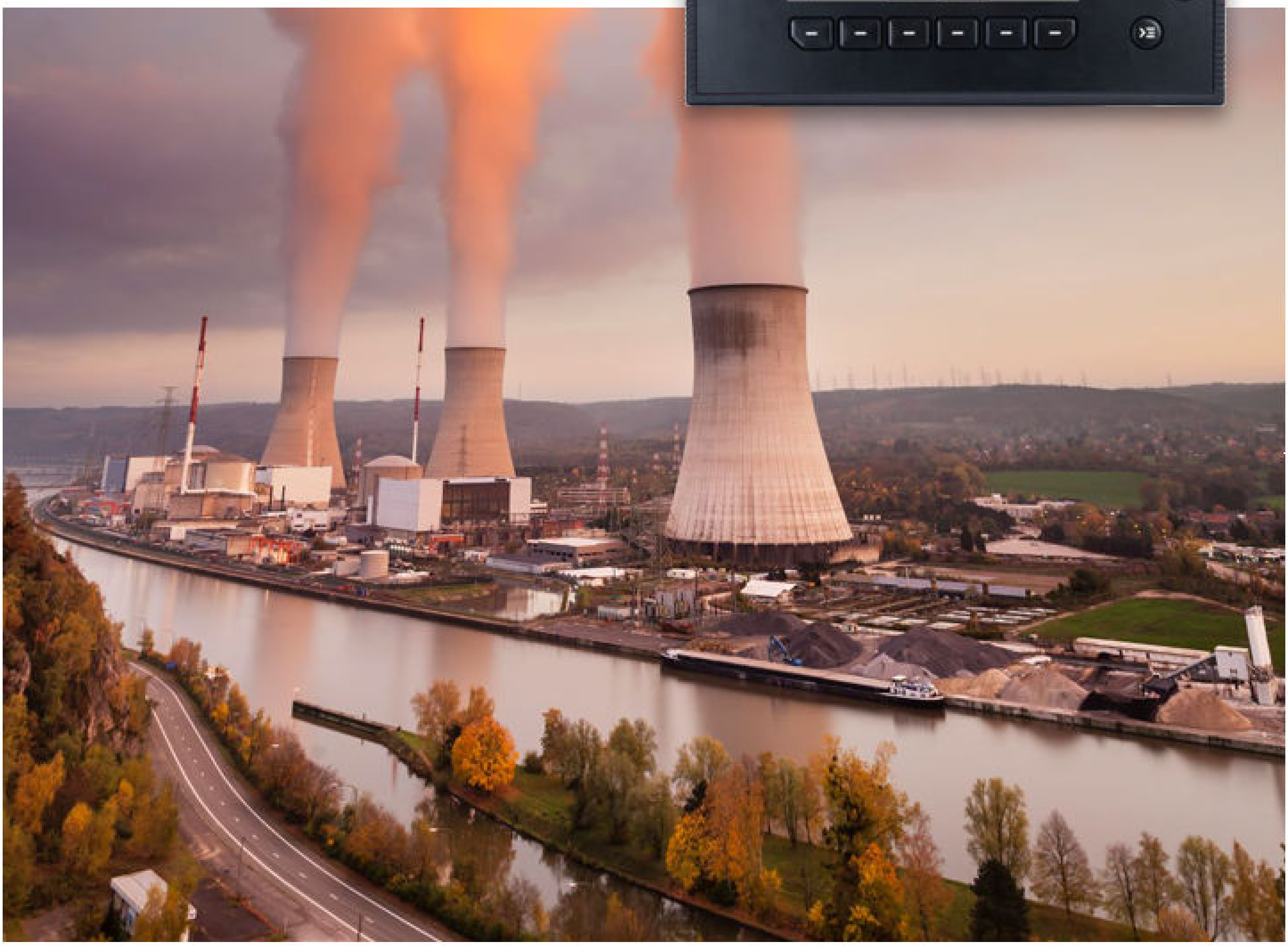
iE 350

Core

Designer's handbook

4189341384-D

Improve Tomorrow



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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 350 Core	Controller application	2.0.11.x
CODESYS libraries	CODESYS	2.0.11.x
PICUS	PC software	1.0.24.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 350 documentation.

Product
iE 350 product page.

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

1.5 CAD drawings

CAD / DWG Drawings

DWG – iE 350 Racks and modules
www.deif.com/rtd/ie350/cad

DWG – iE 7 Display
www.deif.com/rtd/ie7/dwg

STP STEP-file

STP
iE 350
Racks and modules

www.deif.com/rtd/ie350/stp

STP
iE 7
Display

www.deif.com/rtd/ie7/stp

2D PDF

2D PDF
iE 350
Racks
R4.1 and R7.1

www.deif.com/rtd/ie350/2dpdf

2D PDF
iE 7
Display

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

3D PDF

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

3D PDF
iE 350
Racks and modules

www.deif.com/rtd/ie350/3dpdf

3D PDF
iE 7
Display

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

Protect the equipment terminals from electrostatic discharge when not installed in a grounded rack.

Electrostatic discharge could damage the equipment.

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

If the display is opened, then the warranty is void.

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2. System principles

2.1 About the controllers

2.1.1 About the controller types

The iE 350 is a versatile and modular-designed controller for land. Its design enables you to tailor the installation to your needs.

Available hardware versions:

- **iE 350 (Base):** Base-mounted version for DIN rail or fixed (180° rotated) mounting in back panel.

An extensive range of control, protection and supervision features. Applications range from single genset, genset, mains connection, and bus tie breaker. The controller can be used to control and protect a stand-alone genset with its generator breaker and mains breaker. Alternatively, you can connect controllers to create one system, with load sharing sections.

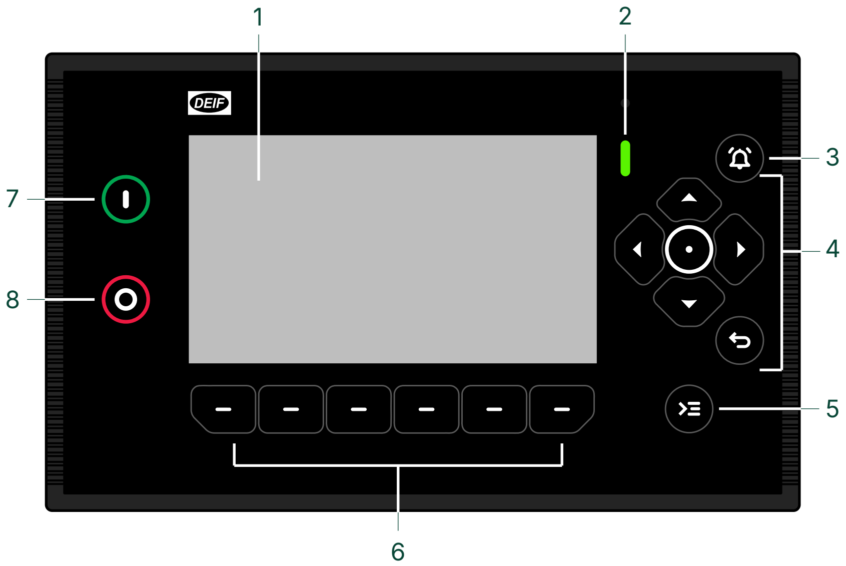
The supported features depend on the software licence installed.

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 • A prime mover, generator, generator breaker, and mains connection • A prime mover, generator, and generator breaker
Genset controller	A prime mover, generator, and generator breaker.
Mains controller	• A mains connection, and mains breaker. • A mains connection, mains breaker, and a tie breaker.
Bus tie breaker controller	A bus tie breaker.

2.1.2 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 • Shows the menu. • 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
```

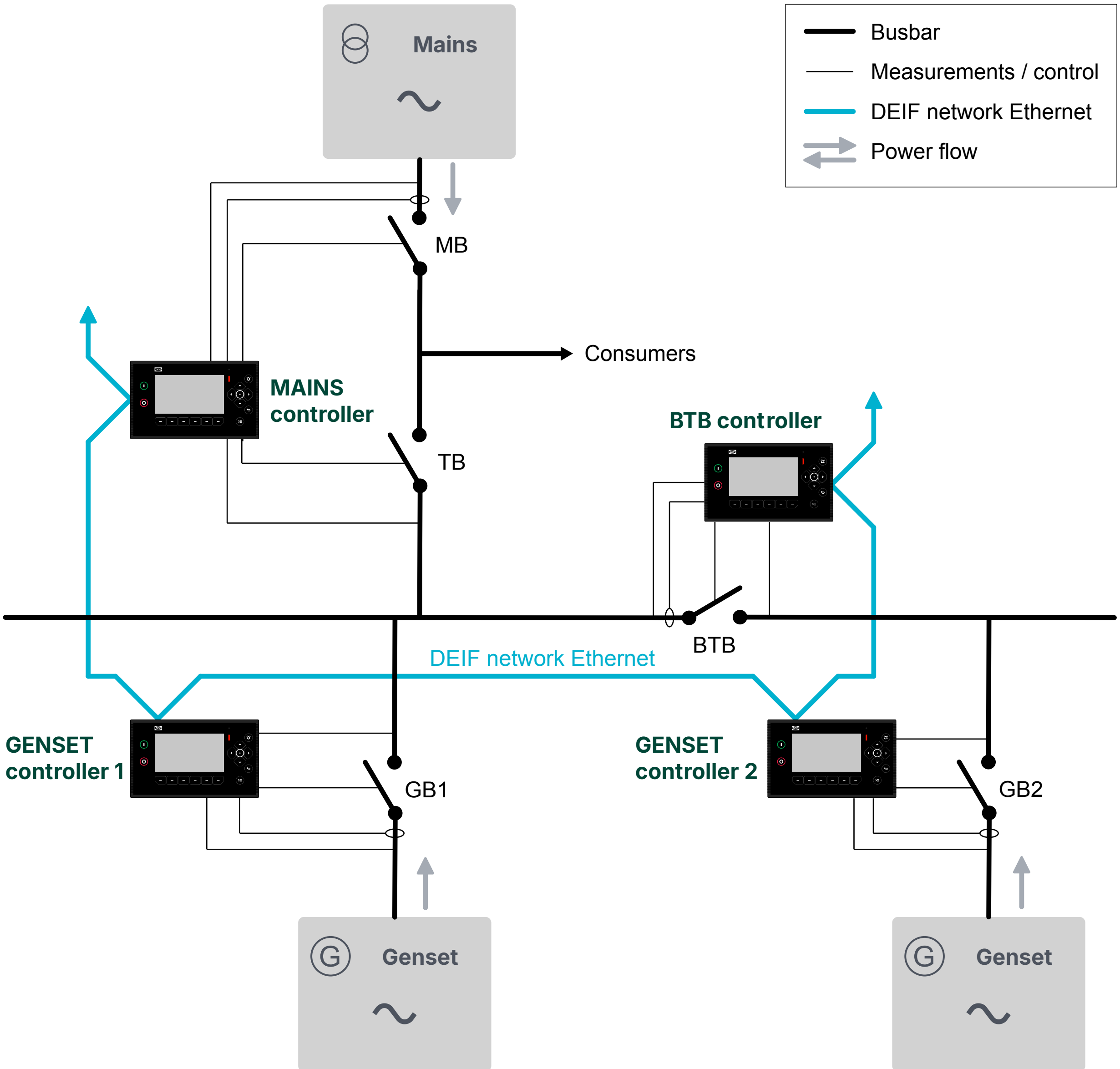
The application drawing is created in PICUS and must be written to all connected controllers in the same system. If different applications are detected in the system, the controller activates an alarm.

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 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.

2.2.4 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.

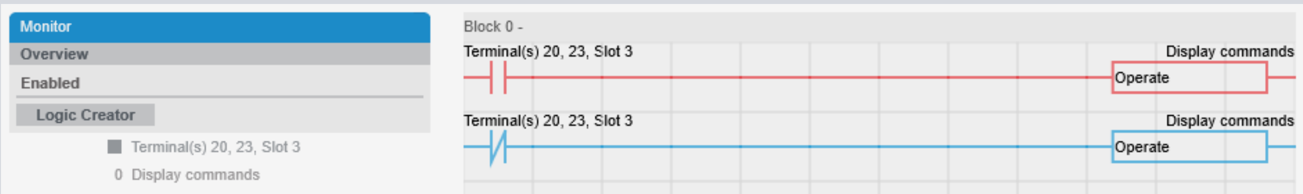
Parameter	Range	Push-button	Notes
Display commands	Remote/Local mode	-	**Remote**: The controller only responds to remote signals. **Local**: The controller only responds to operator inputs using the display unit.
	Mute alarm	-	Allow or prohibit the operator to mute alarms.
	Start/stop engine	 or 	Allow or prohibit the operator to start or stop the engine or power source.
	Open/close [Equipment] breaker	CLOSE or OPEN	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

Command	Bit	OPERATE value
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

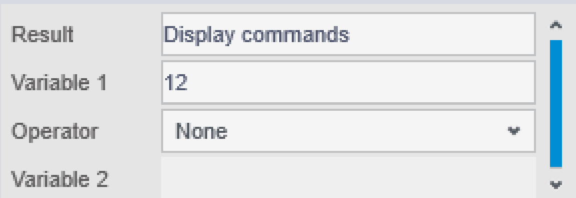
Command	Bit	OPERATE value
[Mode]	0	1
Mute alarm	1	2
Open/close breaker	2	4

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. 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. The operator presses the button on the switchboard, to activate the digital input. 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. 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. The conditions are met, and CustomLogic activates the function. 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. 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*. 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. If the *Duty cycle* is set to 0 %, then the I/O output is always low. 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.

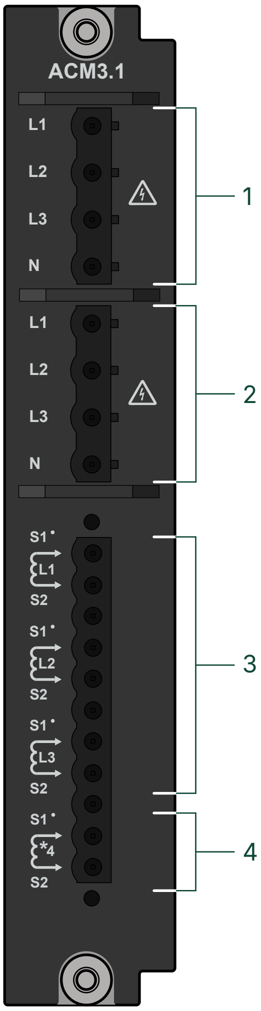
Each controller can store four sets of nominal settings. You can easily change the active set of nominal settings by changing the parameter, using a digital input, analogue input, or an external source (for example, Modbus).

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.

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



1. [B-side] voltage measurements
2. [A-side] voltage measurements
   - For example: **GENSET** controller: The voltage at the genset
3. [A-side] current measurements
   - For example: **GENSET** controller: The current from the genset
4. 4th current measurement
   - For example: Earth current

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 • Nominal settings 2	The selected nominal setting group for the controller.

Parameter	Range	Notes
	• Nominal settings 3 • Nominal settings 4	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 • Q nominal = P nominal • Q nominal = S nominal	**Q nominal calculated**: The controller calculates Q nominal based on S nominal and the power factor. **Q nominal = P nominal**: The controller uses the nominal power as the nominal reactive power. **Q nominal = S nominal**: The controller uses the nominal apparent power as the nominal reactive power.
`P or S nominal`	• No calculation • P nominal calculated • 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. **P nominal calculated**: The controller uses the nominal apparent power (S) and nominal power factor (PF) to calculate the nominal power. **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 • User defined	**Use nominal voltages**: The controller uses the nominal voltage settings. **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.

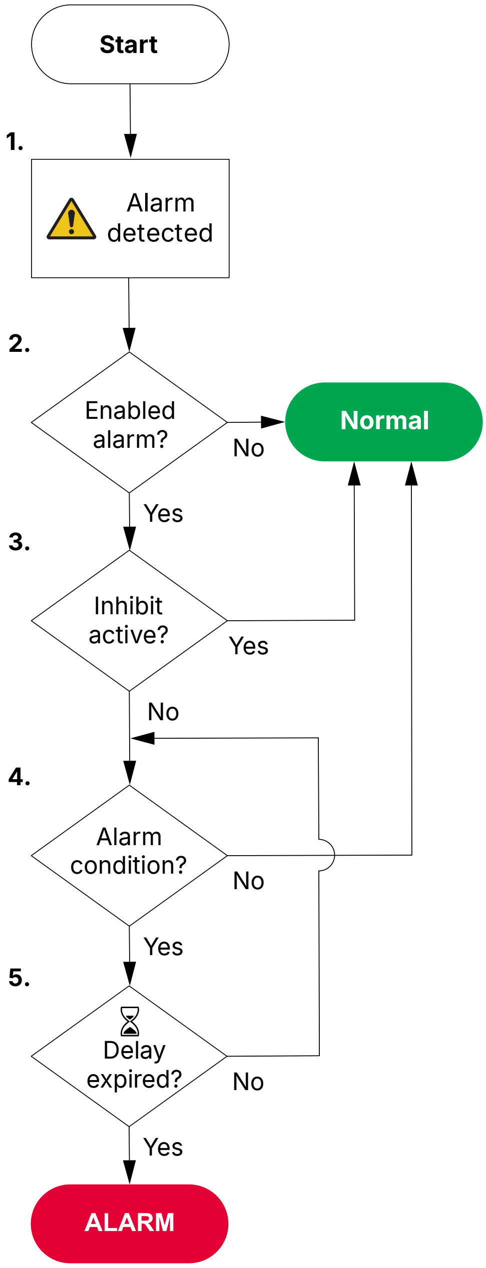
2.6 Alarms and protections

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.

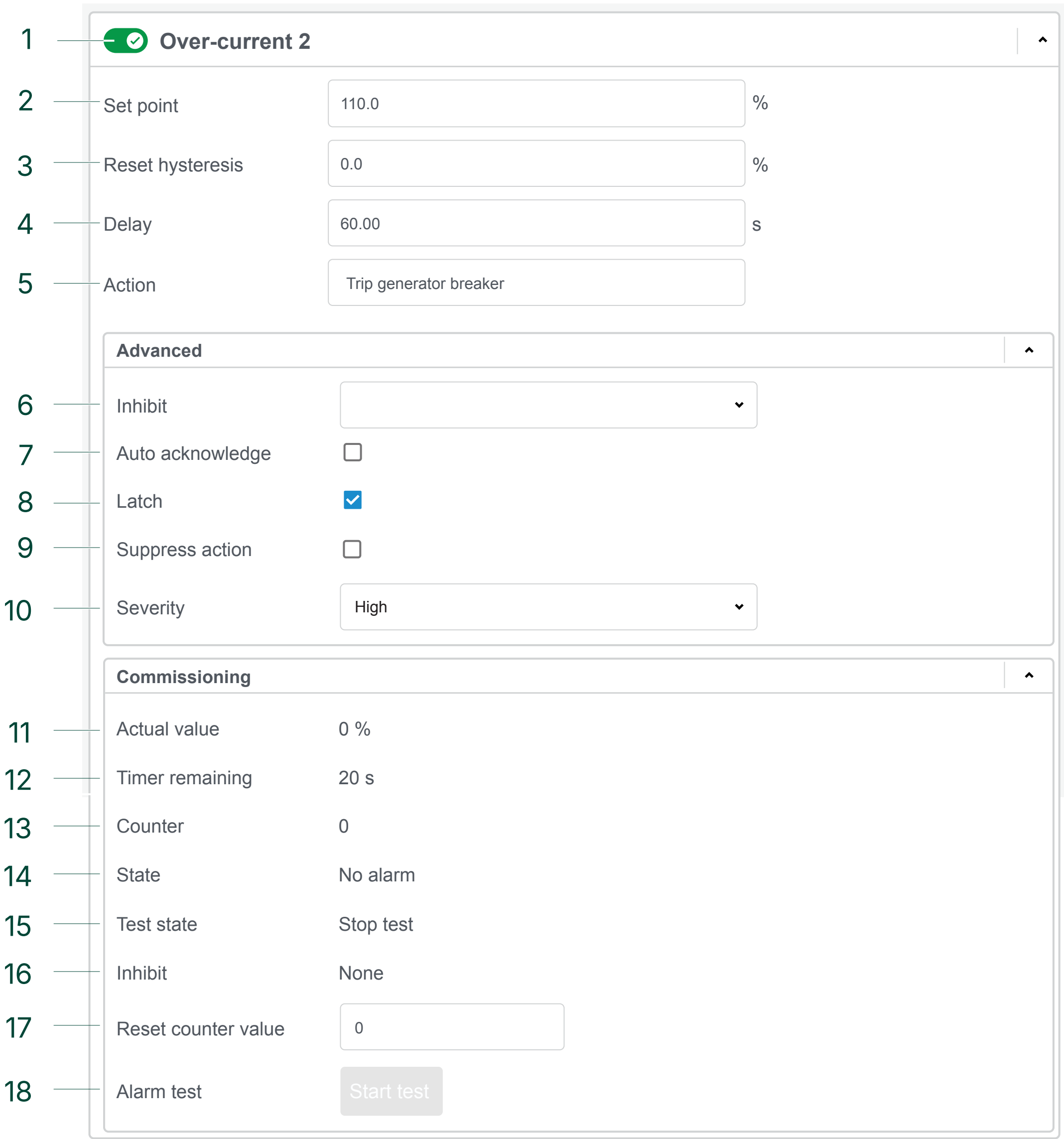
Some alarms can be configured to be automatically acknowledged. *Auto acknowledge* can be useful during commissioning and troubleshooting. However, DEIF does not recommend *Auto acknowledge* during normal operation.

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.
10	`Severity`	High Medium Low	Use severity to mark the alarms with Red (High), Orange (Medium), or Yellow (Low) on the display unit. 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. 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.

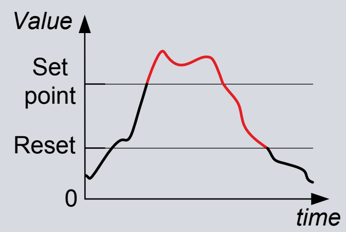
Reset hysteresis

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.

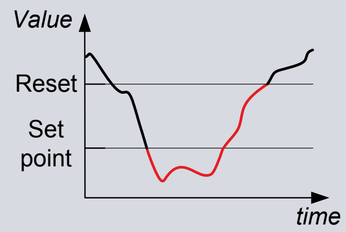
Overspeed example

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

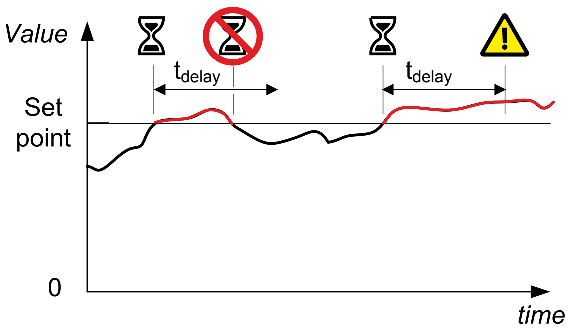
An *Under-speed* alarm with a *Set point* of 80 % of the nominal speed and a *Reset hysteresis* of 5.0 %. The alarm is only reset when the operating value is above 85.0 % of the nominal speed.



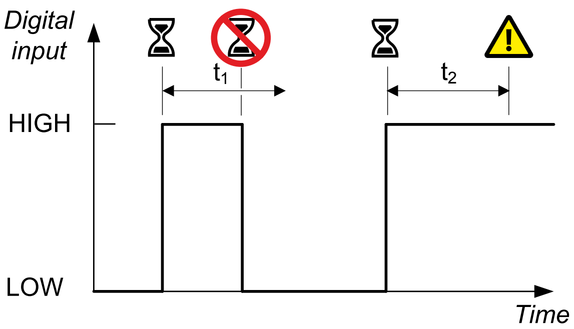
Delay

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.

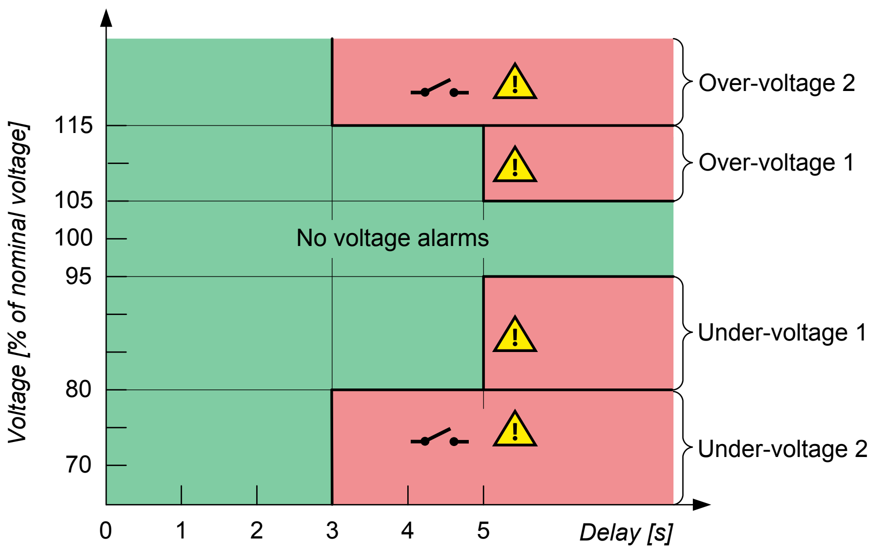
If the delay is **5.00 s**, the controller does the *Over-voltage 1* alarm action **5.10 s** after the alarm *set point* is exceeded.

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.

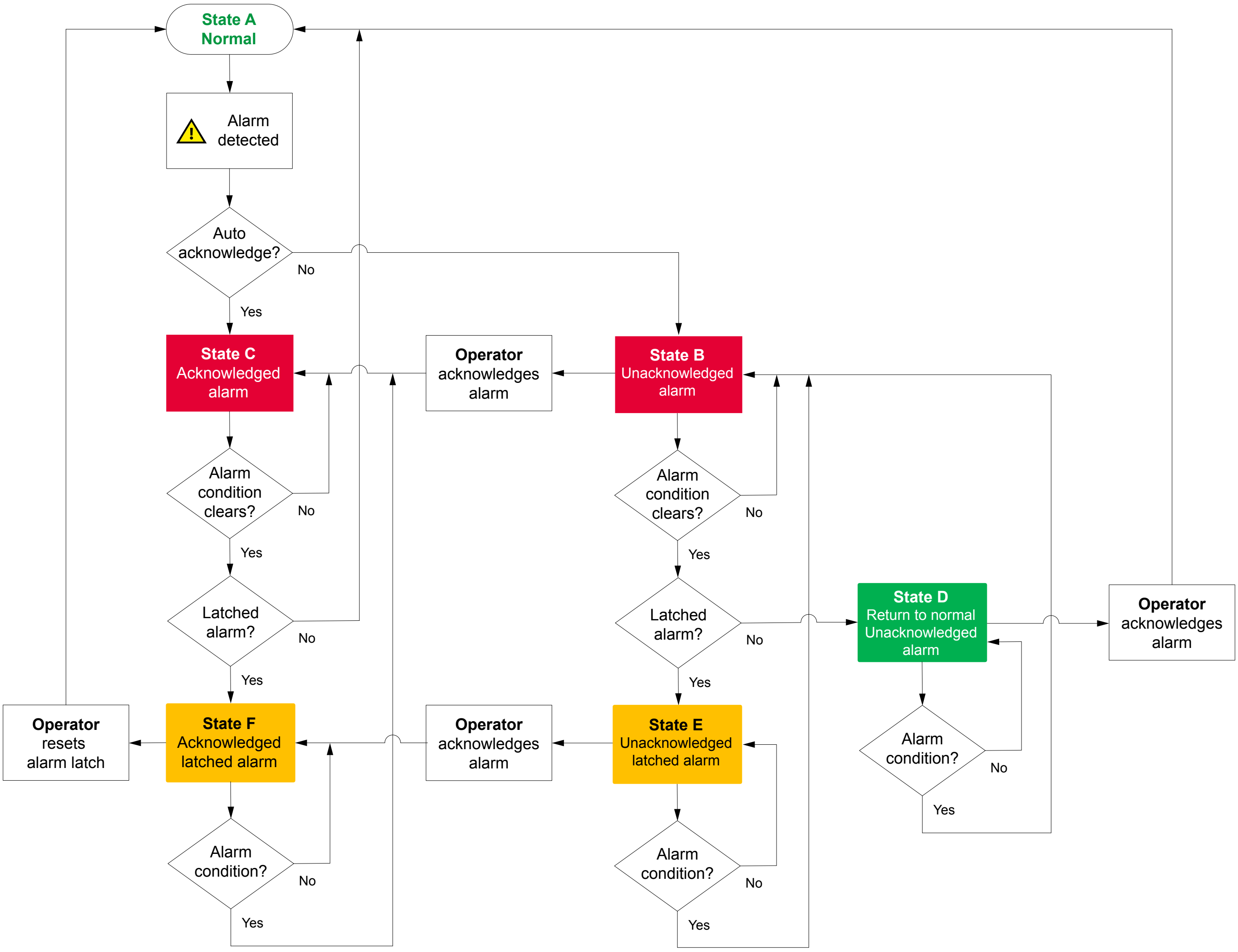
2.6.5 Alarm processing states

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

State	Symbol	Alarm condition	Alarm action	Acknowledge	Notes
					• 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. • The alarm must be acknowledged. • The alarm must be reset (unlatched).
		Inactive	Active	• The alarm must be acknowledged. • The alarm must be reset (unlatched).
	No latch	Active	Active	• The alarm condition must be corrected. • The alarm must be acknowledged.
		Inactive	Inactive	• The alarm must be acknowledged.
Acknowledged	Latch	Active	Active	• The alarm condition must be corrected. • The alarm must be reset (unlatched).
		Inactive	Active	• The alarm condition must be corrected. • 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

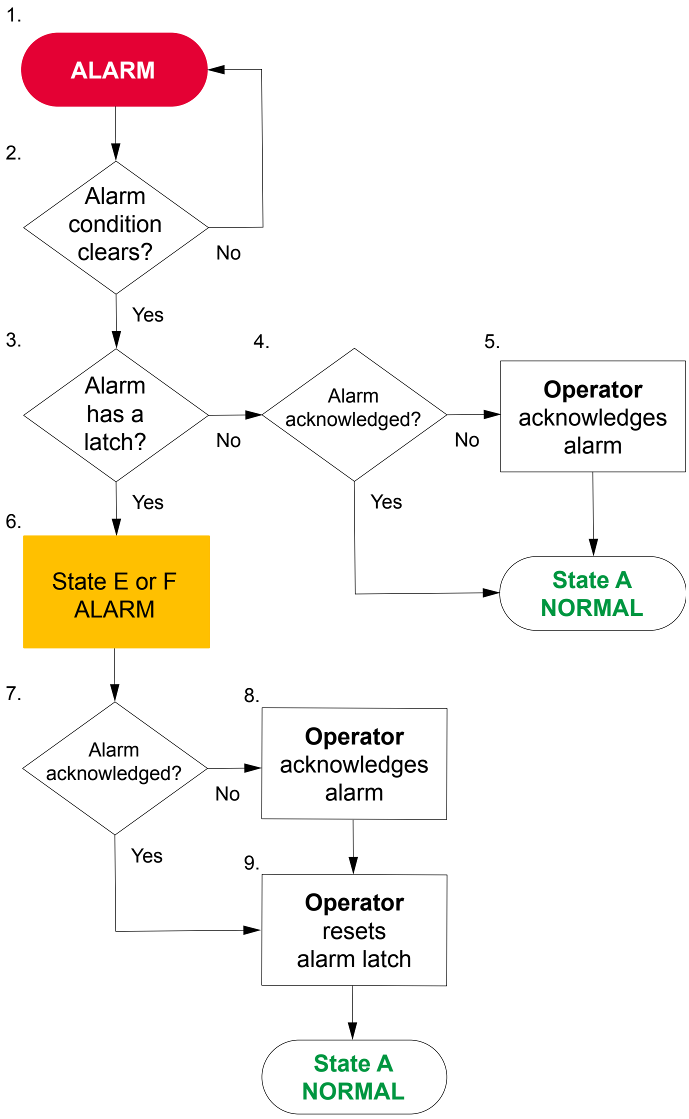
Function	I/O	Type	Details
`Alarm system > Command > Acknowledge all alarms`	Digital input	Pulse	When this input is activated, the controller acknowledges all its alarms.

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.

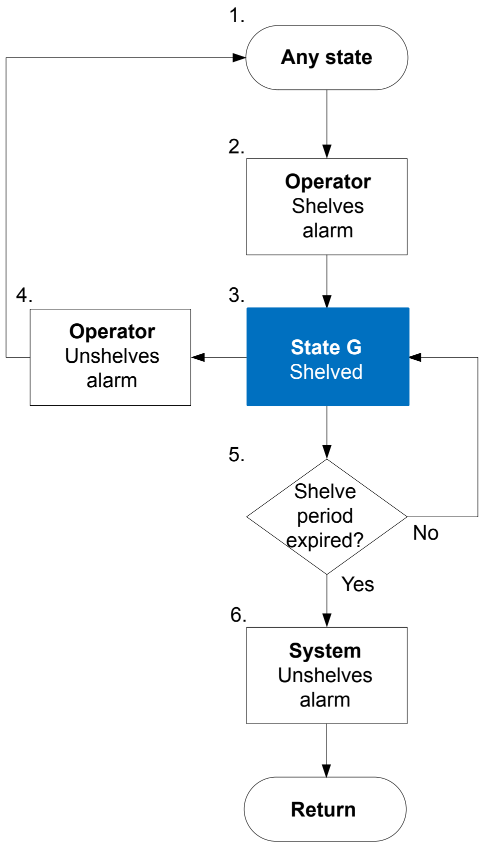
2.6.10 Shelve an alarm

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.

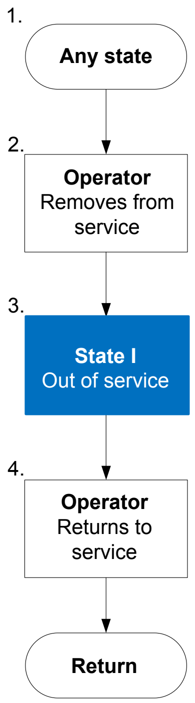


1. The alarm can be in any state.
2. The operator shelves the alarm for a specific period of time.
3. The alarm is now shelved (**State G**).
4. The operator unshelves the alarm, the alarm returns back to its original state.
5. The controller checks if the shelve period has expired:
   - If the shelve 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. 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. 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. 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 Engine interface communication

2.7.1 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.

Priority of engine information with an ECU and analogue input values

A controller can be configured with both an ECU and an EIM3.1 using analogue inputs for values like Engine oil pressure, Coolant level, and more. In this situation, the analogue input values have first priority over the ECU values. If the analogue input values are not able to be read, the controller uses the ECU values in their place.

2.7.2 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 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. **Always ON**: The controller expects the ECU is powered externally and is always powered on.

2.7.3 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

2.7.4 Other EIC information

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

2.8 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. **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.

2.9 CustomLogic

2.9.1 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.

2.9.2 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. **Enabled**: The controller executes the CustomLogic project.

2.9.3 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. 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.

2.9.4 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.

2.9.5 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.

2.9.6 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.

2.10 Date and time

2.10.1 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 • YY-MM-DD • DD-MM-YYYY • DD-MM-YY • MM-DD-YYYY • 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. Daylight savings is not applied to the controller when you select the **Etc/UTC** time zone.
Time format	• 12 hour • 24 hour	The *AM/PM* selector for *Time* is only visible when *12 hour* is selected.
Time	• 00:00:00 to 23:59:59 • 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.

2.10.2 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.

2.11 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*.

2.12 Test functions

2.12.1 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.

2.12.2 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. **Enabled:** When the parameter is saved, the lamp test starts. After the lamp test, the controller automatically changes the parameter to *Not enabled*.

Parameter	Range	Comment
		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. For the default settings, the lamp test will cycle through all the colours twice.

2.13 CODESYS (optional)

You can add a CODESYS licence to your controller to enable it to run a CODESYS application.

More information
See the CODESYS 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.
- Restrict access to authorised persons.

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

3.2.4 Default user

The default administration user is **admin**. Only **admin** can access WebConfig.

User	Password	Role
admin	admin	Admin

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.

3.3 Network communication

3.3.1 Network 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.

Inbound port 443 is opened to allow communication with PICUS.

Inbound port 502 is opened to allow Modbus TCP communication.

Inbound port 80 is opened and re-directed to port 443.

In addition, the controller may use the following ports for application and PLC communication: 123, 5353, 11740, 1217, 12345, 4321, 12346, 12350, 12351, 503, 1740, 1741, 1742, 1743, 4840, 8000, 8443.

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** or **RLOG**.

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.

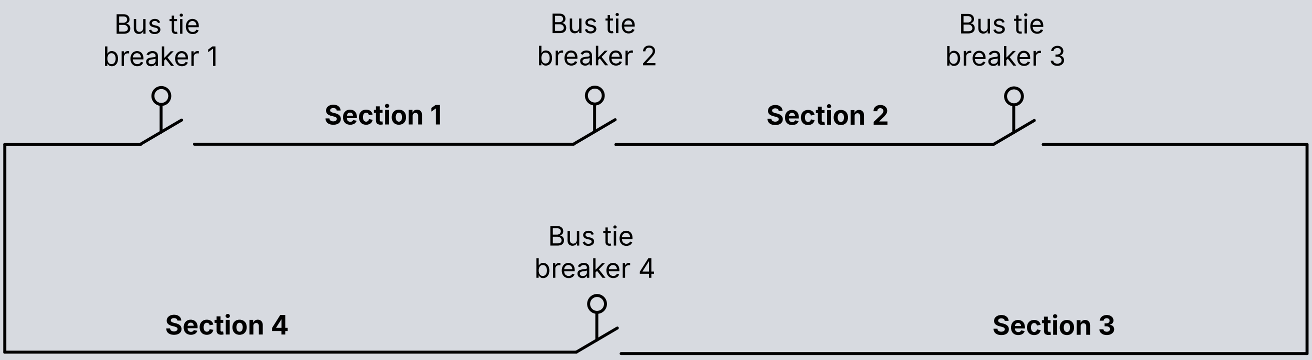
4.1 About busbar sections

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.

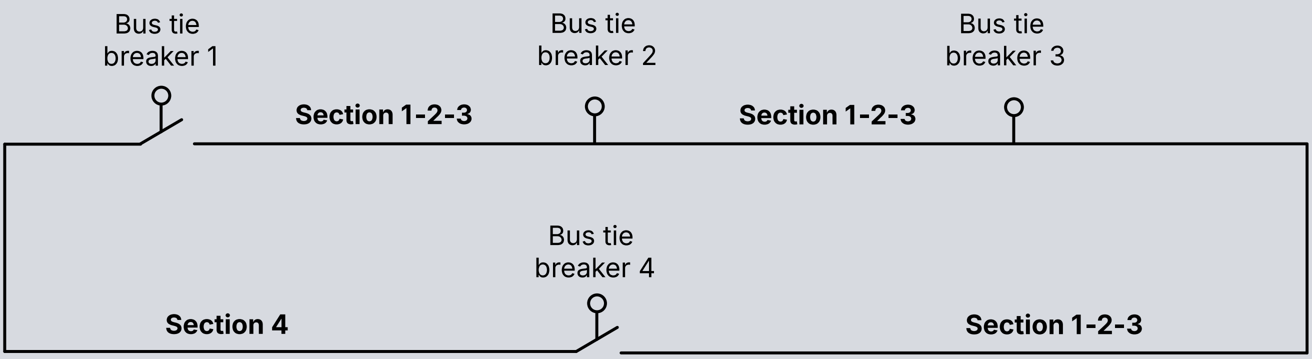
Example of busbar sections



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

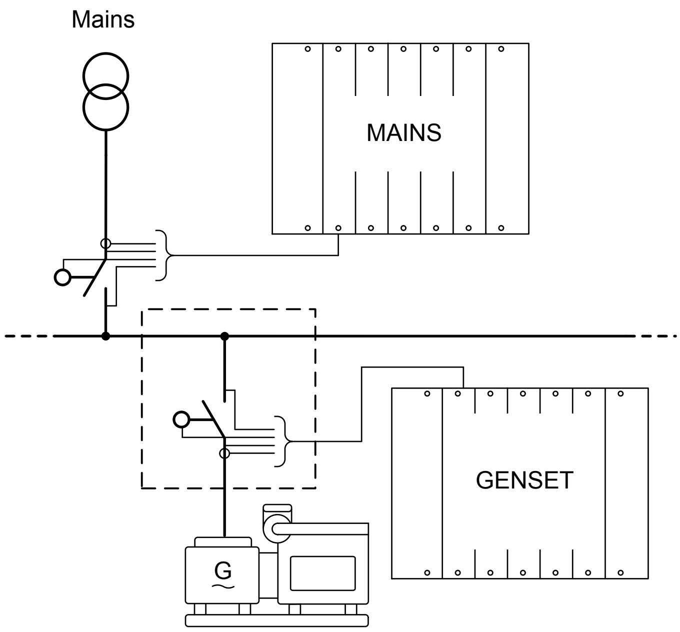
The controllers work together to determine whether there are any gensets connected to the busbar section. The determination includes the relevant breaker states and AC measurements.

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.

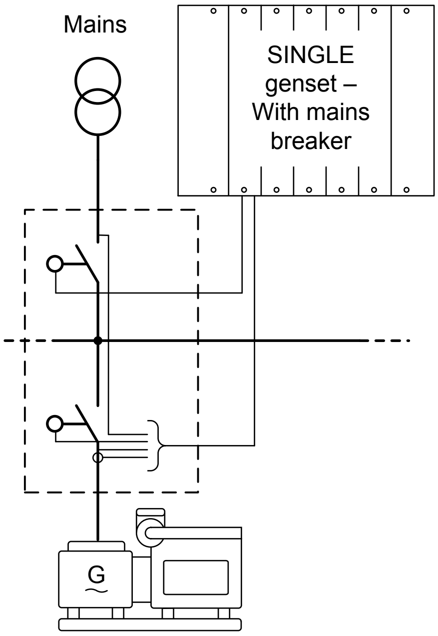
Inhibits

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.

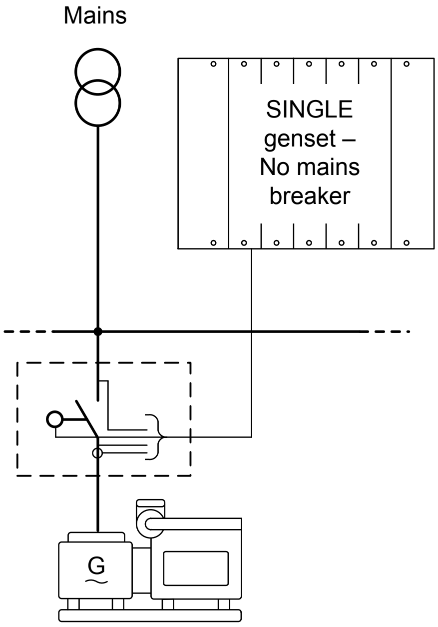
If there is at least one genset and one mains connected to the same busbar section, then the *MAINS in parallel* inhibit is activated.

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

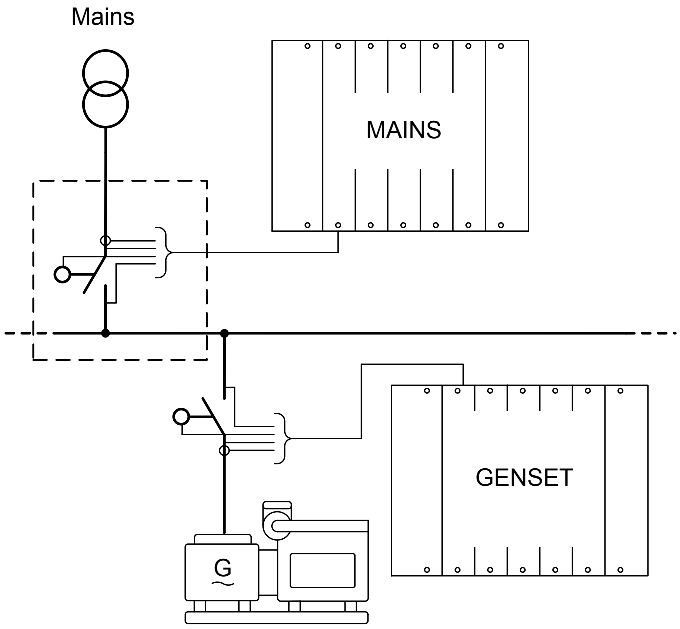
The *SINGLE genset - With mains breaker* controller considers the states of the *Generator breaker* and *Mains breaker*, along with the AC measurements.



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.

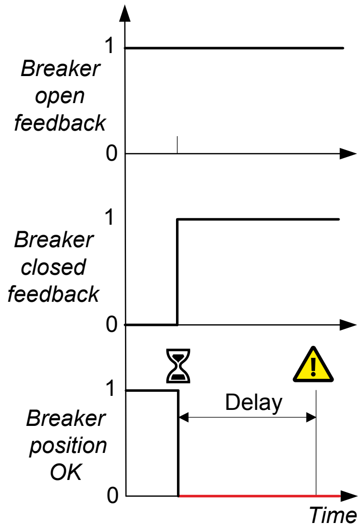
`Regulators > AVR > Monitoring > Q load sharing failure`

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*.

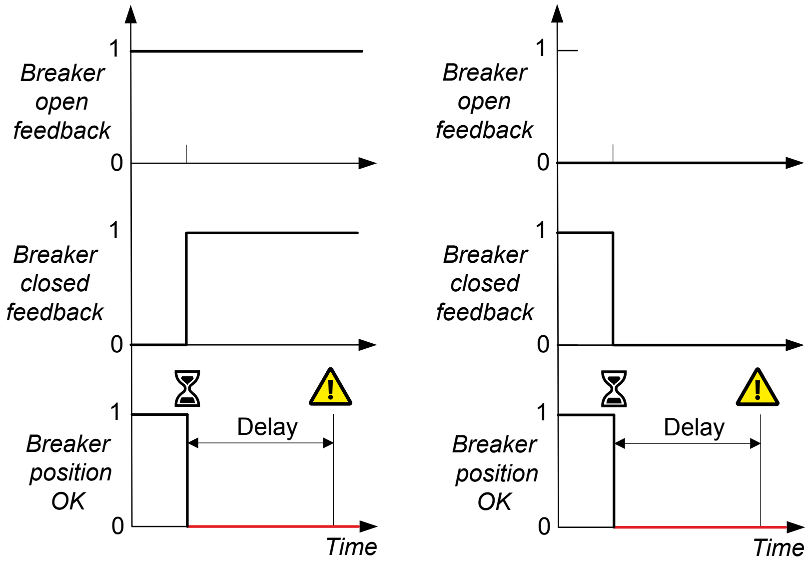
Parameter	Range
`Delay`	0.1 s to 5.0 s

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

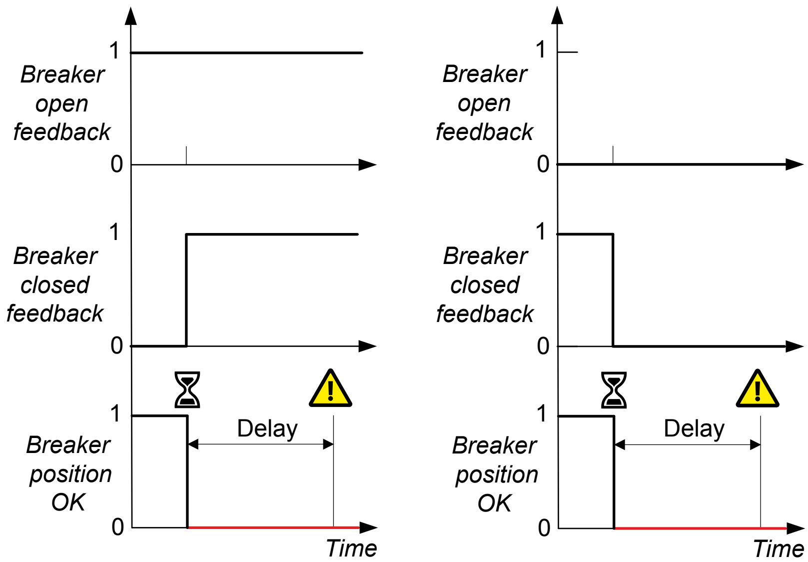
If redundant breaker feedback is configured for the bus tie breaker, then this alarm only activates when a bus breaker position failure is detected on each breaker feedback.

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

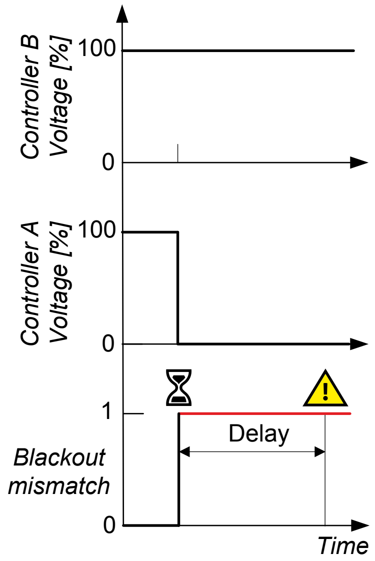
If redundant breaker feedback is configured for the mains breaker, then this alarm only activates when a mains breaker position failure is detected on each breaker feedback.

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 • Three-phase (2 CT, L1-L3) • Three-phase (L1-L2, CT L1) • Split-phase L1-L3 • Split-phase L1-L2 • Split-phase L2-L3 • Single-phase L1 • Single-phase L2 • 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. **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. **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. **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. **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. **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. **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. **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. **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. Some of the controller protections are irrelevant in a single-phase configuration (for example, *Current unbalance*, *Voltage unbalance* and *Phase sequence*).

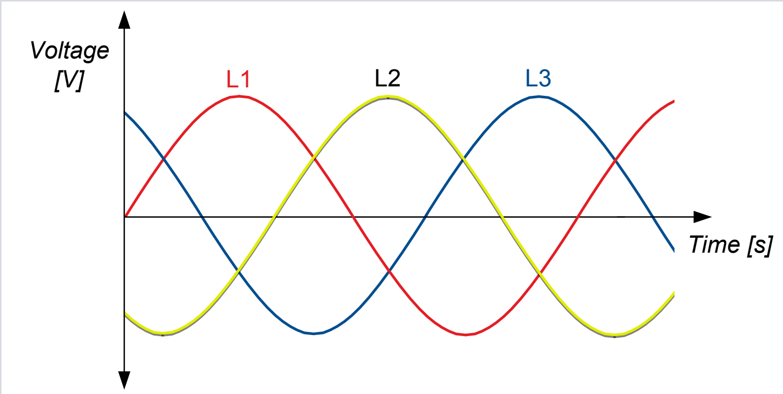
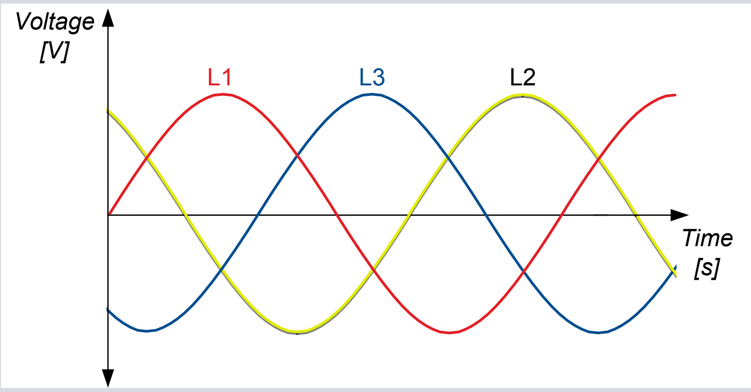
More information
See **System AC configuration** in the **Installation instructions** for examples of three-phase, single-phase wiring, and split-phase wiring.

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 • 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.  **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. 

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] (ACM3.1 terminals 5 to 8)	[B-side] (ACM3.1 terminals 1 to 4)
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

These parameters relate to the terminals on the ACM3.1.

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. **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. **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

These parameters relate to the terminals on the ACM3.1.

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.

More information
See **ACM3.1 terminal connections and default wiring** in the **Installation instructions** for examples of generator current transformer wiring.

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

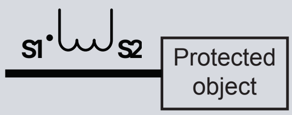
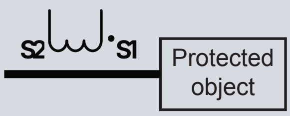
Parameter	Range	Notes
`Primary`	5 to 9000 A	The current transformer primary side (asset side) nominal current.
`Secondary`	1 or 5 A	The current transformer secondary side (controller side) nominal current. You can select either 1 A or 5 A.

CT - ACM3.2 - Consumer side

These parameters are only visible if you have an ACM3.2 installed.

More information
See **ACM3.2 terminal connections and default wiring** in the **Installation instructions** for examples of generator current transformer wiring.

`[A-side] > AC setup > CT - ACM3.2 - Consumer side`

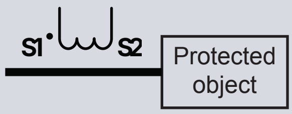
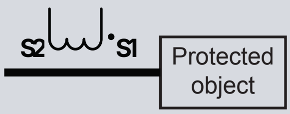
Parameter	Range	Notes
`Primary`	5 to 9000 A	The current transformer primary side nominal current for terminals 1 to 6.
`Secondary`	1 or 5 A	The current transformer secondary side nominal current for terminals 1 to 6. You can select either 1 A or 5 A.
`Current reference dir.`	• Towards prot. obj. • Away from prot. obj.	Defines if the current transformer direction is installed towards or away from the protected object for terminals 1 to 6. **Towards**:  **Away**: 

CT - ACM3.2 - Neutral side

These parameters are only visible if you have an ACM3.2 installed.

More information
See **ACM3.2 terminal connections and default wiring** in the **Installation instructions** for examples of generator current transformer wiring.

[A-side] > AC setup > CT - ACM3.2 - Neutral side

Parameter	Range	Notes
`Primary`	5 to 9000 A	The current transformer primary side nominal current for terminals 7 to 12.
`Secondary`	1 or 5 A	The current transformer secondary side nominal current for terminals 7 to 12. You can select either 1 A or 5 A.
`Current reference dir.`	• Towards prot. obj. • Away from prot. obj.	Defines if the current transformer direction is installed towards or away from the protected object for terminals 7 to 12.  **Towards**:  **Away**:

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.

Parameter	Range	Notes
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. 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. 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.
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: 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: 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.

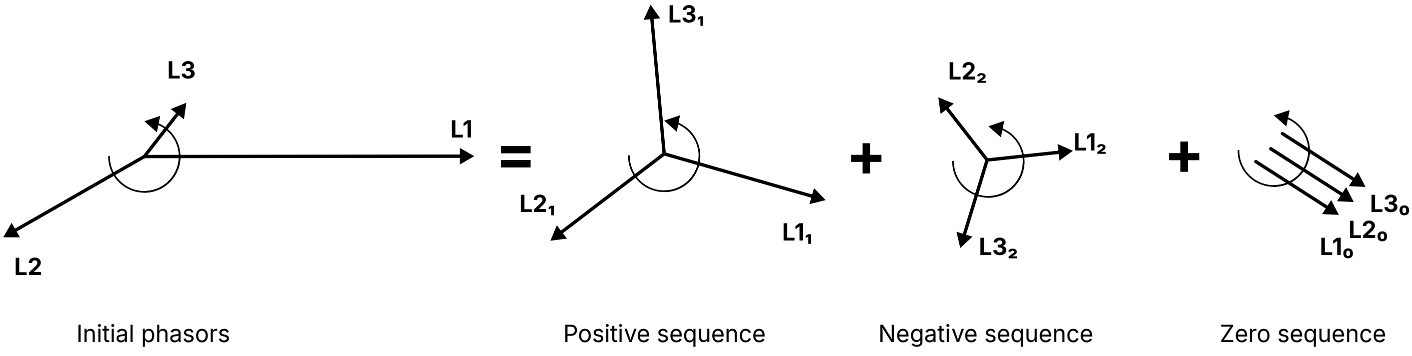
5.2.2 AC measurement filters

`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.



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.
[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).

Function	Details
`[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.
`[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] current - ACM3.2 analogue output functions

`[A-side] > Current (I) - ACM3.2`

Function	Details
`[Asset]	L1 (Consumer side) [A]`	The controller outputs the L1 current from the consumer side.
`[Asset]	L2 (Consumer side) [A]`	The controller outputs the L2 current from the consumer side.
`[Asset]	L3 (Consumer side) [A]`	The controller outputs the L3 current from the consumer side.
`[Asset]	Min. (Consumer side) [A]`	The controller outputs the lowest phase current from the consumer side.
`[Asset]	Max. (Consumer side) [A]`	The controller outputs the highest phase current from the consumer side.
`[Asset]	L1 (Neutral side) [A]`	The controller outputs the L1 current from the neutral side.
`[Asset]	L2 (Neutral side) [A]`	The controller outputs the L2 current from the neutral side.
`[Asset]	L3 (Neutral side) [A]`	The controller outputs the L3 current from the neutral side.
`[Asset]	Min. (Neutral side) [A]`	The controller outputs the lowest phase current from the neutral side.
`[Asset]	Max. (Neutral side) [A]`	The controller outputs the highest phase current from the neutral side.
`[Asset]	L1 differential [A]`	The controller outputs the difference between the consumer and the neutral side of the L1 current.
`[Asset]	L2 differential [A]`	The controller outputs the difference between the consumer and the neutral side of the L2 current.

Function	Details
`[Asset]	L3 differential [A]`	The controller outputs the difference between the consumer and the neutral side of the L3 current.
`[Asset]	Min. differential [A]`	The controller outputs the lowest difference between the consumer and the neutral side phase currents.
`[Asset]	Max. differential [A]`	The controller outputs the highest difference between the consumer and the neutral side phase currents.
`[Asset]	L1 restraint [A]`	The controller outputs the L1 restraint current.
`[Asset]	L2 restraint [A]`	The controller outputs the L2 restraint current.
`[Asset]	L3 restraint [A]`	The controller outputs the L3 restraint current.
`[Asset]	Min. restraint [A]`	The controller outputs the lowest phase restraint current.
`[Asset]	Max. restraint [A]`	The controller outputs the highest phase restraint current.
`[Asset]	Frequency [Hz]`	The controller outputs the frequency of the phase with the highest frequency (based on the ACM3.2 current measurements).

[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.

Function	Details
[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

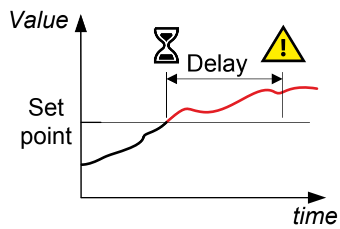
NOTE * TB is only for a **MAINS** controller with a tie breaker.

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.



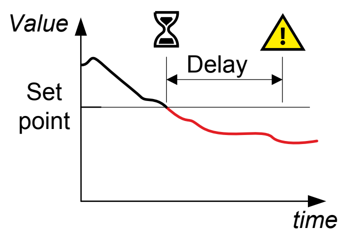
`[A-side] > Voltage protections > Over-voltage #`

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 1 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

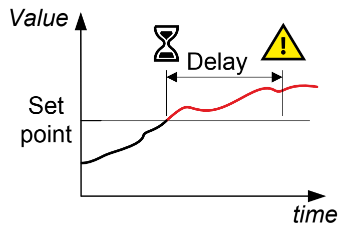
Parameter	Range
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.00 s to 1 h

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 1 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`

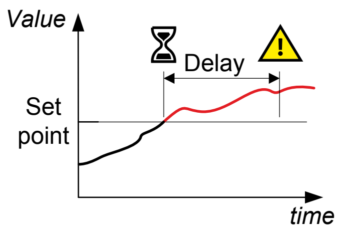
Parameter	Range
`Set point`	10.0 to 110.0 % of nominal voltage
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.02 s to 1 h

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`

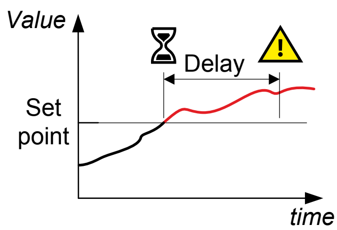
Parameter	Range
`Set point`	1.0 to 100.0 % of nominal voltage
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.10 s to 1 h

5.5.7 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 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.

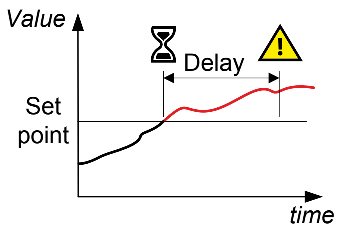
`[A-side] > Voltage protections > Zero sequence voltage`

Parameter	Range
`Set point`	0.0 to 100.0 % of nominal voltage
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.10 s to 1 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 #`

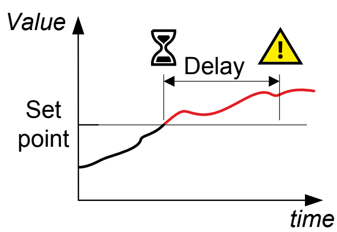
Parameter	Range
`Set point`	Variable. Depends on current transformer settings.
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.00 s to 1 h

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 #`

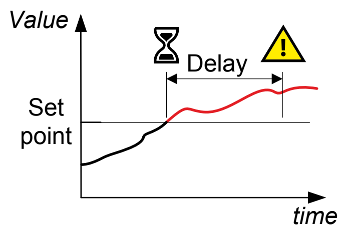
Parameter	Range
`Set point`	Variable. Depends on current transformer settings.
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.00 s to 1 h

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 1 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

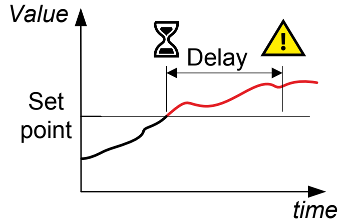
A **GENSET** controller controls a genset with a nominal current of 100 A. The L1 current is 80 A, the L2 current is 90 A, and the L3 current is 60 A.

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 1 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*.

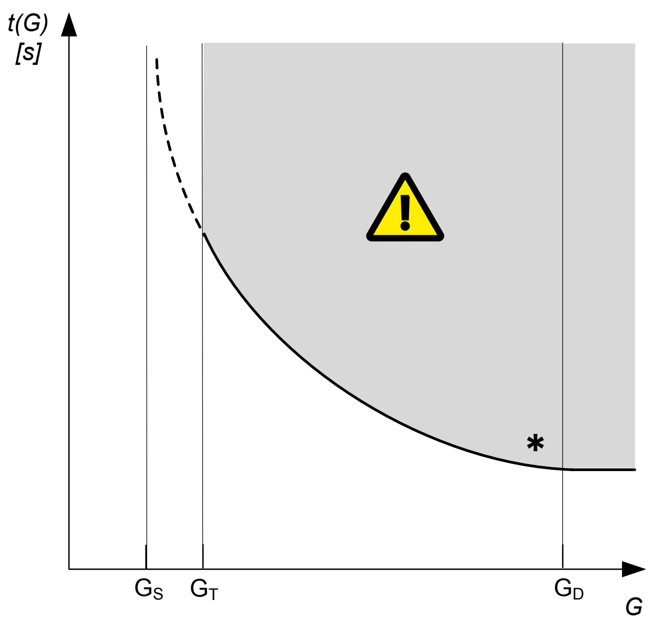
5.5.12 Inverse time over-current (ANSI 51)

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.

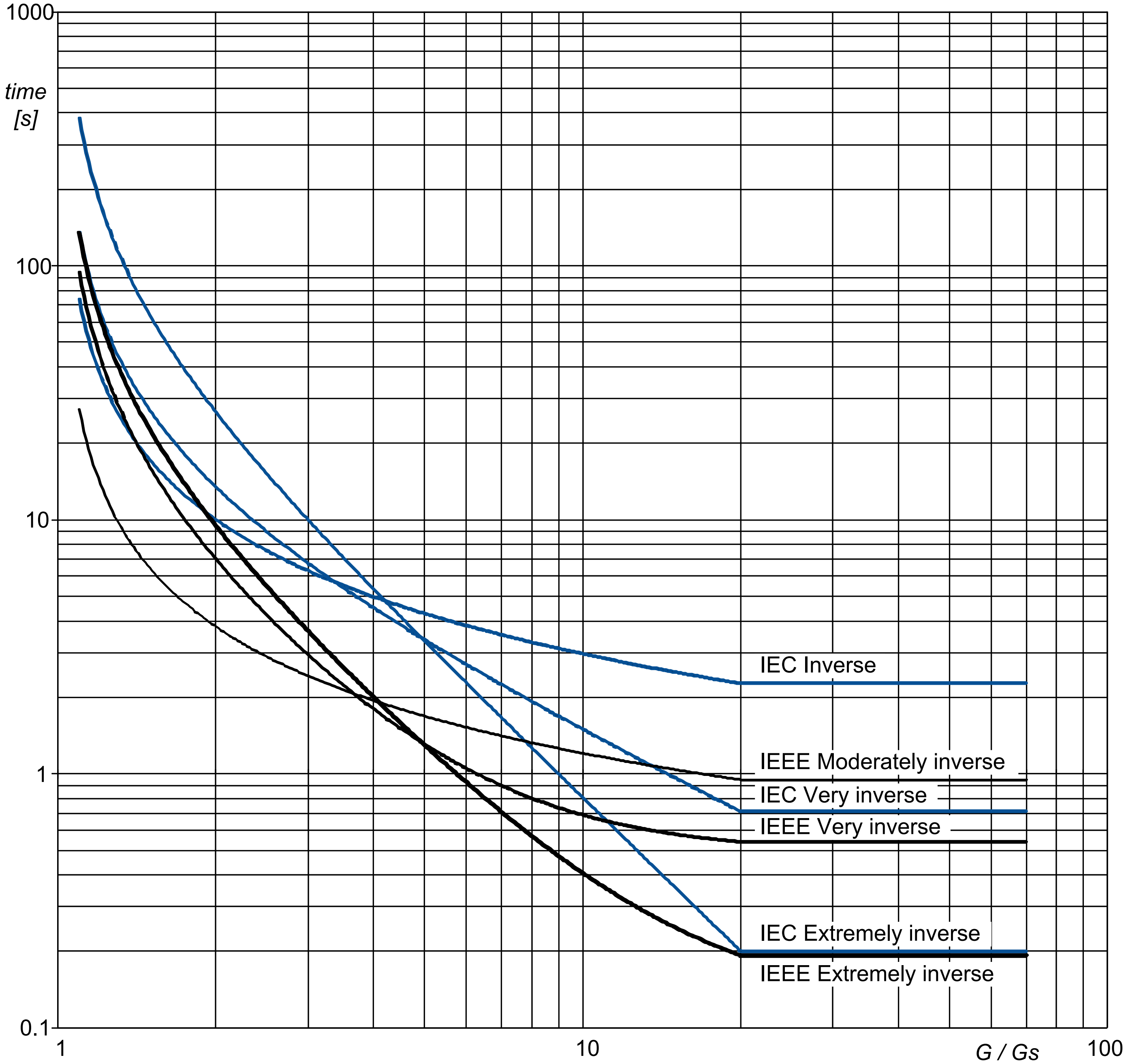
Standard inverse time over-current curves

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

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. • $G_D = 20 \times G_S = 20 \times (I_{nom} \times (\text{Limit} / 100)) = 20 \times (350 \times (1 / 1)) = 7000$ A However, the highest G_D value where measurements can be made is 1750 A. • Because the secondary current rating is 5 A, the formula to calculate the measurable G_D is $G_D = 3.5 \times I_{CT\ primary}$. • $G_D = 3.5 \times I_{CT\ primary} = 3.5 \times 500 = 1750$ 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)

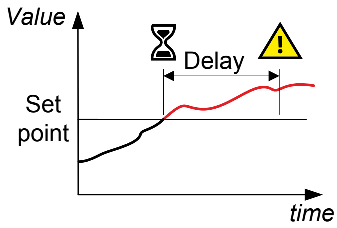
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Negative sequence current	I_2>	46	< 200 ms *

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 1 h

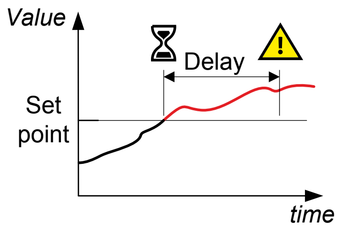
5.5.14 Zero sequence over-current (ANSI 51I_0)

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).



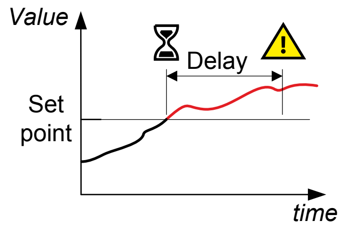
`[A-side] > Current protections > Zero sequence current`

Parameter	Range
`Set point`	0.0 to 100.0 % of nominal current
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.10 s to 1 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.



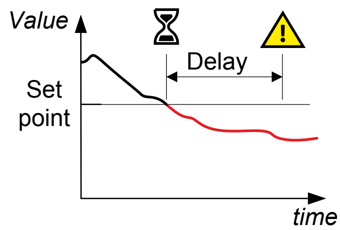
`[A-side] > Frequency protections > Over-frequency #`

Parameter	Range
`Set point`	80.0 to 120.0 % of nominal frequency
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.00 s to 1 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.



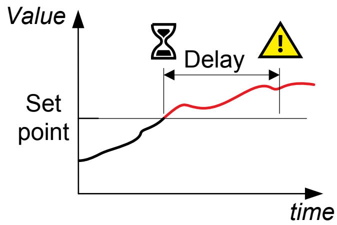
`[A-side] > Frequency protections > Under-frequency #`

Parameter	Range
`Set point`	80.0 to 100.0 % of nominal frequency
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.00 s to 1 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* #

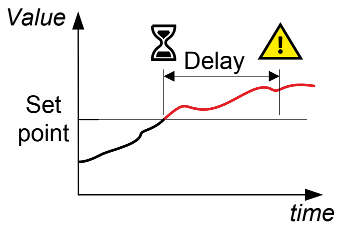
Parameter	Range
`Set point`	0.0 to 200.0 % of nominal power
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.00 s to 1 h

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* #

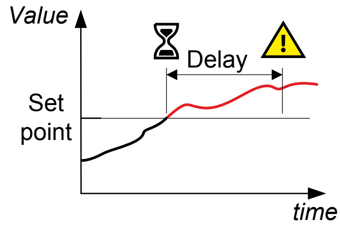
Parameter	Range
`Set point`	0.0 to 200.0 % of nominal power
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.00 s to 1 h

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.



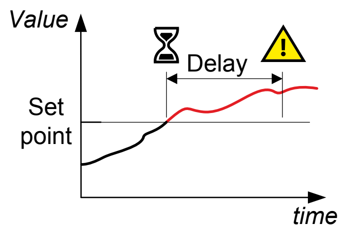
[A-side] > Reactive power protections > Reactive power export #

Parameter	Range
`Set point`	0.0 to 100.0 % of nominal reactive power
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.00 to 3600.00 s

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 #

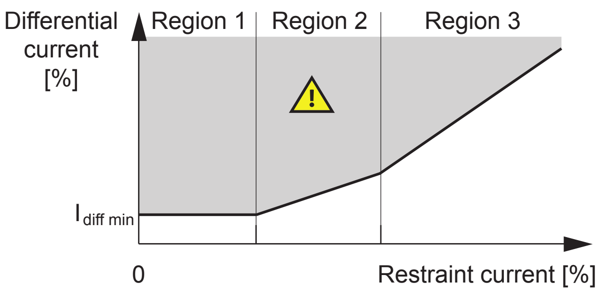
Parameter	Range
`Set point`	0.0 to 150.0 % of nominal reactive power (Q)
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.00 s to 1 h

5.5.21 Generator differential current protection (ANSI 87G)

Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Generator stabilised differential current	Id>	87G	< 40 ms *
Generator high set differential current	Id>>	87G	< 40 ms *

NOTE * When the measured value increases from zero to two times the alarm set point.

The differential current protection detects current faults in the protected zone between the current transformers. The differential current protection consists of two parts, the stabilised differential current protection and the high set differential current protection.



The alarm response of the stabilised differential current protection is dependent on the operating characteristic and the measured restraint and differential currents (evaluation is made per phase). The operating characteristic separates the operation area (grey) and the restraint area (white) in the figure. The restraint current is the highest value of neutral and consumer side RMS currents. The differential current is the RMS value of the fundamental frequency part of the sum (or difference) of the neutral side and consumer side currents.

The alarm response of the high set differential current protection only depends on the differential current. That is, the RMS value of the fundamental frequency part of the sum (or difference) of the neutral side and consumer side currents.

More information
See [A-side] AC configuration for changing the reference direction of the current transformer.

`Generator > Current protections > Stabilised differential current`

Parameter	Range
`I diff. min.`	5 to 100 % of I_{nom}
`Region 1: End`	10 to 150 % of I_{nom}
`Region 2: Slope`	10 to 50 % of I_{nom}
`Region 2: End`	100 to 1000 % of I_{nom}
`Region 3: Slope`	30 to 100 % of I_{nom}
`Delay`	0.00 to 60.00 s

`Generator > Current protections > High set differential current`

Parameter	Range
`Set point`	50 to 1200 % of I_{nom}
`Delay`	0.00 to 60.00 s

5.5.22 Active synchroniser (ANSI 25A)

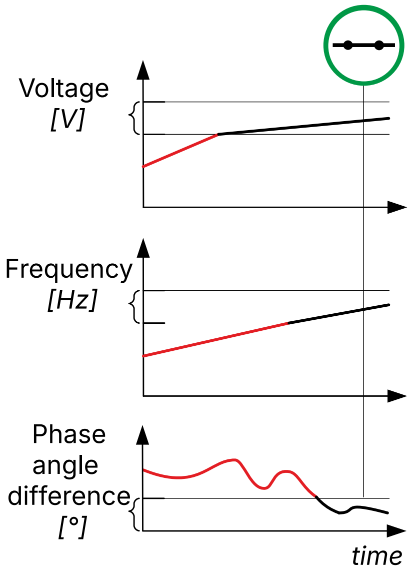
Protection	IEC symbol (IEC60617)	ANSI (IEEE C37.2)	Operate time
Active synchroniser (including blackout close)	-	25A	-

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:

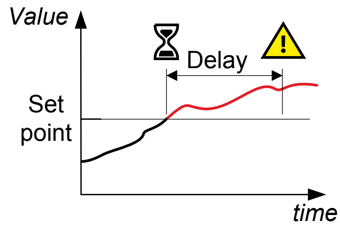
`Breakers > [Breaker] configuration > Synchronisation setting`

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.



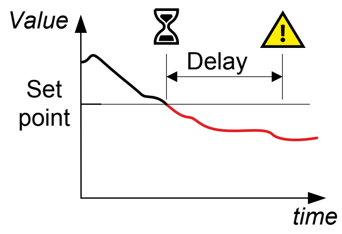
`[B-side] > Voltage protections > Over-voltage #`

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 1 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 1 h

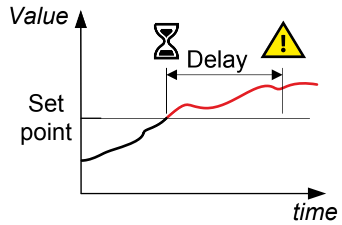
5.6.3 [B-side] voltage unbalance (ANSI 47)

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 1 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 1 h

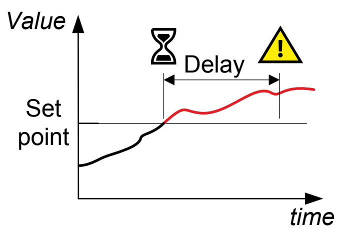
5.6.5 [B-side] negative sequence over-voltage (ANSI 47)

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 1 h

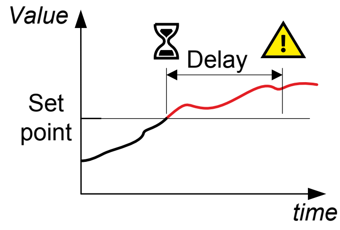
5.6.6 [B-side] zero sequence over-voltage (ANSI $59U_0$)

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.



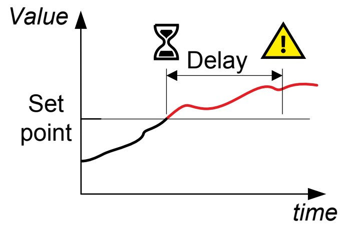
`[B-side] > Voltage protections > Zero sequence voltage`

Parameter	Range
`Set point`	0.0 to 100.0 % of nominal voltage
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.10 s to 1 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.



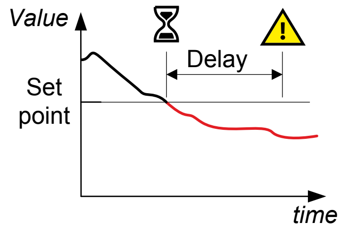
`[B-side] > Frequency protections > Over-frequency #`

Parameter	Range
`Set point`	100.0 to 130.0 % of nominal frequency
`Reset hysteresis`	0.0 to 20.0 %
`Delay`	0.00 s to 1 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 1 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)

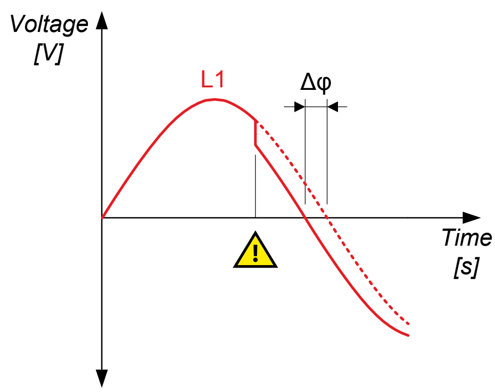


Figure 5.2 Vector shift in phase L1 only

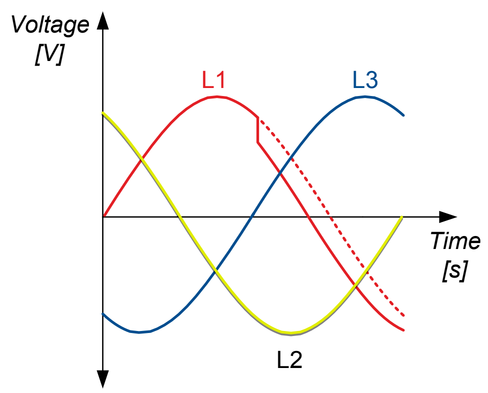
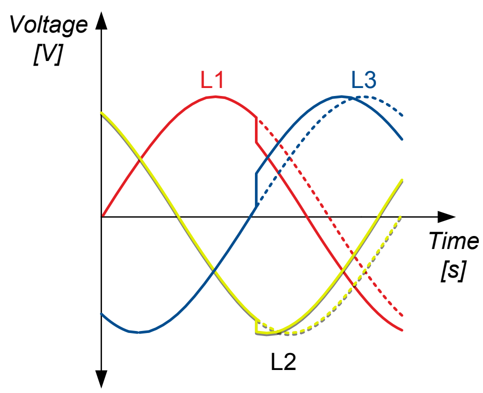


Figure 5.3 Vector shift in all phases



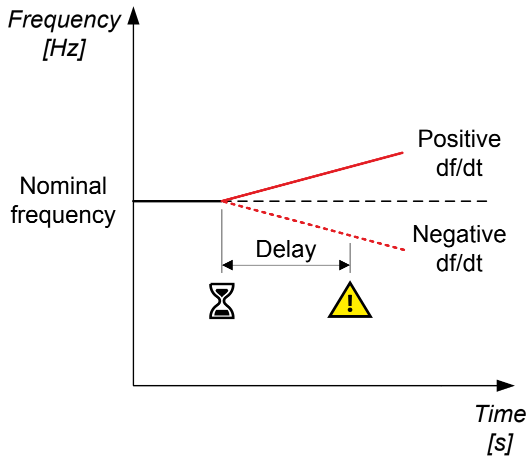
`[B-side] > Additional protections > Vector shift`

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

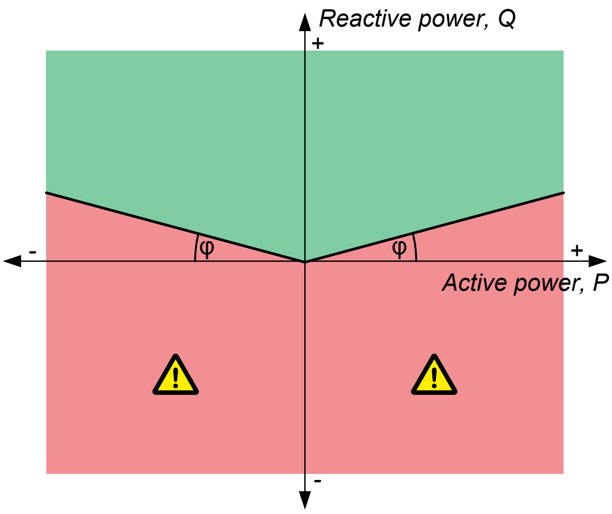
5.7.3 Low voltage low reactive power

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.



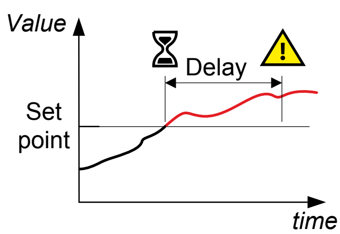
[A-side or B-side] > Additional protections > V< and Q< #

Parameter	Range
AC setup	• Phase-phase [B-side] • Phase-neutral [B-side] • Phase-phase [A-side] • 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] • Phase-phase [A-side] • 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.

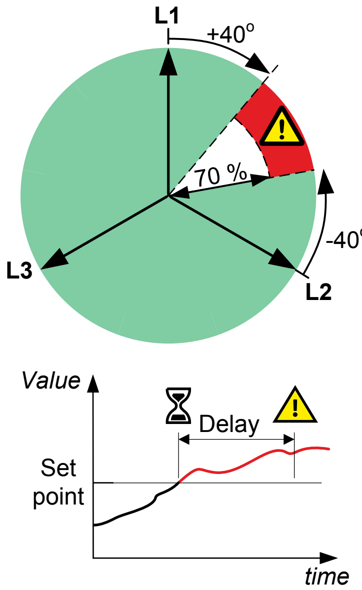
5.8 Other AC protections

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.

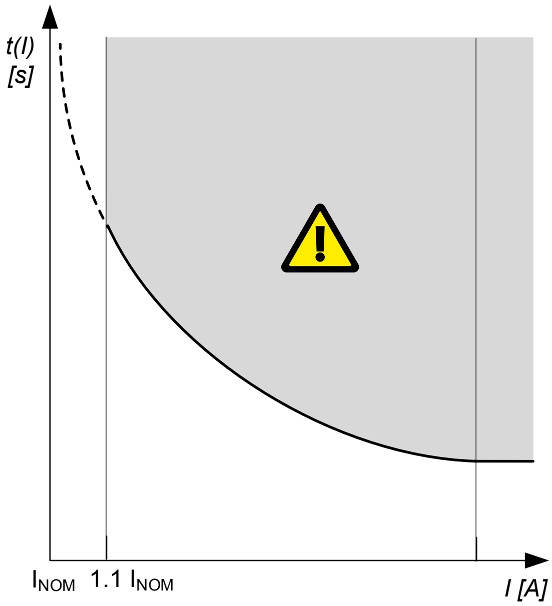
5.8.2 Earth inverse time over-current (ANSI 51G)

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 ACM3.1 (terminals 15,16) 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.

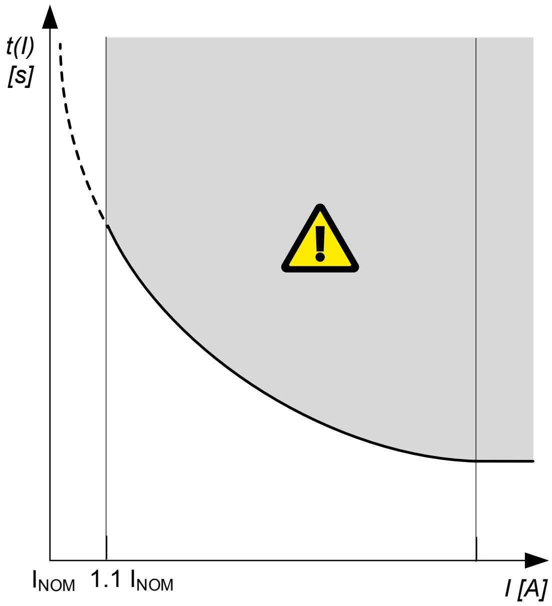
5.8.3 Neutral inverse time over-current (ANSI 51N)

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 ACM3.1 (terminals 15,16) to measure the neutral 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.

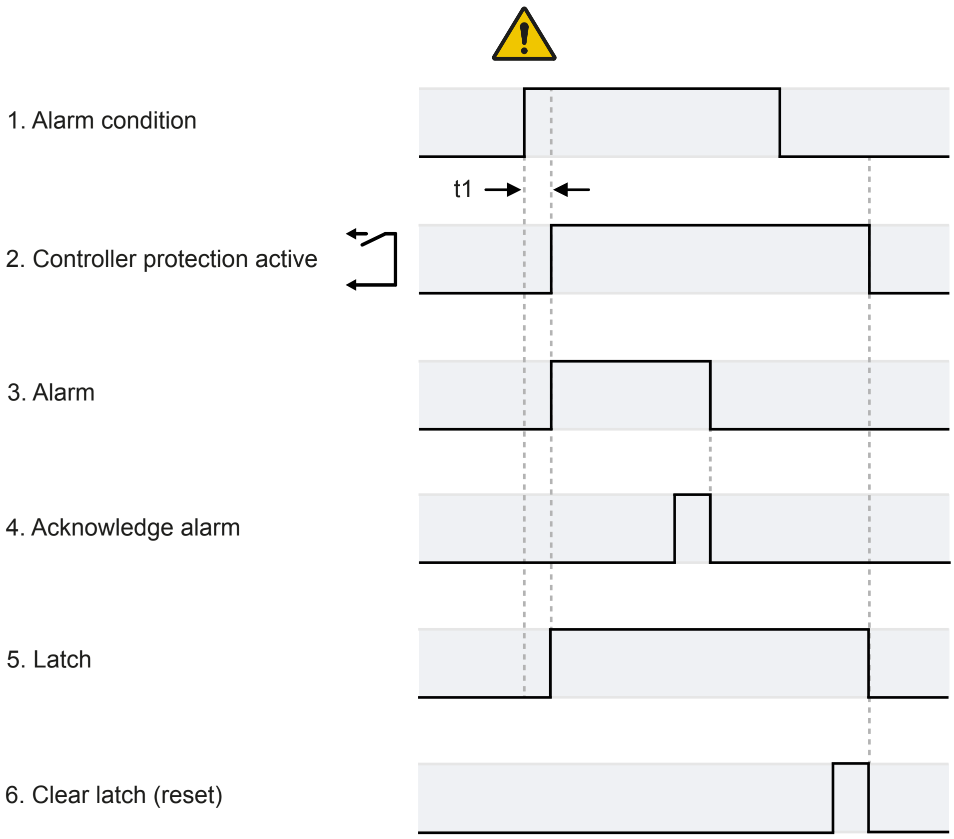
More information
See Inverse time over-current (ANSI 51) for the calculation method, the standard curves, and information about the definite time characteristic.

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 de-energises relays If the controller is not powered, the controller relays de-energise.

NOTICE	
	Latched alarms do not trip breaker again if breaker manually operated 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.

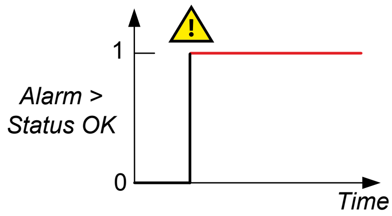
When the controller is connected to an external lockout relay, the controller interfaces with the lockout relay. When the controller interfaces with an external lockout relay, the controller is not seen as the lockout relay for the system.

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 3 and 4 of the power supply module of the controller. This configuration cannot be removed or changed.

`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 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 ACM3.1.

The alarm is always enabled. You cannot see or change the alarm parameters.

6.1.13 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 ACM3.1. 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

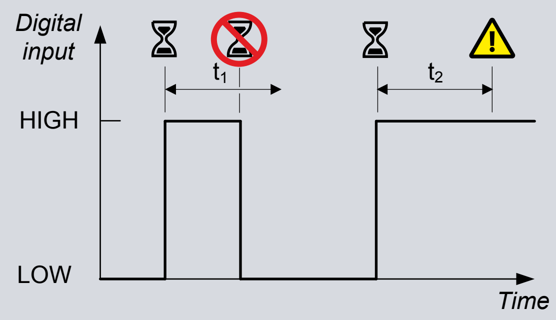
6.2.1 Digital input (DI) alarms

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.

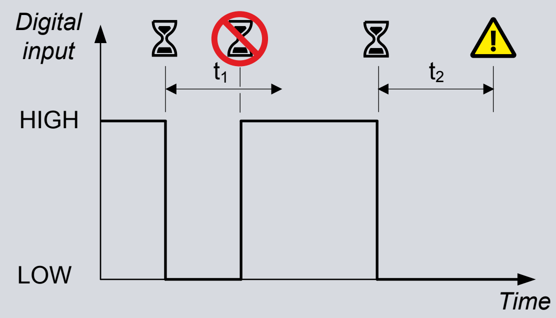
By default, a digital input (DI) is normally low, and the alarm is activated if the digital input is high for longer than the *Time delay*.



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.

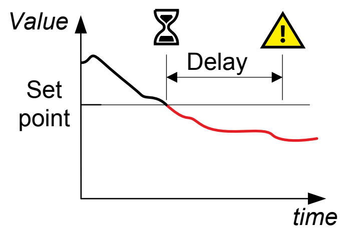
Contact DEIF product support for assistance and help identify the hardware issue. This may require a replacement hardware module.

6.4 Power supply module PSM3.1

6.4.1 PSM3.1 1 supply voltage low alarm

This alarm is for power supply voltage protection.

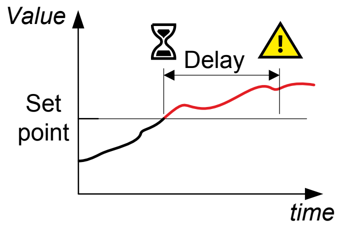
The alarm is based on the power supply voltage measured by the PSM. The alarm is activated when the power supply voltage is less than the set point for the delay time.



`Hardware > PSM3.1 1 > Low voltage alarm`

Parameter	Range
`Set point`	8.0 to 32.0 V DC
`Delay`	0.0 s to 1 h

6.4.2 PSM3.1 1 supply voltage high alarm



This alarm is for power supply voltage protection.

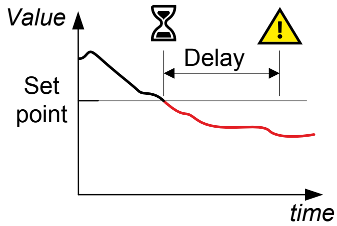
The alarm is based on the power supply voltage measured by the PSM. The alarm is activated when the power supply voltage exceeds the set point for the delay time.

`Hardware > PSM3.1 1 > High voltage alarm`

Parameter	Range
`Set point`	12.0 to 36.0 V DC
`Delay`	0.0 s to 1 h

6.5 Power supply module PSM3.2

6.5.1 PSM3.2 1 supply voltage low alarm



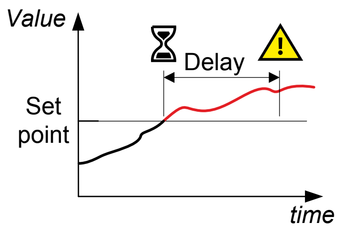
This alarm is for power supply voltage protection.

The alarm is based on the power supply voltage measured by the PSM. The alarm is activated when the power supply voltage is less than the set point for the delay time.

`Hardware > PSM3.2 1 > Low voltage alarm`

Parameter	Range
`Set point`	8.0 to 32.0 V DC
`Delay`	0.0 s to 1 h

6.5.2 PSM3.2 1 supply voltage high alarm



This alarm is for power supply voltage protection.

The alarm is based on the power supply voltage measured by the PSM. The alarm is activated when the power supply voltage exceeds the set point for the delay time.

`Hardware > PSM3.2 1 > High voltage alarm`

Parameter	Range
`Set point`	12.0 to 36.0 V DC
`Delay`	0.0 s to 1 h

6.6 Alternating current module ACM3.1

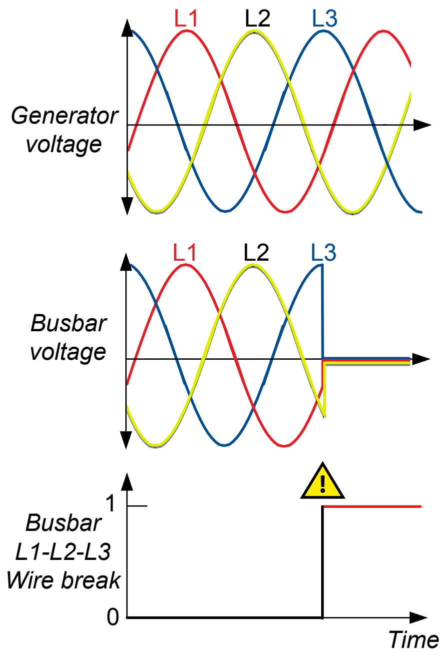
6.6.1 [A-side]/[B-side] L1-L2-L3 wire break

These alarms alert the operator to a voltage measurement failure:

- *[A-side] L1-L2-L3 wire break*
- *[B-side] L1-L2-L3 wire break*

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

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



`[A-side/B-side] > AC setup > Multiple phase wire break`

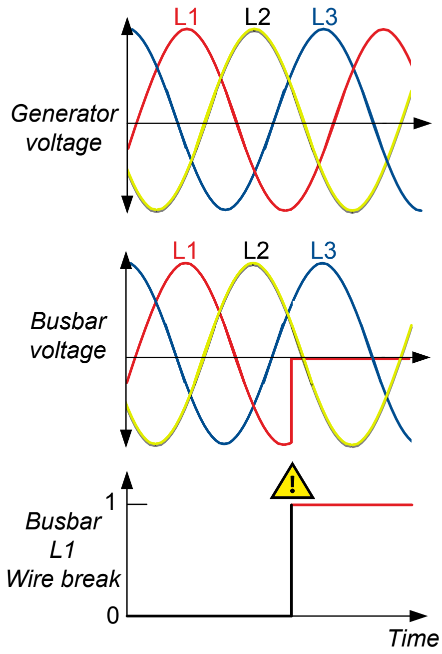
6.6.2 [A-side]/[B-side] L# wire break

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

- *[A-side] L1 wire break*
- *[A-side] L2 wire break*
- *[A-side] L3 wire break*
- *[B-side] L1 wire break*
- *[B-side] L2 wire break*
- *[B-side] L3 wire break*

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

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



`[A-side/B-side] > AC setup > L# * wire break`

NOTE * # is 1 to 3.

6.6.3 AC data is missing

Applicable to ACM3.1 and ACM3.2.

The alarm communicates that the data protocol in the alternating current module (ACM) is not correct.

This can occur when the ACM software version is incorrect. Contact DEIF support if you see this error.

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

6.6.4 ACM 1 protections not running

This alarm communicates that the configuration data for protections and measurements are not correct in the controller alternating current module (ACM).

This alarm can occur if the ACM has unintentionally restarted, or if the ACM configuration data was not received within the time limit. Contact DEIF Support if you see this error.

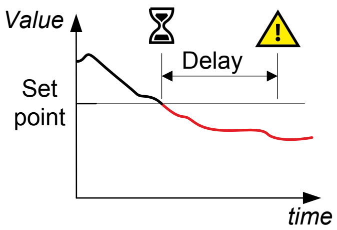
The alarm action is *Warning*, and the alarm is always enabled. The alarm parameters are not visible.

6.7 Engine interface module EIM3.1

6.7.1 EIM3.1 # supply voltage low or missing alarm

This alarm is for auxiliary power supply voltage protection.

The alarm is based on the power supply voltage measured by the EIM. The alarm is activated when the power supply voltage is less than the set point for the delay time.



`Hardware > EIM3.1 # * > Low voltage alarm`

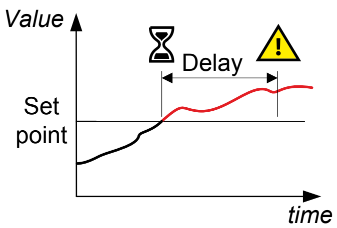
Parameter	Range
`Set point`	8.0 to 32.0 V DC
`Delay`	0.0 s to 1 h

NOTE * # is the module number.

6.7.2 EIM3.1 # supply voltage high alarm

This alarm is for auxiliary power supply voltage protection.

The alarm is based on the power supply voltage measured by the EIM. The alarm is activated when the power supply voltage exceeds the set point for the delay time.



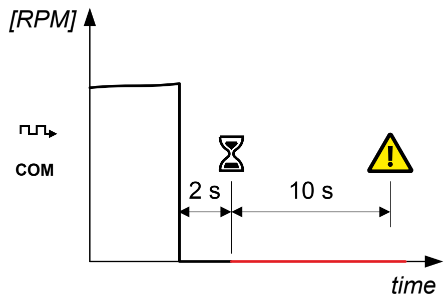
Hardware > EIM3.1 # * > High voltage alarm

Parameter	Range
Set point	12.0 to 36.0 V DC
Delay	0.0 s to 1 h

NOTE * # is the module number.

6.7.3 Magnetic pickup wire break alarm

This alarm is for magnetic pickup wire break. If the engine is running but there is no pulse for 2 seconds, then the controller monitors the cable. If there is no change during the alarm delay time, then the controller activates the alarm.



Engine > Running detection > Magnetic pickup wire break

Parameter	Range
Delay	1 s to 1 h

NOTICE

Third part equipment also connected to magnetic pickup

If third party equipment is connected to the magnetic pickup unit, the wire break detection might not work.

6.7.4 EIM3.1 # relay 4 wire break alarm

This alarm is for EIM3.1 # relay 4 (terminals 9,10) wire break detection (# is 1 to 3). The wire break monitoring is only active when the relay is de-energised.

Relay 4 can be configured for any digital output function, for example, *Stop coil*. This alarm then acts as stop coil wire break detection.

Hardware:

EIM 3.1

Hardware > EIM3.1 # * > Relay 4 supervision

Parameter	Range
Delay	0.0 s to 1 h

NOTE * # is the module number.

6.7.5 EIM3.1 safety shutdown still has control

This alarm activates if the shutdown has been executed by the EIM3.1 hardware module, and manual reset is not set high after, or if an alarm is running then application is started up again.

6.7.6 EIM3.1 safety shutdown configuration is not correct

Activates if the required configuration for active standalone is not correct.

More information

See EIM3.1 standalone for the required configuration.

6.8 Governor and AVR module GAM3.2

6.8.1 GAM3.2 1 status not OK

This alarm communicates that the GAM3.2 cannot perform stand-alone regulation. This may be due to incomplete or incorrect configuration.

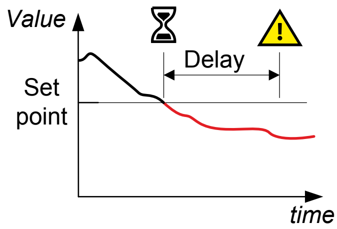
Hardware > GAM3.2 1 > Status not OK alarm

Parameter	Range
Delay	0 s to 1 h

6.8.2 GAM3.2 1 supply voltage low or missing

This alarm is for auxiliary power supply voltage protection.

The alarm is based on the power supply voltage measured by the GAM. The alarm is activated when the power supply voltage is less than the set point for the delay time.



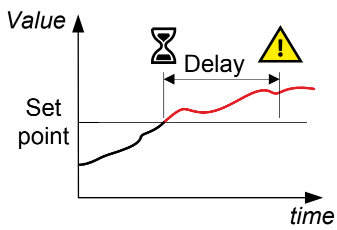
Hardware > GAM3.2 1 > Low voltage alarm

Parameter	Range
Set point	8.0 to 32.0 V DC
Delay	0 s to 1 h

6.8.3 GAM3.2 1 supply voltage high alarm

This alarm is for auxiliary power supply voltage protection.

The alarm is based on the power supply voltage measured by the GAM. The alarm is activated when the power supply voltage exceeds the set point for the delay time.



Hardware > GAM3.2 1 > High voltage alarm

Parameter	Range
Set point	12.0 to 36.0 V DC
Delay	0 s to 1 h

6.9 Processor and communication module PCM3.3

6.9.1 Network and communication alarms

6.9.1.1 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

6.9.1.2 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

6.9.1.3 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.

6.9.1.4 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

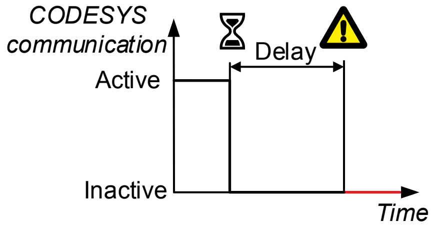
6.10 CODESYS alarms

6.10.1 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

6.10.2 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.

6.11 Event logging

6.11.1 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.

6.11.2 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. 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.

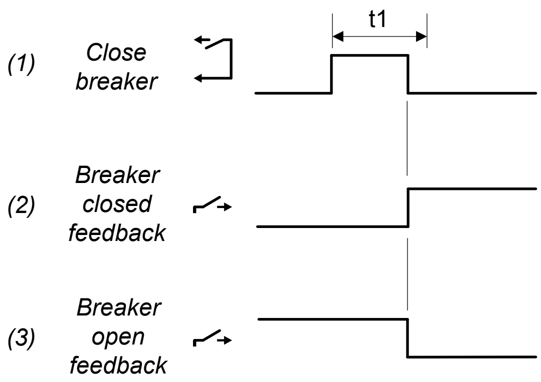
Parameters

`Breakers > [Breaker] configuration > Configuration`

Parameter	Range	Notes
`Breaker type`	• Pulse breaker • Compact breaker • 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). 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

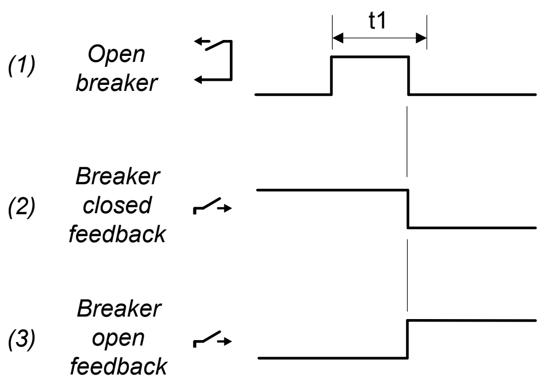


t1 Pulse on (`Parameters > Breakers > [Breaker] > Pulse time ON`)

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

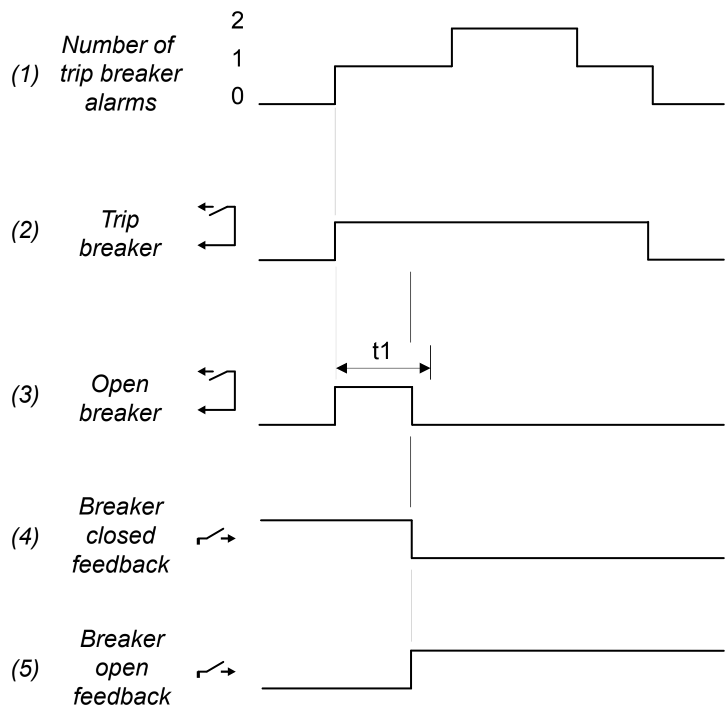


t1 Pulse on (`Parameters > Breakers > [Breaker] > Pulse time ON`)

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. 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.

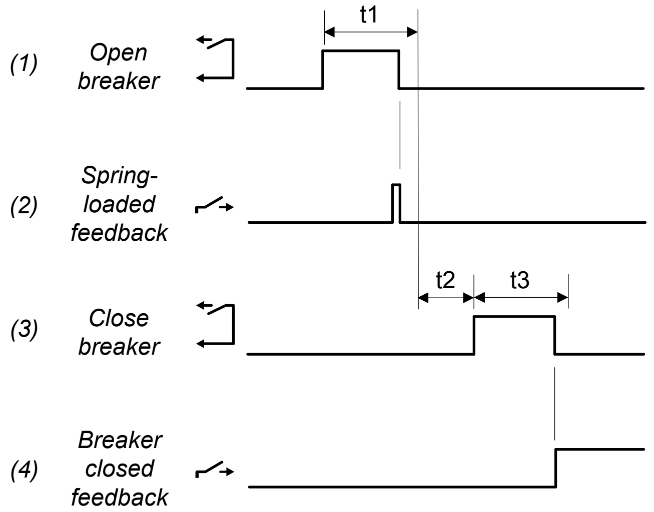
Parameters

`Breakers > [Breaker] configuration > Configuration`

Parameter	Range	Notes
`Breaker type`	• Pulse breaker • Compact breaker • 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. 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). 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

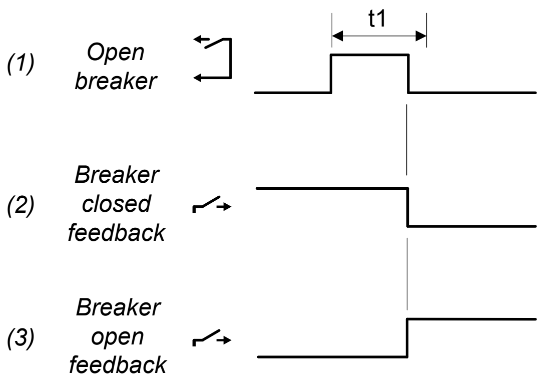


t1	Spring load time (`Breakers > [Breaker] configuration > Spring load time`)
t2	Wait after spring-loading (`Breakers > [Breaker] > Pulse time OFF`)
t3	Pulse on (`Breakers > [Breaker] > Pulse time ON`)

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

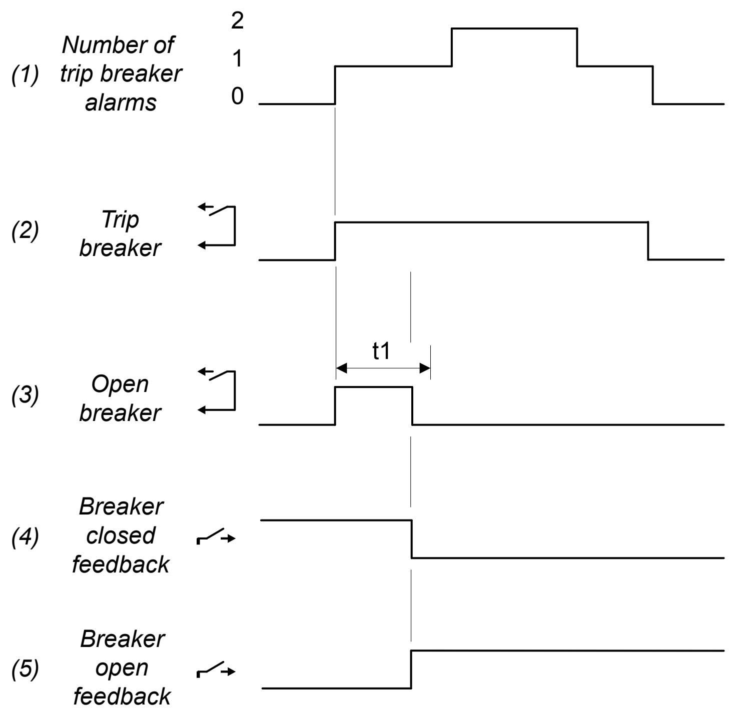


t1	Pulse on (`Breakers > [Breaker] > Pulse time ON`)

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. 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.

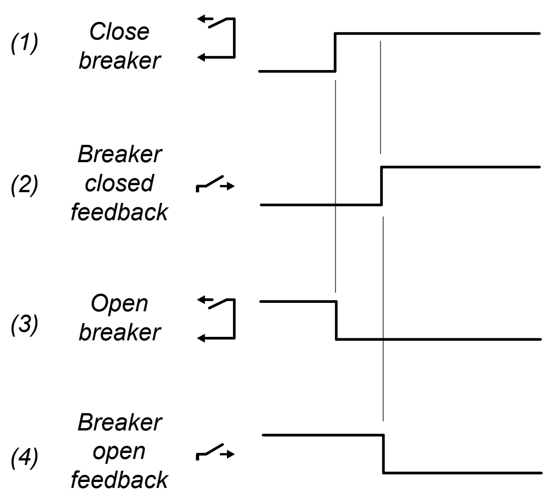
Parameters

`Breakers > [Breaker] configuration > Configuration`

Parameter	Range	Notes
`Breaker type`	• Pulse breaker • Compact breaker • 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. 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].

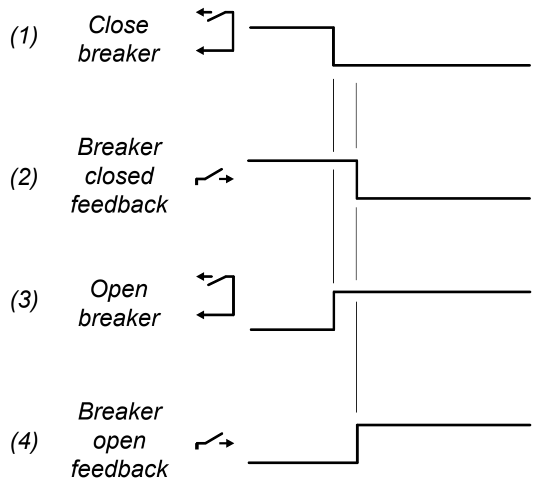
Sequence diagrams

Table 7.7 Closing a continuous breaker



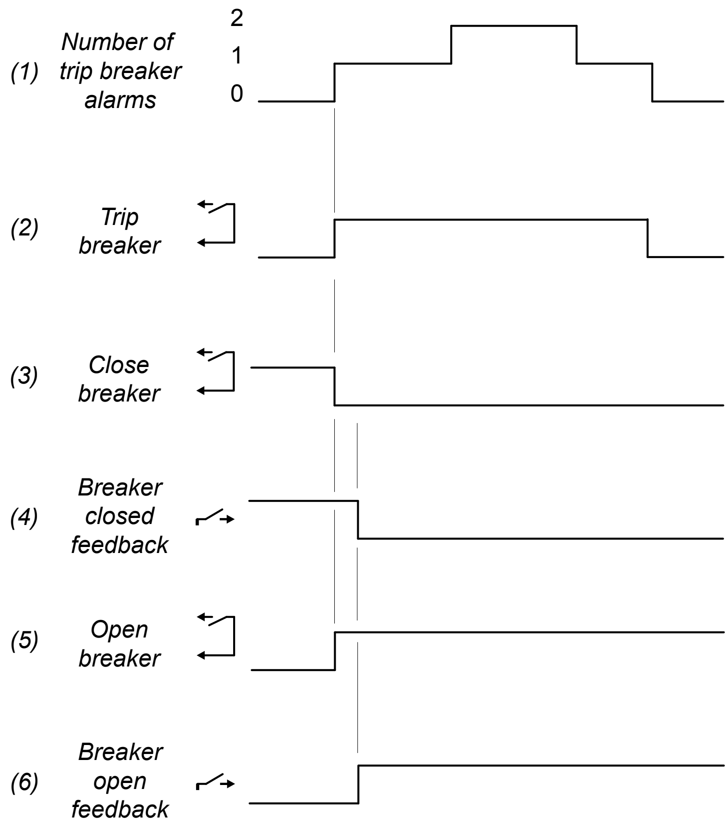
1. **Close breaker:** `Breakers > [Breaker] > Controls > [*B] close` (digital output). The controller activates this output to close the breaker.
2. **Breaker closed feedback:** `Breakers > [Breaker] > Feedback > [*B] closed` (digital input). This input is activated when the breaker is closed.
3. **Open 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. 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. 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. *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:

$$f_{set\ point} = f_{busbar} + \text{Slip frequency}$$

Slip frequency bad example

Delta frequency min.: **-0.3 Hz**
Delta frequency max.: **0.3 Hz**

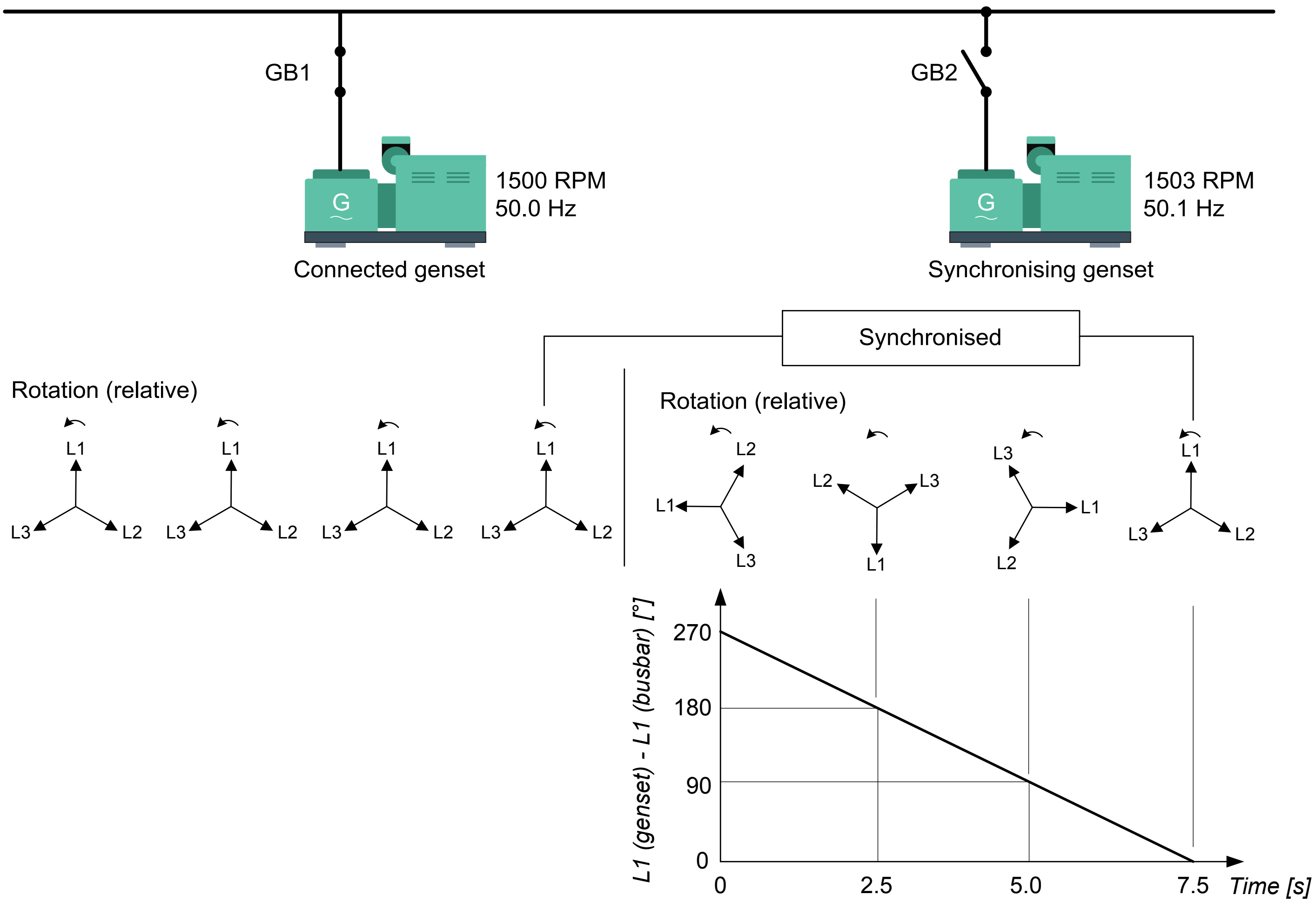
The slip frequency is **0.0 Hz**. There is a risk that there will be a long synchronisation time, because there is no change in the phase difference.

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:

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

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.

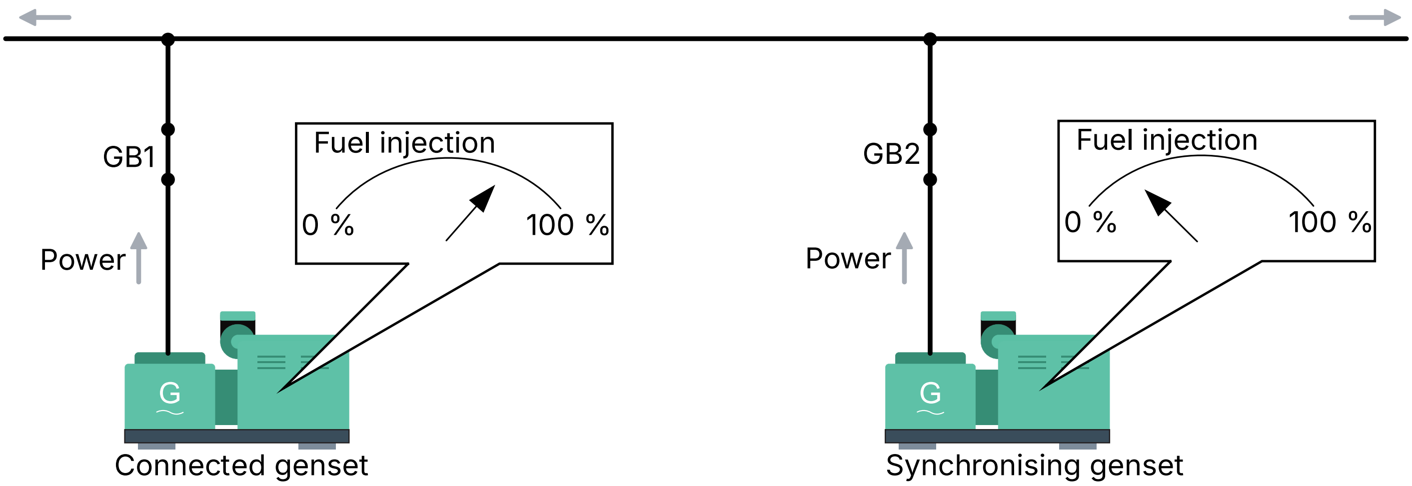
Load distribution after synchronisation

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.

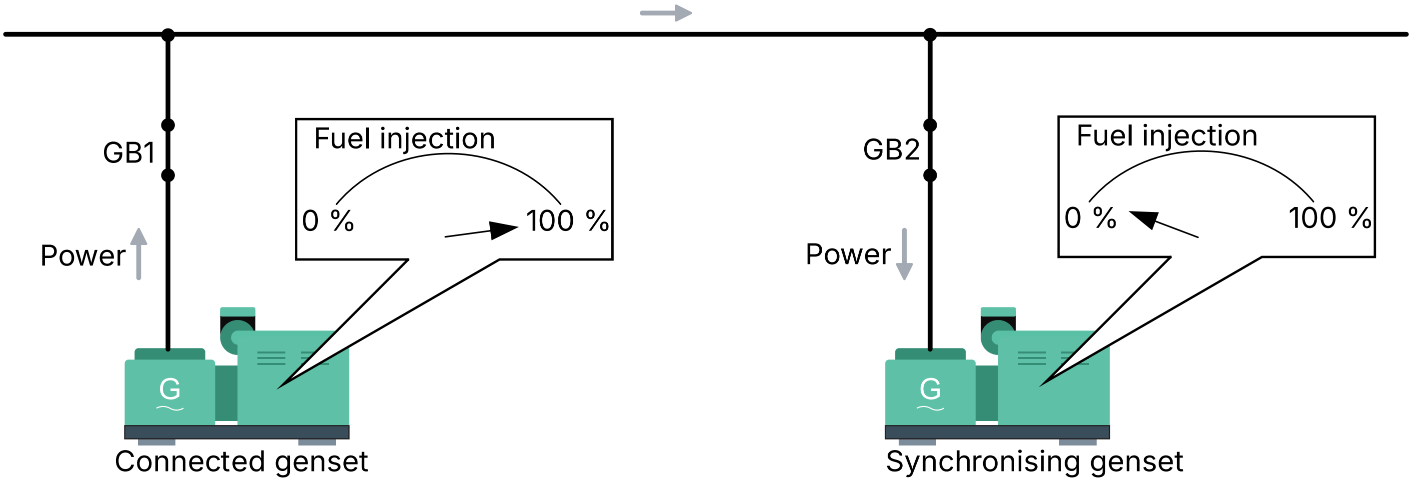
The following example shows that at a given *positive* slip frequency, the synchronising genset will *export* power to the load after the breaker closes.

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:

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

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. **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 • Static • 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. 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. *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**

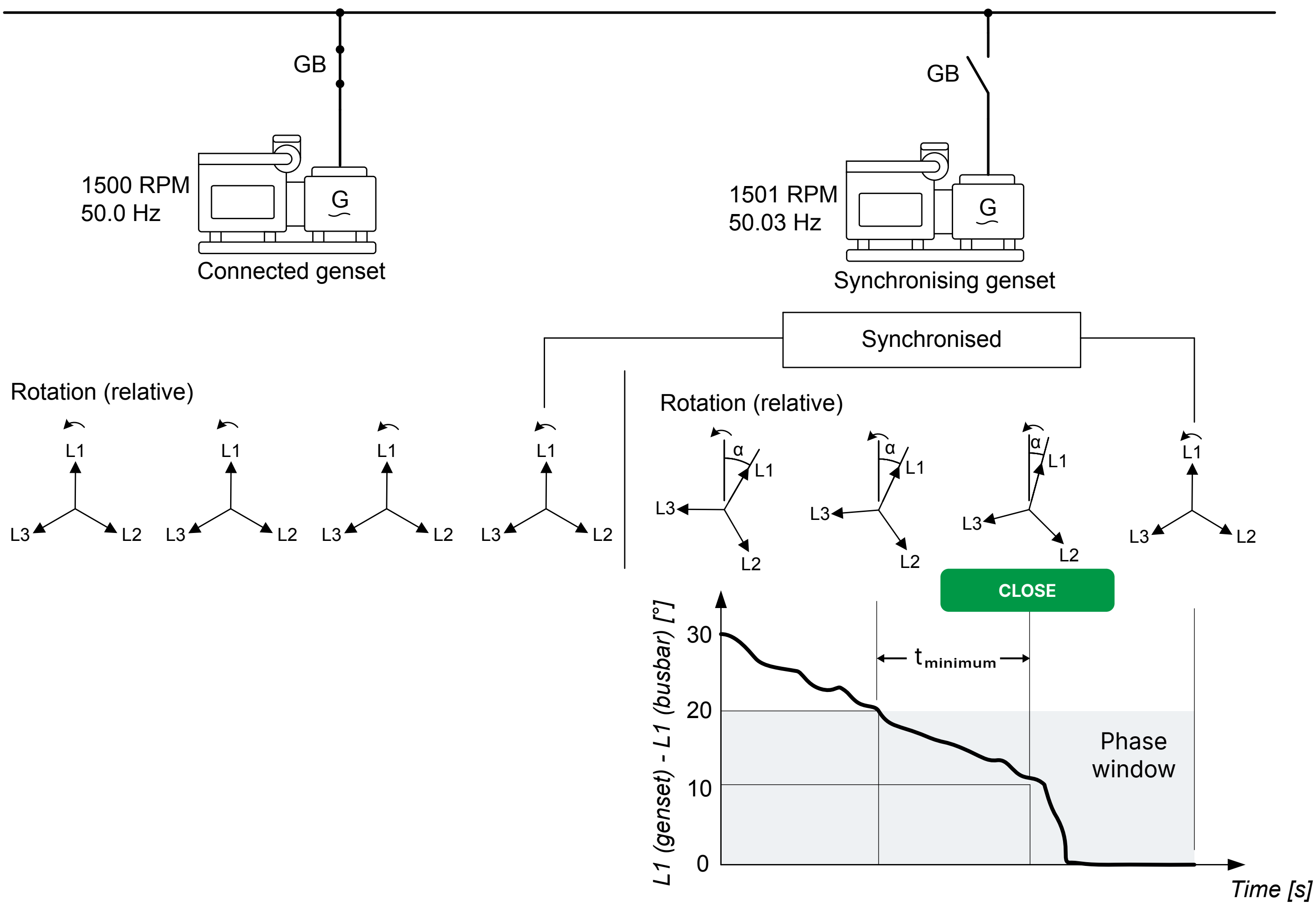
	The generator frequency must be between **50.0 Hz** and **50.4 Hz** for synchronisation.

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.

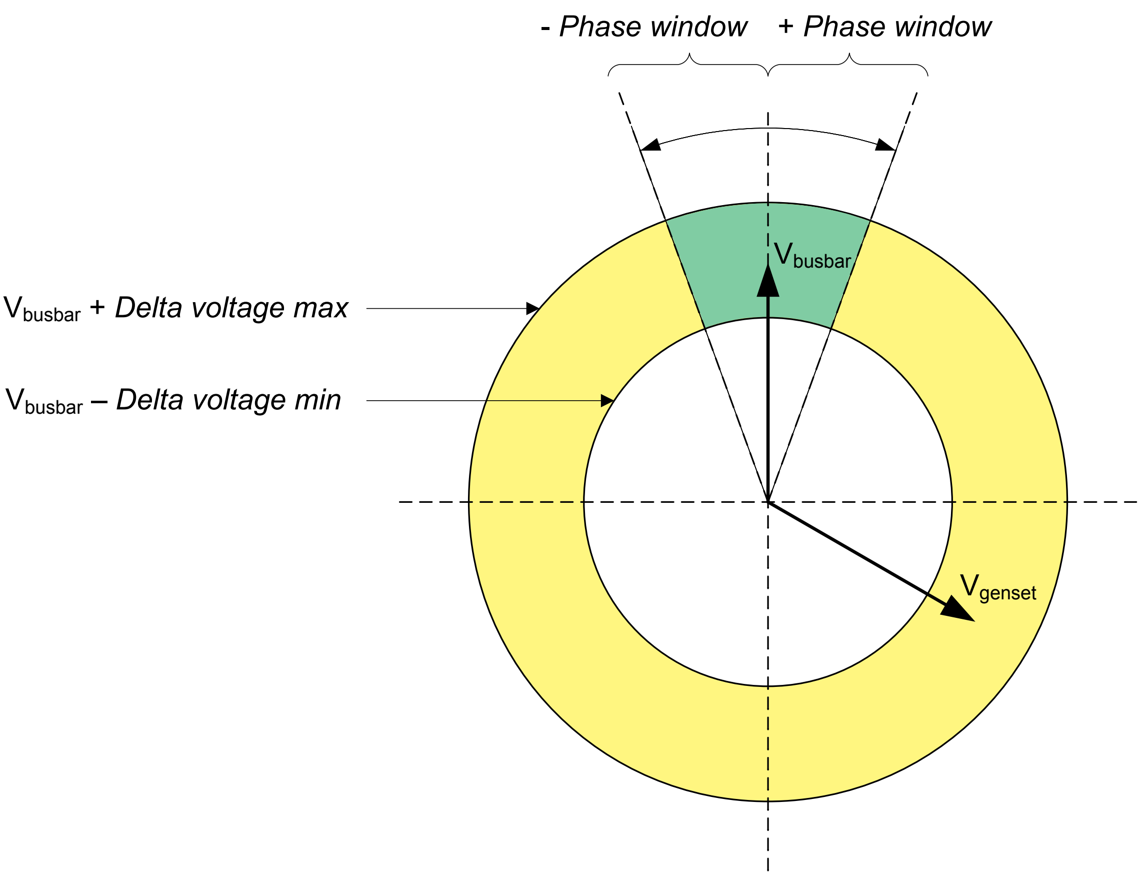
When the genset-busbar difference is 200 mHz, the phase synchronisation function takes over. The phase regulator for synchronisation aims to minimise the angle between the synchronising genset and the busbar.

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. 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. 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

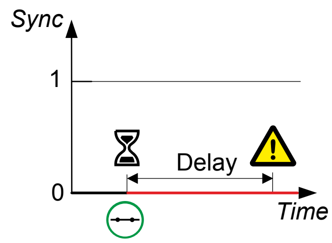
For CustomLogic contacts, access the synchronisation status outputs under `Functions > Breakers > [Breaker] > Outputs > Sync. status`. These outputs are all optional.

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



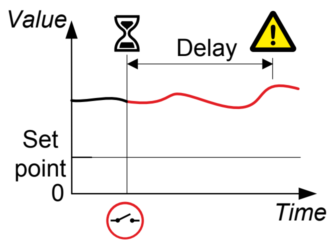
This alarm alerts the operator about a breaker synchronisation failure.

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.

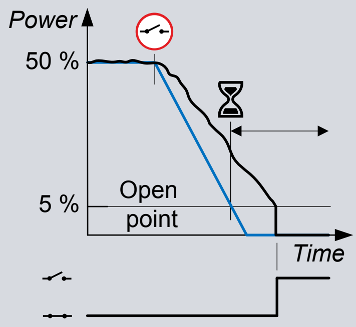
The *Open point (de-loading)* is configured under **Breakers > [Breaker] configuration > Configuration**.

Breakers > [Breaker] monitoring > De-load failure

Parameter	Range
Delay	0.0 s to 1 h

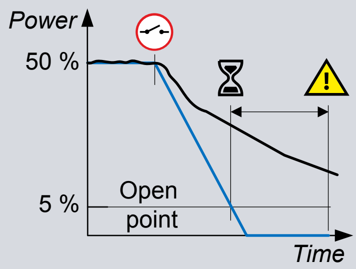
Effect of de-load ramp example

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.



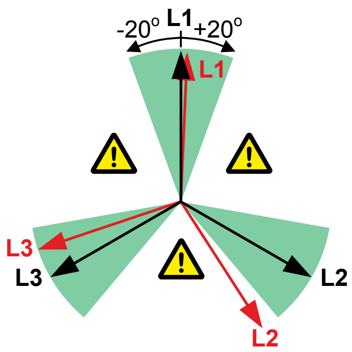
Effect of slow de-loading example

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.

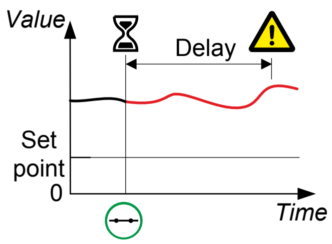
7.5.3 Vector mismatch



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.

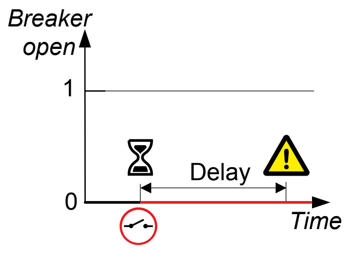
Frequency-based inhibit

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*.

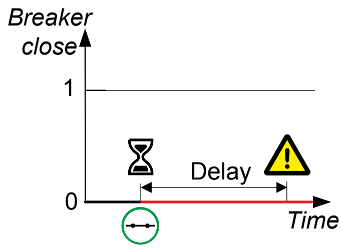
If no breaker feedback is configured in the **Input/output** for the breaker, then the alarm parameters are not visible.

`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`

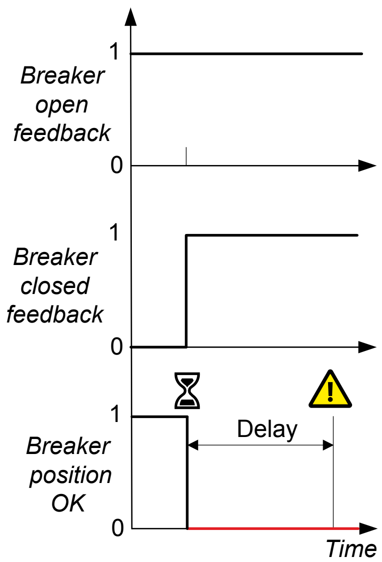
Parameter	Range
`Delay`	0.1 to 60.0 s

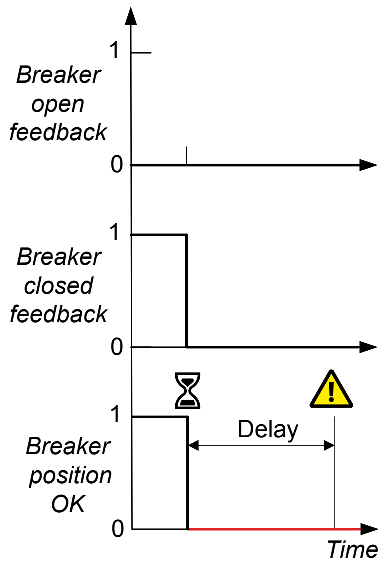
7.5.6 Breaker position failure

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.

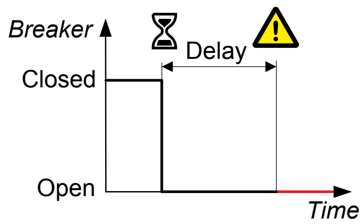
`Breakers > [Breaker] monitoring > Position failure`

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.

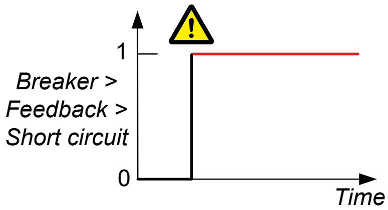


`Breakers > [Breaker] monitoring > Tripped (external)`

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. • 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.

If you have a GAM3.2 module installed, then the controller also has a stand alone regulation mode for both governor and AVR.

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

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) • Analogue / DVR (for AVR) • 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.

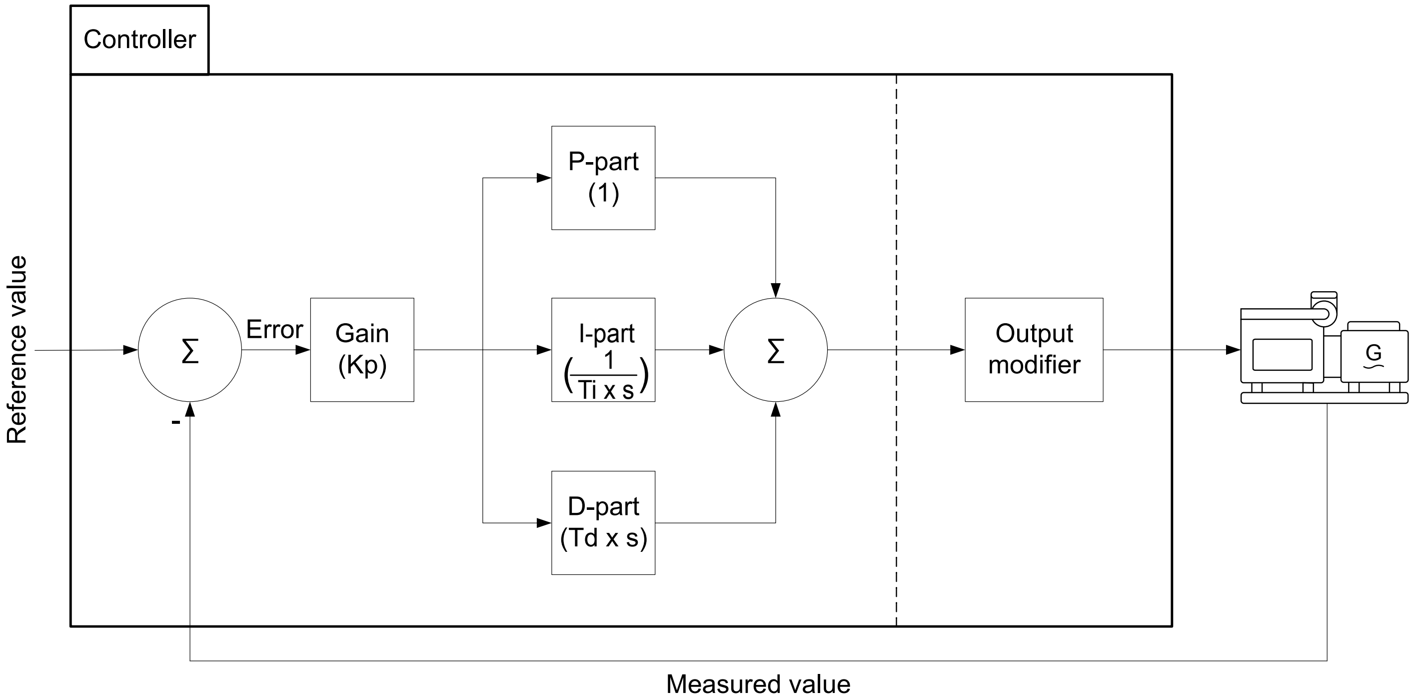
More information
See Pulse width modulation (PWM) output characteristics for the relationship between duty cycles and the PWM output.

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:

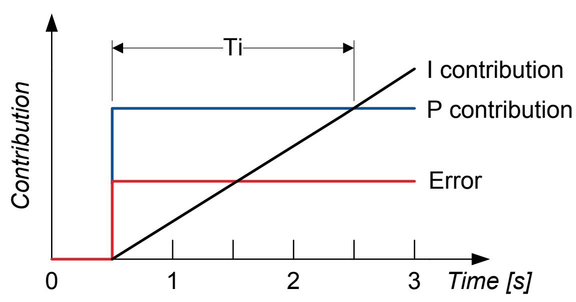
- The gain × error
- The integration time (*Ti*)
- The error history

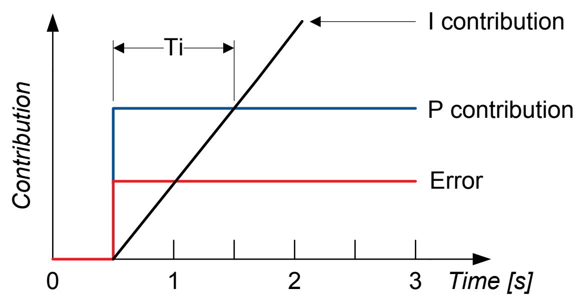
Ti is the time it takes for the contribution of the integral part to be equal to the contribution of the proportional part. If *Ti* is reduced, the contribution of the integral part is increased.

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 • Analogue / ECU (for GOV) • Analogue / DVR (for AVR) • 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. 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. 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. 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. 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. 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)

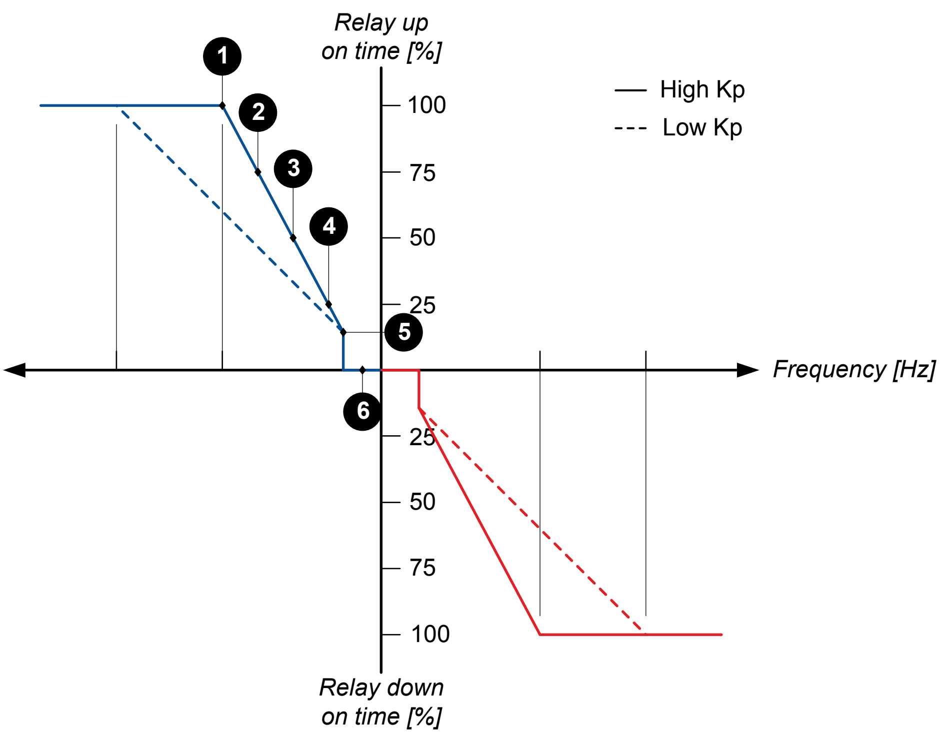
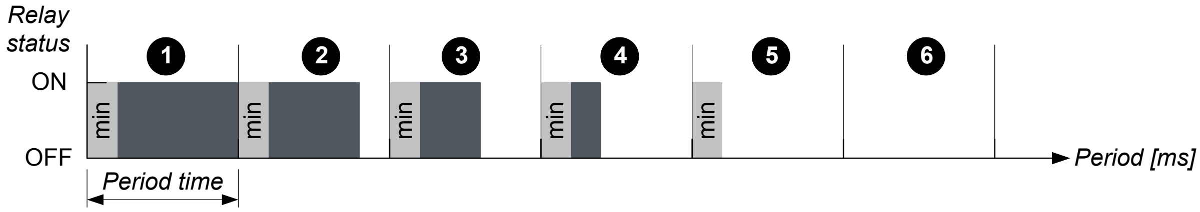


Figure 8.3 Relay action (based on measurements at the end of the period time)



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.

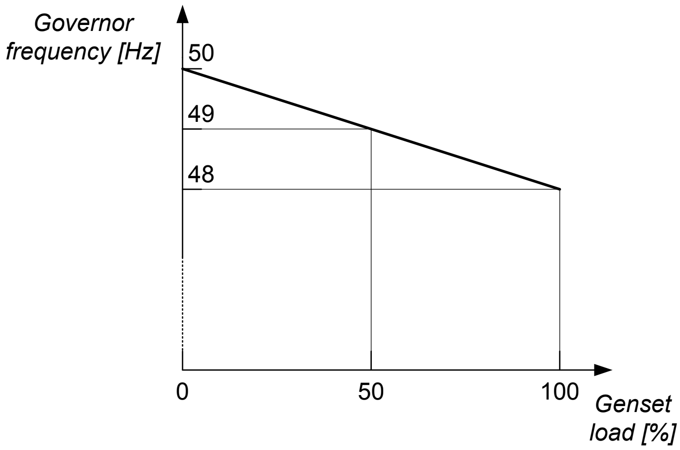
Droop definitions

Droop name	Description
Governor or AVR droop	The droop setting of the governor or AVR. 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. 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

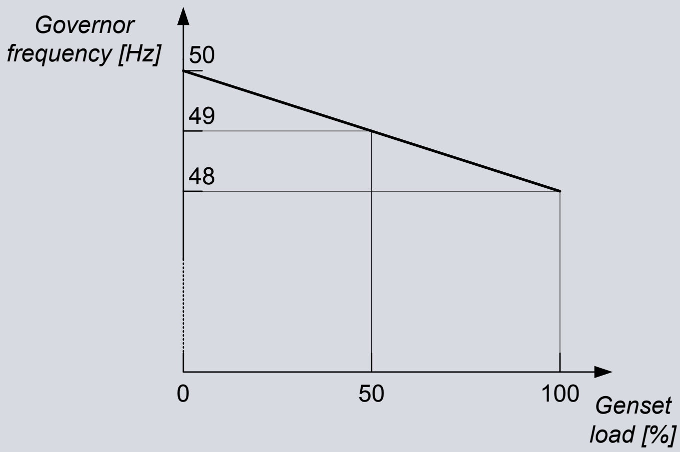


The reactive power output is related to the voltage by the voltage droop curve when droop is activated in the AVR, or when voltage droop is the active regulation mode on the controller. The reactive power load during voltage droop is shared in a similar way as active power is shared during frequency droop.

Gensets with the same droop setting example

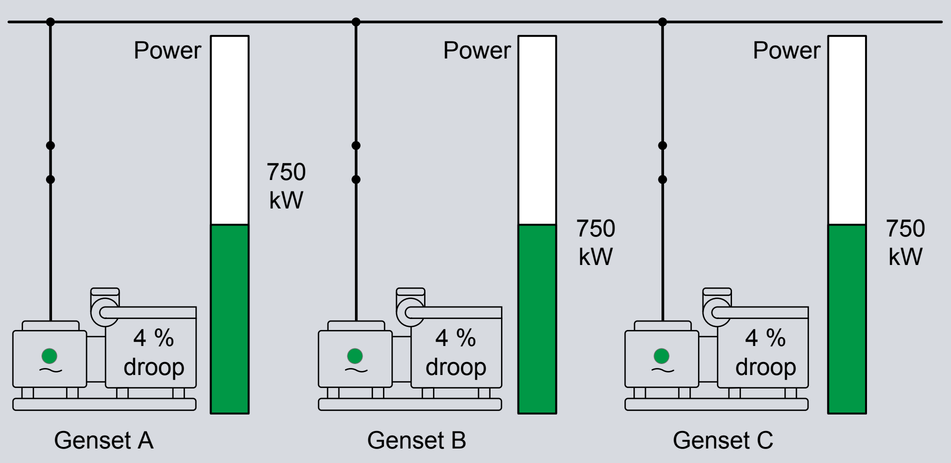
Gensets A, B and C have a nominal power of 1500 kW each and operate at a nominal frequency of 50 Hz. Each genset has a 4 % controller droop. The droop curve for each genset is the same, and is shown in the figure below.

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).

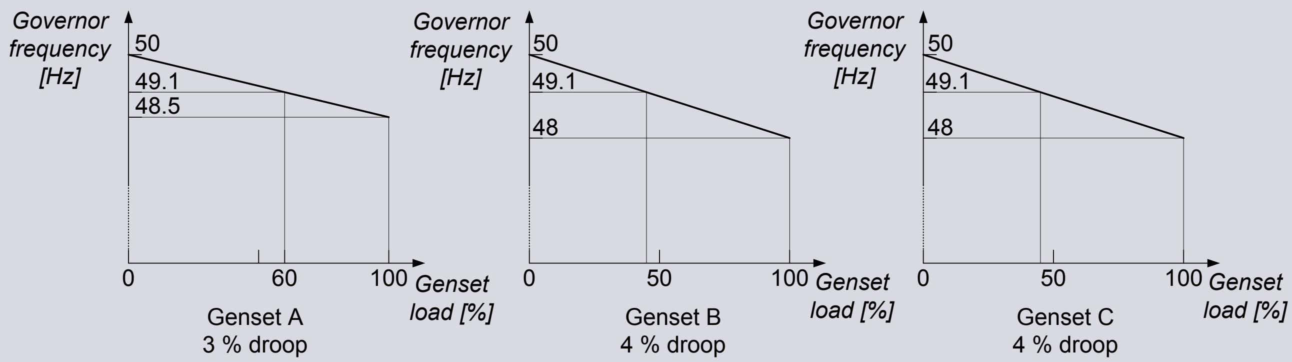


If the gensets that are connected to the same busbar section have different droop settings, the genset(s) with a lower droop will be loaded more. When the droop curve for one or more gensets are different from the other gensets on the busbar, the gensets take a different proportion of the load due to the different droop curves.

Gensets with different droop settings example

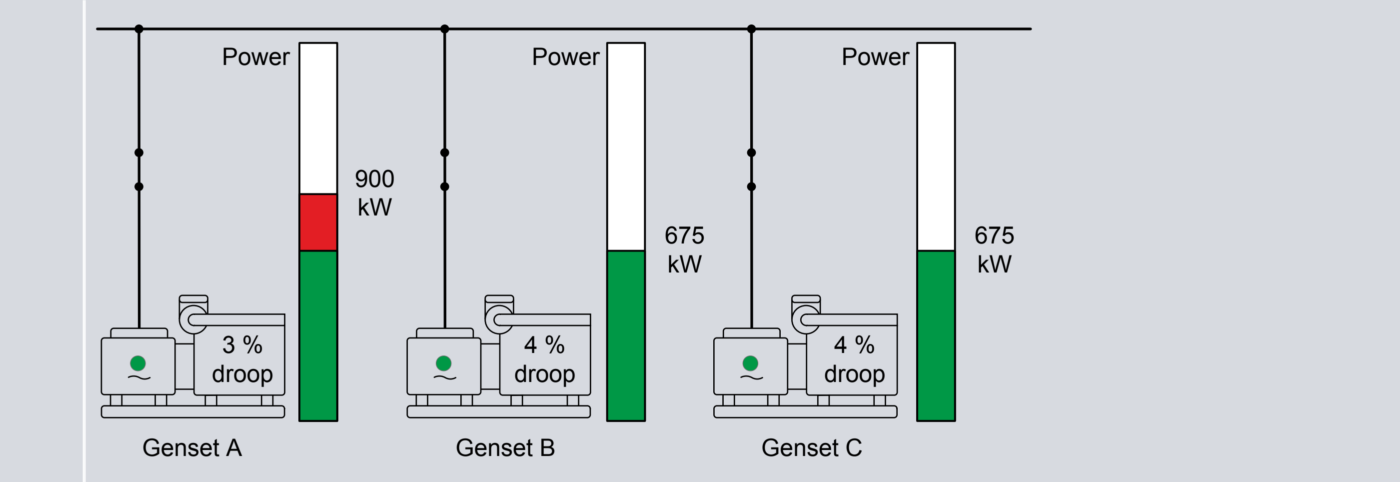
Gensets A, B and C have a nominal power of 1500 kW each and operate at a nominal frequency of 50 Hz. Genset A has a 3 % droop and gensets B and C each have a 4 % droop.

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.

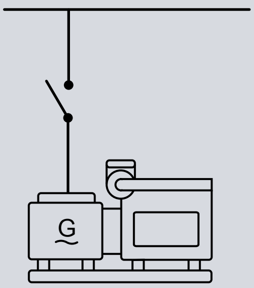
8.1.5 Regulation rules

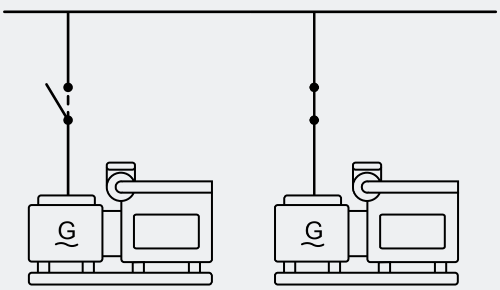
The controller regulates the genset as follows:

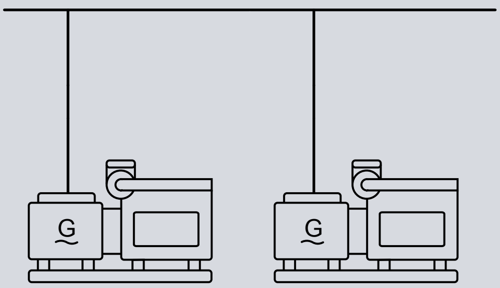
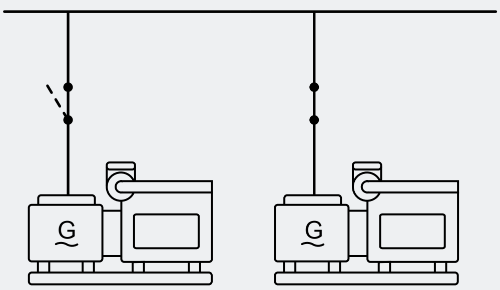
- **Not connected**: According to the selected regulation mode and inputs.
- **Synchronising**: The controller synchronises the genset to the busbar. The regulation mode and other inputs are ignored.
- **Connected**: According to the selected regulation mode and inputs.

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.

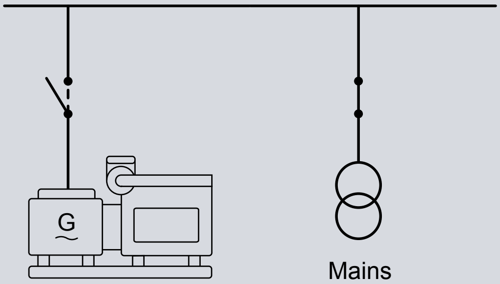
Suggested regulation modes

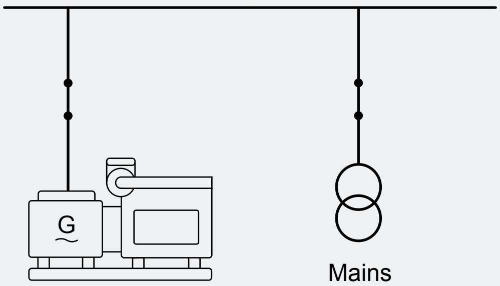
Condition		Suggested governor mode	Suggested AVR mode	Set point source
	The generator breaker is open and the genset is running. This can be a stand-alone genset, or a genset in a system.	• Fixed frequency (Recommended) • Fixed RPM (Recommended for asynchronous gensets) • Power load share • Frequency droop	• Fixed voltage (Recommended) • Reactive power load share • Voltage droop	• Genset nominal frequency • Genset nominal voltage

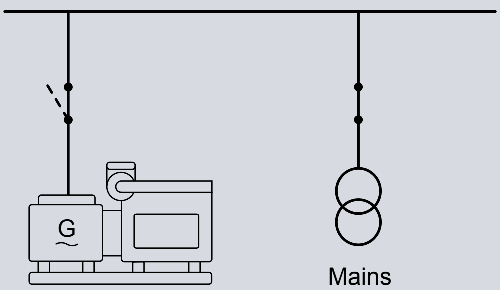
	The generator breaker is open and the **GENSET** controller receives a close breaker command.	• Before sending command to close breaker:
		  ◦ Fixed frequency (Recommended)
		  ◦ Fixed RPM (Recommended for asynchronous gensets)
			• Before sending command to close breaker:
			  ◦ Fixed voltage (Recommended)
			  ◦ Reactive power load share
			  ◦ Voltage droop
			• 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 ◦ Frequency droop • No mode selection required while synchronising		
	The genset is connected to the busbar without mains and is producing power. 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) • Fixed power • Frequency droop	• Reactive power load share (Recommended) • Fixed reactive power • Fixed cos phi • Voltage droop	• Controller set point • External set point ◦ Modbus ◦ Analogue
	The genset is running parallel to another power producing component on the busbar (except mains). The **GENSET** controller receives a open breaker command. The controller sends	• Before sending command to open breaker: ◦ Power load share (Recommended) ◦ Fixed power ◦ Frequency droop • No mode selection required while de-loading	• Before sending command to open breaker: ◦ Reactive power load share (Recommended) ◦ Fixed reactive power ◦ Fixed cos phi ◦ Voltage droop • 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.
 	
The controller sends commands to synchronise genset to the busbar frequency and voltage.
	• Before sending command to close breaker:
	  ◦ Fixed frequency (Recommended)
	  ◦ Fixed RPM (Recommended for asynchronous gensets)
	  ◦ Power load share
	  ◦ Frequency droop
	• No mode selection required while synchronising
		• Before sending command to close breaker:
		  ◦ Fixed voltage (Recommended)
		  ◦ Reactive power load share
		  ◦ Voltage droop
		• No mode selection required while synchronising	


The genset is running parallel to mains and is producing power.
 	
The genset can be part of a system of power producing components on the busbar that are running parallel to mains.
	• Fixed power (Recommended)
	• Frequency droop
		• Fixed reactive power (Recommended)
		• Fixed cos phi (Recommended)
		• Voltage droop
			• Controller set point
			• External set point
			  ◦ Modbus
			  ◦ Analogue


The genset is running parallel to mains. The **GENSET** controller receives a open breaker command.
	• Before sending command to open breaker:
	  ◦ Fixed power (Recommended)
	  ◦ Frequency droop
	• No mode selection required while de-loading
		• Before sending command to open breaker:
		  ◦ Fixed reactive power (Recommended)
		  ◦ Fixed cos phi (Recommended)
		  ◦ 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. 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. 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. A high droop setting results in high frequency deviations from nominal frequency. 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. A high droop setting results in high frequency deviations from nominal frequency. 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. 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. 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. 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. 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. 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*. 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. 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. 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 Governor stand-alone mode

Stand-alone mode allows an operator to send regulation signals manually to regulate the governor using only a GAM3.2. This mode can be used if the rest of the controller is disabled, or if the main controller power supply fails. For stand-alone mode, the controller must have a correctly configured GAM3.2 module.

If you want to use stand-alone mode during emergencies, DEIF recommends a reliable back-up power supply for GAM3.2.

NOTE Governor stand-alone mode is **not** related to a stand-alone genset.

NOTICE

Manual regulation inputs override other regulation in stand-alone mode

The manual regulation inputs in stand-alone mode override any other regulation. The GAM3.2 does not stop the user from sending regulation signals that might damage the genset.

The operator can create a dangerous situation during stand-alone mode. The rest of the controller could be disabled during stand-alone mode, and therefore be unable to provide protection. The system design and operator training must take these dangers into account.

NOTICE

Manual control must be configured on GAM3.2

All inputs or outputs used for manual control must be configured on the GAM3.2. The controller must not have any other governor inputs or outputs.

Digital inputs and outputs

Function	I/O	Type	Details
`Regulators > GOV > Modes > Stand-alone mode`	Digital input	Continuous	The operator activates this input to activate stand-alone mode. If you want one digital input to activate both GOV and AVR stand-alone mode, also configure `Regulators > AVR > Modes > Stand-alone mode` on the same input.
`Regulators > GOV > Manual > Manual GOV increase`	Digital input	Continuous	When this input is activated during stand-alone mode, the GAM3.2 increases the output to the governor. That is, the `Regulator > GOV > Control > GOV output [%]` analogue output, or the `Regulators > GOV > Control > GOV increase` digital output.
`Regulators > GOV > Manual > Manual GOV decrease`	Digital input	Continuous	When this input is activated during stand-alone mode, the GAM3.2 decreases the output to the governor. That is, the `Regulator > GOV > Control > GOV output [%]` analogue output, or the `Regulators > GOV > Control > GOV decrease` digital output.
`Governor output`	-	-	Configure either an analogue governor output (GOV output [%]), or two relay governor outputs (GOV increase and GOV decrease), on the GAM3.2.
`Regulators > GOV > State > Stand-alone is active`	Digital output	Continuous	Optional. The relay activates when stand-alone mode is the active regulation mode.

The digital inputs *Manual GOV increase* and *Manual GOV decrease* are also used for manual regulation.

More information
See Synchronisation in switchboard control for information about manual regulation.

More information
See Configuration alarms for information about the incorrect configuration alarm.

How it works during normal controller operation

When the *Stand-alone mode* digital input is activated during normal operation, the controller status changes to *Manual regulation*.

For relay regulation, the GAM3.2 activates the relay outputs in response to the manual inputs.

For analogue regulation, the GAM3.2 initially keeps the analogue output at its last value. The GAM3.2 then adjusts the analogue output in response to the manual inputs.

How it works if the rest of the controller is disabled

The rest of the controller can be disabled in the following situations:

- PSM3.1 loses power.
- The controller is in service mode, downloading software, and/or internal communication is not working.

The GAM3.2 regards the rest of controller disabled when it cannot communicate with the rest of the controller. As long as the GAM3.2 has power and the required wiring, you can use it for stand-alone manual regulation.

All inputs or outputs used for manual control must be configured on the GAM3.2. The controller must not have any other governor inputs or outputs.

When the controller is disabled, activate the *Stand-alone mode* digital input. The GAM3.2 then sends regulation signals based on manual regulation inputs.

For analogue regulation, the GAM3.2 initially keeps the analogue output at a preset value. The GAM3.2 then adjusts the analogue output in response to the manual inputs.

How it works when stand-alone mode is deactivated

If *Stand-alone mode* is deactivated, the controller determines the regulation mode and the regulation set point.

For analogue regulation, the GAM3.2 initially keeps the governor analogue output at its last value. Before taking over control from GAM3.2, the controller adjusts the regulation set point for bumpless transfer.

8.2.9 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.

8.2.10 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.

Parameter	Range	Notes
		The genset's nominal reactive power is calculated by the controller. 📖 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. 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. 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). 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.
`Offset 2`	Inductive, Capacitive	Select whether the offset has a lagging cos phi value (inductive), or a leading cos phi value (capacitive). 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). 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. 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. 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.

Function	I/O	Type	Details
`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. 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). 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.

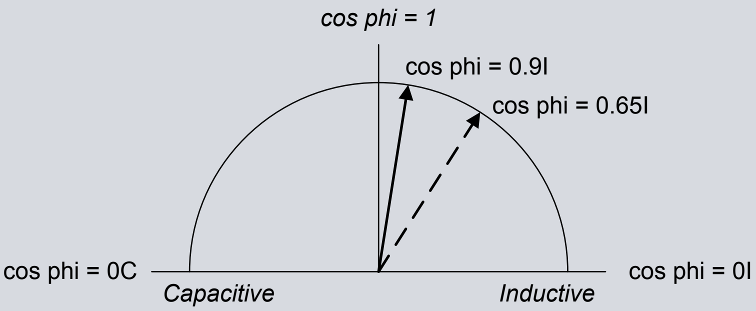
`Regulators > AVR > Regulation set points > Fixed cos phi limit`

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. 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.

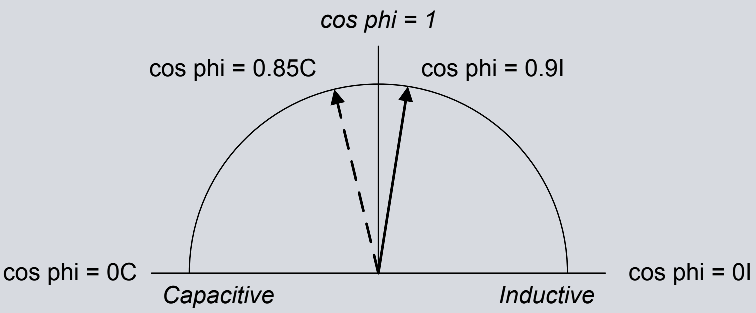
Adding an inductive cos phi offset to an inductive cos phi set point example



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. A high droop setting results in high voltage/reactive power deviations from nominal voltage.

Parameter	Range	Notes
		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.
`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. 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. 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

Parameter	Range	Notes
		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. 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. 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. 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.

Function	I/O	Type	Details
			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. 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. 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. 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. 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.

8.3.9 AVR stand-alone mode

Stand-alone mode allows an operator to send regulation signals manually to regulate the automatic voltage regulator (AVR) using only a GAM3.2. This mode can be used if the rest of the controller is disabled, or if the main controller power supply fails. For stand-alone mode, the controller must have a correctly configured GAM3.2 module.

If you want to use stand-alone mode during emergencies, DEIF recommends a reliable back-up power supply for GAM3.2.

NOTE AVR stand-alone mode is **not** related to a stand-alone genset.

NOTICE

Manual regulation inputs override other regulation in stand-alone mode

The manual regulation inputs in stand-alone mode override any other regulation. The GAM3.2 does not stop the user from sending regulation signals that might damage the genset.

The operator can create a dangerous situation during stand-alone mode. The rest of the controller could be disabled during stand-alone mode, and therefore be unable to provide protection. The system design and operator training must take these dangers into account.

NOTICE

Manual control must be configured on GAM3.2

All inputs or outputs used for manual control must be configured on the GAM3.2. The controller must not have any other governor inputs or outputs.

Digital inputs and outputs

Function	I/O	Type	Details
`Regulators > AVR > Modes > Stand-alone mode`	Digital input	Continuous	The operator activates this input to activate stand-alone mode. If you want one digital input to activate both GOV and AVR stand-alone mode, also configure *Regulators > GOV > Modes > Stand-alone mode* on the same input.
`Regulators > AVR > Manual > Manual AVR increase`	Digital input	Continuous	When this input is activated during stand-alone mode, the GAM3.2 increases the output to the AVR. That is, the *Regulator > AVR > Control > AVR output [%]* analogue output, or the *Regulators > AVR > Control > AVR increase* digital output.
`Regulators > AVR > Manual > Manual AVR decrease`	Digital input	Continuous	When this input is activated during stand-alone mode, the GAM3.2 decreases the output to the AVR. That is, the *Regulator > AVR > Control > AVR output [%]* analogue output, or the *Regulators > AVR > Control > AVR decrease* digital output.
`AVR output`	-	-	Configure either an analogue AVR output (AVR output [%]), or two relay AVR outputs (AVR increase and AVR decrease), on the GAM3.2.
`Regulators > AVR > State > Stand-alone is active`	Digital output	Continuous	Optional. The relay activates when stand-alone mode is the active regulation mode.

More information
See Automatic voltage regulator for general information on regulation.

The digital inputs *Manual AVR increase* and *Manual AVR decrease* are also used for manual regulation.

More information
See Configuration alarms for the incorrect configuration alarm.

How it works during normal controller operation

When the *Stand-alone mode* digital input is activated during normal operation, the controller status changes to *Manual regulation*.

For relay regulation, the GAM3.2 activates the relay outputs in response to the manual inputs.

For analogue regulation, the GAM3.2 initially keeps the analogue output at its last value. The GAM3.2 then adjusts the analogue output in response to the manual inputs.

How it works if the rest of the controller is disabled

The rest of the controller can be disabled in the following situations:

- PSM3.1 loses power.
- The controller is in service mode, downloading software, and/or internal communication is not working.

The GAM3.2 regards the rest of controller disabled when it cannot communicate with the rest of the controller (you could even remove the GAM3.2 from the rack). As long as the GAM3.2 has power and the required wiring, you can use it for stand-alone manual regulation.

When the controller is disabled, activate the *Stand-alone mode* digital input. The GAM3.2 then sends regulation signals based on manual regulation inputs.

For analogue regulation, the GAM3.2 initially keeps the analogue output at a preset value. The GAM3.2 then adjusts the analogue output in response to the manual inputs.

How it works when stand-alone mode is deactivated

If *Stand-alone mode* is deactivated, the controller determines the regulation mode and the regulation set point.

For analogue regulation, the GAM3.2 initially keeps the AVR analogue output at its last value. Before taking over control from GAM3.2, the controller adjusts the regulation set point for bumpless transfer.

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. 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. 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.

Function	I/O	Type	Details
			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. 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. 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 • Relay • Analogue / ECU	**Off:** The controller does not attempt to regulate the governor, and ignores any configured hardware. **Relay:** The controller uses the relay outputs to regulate the governor (only visible if both relays for the governor regulation are configured). **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. 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.

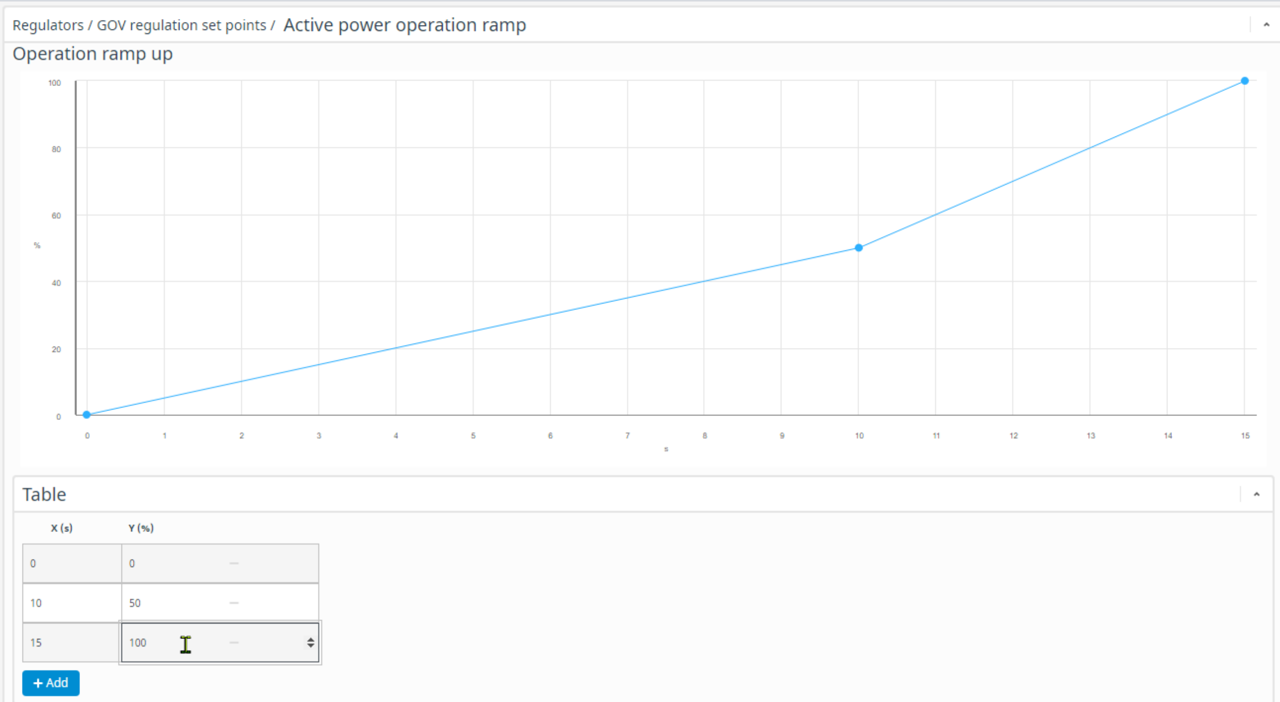
`Regulators > GOV > Regulation set points > Active power ramp up`

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.

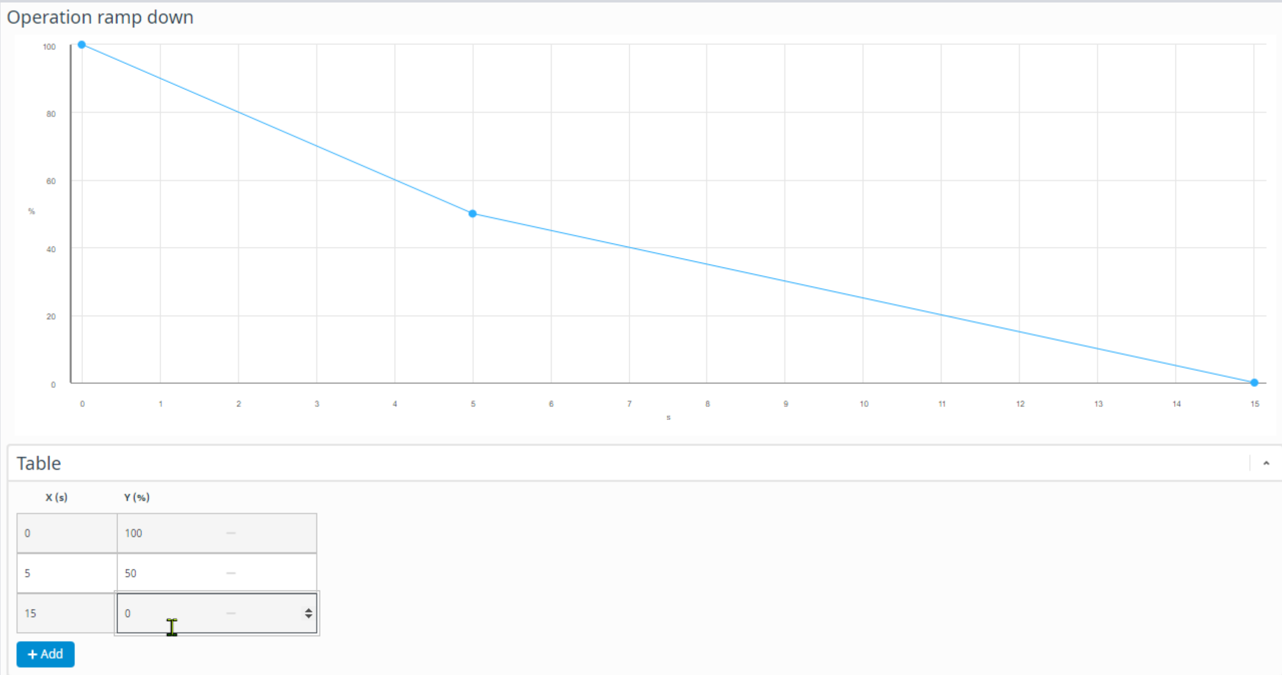
`Regulators > GOV > Regulation set points > Active power ramp down`

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 %).



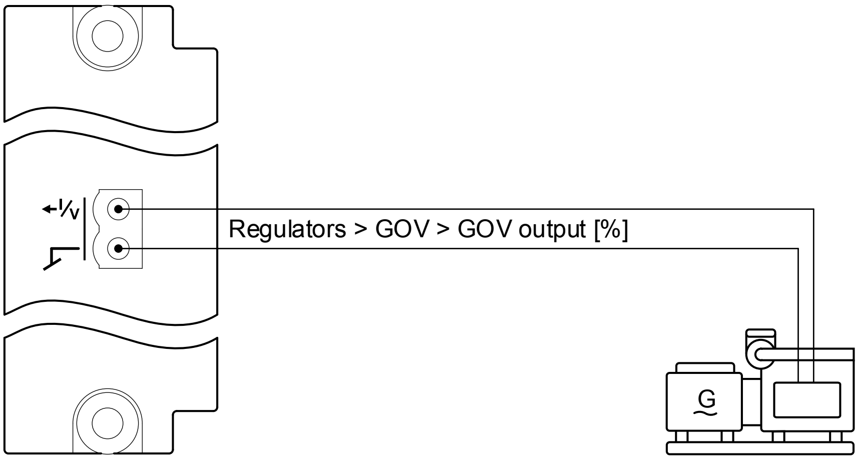
This means that the controller regulates the genset to follow a slope of 10 kW/s between 100 % and 50 % of the genset's nominal power. And the controller regulates the genset to follow a slope of 5 kW/s between 50 % and a 0 % of the genset's nominal power.

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.

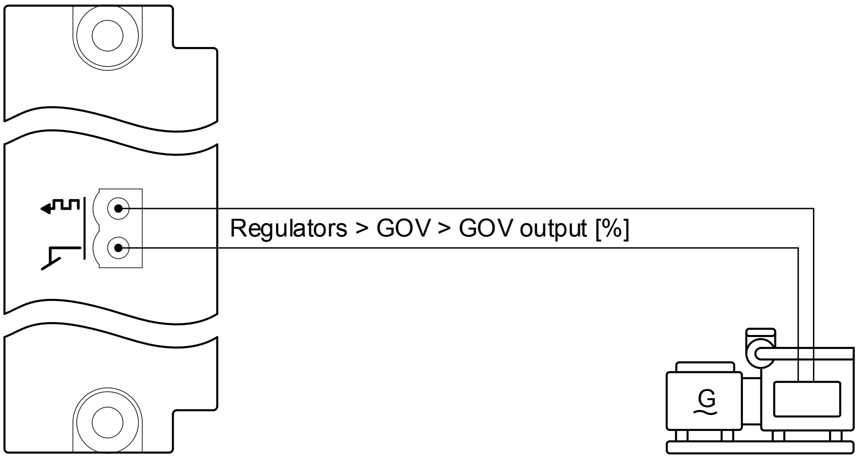
8.5.2 Governor analogue regulation function

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.

Example of analogue output wiring for governor regulation



Example of pulse width modulation analogue output wiring for governor regulation



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. 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`

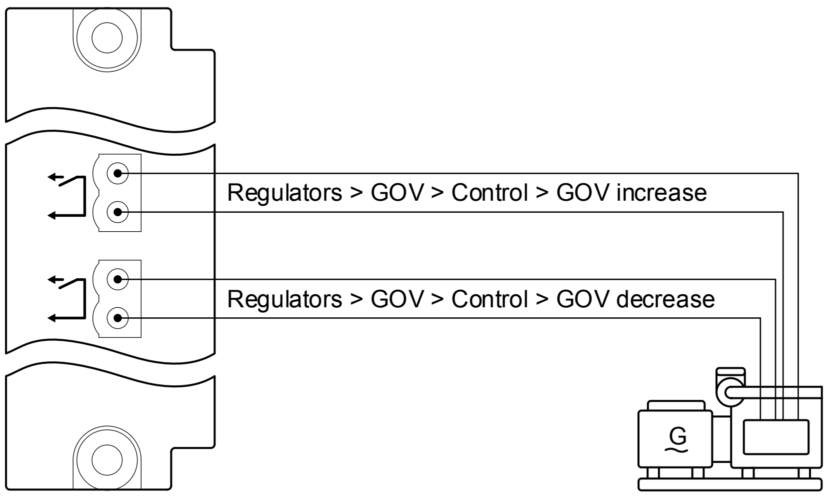
Parameter	Range	Notes

`GOV output offset 1`
`GOV output offset 2`
`GOV output offset 3`
`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.
		
		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.
		
		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.

Wiring example



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*. 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. 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. 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. 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. 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. 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 • Relay • Analogue	**Off:** The controller does not attempt to regulate the AVR, and ignores any configured hardware. **Relay:** The controller uses the configured relay outputs to regulate the AVR (only visible if both relays for governor regulation are configured). **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. 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. When the active power reaches the **Cos phi reset point**, the cos phi value is regulated to 1 in the remaining de-load time. 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 %).

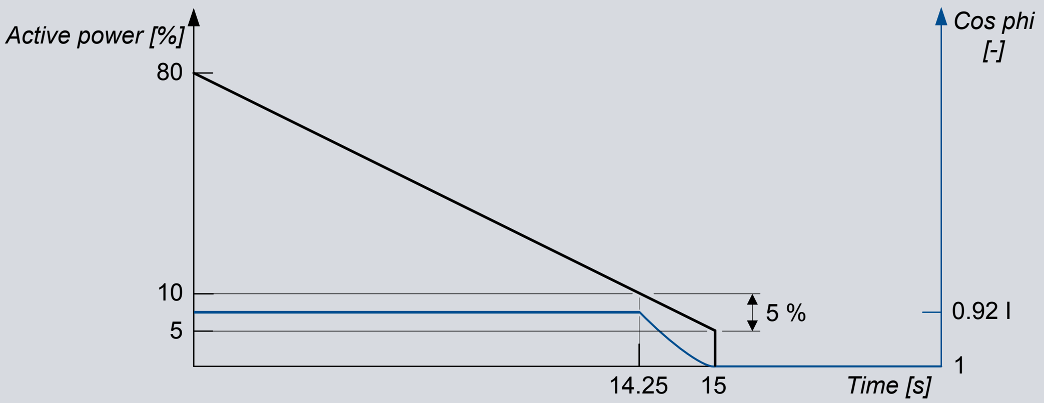
This means that the controller regulates the genset to ensure that the reactive power ramp down does not exceed 10 kvar/s between 100 % and 50 % of the genset's nominal reactive power. And the controller regulates the genset to ensure that the reactive power ramp down does not exceed 5 kvar/s between 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.

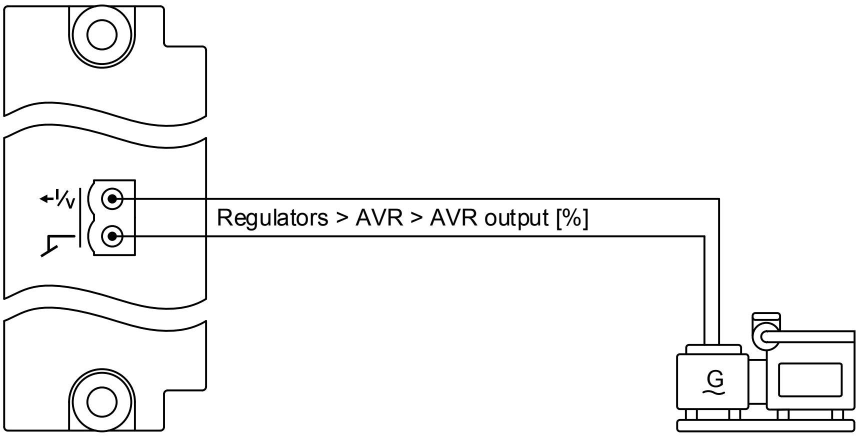
The cos phi reset point is 5 % before the open point. In this example the cos phi value will be regulated to 1 between 14.25 and 15 seconds. The reactive power will respond accordingly. The resultant ramp down can be seen in the image below:



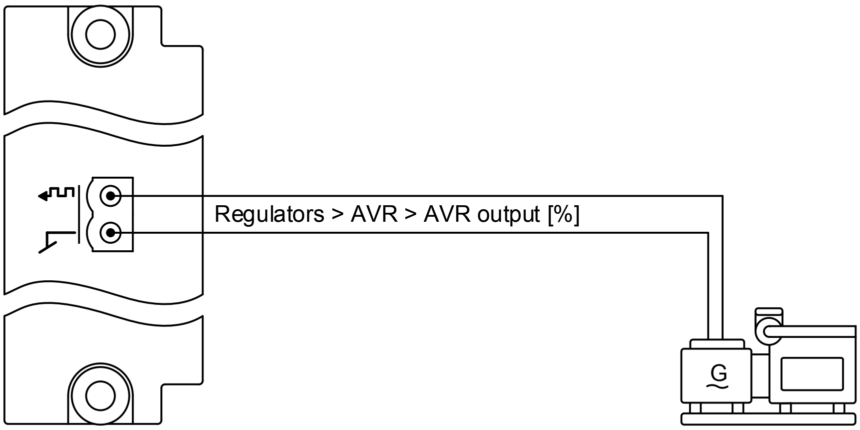
8.6.2 AVR analogue regulation function

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.

Example of analogue output wiring for AVR regulation



Example of pulse width modulation analogue output wiring for AVR regulation



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`

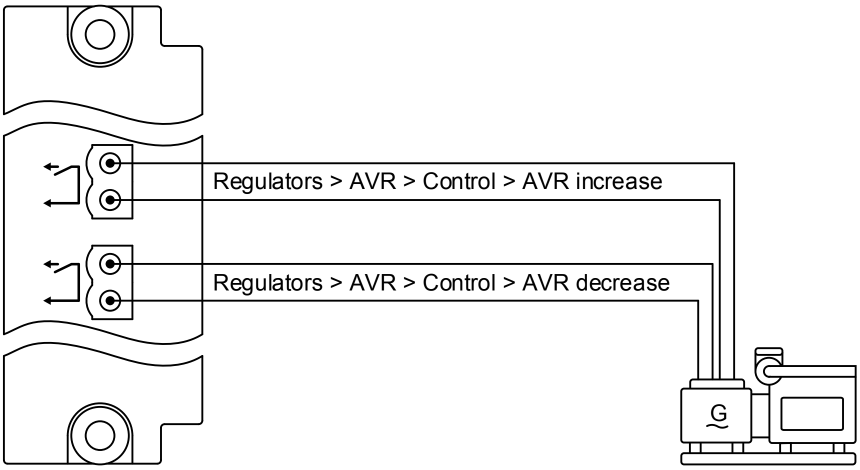
Parameter	Range	Notes

`AVR output offset 1`
`AVR output offset 2`
`AVR output offset 3`
`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.
		
		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.
		
		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.

Wiring example



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. 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. 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. 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. 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.

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.

8.7.3 GOV stand-alone configuration error

The controller activates this alarm if a GAM3.2 is present, but the GAM3.2 does not have inputs and outputs that are correctly configured for governor stand-alone mode.

The following configuration is required for governor stand-alone mode:

- One governor regulation output on the GAM3.2. For example:
  - Two regulation digital outputs (*GOV increase* and *GOV decrease*).
  - One regulation analogue output (AO or PWM, *GOV output [%]*).
- If an analogue governor regulation output is used, the slope of the output curve must be positive.
  - That is, there must be a lower governor output % for a lower voltage or current, and a higher governor output % for a higher voltage or current.
- No governor regulation outputs on any other hardware modules.
- A *Manual GOV increase* digital input on the GAM3.2.
- A *Manual GOV decrease* digital input on the GAM3.2.
- The `Regulators > GOV > Modes > Stand-alone mode` digital input on the GAM3.2
- The parameter `Regulators > GOV general configuration > Stand-alone configuration > GOV stand-alone activation` must be configured High or Low.
  - If using the AVR stand-alone on the same input, this GOV setting must be set the same as the AVR stand-alone activation, otherwise a configuration conflict alarm activates. Both must be configured High or Low. If one is High and the other Low, the alarm activates.

Parameters

`Regulators > GOV general configuration > Stand-alone configuration error`

Parameter	Range
`Delay`	0 s to 1 h

8.7.4 AVR stand-alone configuration error

The controller activates this alarm if a GAM3.2 is present, but the GAM3.2 does not have inputs and outputs that are correctly configured for AVR stand-alone mode.

The following configuration is required for AVR stand-alone mode:

- One AVR regulation output on the GAM3.2. For example:
  - Two regulation digital outputs (*AVR increase* and *AVR decrease*).
  - One regulation analogue output (AO or PWM, *AVR output [%]*).
- If an analogue AVR regulation output is used, the slope of the output curve must be positive.
  - That is, there must be a lower AVR output % for a lower voltage or current, and a higher AVR output % for a higher voltage or current.
- No AVR regulation outputs on any other hardware modules.
- A *Manual AVR increase* digital input on the GAM3.2.
- A *Manual AVR decrease* digital input on the GAM3.2.
- The `Regulators > AVR > Modes > Stand-alone mode` digital input on the GAM3.2.
- The parameter `Regulators > AVR general configuration > Stand-alone configuration > AVR stand-alone activation` must be configured High or Low.
  - If using the GOV stand-alone on the same input, this AVR setting must be set the same as the GOV stand-alone activation, otherwise a configuration conflict alarm activates. Both must be configured High or Low. If one is High and the other Low, the alarm activates.

Parameters

`Regulators > AVR general configuration > Stand-alone configuration error`

Parameter	Range
`Delay`	0 s to 1 h

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 Hz - 50 Hz)| / 50 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 Hz - 60 Hz)| / 60 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 kW - 1000 kW)| / 1000 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 V - 400 V)| / 400 V × 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 × 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

8.8.5 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

8.8.6 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`

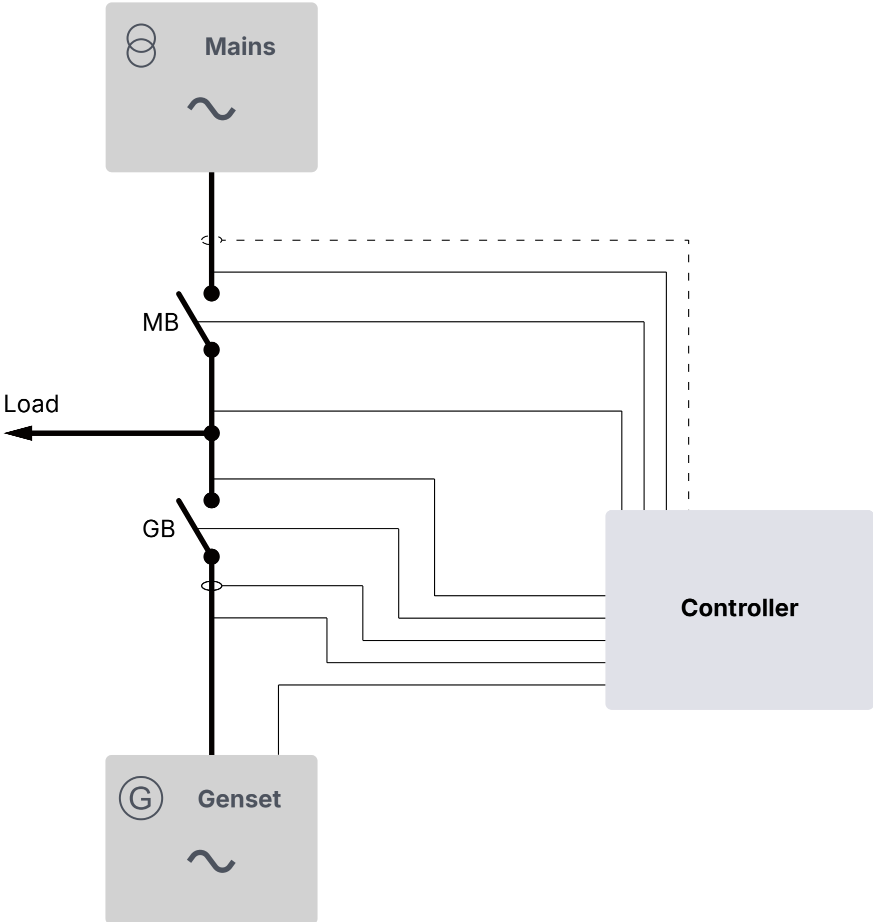
Parameter	Range
`Set point`	0.0 to 50.0 % regulation deviation
`Delay`	0 s to 1 h

9. SINGLE genset controller

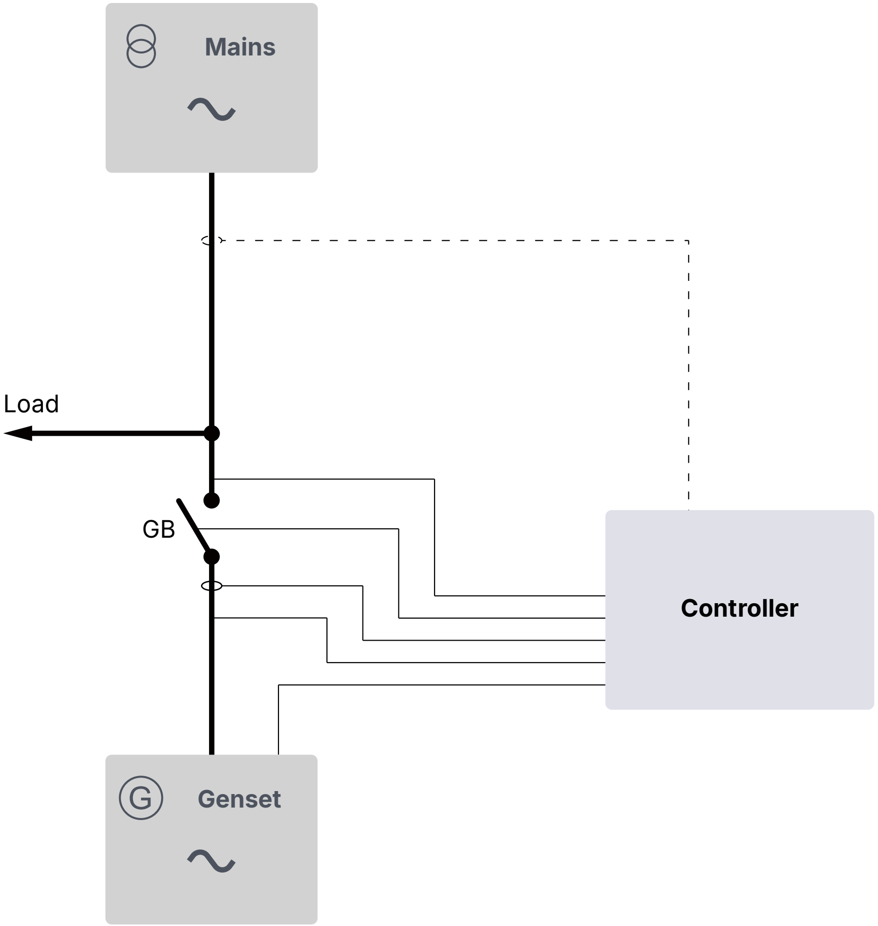
9.1 About the SINGLE genset controller

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
	  ◦ Running detection (Multiple feedback options: Frequency, MPU/W/NPN/PNP (RPM), Digital input, Oil pressure)
	  ◦ Run coil and/or stop coil for engine control
	  ◦ Temperature-dependent cooldown
	• Breaker sequences
	  ◦ Generator breaker close sequence (with synchronisation)
	  ◦ Generator breaker open sequence (with de-loading)
	  ◦ Mains breaker close sequence (with synchronisation) *
	  ◦ Mains breaker open sequence (with de-loading) *
	• Generator breaker blackout close (black busbar negotiation)

Genset regulation	• PID regulators for analogue outputs
	• P regulators for relay outputs
	  ◦ *Relay period time* and *Minimum ON time* configurable
	• Set point selection
	  ◦ Select mode or external set point, using digital input, PICUS, Modbus, CustomLogic, and/or CODESYS
	• Governor modes
	  ◦ Fixed frequency
	  ◦ Fixed active power
	  ◦ Frequency droop (controller regulation emulates droop)

	Functions
	◦ Fixed RPM ◦ External set point: Frequency offset, or Power set point ◦ Manual ◦ Off • AVR modes ◦ Fixed voltage ◦ Fixed reactive power ◦ Fixed cos phi ◦ Voltage droop (controller regulation emulates droop) ◦ External set point: Voltage offset, Reactive power set point, or cos phi set point ◦ Manual ◦ Off • Configurable power ramp up, power ramp down • Temperature-dependent power derate settings (3 sets)
Mains	• Configurable supervision • 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 ◦ Start attempts ◦ Running time (total and trip) ◦ Generator breaker operations and trips ◦ Mains breaker operations and trips * ◦ Energy export to system (active and reactive) ◦ External breaker operations • Energy counters with configurable digital outputs (for external counters) ◦ Energy export to system (active and reactive)
Other functions	• Asynchronous generator (optional) • 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 Q nominal = P nominal Q nominal = S nominal
P or S nominal	No calculation P nominal calculated 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 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 Q nominal = P nominal 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 P nominal calculated S nominal calculated	**P nominal calcuated**: The controller calculates the nominal active power (nominal P), and ignores any entered values. **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.

Digital outputs

For a *Stop coil*, if wire break detection is required, use EIM relay 4 () (terminals 9,10).

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. 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. 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. 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 (on the first EIM3.1 in the controller rack) is connected to an MPU mounted on the engine.
W	HSDI	Continuous	Optional. The W input (on the first EIM3.1 in the controller rack) 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. 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 (connected to the first EIM3.1 in the controller rack) is ignored and not used for running detection. **Enabled:** The MPU/W/NPN/PNP measurement (connected to the first EIM3.1 in the controller rack) 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. 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 measured by the analogue input 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. **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.

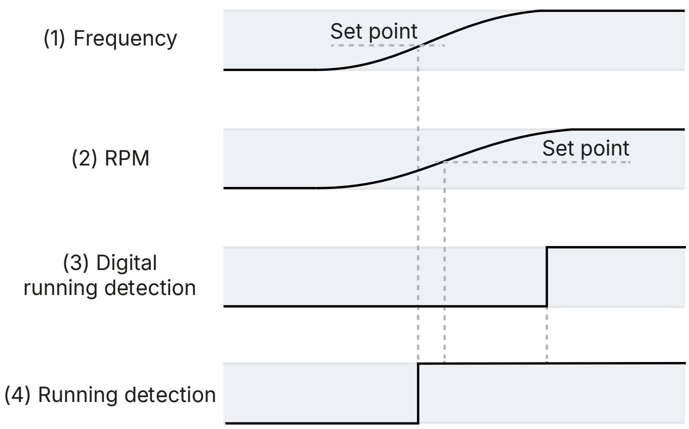
Oil pressure running detection hysteresis

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

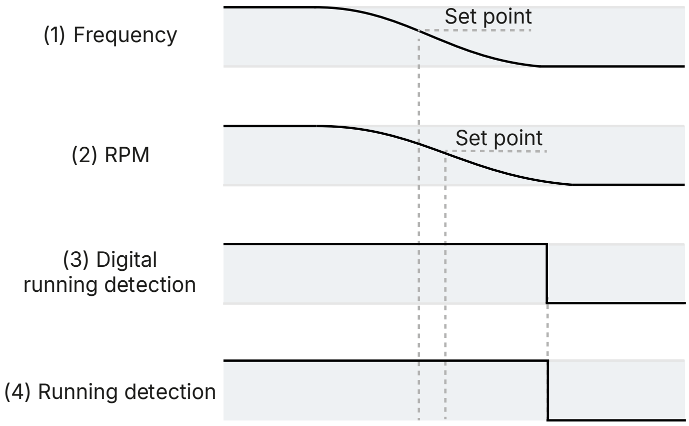


1. **Frequency**: The engine starts and the frequency rises above the set point.
2. **RPM**: (MPU/W/NPN/PNP input). The engine starts and the RPM rises above the set point.
3. **Digital running detection**: *Engine > Feedback > Digital running detection* (digital input). In the example, the response 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

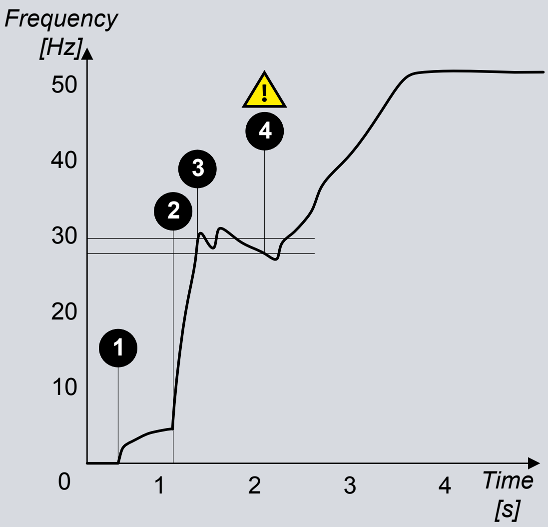
It is possible to only use frequency for running detection. However, using only frequency for running detection increases the risk of not detecting that the genset is running.

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. 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. 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. 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. 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. 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*. **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. **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** I 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** O 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. The external condition is configured with the digital input `Engine > Idle run > End idle run start`, or with CustomLogic or CODESYS.

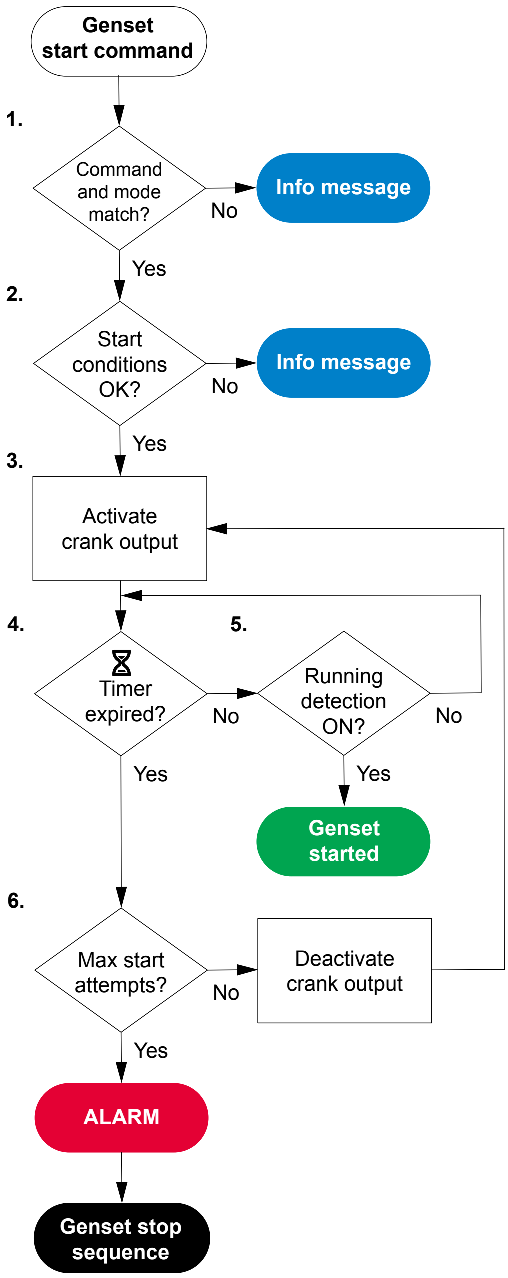
`Engine > Idle run start > Maximum`

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.

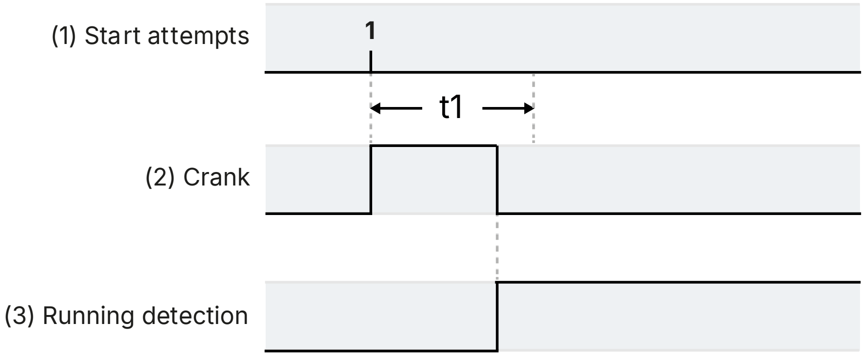
NOTE * The optional *Start prepare* function is not shown here.

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*.

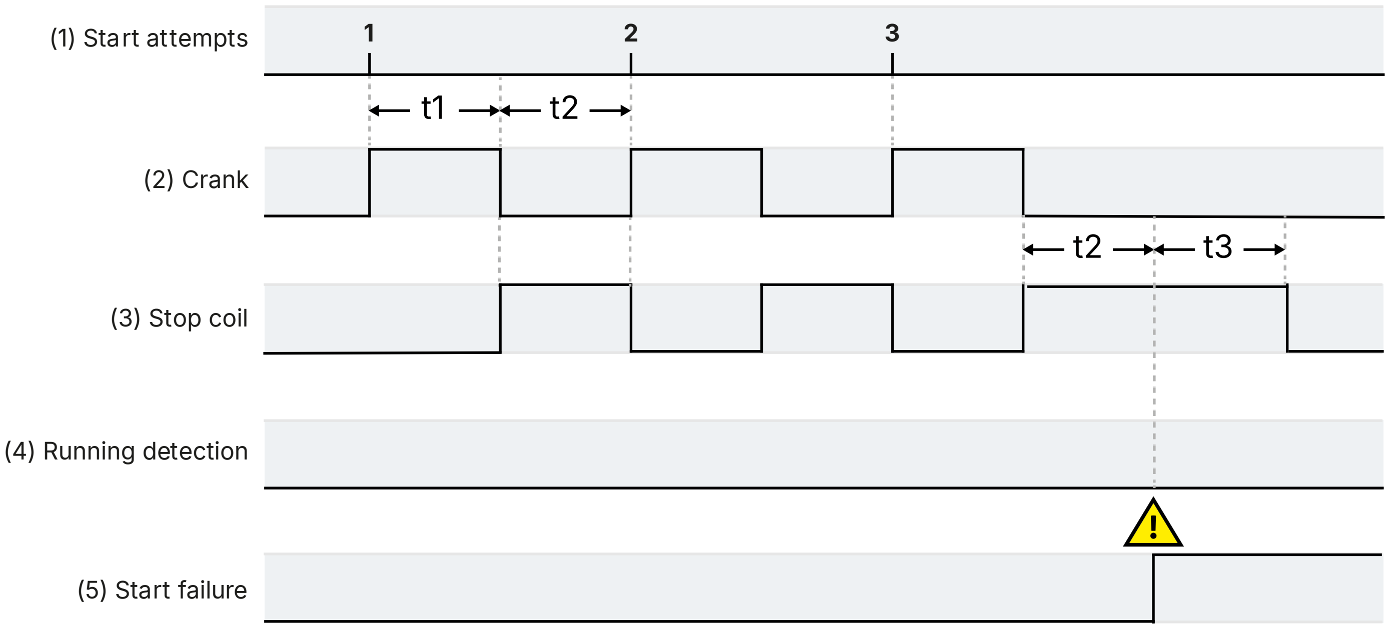
Successful engine start sequence for a stop coil system



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)

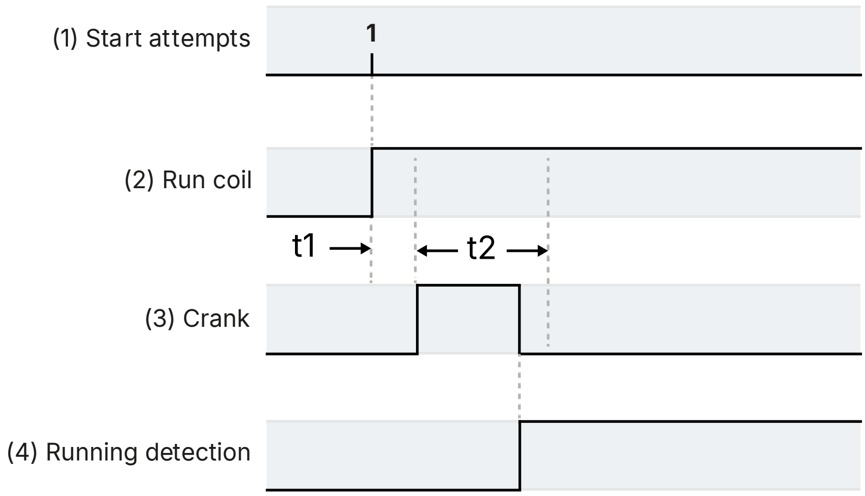
Failure of engine start sequence for a stop coil system:

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*.

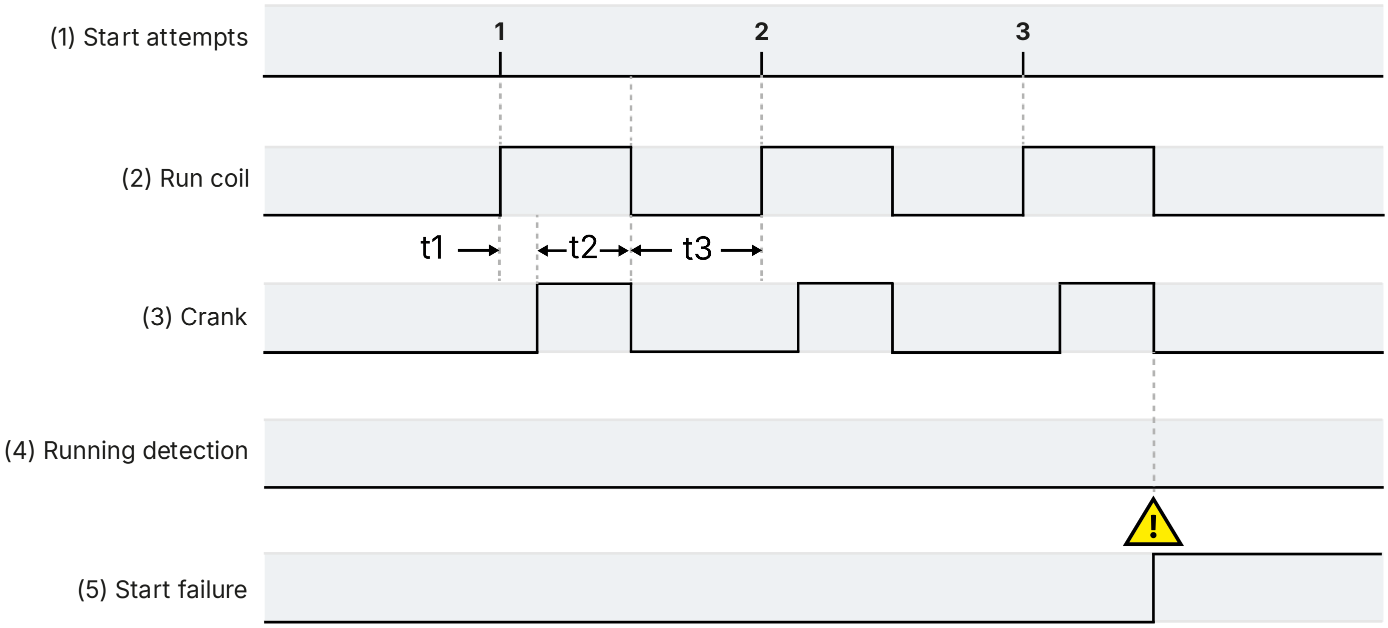
Successful engine start sequence for a run coil system



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`)

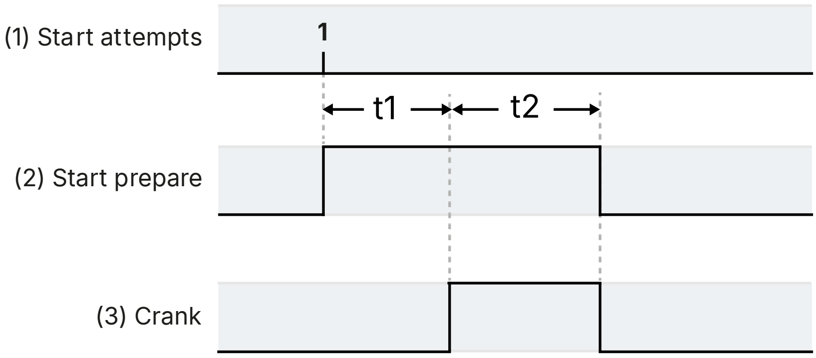
1. **Start attempts**: `Parameters > Engine > Start sequence > Start attempts > Normal` = 3.
2. **Run coil**: `Engine > Controls > Run coil` (digital output). The controller activates the *Run coil* at the time in the *Run coil before crank* parameter. If *Running detection* is still OFF after cranking, 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. 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. 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. The external condition is configured with the digital input Engine > Idle run > End idle run stop, or with CustomLogic or CODESYS.

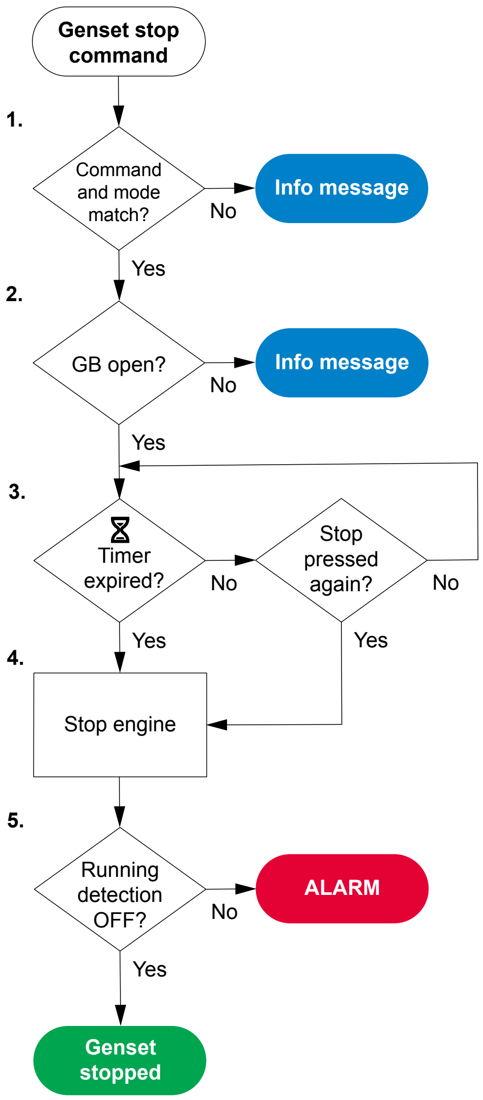
Engine > Idle run stop > Maximum

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.

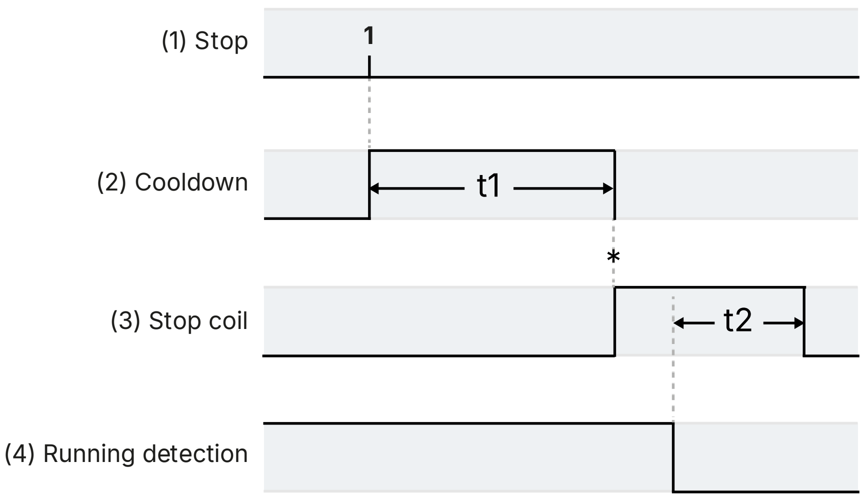
Table 9.2 Engine stop flowchart



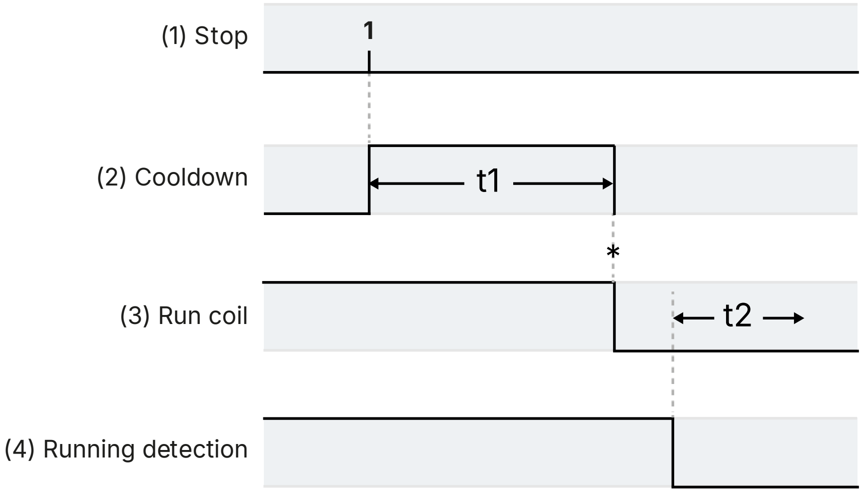
1. **Command and mode match**: The controller checks that the command source and the controller mode match:
   - In REMOTE mode, the command to stop the genset can come from a digital input, PICUS, Modbus, CustomLogic, and/or CODESYS.
   - In LOCAL mode, The operator can press the push-button **Stop** 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.

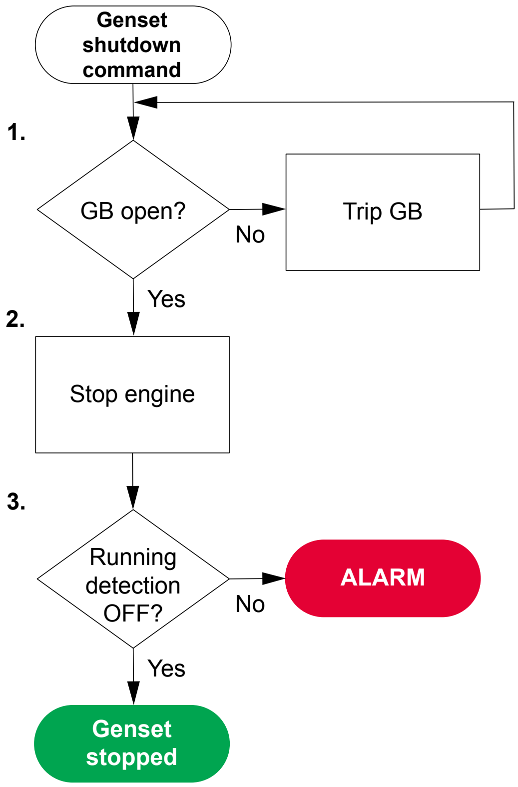
9.5.4 Engine shutdown flowchart

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

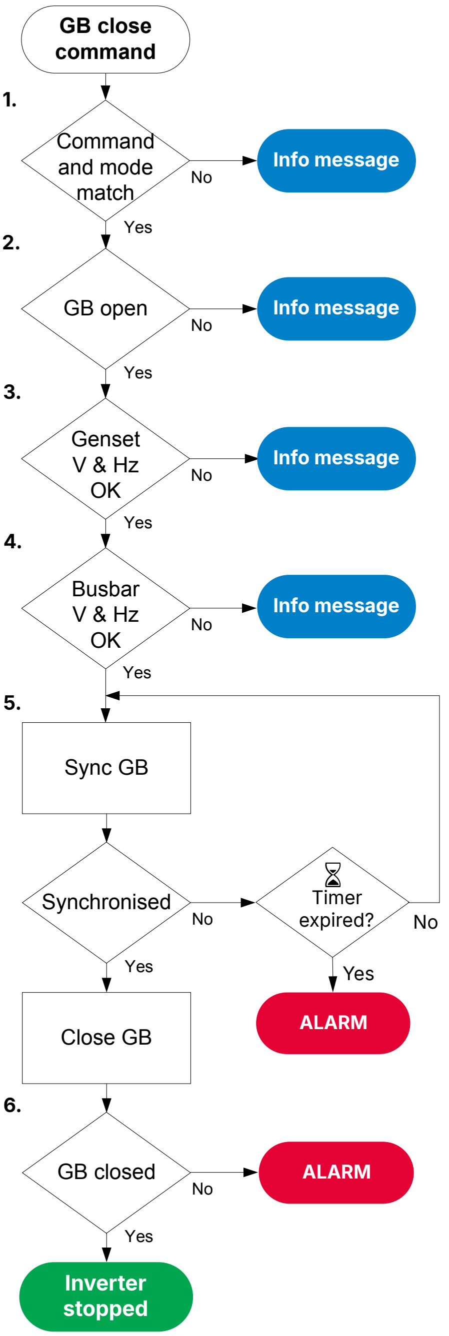
When the generator breaker open button is pressed, the controller checks whether the genset has an active regulation mode. If regulation is off, the controller trips the breaker (without de-loading).

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** 

 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:

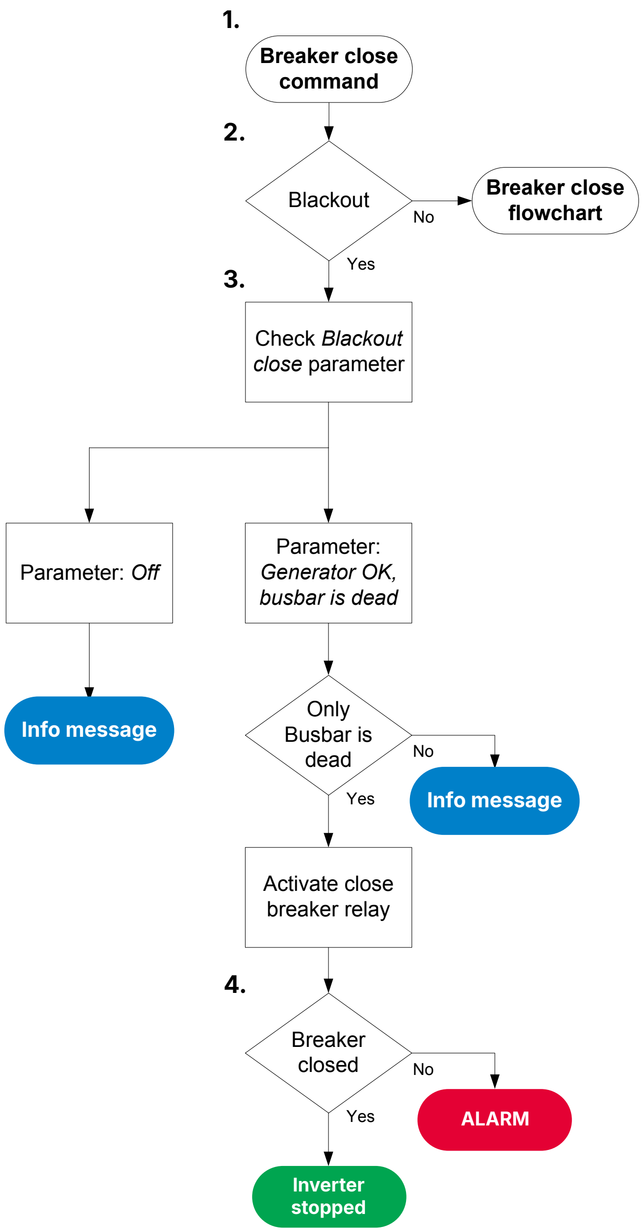
- The breaker position is unknown.
- There is a short circuit.
  - A digital input with the function *Breakers > Generator breaker > Feedback > GB short circuit* was activated.
- There is a blocking alarm.
  - The alarm action determines whether the alarm is a blocking alarm.
- The busbar and/or generator 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 • 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. **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

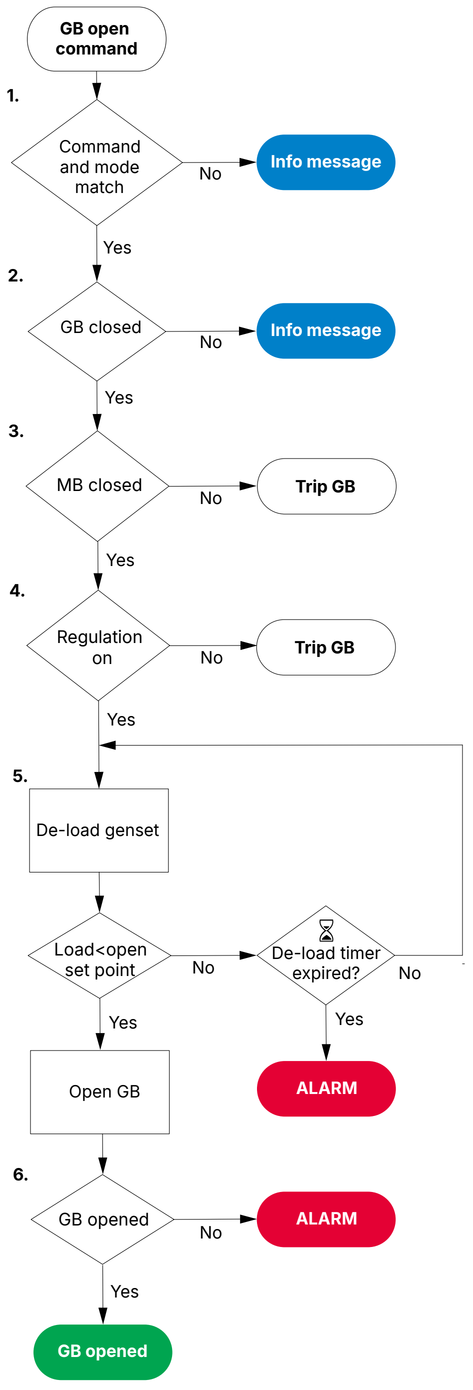
The following flowchart shows the sequence that the controller normally uses to open the generator breaker when the **SINGLE genset** controller controls both a generator breaker and a mains breaker.

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** 

 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.

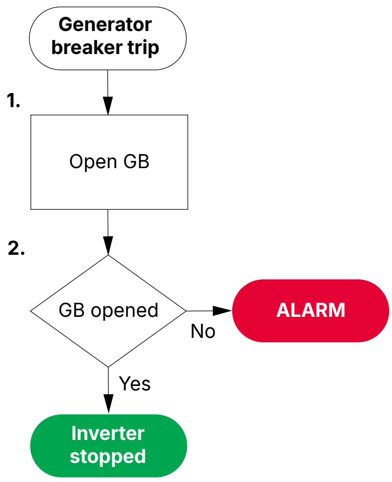
9.6.5 Generator breaker trip flowchart

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.

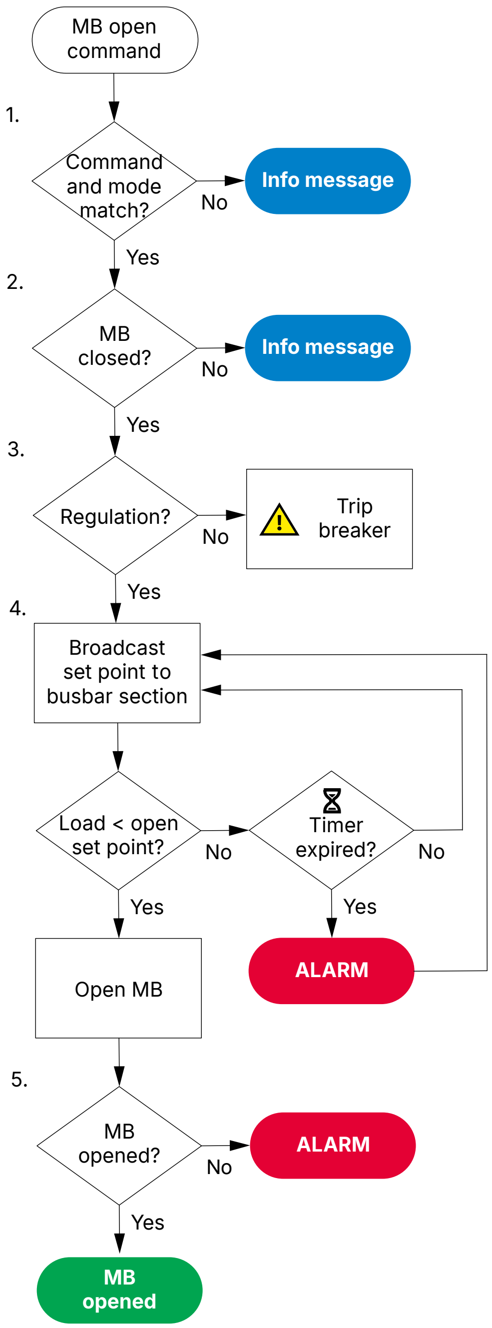
9.7.2 Mains breaker open flowchart

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.

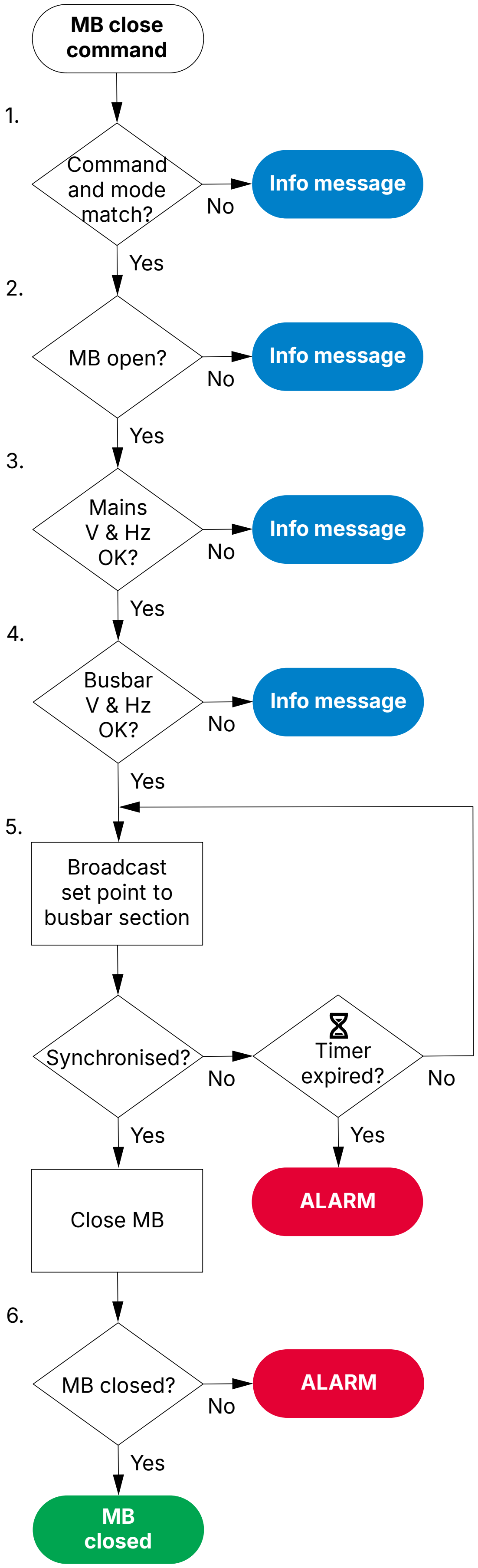
Table 9.6 Mains breaker (MB) open flowchart



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** 

 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**  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

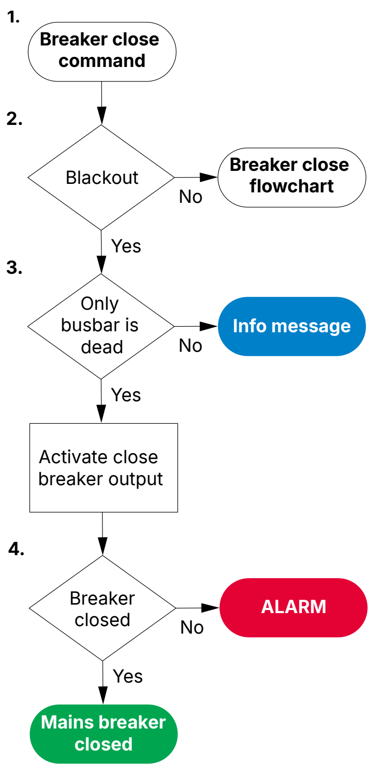
A blackout is present if the phase-to-phase voltage is less than 10 % of the nominal voltage (V_{L-L} < 10 % of V_{nom}). This percentage is fixed.

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 Engine Control Unit (ECU) Emulated droop	**None**: The controller does not use droop. **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. **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. **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. **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. **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 on ACM3.1, 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 • I4 • Analogue input	**None**: No measurement of mains power. The controller does not attempt to de-load the mains breaker. **I4**: The controller uses the 4th current measurement on ACM3.1 to calculate the mains power. **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

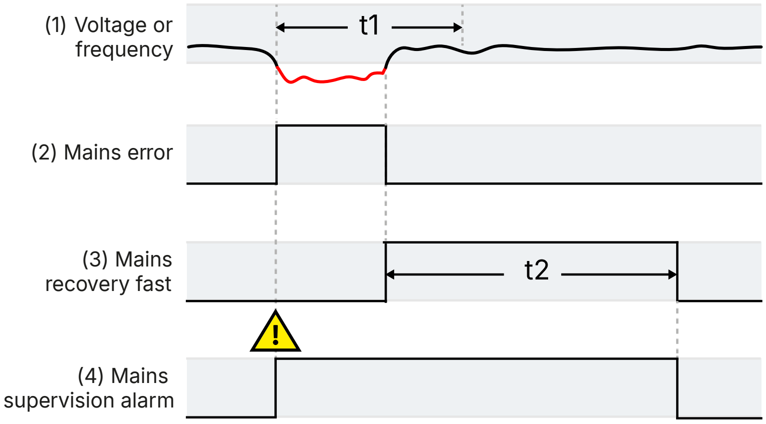
`Mains > AC setup > Supervision selector`

Parameter	Range	Notes
`Enable supervision`	Not enabled, Enabled	**Not enabled**: No mains supervision. **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

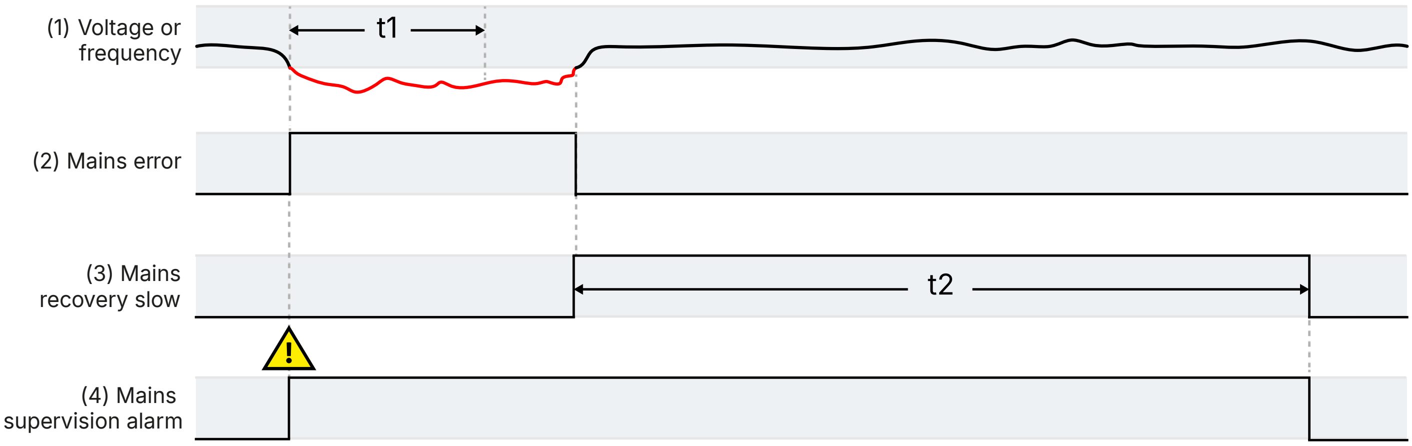


t1 = Recovery selector time (`Mains > AC setup > Supervision selector > Recovery selector time`)

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

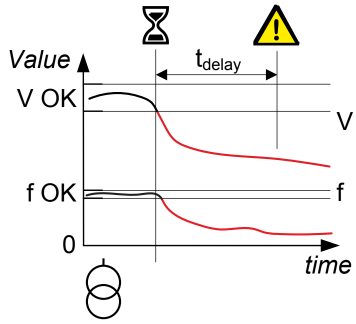


t1 = Recovery selector time (`Mains > AC setup > Supervision selector > Recovery selector time`)

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. **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.

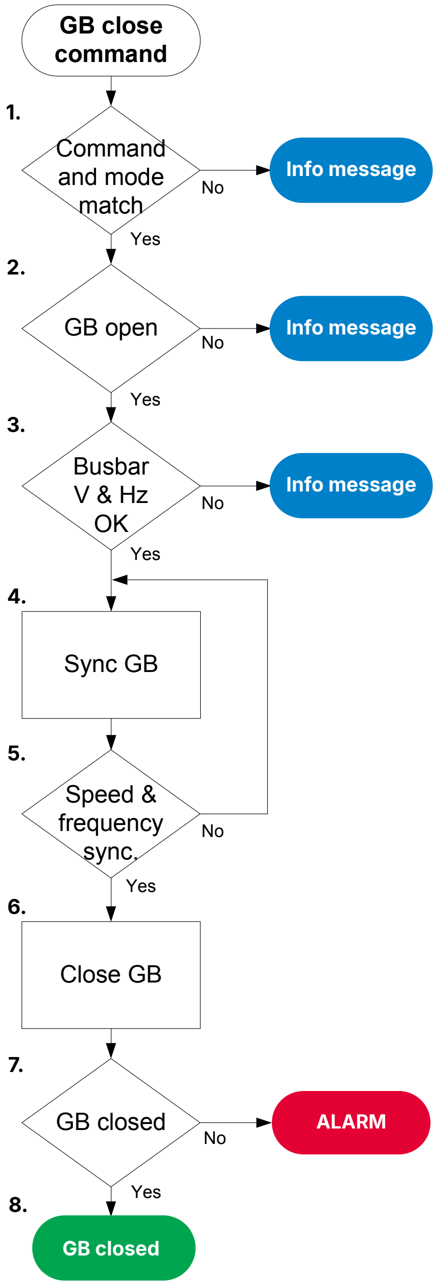
The generator speed that corresponds to the actual busbar frequency is 1500 RPM x 52 Hz / 50 Hz = 1560 RPM. The minimum generator speed for synchronisation is 1560 x (100 - 2) / 100 = 1529 RPM. The maximum generator speed for synchronisation is 1560 x (100 + 5) / 100 = 1638 RPM.

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.

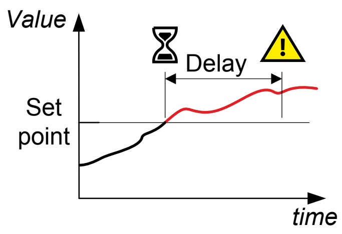
This alarm is only available on **SINGLE genset** and **GENSET** controllers, where the generator type is configured as an asynchronous generator.

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 350 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 stand-alone configuration error *	1
	GOV relay setup incomplete	1
	P load sharing failure	1
	AVR regulation mode not selected	1
	AVR stand-alone configuration error *	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

NOTE * Only in GAM3.2.

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

SINGLE genset alarm	Configure > Parameters >	General name
Vector mismatch	Breakers > Generator breaker monitoring > Vector mismatch	Vector mismatch
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
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

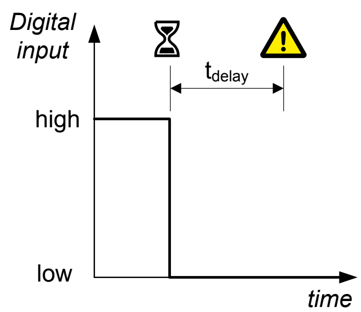
NOTE * Not available in the SINGLE genset controller with no mains breaker.

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.

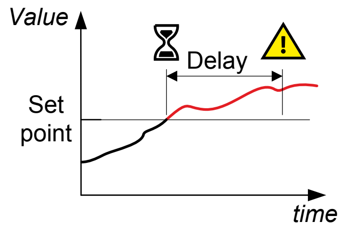
`Engine > Emergency stop > Emergency stop`

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.

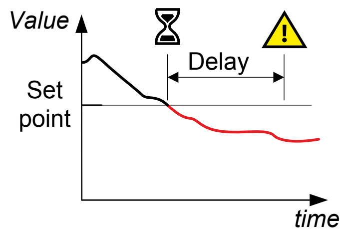
Parameter	Range
`Set point`	10.0 to 150.0 % of nominal speed
`Delay`	0.0 s to 3 min

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 # *

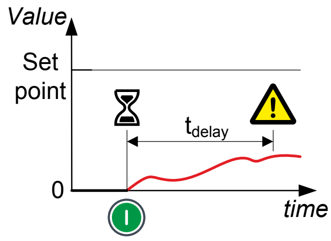
Parameter	Range
Set point (lower than)	0.0 to 100.0 % of nominal speed
Delay	0.0 s to 3 min

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`

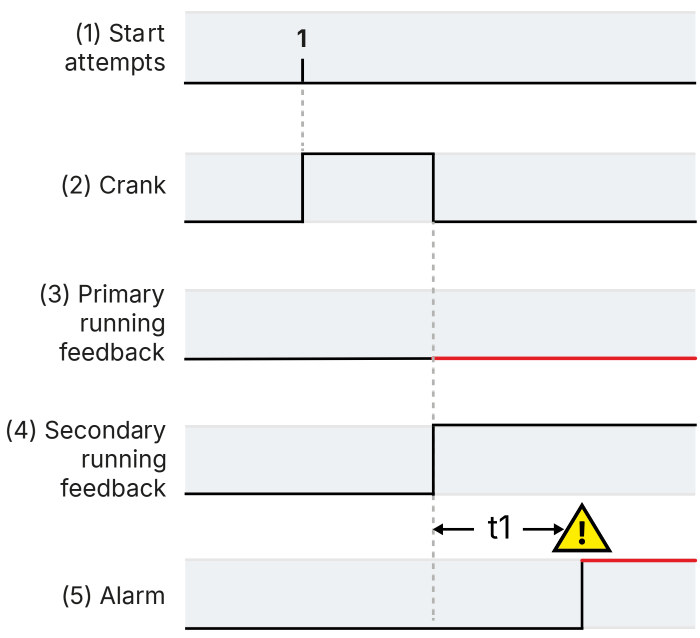
Parameter	Range
`Run detection not reached`	1 s to 20 min

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`

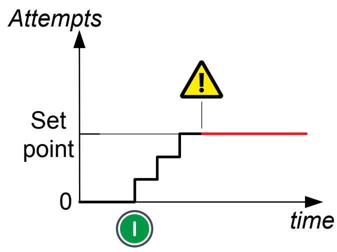
This alarm is always *Enabled*.

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

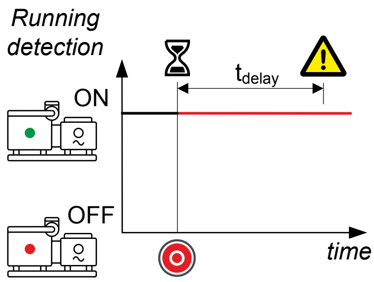
The alarm response is based on the engine start-up sequence. This alarm is activated if the engine start-up procedure is interrupted by the loss of the *Start enable* input before the engine has started.

`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.



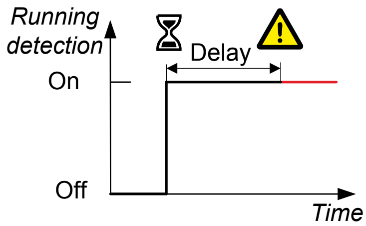
`Engine > Stop sequence > Stop failure`

Parameter	Range
`Delay`	10.0 s to 2 min

9.10.19 Engine started (external)

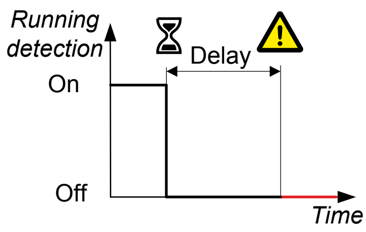
This alarm is to alert the operator to an externally-initiated engine start.

The alarm is activated if the controller did not initiate an engine start, but *Running detection* shows that the engine is running.



Engine > Start sequence > Engine started (external)

9.10.20 Engine stopped (external)



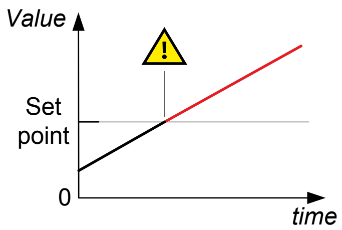
This alarm alerts the operator to an externally-initiated engine stop.

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.

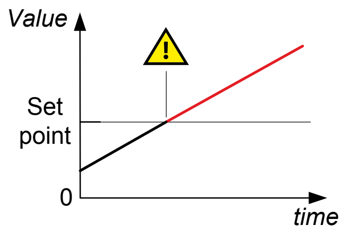
The alarm response is based on the *Total running hours* counter.

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



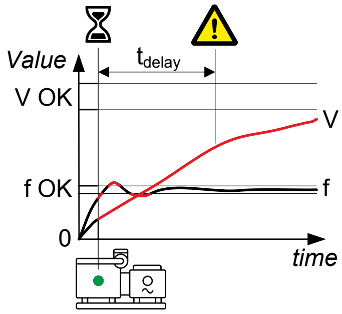
This alarm notifies the operator when the trip running hours exceeds the set point.

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`

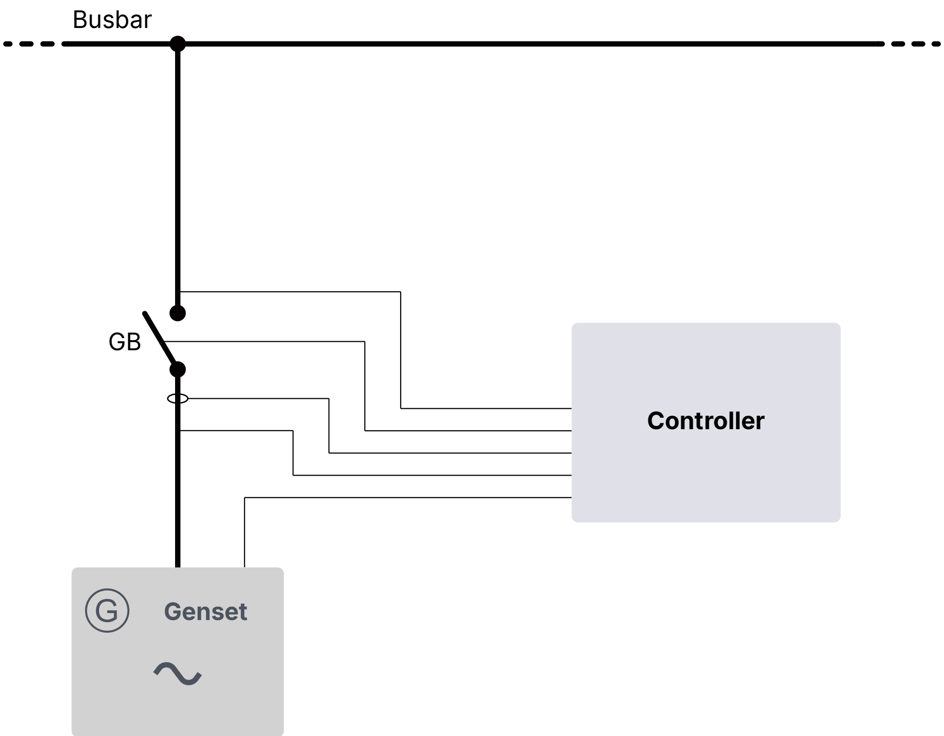
Parameter	Range
`Delay`	1 s to 1 h

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 • Breaker sequences • Generator breaker blackout close
Regulation	• PID regulators for analogue outputs • P regulators for relay outputs • Set point selection using digital input, Modbus, CustomLogic, or CODESYS • Governor ◦ Active power load sharing ◦ Fixed frequency ◦ Fixed active power ◦ Frequency droop ◦ Fixed RPM ◦ External set point: Frequency offset, or Power set point ◦ Manual ◦ Off • AVR ◦ Reactive power load sharing ◦ Fixed voltage

	Functions
	◦ Fixed reactive power ◦ Fixed cos phi ◦ Voltage droop ◦ External set point: Frequency offset, or Power set point ◦ Manual ◦ Off • Configurable power ramp up/down • Three sets of temperature-dependent power derate settings
4th current	• Measurement for earth or neutral protections
Control modes	• Local mode ◦ Generator start/stop with the start/stop push-buttons ◦ The breaker is controlled by the close/open push-buttons • Remote mode ◦ Generator and breaker controlled from a PLC (or integrated CODESYS) combined with parameter settings
Other functions	• Asynchronous generator (optional) • 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 Q nominal = P nominal Q nominal = S nominal
P or S nominal	No calculation P nominal calculated 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 User defined	**Use generator nominal voltage:** • The phase-to-phase nominal voltage for the busbar is the same as the generator nominal voltage. **User defined:** • 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.

Digital outputs

For a *Stop coil*, if wire break detection is required, use EIM relay 4 ( ) (terminals 9,10).

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. 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. 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. 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 (on the first EIM3.1 in the controller rack) is connected to an MPU mounted on the engine.
W	HSDI	Continuous	Optional. The W input (on the first EIM3.1 in the controller rack) 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. 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 (connected to the first EIM3.1 in the controller rack) is ignored and not used for running detection. **Enabled:** The MPU/W/NPN/PNP measurement (connected to the first EIM3.1 in the controller rack) 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. 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 measured by the analogue input 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. **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.

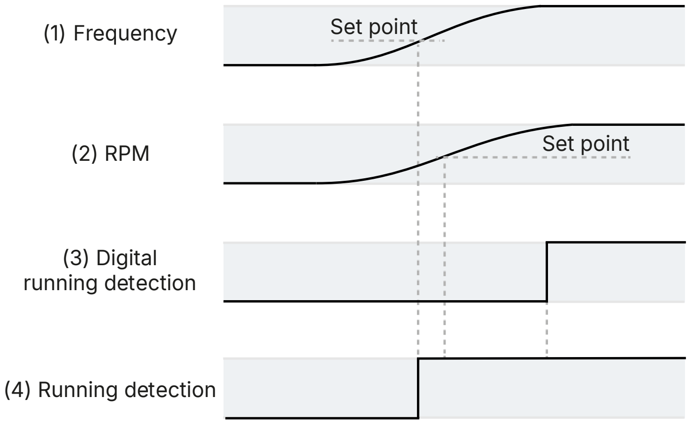
Oil pressure running detection hysteresis

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

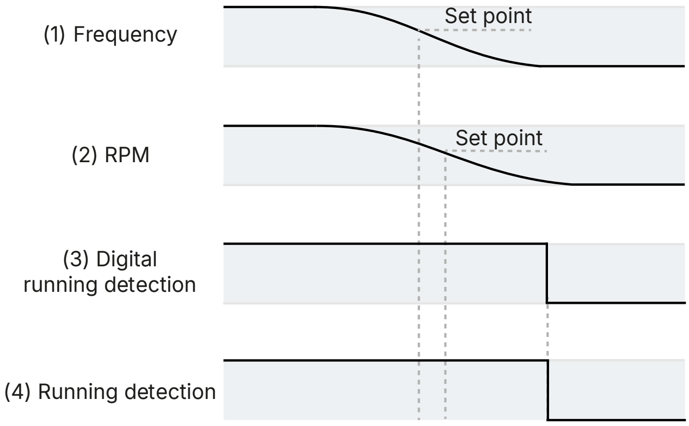


1. **Frequency**: The engine starts and the frequency rises above the set point.
2. **RPM**: (MPU/W/NPN/PNP input). The engine starts and the RPM rises above the set point.
3. **Digital running detection**: *Engine > Feedback > Digital running detection* (digital input). In the example, the response 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

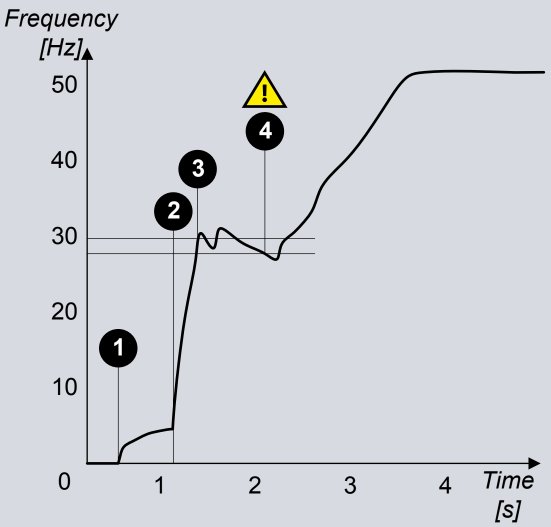
It is possible to only use frequency for running detection. However, using only frequency for running detection increases the risk of not detecting that the genset is running.

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. 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. 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.

Parameter	Range	Comment
		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. 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. 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*. **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. **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`

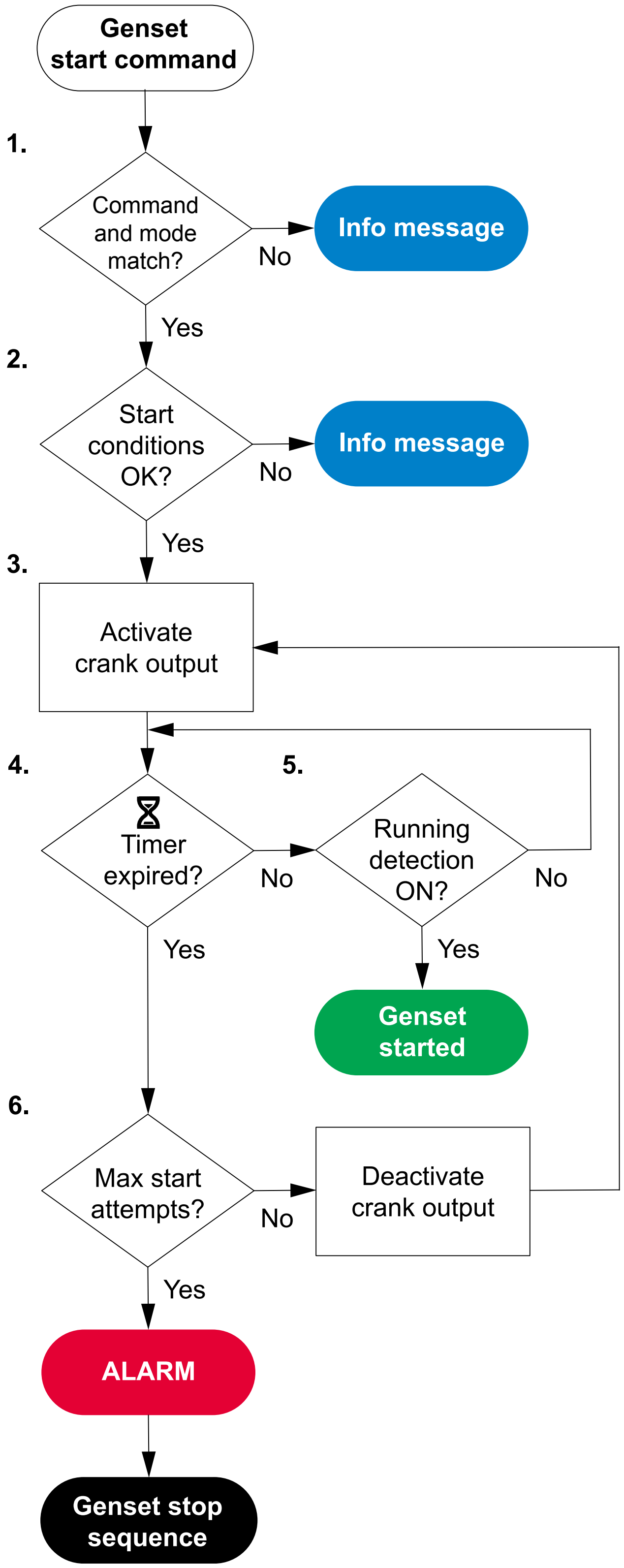
Parameter	Range	Comment
`Use`	Not enabled, Enabled	Uses the external condition to determine if the engine is ready to increase to nominal speed. The external condition is configured with the digital input `Engine > Idle run > End idle run start`, or with CustomLogic or CODESYS.

`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.



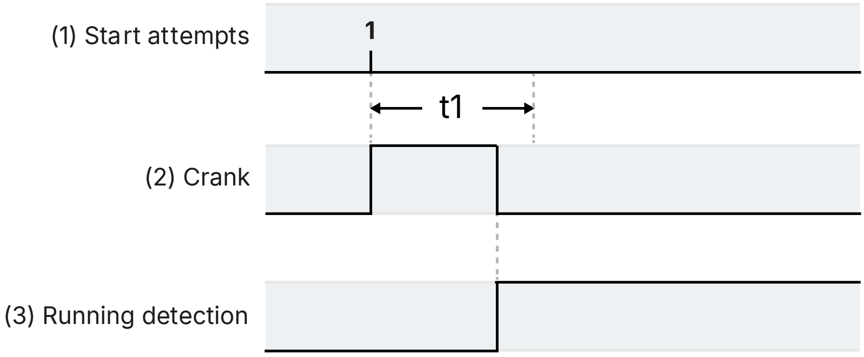
1. **Command and mode match:** The controller checks that the command source and the controller mode match.
2. **Start conditions OK:** The controller checks whether the start conditions are OK:
   - If configured, the *Start enable* digital input is activated.
   - There are no active or unacknowledged 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*.

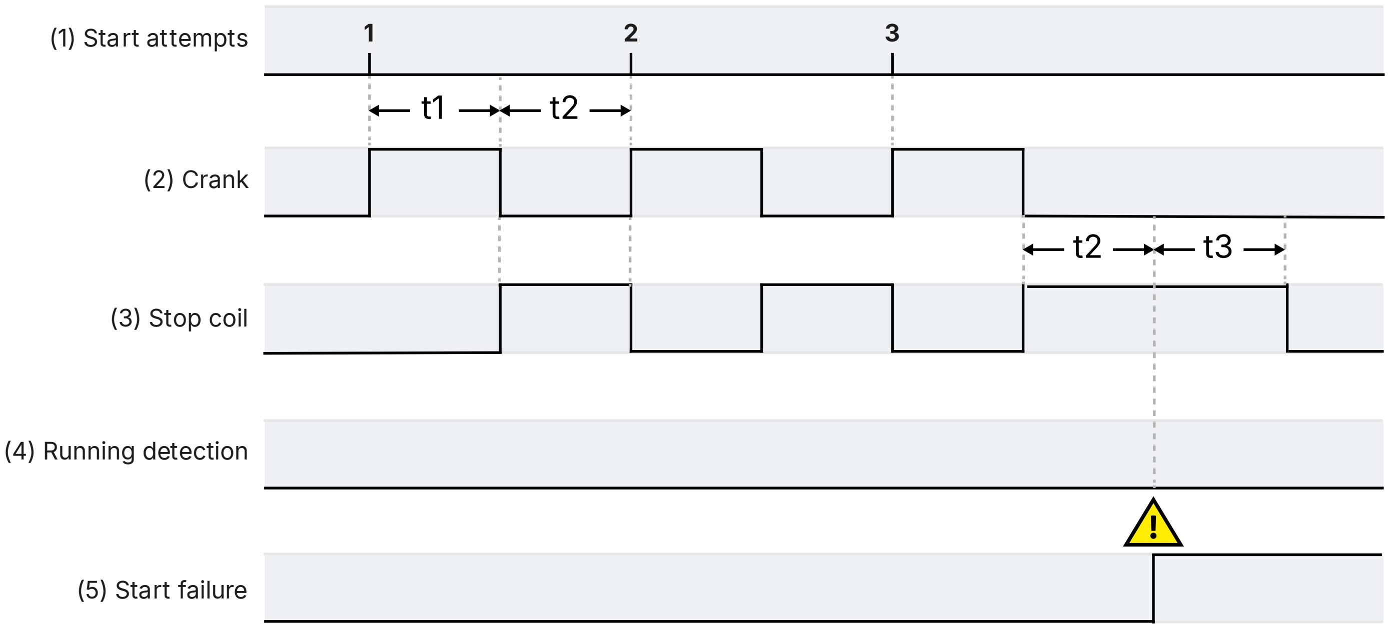
Successful engine start sequence for a stop coil system



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)

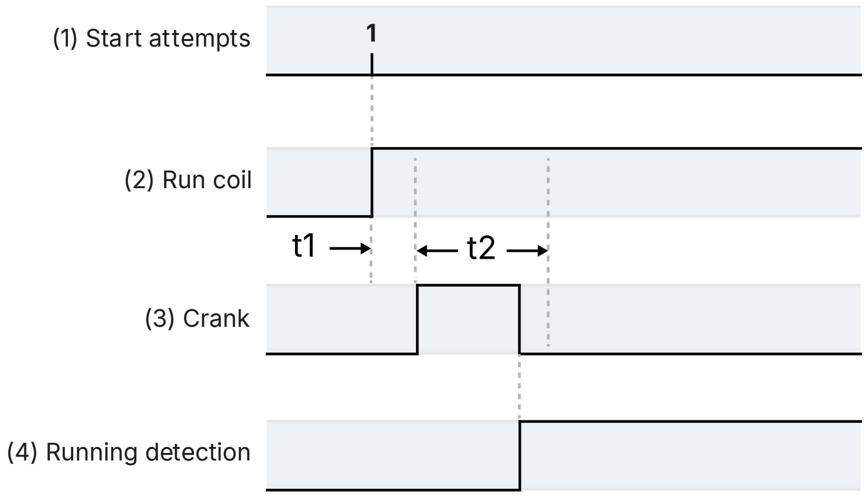
Failure of engine start sequence for a stop coil system:

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*.

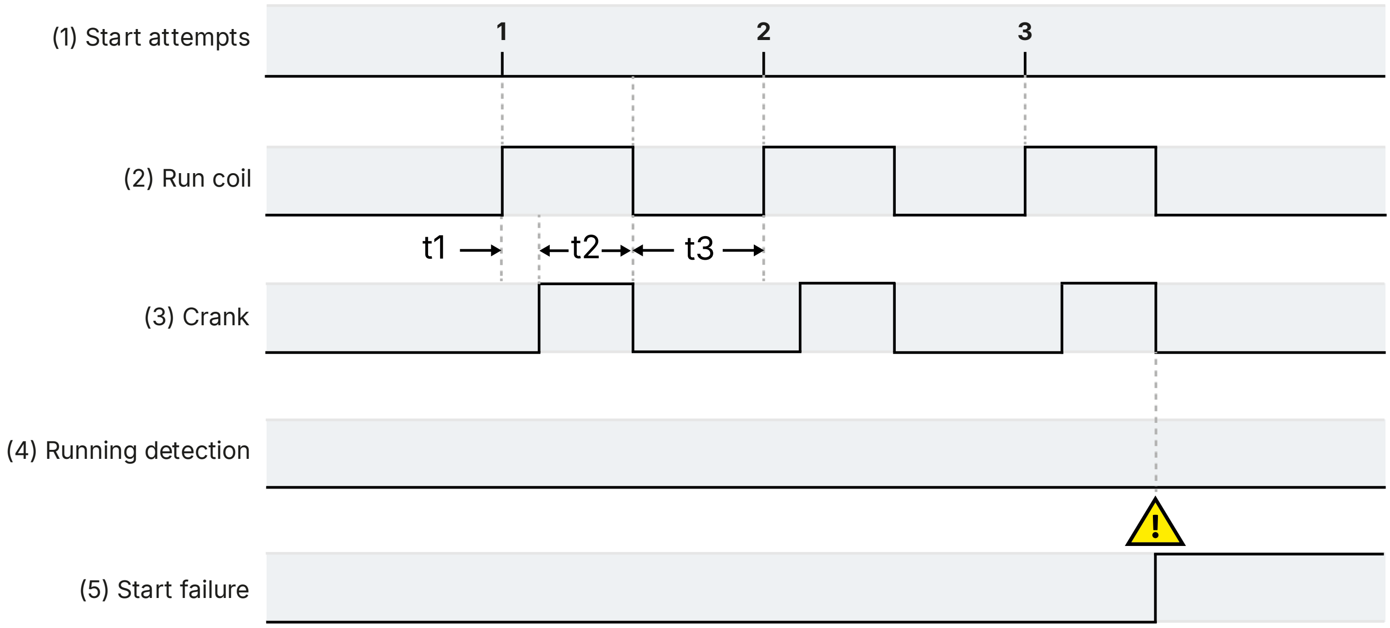
Successful engine start sequence for a run coil system



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`)

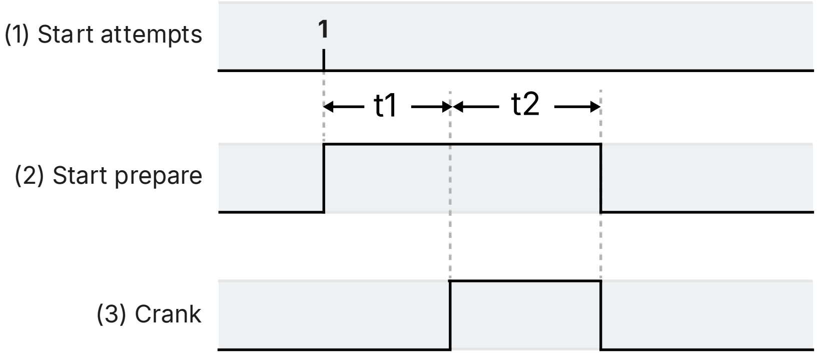
1. **Start attempts**: `Parameters > Engine > Start sequence > Start attempts > Normal` = 3.
2. **Run coil**: `Engine > Controls > Run coil` (digital output). The controller activates the *Run coil* at the time in the *Run coil before crank* parameter. If *Running detection* is still OFF after cranking, 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. 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. 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. The external condition is configured with the digital input Engine > Idle run > End idle run stop, or with CustomLogic or CODESYS.

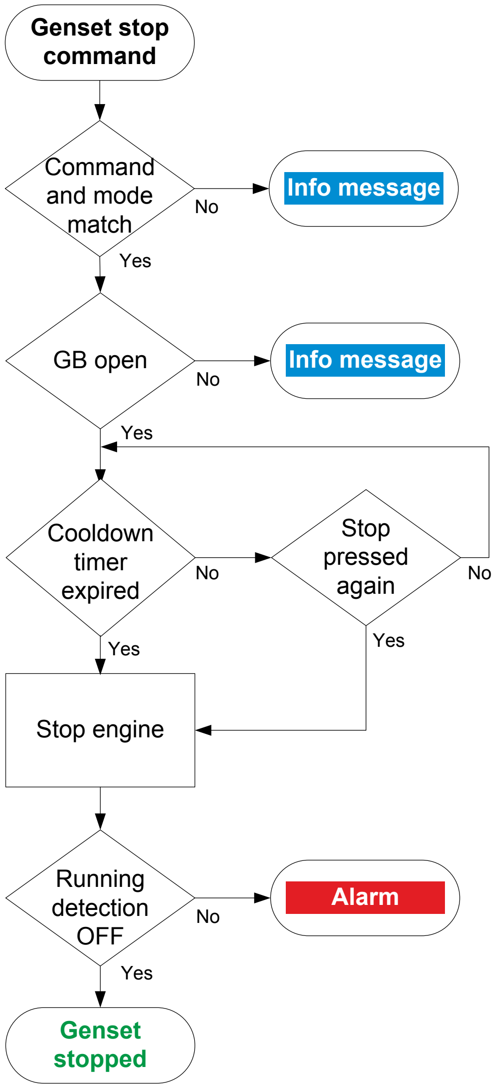
Engine > Idle run stop > Maximum

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.

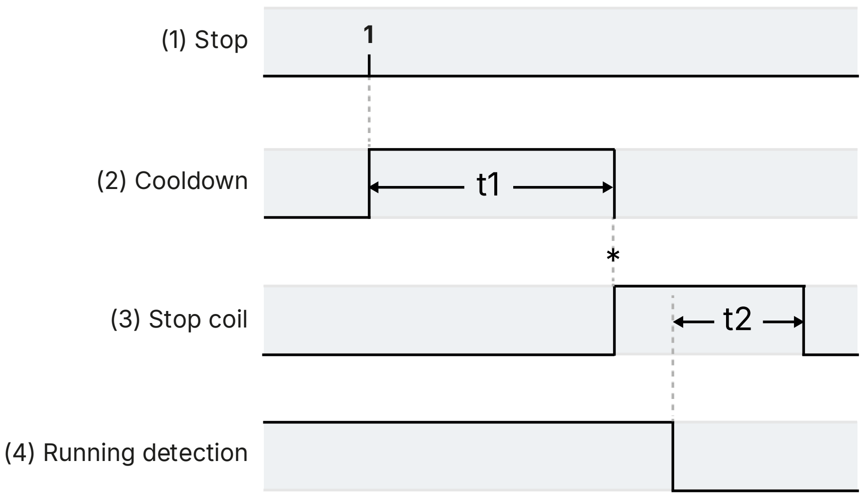
Idle run stop function is not included on this diagram.



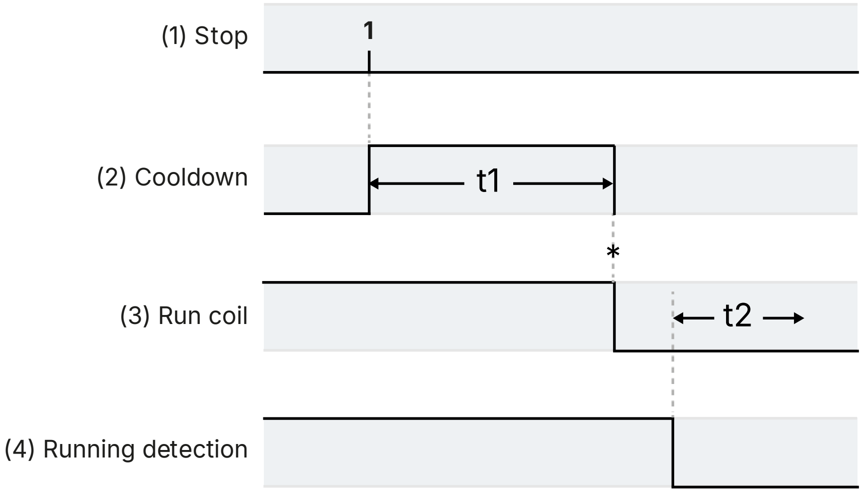
1. **Command and mode match:** The controller checks that the command source and the controller mode match.
2. **GB open:** The controller checks whether the genset breaker is open. If the genset breaker is not open, the controller cancels the stop sequence and the display unit shows an info message.
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.

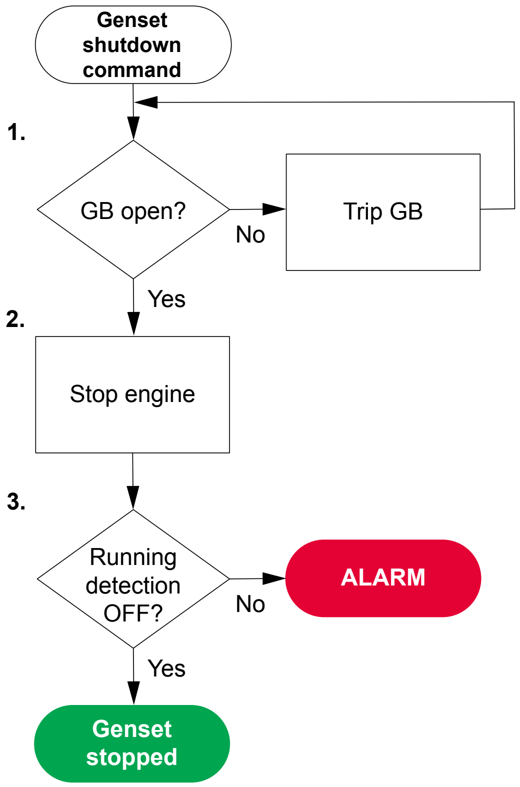
10.4.4 Engine shutdown flowchart

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.

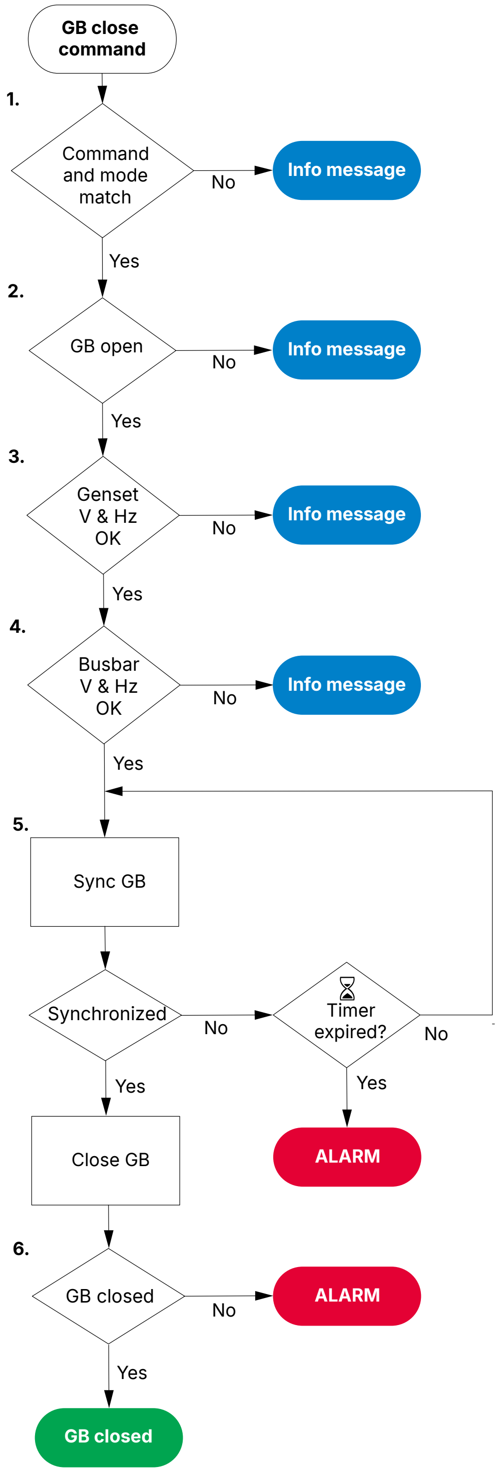
General breaker information

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`

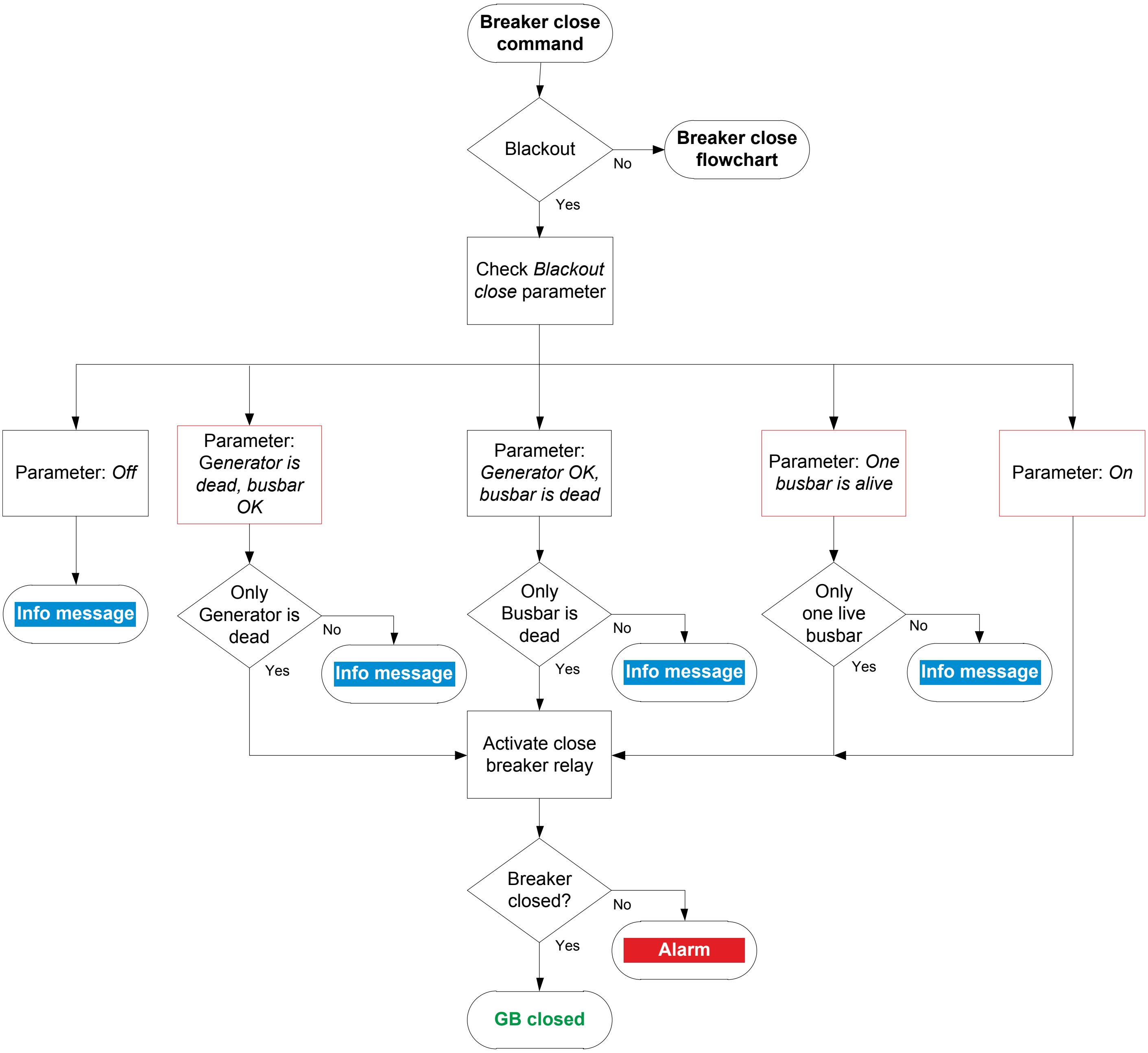
Name	Range	Notes
`Blackout close`	• Blackout close is OFF • Generator is dead, busbar OK • Generator OK, busbar is dead • One busbar is alive • On	**Blackout close is OFF**: The controller will never activate the close breaker relay if any blackout is detected. **Generator is dead, busbar OK** *: If a blackout is detected at the Generator, but the Busbar is stable, then the controller allows the breaker to close. **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. **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. **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.

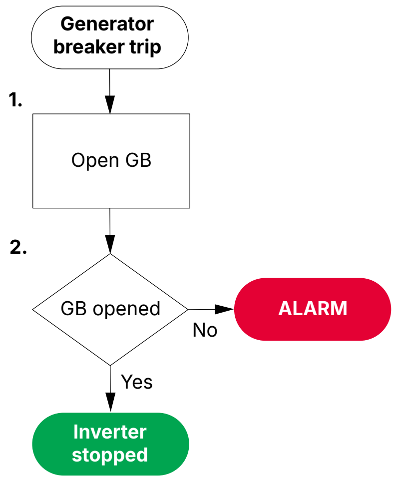
10.5.5 Generator breaker trip flowchart

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 Engine Control Unit (ECU) Emulated droop	**None**: The controller does not use droop. **Engine control unit (ECU)**: The controller sends the specified droop value to the ECU. **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. **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. **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. 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. **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

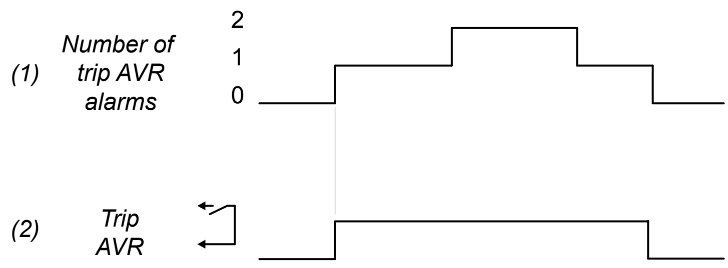
The *Trip AVR* output ensures that excitation is stopped when an alarm activates with a *Trip AVR* alarm action. In cases where there is high voltage present, stopping the excitation reduce the time required to stop an engine in case of an emergency.

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. 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. 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
	EIM3.1 # relay 4 wire break (# is 1 to 3)
	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 stand-alone configuration error *
	GOV relay setup incomplete
	AVR regulation error
	AVR regulation mode not selected
	AVR stand-alone configuration error *
	AVR relay setup incomplete
Other	Trip AVR output not configured

NOTE * Only in GAM3.2.

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: • The generator breaker is closed • Voltage is detected by one set of ACM voltage measurements • 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
GB opening failure	`Breakers > Generator breaker monitoring > Opening failure`	Breaker opening failure

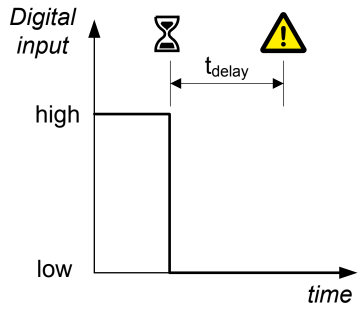
GENSET alarm	Parameters	General name
GB closing failure	Breakers > Generator breaker monitoring > Closing failure	Breaker closing failure
GB position failure	Breakers > Generator breaker monitoring > Position failure	Breaker position failure
GB trip (external)	Breakers > Generator breaker monitoring > Tripped (external)	Breaker trip (external)
GB short circuit	Breakers > Generator breaker monitoring > Short circuit	Breaker short circuit
GB configuration failure	-	Breaker configuration failure
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.

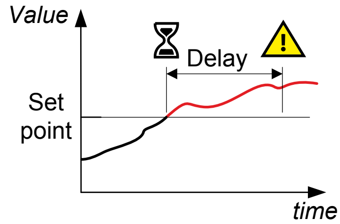
Engine > Emergency stop > Emergency stop

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.

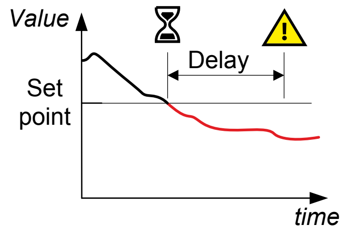
Parameter	Range
`Set point`	10.0 to 150.0 % of nominal speed
`Delay`	0.0 s to 3 min

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 #*`

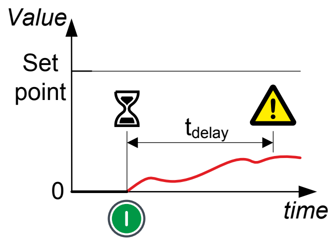
Parameter	Range
`Set point`	0.0 to 100.0 %
`Delay`	0.0 s to 3 min

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

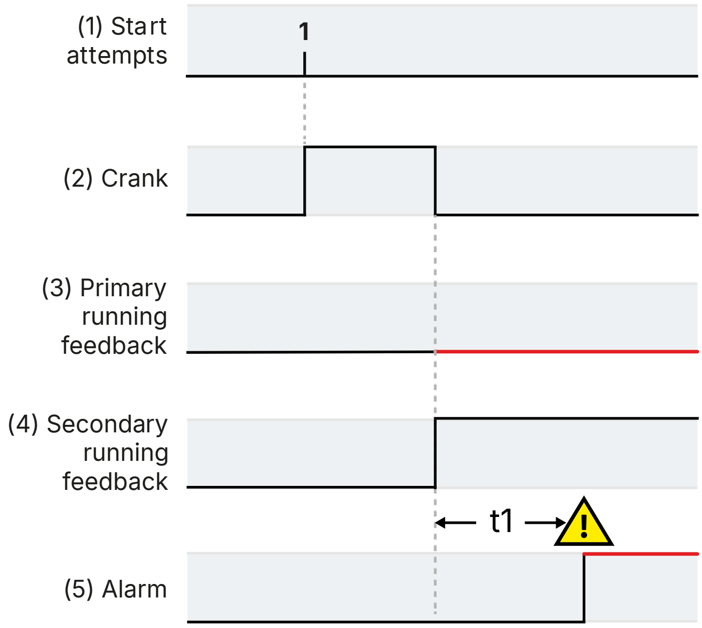
This alarm is activated if the running detection level is not reached.

`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.

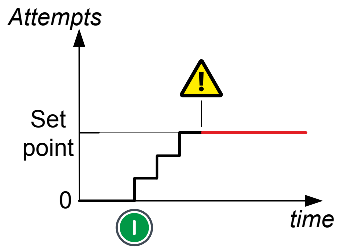
`Engine > Running detection > Magnetic pickup wire break`

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

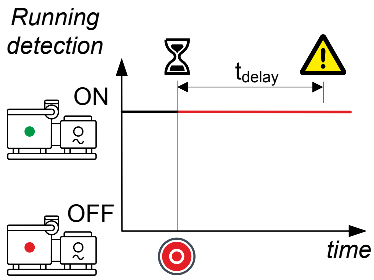
The alarm response is based on the engine start-up sequence. This alarm is activated if the engine start-up procedure is interrupted by the loss of the *Start enable* input before the engine has started.

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.



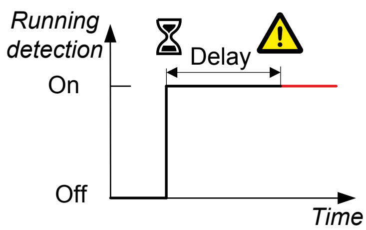
Engine > Stop sequence > Stop failure

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.

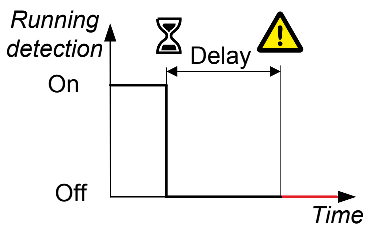


`Engine > Start sequence > Engine started (external)`

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.



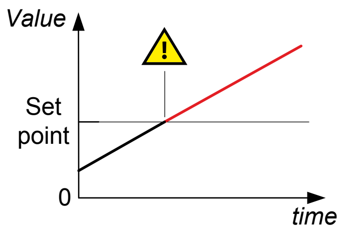
`Engine > Stop sequence > Externally stopped`

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 # *`

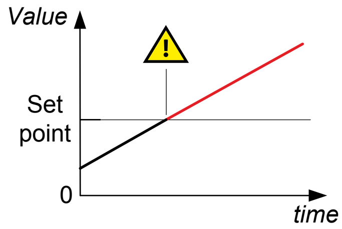
Parameter	Range
`Set point`	0 to 9000 h

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`

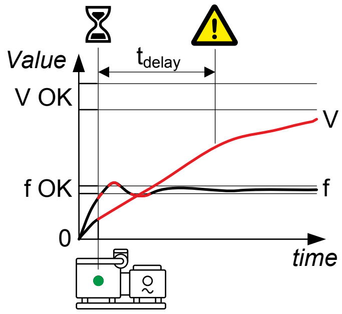
Parameter	Range
`Set point`	0 to 1,000,000 hours

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:

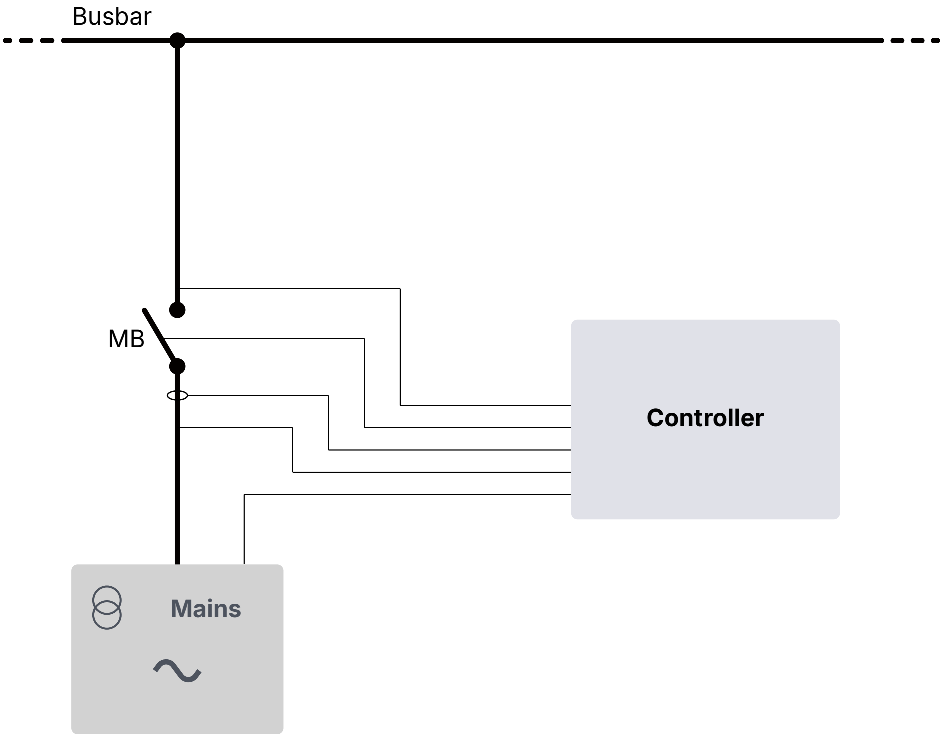
- EIM # relay 4 wire break
- Magnetic pickup wire break
- P load sharing failure
- Q load sharing failure

11. MAINS controller

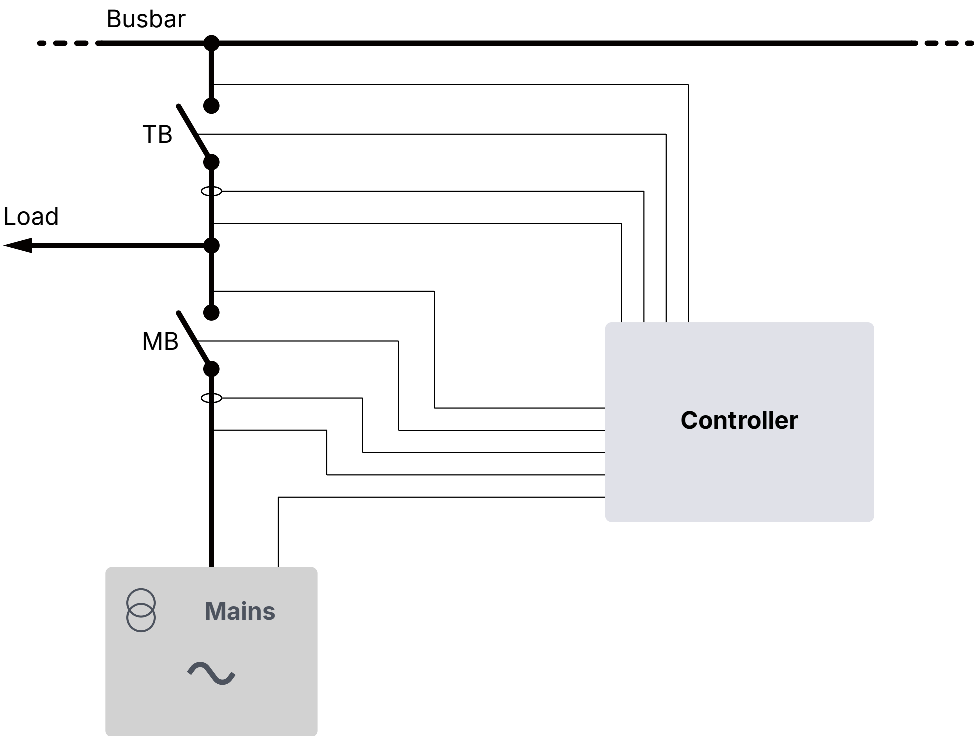
11.1 About the MAINS controller

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 ∘ Breaker operations and trips ∘ External breaker operations ∘ Energy export to mains (active and reactive) ∘ Energy import from mains (active and reactive) ∘ Energy differential (active and reactive) • Energy counters with configurable digital outputs (for external counters) ∘ Energy export to mains (active and reactive) ∘ Energy import from mains (active and reactive) ∘ 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 • Dynamic • Automatic	**Static**: See details below. **Dynamic**: See details below. **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*.

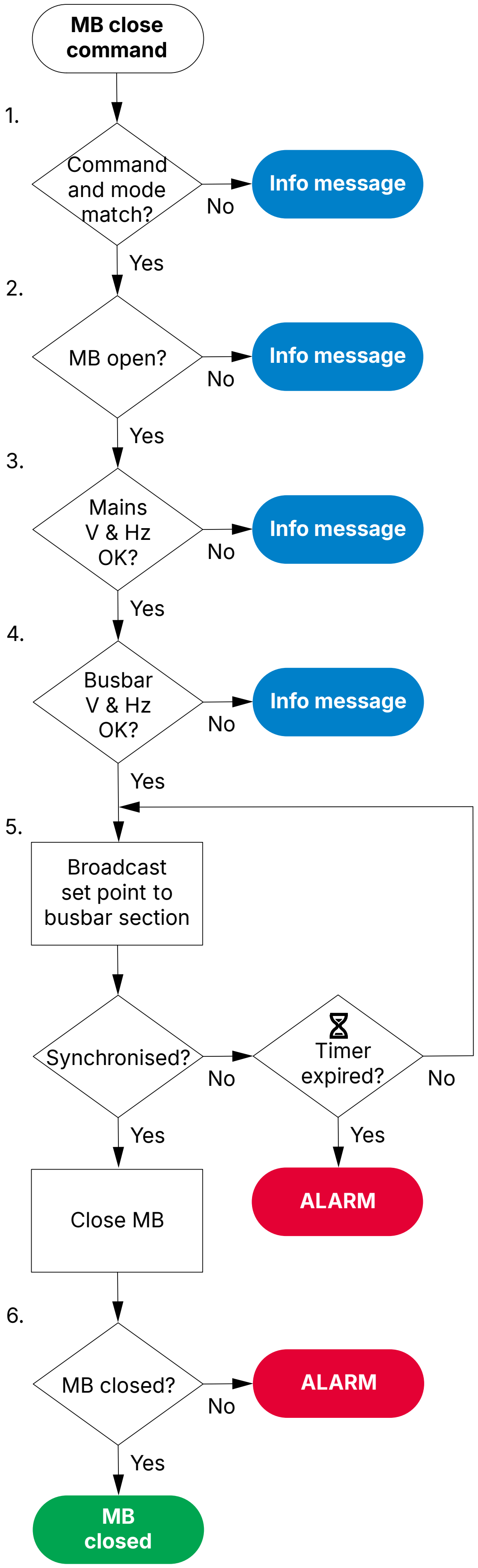
Automatic

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.

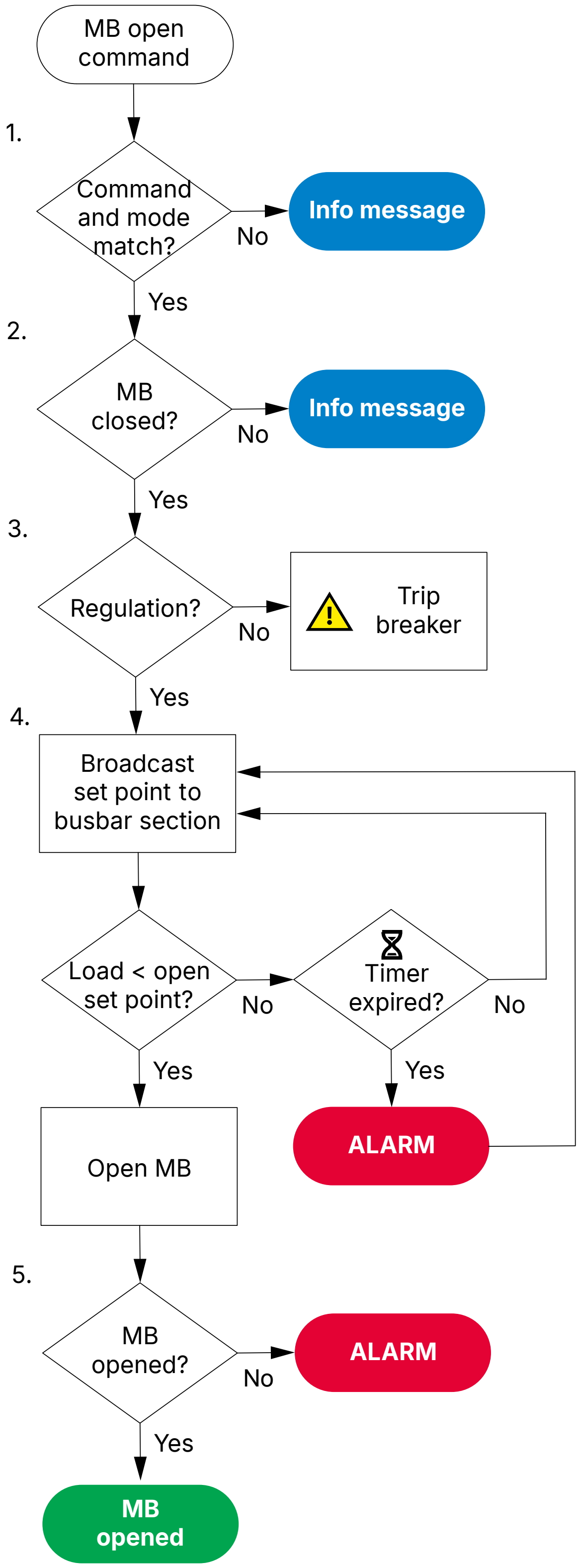
The **MAINS** controller broadcasts the de-loading set points for the **GENSET** controllers in the busbar section connected to the mains breaker. The **GENSET** controller(s) with active regulation modes automatically respond to de-loading set points from the **MAINS** controller. When the mains breaker 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:

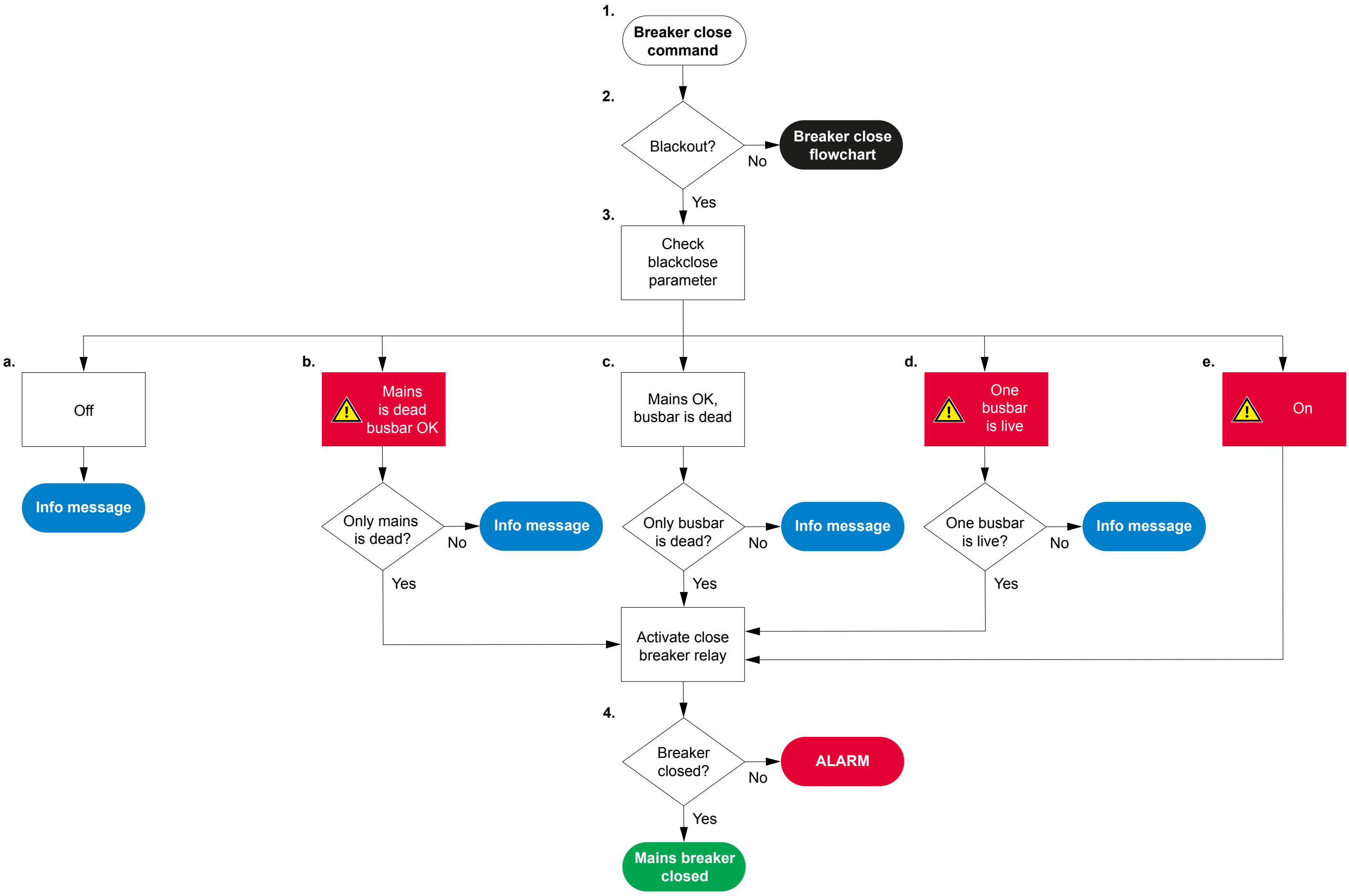
- The breaker position is unknown.
- There is a short circuit.
  - A digital input with the function `Breakers > Mains breaker > Feedback > MB short circuit` was activated.
- There is a blocking alarm.
  - The alarm action determines whether the alarm is a blocking alarm.
- The busbar AC measurements 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 • Mains is dead, busbar OK • Mains OK, busbar is dead • One busbar is alive • On	**Blackout close is OFF**: The breaker is not allowed to close unless both mains and busbar are live and synchronised. **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. **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. **One busbar is live**: If either mains or busbar is alive, then the controller allows the breaker to close. **On**: The breaker is always allowed to close.

Blackout close flowchart



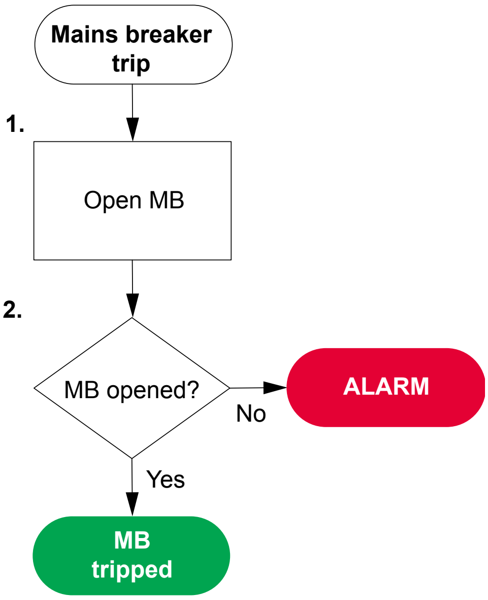
1. **Breaker close command**: An operator or a remote command attempts to close the breaker.
2. **Blackout**: The controller detects a blackout on one or both of the busbars, and the conditions for blackout close are met.
3. **Check *Blackout close* parameter**:
   a. **Blackout close is OFF**: The controller 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 • Dynamic	**Static**: See details below. **Dynamic**: See details below.

Static synchronisation

The **MAINS** controller uses the static synchronisation parameters to determine when there is synchronisation.

Dynamic synchronisation

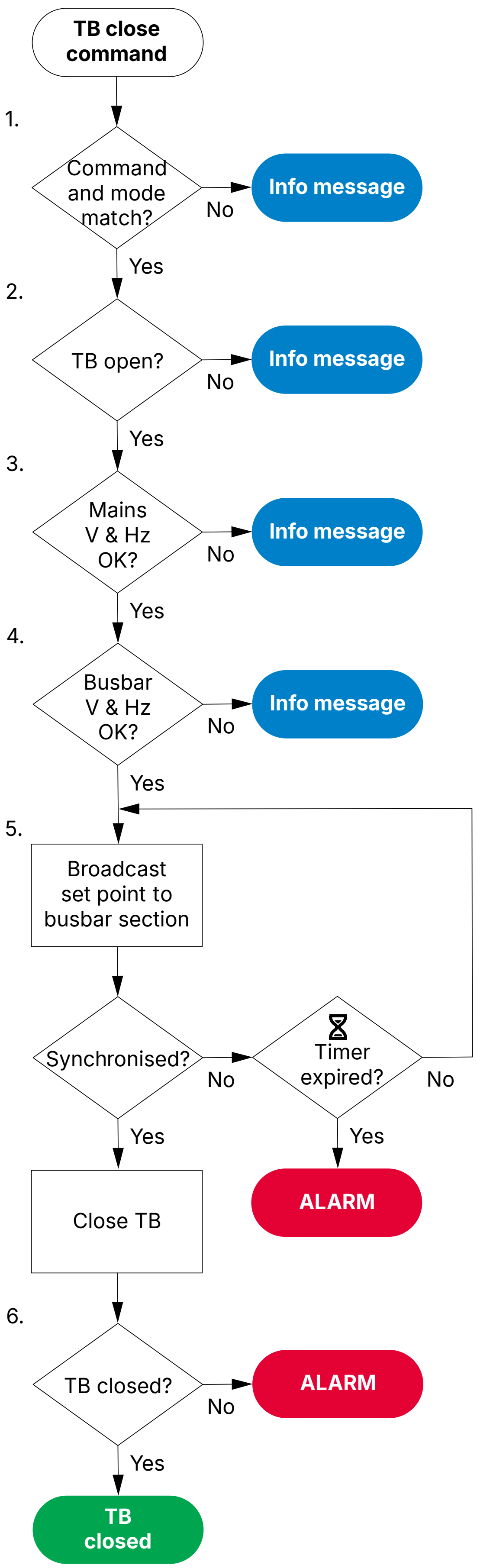
The **MAINS** controller uses the dynamic synchronisation parameters to determine when there is synchronisation.

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** 

 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.

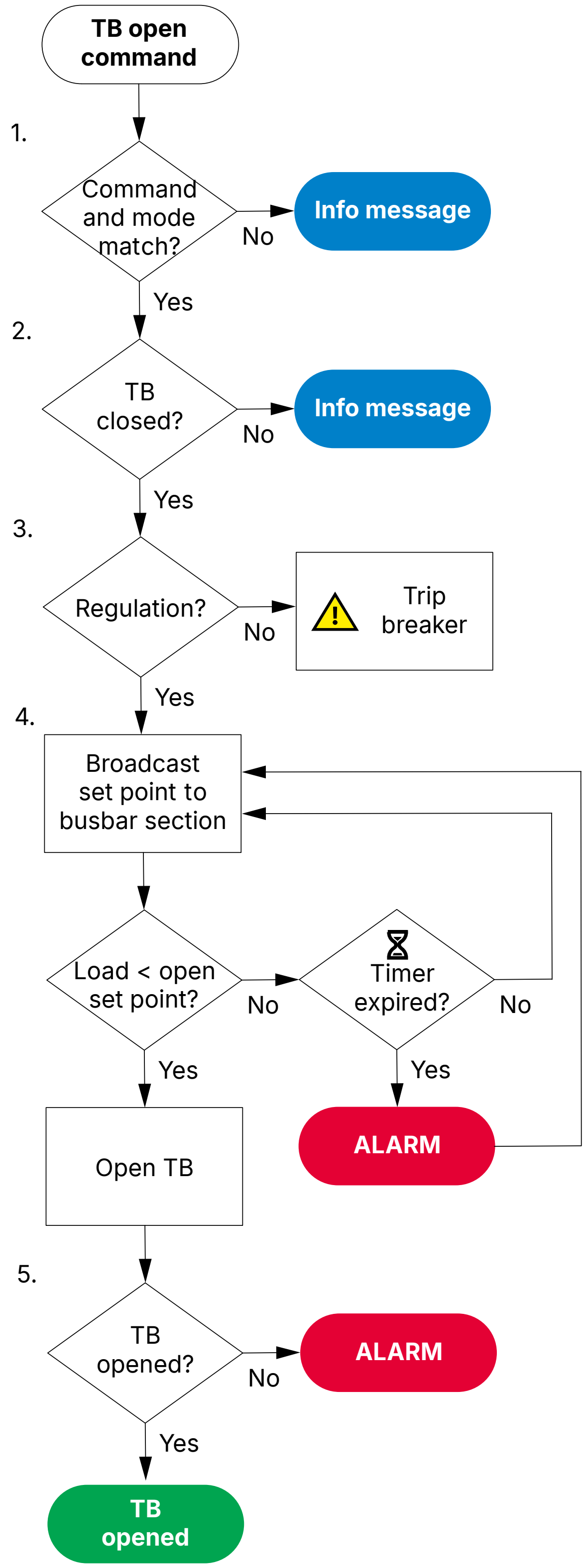
The **MAINS** controller broadcasts de-loading set points for the **GENSET** controllers in the busbar sections connected to the tie breaker. The **GENSET** controller(s) with active regulation modes ignore their regulation modes and automatically respond to de-loading set points from the **MAINS** controller. 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:

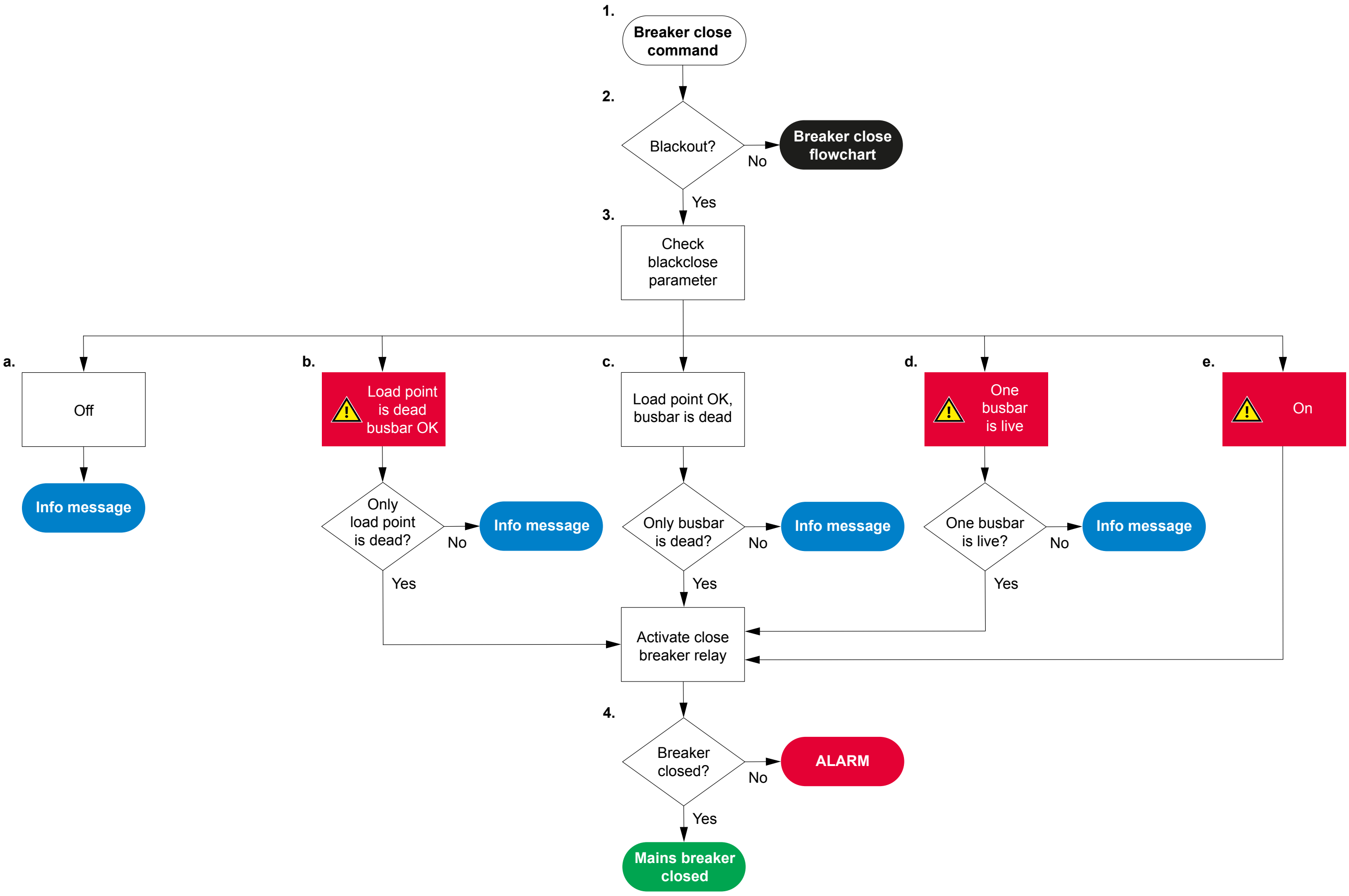
- The breaker position is unknown.
- There is a short circuit.
  - A digital input with the function `Breakers > Tie breaker > Feedback > TB short circuit` was activated.
- There is a blocking alarm.
  - The alarm action determines whether the alarm is a blocking alarm.
- The busbar AC measurements are 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 • Load point is dead, busbar OK • Load point OK, busbar is dead • One busbar is alive • 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. **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. **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. **One busbar is alive**: If either load point or busbar is live, then the controller allows the breaker to close. **On**: The breaker is always allowed to close.

Blackout close flowchart



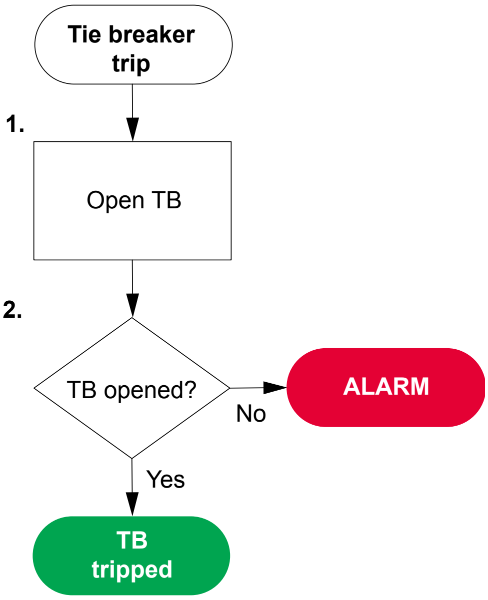
1. **Breaker close command**: An operator or a remote command attempts to close the breaker.
2. **Blackout**: The controller detects a blackout on one or both of the busbars, and the conditions for blackout close are met.
3. **Check *Blackout close* parameter**:
   a. **Blackout close is OFF**: The controller 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

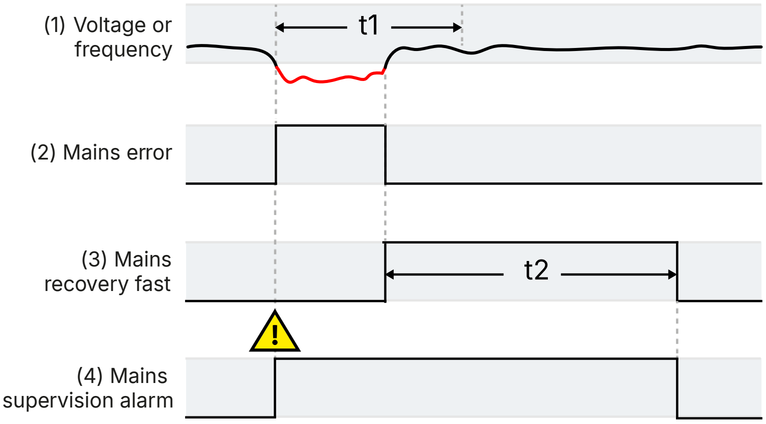
`Mains > AC setup > Supervision selector`

Parameter	Range	Notes
`Enable supervision`	Not enabled, Enabled	**Not enabled**: No mains supervision. **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

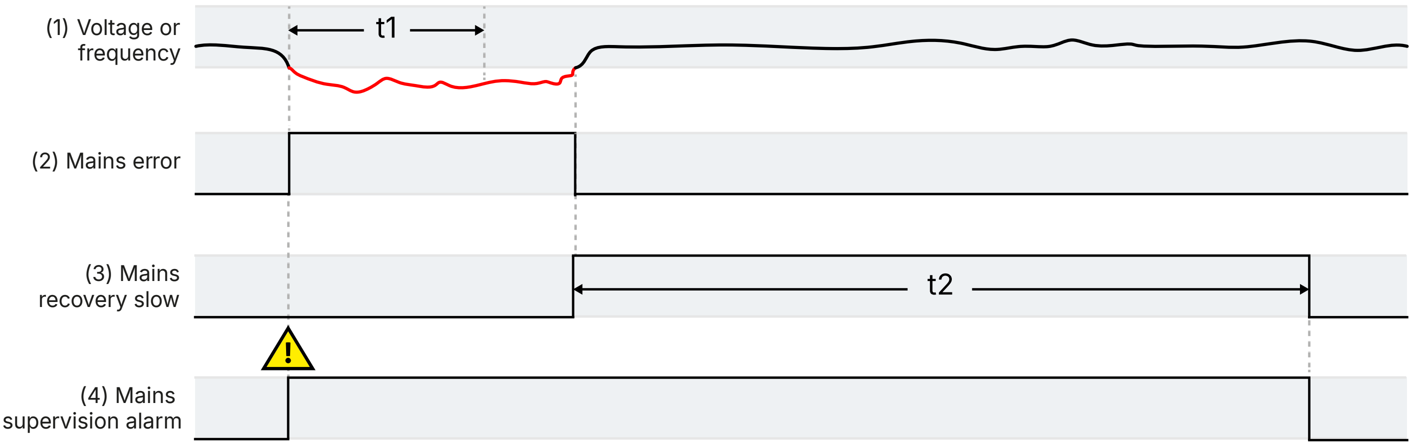


t1 = Recovery selector time (`Mains > AC setup > Supervision selector > Recovery selector time`)

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`)

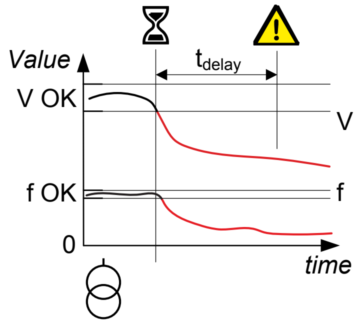
t2 = Recovery time slow (`Mains > AC setup > Supervision selector > Recovery time slow`)

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.
ACM wire break	All these conditions are met: • The mains breaker is closed • Voltage is detected by one set of ACM voltage measurements • 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	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

MAINS alarm	Parameters	General name
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.

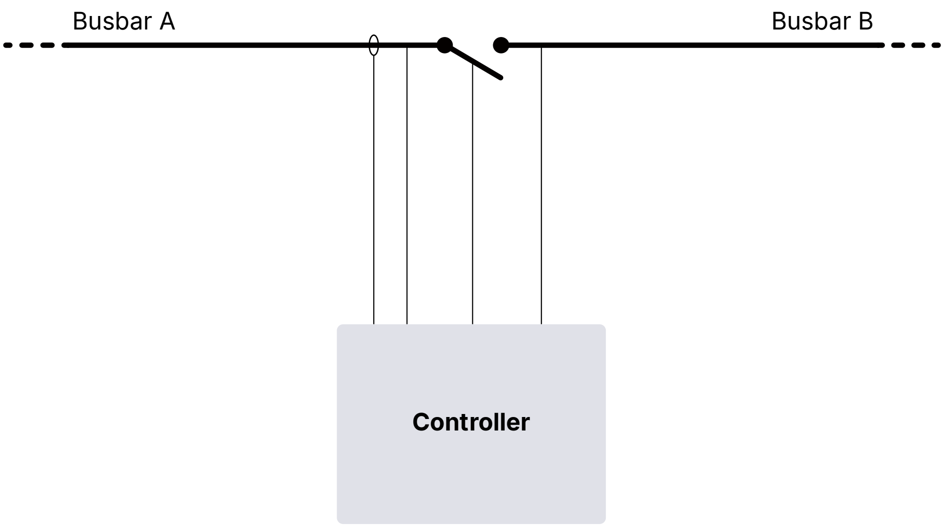
12. BUS TIE breaker controller

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) • Busbar section management • Ring busbar connection

Counters	• Display unit counters, to edit or reset
	  ◦ Bus tie breaker operations and trips
	  ◦ Energy export (active and reactive) (to busbar B)
	  ◦ Energy import (active and reactive) (to busbar A)
	  ◦ External breaker operations
	• Energy counters with configurable digital outputs (for external counters)
	  ◦ Energy export (active and reactive) (to busbar B)
	  ◦ 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 Q nominal = P nominal Q nominal = S nominal
`P or S nominal`	No calculation P nominal calculated 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 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. **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. **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 • Dynamic • Automatic	Automatic	**Static**: See details below. **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.

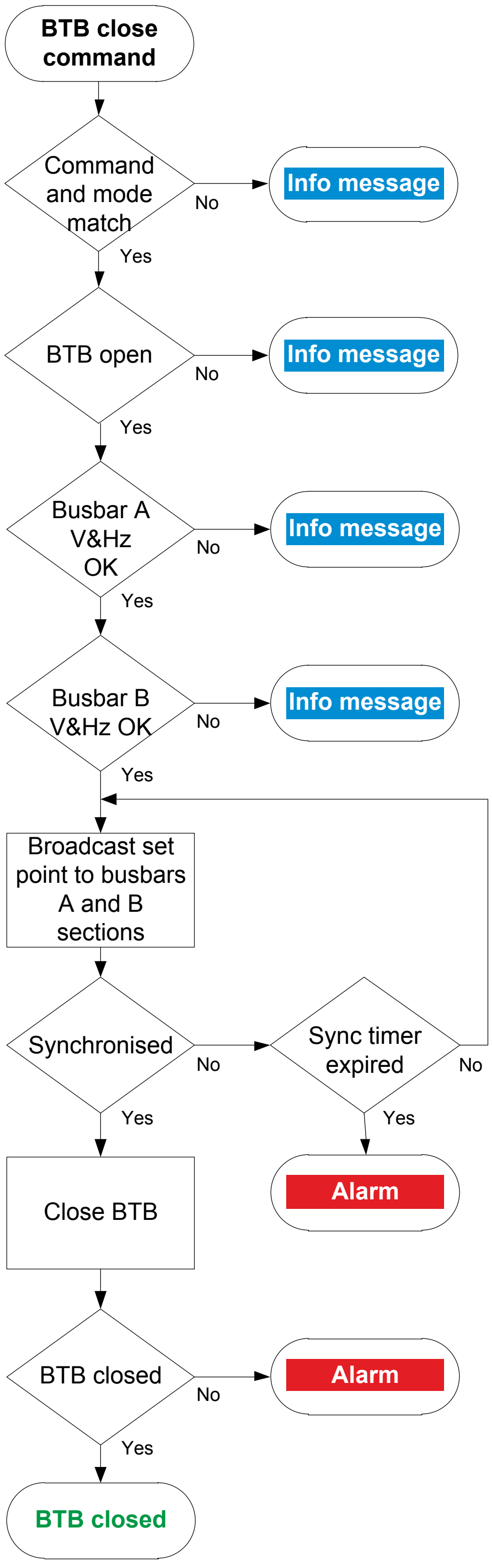
12.3.2 Bus tie breaker close flowchart

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.

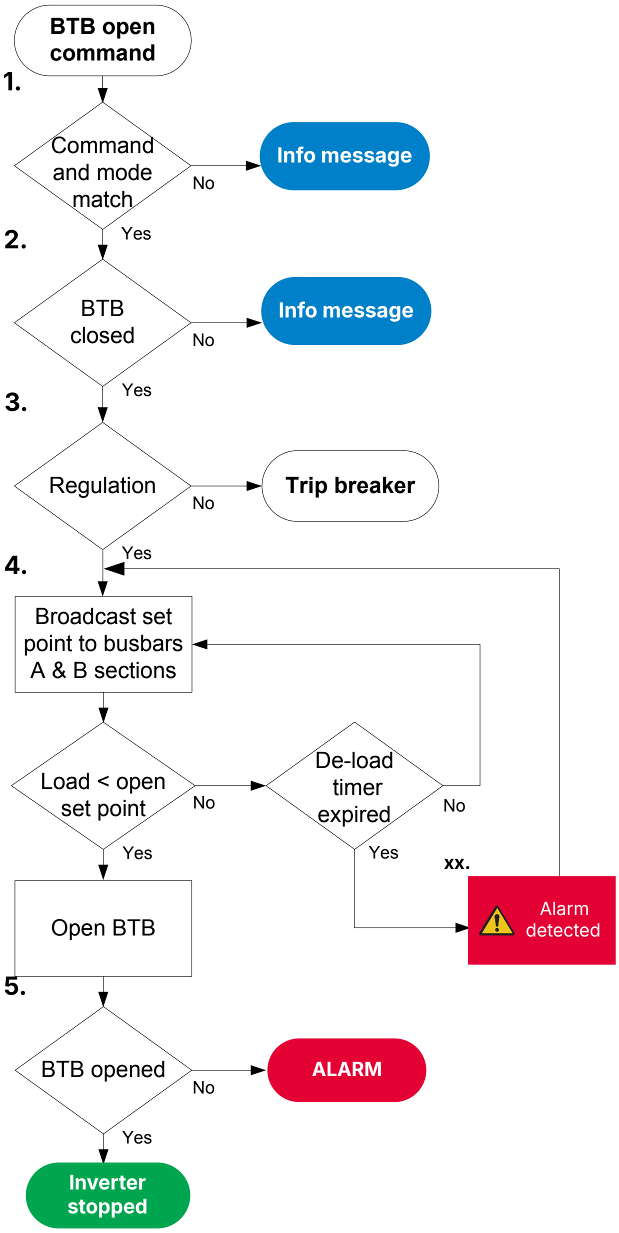
12.3.4 Bus tie breaker open flowchart

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** 

 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:

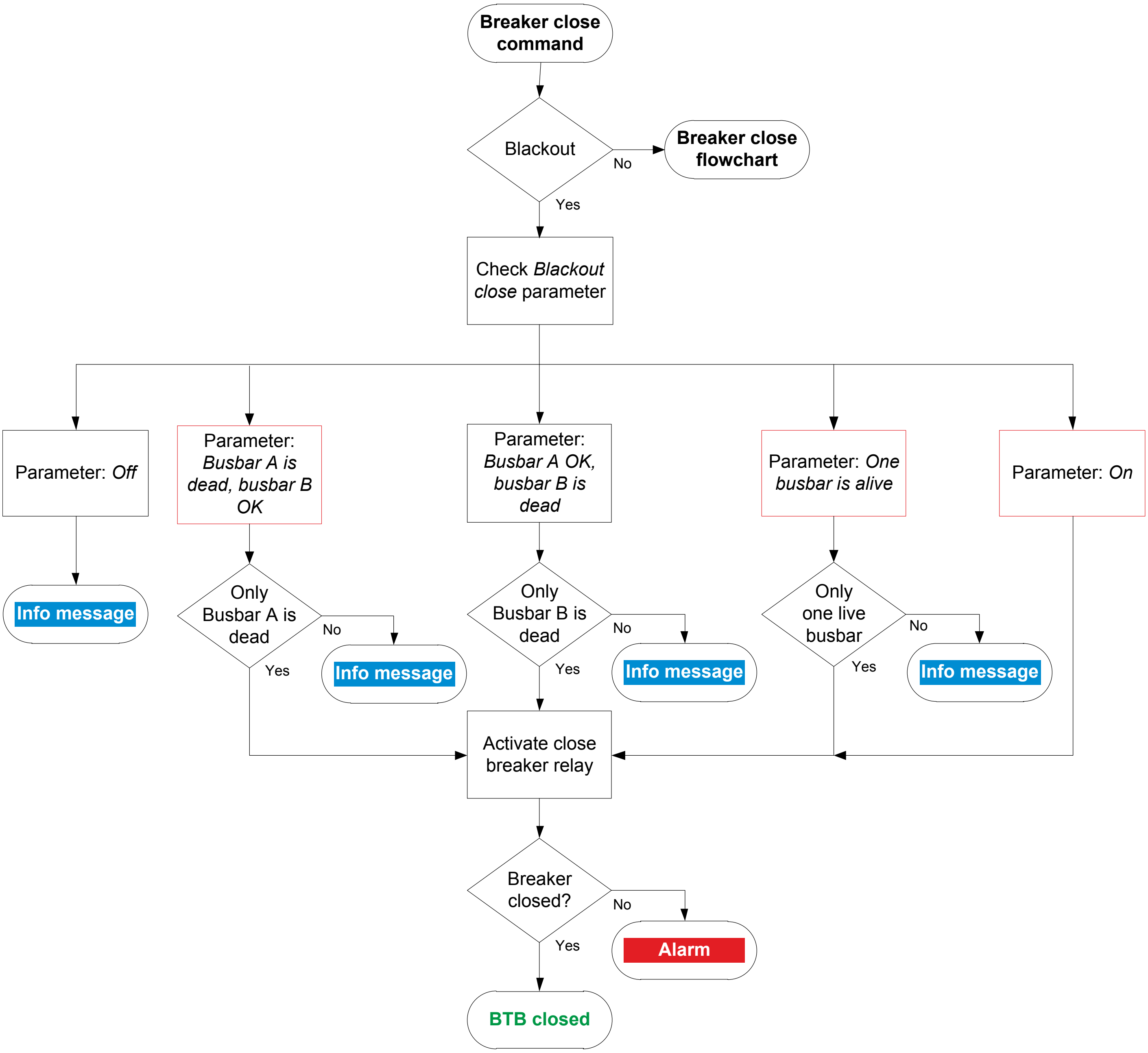
- The breaker position is unknown.
- There is a short circuit.
  - A digital input with the function `Breakers > Bus tie breaker > Feedback > BTB short circuit` was activated.
- There is a blocking alarm.
  - The alarm action determines whether the alarm is a blocking alarm.
- The busbar A and/or busbar 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 • Busbar A is dead, busbar B OK • Busbar A OK, busbar B is dead • One busbar is alive • On	**Blackout close is OFF**: The breaker is not allowed to close, unless both busbars are live and synchronised. **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. **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. **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. **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.

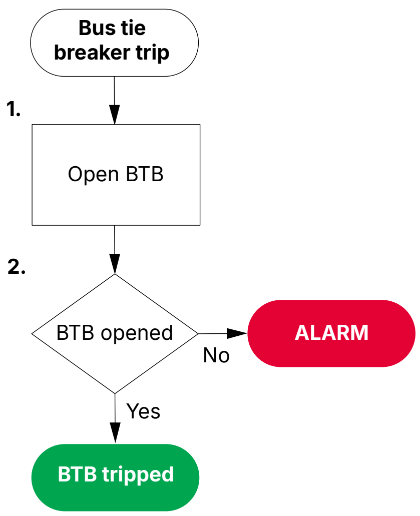
12.3.6 Bus tie breaker trip flowchart

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: • The bus tie breaker is closed • 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. Modbus

13.1 Modbus in the controller

13.1.1 How it works

Modbus is generally accepted as a standard communication protocol between intelligent industrial devices. This means that the Modbus protocol is used as a standard method to represent and communicate data in intelligent industrial devices.

The controller includes a built-in 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.

This document will only describe the information required to communicate with the controller using the Modbus TCP/IP protocol. For more information about Modbus in general and the Modbus TCP/IP protocol, refer to the documentation freely available at http://www.modbus.org.

Refer to the Modbus tables, available for download at www.deif.com, to see how the controller data is mapped to the Modbus addresses. It is possible to map digital and analogue inputs/outputs to Modbus addresses.

NOTE All values in this chapter are decimal values, unless specifically stated that a value is hexadecimal.

13.1.2 Warnings

DANGER!

Access to controller settings with Modbus TCP

All controller settings can be accessed and modified through Modbus TCP.

This includes disabling critical controller protections by changing settings and alarms. Use the Modbus tables provided by DEIF to ensure that you do not disable critical protections.

NOTICE

Modbus and Emulation

Modbus control remains active even during Emulation mode.

If Modbus is allowed to control sources, these will continue to be controlled even if the controller is in Emulation mode.

13.2 Modbus implementation in the controller

13.2.1 Modbus TCP protocol

The controller uses the Modbus TCP protocol to communicate with an external device over the Modbus network and through the internet. The communication protocol uses static IPv4 addresses to send information. Dynamic IPv4 addresses (created by a dynamic host configuration protocol server (DHCP server)) and IPv6 addresses are not supported by the controller for Modbus communication purposes.

More information
See the **Operator's manual** or the **PICUS manual** for how to configure the controller communication settings.

13.2.2 Modbus communication port

By default the controller uses port 502 (standard for Modbus TCP protocol) for TCP communication. Create a custom Modbus server to use a different communication port.

Each controller can process up to 10 communication requests at a single time.

13.2.3 Controller identifier

The Modbus TCP protocol will always use the controller IPv4 address to identify the controller that the client wants to communicate with. However, some Modbus communication tools will still require/automatically add a Modbus server ID, also known as a unit identifier, for the unit that the server is communicating with. For these cases the controller accepts Modbus server IDs from 1 to 247. This is the case for all controllers in the network that communicate using the Modbus TCP protocol.

If two Modbus servers are enabled at the same time that use the same communication port, then a unique Modbus Server ID must be configured for each server.

Specific controller identifiers can be selected for the controller when you configure a custom server.

13.2.4 Data handling

NOTICE

Check Modbus protocol address information

Check the Modbus protocol address information using PICUS to ensure that you are referencing the correct Modbus address for the function that you are executing.

NOTE Always document and store changes that you make to the way that the controller interprets Modbus data.

Data format (endian)

To ensure that the correct data is retrieved from the controller, the request from the Modbus client must match the data format of the selected address. The data format is configured in the Modbus server, and are applied to the *Holding register* and the *Input register*.

Sign

In general, the integer data (16-bit and 32-bit) that is accessed from the controller through Modbus TCP are signed integer values.

Conversion

Data in the *Holding register* and *Input register* of the Modbus table is converted according to the conversion template selected for that address. When data is read using Modbus, then the *Formula* is used to convert the Modbus data. When data is written using Modbus, then the *Reverse formula* is used to convert the data into a form that can be stored in the Modbus protocol.

Conversions can also be used to force unit conversions on specific addresses.
NOTE *Reverse formulas* are NOT automatically determined.

Modbus data conversion example

The parameter nominal power factor is assigned to an unused address in a custom Modbus protocol. The controller can process inputs to the forth decimal value (for example, 0.8002) for the nominal power factor. To read and write values correctly using Modbus a conversion template *X * 10000* is assigned to the address. The *Formula* equal to *x*10000* and a *Reverse formula* equal to *x*0.0001*.

This means that when a value of 0.8002 is read from the controller, the displayed value is:
Result = *Formula* ⇒ Result = x * 10000 ⇒ Result = 0.8002 * 10000 ⇒ Result = 8002

To write a value of 0.85 to the controller using Modbus, the value that should be written to the controller is:
Result = *Reverse formula* ⇒ Result = x * 0.0001 ⇒ 0.85 = x * 0.0001 ⇒ x = 8500

Refresh rate

Data stored in the Modbus addresses is refreshed at the following maximum rates:

Data	Maximum refresh rate	Function group example
AC measurements	20 ms	[A-side] AC measurements
Values	40 ms	Alarm parameter: Enable

13.3 Modbus tables

13.3.1 Download Modbus tables

To download the Modbus tables, use the links below:

Modbus

iE 350 Application SW (Flexible application)

13.3.2 About the Modbus tables

The Modbus tables are stored in a Microsoft® Excel file that contains worksheets with Modbus data.

Worksheet name	Description
Descriptions	An overview of the other four worksheets. The information includes a description of each function group listed in the tables worksheets.
Discrete output coil	You can read or write information to the addresses that are listed in this worksheet. Use Modbus function code 01 to read whether a coil is on or off. Use Modbus function code 05 or 15 to toggle the coil value. Read-only addresses will return a 0 value if you try to write to them.
Discrete input contact	You can only read information from the addresses that are listed in this worksheet. Use Modbus function code 02 to read whether the contact is on or off.
Output holding register	You can read or write information to the addresses that are listed in this worksheet. Use Modbus function code 03 to read the information stored at the requested Modbus address(es). Use Modbus function code 06 or 16 to write information to the Modbus address(es). Read-only addresses will return a 0 value if you try to write to them.
Input register	You can only read information from the addresses that are listed in this worksheet. Use Modbus function code 04 to read the information stored at the requested Modbus address(es).
Controller text	An overview of texts associated to Modbus output values. This association is only available for selected Modbus addresses.

13.4 Specific Modbus function groups

13.4.1 CustomLogic: Modbus signal

You can find the function group *CustomLogic: Modbus signal* in the Discrete output coil (01; 05; 15) and the Discrete input contact (02) worksheets of the Modbus table. The function group allows you to interact with the CustomLogic of the controller using Modbus.

When you read a value from these addresses, the controller will return a value to show if the flag for the signal is active (true, 1) or not active (false, 0). When you write a value to the addresses in the Discrete output coil, the value stored in the address changes to the new value.

NOTE You cannot write values to Modbus signals that have been assigned to coils in CustomLogic.

More information
See **CustomLogic** in the **PICUS manual** for how to assign a Modbus signal to CustomLogic elements.

13.5 Setting up Modbus

13.5.1 Setting up Modbus TCP/IP communication

In order to communicate with a controller through Modbus TCP, the following conditions must be met:

- The device interfacing with the controller must be connected to one of the following:
  - Another controller in the DEIF network.
- The controller must have an IPv4 address.
- Modbus TCP communication software must be installed on the device communicating with the controller.

More information
See the **Installation instructions** for how to wire the Ethernet connection to the controller.

13.6 Modbus alarm

13.6.1 Modbus communication timeout

The controller activates this alarm if there are no Modbus requests within the delay time.

`Communication > Modbus > Modbus communication timeout`

Parameter	Range
`Delay`	0.1 s to 1 h

14. WebConfig

14.1 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.

14.2 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.

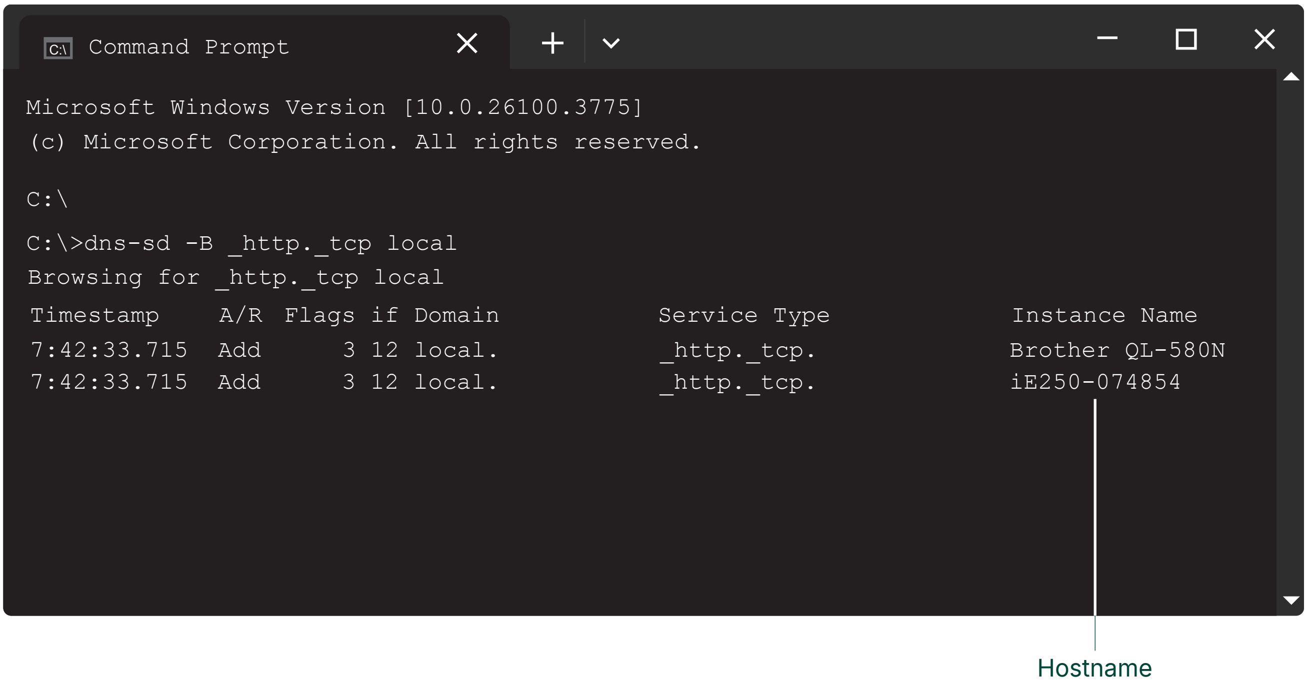
You can connect to the controller with *Hostname*, *IPv6*, or *IPv4* (if configured):

- **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

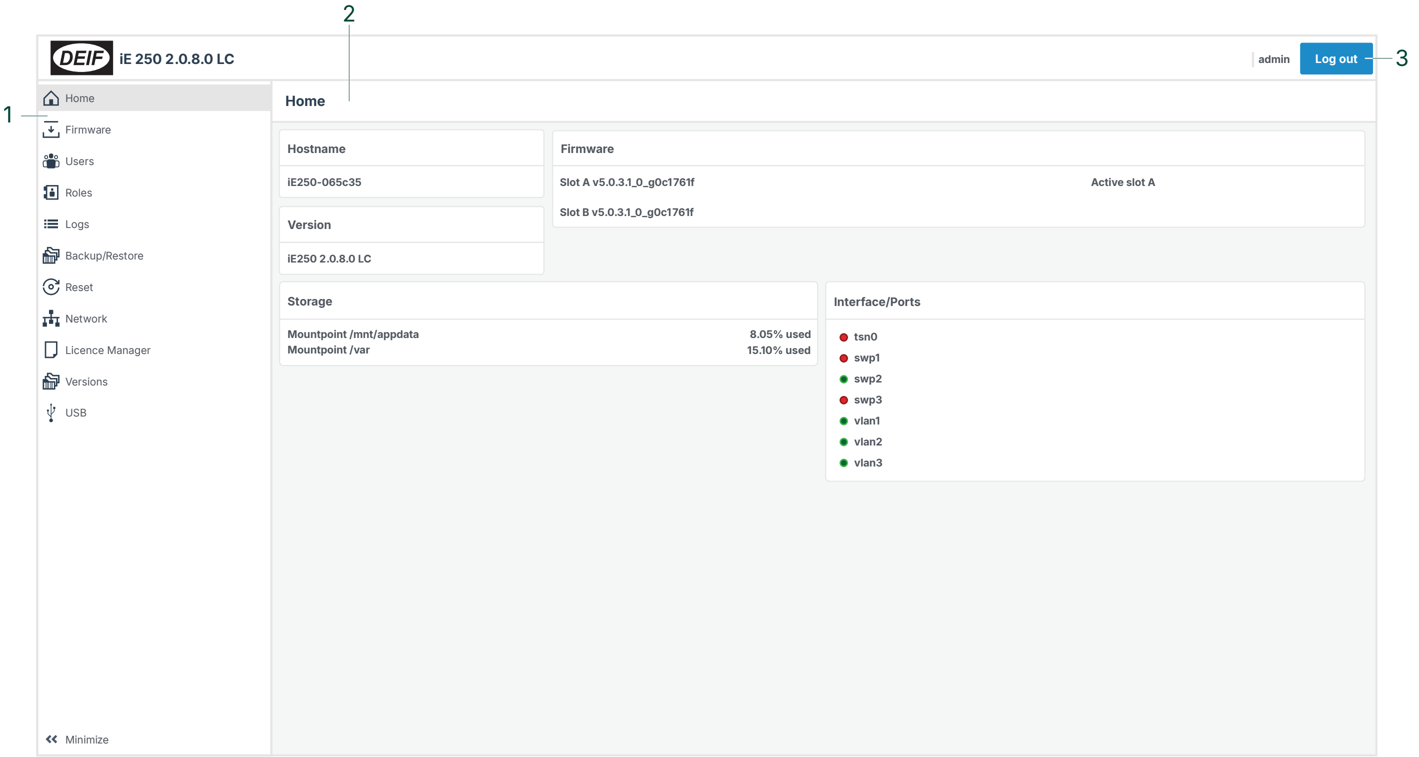
You can then use this Hostname directly in your HTML-capable browser to access the controller configiruation.

Username and password

Access the controller with the same username and password as configured on the controller.

14.3 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.

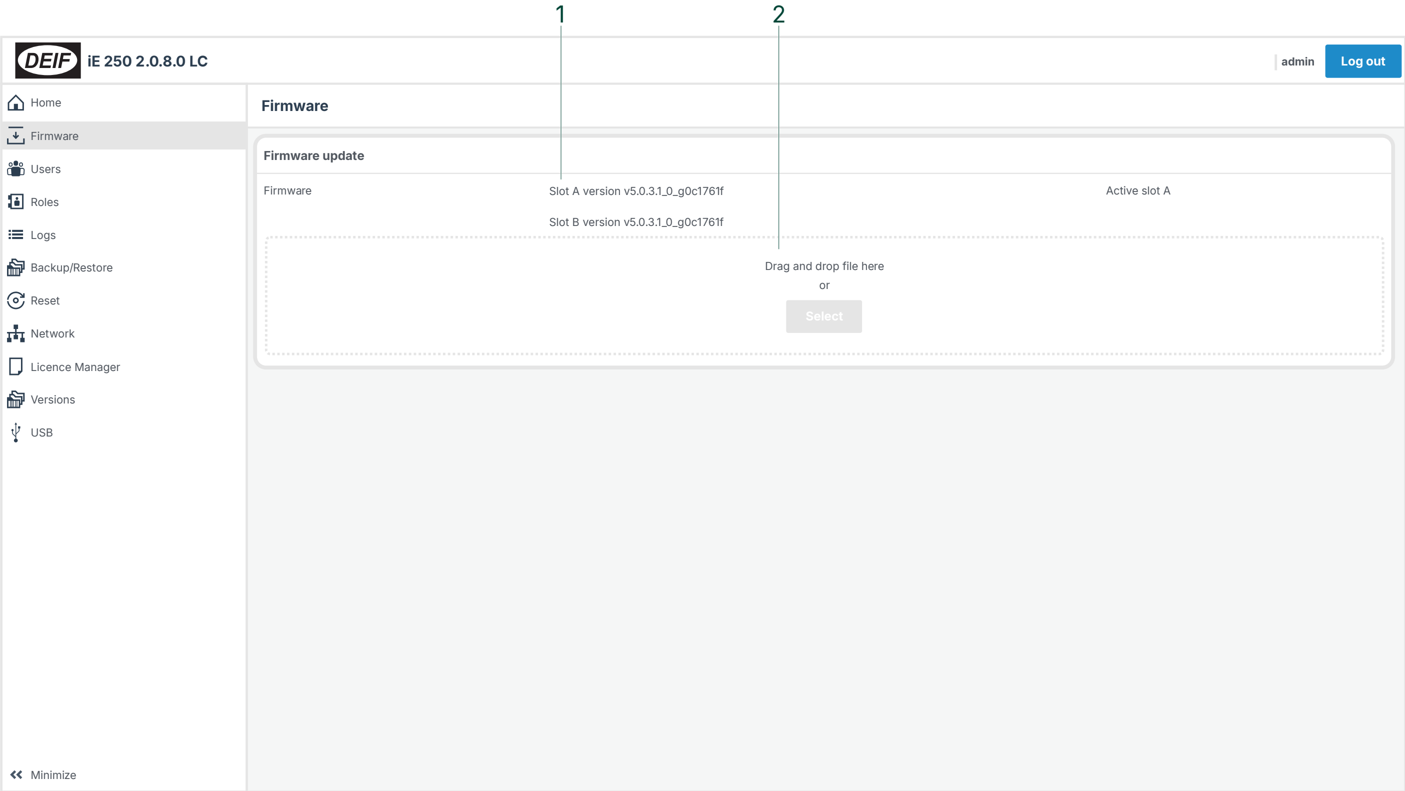


No.	Item	Notes
1	Features	Available features and pages.
2	Page	Selected page.
3	User	Log in / Log out. Logged in user is shown.

14.4 Firmware

14.4.1 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.

14.4.2 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.

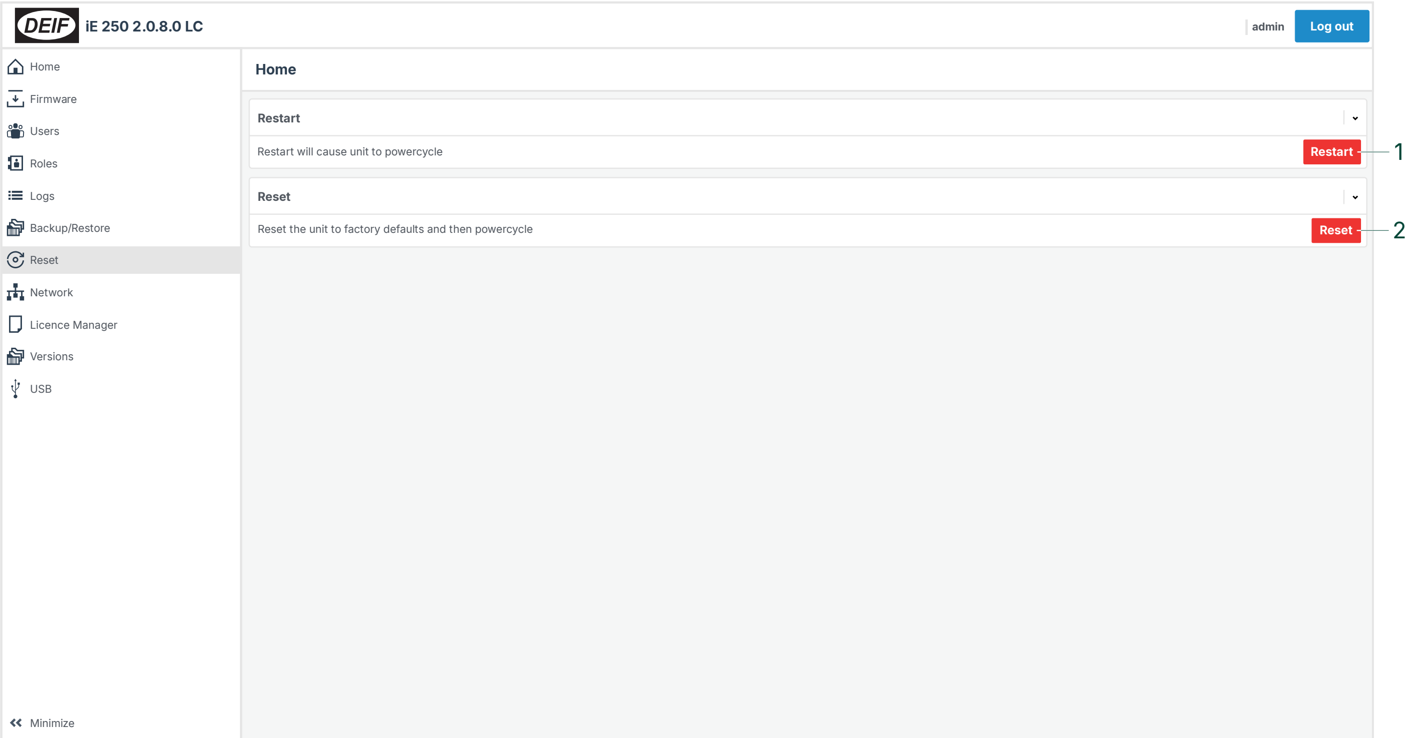
14.4.3 Download firmware

Firmware for your product is available on www.deif.com.

Download the software	
iE 250	https://www.deif.com/software/?product=17655
iE 350	https://www.deif.com/software/?product=22285

14.5 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.

14.6 Communication settings

14.6.1 Network communication

14.6.1.1 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 • Bridge • Standalone • Off	**Auto discover** • 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. • Automatically detects and uses the network settings. Ideal for environments where devices need to be quickly and easily connected without manual configuration. **Bridge** • Connects two network segments, allowing them to function as a single network. Useful for extending networks or connecting different network types. • 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. **Standalone** • Operates independently with its own network settings. Suitable for isolated networks or when specific configurations are needed for a particular device. **Off** • 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 * # is 0 to 4.

14.6.2 USB communication

14.6.2.1 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. • 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.

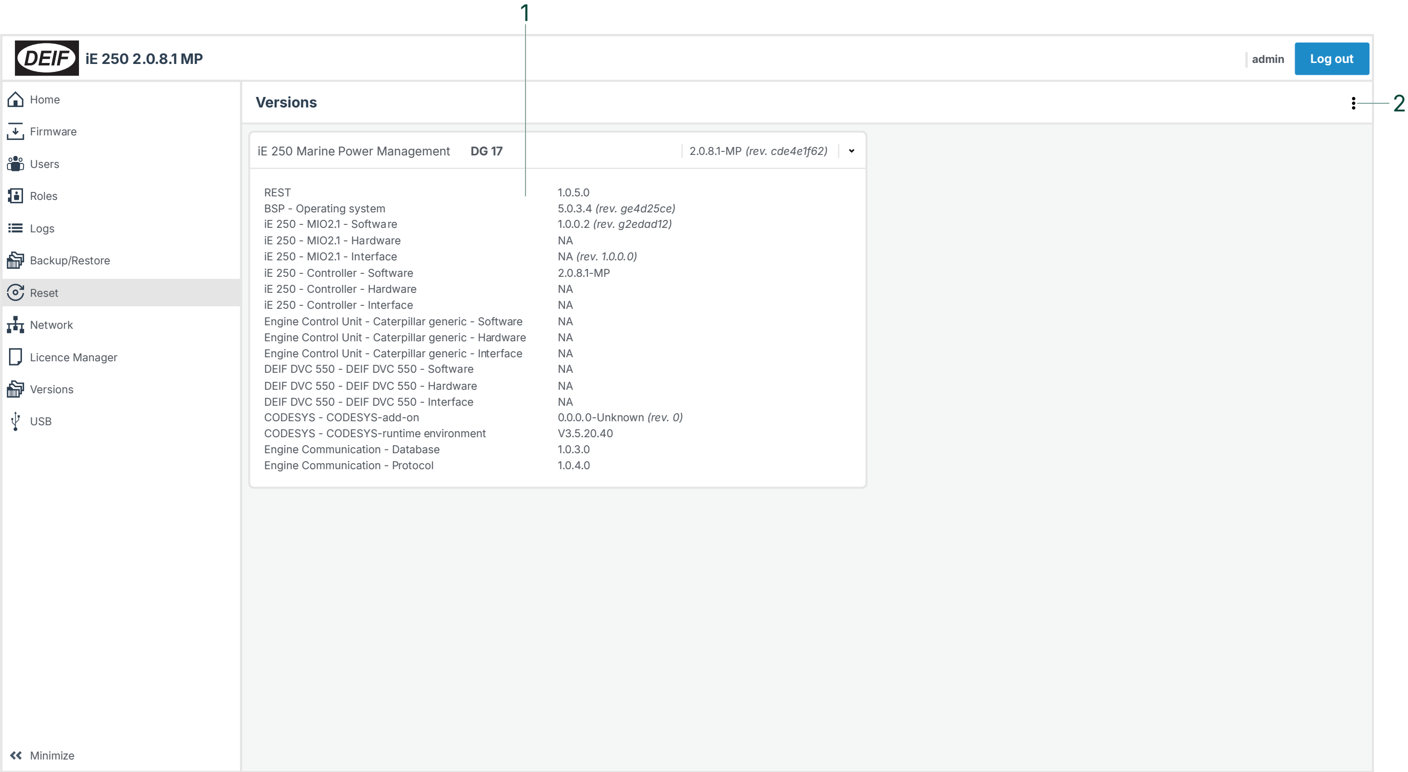
NOTICE

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.

14.7 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: • Revisions • Modules

15. CODESYS

15.1 Extend your application with CODESYS

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.

Contact DEIF to order a CODESYS licence when ordering your controller.

15.2 How it works

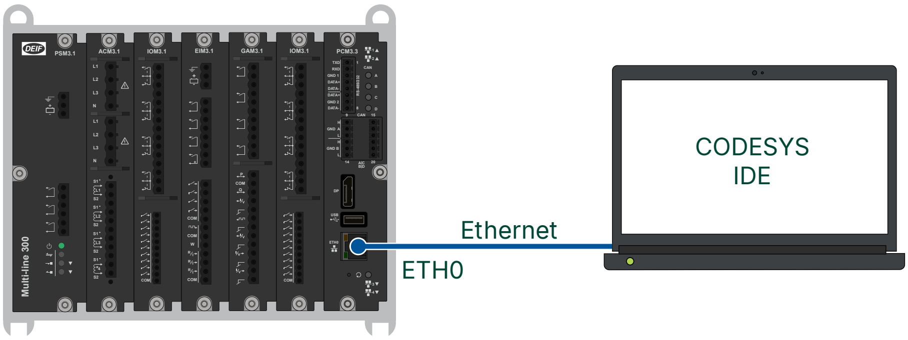
You create and edit your CODESYS projects locally on your computer using the CODESYS IDE (Integrated Development Environment). The project can be tested locally and then deployed to the controller and activated.

The controller must be connected to the development computer directly with an Ethernet cable or over an Ethernet network.

Ethernet connection to controller

When programming for the first time, you must use an Ethernet cable connected to Ethernet port **ETH0**.

iE 350



A typical development workflow for your projects

1. Create your project on your local computer:
   - You start by launching the CODESYS IDE on your computer, select the target device, and choose the programming language (for example: Ladder, Structured Text, and so on).
2. Create and simulate your logic locally:
   - This includes creating visualisations, configuring inputs and outputs, and testing logic in the simulation mode before deploying.
3. Transfer (deploy) your project to the controller:
   - Once the project is ready, it is downloaded to the controller over the Ethernet connection.
   - This is done by logging into the controller from the IDE and transferring the compiled project.

15.3 Prepare and install CODESYS

15.3.1 Essential components

To use CODESYS with your controller you must have installed:

Component	Reason
CODESYS Development System (IDE)	To create and edit your CODESYS projects.
CODESYS licence	A licence to use CODESYS.
DEIF CODESYS TSP package	Support package to access the DEIF specific hardware.
DEIF CODESYS libraries	Functions related to the DEIF applications and features.

15.3.2 CODESYS Development System (IDE)

You can download the **CODESYS Development System (IDE)** free of charge direct from CODESYS by visiting the CODESYS Store: *

```
https://store.codesys.com/en/codesys.html
```

NOTE * DEIF is not responsible for any external links or content.

More information
See Download necessary software for links to the software downloads.

15.3.3 Target Support Package (TSP)

The **Target Support Package** (TSP) is a configuration that enables the CODESYS project to communicate with the DEIF hardware.

You must install the CODESYS Development System (IDE) **before** installing the package.

More information
See Download necessary software for links to the software downloads.

15.3.4 DEIF CODESYS libraries

CODESYS libraries are collections of reusable objects. These are typically functions.

Each DEIF library provides you with access to the different controller functions. When you include the library in your CODESYS project you can then access the objects associated.

Libraries must be downloaded and then installed with the **Library Manager** to use them. You can also install them directly from the package (.package) files if the CODESYS Development System (IDE) is both installed and associated to the file type.

More information
See Download necessary software for links to the software downloads.

More information
See **DEIF library functions** for details of the functions and their use.

15.3.5 Download necessary software

To use CODESYS development you need to download the CODESYS Development System (IDE), Target Support Package (TSP), DEIF libraries, and the latest application software for your controller.

Download the required software from your product's dedicated software page:

Download the software	
iE 250	https://www.deif.com/software/?product=17655
iE 350	https://www.deif.com/software/?product=22285

15.4 Enable CODESYS

To use your CODESYS project with your controller, CODESYS must be enabled in the parameters. If it's not enabled, the CODESYS project cannot run.

CODESYS > Configuration > CODESYS

Parameter	Range	Notes
`Enable`	Not enabled, Enabled	Enabled allows the CODESYS application to be active.

15.5 HTML browser access (WebConfig)

Use WebConfig to configure and manage the controller system-settings directly with any HTML-capable browser. You can use *Hostname*, *IPv6*, or *IPv4* (if configured) to access the controller.

The application-related settings, such as parameter settings, need to be configured with PICUS.

NOTICE

Certificate security-warning

Access to the controller with a browser requires you to accept a browser security-warning. The controller certificate is only local and therefore not published online.

More information
See WebConfig for how to access WebConfig and use the features.

15.6 Inputs and outputs

15.6.1 Inputs and outputs

Assign the CODESYS inputs and outputs with the I/O configuration. These inputs and outputs must first be defined in the CODESYS program, and written to the controller before they can be used.

Function	I/O	Type	Details
`Local > CODESYS > Custom digital input (× 40)`	Digital input	Pulse/ continuous	If this input is activated, then the controller activates the corresponding CODESYS digital input function.
`Local > CODESYS > Outputs > Custom digital output (× 40)`	Digital output	Pulse/ continuous	If CODESYS activates the digital output function, then the controller activates the digital output.

Function	I/O	Type	Details
`Local > CODESYS > State > CODESYS application OK`	Digital output	Continuous	If the **CODESYS_application_OK** output value is "True" and there are no communication errors, then the controller activates the digital output.
`Local > CODESYS > Custom analogue input (× 40)`	Analogue input	-	As the value of this input changes, the corresponding CODESYS analogue input value changes.
`Local > CODESYS > Custom analogue output (× 40)`	Analogue output	-	As CODESYS changes the value of this analogue output, the corresponding analogue output value on the controller changes.

15.6.2 Activating controller outputs

CODESYS cannot activate controller outputs that are configured for controller functions. CODESYS can activate external commands. The controller only follows the command if the controller is in remote control.

Example

CODESYS cannot activate the digital input:

```
Breakers > [Breaker] > Controls > [*B] open
```

CODESYS can activate the command:
`[Breaker] > Open`

Where **[Breaker]** could be *Generator breaker*, and **[*B]** could be *GB*.

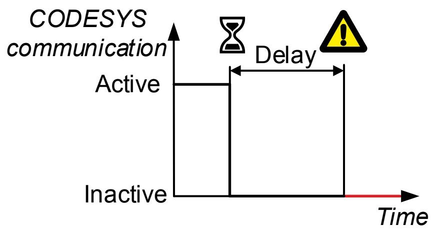
15.7 CODESYS alarms

15.7.1 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

15.7.2 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.

16. Hardware characteristics

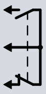
16.1 General characteristics

Some terminal types are common to a number of different hardware modules.

Technical specifications

More information
See the Data sheet for all of the technical specifications.

16.1.1 Relay output characteristics and configuration

Symbol	Hardware modules
	PSM3.1 PSM3.2 EIM3.1 GAM3.1 GAM3.2 IOM3.2
	IOM3.1

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

Configuration

All relay outputs are configurable, except for PSM3.1 terminals 3,4 (*Status OK*), GAM3.2 terminals 14,15 (*GAM3.2 1 Status OK*). A controller can have a number of relay outputs.

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

You can also create customised digital output functions using CustomLogic, and assign a relay output.

Controller types and single-line diagram

The controller type determines which digital output functions are available.

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

Relay state

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

Table 16.1 Relay state

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

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

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

Relay hardware

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

Normally open relay hardware:

- All PSM3.1 relays
- All PSM3.2 relays
- IOM3.1 terminals 1,2
- IOM3.1 terminals 4,5
- IOM3.1 terminals 7,8
- IOM3.1 terminals 10,11
- IOM3.2 terminals 1,2
- IOM3.2 terminals 3,4
- IOM3.2 terminals 5,6
- IOM3.2 terminals 7,8
- All EIM3.1 relays
- All GAM3.1 relays
- All GAM3.2 relays

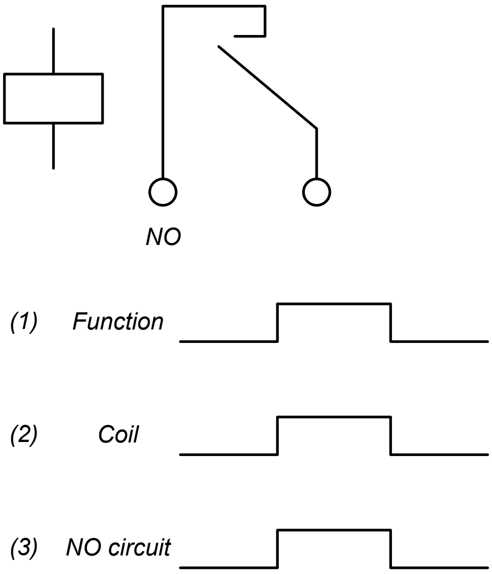
Normally closed relay hardware:

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

Coil state

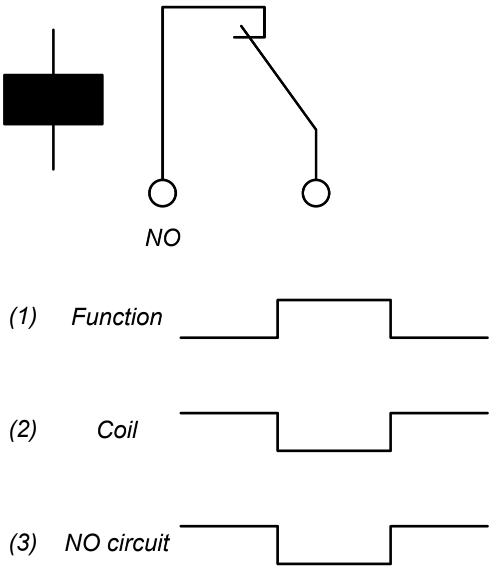
You can configure the normal coil state in the display unit or PICUS. For input/output terminals, select *Normally de-energised* (the default) or *Normally energised* for the *Coil state*.

Table 16.2 Relay, normally de-energised coil



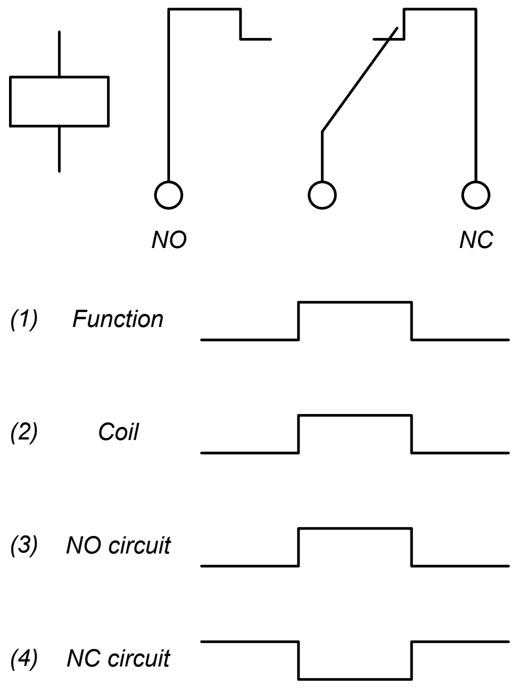
1. **Function**: The digital output function assigned to the terminals. The controller software activates the function. For example: `Breakers > [Breaker] > Command > [*B] Close`.
2. **Coil**: The controller energises the relay coil when the function is activated.
3. **Normally open circuit**: The normally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

Table 16.3 Relay, normally energised coil



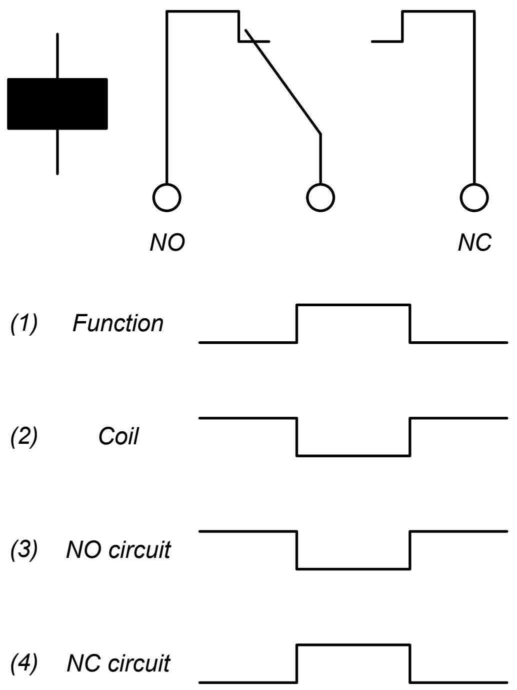
1. **Function**: The digital output function assigned to the terminals. The controller software activates the function. For example: `Breakers > [Breaker] > Command > [*B] Close`.
2. **Coil**: The controller de-energises the relay coil when the function is activated.
3. **Normally open circuit**: The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

Table 16.4 Changeover relay, normally de-energised coil



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

Table 16.5 Changeover relay, normally energised coil



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

16.1.2 Digital input characteristics and configuration

Symbol	Hardware modules
	IOM3.1 IOM3.2 IOM3.4 EIM3.1 GAM3.2

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

Polarity

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

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

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

Configuration

All digital inputs are configurable. A controller can have a number of digital inputs.

For each digital input, you can assign digital input function(s) and/or configure an alarm.

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 single-line diagram

The controller type determines which digital input functions are available.

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

Controller operation

Some of the digital input functions are only applicable in certain controller modes. If the controller is in another mode, it ignores the digital input.

16.1.3 Analogue input characteristics and configuration

Symbol	Hardware modules
I/V →	GAM3.1 (current or voltage inputs)
R/I →	EIM3.1 (current or resistance inputs)
I V R →	IOM3.2 (current or resistance inputs)
→ A B C	IOM3.3 (current or resistance 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.

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 sensor setup

The sensor setup is required.

The sensor setup requires a curve. The curve allows the controller to convert the analogue input to the selected function's value.

You can select a previously customised curve, select a pre-configured curve, or customise a curve.

NOTICE
Pt100 or Pt1000 If you choose a Pt100 pre-configured curve, for the sensor output you must select Pt100 ohm. If you choose a Pt1000 pre-configured curve, for the sensor output you must select Pt1000 ohm.

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.

Supervised binary input

Analogue inputs used for supervised binary inputs should be configured using the sensor output **Dry contact**.

Use an analogue input curve to define the supervised binary input. As shown in the examples, for the supervised binary input the 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).

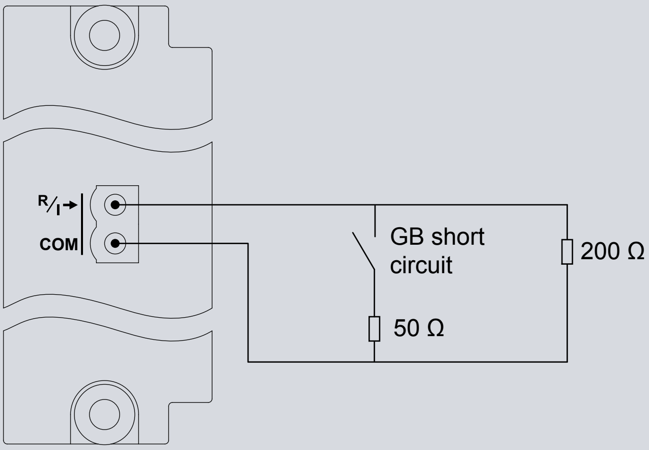
If the sensor output corresponds to the change point, the controller uses the last point specified in the curve. For the **Supervised *GB short circuit* example**, if the sensor output is exactly 150 Ω, then the function input is 0.

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.

Supervised *GB short circuit* example

The designer creates the following wiring for a *GB short circuit* digital input:



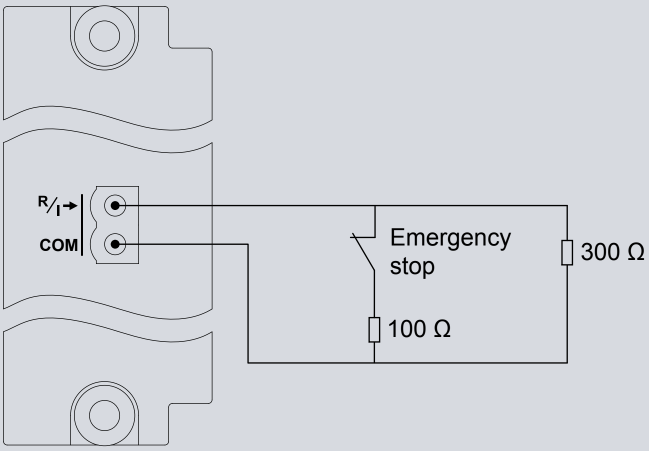
When the *GB short circuit* is open, the circuit has a resistance of around 200 Ω. When the *GB short circuit* is closed, the circuit has a resistance of around 40 Ω (the combined resistance of the 50 Ω and 200 Ω resistors in parallel).

If the *GB short circuit* digital input is activated, the controller activates the *GB short circuit* alarm.

The designer configures a customised function curve with an output of **1** up to 150 Ω, and an output of **0** above 150 Ω. The short circuit sensor failure is below 5 Ω. The wire break sensor failure is above 250 Ω.

Supervised *Emergency stop* example

The designer creates the following wiring for an *Emergency stop* digital input:



When the *Emergency stop* is closed, the circuit has a resistance of around 75 Ω (the combined resistance of the 100 Ω and 300 Ω resistors in parallel). When the *Emergency stop* is open, the circuit has a resistance of around 300 Ω.

The *Emergency stop* function requires that the digital input is normally activated. If the *Emergency stop* digital input is not activated, the controller activates the *Emergency stop* alarm.

The designer therefore configures a customised function curve with an output of **0** up to 200 Ω, and an output of **1** above 200 Ω. The short circuit sensor failure is below 10 Ω. The wire break sensor failure is above 325 Ω.

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 the maximum number of customised alarms for the controller.

16.1.4 Analogue output characteristics and configuration

Symbol	Hardware modules
(PWM symbol)	IOM3.2 (PWM) GAM3.1 (PWM) GAM3.2 (PWM)
⇠I/V	IOM3.2 (current or voltage) GAM3.1 (current or voltage) GAM3.2 (current or voltage)

More information
See the **Data sheet** for the technical specifications for each module terminal and connection.

An analogue output (AO) can be used for regulation (for example, governor regulation or AVR regulation). Alternatively, the AO can be used to output operating data to provide a reading on a switchboard instrument.

Analogue output function

Assign one function to the analogue output.

Analogue output setup

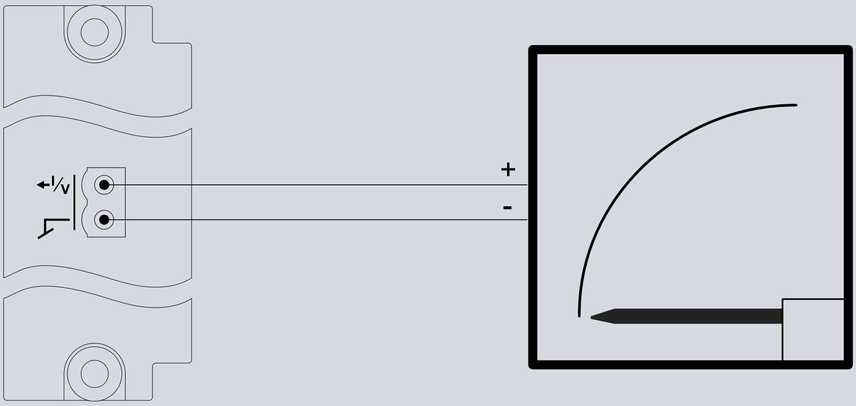
The output setup is required, and requires a curve. The curve allows the controller to convert the selected function's value to the analogue output.

You can select a previously customised curve, select a pre-configured 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 configures a customised function curve with an output of 4 mA for -100 kW, and 20 mA for 1500 kW.

16.2 Power supply module PSM3.1

16.2.1 Power supply

16.2.1.1 Power supply characteristics

Symbol on hardware module:

The power supply is connected to these terminals.

CAUTION

Frame ground

The frame ground is connected to the power supply terminals through transient voltage suppression diodes (commonly known as transorbs).

In order to protect the frame ground and power supply, no more than 36 V allowed across the frame ground and the power supply terminals.

Backup power

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

More information
See **Installation instructions** for how to wire the backup power supply.

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 equipment will not be damaged. However, the DEIF equipment will not be able to operate until the power supply has been connected correctly.

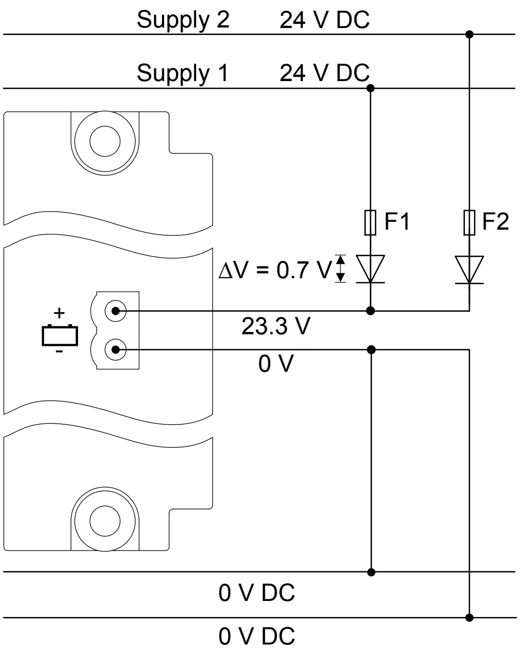
Diode compensation

Diode compensation is available in PSM3.1.

`Hardware > PSM3.1 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.

Figure 16.1 Example of a voltage decrease over a diode



Heat emission

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

16.2.1.2 Power supply voltage as an analogue output

You can configure an analogue output with a function for the power supply voltage. The controller then adjusts the analogue output to reflect the operating value.

Analogue output

Function	I/O	Units	Details
`Hardware > Power supply > PSM3.1 1 > PSM3.1 1 supply voltage [V DC]`	Analogue output	0 to 60 V DC	The controller measures the power supply voltage over the power supply terminals. The controller uses the configured curve to convert this value to an analogue output.

Application

An analogue output with the power supply voltage may be wired to a switchboard instrument to help the operator.

16.2.2 Frame ground characteristics

The frame ground is required by classification societies. Among other things, it makes the equipment more robust, for example against lightning.

CAUTION

Frame ground

The frame ground is connected to the power supply terminals through transient voltage suppression diodes (commonly known as transorbs).

To protect the frame ground and power supply, no more than 36 V is allowed between the frame ground and the power supply terminals.

16.2.3 Relay output characteristics

The first relay output (terminals 3,4) on PSM3.1 is reserved for the *Status OK* function. You cannot change the function for this relay.

The two other relay outputs on PSM3.1 are configurable (that is, terminals 5,6 and terminals 7,8 can be assigned any function).

More information
See Relay output characteristics and configuration.

16.2.4 EtherCAT communication

16.2.4.1 Internal communication (Extension rack)

The controllers communicate with their extension units using the Ethernet cables and the internal communication ports (OUT and IN, marked with a red border on the PSM3.1 and PSM3.2). This is type of communication is referred to as *Internal communication*.

For communication redundancy, the extension units can be connected in a ring. If there is a disruption or failure, the DEIF proprietary ring protocol changes the communication path within 100 milliseconds.

The order that the extension units are wired, determines in which order they appear in the software. The controller the extension units are connected to is always the first unit in the order.

NOTE Extension racks must be powered off when exchanging or re-connecting to another controller. If the extension rack is not powered off, there could be unintended actions from the rack modules.

Internal communication restrictions

- Up to five extension units can be connected to each other in each network chain or ring.
- Only *Network chain* or *Network ring* controller configurations are supported.
  - Do not connect switches or other non-DEIF network equipment as part of the network chain or ring.
- 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.

Hardware changes that do not activate a *Fieldbus conflict* alarm

The controller logs the following hardware changes. However, they do not activate a *Fieldbus conflict* alarm:

- A hardware module is replaced by the same type of hardware module, in the same position.
- Two of the same type of hardware modules swap position.
- An extension rack is replaced with an extension rack with identical hardware.

Factory settings

The hardware configuration for each controller is created in the factory. If the hardware is changed, the controller activates a *Fieldbus conflict* alarm. The controller hardware configuration must be confirmed in PICUS.

When a new extension rack is connected, the controller always activates a *Fieldbus conflict* alarm. The extension rack hardware configuration must be confirmed in PICUS.

More information
See **EtherCAT connections** in the **Installation instructions** for network topology examples and how you can wire the connections.

16.3 Power supply module PSM3.2

16.3.1 Power supply

16.3.1.1 Power supply characteristics

Symbol on hardware module:

The power supply is connected to these terminals.

CAUTION

Frame ground

The frame ground is connected to the power supply terminals through transient voltage suppression diodes (commonly known as transorbs).

In order to protect the frame ground and power supply, no more than 36 V allowed across the frame ground and the power supply terminals.

Backup power

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

More information

See **Installation instructions** for how to wire the backup power supply.

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 equipment will not be damaged. However, the DEIF equipment will not be able to operate until the power supply has been connected correctly.

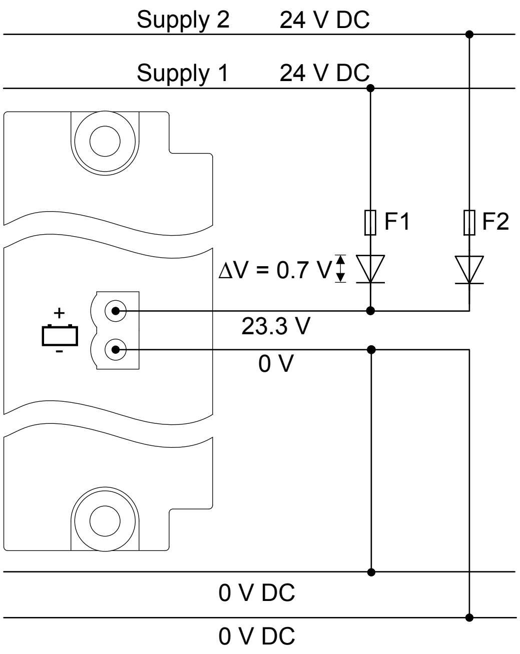
Diode compensation

Diode compensation is available in PSM3.2.

`Hardware > PSM3.2 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.

Figure 16.2 Example of a voltage decrease over a diode



Heat emission

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

16.3.1.2 Power supply voltage as an analogue output

You can configure an analogue output with a function for the power supply voltage. The controller then adjusts the analogue output to reflect the operating value.

Analogue output

Function	I/O	Units	Details
`Hardware > Power supply > PSM3.2 1 > PSM3.2 1 supply voltage [V DC]`	Analogue output	0 to 60 V DC	The controller measures the power supply voltage over the power supply terminals. The controller uses the configured curve to convert this value to an analogue output.

Application

An analogue output with the power supply voltage may be wired to a switchboard instrument to help the operator.

16.3.2 Frame ground characteristics

The frame ground is required by classification societies. Among other things, it makes the equipment more robust, for example against lightning.

> **CAUTION**
>
> **Frame ground**
>
> The frame ground is connected to the power supply terminals through transient voltage suppression diodes (commonly known as transorbs).
>
> To protect the frame ground and power supply, no more than 36 V is allowed between the frame ground and the power supply terminals.

16.3.3 Relay output characteristics

The first relay output (terminals 3,4) on PSM3.2 is reserved for the *Status OK* function. You cannot change the function for this relay.

The two other relay outputs on PSM3.2 are configurable (that is, terminals 5,6 and terminals 7,8 can be assigned any function).

More information
See Relay output characteristics and configuration.

16.3.4 EtherCAT communication

16.3.4.1 Internal communication (Extension rack)

The controllers communicate with their extension units using the Ethernet cables and the internal communication ports (OUT and IN, marked with a red border on the PSM3.1 and PSM3.2). This is type of communication is referred to as *Internal communication*.

For communication redundancy, the extension units can be connected in a ring. If there is a disruption or failure, the DEIF proprietary ring protocol changes the communication path within 100 milliseconds.

The order that the extension units are wired, determines in which order they appear in the software. The controller the extension units are connected to is always the first unit in the order.

NOTE Extension racks must be powered off when exchanging or re-connecting to another controller. If the extension rack is not powered off, there could be unintended actions from the rack modules.

Internal communication restrictions

- Up to five extension units can be connected to each other in each network chain or ring.
- Only *Network chain* or *Network ring* controller configurations are supported.
    - Do not connect switches or other non-DEIF network equipment as part of the network chain or ring.
- 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.

Hardware changes that do not activate a *Fieldbus conflict* alarm

The controller logs the following hardware changes. However, they do not activate a *Fieldbus conflict* alarm:

- A hardware module is replaced by the same type of hardware module, in the same position.
- Two of the same type of hardware modules swap position.
- An extension rack is replaced with an extension rack with identical hardware.

Factory settings

The hardware configuration for each controller is created in the factory. If the hardware is changed, the controller activates a *Fieldbus conflict* alarm. The controller hardware configuration must be confirmed in PICUS.

When a new extension rack is connected, the controller always activates a *Fieldbus conflict* alarm. The extension rack hardware configuration must be confirmed in PICUS.

More information
See **EtherCAT connections** in the **Installation instructions** for network topology examples and how you can wire the connections.

16.4 Alternating current module ACM3.1

16.4.1 Voltage measurement characteristics

The ACM has two sets of terminals for voltage measurement. The first set of terminals (1 to 4) measures the voltage on the B-side (typically the busbar). The second set of terminals (5 to 8) measures the voltage on the A-side (typically from a power source). The ACM uses these measurements for logging, alarms and protective functions. For power functions, the second set of voltage measurements (A-side, terminals 5 to 7) and the current measurements (A-side, terminals 9 to 14) from the ACM are used together.

For 3-phase systems, you do not have to connect and measure the neutral lines (terminals 4 and 8).

16.4.2 Current measurement characteristics

The ACM measures the current, then uses these measurements for logging, alarms and protective functions. For power functions, the second set of voltage measurements (terminals 5 to 7) and the current measurements (terminals 9 to 14) from the ACM are used together.

You do not have to connect and measure the 4th current input (terminals 15,16). You can measure the neutral line, the earth current or a custom current with the 4th current input.

16.5 Differential current module ACM3.2

16.5.1 Current measurement characteristics

The ACM3.2 has two sets of terminals for current measurement. The first set of terminals (1 to 6) measures the current at the consumer side of the generator. The second set of terminals (7 to 12) measures the current at the neutral side of the generator. The ACM3.2 uses these measurements for logging, alarms and protective functions relating to differential current protection in the system.

16.6 Input/output module IOM3.1

16.6.1 Changeover relay output characteristics

IOM3.1 has 4 groups of changeover relay outputs on terminals 1 to 3, 4 to 5, 7 to 8, 10 to 12.

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

Normally open relay hardware:
IOM3.1 terminals 1,2
IOM3.1 terminals 4,5
IOM3.1 terminals 7,8
IOM3.1 terminals 10,11

Normally closed relay hardware:
IOM3.1 terminals 3,2
IOM3.1 terminals 6,5
IOM3.1 terminals 9,8
IOM3.1 terminals 12,11

More information
See Relay output characteristics and configuration for standard changeover relay characteristics.

16.6.2 Digital input characteristics

IOM3.1 has 10 digital inputs on terminals 13 to 22, with a common on terminal 23.

More information
See Digital input characteristics and configuration .

16.7 Input/output module IOM3.2

16.7.1 Relay output characteristics

IOM3.2 has 4 relay outputs on terminals 1 to 2, 3 to 4, 5 to 6, 7 to 8. Default state for all relay outputs is *normally open*.

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

More information
See the **IOM3.2 wiring** in the **Installation instructions** for the relay wiring.

More information
See Relay output characteristics and configuration for standard relay output characteristics.

16.7.2 Analogue multifunctional output characteristics

IOM3.2 has 4 analogue multifunctional outputs on terminals 9 to 10, 11 to 12, 13 to 14, 15 to 16. Terminals 9 to 10 and 11 to 12 can also be used as pulse width modulation (PWM) outputs.

The analogue outputs are active, that is, they have their own power supply, and they must **not** be connected to an external supply.

Using a configured or selected output curve, the controller converts the operating value to the corresponding current (-25 to 25 mA) or voltage (-10 to 10 V).

More information
See the **IOM3.2 wiring** in the **Installation instructions** for the different wiring possibilities and how to connect these to the module.

More information
See Analogue output characteristics and configuration for the general characteristics.

Using an analogue output with a switchboard instrument

The analogue output can be connected directly to a 4 to 20 mA switchboard instrument.

16.7.3 Digital input characteristics

IOM3.2 has 4 digital inputs on terminals 17 to 20, with a common on terminal 21.

More information
See Digital input characteristics and configuration .

16.7.4 Analogue multifunctional input characteristics

IOM3.2 has 4 analogue multifunctional inputs on terminals 22 to 23, 24 to 25, 26 to 27, 28 to 29.

The I/O configuration determines whether the input is current or resistance. For resistance, the I/O configuration also determines the type of resistance input. Using a configured or selected input curve, the controller converts the input to a corresponding value. You can also configure the input to activate functions and/or alarms.

NOTICE

BEFORE connecting external transmitter

Configure the terminals correctly (that is, for current or for voltage) before connecting the external transmitter.

More information
See the **IOM3.2 wiring** in the **Installation instructions** for the different wiring possibilities and how to connect these to the module.

More information
See Analogue input characteristics and configuration for general analogue input characteristics.

16.8 Input/output module IOM3.3

16.8.1 Analogue multifunctional input characteristics

IOM3.3 has 10 analogue multifunctional inputs on terminals 1 to 3, 4 to 6, 7 to 9, 10 to 12, 13 to 15, 16 to 18, 19 to 21, 22 to 24, 25 to 27, and 28 to 30.

The I/O configuration determines whether the input is current or resistance. For resistance, the I/O configuration also determines the type of resistance input. Using a configured or selected input curve, the controller converts the input to a corresponding value. You can also configure the input to activate functions and/or alarms.

NOTICE

BEFORE connecting external transmitter

Configure the terminals correctly (that is, for current or for voltage) before connecting the external transmitter.

More information
See the **IOM3.3 wiring** in the **Installation instructions** for the different wiring possibilities and how to connect these to the module.

More information
See Analogue input characteristics and configuration for general analogue input characteristics.

16.9 Input/output module IOM3.4

16.9.1 Digital output characteristics and configuration

Symbol	Hardware modules
	IOM3.4

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

Configuration

All transistor outputs are configurable. You can assign a digital output function, or configure one alarm, for a transistor output.

You can program customised transistor output functions using CustomLogic.

You can also create customised digital output functions using CustomLogic, and assign a transistor output.

Controller types and single-line diagram

The controller type determines which digital output functions are available.

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

Transistor state

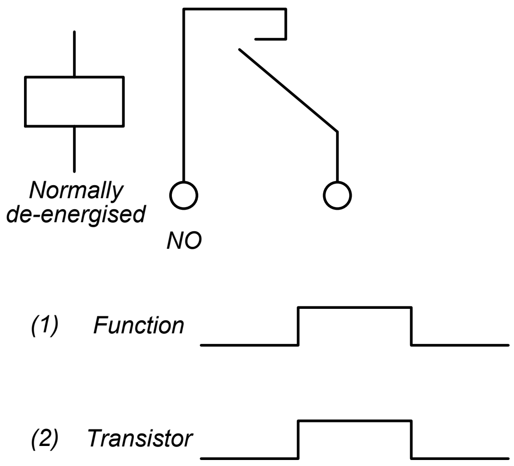
The transistor hardware itself is normally open. The transistor output state (whether it is open or closed) depends on the configuration in software and the function (or alarm) state. The following table shows how these combine to give the transistor state.

Configuration in software	Function (or alarm)	Transistor state
Normally de-energised	Not activated	Open
Normally de-energised	Activated	Closed
Normally energised	Not activated	Closed
Normally energised	Activated	Open

Configured state

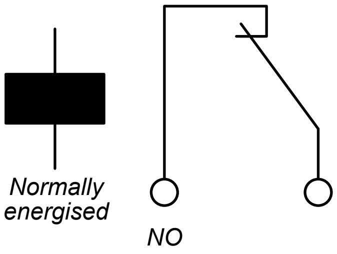
You can configure the normal transistor state in software in the display unit or PICUS. For the terminals, select *Normally de-energised* (the default) or *Normally energised* for the *Coil state*.

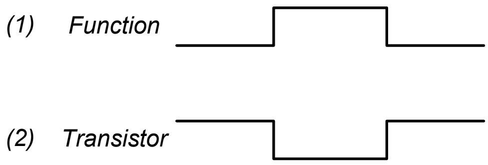
Table 16.6 Transistor, configured in software as normally de-energised



1. **Function**: The digital output function assigned to the terminals. The controller software activates the function. For example: `Breakers > [Breaker] > Command > [*B] Close`.
2. **Transistor**: The controller closes the transistor when the function is activated.

Table 16.7 Transistor, configured in software as normally energised





1. **Function**: The digital output function assigned to the terminals. The controller software activates the function. For example: `Breakers > [Breaker] > Command > [*B] Close`.
2. **Transistor**: The controller opens the transistor when the function is activated.

16.9.2 Digital input characteristics

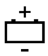
IOM3.4 has 2 groups of 8 digital inputs, a total of 16 digital inputs. The first group is terminals 15 to 22, with a common on terminal 23. The second group is terminals 24 to 31, with a common on terminal 32. The groups are not connected to each other.

More information
See Digital input characteristics and configuration .

16.10 Engine interface module EIM3.1

16.10.1 Power supply

16.10.1.1 Auxiliary power supply characteristics

Symbol on hardware module: 

The auxiliary power supply is connected to these terminals.

CAUTION

Frame ground

The frame ground is connected to the power supply terminals through transient voltage suppression diodes (commonly known as transorbs).

In order to protect the frame ground and power supply, no more than 36 V allowed across the frame ground and the power supply terminals.

Backup power

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

More information
See **Installation instructions** for how to wire the backup power supply.

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 equipment will not be damaged. However, the DEIF equipment will not be able to operate until the power supply has been connected correctly.

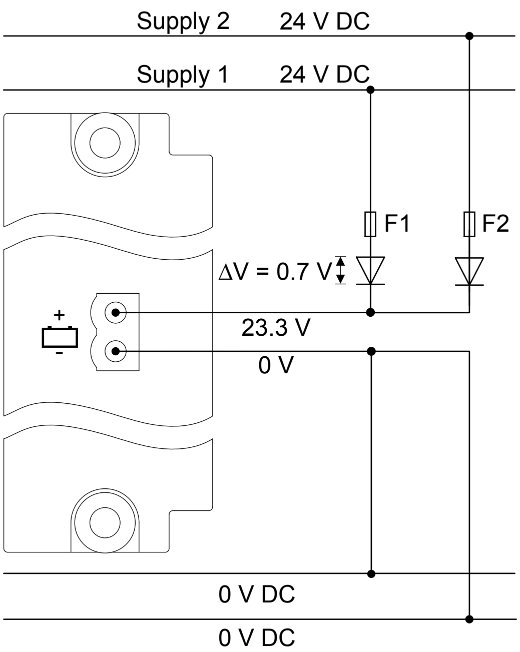
Diode compensation

Diode compensation is available in EIM3.1.

`Hardware > EIM3.1 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.

Figure 16.3 Example of a voltage decrease over a diode



Heat emission

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

16.10.1.2 Auxiliary power supply voltage as an analogue output

You can configure an analogue output with a function for the auxiliary power supply voltage. The controller then adjusts the analogue output to reflect the operating value.

Analogue output

Function	IO	Units	Details
`Hardware > Power supply > EIM3.1 # > EIM3.1 # supply voltage [V DC]`	Analogue output	0 to 60 V DC	The controller measures the auxiliary power supply voltage over the EIM power supply terminals. The controller uses the configured curve to convert this value to an analogue output.

Application

An analogue output with the power supply voltage may be wired to a switchboard instrument. The operator can then see if the auxiliary power supply fails.

16.10.1.3 Power supply requirement

If the EIM power supply fails or is not connected, the PSM will supply power to the EIM. If the PSM power supply fails, the EIM will run on its independent power supply. However, the EIM will not supply power to the PSM.

NOTICE

Independent power supply requirement

Class societies require an independent power supply for the EIM. The EIM must therefore not be connected to the same power supply source as the PSM.

16.10.2 Frame ground characteristics

The frame ground is required by classification societies. Among other things, it makes the equipment more robust, for example against lightning.

CAUTION

Frame ground

The frame ground is connected to the power supply terminals through transient voltage suppression diodes (commonly known as transorbs).

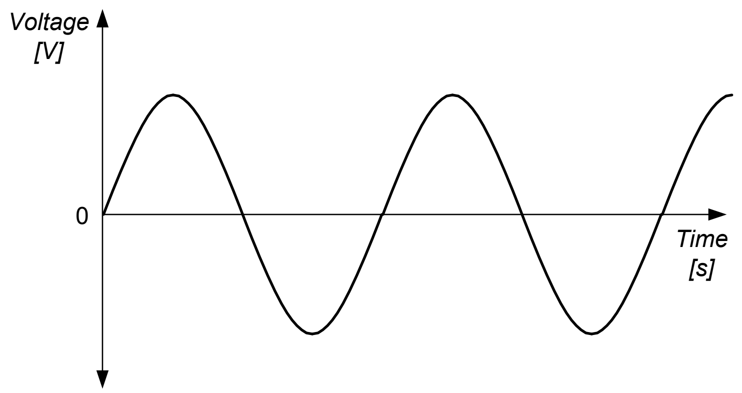
To protect the frame ground and power supply, no more than 36 V is allowed between the frame ground and the power supply terminals.

16.10.3 Magnetic pickup unit (MPU) input characteristics

Figure 16.4 MPU (inductive) voltage-time graph

The magnetic pickup unit (MPU) input can be used for an MPU input. This input can be useful during startup, when the generator frequency is too low to be a reliable indication of genset speed.

By default, the MPU input is used as a backup running detection. However, the MPU input can be used as the primary running detection.



NOTICE

MPU and W input

You cannot use both the MPU and W input at the same time.

Parameters

The MPU input measures the number of pulses as metal teeth on the flywheel pass the detector. It is therefore important to configure the number of teeth correctly, since engine speed (RPM) = pulses per minute / (number of teeth).

More information
See Running detection under **GENSET controller principles** for the parameter to configure the number of teeth for the MPU.

Notes on an MPU input

The MPU input terminal connections on the DEIF equipment can be changed around without any problem.

If an MPU is used, a wire break can be detected and activate an alarm.

16.10.4 W input characteristics

The W input is a signal from one of the phases of the generator, or from an NPN/PNP. This input can be useful during startup, when the generator frequency is too low to be a reliable indication of genset speed.

By default, the W input is used as a backup running detection. However, the W input can be used as the primary running detection.

Figure 16.5 W voltage-time graph

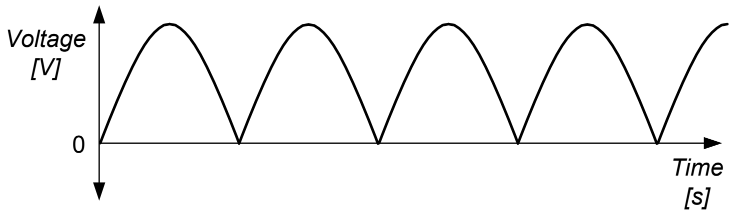
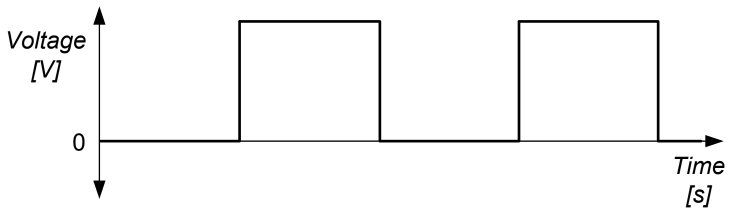


Figure 16.6 NPN/PNP (Hall sensor) voltage-time graph



NOTICE

MPU and W input

You cannot use both the MPU and W input at the same time.

Parameters

The W input is an oscillating signal. Use the generator gear ratio and the number of fields in the generator to configure a "number of teeth" to convert the wave to the engine speed.

More information
See Running detection under **GENSET controller principles** for the parameter to configure the number of teeth.

Notes on a W input

The engine speed calculated from the W input can differ from the actual engine speed. The accuracy depends on the genset design and is producer-specific.

Notes on an NPN/PNP input

NPN/PNP detectors include a transistor that is powered by a direct current supply, and produce a square wave signal.

16.10.5 Analogue input (AI) characteristics

This analogue input can be configured as either current (0 to 25 mA) or resistance (0 to 2500 ohm). Using a configured or selected input curve, the controller converts the input to a corresponding value. You can also configure the input to activate functions and/or alarms.

Maximum voltage

This input is protected against voltages higher than 2.5 V. At higher voltages, the measurement circuit is shut off and gives an error reading. However, if the maximum voltage in the **Data sheet** is exceeded (that is, 36 V), then this input or the equipment may be damaged.

Current input

The current input may be either active or passive, and a combination of active and passive inputs may be used.

Resistance input

The resistance inputs are always passive inputs. The controller sends a small current through the external equipment and measures the resistance.

There is no software compensation for the wire length to the resistance input. Create a custom curve for the analogue input to adjust for errors due to wire length.

If you use a resistance input as a supervised binary input, then the maximum circuit resistance is 330 Ω.

More information
See Analogue input characteristics and configuration.

More information
See the **Installation instructions** for information about wiring details.

16.10.6 Relay output with wire break detection characteristics

There is one relay with wire break detection on EIM3.1, that is, terminals 9,10.

NOTICE
Wire break detection current The wire break detection uses a small constant current for wire break detection. The wire break detection current can activate small relays, and cannot be turned off.

More information
See **Relay output with wire break detection** in the **Installation instructions** for examples of relay wiring and more information about the wire break detection current.

More information
See Relay output characteristics and configuration.

16.10.7 EIM3.1 standalone

The EIM3.1 can operate in standalone mode, where it can act as a hot standby shutdown unit in case the application should be not capable of handling the engine shutdown. The EIM runs in one of two possible modes.

Passive mode (normal operation)

In normal operation the EIM operates as a passive module in the system. It samples inputs and communicates these to the EtherCAT master and the opposite for the outputs. The application and not the EIM, handles all alarms and controls the stop, run and other coils. The EIM continues to check all the alarms and their set point and timer delays, but the EIM does not control the relay activation. The relays are only changed based on control from the application. This is done to prohibit the alarm timer on the EIM starting from 0 when it enters active mode.

Active mode (standalone)

If the connection to the EtherCAT master or the application is lost, due to loss of main power, damaged communication lines, or the application has not yet started, the EIM enters the standalone mode. This mode must be enabled.

`Engine > Safety shutdown`

Parameter	Range	Notes
`Enable`	Not enabled, Enabled	**Not enabled**: The EIM operates in *Passive* mode and the application controls alarms and actions. **Enabled**: The EIM operates in *Active* mode and controls alarms and actions.
`Keep stop coil active`	Not enabled, Enabled	Keeps the stop coil activated. This is used only in the shutdown sequence with manual reset. See below.
`Use magnetic pickup`	Not enabled, Enabled	**Not enabled**: The standalone function does not use the magnetic pickup (MPU) for running feedback. **Enabled**: The standalone function uses the MPU for running feedback.

In active mode, the EIM takes over the function of performing the necessary actions for any alarm conditions that might occur. These actions are pre-configured and stored in the EIM module so that it can enter standalone mode directly from start-up. The EIM does not know what the individual alarms indicate. It only knows the input, set point and timer delay associated with each alarm and then evaluates the alarms according to these. It is the role of the application to understand the configuration of, for example, a low oil pressure alarm related to the EIM's configuration of multi input 2.

During active standalone mode the EIM can evaluate and action both inhibit and shutdown override inputs. These must already have been configured and wired to the EIM module. If the communication with the EtherCAT master and application is restored and no engine shutdown is currently active, the EIM returns the control back to the application.

Required configuration for Active standalone mode

The configuration for the standalone mode must include the following:

1. Inputs
   a. Running feedback
      - Digital input, MPU or oil pressure.
      - At least 1 is mandatory and up to 3 are possible.
   b. Inhibits
      - Up to 3 are possible.
   c. Shutdown override
      - Up to 1 is possible.
   d. Manual reset
      - Up to 1 is possible.
      - This is only relevant for alternative shutdown sequence (see below).
2. Outputs
   a. Stop coil
      - Up to 4 are possible.
   b. Run coil
      - Up to 4 are possible.
3. Alarms
   a. At least 1 alarm with trip and shutdown or trip AVR and shutdown on EIM inputs

    b. Requires the same parameters as in the normal application.
4. Extended stop timer
5. Keep stop coil active until manual reset
    - This is only relevant for shutdown sequence with manual reset (see below).
6. Inhibit values
    a. For example Engine running.

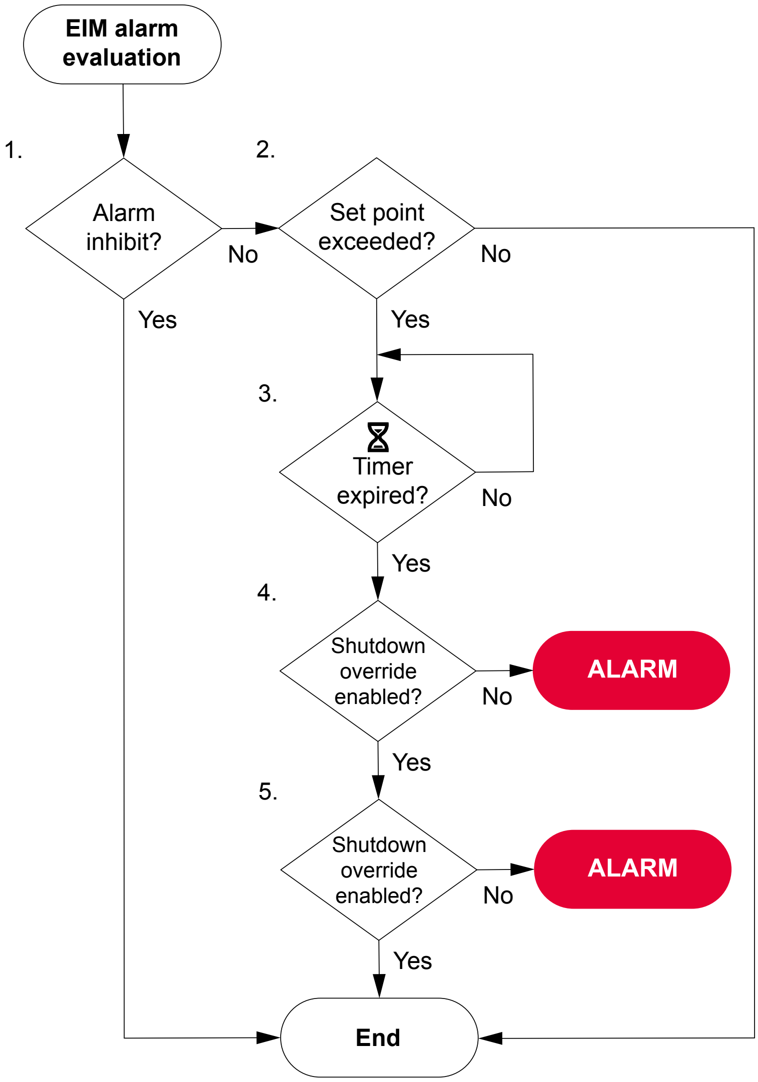
Engine analogue inputs

Function	I/O	Notes
`Engine > Measurements > Lube oil > Engine oil pressure [bar]`	Analogue input	When configured, the controller receives the oil pressure level from this analogue input.
`Engine > Measurements > Coolant > Engine coolant water [C]`	Analogue input	When configured, the controller receives the coolant water temperature from this analogue input.
`Engine > Measurements > Lube oil > Engine oil temperature [C]`	Analogue input	When configured, the controller receives the oil temperature from this analogue input.
`Engine > Measurements > Coolant > Engine coolant level [%]`	Analogue input	When configured, the controller receives the coolant level from this analogue input.

Safety shutdown status digital output

Function	I/O	Type	Notes
`Engine > Safety shutdown > Status OK`	Digital output	Continuous	If activate the configuration of safety shutdown is correct and no inputs have wire breaks.

Alarm handling and alarms



Any alarms configured with the fail class shutdown are used on the first EIM3.1 hardware module:

- Relay 4 supervision
- Emergency stop
- Digital and analogue custom alarms
- Above alarms on inputs
- Below alarms on inputs
- Oil pressure alarms
- Oil temperature alarms
- Coolant temperature alarms
- Coolant level alarms
- Under speed alarms
- Over speed alarms
- MPU wirebreak detection

Table 16.8 Engine analogue input alarms

Alarm	Set point	Action	Notes
Oil pressure 1	2.0 bar	Warning	
Oil pressure 2	1.0 bar	Trip generator breaker and shutdown engine	
Oil temperature 1	120.0 C	Warning	

Alarm	Set point	Action	Notes
Oil temperature 2	140.0 C	Trip generator breaker and stop engine	
Coolant pressure 1	20.0 %	Warning	
Coolant pressure 2	10.0 %	Trip generator breaker and stop engine	
Coolant pressure 3	5.0 %	Trip generator breaker and shutdown engine	
Coolant temperature 1	100.0 C	Warning	
Coolant temperature 2	110.0 C	Trip generator breaker and stop engine	
Coolant temperature 3	115.0 C	Trip generator breaker and shutdown engine	

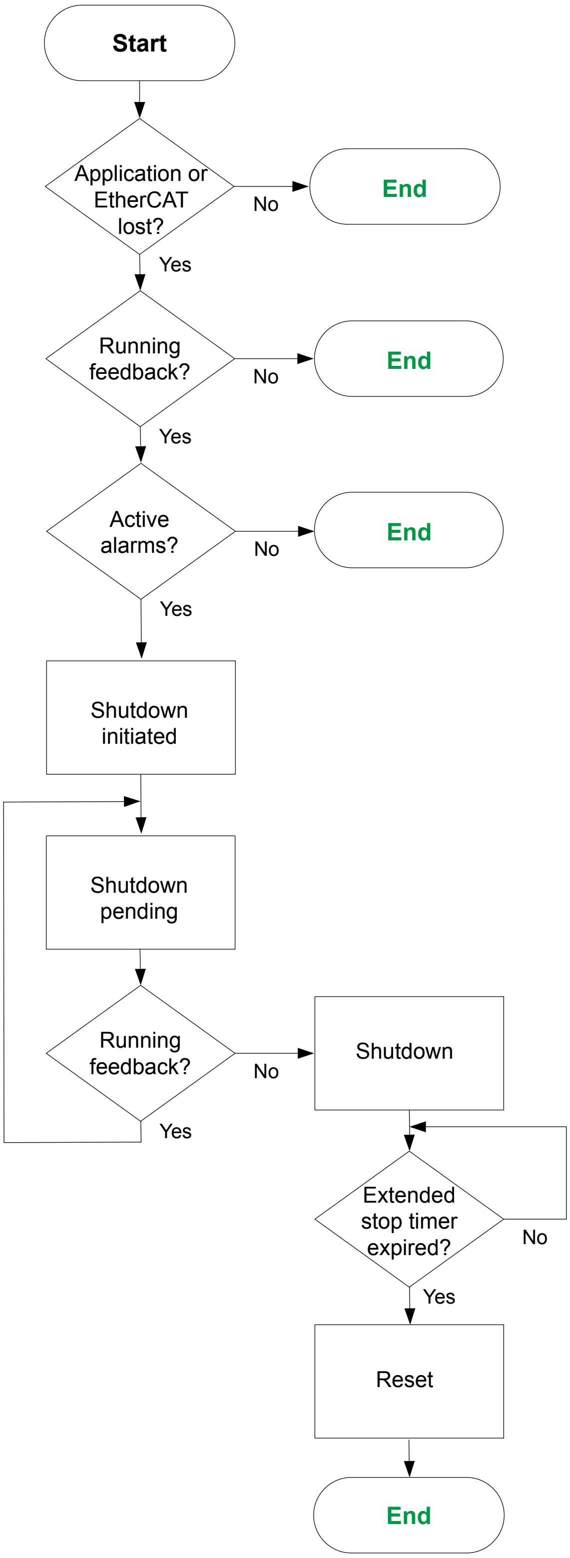
Shutdown sequences

The shutdown sequence can be configured with or without a manual reset. The shutdown sequence with manual reset, which must be both configured and operated before the shutdown is completed.

The manual reset is configured by using the parameter `Engine > Safety shutdown > Keep stop coil active` (see above).

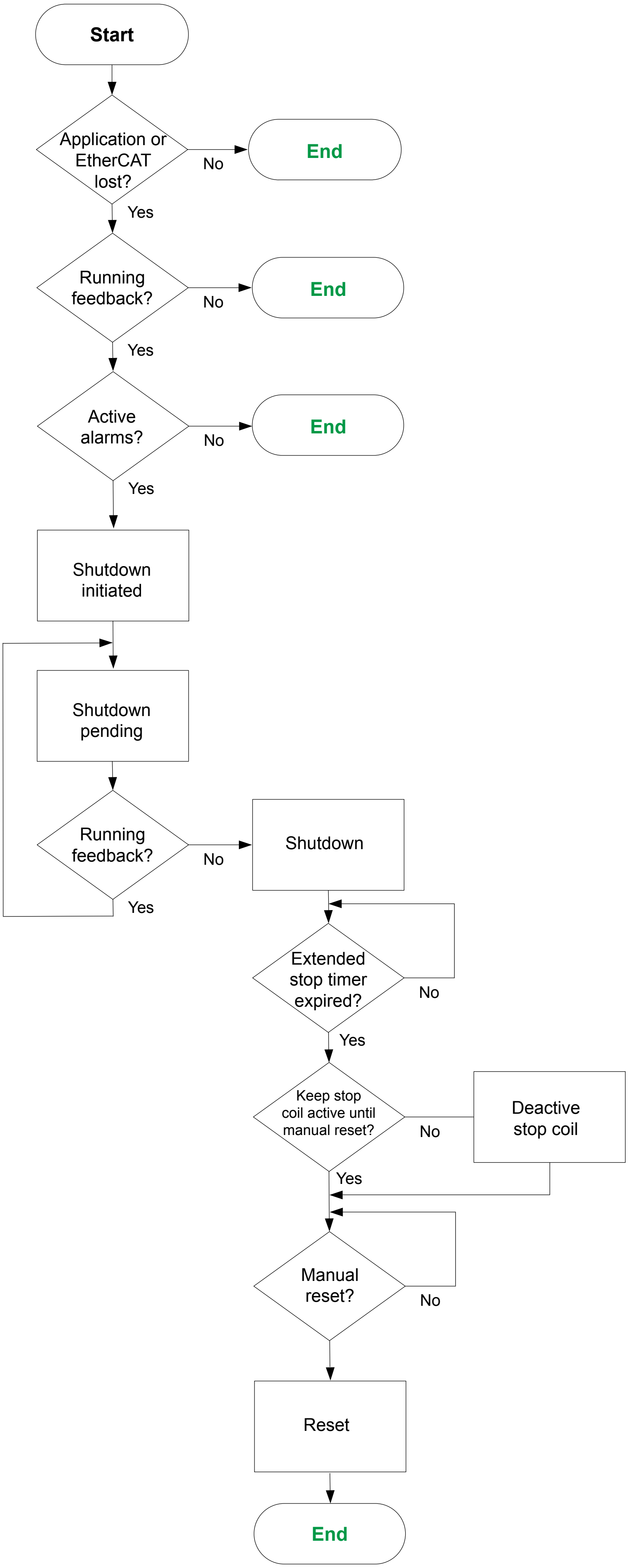
It is important to remember that with a manual reset configured, the EIM must have a manual reset in order to complete the sequence. If no manual reset occurs the engine remains stopped and can only be restarted by power cycling.

Figure 16.7 Shutdown sequence



1. The application or EtherCAT is checked to see if it is still active or connection has been lost.
   - If active then the application continues control.
2. Running feedback is checked it see if it is detected.
   - If there is no running feedback the engine is considered stopped.
   - Engine not active inhibit is activated.
   - Engine running inhibit is deactivated.
3. Alarms are checked to see if any active alarms are present.
   - If there are no active alarms the engine continues operation.
4. With active alarms a shutdown is initiated.
   - Stop coil is actived.
   - Run coil is deactivated.
   - Engine stopping inhibit is activated.
5. Shutdown is pending until there is no running feedback from the engine.
   - When no running feedback is detected the engine is considered stopped.
6. Shutdown initiated.
   - Engine not running inhibit activated.
   - Engine running inhibit deactivated.
   - Engine stopping inhibit deactivated.
7. The extended stop timer delay starts.
8. Reset
   - The stop coil is deactivated.
   - All alarms are reset.

Figure 16.8 Shutdown sequence with manual reset



1. The application or EtherCAT is checked to see if it is still active or connection has been lost.
    - If active then the application continues control.
2. Running feedback is checked it see if it is detected.
    - If there is no running feedback the engine is considered stopped.
    - Engine not active inhibit is activated.
    - Engine running inhibit is deactivated.
3. Alarms are checked to see if any active alarms are present.
    - If there are no active alarms the engine continues operation.
4. With active alarms a shutdown is initiated.
    - Stop coil is actived.
    - Run coil is deactivated.
    - Engine stopping inhibit is activated.
5. Shutdown is pending until there is no running feedback from the engine.
    - When no running feedback is detected the engine is considered stopped.
6. Shutdown initiated.
    - Engine not running inhibit activated.
    - Engine running inhibit deactivated.
    - Engine stopping inhibit deactivated.
7. The extended stop timer delay starts.
8. Checks if a stop coil must be kept active until a manual reset.
    - If the stop coil does not need to be kept active, then the stop coil is deactivated.
9. Manual reset is checked.
    - Manual reset must be activated in order to complete the sequence.
10. Reset
    - The stop coil is deactivated.
    - All alarms are reset.

Additional standalone alarms

These alarms are only present if safety shutdown has been enabled on the EIM module.

Table 16.9 Additional alarms

Alarm	Notes
EIM3.1 hardware revision does not support stand-alone	Activates if EIM3.1 hardware module is revision E or older.
Number of configured stand-alone alarms is too high	Activates if more than 23 alarms have been configured. Above and below using 2 alarms.
EIM3.1 safety shutdown still has control	Activates if the shutdown has been executed by EIM3.1 hadware module, and manual reset is not set high after, or if an alarm is running then application is started up again.
EIM3.1 safety shutdown configuration is not correct	Activates if the required configuration for active standalone is not correct. See **Required configuration for Active standalone mode** above.

16.11 Governor and AVR module GAM3.1

16.11.1 Analogue output (AO) characteristics

The analogue outputs are active, that is, they have their own power supply, and they must **not** be connected to an external supply.

Using a configured or selected output curve, the controller converts the regulation output or operating data to the corresponding current (-25 to 25 mA) or voltage (-10 to 10 V).

More information
See Analogue output characteristics and configuration for the general characteristics.

Using an analogue output with a switchboard instrument

The analogue output can be connected directly to a 4 to 20 mA switchboard instrument.

16.11.2 Pulse width modulation (PWM) output characteristics

The pulse width modulation (PWM) output is a regulation output for low power circuits. It may be used to regulate an electronic engine, but not an actuator.

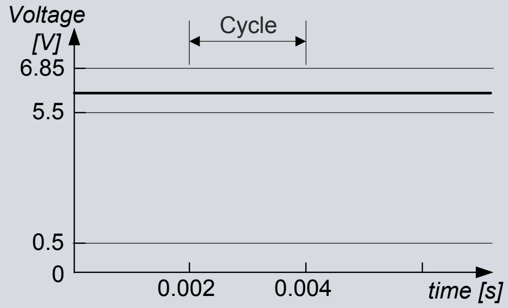
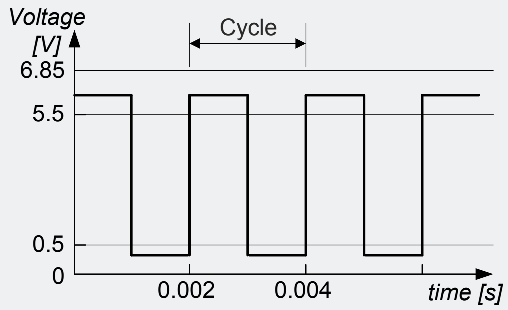
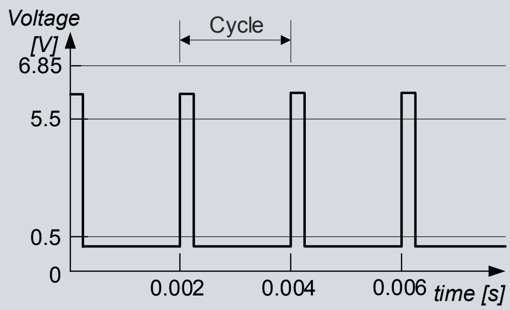
The PWM output (0 to 100 %) is configured as a curve, in the same way as the other analogue outputs.

More information
See Analogue output characteristics and configuration for the general characteristics.

Duty cycles

The PWM uses duty cycles for its output. The PWM frequency determines the cycle length. One cycle is therefore 1/500 Hz = 0.002 seconds long, ±10 %. The following table illustrates the output for various duty cycles.

Table 16.10 Relationship between duty cycles and the PWM output

Duty cycle	Graph
100 %	
50 %	
12.5 %	

16.11.3 Analogue input (AI) characteristics

This analogue input can be configured as either current (0 to 24 mA) or voltage (-10 to 10 V). Using a configured or selected input curve, the controller converts the input to a corresponding value. You can also configure the input to activate functions and/or alarms.

More information
See Analogue input characteristics and configuration for the general characteristics.

Galvanic connection

The two analogue inputs on GAM3.1 are galvanically connected. You therefore cannot use the analogue inputs on GAM3.1 in series with each other (for example, for a back-up measurement).

If you need two analogue inputs in series, you can use an analogue input on another hardware module in series with an analogue input on GAM3.1 (since the hardware modules are galvanically isolated from each other).

Current input

The current input may be either active or passive, and a combination of active and passive inputs may be used.

More information
See the **Installation instructions** for more information about the current input wiring.

Voltage input

More information
See the **Installation instructions** for more information about the voltage input wiring.

16.12 Governor and AVR module GAM3.2

16.12.1 Power supply

16.12.1.1 Power supply characteristics

Symbol on hardware module:

The power supply is connected to these terminals.

CAUTION

Frame ground

The frame ground is connected to the power supply terminals through transient voltage suppression diodes (commonly known as transorbs).

In order to protect the frame ground and power supply, no more than 36 V allowed across the frame ground and the power supply terminals.

Backup power

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

More information
See **Installation instructions** for how to wire the backup power supply.

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 equipment will not be damaged. However, the DEIF equipment will not be able to operate until the power supply has been connected correctly.

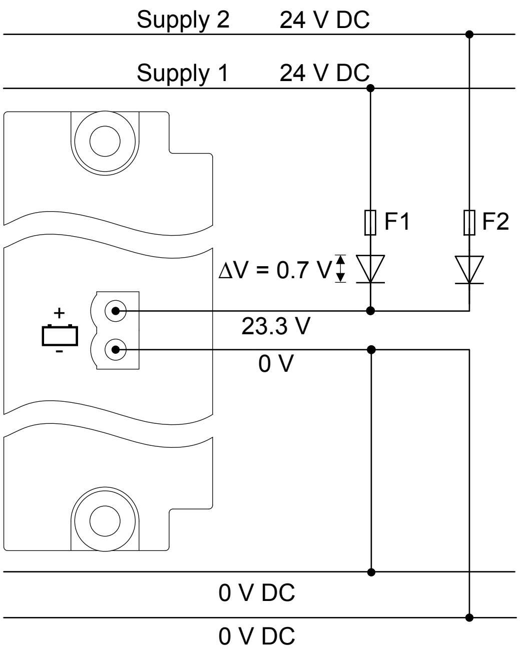
Diode compensation

Diode compensation is available in PSM3.1.

`Hardware > PSM3.1 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.

Figure 16.9 Example of a voltage decrease over a diode



Heat emission

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

16.12.1.2 Power supply voltage as an analogue output

You can configure an analogue output with a function for the power supply voltage. The controller then adjusts the analogue output to reflect the operating value.

Analogue output

Function	I/O	Units	Details
`Hardware > Power supply > GAM3.2 1 > GAM3.2 1 supply voltage [V DC]`	Analogue output	0 to 60 V DC	The controller measures the power supply voltage over the power supply terminals. The controller uses the configured curve to convert this value to an analogue output.

Application

An analogue output with the power supply voltage may be wired to a switchboard instrument to help the operator.

16.12.2 Frame ground characteristics

The frame ground is required by classification societies. Among other things, it makes the equipment more robust, for example against lightning.

CAUTION

Frame ground

The frame ground is connected to the power supply terminals through transient voltage suppression diodes (commonly known as transorbs).

To protect the frame ground and power supply, no more than 36 V is allowed between the frame ground and the power supply terminals.

16.12.3 Analogue output (AO) characteristics

The analogue outputs are active, that is, they have their own power supply, and they must **not** be connected to an external supply.

Using a configured or selected output curve, the controller converts the regulation output or operating data to the corresponding current (-25 to 25 mA) or voltage (-10 to 10 V).

More information
See Analogue output characteristics and configuration for the general characteristics.

Using an analogue output with a switchboard instrument

The analogue output can be connected directly to a 4 to 20 mA switchboard instrument.

16.12.4 Pulse width modulation (PWM) output characteristics

The pulse width modulation (PWM) output is a regulation output for low power circuits. It may be used to regulate an electronic engine, but not an actuator.

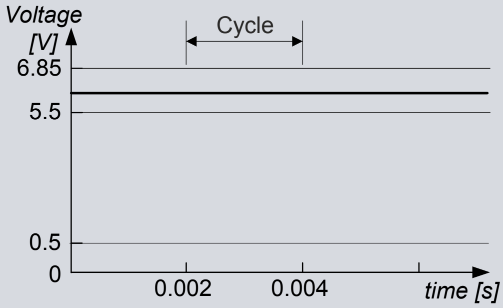
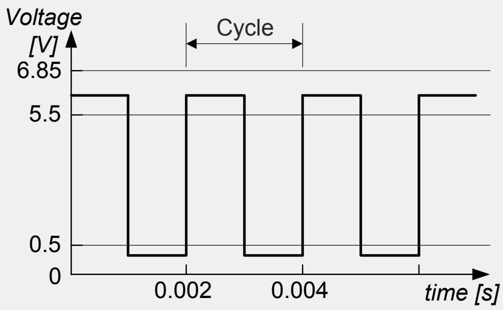
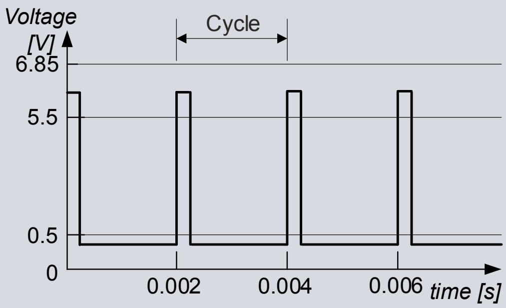
The PWM output (0 to 100 %) is configured as a curve, in the same way as the other analogue outputs.

More information
See Analogue output characteristics and configuration for the general characteristics.

Duty cycles

The PWM uses duty cycles for its output. The PWM frequency determines the cycle length. One cycle is therefore 1/500 Hz = 0.002 seconds long, ±10 %. The following table illustrates the output for various duty cycles.

Table 16.11 Relationship between duty cycles and the PWM output

Duty cycle	Graph
100 %	
50 %	
12.5 %	

16.12.5 Relay output characteristics

The first relay output (terminals 14,15) on GAM3.2 is reserved for the *Status OK* function. You cannot change the function for this relay.

The four other relay outputs on GAM3.2 are configurable (that is, terminals 16,17; 18,19; 20,21; and 22,23 can be assigned any function).

More information
See Relay output characteristics and configuration for the general characteristics.

16.13 Processor and communication module PCM3.3

16.13.1 CAN bus communication

16.13.1.1 About CAN bus communication

CAN bus is used for engine communication and/or control of a DAVR.

16.13.1.2 CAN bus cable

Recommended CAN bus cable

CAN communication (Engine, DAVR) 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.

16.13.1.3 CAN bus ECU or DAVR communication

The CAN bus terminals on the PCM3.3 module can be used for communication with an ECU and/or DAVR.

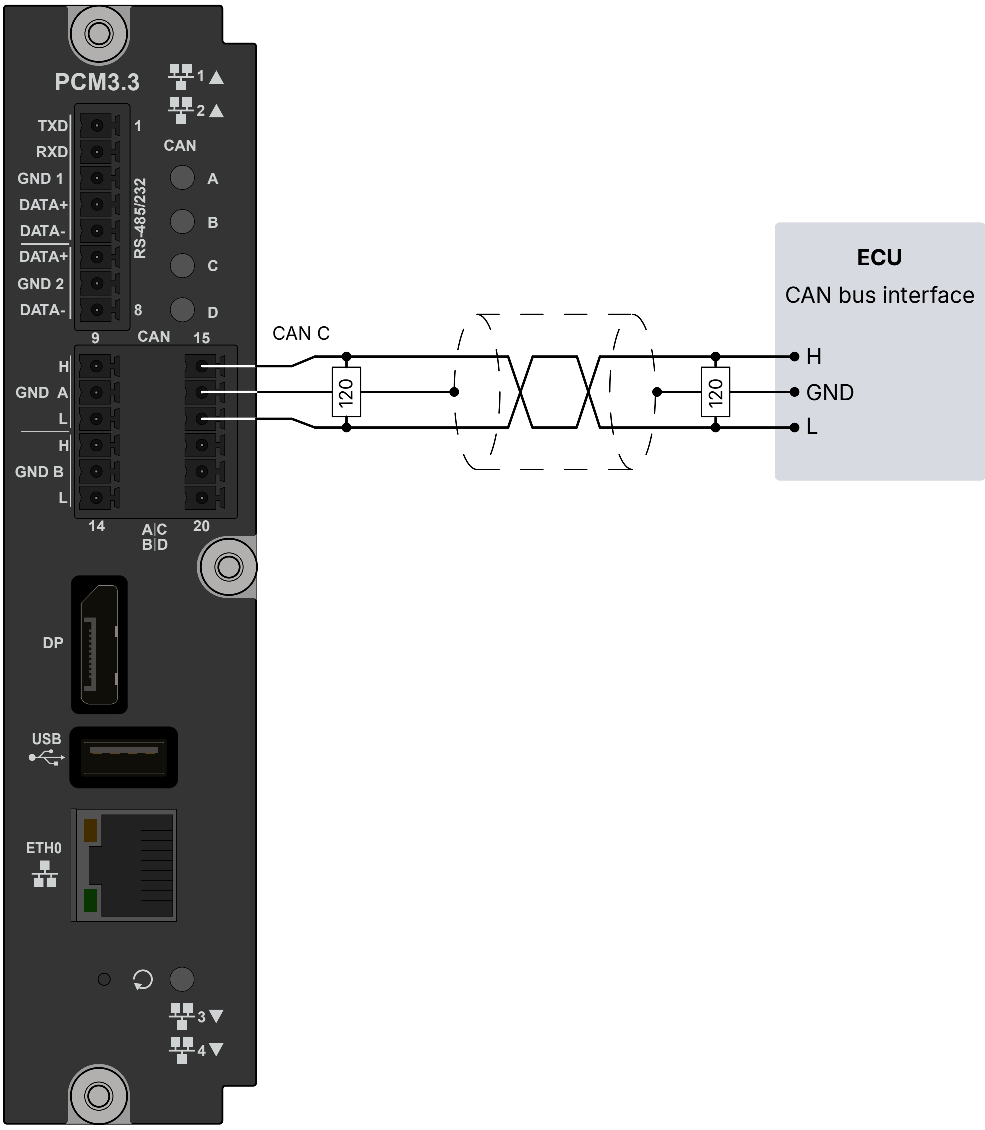
Use 120 Ω (Ohm) shielded twisted pair cable. Terminating resistors at the ends of the cable must be 120 Ω (Ohm).

The ECU may include a terminating resistor (see the engine manufacturer's information).

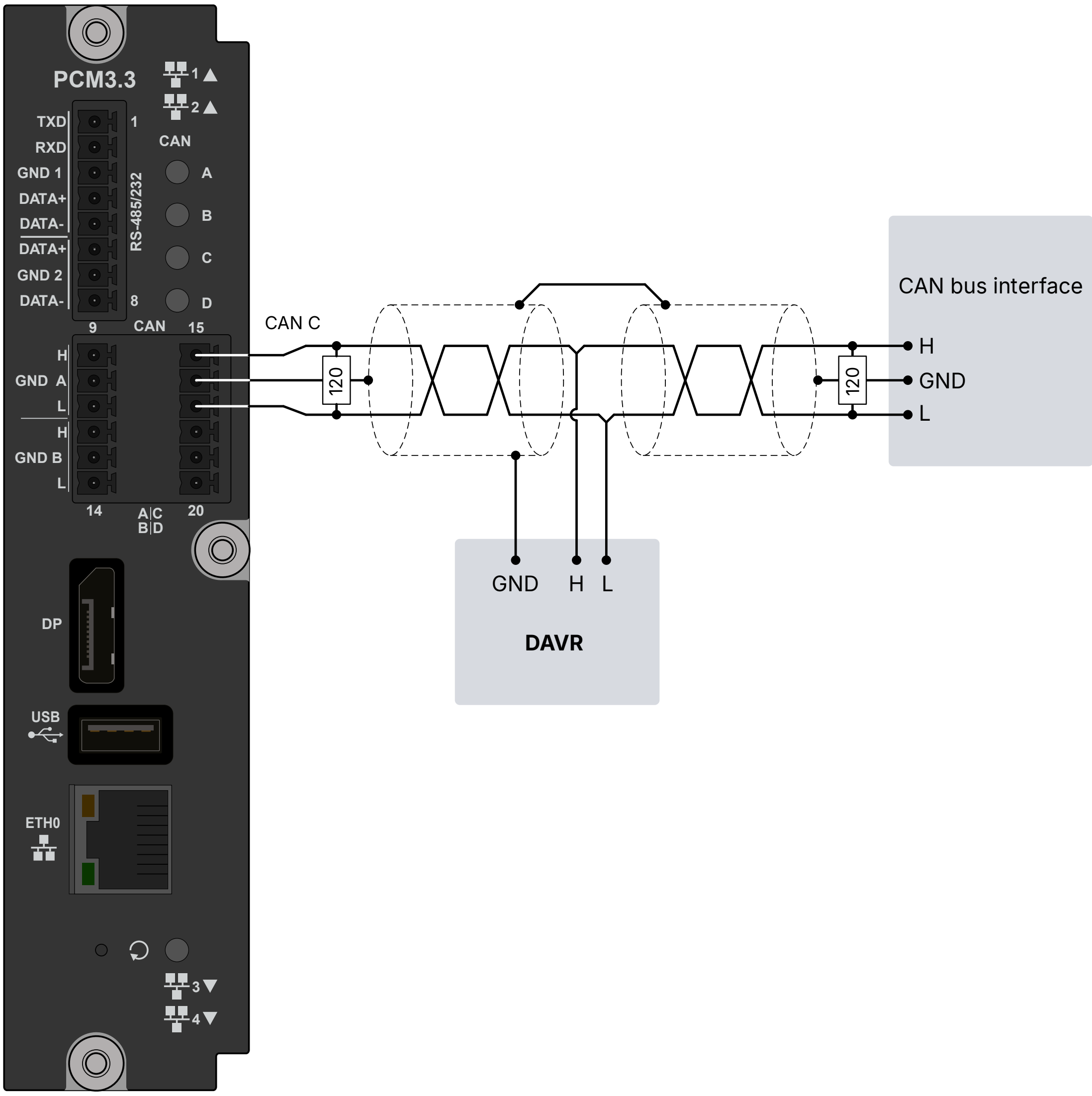
Example cable

Belden 3105A or equivalent, 22 AWG (0.33 mm²) twisted paid, shielded, impedance 120 Ω (Ohm), < 50 mΩ/m, min. 95 % shield coverage.

Wiring to ECU only



Wiring to ECU with DAVR



16.13.2 Ethernet communication

16.13.2.1 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.

More information
See **PCM3.3 network connections** in the **Installation instructions** for topology examples.

16.13.2.2 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.

16.13.2.3 DEIF network Ethernet characteristics

Category	Details
Specifications	• Internet Protocol version 6 (IPv6, Auto), or Internet Protocol version 4 (IPv4, Static) ◦ IPv6 is used by default until Static is specified as the IP address mode • Up to 32 controllers per system • Configure and optionally restrict Ethernet ports 0 to 4.
Functions	• Load sharing communication • Authentication (non-DEIF equipment cannot disrupt communication) • Connects the other controllers. • Password protection ◦ Customisable permission levels

16.13.2.4 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

Setting	Range	Default	Notes
			controller applications, since they are not affected by controller ID changes.) 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.

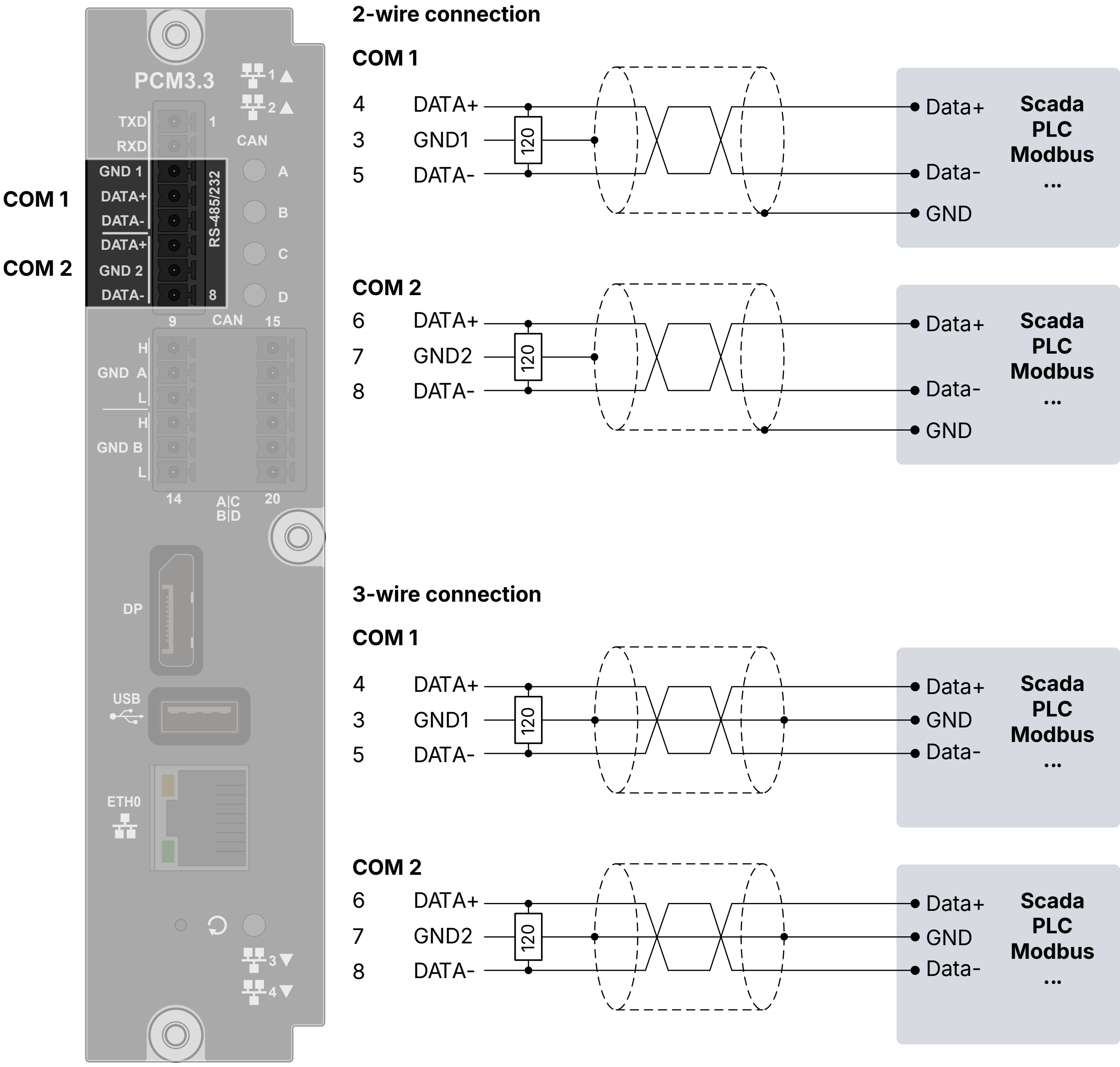
16.13.2.5 Ethernet port settings

Setting	Range	Notes
`Network mode`	• Standard node (sub-ring)	**Standard node (sub-ring)** : • Allows only interconnection between controllers.
`Port 1 to 5`	• Automatic • External network/PICUS • Stand-alone - External configured • RSTP External • Disabled *	**Automatic** : • The port automatically detects the type of device or connection. **External network/PICUS**: • Select to specify external network (Modbus, external switch, PICUS). **Stand-alone - External configured** **RSTP External** **Disabled**: • 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.

16.13.3 Serial communication COM 1 / COM 2

Can be used for example to Modbus RTU, SCADA systems, or PLCs. CODESYS is required.



16.13.4 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

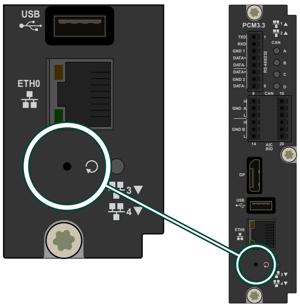
You cannot recover any controller information after a factory reset. All settings, including Ethernet configuration and passwords, are reset to their defaults.

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 inside the PCM:



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.

16.13.5 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.

16.13.6 PCM3.3 clock battery

PCM3.3 includes an internal battery for timekeeping during a power supply failure. If there is no power supplied to the controller or the PCM module, the controller uses the battery power for its internal clock.

During normal operation, the controller power supply powers the internal clock.

If both the power supply and clock battery fail, the controller internal clock time is lost.

For normal operation at a temperature under 40 °C, the battery should last 10 years before it needs replacing.

If the clock battery fails, there is a *PCM clock battery failure* alarm.

More information
See the **Data sheet** for the type of battery required.

More information
See **Maintenance** in the **Installation instructions** for how to change the battery.

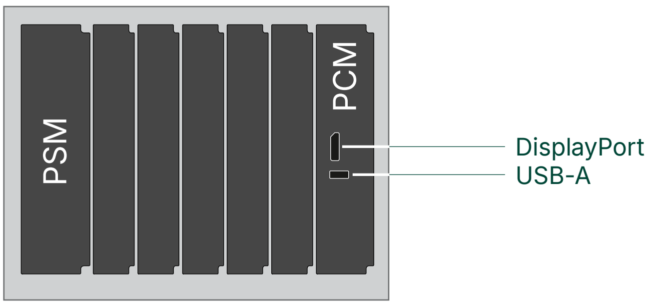
16.14 iE 7 Local display

16.14.1 iE 7 display connections

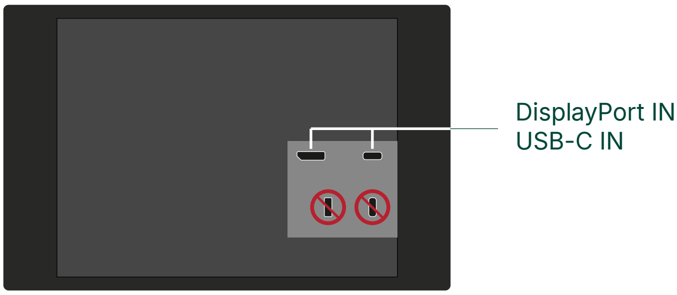
The display has inputs for **DisplayPort IN** and **USB type C IN**. It also has additional USB communication ports for future use.

The **DisplayPort IN** and **USB type C IN** are needed to connect and operate to the base-mounted controller.

Controller



Display

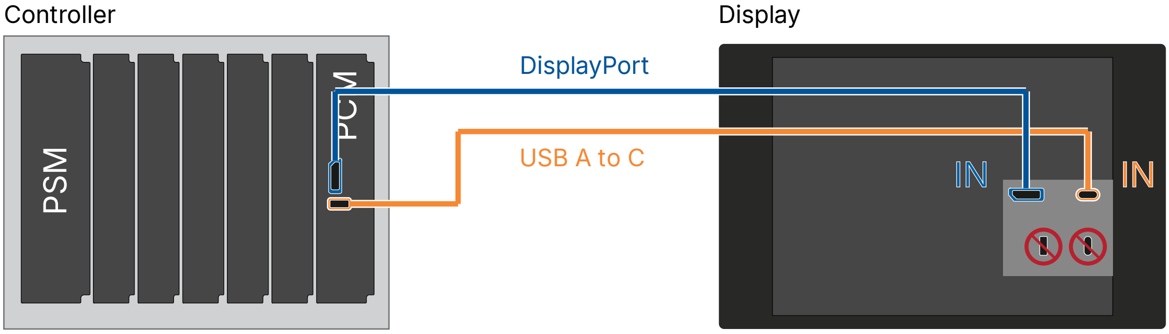


The additional USB ports on the display are for future use.

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.

17. Glossary

17.1 Terms and abbreviations

Term	Abbreviation	Explanation
Action		The pre-defined set of actions that an alarm initiates. Also known as fail class.
Alarm levels		The number of alarms that can be assigned to an operating value. For example, the Over-current protection by default has two alarm levels.
Alarm monitoring system	AMS	Third party equipment used to monitor the controller system's alarms, for example, by using Modbus TCP/IP communication.
Alternating current	AC	
Alternating current module 3.1	ACM3.1	A replaceable PCB with voltage and current measurement inputs. Used in the controller or extension racks.
Alternating current module 3.2	ACM3.2	A replaceable PCB for differential current measurement and protection. Used in the controller or extension racks.
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.
Blind module		A hardware module that consists of only a module faceplate. These are installed over empty slots, to protect the controller electronics.
Breaker		A mechanical switching device that closes to connect 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.

Term	Abbreviation	Explanation
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.
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.
Differential current module	ACM3.2	A replaceable PCB with current measurement inputs on consumer and neutral sides. Used in the controller or extension racks.
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.

Term	Abbreviation	Explanation
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.
Engine interface module 3.1	EIM3.1	A replaceable PCB, with its own power supply. This module includes 4 relay outputs, 4 digital inputs, an MPU and W input, and 3 analogue inputs. Used in the controller or extension racks.
European Norm	EN	Standards issued by the European Committee for Standardisation (also known as Comité Européen de Normalisation).
Firmware		Software that is installed in the controller. This software enables the controller to: process inputs and outputs, display operating data, keep track of the 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.
Governor and AVR module 3.1	GAM3.1	A replaceable PCB, which includes load sharing capability. This module also includes 4 relay outputs, 2 analogue current or voltage outputs, a pulse width modulation output, and 2 analogue current or voltage inputs. Used in the controller or extension racks.
Governor and AVR module 3.2	GAM3.2	A replaceable PCB with its own power supply, two analogue outputs, a pulse width modulation output, five digital inputs, a status relay output, and four relay outputs. Used in the controller or extension racks.
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.
Input output module 3.1	IOM3.1	A replaceable PCB, with 4 relay outputs, and 10 digital inputs. Used in the controller or extension racks.
Input output module 3.2	IOM3.2	A replaceable PCB, with 4 relay outputs, 4 analogue multifunctional outputs, 4 digital inputs, and 4 analogue multifunctional inputs. Used in the controller or extension racks.

Term	Abbreviation	Explanation
Input output module 3.3	IOM3.3	A replaceable PCB, with 10 analogue multifunctional inputs. Used in the controller or extension racks.
Input output module 3.4	IOM3.4	A replaceable PCB, with 12 transistor outputs, and 16 digital inputs. Used in the controller or extension racks.
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.
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.

Term	Abbreviation	Explanation
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.
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.

Term	Abbreviation	Explanation
Rack		An aluminium box with a rack system that houses the hardware modules. Each controller consists of a rack and a number of hardware modules.
Rapid spanning tree protocol	RSTP	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.
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	

Term	Abbreviation	Explanation
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.

17.2 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) 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				

Unit	Name	Measures	US unit	US name	Conversion	Alternative units
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				

17.3 Symbols

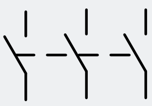
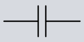
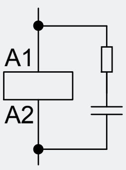
17.3.1 Mathematical symbols

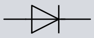
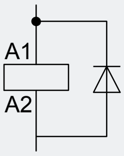
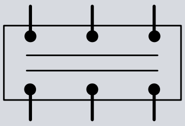
Abbreviation	Symbolises	Example
+	Addition	2 + 3 = 5
-	Subtraction	5 - 2 = 3
x	Multiplication (numbers)	2 × 3 = 6
/	Division	15 / 3 = 5
·	Multiplication (units)	5 N·m = 5 Newton metres
Σ	Summation	Σ Nominal power for connected gensets = 1000 kW + 1500 kW + 500 kW = 3000 kW

17.3.2 Drawing symbols

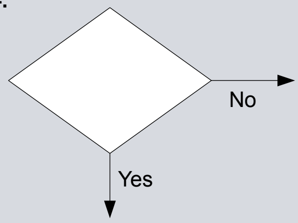
The drawings use EU symbols.

Electrical symbols

Symbol	Symbol name
	3-phase breaker
	Capacitor
Contactor 	Contactor with RC snubber
•	Connector dot

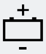
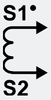
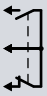
Symbol	Symbol name
	Current transformer (S1 and · show "current in"; S2 shows "current out")
	Diode
	Fuse
	Ohmmeter
Relay 	Relay with freewheeling diode
	Resistor (IEC-60617)
	Single-line diagram closed breaker
	Single-line diagram open breaker
○	Temporary connection dot (for example, connection to a 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.

17.3.3 Flowchart symbols

Symbol	Notes
#. 	Decision # shows step number.
	Process
ALARM	Alarm
Info message	Information message
	Start or end

17.3.4 Module faceplate symbols

Terminals

Symbol	Symbol name
	Frame ground
	Power supply
L1, L2, L3 and N	Three-phase voltage measurements
	Current transformer
COM	Common
	Digital input
	Relay output (normally open)
	Relay with wire break detection (normally open)
	Relay output (changeover relay, with normally open and normally closed terminals)
	Analogue current or voltage input
	Analogue current or resistance measurement input (RMI)
	Magnetic pickup (MPU)
W	W input (for a generator tacho output or NPN/PNP sensor)
	Analogue current or voltage output
	Pulse width modulation (PWM) output
	Analogue input ground Analogue output ground Pulse width modulation (PWM) ground
	Active P load sharing (future use)
	Reactive Q load sharing (future use)
	Transistor positive supply
	Transistor output
	Transistor common
H, CAN-A, L	CAN bus A connection (future use)
H, CAN-B, L	CAN bus B connection (future use)

LEDs

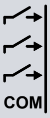
Symbol	Symbol name
CAN-A	CAN bus A (PCM)
CAN-B	CAN bus B (PCM)
	Network and DEIF network (PCM)
	Internal communication in (PSM)

Symbol	Symbol name
	Internal communication out (PSM)
	Internal communication status (PSM)
⏻	Power supply status (PSM)
	System status (PCM)

Other

Symbol	Symbol name
▲	RJ45 connections at the top of the hardware module
▼	RJ45 connections at the bottom of the hardware module
	SD card

Terminal groups

Example	Explanation
	The vertical line to the right of the symbols shows terminal groups. In the example, the digital inputs have the same common.