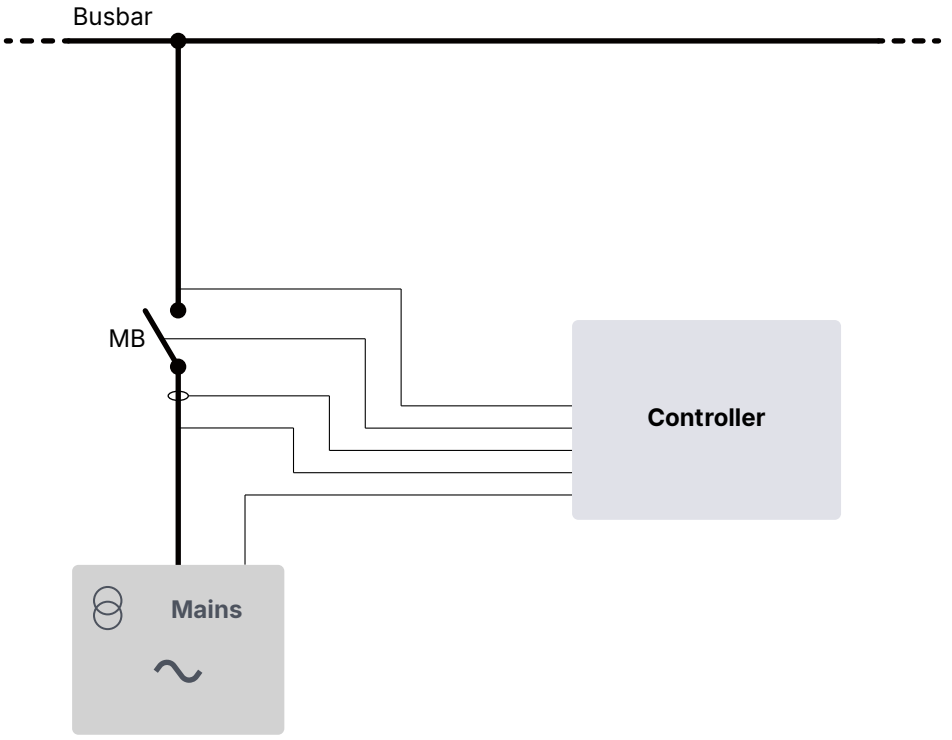
- Magnetic pickup wire break
- P load sharing failure
- Q load sharing failure

# 11. MAINS controller

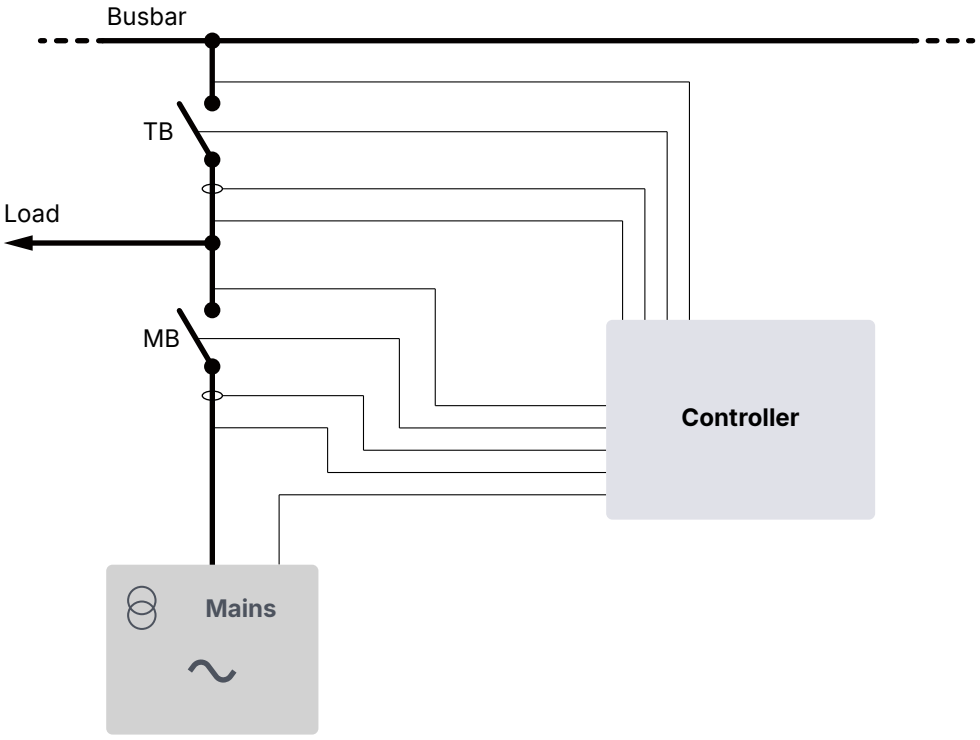
## 11.1 About the MAINS controller

A **MAINS** controller controls a mains breaker (MB) to a mains connection, with or without a tie breaker (TB) to a load point.

**Example application with no tie breaker**




**Example application with tie breaker**



### 11.1.1 MAINS controller functions

| | Functions |
|---|---|
| **Synchronisation and de-loading** | • Broadcast sychronisation/de-loading information for GENSET controllers |
| **Mains** | • Configurable supervision |
| **4th current** | • Measure mains power or neutral current, and can also be used for protections |
| **Counters** | • Display unit counters, to edit or reset<br>◦ Breaker operations and trips<br>◦ External breaker operations<br>◦ Energy export to mains (active and reactive)<br>◦ Energy import from mains (active and reactive)<br>◦ Energy differential (active and reactive)<br>• Energy counters with configurable digital outputs (for external counters)<br>◦ Energy export to mains (active and reactive)<br>◦ Energy import from mains (active and reactive)<br>◦ Energy differential (active and reactive) |

## 11.2 MAINS controller principles

### 11.2.1 MAINS controller nominal settings

**`Mains > Nominal settings > Nominal settings # *`**

| Nominal setting | Range | Notes |
|---|---|---|
| `Voltage (V)` | 10.0 V to 1.5 MV | The phase-to-phase** nominal voltage for the **MAINS** controller. |
| `Current (I)` | 1.0 A to 9 kA | The maximum current flow in one phase (that is, L1, L2 or L3) during normal operation. |
| `Frequency (f)` | 20.00 to 100.00 Hz | The system nominal frequency. All the controllers in the system should have the same nominal frequency. |
| `Power (P)` | 1.0 kW to 900 MW | Configure the value according to the mains connection. Set the value to ensure the mains connection over-power protection is triggered at the correct time. |
| `Apparent power (S)` | 1.0 kVA to 1 GVA | Mains connection apparent power. |
| `Power factor (PF)` | 0.6000 to 1.0000 | Mains connection power factor. |

**NOTE** * # is 1 to 4.
**NOTE** ** In a single-phase set up the nominal AC voltage is phase-to-neutral.

The controller uses the nominal settings to calculate the nominal reactive power (nominal Q) for the mains connection. The controller can be configured to calculate the nominal active power (nominal P) or the nominal apparent power (nominal S). In this case, the controller uses the calculated values, and ignores any entered values.

**More information**
See Nominal power calculations.

# 11.3 Mains breaker

## 11.3.1 How it works

The mains breaker (MB) connects the mains to the busbar. The mains breaker is an important part of the system safety, and trips to protect the busbar from mains problems. The mains breaker also trips to stop busbar problems from disturbing the mains.

For the **MAINS** controller, the breaker abbreviation (*[*B]*) is *MB*. *[Breaker]* refers to *Mains breaker*.

## 11.3.2 Mains breaker synchronisation

When the breaker close button is pressed, the **MAINS** controller tries to synchronise and close the breaker. You can use a parameter to determine what kind of synchronisation to use.

Regardless of the regulation, if the synchronisation requirements are met (within the time available for synchronisation), the controller automatically closes the breaker.

### Parameters

**`Breakers > Mains breaker configuration > Synchronisation setting`**

| Parameter | Range | Notes |
|---|---|---|
| `Sync. type` | • Static<br>• Dynamic<br>• Automatic | **Static**: See details below.<br><br>**Dynamic**: See details below.<br><br>**Automatic**: See details below. |

### Static synchronisation

The **MAINS** controller uses the static synchronisation parameters to determine when there is synchronisation.

### Dynamic synchronisation

The **MAINS** controller uses the dynamic synchronisation parameters to determine when there is synchronisation.

The **MAINS** controller broadcasts synchronisation set points for the **GENSET** controllers in the busbar section connected to the mains breaker. The **GENSET** controller(s) with active regulation modes ignore their regulation modes and automatically regulate based on the synchronisation set points from the **MAINS** controller. When the mains breaker is closed, the **GENSET** controllers return to their previous regulation modes.

If the **GENSET** controller(s) regulation is off or under *Manual regulation*, the controller(s) ignore the set points from the **MAINS** controller. The busbar can be synchronised manually if the **GENSET** controllers are under *Manual regulation*.

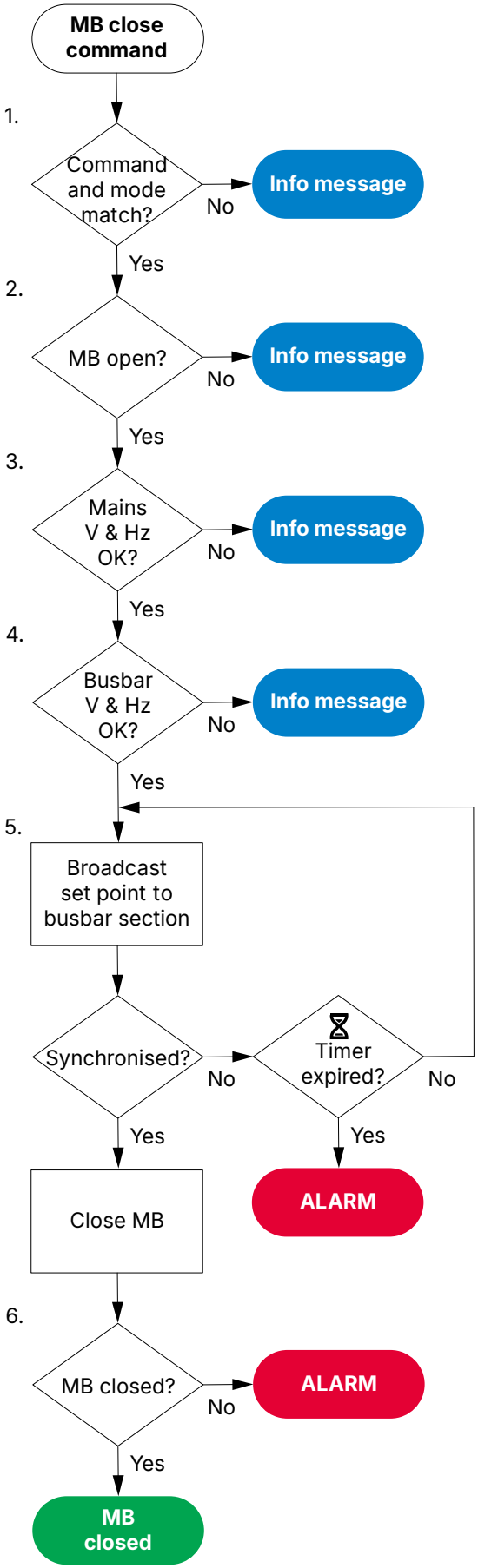
### Automatic

The **MAINS** controller automatically determines the type of synchronisation to use. The **MAINS** controller checks the information for the busbar section connected to the mains breaker. If the section can be regulated, the controller uses dynamic synchronisation. Otherwise the controller uses static synchronisation.

To connect to a busbar section that is already connected to the same mains, you must always use *Static* or *Automatic*.

**More information**
See Breakers, synchronisation and de-loading for synchronisation and breakers. This includes the inputs and output functions and the parameters to configure.

## 11.3.3 Mains breaker close flowchart




1. **Command and mode match**: The controller checks that the command source and the controller mode match:
   - In REMOTE mode, the command to close the breaker can come from a digital input, PICUS, Modbus, CustomLogic, and/or CODESYS.
   - In LOCAL mode, the operator can press the push-button **Close breaker** CLOSE on the display unit. The controller ignores all other commands.
2. **MB open**: The controller checks whether the breaker is open. If the breaker is already closed, the sequence stops, and an info message is shown.
3. **Mains V & Hz OK**: The controller checks whether the voltage and frequency are within the allowed range*. If these are not in the range, then the controller cancels the close command and displays an info message.
4. **Busbar V & Hz OK**: Subject to the *Blackout close* parameter:
   - The controller checks whether the voltage and frequency on the busbar are within range*. If these are not in the range, then the controller cancels the close command and displays an information message.
   - See Mains breaker blackout close flowchart for more information.
5. **Broadcast set point to busbar section**: The controller broadcasts the required set point on the busbar section.
   - If the mains and busbar are synchronised, the controller activates the `Breakers > Mains breaker > Controls > MB close` output to close the breaker.
   - If the mains and busbar do not synchronise within the time allowed, the controller activates an *MB synchronisation failure* alarm.
6. **MB closed**: The controller checks whether the breaker has closed.
   - If the breaker has closed, the breaker close sequence has been completed successfully.
   - If the breaker has not closed, the controller activates the *MB closing failure* alarm.

**NOTE** * See `[Source] / [Busbar] > AC setup > Voltage and frequency OK` for these ranges.

**More information**
See Mains breaker blackout close flowchart for information about how to allow the **MAINS** controller to connect to a dead busbar.

### 11.3.4 Mains breaker de-loading

When the breaker open button is pressed, the **MAINS** controller checks whether regulation is possible in the busbar section connected to the mains breaker. If regulation is not possible, the controller trips the breaker (without de-loading).

If regulation is possible, the **MAINS** controller tries to de-load and open the breaker.

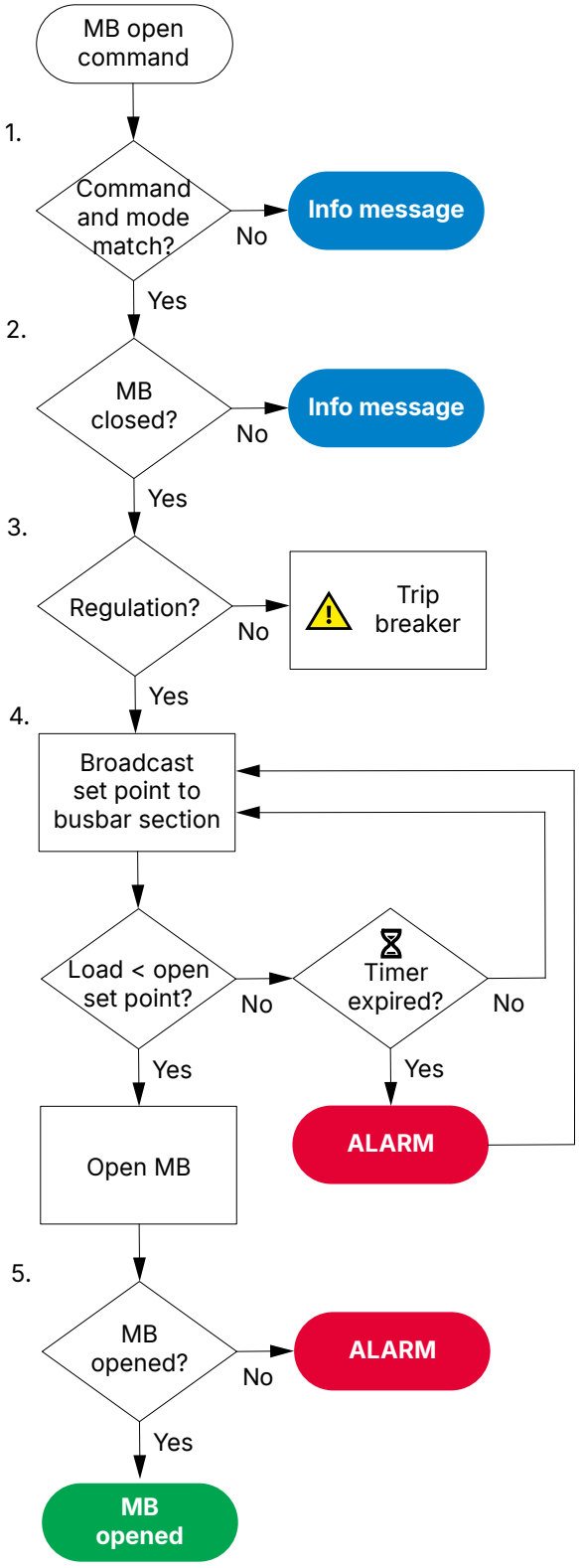
The **MAINS** controller broadcasts the de-loading set points for the **GENSET** controllers in the busbar section connected to the mains breaker. The **GENSET** controller(s) with active regulation modes automatically respond to de-loading set points from the **MAINS** controller. When the mains breaker is open, the **GENSET** controllers return to their previous regulation modes.

The set points from the **MAINS** controller are ignored by **GENSET** controllers in these cases:

- The **GENSET** controller is in fixed power mode, with set point adjustment locked.
- The **GENSET** controller regulation is off.
- The **GENSET** controller is under *Manual regulation*. However, the mains breaker can be de-loaded manually.

### 11.3.5 Mains breaker open flowchart

The alarm action *Block* does not open a closed breaker, although it stops an open breaker from closing. If the controller or an operator sends an MB open command while *Block* is active, the controller uses this sequence.




1. **Command and mode match**: The controller checks that the command source and the controller mode match:
   - In REMOTE mode, the command to open the genset breaker can come from a digital input, PICUS, Modbus, CustomLogic, and/or CODESYS.
   - In LOCAL mode, the operator can press the push-button **Open breaker** OPEN on the display unit. The controller ignores all other commands.
2. **MB closed**: The controller checks whether the breaker is closed. If the breaker is open, the sequence ends.
3. **Regulation**: The controller checks whether regulation is possible in the sections connected to the bus tie breaker.
   - If regulation is not possible, the controller trips the breaker.
   - If regulation is possible, the controller tries to de-load the breaker.
4. **Broadcast set point to busbar section**: The controller broadcasts the required set point on the busbar section.
   - When the load is less than the set point for the breaker to open, the controller activates the `Breakers > Mains breaker > Controls > MB open` output.
   - If the controller cannot de-load the breaker before the de-load timer expires, the controller activates the *MB de-load failure* alarm. The controller continues to try to de-load the breaker.
5. **MB opened**: The controller checks whether the breaker has opened:
   - If the breaker has opened, the mains breaker open sequence has been completed successfully.
   - If the breaker has not opened, the controller activates the *MB opening failure* alarm.

**CAUTION**

**Possible blackout**

Opening the mains breaker may cause a blackout.

## 11.3.6 Mains breaker blackout close flowchart

The *Blackout close* function sets the action that the controller allows when a dead busbar is detected. An operator or a remote input can close the breaker even though there is a blackout (if the parameter is not *Blackout close is OFF*).

**DANGER!**

**Incorrect blackout close settings**

Incorrect blackout close parameter settings can lead to equipment damage or loss of life.

### Blackout conditions

A blackout is present if 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:

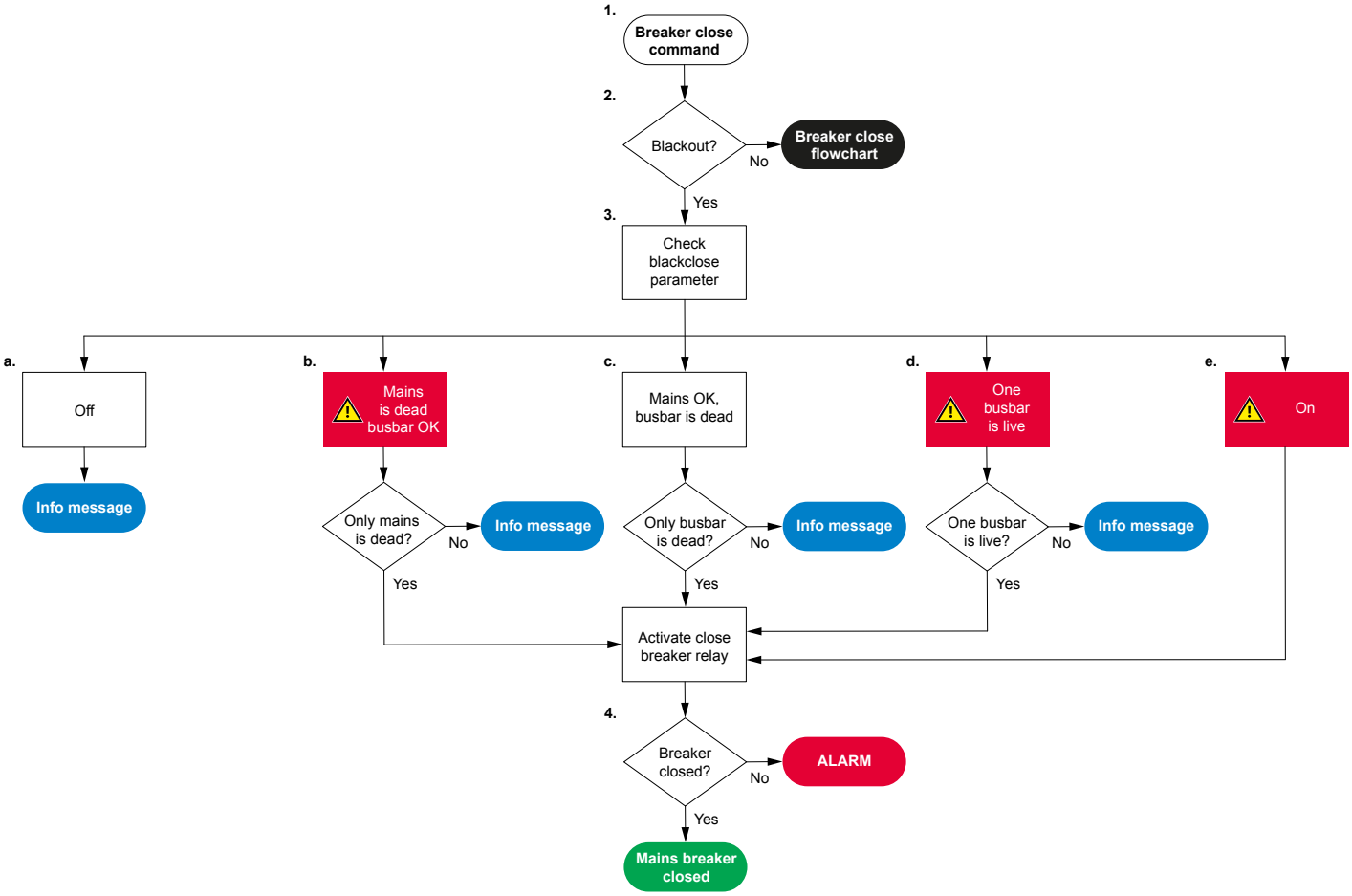
- The breaker position is unknown.
- There is a short circuit.
  - A digital input with the function `Breakers > Mains breaker > Feedback > MB short circuit` was activated.
- There is a blocking alarm.
  - The alarm action determines whether the alarm is a blocking alarm.
- The busbar AC measurements are not OK.
  - A measurement failure is detected on one or more of the phases of the busbar.
- The `Busbar > AC setup > Blackout detection > Blackout delay` timer has not expired.

### Parameters

**`Breakers > Mains breaker configuration`**

| Name | Range | Notes |
|---|---|---|
| `Blackout close` | • Blackout close is OFF<br>• Mains is dead, busbar OK<br>• Mains OK, busbar is dead<br>• One busbar is alive<br>• On | **Blackout close is OFF**: The breaker is not allowed to close unless both mains and busbar are live and synchronised.<br><br>**Mains is dead, busbar OK**: If a blackout is detected at the mains, but the busbar is stable, then the controller allows the breaker to close.<br><br>**Mains OK, busbar is dead**: If a blackout is detected at the busbar and the mains is stable, then the controller allows the breaker to close.<br><br>**One busbar is live**: If either mains or busbar is alive, then the controller allows the breaker to close.<br><br>**On**: The breaker is always allowed to close. |

### Blackout close flowchart



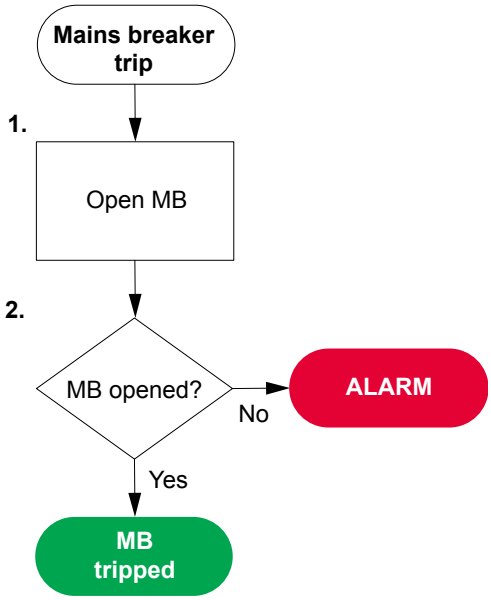

1. **Breaker close command**: An operator or a remote command attempts to close the breaker.
2. **Blackout**: The controller detects a blackout on one or both of the busbars, and the conditions for blackout close are met.
3. **Check *Blackout close* parameter**:
   a. **Blackout close is OFF**: The controller does not allow the breaker to close. The controller shows an info message, and the sequence ends.
   b. **Mains is dead, busbar OK**: The controller checks whether the blackout was detected only at the mains.
      - *Blackout only at the mains*: The controller activates the close breaker relay.
      - *Blackout was only at the busbar or on both sides of the breaker*: The controller shows an info message, and the sequence ends.
   c. **Mains OK, busbar is dead**: The controller checks whether the blackout was detected only at the busbar.
      - *Blackout only at the busbar*: The controller activates the close breaker relay.
      - *Blackout only at the mains or on both sides of the breaker*: The controller shows an info message and the sequence ends.
   d. **One busbar is live**: The controller checks if the blackout was detected only at the mains, or only at the busbar.
      - *Blackout only at the mains, or only at the busbar*: The controller activates the close breaker relay.
      - *Blackout on both sides of the breaker*: The controller shows an info message and the sequence ends.
   e. **On**: If there is a blackout on either mains or busbar, the controller activates the close breaker relay.
4. **Breaker closed**: The controller checks whether the mains breaker has closed.
   - If the mains breaker has closed, the blackout close sequence has been completed successfully.
   - If the mains breaker has not closed the controller activates the *MB closing failure* alarm.

## 11.3.7 Mains breaker trip flowchart

The controller automatically trips the mains breaker (MB) for this alarm action:

- Trip mains breaker

The breaker is not de-loaded for a trip.




1. **Open MB**: When a trip is required, the controller activates the `Breakers > Mains breaker > Controls > MB open` output to open the breaker.
2. **MB opened**: 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 *MB opening failure* alarm.

## 11.4 Tie breaker

### 11.4.1 How it works

The tie breaker (TB) connects a load point to the busbar. The tie breaker is an important part of the system safety, and trips to protects both busbars from problems. The tie breaker also trips to stop busbar problems from disturbing the other busbar.

For the **MAINS** controller, the breaker abbreviation (*[*B]*) is *TB*. *[Breaker]* refers to *Tie breaker*.

### 11.4.2 Tie breaker synchronisation

When the tie breaker close button is pressed, the **MAINS** controller tries to synchronise and close the tie breaker. You can use a parameter to determine what kind of synchronisation to use.

Regardless of the regulation, if the synchronisation requirements are met (within the time available for synchronisation), the controller automatically closes the breaker.

#### Parameters

**`Breakers > Tie breaker configuration > Synchronisation setting`**

| Parameter | Range | Notes |
|---|---|---|
| `Sync. type` | • Static<br>• Dynamic | **Static**: See details below.<br><br>**Dynamic**: See details below. |

#### Static synchronisation

The **MAINS** controller uses the static synchronisation parameters to determine when there is synchronisation.

#### Dynamic synchronisation

The **MAINS** controller uses the dynamic synchronisation parameters to determine when there is synchronisation.

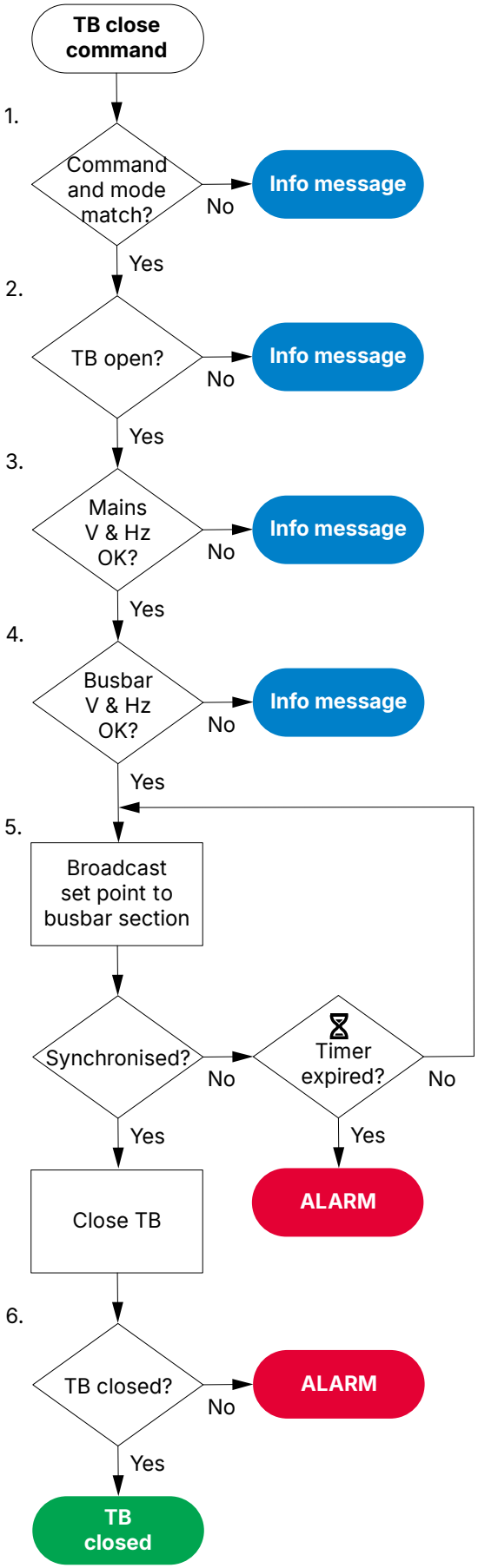
The **MAINS** controller broadcasts synchronisation set points for the **GENSET** controllers in the busbar section connected to the mains breaker. The **GENSET** controller(s) with active regulation modes ignore their regulation modes and automatically

regulate based on the synchronisation set points from the **MAINS** controller. When the tie breaker is closed, the **GENSET** controllers return to their previous regulation modes.

If the **GENSET** controller(s) regulation is off or under *Manual regulation*, the controller(s) ignore the set points from the **MAINS** controller. The busbar can be synchronised manually if the **GENSET** controllers are under *Manual regulation*.

**More information**
See Breakers, synchronisation and de-loading for synchronisation and breakers. This includes the inputs and output functions and the parameters to configure.

## 11.4.3 Tie breaker close flowchart




1. **Command and mode match**: The controller checks that the command source and the controller mode match:
   - In REMOTE mode, the command to close the breaker can come from a digital input, PICUS, Modbus, CustomLogic, and/or CODESYS.
   - In LOCAL mode, the operator can press the push-button **Close breaker** CLOSE on the display unit. The controller ignores all other commands.
2. **TB open**: The controller checks whether the breaker is open. If the breaker is already closed, the sequence stops, and an info message is shown.
3. **Mains V & Hz OK**: The controller checks whether the voltage and frequency are within the allowed range*. If these are not in the range, then the controller cancels the close command and displays an info message.
4. **Busbar V & Hz OK**: Subject to the *Blackout close* parameter:
   - The controller checks whether the voltage and frequency on the busbar are within range*. If these are not in the range, then the controller cancels the close command and displays an information message.
5. **Broadcast set point to busbar section**: The controller broadcasts the required set point on the busbar section.
   - If busbar A and busbar B are synchronised, the controller activates the `Breakers > Tie breaker > Control > TB close` output to close the breaker.
   - If busbar A and busbar B do not synchronise within the time allowed, the controller activates an *TB synchronisation failure* alarm.
6. **TB closed**: The controller checks whether the breaker has closed.
   - If the breaker has closed, the breaker close sequence has been completed successfully.
   - If the breaker has not closed, the controller activates the *TB closing failure* alarm.

**NOTE** * See `[Source] / [Busbar] > AC setup > Voltage and frequency OK` for these ranges.

### 11.4.4 Tie breaker de-loading

When the tie breaker open button is pressed, the **MAINS** controller checks whether regulation is possible in the busbar sections connected to the tie breaker. If regulation is not possible, the controller trips the breaker (without de-loading).

If regulation is possible, the **MAINS** controller tries to de-load and open the breaker.

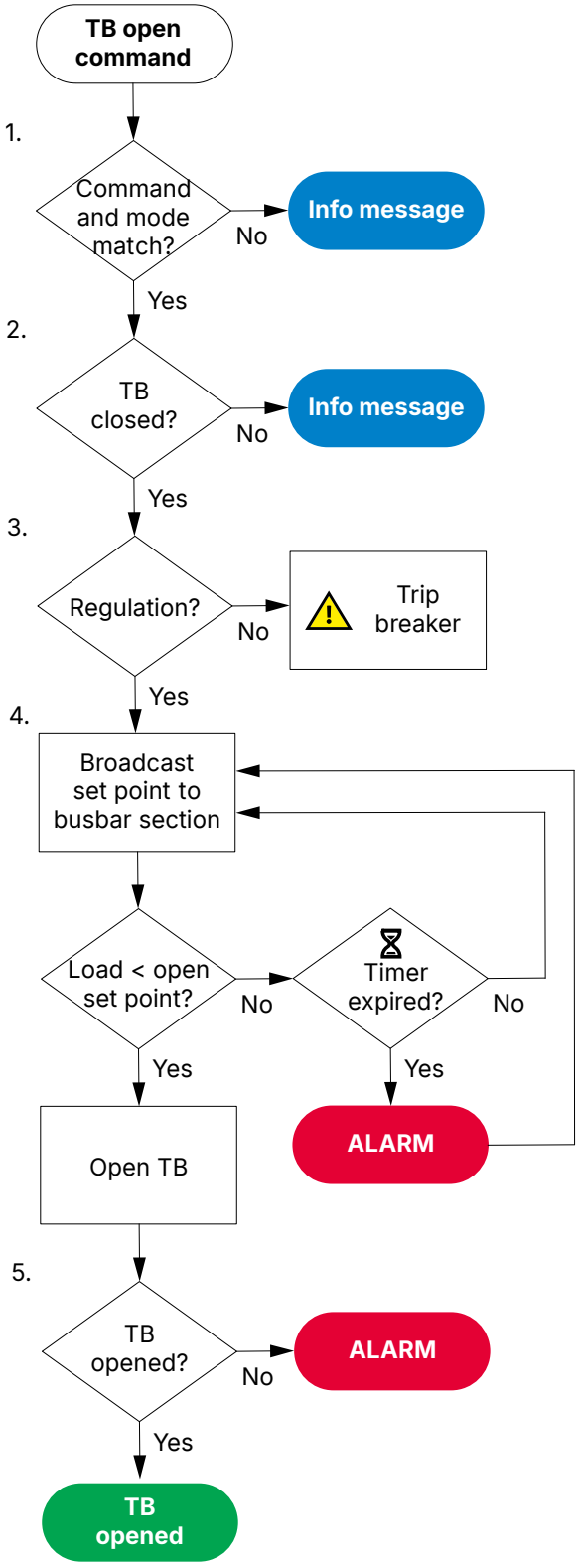
The **MAINS** controller broadcasts de-loading set points for the **GENSET** controllers in the busbar sections connected to the tie breaker. The **GENSET** controller(s) with active regulation modes ignore their regulation modes and automatically respond to de-loading set points from the **MAINS** controller. When the tie breaker is open, the **GENSET** controllers return to their previous regulation modes.

The set points from the **MAINS** controller are ignored by **GENSET** controllers in these cases:

- The **GENSET** controller is in fixed power mode, with set point adjustment locked.
- The **GENSET** controller regulation is off.
- The **GENSET** controller is under *Manual regulation*. However, the bus tie breaker can be de-loaded manually.

### 11.4.5 Tie breaker open flowchart

The alarm action *Block* does not open a closed breaker, although it stops an open breaker from closing. If the controller or an operator sends an TB open command while *Block* is active, the controller uses this sequence.




1. **Command and mode match**: The controller checks that the command source and the controller mode match:
   - In REMOTE mode, the command to open the genset breaker can come from a digital input, PICUS, Modbus, CustomLogic, and/or CODESYS.
   - In LOCAL mode, the operator can press the push-button **Open breaker** OPEN on the display unit. The controller ignores all other commands.
2. **TB closed**: The controller checks whether the tie breaker is closed. If the tie breaker is open, the sequence ends.
3. **Regulation**: The controller checks whether regulation is possible in the sections connected to the tie breaker.
   - If regulation is not possible, the controller trips the tie breaker.
   - If regulation is possible, the controller tries to de-load the tie breaker.
4. **Broadcast set point to busbar section**: The controller broadcasts the required set point on the busbar section.
   - When the load is less than the set point for the tie breaker to open, the controller activates the `Breakers > Tie breaker > Controls > TB open` output.
   - If the controller cannot de-load the tie breaker before the de-load timer expires, the controller activates the *TB de-load failure* alarm. The controller continues to try to de-load the tie breaker.
5. **TB opened**: The controller checks whether the tie breaker has opened:
   - If the tie breaker has opened, the mains breaker open sequence has been completed successfully.
   - If the tie breaker has not opened, the controller activates the *TB opening failure* alarm.

**CAUTION**

**Possible blackout**

Opening the tie breaker may cause a blackout.

## 11.4.6 Tie breaker blackout close flowchart

The *Blackout close* function sets the action that the controller allows when a dead busbar is detected. An operator or a remote input can close the breaker even though there is a blackout (if the parameter is not *Blackout close is OFF*).

**DANGER!**

**Incorrect blackout close settings**

Incorrect blackout close parameter settings can lead to equipment damage or loss of life.

### Blackout conditions

A blackout is present if 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:

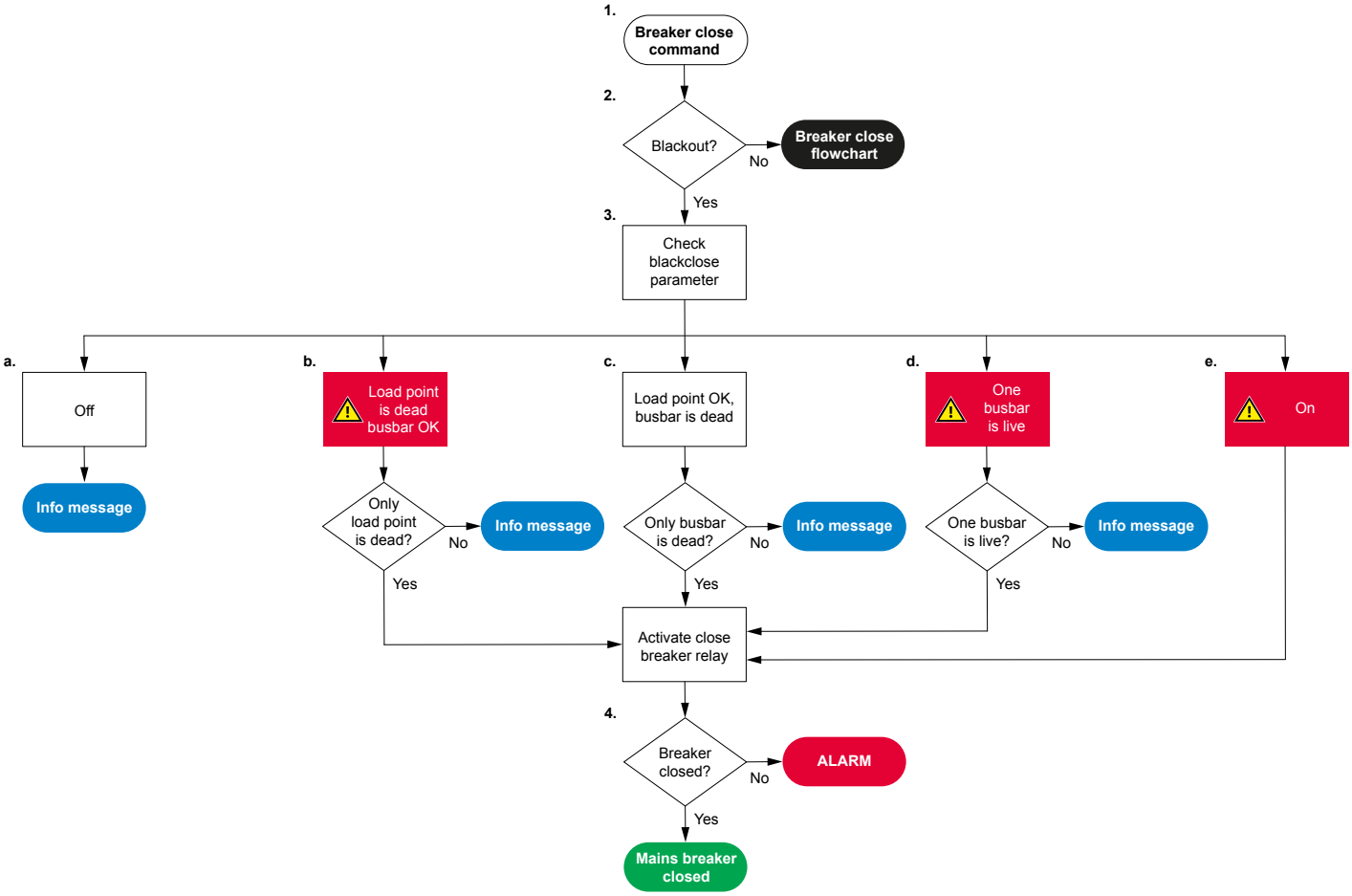
- The breaker position is unknown.
- There is a short circuit.
  - A digital input with the function `Breakers > Tie breaker > Feedback > TB short circuit` was activated.
- There is a blocking alarm.
  - The alarm action determines whether the alarm is a blocking alarm.
- The busbar AC measurements are not OK.
  - A measurement failure is detected on one or more of the phases of the busbar.
- The `Busbar > AC setup > Blackout detection > Blackout delay` timer has not expired.

### Parameters

**`Breakers > Tie breaker configuration`**

| Name | Range | Default | Notes |
|---|---|---|---|
| `Blackout close` | • Blackout close is OFF<br>• Load point is dead, busbar OK<br>• Load point OK, busbar is dead<br>• One busbar is alive<br>• On | Blackout close is OFF | **Blackout close is OFF**: The breaker is not allowed to close unless both load point and busbar are live and synchronised.<br><br>**Load point is dead, busbar OK**: If a blackout is detected at the load point, but the busbar is stable, then the controller allows the breaker to close.<br><br>**Load point OK, busbar is dead**: If a blackout is detected at the busbar and the load point is stable, then the controller allows the breaker to close.<br><br>**One busbar is alive**: If either load point or busbar is live, then the controller allows the breaker to close.<br><br>**On**: The breaker is always allowed to close. |

### Blackout close flowchart



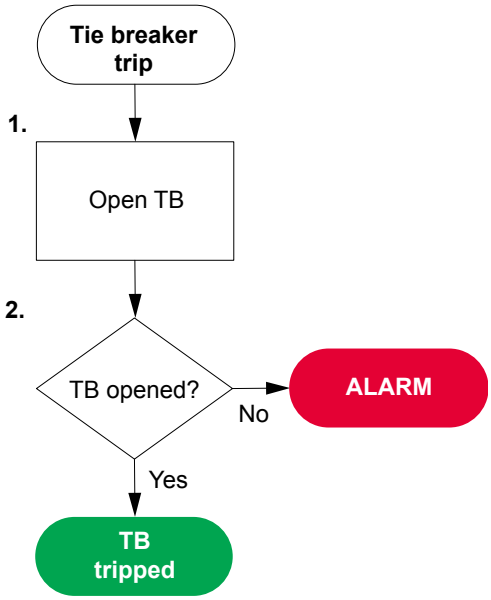

1. **Breaker close command**: An operator or a remote command attempts to close the breaker.
2. **Blackout**: The controller detects a blackout on one or both of the busbars, and the conditions for blackout close are met.
3. **Check *Blackout close* parameter**:
   a. **Blackout close is OFF**: The controller does not allow the breaker to close. The controller shows an info message, and the sequence ends.
   b. **Load point is dead, busbar OK**: The controller checks whether the blackout was detected only at the load point.
      - *Blackout only at the load point*: The controller activates the close breaker relay.
      - *Blackout was only at the busbar or on both sides of the breaker*: The controller shows an info message, and the sequence ends.
   c. **Load point OK, busbar is dead**: The controller checks whether the blackout was detected only at the busbar.
      - *Blackout only at the busbar*: The controller activates the close breaker relay.
      - *Blackout only at the load point or on both sides of the breaker*: The controller shows an info message and the sequence ends.
   d. **One busbar is live**: The controller checks if the blackout was detected only at the load point, or only at the busbar.
      - *Blackout only at the load point, or only at the busbar*: The controller activates the close breaker relay.
      - *Blackout on both sides of the breaker*: The controller shows an info message and the sequence ends.
   e. **On**: If there is a blackout on either load point or busbar, the controller activates the close breaker relay.
4. **Breaker closed**: The controller checks whether the tie breaker has closed.
   - If the tie breaker has closed, the blackout close sequence has been completed successfully.
   - If the tie breaker has not closed the controller activates the *TB closing failure* alarm.

## 11.4.7 Tie breaker trip flowchart

The controller automatically trips the tie breaker (TB) for this alarm action:

- Trip tie breaker

The breaker is not de-loaded for a trip.




1. **Open TB**: When a trip is required, the controller activates the `Breakers > Tie breaker > Controls > TB open` output to open the breaker.
2. **TB opened**: 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 *TB opening failure* alarm.

## 11.5 Other MAINS controller functions

### 11.5.1 Counters

You can view, edit and reset all the counters on the display unit under `Configure > Counters`. The counters include:

- Mains connection breaker operations and trips
- Active and reactive energy export (to grid)
- Active and reactive energy import (from grid)
- Active and reactive energy differential
- External breaker operations

#### Energy counter digital outputs

For each energy counter, you can configure a digital output to send a pulse every time a certain amount of energy is transferred.

#### Digital outputs

You must configure the digital output function to see the parameters.

| Function | I/O | Type |
|---|---|---|
| `Mains > Production counters > Active energy export pulse` | Digital output | Pulse |
| `Mains > Production counters > Reactive energy export pulse` | Digital output | Pulse |
| `Mains > Production counters > Active energy import pulse` | Digital output | Pulse |
| `Mains > Production counters > Reactive energy import pulse` | Digital output | Pulse |
| `Mains > Production counters > Active energy differential pulse` | Digital output | Pulse |
| `Mains > Production counters > Reactive energy differential pulse` | Digital output | Pulse |

### Parameters

**Mains > Production counters > Active energy export**

| Parameter | Range | Comment |
|---|---|---|
| Pulse every | 1 kWh to 10 MWh | The value when a digital output sends a pulse. |
| Pulse length | 0.1 s to 1 h | The length of the pulse that is sent. This value should be long enough so the pulse can be registered by the external counter. |

**Mains > Production counters > Reactive energy export**

| Parameter | Range | Comment |
|---|---|---|
| Pulse every | 1 kvarh to 10 Mvarh | The value when a digital output sends a pulse. |
| Pulse length | 0.1 s to 1 h | The length of the pulse that is sent. This value should be long enough so the pulse can be registered by the external counter. |

**Mains > Production counters > Active energy import**

| Parameter | Range | Comment |
|---|---|---|
| Pulse every | 1 kWh to 10 MWh | The value when a digital output sends a pulse. |
| Pulse length | 0.1 s to 1 h | The length of the pulse that is sent. This value should be long enough so the pulse can be registered by the external counter. |

**Mains > Production counters > Reactive energy import**

| Parameter | Range | Comment |
|---|---|---|
| Pulse every | 1 kvarh to 10 Mvarh | The value when a digital output sends a pulse. |
| Pulse length | 0.1 s to 1 h | The length of the pulse that is sent. This value should be long enough so the pulse can be registered by the external counter. |

**Mains > Production counters > Active energy differential**

| Parameter | Range | Comment |
|---|---|---|
| Pulse every | 1 kWh to 10 MWh | The value when a digital output sends a pulse. |
| Pulse length | 0.1 s to 1 h | The length of the pulse that is sent. This value should be long enough so the pulse can be registered by the external counter. |

**Mains > Production counters > Reactive energy differential**

| Parameter | Range | Comment |
|---|---|---|
| Pulse every | 1 kWh to 10 MWh | The value when a digital output sends a pulse. |
| Pulse length | 0.1 s to 1 h | The length of the pulse that is sent. This value should be long enough so the pulse can be registered by the external counter. |

### Production counter function and corresponding parameter full names

| [Counter pulse] | [Counter] |
|---|---|
| Active energy export pulse | Active energy export |
| Reactive energy export pulse | Reactive energy export |
| Active energy import pulse | Active energy import |
| Reactive energy import pulse | Reactive energy import |
| Active energy differential pulse | Active energy differential |
| Reactive energy differential pulse | Reactive energy differential |

**Application example for an energy counter output**

1. Connect the digital output to an external counter.
2. Configure the digital output using the display unit or PICUS to *Active energy export pulse*.
3. Configure the *Pulse every* parameter to the value where you would like to send a pulse. For example, 100 kWh.
4. Configure the *Pulse length* to the required length of the pulse for your external counter. For example, 1 second.

With the example setup the controller sends a 1 second pulse to the external counter for each 100 kWh the controller logs.

## 11.5.2 Mains supervision

You can set up parameters for mains supervision. If there is a mains error (voltage or frequency outside the configured limits), then the controller can activate an alarm to open the breaker (to protect the asset). The controller can also show the mains status using digital outputs.

### Parameters

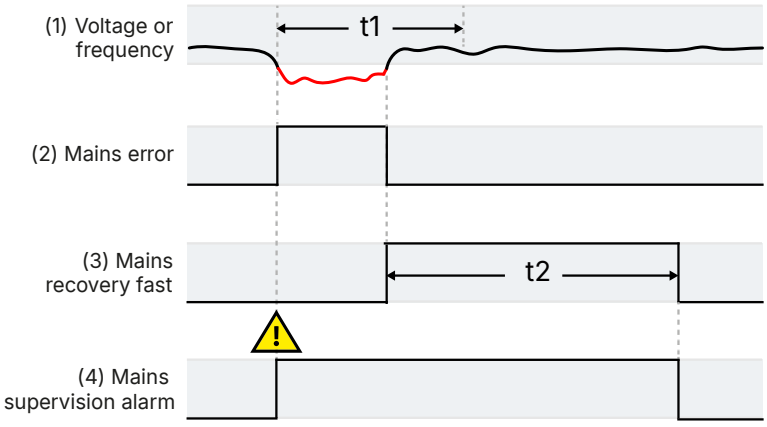
**`Mains > AC setup > Supervision selector`**

| Parameter | Range | Notes |
|---|---|---|
| `Enable supervision` | Not enabled, Enabled | **Not enabled**: No mains supervision.<br><br>**Enabled**: The controller can activate the mains supervision alarm. The mains supervision digital outputs show the mains supervision status. |
| `Recovery selector time` | 0.1 s to 1 h | If the mains error lasts for less than this time, then *Recovery time fast* is used. If the error lasts for longer than this time, then *Recovery time slow* is used. |
| `Recovery time fast` | 0.1 s to 1 h | This is used if the mains error stops within the *Recovery selector time*. The timer starts when the mains error stops. |
| `Recovery time slow` | 0.1 s to 1 h | This is used if the mains error does not stop within the *Recovery selector time*. The timer starts when the mains error stops. |
| `Voltage low` | 80.0 to 100.0 % of nominal voltage | There is a mains error if the mains voltage is below this level. |
| `Voltage high` | 100.0 to 120.0 % of nominal voltage | There is a mains error if the mains voltage is above this level. |
| `Frequency low` | 90.0 to 100.0 % of nominal frequency | There is a mains error if the mains frequency is below this level. |
| `Frequency high` | 100.0 to 110.0 % of nominal frequency | There is a mains error if the mains frequency is above this level. |

### How it works

These sequence diagrams are examples of how mains supervision works.

### Recovery time fast mains error

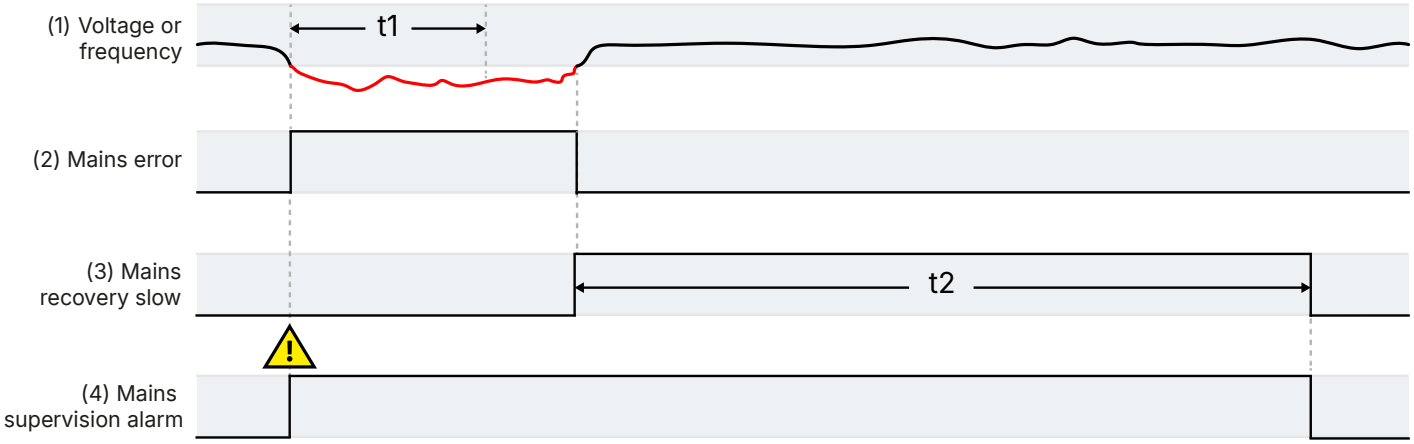



t1 = Recovery selector time (`Mains > AC setup > Supervision selector > Recovery selector time`)

t2 = Recovery time fast (`Mains > AC setup > Supervision selector > Recovery time fast`)

1. **Voltage or frequency**: The mains voltage or frequency is outside the configured limits for less than the *Recovery selector time*. The controller therefore uses the *Recovery time fast*.
2. **Mains error**: `Mains > Supervision > Mains error` (digital output) (optional). The controller activates this digital output while the mains voltage or frequency is outside the configured limits.
3. **Mains recovery fast**: `Mains > Supervision > Mains recovery fast` (digital output) (optional). The controller activates this digital output while the *Recovery time fast* timer is running.
4. **Mains supervision alarm**. The controller activates this alarm while there is a mains error, and while the recovery timer is running.

### Recovery time slow mains error

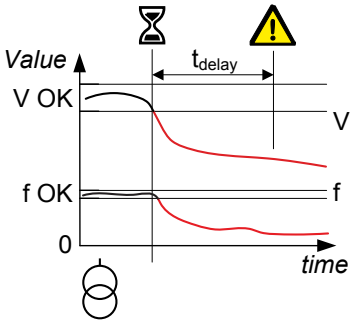



t1 = Recovery selector time (`Mains > AC setup > Supervision selector > Recovery selector time`)

t2 = Recovery time slow (`Mains > AC setup > Supervision selector > Recovery time slow`)

1. **Voltage or frequency**: The mains voltage or frequency is outside the configured limits for more than the *Recovery selector time*. The controller therefore uses the *Recovery time slow*.
2. **Mains error**: `Mains > Supervision > Mains error` (digital output) (optional). The controller activates this digital output while the mains voltage or frequency is outside the configured limits.
3. **Mains recovery slow**: `Mains > Supervision > Mains recovery slow` (digital output) (optional). The controller activates this digital output while the *Recovery time slow* timer is running.
4. **Mains supervision alarm**. The controller activates this alarm while there is a mains error, and while the recovery timer is running.

### 11.5.3 Mains supervision alarm




The controller activates this alarm if the mains voltage or frequency is outside the range configured under `Mains > AC setup > Supervision selector`.

The alarm remains activated for the recovery time.

**`Mains > AC setup > Supervision alarm`**

### 11.5.4 Mains supervision status as digital outputs

You can configure digital outputs with functions for the mains supervision status. The controller activates the digital output when the mains supervision state is activated. These outputs can be useful for troubleshooting.

**Digital outputs**

| Function | I/O | Type | Details |
|---|---|---|---|
| `Mains > Supervision > Mains error` | Digital output | Continuous | Activated when there is a mains error. |
| `Mains > Supervision > Mains recovery fast` | Digital output | Continuous | Activated during the fast recovery period. |
| `Mains > Supervision > Mains recovery slow` | Digital output | Continuous | Activated during the slow recovery period. |

### 11.5.5 Fuel pump

To keep the level in a tank in the required range, you can use the controller's inputs and outputs to control a pump.

**More information**
See **Fuel pump** in the **GENSET controller** chapter for details.

## 11.6 MAINS controller alarms and protections

### 11.6.1 Alarm actions

The controller has the following alarm actions:

- Warning
- Block mains breaker
- Block tie breaker *
- Trip mains breaker
- Trip tie breaker *
- Trip mains and tie breaker *

**NOTE** * Tie breaker actions are only present in **MAINS** controller with mains breaker (MB) and tie breaker (TB).

### 11.6.2 Inhibits

The controller includes the following inhibits:

| Inhibit | Disables the alarm when ... |
|---|---|
| Mains breaker closed | Based on the breaker feedbacks and validation, the mains breaker is closed. * |
| Mains breaker open | Based on the breaker feedbacks and validation, the mains breaker is open. * |
| Tie breaker closed ** | Based on the breaker feedbacks and validation, the tie breaker is closed. * |
| Tie breaker open ** | Based on the breaker feedbacks and validation, the tie breaker is open. * |
| Mains voltage present | The mains voltage is above 10% of the nominal voltage. |
| No mains voltage | The mains voltage is below 10% of the nominal voltage. |
| Mains frequency present | The mains frequency is above 10% of the nominal frequency. |
| No mains frequency | The mains frequency is below 10% of the nominal frequency. |
| Genset in parallel | The busbar section is connected to at least one genset. |
| Genset not in parallel | There are no gensets connected to the busbar section. |
| Inhibit 1 | The Alarm system > Inhibits > Activate inhibit 1 digital input is activated. |
| Inhibit 2 | The Alarm system > Inhibits > Activate inhibit 2 digital input is activated. |
| Inhibit 3 | TheAlarm system > Inhibits > Activate inhibit 3 digital input is activated. |

**NOTE** * There is no inhibit if there is breaker feedback failure.
**NOTE** ** Only on **MAINS** controller with mains breaker (MB) and tie breaker (TB).

### 11.6.3 Breaker alarms

*[Breaker]* is either **MB** for Mains breaker or **TB** for Tie breaker. *

| MAINS alarm | Parameters | General name |
|---|---|---|
| [Breaker] synchronisation failure | Breakers > [Breaker] breaker monitoring > Synchronisation failure | Breaker synchronisation failure |
| [Breaker] de-load failure | Breakers > [Breaker] breaker monitoring > De-load failure | Breaker de-load failure |
| [Breaker] vector mismatch | Breakers > [Breaker] breaker monitoring > Vector mismatch | Vector mismatch |
| [Breaker] opening failure | Breakers > [Breaker] breaker monitoring > Opening failure | Breaker opening failure |
| [Breaker] closing failure | Breakers > [Breaker] breaker monitoring > Closing failure | Breaker closing failure |
| [Breaker] position failure | Breakers > [Breaker] breaker monitoring > Position failure | Breaker position failure |
| [Breaker] tripped (external) | Breakers > [Breaker] breaker monitoring > Tripped (external) | Breaker trip (external) |
| [Breaker] short circuit | Breakers > [Breaker] breaker monitoring > Short circuit | Breaker short circuit |
| [Breaker] configuration failure | - | Breaker configuration failure |
| Phase sequence error mains | Mains > AC setup > Phase sequence error | Phase sequence error |
| Phase sequence error busbar | Busbar > AC setup > Phase sequence error | Phase sequence error |

**NOTE** * The Tie breaker (TB) alarms are only present on a **MAINS** controller with mains breaker (MB) and tie breaker (TB).

**More information**
The Breakers, synchronisation and de-loading for breaker handling and alarms in general.

### 11.6.4 AC alarms

**More information**
See the **Data sheet** for the AC alarms for this controller type. See the **AC configuration** chapter for descriptions of the AC protections.

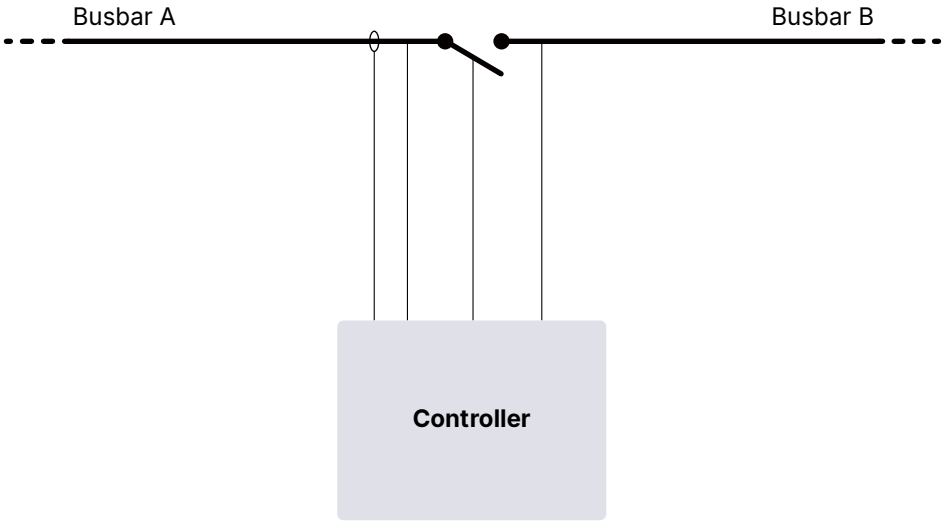
# 12. BUS TIE breaker controller

## 12.1 About the BUS TIE breaker controller

Each **BUS TIE breaker** controller controls one bus tie breaker.

There can be a ring busbar connection.

**Example application**




### 12.1.1 BUS TIE breaker controller functions

| | Functions |
|---|---|
| **Busbar section management** | • Busbar split and connection (configurable)<br>• Busbar section management<br>• Ring busbar connection |
| **Counters** | • Display unit counters, to edit or reset<br>  ◦ Bus tie breaker operations and trips<br>  ◦ Energy export (active and reactive) (to busbar B)<br>  ◦ Energy import (active and reactive) (to busbar A)<br>  ◦ External breaker operations<br>• Energy counters with configurable digital outputs (for external counters)<br>  ◦ Energy export (active and reactive) (to busbar B)<br>  ◦ Energy import (active and reactive) (to busbar A) |
| **Redundancy** | • Redundant breaker feedback on bus tie breakers and externally controlled bus tie breakers |

## 12.2 BUS TIE breaker controller principles

### 12.2.1 Configure a BUS TIE breaker controller

Configure each **BUS TIE breaker** controller on the single-line application drawing with PICUS.

The **BUS TIE breaker** controller measures the current and voltage on busbar A. The **BUS TIE breaker** controller also measures the voltage on busbar B. Busbar A for one **BUS TIE breaker** controller can be busbar B for the next **BUS TIE breaker** controller.

Each **BUS TIE breaker** controller and each externally controlled breaker creates a new busbar section.

**More information**
See Busbar sections and load sharing for more information about busbar sections.

## 12.2.2 BUS TIE breaker controller 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.

### Busbar A nominal settings

**`Busbar A > Nominal settings > Nominal settings # *`**

| Nominal setting | Range | Notes |
|---|---|---|
| `Voltage (V)` | 10.0 V AC to 1.5 MV AC | The phase-to-phase ** nominal AC voltage for busbar A. |
| `Current (I)` | 1.0 A to 9 kA | The maximum current flow in one phase (that is, L1, L2 or L3) in busbar A during normal operation. |
| `Frequency (f)` | 20.00 to 100.00 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)` | 1.0 kW to 900 MW | The nominal active power for the bus tie breaker. Ignored if *P nominal calculated* is selected. |
| `Apparent power (S)` | 1.0 kVA to 1 GVA | The nominal apparent power for the bus tie breaker. Ignored if *S nominal calculated* is selected. |
| `Power factor (PF)` | 0.6000 to 1.000 | The nominal power factor at the bus tie breaker. |

**NOTE** * # is 1 to 4.
** In a single-phase set up the nominal AC voltage is phase-to-neutral.

**`Busbar A > Nominal settings > Nominal settings # > Calculation method *`**

| Calculation method | Options |
|---|---|
| `Reactive power (Q) nominal` | Q nominal calculated<br>Q nominal = P nominal<br>Q nominal = S nominal |
| `P or S nominal` | No calculation<br>P nominal calculated<br>S nominal calculated |

**NOTE** * # is 1 to 4.

**More information**
See **Nominal power calculations** for more information.

### Busbar B nominal settings

**`Busbar B > Nominal settings > Nominal settings # > Voltage (V) *`**

| Nominal setting | Range | Notes |
|---|---|---|
| `Nominal voltage source` | Use busbar A nominal voltage<br>User defined | To configure the voltage, select *User defined*, then write the parameter change to the controller. |
| `Voltage (V)` | 10.0 V AC to 1.5 MV AC | The phase-to-phase nominal voltage for busbar B. If there is no transformer between busbar A and busbar B, the nominal voltage for busbar B is the same as the nominal voltage for busbar A. |

**NOTE** * # is 1 to 4.

### 12.2.3 AC configuration

The following table shows how the general AC configuration description applies to the **BUS TIE breaker** controller.

| BUS TIE breaker | General name |
|---|---|
| Busbar A | [A-side] |
| Busbar B | [B-side] |

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

### 12.2.4 Breaker configuration

**More information**
See the Breakers, synchronisation and de-loading for synchronisation and breakers. This includes the inputs and output functions and the parameters to configure.

For the **BUS TIE breaker** controller, the breaker abbreviation (*[*B]*) is *BTB*. *[Breaker]* refers to *Bus tie breaker*.

### 12.2.5 BTB-specific configuration

**Breakers > Bus tie breaker configuration > Configuration**

| Parameter | Range | Comment |
|---|---|---|
| `BTB supply` | AC voltage, DC voltage | **AC voltage**: An alternating current (AC) bus tie breaker is supplied from the busbar. The breaker can operate when either of the busbars is live. However, it cannot operate if there is a blackout on both busbars.<br><br>**DC voltage**: A direct current (DC) bus tie breaker is supplied from the switchboard power supply. It can operate if there is a blackout. |
| `Tie breaker normally open/ closed` | Normally open, Normally closed | **Normally open**: If there is no power, the BTB is open.<br>**Normally closed**: If there is no power, the BTB is closed. |

## 12.3 BUS TIE breaker controller sequences

### 12.3.1 Bus tie breaker synchronisation

When the breaker close button is pressed, the **BUS TIE breaker** controller tries to synchronise and close the breaker. You can use a parameter to determine what kind of synchronisation to use.

Regardless of the regulation, if the synchronisation requirements are met (within the time available for synchronisation), the controller automatically closes the breaker.

**Parameters**

**`Breakers > Bus tie breaker configuration > Synchronisation setting`**

| Parameter | Range | Default | Notes |
|---|---|---|---|
| `Sync. type` | • Static<br>• Dynamic<br>• Automatic | Automatic | **Static**: See details below.<br><br>**Dynamic**: See details below. |

| Parameter | Range | Default | Notes |
|---|---|---|---|
| | | | **Automatic**: See details below. |

### Static synchronisation

The **BUS TIE breaker** controller uses the static synchronisation parameters to determine when there is synchronisation.

### Dynamic synchronisation

The **BUS TIE breaker** controller uses the dynamic synchronisation parameters to determine when there is synchronisation.

The **BUS TIE breaker** controller broadcasts synchronisation set points for the **GENSET** controllers in the busbar sections connected to the bus tie breaker. The **GENSET** controller(s) with active regulation modes ignore their regulation modes and automatically regulate based on the synchronisation set points from the **BUS TIE breaker** controller. When the bus tie breaker is closed, the **GENSET** controllers return to their previous regulation modes.

If the **GENSET** controller(s) regulation is off or under *Manual regulation*, the controller(s) ignore the set points from the **BUS TIE breaker** controller. The busbars can be synchronised manually if the **GENSET** controllers are under *Manual regulation*.

### Automatic

The **BUS TIE breaker** controller automatically determines the type of synchronisation to use. The **BUS TIE breaker** controller checks the information for the busbar sections connected to the bus tie breaker. If the section(s) can be regulated, the controller uses dynamic synchronisation. Otherwise the controller uses static synchronisation.

To close a ring busbar, or to join two busbar sections that are each connected to the same mains, you must always use *Static* or *Automatic*.

**More information**
See the Breakers, synchronisation and de-loading for the input and output functions and the parameters to configure.

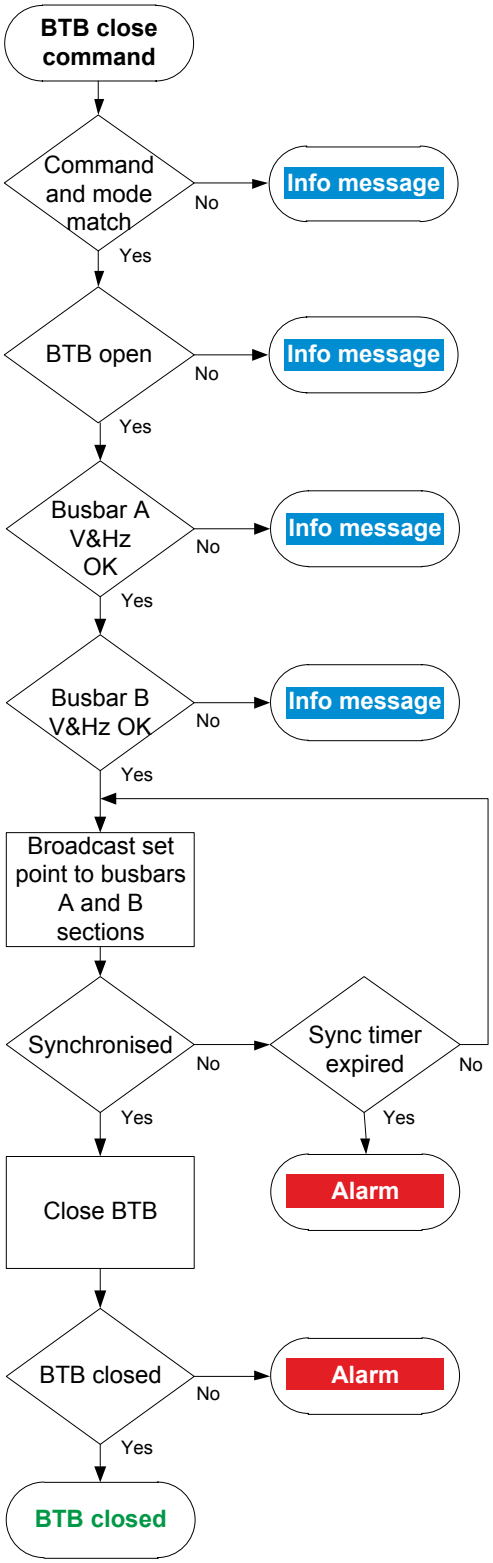
## 12.3.2 Bus tie breaker close flowchart

This is the sequence that the controller normally uses to close the bus tie breaker.

**More information**
See Bus tie breaker blackout close flowchart for how to allow the bus tie breaker connect to a dead busbar.

This flowchart does not apply to switchboard control. When the controller is under switchboard control, it will not close the breaker. If, for example, the operator presses the push-button **Close breaker** CLOSE on the display unit, the controller ignores this command.

**Table 12.1** Bus tie breaker (BTB) close flowchart




1. **Command and mode match:** The controller checks that the command source and the controller mode match.
2. **BTB open:** The controller checks whether the breaker is open. If the breaker is already closed, the sequence stops, and an info message is shown.
3. **Busbar A V&Hz OK:** The controller checks whether the voltage and frequency from busbar A are within the allowed range*. If these are not in the range, then the controller cancels the close command and displays an info message.
4. **Busbar B V&Hz OK:** The controller checks whether the voltage and frequency on busbar B are within range *. If these are not in the range, then the controller cancels the close command and displays an info message.
5. **Broadcast set point to busbars A & B sections:** The controller broadcasts the required set points on the busbar A section and the busbar B section. The GENSET controller(s) that have external network set point activated then use these set points for regulation.
   - If busbar A and busbar B are synchronised, the controller activates the *Breakers > Bus tie breaker > Control > BTB close* output to close the breaker.
   - If the busbars do not synchronise within the time allowed, the controller activates a *BTB synchronisation failure* alarm.
6. **BTB closed:** The controller checks whether the breaker has closed.
   - If the breaker has closed, the breaker close sequence has been completed successfully.
   - If the breaker has not closed, the controller activates the *BTB closing failure* alarm.

**NOTE** * See parameters: `[Busbar A / Busbar B] > AC setup > Voltage and frequency OK` for these ranges.

## 12.3.3 Bus tie breaker de-loading

When the breaker open button is pressed, the **BUS TIE breaker** controller checks whether regulation is possible in the busbar sections connected to the bus tie breaker. If regulation is not possible, the controller trips the breaker (without de-loading).

If regulation is possible, the **BUS TIE breaker** controller tries to de-load and open the breaker.

The **BUS TIE breaker** controller broadcasts de-loading set points for the **GENSET** controllers in the busbar sections connected to the bus tie breaker. The **GENSET** controller(s) with active regulation modes ignore their regulation modes and automatically respond to de-loading set points from the **BUS TIE breaker** controller. When the bus tie breaker is open, the **GENSET** controllers return to their previous regulation modes.

The set points from the **BUS TIE breaker** controller are ignored by **GENSET** controllers in these cases:

- The **GENSET** controller is in fixed power mode, with set point adjustment locked.
- The **GENSET** controller regulation is off.
- The **GENSET** controller is under *Manual regulation*. However, the bus tie breaker can be de-loaded manually.

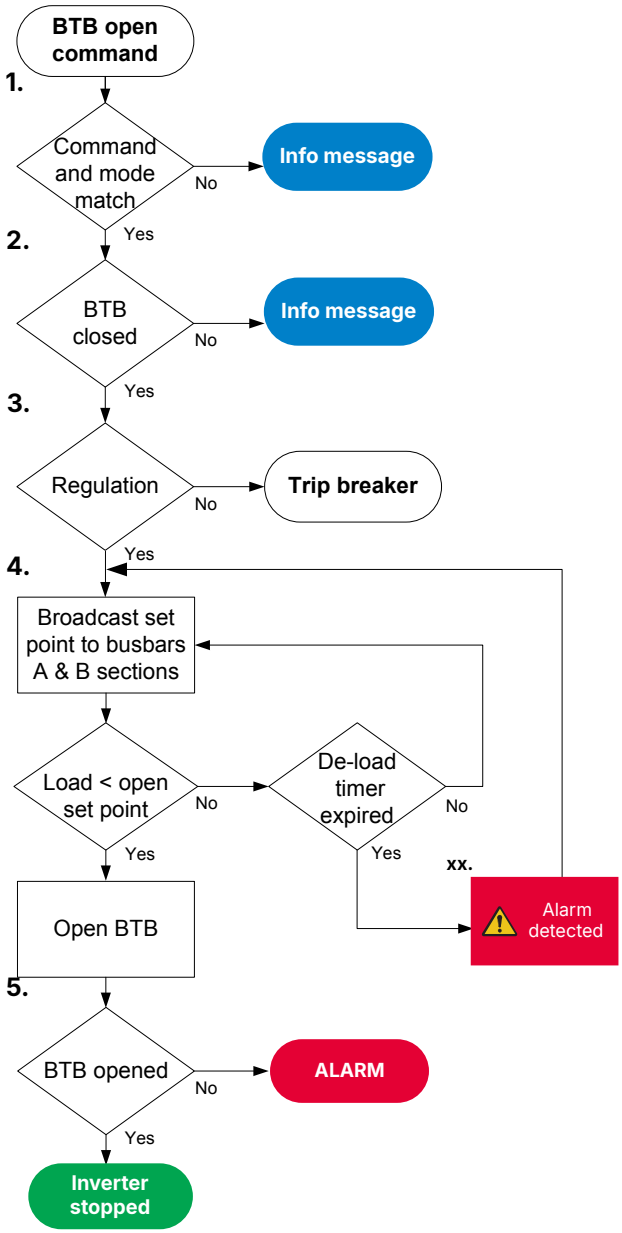
### 12.3.4 Bus tie breaker open flowchart

The following flowchart shows the sequence that the controller normally uses to open the bus tie breaker.

The alarm action *Block bus tie breaker* does not open a closed breaker, although it stops an open breaker from closing. If the controller or an operator sends a BTB open command while *Block bus tie breaker* is active, the controller uses this sequence.

The sequence to trip the bus tie breaker is described in another flowchart.

**Table 12.2** Bus tie breaker (BTB) open flowchart




1. **Command and mode match**: The controller checks that the command source and the controller mode match:
   - In REMOTE mode, the command to open the genset breaker can come from a digital input, PICUS, Modbus, CustomLogic, and/or CODESYS.
   - In LOCAL mode, the operator can press the push-button **Open breaker** OPEN on the display unit. The controller ignores all other commands.
2. **BTB closed**: The controller checks whether the breaker is closed. If the breaker is open, the sequence ends.
3. **Regulation**: The controller checks whether regulation is possible in the sections connected to the bus tie breaker.
   - If regulation is not possible, the controller trips the breaker.
   - If regulation is possible, the controller tries to de-load the breaker.
4. **Broadcast set point to busbar A & B sections**: The controller broadcasts the required set points on the busbar sections. The GENSET controller(s) then use these set points for regulation.
   - When the load is less than the set point for the breaker to open, the controller activates the `Breakers > Bus tie breaker > Control > BTB open` output.
   - If the **GENSET** controller(s) cannot de-load the breaker before the de-load timer expires, the BUS TIE breaker controller activates the *BTB de-load failure* alarm. The **GENSET** controller(s) continue to try to de-load the breaker.
5. **BTB opened**: The controller checks whether the breaker has opened:
   - If the breaker has opened, the bus tie breaker open sequence has been completed successfully.
   - If the breaker has not opened, the controller activates the *BTB opening failure* alarm.

**CAUTION**

**Possible blackout**

Opening the bus tie breaker may cause a blackout.

## 12.3.5 Bus tie breaker blackout close flowchart

The *Blackout close* function sets the action that the controller allows when a dead busbar is detected. An operator or a remote input can close the breaker even though there is a blackout (if the parameter is not *OFF*).

**DANGER!**

**Incorrect blackout parameter settings**

Incorrect blackout close parameter settings can lead to equipment damage or loss of life.

### Blackout conditions

A blackout is present if 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 allow the blackout close:

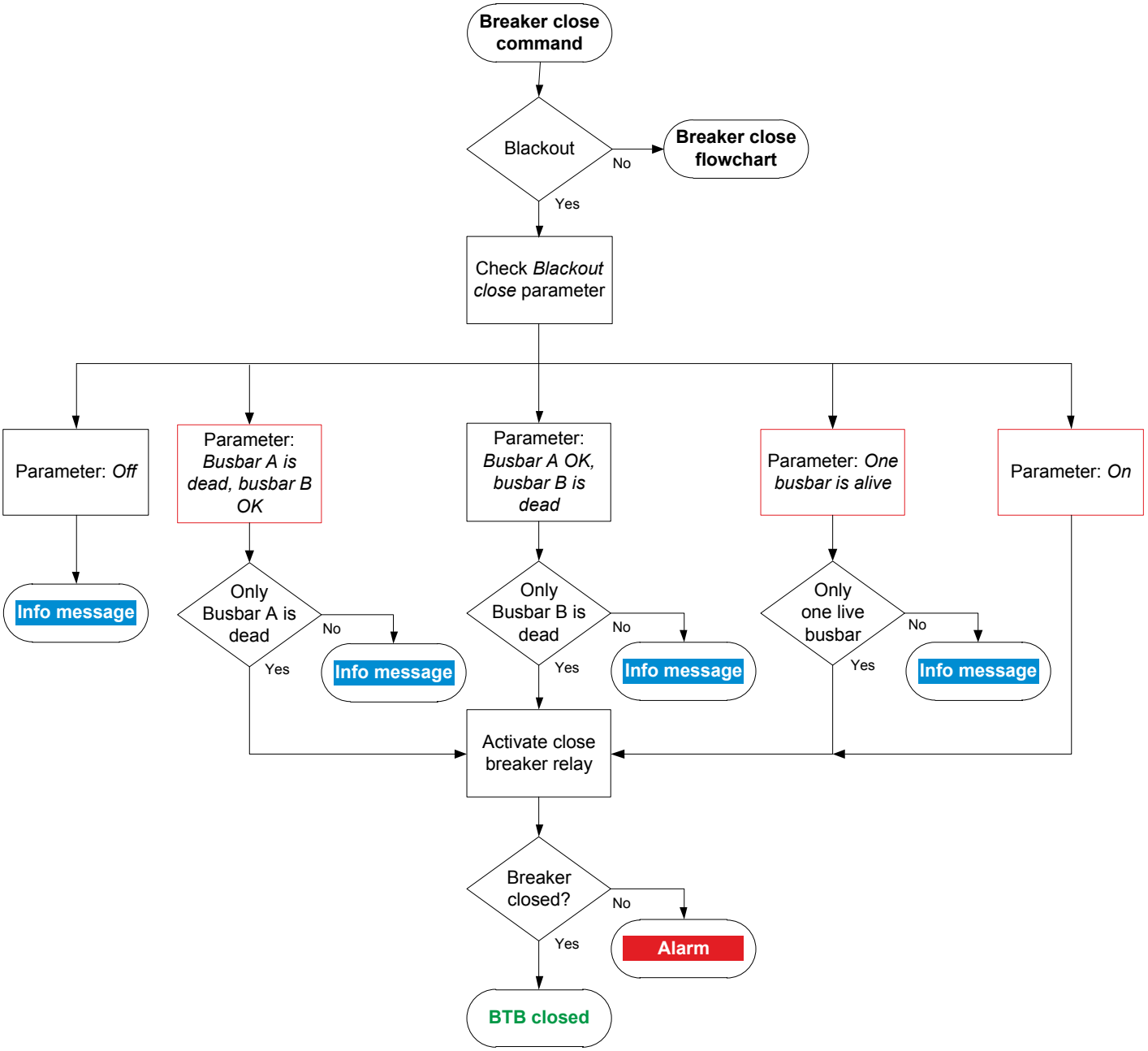
- The breaker position is unknown.
- There is a short circuit.
  - A digital input with the function `Breakers > Bus tie breaker > Feedback > BTB short circuit` was activated.
- There is a blocking alarm.
  - The alarm action determines whether the alarm is a blocking alarm.
- The busbar A and/or busbar B AC measurements are not OK.
  - A measurement failure is detected on one or more of the phases.
- The `Busbar B > AC setup > Blackout detection > Blackout delay` timer has not expired.

### Parameters

**`Breakers > Bus tie breaker configuration > Blackout close`**

| Name | Range | Notes |
|---|---|---|
| `Blackout close` | • Blackout close is OFF<br>• Busbar A is dead, busbar B OK<br>• Busbar A OK, busbar B is dead<br>• One busbar is alive<br>• On | **Blackout close is OFF**: The breaker is not allowed to close, unless both busbars are live and synchronised.<br><br>**Busbar A is dead, busbar B OK**: If a blackout is detected on busbar A, but busbar B is stable, then the controller allows the breaker to close.<br><br>**Busbar A OK, busbar B is dead**: If a blackout is detected on busbar B and busbar A is stable, then the controller allows the breaker to close.<br><br>**One busbar is alive**: If a blackout is detected on busbar A or busbar B, and the live busbar is stable, then the controller allows the breaker to close.<br><br>**On**: If a blackout is detected on busbar A and/or busbar B, then the controller allows the breaker to close. |

### Blackout close flowchart




1. **Breaker close command:** An operator or a remote command attempts to close the breaker.
2. **Blackout:** The controller detects a blackout on one or both of the busbars, and the conditions for blackout close are met.
3. **Check *Blackout close* parameter:** The controller checks the *Blackout close* parameter:
   a. **Off**: The controller takes does not allow the breaker to close. The controller shows an info message, and the sequence ends.
   b. **Busbar A is dead, busbar B OK**: The controller checks whether the blackout was detected only on busbar A.
      - *Blackout only on busbar A*: The controller activates the close breaker relay.
      - *Blackout was only on busbar B or on both sides of the breaker*: The controller shows an info message, and the sequence ends.
   c. **Busbar A OK, busbar B is dead**: The controller checks whether the blackout was detected only on busbar B.
      - *Blackout only on busbar B*: The controller activates the close breaker relay.
      - *Blackout only on busbar A or on both sides of the breaker*: The controller shows an info message and the sequence ends.
   d. **One busbar is alive**: The controller checks if the blackout was detected only on busbar A, or only on busbar B.
      - *Blackout only on busbar A, or only on busbar B*: The controller activates the close breaker relay.
      - *Blackout on both sides of the breaker*: The controller shows an info message and the sequence ends.

e. **On**: If there is a blackout on either/both busbars, the controller activates the close breaker relay.

4. **Breaker closed:** The controller checks whether the bus tie breaker has closed.
   - If the bus tie breaker has closed, the blackout close sequence has been completed successfully.
   - If the bus tie breaker has not closed the controller activates the *BTB closing failure* alarm.

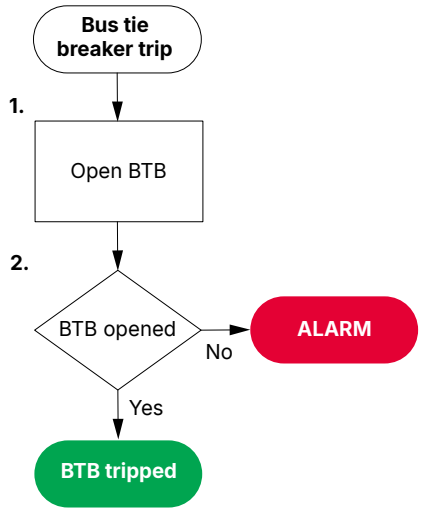
### 12.3.6 Bus tie breaker trip flowchart

The controller automatically trips the bus tie breaker (BTB) for this alarm action:

- Trip bus tie breaker

The bus tie breaker is not de-loaded for a trip.

#### Bus tie breaker trip flowchart




1. **Open BTB:** When a trip is required, the controller activates the *Breakers > Bus tie breaker > Controls > BTB open* output to open the breaker.
2. **BTB opened:** 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 *BTB opening failure* alarm.

## 12.4 Other BUS TIE breaker controller functions

### 12.4.1 Counters

You can view, edit and reset all the counters on the display unit under `Configure > Counters`. The counters include:

- Bus tie breaker operations and trips
- Active and reactive energy export (to busbar B)
- Active and reactive energy import (to busbar A)
- External breaker operations

#### Energy counter outputs

For each energy counter, you can configure a digital output to send a pulse every time a certain amount of energy is transferred. You must configure the digital output function to see the parameters.

Configure the digital outputs under `Busbar A > Production counters > [Counter pulse]`.

### Parameters

**Busbar A > Production counters > Active energy export**

| Parameter | Range | Comment |
|---|---|---|
| Pulse every | 1 kWh to 10 MWh | The value when a digital output sends a pulse. |
| Pulse length | 0.1 s to 1 h | The length of the pulse that is sent. This value should be long enough so the pulse can be registered by the external counter. |

**Busbar A > Production counters > Reactive energy export**

| Parameter | Range | Comment |
|---|---|---|
| Pulse every | 1 kvarh to 10 Mvarh | The value when a digital output sends a pulse. |
| Pulse length | 0.1 s to 1 h | The length of the pulse that is sent. This value should be long enough so the pulse can be registered by the external counter. |

**Busbar A > Production counters > Active energy import**

| Parameter | Range | Comment |
|---|---|---|
| Pulse every | 1 kWh to 10 MWh | The value when a digital output sends a pulse. |
| Pulse length | 0.1 s to 1 h | The length of the pulse that is sent. This value should be long enough so the pulse can be registered by the external counter. |

**Busbar A > Production counters > Reactive energy import**

| Parameter | Range | Comment |
|---|---|---|
| Pulse every | 1 kvarh to 10 Mvarh | The value when a digital output sends a pulse. |
| Pulse length | 0.1 s to 1 h | The length of the pulse that is sent. This value should be long enough so the pulse can be registered by the external counter. |

### Energy counter function and corresponding parameter full names

| [Counter pulse] | [Counter] |
|---|---|
| Active energy export pulse | Active energy export |
| Reactive energy export pulse | Reactive energy export |
| Active energy import pulse | Active energy import |
| Reactive energy import pulse | Reactive energy import |

**Application example for an energy counter output**

1. Connect the digital output to an external counter.
2. Configure the digital output using the display unit or PICUS to *Active energy export pulse*.
3. Configure the *Pulse every* parameter to the value where you would like to send a pulse. For example, 100 kWh.
4. Configure the *Pulse length* to the required length of the pulse for your external counter. For example, 1 second.

With the example setup the controller sends a 1 second pulse to the external counter for each 100 kWh the controller logs.

## 12.4.2 Test mode

For a BTB controller, the BTB test response depends on the mains controller test mode. The BTB controller does not have a test mode.

For a bus tie breaker controller, a mains controller can request that the BTB close if the test mode is *Full test*.

For the *Simple test* and *Load test* mains controller test modes, a BTB will not close automatically, even if more power is needed.

### 12.4.3 Fuel pump

To keep the level in a tank in the required range, you can use the controller's inputs and outputs to control a pump.

**More information**
See **Fuel pump** in the **GENSET controller** chapter for details.

### 12.4.4 Digital outputs

The BTB controller supports the standard controller digital outputs, and also the output below.

| Function | I/O | Type | Details |
|---|---|---|---|
| `Breakers > Bus tie breaker > State > BTB is preparing` | Digital output | Continuous | |

## 12.5 BUS TIE breaker controller alarms and protections

### 12.5.1 BUS TIE breaker controller protections

All the **BUS TIE breaker** controller alarms are included in the AC protections and general alarms for the controller.

### 12.5.2 Alarm actions

The controller has the following alarm actions:

- Warning
- Block bus tie breaker
- Trip bus tie breaker

### 12.5.3 Inhibits

| Inhibit | Disables the alarm when ... |
|---|---|
| Bus tie breaker closed | The `Breakers > Bus tie breaker > Feedback > BTB Closed` digital input is activated. |
| Bus tie breaker open | The `Breakers > Bus tie breaker > Feedback > BTB Open` digital input is activated. |
| Busbar A voltage present | The Busbar A voltage is above 10 % of the nominal voltage. |
| No busbar A voltage | The Busbar A voltage is below 10 % of the nominal voltage. |
| Busbar A frequency present | The Busbar A frequency is above 10 % of the nominal frequency. |
| No busbar A frequency | The Busbar A frequency is below 10 % of the nominal frequency. |
| Busbar B voltage present | The Busbar B voltage is above 10 % of the nominal voltage. |
| No busbar B voltage | The Busbar B voltage is below 10 % of the nominal voltage. |
| Busbar B frequency present | The Busbar B frequency is above 10 % of the nominal frequency. |
| No busbar B frequency | The Busbar B frequency is below 10 % of the nominal frequency. |
| ACM wire break | All these conditions are met:<br>• The bus tie breaker is closed<br>• Voltage is detected by one set of ACM voltage measurements |

| Inhibit | Disables the alarm when ... |
|---|---|
| | • No voltage is detected on a phase, or on all three phases for the other set of ACM voltage measurements |
| Inhibit 1 | The `Alarm system > Inhibits > Activate inhibit 1` digital input is activated. |
| Inhibit 2 | The `Alarm system > Inhibits > Activate inhibit 2` digital input is activated. |
| Inhibit 3 | The `Alarm system > Inhibits > Activate inhibit 3` digital input is activated. |

## 12.5.4 Breaker alarms

### Breaker alarm names for the BUS TIE breaker controller

| BUS TIE breaker alarm | Parameter | General name |
|---|---|---|
| BTB synchronisation failure | `Breakers > Bus tie breaker monitoring > Synchronisation failure` | Breaker synchronisation failure |
| BTB de-load failure | `Breakers > Bus tie breaker monitoring > De-load failure` | Breaker de-load failure |
| Vector mismatch | `Breakers > Bus tie breaker monitoring > Vector mismatch` | Vector mismatch |
| BTB opening failure | `Breakers > Bus tie breaker monitoring > Opening failure` | Breaker opening failure |
| BTB closing failure | `Breakers > Bus tie breaker monitoring > Closing failure` | Breaker closing failure |
| BTB position failure | `Breakers > Bus tie breaker monitoring > Position failure` | Breaker position failure |
| BTB trip (external) | `Breakers > Bus tie breaker monitoring > Tripped (external)` | Breaker trip (external) |
| BTB short circuit | `Breakers > Bus tie breaker monitoring > Short circuit` | Breaker short circuit |
| BTB configuration failure | - | Breaker configuration failure |
| Busbar A phase sequence error | `Busbar A > AC setup > Phase sequence error` | Phase sequence error |
| Busbar B phase sequence error | `Busbar B > AC setup > Phase sequence error` | Phase sequence error |

**More information**
See Breakers, synchronisation and de-loading for breaker handling and alarms in general.

## 12.5.5 AC alarms

**More information**
See the **Data sheet** for the AC alarms for this controller type. See the **AC configuration** chapter for descriptions of the AC protections.

# 13. WebConfig

## 13.1 About WebConfig

You can configure and manage the controller system-settings direct with any HTML-capable browser. With WebConfig you can configure both advanced settings and see more detailed logs and information.

Use the **Admin** user to access and configure the WebConfig. To use a different user, that user must have the **Provisioner** role.

Application-related settings, such as parameter settings, need to be configured with PICUS.

Access to the controller with a browser requires you to accept a browser security-warning, as the controller certificate is only local and therefore not published.

We would love to hear from you.

Help us improve our documentation by giving us feedback.

**Click here**

## 13.2 Connect to the controller

While DEIF has taken great attention to data security and has designed the product to be a secure product, we recommend adopting Information Technology (IT) and Operational Technology (OT) security best practices when connecting the controller to a network.

**NOTICE**

**Initial access**

If your controller has not yet been configured, you must use the default access address and permissions. We strongly recommend that you change the default configuration to protect your system.

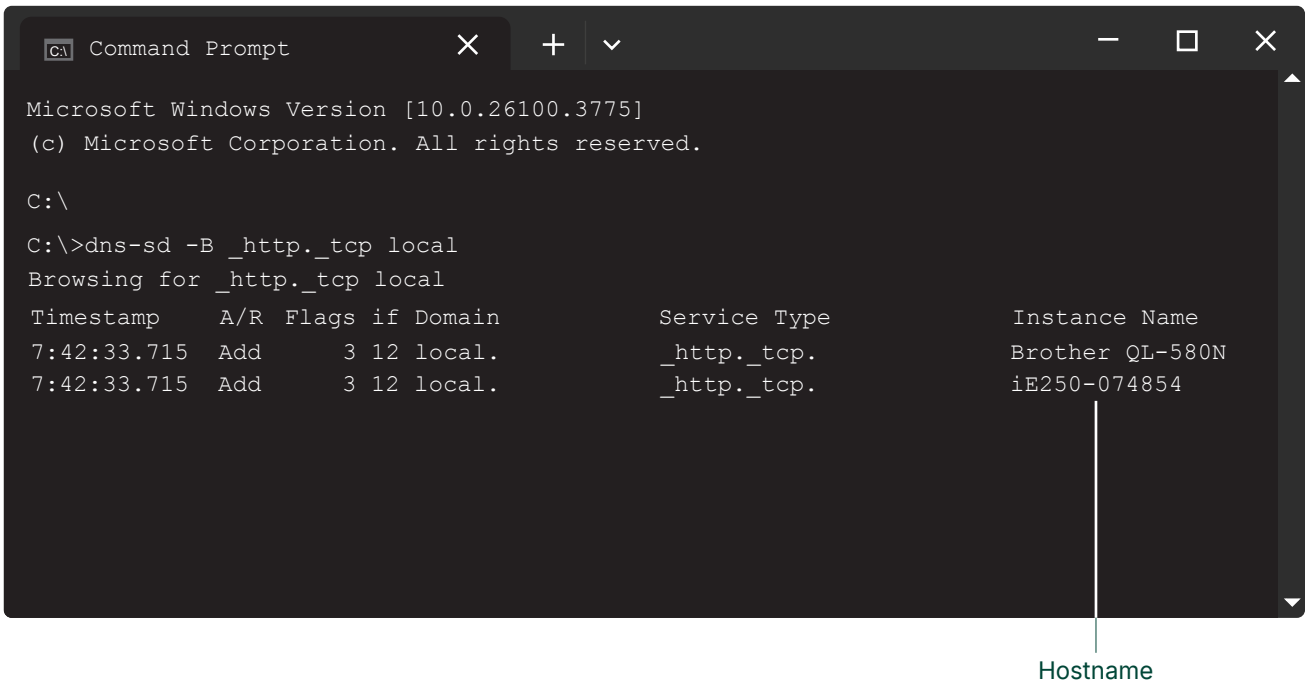
You can connect to the controller with *Hostname*, *IPv6*, or *IPv4* (if configured):

- **Hostname**
  - Example: *https://ie250-079562.local*
- **IPv4 address**
  - Example: *https://192.168.142.6*
- **IPv6 address**
  - Example: *https://[fe80::226:77ff:fe07:9562]*

### How to identify the controller's Hostname

You can identify your controller's **Hostname** by using the Bonjour service and a command prompt. Connect your PC directly to the **ETH0** Ethernet port and run the command:

```
dns-sd -B _http._tcp local
```




This displays all the devices located on your connected network. The **Hostname** includes the product together with a serial code.

Examples:

- ie250-076244.local
- ie350-067215.local
- ie650-071522.local

You can then use this Hostname directly in your HTML-capable browser to access the controller configruation.

### Username and password

Access the controller with the same username and password as configured on the controller.

## 13.2.1 Users

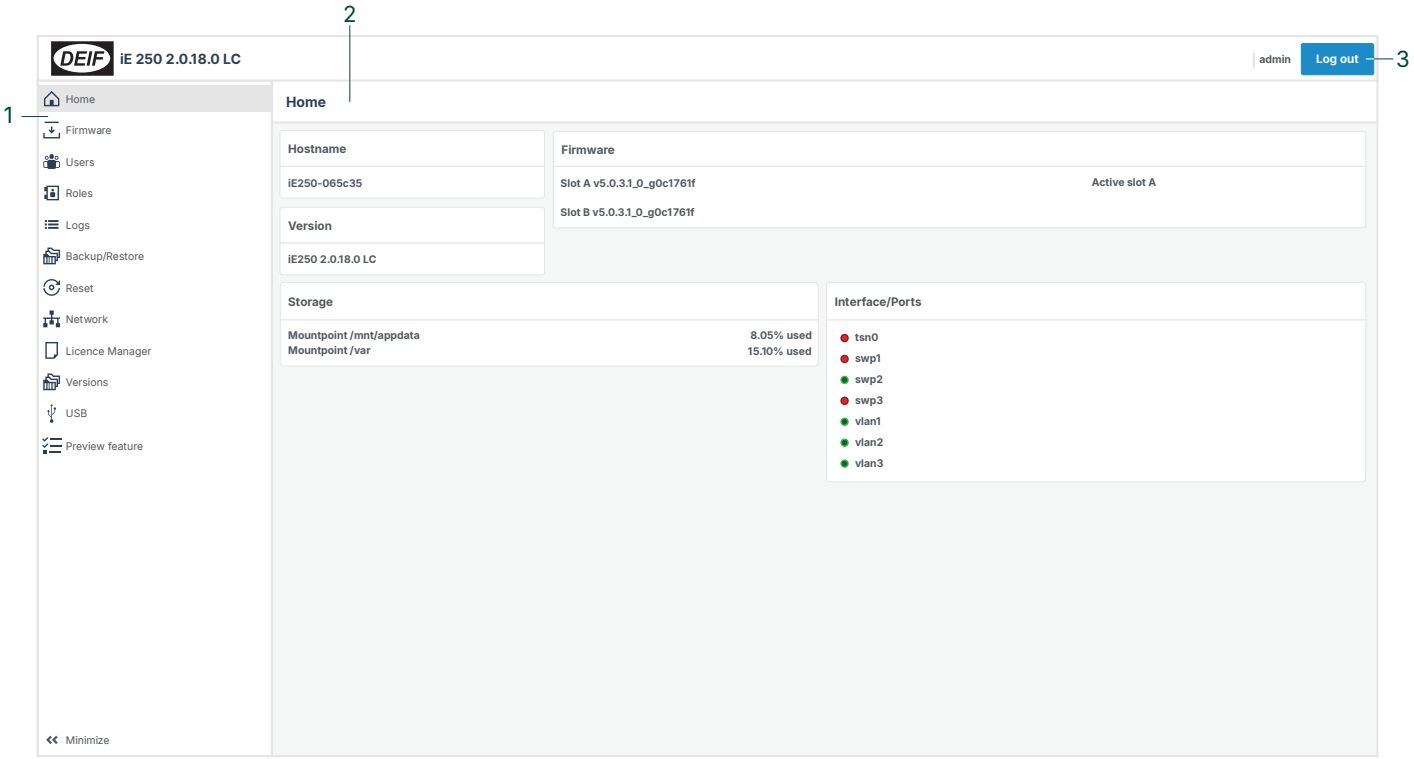
Use the **admin** user to access the WebConfig and configure the controller settings initially. New users must have the **Provisioner** permission to access the WebConfig features.

You can configure new users directly with WebConfig or by using PICUS.

**More information**
See About Permissions in Cybersecurity.

# 13.3 Home

The **Home** page provides a quick overview of the firmware, Ethernet ports and VLAN status. This information can be useful when troubleshooting or contacting DEIF support.

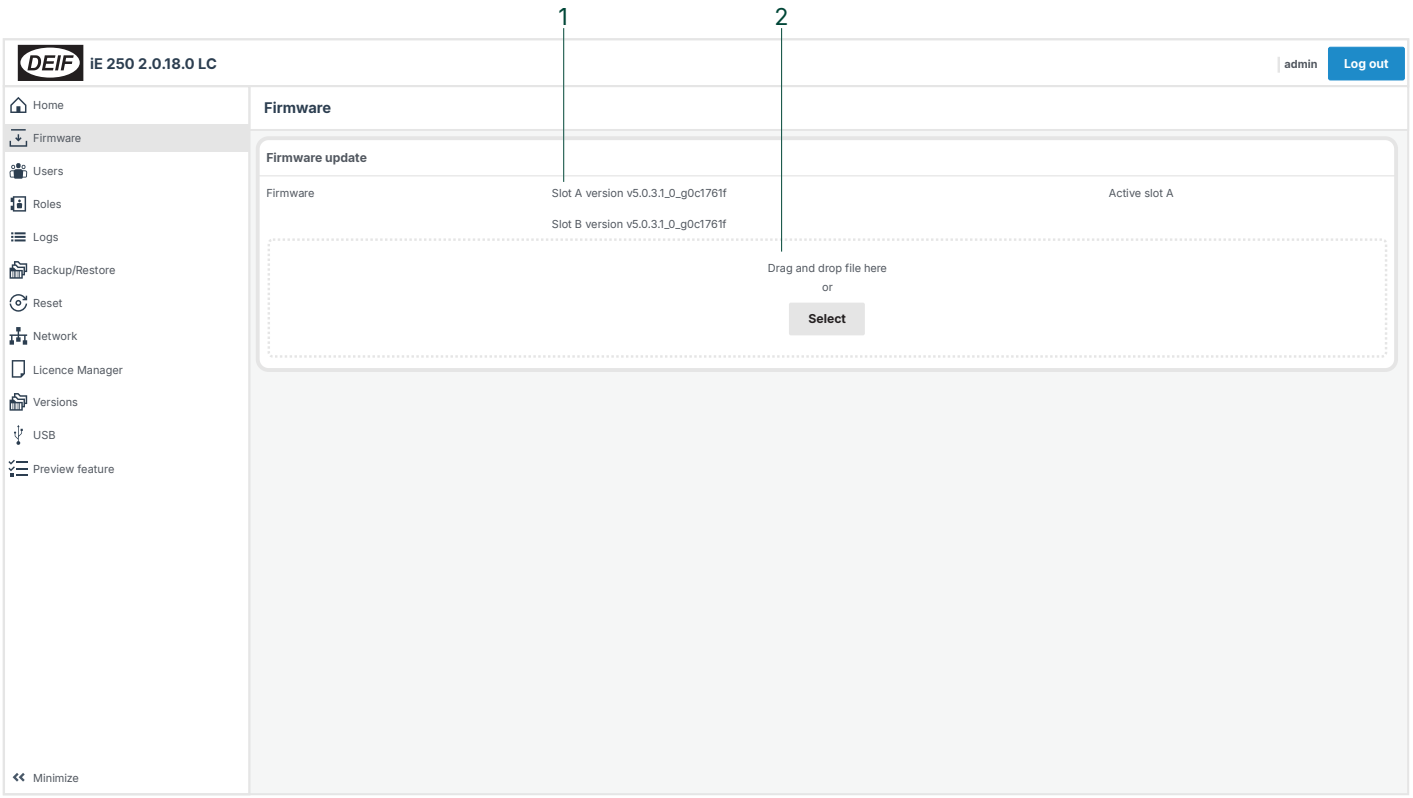



| No. | Item | Notes |
|---|---|---|
| 1 | Features | Available features and pages. |
| 2 | Page | Selected page. |
| 3 | User | Log in / Log out.<br><br>Logged in user is shown. |

# 13.4 Firmware

## 13.4.1 About firmware

Use the firmware feature to update your controllers and displays.




| No. | Item | Notes |
|---|---|---|
| 1 | Firmware installed | Shows the firmware installed in Slot A and Slot B. |
| 2 | Upload | Drag and drop the firmware file or use the Select. |

**NOTE** Alternatively, use PICUS (`Tools > Firmware`) to update the controllers and displays.

## 13.4.2 Firmware constraints

### Controller prerequisites

Before you can apply a firmware update, the controller must meet certain prerequisites. If the controller is in Emulation mode, or has an ID of **0** (and not part of the system), these constraints do not apply.

### Breaker constraint

All controlled breaker(s) must be opened.

### Equipment constraint (if controlled)

The controlled equipment must be stopped.

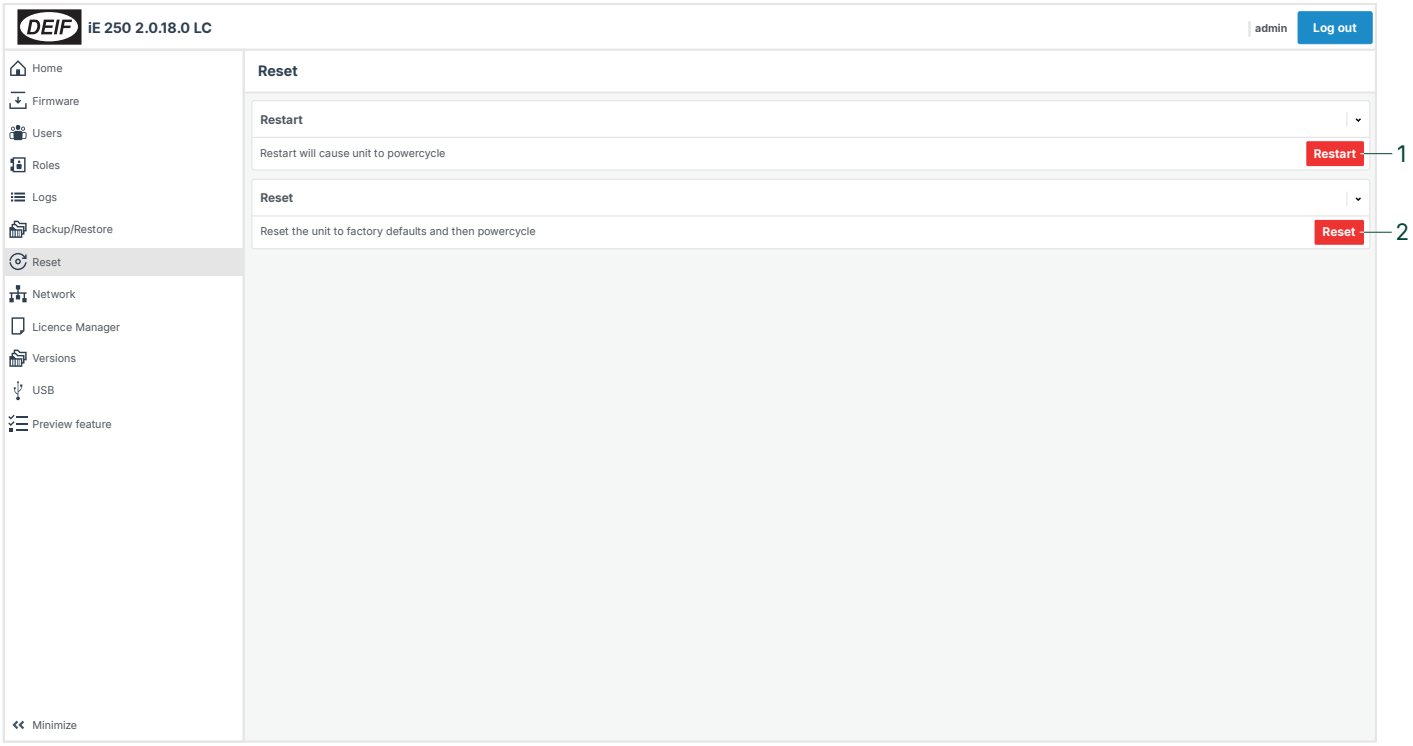
## 13.4.3 Download firmware

Firmware for your product is available on www.deif.com.

| Download the software | |
|---|---|
| iE 250 | https://www.deif.com/software/?product=17655 |

## 13.5 Reset (Factory reset)

You can **Restart** or **Factory reset** the controller. Before using either feature, the controller must not be in operation or controlling any equipment.




| No. | Item | Notes |
|---|---|---|
| 1 | Restart | This restarts the controller and is the same as powercycling the unit. |
| 2 | Reset | This does a *Factory reset* of the controller. All settings, including Ethernet configuration and passwords, are reset to their defaults. |

**DANGER!**

**Controller must not be in operation**

The controller must not be in operation or controlling any equipment when you Restart or Factory reset the controller.

Make the controller safe for commissioning to avoid equipment damage, personal injury, or unexpected critical system operations.

**NOTICE**

**A factory reset deletes all controller information**

You cannot recover any controller information after a factory reset. All settings, including Ethernet configuration and passwords, are reset to their defaults.

Make sure that you want to do a factory reset. Create a full controller backup, and store it safely on your computer. Make sure that you have the information that you will need after the factory reset. This should include the default passwords, along with the new user and password configuration, and the Ethernet communication settings.

**More information**
See the PICUS manual for how to create backups from your controller.

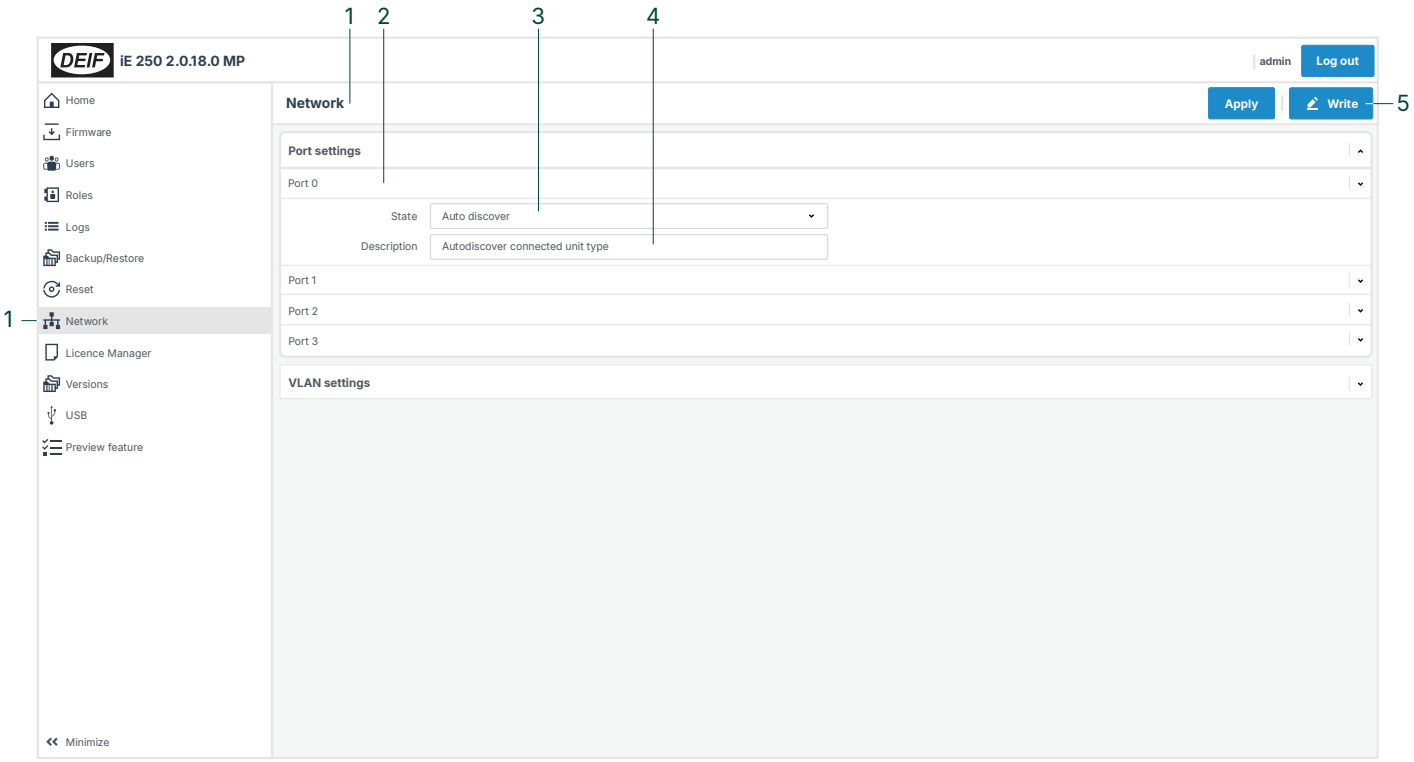
**More information**
See Factory reset for the location of the **Factory reset** button.

# 13.6 Communication settings

## 13.6.1 Network communication

### 13.6.1.1 Network settings

You can configure the communication settings for both Ethernet and VLAN configuration.




| No. | Item | Notes |
|---|---|---|
| 1 | Network | Network settings page. |
| 2 | Port # | Configuration for each port. |
| 3 | State | Log in / Log out.<br><br>Logged in user is shown. |
| 4 | Description | Description for the port configuration. |
| 5 | Apply / Write | Apply the changes immediately.<br><br>Write the changes to the controller. |

### 13.6.1.2 Ethernet ports

You can configure how the Ethernet ports are allowed to operate.

This is for ring topology networks and uses the Media Redundancy Protocol (MRP). The network master is connected to both ends of the network, forming a loop. This configuration allows the master to send and receive data from both directions, which is essential for detecting and compensating for a cable break.

With Auto discover selected, the devices connected in the loop are automatically discovered. It is not possible to connect multiple rings together.

DEIF recommends that you do not use Port 0 (Eth 0) for Auto discover. This is because Auto discover is for ring protocols.

**Network > Port settings > Port # ***

| Parameter | Range | Notes |
|---|---|---|
| State | • Auto discover<br>• Bridge<br>• Standalone<br>• Off | **Auto discover**<br>• This is for ring topology networks and uses the Media Redundancy Protocol (MRP).<br>• The network master is connected to both ends of the network, forming a loop. This configuration allows the master to send and receive data from both directions, which is essential for detecting and compensating for a cable break.<br>• Automatically detects and uses the network settings. Ideal for environments where devices need to be quickly and easily connected without manual configuration.<br><br>**Bridge**<br>• Connects two network segments, allowing them to function as a single network. Useful for extending networks or connecting different network types.<br>• The Ethernet port is associated to one or more VLAN IDs depending on the VLAN port mode. Access mode uses a specific VLAN ID. Trunk mode uses one or more VLAN IDs.<br><br>**Standalone**<br>• Operates independently with its own network settings. Suitable for isolated networks or when specific configurations are needed for a particular device.<br><br>**Off**<br>• No Ethernet traffic is allowed to or from the port. The port is not active. This can be useful for Cybersecurity purposes to prevent unnecessary Ethernet ports being used. |
| Description | - | A descriptive name for the Ethernet port. |

**NOTE** * Where # is 0 to 3 for iE 250 or 0 to 4 for iE 350.

## 13.6.2 USB communication

### 13.6.2.1 Allow or restrict USB access

You can allow or restrict access to the USB port on the controller (where fitted). This can prevent unwanted or unauthorised direct access to the controller using the USB port.

**USB**

| Setting | |
|---|---|
| **Enabled** | The USB port can communicate and transfer data with any USB peripheral that is connected. |
| **Not enabled** | • The USB port can not communicate or transfer any data with any USB peripheral that is connected.<br>• Any devices already connected will no longer be allowed to access the USB port. |

#### How to enable or not enable the USB port

1. Launch your browser and enter your controller's address.
2. Open the **USB section** and toggle the USB setting.

3. The USB setting is immediately applied to the controller.

**NOTICE**

**iE 7 display uses USB port**

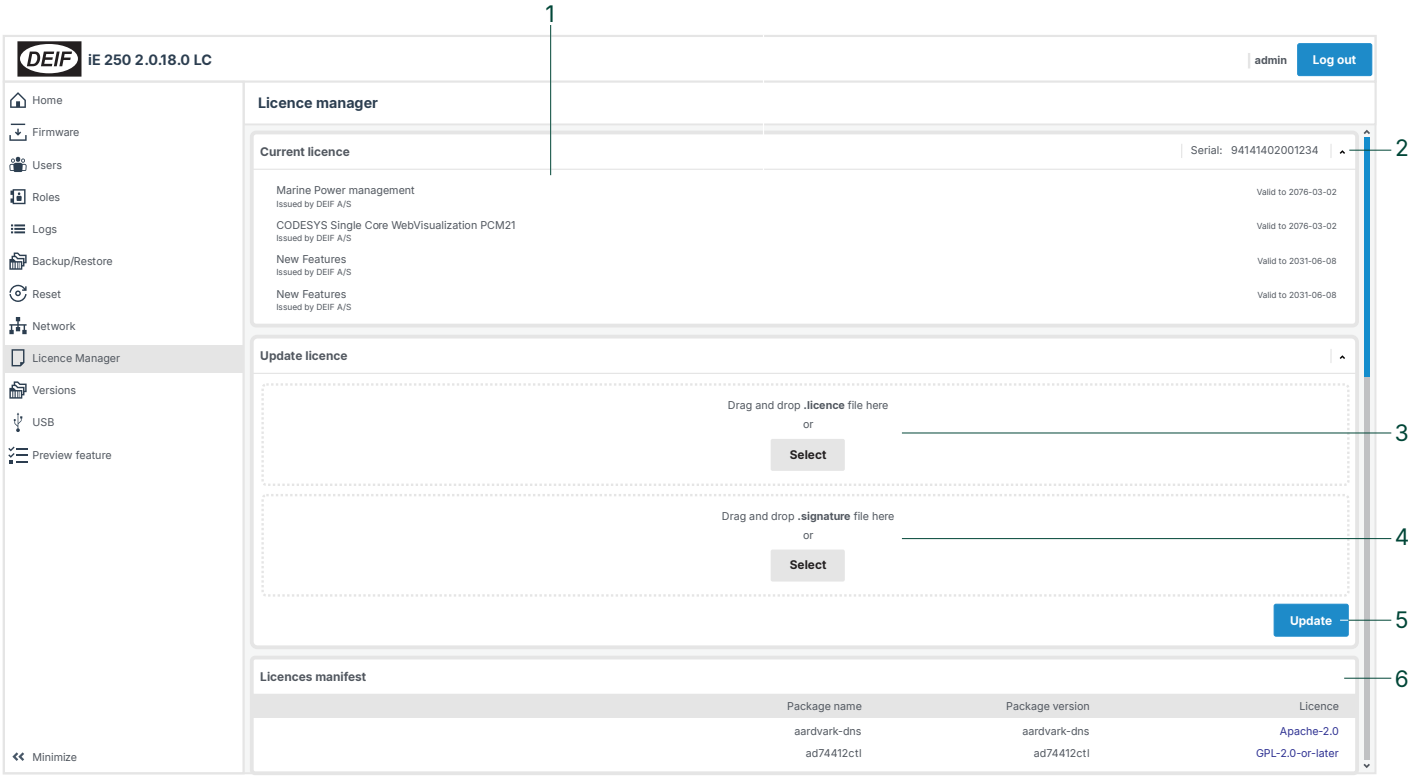
The iE 7 display uses both the USB and DisplayPort for communication with the base mounted controller. If the USB port is not enabled, the display cannot send control signals to the controller.

# 13.7 Licences

## 13.7.1 About Licence manager

Use the **Licence manager** to view or install licences on the controller.

Contact DEIF with your controller serial number to order a new licence.




| No. | Item | Notes |
|---|---|---|
| 1 | Current licences | Shows the installed DEIF application licences on the controller, this includes the expiry date. |
| 2 | Serial number | Shows the controller's serial number.<br>This is required when ordering new licences, as the licences are linked to the serial number. |
| 3 | Licence file | Drag and drop a new **.licence** file or select the file from your computer. |
| 4 | Signature file | Drag and drop a new **.signature** file or select the file from your computer. |
| 5 | Update | Update the controller with the new **.licence** and **.signature** files. |
| 6 | Licences manifest | Shows all other installed licences on the controller.<br>Use the link to view further information about the licence. |

### 13.7.2 Update licence

After sending your serial number to DEIF, you will receive an email with your new licence files.

You will receive two files:

**Table 13.1**

| File | Description |
|---|---|
| **.licence** | This is the licence for the application / features. |
| **.signature** | This is the DEIF-certified signature file. |

Both files are required to successfully update your controller's licence.

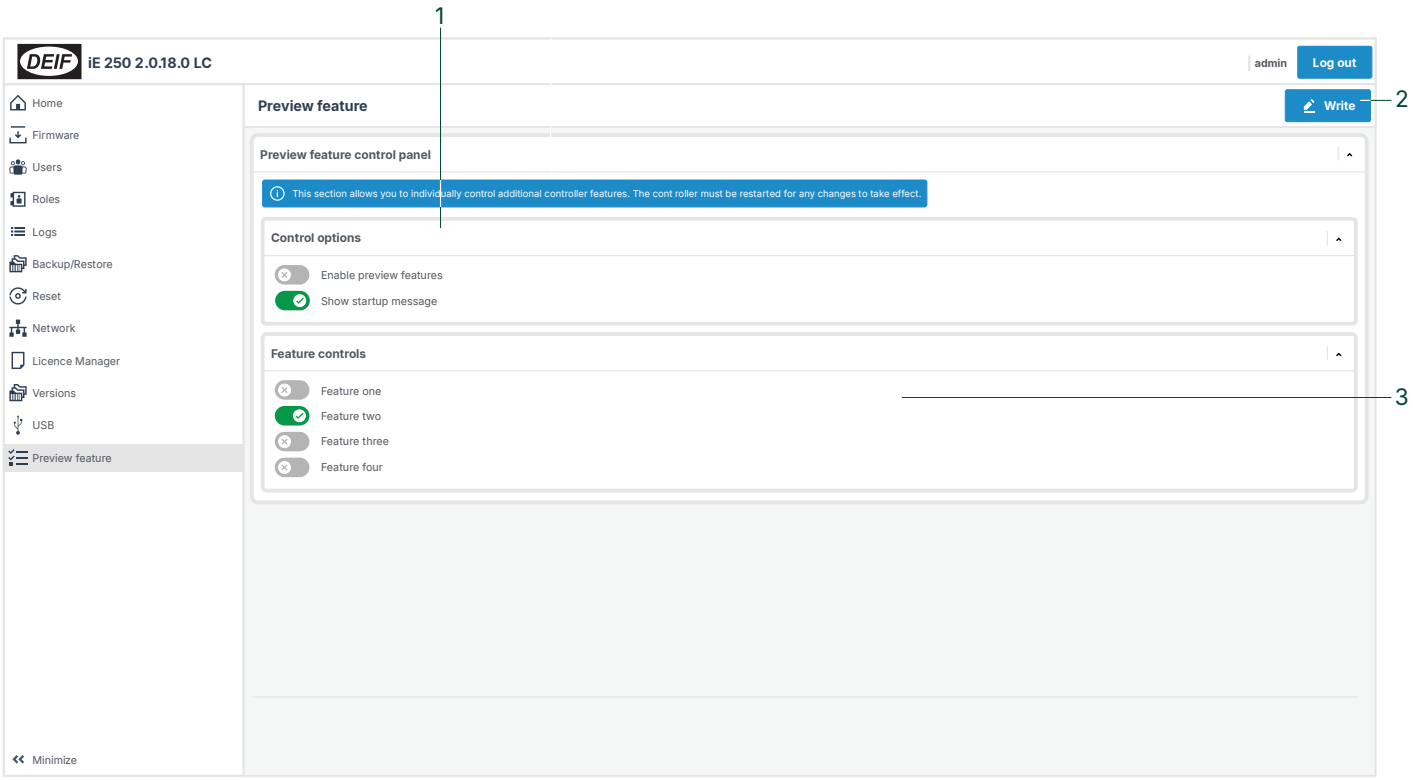
#### How to update the licence

1. Extract the two files, **.licence** and **.signature**, to your local PC or drive.
2. Open the Controller's WebConfig settings with your HTML-browser.
3. Select the Licence manager section.
4. In the Licence area: Drag and drop the **.licence** file or select the file from your computer.
5. In the Signature area: Drag and drop the **.signature** file or select the file from your computer.
6. Select **Update**.
7. A confirmation is shown if the update was successful.

# 13.8 Preview features

## 13.8.1 About Preview feature

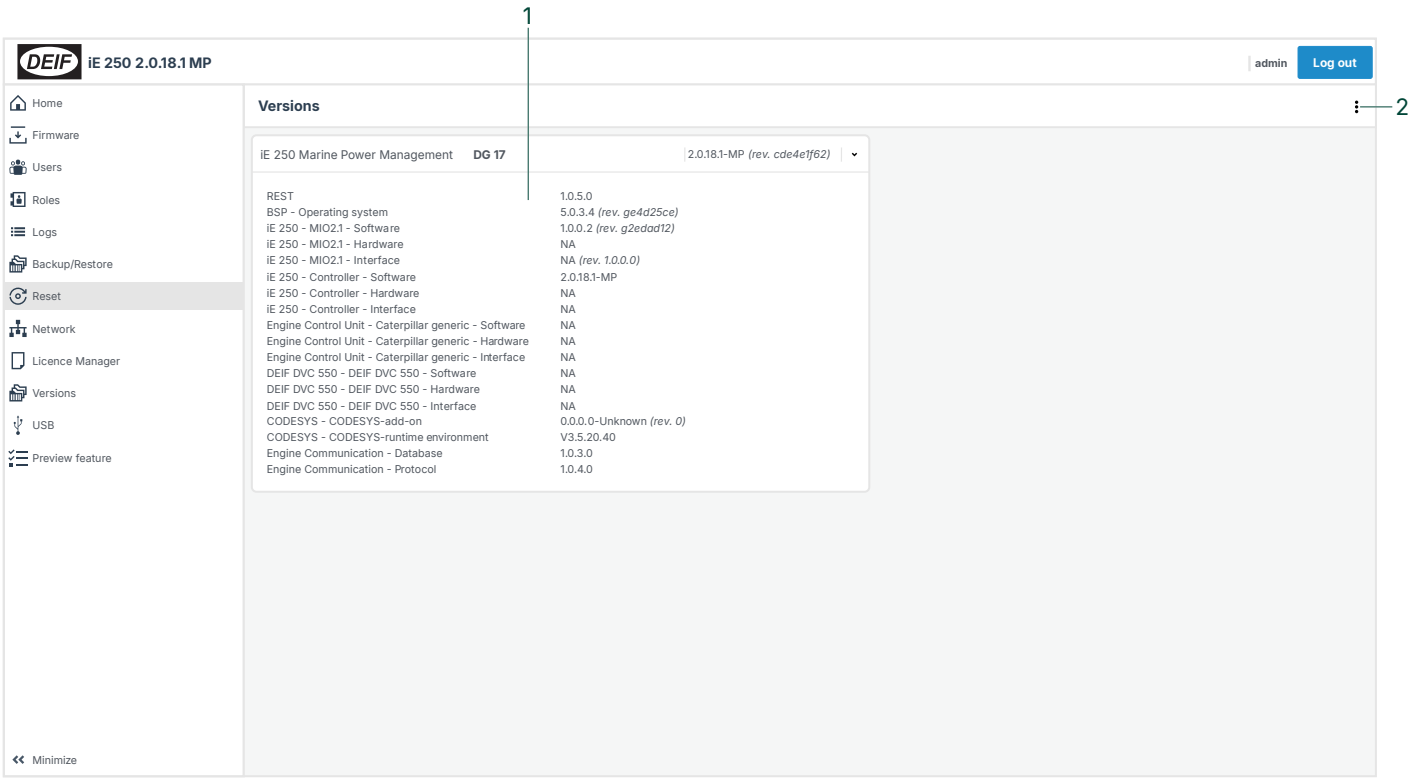
Use the **Preview feature** to try out new features before they are officially released.




| No. | Item | Notes |
|---|---|---|
| 1 | Control options | Enable or Not enable the Preview features selected. You can optionally include a startup message. |
| 2 | Write | Update the controller with the Enabled or Not enabled features. You must restart the controller for this to take effect. |
| 3 | Feature controls | Enable or Not enable the features in the controller application. |

# 13.9 Versions

The versions page can be useful if you need to contact DEIF support for assistance.




| No. | Item | Notes |
|---|---|---|
| 1 | Version information | Shows the version information. |
| 2 | ⋮ More options | Include or exclude extra information:<br>• Revisions<br>• Modules |

# 14. Hardware characteristics

## 14.1 General characteristics

Some terminal types are common to a number of different hardware modules.

The hardware includes digital bi-directional channels. These can be used as either digital outputs or digital inputs. In PICUS, under `Configure > Input/Output`, these terminals are named **DIO**. After selecting a DIO, you can select the IO type (*Digital input*, or *Digital output*) in PICUS.

The hardware includes analogue bi-directional channels. These can be used as either analogue outputs or analogue inputs. In PICUS, under `Configure > Input/Output`, these terminals are named **AIO**. After selecting an AIO, you can select the IO type (*Analogue input*, or *Analogue output*) in PICUS.

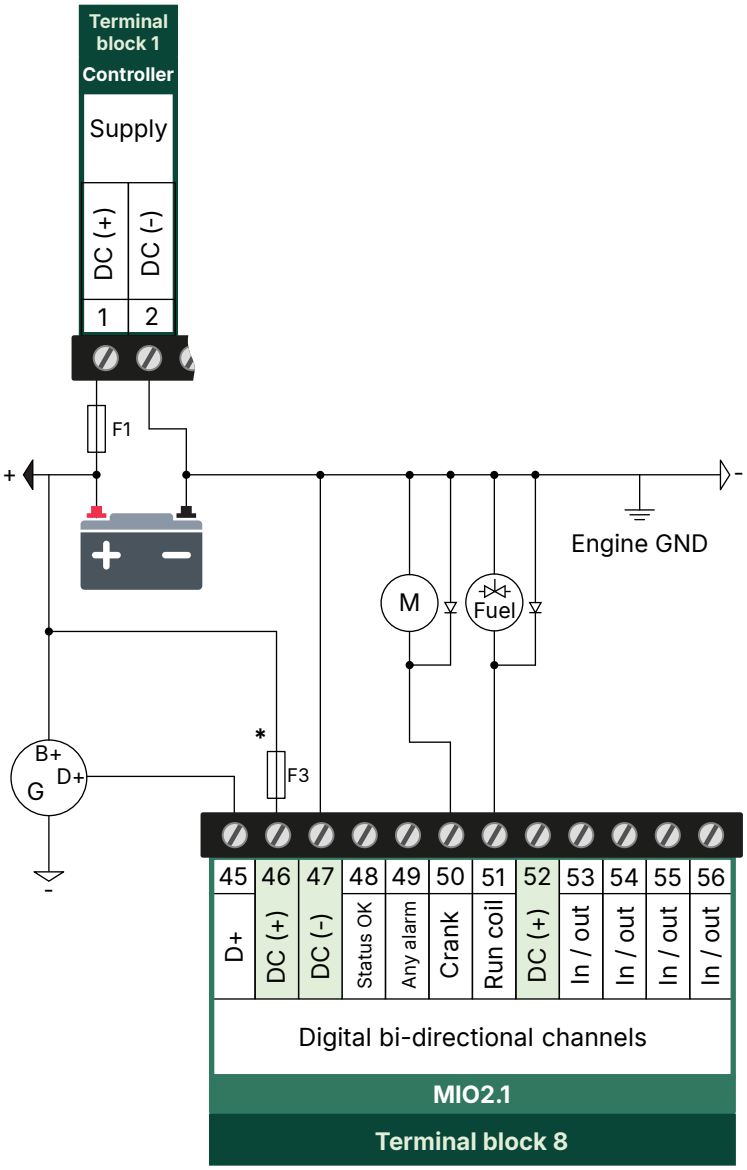
### Technical specifications

**More information**
See the Data sheet for all of the technical specifications.

# 14.2 Controller

## 14.2.1 Power supply

The power supply is connected to terminals 1 and 2 on the controller.




### Backup power

The DEIF controller 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 normally do not have a problem with start current.

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 controller will not be damaged. However, the DEIF controller will not be able to operate until the power supply has been connected correctly.

### * MIO2.1 E-stop power cut-off

You can connect an external emergency stop button to terminal 46. When the external emergency stop button is pressed, the power to the D+ (terminal 45) and DIO channels 9 to 12 (terminals 48 to 51) is broken.

Alternatively, you can connect an external emergency stop button to terminal 52. When the external emergency stop button is pressed, the power to DIO channels 13 to 16 (terminals 53 to 56) is broken.

**NOTE** The hardware emergency stop (terminal 46) is NOT related to the `Alarm system > Additional functions > Emergency stop` input, or the controller emergency stop alarm parameters (configured under `Engine > Emergency stop`).

**NOTE** The DC (+) supply (terminals 46 and/or 52) must be powered for the digital inputs 1 to 8 (terminals 57 to 64) to work.

**More information**
See **E-stop power cut-off** in the **Installation instructions**.

### Diode compensation

**`Hardware > PCM2.1 > Diode compensation`**

| Parameter | Range | Notes |
|---|---|---|
| `Diode offset` | 0.0 to 1.0 V DC | This corrects the power supply measurement values used for the supply voltage alarms. Use this to compensate for a small decrease in voltage over the diode. |

### Heat emission

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

### Power supply voltage analogue output

**`Hardware > Power supply > PCM2.1`**

| Function | I/O | Details |
|---|---|---|
| `PCM2.1 supply voltage [V]` | Analogue output | The supply voltage for the PCM2.1 which can also be configured to an output curve. |

## 14.2.2 Digital inputs

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

### Polarity

The digital inputs use negative switching.

The controller activates the *Emergency stop* safety function for a LOW digital input. For all other digital input functions, the controller activates the function for a HIGH digital input.

### Configuration

The digital inputs are configurable. That is, for each digital input, you can assign digital input function(s) and/or configure alarm(s).

You can also create responses to digital inputs using CustomLogic. You can also activate some digital input functions using a Modbus command.

### Controller types and application drawing

The controller type determines which digital input functions are available.

To see certain digital input functions, you must include the corresponding equipment in the application drawing.

### 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.

## 14.2.3 Digital outputs

### Configuration

All digital outputs are configurable.

You can assign a digital output function or an alarm to a digital output. Alternatively, you can create customised a digital output function using CustomLogic, and assign it to a digital output.

### Controller types and application drawing

The controller type determines which digital output functions are available.

To see certain digital output functions, you must include the corresponding asset in the application drawing.

### Configure output state

On the display or with PICUS, you can select a digital output channel and configure the output state. Under *Output state*, select **Close when active** (the output is closed while the function is active), or **Open when active** (the output is open while the function is active).

## 14.2.4 Analogue inputs

The controller can use an analogue input to receive operating data. The controller can also activate alarms based on the analogue input.

Alternatively, an analogue input can be configured to operate as a supervised binary input (dry contact), and assigned a digital input function. This is described at the end of this topic.

### Analogue input function

Assigning a function to the analogue input is optional.

You can assign one (or more) of the controller's analogue input functions to the input. You can only select functions that use the same units.

Alternatively, if you want to use the analogue input as a supervised binary input, you can assign one (or more) of the controller's digital input functions to the input.

### Analogue input type

Under *Sensor value (x-axis)*, select the input type. You can also adjust the input range.

You can select from these input types:

- 0 to 20 mA
- 0 to 10 V
- 0 to 10000 ohm

### Analogue input sensor setup

The sensor setup requires a curve. The curve allows the controller to convert the analogue input to the selected function's value.

Pre-configured curves may be available for the function. Alternatively, you can select a previously customised curve, or customise a curve.

### Sensor failure

You can configure customised alarms for sensor failure. The *Below range alarm* is activated when the analogue input is below the specified value. Similarly, the *Above range alarm* is activated when the analogue input is above the specified value.

**NOTICE**

**Use of sensor failure alarms**

Do not use the sensor failure alarms to respond to ordinary operating data. Configure customised analogue input alarms instead.

### Analogue input alarms

You must complete the sensor setup before configuring any analogue input alarms.

You can configure any number of alarms for an analogue input. However, you cannot exceed 25 customised alarms for the controller.

### Supervised binary input

Analogue inputs used for supervised binary inputs should be configured using the function type **Supervised binary**.

Use an analogue input curve to define the supervised binary input. The supervised binary input curve is a step function. That is, the curve consists of a horizontal line (with the value 0 or 1), a vertical line (the point where the curve changes), and another horizontal line (with the value 1 or 0).

To avoid instability, configure the curve so that the change point is far away from the input closed and open values.

If the analogue input measurement corresponds to a function input that is **not zero**, then the controller uses **one** as the function input.

## 14.2.5 Analogue outputs

An analogue output can be used to output operating data or values.

### Analogue output function

Assign one function to the analogue output. You can adjust the *Function input (x)* range.

### Analogue output type

After assigning a function, under *Output (y)*, select the output type. You can also adjust the output range.

The output types that can be selected depend on the hardware.

| Module | Terminals | Output types |
|---|---|---|
| Controller | 13, 14, 15 and 16 | 0 to 20 mA<br>0 to 10 V |

### Analogue output curve

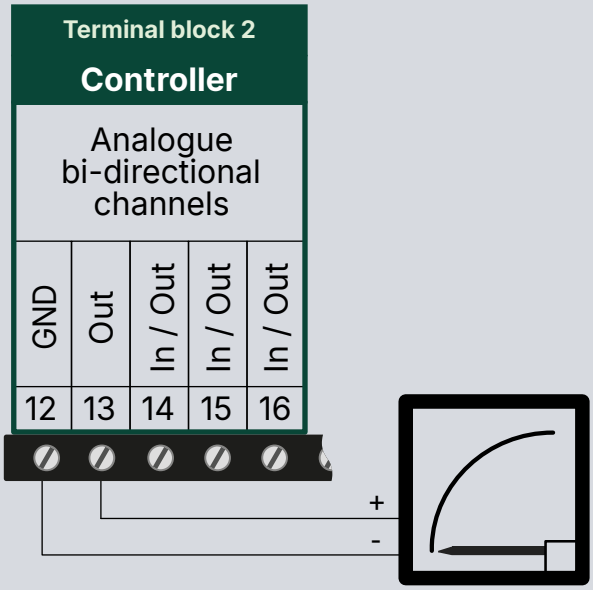
The output requires a curve. The curve allows the controller to convert the selected function's value to the analogue output.

Pre-configured curves may be available for the function. Alternatively, you can select a previously customised curve, or customise a curve.

### Output for a switchboard instrument

**Output *Generator power* example**

The customer has a 1 MW genset, and wants to display the power from the genset on the switchboard. He uses a DEIF DQ-96x with a scale from -100 to 1500 kW.
The designer creates the following wiring for a `Generator > Power (P) > Generator | Total [kW]` analogue output:




The designer selects 0 to 20 mA and configures a customised function curve with an output of 4 mA for -100 kW, and 20 mA for 1500 kW.

## 14.2.6 CAN bus communication

## 14.2.6.1 About CAN bus communication

CAN bus is used for engine communication and/or control of a DAVR.

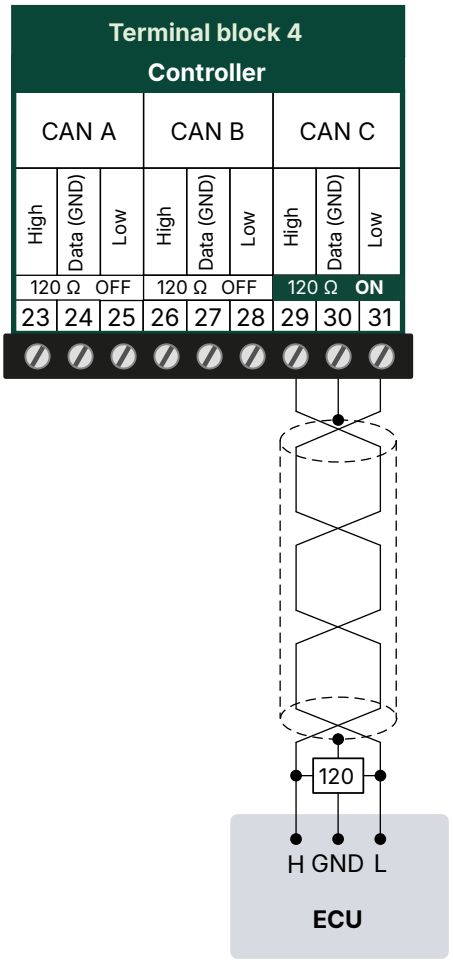
## 14.2.6.2 CAN bus cable

### Recommended CAN bus cable

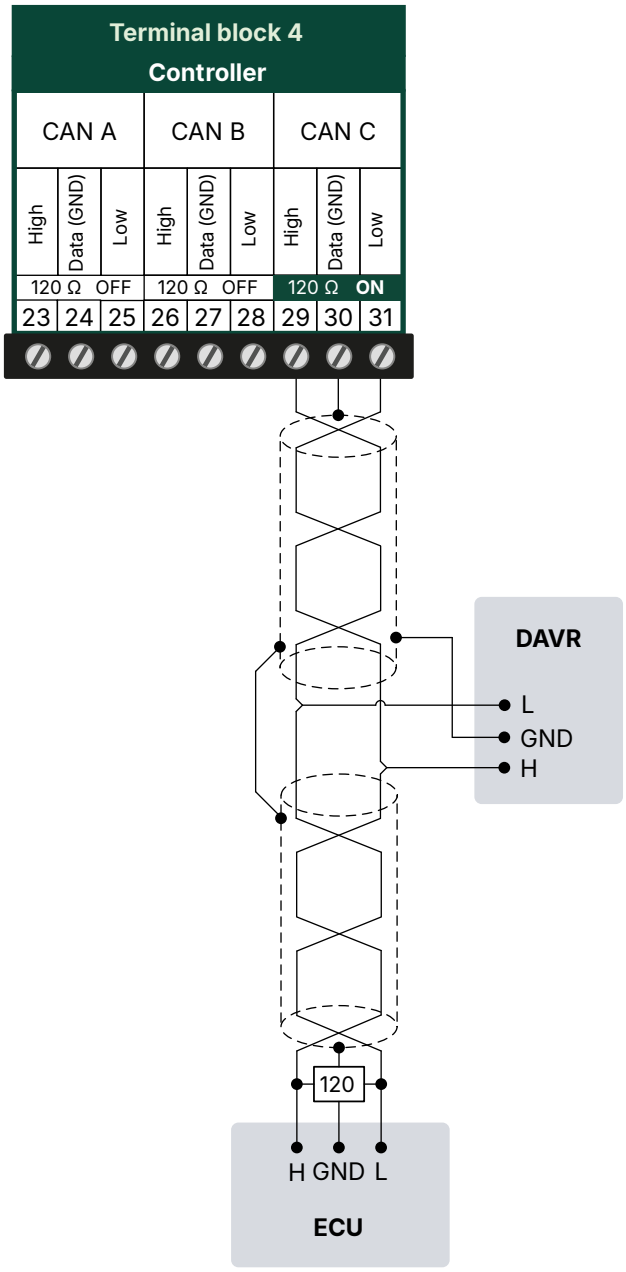
| CAN communication (Engine, DAVR)<br>RS-485 communication (Modbus) |
| --- |
| Belden 3105A or equivalent, 22 AWG (0.33 mm²) twisted pair, shielded, impedance 120 Ω (Ohm), < 40 mΩ/m, min. 95 % shield coverage. |

### 14.2.6.3 CAN bus ECU or DAVR communication

**ECU only**




**DAVR and ECU on same CAN bus**




## 14.2.7 Ethernet communication

### 14.2.7.1 About communication

The controllers communicate with each other to manage the system over the DEIF network Ethernet. Controllers are connected together in a network with Ethernet cables.

Controllers can be connected with **Network chain** or **Network ring** configuration. Do not include display units or other equipment in the chain or ring. Alternatively, controllers can be connected using a star configuration.

Connect the controller in a **Network ring** configuration for communication redundancy. If there is a disruption or failure to one of the connections, the DEIF proprietary ring protocol changes the communication path within 100 milliseconds.

You can use either the **Display** or **PICUS** to configure the controller rack communication. You must use the **Display** to configure the display specific IP address settings. Changes to communication settings require a power cycle.

**DANGER!**

**Power cycle**

The controller or display must be powered off and powered on for communication changes to apply.

This must be done by authorised personnel who understand the risks involved in accessing the power supply or installation design. Take extreme care in the enclosure next to the ACM terminals. The controllers must not be in operation and the controlled breakers must be open.

A new controller has a default **Controller ID** of **0** (zero). You must configure the ID to the required ID number, otherwise an alarm occurs. The controller ID must be the same as on the single-line application drawing.

**More information**
See **Communication** in either the **Operator's manual** or the **PICUS manual** for how to configure the communication settings.

## 14.2.7.2 Constraints

- Up to 64 controllers can be connected to each other in each network.
- Display units can be connected to the controllers, but must not be used as part of a network chain or ring.
- Configurable switches and fiber extenders can be included in the network.
  - It is the customer's responsibility to configure and test these.
  - DEIF is not responsible for the performance or functionality of any non-DEIF equipment in the network.
- 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.
- The Interconnection (major ring) can only be used for infrastructure network.

## 14.2.7.3 DEIF network Ethernet characteristics

| Category | Details |
|---|---|
| **Specifications** | • Internet Protocol version 6 (IPv6, Auto), or Internet Protocol version 4 (IPv4, Static)<br>  ◦ IPv6 is used by default until Static is specified as the IP address mode<br>• Up to 32 controllers per system<br>• Configure and optionally restrict Ethernet ports 0 to 3. |
| **Functions** | • Load sharing communication<br>• Authentication (non-DEIF equipment cannot disrupt communication)<br>• Connects the other controllers.<br>• Password protection<br>  ◦ Customisable permission levels |

## 14.2.7.4 Communication settings

| Setting | Range | Default | Notes |
|---|---|---|---|
| `Controller ID` | 1 to 64 | 0 | If you change the controller ID using the display, you must update the controller ID in the PICUS single-line application drawing. (This is not required for single controller applications, since they are not affected by controller ID changes.) |

| Setting | Range | Default | Notes |
|---|---|---|---|
| | | | The system can have up to 32 controllers, with controller IDs in the given range. |
| IPv6 address | | No default | This cannot be changed. |
| Static IPv4 | Enabled, Not enabled | Not enabled | **Enabled** uses IPv4 address. **Not enabled** uses IPv6 address. |
| IPv4 address | 0.0.0.0, 255.255.255.255 * | No default | Static IPv4 address for the controller. |
| Subnet mask | 0.0.0.0, 255.255.255.255 * | No default | Depends on the IPv4 address. |
| Default gateway | 0.0.0.0, 255.255.255.255 * | No default | |
| Preferred DNS | 0.0.0.0, 255.255.255.255 * | No default | |
| Alternate DNS | 0.0.0.0, 255.255.255.255 * | No default | |

**NOTE** * The range of addresses that you can actually use depends on your network design. If you select **Static**, then you must give the controller a unique IPv4 address. In addition, some addresses in this range are reserved.

**NOTICE**

**Controller restart required**

The controller must be powered off and powered on again for changes to these settings to take effect.

### 14.2.7.5 Ethernet port settings

| Setting | Range | Notes |
|---|---|---|
| Network mode | • Standard node (sub-ring) | **Standard node (sub-ring)** :<br>• Allows only interconnection between controllers. |
| Port 1 to 5 | • Automatic<br>• External network/PICUS<br>• Stand-alone - External configured<br>• RSTP External<br>• Disabled * | **Automatic** :<br>• The port automatically detects the type of device or connection.<br><br>**External network/PICUS**:<br>• Select to specify external network (Modbus, external switch, PICUS).<br><br>**Stand-alone - External configured**<br><br>**RSTP External**<br><br>**Disabled**:<br>• Select to stop any Ethernet communication on the port. |

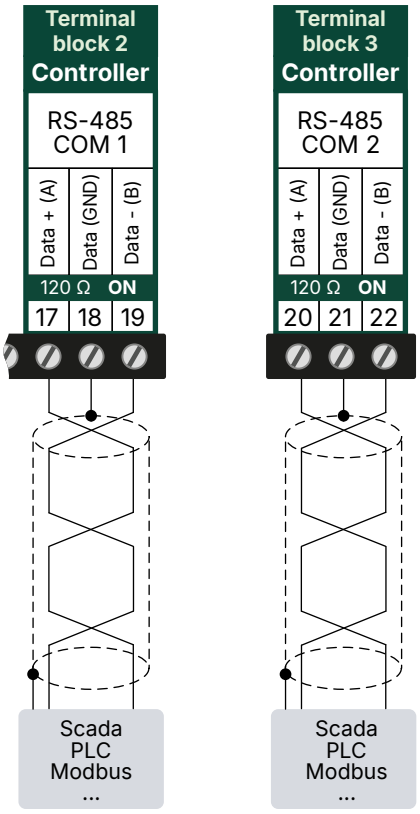
**NOTE** * You cannot configure all Ethernet ports as **Disabled**. At least one Ethernet port must remain configured.

## 14.2.8 Serial communication COM 1 / COM 2

Can be used for example to Modbus RTU, SCADA systems, or PLCs.

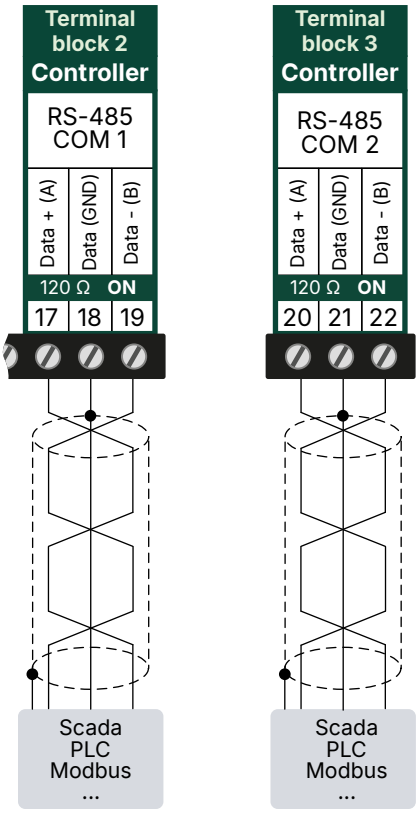
**2-wire connection**

With 2-wires, connect the GND terminal to the cable shield. Only connect the shield to earth at one end.




**3-wire connection**

Only connect the shield to earth at one end.




## 14.2.9 Factory reset

To use the controller in a new application, it can be useful to do a factory reset.

**NOTICE**

**A factory reset deletes all controller information**

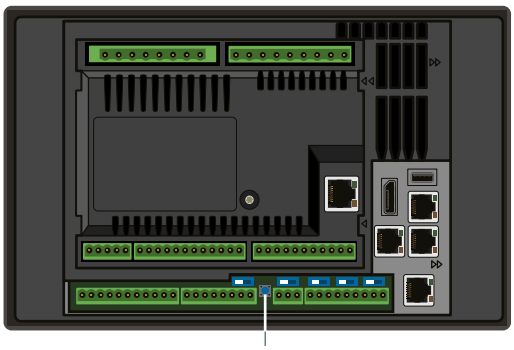
You cannot recover any controller information after a factory reset. All settings, including Ethernet configuration and passwords, are reset to their defaults.

Make sure that you want to do a factory reset. Create a full controller backup, and store it safely on your computer. Make sure that you have the information that you will need after the factory reset. This should include the default passwords, along with the new user and password configuration, and the Ethernet communication settings.

**More information**
See the PICUS manual for how to create backups from your controller.

### How to do a factory reset

1. Remove the controller power supply.
2. Press and hold the factory reset button located at the bottom:




3. Keep the factory reset button pressed and reconnect the controller power supply.
4. Continue to hold the factory reset button until you see the start up screen (this takes about one minute).
5. If the factory reset succeeds, the display does not show an application diagram. The controller also activates several alarms.

**NOTE** Alternatively, you can use the WebConfig Reset function.

## 14.2.10 CPU load as an analogue output

You can configure an analogue output with a function for the CPU load. The controller uses the configured curve to convert this value to an analogue output. You can configure functions for the CPU load overall, or for any of the CPU cores.

### Analogue output

**`Hardware > CPU > Load`**

| Function | I/O | Units | Details |
|---|---|---|---|
| `Currently [%]` | Analogue output | 0 to 100 % | The controller measures the overall CPU load as a percentage. |
| `Average over 10 seconds [%]` | Analogue output | 0 to 100 % | The controller measures the average CPU load over 10 seconds as a percentage. |
| `Average over 1 minute [%]` | Analogue output | 0 to 100 % | The controller measures the average CPU load over 1 minute as a percentage. |
| `Average over 10 minutes [%]` | Analogue output | 0 to 100 % | The controller measures the average CPU load over 10 minutes as a percentage. |

**`Hardware > CPU > Core # *`**

| Function | I/O | Units | Details |
|---|---|---|---|
| `Currently [%]` | Analogue output | 0 to 100 % | The controller measures the CPU core # load as a percentage. |
| `Average over 10 seconds [%]` | Analogue output | 0 to 100 % | The controller measures the average CPU core # over 10 seconds as a percentage. |
| `Average over 1 minute [%]` | Analogue output | 0 to 100 % | The controller measures the average CPU core # over 1 minute as a percentage. |
| `Average over 10 minutes [%]` | Analogue output | 0 to 100 % | The controller measures the average CPU core # over 10 minutes as a percentage. |

**NOTE** # is 1 to 4.

# 14.3 Add-on modules

## 14.3.1 Measurement Input Output module MIO2.1

### 14.3.1.1 Voltage measurements

The MIO2.1 has two sets of terminals for voltage measurement. Terminals 78 to 81 measure the voltage on the A-side. Terminals 83 to 86 measure the voltage on the B-side.

The MIO uses the voltage measurements for synchronisation and protective functions. The measurements are shared with the controller for regulation, supervision, and logging. For power functions, the A-side voltage measurements are used combination with the relevant current measurements (terminals 72 to 77, or 70 to 71).

For 3-phase systems, to supervise phase-neutral or phase-earth voltages, you must also connect the neutral voltage measurements (terminal 78 on the A-side, and terminal 83 on the B-side).

### 14.3.1.2 Current measurements

The MIO2.1 measures the current, then uses these measurements for protective functions. The current measurements are shared with the controller for supervision and logging. For power functions, the A-side voltage measurements are used combination with the relevant current measurements (terminals 72 to 77, or 70 to 71).

You do not have to connect 4th current (terminals 70 and 71). You can use the 4th current input to measure the neutral current, the earth current, or a custom current (for example, the mains current).

### 14.3.1.3 Digital inputs

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

#### Polarity

The digital inputs use negative switching.

The controller activates the *Emergency stop* safety function for a LOW digital input. For all other digital input functions, the controller activates the function for a HIGH digital input.

#### Configuration

The digital inputs are configurable. That is, for each digital input, you can assign digital input function(s) and/or configure alarm(s).

You can also create responses to digital inputs using CustomLogic. You can also activate some digital input functions using a Modbus command.

#### Controller types and application drawing

The controller type determines which digital input functions are available.

To see certain digital input functions, you must include the corresponding equipment in the application drawing.

#### 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.

### 14.3.1.4 Digital outputs

#### Configuration

All digital outputs are configurable.

You can assign a digital output function or an alarm to a digital output. Alternatively, you can create customised a digital output function using CustomLogic, and assign it to a digital output.

### Controller types and application drawing

The controller type determines which digital output functions are available.

To see certain digital output functions, you must include the corresponding asset in the application drawing.

### Configure output state

On the display or with PICUS, you can select a digital output channel and configure the output state. Under *Output state*, select **Close when active** (the output is closed while the function is active), or **Open when active** (the output is open while the function is active).

## 14.3.1.5 Analogue outputs

An analogue output can be used to output operating data or values.

### Analogue output function

Assign one function to the analogue output. You can adjust the *Function input (x)* range.

### Analogue output type

After assigning a function, under *Output (y)*, select the output type. You can also adjust the output range.

The output types that can be selected depend on the hardware.

| Module | Terminals | Output types |
|---|---|---|
| MIO2.1 | 40-41 and 43-44 | -10 to 10 V<br>PWM |

### Analogue output curve

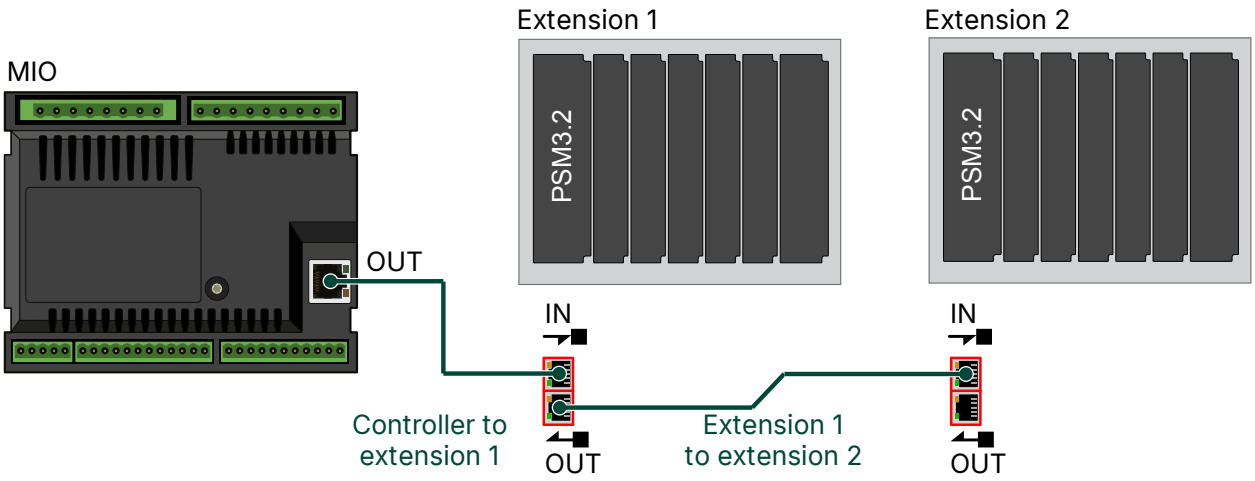
The output requires a curve. The curve allows the controller to convert the selected function's value to the analogue output.

Pre-configured curves may be available for the function. Alternatively, you can select a previously customised curve, or customise a curve.

## 14.3.1.6 EtherCAT communication

## 14.3.1.6.1 Extension rack communication

Extension racks are connected to a controller using the EtherCAT port on the MIO2.1. Do not use this port for any other communication.




**NOTE** EtherCAT ring connections for redundancy are not possible.

**Internal communication requirements**

The OUT port must always be connected to the IN port on the next extension rack.

Power off the extension rack(s) before you exchange or re-connect them to another controller.

- Up to 5 extension racks can be connected to the same controller.
- The controller and extension rack must be connected directly (without a switch between them).

**EtherCAT cable requirements**

- The cables must not be longer than 100 metres from point-to-point.
- The cables must meet or exceed the SF/UTP CAT5e specification.
- The cable bend radius must not be tighter than the minimum bend radius specified by the cable manufacturers.
  - We recommend that you always follow the cable manufacturer's bend radius requirements.
  - It is recommended to use velcro-strips (and not cable-ties) for the Ethernet cables.

**More information**
See **Fieldbus configuration** in the PICUS manual for how to configure communication with extension rack(s).

# 14.4 Plug-in modules

## 14.4.1 8 Digital bi-directional channels

### 14.4.1.1 Digital inputs

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

**Polarity**

The digital inputs use negative switching.

The controller activates the *Emergency stop* safety function for a LOW digital input. For all other digital input functions, the controller activates the function for a HIGH digital input.

**Configuration**

The digital inputs are configurable. That is, for each digital input, you can assign digital input function(s) and/or configure alarm(s).

You can also create responses to digital inputs using CustomLogic. You can also activate some digital input functions using a Modbus command.

### Controller types and application drawing

The controller type determines which digital input functions are available.

To see certain digital input functions, you must include the corresponding equipment in the application drawing.

### 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.

## 14.4.1.2 Digital outputs

### Configuration

All digital outputs are configurable.

You can assign a digital output function or an alarm to a digital output. Alternatively, you can create customised a digital output function using CustomLogic, and assign it to a digital output.

### Controller types and application drawing

The controller type determines which digital output functions are available.

To see certain digital output functions, you must include the corresponding asset in the application drawing.

### Configure output state

On the display or with PICUS, you can select a digital output channel and configure the output state. Under *Output state*, select **Close when active** (the output is closed while the function is active), or **Open when active** (the output is open while the function is active).

## 14.4.2 4 Analogue bi-directional channels

## 14.4.2.1 Analogue inputs

The controller can use an analogue input to receive operating data. The controller can also activate alarms based on the analogue input.

### Analogue input function

Assigning a function to the analogue input is optional.

You can assign one (or more) of the controller's analogue input functions to the input. You can only select functions that use the same units.

### Analogue input type

Under *Sensor value (x-axis)*, select the input type. You can also adjust the input range.

You can select from these input types:

- 0 to 20 mA
- 0 to 10 V
- 0 to 10000 ohm

### Analogue input sensor setup

The sensor setup requires a curve. The curve allows the controller to convert the analogue input to the selected function's value.

Pre-configured curves may be available for the function. Alternatively, you can select a previously customised curve, or customise a curve.

#### Sensor failure

You can configure customised alarms for sensor failure. The *Below range alarm* is activated when the analogue input is below the specified value. Similarly, the *Above range alarm* is activated when the analogue input is above the specified value.

**NOTICE**

**Use of sensor failure alarms**

Do not use the sensor failure alarms to respond to ordinary operating data. Configure customised analogue input alarms instead.

#### Analogue input alarms

You must complete the sensor setup before configuring any analogue input alarms.

You can configure any number of alarms for an analogue input. However, you cannot exceed 25 customised alarms for the controller.

#### Supervised binary input

Analogue inputs used for supervised binary inputs should be configured using the function type **Supervised binary**.

Use an analogue input curve to define the supervised binary input. The supervised binary input curve is a step function. That is, the curve consists of a horizontal line (with the value 0 or 1), a vertical line (the point where the curve changes), and another horizontal line (with the value 1 or 0).

To avoid instability, configure the curve so that the change point is far away from the input closed and open values.

If the analogue input measurement corresponds to a function input that is **not zero**, then the controller uses **one** as the function input.

### 14.4.2.2 Analogue outputs

An analogue output can be used to output operating data or values.

#### Analogue output function

Assign one function to the analogue output. You can adjust the *Function input (x)* range.

#### Analogue output type

After assigning a function, under *Output (y)*, select the output type. You can also adjust the output range.

The output types that can be selected depend on the hardware.

#### Analogue output curve

The output requires a curve. The curve allows the controller to convert the selected function's value to the analogue output.

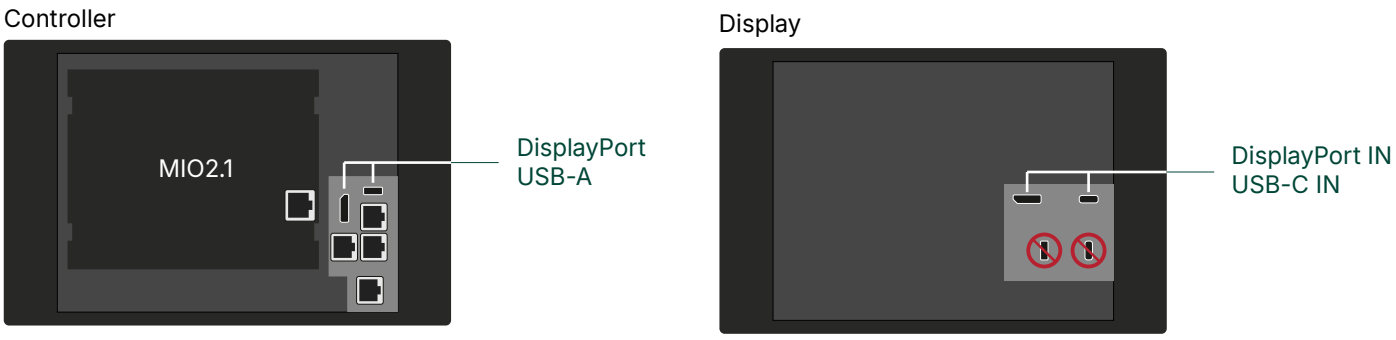
Pre-configured curves may be available for the function. Alternatively, you can select a previously customised curve, or customise a curve.

## 14.5 iE 7 Local display

### 14.5.1 iE 7 display connections

The display has inputs for **DisplayPort IN** and **USB type C IN**. It also has additional USB communication ports for future use.

The **DisplayPort IN** and **USB type C IN** are needed to connect and operate to the base-mounted controller.

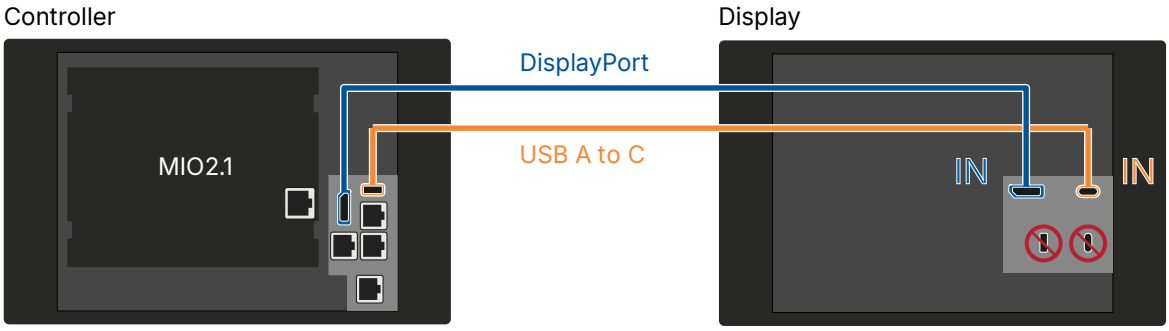



The additional USB ports on the display are for future use.

### Connection constraints

- The display is only for use with a base-mounted controller.
- The **DisplayPort IN** and **USB type C IN** cables must be connected to operate the base-mounted controller.
- Controllers must be connected directly without a USB hub or similar.
- All USBs support 2.0.
- Both the DisplayPort and USB A to C cables are supplied.
- Connection to the display must use the ports marked **IN**.

### Base-mounted controller to display connection




USB Connection to display must use USB IN.

# 15. Glossary

## 15.1 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 | |
| American National Standards Institute | ANSI | |
| American wire gauge | AWG | A standardised wire gauge system, also known as the Brown & Sharpe wire gauge. |
| Analogue input | AI | Terminals on a controller hardware module that the controller uses to measure an analogue input. The analogue input type and range are typically selected during commissioning. You can create a custom range or select from a list of pre-configured voltage, current, and resistance measurement input ranges. A pre-configured analogue input function or alarm can also be assigned to the input. |
| Analogue output | AO | Terminals on a controller hardware module that the controller uses to send an analogue output. The analogue output type and range are typically selected during commissioning. You can create a custom range or select from a list of pre-configured voltage and current output ranges. A pre-configured analogue output function can also be assigned to the output. |
| Apparent power | S | The 3-phase apparent power, measured in kVA. |
| [A-side] | | The A-side side of the breaker. For a **GENSET** controller, this is the generator side. For a **BUS TIE breaker** controller, this is Busbar A. |
| Asset | | The equipment that the controller controls. |
| Automatic voltage regulator | AVR | Regulates the genset voltage. The AVR is external equipment. The AVR can have a fixed voltage set point. Alternatively, the DEIF controller can control the AVR. |
| Blackout | | The busbar voltage is less than 10 % of the nominal voltage, and all generator breakers are open. |
| Breaker | | A mechanical switching device that closes to connect power sources to the busbar, or to connect busbar sections. The breaker opens to disconnect the power sources or to split the busbar. |
| [B-side] | | The B-side side of the breaker. For a **GENSET** controller, this is the busbar. For a **BUS TIE breaker** controller, this is Busbar B. |
| Busbar | | The copper conductors which connect the power sources to the power consumers. Represented on the single-line application drawing 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. |
| Bus tie breaker | BTB | Physically disconnects two main busbars from each other, so that they operate as two separate (split) busbars. Also reconnects split busbars so that they operate as one busbar. A **BUS TIE breaker** controller can control a bus tie breaker. |
| **BUS TIE breaker** controller | | Controls and protects a bus tie breaker. The controller ensures that the two busbars are synchronised before closing the bus tie breaker. |

| Term | Abbreviation | Explanation |
|---|---|---|
| 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. Configuration also refers to the arrangement of hardware and wiring. |
| 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 power source is connected to the system if it is running, synchronised with the busbar, and its breaker is closed. |
| Controller | | DEIF equipment that measures system conditions and then uses outputs to make the system respond appropriately. |
| Current transformer | CT | A transformer for a current measurement, so that the current at the controller is within the controller's specifications. |
| CustomLogic | | The ladder logic system included in the controller software, which can be configured for customised responses to measured or calculated values. |
| Delay | | An alarm must exceed its set point continuously for the period in its delay parameter before the alarm is activated. |
| Diesel generator | DG | A **GENSET** controller can control a diesel generator. |
| 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 | |
| Emulation | | A controller test environment, accessible from PICUS, that does not require live AC power. A virtual operation mode, to simulate the effect of various real world actions. |
| Endian | | Endian refers to how the order of bytes in a multi-byte value is perceived or acted upon. It is the system of ordering the individual elements in a digital word in a computer’s memory as well as describing the order of transmission of byte data over a digital link. |
| European Norm | EN | Standards issued by the European Committee for Standardisation (also known as Comité Européen de Normalisation). |

| Term | Abbreviation | Explanation |
|---|---|---|
| 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 equipment status, and so on. |
| Generator | | The machine that converts mechanical energy into electricity. |
| Generator breaker | GB | The breaker between a generator (for example, a genset) and the busbar. |
| Generator tacho (measurement/ output) | W | A generator tacho measurement. This can be used as a backup measurement for generator speed. |
| Genset | | A prime mover (for example, a diesel engine) combined with a generator. |
| **GENSET** controller | | Controls and protects a genset. This includes control of the generator breaker. |
| Governor | GOV | Regulates the engine speed. |
| Ground | | A connection between the equipment and earth. |
| | GOST | Regional standards maintained by the Euro-Asian Council for Standardization, Metrology and Certification. |
| High speed digital input | HSDI | MPU/W/NPN/PNP sensor digital input. |
| 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. |
| Institute of Electrical and Electronics Engineers | IEEE | |
| International Association of Classification Societies | IACS | |
| International Electrotechnical Commission | IEC | |
| 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. |

| Term | Abbreviation | Explanation |
|---|---|---|
| Liquid crystal display | LCD | The screen of the display unit. The information displayed varies, depending on the controller mode, the equipment operation and the operator input. |
| Load sharing | | For equal load sharing, each genset supplies the same proportion of its nominal power. |
| Local control | LOCAL | A controller operating mode. Operator commands using the display unit push-buttons (for example, close breaker) start pre-programmed sequences in the controller. Remote commands are ignored. |
| Magnetic pickup | MPU | Measures the genset speed (that is, RPM). This sensor is normally located at the genset flywheel. |
| Mains breaker | MB | The breaker between a mains and the busbar. |
| **MAINS** controller | MAINS | Controls a mains breaker (MB) to a mains, and optionally a tie breaker (TB). |
| Mean Time Between Failures | MTBF | |
| Mean Time To Failure | MTTF | |
| Multi-line 300 | ML 300 | A DEIF product platform. |
| Name | [ ] | Square brackets show that the name inside the square bracket must be adapted according to the controller type. For example, for a **GENSET** controller, [A-side] is "Generator". |
| 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. |
| Network ring | | An Ethernet connection topology where the controllers are connected in a line, and the last controller is connected back to the first. |
| Network chain | | An Ethernet connection topology where the controllers are connected in a line. |
| Nominal setting | nom or NOM | The expected voltage and frequency for the system, and each power source's maximum load and current. Many of the controller's alarms are based on percentages of the nominal settings. |
| | NPN | A type of transistor. |
| Number | # | Hash represents a number. The description is the same for each item in the range. For example, "Controller ID #" represents any of the possible controller IDs. |
| Oil pressure | OP | |
| 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. |
| 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. |
| Phasor | | A complex plane representation (that is, a magnitude and direction) of a sinusoidal wave. |
| 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. |
| Printed circuit board | PCB | Supports and electrically connects components. |
| Programmable logic controller | PLC | A digital computer used for the automation of electromechanical processes. |
| Proportional integral derivative | PID | A feedback controller. |
| Pt100, Pt1000 | | Platinum temperature sensors |
| Pulse width modulation | PWM | Terminals with an output that uses variable pulse widths, and behaves as an analogue output. |
| | PNP | A type of transistor. |
| Rapid spanning tree protocol | RSTP | A protocol used to compute the topology of a local area network. |
| Reactive power | Q | The 3-phase reactive power, measured in kvar. |
| Reference | | The signal sent to a control system that represents the desired value of the output. |
| Remote control | REMOTE | A controller operating mode. Remote commands (for example, close breaker) start pre-programmed sequences in the controller. The remote commands can come from a PLC, PICUS or a digital input. Commands from the display unit push-buttons are ignored. |
| Resistance measurement input | RMI | Variable resistance device, used for some of the input terminals on genset controllers. |
| Root mean squared | RMS | Refers to the mean magnitude of a sinusoidal wave. For example, RMS V refers to the mean AC voltage. |
| Running | | A genset is regarded as running if the engine is started and there is running detection. A running engine does not necessarily have to be synchronised with the busbar. |
| Section | | Part of the busbar that is isolated from the rest of the busbar because bus tie breaker(s) are open. Busbar sections can run independently of each other, and do not have to be synchronised. |
| 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. |
| Shielded foiled twisted pair | SFTP | SFTP cables are used to minimise electromagnetic interference. |

| Term | Abbreviation | Explanation |
|---|---|---|
| Shutdown | | An emergency or fast stop of the genset engine. No cooldown time is allowed. |
| **SINGLE genset** controller | SINGLE | Controls and protects prime mover and generator, the generator breaker and optionally a mains breaker. |
| Single-phase | | A system where the load is connected between one phase 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. |
| Supervision | | A PICUS function to monitor the operation of the entire system, and to send commands to any of the controllers. |
| Supervisory control and data acquisition system | SCADA | |
| Switchboard | | The cabinet where the power sources are connected to the power consumers. |
| System | | The gensets, the other power sources, all breakers, the busbars, and all their controllers. Within the system, the DEIF controllers work together to supply the power required safely and efficiently. |
| 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. |
| Tie breaker | TB | The breaker between a mains breaker and the busbar. |
| Time | t | |
| Transmission control protocol/internet protocol | TCP/IP | The Internet protocol suite. It provides end-to-end connectivity by specifying data handling. |
| Trip | | An emergency or fast opening of a breaker. No attempt is made to de-load the breaker before it opens. |
| United Kingdom | UK | |
| United States of America | US, USA | The USA sometimes requires different technical standards. They also use their own system of units. |
| 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 | A transformer for a voltage measurement, so that the voltage at the controller is within the controller's specifications. |

## 15.2 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).

| 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) |

| Unit | Name | Measures | US unit | US name | Conversion | Alternative units |
|---|---|---|---|---|---|---|
| | | | | | | 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 | |
| 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 | | | | |

## 15.3 Symbols

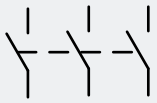
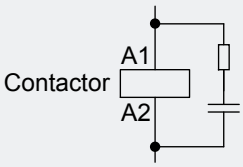
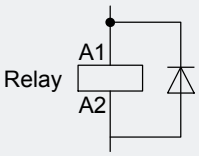
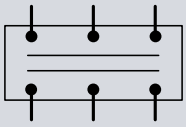
### 15.3.1 Mathematical symbols

| 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 |

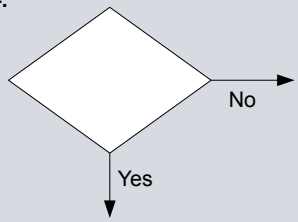
## 15.3.2 Drawing symbols

The drawings use EU symbols.

### Electrical symbols

| Symbol | Symbol name |
|---|---|
|  | 3-phase breaker |
| | Capacitor |
|  | Contactor with RC snubber |
| • | Connector dot |
| | Current transformer (S1 and · show "current in"; S2 shows "current out") |
| | Diode |
| | Fuse |
| | Ohmmeter |
|  | Relay with freewheeling diode |
| | Resistor (IEC-60617) |
| | Single-line diagram closed breaker |
| | Single-line diagram open breaker |
| ○ | Temporary connection dot (for example, connection to a meter) |
|  | Voltage transformer. This is a generic voltage transformer, without any information about the transformer connections. These could for example be: open delta, star-star, closed delta, and so on. |

### 15.3.3 Flowchart symbols

| Symbol | Notes |
|---|---|
| #.<br>  | Decision<br><br># shows step number. |
| | Process |
| | Alarm |
| | Information message |
| | Start or end |